WiMAX
Metropolitan Area Networks and its Future Potentials

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Abstract:
Nowadays many researchers, manufacturers and operators are looking at IEEE 802.16 a WiMAX certified technology. WiMAX networks are foreseen to provide broadband wireless access to mobile users everywhere at lowest costs. But what is WiMAX? This tutorial gives a detailed introduction to the technology, it provides valuable performance evaluations and finally it reports about current activities and future developments. By attending this tutorial the audience will gain insights into the WiMAX system, its capability and future enhancements. One is able to evaluate what such systems can do and what they cannot.

Tutorial Outline:
Chapter one gives an introduction to the WiMAX system. The WiMAX Forum comprises the metropolitan area network standards IEEE 802.16 as well as ETSI/BRAN HiperMAN. Different standardization groups, target frequencies and deployment concepts are outlined.

Based on the reference model the following two chapters elaborate on the IEEE 802.16 protocol stack comprising the medium access control (MAC) and the OFDM-based physical layer. Chapter two illustrates the MAC frame structure and describes the basic control elements. Further QoS management in IEEE 802.16 is presented. Likewise, chapter three outlines the basic physical layer modules of an IEEE 802.16 OFDM transmitter-receiver chain.

The following chapter five evaluates the system performance. The first subchapter derives an example scenario that allows evaluating important influences of the protocol. The example scenario is used in the following subchapter to calculate the physical layer as well as the MAC layer capacity by means of a mathematical analysis. Different protocol features such as packing / fragmentation are evaluated. Several MAC layer configurations are analyzed in the context of throughput and overhead. The trade off between robustness and high capacity is shown. After the introduction of the simulation tool developed at ComNets, characteristic performance and system measures are given based on stochastic event-driven computer simulations.

After the regular modes of operation, enhanced modes are presented. The mobility support of the newly standardised IEEE 802.16e-2006 is introduced in chapter five. This standard amendment extends the protocol with handover functionality, sleep mode and inter base station communication. The optional MESH mode that overcomes the mandatory point-to-multipoint deployment concept and allows for multi-hop communication is presented in chapter six. Additionally, the activities and future potentials of the newly established IEEE Study Group on “Mobile Multi-hop Relay” are shortly introduced. Finally, adaptive antenna systems (AAS) that enhance the base station transmit- and receive capability are outlined. The AAS option reserves portions of the MAC frame to AAS-enabled stations communicating with advanced technologies such as space time coding and MIMO. Different concepts to allow for space division multiple access (SDMA) in IEEE 802.16 networks are presented. The possible increase in system capacity by means of SDMA is shown.

Summary:

1. Introduction to WiMAX systems
2. Medium Access Control Layer
    a. MAC Frame Structure
    b. MAC Management Functions
    c. MAC Quality of Service
3. Physical Layer (OFDM)
4. Performance Evaluation
    a. Simulation Environment
    b. Analytical Results
    c. Simulation Results
5. Mobility Support in IEEE 802.16e
6. Relay-based Mesh mode
    a. Deployment concepts
    b. Comparison of single and multi-hop cells
    c. Mesh support of IEEE 802.16
7. Space Division Multiple Access Support
    a. Regular support of SDMA
    b. Simulative performance evaluation

Author's Biography:

Christian P. Hoymann received a Diploma degree in electrical engineering from RWTH Aachen University in 2002 and a Diploma degree in business administration from the University of Hagen in 2005. During his studies he worked with the Multimedia & Video Technology research group at SIEMENS Corporate Research, Princeton, N.J., USA. Since 2002 he is employed as a Research Assistant for the Chair of Communication Networks (ComNets) of RWTH Aachen University where he is working towards his Ph.D. degree.
He worked in the fields of traffic engineering and dimensioning of GSM/GPRS networks together with his project partners at D2 Vodafone. He has been actively involved in several IST projects (IST-STRIKE, IST-FIREWORKS) where smart antenna systems had been integrated in Metropolitan Area Networks. His current research interests include the optimization of MANs especially in consideration of smart antenna technologies such as SDMA and relaying concepts such as Mesh.
Mr. Hoymann conducted successful GSM/GPRS as well as WiMAX tutorials at several international conferences and industrial companies. He has published several conference and journal papers and was actively involved in the standardization of SDMA technologies for IEEE 802.16.

Bernhard H. Walke is an internationally recognized expert (numerous publications, including several internationally published books) in the field of communication networks. His group's research work focuses on formal specification, modeling, mathematical and simulative analysis, and pilot implementation of protocols and services for communication networks.
Having worked at AEG-TELEFUNKEN Research Institute, and later at Fern University of Hagen (Chair for Data Processing Techniques), he has held the chair of Communication Networks at Aachen University since 1990. He is member of various national and international expert groups and coordination boards (e.g., ITG, AG Mobikom, WWRF) and has frequently served as an advisor to the German national regulation body (RegTP).

Bendikt M. Wolz received a Diploma degree in electrical engineering from RWTH Aachen University in 2005. He also received the "Award of Imperial College International Diploma" after one academical year at Imperial College London. During his studies he worked with the Human Machine Interfaces research group at BMW research centre, Munich, Germany. Since 2006 he is employed as a Research Assistant for the Chair of Communication Networks (ComNets) of RWTH Aachen University where he is working towards his Ph.D. degree. He has been actively involved in the IST-FIREWORKS. His current research interests include the optimization of Metropolitan Area Networks with focus on smart antenna technologies, relaying concepts and intelligent spectrum utilization.