

ARCHITECTURE AND PROTOTYPING OF AN 802.11-BASED SELF-ORGANIZING HIERARCHICAL AD-HOC WIRELESS NETWORK (SOHAN)

S. Ganu, L. Raju, B. Anepu, S. Zhao, I. Seskar and D. Raychaudhuri

WINLAB, Rutgers University, 73 Brett Road, Piscataway, NJ 08854
{sachin, lalit, bhaskar, sulizhao, seskar, ray}@winlab.rutgers.edu

Abstract - This paper describes the design and implementation of a novel 802.11-based self-organizing hierarchical ad-hoc wireless network (SOHAN), and presents some initial experimental results obtained from a proof-of-concept prototype. The proposed network has a three-tier hierarchy consisting of low-power *mobile nodes* (MNs) at the lowest layer, *forwarding nodes* (FNs) with higher power and multi-hop routing capability at the middle layer, and wired *access points* (APs) without power constraints at the highest layer. Specifics of new protocols used for bootstrapping, node discovery and multi-hop routing are presented, and overall operation of the complete hierarchical ad-hoc network is explained. A prototype implementation of the SOHAN network is outlined in terms of major hardware and software components, and initial experimental results are given.

Keywords - Ad-hoc network, discovery and routing protocols, sensor networks, system prototyping.

I. INTRODUCTION

This paper describes a novel self-organizing hierarchical ad-hoc wireless network ("SOHAN") designed to provide significant improvements in system capacity and performance relative to conventional "flat" ad-hoc networking approaches. The proposed hierarchical ad-hoc network is motivated by the fact that flat ad-hoc architectures do not scale well as the number of radio nodes becomes large [1]. In addition, most realistic usage scenarios involve predominant mobile device traffic flows to and from the wired Internet, thus requiring effective integration of wired "access points" with the ad-hoc wireless network nodes.

The approach adopted here is based on a multi-tier hierarchy that scales well and integrates naturally with existing wireless access points or base stations, while retaining much of the robustness, coverage and power advantages of ad-hoc wireless networks. This architecture is applicable to a number of emerging ad-hoc networking scenarios including extended wireless local-area networks, home wireless networks and large-scale sensor networks. In each of these scenarios, the introduction of one or more tiers of ad-hoc forwarding nodes (FN) as intermediate radio relays between the MNs and APs helps to scale network throughput, reduce delay and lower power consumption at end-user devices. In this paper, we focus on practical design aspects and

prototype implementation of protocols used in the SOHAN ad-hoc network, including those used for node bootstrapping, node discovery and multi-hop routing. More detailed consideration of system capacity scaling and network performance of the hierarchical ad-hoc network for alternative routing methods can be found in [2,3,4]. Design trade-offs for both discovery and routing are discussed, and a proof-of-concept prototype (implemented on Linux platforms with 802.11b radios) is described in terms of hardware and software components. Selected validation experiments and measurements are also given for the prototype hierarchical ad-hoc network.

II. SYSTEM ARCHITECTURE

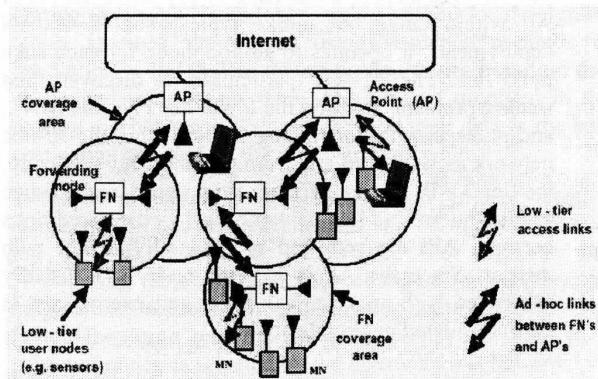


Figure 1. Three tier ad-hoc network architecture

The three-tier hierarchical ad-hoc network consists of the following components: Low-power end-user "mobile nodes" (MN) at the lowest tier, higher powered radio "forwarding nodes" (FN) that support multi-hop routing at the second level, and wired access points (AP) at the third and highest level. Each of the network entities in the proposed system is defined in further detail below

- **Mobile Node (MN)**, is a mobile end-user device (such as a sensor or a personal digital assistant) at the lowest tier (tier 1) of the network. The MN attaches itself to one or more nodes at the higher tiers of the network in order to obtain service using a discovery protocol. The MN uses a single 802.11b radio operating in ad-hoc mode to communicate with the point(s) of attachment. As an end-user node, the MN is not required to route multi-hop traffic from other nodes. It is noted that as a

