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ТЕМАТИЧЕСКИЙ РЕФЕРАТИВНЫЙ СБОРНИК № 33-1

“Radiowave Propagation”
(«Распространение радиоволн»)

Журнальные публикации

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"A Human Body Model for Efficient Numerical Characterization of UWB Signal Propagation in Wireless Body Area Networks"

Wireless body area network (WBAN) is a new enabling system with promising applications in areas such as remote health monitoring and interpersonal communication. Reliable and optimum design of a WBAN system relies on a good understanding and in-depth studies of the wave propagation around a human body. However, the human body is a very complex structure and is computationally demanding to model. This paper aims to investigate the effects of the numerical model's structure complexity and feature details on the simulation results. Depending on the application, a simplified numerical model that meets desired simulation accuracy can be employed for efficient simulations. Measurements of ultra wideband (UWB) signal propagation along a human arm are performed and compared to the simulation results obtained with numerical arm models of different complexity levels. The influence of the arm shape and size, as well as tissue composition and complexity is investigated. [J1]

"On the Physical Limitations of the Interaction of a Spherical Aperture and a Random Field"

This paper derives physical limitations on the interactions of antennas exciting TM or TE modes (but not both) and wireless propagation channels. The derivation is based on the spherical vector wave expansion of the electromagnetic field outside a sphere circumscribing the antennas. The result is an extension of the seminal work of Chu on the classical limitations on maximum antenna gain and radiation Q. Rather than maximizing antenna gain in a single direction we obtain physical limitations on the antenna gain pattern, which is directly translated to more condensed parameters, i.e., the instantaneous effective gain Giand the mean effective gain Geif instantaneous realizations or correlation statistics of the expansion coefficients of the electromagnetic field are known, respectively. The obtained limitations are on the maximum of Gi/Qand Ge/Q, which establish a trade-off between link gain and Q. [J2]

"Localizing WiFi Access Points Using Signal Strength"

When estimating the location of WiFi access points (AP) in an anonymous environment, the required parameters of the radio propagation model are not readily obtainable. This letter investigates the use of received signal strength (RSS) for range-based AP localization when no information on the radio propagation model is provided. To achieve this goal, we linearly approximate the exponential relationship between RSS and distance, and apply a multilateration technique. Our simulation results validate that estimation of an AP location is possible given four or more RSS measurements at different locations. [J3]

"A New Lower Bound on Range-Free Localization Algorithms in Wireless Sensor Networks"

This letter examines the lower bound on localization error, which is an important performance measure for localization algorithms. Unlike some previous works based on the circular coverage model, we consider a more realistic scenario where radio propagation is subject to log-normal shadow fading. In this letter, we present an analytical expression for the distribution of lower bound on localization error for any range-free localization algorithm in WSNs. Finally, the derivation is validated through simulations. [J4]

"Polarimetric Decomposition Over Glacier Ice Using Long-Wavelength Airborne PolSAR"

In recent years, there has been increased interest in using synthetic aperture radar (SAR) to study and monitor glaciers and ice sheets for glaciological and climate change research. However, due to the medium's complexity, SAR backscattering from ice remains poorly understood, including the relative importance of scattering from surface and volume layers and also dependences on frequency and glacier zone. Extreme weather conditions can result in quickly changing surface conditions influencing backscatter signatures while leaving the underlying volume of interest unchanged. Surface and volume components must thus be separated in order to infer information regarding the properties of the ice volume. This paper describes a three-component scattering model

to decompose polarimetric SAR (PolSAR) images of glacier ice. Total backscatter is modeled as the incoherent summation of surface, volume, and sastrugi (wind-induced feature) components. The proposed model adapts and extends the Freeman and Durden decomposition for an ice volume scenario in which the volume is a dielectric medium. Forms of the model for both random and oriented volumes are considered, and a new oriented sastrugi component is introduced which is able to explain backscatter behavior between different winter scenes. Validation is performed with airborne PolSAR data at L- and P-band collected using the E-SAR system of the German Aerospace Center over the Austfonna ice cap in Svalbard, Norway, as part of the ICESAR campaign. [J5]

"Numerical Simulations of Borehole Radar Detection for Metal Ore"

We perform a finite-difference time-domain numerical simulation for metal ore detection by borehole radar. The ore-body model is a practical Ni-Cu-Pt one which is a magmatic deposit located in Sudbury, Canada. We design three boreholes along a cross section perpendicular to the geological strike of the formation which is composed of overburden, ore zone, iron formation, peridotite, granite gneiss, and sediments. We analyze the simulated borehole radar profiles and find that some interfaces could be detected. The ore zone is very absorptive to electromagnetic wave. By combined interpretation of the data from several boreholes, the azimuth ambiguity of the borehole radar could be overcome with some a priori geological information, and the geological structure could be delineated clearly. [J6]

"Periodically Loaded Straight Wires for Radio Wave Transmission Control"

Calculating current distributions along conducting straight wires reveals that the electric influence of the wires is more effectively reduced by loading reactances than it is by disconnecting the loading ports. With the electric influence almost eliminated, a sheet consisting of reactively loaded straight wires can almost perfectly transmit a radio wave of a frequency determined by the interval between the loading ports and the reactance value. The frequency responses of radio wave transmissions for a normal incident plane wave are numerically calculated, and it is shown that by controlling the reactance value, the transmission can be changed more than 30 dB. Thus, a sheet by which radio wave transmission can be electronically controlled is proposed, and its operation is experimentally examined. [J7]

"Ground Wave Propagation Along an Inhomogeneous Rough Surface in the HF Band: Millington Effect for a Flat Earth"

In this paper, for a vertically polarized line source in the high-frequency band (3-30 MHz), a detailed analysis of the ground wave propagation over 1-D highly conducting inhomogeneous (presence of island) smooth and rough surfaces is addressed from two methods: 1) the analytical solution of Bremmer (see also Wait), which assumes that the receiver, emitter, and island heights are zeros and that the surface is composed of three smooth paths of different permittivities, and 2) the efficient rigorous banded matrix iterative approach/canonical grid (BMIA-CAG) method, which is based on the method of moments and is updated to validate the analytical solution of Bremmer. In addition, from the works of Barrick, the sea surface roughness is included in the Bremmer formulation and tested from the BMIA-CAG by considering a surface composed of sea-land-sea mixed paths. The comparisons show a good agreement between the updated BMIA-CAG (reference method) and the Bremmer analytical formulation combined with the works of Barrick. The Earth curvature is neglected. [J8]

"A Single-Base-Station Localization Approach Using a Statistical Model of the NLOS Propagation Conditions in Urban Terrain"

Implementation of the Federal Communications Commission's (FCC) E-911 Phase-2 requirements and commercial location-based services in urban environments requires mobile station (MS) localization capabilities in non-line-of-sight (NLOS) propagation conditions. This work addresses the problem of MS localization in urban environments characterized by the NLOS propagation conditions and limited Global Positioning System (GPS) services. We propose a single-base-station-based localization approach that uses a statistical model of urban propagation conditions in the framework of target classification. The proposed localization approach involves no data collection during the training process, requires no modifications of the MS hardware, is not location specific, and requires no identification and mitigation of the NLOS conditions. The performance of the proposed localization approach was evaluated using collected and ray-traced measurements. [J9]

"Efficient Rasterization for Outdoor Radio Wave Propagation"

Conventional beam tracing can be used for solving global illumination problems. It is an efficient algorithm and performs very well when implemented on the GPU. This allows us to apply the algorithm in a novel way to the

problem of radio wave propagation. The simulation of radio waves is conceptually analogous to the problem of light transport. We use a custom, parallel rasterization pipeline for creation and evaluation of the beams. We implement a subset of a standard 3D rasterization pipeline entirely on the GPU, supporting 2D and 3D frame buffers for output. Our algorithm can provide a detailed description of complex radio channel characteristics like propagation losses and the spread of arriving signals over time (delay spread). Those are essential for the planning of communication systems required by mobile network operators. For validation, we compare our simulation results with measurements from a real-world network. Furthermore, we account for characteristics of different propagation environments and estimate the influence of unknown components like traffic or vegetation by adapting model parameters to measurements. [J10]

"Direct sequence spread spectrum point-to-point communication scheme in underwater acoustic sparse channels"

Owing to multiple access capability, low probability of intercept and immunity against inter symbol interference (ISI) caused by multipath propagation, direct sequence spread spectrum (DSSS) techniques have been utilised in both underwater acoustic (UWA) communication networks and reliable point-to-point communications. To overcome the severe impact of ISI in the UWA channels, we propose a novel multiple pseudo noise (PN) sequence DSSS scheme and analyse its performance in sparse time varying UWA channels. Analytical and simulation results show that using a few PN sequences can remove most of the multipath induced ISI. To further alleviate the ISI effect, we propose a simple ISI reduction algorithm. Numerical results show that our proposed algorithm along with the proposed DSSS scheme can effectively mitigates the effect of remaining ISI, especially in sparse multipath channels. [J11]

"WASP: A System and Algorithms for Accurate Radio Localization Using Low-Cost Hardware"

In this paper, we present a low-cost wireless sensor network platform, called wireless ad hoc system for positioning (WASP), that has been developed for high-accuracy localization and tracking. This platform uses the time of arrival (TOA) of beacon signals periodically transmitted by the nodes at known times for localization. The system was designed to have a unique tradeoff between hardware complexity and processing complexity to provide high accuracy at minimal cost in complex radio propagation environments. To enable the system to perform well in realistic environments, it was also necessary to develop novel extensions to existing algorithms for the measurement of TOA, localization, and tracking. In this paper, we describe the architecture, hardware, and algorithms of WASP and present results based on field trials conducted in different radio propagation environments. The results show that WASP achieves a ranging accuracy of 0.15 m outdoors and 0.5 m indoors when around 12 anchor nodes are used. These accuracies are achieved with operating range of up to 200 m outdoors and 30 m indoors. This compares favorably to other published results for systems operating in realistic environments. [J12]

"Tree-Structured Expectation Propagation for Decoding Finite-Length LDPC Codes"

In this paper, we propose Tree-structured Expectation Propagation (TEP) algorithm to decode finite-length Low-Density Parity-Check (LDPC) codes. The TEP decoder is able to continue decoding once the standard Belief Propagation (BP) decoder fails, presenting the same computational complexity as the BP decoder. The BP algorithm is dominated by the presence of stopping sets (SSs) in the code graph. We show that the TEP decoder, without previous knowledge of the graph, naturally avoids some fairly common SSs. This results in a significant improvement in the system performance. [J13]

"Modeling Radio Transmission Loss in Curved, Branched and Rough-Walled Tunnels With the ADI-PE Method"

We discuss the use of the parabolic equation (PE) along with the alternate direction implicit (ADI) method in predicting the loss for three specialized tunnel cases: curved tunnels, branched tunnels, and rough-walled tunnels. This paper builds on previous work which discusses the use of the ADI-PE in modeling transmission loss in smooth, straight tunnels. For each specialized tunnel case, the ADI-PE formulation is presented along with necessary boundary conditions and tunnel geometry limitations. To complete the study, examples are presented where the ADI-PE numerical results for the curved and rough-walled tunnel are compared to known analytical models and experimental data, and the branched tunnel data is compared to the numerical solutions produced by HFSS. [J14]

"Propagation Over Parabolic Terrain: Asymptotics and Comparison to Data"

Analysis of radio propagation over varying, clutter-covered terrain was carried out aiming at prediction of power

received by a terminal immersed in clutter, with the transmitter placed above clutter. The need for such prediction arises, for example, in planning and assessing coverage and interference in radio communications. Following a general formulation of the problem, particular solutions were found when the terrain has constant curvature. Asymptotic evaluation yielded compact expressions both for parabolic valleys and ridges. In both cases, ray-optical term dominated for short ranges, while a single mode dominated at large ranges. Strong focusing was found to occur in valleys, while ridges produced strong blockage beyond the ??horizon??. The resulting procedure for predicting pathloss over varying terrain is therefore to apply the formulae using the terrain curvature extracted from terrain files. In comparison to measured power across a valley, mean errors of less than 1 dB were found, a marked improvement over standard terrain-unaware models that produce a mean error of 30 dB. [J15]

"A Hybrid Model for Radio Wave Propagation Through Frequency Selective Structures (FSS)"

A novel hybrid model is presented to study the radio wave propagation through frequency selective structures (FSS) used to control propagation in an outdoor to indoor building environment. This hybrid model is based on combining ray-tracing with a commercial tool, Computer Simulation Technology (CST) Microwave Studio. Numerical results of the hybrid model have been compared with those of a full wave rigorous solver for FSS small in wavelength terms. Good agreement has been achieved with substantially increased computation efficiency, which validates the recommended hybrid method for this class of applications. [J16]

"Channel modeling and analysis for wireless networks in underground mines and road tunnels"

Wireless networks can greatly facilitate the communication in underground mines and road/subway tunnels, where the propagation characteristics of electromagnetic (EM) waves are significantly different from those in terrestrial environments. According to the structure of underground mines and road tunnels, two types of channel models can be utilized, namely, tunnel and room/pillar channel models. However, there exists no theoretical model for room-and-pillar channel in underground mines to date, and current existing tunnel channel models do not provide an analytical solution for both near and far regions of the sources. In this paper, the multimode model is proposed, which provides an analytical expression for the received power and the power delay profile at any position in a tunnel.Moreover, the multimode model is extended to characterize the room-and-pillar channel in the underground mines after combining it with the shadow fading model. The theoretical models are validated by experimental measurements. Based on the proposed channel models, the effects of various factors on the signal propagation are analyzed. The factors include: the operating frequency, the size of the tunnel or underground mine room, the antenna position and polarization, and the electrical parameters. [J17]

"UWB Channel Modeling in Roadway and Indoor Parking Environments"

In this paper, the characteristics of ultrawideband (UWB) channels on outdoor roadway and indoor parking environments are investigated. A set of propagation measurements were conducted on roadways and in underground parking garages, and the resulting propagation data consist of approximately 1200 measured signals. Multipath properties are characterized using tapped-delay-line and Saleh-Valenzuela (S-V) models. Power-law-type decay patterns are observed in the ray-energy decay, as well as in the power delay profile. Results are compared with existing UWB models, including the IEEE 802.15.4a channel model. [J18]

"Topology Assessment Provided by Weighted Barycentric Parameters in Harsh Environment Wireless Location Systems"

In wireless location systems deployed in open areas, the statistical distributions of the range estimates are very tractable. However, due to the nature of the wireless propagation in urban and indoor environments, the behavior of the range estimates in such environments is very different. Therefore, the performance assessment results obtained for the systems operating in open areas cannot be transferred to the ones deployed in realistic urban and indoor environments. In this paper, the systematic and random errors (accuracy and precision) and the dilution-of-precision (DOP) in harsh environments are derived for the two most common multilateration algorithms, as well as the performance theoretical benchmark. We show that these quantities are determined by geometric parameters that we call topology-assessment-weighted-barycentric-parameters (TAWBAP), which are the norm of weighted barycenters obtained from the positions of anchors and target. These parameters manage the performance of the multilateration process showing the influence of the geometric configuration in connection with the specific characteristics of each range estimate. The improvement in performance obtained by using the TAWBAP parameters as a network design rule is demonstrated by means of simulations as well as by measurements taken in a real indoor environment. This improvement outperforms at least 25% the one achieved by topology deployments that have been considered as optimal in the literature. [J19]

"Spectral Properties of Modulated Signal in the Doppler Domain in Urban Radio Channels With Fading"

We examine propagation of frequency modulated (FM) radio signals in the urban environments for different elevations of base station (BS) and mobile subscriber (MS) antennas, below and above the rooftops, based on the stochastic multi-parametric approach. We concentrate our attention on the spectral properties of signal power variations in the frequency domain and describe them based on the Doppler-spread spectrum of bandpass signal power. In the framework of the stochastic approach, the total signal power, the correlation function, the Ricean K-parameter of fading, and the scale of correlation of different spectral components of the modulated signal are analyzed. A practical aspect of relationship between the correlation scale of any two components of the FM signal and the coherent bandwidth of the urban channel with fading is examined via prism of special experiment. New effects of buildings' density and the elevation of BS antenna on above characteristics of the FM signal are examined numerically. It is found that, depending on various scenarios occurring in the urban scene, the buildings' density and the elevation of BS antenna can significantly distort the modulated signal within radio link with fading. [J20]

"Four-slope channel model for path loss prediction in tunnels at 400 MHz"

The present study analyses radio propagation at the 400 MHz frequency band inside road and railway tunnels. It proposes, on the basis of field measurements, a path loss model consisting of four segments, namely: the free space segment, the high path loss segment, the waveguide segment and, in the furthest region, the free space propagation segment. Free space propagation is characteristic in a region close to an antenna. In the next region, the near region, only a few reflected rays reach the receiver resulting in high path loss. Further away, in the far region, the waveguide effect occurs because of a set of waves reflected from the tunnel walls resulting in low path loss. In the extreme far region, the waveguide effect vanishes because of attenuation of reflected rays. The points separating the individual segments are analytically defined. Model applicability and accuracy are checked by calculating the mean error and standard deviation. The results indicate reasonable agreement between measurements and the model. This four-slope path loss channel model can be applied for rapid and simple coverage prediction of direct mode operation in TETRA systems. [J21]

"Local High-Resolution Technique in FDTD Modeling of ELF Propagation in the Earth-Ionosphere Cavity"

In this letter, a local high-resolution technique (LHRT) of three-dimensional finite-difference time-domain (3D-FDTD) method is presented for the extremely low-frequency (ELF) electromagnetic (EM) wave propagation in the Earth-ionosphere cavity. This new model is useful for the analysis of the ELF EM wave propagating in a specific region, where the required space interval of the grid-cell is extremely fine. Once the length of the required space interval in the specific region and the cutoff frequency of the source are determined, the model of Earth-ionosphere cavity can be established automatically. It is verified that the simulation results of the new technique are as accurate as those of the traditional methods. [J22]

"Propagation Characteristics of Wideband Relay Channels in Urban Micro-Cell Environment"

In order to evaluate the performance of a relay system, propagation characteristics of relay channels are necessary, especially in urban micro-cell (UMi) environment. We conducted wideband relay channel measurements at 2.35 GHz in two UMi sites in China by employing a real-time channel sounder. Three types of links-base station to mobile station (BS-MS), relay station to mobile station (RS-MS), and base station to relay station (BS-RS)-were measured separately at three sites. Statistical propagation characteristics are presented and compared in this letter, including path loss (PL), root mean square (rms) delay spread (DS), and angular spread (AS). These results are informative for the technical research and evaluation of the relay system. [J23]

"Measurement-Based Evaluation of Interlink Correlation for Indoor Multiuser MIMO Channels"

The properties of the single-link multiple-input-multiple-output (MIMO) propagation channels have been analyzed in many studies based on extensive propagation measurements. In this letter, we extend the measurement-based analysis to dual-link MIMO propagation channels. Here, we examine interlink correlation by evaluating the correlation of eigenvectors obtained from multiple MIMO links. We also investigated how the physical propagation phenomena produced the interlink correlation. Results indicate that interlink correlation may exist. Sometimes it is found to be very high also for far separated receive units, depending on similarity of dominant propagation mechanisms between multiple MIMO links and also on antenna array properties. [J24]

"A Study of Anomalous Propagation in Persian Gulf"

Problem of anomalous propagation with regard to radio broadcasting in the countries surrounding the Persian Gulf is studied in this paper. The extreme conditions of humidity, temperature, water vapor and atmospheric pressure result in anomalous propagation conditions that disturbs the normal mode of radio propagation. The daily and seasonal changes in the meteorological conditions directly affect the carrier to interference plus noise ratio (CINR) in the coverage area with the consequence that the desired minimum CINR within the designated coverage area cannot be guaranteed. In this paper, we study these changes to the propagation conditions by analyzing the meteorological data over nearly three decades and develop a signal strength prediction model that integrates these conditions with the environmental features. The contour maps of refractive index and its gradient over the Persian Gulf Area are produced. To validate the developed model, signal propagation conditions were simulated and measurements made over an experimental link between Manamah in Bahrain and Dhahran in Saudi Arabia. [J25]

"Landmobile Radiowave Multipaths' DOA-Distribution: Assessing Geometric Models by the Open Literature's Empirical Datasets"

??Geometric modeling?? idealizes the spatial geometric relationships among the transmitter, the scatterers, and the receiver in a wireless propagation channel-to produce closed-form formulas of various channel-fading metrics (e.g., the distribution of the azimuth angle-of-arrival of the arriving multipaths). Scattered in the open literature are numerous such ??geometric models,?? each advancing its own closed-form formula of a fading metric, each based on a different idealization of the spatial geometry of the scatterers. Lacking in the open literature is a comprehensive and critical comparison among all such single-cluster geometric-model-based formulas of the arriving multipaths' azimuth direction-of-arrival distribution. This paper fills this literature gap. The comparison here uses all empirical data legibly available in the open literature for landmobile wireless radiowave propagation. No one geometric model is best by all criteria and for all environments. However, a safe choice is the model with a Gaussian density of scatterers centered at the transmitter. Despite this model's simplicity of having only one degree of freedom, it is alwayseither the best fitting model or offers an LSE within one third of an order-of-magnitude as the best fitting model for all empirical dataset of all environments. [J26]

"Efficient Numerical Modal Solutions for RF Propagation in Lossy Circular Waveguides"

The propagation of electromagnetic waves is reconsidered in the context of cylindrical tunnels through material of uniform electrical properties. In the absence of internal conductors, the wave solutions reduce to well-known analytic expressions, requiring the solution of a single transcendental equation in complex phase space. Any given tunnel configuration has a wide range of solutions in phase and frequency space. Identifying these solutions can be a significant numerical challenge. Both the Newton-Raphson method and the winding number technique have been described in previous publications, and each can be prone to missing solutions. This paper reviews these two solution techniques and develops a combination of the two to provide a fast and efficient procedure for locating the roots in well-defined regions of phase space. [J27]

"Effect of Human Presence on UWB Radiowave Propagation Within the Passenger Cabin of a Midsize Airliner"

We have characterized the effect of human presence on path gain and time dispersion over ultrawideband (UWB) channels within the passenger cabin of a typical midsize airliner. We measured a few hundred channel frequency responses over the range 3.1-6.1 GHz between various locations within a Boeing 737-200 aircraft, with and without volunteers occupying the passenger seats. The links were deployed in a point-to-multipoint configuration with the transmitting antenna along the centre-line of the forward part of the cabin at either the ceiling or headrest level and the receiving antenna at the headrest or armrest level at selected locations throughout the rest of the cabin. As the density of occupancy increased from empty to full, path gain dropped by no more than a few dB on the ceiling-to-headrest paths but dropped by up to 10 dB on the ceiling-to-armrest and headrest-to-armrest paths. The gain reduction reached its maximum at the mid-point of the cabin and decreased thereafter. In all cases, increasing the density of occupancy caused the distance dependence of the rms delay spread to decrease greatly, the decay rate of the scattered components in the power delay profile (PDP) to almost double and the number of significant paths to drop by almost half. The results suggest that human presence substantially affects both path gain and time dispersion within the aircraft and should therefore be considered when assessing the performance of in-cabin wireless systems. [J28]

"A Novel Inversion Method for Outdoor Coverage Prediction in Wireless Cellular Network"

A novel coverage-prediction method for outdoor radio propagation based on the inversion theory is proposed here. Coverage prediction in a wireless cellular network is treated as an inverse problem instead of using high-precision geometric modeling. More precisely, the problem is solved by an inversion of the measured data under

some a prioriconstraints, and the complicated propagation-prediction problem is reduced to solving a system of large-scale ill-condition equations. The effectiveness of the proposed method is demonstrated by using experiments under various radio environments in Guangdong, China. The prediction results are approximately consistent with independent checking samples, and the proposed strategy is compared with other existing approaches. [J29]

"Scattering of Electromagnetic Waves From a Rectangular Plate Using an Enhanced Stationary Phase Method Approximation"

A time-efficient high frequency analytical model for the calculation of the scattered field from a perfect electric conductor (PEC) plate is presented here, which is based on the physical optics (PO) approximation and the stationary phase method (SPM). Using the SPM analysis for the three-dimensional (3D) scattering problem under consideration, the scattered electric field is calculated analytically. It follows that the analytical formula proposed here yields an accurate and fast algorithm for the calculation of the scattered electromagnetic (EM) field, which can be used trustfully in a variety of radio propagation problems. The accuracy of the proposed analytical method is checked through a straightforward numerical integration over the PO currents, as well as through finite element boundary integral full-wave exact solution. Comparison results are given in the far field, Fresnel zone and the near field area. [J30]

"Experimental Characterization of UWB On-Body Radio Channel in Indoor Environment Considering Different Antennas"

An experimental investigation to characterize the transient and spectral behavior of the ultrawideband (UWB) on-body radio propagation channel for body-centric wireless communications is presented. The measurements were performed considering over thirty on-body links in the front of human body in the anechoic chamber, and in indoor environment. Two different pairs of planar antennas have been used, namely, CPW-fed planar inverted cone antennas (PICA), and miniaturized CPW-fed tapered slot antennas (TSA). A path loss model is extracted from measured data, and a statistical study is performed on the time delay parameters. The goodness of different statistical models in fitting the root mean square (RMS) delay has been evaluated. Results demonstrate that the TSA, due to its more directive radiation behavior is less affected from the reflections from body parts and surrounding environment. The antenna shows significant size reduction and improved time delay behavior, and hence is an ideal candidate for UWB body area networks (BAN). [J31]

"Sensitive Broadband ELF/VLF Radio Reception With the AWESOME Instrument"

A new instrument has been developed and deployed for sensitive reception of broadband extremely low frequency (ELF) (defined in this paper as 300-3000 Hz) and very low frequency (VLF) (defined in this paper as 3-30 kHz) radio signals from natural and man-made sources, based on designs used for decades at Stanford University. We describe the performance characteristics of the Atmospheric Weather Electromagnetic System for Observation, Modeling, and Education (AWESOME) instrument, including sensitivity, frequency and phase response, timing accuracy, and cross modulation. We also describe a broad range of scientific applications that use AWESOME ELF/VLF data involving measurements of both subionospherically and magnetospherically propagating signals. [J32]

"Radio-Wave Propagation Into Large Building Structures-Part 1: CW Signal Attenuation and Variability"

We report on our investigation into radio communications problems faced by emergency responders in disaster situations. A fundamental challenge to communications into and out of large buildings is the strong attenuation of radio signals caused by losses and scattering in the building materials and structure. Another challenge is the large signal variability that occurs throughout these large structures. We designed experiments in various large building structures in an effort to quantify continuous wave (CW) radio-signal attenuation and variability throughout twelve large structures. We carried radio frequency transmitters throughout these structures and placed receiving systems outside the structures. The transmitters were tuned to frequencies near public safety, cell phone bands, as well as ISM and wireless LAN bands. This report summarizes the experiments, performed in twelve large building structures. We describe the experiments, detail the measurement system, show primary results of the data we collected, and discuss some of the interesting propagation effects we observed. [J33]

"Outdoor Propagation Channel Modeling in Foliage Environment"

Foliage is a rich scattering environment that is slowly time varying. Most previous investigations in foliage models center on the statistical modeling of clutters and targets. Ideally, it would be desirable to characterize the nature

of the propagation channel in foliage; however, it has not been investigated in detail up until now. This paper studies the problem of nonline-of-sight (NLOS) channel modeling based on extensive data collected using both narrowband and ultrawideband (UWB) radars. The modeling adopts the CLEAN algorithm, in which the channel-impulse response (CIR) is accomplished. It is observed that the multipath contributions arriving at the receiver are grouped into clusters. The arrival of clusters can be modeled as a Poisson process, whereas within each cluster, subsequent multipath contributions or rays also arrive according to a Poisson process. However, the arrival rate is quite different, along with the carrier frequency. It is also proposed that the amplitude of multipath channels can more accurately be characterized by a log-logistic distribution (LLD) other than commonly used clutter models such as the log-normal, the Weibull, or the Rayleigh fading model. The proposed foliage channel model is extendable to other outdoor environments. This is a great advantage for the specification and development of future wireless systems. [J34]

"Electromagnetic Mode Theory of Periodically-Loaded Oversized Imperfect Waveguide and Its Application to the Propagation of Radio Waves in Long Wall Coal Mining Face Tunnels"

A long wall coal mining face tunnel is idealized as a periodically-loaded oversized imperfect rectangular waveguide. A rigorous solution for the electromagnetic field distribution is presented. The theoretical analysis is mainly concentrated on obtaining the characteristic equations for HEM and TE modes and reductions are carried out to obtain the mode equations in a form suitable for the numerical computation. The propagation constant of the TEm0mode is computed. The calculated and measured propagation attenuation rates of the dominant TE10mode are compared for a scaled model. They are in good agreement, showing the validity of the theory. [J35]

"Spread spectrum techniques in wireless communication Part 2: Transmission issues in free space"

The second part of Spread Spectrum Techniques in Wireless Communication focuses on wireless transmission issues and implementation of a water quality assessment wireless system. I present concepts of electromagnetic propagation, some important issues in open space electromagnetic transmission particularly when a transmission link is over a conductive surface, and a simplified analysis of common occurrences that impair the transmission's quality or can even block the communication between network nodes. I introduce the primary techniques that are used to mitigate open space propagation problems, giving particular attention to solutions that can be used to mitigate fading effects in spread spectrum communication systems. Then, I present experimental results of a wireless transmission system used in water quality assessment. [J36]

"Radio-Wave Propagation Into Large Building Structures-Part 2: Characterization of Multipath"

We report on measurements that characterize multipath conditions that affect broadband wireless communications in building penetration scenarios. Measurements carried out in various large structures quantify both radio-signal attenuation and distortion (multipath) in the radio propagation channel. Our study includes measurements of the complex, wideband channel transfer function and bandpass measurements of a 20 MHz-wide, digitally modulated signal. From these, we derive the more compact metrics of time delay spread, total received power and error vector magnitude that summarize channel characteristics with a single number. We describe the experimental set-up and the measurement results for data collected in representative structures. Finally, we discuss how the combination of propagation metrics may be used to classify different propagation channel types appropriate for public-safety applications. [J37]

"CMOS Phased Array Transceiver Technology for 60 GHz Wireless Applications"

Based on the indoor radio-wave propagation analysis, and the fundamental limits of CMOS technology it is shown that phased array technology is the ultimate solution for the radio and physical layer of the millimeter wave multi-Gb/s wireless networks. A low-cost, single-receiver array architecture with RF phase-shifting is proposed and design, analysis and measurements of its key components are presented. A high-gain, two-stage, low noise amplifier in 90 nm-CMOS technology with more than 20 dB gain over the 60 GHz spectrum is designed. Furthermore, a broadband analog phase shifter with a linear phase and low insertion loss variation is designed, and its measured characteristics are presented. Moreover, two novel beamforming techniques for millimeter wave phased array receivers are developed in this paper. The performance of these methods for line-of-sight and multipath signal propagation conditions is studied. It is shown that one of the proposed beamforming methods has an excess gain of up to 14 dB when the line of sight link is obstructed by a human. [J38]

"On the Effective Low-Grazing Reflection Coefficient of Random Terrain Roughness for Modeling Near-Earth Radiowave Propagation"

An investigation on the effects of terrain roughness on near-ground radiowave propagation is featured. In spite of the fact that a variety of analytical and numerical routines have been proposed by many workers for the general treatment of the scattering properties of rough surfaces, much disagreement remains in the solution of the problem for near-grazing scenarios. In striving to analytically describe the near-grazing propagation of signals from 2D and 3D radiators, an existing volumetric polarization current-based perturbation approach is exploited in this work to formulate closed-form expressions for the coherent rough surface reflection coefficients. Although the perturbation approach was originally intended for analyzing the scattering coefficients of a ground with scale of roughness much smaller than the wavelength, it is shown through Monte Carlo simulations that the effective reflection coefficients reported herein are applicable for near-ground path-loss prediction even when the surface variation (rmsheight) is on the order of a wavelength or more. [J39]

"Efficient shooting and bouncing ray tracing using decomposition of wavefronts"

A new acceleration technique is presented for shooting and bouncing ray tracing in indoor environments. Tracing just a few rays, the algorithm finds the solid angles around the transmitter that transport electromagnetic power to the receiver. The accuracy is then improved by iteratively increasing the tessellation frequency of the source in the power-transporting solid angles. No rays will be sent through non-power-transporting solid angles, which results in significant reduction of the simulation time. An example of applying the method for studying indoor radio wave propagation is presented and the results are compared with a very high-resolution fully three-dimensional (3D) ray tracing simulation as the reference solution. It is observed that power-transporting solid angles constitute only a small fraction of the total space around the source through which the rays are launched. Therefore a high gain in terms of computational efficiency (about 680% saving in the simulation time) is achieved. Furthermore, concurrent application of the proposed method and binary space partitioning method is shown to be possible, which results in a very efficient ray tracing with about 1080% saving in simulation time. [J40]

"On-Body Radio Channel Characterization and System-Level Modeling for Multiband OFDM Ultra-Wideband Body-Centric Wireless Network"

Given the trend towards a user-centric concept in mobile communications, body area networks have received increasing attention within the wireless personal and body area networks community. In this paper, an experimental investigation is presented to derive suitable radio propagation models for ultra wideband (UWB) body-centric wireless communications. The performance of the body-centric UWB radio channel is investigated by considering several on-body links, including different body postures. System-level modeling of potential multiband orthogonal frequency-division multiplexed UWB system has been conducted and system performance is measured using bit error rate (BER) and signal-to-noise ratio. The conducted system analysis demonstrated that for 78% in the static case and 75% and 61% for stable and unstable transmitter locations in the pseudodynamic in-motion scenarios (respectively) of the specified on-body radio links, the BER is equal to or less than 0.1%. This demonstrates promising applications of the proposed UWB body-centric radio system. Based on these results, clear recommendations are given for best on-body locations leading to optimal system performance. [J41]

"Visual Observations of Characteristic Behaviors of RF Waves in CRLH-TLs and Their Applications to Dispersion Characterizations"

A novel experimental approach is proposed and demonstrated for visually observing characteristic behaviors of radio frequency (RF) waves in metamaterial structures in real time. Space domain analyses of observed wave images are also successfully applied to dispersion characterizations of the structures. These unique functionalities are provided by the RF wave visualization capability of the live electro-optic imaging scheme. Not only successful visualizations of forward and backward propagating RF waves in composite right/left-handed transmission lines are demonstrated, but visual investigation also takes place on their characteristic wave features at boundaries and in the extreme short wavelength region. The RF wave imagery is shown to be useful for determining right/left-handed frequency ranges and evaluating their propagation constants. The derived dispersion diagrams are discussed and compared with those conventionally obtained from unwrapped S21phase data. [J42]

"Spatial correlation-coefficient across a receiving sensor-array-accounting for propagation loss"

In the open literature on the geometric modelling of wireless radiowave landmobile propagation channels, this reported work is the first to attempt to account for the propagation power loss of the multipaths, in deriving closed-form expressions for an uplink received-signal's spatial-correlation-coefficient function across the aperture of a base-station antenna-array. [J43]

"Accuracy and computational efficiency improvement of ray tracing using line search theory"

This study presents a new ray tracing acceleration technique for site-specific propagation modelling in indoor environments. It overcomes one of the major problems regarding the computational efficiency of shooting-and-bouncing-ray (SBR) method, that is most of the rays emitted from the source do not reach the receiver whereas all of them must be traced. Our proposed method solves this problem in a two-step procedure based on the idea of line search theory. In the first step, called the bracketing phase, the solid angles around the transmitter that transport electromagnetic power to the receiver are determined. In the second step, called the sectioning or zoom phase, the accuracy is improved by iteratively increasing the tessellation frequency of the source in the power-transporting solid angles. No ray will be sent through non-power-transporting solid angles in the sectioning phase. Applying the method to a typical indoor problem is presented and the results are compared with fully 3-D SBR simulation. It is observed that power-transporting solid angles constitute only a small fraction of the total space around the source through which the rays are launched. Therefore a high gain in terms of computational efficiency (about 550-800- saving in the simulation time) is achieved. [J44]

"Modeling the Effects of Ionospheric Scintillation on GPS Carrier Phase Tracking"

A characterization is given for the behavior of Global Positioning System phase tracking loops in the presence of severe equatorial ionospheric scintillation. The purpose of this work is to develop a simple, general, and realistic scintillation effects model that can be used to improve the scintillation performance of phase tracking loops. The new characterization of scintillation effects proposed herein employs a differentially detected bit error model to predict cycle slipping rates that approximately agree with data-driven simulation tests. [J45]

"Evaluation of Measurement Techniques to Show Compliance With RF Safety Limits in Heterogeneous Field Distributions"

The paper proposes a conservative, technically rigorous, and time-effective procedure for in situ testing of compliance with radio frequency electromagnetic field (EMF) safety limits. The method employs the maximum hold hand-held sweeping technique, i.e., maximum search. The procedure is based and supported by numerical findings of the absorption characteristics of the human body in scattered EMF environments. The equipment requirements are also discussed. We evaluated the applicability and estimated the uncertainty of the method by an interlaboratory comparison with trained and untrained measurement personnel. [J46]

"Modeling of ESD-Induced Ultrawideband Noise Propagating on the Human Body"

Impulsive electromagnetic waves are produced when a grounded human touches a conducting object with different potential. An experimental setup was designed to measure electromagnetic fields on humans caused by sparks. The measured and computed waveforms are in good agreement. Specifically, measured and computed rise times of a discharge current were approximately 100 ps for a charge voltage of 1 kV. The generated electromagnetic pulses were distorted and dissipated with propagation due to dispersive characteristics of the biological tissues and multireflection in the human body. Computational results suggest that the pulse propagates over the body and is emitted from the top of the head in 10 ns. [J47]

"Reciprocity [JStand on Standards]"

The April 2010 issue of the IEEE Antennas and Propagation Magazine contained two papers that discussed various aspects of the Reciprocity Theorem. Reference [1] referred to various defining statements from several sources (all of which were published prior to 1997) in relation to antennas and propagation. In particular, propagation across the land-sea boundary was revisited. Reference [2] directed a discussion about the circuit applications of reciprocity. Both papers discussed some of the statements used to define reciprocity. [J48]

"Using the Right Terms [JStand on Standards]"

IEEE standards committees are responsible for the creation and maintenance of standards for the profession. Part of these responsibilities relate to standards documents, which define the terms that aim to ensure clarity of expression and mutual understanding around the world. The use of clearly defined terms is one of the hallmarks of a profession. [J49]

"Cognitive-Radio Systems for Spectrum, Location, and Environmental Awareness"

In order to perform reliable communications, a system needs to have sufficient information about its operational environment, such as spectral resources and propagation characteristics. Cognitive-radio technology has capabilities for acquiring accurate spectrum, location, and environmental information, due to its unique features

such as spectrum, location, and environmental awareness. The goal of this paper is to give a comprehensive review of the implementation of these concepts. In addition, the dynamic nature of cognitive-radio systems-including dynamic spectrum utilization, transmission, the propagation channel, and reception-is discussed, along with performance limits, challenges, mitigation techniques, and open issues. The capabilities of cognitive-radio systems for accurate characterization of operational environments are emphasized. These are crucial for efficient communications, localization, and radar systems. [J50]

"Transmission and total reflection of subhertz electromagnetic waves at the earth-atmosphere interface"

For the purpose of providing for a theoretical background for the study of electromagnetic fields generated by precursory effects of earthquakes, the problem of transmission and total reflection at the earth-atmosphere interface is investigated in detail for a subhertz plane electromagnetic wave incident from the earth's crust. The term "subhertz" means "below 1 Hz." First, for the special case of normal incidence, the overall power transmission coefficient at the earth-atmosphere interface is found to take a maximum value at a definite frequency f0which is inversely proportional to the square of the depth of a virtual hypocenter. A typical value of f0falls around 0.01 Hz. For oblique incidence as well, this feature of the overall power transmission coefficient is retained except in the vicinity of the critical angle of incidence for the H-wave. At the critical angle of incidence, the power flow carried by a surface wave along the interface becomes anomalously large for the H-wave. However, over a wide range of angles of incidence greater than the critical angle, the power flow carried by the E-wave exceeds that carried by the H-wave by orders of magnitude. Finally, the energy conservation relations for the incident, reflected, and transmitted waves at the earth-atmosphere interface are discussed. For an incident wave coming from the earth's crust, the interactive power between the incident and reflected waves plays a crucial role for the conservation of energy at the interface. [J51]

"Marconi's Early Experiments in Wireless Telegraphy, 1895"

The importance of the experiments realized by Guglielmo Marconi on the premises of Villa Griffone were probably already universally considered a fundamental step for understanding propagation in real environment, a key point in successful operation of a radio system. Thousands of visitors at the Villa and at the Marconi Museum are evidence of that. However, this official recognition by the IEEE that these experiments marked the beginning of the new era of wireless communication is the proper seal for the adventure of the Marconi genius, started in Italy and continued all over the world for more than forty years. [J52]

"Telecom I+D03-SON Use Case Study "Energy Saving" for LTE eNBs"

The 3GPP is defining a next generation radio access network called LTE (Long Term Evolution), which introduces several improvements respect current mobile systems, one of them are self-organization and self-optimization functions (SON) in base stations (eNB) and OM subsystem, that suppose a considerable increase on the network "intelligence". This paper discusses the application of a SON function, Energy Saving, and evaluates the energy savings and system performance, when applied. To illustrate the effect of the energy saving techniques, several simulations have been carried out with a radio-planning tool in a real mobile network deployment. Two technical approaches have been followed: switching off cells and reducing the eNB transmitted power (TXP). For both approaches a reference scenario with 18 eNBs (with 54 cells) has been selected. This scenario reflects a dense urban area with a Manhattan like distribution, in an area of 2 km Ч 2 km, with an average ISD of 250 m. A 2Ч2 MIMO antenna configuration has been used in all simulations. eNB's transmitted power was 46 dBm, the operation frequency was 2 GHz and the bandwidth was 5 MHz. The Energy Saving is a promising SON Use Case that allows decreasing operator's energy costs, carbon footprint, and the radiation emitted by fixed infrastructure of the mobile telephony systems, such as base stations antennas. [J53]

"RF Sensor Networks for Device-Free Localization: Measurements, Models, and Algorithms"

In this paper, we discuss the emerging application of device-free localization (DFL) using wireless sensor networks, which find people and objects in the environment in which the network is deployed, even in buildings and through walls. These networks are termed "RF sensor networks" because the wireless network itself is the sensor, using radio-frequency (RF) signals to probe the deployment area. DFL in cluttered multipath environments has been shown to be feasible, and in fact benefits from rich multipath channels. We describe modalities of measurements made by RF sensors, the statistical models which relate a person's position to channel measurements, and describe research progress in this area. [J54]

"A Relay Assisted Cooperative Transmission Protocol for Wireless Multiple Access Systems"

In this paper, we propose a spectrally efficient cooperative transmission protocol for multiple access scenarios.

The key feature is to utilize multi-user diversity and fully exploit the dynamic nature of radio propagation. In particular, by carefully scheduling the multiple sources and relays' transmissions, a source with a poor connection to the destination can have higher priority to obtain help from a relay with better channel condition. As a result, the full diversity gain is achievable even though only a fraction of relays is scheduled to help each user. We developed an achievable diversity-multiplexing tradeoff for the proposed transmission protocol to assist performance evaluation. When the number of relays is large, the diversity-multiplexing tradeoff achieved by the proposed scheme can approximate the optimal multiple-input single-output upper bound. Both analytical and numerical results show that the proposed protocol outperform other comparable schemes in most conditions. [J55]

"Multihop Range-Free Localization in Anisotropic Wireless Sensor Networks: A Pattern-Driven Scheme"

This paper focuses on multihop range-free localization in anisotropic wireless sensor networks. In anisotropic networks, geometric distance between a pair of sensor nodes is not always proportional to their hop count distance, which undermines the assumption of many existing range-free localization algorithms. To tolerate network anisotropy, we propose a pattern-driven localization scheme, which is inspired by the observation that in an anisotropic network the hop count field propagated from an anchor exhibits multiple patterns, under the interference of multiple anisotropic factors. Our localization scheme therefore for different patterns adopts different anchor-sensor distance estimation algorithms. The average anchor-sensor distance estimation accuracy of our scheme, as demonstrated by both theoretical analysis and extensive simulations, is improved to be better than 0.4r when the average sensor density is above eight, and the sensor localization accuracy thus is approximately better than 0.5r. This localization accuracy can satisfy the needs of many location-dependent protocols and applications, including geographical routing and tracking. Compared with previous localization algorithms that declares to tolerate network anisotropy, our localization scheme excels in 1) higher accuracy stemming from its ability to tolerate multiple anisotropic factors, including the existence of obstacles, sparse and nonuniform sensor distribution, irregular radio propagation pattern, and anisotropic terrain condition, 2) localization accuracy guaranteed by theoretical analysis, rather than merely by simulations, and 3) a distributed solution with less communication overhead and enhanced robustness to different network topologies. [J56]

"Depth and Rate of Fading on Fixed Wireless Channels Between 200 MHz and 2 GHz in Suburban Macrocell Environments"

Various bands between 200 MHz and 2 GHz have recently been reallocated to multipoint fixed wireless services. The links in such systems are usually obstructed by buildings and foliage and are susceptible to fading caused by windblown trees and foliage. To date, there have been relatively few efforts to characterize either the depth of fading in bands below 1.9 GHz or the rate of fading in any of these bands. We transmitted CW signals in the 220, 850 and 1900 MHz bands from a transmitter located 80 m above ground level in a typical suburban macrocell environment and collected time-series of received signal strength at distances between 1 and 4 km from the site. We reduced the data to show how the depth and rate of fading depend on the frequency band, time-averaged wind speed and distance in such an environment. Our most significant finding is that the rate of signal fading is very similar in all three bands. In particular, it is not proportional to carrier frequency, as a simplistic model involving moving scatterers might suggest. These results will provide useful guidance to those who seek to simulate, or develop detailed physical models of, fade dynamics in such environments. [J57]

"Combined Dynamic Channel Simulator for High Capacity Broadband Fixed Wireless Access Systems"

We present a time dynamic channel simulator for broadband fixed wireless access systems which properly combines earlier reported models for single degradation effects. The wideband model combines the effect of rain, scintillation, vegetation and multipath propagation. The objective is to specify the relationship between propagation effects and combine them to construct a comprehensive channel model suitable for designing fade mitigation techniques and evaluating system performance. The dynamics of rain attenuation is done using the Maseng-Bakken model. The multipath propagation is modeled using the geometrical based single bounce elliptical channel model. The spatial correlation between multipath taps during rain is incorporated using a space-time rain attenuation model. A lowpass filter which models the power spectral density of scintillation is used to describe the dynamic characteristics of scintillation. The signal fading due to swaying vegetation is described by utilizing a multiple mass-spring system to represent a tree and a turbulent wind model. In addition, numerical results under different combinations of propagation impairments are presented. [J58]

"Joint Statistics of Rain Attenuation at 20 GHz in Madrid and Aveiro"

Rain attenuation is the most severe propagation impairment affecting radiowave signals in the Ka-band. The use of these frequencies for satellite communication systems is facilitated by the implementation of fade mitigation techniques (FMTs). Spatial correlation of rain rate and rain attenuation for distances of several hundred kilometers has been rarely characterized in experiments, however it is relevant for site diversity studies, with distances in this range, and for the design and operation of multibeam satellite systems with shared on-board radio resources. In this letter, experimental results regarding joint statistics of rain and rain attenuation are presented for Madrid, Spain, and Aveiro, Portugal, located 420 km apart. These results have been achieved from two years of simultaneous measurements of the Eutelsat HB-6 Ka-band beacon at 19.7 GHz. It is shown that high-attenuation events are independent, whereas there is some correlation for low-attenuation levels. [J59]

"Electrical Engineering Hall of Fame: Edward V. Appleton [JScanning Our Past]"

In 1962, the Institute of Radio Engineers (IRE) awarded its Medal of Honor to Edward V. Appleton. He was cited "for his distinguished pioneer work in investigating the ionosphere by means of radio waves." He spent most of his professional career in teaching and research at the University of London and at Cambridge University. He was the author of approximately 140 scientific papers, primarily on the physics of the upper atmosphere. An interesting footnote to his Medal of Honor award is that he had received the Nobel Prize in Physics 15 years earlier. [J60]

"Analysis and Simulation of the Propagation Channel Complexity on Signal Fading"

Radio propagation environment with scatterers restricted to the far-zone is analyzed to demonstrate how signal fading is affected by the complexity of the environment. To simulate signal fading, an approximate model based on infinite perfectly conducting (PEC) cylindrical scatterers is used and simulated. Depending on the scattering environment, the simulated data match the classical models of Extreme value, Gamma, Rayleigh, and Generalized Gamma. [J61]

"Investigation of Wave Propagation in a Dielectric Rod Array: Toward the Understanding of HF/VHF Propagation in a Forest"

Radiowave propagation inside a forested environment in the HF/VHF frequency ranges has long been of interest for communication and sensing. We report on the measurement of an array of water-filled straws as a simplified, scaled model of a forest. A periodic array is first constructed in the laboratory based on an approximate 1:50 scaling with respect to a typical forest. Transmission loss inside this structure versus frequency and distance is measured. The data are then processed to extract the dominant propagation mechanisms in the structure. The results are compared to the full-wave numerical simulation for an array of infinite rods. To provide physical interpretations for the wave propagation inside the array, an effective medium theory is also applied to calculate the effective permittivity and permeability of the structure. It is found that: (i) Passband/stopband behaviors exist in the measurement and approximately agree with the full-wave simulation for infinite rods. (ii) The water straw array can be described as a -negative (ENG) medium within a certain frequency band in the long wavelength limit. (iii) The extracted propagation constants from measurement, simulation and effective medium theory show good agreement. The positions and heights of the water rods are next perturbed to study the effect of randomization. Finally, the predictions from the dielectric rod array are correlated with the measurement data collected in a real forest in Bastrop, Texas. [J62]

"Propagation Characteristics of Dense Multipath Components"

The dense multipath components (DMC) represent the part of the radio channel that cannot be characterized by a superposition of distinct plane waves, i.e., the specular components (SC). In this letter, the propagation characteristics of the DMC are analyzed in indoor environments from two perspectives. First, the proportion of DMC in the total power is studied as a function of the distance between the transmitter (TX) and receiver (RX). Second, the characteristics of the DMC and SC are compared in angular and delay domains. The measurement results show that the amount of DMC in the total power increases as the TX-RX distance increases in both line-of-sight (LOS) and non-line-of-sight (NLOS) scenarios. In addition, it is shown that the power of the DMC is concentrated around the same angles and delays as the SC. [J63]

"On the Distribution of Signal Phase in Body Area Networks"

In this letter, we investigate the distribution of the phase component of the complex received signal observed in practical experiments using body area networks. Two phase distributions, the recently proposed κ-μ and η-μ probability densities, which together encompass the most widely used fading models, namely Semi-Gaussian, Rayleigh, Hoyt, Rice, and Nakagami-m, have been compared with measurement data. The κ-μ distribution has been found to provide the best fit over a range of on-body links, while the user was mobile. The experiments

were carried out in two dissimilar indoor environments at opposite ends of the multipath spectrum. It has also been found that the uniform phase distribution has not arisen in anyone of the experiments. [J64]

"Comments on "A Novel Vector Network Analyzer""

The authors comments on the work of Hoffman and Skvor "A Novel Vector Network Analyzer"(1998). It was demonstrated in this paper that only five independent parameters are needed to fully map the complex reflection coefficient of an unknown sample to amplitude-only reflection measurement instead of six parameters as concluded in the above paper. [J65]

"Modeling and Characterization of Biotelemetric Radio Channel From Ingested Implants Considering Organ Contents"

The paper introduces numerical and experimental investigations of biotelemetry radio channels and wave attenuation in human subjects with ingested wireless implants. The study covers commonly used frequencies in telemedicine applications: ultrahigh frequencies at 402 MHz, 868 MHz and the industrial, scientific and medical (ISM) band frequency at 2.4 GHz. Numerical electromagnetic analysis is applied to model in/on-body radio propagation channels and the resulted parameters demonstrated the importance of digital phantom accuracy in ccharacterization of wave absorption and attenuation with regards to organ contents, specifically for the digestion system. Path gain variations of biotelemetry radio channels, in the close vicinity of the subject, with wireless implants were measured using a near field scanner. Simulation results were verified with measurement in good agreement. [J66]

"A Modified Diffraction Coefficient for Imperfect Conducting Wedges and Buildings With Finite Dimensions"

Multiple building diffraction loss calculation is often based on the assumption that their dimensions are infinite in the direction perpendicular to the propagation path, even though in reality this assumption is not valid. In this paper, a modified diffraction coefficient model for the calculation of a more realistic diffraction loss caused by a single building with finite dimensions is proposed. The overall diffraction loss is calculated for a group of buildings in a row by using the proposed model. In addition, after carrying out the field measurements, it is shown that for some particular cases where the transmitter and diffracting obstacles are not far away from each other (i.e., microcells or picocells), spherical-wave modeling produces a better accuracy than the plane-wave approximation. It is also demonstrated that the theoretical results can further be improved by considering the higher order terms in the calculation of diffraction coefficients. Lastly, excess path loss obtained for a row of buildings with spherical-wave assumption is compared with our measurement data. This comparison shows reasonable correspondence between our theoretical model and measurements. Therefore, our proposed model can successfully be used for improving the theoretical methods for predicting path loss in urban environments, where diffraction from a number of buildings has to be considered. [J67]

"Transient Characteristics of Wearable Antennas and Radio Propagation Channels for Ultrawideband Body-Centric Wireless Communications"

This paper presents transient characterization of ultrawideband (UWB) body-worn antennas and on-body radio propagation channels for body-centric wireless communications. A novel miniaturized CPW-fed tapered slot antenna is proposed and used for transient measurements of UWB radio channels for body area network (BAN) and personal area network (PAN) scenarios. Unlike conventional UWB CPW-fed antennas, the proposed antenna employs two diverging tapered slots to provide smooth and stable impedance matching. Fidelity analysis is applied to evaluate the time-domain behavior of body-worn antennas and it is found that average fidelity obtained is 88% and 86% for the conventional coplanar waveguide fed antenna and the tapered slot antenna, respectively. However, the tapered slot antenna shows a significant size reduction and hence is suited for body-centric wireless communications. [J68]

"Computationally efficient ray-tracing technique for modelling ultrawideband indoor propagation channels"

The design and development of high-speed data wireless communication systems within buildings call for the investigation of the ultrawideband indoor propagation channel. To date, ray tracing (RT) based approaches have been widely used to characterise the channel; unfortunately, such techniques, although accurate, turn out computationally intensive. In this work, a parallel ray (PR) approximation is successfully used to significantly improve the computational efficiency of the RT method. The accuracy and the applicability of the proposed approximation are assessed through the analysis of the mean square error between the impulse responses

obtained with the PR and the RT methods. [J69]

"Wireless network modeling and simulation tools for designers and developers"

Modeling and simulation methods are employed by scientists and engineers to gain insight into system behavior that can lead to faster product time-to-market and more robust designs. These advantages come at the cost of model development time and the potential for questionable results because the model represents limited attributes of the actual system. M & S techniques are used to characterize complex interactions and performance at various layers of the protocol stack. This article provides a discussion of M & S for wireless network designers and developers, with particular attention paid to the architectural issues, as well as a discussion of the various communication M & S tools available today. The topics presented span the protocol stack, including radio-frequency-propagation M & S tools, physical-layer and waveform M & S, network-layer M & S, and distributed simulation, as well as waveform generation for test and evaluation. [J70]

"Ultra-Wide-Band Propagation Channels"

Understanding ultra-wide-band (UWB) propagation channels is a prerequisite for UWB system design as well as communication-theoretic and information-theoretic investigations. This paper surveys the fundamental properties of UWB channels, pointing out the differences to conventional channels. If the relative bandwidth is large, the propagation processes, and therefore path loss and shadowing, become frequency-dependent, and the well-known wide-sense stationary uncorrelated scattering model is not applicable anymore. If the absolute bandwidth is large, the shape of the impulse responses as well as the fading statistics change. This paper also describes methods for measuring UWB channels and extracing channel parameters. Throughout this paper, the relationship between channel properties and other areas of UWB research are pointed out. [J71]

"An Experiment Study of the Propagation of Radio Waves in a Scaled Model of Long-Wall Coal Mining Tunnels"

A long-wall coal mining tunnel is the most important working area in a coal mine. It has long been realized that radio communications can improve both productivity and safety in this dangerous area. Hence, many attempts to use radio communications in such an environment have been made. Unfortunately, no radio system has satisfactorily provided communication services there, which, we believe, is partially due to poor understanding of the propagation characteristics of radio waves in the long-wall mining tunnel. To have deeper physical insight into the propagation problem, a scaled model of the long-wall mining tunnel was built, and the propagation characteristics of UHF radio waves were measured. The experiment and the measured results are presented and discussed. [J72]

"Coverage Efficiency of Narrow-Band Wave Propagation in Mining Environments"

This paper presents statistical and experimental analyses of narrow-band wave propagation at 2.4 GHz in an underground gallery. The aim of this study is to address the deployment issues associated with wireless communication systems of Wi-Fi wireless access points and their coverage. A genetic algorithm is used to produce all the numerical results present in this paper. Four known statistical models based on different cumulative distribution functions are used to compare these results with those obtained from experimentally. The models are applied to two different galleries in an underground area. Two performance evaluation criteria, the mean square error (MSE) and the Kolmogorov-Smirnov test, are used to comparatively assess models' efficiency. These are the MSE and the Kolmogorov-Smirnov test. [J73]

"Wideband Polarimetric Directional Propagation Channel Analysis Inside an Arched Tunnel"

A wideband directional measurement campaign was managed inside an arched highway tunnel to analyze the radio propagation channel inside such tunnel for future cellular systems in terms of coverage, delay spread and dominant scatterers. Measurements were performed in 3 rounds with different transmitter positions. Using a wideband channel sounder equipped with a cylindrical dual polarized array at the receiver, the spatio-temporal characteristics of the received propagation paths could be estimated by means of a super-resolution estimation algorithm. The extracted paths using this super-resolution algorithm constitute 88% of the total received power. It was also observed that the line-of-sight component (53%) plus single-bounce scattering (26%) comprise up to 79% of the total received power. In other words, more than 90% (i.e. 79% in 88%) of the extracted paths consists of the line-of-sight component and single-bounce scatterings. The strong contribution from single-bounce scattering paths causes the path gain exponent along the tunnel to be larger than -2 which is the value for free space. This validates that there is wave guiding effect in the tunnel and coverage is extended relative to open space. The rms delay spreads are generally less than 20 ns and increase when influenced by scattering objects such as jetfans. The dominant scatterers are identified and classified into 6 classes based on the

structure of the tunnel and existing objects such as ground, wall, light-frame, ceiling, jetfan and cleaner-parking. It was observed that scattering from ground was dominant among all classified scatterers in all scenarios. [J74]

"Generation of Characteristic Basis Functions Defined Over Large Surfaces by Using a Multilevel Approach"

An efficient procedure for the generation of characteristic basis functions (CBFs) over large arbitrary surfaces is presented in this work. The first step is to partition the original object into subdomains and then derive the CBFs for these domains by solving for the currents induced by a set of components of the planewave spectrum (PWS). Next, we aggregate the adjacent domains to obtain enlarged CBFs by expanding the original ones in terms of the weighted planewaves used to compute them. This process can be performed iteratively and involves fast, non-expensive matrix manipulation. We obtain a progressive decrease of the number of unknowns, as we increase the domain size, by following the procedure described above. [J75]

"Modeling the Effects of Nearby Buildings on Inter-Floor Radio-Wave Propagation"

Two buildings (A and B) have been modeled and analyzed with a 2D TEzimplementation of the finite-difference time-domain (FDTD) algorithm in order to identify and characterize the mechanisms allowing signals to propagate between floors, specifically reflection and scattering from nearby buildings. Results have been extended to 2.5D by assuming isotropic spreading in the third dimension. In both scenarios considered, reflections from surrounding buildings are found to increase the average received power on adjacent floors-up to 9.7 dB and 32 dB for buildings A and B respectively. Measurements of the impulse response in Building A, made with a sliding correlator channel sounder, show a number of long-delay pulses, which can be attributed to specific reflection paths. Based on these findings, a simple two-component propagation model to predict the sector-average signal strengths is proposed and validated against measurements of the received power. The direct component is modeled as free space with a 22 dB/floor attenuation factor, and the reflected component is modeled as free space with reflection/transmission coefficients of 0.5. The RMS prediction error for this model is 3.2 dB. [J76]