battery-operated end-user device, the MN will typically have energy constraints

- *Forwarding Node (FN)*, is a fixed or mobile intermediate (tier 2) radio relay node capable of routing multi-hop traffic to and from all three tiers of the network's hierarchy. As an intermediate radio node without traffic of its own, the FN is only responsible for multi-hop routing of transit packets. A forwarding node with one 802.11 radio interface uses the same radio to connect in ad-hoc mode to MNs, other FNs and the higher-tier APs defined below. Optionally, an FN may have two radio cards, one for traffic between FNs and MNs and another for inter FN and FN-AP traffic flows (typically carried on a different frequency). The FN is typically a compact radio device that can be plugged into an electrical outlet, but in certain scenarios, may also be also be a battery-powered mobile device. Thus, the FN is also energy constrained, but the cost is typically an order of magnitude lower than that of the MN defined above
- *Access Point (AP)*, is a fixed radio access node at the highest tier (tier 3) of the network, with both an 802.11 radio interface and a wired interface to the Internet. The AP is capable of connecting to any lower tier FN or AP within range but unlike typical 802.11 WLAN deployments, it operates in ad-hoc mode for each such radio link. The AP also participates in discovery and routing protocols used by the lower tier FNs and MNs., and is responsible for routing traffic within the ad-hoc network as well as to and from the Internet. Logically, the tier 3 APs are no different from tiers 1 and 2 when routing internal ad-hoc network traffic - the wired links between APs are reflected in (generally) lower path metrics. Since the AP is a wired node, it is usually associated with an electrical outlet and energy cost is thus considered negligible

III. SCALABILITY OF HIERARCHICAL NETWORKS

Scalability issues for flat ad-hoc networks as addressed in [1] motivate our proposed hierarchical architecture with more than one tier of ad-hoc radio nodes in which the lower tiers aggregate the traffic up to the intermediate relay nodes, while continuing to use robust ad-hoc self-organization and routing protocols. In order to study the performance of the hierarchical architecture under consideration, the performance of two routing protocols (DSR and AODV) when applied to a hierarchical and a conventional flat ad-hoc network was compared using ns-2 simulations. From Fig 2, it can be seen that the system capacity increases significantly when a hierarchical approach is adopted for the particular system example under consideration. Similar gains are observed for both DSR and AODV. Performance measures such as delay and packet delivery ratio are also improved in the hierarchical system. Further details can be found in [4], in which the authors also study the scalability

of the three-tier hierarchical network's capacity as a function of the relative densities of FNs and APs.

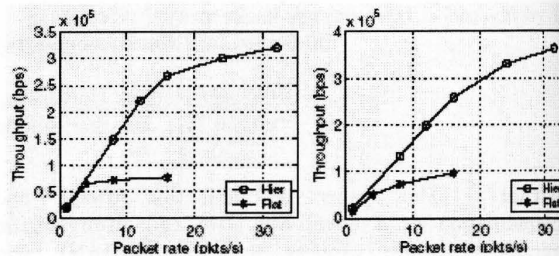


Figure 2. Performance of a) DSR and b) AODV applied to a flat and hierarchical network

Results indicate that it is possible to scale network capacity quite well with a mix of several (lower-cost) radio forwarding nodes and just a few wired access points.

IV. AD-HOC NETWORK PROTOCOLS FOR SOHAN

The above results motivated the design and development of a proof-of-concept prototype for the proposed self-organizing hierarchical ad-hoc network (SOHAN). The ad-hoc protocols used in the hierarchical network including those meant for 1) Bootstrapping, 2) Discovery, 3) Routing and Data Transmission are described below.

A. Bootstrapping

This phase involves the configuration of the different devices in terms of channel assignments and initial transmit power level settings. Note that the devices operate in the 802.11 ad-hoc [6] mode.

- Each AP is initialized on a pre-determined channel
- Each FN has two interfaces, one to communicate with other FNs and MNs (known as the *beaconing* interface) the other interface to communicate with APs (known as the *scanning* interface). These two interfaces are configured to operate on different channels that are specified at initialization so as to minimize interference.

In [7], a distributed bootstrapping mechanism that will automatically select appropriate channels for the particular interface based on the number of nodes already existing on that channel has been proposed. However, for the current implementation, the channel allocations are done manually using scripts.

B. Discovery

In traditional ad-hoc networks, there is no discovery phase and the routing protocol itself is responsible for building up topologies either using on-demand broadcast of route requests or by exchanging neighbor information proactively with one hop neighbors. While this may be sufficient for smaller networks, as the number of nodes increases, it results in denser physical topologies, leading to extensive routing message exchanges. The problem is more severe in a

multi-channel network where the multiple nodes that need to communicate could be on different radio channels. In this case, the routing messages need to be propagated across multiple channels in order to enable data transfer from one node to the other. In [8], using ns-2 simulations, it has been shown that by introducing discovery as a separate layer, the routing overhead is significantly reduced. These results, as shown in Fig. 3, demonstrate the improvement in routing overhead versus varying mobility and number of nodes with AODV as the routing protocol.