"Propagation Issues for Cognitive Radio"

Cognitive radios are expected to work in bands below about 3.5 GHz and may be used for a variety of applications, e.g., broadband fixed wireless access, mobile and nomadic access, etc. Cognitive radio system designers must have access to a wide range of channel models covering a wide span of operating frequencies, carrier bandwidths, deployment conditions, and environments. This paper provides a comprehensive overview of the propagation channel models that will be used for the design of cognitive radio systems. We start with classical models for signal loss versus distance and discuss their dependence on the physical properties of the environment and operating frequency. Here we also introduce the concept of log-normal shadowing resulting from signal blockage by man-made and natural features. Next, we discuss the time-varying nature of the wireless channel, introduced as a result of the motion of objects in the channel. This is followed by a discussion on the dispersion of the signal caused by various effects of propagation, especially in the time and frequency domains. Angular dispersion, which is discussed next, is important because cognitive radios may be based on modems that exploit the spatial domain. Lastly, we summarize channel models that have been standardized for fixed and mobile systems. [J77]

"Propagation Modeling and Measurement for a Multifloor Stairwell"

Reliable wireless communications in stairwells are crucial to law enforcement and firefighting safety. Understanding the radio propagation in stairwells is necessary to successfully design such communications systems. In this letter, we study the radio propagation in a multifloor stairwell using measurements and simulations. Fundamental propagation mechanisms such as reflection from stairwell walls and transmission through the stair steps are investigated. It is found that the stairwell walls in this studied case do not reflect much of the incoming energy and that the transmitted energy through the stairs has significant contributions to the total received power. An image-based ray tracing scheme is used to identify the various propagation mechanisms. The ray-tracing simulation results match the measurements very well. Furthermore, physics-based explanations were provided for the trends and characteristics in the obtained results. [J78]

"Use of Geospatial Resources for Radio Propagation Prediction in Urban Areas"

A method for extracting the three-dimensional (3D) building structures using their single-view images available on the Internet/cyberspace is described. Height measurement technique is combined with two-dimensional (2D) projective transformation to obtain the 3D building information. It is shown that the reconstruction method is

accurate for path-loss calculations using ray-tracing algorithms. Simulated path losses/gains are compared to results in literature, and good agreement is observed. The effect of building footprint and height inaccuracies on path-loss calculations is also examined and is found to result in errors within the common error range between experimental measurements and ray-tracing predictions. [J79]

"Space-time duality in multiple antenna channels"

The concept of information transmission in a multiple antenna channel with scattering objects is studied from first physical principles. The amount of information that can be transported by electromagnetic radiation is related to the space-wavenumber and the time-frequency spectra of the system composed by the transmitting antennas and the scattering objects, and to the spatial extension of the receiving domain. The spatial information content of the field is related to the number of relevant communication modes of the channel. It is shown that for narrow-band frequency transmission space and time can be decoupled, leading to a space-time information duality principle in the computation of the capacity of the radiating system. In contrast, in the case of wide-band frequency transmission, it is shown that time and space cannot be decoupled and they jointly characterize the wave's information content. [J80]

"Channel Characterization for Single- and Multiple-Antenna Wearable Systems Used for Indoor Body-to-Body Communications"

In this paper, an analysis of radio channel characteristics for single- and multiple-antenna bodyworn systems for use in body-to-body communications is presented. The work was based on an extensive measurement campaign conducted at 2.45 GHz representative of an indoor sweep and search scenario for fire and rescue personnel. Using maximum-likelihood estimation in conjunction with the Akaike information criterion (AIC), five candidate probability distributions were investigated and from these the kappa- mu distribution was found to best describe small-scale fading observed in the body-to-body channels. Additional channel parameters such as autocorrelation and the cross-correlation coefficient between fading signal envelopes were also analyzed. Low cross correlation and small differences in mean signal levels between potential dual-branch diversity receivers suggested that the prospect of successfully implementing diversity in this type application is extremely good. Moreover, using selection combination, maximal ratio, and equal gain combining, up to 8.69-dB diversity gain can be made available when four spatially separated antennas are used at the receiver. Additional improvements in the combined envelopes through lower level crossing rates and fade durations at low signal levels were also observed. [J81]

"Quasi 2-D Field Reconstruction Using the Conjoint Cylindrical Wave Expansion"

Off-the-horizon propagation severely degrades the accuracy of any field reconstruction technique that presupposes a two-dimensional (2-D) wireless channel. Therefore, employing the 2-D cylindrical wave expansion (CWE) to interpolate perimeter channel measurements into a planar region often yields poor results. Here, the CWE is adapted for real-world radio channel measurements by selectively combining the basis functions from two similar CWEs. Using both simulated and experimental measurement data, it is shown that this conjoint CWE yields a more accurate reconstruction than the conventional CWE yet requires no additional measurements. Thereby, this field reconstruction-based channel imaging technique will enable more complete investigations of the wireless channel's spatial behavior and allow researchers to isolate and characterize the actual mechanisms underlying radio wave propagation. [J82]

"Diurnal Variation of Rain Attenuation Obtained From Measurement of Raindrop Size Distribution in Equatorial Indonesia"

The measured rain rate, raindrop size distribution (DSD), and the ITU-R model over the frequency range from 1-100 GHz have been used to elucidate the cumulative rainfall rate and the variability of rain attenuation at Kototabang. Rain rate and DSD are recorded from ground-based optical rain gauge and disdrometer measurements, respectively. Considerable differences between the recorded data and the ITU-R model are observed at small time percentage. The specific rain attenuation obtained from the DSD measurement shows diurnal variation with the largest attenuation observed in the morning hours. This characteristic is due to the raindrop spectra of rain events in this period containing more small-sized drops (<2 mm) than at others as described by the largest contribution of these drops on the specific rain attenuation. The diurnal variation is serious for frequencies higher than 60 GHz especially in very extreme rain. [J83]

"The Effects of Tropical Weather on Radio-Wave Propagation Over Foliage Channel"

This paper investigates the dynamic property of a tropical forested channel due to the weather effect on very

high frequency (VHF) and ultrahigh frequency (UHF) radio-wave propagation. In this paper, continuous-wave (CW) envelope fading waveforms are recorded over a period of 50 s with static antennas. This paper focuses on the analysis of the combined effect of wind and rain, which is often encountered in a tropical forest. The induced temporal effects are discussed and compared with theoretical models. It is found that the distribution of temporal fading components resembles a Rician distribution function. Its Rician K factor gradually decreases as the strength of either wind or rain increases due to the movement of the forest components. [J84]

"A novel zonal UWB receiver with superior performance"

A novel ultra-wide bandwidth receiver structure dubbed the "zonal" receiver is based on the qualitative nature of the probability density function of the multiple access interference. It is proposed for time-hopping ultra-wide bandwidth wireless signal detection in multiple access interference channels. In ideal free-propagation channels, the zonal receiver always meets or outperforms the conventional matched filter UWB receiver, the recently proposed soft-limiting UWB receiver and its enhanced version, the adaptive threshold soft-limiting UWB receiver. A new Rake receiver design based on the zonal receiver is proposed for signal detection in multipath fading channels. Simulation results and analysis show that this new Rake receiver can achieve larger signal-to-interference-plus-noise ratio than the standard matched filter Rake receiver when multipath components are resolvable in UWB channels. [J85]

"A Numerical Study of the Retrieval of Sea Surface Height Profiles From Low Grazing Angle Radar Data"

A numerical study of the retrieval of sea surface height profiles from low grazing angle radar observations is described. The study is based on a numerical method for electromagnetic scattering from 1-D rough sea profiles, combined with the ldquoimproved linear representationrdquo of Creamer for simulating weakly nonlinear sea surface hydrodynamics. Numerical computations are performed for frequencies from 2975 to 3025 MHz so that simulated radar pulse returns are achieved. The geometry utilized models a radar with an antenna height of 14 m, observing the sea surface at ranges from 520 to 1720 m. The low grazing angles of this configuration produce significant shadowing of the sea surface, and standard analytical theories of sea scattering are not directly applicable. Three approaches for retrieving sea height profile information are compared. The first method uses a statistical relationship between the surface height and the computed radar cross sections versus range (an incoherent measurement). A second method uses the phase difference between scattering measurements in two vertically separated antennas (ldquovertical interferometry) in the retrieval. The final technique retrieves height profiles from variations in the apparent Doppler frequency (coherent measurements) versus range and requires that time-stepped simulations be performed. The relative advantages and disadvantages of each of the three approaches are examined and discussed. [J86]

"Capacity Measurements in a Cooperative MIMO Network"

Cooperation between adjacent base stations (BSs) may reduce intercell interference in future cellular networks and enhance network capacity in this way. The potential of cooperation is evaluated in this paper based on measurements conducted at 5.2 GHz in a campus environment with four overlapping cells. For each individual link of the four BS and five terminal locations, a 10 times 16 antenna configuration with cross-polarized elements is used. Results show that the direct signal is much stronger than scattering due to the small intersite distances. The polarized line-of-sight (LOS) signal creates two degrees of freedom in the spatial domain, which is also confirmed by a 3-D propagation model. Rich multipath scattering is characteristic for the rest of the links where the direct signal is blocked. Results for a multilink scenario where all users are jointly served by all BSs confirm that such cooperation leads to enhanced rank of the compound channel matrix. The spectral efficiency is five times higher with cooperation, compared with a conventional frequency reuse system, where different radio resources are assigned to adjacent cells. Hence, our measurements confirm the benefits of cooperation in cellular systems. [J87]

"Detection and Tracking of MIMO Propagation Path Parameters Using State-Space Approach"

This paper describes a novel approach for detection, estimation and tracking of multiple-input multiple-output (MIMO) radio propagation parameters from multidimensional channel sounding measurements. A realistic state-space model is developed for the purpose, and the extended Kalman filter (EKF) is applied in a particular computationally efficient form to track the geometrical double-directional propagation path parameters. The observation model utilizes the dense multipath component (DMC), describing the distributed scattering in the channel, as part of the underlying noise process. The DMC model assumes an exponential profile in delay, and allows for an arbitrary angular distribution. In addition, a novel dynamic state dimension estimator using statistical goodness-of-fit tests is introduced. The employed methods are supported by illustrative estimation

examples from MIMO channel sounding measurements. [J88]

"Propagation characteristics of a 2.45 GHz microwave radio frequency identification system"

The propagation characterisation of a 2.45 GHz microwave semi-passive radio frequency identification system in real indoor environment is presented and the effects of three system parameters: the reader orientation, tag antenna designs and propagation environment are evaluated. The unmodulated forward propagation is evaluated by reader signal strength measurements at different tag positions while the modulated backscattered propagation evaluation employs tag read rate as a function of range under horizontal or vertical reader polarisation in an uncluttered or cluttered indoor environment for different tag antenna types. Measured results are used to quantify the variations introduced by the reader polarisation, indoor propagation environment relative to free-space and tag antenna design on the tag response. [J89]

"Comment on "Short-Delay Multipath Mitigation Technique Based on Virtual Multipath""

It is shown that in the above letter by Z. Zhang and C. L. Law (vol. 4, pp. 344348, 2005) the virtual multipath (VM)-based technique for GPS multipath mitigation is only fit for some certain situations where the first multipath signal is the strongest among the direct and all the multipath signals, which hardly agrees with the real propagation circumstances. Two multipath cases are illustrated to invalidate the VM-based technique. [J90]

"Effects of Birefringence Within Ice Sheets on Obliquely Propagating Radio Waves"

In this paper, effects of birefringence on radio waves obliquely propagating though polar ice sheets are examined to facilitate interpretations of bistatic and side-looking radar data. A formalism applicable for arbitrary radar configurations is developed to predict the returned power from within and beneath the ice sheets that have arbitrary alignments of ice crystals (ice fabrics). We applied this formalism to a range of ice fabrics found in ice cores and assessed the effects of birefringence in terms of ray-path configurations, ice fabrics, and radar frequency. Predicted frequency dependence of the bed return power replicates prominent features observed at Greenland NGRIP ice-core site. Results show that birefringence in ice of 1 km or more thickness with strong (weak) fabric can reduce the power returned from the bed 2 dB or more at frequencies higher than 200 MHz (20 MHz) as compared to isotropic ice. This suggests that quantitative interpretation of the power returned from the bed requires careful assessment of birefringence almost everywhere over the ice sheets. Application of this formalism also suggests a radar-frequency range usable for attenuation measurements, possible effects of fabric on synthetic aperture radar processing, and a feasibility of remote sensing of ice fabric. [J91]

"Millimeter-Wave Propagation Channel Characterization for Short-Range Wireless Communications"

This paper presents and analyzes the results of millimeter-wave 60-GHz frequency range propagation channel measurements that are performed in various indoor environments for continuous-route and direction-of-arrival (DOA) measurement campaigns. The statistical parameters of the propagation channel, such as the number of paths, the RMS delay spread, the path loss, and the shadowing, are inspected. Moreover, the interdependencies of different characteristics of the multipath channel are also investigated. A linear relationship between the number of paths and the delay spread is found, negative cross correlation between the shadow fading and the delay spread can be established, and an upper bound exponential model of the delay spread and the path loss is developed to estimate the worst case of the RMS delay spread at given path loss. Based on the DOA measurements that are carried out in a room [line of sight (LOS)] and in a corridor with both LOS and nonline-of-sight (NLOS) scenarios, radio-wave propagation mechanisms are studied. It is found that considering the direct wave and the first-order reflected waves from smooth surfaces is sufficient in the LOS cases. Transmission loss is very high; however, diffraction is found to be a significant propagation mechanism in NLOS propagation environments. The results can be used for the design of 60-GHz radio systems in short-range wireless applications. [J92]

"A Joint TOA/AOA Constrained Minimization Method for Locating Wireless Devices in Non-Line-of-Sight Environment"

Non-line-of-sight (NLOS) propagation degrades the performance of wireless location systems. Thus, developing algorithms that are robust to NLOS considerations is of great importance. Based on time-of-arrival (TOA) and angle-of-arrival (AOA) measurements, this correspondence introduces a new approach, which consists of incorporating the coordinates of dominant scatterers as unknowns in the location algorithm. It is assumed that the first arriving path signal at each base station (BS) experiences a single dominant scatterer, but the BSs are allowed to have different dominant scatterers. Locating the mobile station is accomplished by means of a

nonlinear optimization procedure under nonlinear constraints. Two algorithms are proposed: The first algorithm assumes that hybrid TOA/AOA measurements are available at three BSs. In the second algorithm, the AOA is assumed to be available at the serving BS only. The performance of the proposed algorithms is assessed and compared with that of existing algorithms through extensive simulations. [J93]

"Outdoor-to-Indoor Propagation Loss Prediction in 800-MHz to 8-GHz Band for an Urban Area"

In mobile communication systems, it is important to clarify the outdoor-to-indoor propagation loss (building penetration loss) characteristics to improve the quality of communication within buildings. This paper proposes a penetration loss prediction formula that is derived based on measurement results. We measured and analyzed the building penetration loss at higher frequencies that are appropriate for the next-generation system. We measured the propagation loss on 71 floors in 17 buildings in an urban area using four frequencies in the 800-MHz to 8-GHz band. The measurement results showed that the attenuation based on the penetration distance is 0.6 dB/m, the floor height gain is 0.6 dB/m, the constant value for the penetration loss is 10 dB, and there is no frequency dependence of the penetration loss in the frequency range from 0.8 to 8 GHz. [J94]

"UTD-PO Formulation for the Multiple-Diffraction of Spherical Waves by an Array of Multimodeled Obstacles"

A hybrid uniform theory of diffraction-physical optics (UTD-PO) solution for the analysis of the multiple-diffraction of spherical waves caused by an array of obstacles, which have been modeled by different shapes, is hereby presented. The formulation, validated with measurements from technical literature, does not need to incorporate high-order diffraction terms (slope diffraction) thanks to a recursive relation, therefore producing an easier, faster solution-when compared with other methods-that, at the same time, achieves accurate results. Such results can be applied in radiowave propagation analysis when multiple-diffraction over obstacles with quite different shapes has to be considered. [J95]

"An Analysis of Probability Distribution of Doppler Shift in Three-Dimensional Mobile Radio Environments"

The Doppler shift (DS) distribution of the signal that is received by a mobile station in 3D mobile radio environments is closely related to the signal's power spectral density (PSD). From the relationship between the arriving angles and the DS, general equations are derived, bridging the probability density function (pdf) of the elevation angle with the pdf of the DS, its variance, and the characteristic function. These equations are then used to analyze the statistic distribution of the DS based on the semispheroid model, which has been recently proposed by Janaswamy. For this particular model, analytical expressions for the pdf and the variance of the DS have been derived, and a definite-integral expression is provided for the characteristic function. When the average strengths of the waves that are distributed on different equal-Doppler-shift surfaces are assumed to be equal, the derived pdf of the DS is equivalent to the signal's PSD, and the derived characteristic function of the DS is equivalent to the signal's autocorrelation function. [J96]

"High-frequency method for scattering from coated targets with electrically large size in half space"

The high-frequency method for solving the scattering from coated targets of electrically large size in half space is presented. In order to consider the scattering fields of the targets in half space, the half-space physical-optic (PO) method is deduced by introducing the half-space Green's function into the conventional PO method. Combined with the graphical-electromagnetic computing method to read the geometric information of all visible facets, the impedance boundary conditions are utilised to account for the targets-covered with radar-absorbing material in half space. The numerical results show that this method is efficient and accurate. [J97]

"A Hybrid Parabolic Equation-Integral Equation Technique for Wave Propagation Modeling of Indoor Communications"

We present a 3D hybrid technique for the simulation of wave propagation in complex indoor communication environments. The hybrid method employs a wide-angle parabolic equation to estimate the electromagnetic field within walls and obstacles, whereas a correction based on a Green's function approach provides clearly improved field approximations. The proposed method is applied in 3D using simple validation models, whereas an approximate 2D analysis is attempted for a much more realistic office space. The simulation is compared with measurements and a particularly enhanced accuracy is observed. The hybrid technique is more systematic and automated, compared to ray-tracing methods and has moderate computational requirements. [J98]

"A New Prediction Model of Rain Attenuation That Separately Accounts for Stratiform and

Convective Rain"

An improved version of the exponential cell (EXCELL) rain attenuation model is presented here. Analogously to the original one, it predicts attenuation through a cellular representation of precipitation, but, in addition, is able to discriminate between stratiform and convective rain by means of an embedded algorithm. Accordingly, two separate physical rain heights, derived from the ERA-15 database, are used to calculate stratiform and convective rain attenuation and, when considering stratiform precipitation, the melting layer contribution to attenuation is added. Eventually, the predicted cumulative distribution function (CDF) of excess attenuation is the combination of the contributions due to stratiform and convective precipitation types. Some input parameters of the prediction model, such as those defining the melting layer process or the rain plateau embedding rain cells, can be modified in order to account for the local meteorological characteristics. [J99]

"Vehicle-to-Vehicle Communication: Fair Transmit Power Control for Safety-Critical Information"

Direct radio-based vehicle-to-vehicle communication can help prevent accidents by providing accurate and up-to-date local status and hazard information to the driver. In this paper, we assume that two types of messages are used for traffic safety-related communication: 1) Periodic messages (ldquobeaconsrdquo) that are sent by all vehicles to inform their neighbors about their current status (i.e., position) and 2) event-driven messages that are sent whenever a hazard has been detected. In IEEE 802.11 distributed-coordination-function-based vehicular networks, interferences and packet collisions can lead to the failure of the reception of safety-critical information, in particular when the beaconing load leads to an almost-saturated channel, as it could easily happen in many critical vehicular traffic conditions. In this paper, we demonstrate the importance of transmit power control to avoid saturated channel conditions and ensure the best use of the channel for safety-related purposes. We propose a distributed transmit power control method based on a strict fairness criterion, i.e., distributed fair power adjustment for vehicular environments (D-FPAV), to control the load of periodic messages on the channel. The benefits are twofold: 1) The bandwidth is made available for higher priority data like dissemination of warnings, and 2) beacons from different vehicles are treated with ldquoequal rights,rdquo and therefore, the best possible reception under the available bandwidth constraints is ensured. We formally prove the fairness of the proposed approach. Then, we make use of the ns-2 simulator that was significantly enhanced by realistic highway mobility patterns, improved radio propagation, receiver models, and the IEEE 802.11p specifications to show the beneficial impact of D-FPAV for safety-related communications. We finally put forward a method, i.e., emergency message dissemination for vehicular environments (EMDV), for fast and effective multihop information di--ssemination of event-driven messages and show that EMDV benefits of the beaconing load control provided by D-FPAV with respect to both probability of reception and latency. [J100]

"Three-Dimensional Urban EM Wave Propagation Model for Radio Network Planning and Optimization Over Large Areas"

A new 3D urban electromagnetic wave propagation model is presented. It provides fast 3D deterministic predictions in urban radio configurations and over large areas. The various techniques to make it suitable to the network planning and optimization of large wireless networks are described. The resulting radio propagation maps exhibit seamless coverage between the various environments (dense urban, urban, and suburban). The model efficiently addresses all types of outdoor transmitter configurations (macrocells, minicells, microcells, and picocells) and all types of receiver locations (at ground level, over the rooftop, and at high building floors). It predicts the field strength as well as the dominant specular contributions of the impulse responses to build ray spectra (including delays and angles). Thus, the model may also be used to estimate the performances of new radio systems [diversity and multiple-input-multiple-output (MIMO)]. The narrowband power prediction of the model is evaluated by comparison with microcell measurements. The evaluation stresses the advantage of 3D modeling compared with the vertical-plane approach or 2D ray tracing. Finally, the ability of the model to simulate radio wideband characteristics in a complex environment is demonstrated by comparing delay-spread estimates to measurements collected from a high-macrocell transmitter in a hilly city and to arrival angles collected in a suburban macrocell area. [J101]

"Angular Correlation Properties With Random Multiple Scattering"

The angular correlation of received fields in multipath environments is studied. The focus is put on two-dimensional (2-D) cases, and the frequently used uncorrelated scattering assumption is tested through full-wave Monte Carlo simulations. The results show that this assumption is valid for the discrete finite spectra of the received waves when the scattering objects in the environments are distributed in complete randomness, either when they are surrounding the transmit/receive regions or in clusters away from them. The correlation among wave components from different angles increases only when the randomness of the scatterer deployment is reduced. [J102]

"Analysis of the DVB-T Signal Variation for Indoor Portable Reception"

A study of DVB-T (Digital Video Broadcasting-Terrestrial) signal variability for indoor reception environments is stated in this paper. A commercial signal was measured and analyzed in order to obtain C/N threshold values that account time and space fluctuations. In this way, results increase the accuracy of the values provided by the ETSI (European Telecommunications Standards Institute) standard and other studies that assume static propagation channels. On the other hand, the fading influence due to people walking near the reception antenna has been proved as critical for correct reception. Characterization of this effect has been made in terms of its depth and duration. The results obtained results improve DVB-T network planning and could be also relevant for other technologies sharing similar frequencies and bandwidths. [J103]

"Modelling fading properties for mobile satellite link channels using non-stationary hidden Markov model"

Hidden Markov models (HMMs) of propagation fading channels are widely used. However, the standard HMM cannot effectively predict the state duration of a propagation channel. This investigation study develops a propagation channel model using a non-stationary hidden Markov approach to accurately predict the characteristics of the satellite-to-earth propagation channel. The proposed model can not only describe the propagation state characteristics but also capture the relationship between the times associated with the states. Typical measured data are used to derive optimal model parameters and generate a fading signal simulator. A close match between the simulated and measured data shows that the proposed model satisfactorily predicts the first- and second-order statistics of the propagation characteristics in several user environments. This new method produces more accurate simulation results than the standard HMM, in predicting the fading properties of the state duration statistics. [J104]

"Theoretical Investigation of Iterative Phase Retrieval Algorithm for Quasi-Optical Millimeter-Wave RF Beams"

In this paper, we present a detailed analysis of the iterative phase retrieval approach (IPRA) for determining the phase profile of the output microwave beam of a gyrotron from known intensity patterns emphasizing the field propagation techniques which are used to propagate the RF field of the microwave beam between known intensity planes. The propagation method, based on first Rayleigh-Sommerfeld diffraction integral (RSDI), is solved using fast Fourier transform (FFT) technique and zero padding. It is observed that the use of FFT and, therefore, the discretization of the RSDI propagation kernel introduce aberrations in the propagated field due to the superposition of the original field with its replicated versions. This problem is solved by approximations leading to the Huygens-Fresnel propagation method which further imposes the restrictions on the distances of propagation depending on the size of the transverse plane used to discretize the intensity pattern. This constraint of the distance of propagation causes problem in the iterative phase retrieval approach (IPRA) when more than two intensity planes are used. A method based on interpolation is proposed to overcome this restriction. IPRA is then further discussed to optimize several parameters, such as plane separation, plane dimension, mesh size, and measurement accuracies, which become more of an issue during the measurements of infrared intensity thermograms of the output microwave beam. [J105]

"Rain Depolarization Measurements on Low Margin Ku-Band Satellite Signal at a Tropical Location"

The phenomenon of depolarization of a Ku-band satellite signal caused by rain has been studied with a simple experimental system in which the attenuation of the copolar component and the enhancement of the cross-polar component signal have been measured at a tropical location. The degradation of cross-polarization discrimination (XPD) due to rain over the Earth space path has been obtained from these measurements and compared to that estimated from the ITU-R model, indicating the characteristic feature of a tropical location. [J106]

"Mapping link SNRs of real-world wireless networks onto an indoor testbed"

Network simulation packages such as NS-2 and OPNET have been shown to be a limited option for cross-layer experimentation in wireless networking because they cannot faithfully capture the propagation and interference characteristics of wireless channels. Recent research on network cross-layer optimizations further raises this concern due to the close interaction between physical layer feedback and higher layer protocols. To overcome this shortcoming, wireless testbeds have been used wherein novel protocols and application concepts can be assessed in a realistic environment under controlled and repeatable conditions. Since average signal-to-noise-ratio (SNR) often determines the performance of a wireless link, our goal is to seek link SNR mapping methods that replicate real-world link SNRs onto an indoor testbed. Specifically, we devise and assess link SNR mapping

methodologies for two different applications: hierarchical networks with a fixed access point (AP), and mesh networks. For the AP-based networks, we employ the minimum weight matching algorithm to minimize the root-mean-square (RMS) mapping error between the testbed and real-world SNRs. For the mesh networks, to avoid the technical difficulties inherent in ldquoforward mappingrdquo, we develop a ldquoreverse mappingrdquo method by which we turn a testbed configuration with specified link SNRs into a real-world configuration. By inducing the link gain difference between the testbed and the real-world distance-dependent path loss to have a log-normal distribution, a very close approximation to real-world shadow fading is achieved. We present results for a variety of indoor and outdoor real-world scenarios to demonstrate the generality of our method. [J107]

"Analysis and Parameterization of Methodologies for the Conversion of Rain-Rate Cumulative Distributions from Various Integration Times to One Minute"

The conversion of rain-rate cumulative distributions from any integration time, T, to one minute is a viable option whenever local one-minute data (time series or cumulative distribution functions) are not available for microwave system design. This paper reviews some of the most common rain-rate cumulative-distribution conversion methods. For selected models, it provides a complementary set of coefficients for regional and global application by performing regression to a measurements database. The performance of each model is analyzed, together with its adaptability to various climatic regions. Finally, recommendations with regard to the global applicability of models are given. [J108]

"The Practical Behavior of Various Edge-Diffraction Formulas"

The scalar knife-edge diffraction (KED) solution is a workhorse for RF and optics engineers who regularly encounter practical diffraction phenomena. However, the approximate, polarization-independent KED result is formulated in a way that does not provide direct physical insight. In this article, we demonstrate how the KED formula contains similar underlying physics to other more-rigorous half-screen diffraction solutions, allowing engineers to apply common geometrical theory of diffraction (GTD) formulations for all screen diffraction problems. The underlying geometrical behavior of the scalar KED solution sheds new light on these old problems, revealing why it is so useful for solving real-word problems in radiowave propagation. [J109]

"Non-line-of-sight on-body ultra wideband (16 GHz) channel characterisation using different antenna polarisations"

Ultra wideband (UWB) is a promising technology for wireless body area networks (WBANs). The authors investigate the wave propagation in the frequency range of 1-6-GHz for non-line-of-sight (NLOS) channels from the front to back of a human body by considering different wave polarisations: perpendicular and tangential with respect to the body. Time domain electromagnetic (EM) simulation using the anatomical model of a human body assuming frequency-dependent tissue properties is conducted. Radiographs of the energy density and delay spread of the NLOS channels are provided. The energy fading of UWB signals for the on-body channel suggests that the optimisation of the receiving antenna position for efficient signal transmission can be useful. A significant enhancement of the on-body communication link is identified by exploiting the transceiver antennas at the perpendicular to body polarisations. The impacts of body environment reflections on the channel characteristics of different polarisations are studied. The results show that the perpendicular polarisation channel characteristics are less influenced by the body environment reflections and are more stable regarding energy density and delay spread than tangential polarisation. The frequency-dependent propagation loss of on-body UWB channels is derived, where the efficient communication bandwidths for both perpendicular and tangential wave polarisations are given. [J110]

"Simulation of Near-Ground Long-Distance Radiowave Propagation Over Terrain Using NystrЦm Method With Phase Extraction Technique and FMM-Acceleration"

A 2D surface integral equation-based NystrOumlm solver in which a phase extraction technique is utilized to reduce the number of surface unknowns is described. As forward scattering is the dominant mechanism for the near-ground wave propagation scenario, the associated rapidly-varying phase components of the integral equation kernel and solution unknowns are deduced and isolated in advance and subsequently built into the solver. It is shown that by applying this method, when combining with an adaptive surface segmentation routine, as few as one to two average unknowns per wavelength is adequate in obtaining accurate solutions. This significantly reduces the memory storage and computational expense for the simulation of long-distance propagation effects. The efficiency of this method is further improved by incorporating it into the framework of the fast multipole scheme. The full details of the algorithm are discussed, along with performance comparisons of the new solver to a regular NystrOumlm solver for terrain surfaces in terms of solution convergence. [J111]

"A new worm exploiting IPv6 and IPv4-IPv6 dual-stack networks: experiment, modeling, simulation, and defense"

It is commonly believed that the IPv6 protocol can provide good protection against network worms that try to find victims through random address scanning due to its huge address space. However, we discover that there is serious vulnerability in terms of worm propagation in IPv6 and IPv4-IPv6 dual-stack networks. It is shown in this article that a new worm can collect the IPv6 addresses of all running hosts in a local subnet very quickly, leading to accelerated worm propagation. Similar to modeling the self-replicating behaviors of biological viruses, a Species-Patch model and a discrete-time simulator are developed to study how the dual-stack worm spreads in networks with various topologies. It is shown that the worm could propagate in the IPv6 and IPv4-IPv6 dual-stack networks much faster than in the current IPv4 Internet. Several effective defense strategies focusing on network deployment are proposed. [J112]

"Comparison of Various Urban Radiowave Propagation Models With Measurements"

A measurement campaign performed at 1.8 GHz in an urban environment of the city of Cartagena, Spain, is presented. The measurement procedure and data analysis are properly described. The experimental results are then compared with various urban propagation models in order to study their validity in predicting radio signal losses. The analysis shows that different considerations assumed in the models such as the type of wave incidence that is impinging over the series of buildings (plane or spherical) as well as the number of the latter existing across the different propagation paths can be significant in order to obtain more precise and realistic predictions of signal losses. [J113]

"Multiple access coding interferometers in wave radio"

Wave radios in the past have used passive wide-band with no multiple access (MA) coded interferometer architectures in modulator and demodulator circuits for QPSK digital data transmission and reception. The authors provide information and design insight on the use of MA coded interferometers in modulator and demodulator for UWB wave radio. Wave radio fitted with hardware MA coded interferometers offers MA to users as does CDMA using data codes. Experimental and simulation analyses of coded interferometers show that it is possible to establish a one-to-one wave radio hardware link by means of hardware-based codes (addresses). The number of UWB hardware-coded interferometers investigated is limited to three codes (code 0, code 1 and code 2) for demonstration purposes only. [J114]

"On Using the Compound Interferometer to Obtain the Power Pattern of a Conventional Receiving Array"

The compound interferometer is a well-known multiplicative receiving array. This paper shows that its product pattern can be made equal to the power pattern of a conventional linear array with uniform element weighting. Moreover, the compound interferometer has fewer elements, effectively a thinned array. The thinning factor improves as the size of the arrays increases. It is also shown that the method can be extended to planar arrays with very significant thinning as the array size increases. [J115]

"Propagation Between On-Body Antennas"

The theory of propagating waves near a surface is reviewed with an eye to gain insight into the mechanisms involved, and to provide analytical-based models, for power-efficient on-body propagation. The Zenneck wave, and in particular the Norton wave, are appraised as candidate mechanisms for the propagation. For flush-mounted (ldquoband aidrdquo) antennas, desired for on-body sensors, the Norton wave is the only direct propagation mechanism between the sensors. The Norton wave fits very well to simulation results presented here, and comparisons are also made with available published physical experiments, although these measurements typically feature the optical paths of elevated, or non-flush, antennas. [J116]

"Time domain UTD-PO solution for multiple building diffraction for UWB signals"

A time domain (TD) solution for the analysis of the multiple-diffraction is presented. This proposed solution is based on representation of the inverse Laplace transform of the corresponding frequency domain solution, as it is given by a hybrid of UTD-PO solutions. The TD results can be applied in pulse propagation analysis when multiple-diffraction has to be considered. [J117]

"Edouard Branly, the Coherer, and the Branly effect [JHistory of Communications]"

Critical to the success of Marconi's pioneering work on radio telegraphy was the device needed to detect the

radio telegraph messages on reception. Marconi finally settled on the "coherer." The invention of the device is often attributed to Oliver Lodge, a British physicist of the late 19th century. The detection properties of this device were, in fact, discovered by Edouard Branly, a French experimental physicist of the same period. As Dr. Dilhac makes clear in the following, Lodge himself attributed the signal detection properties of the coherer to Branly, coining the term coherer, and calling the device the "Branly coherer." The article clearly and succinctly discusses Branly's life, and describes the circumstances around which the coherer detection property was discovered by Branly. As pointed out by Dr. Dilhac, the physics behind the coherer long eluded scientists, and is just now, hopefully, becoming understood. During his life, Branly constantly denied being the inventor of radio, claiming that as a scientist he had only discovered an effect that had permitted others, like Popov, to develop wireless transmission. On the other hand, he was one of the earliest promoters of the remote control of equipment. During a largely publicized demonstration on 30 June 1905 at Palais de Chaillot in Paris he demonstrated the possibility to remotely and wirelessly turn light bulbs on and off or activate various electromechanical apparatus including motors. He made a publication on that topic in Compte-rendus a l'Academie des Sciences de Paris in March 1905. What is today called the Branly effect refers to a set of phenomena some of which were discovered before Branly. However, Branly was undoubtedly the first to publish about the effect of a spark that is, in modern words, the effect of an electromagnetic wave. Therefore, through the coherer and the demonstration that radio waves could easily be detected over long distances, he permitted early developments in wireless tel-ecommunications. Finally and surprisingly, because of both its own intrinsic complexity and its potential involvement in modern technology, the Branly effect is today still a subject of investigation. [J118]

"Robust Indoor Positioning Provided by Real-Time RSSI Values in Unmodified WLAN Networks"

The positioning methods based on received signal strength (RSS) measurements, link the RSS values to the position of the mobile station(MS) to be located. Their accuracy depends on the suitability of the propagation models used for the actual propagation conditions. In indoor wireless networks, these propagation conditions are very difficult to predict due to the unwieldy and dynamic nature of the RSS. In this paper, we present a novel method which dynamically estimates the propagation models that best fit the propagation environments, by using only RSS measurements obtained in real time. This method is based on maximizing compatibility of the MS to access points (AP) distance estimates. Once the propagation models are estimated in real time, it is possible to accurately determine the distance between the MS and each AP. By means of these distance estimates, the location of the MS can be obtained by trilateration. The method proposed coupled with simulations and measurements in a real indoor environment, demonstrates its feasibility and suitability, since it outperforms conventional RSS-based indoor location methods without using any radio map information nor a calibration stage. [J119]

"Illustrating Multipath Propagation by Means of Sound Waves"

A method is presented that uses sound waves to illustrate multipath-propagation concepts. This is based on the existing analogy between radio and sound waves, and has the advantage that the required equipment is easily available. Different measurement techniques are introduced to respectively examine time dispersion, time variation, and both aspects of the multipath channel simultaneously. The proposed techniques are justified, example results are given, and the specific features that are illustrated by each type of measurement are discussed. Suggestions are given regarding application in courses on wireless communications. [J120]

"Secure communications in local multipoint distribution service (LMDS) networks"

The transmission of confidential information over LMDS networks is investigated in the present paper from an information-theoretic standpoint. The major factor impairing the link performance at these networks is rain attenuation, a physical phenomenon exhibiting both spatial and temporal variation. Based on an accurate channel modeling, analytical expressions of the probability of non-zero secrecy capacity and the outage probability for this type of networks are provided, giving for the first time an information-theoretic approach of the problem of secure transmission for LMDS networks. Useful conclusions are drawn through extended numerical results suggesting the increase of operational frequency and the use of more directional antennas to improve security in transmission of confidential messages for this type of networks. [J121]

"On the Utility of Laguerre Series for the Envelope PDF in Multipath Fading Channels"

It is well known that multipath fading significantly affects the performance of communication systems. In order to incorporate the impact of this random phenomenon on system analysis and design, in many cases, we need to calculate the probability density function (pdf) of the received signal envelope in multipath fading channels. In this paper, we consider a general multipath fading channel with arbitrary number of paths, where the amplitudes of multipath components are arbitrary correlated positive random variables, independent of phases, whereas the

phases are independent and identically distributed random variables with uniform distributions. Since the integral form of the envelope pdf for such a general channel model is too complicated to be used for analytic calculations, we propose two infinite expansions for the pdf: a Laguerre series and a power series. Based on the tight uniform upper bounds on the truncation error of these two infinite series, we show that the Laguerre series is superior to the power series due to the fact that for a fixed number of terms, it yields a smaller truncation error. This Laguerre series with a finite number of terms, which expresses the envelope pdf just in terms of simple polynomial-exponential kernels, is particularly useful for mathematical performance prediction of communication systems in those indoor and outdoor multipath propagation environments, where the number of strong multipath components is small. [J122]

"Analysis of Correlated Shadow Fading in Dual-Link Indoor Radio Wave Propagation"

In this letter, we analyze the results of dynamic, double-directional, dual-link channel sounding, where the measurement system consists of one transmitter moving along a continuous route and two fixed receivers. The results show that despite a large terminal separation at one side of the link, the fading behaviors of the two links can be strongly correlated. In this special case, correlated shadow fading was found to be caused by the similar initial signal directions at the transmitter side and due to pillars that shadowed the signals at that side of the link. The fading phenomenon has been analyzed by dividing the received power into groups of multipath components revealing similar propagation mechanisms and by investigating the properties of those multipath components that are most severely shadowed by the pillars. [J123]

"Invisibility Cloaks Modeled by Anisotropic Metamaterials Based on Inductor-Capacitor Networks"

Based on the transformation optics, a novel transmission-line (TL) approach to realize invisibility cloaking using planar anisotropic metamaterials (MTMs) is proposed. The two-dimensional (2D) cylindrical cloaks are modeled based on inductor-capacitor (LC) MTMs networks. The three elements of the constitutive parameters mutau, muthetas, and epsivzetaare all allowed to be spatially inhomogeneous, which leads to the full parameter realization of a cylindrical cloak. As an example, a cloak working at VHF band is modeled, and its invisibility behavior is demonstrated based on the solution of the node voltage distribution. Due to the nonresonant properties of the LC elements, the broadband characteristic of the proposed cloaks is also evident. [J124]

"Investigation of Short-Range Radiowave Propagation at HF/VHF Frequencies in a Forested Environment"

Short-range radiowave propagation measurements are conducted in a loblolly pine forest and an open field at frequencies from 20 to 100 MHz. The measurement results are processed and the propagation constant of the dominant propagation mechanism is extracted. Comparison of the forest and the open field results shows a distinct resonance behavior for forest propagation in the frequency band from 33 to 42 MHz. The observed phenomena are corroborated by full-wave simulation results. [J125]

"A comprehensive framework for performance analysis of dual-hop cooperative wireless systems with fixed-gain relays over generalized fading channels"

In the present contribution, we propose a comprehensive framework for the analysis of cooperative dual-hop wireless systems over generalized fading channels, which use an amplify and forward (AF) relaying mechanism with blind and semi-blind relays. In particular, the proposed framework provides either exact results or very accurate bounds for computing the moment generating function (MGF) of the end-to-end signal-to-noise ratio (SNR) for various fading channel models typically encountered in real propagation environments. Furthermore, with the help of the MGF-based approach for performance analysis of wireless systems over fading channels, we will show that important performance indexes can be easily derived from the MGF. With respect to previous published articles on the matter, the main contribution of the paper is twofold: i) by relying on the properties of the Meijer-G function, either exact expressions or accurate bounds for the MGF of the end-to-end SNR are provided, and ii) the analysis encompasses the vast majority of fading channel models. Numerical and simulation results will be compared to substantiate the analytical derivation. [J126]

"Characterization of fading on fixed wireless channels between 200 MHz and 2 GHz in suburban macrocell environments"

Growing use of point-to-multipoint fixed wireless networks to support network access and SCADA applications in suburban macrocell environments has prompted regulators to re-allocate various bands between 200 MHz and 2 GHz to such applications. Links in such networks are usually obstructed by buildings and foliage and are classified as non-line-of-sight. Although it is well-known that such links are susceptible to fading caused by

windblown trees and foliage, most past efforts to characterize fading on such links have focused on frequency bands at 1.9 GHz and above. Here, we show how signal fading in the 220, 850 and 1900 MHz bands vary with both distance and time-averaged wind speed in a representative macrocell environment. Based upon time-series of received signal strength collected in a typical macrocell environment with moderate foliage at locations between 1 and 4 km from a transmitting site located 80 m above ground level, we show that fading on such links is relatively severe at 1.9 GHz but decreases rapidly as the carrier frequency decreases. We have expressed our results in the form of a first-order simulation model. Additional data will be required to estimate standardized model parameters that can be applied to a broad range of environments. [J127]

"Spatial-polarizational correlation-coefficient function between receiving-antennas in radiowave communications-geometrically modeled, analytically derived, simple, closed-form, explicit formulas"

This paper analytically derives closed-form expressions of the uplink received-signal's polarization-parameterized spatial-correlation-coefficient functions across the basestation antenna-array's spatial aperture, based on a geometrical model of idealized spatial relationships among the transmitter, the scatterers, and the receiving antennas. The derived formulas fit well with some empirical data. [J128]

"An ADI-PE Approach for Modeling Radio Transmission Loss in Tunnels"

Alternate direction implicit (ADI) method is used to study radio wave propagation in tunnels using the parabolic equation (PE). We formulate the ADI technique for use in tunnels with rectangular, circular and arched cross sections and with lossy walls. The electrical parameters of the lossy walls are characterized by an equivalent surface impedance. A vector PE is also formulated for use in tunnels with lossy walls. It is shown that the ADI is more computationally efficient than the Crank Nicolson method. However, boundary conditions become more difficult to model. The boundary conditions of the ADI intermediate planes are given the same boundary conditions as the physical plane and the overall accuracy is reduced. Also, when implementing the ADI in tunnels with circular cross sections the order at which the line by line decomposition occurs becomes important. To validate the ADI-PE, we show simulation results for tunnel test cases with known analytical solutions. Furthermore, the ADI-PE is used to simulate real tunnels in order to compare with experimental data. It is shown that the PE models the electric fields most accurately in real tunnels at large distances, where the lower order modes dominate. [J129]

"Diffraction and Reflection of a Plane Electromagnetic Wave by a Right-Angled Impedance Wedge"

The interior of a right-angled impedance wedge is a natural model of a corner reflector and is of interest in the development of wireless propagation models. Using a previously-developed solution for the diffraction of a plane wave by a wedge of arbitrary angle, the geometrical optics field is determined and the diffracted field is computed. If an impedance compatibility condition is not met, the geometrical optics field is discontinuous across a plane specified by the edge of the wedge and the incident field direction. The diffracted field is required to compensate for this and its magnitude is proportional to the discontinuity. The field is computed for a variety of impedances and incident angles. Simple analytical approximations are also provided and their accuracy quantified. [J130]

"Transmission of RF Signals Between MICS Loop Antennas in Free Space and Implanted in the Human Head"

This communication characterizes the transmission of radio frequency (RF) signals in Medical Implant Communications Service (MICS) band (402-405 MHz) between the loop antennas placed in free space and implanted into a human head (beneath the skull) for medical applications. The investigation is carried out using a commercial EM simulator XFDTD based on a finite-difference time-domain (FDTD) method with a numerical human head model, and verified by the measurements with a phantom. The study shows the effects of human head on the transmission of RF signals between the antennas inside and outside a human head. The information derived from this study is useful for the link budget of medical systems with the wireless connection between implanted devices in human heads and external central controllers. [J131]

"Channel-Based Detection of Sybil Attacks in Wireless Networks"

Due to the broadcast nature of the wireless medium, wireless networks are especially vulnerable to Sybil attacks, where a malicious node illegitimately claims a large number of identities and thus depletes system resources. We propose an enhanced physical-layer authentication scheme to detect Sybil attacks, exploiting the spatial variability of radio channels in environments with rich scattering, as is typical in indoor and urban environments. We build a hypothesis test to detect Sybil clients for both wideband and narrowband wireless systems, such as

WiFi and WiMax systems. Based on the existing channel estimation mechanisms, our method can be easily implemented with low overhead, either independently or combined with other physical-layer security methods, e.g., spoofingattack detection. The performance of our Sybil detector is verified, via both a propagation modeling software and field measurements using a vector network analyzer, for typical indoor environments. Our evaluation examines numerous combinations of system parameters, including bandwidth, signal power, number of channel estimates, number of total clients, number of Sybil clients, and number of access points. For instance, both the false alarm rate and the miss rate of Sybil attacks are usually below 0.01, with three tones, pilot power of 10 mW, and a system bandwidth of 20 MHz. [J132]

"High-speed ultra-wide band in-car wireless channel measurements"

Among the different wireless solutions, ultra-wide band (UWB) is a promising technology for in-car communications because of its high data rates. To optimise the UWB radio system design, knowledge of the propagation channel within the car is required. The performance of a high-speed 480 Mbps UWB radio system is studied within a real in-car environment measured under mobility. A comprehensive set of measurements is presented, including several possible non-line of sight scenarios while the vehicle is stationary and mobile, for open- and closed-window environments and with/without occupants. These measurements are used to characterise the in-car channel and evaluate the performance of a typical UWB radio system in this setting. [J133]

"3D-Wave Propagation Analysis of Indoor Wireless Channels Utilizing Hybrid Methods"

A full 3D hybrid method for analyzing electromagnetic wave propagation in buildings with realistic wall types and structures is presented. This hybrid method combines full-wave techniques which are used for the analysis of one unit cell of inhomogeneous periodic walls with a ray-tracing-like field calculation for the interaction between the walls. Consequently, the method can overcome the inadequacy of traditional ray-tracing in the presence of inhomogeneous periodic wall structures like cinderblock, rebar structure, etc. but is still computationally tractable. Because of this, both indoor wireless channel characterizations and signal fading statistics are shown to be more accurate with this method. Numerical results of the hybrid method are presented for two simple scenarios and validated with theory and measurement. Furthermore, numerical results for a realistic indoor scene are given and compared to a scene where the periodic walls are replaced with effective homogeneous walls. For both setups, the propagation channel is characterized, fast fading signal statistics are extracted and the inadequacies of the homogeneous wall implementation are pointed out. [J134]

"Multipath Directivity and Spatial Selectivity in Three-Dimensional Wireless Channels"

A generalized definition is presented of multipath angular spread, used to study the spatial correlation of the signal envelope in a three-dimensional wireless channel, both in the cases of a three-dimensional and a horizontal travel direction. Previous results from two-dimensional modeling are shown to be a special case of this general analysis when the multipath power and the travel direction are confined to a single plane in space. The results show that the main lobe of the spatial correlation of the signal envelope at a given distance has an approximately Gaussian dependence on the three-dimensional multipath directivity metric proposed in this paper, for both cases for the travel direction. [J135]

"Physically motivated fast-fading model for indoor peer-to-peer channels"

To model the fast-fading statistics of the wireless transmission channel in indoor peer-to-peer scenarios, an amplitude distribution composed of three distinct components was investigated. They correspond to line-of-sight, once-reflected and twice-reflected propagation paths. It is shown experimentally that this distribution matches indoor peer-to-peer links better than the available alternatives. Furthermore, an interesting structure in the parameter space of the distribution is pointed out, leading to a simple stochastic parameterisation based on a three-modal normal distribution. [J136]

"A Relationship Between Phase Delay and Attenuation Due to Rain and Its Applications to Satellite and Deep-Space Tracking"

We present and discuss two main results concerning the relationship between phase delay due to rain and rain attenuation, useful in calculations concerning high precision tracking of satellites and deep-space spacecrafts using interferometry techniques. We have found these two results with the Synthetic Storm Technique [SST] applied to a large data bank of rain rate time series collected at three sites in Italy. The first result concerns a formula that provides the extra signal phase delay tau (picoseconds) due to rain as a function of rain attenuation A (dB), frequency f (GHz) and slant path elevation angle thetas (degrees), given by tau = (860.4 4.82 thetas)f-1.71A0.73, for 20deg les thetas les 44deg, and by tau = 648.3 f1.71A0.73,for 44deg les thetas les 90deg. The

formula allows estimating the phase delay due to rain attenuation, with overall average (normalized) error -3%, standard deviation 11.1%, rootmean square 11.5 % for 20deg slant paths. The second result concerns a method to predict phase delay from the probability distribution of rain rate (SST probability model), very useful when only the probability distribution of rain rate is known. [J137]

"Effect of urban-site and vegetation on channel capacity in higher altitude platform communication system"

Communication services using higher altitude platforms have highlighted a need for estimating the effect of local obstructions on radio wave link. Vegetation and buildings are the major factors responsible for attenuation. The authors have calculated the radio wave attenuation because of vegetation and buildings. Here, the authors have used the fitted radio international telecommunication union model to calculate the vegetation attenuation. The attenuation because of buildings is calculated for an urban-site (residential area of Netaji Subhas Institute of Technology, NSIT, New Delhi, India) using geometrical optics and a uniform theory of diffraction. Further, channel capacity is calculated for vegetation and urban-site environment using Shannon's channel capacity theorem. [J138]

"Indoor Radio Reception at 60 GHz: Fading Mitigation Using Diversity Techniques"

Several radio propagation experiments have been conducted to analyze the propagation impairments in indoor scenarios at 60 GHz when mobile and portable terminals are used. The power variation with distance and the signal fading has been measured and characterized. Results show that the power decay with distance is similar for both types of terminals, while signal fading is more relevant in mobile reception, with fades up to 6 dB occurring as often as 1% of the time. Moreover, when a mobile terminal is considered, wideband measurements show that the coherence bandwidth is lower than the channel bandwidth, and that a wideband modulation scheme like COFDM should be adequate to reduce signal fading. Alternatively, the use of space diversity at the receiver has been considered to mitigate signal fading. The antenna separation needed to assure a low envelope correlation has been determined. Diversity gain, for an outage probability of 1%, has been calculated and ranges from 3 to 5 dB, depending on the combination technique used. [J139]

"Performance of M-PSK in mobile satellite communication over combined ionospheric scintillation and flat fading channels with MRC diversity"

Combined scintillation and terrestrial fadings occur in mobile satellite communication channels as the signal passes through the ionosphere and the lower atmosphere. This results in a product fading channel, which negatively affects the performance of the system. The challenge is to evaluate the performance of the system, in terms of the average bit error probability (BEP). In this paper, through the use of the moment generating function, we derive expressions for the average BEP and an upper bound for M-ary phase-shift keying (M-PSK) modulation with maximal-ratio combining (MRC) diversity over the product RiciantimesRician channel. The results are expressed as double summations in terms of the generalized hypergeometric function, which can be computed using standard commercial software. For a large Rician factor, the expression is simplified to a single summation. Numerical results are obtained from the derived expressions and compared with simulation results. They show very good agreement for various Rician factors and the number of diversity branches. The upper bound is also evaluated and shown to be reasonably tight. [J140]

"A geometry-based stochastic MIMO model for vehicle-to-vehicle communications"

Vehicle-to-vehicle (VTV) wireless communications have many envisioned applications in traffic safety and congestion avoidance, but the development of suitable communications systems and standards requires accurate models for the VTV propagation channel. In this paper, we present a new wideband multiple-input-multiple-output (MIMO) model for VTV channels based on extensive MIMO channel measurements performed at 5.2 GHz in highway and rural environments in Lund, Sweden. The measured channel characteristics, in particular the nonstationarity of the channel statistics, motivate the use of a geometry-based stochastic channel model (GSCM) instead of the classical tapped-delay line model. We introduce generalizations of the generic GSCM approach and techniques for parameterizing it from measurements and find it suitable to distinguish between diffuse and discrete scattering contributions. The time-variant contribution from discrete scatterers is tracked over time and delay using a high resolution algorithm, and our observations motivate their power being modeled as a combination of a (deterministic) distance decay and a slowly varying stochastic process. The paper gives a full parameterization of the channel model and supplies an implementation recipe for simulations. The model is verified by comparison of MIMO antenna correlations derived from the channel model to those obtained directly from the measurements. [J141]

"Simulating Ionosphere-Induced Scintillation for Testing GPS Receiver Phase Tracking Loops"

A simple model is proposed for simulating equatorial transionospheric radio wave scintillation. The model can be used to test Global Positioning System phase tracking loops for scintillation robustness because it captures the scintillation properties that affect such loops. In the model, scintillation amplitude is assumed to follow a Rice distribution, and the spectrum of the rapidly-varying component of complex scintillation is assumed to follow that of a low-pass second-order Butterworth filter. These assumptions are justified, and the model validated, by comparison with phase-screen-generated and empirical scintillation data in realistic tracking loop tests. The model can be mechanized as a scintillation simulator that expects only two input parameters: the scintillation index S4and the decorrelation time tau0. Hardware-in-the-loop tests show how the model can be used to test the scintillation robustness of any compatible GPS receiver. [J142]

"Recursive Two-Way Parabolic Equation Approach for Modeling Terrain Effects in Tropospheric Propagation"

The Fourier split-step method is a one-way marching-type algorithm to efficiently solve the parabolic equation for modeling electromagnetic propagation in troposphere. The main drawback of this method is that it characterizes only forward-propagating waves, and neglects backward-propagating waves, which become important especially in the presence of irregular surfaces. Although ground reflecting boundaries are inherently incorporated into the split-step algorithm, irregular surfaces (such as sharp edges) introduce a formidable challenge. In this paper, a recursive two-way split-step algorithm is presented to model both forward and backward propagation in the presence of multiple knife-edges. The algorithm starts marching in the forward direction until the wave reaches a knife-edge. The wave arriving at the knife-edge is partially-reflected by imposing the boundary conditions at the edge, and is propagated in the backward direction by reversing the paraxial direction in the parabolic equation. In other words, the wave is split into two components, and the components travel in their corresponding directions. The reflected wave is added to the forward-wave in each range step to obtain the total wave. The wave-splitting is performed each time a wave is incident on one of the knife-edges. This procedure is repeated until convergence is achieved inside the entire domain. [J143]

"Complete Link Budgets for Backscatter-Radio and RFID Systems"

Backscatter radio-wireless communication by modulating signals scattered from a transponder (RF tag)-is fundamentally different from conventional radio because it involves two distinct links: the power-up link for powering passive RF tags, and the backscatter link for describing backscatter communication. Because of severe power constraints on the RF tag, a thorough knowledge of the backscatter channel is necessary to maximize backscatter-radio and radio-frequency identification (RFID) system performance. This article presents four link budgets that account for the major propagation mechanisms of the backscatter channel, along with a detailed discussion of each. Use of the link budgets is demonstrated by a practical UHF RFID portal example. The benefits of future 5.8 GHz multi-antenna backscatter-radio systems are shown. An intuitive analogy for understanding the antenna polarization of RF tag systems is presented. [J144]

"Compact Rayleigh and Rician fading simulator based on random walk processes"

This article describes a significantly improved sum-of-sinusoids-based model for the accurate simulation of time-correlated Rayleigh and Rician fading channels. The proposed model utilises random walk processes instead of random variables for some of the sinusoid parameters to more accurately reproduce the behaviour of wireless radio propagation. Every fading block generated using our model has accurate statistical properties on its own and hence, unlike previously proposed models, there is no need for time-consuming ensemble-averaging over multiple blocks. Using numerical simulation it is shown that the important statistical properties of the generated fading samples have excellent agreement with the theoretical reference functions. A fixed-point hardware implementation of the corresponding Rayleigh and Rician fading channel simulator on a field-programmable gate array (FPGA) is presented. By efficiently scheduling the operations, the reconfigurable fading channel simulator is compact enough that it can be efficiently used to simulate multipath scenarios and multiple-antenna systems (e.g. a 4 times 4 MIMO channel) using a single FPGA. [J145]

"Spherical Vector Wave Expansion of Gaussian Electromagnetic Fields for Antenna-Channel Interaction Analysis"

In this paper, we introduce an approach to analyze the interaction between antennas and the propagation channel. We study both the antennas and the propagation channel by means of the spherical vector wave mode expansion of the electromagnetic field. Then we use the expansion coefficients to study some properties of general antennas in those fields by means of the antenna scattering matrix. The focus is on the spatio-polar

characterization of antennas, channels and their interactions. We provide closed form expressions for the covariance of the field multimodes as function of the power angle spectrum (PAS) and the channel cross-polarization ratio (XPR). A new interpretation of the mean effective gains (MEG) of antennas is also provided. The maximum MEG is obtained by conjugate mode matching between the antennas and the channel; we also prove the (intuitive) results that the optimum decorrelation of the antenna signals is obtained by the excitation of orthogonal spherical vector modes. [J146]

"Seasonal variation of site diversity performance"

A study of the seasonal performance of site diversity (SD) using four years of rain radar measurements in South England is presented. Detailed analyses of site diversity gain as well as the spatial correlation of rain attenuation at pairs of sites of various separation distances and baseline orientations reveal significant seasonal dependence, a much greater efficacy of SD for fade mitigation in the summer and a larger sensitivity of the technique to baseline orientation in non-summer seasons. [J147]

"Path-Loss and Time-Dispersion Parameters of UWB Signals in a Military Airplane"

This study aims to obtain a comprehensive understanding of the potentials of ultrawideband (UWB) technology by characterizing the UWB propagation channel in a Hercules C-130 military airplane. In particular, we present a method for calculating the frequency-dependent path-loss factor. Moreover, results include the distance-dependent and frequency-dependent path-loss factors and their standard deviation. Finally, we provide empirical values for the time-dispersion parameters such as the mean excess delay, the maximum excess delay, and the root mean square (rms) delay spread. The values of these parameters can be used for UWB channel modelling. [J148]

"Terminal-to-Terminal Hybrid Full-Wave Simulation of Low-Profile, Electrically-Small, Near-Ground Antennas"

An investigation into the simulation and performance of low-profile, electrically-small antennas for unattended ground sensor (UGS) networks is featured in this study. Because UGS transceivers are intended for operation near the ground, ground proximity effects become extremely important for considerations related to antenna efficiency, input matching, radiation pattern, and the overall path loss between the transmitter and receiver nodes. While vertical wire antennas are shown to be less susceptible to path loss, a low-profile alternative is desired for UGS applications and is often required in the fabrication of low-cost, monolithic on-chip, miniaturized systems. In this work, the performances of different transceiver systems utilizing different types of near-ground antenna structures including the dipole, loop, ordinary circular slot, and cavity-backed circular slot are analyzed using a full-wave hybrid approach consisting of the moment method in conjunction with a near-ground asymptotic field propagation model. The figure of merit for comparison among the various configurations is identified as the efficiency factor calculated from the ratio of the input power at the transmitting antenna terminal to the received power at the receiving antenna terminal. The unique features of ground proximity effects as pertaining to near-ground operation are discussed and an optimal radiator is identified from the set of structures analyzed. [J149]

"Evaluation of Signal Quality Improvement With Rake Reception Using an Ultrawideband Indoor Area Propagation Measurement"