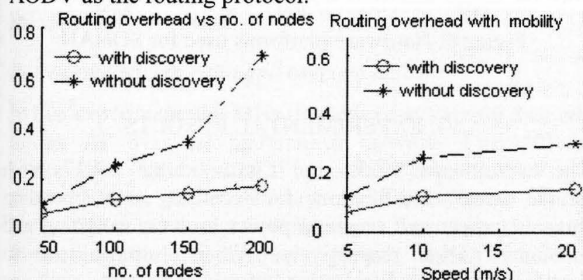


Figure 3. a) Routing overhead with increasing nodes b) Routing overhead with increasing mobility

Based on these results, we use augmented 802.11 MAC beacons and associations in SOHAN to support neighbor discovery and determination of the logical topology. Note also that for ease of implementation, the beacons used in the prototype are application-level packets, since actual 802.11 beacons are generated by the firmware in most of the existing 802.11b network adapters and are not customizable. The beacon format in SOHAN is shown in Fig 4.

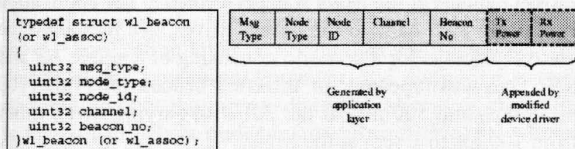


Figure 4. Beacon and Association Message Format

In SOHAN, FNs and APs periodically send beacons while the MNs scan different channels, listen to the beacons and send an association message to the best "cost" parent using the discovery metric described below.

1) Discovery metric

For our implementation, energy conservation at the MNs was chosen as the objective and the discovery metric was based on minimizing the transmit power consumption at the MNs. We modified the device drivers to append transmit power to each outgoing beacon at the APs/FNs and the received signal strength for each incoming beacon at the MNs. Using this information and assuming reciprocity of channel, the node with the minimum transmit power was chosen as the next hop neighbor. In case, there were two or more such nodes, the node whose beacon was received with the higher signal strength was chosen.

C. Routing

Motivated by the results in Fig. 3, we have implemented a distance-vector based routing protocol that uses the "logical" topology information presented by the discovery mechanism in order to create and maintain local neighbor tables at each of the FNs and APs. A combination of MAC addresses and node ID of the nodes is used for the routing protocol to handle the case of FNs that have two different MAC addresses for the two different interfaces but the same node ID. The routing protocol involves two phases: 1) Neighbor Table Formation and 2) Periodic Table Update and Exchange. In phase 1, the FNs and APs build their local neighbor tables based on the beacons and the association messages exchanged during the discovery phase. The neighbor table format is shown in Table 1. Each entry is associated with a refresh timer that is reset or decremented respectively based on whether or not beacons are received from that neighbor every beacon interval.

Table 1. Local Neighbor Table Format

MAC Addr	Node Type	Refresh Timer	Channel to Next Hop	Cost to Dest	Interface to next Hop	Next Hop
----------	-----------	---------------	---------------------	--------------	-----------------------	----------

During phase 2, FNs and APs exchange their local neighbor tables amongst themselves using sequence numbers to handle loops and update their neighbor tables based on this exchanged information. The MNs are not involved in the routing mechanism and simply forward their data to the best cost parent selected by the discovery procedure.

Note that any existing proactive (DSDV [5]) or reactive (DSR, AODV) routing mechanism can be implemented on top of our discovery mechanism. For DSDV, the "forwarding table" at each node could be replaced by the neighbor table provided by discovery, while in AODV (or DSR), the route requests could be propagated only to a subset of nodes as selected by the discovery mechanism.

After the table exchanges, each FN computes a path that it can use to route data to the AP. The FN maintains a latest best cost path towards the AP at every instant and whenever it receives data packets (originated at the sensors), it consults the neighbor table to forward the data to the next hop on the appropriate channel and interface. If an FN is disconnected from the network (there is no entry for an AP that exists in its neighbor table), it discards the packet and indicates a routing failure. Note that this routing implementation is based on the assumption that most of the traffic flow is from the MNs to the APs.

V. PROTOTYPE IMPLEMENTATION OF SOHAN

In this section, the practical design aspects and implementation of a proof-of-concept prototype for SOHAN architecture are described. The software architecture, protocol details, hardware architecture and initial experimental results are discussed in detail.

A. Software Architecture and Protocol Implementation

The implementation of the discovery and routing mechanism was done using C programming on embedded devices running Linux. We used the Libnet [9] open-source library to generate, send and receive custom packets. Fig. 5 shows the software architecture of the prototype. The modular software design as described below is consistent with the protocol stack and thus provides an easy way to modify functionality and add features at any layer.

- **Physical Layer:** The functionality of transmitting and receiving packets is handled using Libnet packet handling library that provides a portable and simplified interface for low-level network packet shaping, handling and injection.