Achievable improvement of signal quality using rake reception was evaluated for ultrawideband impulse-radio and spread-spectrum systems. The evaluation was based on extensive area propagation measurement in a line-of-sight office environment. Influence of large- and small-scale propagation behavior on improvement of receiving signal-to-noise ratio (SNR) was analyzed. The analyses revealed that having eight fingers could achieve sufficient improvement of receiving SNR under practical conditions. It was also demonstrated that eight-finger rake reception could extend service coverage and reduce outage probability. [J150]

"Analysis of Multipath Propagation in Urban Environment Through Multidimensional Measurements and Advanced Ray Tracing Simulation"

A multidimensional analysis of multipath propagation in urban micro- and macro-cellular environment has been carried out. Multidimensional measurement data, including path-loss, delay spread and direction-of-arrival are compared with simulations performed with a 3D ray tracing model which takes diffuse scattering into account. The results are analyzed highlighting the dominant propagation mechanisms in the different cases and model performance/shortcomings. In particular, the results show that diffuse scattering plays a key role in urban propagation, with an impact on both narrowband and wideband parameters in most cases. Also, the accuracy

and the characteristics of environment representation can have a significant impact on prediction even in simple topologies. [J151]

"Sensitivity of the System Performance to the Propagation Parameters in LOS Microcellular Environments"

Propagation loss is a fundamental phenomenon that affects the performance of any wireless network. Although propagation characteristics in line-of-sight (LOS) microcellular systems are well known, so far, only a few papers have investigated its effect on system performance in a comprehensive manner. In this paper, the impact of both system parameters (i.e., cell size, antenna height, operating frequency, and reuse factor) and propagation loss parameters (i.e., breakpoint distance, path loss exponents, standard deviation of the shadowing component, signals correlation, and effective road height) on the performance of both time-division multiple access (TDMA)- and code-division multiple access (CDMA)-based LOS microcellular networks is studied. Performance is evaluated in terms of outage probability in TDMA-based systems and in terms of the other-cell interference factor in CDMA-based systems. This paper includes substantial numerical results and new insights into the behavior of wireless system performance. For instance, novel insights into the impact of both distance-dependent shadowing and the effective road height on system performance are provided. In particular, nontypical fluctuational and discontinuous behavior on performance metrics are observed, and at microwave frequencies, the spectral efficiency is greater for heavy vehicular traffic conditions (i.e., during daytime) than for light vehicular traffic conditions (i.e., during nighttime). Such an understanding of interference engineering issues is vital for the planning, designing, dimensioning, and the optimization of mobile LOS microcellular networks for present and future wireless systems beyond third generation. [J152]

"A Tunable Closed-Form Model for the Structure Function of Tropospheric Delay"

Several interferometric synthetic aperture radar applications could benefit from the availability of a closed-form model for the second-order statistics of atmospheric delay. Due to the variability of the latter, it would also be desirable for the model to be tunable to some acquisition-specific information, describing the atmospheric state. In this letter, a closed-form expression for the zenith delay structure function of tropospheric propagation delay is derived from a two-regime power spectral density function reported in the literature. The power at a specific spatial frequency is used as a free model parameter, which may be tuned to available measurements or, in the absence of these, to atmospheric statistics. The latter approach is used to compare the derived model with previously published results. [J153]

"Application of the Characteristic Basis Function Method Utilizing a Class of Basis and Testing Functions Defined on NURBS Patches"

A novel implementation of the characteristic basis function method (CBFM) is given, in which the high-level basis functions, called characteristic basis functions (CBFs), are represented in terms of curved rooftops generated from nonuniform rational B-splines (NURBS) in the parametric (u,v) domain. The associated macro-testing functions are defined by using curved razor-blade functions corresponding to each rooftop. The underlying objective of the CBFM is the reduction of the number of unknowns that arise from the discretization process when applying the conventional method of moments (MoM). The result is, therefore, an approach which can handle many complex cases via direct solvers, without suffering from convergence problems as many of the iterative techniques are known to do when dealing with ill-conditioned matrices. As a result of the combination of the CBFM with the special class of low-level basis and testing functions directly located over NURBS surfaces, complex and realistic geometries can be efficiently analyzed to yield accurate results while reducing the CPU time as well as required memory resources. [J154]

"On the Possibility of Interpreting Field Variations and Polarization in Arched Tunnels Using a Model for Propagation in Rectangular or Circular Tunnels"

We investigate the possibility of using the modal theory of the electromagnetic propagation in rectangular or circular tunnels, to satisfactorily interpret experimental results, including polarization, in arched tunnels. This study is based on extensive measurement campaigns carried out in the 450 MHz-5 GHz frequency range. [J155]

"Elevation Dependent Shadowing Model for Mobile Communications via High Altitude Platforms in Built-Up Areas"

An empirical propagation prediction model is described for mobile communications from high altitude platforms (HAPs) in different types of built-up areas. The model introduced here is defined as a function of the angle of elevation. The target frequencies are selected from the 2 to 6 GHz frequency band prospective for 3G and 4G

mobile systems, namely at 2.0,3.5, and 5.5 GHz. This new HAP model recognizes two cases-line of sight (LOS) and non-line of sight (NLOS) between a HAP and a user at street level. The simulation of the urban environment is based on a statistical approach. Additional shadowing path loss is calculated using the uniform theory of diffraction for NLOS conditions. Normal distribution of the additional shadowing path loss was distinguishable from the simulation results. The shadowing path loss is defined as a function of the elevation angle. The results of the empirical model developed for idealized conditions are verified by measurements taken from a remote-controlled airship in different types of urban environment. Close correlation was achieved between the theoretical model and the experimental data. The HAP elevation dependent shadowing model is easy to implement and can be used for realistic planning and simulations of mobile networks provided via HAPs in built-up areas. [J156]

"Sinusoidal current duality"

The paper is a comment to the work of Miller-"The incremental far field and degrees of freedom of the sinusoidal current filament". The author concluded that there is a sinusoidal current duality; sinusoidal currents are suitable for the calculation of fields, but not for the direct calculation of impedance, based on Miller's formula. [J157]

"Investigation of Rainfall Effect on Forested Radio Wave Propagation"

In this paper, the rainfall is found to have distinct effect on various parts of the propagating components for the VHF radio wave propagation in a tropical forest. By the studies of the measured power delay profiles under different weather conditions, it is observed that the lateral wave is the dominant mode of the VHF propagation and is not affected by the presence of rain as it is similar to free space propagation over the tree tops, while the significant multipath components which propagate through the forest medium is heavily influenced. This is again verified through the estimated delay spread statistics. [J158]

"Propagation Over Clutter: Physical Stochastic Model"

Propagation of radio signals from a base above clutter, such as buildings and trees, to a mobile immersed in clutter is treated theoretically by accounting for random diffuse scattering at the mobile. Small-scale fading and distance-dependent loss are treated in a unified way, as opposed to the heuristic methodologies, which formulate them as separate factors. Closed form expressions are derived for path gain and for angular spectrum at the base in both urban and heavily foliated environments. The resulting predictions are in close agreement with widely accepted models and empirical results. The angular spectrum at the base in urban environments is found to be Lorentzian of width close to that reported for measurements in Aarhus. In foliated environments, vegetation is represented as statistically homogeneous diffuse scattering medium, resulting in a Gaussian-shaped angular spectrum at the base. [J159]

"Update: GPS Signals Spot Signs of Typhoons"

This article presents a briefs description of the COSMIC (Constellation Observing System for Meteorology, Ionosphere, and Climate) constellation's capabilities as a GPS based meteorological instrument. It demonstrates the predictive powers of a new technique called near-real-time radio occultation. [J160]

"Response to R. C. Hansen's "sinusoidal current duality""

The paper is the authors' response regarding the the comment made by R.C. Hansen on his work " The incremental far field and degree of freedom of the sinusoidal current filament". Hansen claims the duality in applying sinusoidal currents in the equation formulated by the author. [J161]

"Cumulative Fading and Rainfall Distributions for a 2.1 km, 38 GHz, Vertically Polarized, Line-of-Sight Link"

Between February 1,1997 and January 31,1998, a 2.1 km vertically polarized 38 GHz communications link was studied in the subtropical city of Brisbane, Australia. According to the current ITU fading prediction method the link would be expected to experience a rainfall intensity of approximately 50 mm/h for 52.6 min during the year, when averaged over a 60 s integration time. This should have caused approximately 20 dB of fading for 52.6 min [1]-[3]. However the link actually experienced 20 dB of fading for 150.5 min, with fading of 37 dB exceeded for 53.5 min during the year. A rainfall intensity of 84 mm/h was exceeded for 64 min at the receive end, and a rainfall intensity of 72 mm/h was exceeded for 52 min at the transmit end of the hop. [J162]

"Assessment of Radar Signal Attenuation Caused by the Melting Hydrometeor Layer"

Attenuation of radar signals by melting hydrometeors is studied using modeling approaches and comparisons of

simulated and observed results. In spite that the melting layer in precipitating systems is usually relatively thin (~ 500 m), this attenuation can be substantial at X-band frequencies for low elevation angles and at millimeter-wavelength frequencies that are used by the U.S. Department of Energy's Atmospheric Radiation Measurement Program and CloudSat radars operating at vertical/nadir incidence. Melting layer attenuation is stronger than the attenuation in the resultant rain at comparable path lengths and needs to be accounted for in remote sensing methods that use radar reflectivity measurements for retrieving cloud and precipitation parameters if the radar beam penetrates this layer. The choice of the mixing rule for calculating dielectric constants of melting hydrometeors determines, to a significant degree, the magnitude of the modeled attenuation values. A relatively simple Wiener mixing rule provides results that are consistent with melting layer reflectivity enhancements and attenuation estimates from the X-band radar observations. The total melting layer attenuation Ais related to the resultant rain rate Rin an approximately linear manner at X- and Kalpha-band frequencies, whereas at W-band, the melting layer attenuation increase with rain rate is slower due to strong non-Rayleigh scattering effects. Typical A-Rrelations are suggested, and the variability of these relations is discussed. This paper is mostly concerned with precipitating systems associated with snowflakes that are unrimed or only slightly rimed above the freezing level, as indicated by relatively low values of vertical Doppler velocities. [J163]

"The 5-GHz Airport Surface Area Channel-Part II: Measurement and Modeling Results for Small Airports"

This paper describes results from a channel measurement campaign performed at several small airports in the U.S. in the 5-GHz band. This paper is a companion to another paper, which describes channel models for large airports. We classify the small airport surface channel into three propagation regions based upon different delay dispersion conditions. The channel characteristics of these regions in the delay and frequency domains are discussed with examples. We provide empirical stochastic channel models (of different bandwidths) to accurately represent the channel on the airport surface area for all propagation regions. The models are provided in the form of tapped delay lines, and complete statistical tap descriptions are given. Several key observations, including the presence of severe amplitude fading, some correlated scattering, and statistically nonstationary behavior, are also discussed. [J164]

"Direction-of-Arrival Estimation System for Multipath Propagation in Code-Division Multiple-Access Systems With Synthesized Virtual Planar Array Using Pilot Signals"

Here, we propose a method for estimating the direction of arrival (DOA) using pilot signals in code-division multiple-access (CDMA) systems. We also report the evaluation of the performance of the proposed method by conducting simulations and experiments in an anechoic chamber and an outdoor environment. This method estimates the DOA of the arrival waves by synthesizing the data received by a virtual planar array using pilot signals. First, we describe a method for synthesizing the data received by the virtual planar array using pilot signals. Next, we present simulation results that confirmed that the accuracy of the estimation based on the virtual planar array was the same as that based on a real planar array. Last, we describe the effectiveness of the proposed system that is demonstrated through experiments in both the anechoic chamber and in an outdoor environment. [J165]

"Interpretation of MIMO Channel Characteristics in Rectangular Tunnels From Modal Theory"

We develop a modal approach for analyzing multiple-input-multiple-output (MIMO) wireless channel propagation in a tunnel with lossy walls. We use parametric methods to study the effects of the number of modes and of the separation among antennas. We evaluate the performance of the MIMO channel in terms of capacity as a function of range and tunnel size. [J166]

"A Statistical Radio Range Model for a Robot MANET in a Subterranean Mine"

We present a statistical model for the radio range between robots in a mobile ad hoc network (MANET) deployed in an underground mine. Such unmanned mobile robotic networks could potentially be used in hazard mitigation and search and rescue in tunnel environments such as mines and subways, as well as in building environments. In addition to fading characteristics, our model is able to represent the variable nature of the propagation path-loss exponent. To support our model, we present path-loss measurements made in a real mine. The usefulness of our model lies in the fact that it represents an overall propagation model for a mine and therefore can be used to calculate the wireless connectivity probability of an arbitrary node in the network without requiring a detailed physical representation of the MANET within the mine. [J167]

"Evaluation of the Propagation Model Recommendation ITU-R P.1546 for Mobile Services in Rural Australia"

In this paper, the validity of recommendation ITU-R P.1546 in a short-range terrestrial environment is analyzed. Its three versions (P.1546, P.1546-1, and P.1546-2) are compared against simple models and evaluated using measurement results that were obtained by utilizing the pilot signal of a commercial code-division multiple-access mobile telephone network. Measurement results show that P.1546-2, on average, underestimates the field strength by more than 10 dB for typical Australian rural areas. However, it improves the error standard deviation compared to previous versions. The causes of these effects and the suggestions for further development of the Recommendation are discussed and evaluated. [J168]

"Path-Loss Prediction Models for Intervehicle Communication at 60 GHz"

Propagation path losses affecting intervehicle communication (IVC) at 60 GHz are presented. In order to examine the radio-propagation characteristics in the IVC system, in the first stage of our investigation, we have carried out propagation tests between two vehicles communicating in a line-of-sight (LOS) situation at fixed positions on a smooth surface paved with asphalt, which is the normal communication condition. Furthermore, the non-LOS (NLOS) situation with up to three intermediate vehicles, which can cause an obstruction, has been conducted. To construct path-loss models in NLOS cases, the uniform theory of diffraction technique was applied to the calculation of waves propagating through the intermediate vehicles. The propagation path models were derived from the measured results. In the second stage, a path-loss prediction formula was derived by statistically processing the data that had been calculated using the propagation path model. The propagation tests between the vehicles in motion confirm that the path-loss prediction formula is very useful when the communicating vehicles are moving, and it is therefore suitable for designing the cells that form the IVC. [J169]

"Statistical Analysis of UWB Channel Correlation Functions"

Various performance metrics of impulse-radio (IR) ultrawideband (UWB) receivers are closely connected to the correlation functions of the multipath channel responses to UWB pulses. Interpulse interference is related to the autocorrelation function (ACF) of the received pulse (RP), the RP energy and its fading correspond to the ACF at zero lag, and multiple access interference is connected to the cross-correlation function (CCF) between two channel pulse responses. Each realization of the multipath channel shows different correlation functions due to the ldquorandomnessrdquo of the UWB propagation environment. This paper derives the first- and second-order statistics of the ACF and CCF, capturing this randomness. Such results are useful for incorporating the multipath channel into the performance and design optimization studies of UWB systems. The analysis is based on a model of the received UWB pulse. The model describes the random channel response by two continuous functions of the excess delay time-one expresses the power, the other expresses power variations-and by a prototype pulse shape representing all linear system components including the band limitation of the RP and antenna effects. The analytical results are validated through the analysis of simulated and measured channel responses. [J170]

"Sensing Coverage for Randomly Distributed Wireless Sensor Networks in Shadowed Environments"

Sensing coverage is an important issue for sensor networks and is viewed as one of the critical measures of the performance offered by a sensor network. In previous studies, the sensing range of a node is generally assumed to be a deterministic value in all directions. For most types of sensing signals emitted from a far field, the obstructions in the propagation path will induce an extra loss in the received signal power and cause a large variation in the received signal strength. This variation is classified as the shadowing effects similar to the phenomenon in radio wave propagation. The objective of this paper is to examine the impact of the shadowing effects on the sensing coverage. The analytical results of the sensing coverage for a large-scale randomly distributed sensor network in shadowed environments are provided. It was found that the increase in standard deviation of the shadowing effects severely degrades the sensing coverage. For an increase of 2 dB in the standard deviation, the sensing coverage degrades by about 10%. [J171]

"Evaluation of a Near-Field Monostatic-to-Bistatic Equivalence Theorem"

This paper presents the results of an investigation to quantitatively determine the limits of Falconer's monostatic-to-bistatic equivalence theorem (MBET). Falconer developed two extensions to Kell's MBET: one that is applicable to near-zone data and one that is valid in both the near- and far-zone regions. This paper encompassed collecting and analyzing both monostatic and bistatic radar cross-section data for perfect electrically conducting objects. Specifically, the authors analyzed the effects of varying the transmission frequency, scattering object complexity, and receiver bistatic angle. Objects ranged in geometric complexity from simple canonical objects to multifaceted shapes that produce multiple reflections. Empirical data collected in the far zone were compared with the analytical predictions produced by a commercially available method-of-moment

(MoM) code. The code was run at X-band through K-band frequencies for a comparison with the measured data. The empirical bistatic data were then compared with the estimate produced by the MBET to ascertain the region in which the MBET approximation is applicable. Finally, the MoM code was used to produce near-field scattering predictions to facilitate the evaluation of Falconer's near-field MBET. It is shown that the complexity of the scatterer restricts the region of validity for the MBET, where shadowing and multipath interactions prevail. The disparity between the MBET accuracies for the different test objects used clearly illustrates this point. [J172]

"Modeling, analysis, and simulation of MIMO mobile-to-mobile fading channels"

This paper' deals with the modeling, analysis, and simulation of multiple-input multiple-output (MIMO) narrowband fading channels for mobile-to-mobile communications. A stochastic MIMO mobile-to-mobile reference channel model is derived from the geometrical two-ring scattering model under the assumption that both the transmitter and the receiver are surrounded by an infinite number of local scatterers. Using a wave propagation model, the complex channel gains are derived and their statistical properties are studied. General analytical solutions are provided for the three-dimensional (3-D) space-time cross-correlation function (CCF). We show that this function can be expressed as the product of two 2D space-time cross-correlation function (CFs), called the transmit and receive CF. From the non-realizable reference model, a stochastic and a deterministic simulation model are derived using a double sum of complex exponential functions. It is shown how the parameters of the simulation model can be determined for any given distribution of the angle of departure (AOD) and angle of arrival (AOA). In case of isotropic scattering, we present a closed-form solution for the parameter computation problem and illustrate some numerical results concerning the transmit CF. The proposed procedure provides an important framework for designers of future mobile-to-mobile communication systems to verify new transmission concepts employing MIMO techniques under realistic propagation conditions. [J173]

"Frequency domain detectors for ultra-wideband communications in short-range systems"

In this paper, we propose an original detection scheme for high rate short-range impulse radio ultra-wideband systems. The proposed receiver relies on both the introduction of the cyclic prefix at the transmitter and the use of a frequency domain multiuser detector at the receiver. Zero forcing (ZF) and minimum mean square error (MMSE) detection strategies have been investigated and compared with the classical RAKE, considering a scenario where several mobile terminals communicate with a base station in an indoor environment characterized by severe multipath propagation. The results show that the MMSE receiver achieves the best performance, irrespective of the number of active terminals, both in the uplink and in the downlink communications. Hence, the proposed approach is well suited in indoor wireless environments where the multipath propagation tends to increase the effects of both the inter-path and the inter-user interference. [J174]

"An Integrated Method of Ray Tracing and Genetic Algorithm for Optimizing Coverage in Indoor Wireless Networks"

This letter presents a method for determining the required number and locations of transmit antennas to optimize wireless propagation coverage in a given indoor environment. The ray-tracing method is employed to calculate the field distribution due to one or more transmitting antennas and the genetic algorithm (GA) is used to determine the required number and the locations of these antennas to achieve optimized wireless coverage in a given area. In the ray-tracing method, detailed parameters such as thickness, dielectric constant, and the conductivity of individual walls are assigned for realistic field calculations. Obtained simulation results illustrate the feasibility of using the integrated ray-tracing/GA method in determining the optimized coverage of a wireless network. [J175]

"Convolution-Based Placement of Wireless Base Stations in Urban Environment"

In this paper, we introduce a novel approach for computing the number, location, and transmission powers of wireless base stations in a 2-D urban setup. The new approach utilizes 2-D convolution to extract the supply-demand correlation. Available efficient methods for computing the convolution are then used to substantially reduce the complexity of the solution. The proposed approach enables network designers to choose arbitrary antenna propagation and radio demand patterns using a simple color-coding mechanism. Simulations of the proposed algorithm show its efficiency and flexibility in solving the placement problem. In this paper, we consider only the coverage planning. Consequently, the technique in this paper is useful in networks that operate with time-division multiple-access technology. However, the work can be extended to consider simultaneous coverage and frequency planning. [J176]

"Analytical Expression for Impulse Response Between Two Nodes in 2-D Rectangular Digital Waveguide Mesh"

The digital waveguide mesh models multidimensional wave propagation in discrete space and time. The finite difference wave equation used in the mesh is expressed in the space-time domain, which is not straightforward to reveal the analytical expression for the impulse response between a source and a receiver. This letter describes a procedure to derive an analytical impulse response expression between two nodes in a 2-D rectangular digital waveguide mesh based on the wave equation. The analytical expression can provide helpful insights and help verify simulation results for the digital waveguide mesh. [J177]

"Multi-Dimensional Detector for UWB Ranging Systems in Dense Multipath Environments"

The use of ultra wideband (UWB) technology for high-resolution ranging is widely addressed in the literature, and most these studies assume the use of a correlation detector to determine the arrival time of the first path component. The correlation detector well performs in environments without signal distortion. However, dense multi-path propagation and frequency selective fading, as encountered in a typical UWB environment, force the received UWB signal to behave like a random waveform. Such a waveform is multi-dimensional in the sense that any single preset template can only capture partial signal energy for ranging. In coping with this situation, we show in this paper how to use multi-dimensional detectors for enhancing the ranging performance. The superiority of the new detectors to the conventional one is theoretically analyzed and confirmed through simulations based on real UWB data. [J178]

"Radio Wave Characterization and Modeling in Underground Mine Tunnels"

Results are presented on wideband radio propagation measurements and statistical modeling at 2.4 GHz and 5.8 GHz in real underground mine tunnels. This peculiar type of confined environment is characterized by very rough surfaces and a frequent absence of a line-of-sight between transmitting and receiving antennas. The resulting propagation characteristics differ from those frequently encountered in more typical indoor environments such as offices and corridors. Indeed, the rms delay spread shows little or no correlation with respect to transmitter-receiver distance and, in addition, no impulse response path arrival clustering effect is observed. However, the path amplitude distribution does tend to follow a Rice distribution in the line-of-sight case, and a Rayleigh distribution otherwise. [J179]

"Earth-Viewing L-Band Radiometer Sensing of Sea Surface Scattered Celestial Sky Radiation-Part II: Application to SMOS"

We examine how the rough sea surface scattering of L-band celestial sky radiation might affect the measurements of the future European Space Agency Soil Moisture and Ocean Salinity (SMOS) mission. For this purpose, we combined data from several surveys to build a comprehensive all-sky L-band celestial sky brightness temperature map for the SMOS mission that includes the continuum radiation and the hydrogen line emission rescaled for the SMOS bandwidth. We also constructed a separate map of strong and very localized sources that may exhibit L-band brightness temperatures exceeding 1000 K. Scattering by the roughened ocean surface of radiation from even the strongest localized sources is found to reduce the contributions from these localized strong sources to negligible levels, and rough surface scattering solutions may be obtained with a map much coarser than the original continuum maps. In rough ocean surface conditions, the contribution of the scattered celestial noise to the reconstructed brightness temperatures is not significantly modified by the synthetic antenna weighting function, which makes integration over the synthetic beam unnecessary. The contamination of the reconstructed brightness temperatures by celestial noise exhibits a strong annual cycle with the largest contamination occurring in the descending swaths in September and October, when the specular projection of the field of view is aligned with the Galactic equator. Ocean surface roughness may alter the contamination by over 0.1 K in 30% of the SMOS measurements. Given this potentially large impact of surface roughness, an operational method is proposed to account for it in the SMOS level 2 sea surface salinity algorithm. [J180]

"Evaluation of Diversity and Power Control Techniques for Satellite Communication Systems in Tropical and Equatorial Rain Climates"

Satellite communication systems operating at frequencies above 10 GHz in tropical climates are subjected to many fade occurrences due to heavy rain. Service providers need to consider the use of appropriate forward error correction codes, the choice of modulations, diversity techniques, and the range of uplink/downlink power controls to use during severe rain fade periods in the overall design of their communications networks. The probable duration of a rain fade at a given level, what time of day it is likely to occur, how frequently it happens, and when it might next return are all important aspects that will contribute to customer perceptions. This paper presents the performances of annual and seasonal site-diversity and time-diversity measurements. Statistics of fade duration and fade slope variations are provided to give the detailed insight necessary for the design of very

small aperture terminal (VSAT) systems, in particular, in choosing an economical link margin and a suitable adaptive power control subsystem. Furthermore, the variations in the received clear-sky level of the satellite beacon show evidence of a diurnal variation that has a period of a solar day due to the atmospheric thermal tide. There is also evidence for annual periodicity in absorption levels through the atmosphere on top of the diurnal tidal effect, again suspected to be due to a longer period atmospheric tide. In rain-fade countermeasure design (now more commonly referred to as fademitigationtechniques) for Ku/Ka-band systems in the tropics, the compensation for signal impairment due to tropospheric/atmospheric thermal tide should also be included in the fade countermeasure algorithm. [J181]

"Statistical Distribution of Integrated Liquid Water and Water Vapor Content From Meteorological Reanalysis"

A worldwide modelling of integrated liquid water and water vapor content distributions is proposed and evaluated. The knowledge of those distributions is valuable to predict attenuation for Earth-space communication systems operating at frequencies higher than 10 GHz. [J182]

"Comparative study of field strength prediction methods in medium wave band"

Recently developed digital radio systems for the medium wave band require accurate field strength prediction algorithms for coverage estimation. Presented is a comparison of estimation accuracy provided by the most relevant field strength prediction methods employed for ground-wave propagation at this band. Moreover, a field strength prediction method recently developed by the authors, has been considered in the analysis. Empirical values from measurement campaigns carried out in three different broadcasting networks have been used to analyse the accuracy of the prediction methods. Comparison between predicted and measured values allows objective evaluation of the estimation accuracy of each method under different reception conditions. The proposed method provides the most accurate results on field strength predictions, consequently it is a suitable method for the coverage estimation of the new digital radio systems. [J183]

"Prediction, Detection, and Correction of Faraday Rotation in Full-Polarimetric L-Band SAR Data"

With the synthetic aperture radar (SAR) sensor PALSAR onboard the Advanced Land Observing Satellite, a new full-polarimetric spaceborne L-band SAR instrument has been launched into orbit. At L-band, Faraday rotation (FR) can reach significant values, degrading the quality of the received SAR data. One-way rotations exceeding 25 degare likely to happen during the lifetime of PALSAR, which will significantly reduce the accuracy of geophysical parameter recovery if uncorrected. Therefore, the estimation and correction of FR effects is a prerequisite for data quality and continuity. In this paper, methods for estimating FR are presented and analyzed. The first unambiguous detection of FR in SAR data is presented. A set of real data examples indicates the quality and sensitivity of FR estimation from PALSAR data, allowing the measurement of FR with high precision in areas where such measurements were previously inaccessible. In examples, we present the detection of kilometer-scale ionospheric disturbances, a spatial scale that is not detectable by ground-based GPS measurements. An FR prediction method is presented and validated. Approaches to correct for the estimated FR effects are applied, and their effectiveness is tested on real data. [J184]

"Optimal Sliding Correlator Channel Sounder Design"

The sliding correlator technique remains one of the most versatile and effective methods for sounding the radio propagation channel in next-generation wireless systems. Despite their utility, there has never been a comprehensive set of metrics and rules for the design of a sliding correlator channel sounder. This paper presents quantitative guidelines for balancing the many system parameters to achieve optimal levels of temporal resolution, dynamic range, processing gain, and Doppler resolution. The design procedure presented at the end of the paper will allow researchers to probe the new radioscapes that result as wireless systems are pushed to higher carrier frequencies, wider bandwidths, multiple antennas, and ubiquitous operation. [J185]

"A Hybrid UTD-PO Solution for Multiple-Cylinder Diffraction Analysis Assuming Spherical-Wave Incidence"

A modified hybrid uniform theory of diffraction-physical optics formulation for the analysis of the multiple diffraction caused by an array of cylinders, assuming spherical-wave incidence, is hereby presented. The solution, validated with numerical data from technical literature, is mathematically less complex and computationally more efficient-particularly for a large number of cylinders-than other existing methods, due to the fact that high-order diffraction terms (slopediffraction) are not considered, without such lack of terms barely entailing any loss in accuracy. Results can be applied in radiowave propagation analysis when multiple diffraction

over rounded obstacles has to be considered. [J186]

"Blind adaptive and iterative interference cancellation receiver structures based on the constant modulus criterion in multipath channels"

Blind adaptive and iterative interference cancellation (IC) receiver structures for direct sequence code division multiple access systems in multipath channels are proposed. A code-constrained constant modulus design criterion based on constrained optimisation techniques and adaptive algorithms for receiver and channel parameter estimation are described for successive IC (SIC) and parallel IC (PIC) detectors and a new hybrid IC (HIC) scheme in scenarios subject to multipath fading. The proposed HIC structure combines the strengths of linear, SIC and PIC receivers and is shown to outperform the conventional linear, SIC and PIC structures. A novel iterative detection approach that generates different cancellation orders and selects the most likely symbol estimate on the basis of the instantaneous minimum constant modulus criterion is also proposed and combined with the new HIC structure to further enhance performance. Simulation results for an uplink scenario assess the algorithms, the proposed blind adaptive IC detectors against existing receivers and evaluate the effects of error propagation of the new cancellation techniques. [J187]

"Dielectric-Resonator-Based Composite Right/Left-Handed Transmission Lines and Their Application to Leaky Wave Antenna"

Propagation and radiation characteristics of 1-D dielectric-resonator-based composite right/left-handed metamaterial structures with open mesh plates are investigated as a function of configuration parameters. The complex effective permittivity and permeability are estimated from the scattering parameters of the unit-cell structure. Based on this configuration, the single-mode transmission line is designed and the backfire-to-endfire frequency-scanned leaky wave antenna is implemented. It is found from numerical simulations that the 30-cell leaky wave antenna has a gain of 10 dBi with a scanning angle of over 90deg covering backfire-to-endfire directions. The measurement results show as wide beam-steering angles as numerically predicted. [J188]

"Electrical Engineering Hall of Fame: Ralph Bown"

This paper gives an over view on the works of Ralp Bown .In 1940, the Institute of Radio Engineers awarded its medal of honor to Ralph Bown for his extensive contributions to the field of radio and for his leadership in institute affairs. He worked for almost four decades as a research engineer and administrator with the American Telephone and Telegraph Company (AT&T). He was a leading participant in a program of research on radio wave propagation carried out by AT&T during the 1920s and 1930s. [J189]

"A Measurement-Based Fading Model for Wireless Personal Area Networks"

Personal area networks (PANs) are wireless communications systems with high data rates but small coverage area. PAN propagation channels differ from the well-explored propagation channels of wide-area networks due to several reasons: (i) the distances are typically very small, (ii) the antenna arrangements can be quite different, and (iii) the influence from human presence in the environment is different. The current paper presents results of a channel measurement campaign, where measurements are conducted over distances of 1-10 m using several multi-antenna devices, combined to create different PAN scenarios. For each measured Tx-Rx separation, channel realizations are obtained by small spatial movements of the antenna devices, and by rotating the persons holding the devices. From the results, we draw two main conclusions: (i) The small scale amplitude statistics, analyzed as the variations over a small sampling area and frequency subchannels, cannot be described in a satisfactory way using only the Rayleigh or Ricean distribution, rather a mixed distribution, the generalized gamma distribution, is more suitable; (ii) it is advantageous to distinguish between two types of large-scale fading: body shadowing (due to the orientation of the person holding the device) and shadowing due to surrounding objects (lateral movement). We also define and parameterize a complete statistical model for all fading. [J190]

"Educational Software for Project and Analysis of Radiowave Propagation"

In this work, we illustrated the development of an educational software for project and analysis of radiowave propagation (SEPAR). This software is composed by tools to project links radiowave-based and a tutorial with theoretical elements of electromagnetic waves propagation. In the radiowave design are considered the propagation losses, atmospheric effect, fading, modulation, relief and antennas characteristics. The software was utilized at radiowave design course and the observed results showed that the software is a strong tool to learning and motivation the student's autonomy. It was observed that after supplied the first theoretical concepts the students start to use the software intuitively and could consolidate the illustrated concepts. [J191]

"Polarized Indoor MIMO Channel Measurements at 2.45 GHz"

In this paper, a 4 times 4 indoor multiple-input multiple-output (MIMO) measurement campaign at a frequency of 2.45 GHz is presented. The main contribution of this work is the analysis of the impact of radio-wave polarization in MIMO systems operating at a typical indoor scenario through the calculation-from the measurements carried out-of a great deal of parameters such as the mean path loss, the cross polarization discrimination (XPD), and the RMS delay spread, which are all essential to estimate the performance of real MIMO systems. In this sense, some path loss models-which have been adjusted according to the measurements-are given, taking into account polarization, attenuation through walls, and the effect of T-junctions existing in the considered indoor scenario. Moreover, additional parameters such as the K-factor and statistical distribution, as well as spatial parameters, are discussed. [J192]

"New Aspects of Electromagnetic Information Theory for Wireless and Antenna Systems"

This paper investigates information-theoretic characterization, via Shannon's information capacity and number of degrees of freedom, of wave radiation (antenna) and wireless propagation systems. Specifically, the paper derives, from the fundamental physical point of view of Maxwell's equations describing electromagnetic fields, the Shannon information capacity of space-time wireless channels formed by electromagnetic sources and receivers in a known background medium. The theory is developed first for the case of sources working at a fixed frequency (time-harmonic case) and is expanded later to the more general case of temporally bandlimited systems (time-domain fields). In the bandlimited case we consider separately the two cases of time-limited and essentially bandlimited systems and of purely bandlimited systems. The developments take into account the physical radiated power constraint in addition to a constraint in the source L2norm which acts to avoid antenna superdirectivity. Based on such radiated power and current L2norm constraints we derive the Shannon information capacity of canonical wireless and antenna systems in free space, for a given additive Gaussian noise level, as well as an associated number of degrees of freedom resulting from such capacity calculations. The derived results also illustrate, from a new information-theoretic point of view, the transition from near to far fields. [J193]

"An Alternating-Direction Implicit FDTD Modeling of Dispersive Media Without Constitutive Relation Splitting"

In recent years, the alternating-direction implicit finite-difference time-domain (ADI-FDTD) method has been extended to dispersive media. To this end, a constitutive relation is appended to Maxwell's curl equations. A common feature of all of the existing formulations is that the integration over a full time step, of Maxwell's equations and the constitutive relation, is split into two sub-steps. [J194]

"Investigation of non-specular scattering by comparing directional channel characteristics from microcell measurement and simulation"

Channel characteristics from microcell measurement and simulation are compared. In microcell environment, the dominant propagation mechanisms are not only from reflections and diffractions from buildings but can also come from non-specular scatterings. Propagation prediction tools such as ray-tracing algorithms which calculate only reflections and diffractions are hence not enough to completely predict the channel. To address this issue, an implementation called polygon meshed physical optics (polygon meshed PO) is used. Polygon meshed PO approximates the traditional PO by dividing the scatterer surface into triangular meshes to reduce the surface integral (for calculating the scattering field) into summation of mesh areas. This makes it flexible even for irregularly shaped objects. As PO utilises the whole illuminated scatterer surface to calculate the scattering field, it is not limited to specular directions and can be used to compute the contribution of non-specular scattering. To know the actual propagation channel, wideband measurement was performed inside a university campus. With antenna arrays on both the transmit and receive sides, wideband double-directional channel characteristics such as azimuth-delay power spectrum can be obtained after applying the conventional beamforming. Comparison of measurement and simulation results reveals that small metallic objects cause non-specular scattering and affect the propagation channel. These objects can be predicted by the proposed polygon meshed PO in cooperation with ray tracing. [J195]

"Profiling the Atmosphere Using the Airborne GPS Radio Occultation Technique: A Sensitivity Study"

Global Positioning System (GPS) radio occultation (RO) sounding, with its high vertical resolution temperature and humidity profiling capability, is revolutionizing atmospheric science, particularly through assimilation in numerical weather prediction (NWP) models. Currently, the observations are derived from GPS receivers

onboard low Earth orbiting satellites. However, with the current number of satellites, it is difficult to provide dense sounding measurements in a specific region within a limited time period. With a GPS receiver onboard an airplane, the GPS RO technique offers such an opportunity while retaining the high vertical resolution sounding capability. The GNSS Instrument System for Multistatic and Occultation Sensing is currently under development for the National Science Foundation's High-performance Instrumented Airborne Platform for Environmental Research (HIAPER) aircraft. This paper presents a sensitivity analysis of the airborne occultation technique that will be used for the HIAPER system. The results demonstrate an anticipated overall accuracy of better than 0.5% for the retrieved refractivity from the surface to about 1 km below the airplane, where the expected airplane velocity errors of up to 5 mm/s limit the accuracy. The effects on the retrievals due to horizontal variations in atmospheric refractivity are significant, and retrieval errors may reach several percent inside frontal systems when the front is perpendicular to the ray paths and within 200 km of the tangent point. In general, the airborne GPS RO system provides a promising new data source for NWP and targeted observational studies. [J196]

"High Resolution 3-D Angle of Arrival Determination for Indoor UWB Multipath Propagation"

Propagation measurements using a large array are used to study the angle of arrival (AOA) across the ultrawideband (UWB) frequency range of 3.1 to 10.6 GHz. A two-dimensional Unitary ESPRIT algorithm is employed to give a high resolution estimation of AOA including both the azimuth and elevation angles of multipath components. The frequency dependence of AOA is investigated over the UWB frequency band. The multipath rays form clusters in both angular and temporal domains. Within a cluster the azimuth and elevation AOAs are determined to follow Laplacian and Gaussian distributions respectively. In the indoor environment considered, a typical cluster extends over an angular sector of approximately 14 degrees in azimuth and 9 degrees in elevation, with up to 5 clusters observed. We note that these propagation characteristics will allow UWB systems to utilise smart antennas or MIMO structures to improve overall throughput. [J197]

"Spatial correlation and capacity measurements for wideband MIMO channels in indoor office environment"

This paper describes a broadband multiple input, multiple output (MIMO) channel characterization platform and capacity measurement results in indoor office environment. The MIMO testbed has been designed for broadband MIMO channel sounding, capacity measurements and for characterizing the directional-multipaths of the radio propagation channel. The MIMO channel data have been collected in 5 GHz band inside a modern office environment. Capacity results from these experiments are discussed for different propagation conditions, including non line-of-sight (NLOS) and LOS propagations with various spacings between array elements. Spatial correlations are analyzed from the measured data and a frequency selective MIMO channel model based on the correlation statistics is validated. Post-processing of the measured data with a sequential ESPRIT (Estimation of Signal Parameters via Rotational Invariance Techniques) algorithm is utilized to extract the directions of departures and arrivals of multipath components at the transmitting and receiving arrays, respectively. A method of obtaining broadband MIMO capacity, indirectly, from a single directional measurement of MIMO propagation channel is also proposed and verified from the measurement results. [J198]

"An Integrated Overview of the Open Literature's Empirical Data on the Indoor Radiowave Channel's Delay Properties"

A comprehensive and integrative overview (excluding ultrawideband measurements) is given of all the empirical data available from the open literature on various temporal properties of the indoor radiowave communication channel. The concerned frequency range spans over 0.8-8 GHz. Originally, these data were presented in about 70 papers in various journals, at diverse conferences, and in different books. Herein overviewed are the multipaths' amplitude versus arrival delay, the probability of multipath arrival versus arrival delay, the multipath amplitude's temporal correlation, the power delay profile and associated time dispersion parameters (e.g., the RMS delay spread and the mean delay), the coherence bandwidth, and empirically ldquotunedrdquo tapped-delay-line models. Supported by the present authors' new analysis, this paper discusses how these channel-fading metrics depend on the indoor radiowave propagation channel's various properties, (e.g., the physical environment, the floor layout, the construction materials, the furnishing's locations and electromagnetic properties) as well as the transmitted signal's carrier-frequency, the transmitting-antenna's location, the receiving-antenna's location, and the receiver's detection amplitude threshold. [J199]

"The Reverberating Chamber as a Line-of-Sight Wireless Channel Emulator"

The reverberating chamber (RC) is employed to physically emulate line-of-sight (LOS) propagation channels and to test the quality of a digital transmission. Use of different absorber configurations is able to generate various LOS propagation channels. The LOS channels are objectively characterized by the Rician K factor and results

show that K is not generally dependent only on the number of absorbers but also on their configuration. Experiments are accomplished at the electrically large mode-stirred RC of the Universita di Napoli Parthenope, formerly Istituto Universitario Navale (IUN) and a global system for mobile communications (GSM) digital signal is used. [J200]

"Fast Computation of the Nonlocal Boundary Condition in Finite Difference Parabolic Equation Radiowave Propagation Simulations"

Finite difference parabolic equation method (FD-PEM) codes using a nonlocal boundary condition to model radiowave propagation over electrically large domains, require the computation of time consuming spatial convolution integrals. For the first time, we propose the use of recursive convolution (RC) with vector fitting (VF) to reduce this computational burden. RC is based on the ability to express functions as a sum of exponential terms. This is achieved using the VF method. Details of the RC formulation applied in a two-dimensional (2D) Wide-angle FD-PEM (WA-FD-PEM) are presented together with 2D simulations which demonstrate the computational speed and accuracy of the synthesized RC-WA-FD-PEM code. [J201]

"Refocusing Through Building Walls Using Synthetic Aperture Radar"

Through-wall imaging/sensing using a synthetic aperture array technique is studied by employing ultrawideband antennas and for wide incidence angles. The propagation through building walls, such as brick and poured concrete in response to point sources near the walls, is simulated by using high-frequency methods. Reciprocity is used to find the responses of point targets behind walls, which are then used to simulate the synthetic aperture radar (SAR) imaging through the walls. The effect of building walls on the target-image distortions is investigated by simulations and measurements. It is shown that by using the idea of match filtering, the effect of the wall can be compensated for, and the point target response can be reconstructed, provided that the wall parameters are known. An optimization method based on minimization of squared error in the SAR image domain within an area confined within the expected point-spread function is used to estimate the wall parameters and sharpen the image simultaneously. A controlled experiment within the laboratory environment is performed to verify the methods presented. It is shown that for an ultrawideband system operating over a frequency band of 1-3 GHz, highly distorted images of two point targets in close proximity of each other behind a wall can be resolved after refocusing. A dual-frequency synthetic method is also presented that can improve the cross-range resolution of the refocused image. [J202]

"Modal Propagation and Excitation on a Wire-Medium Slab"

A grounded wire-medium slab has recently been shown to support leaky modes with azimuthally independent propagation wavenumbers capable of radiating directive omnidirectional beams. In this paper, the analysis is generalized to wire-medium slabs in air, extending the omnidirectionality properties to even modes, performing a parametric analysis of leaky modes by varying the geometrical parameters of the wire-medium lattice, and showing that, in the long-wavelength regime, surface modes cannot be excited at the interface between the air and wire medium. The electric field excited at the air/wire-medium interface by a horizontal electric dipole parallel to the wires is also studied by deriving the relevant Green's function for the homogenized slab model. When the near field is dominated by a leaky mode, it is found to be azimuthally independent and almost perfectly linearly polarized. This result, which has not been previously observed in any other leaky-wave structure for a single leaky mode, is validated through full-wave moment-method simulations of an actual wire-medium slab with a finite size. [J203]

"Stratification Effect Compensation for Improved Underwater Acoustic Ranging"

Underwater acoustic localization usually relies on time-of-arrival (ToA) measurements, which are then converted into range estimates. However, the water medium is inhomogeneous and the sound speed varies depending on several parameters, e.g., the temperature, pressure and salinity. As a result, sound waves do not necessarily travel in straight lines. Ignoring this stratification effect could lead to considerable bias in the range estimates. We propose a depth-based approach to compensate the stratification effect for improved underwater ranging. We assume that the sound velocity profile (SVP) is only vertically stratified, the position of the sender is known, and the receiver has a noisy depth estimate via a depth sensor. We find a numerically simple range estimator, based on reconstructing the slanted path using Fermat's Principle and calculus of variations. This estimator removes the bias and is asymptotically efficient. We compare our solution to the simplistic linear estimator that assumes straight-line propagation in a shallow-water example where the sound speed decreases monotonically with depth. We find that the bias of the linear estimator increases with range and is non-negligible when the ToA measurements have a small variance, while our solution is bias-free and meets the Cramer-Rao lower bound (CRLB). [J204]

"Correlation Between Ground Refractivity and Refractivity Gradient and Their Statistical and Worst Month Distributions in Abu Dhabi"

Information based on 14 years of radio sounding data has been used to investigate the correlation between ground refractivity and refractivity gradient in Abu Dhabi city. The results of this analysis, which includes as well the statistical and worst month distributions of both parameters, are presented in this letter. [J205]

"A High-Order Compact-FDTD Algorithm for Electrically Large Waveguide Analysis"

To model electrically large waveguiding structures, the compact-finite-difference time-domain (FDTD) algorithm needs to use severely scaled down time steps to properly contain the rapidly growing numerical dispersion errors with increased operating frequency. In this work, a high-order compact-FDTD algorithm based on fourth-order spatial central finite differencing and fourth-order temporal backward finite differencing is developed. The accuracy and efficiency of this proposed algorithm are verified through its dispersion relation analysis and validated by modeling high-frequency wave propagation through an earth tunnel. The obtained computational efficiency allows this high-order algorithm to model wireless propagation through longitudinally-invariant road and railway tunnels using several hundred compact-FDTD cells as opposed to the several million FDTD cells required by three-dimensional FDTD algorithms. [J206]

"The industrial indoor channel: large-scale and temporal fading at 900, 2400, and 5200 MHz"

In this paper, large-scale fading and temporal fading characteristics of the industrial radio channel at 900, 2400, and 5200 MHz are determined. In contrast to measurements performed in houses and in office buildings, few attempts have been made until now to model propagation in industrial environments. In this paper, the industrial environment is categorized into different topographies. Industrial topographies are defined separately for large-scale and temporal fading, and their definition is based upon the specific physical characteristics of the local surroundings affecting both types of fading. Large-scale fading is well expressed by a one-slope path-loss model and excellent agreement with a lognormal distribution is obtained. Temporal fading is found to be Ricean and Ricean K-factors have been determined. Ricean K-factors are found to follow a lognormal distribution. [J207]

"Simulation and measurement of effective propagation constant of cut-wire array"

The wave propagation inside a periodic cut-wire array is investigated. The effective propagation constant is extracted from numerical simulation and measurement. Both the plasmonic cutoff behaviour and the cut-wire resonance are presented and analysed. [J208]

"On the Mutual Coherence Function and Mean Arrival Time of Radio Propagation Through the Turbulent Ionosphere"

On the basis of a solution to the mutual coherence function (MCF) obtained recently, this paper investigates the characteristics of pulse propagation through the turbulent ionosphere in arbitrary scattering regimes. First, the MCF is numerically discussed using different spectra of irregularities with different frequencies, bandwidths, and fluctuation regimes. Second, the mean arrival time of a pulse through the turbulent ionosphere is investigated. The dominant term is the travel time at the group velocity. Other effects are mainly from the higher order dispersion of background and scattering of irregularities, while the dispersion of irregularities is relatively small and can be neglected. It is found that effects from the scattering and dispersion of irregularities to the excess time delay decrease with increasing of the spectral index, the outer and inner scale, while increase quickly with fluctuations. [J209]

"A Hybrid Method for Indoor Wave Propagation Modeling"

A novel method of analyzing wave propagation in a building consisting of a heterogeneous mixture of homogeneous and periodic walls is presented. In this method walls are discretized into finite-size building blocks and a finite-difference time-domain (FDTD) approach is used to compute their electromagnetic response in a periodic arrangement as well as in corner and terminal locations. These results in conjunction with an iterative field/current calculation algorithm are used to compute the interactions among the walls. The theory and the implementation of this method are described for the 2-D case. The algorithm will henceforth be referred to as ldquobrick-tracingrdquo algorithm. This field calculation leads to more accurate indoor field predictions, as it accounts for multiple scattering from periodic (cinderblocks, rebar structures, etc.) and nonperiodic wall structures and yet is computationally tractable. The FDTD computation of the walls is fast because of the finite and relatively small size of the building blocks and the iterative current computation only uses simple radiation

integral calculations. Consequently computational time is much less than any full-wave simulation. At 1.0 GHz, the 2-D approach of this hybrid method is validated with a full-wave FDTD code and its capability to analyze complex indoor environments is shown. [J210]

"High-Resolution Angle-of-Arrival Measurements on Physically-Nonstationary Mobile Radio Channels"

A high-resolution measurement system for the characterization of the delay and angle-of-arrival properties of all significant multipath components on mobile radio channels is presented. The system uses complex impulse response data obtained from a novel 3-D tilted cross switched antenna array as input to an improved version of 3-D Unitary ESPRIT. Results from simulations and measurements show that the approach is capable of accurately characterizing the delay and angle-of-arrival characteristics of the dominant multipath components at moderate urban speeds along a trajectory in mobile propagation environments with high resolution in both azimuth and elevation. [J211]

"Wideband synthetic aperture beamforming for through-the-wall imaging [JLecture Notes]"

Through-the-wall radar imaging (TWRI) and sensing is emerging as an important area of research and development. A TWRI system provides enhanced situational awareness in operational environments for a variety of civilian and military applications. In particular, a TWRI system facilitates realtime information gathering and intelligent decision-making about the contents of the indoor scene. Compared to other radar applications, TWRI faces unique challenges due to signal propagation through walls. The composition and thickness of the wall, its dielectric constant, and the angle of incidence affect the strength and characteristics of the propagating signal. The change in propagation speed and wave refraction must be taken into account for effective and accurate imaging. In this article, we present a synthetic aperture beamforming approach that uses ray perturbation theory to account for the effects of transmission through a single uniform wall. [J212]

"Potential Effects of the Ionosphere on Space-Based SAR Imaging"

There has been a considerable interest in the use of lower frequency (VHF/UHF) space-based synthetic aperture radar (SAR) for realizing the foliage and ground penetration. The phase perturbation, signal distortion and imaging resolution degradation by the ionosphere will be particularly severe, however the model is not yet well established and still needs to be further studied. In this paper, on the basis of possible improvements for the model proposed by Ishimaru and others, potential ionospheric effects on SAR imaging are evaluated. First, for analyzing azimuthal resolution, we apply the fourth moment recently obtained in general case of strong fluctuation regimes, which is expected to give results for wider conditions. The Gaussian approximation was used in the previous model; however it is only valid in the fully saturated regimes. Second, for analyzing image shift and distortion, besides group delay, the higher-order dispersion is considered. Third, for discussing range resolution degraded due to pulse broadening, besides the dispersion, the multiple scattering of ionospheric turbulence is studied. Fourth, the Faraday rotation effect is analyzed. Numerical simulations are shown using ionospheric turbulence spectrum and TEC inferred from the International Reference Ionosphere (IRI) and satellite beacon observations. [J213]

"Multiple Diffraction Shadowing Simulation Model"

This article presents a shadowing simulation model based on multiple-edge diffraction. Such model provides an appropriate tool for simulating shadowing in cases where over-obstacle diffraction is the main propagation mechanism. Results show that the model is in good agreement with literature in terms of its statistical parameters. Moreover, its capability for dealing with variations in antenna height makes it appropriate for simulating a wide range of wireless systems [J214]

"A Simplified Analytical Model to Predict the Specific Attenuation of a Tree Canopy"

A simplified analytical model is presented to predict the specific attenuation for propagation through a tree canopy in a residential environment for frequencies of up to 2 GHz. In this approach, the canopy of a tree is modeled as an ensemble of leaves and branches all having prescribed location and orientation statistics. The Foldy-Lax discrete scattering theory is used to find the specific attenuation of a tree associated with the mean field. Explicit formulas are presented to calculate the specific attenuation of a tree canopy. It is shown that the specific attenuation of a tree canopy depends on the frequency, polarization, electrical and geometrical characteristics of branches and leaves, biophysical parameters of a tree, and statistical distribution of branches and leaves in reference to the angle of incidence of the plane wave. It is also shown that for deciduous trees, as opposed to coniferous trees, the inclination angle distribution of the branches is more vertical, producing a higher specific attenuation for the vertical-polarization incident wave than for the horizontal-polarization incident wave

[J215]

"Domain Decomposition Algorithm for Complex Boundary Modeling using the Fourier Split-Step Parabolic Equation"

This paper addresses the use of parabolic equation in radiowave propagation problems involving impedance-boundary modeling. The Fourier split-step technique for solving the parabolic equation provides numerical efficiency but lacks the ability to represent complex boundary conditions. A method that makes use of the domain decomposition technique to solve two-dimensional problems of impedance-boundary modeling using the Fourier split-step technique is introduced. A test case, using an urban scenario represented by buildings with various electrical parameters, was used to validate the results given by the method with results obtained by geometrical optics [J216]

"Concurrent Operation of Two Over-the-Horizon Radars"

By exploiting the reflective and refractive nature of high-frequency (HF) radiowave propagation through the ionosphere or the conducting sea surface, over-the-horizon radar (OTHR) systems perform wide-area surveillance at long range well beyond the limit of the horizon of conventional line-of-sight (LOS) radars. Improved characterizations of the targets can be achieved by using multiple OTHRs operating simultaneously as compared to a single OTHR operating alone. In this paper, we consider concurrent operations of two OTHR systems that occupy the same frequency band with different chirp waveforms. The objective is to respond to the advanced wide-area surveillance needs without reducing the wave repetitive frequency. For this purpose, a new cross-radar interference cancellation technique is developed and its effectiveness is verified through both analytical and simulation results [J217]

"Statistical modelling of building transmission in a cellular urban environment"

Channel sounding measurements have been reported which show that transmission through buildings can be important for microcellular coverage planning. A theoretical-statistical model for propagation through a building, or row of buildings, is proposed in the paper. Expressions for the mean and covariance of the channel transfer function are obtained and compared with measurements. The model exhibits good prediction accuracy for residential homes, while similar trends with the measurements for office blocks were obtained also [J218]

"Analytical Solution to the n -nth Moment Equation of Wave Propagation in Continuous Random Media"

Higher order symmetrical moments play an important role in wave propagation and scattering in random media, however it remains to be solved under strong fluctuations. In this paper, a modified Gaussian solution method is proposed for analytically solving the n-nth moment. After propagating through a random medium in the fully saturated regime, the higher order symmetrical moment of the received wave is the sum of products of the second moments, i.e., the Gaussian solution. In strong scattering regimes, the higher order symmetrical moment can be considered as a sum of the Gaussian solution and a non-Gaussian correction term, where the key issue is how to solve the derived equation of the correction term. Two methods are proposed, i.e., Green's function method and the Rytov approximation approach. Green's function method leads to a rigorous solution form, but it is complicated due to an integral equation. The approach using the Rytov approximation is found to be reasonable, as the correction is relatively small [J219]

"Effects of Phase Characteristics of Telescopes on Same-Beam Differential VLBI"

Phase characteristics, which are systematic phase offsets across the main beam of an actual telescope, may be a problem for achieving the same-beam differential very long baseline interferometer (VLBI) technique. This technique is essential for differential phase delay measurements such as those used in the Japanese Selenological and Engineering Explorer (SELENE) project, where the phase has to be determined to an accuracy of 0.075 radians rms. Accurate measurement and correction of phase characteristics are very important. The phase characteristics at 2.2375 and 2.2807 GHz of the 20-m and 10-m telescopes at Mizusawa were measured to an error of approximately 0.04 radians rms. The phase characteristics were 0.06 radians rms for the 20-m and 0.055 radians rms for the 10-m telescopes in the main beams, and the post-fit residuals decreased to 0.03 and 0.04 radians rms, respectively, after correcting by using quadratic formulas. These results confirmed the effectiveness of the same-beam differential VLBI technique for VLBI observations of SELENE [J220]

"Microwave measurements Part I: Linear Measurements"

By convention, radio frequency (RF) and microwave frequencies range between 30 MHz and 300 GHz. Conversely, this means their wavelengths range between 10 m and 1 mm. Intense research in radar development during World War II extended the RF spectrum beyond the usual applications in radio communications. The use of shorter wavelengths resulted in laboratory equipment with proportionally smaller dimensions to generate, convey, transmit, and detect higher-frequency signals. Wavelengths shorter than 1 mm require equipment too small to be realized. Voltage, current, and impedance concepts lose their conventional meanings when the operating wavelength is approximately equal to the dimensions of the structures under test. The behavior of propagating electromagnetic waves must then be analyzed in terms of electric and magnetic field. Unfortunately, no simple and direct way exists to measure these quantities, so we must resort to indirect methods. In the following sections, we briefly review the concept and need for measurements of scattering parameters. We also describe the two key instruments for microwave measurements: VNAs and spectrum analyzers. [J221]

"A Multitemporal Method for Correction of Tropospheric Effects in Differential SAR Interferometry: Application to the Gulf of Corinth Earthquake"

Tropospheric inhomogeneities can form a major error source in differential synthetic aperture radar interferometry measurements, which are used in slow-deformation monitoring. Indeed, variations of atmospheric conditions between two radar acquisitions produce variations in the signal path of two images and, thus, additional fringes on differential interferograms. These effects have a strong influence on interferograms and must be compensated to obtain reliable deformation measurements. This paper presents a methodological approach to reduce at both global and local scales tropospheric contributions directly from differential interferograms. It first requires refined knowledge of the stable scatterers that can only be obtained from the analysis of a large population of multitemporal interferograms. The correction of global-scale atmospheric contribution exploits the correlation between phase and topography. The correction of local artifacts is based on the correlation between interferograms containing one common acquisition. This technique is validated on a database of 81 differential interferograms covering the Gulf of Corinth (Greece) and used to improve the measurements of ground deformation compared to global positioning system measurements [J222]

"Propagation Corner-In Memorian George W. Haydon"

Recounts the life and career of George W. Haydon, recipient of the Army's Superior Civilian Service Award. [J223]

"Radio-Wave-Propagation Modeling in the Presence of Multiple Knife Edges by the Bidirectional Parabolic-Equation Method"

Fast full-wave computation of fields is the main reason for a radio system planner to apply the parabolic-equation method (PEM) for radio-coverage prediction. In this paper, the capability of PEM for the determination of backward electromagnetic-field scattering by single and multiple knife edges is investigated. For the wave equation, a suitable solution is considered. Contrary to the available formulations for the PEM, the proposed method includes a backward-propagating term. For both the forward and backward terms, the split-step algorithm is employed. Similar to the terrain-masking method, the effect of edges is exerted by the Fresnel-Kirchhof approximation into the forward-propagating wave. For the backward field, a similar algorithm is derived. Then, an iterative marching algorithm is developed for modeling radio wave propagation over multiple knife edges. Numerical results are compared with those of Uniform Theory of Diffraction (UTD) and finite-difference time-domain methods for the single-knife-edge problem. In addition, the effect of the backward-propagating field on radio wave propagation is investigated. The effect of edge locations and heights on the backward scattered field and number of computational iterations is studied. It is seen that, for the single knife edge, the backward scattered field depends on the height and location of the edge. The intensity of the backscattered field is a monotonic increasing function of the edge height. In addition, by increasing the edge height, the beam width of the backward scattered field increases. In ranges far from the knife edge in front of it, the field spreads, and its amplitude decreases. For multiple knife edges, it is seen that, in addition to the single backward scattered field, radio-wave-propagation modeling requires multiple forward-backward terms between successive edges. The geometry of the problem determines the required number of terms for sufficient accuracy [J224]

"Millimeter-Wave MIMO Radio Channel Sounder"

Nowadays, the need for high-data-rate-communication channels is increasing and will ineluctably continue to increase in the future. From a theoretical point of view, the multiple input multiple output (MIMO) approach seems to be one of the best solutions to provide such a high capacity. This paper presents a millimeter-wave MIMO channel measurement system developed in the Radio Laboratory of Helsinki University of Technology.

The system is based on a sounder and virtual antenna arrays: The antenna arrays are obtained by two 2-D scanners which shift a single transmit antenna and a single receive antenna. Measurements in line of sight (LOS) and non-LOS are reported from what the MIMO channel capacity is calculated for various antenna array sizes. Furthermore, from the same measurements, the direction of departure and direction of arrival are estimated [J225]

"Prediction of Multiantenna Propagation Around Regular and Chaflane Street Corners"

Two microcellular environments, which are the regular and chaflane street corners, are compared using a ray-launching engine based on the uniform theory of diffraction and geometric optics. This paper includes a study on the signal-to-noise ratio (SNR), K factor, correlation, and multiple-input multiple-output capacity. Two situations, which are the line-of-sight (LoS) and the non-LoS (NLoS), are distinguished and studied separately. In NLoS, the influence of the SNR is higher than the effect of the correlation. However, in LoS, the SNR is comparable in both environments, and correlation determines capacity [J226]

"Efficient Multielement Ray Tracing With Site-Specific Comparisons Using Measured MIMO Channel Data"

In this paper, an advanced site-specific image-based ray-tracing model is developed that enables multielement outdoor propagation analysis to be performed in dense urban environments. Sophisticated optimization techniques, such as preprocessing the environment database using object partitioning, visibility determination, diffraction image tree precalculation, and parallel processing are used to improve run-time efficiency. Wideband and multiple-input-multiple-output (MIMO) site-specific predictions (including derived parameters such as theoretic capacity and eigenstructure) are compared with outdoor site-specific measurements at 1.92 GHz. Results show strong levels of agreement, with a mean path-loss error of 2 dB and a mean normalized-capacity error of 1.5 b/s/Hz. Physical-layer packet-error rate (PER) results are generated and compared for a range of MIMO-orthogonal frequency-division-multiplexing (OFDM) schemes using measured and predicted multielement channel data. A mean Eb/N 0error (compared to PER results from measured channel data) of 4 and 1 dB is observed for spatial-multiplexing and space-time block-code schemes, respectively. Results indicate that the ray-tracing model successfully predicts key channel parameters (including MIMO channel structure) and thus enable the accurate prediction of PER and service coverage for emerging MIMO-OFDM networks such as 802.11n and 802.16e [J227]

"Depolarization, Scattering, and Attenuation of Circularly Polarized Radio Waves by Spherically Asymmetric Melting Ice Particles"

The eccentric spheres model and an extended Mie solution are used to formulate scattering of a plane, electromagnetic wave by a single melting ice particle as well as by a horizontal layer of such particles. The incident wave is left-hand circularly polarized, whereas the scattered wave, as a result of depolarization by the spherically asymmetric particles, comprises left-hand and right-hand circularly polarized components. The Stokes parameters of the scattered wave are calculated throughout the melting process. Furthermore, radar observables of backscattering and depolarization, as well as the specific attenuation, across the melting layer are calculated. The numerical application manifests how the internal spherical asymmetry of melting ice particles is imprinted on backscattering, forward scattering, and depolarization. Moreover, it is shown how each part of the melting layer contributes to the attenuation and depolarization of the radio waves crossing that layer [J228]

"Location Estimation via Support Vector Regression"

Location estimation using the global system for mobile communication (GSM) is an emerging application that infers the location of the mobile receiver from multiple signals measurements. While geometrical and signal propagation models have been deployed to tackle this estimation problem, the terrain factors and power fluctuations have confined the accuracy of such estimation. Using support vector regression, we investigate the missing value location estimation problem by providing theoretical and empirical analysis on existing and novel kernels. A novel synthetic experiment is designed to compare the performances of different location estimation approaches. The proposed support vector regression approach shows promising performances, especially in terrains with local variations in environmental factors [J229]

"Rain attenuation model for south east asia countries"

A model for predicting rain attenuation on Earth-to-space is developed by using the measured data obtained from tropical and equatorial regions that was revised from the ITU model. The proposed rain attenuation model uses the complete rainfall rate cumulative distribution as input data. It is shown that significant improvements in

terms of prediction error over existing attenuation models are obtained [J230]

"Remote locations coverage analysis with wireless mesh networks based on IEEE 802.16 Standard"

This article analyzes the wireless coverage problem of remote regions with low user density and propagation problems due to irregular terrain and high tree density. The use of a wireless mesh network is proposed as a solution where user data is transmitted directly to a base station when it is possible or relayed through other nodes in a multi-hop manner when there is not a direct link. The mesh topology uses short links with higher capacity instead of long links with low capacity. We analyze radio propagation and MAC protocols, including random sources, queues, and packet delays. The article is based on the coverage of a realistic rural region near Medellin, a mid size city in Colombia, and it shows that a wireless mesh network is an alternative to a typical cell based solution. It includes propagation analysis and MAC protocol behavior, so it is not limited to a radio coverage problem but also traffic, scheduling, and routing analysis [J231]

"Stochastic Maximum-Likelihood Method for MIMO Propagation Parameter Estimation"

In this paper, we derive a stochastic maximum-likelihood (ML) method for estimating spatio-temporal parameters for multiple-input multiple-output (MIMO) channels. Such estimators are needed in propagation studies where extensive channel measurements and sounding are required. These are seminal tasks in the process of developing advanced channel models. The proposed method employs an angular von Mises distribution model which is appropriate for angular data observed in channel measurement campaigns. The signal model is stochastic, and consequentially the method is particularly useful for estimation of the diffuse scattering component. This approach leads to lower complexity and faster convergence in comparison to deterministic models. These benefits are due to lower dimensionality of the model, leading to a simpler optimization problem. The statistical performance of the estimator is studied by establishing the Crameacuter-Rao lower bound (CRLB) and comparing the variances. The simulations show that the variance of the proposed estimation technique reaches the CRLB for relatively small sample size. The estimator is robust in the sense that meaningful results are obtained when applied to data generated by channel models other than the one used in its derivation [J232]

"Statistical Analysis and Performance Evaluation for On-Body Radio Propagation With Microstrip Patch Antennas"

On-body propagation channel measurements using two microstrip patch antennas for various links are presented and statistically analyzed. The attenuation attributed to factors such as the body, head and clothing are: 19.2, 13.0, and 1.7 dB, respectively, when measurement performed in the anechoic chamber. Measured cumulative distribution function (CDF) of data in the chamber and lab fits to lognormal distribution with deviation factors comparable in both cases. The results demonstrate that the human body is a major shadowing contributor in body area network (BAN) radio systems. The performance of potential radio systems under the measured channel variations is also investigated. Excellent system performance is achievable with power levels as low as 0.01mW. These results support the significance of channel characterization and modelling in producing suitable wireless systems for ultra low power BANs [J233]

"Measurement and Modelling of Scattering From Buildings"

The results of a measurement campaign aimed at determining the far-field diffuse scattering pattern of typical building walls are shown in the paper. Such results are then used to determine and tune simple diffuse scattering models based on the effective roughness approach, to be embedded into ray tracing simulators. It is shown that by adopting an appropriate single-lobe scattering pattern the agreement between simulation and measurement is very good [J234]

"Efficient Ray Tracing for Radio Channel Characterization of Urban Scenarios"

This paper presents an efficient ray tracing algorithm for the use of the uniform theory of diffraction (UTD) in radio channel characterizations of urban environments. The algorithm is based on a 2-D image theory, which is properly modified to yield 3-D ray trajectories. Multiple reflections and diffractions are considered through the classification of multipath components into four different categories. The adoption of such ray classes eliminates redundant calculations throughout the ray-tracing process, improving the analysis of the electromagnetic propagation over the coverage area [J235]

"Scattering-Model-Based Methods for TOA Location in NLOS Environments"

In this paper, we address methods of mitigating one of the major issues affecting wireless location accuracy in

land mobile terrestrial environments: nonline-of-sight (NLOS) propagation. In order to improve location accuracy under such conditions, we propose a novel methodology for NLOS environments based on the use of scattering models to classify propagation environments. The scattering models allow modeling of the NLOS error so that the NLOS effect can be incorporated into a location algorithm. Through the use of the scattering models, we develop three novel location techniques based on the statistics of measured ranges via moment matching, the expectation maximization algorithm, and a Bayesian algorithm. Simulation results and discussion are given to illustrate the performance in typical NLOS environments. The results show that the algorithms provide improvement over traditional location algorithms [J236]

"A General Bivariate Ricean Model and Its Statistics"

In this paper, an extensive and detailed investigation of the joint statistics of two narrowband signals with space-frequency separation in a Ricean fading channel is carried out. All the analysis and its results include nonstationary environments, where the parameters of the bivariate Ricean model differ from one signal to the other. A general treatment of the angles of arrival of the multipath propagation waves is also performed. A comprehensive expression for the space-frequency correlation coefficient of arbitrary orders of the envelopes is provided. Some insightful plots of this coefficient are presented and examined. The coherence distance (or time) and the coherence bandwidth are obtained and analyzed [J237]

"Experimental investigation of reflection characteristics of left-handed metamaterials in free space"

The transmission and reflection characteristics are presented of a one-dimensional (1D) left-handed metamaterial (LHM) and its constituents, split ring resonator and thin wire arrays. A well-defined left-handed transmission band with a peak value of -7.2 dB is obtained at frequencies where effective permittivity and permeability are both negative. A sharp dip (-34.5 dB) at the reflection spectrum of 1D ordered LHM is observed. The frequency of ultra-low reflection did not change considerably for another LHM with a different thickness, meaning that the low reflection is not because of the thickness resonance but rather the impedance-matching of LHM at the surface. Disorder in LHM structures is shown to affect the reflection characteristics [J238]

"Correlated multivariate Weibull fading channels with selection diversity"

The dependent multivariate Weibull distribution is modelled for correlated fading channels, where the probability density function of a Weibull fading factor is defined with two parameters (omega, beta), and the case of equal beta is considered. The joint cumulative distribution function and probability density function of the Weibull distribution are derived, and the outage probability of selection diversity is evaluated [J239]

"Deterministic Approach for Fast Simulations of Indoor Radio Wave Propagation"

The multiresolution frequency domain parflow (MR-FDPF) approach is applied to radio wave propagation in indoor environments. This method allows for a better understanding of indoor propagation and hence greatly assists the development of WiFi-like network planning tools. The efficiency of such wireless design tools is strongly impacted by the quality of the coverage predictions which have to be estimated with a limited computational load. The usual approaches are based either on an empirical modeling relying on measurement campaigns or on geometrical optics leading to ray-tracing. While the former approach suffers from a lack of accuracy, the later one needs to balance accuracy with computational load requirements. The new approach proposed herein is based on a finite difference formalism, i.e., the transmission line matrix (TLM). Once the problem is developed in the frequency domain, the linear system thus obtained is solved in two steps: a pre-processing step which consists of an adaptive MR (multigrid) pre-conditioning and a propagation step. The first step computes a MR data structure represented as a binary tree. In the second step the coverage of a point source is obtained by up-and-down propagating through the binary tree. This approach provides an exact solution for the linear system whilst significantly reducing the computational complexity when compared with the time domain approach [J240]

"Modeling and Simulation of Near-Earth Propagation in Presence of a Truncated Vegetation Layer"

The far-field radiation from an infinitesimal electric dipole embedded inside a truncated vegetation layer above a dielectric ground plane is calculated in this paper. Through an application of the equivalence or Huygen's principle, a semi-exact solution for the received field at locations exterior to the vegetation layer is obtained by a surface-field integration technique in which the spatial domain of integration is over a plane containing the truncated face of the vegetation canopy. The numerical results are computed using stationary phase approximations and show improvement over those determined through an existing ray-tracing approach. Simulation results are also compared against measured data from controlled experiments carried out within a laboratory environment using a well-characterized scaled-replica of the propagation medium at a proportionally

higher frequency. It is shown that ray-tracing provides accurate results at distant points from the vegetation truncation plane when the receiver height is large in terms of the wavelength but slightly underestimates the path loss when the receiver is close to the ground [J241]

"Solution for the Fourth Moment Equation of Waves in Random Continuum Under Strong Fluctuations: General Theory and Plane Wave Solution"

The fourth moment plays an important role in wave propagation and scattering in random media. However, in the strong scattering regimes, it remains to be solved although a rich variety of methods have been proposed. The fourth moment equation is solved using the modified Gaussian solution method proposed in this paper. The fourth moment can be considered as a sum of the Gaussian solution and non-Gaussian correction term. The Gaussian solution is the fourth moment in the saturated regime, and can be obtained as a sum of products of the second-order moments. The derived equation of the non-Gaussian correction term is solved using the Rytov approximation and the Green's function. The fourth moment solution obtained is general for without restrictions on incident wave forms. Specifically, the solution for a plane wave is derived and applied to study the amplitude scintillation and intensity correlation function of trans ionospheric radio signals. The theoretical calculation on the scintillation index agrees well with the experimental results, which confirms the fourth moment solution to some extent. [J242]

"Survey of Wireless Indoor Positioning Techniques and Systems"

Wireless indoor positioning systems have become very popular in recent years. These systems have been successfully used in many applications such as asset tracking and inventory management. This paper provides an overview of the existing wireless indoor positioning solutions and attempts to classify different techniques and systems. Three typical location estimation schemes of triangulation, scene analysis, and proximity are analyzed. We also discuss location fingerprinting in detail since it is used in most current system or solutions. We then examine a set of properties by which location systems are evaluated, and apply this evaluation method to survey a number of existing systems. Comprehensive performance comparisons including accuracy, precision, complexity, scalability, robustness, and cost are presented. [J243]

"Model of Incoming Waves at Base Station to Evaluate the Performance of Intersector Soft Handover"

A propagation model is needed to evaluate the performance of handover in mobile-communication systems. Generally, the received signal level from base stations (BSs) is calculated assuming path loss, and a lognormal (shadow)-fading model is used for evaluating intercell handover. The lognormal fading was assumed to be uncorrelated between cells. However, since the correlation between sectors is not clarified, an appropriate shadow-fading model to evaluate intersector handover has not yet been proposed. To obtain shadow-fading characteristics between neighboring sectors, the change in signal level and the direction of arrival of incoming waves at a BS must be clarified. This paper proposes a simple model of incoming waves to evaluate the performance of intersector handover. The validity of the proposed model is confirmed by comparing the difference between signal levels in BS sectors that are calculated using the proposed model and the measured power azimuth spectrum. [J244]

"Characterizing Wideband Signal Envelope Fading in Urban Microcells Using the Rice and Nakagami Distributions"

In this paper, we show that the cumulative and probability distribution functions (cdf and pdf, respectively) of small-scale wideband signal envelope fading in microcells can be very closely approximated by both the Rice and Nakagami distributions, which are already known to describe the cdfs and pdfs of small-scale narrowband signal envelope fading. Our results are obtained by means of an extensive Monte Carlo-based study of a wideband propagation model by Yan and Kozono, which is itself supported by extensive measurements. Over a comprehensive range of microcell propagation parameters, the average maximum error in the approximation is 1.65% and 1.78% for the Rice and Nakagami cdfs, respectively. The error in the approximation is 3.58% and 3.87% for the 95th percentile and does not exceed 7.61% and 7.80%, respectively, in the worst case. We propose an expression that maps the significant wideband small-scale signal envelope fading parameters to their narrowband counterparts for different standards like Dedicated Short Range Communication, WiMAX, Universal Mobile Telecommunications Service, and the family of the IEEE 802.11 standards. This mapping enables narrowband small-scale signal envelope fading statistical distributions, which are currently used, e.g., in fading simulators, link quality determination algorithms, and outage probability calculators, to be readily adapted to deal with small-scale wideband signal envelope fading. As an application example of this proposed mapping, we derive the appropriate sample spacing and averaging interval (window size) that ought to be used to estimate the

large-scale fading signal in an IEEE 802.11 receiver. [J245]

"Propagation Mechanisms of Radio Waves Over Intra-Chip Channels With Integrated Antennas: Frequency-Domain Measurements and Time-Domain Analysis"

The propagation mechanisms of radio waves over intra-chip channels was studied with integrated antennas for wireless chip area networks. Test vehicles were designed and fabricated on silicon wafers of both low and high resistivities, respectively, using complementary metal oxide semiconductor (CMOS) processes. On-wafer measurements for propagation of radio waves over intra-chip channels were conducted in the frequency domain from 10 to 110 GHz with a network analyzer. Time-domain analysis was performed to characterize intra-chip radio channels and more importantly to understand the propagation mechanisms. It was found that path loss factor is constantly less than two and propagation delay of the first-arrival wave is significantly longer than that by free-space transmission. Thus, we concluded that the propagation of radio waves over intra-chip channels is mainly realized with surface wave rather than space wave. Surface wave is guided on air-wafer interface. In addition, effects of metal lines, in both parallel and normal placements with respect to wave propagation direction, on signal propagation were also investigated. [J246]

"Measurements and Modeling of Distributed Antenna Systems in Railway Tunnels"

This paper covers some of the work carried out in the planning of the global system for mobile communication for railway (GSM-R) of the tunnels on the new high-speed trains in Spain. Solutions based on distributed antenna systems have been tested by installing several 900-MHz transmitters inside and outside of a 4000-m tunnel and measuring the propagation in different conditions. The measurements have been used to model the effects of tunnel propagation, including curves, trains passing from the outside to the inside, and the effect of two trains passing inside the tunnel. All cases have been tested by comparing solutions using isofrequency and multifrequency distributed transmitters inside the tunnel. The improvements of signal-to-noise ratio and the reduction of the blocking effects of two trains passing have demonstrated the advantages of using isofrequency distributed antenna systems in tunnels. Finally, a complete propagation model combining both modal analysis and ray tracing has been applied to predict the propagation loss inside and outside these tunnels, and results have been compared with the measurements. The model has proven to be very useful for radio planning in new railway networks. [J247]

"A Comparative Study of Radio Wave Propagation Over the Earth Due to a Vertical Electric Dipole"

A comparative study of the electromagnetic field excited by a vertical electric dipole on the Earth is presented. Four sets of formulas for both the planar Earth model and the spherical Earth model (of large radius) are compared to find out their valid ranges. Numerical computations are also carried out specifically for a three-layered Earth model. For the planar Earth model, when both the source and observation points are on the surface, and the planar Earth covered with a thick-enough dielectric layer, the method by Zhang is more accurate; while for the fields above the surface and the thin-enough dielectric layer, the method by King and Sandler is more accurate. However, the hybrid of the trapped surface wave and the lateral wave were exhibited in the curves in, but they were not shown in the curves. Numerical calculation also shows that the amplitude of the trapped surface wave attenuates as rho-1/2in the rho direction as expected. However, the lateral wave given by does not exhibit rho-2decay in the rho direction. For the layered spherical Earth model, the exact series summation, which serves as an exact solution to the classic problem, is computed and compared with the residue series. Numerical results show that the residue series gives a good approximation to the field, but the smooth curve illustrates that the hybrid effect due to the trapped surface wave and the lateral wave was ignored in literature. The field strength of the trapped surface wave decreases with the dielectric layer thickness and is affected by the curvature of the Earth. The exact series shows the oscillation of the field caused by the hybrid effects, which can be considered as the dielectric resonance between the upper and lower dielectric interfaces when it is guided to propagate, but none of the other three approximations can depict the effects. [J248]

"Performance of UWB Impulse Radio With Planar Monopoles Over On-Human-Body Propagation Channel for Wireless Body Area Networks"

Ultrawideband (UWB) is a promising technology for wireless body area networks (WBANs). This paper studied the impacts of 3.1-10.6 GHz on-human-body UWB channel on the impulse radio WBAN system. A performance evaluation method is presented for the realistic UWB WBAN systems, which observes the waveform distortion along the signal path. The measurement and characterization of the 3.1-10.6 GHz on-human-body UWB channel are devised to generate the radiographs of path loss and delay spread for the first time. The performance of the UWB impulse radio WBAN transceiver in terms of bit error rate (BER) is evaluated based on the waveform distortion and on-human-body channel measurement, which shows the human body effect is more significant

than the environment effect, especially when the propagation channel contains no line-of-sight path. Various candidate pulse shapes and modulation schemes for UWB WBAN are studied and their performances with the measured WBAN channel are evaluated and compared. [J249]

"Angular Position Determination of Spacecraft by Radio Interferometry"

This paper describes a variety of interferometric techniques that may be used for measuring the angular location of a spacecraft with respect to natural celestial radio sources or another spacecraft. The differential propagation time-delay techniques largely cancel the common error sources and normally achieve low angular coordinate errors. Currently, the accuracy of the techniques are in the 1-2 nrad range for observations with a duration of one hour and 3-6deg of mean angular separation between the spacecraft and the reference sources at X-band frequencies. There are various possible ways to implement the differential angular measurements depending upon the determination of the phase cycle ambiguities associated with the differential propagation time delays of remote sources. There are methods that utilize a sufficiently large range of observing frequencies and others that rely upon the spatial arrangement of the receiving system and the rotation of the terrestrial platform. We summarize the methodologies and the advantages and disadvantages of the various techniques. [J250]

"A Novel MoM- and SSPE-based Groundwave-Propagation Field-Strength Prediction Simulator"

Knowledge of the local groundwave-propagation characteristics is essential in wireless systems. Although Maxwell's equations establish the theoretical background, only a limited number of highly idealized groundwave-propagation problems have mathematically exact and/or approximate solutions. Therefore, semi-analytical/numerical and pure numerical simulation methods are almost the only way to handle realistic groundwave-propagation problems. To a certain extent, numerical simulators should be capable of taking non-flat, penetrable terrain and inhomogeneous atmospheric effects into account. Unfortunately, a generally applicable simulator has not yet appeared; there are many methods that have been developed under different assumptions and approximations, valid in different parameter regimes. It is therefore a challenge to apply these methods to the same physical problems, to do comparisons, and to evaluate numerical results. With all these factors in mind, a new MATLAB-based package GrMoMPE is introduced. It is first validated and calibrated, and then applied to some characteristic groundwave-propagation problems. The introduction of GrMoMPE has made it possible to do direct and accurate comparisons and reliable physical interpretations. [J251]

"On-body propagation velocity estimation using ultra-wideband frequency-domain spatial correlation analyses"

On-body communications around the human torso are considered, using ultra-wideband transmissions. The velocity of the diffracted wave propagating around the body is extracted from frequency- domain spatial correlation analyses. [J252]

"Optimal Radiated Waveforms From an Arbitrary UWB Antenna"

Solutions are presented for the optimal electric field waveforms radiated by an arbitrary ultrawideband (UWB) antenna. Optimization criteria include maximization of the electric field amplitude at a particular time and location, or maximization of energy density over a specified time interval at a particular location. Assuming bandpass signals, constraints are placed on the total radiated energy, the Q of the antenna, and the size of the antenna. The solution is developed using a spherical mode expansion of the fields radiated by an arbitrary antenna enclosed by a spherical mathematical surface, and optimized using variational methods. A closed-form result is obtained for the case of amplitude maximization, while an integral equation must be solved numerically for the case of energy maximization in a time interval. An interesting result from these solutions is that the shapes of the optimal radiated field waveforms are largely independent of the size of the antenna. The solutions also indicate that the antenna characteristics that provide optimum field amplitude or energy in the transient case are identical to those associated with maximum gain in the CW case. [J253]

"Radio Wave Propagation Prediction Based on 3-D Building Structures Extracted From 2-D Images"

A new method is proposed for the extraction of three-dimensional (3-D) building structures for simulating radio waves propagation in urban environments. The procedure is based on obtaining readily available high-resolution 2-D images (satellite and/or aerial photos) and images on the Internet (e.g., the google earth); and building accurate 3-D models of structures through a process of coordinates and dimensions matching. The new method provides an efficient and economic way for 3-D structure extraction. Combined with the computationally efficient ray-tracing algorithms recently developed by our group and reported in the literature, it is now possible to carry

out radio wave propagation predictions for many outdoor urban areas efficiently and accurately. [J254]

"Peer-to-Peer MIMO Radio Channel Measurements in a Rural Area"

The wireless communication channel between vehicular nodes in an ad-hoc network was assessed in a comprehensive measurement and modeling effort. Nodes were equipped with roof mounted azimuthally omnidirectional antennas, and measurements were taken at both short (line-of-sight) and long ranges, at a center frequency of 2.5 GHz. The median MIMO capacity with 8 transmitters and 10 receivers (8 times10) was found to be about five times the corresponding 1times1 SISO capacity, and three times the corresponding 1times10 SIMO capacity. Wideband soundings of such channels were conducted, where the median rms delay spread was found to be 0.6 mus. Measurements, spatial correlation scales, an empirical model of pathloss, and cross- polarization properties of peer-to-peer channels in a rural area are reported. [J255]

"Optimal training design for linearly time-varying MIMO/OFDM channels modelled by a complex exponential basis expansion"

Time- and frequency-selective fading of propagating channels degrades the performance of multiple-input multiple-output/orthogonal frequency-division multiplexing (MIMO/OFDM) systems extensively by introducing double convolutions in both time-domain and frequency- domain. The author addresses the problem of linearly time-varying (LTV) channel estimation of MIMO/OFDM systems. First, the time-varying coefficients of the LTV channel are modelled by complex exponential basis expansions. Secondly, the LTV channel is estimated and the optimal pilot symbols are derived following the minimum mean square error criterion. It is shown that the optimal pilot strategy is to group consecutive pilot tones together as a pilot cluster and to distribute uniformly all pilot clusters in frequency-domain. In addition, the LTV channel estimation is further improved by imposing a window function on received signals. Finally, through simulations, it is shown that the new channel estimator can provide a considerable performance improvement in estimating MIMO-LTV channels, especially for the rapidly time-varying channel of a large Doppler frequency. [J256]

"Active Perturbation of Dust-Associated Electron Irregularities in the Earth's Mesosphere: Discrete-Charging Effects"

Polar mesospheric summer echoes (PMSEs) are strong radar echoes produced by scattering from electron irregularities associated with charged dust in the Earth's mesosphere. Recent experimental observations have shown that PMSEs can be modulated by radio wave, heating the irregularity source region with a ground-based ionospheric heating facility. This radar-signal modulation shows very interesting and important behavior, which can be used to study the basic physics of the Earth's mesospheric dusty plasma. Previous works employed continuous-charging models to investigate the temporal behavior of plasma irregularities during ionospheric heating. Due to the relatively small size of the dust grains, the use of a continuous-charging model may certainly be brought into question. This paper describes a new model that incorporates discrete-charging effects, which has been used to investigate the temporal behavior of charged-dust-associated electron irregularities during electron temperature enhancement associated with radio-wave heating. The dust-charge-number distribution evolution during the ionospheric heating is also studied using the discrete-charging model. The discrete model results show reasonably close behavior with the continuous model. The differences between these two models are also discussed. [J257]

"Single- and double-difference algorithms for position and time-delay calibration of transducer-elements in a sparse array"

A method for the calibration of the position and time delay of transducer elements in a large, sparse array used for underwater, high-resolution, ultrasound imaging has been described in a previous work. This algorithm is based on the direct algorithm used in the global positioning system (GPS), but the wave propagation speed is treated as one of the to-be-calibrated parameters. In this article, the performance of two other commonly used GPS algorithms, namely the single-difference algorithm and the double-difference algorithm, is evaluated. The calibration of the propagation speed also is integrated into these two algorithms. Furthermore, a novel, least-squares method is proposed to calibrate the time delay associated with each transducer element for these two algorithms. The performances of these algorithms are theoretically analyzed and evaluated using numerical analysis and simulation study. The performance of the direct algorithm, the single-difference algorithm, and the double-difference algorithm is compared. It was found that the single-difference algorithm has the best performance among the three algorithms for the current application, and it is capable of calibrating the position and time delay of transducer elements to an accuracy of one-tenth of a wavelength. [J258]

"Propagation-prediction and site-planning software for wireless communication systems"

Propagation-prediction and site-planning software for wireless communication networks has been developed. The software has a user-friendly graphical user interface (GUI), and provides calculations for large-scale and small-scale propagation parameters, including path loss (or received power) and delay profiles. Angles of arrival/departure, which are useful for the design of wireless systems employing multiple antennas, are also provided in the simulation. Some of the main features of the software include the use of a computationally efficient ray-tracing approach for simulating propagation in wireless environments, and the fact that users can upload AutoCAD .dxf files for indoor or outdoor environments. Both a single-building floor plan or an entire city layout can be simulated, and the user is provided with the ability to assign wall geometries and electrical parameters. User-defined realistic antenna radiation patterns for both the transmitting and receiving antennas are incorporated in the simulation. Broadband as well as polarization-dependent simulations are also included in the software. [J259]

"Groundwave Modeling and Simulation Strategies and Path Loss Prediction Virtual Tools"

Reliable and accurate groundwave propagation path loss prediction between a pair of transmitter/receiver necessitates a good understanding of electromagnetic wave scattering in the presence of non-flat terrain and inhomogeneous atmosphere, and this is one of the major issues in radio communication and radar systems design. A propagation engineer desires to have a numerical propagator that calculates the radiowave path loss, without going into details and/or having a deep knowledge of the propagation phenomena, between any two points specified on a digital map of the area of interest. Since a generally applicable, all-purpose propagation prediction method has not developed yet one has to understand validity and accuracy ranges, and the limitations of available prediction models and tools; this certainly requires, to some extent, the physical insight of the propagation problem at hand. This article aims to summarize groundwave propagation modeling and numerical simulation strategies, and to review some of the virtual tools, introduced recently. [J260]

"Path loss models based on stochastic rays"

Two-dimensional percolation lattices are applied to describe wireless propagation environment, and stochastic rays are employed to model the trajectories of radio waves. First, the authors derive the probability that a stochastic ray undergoes certain number of collisions at a specific spatial location. Three classes of stochastic rays with different constraint conditions are considered: stochastic rays of random walks and generic stochastic rays with two different anomalous levels. Subsequently, the authors obtain the closed-form formulation of mean received power of radio waves under non-line-of-sight conditions for each class of stochastic ray. Specifically, the determination of model parameters and the effects of lattice structures on the path loss are investigated. The theoretical results are validated by comparison with the experimental data [J261]

"Estimation of time of arrival of UWB multipath clusters through a spatial correlation technique"

This study estimates the time of arrival (TOA) of ultra wideband multipath components (MPCs) by analysing the spatial correlation of multipath signals captured by a 7times7 antenna array. In this study, both line-of-sight and non-line-of-sight radio propagation paths were considered. Each power-delay profile bin from all the array positions was used to calculate the spatial correlation between itself and the adjacent receiving point bins. Consequently, some MPC time delays and clusters, associated with high correlation values, were selected and compared with the TOA computed by the Sensor-CLEAN algorithm. A close agreement of the TOA estimated by both techniques was obtained. Finally, multipath cluster distributions and clustering model parameters are presented and compared with previously published results [J262]

"Comparison of spherical against plane-wave incidence assumption in prediction of over-rooftop multiple-building diffraction"

This work presents a comparison between multiple-building forward diffraction loss predicted in urban areas when considering a plane-wave incidence over the rooftops, and when assuming the wavefront impinging on the array of buildings to be spherical. The mentioned comparison is carried out through two hybrid uniform theory of diffraction-physical optics (UTD-PO) solutions, and is intended to clarify the validity of each assumption in a typical urban environment. Results can be used to achieve a more accurate and realistic planning of radio communication systems [J263]

"Antennas and Propagation for On-Body Communication Systems"

On-body communication channels are of increasing interest for a number of applications, such as medical-sensor networks, emergency-service workers, and personal communications. This paper describes investigations into channel characterization and antenna performance at 2.45 GHz. It is shown that significant channel fading

occurs during normal activity, due primarily to the dynamic nature of the human body, but also due to multipath around the body and from scattering by the environment. This fading can be mitigated by the use of antenna diversity, and gains of up to 10 dB are obtained. Separation of the antenna's performance from the channel characteristics is difficult, but results show that for many channels, an antenna polarized normal to the body's surface gives the best path gain. Simulation and modeling present many challenges, particularly in terms of the problem's scale, and the need for accurate modeling of the body and its movement. [J264]

"A New Solution for the Analysis of Multiple-Building Diffraction in Urban Areas With Shadowing Caused by a Cylindrical Hill"

A hybrid uniform theory of diffraction (UTD)-physical optics (PO) formulation for the analysis of the multiple diffraction which takes place in urban environments where a cylindrical hill, either smooth or with buildings located on its surface, causes shadowing of the transmitter from the receiver (a non-line-of-sight situation) is presented, thus furthering a previous study published by the authors, in which the hill is modeled as a wedge. The mentioned UTD-PO solution, which is validated by numerical results from technical literature, is of a good computational efficiency, while at the same time increasing the versatility over other methods for the analysis of the same scenarios, since the presented hybrid formulation allows for the study of the above-mentioned environment when the urban area consists of a small number of buildings. [J265]

"Effect of Scintillation on Timing Applications of GPS in Indian Subcontinent"

On the Indian subcontinent, scintillations are quite frequent and intense and have a longer duration during a peak period of an 11-year solar cycle. This phenomenon quite significantly informs us about the performance of the Global Positioning System (GPS). A special experiment has particularly been conducted to study the effect of scintillations on GPS time. This paper discusses the findings of this experiment. A degradation of timing accuracy of the order of 60 ns has been observed. [J266]

"Mobile Reception of Digital AM Audio and Data Services Using Long-Range Skywave Propagation"

Digitization of AM radio systems promises a revival of the currently underutilized broadcasting bands below 30 MHz. Its prospects are near-FM sound quality, automatic tuning, and interference-free reception. Using skywave propagation in some of the bands, a potentially very large area can be covered by a single transmitter if the appropriate frequency and power are chosen. In this paper, we compare mobile and stationary reception at various frequencies, investigate the correlation between solar sunspot activity and reception quality, and analyze how non-audio data service can efficiently be broadcast with digital radio systems in the AM bands. Restrictions regarding the antenna size together with varying ionospheric conditions and and man-made noise make the reception of radio transmissions below 30 MHz in a car a challenging problem. Using the Digital Radio Mondiale (DRM) system, a total of 58 measurements were conducted both in rural and urban environments in fall 2005, most of them in the 49 m, 41 m and 17 m short wave bands, but also in long wave and medium wave bands. A stationary reference receiver recorded data of the same transmission in parallel with the mobile measurements. Comparison of both data sets allowed for a detailed analysis of the impact of mobility on the reception quality. The results show that particularly in rural areas, mobile reception is indeed reliable and perceived as high quality. Only when ionospheric disturbances push signals to just above the required Signal-to-Noise Ratio (SNR), in-car reception fades more frequently than at a stationary receiver. In urban and industrial areas, shadowing effects (tunnels, large buildings) and man-made noise (power lines, etc.) cause even more frequent dropouts. Thus most of the problems known from analog AM reception in cars will remain the same for digital broadcasting. However, where it works, the digital audio quality is clearly superior to that of analog AM. Therefore, we believe that digital ra- dio in the AM bands is a valuable complement to other digital broadcast services, e.g. by augmenting their coverage in rural areas, where network deployments for higher frequencies may economically not be feasible. Further, the data features-although limited-make digital broadcasting in the AM bands an interesting candidate for telematics and traffic information services covering very large areas. [J267]

"A radio-coverage prediction model in wireless communication systems based on physical optics and the physical theory of diffraction [JWireless Corner]"

In this paper, a two-dimensional (2D) simulation method for the calculation of radio coverage in urban-area sites is presented, based on the analytical methods of physical optics (PO) and the physical theory of diffraction (PTD). The method takes into account the electromagnetic field at the receiving antenna due to first- and higher-order propagation mechanisms. Emphasis is given on the computation of the scattered near or Fresnel-zone field using numerical techniques, since in a typical urban environment, the scattered near or Fresnel-zone field

occupies a large percentage of the area under investigation. The high resolution radio-coverage plots are computed by complex vector addition of all of the received signals for several values of the channel parameters. Finally, a comparison of the radio-coverage results obtained through this method with the corresponding results based on different electromagnetic methods and measurements, previously published in the literature, is presented. [J268]

"Adjacent Satellite Interference Effects on the Outage Performance of a Dual Polarized Triple Site Diversity Scheme"

The design of reliable, modern satellite communication networks, in which both frequency and orbital congestion are increasing, requires modeling of interference effects. The dominant sources of aggravation of nominal interference due to propagation phenomena are assumed to be differential rain attenuation from an adjacent satellite communication network operating at the same frequency and cross polarization due to rain and ice-crystals. A physical methodology to predict the statistics of the carrier-to-noise-plus-total-interference (CNIDR), which has already been applied to single and double-site systems, is extended to include triple-site diversity reception schemes. This method is based on a model of convective raincells model and the lognormal assumption for both the point rainfall statistics and slant path rain attenuation. The statistical properties of spatial inhomogeneity of rain attenuation over six satellite slant paths is firstly here presented. A set of simple, approximate formulas are presented which follow from a regression analysis on the previous theoretical results. The results serve to examine the influence of various parameters upon the total availability performance. [J269]

"Low Elevation Wideband Land Mobile Satellite MIMO Channel Characteristics"

This paper presents wideband characteristics of a low elevation, land mobile, single satellite, dual circularly polarized, multiple-input multiple-output (MIMO) radio propagation channel. The work is based on S-band measurements using an artificial platform to represent the satellite, situated on a hilltop, to a mobile vehicle located in three environments: tree-lined road, suburban and urban. First and second order statistics and inter-tap cross-correlations are derived for both large and small scale fading, over the delay and combined spatial/polarization domains from the measured 2times2 MIMO matrix channel data. The work is aimed towards further development of a valid wideband land mobile satellite (LMS) MIMO channel model. Such systems may form the next generation of satellite delivered mobile broadband Internet services. [J270]

"The Relative Importance of Different Propagation Mechanisms for Radio Coverage and Interference Prediction in Urban Scenarios at 2.4, 5.8, and 28 GHz"

Radio coverage and interference in communications systems can be provided by various propagation mechanisms depending on the frequency of the radiowaves and the propagation environment. Key propagation mechanisms include line-of-sight (LOS), diffraction, transmission (or penetration), incoherent scattering, and specular reflections. Knowledge of which propagation mechanisms dominate for coverage and interference calculations is important for cell planning issues. In this communication, we present a novel surface model unifying scatter and Fresnel models and use it to evaluate the relative importance of the different propagation mechanisms in an urban scenario at three frequencies of interest through simulation using an accurate database. The results obtained show that a significant coverage fraction may be provided by reflected paths at low frequencies. At higher frequencies incoherent scattering becomes an increasingly important mechanism and may significantly affect interference predictions [J271]

"A Discussion About Some of the Principles/Practices of Wireless Communication Under a Maxwellian Framework"

There has been a plethora of papers dealing with wireless communication that use techniques, which when viewed from the perspective of a Maxwellian framework raise more questions than they answer. By Maxwellian framework we imply not only the relevance of electromagnetics in studying communication systems but also the proper interpretation of an ensemble processing in mathematical physics which was first introduced by Maxwell to study the behavior of an aggregate of molecules rather than the property of individuals. Initially, most of the modern signal processing techniques was developed for scalar acoustic problems. However, with the advent of wireless, these same techniques are being applied to the vector electromagnetics problem, which is fundamentally different in concept with respect to the scalar acoustic problem. The objective is to discuss some of these concerns associated with some of the current modeling methodologies particularly related to propagation modeling and antenna diversity. A goal is to initiate a dialog about the scientific merits of these new applications. One of the points to be made is that an incorrect use of probability theory can often lead to erroneous conclusions that directly contradict the principles of physics. A few examples are presented to initiate this dialog, mainly the applicability of scalar techniques to the vector wireless problem, including a proper interpretation of

the Shannon channel capacity theorem. A methodology is also presented to illustrate how a simple multiple-input-multiple-output system can be based on the principles of reciprocity. Integration of the electromagnetic principles in some of the current methodologies of signal processing and communications theory may lead to a better system [J272]

"Cluster Properties Investigated From a Series of Ultrawideband Double Directional Propagation Measurements in Home Environments"

Results from double directional ultrawideband (UWB) channel sounding in a wooden house are described. The double directional channel sounder estimates directional information at both ends of the link, so that we can separate antenna directivity from the channel sounding results. We investigated the dominant propagation mechanisms by introducing cluster analyses. The detected propagation paths from the channel sounding were first classified into clusters in the angular-delay domain, and then properties of the clusters such as standard deviation of path positions, dynamic range of path power, and power distribution of clusters were derived. From the results, we discussed the similarities and differences between the measurement environment and the physical propagation phenomena. Finally, different types of scattering losses of the propagation paths were derived and modeled. The results from sounding and analysis contribute in the development of UWB propagation models and can be used in UWB propagation simulations [J273]

"Ultra-wideband channel model for communication around the human body"

Using ultra-wideband (UWB) wireless sensors placed on a person to continuously monitor health information is a promising new application. However, there are currently no detailed models describing the UWB radio channel around the human body making it difficult to design a suitable communication system. To address this problem, we have measured radio propagation around the body in a typical indoor environment and incorporated these results into a simple model. We then implemented this model on a computer and compared experimental data with the simulation results. This paper proposes a simple statistical channel model and a practical implementation useful for evaluating UWB body area communication systems. [J274]

"Broadband ing interferometry for weak multipath signal detection"

An appropriate technique dedicated to indoor channel sounding and characterisation is described. Generally screened by strong line of sight (LOS) signals, weak non-line of sight multipath is difficult to detect and to quantify accurately. For this reason the ing interferometric approach, well suited for achieving LOS dimming, is proposed to emphasise multipath contributions. Preliminary experimental results, performed in the millimetre band, are presented. [J275]

"On-body propagation loss estimation using method of equivalent sources"

A new method for the fast estimation of the on-body propagation loss is proposed. The method is applicable for a variety of propagation models but limited by a far-field zone observation point. The technique is based on the equivalent source theorem. Knowing the propagation losses for an infinitesimal current source, propagation losses of real antennas can be obtained with only the knowledge of their equivalent currents over a surface surrounding the antenna. The method can be applied for any kind of excitation signals and offers reduction in simulation time. It has been verified using both monochromatic and Gaussian pulse excitation and good agreement is obtained compared with a full conventional FDTD model with a simple antenna. [J276]

"A Novel Measurement-Based Algorithm for Coverage Prediction of Urban and Suburban Cells in Wireless Networks"

A novel approach is proposed to predict the coverage of urban and suburban cells in wireless networks. By this approach, the propagation loss between any two points along the virtual propagation path from the base-station to the mobile-station within a predicted area can be deduced in an average sense with reasonable accuracy, based on an a priori series of measurements, finite and limited in extent, taken along the periphery of this area. The effectiveness of the proposed method has been demonstrated using experiments under various radio environments in Guang Dong, China. It was shown that the prediction results were approximately consistent with independent checking samples [J277]

"Frequency, Temperature and Salinity Variation of the Permittivity of Seawater"

With the emergence of unmanned marine robots, underwater communication systems have received much attention in recent years. To successfully develop radio wave based communication solutions, it is essential to understand properties of electromagnetic wave transmission in seawater. These properties are determined by the

frequency variation of the permittivity of seawater. Existing models for the permittivity of saline water are empirical ones that best fit experimental data. We propose a physically realistic model, similar to the one used in plasma physics, for the variation of the dielectric constant of water with varying frequencies and salinities. Our model is in excellent agreement with existing empirical fits for frequencies between 1 and 256 GHz. We use this model to study the propagation of electromagnetic waves in seawater. We explain that large propagation distances would be possible at MHz frequencies if the conductivity of seawater decreases at small field strengths due to the hydrogen bonding of water molecules. However, we were unable to experimentally verify any reduction in the conductivity of seawater [J278]

"Statistical Analysis of the Multiple Scattering Radio Channel"

The concept of multiple scattering radio propagation channels-in contrast to the conventional single (Rayleigh) scattering-has been proposed and found to be a fitting model in certain propagation scenarios. Except for some special cases, expressions for the amplitude distribution of such channels are unknown. In this paper, we derive distribution functions for the amplitude of the general multiple scattering radio channel. Rice, Rayleigh, and double-Rayleigh distributions are special cases of the general result. We also derive a computationally simple moment-based estimator for the parameters of the distribution. In addition to the measurement analysis of multiple scattering propagation channels, our results can also be applied in the performance evaluation of communication schemes over such media [J279]

"The Impact of Antenna Directivity on the Small-Scale Fading in Indoor Environments"

Results obtained from using a geometrically based, single-bounce propagation model are presented to characterize small-scale fading in indoor propagation channels when directional antennas are used. The model is verified by comparing simulated results to measured results. The model is then used to obtain, via simulation, fading statistics for an indoor, line-of-sight channel. The results show that when directive antennas are used, the parameters of the Nakagami- or Rician-distributed small-scale fading vary with separation between the transmit and receive antennas. Furthermore, the strength of the variation depends on antenna directivity. Some physical mechanisms for this effect are discussed [J280]

"A Novel Simple Semi-Empirical Model for the Effective Earth Radius Factor"

This paper presents a dual cumulative probability distribution model for predicting the cumulative distribution of the probability that a particular value of the propagation k-factor will be exceeded. The distributions relate to so-called "dry" and "wet" (or "climatic") components. The model is based on meteorological radiosonde data observed over a period of some 11 years and published by other workers. The model is extended by a simple height regression analysis in order to predict the cumulative behavior of the k-factor at different ground level heights in the summer rainfall area of South Africa during different months. Comparisons are made between predicted and observed data. The model may have potential applications in other parts of the world where data on k-factor behavior are scarce [J281]

"Medium Wave Digital Radio Mondiale (DRM) Field Strength Time Variation in Different Reception Environments"

This paper examines the temporal variability in fixed reception of the ground-wave propagated DRM (Digital Radio Mondiale) signal. This field strength analysis in the medium wave band has been performed using the first Spanish DRM field trial. Several fixed reception points located along radial routes provided the field strength sample distributions in rural and suburban areas. Additionally a second measurement campaign was carried out in several dense and open areas of downtown Madrid. The maximum likelihood estimations and logarithmic functions were used to analyse the fit of the experimental data with theoretical statistical distributions. A deep analysis of the most important parameters of the distribution has been carried out in order to characterize the field strength behavior in the different reception situations. It has been taken into account the influence of environment, measurement time interval, distance to the transmitter and the presence of critical reception impairments. The most remarkable result of this study has shown that the time variability of the ground-wave medium wave DRM channel is well approximated by a Log Normal and also by a Nakagami process. The Log Normal distribution is preferred as it is the one considered by the analog medium wave broadcasts for the ground-wave propagation case [J282]

"Performance enhancement of differential UWB autocorrelation receivers under ISI"

The autocorrelation receiver (AcR) is a suboptimum, low-complexity receiver architecture particularly suited to ultra-wideband (UWB) communication systems. As the bit rate increases, interference among pulses due to multipath propagation causes serious impairments of the AcR's performance. To mitigate this effect, we propose

an appropriate design of the chip code and of the delay hopping (DH) code. We provide conditions to be satisfied by the DH code in order to reduce the nonlinear intersymbol interference (ISI) and the bias term, which are peculiar nuisance parameters of autocorrelation receivers. By extending the length of the chip code, we show that Nptransmitted pulses per symbol can be employed to suppress the average linear ISI of Np-1 previous symbols. Simulated results confirm the performance improvement in terms of bit-error rate. However, in previous work it has been shown that the noise power linearly increases with Np. Although a large number of pulses per symbol is favorable for ISI mitigation, we show that the transmission of a single pulse minimizes the probability of error, for bit rates lower than an upper bound depending on the channel root mean-square delay spread and on the noise power. [J283]

"The distribution of the product of independent Rayleigh random variables"

We derive the exact probability density functions (pdf) and distribution functions (cdf) of a product of n independent Rayleigh distributed random variables. The case n=1 is the classical Rayleigh distribution, while n≥2 is the n-Rayleigh distribution that has recently attracted interest in wireless propagation research. The distribution functions are derived by using an inverse Mellin transform technique from statistics, and are given in terms of a special function of mathematical physics, the Meijer G-function. Series forms of the distribution function are also provided for n=3, 4, 5. We also derive a computationally simple moment-based estimator for the parameter occurring in the distribution, and evaluate its variance. [J284]

"Ellipticity statistic as measure of MIMO multipath richness"

Multipath richness' characterises the capability of a propagation environment to support parallel communication modes. The so-called ellipticity statistic is proposed as a measure of multipath richness of a MIMO radio channel. A measurement example clarifies the proposed figure of merit. [J285]

"UWB on-body radio propagation and system modelling for wireless body-centric networks"

Given the trend towards a user-centric concept in mobile communications, body area networks have received increasing attention within the wireless personal area community. Researchers and designers have been investigating radio propagation characterisation and modelling owing to its importance in developing and designing efficient and reliable radio systems. The paper presents an experimental investigation of ultra-wideband (UWB) on-body radio propagation. Channel models with respect to large scale and delay analysis have been derived from measured parameters. Effects of different antenna types on channel behaviour are also demonstrated. Results and analyses highlight the consequences of changes in body postures and positions in addition to antenna orientations on the communication channels. Measurement data are also used in predicting the performance of potential UWB wireless systems and their applications in body-centric networks. It is indicated that bi-phase modulation for UWB body-centric networks performs better than pulse position modulation systems. The study also concludes that the use of hybrid antenna types for different on-body links will provide better system performance. [J286]

"Digital signal processing in a real-time propagation simulator"

The hardware and software interface to a programmable real-time RF propagation simulator is described. First, fading models are reviewed; and next, the digital filter design of the fade spectra filtering is detailed along with the implementation on a floating point digital signal processor (DSP). The hardware system design is given, followed by the application of this system to radio link propagation. [J287]

"Information theoretic framework of trust modeling and evaluation for ad hoc networks"

The performance of ad hoc networks depends on cooperation and trust among distributed nodes. To enhance security in ad hoc networks, it is important to evaluate trustworthiness of other nodes without centralized authorities. In this paper, we present an information theoretic framework to quantitatively measure trust and model trust propagation in ad hoc networks. In the proposed framework, trust is a measure of uncertainty with its value represented by entropy. We develop four Axioms that address the basic understanding of trust and the rules for trust propagation. Based on these axioms, we present two trust models: entropy-based model and probability-based model, which satisfy all the axioms. Techniques of trust establishment and trust update are presented to obtain trust values from observation. The proposed trust evaluation method and trust models are employed in ad hoc networks for secure ad hoc routing and malicious node detection. A distributed scheme is designed to acquire, maintain, and update trust records associated with the behaviors of nodes' forwarding packets and the behaviors of making recommendations about other nodes. Simulations show that the proposed trust evaluation system can significantly improve the network throughput as well as effectively detect malicious behaviors in ad hoc networks. [J288]

"Comparing adaptive beamforming in micro- and macro-cells"

This paper shows how wideband and directional channel physical constraints fundamentally condition adaptive beamforming, comparing between micro- and macro-cells. We define the angular and temporal densities, and multiuser multipath frequency parameters. Their meaning roots from the way that temporal and angular dispersions affect the original correlation properties of signals transmitted among links, reflecting channel richness in the multiuser sense. Their trends are consistent with beamforming performance divergences between those cell environments, helping to establish the main physical constraints. Among key micro- and macro-cell multiuser propagation scenarios, multiuser multipath frequency values are near one order of magnitude larger in micro-cells, compared to macro-cells. This is in agreement with the better beamforming obtained for the micro-cells channel. In the case of terminal grouping, where multiuser channels contribute with the same angles- and times-of-arrival, beamforming gains are limited to being close to 0 dB in macro-cells. In similar conditions, micro-cells' results reach up to 11.6 dB for 4 users, or 9.6 dB for 16, and also render larger beamforming robustness. The physical-level reasoning behind this work is flexible to be applied to most wideband directional propagation models. The presented parameters are general and useful in evaluating spatial filtering techniques, together with those models. [J289]

"Path-loss and time dispersion parameters for indoor UWB propagation"

The propagation of ultra wideband (UWB) signals in indoor environments is an important issue with significant impacts on the future direction and scope of the UWB technology and its applications. The objective of this work is to obtain a better assessment of the potentials of UWB indoor communications by characterizing the UWB indoor communication channels. Channel characterization refers to extracting the channel parameters from measured data. An indoor UWB measurement campaign is undertaken. Time-domain indoor propagation measurements using pulses with less than 100 ps width are carried out. Typical indoor scenarios, including line-of-sight (LOS), non-line-of-sight (NLOS), room-to-room, within-the-room, and hallways, are considered. Results for indoor propagation measurements are presented for local power delay profiles (local PDP) and small-scale averaged power delay profiles (SSA-PDP). Site-specific trends and general observations are discussed. The results for path-loss exponent and time dispersion parameters are presented. [J290]

"A UTD solution for multiple rounded surfaces"

This paper describes the diffraction mechanism when a ray optical field is obstructed by a cascade of smooth convex obstructions. A new formulation of the uniform theory of diffraction (UTD) is presented that incorporates the slope diffraction term. The solution follows a generic approach that can be applied to arbitrary placed convex structures. It will be shown that the slope diffraction term provides the required accuracy in radio propagation predictions when more than one obstruction exists in the propagation path. The proposed solution is then compared with measurements and other analytical models with excellent agreement. It is also found that the presented slope-UTD solution seems to be superior in terms of computation time and complexity, while achieving very accurate results. In addition, when the radius of the cylinder tends to be very small, the solution approaches the UTD solution for multiple knife-edge predictions. [J291]

"Signal model and receiver algorithms for a transmit-reference ultra-wideband communication system"

A communication system based on transmit-reference (TR) ultra-wideband (UWB) is studied and further developed. Introduced by Hoctor and Tomlinson, the aim of the TR-UWB transceiver is to provide a straightforward impulse radio system, feasible to implement with current technology, and to achieve either high data rate transmissions at short distances or low data rate transmissions in typical office or industrial environments. The main contribution in this paper is the derivation of a signal processing model that takes into account the effects of the radio propagation channel, in particular, for the case where the two pulses in a doublet are closely spaced. Several receivers based on the code-division multiple-access-like properties of the proposed model are derived, and the performance of the algorithms is tested in a simulation. [J292]

"Architectural features and urban propagation"

Radiocoverage measurements in urban environments often unveil unexpected power distribution patterns. Architectural features seem to be the cause of this behavior, as demonstrated in this paper. We demonstrate that the elements of a typical building facade, such as windows, exterior doors, balconies and railings, should be considered as significant "sources" of EM radiation in several current wireless communication systems. We propose a method for modeling the influence of those scatterers in EM wave propagation. In our model, the major structural elements are represented by two sets of orthogonally arranged wedges. The uniform geometrical

theory of diffraction is employed to calculate the scattering field. The simulation results show that such "urban" scatterers may create a dominant propagation mode in an urban canyon. Our predictions are additionally verified by experimental measurements, performed at two different sites. Finally, the influence of roadside foliage is investigated and conclusions are drawn on the resultant field [J293]

"Matrix-based FDTD parallel algorithm for big areas and its applications to high-speed wireless communications"

A formulation of the finite-difference time-domain (FDTD) equations as a system of linear equations in matricial form is used to develop a novel parallel algorithm that solves the variables of a 2-D FDTD simulation using less memory than required by the common FDTD algorithm, at the cost of some increase in the number of operations. For the sake of speeding-up the simulation of urban channels for personal wireless communications, the geometry of those channels and its relation with a numerical Green's function is used to increase the speed of this algorithm. Simulations are carried out in order to propose a FDTD-based model of urban microcells and their delay profiles, and some comparisons against uniform theory of diffraction based models are discussed. Finally, propagation of time division multiple access and code division multiple access signals of high bit rate in those channels are simulated, and the results allows us to evaluate the effect of multipath interference in high speed wireless communications [J294]

"Electrical Engineering Hall of Fame: Jonathan Zenneck"

In 1928, the Institute of Radio Engineers (IRE) selected Jonathan Zenneck as the recipient of its Medal of Honor. He was cited for "his contribution to original researches in radio circuit performance and to the scientific and educational contributions to the literature of the pioneer radio art." His research interests included cathode-ray tube instruments, coupled resonant circuits, and directive antennas. He also performed experimental and theoretical investigations of electric wave propagation over land and water surfaces. He authored about 200 technical papers and two influential books on electric waves and wireless communication. He became a Fellow of the IRE in 1914. [J295]

"Identification of Scattering Objects in Microcell Urban Mobile Propagation Channel"

A series of measurements in two streets in a dense urban area were accomplished. The measurement scenario was small microcell line-of-sight (LoS) with low antenna height at both link ends where dipole sleeve transmitter (Tx) antenna, directive receiver (Rx) antenna, wideband pseudo-noise (PN) signal and correlator were employed. We analyze the data obtained from the measurements by careful investigation of the single-bounce scattering power distribution conforming to precise maps of the environments including all present objects. We try to identify the single-bounce scatterers for the cluster received waves appearing in the single-bounce scattering power distribution. A number of objects were identified by this method as single-bounce scatterers within the spatial resolution bins. The identified objects are signboards, traffic signs, etc. and we conclude that any metallic object visible to both Tx and Rx with dimensions in orders of tens of wavelengths can be a significant source of scattering in small cell scenarios with low antenna heights. The contribution of the scattering from these identified objects to the received power compared to other micromechanisms is evaluated. Results show that the scattering from these objects can be comparable to the wall reflections [J296]

"Azimuth, elevation, and time-delay distributions in wireless communication channels"

We investigate the wave-propagation characteristics in urban environments as functions of the angle-of-arrival distribution, both in the azimuth and elevation planes. We also take into consideration the time delays for various base-station antenna elevations. We combine a statistical multi-parametric model, describing randomly distributed buildings, and a waveguide model, describing a grid of crossing streets with buildings lining the sides to create a new stochastic model. The joint probability of signal distributions in the azimuth-elevation, azimuth-time delay, and elevation-time delay planes are obtained and compared with high-resolution three-dimensional experiments carried out in urban areas in Helsinki, Finland. A good agreement between experimental and theoretical results is obtained [J297]

"Evidence of atmospheric tides from satellite beacon experiment"

Long-term satellite beacon measurements have been extensively used to establish ground truth data for prediction procedures. Initially, attenuation and depolarisation were the key parameters sought, supplemented more recently with secondary data on fade duration and intervals, site diversity and fade rates. An analysis of four years' worth of data from an experiment in Papua New Guinea has shown evidence of diurnal, seasonal and annual variations in the clear sky level that appear to show evidence of atmospheric tidal effects that have

implications in the design of satellite systems. [J298]

"FDTD modeling of a novel ELF Radar for major oil deposits using a three-dimensional geodesic grid of the Earth-ionosphere waveguide"

This paper reports the first application of an optimized geodesic, three-dimensional (3-D) finite-difference time-domain (FDTD) grid to model impulsive, extremely low-frequency (ELF) electromagnetic wave propagation within the entire Earth-ionosphere cavity. This new model, which complements our previously reported efficient 3-D latitude-longitude grid, is comprised entirely of hexagonal cells except for a small, fixed number of pentagonal cells. Grid-cell areas and locations are optimized to yield a smoothly varying area difference between adjacent cells, thereby maximizing numerical convergence. Extending from 100 km below sea level to an altitude of 100 km, this technique can accommodate arbitrary horizontal as well as vertical geometrical and electrical inhomogeneities/anisotropies of the excitation, ionosphere, lithosphere, and oceans. We first verify the global model by comparing the FDTD-calculated daytime ELF propagation attenuation with data reported in the literature. Then as one example application of this grid, we illustrate a novel ELF radar for major oil deposits. [J299]

"Statistical scattering model in urban propagation environment"

A statistical scattering model for mobile radio channels that has the following three features is proposed: 1) the effective scattering area (ESA) is expressed by an ellipse, the center of which is the mobile station (MS) location; 2) the major axis of the ellipse runs parallel along the street where the MS is located; and 3) the scattering power density function around the MS is expressed by a combination of two Laplacian distributions in which the standard deviations are different. To verify the proposed model and obtain realistic values for the model parameters, the spatiotemporal path data observed at a base station (BS) were measured using a 2.2-GHz band in a macrocell scenario (BS antenna height is 60 m) in a typical urban area. The scattering positions are detected from the path information such as the azimuth arrival angle and path length, assuming a single bounce. The spatial distribution of the scattering power is analyzed using principal component analysis. The results showed the ESA to be the anticipated ellipse with the major and minor axes of approximately 210 and 120 m, respectively (axis ratio: approximately 1.7). Furthermore, the power profiles that are projected for each axis of the ellipse can be approximated as Laplacian distributions. Finally, simplification of the proposed model is discussed [J300]

"5.3-GHz MIMO radio channel sounder"

A radiowave propagation measurement system for wideband multichannel multiple-input-multiple-output (MIMO) measurements at 5.3 GHz is presented. The MIMO channel matrix of size 32·32 can be measured using microwave switches at the transmitter (TX) and the receiver (RX). The system is capable of measuring direction of departure and direction of arrival with a dual polarization in both TX and RX. The antenna configuration can be selected to include a planar array or semispherical groups at each end of the link. A high-power switch is used at TX to enable large measurement distances. Results from a calibration in an anechoic chamber and from the measurement campaigns are shown. [J301]