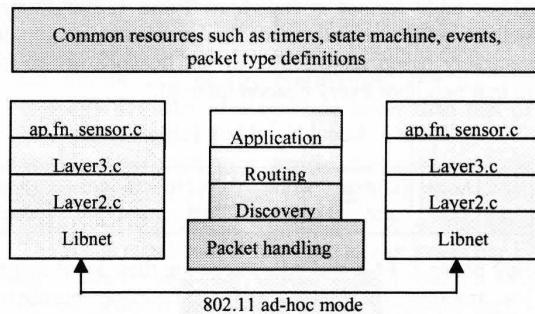


Figure 5. Software architecture of SOHAN

- **Layer2.c:** This layer handles the discovery and MAC layer functionality. Whenever a packet arrives from the lower layer, this layer handles the packet processing and passes the information to the higher layers.
- **Layer3.c:** This layer is responsible for handling the maintenance of the local neighbor tables and periodic exchange of neighbor tables amongst one-hop neighbors. The neighbor table is maintained and updated based on the beacons and the associations that are received from layer2.c. Upon the expiration of the route update timer, a periodic neighbor table exchange takes place. Entries are purged upon expiration of the refresh timer.
- **Application Layer (Sensor.c, fwnode.c, ap.c):** This layer handles the application specific functionality that depends on the type of the nodes.
- **Common functions:** The common functionality such as timer management, event management, finite state machine, packet type definitions and common wireless utilities is handled by programs common to all layers.

B. Hardware Platforms Used

The APs were based on a US Robotics 2450 Access Points running customized AP code for ad-hoc mode. The FNs were built on Compulab 586 CORE platform running a 133 MHz processor with two PCMCIA slots for two wireless interfaces. The MNs were built on the embedded Cerfcube platform that was battery operated and ran our custom

sensor application. The selection of the hardware platforms was consistent with the system architecture and operated under the same set of constraints at each tier. Fig. 6 captures the different platforms used for the devices.

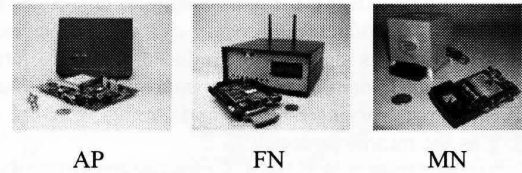


Figure 6. Hardware platforms used for SOHAN

VI. EXPERIMENTAL RESULTS

The experimental nodes ran Linux (kernel 2.4.17) with device driver modifications for recording and appending transmit power and received power to every outgoing and incoming packet respectively. We ran simple tests to determine appropriate values for parameters such as beaconing interval, and channel dwell time prior to conducting our benchmark experiments.

A. Discovery delays versus beacon interval and dwell times

The MNs were configured to scan every channel and varied the channel dwell times (from 100 ms to 1 sec) for different experimental runs. At the AP, the beacon interval was varied from 100 ms to 500 ms. As described in section III.B, the beacons were generated at the application layer and injected into the card using Libnet packet library. Also, scanning across channels at the MNs was performed at the application layer using *ioctl* calls to the device driver. We measured the discovery delays for a scenario consisting of a single AP and MN. This was repeated for different beacon intervals (100 ms, 250ms and 500 ms) at the AP with varying dwell times (from 100 ms to 1 sec) at the MNs.

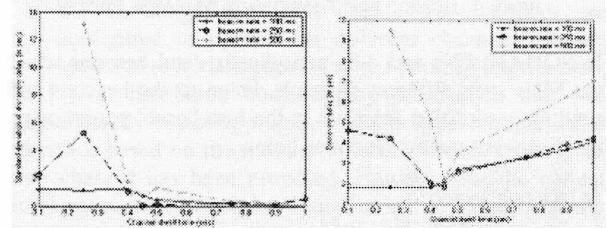


Figure 7. a) Discovery delays with different dwell times and beacon intervals b) Variance of discovery delay

Discovery delay is the time interval between beginning the experiment (both nodes starting at the same time) until the AP received the first 'association' message from the MN. Figure 7a show the results for the average discovery delays (in sec) for several sample runs for each setting along with the standard deviation of the delays. As shown in Figure 7b, for dwell times below 450ms, the discovery delay showed a high variation. This was because the application at the

sensor missed a lot of beacons during its scan and hence the time instant at which the first beacon was received was highly variable. When the dwell time per channel was higher than 450 ms, the variation of the discovery delay is significantly lesser than in the previous case. The performance with beacon intervals of 100ms and 250 ms was very similar. Hence, the beacon interval at the APs/FNs was chosen to be 250 ms with a channel dwell time of 450 ms at the MNs as a compromise between discovery delays and injecting more beacons in the network, which increased the discovery overhead.

B. Packet delivery ratio and average delays

In this experiment, the MNs transmitted at varying data rates to the AP over the hierarchical network. Two different packet sizes (1024 and 1472 bytes, UDP) were used. Fig. 8a shows that the packet delivery ratio for moderate loads is high. The small loss of packets may be attributed to the forwarding node rediscovery period, during which all packets received at the FN are dropped. For higher loads, the network degrades to deliver only 50 percent of the offered data. This is largely due to packets being dropped at the transmitter's interface. We also noticed that in such conditions, the application level beacons that we use were also dropped. This resulted in extremely large discovery times, which further amplified the problem of packet loss. However, using firmware-generated beacons should solve this problem. Fig. 8b shows that the end-to-end delay even for moderate loads is high (on the order of a second) which can be attributed to relatively high software latency with the embedded devices used. We note that this delay is the time elapsed between the MN application layer sending data and the AP application layer receiving data and includes system delays at the transmitter, receiver and switching between two interfaces at the intermediate FN. However, the system is tolerant to delays under increased traffic loads, which is due to the presence of two radio interfaces at each FN operating on different channels.