"Position measurement using Bluetooth"

A Bluetooth wireless indoor position-measurement system is described. Normal Bluetooth operation uses receiver signal strength indicator (RSSI) for automatic transmitter power control to ensure satisfactory received signal-to-noise ratio. This feedback system was disabled and a novel use of RSSI allowed a series of measurements to be made. The distance was estimated between a reference transmitter and a mobile receiver, using a line-of-sight radio propagation model within a single cell. The design, implementation and evaluation of the system demonstrated that a mean absolute range error of 1.2 m was feasible in the presence of multipath fading. [J302]

"A novel absorb/transmit FSS for secure indoor wireless networks with reduced multipath fading"

A novel absorb/transmit frequency selective surface (FSS) is presented for 5-GHz wireless local area network (WLAN) applications. The novelty of the design is that it is capable of absorbing, as opposed to reflecting, WLAN signals while passing mobile signals. The FSS consists of two layers, one with conventional conducting cross dipoles and the other with resistive cross dipoles. The absorption of the WLAN signal is important to reduce additional multipaths and resultant fading otherwise caused by the FSS. The structure has good transmission characteristics for 900/1800/1900-MHz mobile bands and performs well for both horizontal and vertical polarizations. The distance between the two layers is less than a quarter free-space wavelengths. Theoretical and experimental results are presented. [J303]

"Radio frequency electromagnetic fields in large conducting enclosures: effects of apertures and human bodies on propagation and field-statistics"

Radio frequency propagation in an electrically large resonant chamber (a screened room) was simulated by two models: a statistical combination of multiple resonant modes and a computational electromagnetic simulation [the transmission line matrix (TLM) method]. The purpose of this work was to investigate the effects of passengers and windows on electromagnetic fields (EMF) in aircraft and other vehicles. Comparison of the multimode models with measurements made in a screened room showed that as the electromagnetic losses increased, the transmission between two internal antennas was reduced, and there were fewer turning points in its frequency response. The autocorrelation of this frequency response provided a useful estimate of the composite Q-factor of the resonances and showed that the Q of the chamber was reduced from a value of the order of 10 000 when emptied to 1000 when windows were added and when filled with people to 100. The TLM simulation provided further useful information about the statistical variation of electric field strength with position. [J304]

"Measurements and modelling of wind influence on radiowave propagation through vegetation"

Movement of vegetation structures introduces an adverse environment for high frequency radiowave propagation. This paper examines a series of vegetation scattering measurement campaigns during various wind conditions. The measurements were divided into controlled and outdoor environments. The controlled environment measurements were conducted in an anechoic chamber at 0.9, 2, 12 and 17 GHz. The outdoor measurements were carried out at 1.8 GHz and involved in recording of a transmitted signal originating from an existing digital cellular system (DCS-1800) base station. The obtained results are discussed and presented in terms of their first- and second-order statistics. Analysis demonstrates that the received signal behaviour is highly wind dependent, especially when the environment is changing from calm to a windy condition. The signal fast-fading is found to be Rician distributed and an empirical model of the k-factor variation over wind speed is also presented. [J305]

"An attenuation time series model for propagation forecasting"

A key problem in the efficient use of higher (Ka- and V-band) frequencies lies in the mitigation of propagation impairments caused by meteorological phenomena. The traditional approach to this problem is based upon a relatively simplistic statistical model in the form of a fade margin. At higher frequencies this traditional approach becomes inefficient due to the large margin required. This inefficiency has lead to the introduction of dynamic fade mitigation techniques (FMTs). We present a method of generating attenuation time series that can be used for the development and evaluation of FMTs. The method we propose is based on the use of proven numerical weather prediction models in conjunction with a propagation model. This approach has two unique aspects. First, the spatial correlation and dynamic behavior of the attenuation fields are inherited from the meteorological environment. Second, the model can provide forecasts of attenuation. It is foreseen that this a priori knowledge of the occurrence of fades, their likely depth and likely duration can be exploited to manage the resource control of entire networks. This paper presents a description of the method and demonstrates the ability to generate attenuation time series. Conclusions are drawn regarding its use in real-time for network resource management. [J306]

"Indoor propagation models based on rigorous methods for site-specific multipath environments"

This paper presents a full wave simulation technique for modeling indoor propagation channels. A key feature of the technique is the use of a domain decomposition approach that accounts for repeatable components such as bricks, chairs, tables, etc. This leads to significant memory reduction, thus permitting the modeling of an entire classroom. Several simulations with different transmitting locations are presented and used to predict the statistical profiles of the received signal strength. These profiles are subsequently used to evaluate the bit error rate for specific digital modulation schemes. [J307]

"Impact of frequency offsets and IQ imbalance on MC-CDMA reception based on channel tracking"

New air interfaces are currently being developed to meet the high spectral efficiency requirements of the emerging wireless communication systems. Multicarrier code-division multiple access (MC-CDMA) is seen as a promising candidate for the fourth-generation (4G) cellular communication systems because it can interestingly deal with the multipath propagation at a low processing complexity. Besides spectral efficiency and power consumption, the production cost of the transceiver should also be optimized. Direct conversion radio frequency (RF) receivers are appealing because they avoid costly intermediate frequency (IF) filters. However, they imply RF IQ separation, introducing a phase and amplitude mismatch between the I and Q branches. A

communication system based on MC-CDMA is sensitive to synchronization errors and front-end non-idealities because it uses a long symbol duration. The goal of this paper is to evaluate the impact of the carrier frequency offset, the sampling clock offset, and the IQ imbalance on the MC-CDMA downlink system performance, considering a receiver based on channel tracking designed to cope with high mobility conditions. It is demonstrated that part of the effects is compensated by the channel estimation and an expression of the variance of the remaining symbol estimation error is provided. For the cellular system and the target performance considered in this paper, specifications are defined on the non-idealities. The results are validated with bit-error rate simulations [J308]

"Far-field radiated from a vertical magnetic dipole in the sea with a rough upper surface"

The problem of communication in the sea has been considered as propagation of radio waves in a three-layered medium (air, sea, and ground). With the aid of the perturbation calculus, this paper analyzes the influence exerted onto the electromagnetic field of arrangements radiating a pure transverse electric field in the sea. The sea height varies continuously with the distance from the transmitting end due to sea waves. Knowledge of the solution for the case of uniform sea height is presumed. The problem of the transition conditions at the upper boundary of the sea is solved in the imaging space of a Hankel transformation. Its reversal produces an integral presentation of the interfering field, which was previously quite difficult to evaluate. In this study, closed-form expressions for the far-field of a vertical magnetic dipole embedded below the sea surface are obtained by using a new technique to evaluate this integral with the aid of the complex image theory. The results obtained are compared with those mentioned elsewhere [J309]

"An intuitive electromagnetic approach to MIMO communication systems"

The aim of this paper is to introduce MIMO propagation in a simple and intuitive way, which exalts the role of the laws of electromagnetism in the channel capacity of space-time communication systems. The approach takes advantage of mode expansions in waveguides and spherical-harmonics expansions in free space to clarify the physical limitations in the channel capacity of MIMO systems [J310]

"Pre-announcement ISAP 2007"

{no data available} [J311]

"A New Heuristic Geometrical Approach for Finding Non-Coplanar Multiple Edge Diffraction Ray Paths"

Rooftop diffraction can contribute significantly to the propagation path loss in outdoor microcellular environments. For non-coplanar multiple edges, the finding of exact ray paths requires a complex algebraic analysis that is infeasible for rapid application in deterministic ray tracing models. A new heuristic geometrical approach is reported that finds the ray paths for arbitrary height rooftop diffraction and rooftop-to-building corner diffraction. This method can be applied to any 3-D image based ray tracing model. The accuracy of the new method is first quantified using two specific test cases. The method is then implemented in an existing microcellular ray model and path loss predictions are compared with measured data. The heuristic diffraction approach is shown to be simple to implement and lowers the prediction error when compared with the traditional Vertical Plane diffraction approximation [J312]

"Capability of 3-D Ray Tracing for Defining Parameter Sets for the Specification of Future Mobile Communications Systems"

Three-dimensional (3-D) ray tracing has advanced to such a degree that it can provide channel parameters like delay spread, Doppler spread, angular spread, and distribution functions of long- and short-term fading with high accuracy for fixed to mobile and mobile to mobile communications. These parameters are absolutely required during the specification phase of future mobile communications systems in order to define the air interface and a variety of other relevant system parameters. This paper describes state-of-the-art ray tracing capabilities. A 3-D ray tracing model developed at the Universitaumlt Karlsruhe is presented. Important characteristic channel parameters are briefly discussed. Based on these parameters the model is verified by wideband nondirectional and directional measurements at 2 and 5.2 GHz, respectively, showing a good agreement. The proposed 3-D ray tracing model can therefore be used in order to extract parameter sets for the specification of future mobile communications systems and to optimize existing ones [J313]

"ELF Radar System Proposed for Localized D-Region Ionospheric Anomalies"

This letter proposes a novel extremely low frequency (ELF) radar for localized D-region (altitude < 95 km)

ionospheric anomalies that have been generated by natural geophysical processes. The proposed system would use the former U.S. Navy Wisconsin Transmitting Facility as a distant well-characterized impulsive ELF source. Sample calculations that demonstrate how passive vertical E-field detectors could characterize ionospheric conductivity depressions of variable diameter located above Los Angeles are provided. These calculations have been obtained using our recently developed three-dimensional whole-Earth electromagnetic wave propagation model based upon the rigorous finite-difference time-domain solution of Maxwell's equations. A key potential application of the proposed ELF radar system is the detection of hypothesized ionospheric earthquake precursors [J314]

"A multipurpose FDTD-based two dimensional electromagnetic virtual tool"

A novel, multipurpose, FDTD-based two-dimensional electromagnetic virtual tool has been designed and introduced. A variety of electromagnetic problems, including radio wave indoor/outdoor, urban/rural propagation, electromagnetic compatibility, resonators, closed/open periodic structures, and linear and planar arrays of radiators can be simulated. This paper describes the software and its use in electromagnetics courses [J315]

"Simulations and Measurements of Wave Propagations in Curved Road Tunnels for Signals From GSM Base Stations"

This paper presents a ray-tube tracing method to simulate waves propagating in curved road tunnels from base stations for mobile communications. Ray tubes are traced by including multiple reflections in the curved tunnels and diffractions from wedges of the tunnel structures, together with the direct path. To verify this ray-tube tracing approach, field measurements of 900 MHz signals in two curved road tunnels from GSM base stations were performed for comparisons with the ray-tube tracing simulations. By tracing ray tubes reflected and diffracted from the curved structures of the tunnels, the effects of the curvature on wave propagations in large guiding structures can be evaluated. Good agreement between simulations and measurements has been obtained. A parametric study of the influence of the tunnel geometry and the signal frequency on the path loss is also presented by applying this ray-tube tracing method. Curved tunnels for different radii of curvature in the tunnel cross-section and horizontal plane and also lengths of the curved part are compared, together with rectangular tunnels. Simulations of the field distribution over the cross-section of the curved tunnel away from the transmitting antenna are demonstrated as well. The ray-tube tracing program can be applied to determine the deployment of the base-station antennas for improving signal coverage in tunnels, which may have curved structures [J316]

"Uncertainty evaluation of an in vivo near-field exposure setup for testing biological effects of cellular phones"

In designing an in vivo near-field exposure setup for testing biological effects of cellular phones, one generally uses a small still animal because a plastic holder is used to restrain it. One also takes no account of the exposure box with radio wave absorbers as well as the plastic holder. In this paper, for the in vivo exposure setup developed in the National Institute of Information and Communications Technology (NICT), which was used for testing the promoting effect of 1.439- and 1.95-GHz digital cellular phones on rat brain carcinogenesis, we investigated the effects of the above-mentioned factors on the dosimetry design using the finite-difference time-domain (FDTD) method in conjunction with an anatomical rat model. As a result, we found that the specific absorption rate (SAR) averaged in the brain was 18% higher at maximum than the previously designed level due to the existence of the exposure box and the plastic holder and that the variation due to the rotation of the rat's head inside the plastic holder was within 10%. The backward movement of the rat along the plastic holder was more serious, which yielded a decrease of nearly 20% for the average SAR in the brain [J317]

"Correction for Rain Path Specific and Differential Attenuation of X-Band Dual-Polarization Observations"

The accuracy of attenuation correction for X-band reflectivity (Z H) and differential reflectivity (ZDR) measurements in rainfall is analyzed using coincident X-band and S-band polarimetric radar observations collected during the International H2O Project in the period of May-June 2002 at northwestern Oklahoma. Two distinct attenuation correction techniques that use the differential propagation phase shift (PhiDP) information, which is not a power-dependent measurement, as a means to provide independent estimates of path-integrated attenuation are assessed. The study is facilitated by nonattenuated X-band ZHand ZDR profiles simulated based on raindrop size distribution parameters retrieved from matched multiparameter (ZH, ZDR, and KDP) S-band observations. The major outcome of this assessment is that PhiDP-based attenuation correction for both techniques can reach almost unbiased measurements (within 5% mean relative error) and low random error (15-20% relative standard deviation). The study shows moderate differences in the error statistics of the evaluated

techniques. The sensitivity of attenuation correction uncertainty with respect to the assumed variability in raindrops' oblateness-size relation and the noise in PhiDPmeasurement is also shown [J318]

"Full time-domain DORT for ultrawideband electromagnetic fields in dispersive, random inhomogeneous media"

We investigate the decomposition of the time-reversal operator (DORT under its French language acronym) method applied to ultrawideband electromagnetic pulses propagating in dispersive and (continuous) inhomogeneous random media where volumetric scattering effects are important. We analyze the effects of random medium statistics on the time-reversal operator (TRO) eigenvalues and eigenvectors, and on subsequent selective focusing performance. We develop and employ a full time-domain DORT by tracking the excitation eigenvectors from a singular value decomposition of the TRO over the entire bandwidth of operation. We also study effects of frequency dispersion and conduction losses on the TRO and consider dispersion/loss compensation techniques to improve DORT operation in those cases [J319]

"Optimum training symbol design for MIMO OFDM in correlated fading channels"

Multiple transmit and receive antennas (MIMO) have been used with orthogonal frequency division multiplexing (OFDM) for capacity improvement in frequency-selective channels. In certain propagation environments, there exists spatial correlation among channels corresponding to different pairs of transmit and receive antennas. In this paper, we investigate training sequence design for channel estimation in MIMO-OFDM systems. We develop necessary conditions for a training sequence to minimize the mean-square error (MSE) of channel estimation when spatial correlation of MIMO channel is known to the transmitter and discuss training sequence design for some special cases. The performance improvement of the designed training sequences is confirmed by simulation examples [J320]

"Transactions Papers-Space-time-frequency characterization of MIMO wireless channels"

In this paper, we characterize the cross-correlation function (CCF) between the time-frequency transfer functions (TF)s of two sub-channels of a multiple-input multiple-output (MIMO) wireless fading channel. The TF of each sub-channel consists of a number of multi-path components caused by propagation of a transmitted signal in random scattering media. The proposed CCF is expressed in terms of several environmental parameters (such as the moment generating function (MGF) of the delay profile (DP) and the pathloss exponent). It is a summation of two terms: the first term is due to the autocorrelation of multi-path components while the second term is due to the cross-correlation of multi-path components. Each term is a product of several correlation functions. Each of these correlation functions represents different dependencies of the wireless channel in terms of time, carrier frequency and the position of the antenna elements around both the transmitter and the receiver site. Interestingly, the last two terms of these functions are (n/2)-order (or n-order) integrations of the MGF of the DP, evaluated at two carrier frequencies (or the difference between carrier frequencies), where n is the pathloss exponent of the environment [J321]

"Joint statistics for two correlated Weibull variates"

This paper derives closed-form formulas for the joint statistics of two correlated Weibull variates. In particular, the joint probability density function, the general joint moments, and the general correlation coefficient are obtained in terms of well-known fading physical parameters. [J322]

"A novel hybrid approach for far-field characterization from near-field amplitude-only measurements on arbitrary scanning surfaces"

A novel hybrid procedure is proposed in this paper for far-field reconstruction from phaseless near-field data. A basically interferometric approach is adopted to retrieve the near-field phase from amplitude-only measurements, which are collected by a simple microstrip circuit used in conjunction with two identical probes moving on the scanning surface. A certain number of sets of complex near-field data is obtained, apart from constant phase-shifts to be computed, one for each set. A nonredundant representation based on the introduction of the reduced field is then adopted to evaluate these shifts, with an accurate and fast convergence to the solution. In order to validate the proposed technique, an X-band prototype using two flanged WR-90 waveguides is successfully designed and tested on a cylindrical geometry for a standard pyramidal horn. [J323]

"Ray propagation in a random lattice: a maximum entropy, anomalous diffusion Process"

The typical model for diffusion in disordered systems is that of a random walk that proceeds in discrete steps over a random lattice, where not all the nearest sites can be reached at each step. We study the related

problem of ray propagation in percolating lattices, and observe that it follows an anomalous diffusion process, whose appropriate metric is the "Manhattan" distance defined by the lattice geometry. The proposed solution is the one that exhibits the maximum Shannon's entropy, among all propagation processes with appropriate moment constraints imposed by the geometry of the lattice. Ray propagation in percolating lattices has been recently proposed as a model for urban area propagation of radio waves. We discuss implications of our results in this scenario. [J324]

"Field measurement based characterization of the wideband urban multipath channel for portable DTV reception in single frequency networks"

This paper presents a study developed to obtain several parameters of the small scale fading of the wideband propagation channel applied to the portable and mobile reception of Digital Terrestrial Television (DTV) services in an urban Single Frequency Network (SFN) environment. The study is focused on the calculation of some relevant parameter values related to the multipath behavior of the channel, using field data collected in a real network. Mean values for the Root mean square Delay Spread (RDS) and the frequency domain Level Crossing Rate (LCR) are given, together with an analysis of the influence of the specific environment and network (SFN) features. [J325]

"An efficient Integral equation-based electromagnetic propagation model for terrain"

An improved fast integral equation (IE) method to evaluate the slow fading signal at 970 MHz over terrain is described here. An 11.1 km, two-dimensional, semi-rural terrain profile is modeled as a series of interconnecting perfectly electrically conducting (PEC) segments. The algorithm achieves its computational speed by approximating the local surface current as a constant-amplitude sinusoid. An appropriately scaled value of this current can be used to quickly compute the scattered field. This process takes 0.05 s on a PC with a 2.2 GHz Pentium 4 processor giving a standard deviation of 15.57 dB and 9.48 dB from the full-wave solution and measurements, respectively. Where the local surface current is modeled as having a Rayleigh distributed envelope the computation time is 2.66 s but a reduction in the standard deviation to 3.07 dB and 8.77 dB from the full-wave solution and measurements ensues. [J326]

"Experimental characterization of radio wave propagation in hospitals"

This paper reports the characterization of radio wave propagation in hospitals. In contrast to other buildings with usual walls, some rooms within hospitals are constructed with special walls that include metallic layers. The structure of the walls depends on the purpose of each hospital room. To consider all the different wall types, measurements were performed in all relevant areas of four hospitals. Rooms, such as operating rooms, X-ray and magnetic resonance tomography (MRT) rooms were taken into account. The measurements were performed at eight discrete frequencies ranging from 42.6 MHz up to 5.2 GHz. In order to investigate accurately the wave propagation properties, several antennas and measurement systems were used. Results show that radio wave propagation characteristics vary from room-to-room. It turned out that it is important to consider the room as a whole when determining the attenuation between adjacent rooms, because a small part of the wall is not enough. In addition to usual wave propagation phenomena such as reflection and transmission, slots and openings give rise to coupling effects through walls containing metallic layers in their structure. The measurement data is useful for hospital designers and hospital engineers. [J327]

"Rapid search algorithms for code acquisition in UWB impulse radio communications"

Ultrawideband (UWB) impulse radio is an emerging technology suitable for high-rate tactical wireless communications. One of the crucial challenges for a connecting station remains the initial code acquisition, in a hostile propagation environment (e.g., urban combat). In this paper, we address the coarse acquisition of pseudonoise (PN) codes and propose algorithms for speeding up the acquisition process and/or reducing the complexity of the acquisition algorithm itself. Also, in the case of energy detection, we show that the front-end sampling rate may be reduced. An in-depth analysis, supported by simulations in the presence of multipath is presented, and the results discussed. [J328]

"A novel technique for the approximation of 3-D antenna radiation patterns"

In this paper, a novel technique for the approximation of three-dimensional (3-D) antenna radiation patterns is presented. The proposed method combines the two principal cuts in order to acquire an adequate estimate of the 3-D antenna radiation solid. The absolute error from the theoretical solution is analyzed along with other statistical measures for various types of antenna structures, namely omni-directional and directive arrays. The performance of the method is compared against other existing extrapolation algorithms. The proposed technique exhibits low approximation errors and is easily integrated into 3-D radio propagation planning tools (such as ray-

tracing algorithms). [J329]

"Propagation models for short-range wireless channels with predictable path geometries"

We consider wireless data services characterized by short distances, no shadowing, low power, and low antenna heights, deployed in places where a high frequency of potential users is expected, e.g., toll booths, parking lots, intersections, etc. Within such a system, we expect to see a well-defined geometry of base-to-user radio paths, as well as a predictable user trajectory, neither of which can be assumed for the wide-area cellular case. This offers the promise of a strong deterministic component of the channel response, in addition to a weaker stochastic component. Here, we combine analysis of the former with measurements and modeling of the latter for three typical outdoor scenarios. Comparisons between predicted and measured behavior show excellent agreement. [J330]

"Simulation of Radiowave Propagation in Hospitals Based on FDTD and Ray-Optical Methods"

This paper addresses the simulation of radiowave propagation in hospitals in the frequency range from 42.6 MHz to 5.2 GHz. Due to the special construction of the walls, wave propagation in hospitals is different from other buildings. These walls contain metallic layers within their structure, e.g., operating rooms with CrNi-steel faced walls, X-ray rooms with lead shielded walls or magnetic resonance tomography rooms with an explicit EMC shielding made of copper. Wave propagation in such rooms has not been simulated yet. This work uses a simulation tool based on the finite-difference time-domain method that allows a detailed simulation of the walls, floors and ceilings for frequencies from 42.6 to 300 MHz. For higher frequencies up to 5.2 GHz a ray-optical simulation tool must be used and the walls must be modeled homogeneously by multiple layers of different materials. In order to accurately model the walls, the electromagnetic properties of the different material layers inside the walls have to be known. The results of extensive wave propagation measurements in four different hospitals are used for the determination of these parameters. This paper presents the methods used to obtain these material parameters and their performance in a ray-optical simulation tool. [J331]

"On the Modeling of Reflected Energy From Building Faces in Microcellular Mobile Radio Planning Tools"

A semideterministic model of electromagnetic scattering from exterior urban building walls that is capable of modeling scattering from large-scale discontinuities such as ledges, windows, etc., is presented. The model is in quantitative agreement with spatiotemporally resolved measurements of scattering from a building wall at 2.4 GHz and can be used to construct relatively simple modified reflection coefficients that can be used in ray-optical microcellular planning tools. [J332]

"Deterministic Wideband Modeling of Satellite Propagation Channel With Buildings Blockage"

The article presents an example of satellite propagation modeling, applying the radio channel transfer function analysis as described and experimentally verified in scientific literature. The simulation of a satellite radio channel is executed by employing "ray tracing" and the uniform geometric theory of diffraction-based method for an assumed urban and suburban environment and different polarizations. Derived results regarding the channel transfer function are analyzed via a simulation of the wideband propagation measurement system and the Fourier transform procedures. It has been concluded that, contrary to ground cell radio system situations, where two-ray models usually suffice, a more detailed calculation should be considered for wideband satellite radio systems. Moreover, it is shown that the conclusions derived for the path loss and the delay spread depend not only on the specific propagation scenario, but also on the building permittivity. [J333]

"Long-term rain attenuation probability and site diversity gain prediction formulas"

Simple models for long-term induced rain attenuation on a slant path and site diversity gain are presented in this work. As verified by numerous tests against the ITU-R databank and other data from the literature, the proposed models exhibit a very good performance. The novel slant path rain attenuation prediction model compared to the ITU-R one exhibits a similar behavior at low time percentages and a better root-mean-square error performance for probability levels above 0.02%. Moreover, comparing the proposed site diversity gain model with other widely accepted models from the literature, an improved performance is observed for distances less than 15 km, while the model performs equally well for greater distances. Furthermore, a sensitivity test between the proposed and Hodge's formula with respect to the separation distance D is also carried out. While the lower limit of the proposed model is found to be D=1.7 km, its extension covering large-scale site diversity is successfully compared with experimental data coming from Japan. The set of presented models exhibits the advantage of easy implementation with little complexity and is considered useful for educational and back of the envelope

computations. [J334]

"Maximum diversity in single-carrier frequency-domain equalization"

In broadband wireless communications, multipath propagation often results in an overall channel with a long impulse response that could span tens or even hundreds of symbol intervals. To equalize such long channels, conventional single-carrier time-domain equalization becomes infeasible due to high computational complexity. Relying on the use of fast Fourier transform, single-carrier frequency-domain equalization (SC-FDE) offers low-complexity equalization as well as other desirable features. In this correspondence, we prove that SC-FDE is also capable of collecting full multipath diversity even without channel coding. As far as we are aware, this is the first analytical proof of the diversity gain of SC-FDE. This conclusion justifies those existing simulation results regarding the performance comparison between SC-FDE and orthogonal frequency-division multiplexing (OFDM), and offers important guidelines for further improving SC-FDE and OFDM [J335]

"The Impedance of a Short Dipole Antenna in a Magnetized Plasma Via a Finite Difference Time Domain Model"

The traditional analytical analysis of plasma probes requires the use of quasi-static approximations, while numerical methods require the use of an equivalent dispersive media, both producing a nontrivial analysis of the plasma environment. On the other hand, a few techniques that combine the plasma fluid equations with Maxwell's equations have only addressed wave propagation through spatially constant plasma. All of these models are limited in analysis of in situ measurements. This paper modifies the current finite-difference time-domain methods to more accurately model the ionospheric environment. Decoupled boundary conditions are presented in an attempt at coping with the instabilities of the plasma at the boundaries. The final model is then compared to analytical theory of radio-frequency plasma probes. [J336]

"Correlations between slant wet delays measured by microwave radiometry"

We present an analysis of the correlation between the atmospheric slant wet delays in different directions using data from a microwave radiometer. The correlations between wet delays observed in different directions using different temporal constraints are compared to a model derived from theories of turbulence. The agreement between the model and the radiometer data was good, and the average squared difference between zenith mapped slant wet delays could be predicted with an accuracy of 0.01-0.04 cm2. Our analysis shows a large short-term variability which variance has a seasonal dependence of about ±26%, largely depending on the refractivity structure constant Cn. We also demonstrate how the model can be used to characterize the stability of a microwave radiometer. [J337]

"Scintillation effect on LEO radio-occultation"

Absorption at different frequencies in radio-occultation links may be used to derive atmospheric parameters. The impact of scintillation on this type of link is assessed for three different frequencies. Results on this impact are presented and show that scintillation may be the limiting factor in the lower part of the atmosphere when designing this type of link. [J338]

"LMDS diversity systems: a new performance model incorporating stratified rain"

Cell-site diversity may prove an efficient fade mitigation technique to increase the availability of local multipoint distribution service systems, in this Letter, a recently suggested physical model for the prediction of cell-site diversity performance is properly modified to include stratified rain. The model-obtained is satisfactorily verified using radar derived data from UK and Canada. Simulated BEP results concerning LMDS diversity systems are also presented. [J339]

"Basic transmission loss and delay spread measurements for frequencies between 430 and 5750 MHz"

Impulse response radiowave propagation measurements from an urban area of Denver, CO, are described. The basic transmission loss and delay spread are used to characterize the mobile communications environment. These metrics are quantified using path loss slope and delay spread statistics. By analyzing the results versus carrier frequency, the relative propagation impairments at 430, 1350, 2260, and 5750 MHz are compared. It was found that the path loss slope increased on average by 11 dB/dec and the median delay spread decreased from 0.7 to 0.3 μs over the decade of frequencies measured. [J340]

"A maximum-likelihood estimator to simultaneously unwrap, geocode, and fuse SAR interferograms from different viewing geometries into one digital elevation model"

This paper presents theory, algorithm, and results of a maximum-likelihood algorithm that is capable to fuse a number of heterogeneous synthetic aperture radar interferograms into a single digital elevation model (DEM) without the need for the critical phase-unwrapping step. The fusion process takes place in the object space, i.e., the map geometry, and considers the periodic likelihood function of each individual interferometric phase sample. The interferograms may vary regarding their radar wavelength, their baseline, their heading angle (ascending or descending), and their incidence angle. Geometric baseline error estimates and a priori knowledge from other estimates like existing DEMs are incorporated seamlessly into the estimation process. The presented approach significantly differs from the standard DEM generation method where each interferogram is first phase-unwrapped individually, then geocoded into a common map geometry, and finally averaged with DEMs generated from other interferograms. By avoiding the phase-unwrapping step, the proposed algorithm does not depend on gradients between samples and is therefore capable to reconstruct the arbitrary height of each single scatterer. Because the height of each DEM sample is determined individually, spatial propagation of phase-unwrapping errors is avoided. The algorithm is targeted to fuse an ensemble of interferometric multiangle or multibaseline observations in areas of rugged terrain or highly ambiguous data where algorithms based on phase unwrapping may fail. The algorithm is explained, and examples with real data from the Shuttle Radar Topography Mission are given. Conditions of future missions are simulated, and optimization criteria for the viewing geometry are discussed. [J341]

"Characterization of space-time focusing in time-reversed random fields"

This paper proposes various metrics to characterize space-time focusing resulting from application of time reversal techniques in richly scattering media. The concept and goals of time reversal are presented. Pertinent metrics describing both the time and space focusing effects are outlined. Two examples based on a model of discrete and continuous scattering media are used to illustrate how the proposed metrics vary as a function of various system and channel parameters, such as the bandwidth, delay and angle spreads, number of antennas, etc. [J342]

"Effects of lateral terrain variations on tropospheric radar propagation"

The numerical simulation of long-distance, over-terrain propagation of electromagnetic waves has received considerable attention due to its strong impact on radar and communication technology. One highly desirable feature of the methods currently used in these simulations is numerical efficiency, which is typically achieved by approximating the actual three-dimensional (3-D) propagation medium by a two-dimensional (2-D) medium. In this medium, the atmospheric variations are confined to the range/altitude (x/z) propagation plane while terrain variations are confined to the range direction (one-dimensional terrain). With an additional, paraxial assumption, these models arrive at an extremely efficient, scalar parabolic wave equation (PWE) that can be solved with marching techniques. A significant drawback, however, is that the 2-D approximation discards propagation effects associated with the lateral variations of the 2-D terrain-namely lateral diffraction, lateral scattering and depolarization. These effects may have substantial impact on clutter modeling in radar detection and imaging. In this paper, the propagation effects associated with lateral terrain variations are examined via 3DVPWE, a full 3-D numerical model based on the vector PWE. A notional urban terrain configuration, as well as a realistic digital-map terrain example is considered. The 3DVPWE results are then compared to results from 2-D PWE model to assess the performance of this commonly used approximation. The main emphasis of the paper will be placed on lateral diffraction and scattering. The examination of depolarization effects will be deferred to a future publication. [J343]

"Wireless propagation in circular tunnels"

We study models for propagation in circular tunnels. The excitation is either a circular magnetic or circular electric current loop. We produce expressions for the fields in terms of a Fourier transform over the axial variable. We then produce the modes in the lossy structure by contour integration techniques. We include numerical results for the field intensity both as a function of axial distance and as a function of radial distance for several frequencies, radii, and constitutive parameters of interest. We comment in particular concerning the specific form of the field both near to and far from the antenna source. [J344]

"An improved solution expressed in terms of UTD coefficients for the multiple-building diffraction of plane waves"

A new formulation expressed in terms of uniform theory of diffraction (UTD) coefficients for the prediction of the multiple diffraction produced by an array of finitely conducting buildings considering plane-wave incidence is

presented. The solution considers the building cross sections to be rectangular as well as the source to be above or level with the building's height and, due to the fact that only single diffractions over finitely conducting wedges are involved in the calculations, an easier final formulation is achieved. Furthermore, the computing time is reduced over existing solutions especially when the number of buildings is large. The proposed formulation can find application in the development of theoretical models to predict more realistic path loss in urban environments when multiple-building diffraction has to be considered. [J345]

"Implications of power control and successive interference cancellation on indoor DS-CDMA system deployment and performance"

We investigate the optimal combination of power control and successive interference cancellation to yield performance gains in a multi-floor indoor DS-CDMA system. Using measured indoor propagation data and a Monte Carlo simulation, it is shown that the performance gains achieved are significantly influenced by the base station deployment strategy chosen. [J346]

"Statistical Characteristics of atmospheric phase fluctuations observed by a VLBI system using a beacon wave from a geostationary Satellite"

This paper reports the statistical characteristics of phase fluctuations obtained by a very long baseline interferometry, which received beacon waves from a geostationary satellite. Observations were made in different weather conditions by the 6-m Kagoshima and the 10-m Mizusawa radio telescopes, which were 1284 km apart from one another. Atmospheric phase fluctuations ranging from 0.2 to about 1000 s were detected. To study a variety of statistical characteristics of these phase fluctuations, the Allan standard deviation, σy(τ), the temporal structure function, Dφ(τ), and the square root of power spectrum, Gφ(f), were calculated from the observation results. These qualities were found to depend on the time interval τ or the frequency f (f=1/2τ) as follows: σy(τ) τ-0.6, τ-0.3, Dφ(τ) τ0.9, τ1.3for 0.2 sφ(f) f-0.8for 2.5 Hz>f>0.33 Hz and Gφ(f) f-1.3for 0.33 Hz>f>0.00125 Hz. The curves of σy(τ) and Dφ(τ) exhibited shifts whose magnitudes followed the weather order clear, cloudy, and rainy. For τ>1.5 s (or f0.33 Hz), the model has to be modified to explain the experimental results. [J347]

"Whistler wave propagation and whistler wave antenna radiation resistance measurements"

Whistler waves are a common feature of ionospheric and magnetospheric plasmas. While the linear behavior of these waves is generally well understood, a number of interesting observations indicate that much remains to be learned about the nonlinear characteristics of the mode. For example, in space, very low frequency (VLF) emissions triggered by whistler modes launched from ground-based transmitters have been observed. Emission is assumed to come from transverse currents formed by counterstreaming electrons that are phase bunched by the triggering signal. In the laboratory, it has been shown that with increasing amplitude of the driving signal applied to an antenna, the whistler mode radiation pattern forms a duct with diameter of the order of the parallel wavelength. The ducted waves were observed to propagate virtually undamped along the length of the plasma column. These observations have prompted an Naval Research Laboratory's (NRL) Space Physics Simulation Chamber study of whistler wave dynamics. The goals are to investigate whistler wave ducting, self-focusing, and amplification, and to study nonlinear whistler-plasma interactions. [J348]

"New forms of cumulative probability distribution and their applications in communications"

Cumulative probability distribution (CPD) is a statistical approach in the comparison of multi-path fading models. One problem encountered in this comparison method is its inability to distinguish between certain sets of data. This problem is covered thoroughly and a solution is discussed for overcoming it. The overall new method is named 'new forms of CPD' (NFCPD). These three new forms are: simple sigma-r (SSR), complex sigma-r (CSR) and the 3-D mesh method. Each method has been covered thoroughly and shown to correct CPD's incompleteness, and although all three methods are very similar in structure and algorithms, each has a unique use of its own. Also, new applications of SSR are proposed in three fields: communication channel recognition, channel distortion measurement, and MTI radars. Although all results presented are obtained from SSR, they could also be obtained by CSR and the 3-D mesh method. SSR has been chosen because of its simplicity and relative accuracy. [J349]

"Can LORAN meet GPS backup requirements?"

The Federal Aviation Administration (FAA) is currently leading a team consisting of members from industry, government, and academia to provide guidance to the policy makers in their evaluation of the future of Loran-C in the United States. In a recently completed Navigation Transition Study, the FAA concluded that Loran-C, as

an independent radio navigation (RNAV) system, is theoretically the best backup for the global positioning system (GPS). However, for Loran-C to be considered a viable backup system to GPS, it must be able to meet the requirements for non-precision approaches (NPAs) for the aviation community, and the Harbor Entrance and Approach (HEA) requirements for the maritime community. Through FAA sponsoring, the US Coast Guard Academy (USCGA) is responsible for conducting some of the tests and evaluations to help determine whether Loran can provide the accuracy, availability, integrity, and continuity to meet these requirements. A major part of assessing the suitability of Loran is in understanding the nature of Loran ground wave propagation over paths of varying conductivities and terrain. Propagation time adjustments, called "additional secondary factors" (ASFs), are used to adjust receiver times of arrival (TOAs) to account for propagation over non-seawater path(s). These ASFs vary both spatially and temporally, and unless understood and/or modeled, we lose accuracy and may not be able to guarantee a hazardously misleading information (HMI) probability of less than 1times 10-7. During the summer of 2003, the Coast Guard Academy, with flight support from the FAA Technical Center, conducted a series of tests to measure ASF variations in the vicinity of several selected airfields in Colorado, Arkansas, Florida, and California. In addition, approaches were flown at several airports in each of these areas. ASF and TOA data collected during these trials has been analyzed through post-processing to determine the Loran position accuracy during app- roaches. The accuracy of raw (uncorrected Loran) as well as ASF-corrected Loran positions are shown for a variety of ASF profiles. Using the BALOR ASF modeling software produced by the University of Wales at Bangor, we have also done some simulations of best-case performance analysis for receivers with little or no noise. In addition, we present some ideas for using a Kalman-filtered integrated Loran-INS receiver to smooth out Loran position errors. Finally, how all of these efforts lead toward meeting the accuracy requirements is shown [J350]

"Comparison between two different antennas for UWB on-body propagation measurements"

The effect of two different antenna types on radio propagation in ultrawideband (UWB) on-body channel measurement are analyzed. Statistical path loss parameters and time domain channel characteristics [mean delay and root mean square (rms) delay spread] are extracted from measurement data. Reduction in rms delay spread is experienced when using printed horn shaped self-complementary antennas (HSCA) for specific body area links in comparison to monopole-like omnidirectional antennas, e.g., planar inverted cone antennas (PICA). Results show that the hybrid use of different type UWB antennas can effectively improve channel behavior in body-centric wireless networks. [J351]

"Subspace-based approach for DOA estimation using pilot symbol channel identification"

In the paper, antenna processing is applied in the radio localisation frame. For a source of interest, the multipath directions of arrival (DOA) are estimated and the shortest/direct propagation path is identified. First, an unstructured estimate of the sampled channel impulse response is derived by use of pilot symbols. The channel response samples are then separately processed to recover the DOA of the relative paths. For stationary channels, it is suggested that smoothing be used in the case of a uniform and linear antenna array (ULA) to recover the source subspace. For fast fading channels, which is typically the case for high speed mobiles, it is shown that using a MUSIC like algorithm allows source subspace recovery by exploiting the gain diversity over a reduced number of slots with unchanged DOA and time delays. Separate processing of channel response samples reduces the constraint on antenna array size and allows comparison of the path lengths. [J352]

"Analytical Formulae for Path Loss Prediction in Urban Street Grid Microcellular Environments"

Rapid growth in the demand of wireless communications makes the use of microcells essential. Ray tracing models have shown good path loss prediction accuracy in microcellular environments. However, these techniques have great computational and memory requirements. The purpose of this paper is to derive analytical propagation path loss formulae for microcellular communications in urban street grid environments. The formulae are derived based on the geometrical optics and diffraction theory and they take into account multiple reflections along street walls and diffractions around street corners with ground reflections neglected; i.e., a two-dimensional approach. Comparisons between our theoretical results and published measurements in Tokyo and New York Cities show good agreement. [J353]

"Distortions of the low frequency signal by Martian ionosphere at vertical propagation"

A mathematical tool is described that takes into account signal distortions caused by phase dispersion and signal absorption in the Mars ionosphere during reflection from the Mars surface below the orbiter. This tool is used to estimate the distortion of the cross-correlation function by phase dispersion and signal absorption caused during a double traverse of the radio signal through the Mars nighttime ionosphere on frequencies used for the radar experiment MARSIS. Ionospheric absorption reduces the cross-correlation function distortions caused by

ionospheric dispersion. It is shown, that the value of signal absorption depends on free electron number density in the lower part of an ionosphere. [J354]

"Clusters extracted from measured propagation channels in macrocellular environments"

The urban physical propagation environment around the mobile station is often described as a multipath environment, where power is received through diffractions over rooftops and building corners, reflections from walls and scattering in general from other surrounding objects. Since there are only finite number of these scatterers, the waves are received in clusters each originating from one of the scattering sources. To study these scatterers, direction-of-arrival data measured along continuous routes in two small macrocellular environments were analyzed. Multipaths received with approximately the same directions and delays were combined as clusters. Therefore each of the clusters corresponds to the signal received from one scatterer. This paper focuses on both the identification of the physical scatterers in the surrounding environment and studying the radio wave propagation in more detail, including the amount of significant scatterers in terms of contributed power, XPR values, and delay and azimuth spreads of the individual clusters. The results show that there are only a few dominant scatterers. They were usually building corners and walls, and building structures over the rooftop level. The delay and azimuth spreads inside the clusters were small, and depolarization was almost negligible. Both propagation over the rooftop level and propagation along the street canyons were significant in the considered environments. [J355]

"Linear dependence of double-directional spatial power spectra at 2.4 and 5.2 GHz from indoor MIMO channel measurements"

Multiple-input multiple-output (MIMO) double-directional spatial channel responses for co-located indoor measurements at 2.4 and 5.2 GHz using eight element uniform circular arrays are compared. Correlation coefficients of the power spectra demonstrate a linear dependence, indicating similarity in propagation mechanisms at the two frequencies. [J356]

"RF propagation in finite thickness unidirectional magnetic photonic crystals"

This paper presents an analysis of a new class of magnetic photonic crystals (MPCs) constructed from periodic arrangements of available (possibly anisotropic) homogeneous material layers. Earlier, analytical studies of semi-infinite versions of these crystals demonstrated that they exhibit the phenomena of minimal reflection at their interface, large amplitude growth of the harmonic wave within the crystal, and concurrent group velocity slow-down. These characteristics are associated with the so called frozen mode and occur at a specific frequency associated with a stationary inflection point within the Bloch diagram. In this paper, we present a characterization of these phenomena for a practical, finite thickness crystal slab and propose a realizable combination of materials consisting of available ferrite and dielectric media. The existence of significant wave amplitude growth and slow down are verified for materials with realistic losses. In addition, we identify and characterize the bandwidth of the magnetic photonic crystals and examine its relationship to the amplitude growth. [J357]

"Prediction of available path number in wideband mobile propagation"

A formula to predict the available path number in wideband mobile propagation is proposed. It is based on the authors' previously proposed empirical path delay profile model. The predicted values are in good agreement with measured data, demonstrating that the proposed formula is valid. [J358]

"Electrical Engineering Hall of Fame: Louis W. Austin"

The Institute of Radio Engineers (IRE) selected Louis W. Austin as the recipient of its Medal of Honor in 1927. He was cited for "his pioneer work in quantitative measurement and correlation of factors involved in radio wave transmission." He had served as the third president of the IRE in 1914 and authored numerous papers for the Proceedings of the IRE during the period from 1913 to 1932. He conducted systematic data collection and analysis of wave propagation phenomena as a longtime employee of the National Bureau of Standards. His work provided a scientific basis for the design of early transoceanic radio transmitters for the U.S. Navy and private communication companies. [J359]

"A novel site adaptive propagation model"

A site adaptive knowledge guided neural network (KGNN) propagation model, using Hata model as knowledge base (KB) is presented. It adapts to measured data with rapid convergence. [J360]

"Ultrawideband through-the-wall propagation"

The propagation of ultrawideband (UWB) signals in indoor environments is an important issue with significant impacts on the future direction and scope of UWB technology. The propagation of UWB signals is governed, among other things, by the properties of materials in the propagation medium. The information on electromagnetic properties of construction materials in the UWB frequency range would provide valuable insights into the appreciation of the capabilities and limitations of UWB technology. Although electromagnetic properties of certain construction materials over relatively narrow bandwidths in GHz frequency ranges are available, ultrawideband characterisation of most typical construction materials for UWB communication purposes has not been reported. In narrowband wireless communications, only the magnitude of insertion loss has been the quantity of interest. But for UWB signals, in addition to the magnitude, the phase information is an equally important factor that needs to be accounted for. In fact, UWB signals not only suffer attenuation when propagating through walls, but also suffer distortion due to the dispersive properties of the walls. This research examines propagation through typical construction materials and their ultrawideband characterisation. Ten commonly used construction materials are chosen for this investigation. Results for the dielectric constant and loss tangent of the materials over the UWB frequency range are presented. Accuracy of the measured results is discussed and distortions of UWB signals due to the dispersive properties of wall materials are addressed. [J361]

"A MATLAB-based two-dimensional parabolic equation radiowave propagation package"

{no data available} [J362]

"Direct conversion receiver for radio communication systems"

Direct conversion receiver (DCR) architecture, which has introduced the zero intermediate frequency (IF) approach, supports efficient wireless handset designs with a high level of integration. Transmission over wireless channels is subject to time dispersion due to multipath propagation and frequency dispersion due to Doppler effect, the design of wireless receivers are tremendously important in supporting reliable communication links. With wireless technology growing, the choice of optimal wireless receiver architecture that supports monolithic integration without performance degradation becomes an important dimension in modern handset design. The increasing demand for mobile terminals with smaller physical dimensions has led to the investigation of DCR, which supports single chip and multinode designs. Since DCR is a promising architecture for fourth generation mobile terminals, it is important to note that implementation of a certain dc offset technique does not compromise the benefits of low complexity receiver design. [J363]

"Pre-Announcement"

{no data available} [J364]

"Propagation corner"

{no data available} [J365]

"Three-dimensional modal transmission-line method for radio wave propagation through periodic building structures"

The modal transmission-line (MTL) method is used to study the transmission and reflection characteristics of a periodic building structure under the most general condition of oblique incidence (three-dimensional incidence). The presented method extends a previous analysis for the two-dimensional incidence case. Using a coordinate transformation, the reflection and transmission coefficients for an electromagnetic plane wave obliquely incident onto a periodic building structure can be solved rigorously by combining the 2-D incidence result for TE and TM polarisation, respectively. The transmission and reflection properties of concrete block and reinforced concrete walls are also analysed. Simulation findings are compared with those obtained by other researchers and the good agreement validates the extended MTL method. [J366]

"The influence of horizontally variable refractive index height profile on radio horizon range"

This letter addresses refraction effects, assuming a horizontally nonhomogeneous troposphere. The influence of a range-dependent refractivity profile on a terrestrial radio link is investigated in terms of radio horizon range. The results can be used for interference analysis in metropolitan wireless networks. An analytical ray-tracing approach was employed to derive formulas for the radio horizon range calculation, considering a horizontally variable refractivity height profile. [J367]

"Predicting the radio channel beyond second-generation wireless systems"

Ray-optical methods incorporating Geometric Optics (GO) and the Uniform Theory of Diffraction (UTD) are appropriate for the representation of radiowave propagation in cities for frequencies in the UHF band and above, where the wavelength is small compared to building dimensions. Various ray codes have been written to implement the ray representation. Because the rays undergo multiple interactions with the buildings over long distances, the codes make various assumptions to reduce running time. This paper reviews the types of assumptions that have been made, the ways in which the ray procedures have been implemented, and the accuracy that can be expected from the predictions. The paper gives examples of how the computed ray quantities have been used to simulate the characteristics of the radio channel (besides received power) that impact the designs of different radio systems. [J368]

"Neural network approach to short-term fade prediction on satellite links"

An adaptive linear neuron (ADALINE) approach to short-term prediction with application to fade mitigation control for satellite networks is presented and compared with four other short-term prediction methods. The neural network approach was found to be able to predict the underlying attenuation process the most accurately of the five methods, with few exceptions. [J369]

"A Kirchhoff Integral approach to estimating propagation in an environment with nonhomogeneous atmosphere and complex boundaries"

For terrestrial radio wave propagation, it has been previously demonstrated that second order effects, such as diffraction, can be estimated through a combination of geometric optics and Kirchhoff style integral relations. In the present paper, it is shown that the approach can also yield accurate estimates when refractive effects, such as atmospheric ducting, are present. [J370]

"In situ characterization of building materials for propagation modeling: frequency and time responses"

We propose original data processing methods for the dielectric characterization of frequency-dependent reflection coefficients of construction materials considering a very wide frequency band. Two types of approaches have been developed to obtain, from spectral measurements, estimates of the equivalent complex permittivity versus frequency or reconstruction of the impulse response. In particular, high-resolution (HR) algorithms based on the matrix pencil method have been used in an original way to identify wave multipath inside a sample. Both approaches have been used for the characterization of different types of building materials. A database of dielectric responses of materials is under construction in order to provide the deterministic propagation simulator with the characteristics of building materials. [J371]

"Decision feedback detection with error compensation for hybrid space-time block codes"

Spatial division multiplexing (SDM) techniques increase the total throughput by transmitting independent information streams through multiple transmit antennas whereas space time coding (STC) techniques utilize diversity gain. Hybrid space-time block code (STBC) schemes proposed combine the above two techniques to maximize the link performance. We propose a decision feedback detection method to improve the performance of the hybrid STBC scheme for orthogonal frequency division multiplexing (OFDM). In this scheme, we take the error propagation effect into account to enhance the detection performance. Simulation results show that the proposed method outperforms the conventional hybrid STBC detection algorithm by more than 3dB at 1% frame error rate for frequency selective fading channels. [J372]

"Minimum ON requirements for DRM reception based on field trials"

This paper presents field measurements results of minimum signal to noise ratio required to achieve a threshold BER based on the first medium wave Digital Radio Mondiale (DRM) measurement campaign in Spain. The main goal of these measurements has been to compare the laboratory simulated values recommended by the ITU with field measurements using real transmission and reception systems and real propagation and reception environments. [J373]

"Electrical Engineering Hall of Fame: Greenleaf W. Pickard"

In 1926, the Institute of Radio Engineers (IRE) awarded its Medal of Honor to Greenleaf Whittier Pickard. The award was in recognition of his contributions to research on crystal detectors, antennas, wave propagation, and noise suppression. During his long career, he was a leader in the creation of the radio engineering profession

and a prolific author of research papers published in the Proceedings of the IEEE. He served as the second president of the IRE during 1913. [J374]

"A parametric formulation of the UTD diffraction coefficient for real-time propagation prediction modeling"

This letter presents a new solution to the diffracted field for dielectric wedges within the context of the uniform theory of diffraction (UTD). The relationship between the diffraction coefficient and the four characterization factors in its formulation is studied by using the high-frequency solution for impedance-surface wedge diffraction at normal incidence in a UTD-like form in a previous paper. A polynomial curve-fitting procedure is employed through the least square criterion to obtain simplified expressions of the four factors. The result is compared with rigorous and heuristic formulations. Both parallel and perpendicular field polarizations are tested. The new parametric formulation agrees the rigorous solution reasonably well and exhibits significant improvement in accuracy over heuristic methods. This approach enables faster and more accurate evaluation of diffracted field in propagation prediction models for urban and indoor environments for potential use in real-time propagation computations. [J375]

"Block-error rate model for DPSK in Rayleigh- and sub-Rayleigh-fading channels"

Wireless transmission channels experience substantial signal degradation due to irregularities in the propagation path that impact synchronization between two communicating ends. Consequently, differential and noncoherent techniques that require no such synchronization have gained wide popularity. However, the transmitted data are still highly prone to transmission errors and appropriate error-control mechanisms have to be employed. Knowledge of the error statistics becomes crucial when designing these systems. A block-error rate (BLER) characteristic defines the error distribution within data blocks and in this paper, we propose a finite-state Markov chain-based method to evaluate BLERs in slow frequency-nonselective Rayleigh-fading channels for differential phase-shift keying. The methodology is then extended to the cases of faster Rayleigh and sub-Rayleigh fading. The model is verified by means of numerical simulation. The proposed model possesses many advantages of the well-developed Markov theory and may be easily extended to other modulation schemes such as noncoherent frequency shift keying. [J376]

"Equivalent system model and equalization of differential impulse radio UWB systems"

A discrete-time equivalent system model is derived for differential and transmitted reference (TR) ultra-wideband (UWB) impulse radio (IR) systems, operating under heavy intersymbol-interference (ISI) caused by multipath propagation. In the systems discussed, data is transmitted using differential modulation on a frame-level, i.e., among UWB pulses. Multiple pulses (frames) are used to convey a single bit. Time hopping and amplitude codes are applied for multi user communications, employing a receiver front-end that consists of a bank of pulse-pair correlators. It is shown that these UWB systems are accurately modeled by second-order discrete-time Volterra systems. This proposed nonlinear equivalent system model is the basis for developing optimal and suboptimal receivers for differential UWB communications systems under ISI. As an example, we describe a maximum likelihood sequence detector with decision feedback, to be applied at the output of the receiver front-end sampled at symbol rate, and an adaptive inverse modeling equalizer. Both methods significantly increase the robustness in presence of multipath interference at tractable complexity. [J377]

"Near-Earth wave propagation characteristics of electric dipole in presence of vegetation or snow layer"

The problem of near-earth wave propagation in the presence of a dielectric layer such as a vegetation or snow covering is considered in this paper by modeling the propagation environment as a homogeneous two-layer medium (air/dielectric/ground). A number of studies have demonstrated the relevancy of the lateral wave for the case when both the transmitter and receiver are located within a simple half-space dielectric medium . Unfortunately, for the generalized two-layer model, for configurations in which the transmitter or receiver (or both) is located above the dielectric layer, far-field analytical expressions that include all propagation features do not exist. In this paper, in order to arrive at a computational efficient solution for the two-layer model, a second-order asymptotic evaluation for the electric fields of an arbitrarily oriented, infinitesimal electric dipole-for source and observation points located in the vicinity of the air/dielectric interface-is carried out through the method of steepest descents. The formulations are valid in the far field, with the limitation that the exponentially decaying pole and branch cut contributions have been ignored. It is observed that the Norton wave, though it is highly localized near the air/dielectric interface, is a significant contribution either when the dipole and observation points are both located above the dielectric layer or when one is above and the other is within the layer. [J378]

"Comparison of near-field scattering for finite and infinite arrays of parallel conducting strips, TM incidence"

Diffraction by multiple edges are of interest for mobile radio. In this paper, the near-field scattering of an array of parallel conducting strips was computed, using an incident transverse magnetic (TM) plane wave. Finite and infinite periodic arrays were compared. The electric field integral equation together with the method of moments was employed to solve the problem; the infinite case used Floquet modes. The effect of the incidence angle on the field between strips was investigated. Comparison of results with our previous work on the transverse electric (TE) case has allowed us to observe the influence of polarization. For grazing incidence angles, it is shown that the field strength of the TM case is much weaker than the TE case. Good agreement between the finite and infinite cases is possible, even when the number of strips N is only moderately large. The infinite array uses Floquet modes and is computationally more efficient. [J379]

"Fresnel-Kirchhoff integral for 2-D and 3-D path loss in outdoor urban environments"

A deterministic model for propagation in outdoor urban environments based on the Fresnel-Kirchhoff integral is presented. Both two-dimensional (2-D) and three-dimensional (3-D) formulations considering reflection and diffraction are given. The theoretical predictions are compared with 2-D and 3-D measurements and good agreement is achieved. The 3-D experiments, conducted in an anechoic chamber with scaled models representing buildings, are described in detail and provide a benchmark for comparisons with other methods. [J380]

"Analysis of scattering from very large three-dimensional rough surfaces using MLFMM and ray-based analyses"

Several techniques are considered for the analysis of electromagnetic scattering from rough ocean surfaces. A rigorous Multi-level Fast Multipole Method (MLFMM) is employed, as well as a high-frequency ray-based solution. The MLFMM analysis is implemented in scalable form, allowing consideration of scattering from very large surfaces (in excess of 100λЧ100λ, where A represents the electromagnetic wavelength). Plane-wave incidence is assumed, and a key aspect of the MLFMM study involves investigating techniques for rough-surface truncation. The rough surface is modeled as a target placed in the presence of an infinite half-space background; to minimize edge effects, the surface is smoothly tapered into the planar half space. We also consider the technique of employing a resistive taper on the edges of the rough surface. These two truncation techniques are compared in accuracy, memory requirements (RAM), and in computational time (CPU). The MLFMM results are used to validate an approximate ray-based high-frequency model that allows rapid analysis of large surfaces. The computational results are compared to measured forward-scattering data from scaled laboratory measurements, used to simulate scattering from an ocean surface. [J381]

"Field-based scattering-matrix extraction scheme for the FVTD method exploiting a flux-splitting algorithm"

This paper introduces a novel field-based scheme for the extraction of a generalized-scattering matrix. A flux-splitting (FS) algorithm that separates the total electromagnetic field into an incident and a reflected part is used for a new definition of power waves. This flux-separation scheme, based on a plane-wave approach of the split waves, originates from finite-volume techniques. However, it can be applied locally in any numerical scheme that uses a volume discretization. To yield correct S-parameters, the FS matrix needs to be adapted through introduction of modified wave velocities to match the plane-wave condition. The introduced extraction scheme is applied to the finite-volume time-domain method and compared successfully to reference solutions for TEM and non-TEM structures, both with homogeneous and inhomogeneous cross sections. [J382]

"Courant-Hilbert waves in the troposphere"

The Courant-Hilbert solutions of the wave equation in free space are form invariant along their propagation, an important property for those interested in transmitting undistorted signals. Their amplitude does not remain constant but the fading may be compensated by convenient amplifiers. This property is not expected to persist along propagation in nonhomogeneous media but it is proved that in the troposphere with refractive index n(z)=1+βf(z) and small β, Gaussian-like beams of the Courant-Hilbert type are form invariant to the 0(β3) order of approximation. Courant-Hilbert solutions of Maxwell's equations in the troposphere are discussed and the 0(β3) explicit expressions for TE and TM Gaussian beams are given. Calculations are performed for a troposphere above a flat Earth in the vertical direction. [J383]

"Using adaline neural network for performance improvement of smart antennas in TDD wireless

communications"

In time-division-duplex (TDD) mode wireless communications, downlink beamforming performance of a smart antenna system at the base station can be degraded due to variation of spatial signature vectors corresponding to mobile users especially in fast fading scenarios. To mitigate this, downlink beams must be controlled by properly adjusting their weight vectors in response to changing propagation dynamics. This can be achieved by modeling the spatial signature vectors in the uplink period and then predicting them to be used as beamforming weight vectors for the new mobile position in the downlink transmission period. We show that ADAptive LInear NEuron (ADALINE) network modeling based prediction of spatial signatures provides certain level of performance improvement compared to conventional beamforming method that employs spatial signature obtained in previous uplink interval. We compare the performance of ADALINE with autoregressive (AR) modeling based predictions under varying channel propagation (mobile speed, multipath angle spread, and number of multipaths), and filter order/delay conditions. ADALINE modeling outperforms AR modeling in terms of downlink SNR improvement and relative error improvement especially under high mobile speeds, i.e., V=100 km/h. [J384]

"12-GHz fade durations and intervals in the tropics"

Direct-to-home very small aperture terminals systems operating at frequencies above 10 GHz in tropical climates are subjected to many fade occurrences due to heavy rain. In addition to annual and worst month cumulative rainfall rate and rain fade exceedances, statistics of seasonal and diurnal variations, together with average event length and separation, are needed to give the detailed insights for system design. This paper presents seasonal fade duration statistics and fade interval characteristics for a wet, tropical location in Lae, Papua New Guinea (PNG), measured over four years using satellite beacon and collocated radiometer receivers. [J385]

"Using radio waves to study planetary atmospheres"

In the field of electrical engineering, complex coding and signal processing techniques are the norm. Thus, it is refreshing to consider the amount of planetary science that can be done simply by using a high-quality radio. The radio, usually located on an exploring spacecraft, transmits a simple, single-frequency, sinusoidal tone that sweeps through a planet's atmosphere. After the electromagnetic energy passes through the atmosphere, it is received on the other side of the planet. Then, researchers analyze and detect the changes in the received signal energy caused by the interaction with the planet's atmosphere. The information from the received signal is used to determine the number density of particles, the temperature, and the pressure of the volume of atmosphere that the signal passed through. This method of remote sensing is known as radio occultation. The technique was first used in the summer of 1965 to measure the surface pressure on Mars. Since then, the atmospheres of all of the planets in the solar system (except for Pluto), and of some satellites, have been studied just by using a simple, sinusoidal radio signal. With continued application of the radio occultation method and with the development and implementation of higher-output multiple spacecraft constellations, the future promises to be even more productive. [J386]