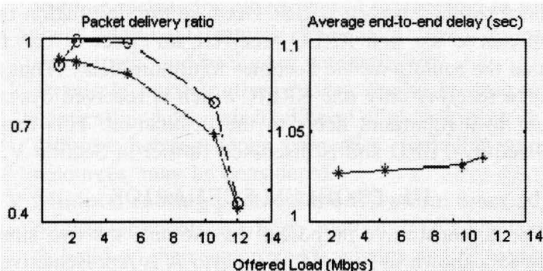


Figure 8.a) Packet delivery ratio and b) average delay of the network with increasing offered loads

A similar flat 802.11b ad-hoc network will tend to have a lower system capacity due to larger hop counts and a single frequency. These benchmark results indicate that the hierarchical network prototype we have developed provides promising results, which are fairly consistent with

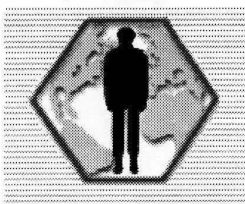
predictions from simulation. It is observed that implementing the discovery protocol in firmware will result in better network performance.

VII. CONCLUSIONS AND FUTURE WORK

We have presented the architecture and prototyping of SOHAN, a hierarchical self-organizing wireless ad-hoc network consisting of 802.11 based heterogeneous radio nodes at the three tiers. The architecture is motivated by potential improvements in scalability and system performance when compared with conventional flat ad-hoc networks. A proof-of-concept prototype was developed for evaluation of protocol design options and validation of system performance. Experimental results obtained so far are fairly consistent with predictions from simulation, and are indicative of the advantages of the proposed hierarchical structure with self-organizing discovery and routing protocols. Topics for future work include further optimization of discovery and routing algorithms, mobility support and joint MAC/routing methods for capacity and quality-of-service improvements.

VIII. REFERENCES

- [1] P. Gupta and P.R. Kumar, "The Capacity of Wireless Networks", *IEEE Transactions on Information Theory*, vol. 46, March 2000, pp. 388-404.
- [2] J. Broch, D. Maltz and D. Johnson, "Supporting Hierarchy and Heterogeneous Interfaces in Multihop Wireless Ad Hoc Networks", *Workshop on Mobile Computing*, June 1999
- [3] E.M. Belding-Royer, "Hierarchical Routing in Ad hoc Mobile Networks", *Wireless Communication and Mobile Computing*, pp.515-532, 2002.
- [4] S. Zhao, I. Seskar and D. Raychaudhuri, "Performance and Scalability of Self-Organizing Hierarchical Ad Hoc Wireless Networks", to appear in the *Proceedings of the IEEE WCNC 2004*, March 21-24, 2004, Atlanta.
- [5] C. E. Perkins and P. Bhagwat, "Highly dynamic destination-sequenced distance-vector routing (DSDV) for mobile computers", *Proc. ACM SIGCOMM' 94*, pp 234-244.
- [6] IEEE 802 LAN/MAN Standards Committee, "Wireless LAN medium access control (MAC) and physical layer (PHY) specifications", IEEE Standard 802.11, 1999.
- [7] L. Raju, S. Ganu, B. Anepu, I. Seskar and D. Raychaudhuri, "BOOST: A Bootstrapping Protocol for Self-Organizing Hierarchical Ad-hoc Networks", *IEEE Sarnoff Symposium*, April 2004.
- [8] L. Raju, S. Ganu, B. Anepu, I. Seskar and D. Raychaudhuri, "Beacon Assisted Discovery Protocol for Self-Organizing Hierarchical Ad-hoc Networks", under review at *IEEE Globecom 04*, Nov. 2004.
- [9] Libnet Packet Library, <http://www.packetfactory.net/libnet/>



**2004 IEEE 15th INTERNATIONAL SYMPOSIUM ON
PERSONAL, INDOOR AND
MOBILE RADIO COMMUNICATIONS**

PIMRC 2004

**BARCELONA, Spain
5-8, September 2004
Hotel Princesa Sofia**

Proceedings Volume 2 of 4

TKS103-2
I33
2004
quarto



2004 IEEE 15th INTERNATIONAL SYMPOSIUM ON PERSONAL, INDOOR AND MOBILE RADIO COMMUNICATIONS

11-11-04 6:22

Copyright and Reprint Permission: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923. For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Operations Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331. All rights reserved. Copyright ©2004 by the Institute of Electrical and Electronics Engineers, Inc.

IEEE Catalog Number: 04TH8754

ISBN: 0-7803-8523-3

Library of Congress: 2004106476

Cover design: Mercè Ortí

Editor: SuviSoft Oy Ltd
Hermiankatu 3A
FIN- 33720 Tampere
FINLAND

11-4-04 GRL

Patrons

Platinum



Gold



Bronze



Technical co-sponsors



UNIVERSITAT POLITÈCNICA
DE CATALUNYA



KING'S
College
LONDON
University of London



iii

Linda Hall Library
Kansas City, MO.

Table of Contents

Volume II

Conference Co-chairs' Message	xix
Organizing Comittee	xxi
Technical Program Comittee	xxii
Reviewing Comittee	xxiv

Tuesday, September 7th, 2004

SESSION TueAmOR1: 4G or Beyond (1)

-INVITED PAPER- PERFORMANCE EVALUATION OF A FIXED RELAY CONCEPT FOR NEXT GENERATION WIRELESS SYSTEMS	744
<i>Norbert Esseling, T-Mobile, Germany; Bernhard Walke and Ralf Pabst, Aachen University, Germany</i>	
A FRAMEWORK FOR THE EVALUATION OF CONVERGED MOBILE AND WIRELESS COMMUNICATION SYSTEMS	752
<i>Jorge Aguiar and Luis M. Correia, IT/IST, Technical University of Lisbon, Portugal</i>	
INTEGRATION OF MULTI-RADIO ACCESS IN A BEYOND 3G NETWORK	757
<i>Joachim Sachs, Henning Wiemann, Johan Lundsjö and Per Magnusson, Ericsson Research, Sweden</i>	
QOS AND MICROMOBILITY COUPLING INTEGRATED WITH UMTS	763
<i>Luis Angel Galindo, Telefonica Moviles España, Spain; and Pedro M. Ruiz, Universidad de Murcia, Spain</i>	
ADHOC RELAY NETWORK PLANNING FOR IMPROVING CELLULAR DATA COVERAGE	769
<i>Hung-yu Wei, Columbia University, USA; Samrat Ganguly and Rauf Izmailov, NEC Labs America, USA</i>	

SESSION TueAmOR2: Coding, Modulation and Equalization (4)

CONVERGENCE OF ITERATIVE DECODING WITHOUT CHANNEL ESTIMATION	774
<i>Lutz Lampe and Robert Schober, University of British Columbia, Canada</i>	
NONCOHERENT REDUCED STATE DIFFERENTIAL SEQUENCE DETECTION OF CONTINUOUS PHASE MODULATION	780
<i>Jinhua Sun, Jiandong Li, Lijun Jin, State Key Lab. of Integrated Service Networks, Xidian University, China; and Xiaojun Wu, Department of Computer Science and Engineering, Northwestern Polytechnical University, China</i>	
ITERATIVE DECODING NETWORKS WITH ITERATIVELY DATA ELIMINATING SDD AND EM BASED CHANNEL STATE ESTIMATOR	785
<i>Jan Sykora, Czech Technical University in Prague, Czech Republic; and Alister Burr, University of York, U.K.</i>	
A REDUCED-STATE SISO ALGORITHM FOR MULTILEVEL MODULATION IN TURBO EQUALIZATION	791
<i>Maurizio Magarini, Luca Reggiani and Arnaldo Spalvieri, Politecnico di Milano, Italy</i>	
PERFORMANCE OF TURBO CODED PARTIAL RESPONSE QUATERNARY CPM OVER CORRELATED FADING CHANNELS	796
<i>Manjeet Singh, Institute for Infocomm Research, Singapore</i>	

SESSION TueAmOR3: MIMO (4)

SPATIAL MULTIPLEXED CODED MC-CDMA WITH ITERATIVE RECEIVER	801
<i>Pierre-Jean Bouvet, Vincent Le Nir, Maryline H��lard and Rodolphe Le Gouable, France Telecom R&D, FRANCE</i>	
CHANNEL FEEDBACK QUANTIZATION METHODS FOR MISO AND MIMO SYSTEMS	805
<i>June Chul Roh and Bhaskar D. Rao, University of California, San Diego, USA</i>	
A REDUCED-COMPLEXITY SOFT-INPUT SOFT-OUTPUT DETECTION SCHEME FOR WIDEBAND MIMO CHANNELS	810
<i>Yvo De Jong and Tricia Willink, Communications Research Centre, Canada</i>	
CHOICE OF INTERLEAVERS FOR SPACE-DIVERSITY CODES IN HIPERMAN AND 802.16A BROADBAND WIRELESS SYSTEMS	815
<i>Roshano Roberts, Reza Hoshyar, M. Sadegh Fazel and Rahim Tafazolli, University of Surrey, United Kingdom</i>	
TURBO PIC AND ANTENNA DIVERSITY FOR DS-CDMA COMMUNICATIONS IN WIRELESS BLOCK FADING CHANNEL	820
<i>Simone Morosi, Enrico Del Re and Ottavio Gremigni, University of Firenze, Italy</i>	

SESSION TueAmOR4: WLAN (4)