"Generation of 3-D synthetic data for the modeling of the CONSERT experiment (the radiotomography of Comet 67P/Churyumov-Gerasimenko)"

This paper presents a 3-D simulation of the COmet Nucleus Sounding Experiment by Radiowave Propagation (CONSERT) radiotomography experiment of Comet 67P/Churyumov-Gerasimenko. This experiment is part of the ROSETTA space mission. Our simulation is based on a ray tracing algorithm and takes into account multiple internal reflections, power losses, phase delays and polarization distortions. We emulate as closely as possible the true CONSERT data and discuss the results of the simulation. [J387]

"Cylindrical vector eigenfunction expansion of Green dyadics for multilayered anisotropic media and its application to four-layered forest"

A complete eigenfunction expansion of the dyadic Green's functions (DGFs) for planar, arbitrary multilayered anisotropic media using cylindrical vector wave functions is presented. These formulations are constructed based on the principle of scattering superposition. For the scattering dyadic Green's function in each layer, the scattering coefficients of TE and TM modes are determined from the boundary conditions matched at the planar interfaces. The explicit representation of the DGFs after reduction to the isotropic case agrees well with the existing results corresponding to the isotropic media. The general DGFs for multilayered anisotropic media are then reduced to those for a four-layered forest where the trunk layer is modeled as anisotropic medium. Application is further made for radio-wave propagation through forests of a four-layered geometry, whereas it is shown how these Green dyadic formulations are used in a practical way and how the field distributions due to a dipole can be obtained. [J388]

"Three-dimensional FDTD modeling of impulsive ELF propagation about the earth-sphere"

This paper reports the application of an efficient finite-difference time-domain (FDTD) algorithm to model impulsive extremely low frequency (ELF) propagation within the entire Earth-ionosphere cavity. Periodic boundary conditions are used in conjunction with a three-dimensional latitude-longitude FDTD space lattice which wraps around the complete Earth-sphere. Adaptive combination of adjacent grid cells in the east-west direction minimizes cell eccentricity upon approaching the poles and hence maintains Courant stability for relatively large time steps. This technique permits a direct, three-dimensional time-domain calculation of impulsive, round-the-world ELF propagation accounting for arbitrary horizontal as well as vertical geometrical and electrical inhomogeneities/anisotropies of the excitation, ionosphere, lithosphere, and oceans. The numerical model is verified by comparing its results for ELF propagation attenuation with corresponding data reported in the literature. [J389]

"Modeling the effects of ionospheric scintillations on LEO Satellite communications"

The fading statistics of the received signal caused by ionospheric scintillations for a given Earth station in low-Earth orbit (LEO) satellite communication network are studied using the recently available scintillation model. The path distribution from the Earth station to the satellite and the fading statistics of each path are considered. This time-varying channel model allows engineers to understand the effects of ionospheric scintillations on a given Earth station and then determine margins necessary for communication systems in times of severe scintillations. [J390]

"A tree-scattering model for improved propagation prediction in urban microcells"

This paper presents a model for the scattering of radiowaves from the canopy of a single tree. The canopy is modeled as a cylindrical volume containing randomly distributed and oriented cylinders, representing the branches, and thin disks, representing the leaves. A simple expression for the incoherent scattered field outside the canopy is obtained using Twersky's multiple scattering theory. This expression is shown to agree well with results of scattering measurements on a live tree typical of those found in urban environments. The scattering model can be readily incorporated in ray-based propagation prediction tools that assist the planning of microcellular radio networks. This involves the use of so-called tree-scattered rays, which interact at the tree centers. Path loss predictions generated with the aid of the new model are shown and compared with measured data to illustrate the considerable improvement in prediction accuracy that can be achieved in realistic urban microcellular scenarios by taking into account the scatter from trees. [J391]

"OTHR multipath tracking with uncertain coordinate registration"

Multipath probabilistic data association (MPDA) exploits discrete multipath propagation to improve tracking performance for systems such as over-the-horizon radar (OTHR). The original formulation assumed a known ionospheric environment for mapping radar measurements to ground coordinates. We consider an extension of the technique that allows for ionospheric uncertainties affecting the transformation between slant and ground coordinates in addition to the usual sensor noise. A new technique, MPDA for uncertain coordinate registration (MPCR), is described and tested on simulated and real OTHR data. The study assumes a two-layer spherical mirror ionosphere with random fluctuations of the ionospheric heights around known mean values. An extensive Monte Carlo analysis of track errors and track loss is carried out for MPCR under two scenarios and the results are compared with a baseline probabilistic data association (PDA) approach and with MPDA. The results indicate the high reliability of the MPCR approach. [J392]

"In-vehicle WLAN radio-frequency communication characterization"

Recently, new standards have emerged in the telecommunication industry, which provide an open global specification that enables mobile devices to access and interact with information and services instantly. These mobile devices are, for example, laptops and personal digital assistants. These emerging standards, generically called wireless "x" area networks (WxAN), will in the future be frequently operated from inside vehicles as part of the deployment of mobile offices and to support advanced intelligent transportation system services. These wireless networks currently operate between 1-6 GHz, although 60 GHz could be used when the technology will be economically viable. These mobile devices are frequently put to use in vehicles. To be ensure that portable equipment left in a jacket pocket somewhere in the trunk can interact with other car equipment or portable objects elsewhere in the car needs some investigation. Thus, this paper characterizes radio-frequency propagation inside vehicle bodies, with passengers, in order to evaluate the effectiveness of such a WxAN in vehicle environments. [J393]

"Observed effects of cloud and wind on the intensity and spectrum of scintillation"

This paper examines the observed effects of wind and cloud presence on the intensity and power spectrum of tropospheric scintillation, using propagation data recorded during a three-month period (May-July 1997) at Sparsholt from the ITALSAT satellite beacons at 39.59 and 49.49 GHz. The results show strong correlation between corner frequency and transverse wind speed, a weaker correlation with overall wind speed and a negligible correlation between scintillation intensity and transverse wind speed. Furthermore, it was found that the presence of cumulus clouds led on average to increased scintillation levels and a reduced correlation of the corner frequency with wind speed. [J394]

"Comparison of measurements with prediction methods for propagation by diffraction at 88-108 MHz"

Three methods for predicting attenuation due to diffraction are tested against a large database of 115 614 measurement points, representing 115 614 different path profiles of 100-m horizontal resolution, and vertical root mean square error of about 6 m. The signal level at each geographic measurement point is calculated as the median of about 40 basic measurements, and the measurement database is thus reduced from about four million basic measurements. The mobile measurements are taken from main FM (88-108 MHz) broadcasting emitters located in southern Norway, and the corresponding broadcasting antenna diagrams have been measured by helicopter. Path profiles are categorized by number of terrain obstructions between emitter and receiver, in order to study their effect on each propagation loss method. The current ITU method and Picquenard's construction, with a variable number of included terrain obstructions, are compared with the measurements, and difference statistics are calculated. A particular version of Picquenard's construction is shown to be better than the current ITU method in terrain of Norwegian type. This new method is, in contrast to the ITU method, within the estimated expected errors resulting from using Norwegian digital terrain elevation data. [J395]

"Optimisation of radio coverage in urban microcells using a UTD based ray-tracing model"

In cellular communications, requirements for increased system capacity, improved coverage, better quality and reduced transmitter power, along with the need to rationalise cellular system planning, have prompted a considerable interest in the development of valid and efficient radiowave propagation models. This work utilises recent advances that improve the accuracy and efficiency of ray-tracing models, using a three-dimensional representation of the terrain and urban topographies, in conjunction with adaptive and selective ray-tracing. These improvements allow utilisation of the field computation algorithms in the network design and radio coverage planning processes. They include optimum automated selection of base station locations and phased array excitation. A reliable ray-tracing scheme can be utilised directly in the optimum and, potentially, adaptive beamforming of base station antenna systems by interfacing field computations with design aims. The paper addresses a cellular planning process, which involves determination of the antenna array position and beam shape or, equivalently, the array excitation coefficients, for a desired power distribution over the defined cell area. [J396]

"Impact of ionospheric scintillations on LEO satellite DS-CDMA communication system"

The impact of ionospheric scintillations is investigated in terms of bit error rate for a multispot beam LEO satellite communication system employing direct sequence-code division multiple access (DS-CDMA) technique. Depending on the satellite orbit parameters and the Earth station location, the effect of time-varying ionospheric scintillation on the system varies. Performance degradation can be substantial in times of severe scintillations. [J397]

"Simulation of dual array multipath channels using mode-stirred reverberation chambers"

A new way to experimentally simulate propagation channels between antenna arrays using coupled mode-stirred reverberation chambers is presented. This technique, which can be performed in a laboratory facility, is simple to use and allows the easy modification of the channel characteristics. [J398]

"Fade-resistant transmission over time-varying wireless channels"

Performance of a parallel symbol transmission scheme is analyzed in time-varying Nakagami fading channels. We show that instantaneous signal-to-interference-plus-noise ratio of the parallel symbol transmission scheme at the matched-filter output is higher than that of a conventional system. Furthermore, the performance gain of the parallel symbol transmission scheme over the conventional system increases as the number of independent fades within the frame increases and/or the Nakagami parameter m decreases. [J399]

"A building-transmission model for improved propagation prediction in urban microcells"

This paper presents a model for the propagation of radiowaves through buildings. The model can be used as a seamless extension to ray-based propagation prediction models that only consider external reflection and diffraction, as do most current models. This involves the use of so-called transmitted rays, which are traced through building walls. Outdoor-to-indoor propagation (building penetration) is automatically taken into account as a "by-product". The transmission model requires no information about each building's interior other than a specific attenuation factor that describes the global behavior of the field inside the building. This coefficient can be determined for individual buildings by measuring the excess loss associated with the propagation path through the building. It is shown, however, that no large errors are to be expected if all buildings are characterized by the average of the empirical values obtained in this study, at 1.9 GHz. Path loss predictions generated with the aid of the new model are shown and compared with measured data to illustrate the considerable improvement in accuracy that can be achieved in realistic urban microcell scenarios by taking into account building penetration and transmission. [J400]

"Super-resolution TOA estimation with diversity for indoor geolocation"

This paper presents an in-depth investigation of frequency-domain super-resolution time-of-arrival (TOA) estimation with diversity techniques for indoor geolocation applications. A methodology for performance evaluation of super-resolution techniques based on the measurements of indoor radio propagation channels is presented. The performance of super-resolution techniques is compared with the performance of conventional TOA estimation techniques. The effects of diversity techniques on the performance of super-resolution techniques are evaluated. The measurement and simulation methods presented in this paper can be used to establish empirical performance bounds for real implementation of super-resolution indoor geolocation systems. [J401]

"Rain attenuation measurement on Ku-band satellite TV downlink in small island countries"

Analysis of 13-year rain-rate measurements in Fiji shows that the rain exceeded 50 mm/h for 0.01% of a year (R0.01), which is significantly lower than those predicted by existing models. Simultaneous measurements of Ku-band attenuation and rain-rate give A0.01and R0.01as 9.7 dB and 54 mm/h, respectively. The ratio of attenuation exceedence for the worst month and yearly (at A=A0.01) was 1.8, which is lower than that predicted by the ITU-R study group. The attenuation exceeds the Ku-band link margin for about 15.6 h in a year. [J402]

"Accuracy of geometric channel-modeling methods"

When constructing a propagation channel model, a substitute is often created by giving an arbitrary shape or form to scatterer distributions based on its intuitive appeal for a certain radio environment. However, such models do not necessarily represent the actual propagation process and may yield inaccurate results. The main objective of this paper is to provide an insight into the underlying relationship between geometric models and the particular physical propagation process they represent. The workhorse is the semi-geometrically based statistical (SGBS) model and the two heuristic rules. The SGBS model defines the distribution of dominant scatterers contributing to the last reradiation of multipath components to the base station. The earlier multiple-reflection process is modeled using the composite Nakagami/log-normal probability density function. Two parameters are then introduced; namely, the effective path length and the normalized space-dependent intensity measure. Using these two metrics, two heuristic rules are subsequently proposed to provide the missing link between the canonical models and the physical channel. The rules are then applied to revisit several widely used geometric models in macro- and microcellular environments. As a working example, the Gaussian scatterer density model is further extended using such an approach. Important channel parameters such as power azimuthal spectrum, power delay spectrum, and azimuthal and delay spreads are then calculated and compared with simulation results. [J403]

"Analysis of multipath Routing-Part I: the effect on the packet delivery ratio"

In this paper, we develop an analytical framework for evaluating multipath routing in mobile ad hoc networks. The instability of the topology (e.g., failure of links) in this type of network due to nodal mobility and changes in wireless propagation conditions makes transmission of time-sensitive information a challenging problem. To combat the inherent unreliability of these networks, we propose a routing scheme that uses multiple paths simultaneously by splitting the information between a multitude of paths, so as to increase the probability that the essential portion of the information is received at the destination without incurring excessive delay. Our scheme works by adding an overhead to each packet, which is calculated as a linear function of the original packet bits. The resulting packet (information and overhead) is fragmented into smaller blocks and distributed over the

available paths. The probability of reconstructing the original information at the destination is derived in an analytical form and its behavior is studied for some special cases. It is shown that, under certain constraints, the packet dropping probability decreases as the number of used paths is increased. [J404]

"A generic model for MIMO wireless propagation channels in macro- and microcells"

This paper derives a generic model for the multiple-input multiple-output (MIMO) wireless channel. The model incorporates important effects, including i) interdependency of directions-of-arrival and directions-of-departure, ii) large delay and angle dispersion by propagation via far clusters, and iii) rank reduction of the transfer function matrix. We propose a geometry-based model that includes the propagation effects that are critical for MIMO performance: i) single scattering around the BS and MS, ii) scattering by far clusters, iii) double-scattering, iv) waveguiding, and v) diffraction by roof edges. The required parameters for the complete definition of the model are enumerated, and typical parameter values in macro and microcellular environments are discussed. [J405]

"Adaptation of the code rate and transmitter power in frequency-hop communications"

An adaptive transmission technique for frequency-hop packet transmission is described and its performance is evaluated for certain channels with unknown or time-varying parameters. The power in the transmitted signal and the rate of the error-control code are adapted in a way that provides energy-efficient communications. The slow-frequency-hop packet transmissions have several bits per hop and several hops per packet. Feedback is limited to a few bits in each acknowledgment packet, and the feedback for our adaptive transmission consists of only the counts of errors and erasures from the previous packet transmission. The performance of the adaptive transmission system is evaluated for channels with unknown but fixed partial-band interference and propagation loss and for certain channels with time-varying partial-band interference and propagation loss. [J406]

"Range and antenna beamwidth dependencies in multidimensional fixed wireless channels"

This paper describes a multidimensional model of the fixed wireless propagation channel, which is well suited to system-level simulations. The proposed method yields realistic predictions of various channel characteristic parameters as a function of the range and antenna beamwidths, in agreement with experimentally observed results. The originality of the approach is that the power-delay profile for omnidirectional antennas at the edge of the cell is used to predict the time-varying channel over the whole cell for any antenna beamwidth. The method is based on a set of spatially distributed scatterers, which can be scaled to any range within the cell. The time-varying channel impulse response is then calculated as the combination of all scattered contributions by means of a ray approximation. The multidimensionality of the channel model is explored through predictions of signal statistics, level-crossing rate, delay-spread and angle-spread. In contrast to most existing models, the impact of range and antenna beamwidth is clearly addressed and found to be close to experimentally observed behaviors. [J407]

"Ionospheric effects for L-band 2-D interferometric radiometry"

Ionospheric effects are a potential error source for the estimation of surface quantities such as sea surface salinity, using L-band radiometry. This study is carried out in the context of the SMOS future space mission, which uses an interferometric radiometer. We first describe the way the Faraday rotation angle due to electron content along the observing path varies across the two-dimensional field of view. Over open ocean surfaces, we show that it is possible to retrieve the total electron content (TEC) at nadir from radiometric data considered over the bulk of the field of view, with an accuracy better than 0.5 TEC units, compatible with requirements for surface salinity observations. Using a full-polarimetric design improves the accuracy on the estimated TEC value. The random uncertainty on retrieved salinity is decreased by about 15% with respect to results obtained when using only data for the first Stokes parameter, which is immune to Faraday rotation. Similarly, TEC values over land surfaces may be retrieved with the accuracy required in the context of soil moisture measurements. Finally, direct TEC estimation provides information which should allow to correct for ionospheric attenuation as well. [J408]

"Satellite communications at KU, KA, and V bands: Propagation impairments and mitigation techniques"

This article surveys the alternative fade mitigation techniques for satellite communication systems operating at Ku, Ka and V frequency bands. The specific phenomena influencing the propagation of radiowaves on Earth-space links are also overviewed. Emphasis is placed on modeling, experimental work carried out in the past, and practical implementations related to each mitigation technique. [J409]

"Numerical method for calculating LF sky-wave, ground-wave and their resultant wave field strengths"

A wave hop method for calculating field strengths of sky-waves, the ground-wave and the resultant of those wave components at frequencies from 60 to 500 kHz up to 4000 km is presented. The diurnal and distance variations of resultant field strengths predicted with the method for various transmission conditions show good agreement with those measured. [J410]

"Effects of the ground and the human body on the performance of a handset antenna"

The effects of the whole human body and the ground on the performance of a handset antenna are studied through EM simulation. The complexity of the radiation pattern of a handset antenna is illustrated, and the specific absorption rate (SAR) level inside the head is increased using a more realistic model which includes the partial ground, the whole body and the hand. Four human models of different heights are compared, showing that the changing of model height has an effect on the SAR inside the human body and causes a slight variation of the far-field pattern. However, the different property of the ground plane has a more noticeable effect on the SAR and the far-field patterns. [J411]

"Progressive and approximate techniques in ray-tracing-based radio wave propagation prediction models"

Progressive and approximate techniques are proposed here for ray-tracing systems used to predict radio propagation. In a progressive prediction system, intermediate prediction results are fed back to users continuously. As more raypaths are processed, the accuracy of prediction results improves progressively. We consider how to construct a progressive system that satisfies the requirements of continuous observability and controllability as well as faithfulness and fairness. Adding a workload estimator to such a progressive prediction system allows termination of the computation when a desired accuracy (mean and standard deviation of the error) is achieved without knowing the final result that would be obtained if the prediction system runs to completion. The sample generator is at the core of the progressive prediction system and serves to cluster and prioritize raypaths according to their expected contributions to prediction results. Two types of progressive approaches, source-group-raypath-permute and raypath-interleave, are proposed. The workload estimator determines the number of raypaths to be processed to achieve the specified requirement on prediction accuracy. Two approximate models are described that adjust the workload dynamically during the prediction process. Our experiments show that the proposed progressive and approximate methods provide flexible mechanisms to trade prediction accuracy for prediction time in a relatively fine granularity. [J412]

"Radio disturbance of high frequency surface wave radar"

Based on a dual-polarisation high frequency surface wave radar system, main characteristics and performance of radio are described, and a new polarisation filter (adaptive phase-shift polarisation (ANPSP)) is proposed. Filtering the disturbance in each pulse and keeping the original phases of the targets, more than 50 dB SIR improvement is expected with experimentally derived data. [J413]

"Deployable antenna with 10-m maximum diameter for space use"

This paper describes a large deployable antenna which is used at L-, C-, and Ka-bands on an artificial satellite in space. The main reflector with 10-m maximum diameter is formed using the tensioned truss concept which was proposed by one of the authors. The mechanical structure of the antenna is briefly explained and a more detailed description given of the electrical design of the antenna and the verification method of electrical characteristics. This antenna was successfully launched and deployed in space in 1997 and is used for a Space VLBI mission. [J414]

"A statistical model for over rooftop propagation"

A novel statistical model for over rooftop (ORT) propagation in an urban environment is presented in this paper. The proposed algorithm is based on an automatic extraction of the relevant environment parameters from the urban map. These parameters are used to build up a statistical description of the environment geometry through analytical pdf functions from which statistical estimates of the propagation loss are derived by mathematical processing and the use of simple, deterministic ORT models. Finally, analytical formulas for the direct derivation of the average ORT loss and its variance from the environment parameters are proposed. [J415]

"Rain attenuation statistics over terrestrial microwave link at 19.4 GHz at Amritsar"

Rain induced attenuation at 19.4 GHz over a terrestrial path link of 2.29 km was measured for the period of one year (i.e. from January to December 2001) at Amritsar (31°36' N 74° 52' E). An empirical model for predicting rain-induced attenuation on terrestrial line of sight microwave link has been proposed in this paper. Experimentally measured results have been compared with those obtained using international radio communication union (ITU-R). It has been observed that our results differ from those predicted using ITU-R model. [J416]

"On the analysis of statistical distributions of UWB signal scattering by random rough surfaces based on Monte Carlo simulations of Maxwell equations"

The field strength level of received signal and its statistical distributions are important in the study of signal propagation and scattering for wireless communication and remote sensing. In this paper, the scattering by random rough surface is analyzed by solving the solution of Maxwell equation. The method of moments is used to discretize the integral equation into the matrix equation. The sparse-matrix canonical grid method, which is a fast matrix solver, is applied in the analysis. Conjugate gradient (CG) method is adopted to solve the solution of matrix equation. With the solution of Maxwell equations, the magnitude of the scattered field is then used to predict the field statistics. Both time harmonic scattering and ultrawide-band (UWB) scattering are considered. For the time domain response, the electromagnetic scattered field in the vicinity of center of rough surfaces is first calculated in the frequency domain. Then the time domain signal is obtained by mean of the Fourier transform. The fading statistics are compared with that of the Rayleigh and Nakagami distributions. Results reveal that UWB signal exhibits less fading than the narrow band signal. [J417]

"Correction to "Separation of Simultaneous Rain and Ice Depolarization""

{no data available} [J418]

"Effects of multipath propagation delay on uplink performance of synchronous DS-CDMA systems communicating in dispersive Rayleigh fading channels"

The effect of the maximum asynchronous arrival time difference (AATD) of the delayed multipath components on the uplink performance of synchronous DS-CDMA systems is investigated, when communicating in a frequency-selective Rayleigh fading channel. Numerical results demonstrate that the achievable user capacity gain may be as high as 64% at a bit error rate (BER) of 10-2, when the maximum AATD is sufficiently low. [J419]

"Rough surface scattering from exterior walls at 28 GHz"

In this study we investigated the Local Multipoint Distribution Service band (28 GHz) rough surface scattering properties of limestone and brick walls. Our ultimate goal is to understand the characteristics of radio paths that involve one or more bounces from these walls. In the experiment described here, we processed impulse response data to produce power delay profiles and calculate relevant channel metrics. In particular, we investigated the scattered signal behavior for different incident angles and transmitter-receiver geometries. Using the reflected pulse width and maximum excess delay derived from each power delay profile, we found that limestone and brick walls exhibited measurable diffuse scattering. The reflected pulse from a limestone wall has more maximum excess delay spread than does a brick wall at the -15 dB power threshold. The mean maximum excess delay for the reflected pulse for the limestone wall measurement configurations was more than twice that of the brick wall. With equal transmitter and receiver distances to the wall, we found that the maximum excess delay decreased and the perpendicular reflection coefficient increased with incident angle. [J420]

"Propagation of electromagnetic waves at MHz frequencies through seawater"

The nature of the ocean environment and its vast size has necessitated the development of sophisticated equipment and techniques for various underwater applications including diver-to-diver communications, ROV/AUV docking, communications and oil and gas explorations. To facilitate scientific exploration a wide variety of systems and vehicles have been developed to operate within the shallow continental shelf region or in deep oceans. For successful underwater electromagnetic (EM) wave operation, knowledge is required of the wave transmission properties of seawater over all distances both short and long. This information is required for such activities such as: sensor systems, imaging, position fixing, measurement of speed, obstacle detection and avoidance, guidance, communication of data/voice and remote control. This paper presents a new approach of EM wave propagation through seawater. The experimental results conducted in the laboratory and the real environment of seawater is presented. [J421]

"Feed forward neural networks for path loss prediction in urban environment"

A new method based on feed-forward neural networks for propagation loss prediction in urban environment is introduced in this paper. This method is particularly suited for application in mobile network planning. [J422]

"Height gain measurements for DTV reception in Singapore"

Very few height-gain measurements have been made especially in built-up areas. Measurements made in Singapore confirm that the height-gain is different in different locations and depends on the local clutter, ground reflection and the radiation pattern of the transmitting antenna. In high rise HDB (Housing Development Board) estates, height loss is observed instead of gain. [J423]

"A ray-shooting visualization MATLAB package for 2D ground-wave propagation simulations"

This paper introduces a simple ray-shooting MATLAB package for the visualization of ray paths for ground-wave propagation simulations. The package can be used to model wave propagation though complex wave-guiding environments, either as an educational tool for understanding electromagnetics (EM), or as a design tool to visualize geometrical optics (GO) ray propagation, reflection, and refraction. [J424]

"Signal distribution in the azimuth, elevation, and time-delay domains in urban radio communication links"

We investigate the mutual power-spectra distributions in the azimuth, elevation, and time-delay domains in different urban environments with randomly distributed arrays of buildings placed on rough terrain. This is done for various orientations of street guiding structures in the urban scene, and for different elevations of the terminal antenna, the base station, and the subscriber, whether mobile or not, and with respect to the buildings' overlay profile. A combination of the stochastic multi-parametric and crossing-street waveguide models, created earlier, is used to describe a total probability-density function (PDF) of mutual azimuth time-delay, elevation time-delay, and azimuth-elevation distribution of multiply reflected signals arriving at the receiver after multiple reflection, diffraction, and scattering from the numerous obstructions surrounding both terminal antennas. Comparisons with some high-resolution three-dimensional measurements, as well as with the corresponding three-dimensional numerical ray-tracing model, are done to describe directional and spatial-temporal urban channel characteristics, and to predict propagation situations in the urban scene for various locations and directional properties of the terminal antennas. [J425]

"Dispersive FDTD characterisation of no phase-delay radio transmission over layered left-handed meta-materials structure"

At the interface of two materials with different permittivity and permeability, evanescent waves are excited and will constrain perfect imaging using left-handed meta-materials (LHMs). The dispersive finite-difference time-domain method is used to demonstrate that multilayer stacks, which consist of thin alternating layers of conventional materials and LHMs, can guide evanescent waves with very little attenuation at microwave frequencies and over large stack thicknesses. In addition, such layered structures demonstrate zero phase-delay over the stack thickness, a property that may be applied to construct a no phase-delay transmission line for applications such as beam forming networks for antenna arrays. [J426]

"ELF communication: an obituary"

Briefly reviews the history of ELF communications. [J427]

"Globally optimal transmitter placement for indoor wireless communication systems"

A global optimization technique is applied to solve the optimal transmitter placement problem for indoor wireless systems. An efficient pattern search algorithm-DIviding RECTangles (DIRECT) of Jones et al.- has been connected to a parallel three-dimensional radio propagation ray tracing modeler running on a 200-node Beowulf cluster of Linux workstations. Surrogate functions for a parallel wideband code-division multiple-access (WCDMA) simulator were used to estimate the system performance for the global optimization algorithm. Power coverage and bit-error rate are considered as two different criteria for optimizing locations of a specified number of transmitters across the feasible region of the design space. This paper briefly describes the underlying radio propagation and WCDMA simulations and focuses on the design issues of the optimization loop. [J428]

"On the eigenvalue distribution of smart-antenna arrays in wireless communication systems"

The recent development of communication theory and smart-antenna techniques such as space-time coding (STC), which exchange efficiency for complexity, has intensified the interest in a general theory of multiple-

antenna communication. These techniques use parallel channels to increase the capacity of wireless systems. The parallel channels are formed either in a natural way, due to radiowave propagation (receiving diversity, RD, RAKE), or in an artificial way, due to appropriate pre-processing and coding (transmitting diversity, TD, STC), or in both ways (multiple-input multiple-output, MIMO, systems, STC, BLAST). The demand for ubiquitous, heterogeneous, and sophisticated wireless systems has led to the need for a better understanding of fundamental issues in space-time communication theory, and their implications for the design of reliable, high-bandwidth and high-speed wireless communications. The authors discuss the issue of eigenvalue distribution for antenna arrays. The present article provides an approach that should be useful in simulations, analysis, and design of smart-antenna wireless systems. The results show that this parameter of the spatial channel has an important rcHe to play in analyzing the performance of antenna arrays in wireless systems. [J429]

"Doppler measurements of smooth and rough surface high frequency scattering from spinning steel cylinders"

Preliminary measurement results gathered using a fully coherent 77GHz phase coded pulse Doppler polarimetric radar and investigating the electromagnetic signatures of electrically large spinning steel cylinders are presented. New and novel results showing the Doppler contributions due to dynamic rough and smooth surface scattering effects are discussed and analysed. In the latter case, significant sideband conversion occurs together with a rapid fall off in the power density spectrum. Future work is proposed and discussed. A fuller analysis of these preliminary results and further results was presented. [J430]

"From Poldhu to the Italian station of Coltano: Marconi and the first years of transcontinental wireless"

This paper presents the evolution of low-frequency, high-power transcontinental transmission, starting from the first successful transatlantic link from Poldhu up to the Italian transcontinental station of Coltano. The trend toward higher and higher transmitting power, and the dead end into which wireless was heading if it were not for research in the higher frequency ranges, are pointed out. [J431]

"Omnidirectional vehicle antenna for measurement of radio coverage at 2 GHz v.2.0"

To accurately determine radio coverage, it is necessary to have an omnidirectional antenna pattern. Our measurement results show that this is not the case for an antenna mounted on a vehicle. We present two improved antenna solutions with an additional ground plane in the form of a disk and a corrugated cone. The peak-to-peak variation in the horizontal plane is then reduced from 5 to 2.5 dB and 1.7 dB, respectively. Although our results are limited to a medium-size vehicle and frequencies around 2 GHz, we believe that they are of interest for all measurements where high accuracy is desired. [J432]

"Wide-band measurements of nondeterministic effects on the BRAN indoor radio channel"

External nonstatic effects on the indoor radio channel can be classified according to their natures; they can be quasistatic, as are those due to the furnishing and decoration of rooms, or clearly dynamic, as are those forced by the movement of people and pets within the propagation environment. So, it can be stated that people acting and walking nearby the antennas of radio-communication systems introduce nondeterministic effects in the radio channel, whereas walls, ceiling, floors, and even doors and windows are structural elements whose influence can be modeled by ray-tracing tools, the activity of people (both movement and variations in the distribution of elements such as furniture or decorative objects) introduces stochastic components in the channel characteristics prediction. Deterministic tools cannot model these effects, but their experimental knowledge will allow radio-network designers to keep guard values for the different design parameters at the same time that they plan the radio network. In this manner, the quality of service provided by these communication systems could be preserved. This paper shows the results and analysis of measurement campaigns performed in static and dynamic conditions, in order to compare the behavior of both narrow and wide-band parameters of the radio channel, including people activity within the environment. [J433]

"Propagation model for vegetation effects in terrestrial and satellite mobile systems"

This communication presents information about the characteristics of vegetation in terms of their effects in a propagation environment for terrestrial and satellite mobile communications. This information has been obtained through a measurement campaign and comparison of measured data and existing models. The results can be used in prediction models and ray-tracing algorithms for mobile communications and land mobile satellite systems applications. A new propagation model useful for path loss prediction in roadside tree environment is also proposed. [J434]

"Recent system applications of short-pulse ultra-wideband (UWB) technology"

Developed in the early 1960s, time-domain electromagnetics, the study of electromagnetic-wave propagation from a time-domain perspective, has given birth to a fascinating new technology, which today is commonly referred to as ultra-wideband (UWB). It has now been slightly more than 25 years since the 1978 seminal paper of Bennett and Ross, which summarized UWB's early applications. It thus seems appropriate, given the tremendous increase in interest in the technology since the Federal Communications Commission modified its Part 15 rules to accommodate UWB transmissions, to take a look at more recent system applications of this unique technology. This paper provides a brief historical perspective of UWB, discusses recent techniques for the generation and reception of short-pulse electromagnetic waveforms, and examines a number of recently developed UWB systems in the communications, radar, and precision-positioning fields. Finally, a brief assessment of future trends for the technology is provided. [J435]

"Rice statistical propagation channel sounding: coherence bandwidth measurement by microwave interferometric sensor"

Numerical and wireless communications systems are led by the coherent frequency bandwidth (BC) of the propagation channel where the wireless link is considered. An original method is presented to achieve the BC of a channel having a Rice's statistic law (one or more paths are without reflection between transmitter and receiver) which is based on the mitigation, by using a microwave interferometric sensor and a narrowband multitone transmitter, of the phase difference error due to multipaths. [J436]

"Performance of directed retry in nonuniform cellular environments"

This paper investigates the effects of directed retry (DR) in cellular networks characterized by a nonuniform environment, that is, with unequal distribution of users and/or radio resources. We propose an analytical model able to take both propagation and network aspects into account. The nonuniform environment is modeled assuming the superposition on a uniform scenario of a circular area characterized by different offered load or radio capacity. The case of a hot spot of users is included. Path loss and lognormal shadowing have been considered. This is done through a statistical approach which is very general, and provides an expression for the probability of receiving a suitable power level from a given number of base stations within a fixed distance from the mobile. A comparison to simulation results is performed to validate the model. We show that the impact of DR on the blocking probability depends largely on the propagation parameters considered. [J437]

"Electromagnetic forward-scattering measurements over a known, controlled sea surface at grazing"

A series of low-angle radar measurements were conducted over a large wave pool capable of producing a wide range of scaled sea conditions. The X-band (8-12 GHz) measurements were performed for 1°, 3°, and 5° look down angles (LDAs) for the HH and VV polarizations. The roughened water simulated a one-dimensional 1/10th-scale Pierson-Moskowitz surface at sea states 0, 3, and 5. The wave profiles were detailed using both ultrasonic point detectors and a laser sheeting technique capable of measuring a cross section of the sea. The compiled data represent the first forward-scattering measurement 1) preformed under a variety of controlled conditions for low grazing angles and 2) with detail profiling of the wave structure syncronized with the radar. Presented are the experimental setup with calibration methodology, measurement conditions, and selected radio-frequency forward-scattering (HH polarization) results for the 5° LDA for sea state 0, 3, and 5 sea conditions. [J438]

"An advanced field prediction model including diffuse scattering"

Ray tracing (RT) models are now widely adopted for field prediction in urban environment. Nevertheless, conventional RT tools still suffer for excessive central processing unit (CPU) time and inaccuracy in wide-band prediction. By increasing the maximum number of successive interactions (reflections, diffractions) little improvement in wide-band results can be usually achieved while CPU time increases exponentially. In the present paper, it is shown that by integrating reflection/diffraction with diffuse scattering, good narrow-band and wide-band results can be obtained with a low number of interactions. The adopted scattering model is a simple ray-based model, which has been embedded in a three-dimensional (3-D) RT program. The impact of diffuse scattering on narrowband and wide-band parameters is analyzed in the paper and the complete model is compared with measurements in a variety of cases, showing the validity of the approach. [J439]

"Multibaseline ATI-SAR for robust ocean surface velocity estimation"

An open problem of along-track interferometry (ATI) for synthetic aperture radar (SAR) sensing of ocean surface

currents is the need of ancillary wind information for inversion of Doppler centroid measurements, that have to be compensated for the propagation velocity of advancing and/or receding Bragg scatterers. We propose three classes of estimators which exploit multibaseline (MB) ATI acquisition and Doppler resolution for robust data inversion under different degrees of a priori information about the wind direction and the value of the characteristic Bragg frequency. Performance analysis and comparison with conventional ATI show that the proposed MB estimators can produce accurate velocity estimates in the absence of detailed ancillary data. [J440]

"Rigorous coupled-wave analysis of radio wave propagation through periodic building structures"

The transmission and reflection characteristics of a periodic wall structure are studied by a rigorous coupled-wave analysis (RCWA) method. The presented method solves the reflection and transmission coefficients for an electromagnetic plane wave, obliquely incident onto a periodic multilayer building structure. Simulation findings are compared with those obtained by other researchers. The transmission and reflection properties of concrete block and reinforced concrete walls are also analyzed. The good agreement of the simulation results with previous published results validates the recommended RCWA method. [J441]

"A novel ToA location algorithm using LoS range estimation for NLoS environments"

One of the main problems facing accurate location in wireless communication systems is nonline-of-sight (NLoS) propagation. In this paper, we propose a novel location technique that estimates the true, or line-of-sight (LoS), ranges based on NLoS range measurements. This approach utilizes a constrained nonlinear optimization approach, when range measurements are available from three base stations (BSs) only. Bounds on the NLoS error and the relationship between the true ranges are extracted from the geometry of the cell layout and the measured range circles to serve as constraints. Simulations studying the performance of the algorithm for different NLoS error distributions and BS configurations show that the location accuracy is significantly improved over traditional algorithms, even under highly NLoS conditions. [J442]

"Efficient multi-ray propagation model for DSRC EM environment on express highway"

An efficient multi-ray propagation model, which uses 3D geometry and image techniques to trace multiple signal rays from transmitter to receiver, is employed to analyse the electromagnetic environment of a dedicated short-range communication system on an express highway. The employed model is effective for investigating the location of EM wave absorbers to be set up on the highway, and it takes only a fraction of a minute for computation. [J443]

"Stochastic rays pulse propagation"

We consider a stochastic-ray model of wave propagation based on the theory of random walks that accounts for only two parameters: the amount of clutter and the amount of absorption in the environment. This model applies to indoor and outdoor environments, characterized by a large number of (small) scattering objects. Examples are microcells for personal communication and networks of multihop wireless sensors or laptop computers. We extend our previous results on narrow-band signals to impulse waveforms, deriving a closed form solution for the power delay profile of the received signal. [J444]

"A novel single base station location technique for microcellular wireless networks: description and validation by a deterministic propagation model"

Positioning algorithms in cellular networks has become increasingly important as a means of supporting emerging services that require a sufficiently precise estimation of the position of the mobile terminal (MT) associated with a given base station (BS). Currently, even the most sophisticated positioning algorithms require at least three BSs to achieve satisfactory precision. This paper presents a novel algorithm that makes use of a single-BS antenna array to locate MTs in cellular networks. A triangulation technique is utilized and supported by some minimal information about the environment in the BS neighborhood. This algorithm is shown to perform well when operating in a microcellular environment with perfect channel-parameter estimation. The effect of finite resolution of the input parameters is also investigated. The performance is analyzed for a universal mobile telecommunications system microcellular scenario through a three-dimensional deterministic channel model. Finally, the performance of the proposed positioning technique is compared to the well-known location method based on the time-of-arrival measurements at three different BSs. [J445]

"Wave mode and path characteristics in a four-layered anisotropic forest environment"

A four-layered forest geometry with two anisotropic slabs representing canopy and trunk is used for the investigation of wave characteristics in forest environment. Propagation of radio waves is examined in which the

transmitter is embedded inside the forest, while the receiving point is located either inside the forest or above the vegetation. Dyadic Green's functions in their eigenfunction expansion forms for planarly layered anisotropic media are applied to analyze this problem. The analytical close forms of these electric fields are then obtained by using the saddle point techniques, and branch cut integrations in the complex plane and, hence, expressed in terms of quasidirect wave, multiply reflected waves, and lateral waves. Propagation mechanisms of these waves are studied and radio losses in a typical forest are calculated numerically. [J446]

"Efficient modeling of impulsive ELF antipodal propagation about the Earth sphere using an optimized two-dimensional geodesic FDTD grid"

The letter reports the initial application of a geodesic finite-difference time-domain (FDTD) grid to model impulsive extremely low frequency electromagnetic wave propagation about the Earth sphere. The two-dimensional transverse-magnetic grid is comprised entirely of hexagonal cells, except for a small fixed number of pentagonal cells needed for grid completion. Grid-cell areas and locations are optimized to yield a smoothly varying area difference between adjacent cells, thereby maximizing numerical convergence. The new FDTD grid model is considerably superior to our previously reported latitude-longitude grid because it is simpler to construct, avoids geometrical singularities at the poles, executes about 14 times faster, provides much more isotropic wave propagation, and permits an easier interchange of data with state-of-the-art Earth-simulation codes used by the geophysics community. We verify our new model by conducting numerical studies of impulsive antipodal propagation and the Schumann resonance. [J447]

"Dynamic model of tropospheric scintillation on earth-space paths"

A dynamic model of tropospheric scintillation is presented which permits the generation of a scintillation time series based on known scintillation characteristics, such as spectral shape and probability density function. The model employs readily obtainable input parameters (antenna diameter, path elevation angle, frequency, ground temperature and humidity) and yields statistics that compare extremely well with existing prediction models as well as measured scintillation data (up to the fourth moment). Important applications of the new model are for simulating the performance of scintillation-degraded communication links and predicting required scintillation fade margins. [J448]

"Rainfall-induced satellite beacon attenuation in tropical and equatorial regions"

A four-year campaign of rainfall rate and rain-induced slant-path attenuation measurements was conducted on four satellite beacon links located in the equatorial, tropical and subtropical regions of Brazil. The cumulative distributions of attenuation derived from the measured data are presented and compared with those obtained with existing prediction methods. [J449]

"A physical scattering model for MIMO macrocellular broadband wireless channels"

This paper presents a physical scattering model that predicts multiple-input multiple-output (MIMO) channel characteristics conforming well to experimental observations in macrocells. Our approach is to start with a given single-input single-output power-delay profile (defined for specific range, bandwidth and antenna parameters) and fit a scattering model that characterizes the MIMO channel. From the derived scattering model and antenna array configurations, the MIMO channel is computed using a ray-based method. Simulations of several MIMO channels are shown to exhibit experimentally observed channel correlations, antenna beamwidth effect, range dependency, and frequency selectivity. [J450]

"Correlation analysis based on MIMO channel measurements in an indoor environment"

Multiple-input-multiple-output (MIMO) systems have the potential to achieve very high capacities, depending on the propagation environment. Capacity increases as signal correlation decreases. We present the measurements of a MIMO system under strong and weak line-of-sight conditions. The system capacity decreases as the distance from the transmitter increases. Indeed the transmitter correlation increases as the distance increases. The receiver correlation is lower than the transmitter correlation under both propagation conditions. [J451]

"Capacity bounds and estimates for the finite scatterers MIMO wireless channel"

We consider the limits to the capacity of the multiple-input-multiple-output wireless channel as modeled by the finite scatterers channel model, a generic model of the multipath channel which accounts for each individual multipath component. We assume a normalization that allows for the array gain due to multiple receive antenna elements and, hence, can obtain meaningful limits as the number of elements tends to infinity. We show that the capacity is upper bounded by the capacity of an identity channel of dimension equal to the number of scatterers.

Because this bound is not very tight, we also determine an estimate of the capacity as the number of transmit/receive elements tends to infinity which is asymptotically accurate. [J452]

"Level crossing rate and average fade duration of MRC and EGC diversity in Ricean fading"

The average level crossing rate and average fade duration of the output signal of a maximal ratio combiner (MRC) and equal gain combiner (EGC), operating on independent Ricean fading input branch signals, are derived. Exact, closed-form results are obtained for MRC diversity, while precise expressions for EGC diversity are presented with an infinite series method. The results are valid for an arbitrary number of independent, identically distributed diversity branches, isotropic scattering, and a specular component perpendicular to the line of motion of the mobile. [J453]

"An analytical calculation of power delay profile and delay spread with experimental verification"

Realistic system and link level simulations require specific information about the radio channel. A key role is played by the power delay profile which is widely agreed to be a negative exponential characterized by the delay spread. Since this finding is based on empirical evidence only, the delay spread must be derived from measured data. The power delay profile is rigorously derived by combining ray optical and statistical properties of wave propagation in a single room. We show that the power delay profile is indeed a negative exponential and provide a decay constant which serves as an analytical upper bound for experimentally obtained delay spreads of indoor environments. To the best knowledge of the author, this is the first derivation of the power delay profile from first principles. [J454]

"Thinned coincident arrays for the direct measurement of the principal solution in radio astronomy"

A new technique is described for the design of a thinned, linear, multiplicative array which directly measures the principal solution of a radio source distribution. The original filled multiplicative array with uniform element spacing ℓ is first generalized to an array of N1+1 subarrays each with M1+1 elements. A thinning factor of 1/2 is shown to be possible if M1=N1. Finally, if each subarray is further divided into smaller subarrays until the smallest are simply two element interferometers, then the principal solution can be directly measured but with far fewer elements. Significant thinning factors are achieved when the array is very large. The method can also be used to measure the principal solution with planar arrays, with very strong thinning occurring for large arrays. [J455]

"Path loss predictions in the presence of buildings on flat terrain: a 3-D vector parabolic equation approach"

Starting from a parabolic approximation to the Helmholtz equation, a three-dimensional (3-D) vector parabolic equation technique for calculating path loss in an urban environment is presented. The buildings are assumed to be polygonal in cross section with vertical sides and flat rooftops and the terrain is assumed to be flat. Both buildings and ground are allowed to be lossy and present impedance-type boundary condition to the electromagnetic field. Vector fields are represented in terms of the two components of Hertzian potentials and depolarization of the fields is automatically included in the formulation. A split-step algorithm is presented for marching the aperture fields along the range. Boundary conditions on the building surfaces are treated by using a local Fourier representation of the aperture fields. Several test cases are considered to check the boundary treatment used in the technique as well as to validate the overall approach. Comparison is shown with uniform theory of diffraction (UTD), exact solutions, as well as with measurements. [J456]

"An extension of stochastic radio channel modeling considering propagation environments with clustered multipath components"

A novel approach of a parametric stochastic radio channel model describes the dispersive nature of the wave propagation in indoor and outdoor environments with regard to delay and incidence angle. Effects of large-scale fluctuations are considered, too. Channel dispersion is mathematically denoted by the delay-angle spread function which results from the coherent superposition of the contributions arising from a certain number of multipath components (MPC). A classification of the propagation scenarios can be achieved by means of their topological properties. Local parameters defining the instantaneous constellation of the impinging MPC as well as global parameters giving a statistical characterization of the propagation environment (PE) are derived and form the elements of the channel model. This paper focuses on two indoor PE characterized by a line-of-sight (LOS) and a nonline-of-sight (NLOS) connection between the transmitter and receiver, respectively. Measurements in the 24 GHz range (ISM band) are presented to demonstrate the physical properties of the propagation process in both PE and to determine their global parameters. LOS scenarios show "discrete" MPC arising from specular

reflections. In case of a NLOS situation the MPC exhibit a clustering pattern due to building and wall structures which can be statistically described by means of a cluster model, an extension of the previously given modeling approach. [J457]

"Low-noise, high-efficiency optics design for ALMA receivers"

The Atacama Large Millimeter Array (ALMA) will be a powerful new interferometer for millimeter and submillimeter astronomy on an excellent site in Chile. The design of the receiver optics plays a crucial role in the ultimate sensitivity of the ALMA instrument. We present the design concepts used in the development of the optical layout of the receivers. Properties of optical elements are reviewed, and the suitability of various types of optical components is discussed. Particular emphasis is placed on principles of high efficiency optical train designs. It is shown that the optical systems should be a simple as possible and that truncation losses have to be minimized. The areas which have the greatest uncertainty are the windows and IR filters where the tradeoffs between the radio frequency losses, IR blocking, pressure resistance and gas permeability have to be carefully evaluated. A sample design for the ALMA Band 3 (84-116 GHz) is given. [J458]

"Hotspot wireless LANs to enhance the performance of 3G and beyond cellular networks"

At present, WLANs supporting broadband multimedia communications are being developed and deployed around the world. Standards include HIPERLAN/2 defined by ETSI BRAN and the 802.11 family defined by the IEEE. These systems provide channel adaptive data rates up to 54 Mb/s (in a 20 MHz channel spacing) over short ranges up to 200 m. The HIPERLAN/2 standard also specifies a flexible radio access network that can be used with a variety of core networks, including UMTS. It is likely that WLANs will become an important complementary technology to 3G cellular systems and will typically be used to provide hotspot coverage. In this article the complementary use of WLANs in conjunction with UMTS is presented. In order to quantify the capacity enhancement and benefits of cellular/hotspot interworking we have combined novel ray tracing, software-simulated physical layer performance results, and optimal base station deployment analysis. The study focuses on an example deployment using key lamppost mounted WLAN access points to increase the performance (in terms of capacity) of a cellular network. [J459]

"Neurofuzzy classification and rule generation of modes of radiowave propagation"

This paper describes, in a neurofuzzy framework, a method for the classification of different modes of radiowave propagation, followed by generation of linguistic rules justifying a decision. Weight decay during neural learning helps in imposing a structure on the network, resulting in the extraction of logical rules. Use of linguistic terms at the input enables better human interpretation of the inferred rules. The effectiveness of the system is demonstrated on radiosonde data of four different seasons in India. [J460]

"A simple model for orbital diversity gain on Earth-space propagation paths"

Simple formulas, appropriate for use by the system designer, have been generated to estimate orbital diversity gain on Earth-space propagation paths, as a function of satellite aperture angle, link frequency and elevation angles. The proposed relationships are based on a regression fitting analysis implemented on an analytical propagation model for calculating the outage probability of an orbital diversity protection scheme. The root mean square error of the simple model is less than 0.5 dB in all tested situations and over the entire range of angular separation, frequency and elevation angle. The resulting simple model is tested with experimental data taken from Japan. The agreement was found to be quite encouraging. Tabulated values for the 12 parameters are presented for some heavy rain climatic regions. The dependence on climatic zone is obvious. [J461]

"The Ricean K factor: estimation and performance analysis"

In wireless communications, the relative strength of the direct and scattered components of the received signal, as expressed by the Ricean K factor, provides an indication of link quality. Accordingly, efficient and accurate methods for estimating K are of considerable interest. In this paper, we propose a general class of moment-based estimators which use the signal envelope. This class of estimators unifies many of the previous estimators, and introduces new ones. We derive, for the first time, the asymptotic variance (AsV) of these estimators and compare them with the Cramer-Rao bound (CRB). We then tackle the problem of estimating K from the in-phase and quadrature-phase (I/Q) components of the received signal and illustrate the improvement in performance as compared with the envelope-based estimators. We derive the CRBs for the I/Q data model, which, unlike the envelope CRB, is tractable for correlated samples. Furthermore, we introduce a novel estimator that relies on the I/Q components, and derive its AsV even when the channel samples are correlated. We corroborate our analytical findings by simulations. [J462]

"Full- and half-square cell plans in urban CDMA microcellular networks"

The Erlang capacity per cell and per unit area in urban code-division multiple-access (CDMA) microcellular environments is evaluated. Special emphasis is given to the effect of breakpoint distance and cell size on the system Erlang capacity. Two different cell plans are considered in which the communication between the base station (BS) and the mobile unit always occurs in a line-of-sight (LOS) condition: the full- and half-square cell plans. Our main result has been to obtain analytical expressions for the Erlang capacity, which are evaluated through a cell radius-normalization procedure, as a function of the breakpoint to the cell radius ratio (Rb/Rc). This has allowed us to notice some important facts not previously reported in the literature. In particular, we observe that the Erlang capacity is a monotonically decreasing function of Rb/Rcand that close to the highest reuse efficiency is achieved for Rbc. Thus, given a breakpoint distance, higher Erlang capacity per cell can be achieved with greater cell radius. Or, equivalently, given a cell radius, higher system capacity can be achieved with smaller breakpoint distances; that is, with smaller base-station antenna heights and/or smaller frequencies. Also, we show that the capacity increase due to the BSs doubling or cell radius-reduction depends on the antenna heights, frequency of operation, and distance between streets. It ranges from 64 to 100%. [J463]

"Broadband wireless local-area networks at millimeter waves around 60 GHz"

During the past few years, research covering propagation, channel characterization, and wireless system performance has yielded a substantial knowledge of the 60 GHz channel. The unlicensed 60 GHz frequency band presents many attractive properties for wireless communications. This paper addresses some wideband propagation characteristics for broadband wireless LANs (BWLANs). Important system-design characteristics, from measured results obtained from two wideband 60 GHz LOS radio links, are presented. Measurements were undertaken using the swept-frequency channel-sounding method. Analysis from the complex frequency responses in a worst-case scenario has yielded a lower-coherence-bandwidth value of 5 MHz. Minimum and maximum B0.9coherence bandwidths, obtained with a directional-horn transmitting antenna and an omnidirectional receiving antenna, were 1.10 MHz and 105.33 MHz, respectively. It was observed that the coherence bandwidth fluctuated significantly with the location of the receiver with respect to the base station. These results can be used for the modeling and design of future BWLANs. [J464]

"Performance evaluation of OFDM transmission over a challenging urban propagation environment"

The paper introduces a performance evaluation of orthogonal frequency division multiplexing (OFDM) transmission schemes over a challenging urban propagation environment, considering 3D scattering, providing also a comparison with 2D considerations. After an analytic calculation of the power of received signal components (faded useful signal, intercarrier interference, intersymbol interference and noise) the authors present results of system performance evaluation under different propagation conditions (e.g., various Doppler shift values) and various values of key system parameters. BER (bit error rate) calculations are provided for a 16-QAM OFDM transmission scheme over Rayleigh fading channels, with and without Reed-Solomon coding techniques. Finally, the influence of carrier offset on the system performance is examined. [J465]

"Investigation on MIMO channels in subway tunnels"

The purpose of this paper is to examine the possibilities of increasing the channel capacity in tunnels, and particularly in railway tunnels, due to the use of multiple-input-multiple-output techniques. Many measurement campaigns have been carried out, considering the complicated geometric structure of these tunnels. We determine the channel characteristics by making a statistical analysis of correlation matrices between antennas and singular values of the channel transfer matrix. A comparison between the theoretical and experimental results is also presented. A stochastic channel model is then proposed and validated. [J466]

"Relation between multipath and wave propagation attenuation"

A theoretical multi-slope wave propagation model is proposed based on ultra-wideband radio channel impulse response measurements in a dispersive channel. The theory, which applies to radiowave and acoustic propagation, relates multipath delay spread, propagation attenuation exponent, and the maximum possible rake gain for the multipath propagation channel. [J467]

"Error modeling schemes for fading channels in wireless communications: A survey"

Network system designers need to understand the error performance of wireless mobile channels in order to improve the quality of communications by deploying better modulation and coding schemes, and better network architectures. It is also desirable to have an accurate and thoroughly reproducible error model, which would allow

network designers to evaluate a protocol or algorithm and its variations in a controlled and repeatable way. However, the physical properties of radio propagation, and the diversities of error environments in a wireless medium, lead to complexity in modeling the error performance of wireless channels. This article surveys the error modeling methods of fading channels in wireless communications, and provides a novel user-requirement (researchers and designers) based approach to classify the existing wireless error models. [J468]

"Bluetooth and IEEE 802.11b coexistence: analytical performance evaluation in fading channels"

In this paper, the issue of Bluetooth and IEEE802.11b coexistence in a heterogeneous environment is addressed by means of an integrated analytical approach. The methodology proposed carefully takes both physical (i.e., thermal noise, propagation, interference, modulation formats, and coding techniques) and medium access control (frequency hopping, packet structures, traffic loads) aspects into account. This model can be easily implemented when developing network simulators, thus avoiding the need of extensive bit level Monte Carlo simulations at the physical level. The mean packet error probability is evaluated as a function of the relative distance between the two systems for different conditions (e.g., propagation, packet type, traffic loading, etc). In particular, how the presence or absence of line-of-sight propagation significantly affects the coexistence distance is emphasized. Furthermore, for a fixed quality-of-service level we derive the coexistence domain of the two considered systems in terms of relative distance. [J469]

"Wall surface wave effects in WLAN propagation environments"

Indoor and outdoor urban environments are a class of open boundary structures capable of supporting surface waves on walls of buildings. The excitation of surface waves on common building materials is investigated and demonstrated to illustrate the implications for wireless local area networks. [J470]

"Impact of the propagation environment on the performance of space-frequency coded MIMO-OFDM"

Previous work on space-frequency coded multiple-input multiple-output orthogonal frequency-division multiplexing (MIMO-OFDM) has been restricted to idealistic propagation conditions. In this paper, using a broadband MIMO channel model taking into account Ricean K-factor, transmit and receive angle spread, and antenna spacing, we study the impact of the propagation environment on the performance of space-frequency coded MIMO-OFDM. For a given space-frequency code, we quantify the achievable diversity order and coding gain as a function of the propagation parameters. We find that while the presence of spatial receive correlation affects all space-frequency codes equally, spatial fading correlation at the transmit array can result in widely varying performance losses. High-rate space-frequency codes such as spatial multiplexing are typically significantly more affected by transmit correlation than low-rate codes such as space-frequency block codes. We show that in the MIMO Ricean case the presence of frequency-selectivity typically results in improved performance compared to the frequency-flat case. [J471]

"A new simple model for land mobile satellite channels: first- and second-order statistics"

We propose a new shadowed Rice (1948) model for land mobile satellite channels. In this model, the amplitude of the line-of-sight is characterized by the Nakagami distribution. The major advantage of the model is that it leads to closed-form and mathematically-tractable expressions for the fundamental channel statistics such as the envelope probability density function, moment generating function of the instantaneous power, and the level crossing rate. The model is very convenient for analytical and numerical performance prediction of complicated narrowband and wideband land mobile satellite systems, with different types of uncoded/coded modulations, with or without diversity. Comparison of the first- and the second-order statistics of the proposed model with different sets of published channel data demonstrates the flexibility of the new model in characterizing a variety of channel conditions and propagation mechanisms over satellite links. Interestingly, the proposed model provides a similar fit to the experimental data as the well-accepted Loo's (1985) model but with significantly less computational burden. [J472]

"On uplink CDMA cell capacity: mutual coupling and scattering effects on beamforming"

It has been shown that code-division multiple-access (CDMA) systems that employ digital beamforming and base station antenna arrays have the potential to increase capacity significantly. Therefore, accurate performance prediction of such systems is important. We propose to take the electromagnetic behavior of the base station antenna array into account, as well as its impact on wireless channel propagation. Specifically, the wideband channel introduces scattering, while the mobile environment causes Doppler fading, which in turn degrades power controllability. We develop a more accurate performance analysis of antenna arrays, where the performance degradation in digital beamforming, due to the combination of mutual coupling, scatter and

imperfect power control, and its impact on uplink CDMA system capacity is quantified. A Rayleigh fading amplitude with varying angle-of-arrival spread is assumed, and maximum signal-to-noise ratio beamforming weights are used. These weights are further correlated with mutual coupling at the base station array. Despite the degradation due to the combination of mutual coupling, scattering, and imperfect power control, significant capacity increases are possible. [J473]

"Polarisation diversity reception of nonorthogonal multipulse signals in multiuser Rayleigh fading channels"

The use of polarisation diversity techniques in conjunction with nonorthogonal multipulse modulation is considered for a multiuser communication system operating on a single-path Rayleigh fading channel. Indeed, in mobile environments multiple reflections and scattering phenomena introduce polarisation rotation of the transmitted power, and polarisation diversity is a suitable means of taking advantage of this effect. Several different two-stage receiving structures, each one relying on different amounts of a priori information on the channel status, are introduced. The performance of the proposed detectors is analysed through Monte Carlo counting techniques. It is seen that these receivers yield a remarkable performance improvement with respect to those not exploiting polarisation diversity. [J474]

"Optimal training for block transmissions over doubly selective wireless fading channels"

High data rates give rise to frequency-selective propagation, whereas carrier frequency-offsets and mobility-induced Doppler shifts introduce time-selectivity in wireless links. To mitigate the resulting time- and frequency-selective (or doubly selective) channels, optimal training sequences have been designed only for special cases: pilot symbol assisted modulation (PSAM) for time-selective channels and pilot tone-assisted orthogonal frequency division multiplexing (OFDM) for frequency-selective channels. Relying on a basis expansion channel model, we design low-complexity optimal PSAM for block transmissions over doubly selective channels. The optimality in designing our PSAM parameters consists of maximizing a tight lower bound on the average channel capacity that is shown to be equivalent to the minimization of the minimum mean-square channel estimation error. Numerical results corroborate our theoretical designs. [J475]

"Full-wave simulation of overland radar pulse propagation"

A simple and efficient method of high-frequency electromagnetic pulse simulation is proposed. An asymptotic solution yields a paraxial version of geometric optics with complex eikonals and amplitudes determined from numerical solution of the parabolic wave equation. As an example, radar pulse propagation over realistic irregular terrain is considered. [J476]