IMPACT OF INTER-CELL INTERFERENCE IN A IEEE 802.11A NETWORK WITH OVERLAPPING CELLS	825
<i>Jean-christophe Dunat, Lucas EliceGUI, Motorola Labs, France; and Christian Bonnet, Institut Eurecom, France</i>	
PERFORMANCE EVALUATION OF QOS CONTROL SCHEME THAT USES BACK PRESSURE TRAFFIC CONTROL	830
<i>Fusao Nuno, Ichihiko Toyoda and Masahiro Umehira, NTT Network Innovation Laboratories, NTT Corporation, Japan</i>	
REDUCED COMPLEXITY DECORELLATING DETECTOR FOR MULTICODE SYSTEM	835
<i>Rafal Krenz, Poznan University of Technology, Poland</i>	
BEHAVIOR BASED STRATEGIES IN RADIO RESOURCE SHARING GAMES	840
<i>Lars Berlemann, Bernhard Walke, Aachen University, ComNets, Germany; and St��fan Mangold, Philips Research Laboratories, USA</i>	
WI-FI (IEEE802.11) AND BLUETOOTH COEXISTENCE:ISSUES AND SOLUTIONS	847
<i>Lior Ophir, Yigal Bitran and Itay Sherman, Texas Instruments Inc., Israel</i>	

SESSION TueAmOR5: Radio Resource Management (3)

ON SOME PROPERTIES OF THE PROPORTIONAL FAIR SCHEDULING POLICY	853
<i>Dan Avidor, Sayandev Mukherjee, Jonathan Ling and Constantinos Papadias, Bell Laboratories, Lucent Technologies, USA</i>	
COMPENSATION OF INTERFERENCE NON-RECIPROCITY IN ADAPTIVE TDD SYSTEMS	859
<i>Antti T��lli and Marian Codreanu, CWC, University of Oulu, Finland</i>	

ADAPTIVE NEURAL-FUZZY CONTROLLERS FOR DYNAMIC CHANNEL BORROWING IN WIRELESS CELLULAR NETWORKS	864
<i>Wang Yao-Tien, Department of Information Management Kai-Nan University, Taiwan</i>	
A SIMULATION TOOL FOR PERFORMANCE ASSESSMENT OF REALISTIC MOBILE	869
<i>Alberto Zanella, Luca Zuliani, Roberto Verdone, Oreste Andrisano, IEIIT-BO/CNR, DEIS University of Bologna, Italy; Alessandro Marazzi, Roberto Moretti and Ettore Agrati, Siemens Mobile Comm., Italy</i>	
OPTIMAL HARQ PROCEDURES FOR REVERSE LINK	875
<i>Jian Gu, Sen Nie, Daqing Wang and Xiangguang Che, Nokia Research Center, Nokia China Investment Co., China</i>	

SESSION TueAmOR6: Ad-Hoc Networks (4)

-INVITED PAPER- ARCHITECTURE AND PROTOTYPING OF AN 802.11-BASED SELF-ORGANIZING HIERARCHICAL AD-HOC WIRELESS NETWORK (SOHAN)	880
<i>Sachin Ganu, Lalit Raju, Bhaskar Anepu, S Zhao, I Seskar and D Raychaudhuri, WINLAB, Rutgers University, USA</i>	
TRANSPARENT INFLUENCE OF PATH SELECTION IN HETEROGENEOUS AD HOC NETWORKS	885
<i>Ian Chakeres and Elizabeth Belding-Royer, University of California Santa Barbara, USA</i>	
AN ALGORITHM FOR ENERGY-EFFICIENT BLUETOOTH SCATTERNET FORMATION AND MAINTENANCE	890
<i>Canan Pamuk and Ezhan Karasan, Bilkent University, Turkey</i>	
ON BLUETOOTH PERFORMANCE WITH DIVERSITY RECEPTION IN FADING CHANNELS	895
<i>Gianni Pasolini, Andrea Conti, Davide Dardari and Barbara Mavi Masini, IEIIT-BO/CNR, Univ. of Bologna, Italy</i>	
PERFORMANCE OF A MULTI-HOPS CONFIGURATION WITH 802.11: FROM SIMULATION TO EXPERIMENTATION	900
<i>Dominique Dhoutaut, INSA de Lyon, France; and Isabelle Guérin Lassous, INRIA, France</i>	

SESSION TueAmOR7: Multiple Access Techniques (4)

CONNECTION ADMISSION CONTROL CAC FOR A MIXED BURST/PACKET SERVICE BASED ON SERVICE DIFFERENTIATION IN A LOW EARTH ORBIT LEO SATELLITE CONSTELLATION	905
<i>Rima Abi Fadel, Ecole Supérieure d'Ingénieurs de Beyrouth, Lebanon; and Samir Tohmé, Université de Versailles Saint Quentin, France</i>	
DYNAMIC AND EFFICIENT TUNING OF IEEE 802.11 FOR MULTIMEDIA APPLICATIONS	910
<i>Fethi Filali, Institut Eurécom, France</i>	
POINTER CONTROLLED POWER SAVING MEDIUM ACCESS CONTROL PROTOCOL FOR IEEE 802.11 INFRASTRUCTURE NETWORKS	915
<i>Ghazanfar Safdar and William Scanlon, Queen's University, Belfast, United Kingdom</i>	
A NEW LINEAR HYBRID MULTIUSER DETECTOR FOR CDMA SYSTEMS	920
<i>Abdelouahab Bentrchia, Asrar Sheikh and Azzedine Zerguine, king fahd university of petroleum and minerals, Saudi Arabia</i>	