"A method for expressing mobile propagation loss characteristics in a street microcell system"

Data from the received signal-level in the personal handy-phone system commercial communication service are used to evaluate a method for expressing mobile propagation loss characteristics. The standard deviation of the difference between the measured signal level and the signal level given by empirical equations is calculated on the basis of a macrocell mode (loss versus direct distance from base station) and a street microcell mode (classified as base-station road and crossed road). The results show that the expression of street microcell mode is better than that of the macrocell mode. [J477]

"A TOA-based location algorithm reducing the errors due to non-line-of-sight (NLOS) propagation"

An effective location algorithm, which considers non-line-of-sight (NLOS) propagation, is presented. By using a new variable to replace the square term, the problem becomes a mathematical programming problem, and then the NLOS propagation's effect can be evaluated. Compared with other methods, the proposed algorithm has high accuracy. [J478]

"Generalised space-time model for Rayleigh fading channels with non-isotropic scatterer distribution"

A generalised space-time model based on Clarkes/Jakes model is extended to the case of a non-isotropic distribution of scatterers. The respective space-time correlation function and space-frequency cross spectrum around the receiver are derived. A 3-D space-time plot of the correlation function is shown for a specific scatterer distribution based on a typical mobile radio scenario. [J479]

"High-resolution time-frequency distributions for manoeuvring target detection in over-the-horizon

radars"

A novel high-resolution time-frequency representation method is proposed for source detection and classification in over-the-horizon radar (OTHR) systems. A data-dependent kernel is applied in the ambiguity domain to capture the target signal components, which are then resolved using root-MUSIC based coherent spectrum estimation. This two-step procedure is particularly effective for analysing a multicomponent signal with time-varying complex time-Doppler signatures. By using the different time-Doppler signatures, important target manoeuvring information, which is difficult to extract using other linear and bilinear time-frequency representation methods, can be easily revealed using the proposed method [J480]

"Channel estimation for the uplink of a DS-CDMA system"

This paper deals with channel estimation in the uplink of a direct-sequence code-division multiple-access system operating in a multipath environment. The parameters of interest are the delays and the complex attenuations incurred by the signal echoes along the propagation paths. We propose an iterative approach for estimating the channel parameters of a new user entering the system. The method is based on the space-alternating generalized expectation-maximization algorithm and exploits a training sequence. In comparison to other estimation algorithms, it reduces a complicated multidimensional optimization problem to a sequence of one-dimensional problems. In addition, it can be effectively used in applications over fast-fading channels. Computer simulations are employed to assess the performance of the proposed scheme. It is found that it is resistant to multiuser interference and has accuracy close to the Cramer-Rao lower bound even with very short training sequences. [J481]

"A radiance model for predicting radio wave propagation in irregular dense urban areas"

We present a deterministic model of radio wave propagation based on radiance transfers. Our model uses radiosity techniques to determine facet-to-facet specular reflections according to a three-dimensional building description. The model contains two main components. First, visibility between elements is determined and used to establish links that represent radiance transfers that include diffraction and free space losses based on geometric approximations. Second, links are used to define a transfer equation whose solution provides the transfer interreflection. The solution is obtained by using hierarchical techniques. The results of the model show good agreement with measurements made in urban areas. [J482]

"Capacity of multiple-antenna fading channels: spatial fading correlation, double scattering, and keyhole"

The capacity of multiple-input multiple-output (MIMO) wireless channels is limited by both the spatial fading correlation and rank deficiency of the channel. While spatial fading correlation reduces the diversity gains, rank deficiency due to double scattering or keyhole effects decreases the spatial multiplexing gains of multiple-antenna channels. In this paper, taking into account realistic propagation environments in the presence of spatial fading correlation, double scattering, and keyhole effects, we analyze the ergodic (or mean) MIMO capacity for an arbitrary finite number of transmit and receive antennas. We assume that the channel is unknown at the transmitter and perfectly known at the receiver so that equal power is allocated to each of the transmit antennas. Using some statistical properties of complex random matrices such as Gaussian matrices, Wishart (1928) matrices, and quadratic forms in the Gaussian matrix, we present a closed-form expression for the ergodic capacity of independent Rayleigh-fading MIMO channels and a tight upper bound for spatially correlated/double scattering MIMO channels. We also derive a closed-form capacity formula for keyhole MIMO channels. This analytic formula explicitly shows that the use of multiple antennas in keyhole channels only offers the diversity advantage, but provides no spatial multiplexing gains. Numerical results demonstrate the accuracy of our analytical expressions and the tightness of upper bounds. [J483]

"Shielding and radiation characteristics of planar layered inhomogeneous composites"

We propose an analytical study in the spectral domain of inhomogeneous layers that are characterized in terms of transmission matrices leading to an equivalent circuit representation of the whole multilayered structure. Within the framework of this two-port formalism, we present a new contribution to the computation of the Green's function arising in the analysis of multilayered integrated antennas loaded with inhomogeneous materials. Such materials offer new degrees of freedom and, besides, may allow pattern control, frequency shifting, and enlargement of the bandwidth. We also propose an analytical study of the shielding effectiveness of isotropic inhomogeneous materials located in a multilayered configuration. The expression for the shielded fields sustained both by plane wave and arbitrary sources is deduced in a closed analytical form. Numerical results are also presented showing the effects of the electromagnetic parameters on radiation pattern, matching properties and radar cross section of the integrated structure. [J484]

"A three-dimensional spatial fading correlation model for uniform rectangular arrays"

A closed-form expression for the spatial fading correlation function of a uniform rectangular array (URA) in a three-dimensional (3D) multipath channel is derived. The fading correlation function is expressed in terms of both the azimuth and elevation angle of arrival as well as the antenna spacing and geometry of the URA. Verification is achieved by means of computer simulation where the theoretical and simulation results are shown to be in good agreement. Our results demonstrate that azimuth spread (AS) is the primary determinant of the antenna correlation and the impact of the elevation spread is mainly noticeable at low AS values. The results obtained are vital for capacity analysis in multiple-input multiple-output systems, as well as for sensitivity analysis of the antenna array under study. [J485]

"Three-dimensional imaging of buried objects in very lossy earth by inversion of VETEM data"

The very early time electromagnetic system (VETEM) is an efficient tool for the detection of buried objects in very lossy earth, which allows a deeper penetration depth compared to the ground-penetrating radar. In this paper, the inversion of VETEM data is investigated using three-dimensional (3-D) inverse scattering techniques, where multiple frequencies are applied in the frequency range from 0-5 MHz. For small and moderately sized problems, the Born approximation and/or the Born iterative method have been used with the aid of the singular value decomposition and/or the conjugate gradient method in solving the linearized integral equations. For large-scale problems, a localized 3-D inversion method based on the Born approximation has been proposed for the inversion of VETEM data over a large measurement domain. Ways to process and to calibrate the experimental VETEM data are discussed to capture the real physics of buried objects. Reconstruction examples using synthesized VETEM data and real-world VETEM data are given to test the validity and efficiency of the proposed approach. [J486]

"Channel models for ultrawideband personal area networks"

This article describes the modeling of ultrawideband wireless propagation channels, especially for the simulation of personal area networks. The IEEE 802.15.3a standards task group has established a standard channel model to be used for the evaluation of PAN physical layer proposals. We discuss the standard model, the measurements that form its basis, and the possibilities for future improvements. This article points out the important differences between UWB channels and narrowband wireless channels, especially with respect to fading statistics and time of arrival of multipath components. The impacts on the different propagation conditions on system design, like RAKE receiver performance, are elaborated. [J487]

"Observed frequency scaling of amplitude scintillation at 20, 40, and 50 GHz"

This paper presents an analysis of instantaneous frequency scaling of scintillation using propagation data recorded during a three month period (May-July 1997) at Sparsholt UK from the ITALSAT satellite beacons at frequencies 18.7, 39.6, and 49.5 GHz. Variations in the height of turbulence within reasonable limits were found to have a negligible effect on the scaling ratios. Furthermore, the exponent in the power law dependence of scintillation intensity on signal frequency was found to be on average 27% smaller than the theoretical value of 7/12 and to exhibit a slight diurnal effect. It is shown that this behavior can be partly accounted for by receiver thermal noise contribution to the measured signal variance. Ascribing the minimum observed short-term variance in each beacon to thermal noise and excluding this contribution yielded a higher exponent, which was nevertheless 15% below the theoretical value. [J488]

"Analytically derived TOA-DOA statistics of uplink/downlink wireless multipaths arisen from scatterers on a hollow-disc around the mobile"

The paper rigorously derives explicit closed-form expressions for the joint/marginal probability density functions of the uplink/downlink multipaths' time-of-arrival (TOA) and azimuth angle-of-arrival (AOA) in a wireless-communication fading channel. This derivation is based on a new "geometrical model" of omnidirectional scatterers as spatially distributed uniformly on a two-dimensional hollow-disc (i.e., a thick ring) centered upon the mobile. By varying the hollow-disc's thickness, this spatial density degenerates to the well-known uniform-ring or uniform-disc densities. [J489]

"Dynamic impact characterization of vegetation movements on radiowave propagation in controlled environment"

The statistical nature of fast variations in received signals at 0.9, 2, 12, and 17 GHz through a single moving tree was investigated. The experiments were conducted in a controlled environment in an anechoic chamber. The

results from measurements performed are discussed and presented in terms of their first- and second-order statistics. [J490]

"Near-field-far-field transformation with spherical spiral scanning"

An efficient near-field-far-field transformation technique with spherical spiral scanning, which uses a minimum number of data, is proposed. A nonredundant sampling representation of the electromagnetic field on the spiral and a fast, accurate and stable interpolation algorithm are developed to this end. By choosing the elevation step of the spiral coincident with the sample spacing needed to interpolate the field on a meridian, it is possible to reconstruct the field at any point on the spherical surface. This allows the evaluation of the data required by a spherical near-field-far-field transformation. Numerical examples assessing the effectiveness of the proposed technique are reported. [J491]

"Derivation of antenna pattern shaping criteria for urban base stations using ray tracing"

A novel method for the derivation of the optimum base station (BS) antenna radiation pattern in urban microcellular systems or wireless systems in general is presented. The multipath radio channel is sounded with a ray-tracing (RT) tool; then the BS antenna pattern is optimized in order to minimize channel dispersion and maximize field strength in the selected service area. The procedure can be performed for the different classes of microcellular BS sites, allowing the derivation of useful criteria for the shaping of the corresponding antenna patterns. The aim of the paper is to demonstrate the possibility of using the RT in combination with an optimization procedure to derive interesting antenna design indications. [J492]

"Maximum-likelihood estimation of specific differential phase and attenuation in rain"

Precise estimation of propagation parameters in precipitation media is of interest to improve the performance of communications systems and in remote sensing applications. In this paper, we present maximum-likelihood estimators of specific attenuation and specific differential phase in rain. The model used for obtaining the cited estimators assumes coherent propagation, reflection symmetry of the medium, and Gaussian statistics of the scattering matrix measurements. No assumptions about the microphysical properties of the medium are needed. The performance of the estimators is evaluated through simulated data. Results show negligible estimators bias and variances close to Cramer-Rao bounds. [J493]

"Faraday rotation effects on L-band spaceborne SAR data"

Several proposed near-future spaceborne radar missions, such as the Advanced Land Observing Satellite (ALOS) and TerraSAR, will include an L-band instrument. At such low frequencies, the Faraday rotation in the ionosphere, which rotates the polarization plane of the radar signal, becomes an important consideration in instrument design. In this paper, both simple analytic approximations and numerical models are used to derive likely values of Faraday rotation and determine their impact on polarimetric imagery and derived products. One-way rotations exceeding 5° are likely to significantly reduce the accuracy of geophysical parameter recovery, such as forest biomass. On average, Faraday rotation can be neglected at solar minimum, but correction methods are needed at other times of the solar cycle and under disturbed conditions. Methods for implementing such corrections based on estimates of the Faraday rotation and prerotation of the transmitted signal are described. [J494]

"Preconditioned astigmatic beam tracing for urban propagation"

In wireless communication network planning, deterministic and statistical propagation tools have been developed. Astigmatic Beam Tracing, a deterministic method based on ray tracing (GO/UTD), can be applied to urban propagation modeling. A numerical code has been applied to a model of urban scenario with increasing complexity. The results of a numerical analysis are discussed to evaluate the relevance of the test case size on the computational charge. [J495]

"Characterization of radio wave propagation into buildings at 1800 MHz"

The paper presents the results of signal strength measurements at 1800 MHz in four office buildings in The Hague, illuminated by an outdoor base station with an antenna above the rooftop. The objectives of these experiments are to study the behavior of the received signal strength at different floors of a building and to determine the main characteristics concerning cell coverage, namely, signal attenuation and variation within these buildings. It is shown that large fluctuations occur between average signal levels in line-of-sight (LOS) and non-LOS areas of multifloor buildings. [J496]

"The mean received power in ad hoc networks and its dependence on geometrical quantities"

System-level simulations for ad hoc networks require the mean power that is received by an arbitrary unit of the piconet as an input parameter. Since the radio channel in piconets depends strongly on the environment in which two communicating units are located, easily applicable models for the mean received power must be determined by a few relevant, explicitly geometrical quantities. Starting from a very general description of the stochastic radio channel by an integral equation, it is shown that these quantities are the surface area and the volume of the domain in which the transmitter and the receiver can move. On the basis of an exponential path loss model with path loss exponent q, a lower and an upper bound for the mean received power are derived. The resulting analytical expressions are highly flexible and allow a quick calculation of bounds for the mean received power in many practically relevant cases. [J497]

"Modal transmission-line modeling of propagation of plane radiowaves through multilayer periodic building structures"

The modal transmission-line (MTL) method is used to analyze the shielding effectiveness of buildings, which is an important parameter for the accurate planning of microcellular communication networks. For that, the buildings are modeled as multilayer lossy periodic structures. After a description of the extended MTL-theory, the newly developed MTL model is applied to brick walls, reinforced-concrete walls and concrete block walls. From a comparison of the MTL-results with previously published theoretical or experimental results it is concluded that the MTL method is very well suited, because it is accurate as well as computational time-efficient. [J498]

"Effect of Loran-C signal parameters on skywave delay estimation of IFFT technique"

A simple but efficient technique (IFFT spectral-division) for adaptive adjustment of the sampling points in Loran-C receivers is presented, and the signal parameters that might affect its performance are investigated. Simulation results show that the algorithm can operate successfully under adverse propagation conditions. [J499]

"Measurement of keyhole effect in a wireless multiple-input multiple-output (MIMO) channel"

It has been predicted theoretically that for some environments, the capacity of wireless multiple-input multiple-output systems can become very low even for uncorrelated signals; this effect has been termed "keyhole" or "pinhole." In this letter, we present the (to our knowledge) first measurement of this effect. The measurements are done in a controlled indoor environment, with transmitter and receiver in two adjacent rooms. One of the rooms is shielded, and propagation to the other room can occur only through a hole or a waveguide in the wall. We find that only the waveguide leads to an unambiguous keyhole, while a hole of the same size still allows multimodal propagation. Measurement of amplitude statistics also confirm theoretical predictions. [J500]

"Dynamic model-based filtering for mobile terminal location estimation"

Mobile terminal location is an important area of research because of its applications in location-sensitive browsing and resource allocation. The paper presents a method for reducing the error in mobile terminal location estimation. A preprocessor using nonparametric estimation is used to reduce the effects of non-line-of-sight and multipath propagation on the location procedure. A model-based dynamic filter is presented that uses an accurate model of mobile terminal motion to combine information from location measurements made at different time instances to create an improved location estimate. The model of mobile terminal motion has a kinematic state space model describing the physical rules governing terminal motion and a control model that describes the human control input into the motion process. Location dependency in the control input model is used to derive a new dynamic filter. This filter provides greatly improved accuracy over previously known location techniques and is much more robust to variations in the mobile terminal motion and nonlinear effects in the propagation environment. [J501]

"Location of mobile terminals using time measurements and survey points"

Mobile terminal location has attracted much interest for its applications in emergency communications, location-sensitive browsing, and resource allocation. The paper introduces the use of nonparametric kernel-based estimators for location of mobile terminals using measurements of propagation delays. It is demonstrated that these estimators perform better than the previously used parametric maximum likelihood estimators for the case of a simulated microcell environment with line-of-sight (LOS) and non-line-of-sight (NLOS) radio propagation at several different levels of measurement noise. Their performance is not greatly degraded by NLOS effects. Methods for calculating good values for parameters of the kernel functions are demonstrated, as well as the robustness of the estimators when the values of the parameters vary from the optimal points. A lower bound on the mean square error of location estimation that considers the transition between LOS to NLOS propagation

over short distances is presented. It is demonstrated the proposed location estimation method comes close to meeting this bound. [J502]

"Visibility of far clusters in directional mobile radio channels"

We describe a new approach to determine the visibility of far clusters as seen from the receiver at a certain location in a directional radio channel. The probability density functions of visibility regions and invisibility regions are proposed based on the statistical description of the terrain and the specular properties of far clusters. The Neyman-Pearson approach is then applied to detect the visibility of an exiting far cluster in a multi-cluster scattering environment. We further discuss the application of the detection technique in the context of average-received-power maximization in a multiple antenna beam system. [J503]

"Multicarrier DS-CDMA: a multiple access scheme for ubiquitous broadband wireless communications"

We identify some of the key problems that may be encountered when designing a broadband multiple access system with bandwidth on the order of tens or even hundreds of megahertz. We commence with a comparative discussion in terms of the characteristics of three typical code-division multiple access schemes: single-carrier direct-sequence CDMA (SC DS-CDMA), multicarrier CDMA (MC-CDMA), and multicarrier DS-CDMA (MC DS-CDMA). Specifically, their benefits and deficiencies are analyzed when aiming to support ubiquitous communications over a variety of channels encountered in indoor, open rural, suburban, and urban environments. It is shown that when communicating in such diverse environments, both SC DS-CDMA and MC-CDMA exhibit certain limitations that are hard to circumvent. By contrast, when appropriately selecting the system parameters and using transmit diversity, MC DS-CDMA becomes capable of adapting to such diverse propagation environments at a reasonable detection complexity. [J504]

"GPS signal fading model for urban centres"

The use of GPS receivers in wireless telephones has been proposed as a means of automatically identifying the position of wireless 911 callers. GPS simulators are an efficient means of testing the accuracy of such technology but require a channel model for GPS satellite signals. The paper presents a methodology for measuring and modelling the fading distribution of GPS satellite signals received in outdoor urban centres. GPS fading data, as collected in the downtown areas of Calgary and Vancouver, Canada, are used to generate fade histograms as a function of satellite elevation angle. These histograms are found to be sufficiently similar between the two cities and, therefore, lead to the conclusion that a generic fade distribution for urban centres is reasonable. Parameters for the urban three-state fade model (Akturan, R., and Vogel, W.J., IEEE Trans. Antennas Propag., vol.45, no.7, p.1107-16, 1997) are estimated from the empirical fading data collected in each city. Correlation between the model parameters derived for each city is significant and this also suggests that a generic model may be derived. The parameters from the two cites are averaged to produce a generic urban three-state fade model, which adequately represents the fade histograms of each city. These averaged parameters generally agree with parameters derived from data collected in Tokyo, Japan. [J505]

"On performance of an equalization algorithm based on space and time diversity for wireless multimedia services to home users"

Wireless networks often operate under harsh environmental conditions with many uncontrollable factors causing data corruption and network outage. Atmospheric phenomena such as rain and snow make signal reception difficult for such systems. Furthermore, factors such as multipath fading and depolarization due to rain attenuation can severely and adversely impact the performance of wireless networks. This paper presents an equalization algorithm that uses spatial and temporal diversity. By using such information of the received signal, it is possible to minimize the effects of intersymbol interference, and leads to a reduction in computational complexity. Results show that the proposed equalization algorithm offers a noticeable improvement with single-carrier modulated signals. [J506]

"Performance degradation of differential space-time modulation in fast frequency flat fading Rayleigh MIMO channels"

The performance degradation of differential unitary space-time modulation of any data rate, RD, due to time selectivity is quantified for any number of transmit antennas, M, for fast frequency flat fading Rayleigh multiple-input multiple-output (MIMO) channels. The degradation bounds related to the Doppler fading parameter are tabulated and demonstrated for varying RDand M. [J507]

"Limit and application range of the slope-diffraction method for wireless communications"

We investigate the limitations on the use of the uniform theory of diffraction (UTD) slope-diffraction method for propagation past knife edges. The settled field that is diffracted past rows of buildings, as computed by numerical integration, has the characteristics of amplitude and phase variation with a scale length that is large compared to the wavelength and has small amplitude near the edges. Using this field, it is shown that the error in the UTD slope-diffraction method for diffraction past a final screen is connected with the Fresnel width, as compared to the scale length of the settled field. [J508]

"A survey of various propagation models for mobile communication"

In order to estimate the signal parameters accurately for mobile systems, it is necessary to estimate a system's propagation characteristics through a medium. Propagation analysis provides a good initial estimate of the signal characteristics. The ability to accurately predict radio-propagation behavior for wireless personal communication systems, such as cellular mobile radio, is becoming crucial to system design. Since site measurements are costly, propagation models have been developed as a suitable, low-cost, and convenient alternative. Channel modeling is required to predict path, loss and to characterize the impulse response of the propagating channel. The path loss is associated with the design of base stations, as this tells us how much a transmitter needs to radiate to service a given region. Channel characterization, on the other hand, deals with the fidelity of the received signals, and has to do with the nature of the waveform received at a receiver. The objective here is to design a suitable receiver that will receive the transmitted signal, distorted due to the multipath and dispersion effects of the channel, and that will decode the transmitted signal. An understanding of the various propagation models can actually address both problems. This paper begins with a review of the information available on the various propagation models for both indoor and outdoor environments. The existing models can be classified into two major classes: statistical models and site-specific models. The main characteristics of the radio channel-such as path loss, fading, and time-delay spread-are discussed. Currently, a third alternative, which includes many new numerical methods, is being introduced to propagation prediction. The advantages and disadvantages of some of these methods are summarized. In addition, an impulse-response characterization for the propagation path is also presented, including models for small-scale fading, Finally, it is shown that when two-way communication ports can be defined for a mobile system, it is possible to use reciprocity to focus the energy along the direction of an intended user without any explicit knowledge of the electromagnetic environment in which the system is operating, or knowledge of the spatial locations of the tr- ansmitter and the receiver. [J509]

"Comparison of monostatic and bistatic radar images"

Relationships between monostatic and bistatic radar images are reviewed and discussed, both from the point of view of identical receiver locations, and from the conventional point of view where the monostatic radar is located at the angular bisector between the bistatic transmitter and receiver. Example images are computed using scattered fields from two three-dimensional (3D) body-of-revolution (BOR) geometries. A Method-of-Moments solution is used to calculate scattered fields so that no scattering interactions are neglected. In the conventional comparison, sample bistatic images show direct-scattering mechanisms similar to those of monostatic images as expected, although significant differences are observed in higher-order scattering effects. With identical. receiver locations, the sample bistatic images generated are very different from the monostatic images, and illustrate the practically important fact that geometries designed to minimize monostatic scattering can produce large bistatic returns. [J510]

"The effect of the ionosphere on remote sensing of sea surface salinity from space: absorption and emission at L band"

The purpose of this work is to examine the effects of Faraday rotation and attenuation/emission in the ionosphere in the context of a future remote sensing system in space to measure salinity. Sea surface salinity is important for understanding ocean circulation and for modeling energy exchange with the atmosphere. A passive microwave sensor in space operating near 1.4 GHz (L-band) could provide global coverage and complement in situ arrays being planned to provide subsurface profiles. However, the salinity signal is relatively small and changes along the propagation path can be important sources of error. It is shown that errors due to the ionosphere can be as large as several psu. The dominant source of error is Faraday rotation but emission can be important. [J511]

"On the systematic measurement errors of correlative mobile radio channel sounders"

We show that measurements of time-varying mobile radio channels obtained with uncalibrated correlative channel sounders are affected by four different types of systematic errors (commutation, pulse-compression,

aliasing, and misinterpretation error). We analyze these errors and provide upper error bounds that are formulated in terms of channel and sounder parameters. Based on these error bounds, we provide guidelines for a judicious choice of important sounder parameters. Computer simulations using a simple two-path channel illustrate our theoretical results. Finally, we show how our results can be used to assess the accuracy of measured channel data [J512]

"A new measurement technique for obtaining the complex relative permittivity of terrain surfaces"

A new method for measuring the effective complex relative permittivity of a reflecting surface is presented. The approach is based on the two-ray model. We derive an equation of a circle representing the complex reflection coefficient which relates the incidence angle, frequency, and received power from the path gain using the two-ray model. The intersection point of three such circles at different heights, while maintaining the same incidence angle, yields the correct complex reflection coefficient value. By measuring the received power for both the vertical and horizontal polarizations, the relative permittivity of the surface can be determined. The technique is validated using computer simulation, as well as field measurements of typical terrain surfaces, such as asphalt, grass, and bare soil. A major advantage of this method is that it obviates the need to use antennas with a narrow beam pattern [J513]

"New analytical models and probability density functions for fading in wireless communications"

This paper presents new envelope probability density functions (PDFs) that describe small-scale, local area fading experienced by narrow-band wireless receivers. The paper also develops novel PDFs that describe the local area fading of two specular multipath components in the presence of other diffusely propagating waves. These PDFs are studied in the context of classical fading PDFs such as the Rayleigh, Rician, and other distributions [J514]

"Second-order statistical properties of the WSS Jakes' fading channel simulator"

An improved Jakes' (1994) fading channel simulator was proposed by Pop and Beaulieu (see ibid., vol.49, p.699-708, Apr. 2001) to eliminate the stationarity problem occurring in Jakes' original design. In this paper, second-order statistical properties of the improved Jakes' simulator are analyzed. Consistent with Pop and Beaulieu's caution about high-order statistics of the simulator, it is proved that some second-order statistics of both the quadrature components and the envelope do not match the desired ones even if the number of sinusoids approaches infinity. Therefore, care must be taken when the simulator is employed to evaluate algorithms and systems [J515]

"Reginald Aubrey Fessenden and the birth of wireless telephony"

The year 2000 was the 100th anniversary of the transmission of the first voice over radio. On December 23, 1900, Prof. Reginald Aubrey Fessenden after a number of unsuccessful tries-transmitted "words without wires" over a distance of 1600 m, between twin aerial systems employing 15 m masts, located on Cobb Island, Maryland. The quality of the received wireless-telephony transmission was reported to be perfectly intelligible, but the speech was accompanied by an extremely loud, disagreeable noise, due to the irregularity of the spark. Spark? Yes. Fessenden had not yet developed a method to generate continuous waves. The sender was a spark transmitter, operating at 10,000 sparks/second, with an asbestos-covered carbon microphone inserted in the antenna lead. In spite of the primitive apparatus-used, the poor quality of the transmission, and the short distance, intelligible speech had been transmitted by electromagnetic waves for the first time in the history of wireless. Who was Fessenden? The purpose of this paper is to touch upon his life's history, and to give some detail of his accomplishments. However, the paper begins with an account of the birth of radio, so that the reader can appreciate Fessenden's place in history [J516]

"An empirical formula for the prediction of rain attenuation in frequency range 0.6-100 GHz"

An empirical formula for calculating the extinction cross section (ECS) by raindrops over a broad frequency range is first derived based on extensive calculations made on a widely varying in mean radius of modified Pruppacher and Pitter (MPP) raindrop models ranging from 0.25 to 3.5 mm. The expansion coefficients in the empirical formula are determined by least-squares curve fitting of numerical data obtained by the volume integral equation formulation (VIEF). The formula satisfies the frequency and raindrop size dependence. Numerical results obtained from the empirical formula for calculating the ECS are generally in good agreement with those calculated by the VIEF for raindrops with mean radius varying from 0.25 to 3.5 mm in the frequency range from 0.6 to 100 GHz. The average error in the ECS is less than 10%. The formula thus provides a simple and inexpensive method for calculating the ECS of raindrops, which otherwise requires complicated and expensive methods of calculation. By implementing this empirical formula of ECS into the rain attenuation equation, a new

numerically empirical formula for calculating the specific rain attenuation is also proposed. The validity of the empirical formula for calculating the specific rain attenuation is also checked by comparing the obtained results of specific rain attenuation with those obtained from Li et al.'s (1995) solution, Yeo et al.'s (1993) measurement, and Olsen et al.'s (1978) power-law equation [J517]

"Propagation Corner"

First Page of the Article [J518]

"Microwave link dual-wavelength measurements of path-average attenuation for the estimation of drop size distributions and rainfall"

Microwave attenuation measurements at 25 and 38 GHz made on a 2.3-km microwave link are employed to estimate drop size distributions (DSD), rainfall rate, and rainfall accumulation. A theoretical model for the propagation of microwaves in a link system sets forth the basis for the development of a dual-wavelength analytical technique to invert two parameters of a path-average gamma DSD. The DSDs obtained from the technique are evaluated in conjunction with point measurements performed with a 2-D video disdrometer. Additionally, the DSDs yield path-average rainfall rates and rainfall accumulation which are compared with path-average measurements from a network of optical and tipping bucket rain gauges located beneath the link path, and with estimates based on empirical power law relations [J519]

"Estimate of the tropospherical water vapor through microwave attenuation measurements in atmosphere"

The objective of this paper is to proceed, by investigating the statistics of simulated measurements based on a large dataset of radiosonde profiles, to assess the feasibility of active systems providing water vapor profile information based on Earth-satellite multifrequency differential attenuation measurements made in the 18-22-GHz range. Recently, in fact, we pointed out the potential and the advantages of such measurements, showing in particular how a spectral sensitivity parameter could be exploited to provide the total water vapor content and further information about the shape of its vertical profile. In this work, we present an in-depth statistical analysis of the relationship between the spectral sensitivity parameter and the water vapor content at different tropospheric layers. Furthermore, we discuss the performance of a simple amplitude modulation transmit-receive system that could be adopted to provide the sensitivity measurements. It is shown that a dual-frequency system can directly provide with good accuracy the columnar water vapor content separately from the content of the 3-9 km atmospheric layer [J520]

"Evaluation of an ultra-wide-band propagation channel"

This paper describes the results of an ultra-wideband (UWB) propagation study in which arrays of propagation measurements were made. After a description of the propagation measurement technique, an approach to the spatial and temporal decomposition of an array of measurements into wavefronts impinging on the receiving array is presented. Based on a modification of the CLEAN algorithm, this approach provides estimates of time-of-arrival, angle-of-arrival, and waveform shape. This technique is applied to 14 arrays of indoor propagation measurements made in an office/laboratory building. Statistical description of the results is presented, based on a clustering model for multipath effects. The parameters of these statistical models are compared to results derived for narrowband signal propagation in the indoor environment [J521]

"Scattering from periodic array of grounded parallel strips, TE incidence"

The field distribution between strips in a periodic array of parallel strips was modeled. The electric field integral equation (EFIE) together with method of moments (MoM) was employed to solve the problem. The incident plane wave was assumed to be transverse electric (TE). The effect of the incident angle on the field between strips was investigated. For comparison, an array of the same configuration but containing a finite number of parallel strips was also modeled using the EFIE and solved via MoM. Good agreement was found even when the number of strips was small. The results are of interest for mobile radio [J522]

"Angle and time of arrival statistics for the Gaussian scatter density model"

Starting from a Gaussian distribution of scatterers around a mobile station, expressions are provided for the probability density function (PDF) in the angle of arrival, the power azimuth spectrum, the PDF in the time of arrival, and the time delay spectrum, all as seen from a base station. Expressions are also provided for some of the quantities of practical interest such as the root-mean-square (RMS) angular spread, the RMS delay spread, and the spatial cross-correlation function. Results for the Gaussian scatter density model are compared with

those for the circular scattering model and the elliptical scattering model as well as with experimental results available for outdoor and indoor environments. Comparison is shown for the PDFs as well as for the power spectra in angle and delay. It is shown that the present model, in contrast to the previous models, produces results that closely agree with experimental results. With an appropriate choice of the standard deviation of the scattering region, the Gaussian density model can be made suitable both for environments with very small angular spreads as well as those with very large angular spreads. Consequently, the results provided in the paper are applicable to both macrocellular as well as picocellular environments [J523]

"The IST METRA project"

This article summarizes the main achievements of the Multi-Element Transmit and Receive Antennas (METRA) Project, an IST research and technological development project carried out between January 2000 and June 2001 by Universitat Politecnica de Catalunya, the Center for Personkommunikation of Aalborg University, Nokia Networks, Nokia Mobile Phones, and Vodafone Group Research and Development. The main objective of METRA was the performance evaluation of multi-antenna terminals in combination with adaptive antennas at the base station in UMTS communication systems. A MIMO channel sounder was developed that provided realistic multi-antenna channel measurements. Using these measured data, stochastic channel models were developed and properly validated. These models were also evaluated in order to estimate their corresponding channel capacity. Different MIMO configurations and processing schemes were developed for both the FDD and TDD modes of UTRA, and their link performance was assessed. Performance evaluation was completed by system simulations that illustrated the benefits of MIMO configurations to the network operator. Implementation cost vs. performance improvement was also covered by the project, including the base station and terminal manufacturer and network operator viewpoints. Finally, significant standards contributions were generated by the project and presented to the pertinent 3GPP working groups [J524]

"Radiated pulses decay exponentially in materials in the far fields of antennas"

There has been interest in using short-pulse radar to detect targets in lossy clutter. The analysis presented here shows that the energy and peak-power densities of pulses decay exponentially with depth in homogeneous, lossy, dispersive materials, provided the frequency bands of the pulses are separated from DC. Many numerical examples verify the analytical results [J525]

"Enhanced correlated shadowing generation in channel simulation"

An enhanced method of generating a shadow fading for mobile radio channel simulation is proposed. It is verified that simulated samples satisfy the properties of variance, autocorrelation and cross-correlation. The proposed channel simulation method can be utilized for evaluating the performances in mobile communication systems where the exchange of interactive information between uplink and downlink channels is required [J526]

"Time-domain analysis of measurements on scaled urban models with comparisons to ray-tracing propagation simulation"

This work deals with propagation prediction for wireless communications in urban environments. Its purpose is to clearly distinguish the different field contributions collected by the receiving antenna through a series of wide-band frequency measurements and a time-domain (TD) analysis of the obtained results. The experimental data are then compared to the field predictions given by a ray-tracing electromagnetic wave propagation simulator. The application of this research lies in the modeling of the urban channel for wireless communication systems of the third generation such as UMTS and beyond [J527]

"Influence of diffraction coefficient and corner shape on ray prediction of power and delay spread in urban microcells"

For a low base-station (BS) antenna located on one street, signals propagate into crossing and parallel streets by reflection and diffraction at corners of buildings. Therefore, in order to accurately predict the received signals, it is necessary to properly model the diffraction coefficient at the building edge and to accurately represent the shape and the electrical properties of the building near the corner. This paper compares ray-tracing predictions to measurements of received power and root mean square (rms) delay spread and shows the need for a diffraction coefficient having larger values than suggested by the commonly used heuristic diffraction coefficient. A new heuristic diffraction coefficient is proposed that has higher diffracted field strength in the deep shadow region and in the region between the two shadow boundaries. The proposed diffraction coefficient shows better agreement with measurements of both received power and delay spread compared to the commonly used heuristic diffraction coefficient. The influence of building shape near the corner and its electrical properties on the

ray-tracing predictions are also presented. The shape is shown to have an important role in accurately predicting both received power and delay spread [J528]

"A ray-tracing method based on the triangular grid approach and application to propagation prediction in urban environments"

This paper presents a fast ray-tracing procedure based on triangular division of the propagation environments. Unlike other accelerating methods that are mostly based on pre-establishment of visibility, this method does not require knowledge of the position information of the base station and/or receiving antennas and is thus more general. Although the triangulation is done in a two-dimensional (2-D) plane, this method is suitable for three-dimensional (3-D) simulations when a proper data structure for buildings is constructed. Validation results show good agreement between calculated and measured data from the European COST 231 project. The improvement in the computational efficiency is clearly demonstrated in examples [J529]

"Theoretical analysis of frequency-correlation coefficient for received signal level in mobile communications"

Frequency-correlation coefficient characteristics that define frequency separation in frequency-diversity techniques were studied theoretically using a propagation model that makes allowances for received bandwidth. Equations of frequency-correlation coefficients in non- and line-of-sight propagation paths were derived. The equations showed that frequency-correlation coefficient depends on such factors as frequency separation, received bandwidth, differences in pathlengths, and the power ratios of the direct to indirect waves. The frequency-correlation coefficient increases as the received bandwidth increases and decreases as the difference in pathlength increases. However, when the difference in the pathlength was small (30 m), the effect of the received bandwidth was minimal. The frequency-correlation coefficient also depended somewhat on the power ratio. To confirm the accuracy of our theoretical derivations, computer simulations were performed. Frequency-correlation coefficients were calculated by simulating instantaneous received signal levels. The theoretical results matched those of the simulation [J530]

"Propagation path loss-a comparison between ray-tracing approach and empirical models"

The results obtained with a two-dimensional (2-D) propagation model for wireless communications in an urban environment are compared against the results of other propagation models, such as COST-231 Walfisch-Ikegami (1988, 1984), Hata's (1980), and Zhang's (1997) [J531]

"A parametric model for the distribution of the angle of arrival and the associated correlation function and power spectrum at the mobile station"

One of the main assumptions in Clarke's classic channel model is isotropic scattering, i.e., uniform distribution for the angle of arrival (AOA) of multipath components at the mobile station. However, in many mobile radio channels we encounter nonisotropic scattering, which strongly affects the correlation function and power spectrum of the complex envelope at the mobile receiver. We propose the use of the versatile von Mises (1918) angular distribution, which includes and/or closely approximates important distributions like uniform, impulse, cardioid, Gaussian, and wrapped Gaussian, for modeling the nonuniform AOAs at the mobile. Based on this distribution, the associated correlation function and. power spectrum of the complex envelope at the mobile receiver are derived. The utility of the new results is demonstrated by comparison with the correlation function estimates of measured data [J532]

"The effect of precipitation on microwave LMDS networks-performance analysis using a physical raincell model"

This article proposes an application of the EXCELL model to microwave local multipoint distribution systems. With EXCELL, validated in many years of observations with a meteorological radar, rain is modeled by a population of exponentially-profiled raincells. Their statistics can be made to honor any given rainfall cumulative distribution function. It is, thus, possible to simulate synthetic precipitation events so that rain effects on various radio link topologies (point-to-point or multipoint) can be evaluated on each event. Both copolar and crosspolar effects were modeled, and the C/I and C/N statistics were evaluated for a large number of events [J533]

"Impact of clustering in statistical indoor propagation models on link capacity"

Explicit clustering in a statistical indoor propagation model is found to have significant effects on the capacity of an array-to-array link or matrix channel. Effects of antenna spacing, Poisson homogeneity, block size, and

transmit power allocation strategies are also considered [J534]

"Statistical characterization of urban spatial radio channels"

We present a statistical analysis of wideband three-dimensional channel measurements at base station locations in an urban environment. Plots of the received energy over azimuth, elevation, and delay planes suggest that the incident waves group to clusters in most measured transmitter positions. A super-resolution algorithm (Unitary ESPRIT) allows one to resolve individual multipath components in such clusters and hence enables a detailed statistical analysis of the propagation properties. The origins of clusters-sometimes even individual multipath components-such as street apertures, large buildings, roof edges, or building corners can be localized on the city map. Street guided propagation dominates most of the scenarios (78%-97% of the total received power), while quasi-line-of-sight over-the-rooftop components are weak(3%-13% of the total received power). For this measurement campaign, in 90% of the cases, 75% of the total received power is concentrated in the two strongest clusters, but only 55% in the strongest one. Our analysis yields an exponential decay of power with 8.9 dB/μs, and a standard deviation of the log-normally distributed deviations from the exponential of 9.0 dB. The power of cross-polarized components is 8 dB below copolarized ones on average (vertical transmission) [J535]

"Analysis of observed Doppler fading signal in low-VHF band"

Short-term amplitude variations of a tropospheric radio signal are presented and discussed. Radio wave transmissions from Newbury on 46.95 MHz were received at the University of Hull. These fluctuating signals were recorded, edited and finally analysed using time-frequency and regression techniques [J536]

"Physical optics and field-strength predictions for wireless systems"

Physical optics, or Fresnel-Kirchhoff theory, is often used for studies of particular problems in terrestrial radio-wave propagation. With efficient techniques of numerical integration, it can also be used effectively for routine predictions and for designing terrestrial wireless systems. A computer program of this type has been in use for several years. It is most useful in situations in which the base station (BS) antenna is above local clutter, and over areas large enough that ground cover can be characterized with categories such as "open," "forest," "dense residential," etc., rather than individual buildings. The main calculation is a marching algorithm that simulates diffraction over all the variations in terrain height along radials from the BS. A secondary calculation estimates the additional attenuation due to buildings and trees close to the mobile antenna. This part of the calculation is based on several parameters characterizing the local environment of the mobile antenna. Calculations are slow compared to many traditional methods, but are fast enough for routine use on a PC [J537]

"Angle-of-arrival statistics for low resolution antennas"

In a scattering environment, the propagation paths to a receiving antenna arrive from a certain angular spread of directions. For a low-resolution antenna, an apparent direction of arrival may be defined as the azimuth direction of maximum power. A small array is used as the antenna and the spatial derivative of the phase along the array axis is taken as a measure of the sine of the apparent angle of arrival. The sine of the angle is shown to be Student's t-distributed and from this result the PDF and power spectrum of the angle-of-arrival is determined. The distributions are compared with experimental results for indoor as well as for outdoor measurements [J538]

"Measurement validation of ray-tracing propagation model on double-diffracted paths"

This paper presents a ray-tracing propagation model that includes double-diffraction paths from orthogonal edges. Good agreement between the predicted and measured power delay profiles in a typical cellular scene shows the validity and applicability of our model [J539]

"A two-element horn-reflector antenna for cosmic microwave background astronomy"

We present the design of a novel two-element horn-reflector antenna, which has been used on an interferometer built for studying the anisotropy in the cosmic microwave background at an angular scale of ≈2° and a frequency of 33 GHz. The design consists of a pair of closely packed parabolic mirrors fed by two rectangular corrugated horns, each at an offset angle of 75° to the axis of its mirror. The offset angle and the horn-reflector dimensions were chosen so that the antenna has elliptical primary beams producing a synthesized beam with circular lobes. We have designed and tested the radiation pattern of the individual antennas and the performance of the interferometer using bright radio sources. Our measurements revealed that the individual antennas have low sidelobes and that the crosstalk between the two elements of the interferometer is less than -80 dB. We therefore conclude that this design is suitable for the required astronomical application [J540]

"FDTD method with oblique incidence for ionospheric wave propagation problems-application to an HF one-hop radio-link study"

This paper introduces a new finite-difference time-domain (FDTD) approach for electrically very large wave-propagation problems and especially for high-frequency (HF) ionospheric radio-link studies. An appropriate modification of the FDTD technique is presented, which reduces the problem's dimension by the appropriate introduction of an effective magnetic permeability for the ionospheric layers. The proposed approach gives an answer to the demand for accurate radio-link design, taking into account the characteristics of ionosphere all over the path of propagation, unlike existing simplified analytical methods. The methodology is successfully applied to a practical HF one-hop ionospheric radio-link study [J541]

"Groundwave propagation modeling: problem-matched analytical formulations and direct numerical techniques"

In this overview of groundwave propagation, we address a particular class of propagation scenarios in the presence of surface terrain and atmospheric refractivity. Beginning with idealized analytically solvable models over a smooth spherical Earth, we trace the progression toward more "reality" through physics-based numerical algorithms, operating in the frequency and short-pulse time domain, which take advantage of computational resources. An extensive sequence of simulations for various terrains and atmospheric refractivities, as well as different source-receiver arrangements and operating frequencies, serves to calibrate these algorithms one against the other, and establishes the range of problem parameters for which each is more effective [J542]

"Keyholes, correlations, and capacities of multielement transmit and receive antennas"

Multielement system capacities are usually thought of as limited only by correlations between elements. It is shown here that degenerate channel phenomena called "keyholes" may arise under realistic assumptions which have zero correlation between the entries of the channel matrix H and yet only a single degree of freedom. Canonical physical examples of keyholes are presented. For outdoor environments, it is shown that roof edge diffraction is perceived as a "keyhole" by a vertical base array that may be avoided by employing instead a horizontal base array [J543]

"Capacity scaling in MIMO wireless systems under correlated fading"

Previous studies have shown that single-user systems employing n-element antenna arrays at both the transmitter and the receiver can achieve a capacity proportional to n, assuming independent Rayleigh fading between antenna pairs. We explore the capacity of dual-antenna-array systems under correlated fading via theoretical analysis and ray-tracing simulations. We derive and compare expressions for the asymptotic growth rate of capacity with n antennas for both independent and correlated fading cases; the latter is derived under some assumptions about the scaling of the fading correlation structure. In both cases, the theoretic capacity growth is linear in n but the growth rate is 10-20% smaller in the presence of correlated fading. We analyze our assumption of separable transmit/receive correlations via simulations based on a ray-tracing propagation model. Results show that empirical capacities converge to the limit capacity predicted from our asymptotic theory even at moderate n = 16. We present results for both the cases when the transmitter does and does not know the channel realization [J544]

"Asymptotic performance of ray tracing simulators"

The asymptotic performance of ray tracing (RT) simulators in terms of narrowband predictions is considered. From statistical models for urban propagation, an analytical formulation can be obtained to characterise RT asymptotic properties. The formation is exploited to develop an empirical model to speed-up simulation times [J545]

"Simulation of flat fading using MATLAB for classroom instruction"

An approach to demonstrate flat fading in communication systems is presented here, wherein the basic concepts are reinforced by means of a series of MATLAB (Mathworks, Inc., Natick, MA 01760-2098 USA) simulations. Following a brief introduction to fading in general, models for flat fading are developed and simulated using MATLAB. The concept of outage is also demonstrated using MATLAB. The authors suggest that the use of MATLAB exercises will assist the students in gaining a better understanding of the various nuances of flat fading [J546]

"Capacity and interference statistics of highways W-CDMA cigar-shaped microcells (uplink analysis)"

The capacity and the interference statistics of the sectors of the shaped W-CDMA cell are studied. A model of five cells is used to analyze the uplink. The cells are assumed to exist in rural zones. The capacity and the interference statistics of the cell are studied using a two-slope propagation model. The expected value and the variance of the interference are given for different propagation exponent [J547]

"A new statistical model for site-specific indoor radio propagation prediction based on geometric optics and geometric probability"

The ray-tracing (RT) algorithm has been used for accurately predicting the site-specific radio propagation characteristics, in spite of its computational intensity. Statistical models, on the other hand, offers computational simplicity but low accuracy. In this paper, a new model is proposed for predicting the indoor radio propagation to achieve computational simplicity over the RT method and better accuracy than the statistical models. The new model is based on the statistical derivation of the ray-tracing operation, whose results are a number of paths between the transmitter and receiver, each path comprises a number of rays. The pattern and length of the rays in these paths are related to statistical parameters of the site-specific features of indoor environment, such as the floor plan geometry. A key equation is derived to relate the average path power to the site-specific parameters, which are: 1) mean free distance; 2) transmission coefficient; and 3) reflection coefficient. The equation of the average path power is then used to predict the received power in a typical indoor environment. To evaluate the accuracy of the new model in predicting the received power in a typical indoor environment, a comparison with RT results and with measurement data shows an error bound of less than 5 dB [J548]

"Multiuser capacity in block fading with no channel state information"

Consider M independent users, each user having his own transmit antenna, that transmit simultaneously to a receiver equipped with N antennas through a Rayleigh block-fading channel having a coherence interval of T symbols, with no channel state information (CSI) available to either the transmitters or to the receiver. The total transmitted power is independent of the number of users. For a given coherence time T, we wish to identify the best multiaccess strategy that maximizes the total throughput. If perfect CSI were available to the receiver, it is known that the total capacity would increase monotonically with the number of users. If the CSI is available to both the receiver and to all transmitters, the throughput maximizing strategy implies for N=1 that only the single user who enjoys the best channel condition transmits. In the absence of CSI one is forced to a radically different conclusion. In particular, we show that if the propagation coefficients take on new independent values for every symbol (e.g., T=1) then the total capacity for any M > 1 users is equal to the capacity for M=1 user, in which case time division multiple access (TDMA) is an optimal scheme for handling multiple users. This result follows directly from a recent treatment of the single-user multiple antenna block-fading channel. Again, motivated by the single-user results, one is lead to the following conjecture for the multiple-user case: for any T > 1, the maximum total capacity can be achieved by no more than M = T users. The conjecture is supported by establishing the asymptotic result that, for a fixed N and a constant M/T for large T, the total capacity is maximized when M/T→0, which yields a total capacity per symbol of N log(1 + ρ), where ρ is the expected signal-to-noise ratio (SNR) at the receiver. We further support the conjecture by examining the asymptotic behavior with large to for fixed M, T, and N ⩽ T [J549]

"Aeronautical channel modeling"

A class of aeronautical wide-band channel models is proposed, featuring parking and taxi environments, takeoff and landing situations, and en-route scenarios for ground-air and air-air links. Typical and worst case parameter sets are suggested, based on published measurement results and empirical data. The models are suitable for channel emulators that can be easily implemented on digital computers or in hardware and thus are useful for the validation of digital aeronautical links. A time-domain and frequency-domain implementation of such a channel emulator are derived, and results for a typical multicarrier system are presented. It is shown that the scenarios have distinguishable performance results depending on the underlying maximum ranges and shapes of the Doppler and delay spectra and the presence of a line-of-sight path. Finally, the degrading effects of intersymbol interference and intersubcarrier interference on the multicarrier signal are explained [J550]

"Hybrid2 : combining the three-dimensional hybrid finite element-boundary integral technique for planar multilayered media with the uniform geometrical theory of diffraction"

The fully three-dimensional (3-D) hybrid finite element (FE)-boundary integral (BI) technique is extended by further hybridization with the uniform geometrical theory of diffraction (UTD) resulting in a so-called hybrid2FE-BI-UTD approach. The formulation is capable of modeling arbitrarily shaped strongly inhomogeneous objects

together with electrically large obstacles of relatively simple shape within the common environment of a planar-multilayered medium. The arbitrarily shaped inhomogeneous objects are discretized by finite elements, whereas, the electrically-large obstacles are described by the UTD and both of these models are included into an integral equation derived from the equivalence principle for planar-multilayered media. Thus, full-electromagnetic coupling is realized between all parts of the formulation. The integral equation is implemented using mixed potentials with appropriate Green's functions derived from Sommerfeld integral representations for planar-multilayered media. The UTD contributions are accounted for by corresponding modifications of the Green's functions and the FE technique is coupled to the integral equation via introduction of equivalent surface current densities in the bounding surfaces of the discretized objects. After presenting the formulation of this novel fully 3-D hybrid2technique, the implemented computer code is validated against conventional hybrid FE-BI computations and a wireless base station antenna is analyzed in several situations of complex real world, microcell environments [J551]

"Geometrical-based statistical macrocell channel model for mobile environments"

We develop a statistical geometric propagation model for a macrocell mobile environment that provides the statistics of angle-of-arrival (AOA) of the multipath components, which are required to test adaptive array algorithms for cellular applications. This channel model assumes that each multipath component of the propagating signal undergoes only one bounce traveling from the transmitter to the receiver and that scattering objects are located uniformly within a circle around the mobile. This geometrically based single bounce macrocell (GBSBM) channel model provides three important parameters that characterize a channel: the power of the multipath components, the time-of-arrival (TOA) of the components, and the AOA of the components. Using the GBSBM model, we analyze the effect of directional antennas at the base station on the fading envelopes. The level crossing rate of the fading envelope is reduced and the envelope correlation increases significantly if a directional antenna is employed at the base station [J552]

"On the application of adaptive antennas to microcellular environments: radio channel characteristics and system performance"

The possible application of adaptive antennas in microcellular operational environments is studied in this paper with the help of a site-specific ray-tracing propagation model. First are examined the statistics of propagation parameters that play an important role for the performance of adaptive antennas. Particular emphasis is put on the spatial characteristics of the radio channel under line-of-sight (LOS) and non-LOS conditions. For this reason, area statistics are produced for a typical small-cell environment for parameters such as the number of multipath clusters, number of rays, angular size, and excess delay of each impulse response, as well as the number of rays, angular size and power of the multipath clusters. Results show that contrary to the common belief for such environments, the signal is not "almost" uniformly distributed in the spatial domain, instead is contained in a few narrow clusters. Then the effect of the microcellular environment on the uplink performance of some well-known techniques like conventional beamforming, maximum entropy, switched beams, maximum ratio and optimum combining, and beam-space optimum combining is examined . The results show that for typical time-division multiple-access (TDMA) scenarios with one and two users, the beam space optimum combining (strongest eigenvalue version) and the switched beams methods, offer the best performance [J553]

"Modelling EM transient propagation over irregular dispersive boundary"

On the basis of the time-domain parabolic equation, a numerical simulation of single pulse electromagnetic (EM) propagation over a smoothly non-uniform terrain is performed. Ground conductivity is taken into account via a generalised impedance boundary condition (BC). A time-domain version of a perfectly transparent BC is used to simulate radiation into free space [J554]

"Deterministic channel modeling and performance simulation of microcellular wide-band communication systems"

To evaluate the performance of future microcellular IMT-2000 modems, simple physical models are required, so that a number of system characteristics, such as the signal bandwidth, the antenna beamwidth, or the base station height can be accounted for at a limited computational cost. This paper describes a deterministic three-dimensional electromagnetic model, which allows simulation of the radiowave propagation for microcellular wide-band communication systems in urban areas. The model is based on a UTD ray-tracing tool and makes use of an improved mirror method. Simulated power-delay profiles are plotted against measured power-delay profiles recorded at 1.87 GHz in a street of Louvain-la-Neuve, Belgium, by means of an 80-MHz channel sounder. Despite several discrepancies, a satisfying matching is found considering three orders of reflection and single diffraction. Predictions of rms delay-spread accounting for the sounder limited bandwidth are presented. Finally,

simulated and measured channels are also compared through the resulting performance of a typical IMT-2000 service in the presence of multiple access interference. [J555]

"Signal design for ultra-wide-band communications in dense multipath"

Ultra-wide-band (UWB) wireless communications utilizes information signals characterized by a radiated spectrum with a very wide bandwidth around a relatively low center frequency. We formulate the signal design for binary UWB communications taking into consideration the particular characteristics of UWB propagation in a dense multipath channel. [J556]

"Distributed dynamic channel assignment with violation to the reuse pattern for microcellular networks"

In this paper, the frequency reuse and the distributed dynamic channel assignment for microcellular networks are studied. We show that it is possible to use carriers with violation to the frequency reuse pattern with an insignificant degradation of the quality of service. As a result, a new family of distributed dynamic channel assignment algorithms is presented: the DDCA with violation to the reuse pattern (DDCA with VRP) strategies. The DDCA with VRP schemes allow the use of carriers with at most one violation to the reuse pattern, under the restriction that both cells using simultaneously the same carrier must be the farthest cells of their interference neighborhoods. The results show that the use of carriers with VRP is an effective strategy to increase the system capacity at the expense of an insignificant degradation of the quality of service. This is due to the fact that the carriers are employed with VRP by short time intervals in the least harmful situations. We propose and evaluate five DDCA with VRP schemes and everyone overcomes the performance of the maximum packing (MP) algorithm, with limited carrier usage information and without the need of centralized coordination neither global carrier rearrangements. [J557]

"Optimization methods for optimal transmitter locations in a mobile wireless system"

A combination of a simple indoor propagation model with different optimization methods enables optimal single and multiple transmitter locations and antenna sectorization in wireless systems. [J558]

"Evaluation of exposure levels generated by cellular systems: methodology and results"

During the past years, the number of antenna installations has considerably increased mainly as a consequence of the great diffusion of cellular systems. While the emissions of mobile terminals principally concern cellular system users, the exposure due to base stations (BSs) is permanent and spread over the entire territory. In this paper, a flexible approach for the evaluation of exposure levels generated by cellular systems BSs is proposed. Both a conceptual method for the evaluation of the overall exposure level and a site specific method for the computation of the field in the surroundings of BS antennas are proposed. This last method is based on a combination of three different propagation models which enable an accurate evaluation of the field both close to the antenna and farther off. The validity of the approach is checked by comparison with measurements in single-antenna and multiantenna cases. [J559]

"A space-time model for mobile radio channel with hyperbolically distributed scatterers"

We present a geometrical and time-variant wireless vector channel model with hyperbolically distributed scatterers for a macrocell mobile environment. This model is based on the assumption that the scatterers are arranged circularly around the mobile station, whereby the distance between the mobile and the local scatterers and the distance between the local scatterers and the dominant scatterers are distributed hyperbolically. The proposed model allows investigation of beamforming aspects as well as space-time processing techniques. Simulation results for this model are presented and compared with the exponential model results. [J560]

"A study of the ultra-wideband wireless propagation channel and optimum UWB receiver design"

The paper addresses a crucial point in ultra-wideband (UWB) radio wave propagation, which is the spatial-temporal resolution of scattering objects into multiple frequency-dependent scattering centers. The effect contributes to the widely observed temporal dispersion of pulse-shaped transmit signals and their distortion, respectively. Particularly the latter is explained by (multiple) diffraction of the incident wave, leading to (multiple) band-limited impulse responses with characteristic frequency content, which in turn causes signal distortion and a degradation of the signal-to-noise ratio in a correlation receiver. We presented a new approach on UWB propagation modeling and optimum design of correlation receivers. [J561]

"Diffraction by a randomly rough knife edge"

The intent of this paper is to predict the effects of random edge roughness on the knife-edge diffraction of an incident wave. This has been accomplished by approximating the field beyond the diffracting half plane with spectral techniques and the Kirchhoff approximation. By restricting the point of observation of the diffracted field to the side opposite from the incident field and not too far into the shadow zone of the edge, the results for a straight knife edge should be very accurate. By similarly restricting the spatial frequency spectrum of the knife-edge roughness to contain no frequencies comparable to or shorter than the electromagnetic wavenumber, the method used to estimate the effects of the roughness is also accurate. The relationships developed for the mean or average diffracted field and the incoherent diffracted power are studied for a range of electrophysical parameters that are representative of the situation encountered in a point-to-point communications link with blockage by a rough-edged half plane. The interpretation of the results is facilitated by the observation that the total diffracted field is a superposition of the incident field and the edge-diffracted field. Thus, the conventional oscillating behavior of the total field as the point of observation recedes from the edge and is attributed to the phase interference between these two fields. When the roughness on the edge increases, the edge diffracted-field becomes more incoherent and the phase interference diminishes; this leads to an attenuation of the oscillations in the coherent or mean total field. The model also predicts that the incoherent power is strongest near to the rough knife and is not generally appreciable when the point of observation of the diffracted field is far away from the edge. This, of course, is in complete agreement with our understanding that shadows, and hence, the details of the shadow-causing boundary (knife-edge), exists only a finite distance behind the boundary. [J562]

"Outdoor MIMO wireless channels: models and performance prediction"

We present a new model for multiple-input-multiple-output (MIMO) outdoor wireless fading channels and their capacity performance. The proposed model is more general and realistic than the usual independent and identically distributed (i.i.d.) model, and allows us to investigate the behavior of channel capacity as a function of the scattering radii at transmitter and receiver, distance between the transmit and receive arrays, and antenna beamwidths and spacing. We show how the MIMO capacity is governed by spatial fading correlation and the condition number of the channel matrix through specific sets of propagation parameters. The proposed model explains the existence of "pinhole" channels which exhibit low spatial fading correlation at both ends of the link but still have poor rank properties, and hence, low ergodic capacity. In fact, the model suggests the existence of a more general family of channels spanning continuously from full rank i.i.d. to low-rank pinhole cases. We suggest guidelines for predicting high rank (and hence, high ergodic capacity) in MIMO channels, and show that even at long ranges, high channel rank can easily be sustained under mild scattering conditions. Finally, we validate our results by simulations using ray tracing techniques. Connections with basic antenna theory are made. [J563]

"A UAPO solution for the field diffracted by building corners in wireless radio environments"

A uniform asymptotic physical optics (UAPO) solution is proposed to determine the field diffracted by building edges in mobile radio environments. A Gaussian rough lossy surface model is applied to describe the wedge surfaces. The diffraction coefficients are obtained by using a physical optics (PO) approximation of the surface current densities induced by an incident electromagnetic field on the illuminated face and by performing a uniform asymptotic evaluation of the resulting radiation integral. The resulting analytical expression is given in terms of the transition function of the uniform theory of diffraction (UTD) and is easy to handle and to implement in a computer code. [J564]

"Simulation of mobile fading channels"

Many aspects of a mobile radio system are basically determined by the propagation characteristics of the channel. Therefore, an understanding and good knowledge of mobile radio channels is essential for the analysis, design, and operation of wireless systems. It allows the successful development, evaluation, and testing of any current or future communication system, whether it is for cellular mobile telephony, for radio paging, or for mobile satellite systems. This article tries to present a simple and efficient way to simulate mobile channels for development and testing of mobile wireless systems, using some of the commercial circuit-analysis and simulation programs. So, in parallel with an overview of fading-channel propagation mechanisms and aspects, compact simulation models are given that can effectively be used for further analysis and understanding of the operation of mobile fading channels. [J565]

"The Jakes fading model for antenna arrays incorporating azimuth spread"

A new method for simulating the multiplicative fading of the narrow-band, flat wireless channel for antenna array

receivers is presented. The new approach produces a set of fading waveforms, one waveform associated with each receiver element, in which the waveforms are appropriately correlated to take into account the spread, or dispersion, in the azimuth (arrival angle) of the received signal. The new method is an extension of the Jakes (1974) method of simulating fading in which the appropriate correlation of the set of waveforms is accomplished by directly considering the azimuth of scatterers in a particular distribution about the mobile transmitter. The models used for this cluster of scatterers are a ring and a disk of scatterers. Further modifications of the disk model permit the generation of fading waveforms which are correlated in a manner which reflect actual field measurements of azimuth dispersion. Analytical correlation of these models is reviewed for purposes of verification with the waveforms generated by the method. [J566]

"Methods for modeling of specified and measured multipath power-delay profiles"

Five fundamental methods are proposed to model the multipath power-delay profile of frequency-selective indoor and outdoor wireless channels. Three of them are new, and the other two are well known, but their performance, however, has not been studied in detail up until now. All procedures are universally valid so that they can be applied to any specified or measured multipath power-delay profile. The performance of the proposed methods is investigated with respect to important characteristic quantities such as the frequency correlation function (FCF), average delay, and delay spread. The method found to perform best is the so-called LP-norm method (LPNM). This procedure is applied to measurement data of multipath power-delay profiles collected in different propagation environments. It is shown that the realization complexity of tapped-delay line-based simulation models for fading channels can be reduced considerably by using the LPNM. This is a great advantage for the development and specification of channel models for future wireless systems. [J567]

"The effects of the human body on UWB signal propagation in an indoor environment"

Ultra-wideband (UWB) communication systems are investigated for their ability to operate in dense multipath environments. While a great deal of time and effort has been spent characterizing both the indoor and outdoor UWB channels, the effects of human body interaction with a close proximity UWB antenna remains unexplored. Measurements of a commercially available UWB antenna performance in an anechoic chamber and in various indoor multipath environments were conducted. Comparisons of these measurement results indicate that while the human body creates a deep (23.6 dB) in a light multipath environment, this is drastically reduced (6.8 dB) in a dense multipath environment. [J568]

"Ranging in a dense multipath environment using an UWB radio link"

A time-of-arrival (ToA)-based ranging scheme using an ultra-wideband (UWB) radio link is proposed. This ranging scheme implements a search algorithm for the detection of a direct path signal in the presence of dense multipath, utilizing generalized maximum-likelihood (GML) estimation. Models for critical parameters in the algorithm are based on statistical analysis of propagation data and the algorithm is tested on another independent set of propagation measurements. The proposed UWB ranging system uses a correlator and a parallel sampler with a high-speed measurement capability in each transceiver to accomplish two-way ranging between them in the absence of a common clock. [J569]

"Performance of ultra-wideband communications with suboptimal receivers in multipath channels"

The performance of a single-user ultra-wideband (UWB) communication system employing binary block-coded pulse-position modulation (PPM) and suboptimal receivers in multipath channels is considered. The receivers examined include a RAKE receiver with various diversity combining schemes and an autocorrelation receiver, which is used in conjunction with transmitted reference (TR) signaling. A general framework is provided for deriving the performance of these receivers in multipath channels corrupted by additive white Gaussian noise (AWGN). By employing previous measurements of indoor UWB channels, we obtain numerical results for several cases which illustrate the tradeoff between performance and receiver complexity. [J570]

"Bivariate Nakagami-m distribution with arbitrary fading parameters"

The bivariate Nakagami-m distribution with arbitrary fading parameters is derived, obtaining the probability density function, the cumulative density function and the central moments. Additionally, limitations of that distribution are discussed. [J571]

"A new heuristic diffraction coefficient for lossy dielectric wedges at normal incidence"

A new heuristic diffraction coefficient is proposed for dielectric wedges with losses. This new diffraction coefficient, based on the uniform theory of diffraction (UTD), is valid for incidence orthogonal to the edge and

when losses are such that the field transmitted through the wedge can be neglected. This applicability range fits typical scenarios for urban propagation models. Our results are compared to those predicted by using the diffraction coefficients of R.J. Luebbers (see IEEE Trans. Antennas Propagat., vol.AP-32, p.70-76, 1984) and P.D. Holm (see IEEE Trans. Antennas Propagat., vol.48, p.1211-19, 2000), and the rigorous diffraction coefficient (RDC) of G.D. Maliuzhinets (see Sov. Phys. Dokl., vol.3, no.4, p.752-5, 1958). Comparisons with a diffraction coefficient derived from the finite-difference time-domain (FDTD) simulations are also presented for right angle wedges. Parallel and perpendicular field polarizations are tested. The new heuristic diffraction coefficient shows clear improvement in agreement with the RDC and the FDTD results. Moreover, the proposed diffraction coefficient is as simple to compute as Luebbers' and Holm's coefficients. [J572]

"Model for emission electric field of distributed unstructured telecommunication transmission networks"

A model for the estimation of the cumulative electric field of distributed unstructured telecommunication transmission networks in three dimensional space is presented. Example calculations for the cumulative ground and space wave field of a typical city, where ADSL modems have been deployed on a large scale are given. [J573]

"A complex baseband platform for spatial-temporal mobile radio channel simulations"

Joint spatial-temporal signal processing has been recognized as the key to reducing the effects of the intersymbol and cochannel interference seen in very high bit-rate mobile radio communications systems. Developing hardware simulators that can simulate mobile radio propagation scenarios in time and space domains is essential for evaluating the real-time performance of spatial-temporal signal processing schemes. This paper outlines a complex baseband platform developed for spatial-temporal mobile radio channel simulations. The platform consists of a complex baseband fading/array response simulator, a digital signal processor (DSP) board, and a general-purpose parameter estimator that uses systolic array implementation of the recursive least square (RLS) algorithm. Results of experiments conducted using the developed platform are presented to confirm the proper operation of the system. [J574]

"Ka-band aeronautical satellite communications experiments using COMETS"

This paper describes the results of evaluation tests of an aeronautical satellite communications experiments system in the Ka-band using Japan's communications and broadcasting engineering test satellite (COMETS). An active phased-array antenna with an open-loop satellite tracking capability operating in the Ka-band was installed just behind the passenger window of an airplane to receive a satellite signal. The propagation measurements showed that the received signal power was stable within a signal-power variation of 1 dBp-p while the airplane was cruising at 600 km/h. At specific directions of the antenna, the radiowave reflected from the wing of the airplane was measured to be 18.5 dB lower in power compared with the line-of-sight signal. To confirm the designed link budget, the multibeam antenna pattern of COMETS' on-board antenna was measured while the airplane flew across two antenna beams. The antenna pattern matched the one measured in a ground test before launch. Two binary phase-shift keying (BPSK) modems, one for pilot-assisted coherent detection and the other for multiple-symbol differential detection, were used to measure the bit-error rate (BER). The measured received signal energy per bit per noise power density (Eb/N0) at a BER of 10-4showed only a small degradation of about 1 dB from that measured in a translator loop-back test. [J575]

"Characterization of ultra-wide bandwidth wireless indoor channels: a communication-theoretic view"

An ultra-wide bandwidth (UWB) signal propagation experiment is performed in a typical modern laboratory/office building. The bandwidth of the signal used in this experiment is in excess of 1 GHz, which results in a differential path delay resolution of less than a nanosecond, without special processing. Based on the experimental results, a characterization of the propagation channel from a communications theoretic view point is described, and its implications for the design of a UWB radio receiver are presented. Robustness of the UWB signal to multipath fading is quantified through histograms and cumulative distributions. The all RAKE (ARAKE) receiver and maximum-energy-capture selective RAKE (SRAKE) receiver are introduced. The ARAKE receiver serves as the best case (bench mark) for RAKE receiver design and lower bounds the performance degradation caused by multipath. Multipath components of measured waveforms are detected using a maximum-likelihood detector. Energy capture as a function of the number of single-path signal correlators used in UWB SRAKE receiver provides a complexity versus performance tradeoff. Bit-error-probability performance of a UWB SRAKE receiver, based on measured channels, is given as a function of the signal-to-noise ratio and the number of correlators implemented in the receiver. [J576]

"A 3-D spatio-temporal simulation model for wireless channels"

A three-dimensional model is proposed for simulating the wireless channel. The model allows simulation of the effects of realistic channels on space-time processing and coding systems. The model is characterized by a set of scattering centers with a given mean angle of arrival (departure), angle spread (azimuth and elevation), and propagation delay. Additionally, the model accommodates either transmitter or receiver motion. Spatial characteristics of the simulated channels match previously obtained analytical results. We use the model to generate standardized temporal and spatial channel conditions from Global System for Mobile communication and third-generation standards. We demonstrate the need for such a spatial description by contrasting our results to classic methods of generating these standardized channel conditions. [J577]

"A stochastic multipath channel model including path directions for indoor environments"

A novel stochastic channel model for the indoor propagation channel is presented. It is especially for, but not limited to future communication systems with multiple antennas like space division multiple access (SDMA), spatial filtering for interference reduction (SFIR), or multiple-input/multiple-output (MIMO). The model is designed for indoor scenarios, straight forward extendable to urban environments. It is based on physical wave propagation. The new approach describes the channel by multipath components, each characterized by its transfer matrix (including loss), delay, direction of arrival, and departure. The appearance and disappearance of multipath components over time is modeled as a birth and death process, a marked Poisson process. This enables first-time the correct modeling of spatial and temporal correlations. In each modeling step, path properties change according to the motion of transmitter and receiver. The changing delay times of propagation paths yield a realistic Doppler behavior of the channel. Deterministic ray tracing results are used to produce the huge data sets required for the statistical evaluation of the parameters of the proposed model. This method enables an automated parameter extraction for new environments or frequencies. The ray tracing tool has been verified by narrowband, wideband, and directional channel measurements. The novel stochastic spatial channel model allows the simulation of third-generation broadband radio systems including arbitrary antenna configurations and patterns. System simulations for the bit-error rate of radio links can be performed including intelligent antenna configurations like SDMA, SFIR, or MIMO. Furthermore, the capacity of complete systems can be investigated. [J578]

"Multipath propagation model of spatio-temporal dispersion observed at base station in urban areas"

This paper presents a multipath propagation model for microcells in urban areas. The proposed model is a statistical geometric model that describes the propagation characteristics for propagation loss, power delay profiles, and power azimuth spectra. The applicable target of the proposed model is long-term characteristics such as the characteristics that depend on the height of a base station (BS) and the distance between the BS and a mobile station. Calculated power delay profiles and power azimuth spectra based on the model are similar to those of the power function. In order to verify the validity of the model, the power delay profiles and power azimuth spectra are measured. The measurement results agree well with the simulation results based on the model and the validity of the model is confirmed. [J579]

"Effect of antenna polarization on the capacity of a multiple element system in an indoor environment"

We analyze the behavior of a multiple element antenna system in an indoor environment based on the measurements taken in the Lucent Bell Labs building in Crawford Hill, NJ, with a system of 12 transmitters and 15 receivers. In particular, we investigate the capacity behavior with respect to the polarization of the transmitting/receiving elements and the distance between the transmitting and the receiving arrays. The analysis of the power rolloff versus distance clearly demonstrates the different propagation characteristics of the horizontally versus the vertically polarized electric fields. Under strong line-of-sight (LOS) conditions (hallway environment), the power of the horizontally polarized waves falls off faster with distance than that of the vertically polarized fields. Also, the cross-polarization coupling is about -15 dB. Under nonline-of-sight (NLOS) conditions (labs), both polarizations display similar rolloff behavior with distance and the cross-polarization coupling is about 0 dB. There is a power loss of at least 15 dB under NLOS conditions relative to LOS conditions. The average received signal power affects the system capacity. In the hallway, horizontally polarized systems achieve lower capacities than their vertically polarized counterparts. Also the achievable capacity in the labs is much lower than that in the hallway, because of the lower average received power. The comparison of single polarization systems to hybrid polarization systems shows that combined polarization systems perform better in terms of achievable capacity. Therefore, there lies an advantage in using both electric field polarizations. However, under strong LOS conditions the channel itself inherently limits the capacity behavior of the system. [J580]

"A stochastic MIMO radio channel model with experimental validation"

Theoretical and experimental studies of multiple-input/multiple-output (MIMO) radio channels are presented. A simple stochastic MIMO model channel has been developed. This model uses the correlation matrices at the mobile station (MS) and base station (BS) so that results of the numerous single-input/multiple-output studies that have been published in the literature can be used as input parameters. The model is simplified to the narrowband channels. The validation of the model is based upon data collected in both picocell and microcell environments. The stochastic model has also been used to investigate the capacity of MIMO radio channels, considering two different power allocation strategies, water filling and uniform and two different antenna topologies, 4Ч4 and 2Ч4. Space diversity used at both ends of the MIMO radio link is shown to be an efficient technique in picocell environments, achieving capacities within 14 b/s/Hz and 16 b/s/Hz in 80% of the cases for a 4Ч4 antenna configuration implementing water filling at a SNR of 20 dB. [J581]

"Effect of earth surface curvature on attenuation of electromagnetic waves by multiple building diffraction"

A theoretical explanation is proposed of an empirical formula for additional attenuation of radio waves due to the earth surface curvature in the presence of buildings. The theoretical formula is recommended for practical use since it has a wider scope of application than the empirical formula [J582]

"Vector channel modeling and prediction for the improvement of downlink received power"

Many researchers have done significant work to reduce fast fading in single channel wireless systems using prediction. We introduce a novel synthesis and prediction filter at the smart antenna base station to predict the vector channel in time-division duplex systems. We show the advantage of modeling each component of the vector channel with the same coefficients over modeling each channel separately. Experimental results from measurements taken in downtown Austin show that prediction of the vector channel is feasible, even as far as ten steps ahead. Ray tracing simulations of downtown Austin, assuming noiseless line-of-sight and nonline-of-sight channels, show that these predictions enhance downlink beamforming resulting in improvements in downlink received power in excess of 10 dB in nonline-of-sight scenarios compared to beamforming without predictions. Furthermore, this improvement allows an increase in the duplex interval by more than three times, assuming constant mobile velocity. [J583]

"Estimating frequency correlation functions from propagation measurements on fading radio channels: a critical review"

A significant number of propagation and channel modeling papers have reported channel parameters like RMS delay spread, correlation bandwidth, and the Rician K factor, derived by various new methods from instantaneous, or snapshot measurements. This conflicts with the original definitions of these parameters, which formally should be derived from time averages, under an assumption of ergodicity and applied for the assessment of time-averaged link performance. It appears that the origins of fading channel characterization parameters, and the conditions under which they can be estimated and applied are now often ignored, leaving interpretation of new results subject to skepticism. This paper, therefore, provides a critical review of the estimation of frequency correlation and one of these parameters, correlation bandwidth, using channel impulse response estimates derived from propagation measurements. The practical application for knowledge of frequency correlation is summarized. Then, the derivation of the equation relating a channel's average power delay profile to its frequency correlation function via a Fourier transform is reviewed, with emphasis on conditions needed for validity. An alternate method, free from most of these conditions is also reported. Examples are given and comparisons are made of results from analyses using the two methods to estimate frequency correlation on Rayleigh and Rician mobile radio channels, which are shown to have significantly different frequency correlation characteristics. Finally, a measure of frequency correlation that is free from ambiguity concerning the value (e.g., 0.5, 0.75, or 1/e) at the correlation band edges is recommended. [J584]

"Macrocell electric field strength prediction model based upon artificial neural networks"

A new macrocell prediction model for mobile radio environment is presented. The use of feedforward artificial neural networks makes it possible to overcome some important disadvantages of previous prediction models, including both deterministic and statistical types. Our sample implementation is based upon extensive electric field strength measurements (in the 900-MHz frequency band) that were carried out in the city of Belgrade using six different test transmitter locations. Comparison between the data obtained by the proposed electric field strength prediction model and independent measurement sets show that the proposed model is sufficiently accurate for use in planning mobile radio systems. [J585]

"Spherical outdoor to indoor power spectrum model at the mobile terminal"

Mobile terminals are often used indoor with the base station outdoors. At the mobile terminal the major part of the signal energy comes through openings in the building such as windows. Typically, only one of the sides in a room has windows, and seldom does a room have windows on all sides. Hence, the dominating signal can be expected to arrive at the mobile terminal from a narrow range of angles. Mobile terminal antennas used next to the head in the speaking position will be directional due to the fact that part of the radiation pattern facing the head will be attenuated and reflected. Having a directive antenna in a directive environment, the performance will depend on the orientation of the antenna in the radio environment. A new statistical spherical outdoor to indoor power spectrum model has been proposed to be able to calculate the directional performance of mobile terminals with a single or multiple antennas. The model consists of a major scattering area in one direction and more uniformly distributed minor scatterers in the other directions. A verification of the proposed model was performed and 60 data sets of spherical power spectrum measurements were collected in a typical urban environment. Using the new model, the directional performance of mobile terminal antennas including a human operator has been investigated through directional mean effective gain, branch power ratio, and correlation calculations using spherical radiation pattern measurements of a mobile terminal including the effect of 42 different persons. The accuracy of the calculated values was verified by directly measured values using 200 persons walking with the mobile terminal in the same office-like environments as where the spherical power spectrum measurements were performed. [J586]

"A novel stochastic millimeter-wave indoor radio channel model"

The paper introduces a model for the stochastic millimeter-wave indoor radio channel. This model relates the stochastic properties of the radio channel to the underlying geometry of the investigated environment. The geometric simplicity of the millimeter-wave channel allows examining fundamental deterministic properties of the wave propagation behavior in environments of predefined randomness, i.e., environments whose dimensions and properties are described by various probability distributions. The influence of the randomness on the radio channel is studied for the down-link of a wireless local area network at 60 GHz. Joint amplitudes of path lengths, angles of departure, and amplitudes, as well as spatial power densities, average power of the direct paths, and k factors are investigated. [J587]

"Application of the modal transmission-line method to radiowave propagation through building walls"

The modal transmission-line (MTL) method is used to analyse the transmission coefficient of building walls, which is an important parameter for the accurate planning of microcellular mobile networks. For that, the buildings walls are modelled as multilayer periodic structures. After a description of the extended MTL theory, the newly developed MTL method is applied to reinforced-concrete walls. From a comparison of the MTL results with previously published theoretical results obtained by the finite-element method, it is concluded that the MTL method is very well suited because it is accurate as well as computational-time efficient. [J588]

"Two-dimensional FDTD model of antipodal ELF propagation and Schumann resonance of the Earth"

This article reports the initial application of the finite-difference time-domain (FDTD) method to model extremely low-frequency (ELF) propagation around the entire Earth. Periodic boundary conditions are used in conjunction with a variable-cell two-dimensional TM FDTD grid, which wraps around the complete Earth sphere. The model is verified by numerical studies of antipodal propagation and the Schumann resonance. This model may be significant because it points the way toward direct three-dimensional FDTD calculation of round-the-world ELF propagation, accounting for arbitrary horizontal as well as vertical geometrical and electrical inhomogeneities of the ionosphere, continents, and oceans. [J589]

"Use of Global Positioning System (GPS) receivers under power-line conductors"

The use of Global Positioning System (GPS) technology continues to grow and accuracy augmentations will generate ever more innovative applications. The issue of GPS use under or near electric power lines has been raised since some GPS documents have vague warnings about such use. First, GPS and the satellite microwave signals used to determine position, velocity, and time are described. Then, the potential effects of electromagnetic interference and/or signal scattering from overhead conductors are evaluated analytically and with some practical measurements under transmission lines. This work demonstrates that it is unlikely that power line conductors will interfere with use of the GPS satellite signals. [J590]

"Applications of the PSTD for scattering analysis"

In this paper, we apply a pseudospectral time domain (PSTD) algorithm for calculation of the radar cross section of three-dimensional scattering objects. For the purpose of exciting an incident wave without leading to unwanted Gibbs' phenomenon, we utilize an initial condition-excitation technique. Meanwhile, we adopt the pure scattered field formulation to surmount a difficulty of introducing the incident field into computational space. In addition to accommodating a PSTD near-to-far-zone field transform for far-field computations in the algorithm, we develop a one-dimensional memory-saving storage technique for efficient truncation of computational boundary. [J591]

"Focused Gaussian beams in the problem of holographic imaging"

A simplified scheme of microwave near-field radar is considered. Focused Gaussian beams form a functional basis for holographic migration. Two-frequency phase measurements are used for the target localization. Numerical examples are given. [J592]

"Direct estimation of NLOS propagation delay for mobile station location"

For an accurate location-determination of a mobile station, a new location estimator is presented that directly estimates and compensates for an unavoidable non-line-of-sight (NLOS) propagation error usually contained in the time-delay measurements. The proposed estimator is applied to both simulations and field trials of CDMA wireless location for verification [J593]

"A random matrix model of communication via antenna arrays"

A random matrix model is introduced that probabilistically describes the spatial and temporal multipath propagation between a transmitting and receiving antenna array with a limited number of scatterers for mobile radio and indoor environments. The model characterizes the channel by its richness delay profile which gives the number of scattering objects as a function of the path delay. Each delay is assigned the eigenvalue distribution of a random matrix that depends on the number of scatterers, receiving antennas, and transmitting antennas. The model allows one to calculate signal-to-interference-and-noise ratios (SINRs) and channel capacities for large antenna arrays analytically and quantifies to what extent rich scattering improves performance. [J594]

"The ultra-wide bandwidth indoor channel: from statistical model to simulations"

We establish a statistical model for the ultra-wide bandwidth (UWB) indoor channel based on an extensive measurement campaign in a typical modern office building with 2-ns delay resolution. The approach is based on the investigation of the statistical properties of the multipath profiles measured in different rooms over a finely spaced measurement grid. The analysis leads to the formulation of a stochastic tapped-delay-line (STDL) model of the UWB indoor channel. The averaged power delay profile can be well-modeled by a single exponential decay with a statistically distributed decay constant. The small-scale statistics of path energy gains follow Gamma distributions whose parameters m are truncated Gaussian variables with mean values and standard deviations decreasing with delay. The total received energy experiences a lognormal shadowing around the mean energy given by the path-loss power law. We also find that the correlation between multipath components is negligible. Finally, we propose an implementation of the STDL model and give a comparison between the experimental data and the simulation results. [J595]

"Experimental evaluation of RAKE finger life distance for CDMA systems"

Future mobile communication systems based on direct sequence code division multiple access (DS-CDMA) require characterization of the radio channel in the multipath delay (i.e., Rake finger) domain (for short, the finger domain). CDMA system designers require channel information about number of significant Rake fingers and their lifetime. This work presents analysis of urban microcellular measurement results for obtaining the active Rake fingers and their life distance. [J596]

"Deconstructing multiantenna fading channels"

Accurate and tractable channel modeling is critical to realizing the full potential of antenna arrays in wireless communications. Current approaches represent two extremes: idealized statistical models representing a rich scattering environment and parameterized physical models that describe realistic scattering environments via the angles and gains associated with different propagation paths. However, simple rules that capture the effects of scattering characteristics on channel capacity and diversity are difficult to infer from existing models. We propose an intermediate virtual channel representation that captures the essence of physical modeling and provides a simple geometric interpretation of the scattering environment. The virtual representation corresponds to a fixed

coordinate transformation via spatial basis functions defined by fixed virtual angles. We show that in an uncorrelated scattering environment, the elements of the channel matrix form a segment of a stationary process and that the virtual channel coefficients are approximately uncorrelated samples of the underlying spectral representation. For any scattering environment, the virtual channel matrix clearly reveals the two key factors affecting capacity: the number of parallel channels and the level of diversity. The concepts of spatial zooming and aliasing are introduced to provide a transparent interpretation of the effect of antenna spacing on channel statistics and capacity. Numerical results are presented to illustrate various aspects of the virtual framework. [J597]

"On call admission control in DS/CDMA cellular networks"

Analytical models are proposed for various direct sequence code-division multiple-access (DS/CDMA) call admission control schemes. Many mathematical call admission models for DS/CDMA cellular networks have been proposed. However, they have shortcomings. First, by ignoring the stochastic traffic load variation or call blocking effect, they failed to sufficiently characterize the second moment of other-cell interference. This leads to inaccurate analysis of a real network. Second, the optimal control parameters were often obtained through an exhaustive search which was very time consuming. Finally, the estimation of system capacity in previous models was obtained by using a simple one-slope path-loss propagation model. However, it is well known that a two-slope path loss propagation model is needed in a line-of-sight (LOS) microcell propagation environment. We propose an analytical model for call admission to overcome these drawbacks. In addition, we combine a modified linear programming technique with the built analytical model to find better call admission control schemes for a DS/CDMA cellular network [J598]

"On joint power-delay double packet capture in an SSMA network with Rayleigh fading, shadowing, and propagation path loss"

In this paper, joint power-delay double-capture probabilities of a spread-spectrum packet network are derived. What we mean in terms of "double-capture" is that a receiver can simultaneously capture the first two incoming packets (from different transmitters) encoded by the same spreading code. The power capture model concerned takes into account multiuser interference, multipath Rayleigh fading, shadowing, and propagation path loss. To derive delay capture probability with an arbitrary arrival delay, a discrete-time approximation is applied. The method of deriving double-capture probability can also be extended to calculating multiple-packet (more than two) capture probabilities. Performance of a common-code slotted ALOHA system is evaluated with the double-capture effect and the results are compared with those of a traditional ALOHA system. It is shown that the channel impairing factors can be greatly mitigated by exploiting joint power-delay double-capture effect [J599]

"Spatial diversity analysis for digital TV systems"

Spatial diversity for digital TV systems has been studied using the results of a measurement campaign of the radio channel complex frequency response for two different situations: an outdoor-indoor channel and an indoor-indoor channel. It is shown that the actual improvement of spatial diversity is not only the mean level increase, but the reduction of both the level crossing rate (LCR) and the average fade duration (AFD). The mean level gain is in the range 1.2-3 dB for the indoor-indoor channel and within 1.4-2.9 dB for the outdoor-indoor channel and the LCR/AFD improvement is between 9.5 and 15 dB for both environments. To explain the behavior of the diversity system, high resolution angle of arrival and delay information was obtained. It is concluded that it is the interference of the direct propagation path with the main reflections that causes the received field to follow a standing wave pattern and shapes the spatial diversity gain behavior [J600]

"High-resolution phase sampled interferometry using symmetrical number systems"

This paper identifies a new phase sampling interferometer approach that can he easily incorporated into the established techniques to provide a high resolution, small-baseline array with a fewer number of phase sampling comparators. The approach is based on preprocessing the received signal using symmetrical number systems (SNS). Antennas based on both an optimum symmetrical number system (OSNS) and a robust symmetrical number system (RSNS) are investigated. The SNS preprocessing is used to decompose the spatial filtering operation into a number of parallel suboperations (moduli) that are of smaller computational complexity. A much higher direction finding (DF) spatial resolution is achieved after the N different moduli are used and the results of these low precision suboperations are recombined. By incorporating the OSNS or RSNS preprocessing concept, the field of view of a specific configuration of interferometers and phase sampling comparator arrangements can be analyzed exactly. The OSNS gives the maximum dynamic range or number of spatial resolution bins while the RSNS reduces considerably the number of possible encoding errors. Experimental results for both a 5-bit OSNS and a 6-bit RSNS array are compared. The errors in the encoding of the direction of arrival are quantified

for both architectures [J601]

"Space-time autocoding"

Prior treatments of space-time communications in Rayleigh flat fading generally assume that channel coding covers either one fading interval-in which case there is a nonzero “outage capacity”-or multiple fading intervals-in which case there is a nonzero Shannon capacity. However, we establish conditions under which channel codes span only one fading interval and yet are arbitrarily reliable. In short, space-time signals are their own channel codes. We call this phenomenon space-time autocoding, and the accompanying capacity the space-time autocapacity. Let an M-transmitter antenna, N-receiver antenna Rayleigh flat fading channel be characterized by an МЧN matrix of independent propagation coefficients, distributed as zero-mean, unit-variance complex Gaussian random variables. This propagation matrix is unknown to the transmitter, it remains constant during a T-symbol coherence interval, and there is a fixed total transmit power. Let the coherence interval and number of transmitter antennas be related as T=βM for some constant β. A ТЧМ matrix-valued signal, associated with R·T bits of information for some rate R is transmitted during the T-symbol coherence interval. Then there is a positive space-time autocapacity Casuch that for all R<Ca, the block probability of error goes to zero as the pair (T, M)→∞ such that T/M=β. The autocoding effect occurs whether or not the propagation matrix is known to the receiver, and Ca=Nlog(1+ρ) in either case, independently of β, where ρ is the expected signal-to-noise ratio (SNR) at each receiver antenna. Lower bounds on the cutoff rate derived from random unitary space-time signals suggest that the autocoding effect manifests itself for relatively small values of T and M. For example, within a single coherence interval of duration T=16, for M=7 transmitter antennas and N=4 receiver antennas, and an 18-dB expected SNR, a total of 80 bits (corresponding to rate R=5) can theoretically be transmitted with a block probability of error less than 10-9, all without any training or knowledge of the propagation matrix [J602]

"Educational software tool based on a geographical information system (GIS) for radio wave propagation analysis"

A tool is presented to evaluate and represent path loss, delay-spread, and the direction of arrival in graph form of each contribution considered in the propagation over buildings in urban scenarios. A geographical information system (GIS) and a ray-tracing technique are used in order to facilitate the understanding of the main propagation mechanisms in a more realistic environment, and the fields are evaluated using geometrical optics (GO) and the uniform theory of diffraction (UTD). This tool may be used to illustrate the influence of the propagation environment on radio wave parameters to telecommunications engineering students [J603]

"Estimation of directions of arrival of multiple scattered sources"

We consider the problem of estimating the directions of arrival (DOA) of multiple sources in the presence of local scattering. This problem is encountered in wireless communications due to the presence of scatterers in the vicinity of the mobile or when the signals propagate through a random inhomogeneous medium. Assuming a uniform linear array (ULA), we develop DOA estimation algorithms based on covariance matching applied to a reduced-size statistic obtained from the sample covariance matrix after redundancy averaging. Next, a computationally efficient estimator based on AR modelling of the coherence loss function is derived. A theoretical expression for the asymptotic covariance matrix of this estimator is derived. Finally, the corresponding Cramer-Rao bounds (CRBs) are derived. Despite its simplicity, the AR-based estimator is shown to possess performance that is nearly as good as that of the covariance matching method [J604]

"What is RF?"

It seems RF will remain a popular phrase for some time to come. Components and circuits whose design share a number of these concerns are RF, regardless of the numerical value of the frequency or bandwidth of electromagnetic signals involved. With a definition based on the designers' mind-set, we can include many kinds of components under the umbrella of RF at virtually any frequency from LF to IR [J605]

"Synthesis of large low-redundancy linear arrays"

Aperture synthesis interferometric radiometers can overcome mass, weight and mechanical scan limitations of present-day radiometers. A full antenna array is "thinned" by eliminating selected antennas, while keeping all possible antenna separations. This paper describes a new technique for the direct synthesis of low-redundancy large arrays, consisting in growing small arrays by inserting a seed repeatedly. This technique has achieved the largest thinned arrays with the least redundancy reported in the literature [J606]

"Use of VNAs for wideband propagation measurements"

Vector network analyser systems have been used by many workers to measure the wideband radio channel characteristics of short-range and indoor environments. The authors provide a detailed examination of the performance of such a measurement system and show how it can be extended to a synthetic aperture technique to obtain simultaneous angle and time of arrival information. Particular regard is given to the calibration process and the various performance metrics, such as delay resolution and delay range. In addition, measurement sensitivity and dynamic range are discussed. The paper also contains illustrative results of sequential radio imaging of a deep-shadow microcellular environment [J607]

"Satellite propagation channel modelling using photogrammetry and hidden Markov model approach"

In a typical satellite-Earth propagation path, the field strength of the received signal level changes with respect to time and space according to the changing morphology of the environment. It has been shown that the switching between different attenuation levels can be represented as a Markov stochastic process using the assumption that the channel properties are quasi-stationary in small periods of time. A hidden Markov model is introduced to replace the often used channel fading models, such as Rice, Loo and Rayleigh distributions. Three sets of parameters are trained to simulate the state transition and observation conditional probability density function among three basic propagation states that are categorised according to the environmental images. The simulated data were compared to the real RF measurement of satellite signals in several propagation properties, such as the cumulative fading distribution, level cross rate and error probability performance, at typical user environments. With the help of observation sets and their conditional probability densities, the proposed propagation channel simulator can model the satellite propagation properties with better accuracy than three-state Markov transition models [J608]

"Wave emission from an open-ended cylindrical channel in a cold magnetoplasma"

We study wave emission from a transmitting system consisting of a magnetic-field-aligned cylindrical plasma channel of enhanced density and a loop antenna immersed in it. An ambient medium is assumed to be a cold uniform magnetoplasma. It is found that when the plasma density in the near-antenna zone increases, the total power radiated from the antenna increases considerably due to the efficient excitation of guided modes on the channel. We consider the emission of these modes from the channel end, assuming that the plasma density in the channel decreases gradually with distance from the loop. It is shown that under ionospheric conditions this transmitting system can be useful for improving the antenna coupling to VLF waves of the ambient plasma [J609]

"Estimation of mobile speed and average received power in wireless systems using best basis methods"

A new method is presented for estimating the mobile speed and the average received power in general wireless propagation environments. The locally stationary received signal is expanded in a local exponential basis using best basis methods of wavelet analysis. An estimate of the time-varying Doppler power spectrum is obtained together with an estimate of the maximum Doppler frequency, which is proportional to the mobile speed. The average received power is then estimated by integrating the time-varying spectrum. Simulations demonstrate good tracking of variable mobile speed and average received power for a wide range of angular distributions of incident power. The estimator is shown to perform significantly better than an adaptive averaging method described in the literature. The speed and average power estimates are also used to detect the corner effect in urban cellular systems to improve handoff performance and reduce the call dropping rate [J610]

"Two- and three-dimensional ray tracing applied to the land mobile satellite (LMS) propagation channel"

This work examines the application of ray-tracing propagation models to system simulations for satellite mobile communications. A two-dimensional (2D) and a three-dimensional (3D) algorithm are outlined and compared using canonical propagation problems. Additional comparisons of both models with measurement campaigns are performed. The results show that two-dimensional models are suited for coverage and network planning. For system-design studies, however, three-dimensional ray tracing is mandatory. The novel three-dimensional ray-tracing model is able to predict time series of power delay profiles, Doppler and polarimetric information with high precision. It includes the time-variant correlation between the propagation channels of all visible satellites of an arbitrary satellite constellation. It therefore proves to be especially suited for system investigation of future LMS communication and navigation systems [J611]

"Prediction of loss characteristics in built-up areas with various buildings' overlay profiles"

We continue the analysis of a probabilistic approach and the corresponding stochastic multi-parametric model of wave propagation in built-up areas with randomly distributed buildings. We concentrate on the influence of buildings' overlay profiles on signal spatial decay, and on path-loss dependence in the frequency domain within UHF/X-band urban propagation channels. Using different buildings' overlay profiles, the field-intensity attenuation along radio paths is examined, taking into account single-scattering and multiple-scattering phenomena, and diffraction from buildings' corners and rooftops, for various positions of receiver and transmitter antennas with respect to surrounding obstacles. The comparison between experimental and theoretical predictions was motivated by the proposed stochastic multi-parametric model and the experimental data obtained for actual areas in Jerusalem (Israel) and Lisbon (Portugal), as well as by other models of multiple diffraction. The discussion is presented for realistic elevations of both terminal antennas to assess the accuracy and limits of the proposed stochastic model. A sensitivity analysis of the influence on the path loss of built-up terrain parameters and the elevation of antennas relative to the buildings surrounding them is presented [J612]

"Physical model for broadband wireless channels"

A physical wideband propagation model for the fixed wireless channel, with particular emphasis on K-factor and RMS delay spread and their variation as a function of range and antenna beamwidth, is described. The purpose of the model is to generate a set of spatially distributed scatterers, in accordance with given empirical channel characteristics. The model is successfully compared with existing empirical models [J613]

"Bearing estimation in a Ricean channel .I. Inherent accuracy limitations"

This paper considers the problem of estimating the bearing of a single, far-field source using passive sensor array measurements when the spatial propagation channel formed between the source and the array may be described as “Ricean.” Such a channel consists of a direct, line-of-sight (LOS) component as well as an indirect, nonline-of-sight (NLOS) component due to scattering. A parametric description of the resulting spatial propagation channel is presented. A related source-bearing estimation problem is formulated, and the associated Cramer-Rao lower bound (CRLB) is evaluated. The bound is used to study the relationship among the bearing estimation problems under the Ricean (LOS/NLOS), point source (LOS), and scattered source (NLOS) models. Exact and simplified approximate forms of the bound are derived explicitly in terms of the point source and scattered source CRLBs. A number of properties of the bound are presented. In particular, it is shown that the bound is a monotonically decreasing function of the Rice factor (the ratio of the LOS component power to the NLOS component power). This implies that for a given signal-to-noise ratio (SNR), the CRLB is bounded from below by the point source bound and bounded from above by the scattered source bound. It is also shown that given a NLOS component, the addition of a LOS component necessarily makes the bearing estimation problem easier. On the other hand, given an LOS component, the addition of an NLOS component does not necessarily make the bearing estimation problem easier (and may even make it harder). Lastly, the CRLB for estimation of the Rice factor is considered, and some of its properties are studied [J614]

"Prediction of local mean power using 2-D ray-tracing-based propagation models"

A new method is presented for the computation of local mean power from individual multipath signals predicted by two-dimensional ray-tracing-based propagation models. This method is based on an expression for the spatial average of the received power, which takes into account the spatial correlation between signals. Numerical results for some simple test configurations show that application of the common method of simply adding the ray powers can result in considerable errors, while the new method remains accurate-at the cost of slightly increased computational complexity [J615]

"Coverage analysis of a stratospheric communication system"

An original method for predicting the performance of upcoming stratospheric communication systems is presented. The prediction is based on a physical-statistical model of the built-up channel, used in combination with existing models of the tropospheric mechanisms. The physical nature of the approach allows the fade and BER statistics to be obtained as a function of any input parameter, such as the size of the target area, the platform height or the area characteristics. Simulations provide, for example, values of BER achieved over a certain percentage of area during a given percentage of time, as a function of the ground range right below the platform. Various system procedures, such as error correction and power control, are also investigated [J616]

"Limitations of sum-of-sinusoids fading channel simulators"

Rayleigh signal fading due to multipath propagation in wireless channels is widely modeled using sum-of-sinusoids simulators. In particular, Jakes' (1994) simulator and derivatives of Jakes' simulator have gained widespread acceptance. Despite this, few in-depth studies of the simulators' statistical behavior have been

reported in the literature. Here, the extent to which Jakes' simulator adequately models the multipath Rayleigh fading propagation environment is examined. The results show that Jakes' simulator does not reproduce some important properties of the physical fading channel. Some possible improvements to Jakes' simulator are examined. The significances of the number and the symmetries of the Doppler frequency shifts on the validity of the simulator's reproduction of the physical fading channel are elucidated [J617]

"3D tetrahedron ray tracing algorithm"

A new three-dimensional (3D) tetrahedron meshed ray tracing (TMRT) method is proposed. It is based on dividing the propagation region into tetrahedral cells whereby the number of tetrahedrons is decided by the number of vertices of structures instead of their dimensions. This method represents a 3D extension to the 2D procedure described in an earlier paper. Results from the 3D TMRT method show significant improvement in computational efficiency and are typically less than one half of those of the visibility ray tracing approach. These results were illustrated by calculating the delay spread in a typical indoor propagation environment [J618]

"A quality measure for ray-tracing algorithms"

The paper focuses on the validation of ray-optical techniques as tools fur predicting wide-band radio propagation, in the case of indoor environments. A novel approach to address the topic is proposed: it is based on a likelihood test between the simulations and the measures appropriately treated with a super-resolution technique [J619]

"Corrections to “The path loss model for UMTS vehicular test environment”"

Some inaccuracies have been found in the path loss model that has been proposed by ETSI (Universal Mobile Telecommunications System; Selection Procedures for the Choice of Radio Transmission Technologies of the UMTS (UMTS 30.03 version 3.2.0): European Telecommunications Standards Institute, 1998. Section 1.8.1.3) for the vehicular test environment of the Universal Mobile Telecommunications System (UMTS). Since this propagation model is being used for simulation and system evaluation purposes, the present authors consider that it is important to point out this fact [J620]

"Comments on “A new theoretical model for the prediction of rapid fading variations in an indoor environment”"

For original paper see IEEE Trans. Veh. Technol., vol.46, p.748-54 (1997). The present author discusses the number of scatterers assumption in modeling the envelope probability density functions for indoor radio [J621]

"Analytical evaluation of blocking probability in a mobile radio system with directed retry"

The blocking probability in a cellular network implementing directed retry (DR) is analyzed as a function of the main characteristics of the scenario (the density of base stations), the propagation model (path loss and shadowing), and the speed of mobiles. The analytical approach allows the evaluation of the blocking probability as a function of the maximum number of cells that can be considered at call setup by the DR algorithm. It is shown that the effectiveness of the DR strategy depends on the values of the variance of shadowing and the path loss model. Moreover, the blocking probability is found to be approximately independent from the mobile speed. The analytical results are compared to those obtained by means of simulation: a good agreement has been found, and the analytical model has been shown to be able to reflect the main effects of propagation and mobility on the advantages of DR in a real cellular network [J622]

"Lessons from a full-scale multihop wireless ad hoc network testbed"

This article describes our experiences building a multihop wireless ad hoc network of eight nodes driving around a 700 m by 300 m site. Each node runs the dynamic source routing protocol and interfaces seamlessly with existing Internet infrastructure and the Mobile IP protocol. We present quantitative results from data collected during runs of our testbed under a composite workload including voice, bulk data, and real-time data. Based on careful analysis of our data, we highlight radio propagation issues that network protocols will need to address in the future [J623]

"Tomography of the lower troposphere using a small dense network of GPS receivers"

The application of tomographic techniques to the troposphere with GPS signals was demonstrated in previous work using data from the Kilauea permanent network, Hawaii. Local orography of the network considered there, however, played a key role in the resolution capabilities of the technique. The authors explore the possibilities of

tomographic reconstruction of the four-dimensional (4D) structure of water vapor using a very small network of global positioning satellite (GPS) receivers with virtually no height differences between the stations. The analyzed campaign consisted of seven GPS receivers located at the Onsala Space Observatory, Onsala, Sweden, and was carried out in August 1998. Traditional meteorological data sources and tools such as the numerical weather model NCAR Mesoscale Model (MM5), satellite data from the National Oceanic and Atmospheric Administration (NOAA), Washington, DC, and data and analysis from the European Center for Medium-Range Weather Forecasting (ECMWF), Reading, UK, have been used to evaluate the results. A good agreement is found between GPS tomography and classical methods, even in meteorological situations with complex vertical structure of water vapor [J624]

"Observed extinction by clouds at 95 GHz"

Measurements of backscattered power were made in maritime stratus clouds with a 95 GHz radar mounted on an aircraft. The aircraft also carried probes for in situ cloud measurements of liquid water content (LWC) and hydrometeor size distribution. Horizontal flight segments of 5-10 km length, over which the LWC was relatively uniform, were selected for analysis. Mean values of LWC ranged from 0.05 to 0.8 g/m3. The observations yielded an extinction coefficient of 4.6 dB/km per g/m3of cloud water [J625]

"Space-time measurement of indoor radio propagation"

Most existing techniques for indoor radio propagation measurement do not resolve the angles from which signal components arrive at the receiving antenna. Knowledge of the angle-of-arrival is required for evaluation of evolving systems that employ smart antenna technology to provide features such as geolocation, interference cancellation, and space-division multiplexing. This paper presents a novel technique for the joint measurement of the angles, times and complex amplitudes of discrete path arrivals in an indoor propagation environment. A data acquisition system, based upon a vector network analyzer and multichannel antenna array is described, together with its use to collect channel measurement matrices. The inherent error sources present in these measurement matrices are investigated using a compact indoor anechoic range. Two signal processing algorithms are presented whereby the channel parameters may be estimated from raw measurements. In the first approach, an optimum beamformer is derived which compensates for systematic errors in the data acquisition system. This approach features very low computational complexity, and delivers modest resolution of path components. The second algorithm is based upon the maximum likelihood criterion, using the measured calibration matrices as space-time basis functions. This algorithm provides super-resolution of all path parameters, at the cost of increased computation. Several example measurements are given, and future directions of our research are indicated [J626]

"A complete physics-based channel parameter simulation for wave propagation in a forest environment"

At HF through UHF frequencies, wave propagation in a forest environment is mainly attributed to a lateral wave which propagates at the canopy-air interface. Due to the existence of tree trunks, significant multiple scattering also occurs which is the dominant source of field fluctuations. Basically, the current induced in the tree trunks by the source and the lateral wave reradiate and generate higher order lateral waves and direct scattered waves. Using a full-wave analysis based on the method of moments in conjunction with Monte Carlo simulations, the effect of multiple scattering among a very large number of tree trunks is studied. It is shown that only scatterers near the source and the observation points contribute to the field fluctuations significantly. This result drastically simplifies the numerical complexity of the problem. Keeping about 200 tree trunks in the vicinity of the transmitter dipole and the receiver point, a Monte Carlo simulation is used to evaluate the statistics of the spatial and spectral behavior of the field at the receiver. Using a wide-band simulation, the temporal behavior (impulse response) is also studied as is performance of antenna arrays and the effects of different spatial diversity combining schemes in such a multipath environment [J627]

"An accurate and efficient method based on ray-tracing for the prediction of local flat-fading statistics in picocell radio channels"

Ray-tracing techniques have proven to be very useful for the analysis and design of wireless systems both in urban microcells and in indoor picocells. At present, the optimization of these techniques enables not only the signal mean level but also the local statistics to be estimated accurately, which is of great practical importance. A wide range of comparisons between measurements and simulations confirming this have been carried out by the authors, and some examples are presented. The most interesting contribution of this paper is that starting from the signal information at one single point, obtained using ray-tracing techniques, it is possible to estimate the signal statistics in a local area of that point. This possibility substantially reduces the local statistics calculation

time, confirming the idea that an efficient site specific channel model might be feasible. Finally, it is also shown that ray-tracing techniques are able to accurately estimate the first- and second-order statistics in those environments where the Clarke (1968) or isotropic scattering model is not applicable [J628]

"Microwave attenuation measurements in satellite-ground links: the potential of spectral analysis for water vapor profiles retrieval"

The authors address the problem of estimating vertical profiles of atmospheric water vapor by means of attenuation measurements simultaneously made at different frequencies along a vertical satellite-ground link. The operating frequencies selected are those around the spectral absorption lines of water vapor at 22.235 GHz. A simulation is presented of multifrequency attenuation measurements, based on an atmospheric propagation model and on radiosonde data providing true profiles of temperature, pressure, and water vapor. The results indicate that such multifrequency measurements are correlated to variations of the vertical profiles of water vapor. It is therefore expected that vertical detail of such profiles depends on number and position of the frequencies utilized [J629]

"Effects of irregular terrain on waves-a stochastic approach"

This paper treats wave propagation over an irregular terrain using a statistical approach. Starting with the Helmholtz wave equation and the associated boundary conditions, the problem is transformed into a modified parabolic equation after taking two important steps: (1) the forward scatter approximation that transforms the problem into an initial value problem and (2) a coordinate transformation, under which the irregular boundary becomes a plane. In step (2), the terrain second derivative enters into the modified parabolic equation. By its location in the equation, the terrain second derivative can be viewed as playing the role of a fluctuating refractive index, which is responsible for focusing and defocusing the energies. Using the propagator approach, the solution to the modified parabolic equation is expressed as a Feynman's (1965) path integral. The analytic expressions for the first two moments of the propagator have been derived. The expected energy density from a Gaussian aperture antenna has been analytically obtained. These expressions show the interplay of three physical phenomena: scattering from the irregular terrain; Fresnel phase interference; and radiation from an aperture. In particular the obtained expected energy density expression shows contributions from three sources: self energy of the direct ray; self energy of the reflected ray; and cross energy arising from their interference. When sufficiently strong scattering from random terrain may decorrelate the reflected ray from the direct ray so that the total energy density becomes the algebraic sum of two self energies. Formulas have been obtained to show the behavior of the energy density function [J630]

"Catching up with Professor Scarry [JAP-S Turnstile]"

Readers of this column may remember Elaine Scarry, a Harvard English(!)professor, whose theory of how electromagnetic interference (EMI) might have caused the explosion and crash of TWA Flight 800 011 July 17, 1996, off Long Island, New York, was discussed in this space in August, 1998 [l]. After Professor Scarry published a long article, "The Fall of TWA 800: The Possibility of Electromagnetic Interference," in the April 9, 1998, issue of The New York Review of Books, the National Transportation Safety Board (NTSB) "allocated several hundred thousand dollars for fresh research into EMI," and "Scarry's work was cited on the first page of a NASA study of EM1 commissioned by TWA 800 investigators." [J631]

"WLAN and WPAN coexistence in UL band"

Wireless local- and personal-area networks provide complimentary services in the same unlicensed (UL) radio frequency band of operation. As the mutual benefits of utilizing these services become increasingly apparent, the likelihood of mutual interference may also increase. A method was developed for examining wireless services coexistence in order to evaluate the impact that interference may have on network performance. The methodology for the analysis was centered on deriving a closed-form solution for the probability of collision Pr[C] in terms of the network and radio propagation parameters. In addition, a set of measures of performance was derived based on Pr[C]. In this fashion, the network performance was investigated in regards to the presence of interference. The approach was then illustrated by examining the coexistence between 802.11b and Bluetooth UL band wireless services and summarizing the impact on network performance [J632]

"Two-dimensional simulator for propagation in urban environments"

A new two-dimensional (2-D) ray-tracing simulator for electromagnetic (EM) propagation prediction in an urban environment is described. The new features are that no practical restrictions are imposed on the profile of the cross section connecting the transmitter to the receiver and that each surface is characterized by its own value for the surface impedance; also, second-order diffraction coefficients for impedance wedges are used to allow

for arbitrary values of the heights of both antennas. Comparisons with other methods and numerical results are presented [J633]

"Far-region electromagnetic radiation with a vertical magnetic dipole in sea"

Great attention has been paid to conveniently calculating the electromagnetic (EM) field due to a vertical magnetic dipole (VMD) buried in stratified media. It is quite difficult because this topic involves the computation of Sommerfeld (1949) type integrals (SI). In this paper closed-form expressions for the far field of a VMD embedded below the sea surface are obtained easily by using a new technique to evaluate the SI with the aid of complex image theory. The present approach can be also used to get the far field formulas for other similar cases [J634]

"Field test measurement of DS-CDMA RAKE receiver with TWCL in an urban area"

This paper presents field test measurement results from a postdetection RAKE receiver system using a time-window control loop (TWCL). TWCL is a code synchronization scheme, and its performance with delay paths is better than the performance, in terms of acquisition and tracking, without delay paths because of the path-diversity effect. This receiver is suitable for systems that use short spreading codes such as wireless local area networks because it employs a matched filter for despreading. The RAKE method is a simple integral demodulation method used to combine correlation peaks including delay paths in a time window, and two-branch-antenna combining diversity is available. A field test is implemented while walking in an urban area, including the no-line-of-sight situation, taking into consideration microcellular systems. The results show that when the bit error rate is 10-3and the spreading-chip rate is 4.096 Mchip/s, path-diversity gain from the theoretical differential quadrature phase-shift keying value is more than 12 dB without antenna diversity. This path-diversity gain value corresponds to a path-diversity reception gain of between two and three. Using two-branch-antenna diversity, the total of path- and antenna-diversity gain is up to 18 dB in the no-line-of-sight situation. From the above results, it is clear that this RAKE receiver is effective even in the no-line-of-sight situation and that TWCL provides good performance under the given field conditions [J635]

"Empirical characterization of wideband indoor radio channel at 5.3 GHz"

Characteristics of wideband indoor radio channel at 5.3 GHz were defined based on an extensive measurement campaign using a wideband channel sounder with 19 ns delay resolution. Pathloss exponents were 1.3-1.5 in LOS and 2.9-4.8 in non-line of sight (NLOS). Large difference in NLOS exponents was due to different dominating propagation mechanisms in different types of building structures. The delay dispersion was characterized by cumulative distribution functions (CDF) of the RMS delay spreads, the values for CDF=0.9 varied from 20 to 180 ns in different setups in an office building and large hall environments. The correlation functions of the radio channel in spatial and frequency domains were extracted. Small scale models for five typical indoor scenarios were developed using tapped delay lines [J636]

"Multipath propagation study combining terrain diffraction and reflection"

A multiple knife-edge attenuation formula is derived by combining diffraction and ground reflection. As an example, the attenuation by double knife edges with ground reflection is derived in detail and the attenuation by a flat-topped obstacle with slanted sides is also calculated. The attenuated fields are proven to be the combination of eight field components, and the number of multipath reflection rays can be reduced based on the location of the main reflection point defined by path parameters. The formulas have clear physical meanings and can be used for field strength prediction in both mobile and fixed communications [J637]

"Height amplification factor for multiple half-plane diffraction"

A new recurrent formula has been obtained for the height amplification factor at an arbitrary number of half-planes. It has been shown that at an infinite number of half-planes the solution is factorised and the height amplification factor depends on one dimensionless parameter only [J638]

"Frequency and noise dependence of the image reconstruction of ground surfaces using the conjugate gradient based algorithm"

It has been shown previously that the ground surface of the Earth can be imaged using radio ground waves with antennas positioned on the ground surface. The image of the surface is obtained by reconstructing the distribution of the normalised surface impedance of the surface from the measurements of the scattered fields at a number of positions around the surface being imaged with electromagnetic radiation from different azimuthal directions. It has also been shown that the inverse problem can be solved iteratively using a conjugate gradient

method and the images of ground surfaces can be produced using the noiseless data of the measured scattered fields at an operating frequency at which the size of the surface is approximately one wavelength. In practice, the image reconstruction depends on the operating frequency, and the measured scattered fields are subject to white noise and measurement errors. The dependence of the image reconstruction using the conjugate gradient method on the operating frequency and noise in the measured data is thus studied and the results of reconstruction errors at different frequencies and signal-to-noise ratios and the reconstructed images are presented. It is shown that the image reconstruction using the conjugate gradient based algorithm has a strong dependence on the operating frequency and noise. However, the algorithm is able to reconstruct the images of ground surfaces in a small number of iterations when the signal-to-noise ratio is greater than 12 dB [J639]

"GQR models for multipath Rayleigh fading channels"

In this paper, reduced complexity statistical models for the representation of wide sense stationary-uncorrelated scattering doubly selective fading channels are developed. Their derivation is based on the evaluation of Fourier integrals by means of Gaussian quadrature rules. The accuracy and the complexity of the proposed models is assessed, and is then compared to that provided by other modeling techniques available in the literature [J640]

"A physical-statistical shadowing correlation model and its application to low-Earth-orbit systems"

A shadowing correlation model is proposed in the context of a physical-statistical approach in the view of satellite diversity in built-up areas. The model relies on a model based on the uniform theory of diffraction, applied in a canonical built-up scenario. The correlation model is described and simulation results are presented and analyzed within a physical point of view. The shadowing correlation model is finally applied to several low-Earth-orbit constellations. The impact of geometrical parameters and of the constellation is investigated [J641]

"Propagation of HF radio waves over sloping coastal land"

The field of a TM wave at a reception point over sloping coastal land, farther than a wavelength from the sea, has been calculated for a transmitting element located infinitely far away over a flat sea. The field obtained is normalized to that of a wave approaching the water/land boundary from infinity. A transmitting element placed both at some elevation angle and on the surface of the sea has been considered. In both instances, simple formulas providing fast computation of the field have been obtained by employing the integral equation approach formulated in terms of the normalized surface impedance. It has been found that the sloping land to some extent compensates for power losses in the ground and may even enhance the power density of high-frequency waves coming from low elevation angles. The expressions obtained remain valid for flat ground in place of sea. In this instance, the permittivity and conductivity of the sea should simply be substituted by those of the ground [J642]

"Planning system for indoor wireless network"

A novel wireless LAN prediction tool using the genetic algorithm and neural network has been proposed. We establish a site survey tool system to predict the received signal strength index (RSSI) in an indoor environment. The system includes six items. (1) The fading function: it corrects the functional characteristics of the RSSI for different types of wireless LAN cards in free space. (2) The setting of the attributes of obstacles in the indoor environment: the idea of a “single attribute of local area” is proposed. If there are the same obstacles in one area, we set the area as one attribute. (3) The genetic algorithm: where we use reproduction, crossover and mutation to obtain the propagation loss through the different obstacles (Li). (4) The neural network: we use neural network concept to correct the prediction error arising from the multipath effect in the indoor environment. (5) The auxiliary judgment for the sampling points: the method is helpful to users in establishing the best sampling points. (6) The calibration of prediction results: we use calibration to correct the prediction error arisen from Li [J643]

"Ka-band land mobile satellite channel model incorporating weather effects"

A Ka-band land mobile satellite (LMS) channel model which is able to take into account weather impairments is proposed. The statistics of the received signal and the BER performance of the system under the proposed channel model are obtained and compared with the results generated using Loo's weather-affected LMS channel model. The proposed Ka-band (20/30 GHz) LMS channel model is shown to be more reasonable as it gives realistic results [J644]

"Radiowave propagation and smart antennas for wire less communications [JRecent Books]"

First Page of the Article [J645]

"A direction-finding technique for wide-band impulsive noise source"

A direction-finding technique for wide-band impulsive electromagnetic interference is presented. An experimental investigation was performed using a spark generator as the impulsive noise source. The signals were captured using a two-antenna array directly sampled at 1 Gs/s. A digital signal processing based correlation technique allowed assessment of the time delay between the antennas. The results in a nonideal radio propagation environment show the bearing can be estimated to an accuracy of 20 [J646]

"A new stochastic spatio-temporal propagation model (SSTPM) for mobile communications with antenna arrays"

In order to evaluate the performance of third-generation mobile communication systems, radio channel models are required. The models should be capable of handling nonstationary scenarios with dynamic evolution of multipath. In this context and due to the introduction of advanced antenna systems to exploit the spatial domain, a further expansion is needed in order to include the nonstationary characteristics of the channel. In an attempt to solve these problems, this paper presents a new stochastic spatio-temporal propagation model. The model is a combination of the geometrically-based single reflection and the Gaussian wide-sense stationary uncorrelated scattering models, and is further enhanced in order to be able to handle nonstationary scenarios. The probability density functions of the number of multipath components, the scatterers' lifetime, and the angle of arrival are calculated to support these features. The input parameters of the model are based on results from measurement campaigns published in the open literature [J647]

"Minimum sprite plasma density as determined by VLF scattering"

The scattering of VLF sub-ionospheric transmissions by sprite plasma through horizontal angles up to 180° shows that sprite plasma is highly conducting. Following a simple transmission-line (one-dimensional-wave) model in 1997, two-dimensional and three-dimensional models have been produced. Here, we compare the results of the three models, and show that all require a uniform conductivity of at least 30 μS/m, corresponding to an electron density at 70 km altitude of ~1010m-3(~104 electrons per cc), and so about 105/cc at 55 km. The latter ionization density is about that of the daytime E-region, and over six orders of magnitude above the ambient density at 55 km. By contrast, the “early/fast” events, as defined by the Stanford group, do not exhibit scatter angles above 15°, suggesting that the sprite conductivity rises too slowly (as the plasma cools) to reach adequate backscatter within the time allowed by the “early/fast” definition [J648]

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