BLIND ADAPTIVE DECISION FEEDBACK DS-CDMA RECEIVERS FOR FREQUENCY SELECTIVE CHANNELS	925
<i>Rodrigo De Lamare and Raimundo Sampaio-Neto, CETUC/PUC-RIO, Brazil</i>	

SESSION TueAmOR8: Smart Adaptive Antennas (1)

-INVITED PAPER- MULTIPLE ANTENNA SYSTEMS: FRONTIER OF WIRELESS ACCESS.....	930
<i>Enrico Del Re and L. Pierucci, University of Florence, Italy</i>	
A DOWNLINK PATTERN OPTIMISATION ALGORITHM FOR A SMART ANTENNA IN AN INDOOR INFRASTRUCTURE WLAN	935
<i>Karim Nasr, Fumie Costen and Stephen Barton, The University of Manchester, UK</i>	
OUTAGE PROBABILITY WITH MAXIMAL RATIO COMBINING IN THE PRESENCE OF MULTIPLE INTERFERERS UNDER RAYLEIGH AND NAKAGAMI FADING CHANNELS	940
<i>Juan P. Peña-Martín and Juan Manuel Romero Jerez, University of Malaga, Electronic Technology Dpt., Spain</i>	
DOA ESTIMATION USING ARRAY ANTENNA WITH ARBITRARY GEOMETRY	945
<i>Qiaowei Yuan, Intelligent Cosmos Research Institute Co. Ltd, Japan; Qiang Chen and Kunio Sawaya, Tohoku University, Japan</i>	
LINEAR SPACE-TIME PRECODING FOR OFDM SYSTEMS BASED ON LONG-TERM CSI.....	949
<i>Katsutoshi Kusume, DoCoMo Communications Laboratories Europe GmbH, Germany</i>	

SESSION TueAmPO1: Ad-hoc networks

MODELING EFFECTS OF CO-CHANNEL INTERFERENCE OVER PERFORMANCE IN SINGLE-SLAVE BLUETOOTH PICONETS	954
<i>Daniel Cascado, Jose Luis Sevillano, Saturnino Vicente, Fernando Diaz, Gabriel Jimenez, Alejandro Linares and Anton Civit, University of Seville, Spain</i>	
ALARM MODEL SPECIFICATION AND DYNAMIC MULTI-LAYER SELF-HEALING MECHANISMS FOR COMMERCIAL AND AD-HOC WIRELESS NETWORKS	959
<i>Latha Kant and Wai Chen, Telcordia Technologies, USA</i>	
DISTRIBUTED SCHEDULING FOR MOBILE AD HOC NETWORKS - A NOVEL APPROACH	964
<i>Jimmi Gronkvist, Swedish Defence Research Agency, Sweden</i>	
AD-HOC WIRELESS NETWORK BASED ON THE UWB TECHNOLOGY	969
<i>Vasily Aristarhov, Andrei Gainulin, Andrei Kalinin, Vladimir Krylov, Roman Levchenko, Andrei Pluzhnikov and Victor Shkunov, Nizhny Novgorod State Technical University, Russia</i>	
DOWNLINK POWER CONTROL AND BEAMFORMING FOR A COOPERATIVE WIRELESS SYSTEM ...	974
<i>Gema Piñero, Carmen Botella, Alberto González, María De Diego and Narcis Cardona, Universidad Politécnica de Valencia (IMCO2), Spain</i>	
THROUGHPUT ANALYSIS FOR WIRELESS MULTI-HOP CSMA	979
<i>Athanasios Gkelias, Mischa Dohler and Hamid Aghvami, Centre for Telecommunication Research, King's College London, UK</i>	

FINDING SENSING COVERAGE AND BREACH PATHS IN SURVEILLANCE WIRELESS SENSOR NETWORKS.....	984
<i>Ertan Onur, Cem Ersoy and Hakan Delic, Bogazici University, Turkey</i>	
END-TO-END RELIABLE EVENT TRANSFER IN WIRELESS SENSOR NETWORKS	989
<i>Nurcan Tezcan, Bogazici University, Turkey; Erdal Cayirci, Istanbul Technical University, Turkey; and M. Ufuk Caglayan, Bogazici University, Turkey</i>	
A BATTERY AWARE MEDIUM ACCESS CONTROL (BAMAC) PROTOCOL FOR AD HOC WIRELESS NETWORKS.....	995
<i>Jayashree Subramanian, Manoj B. S. and C. Siva Ram Murthy, Indian Institute of Technology Madras, India</i>	
MULTICAST ROUTING FOR AD HOC NETWORKS WITH A QUALITY OF SERVICE SCHEME FOR SESSION EFFICIENCY	1000
<i>Kaan Bür and Cem Ersoy, Bogaziçi University, Turkey</i>	
A DYNAMIC HIERARCHICAL RADIO RESOURCE ALLOCATION SCHEME FOR MOBILE AD-HOC NETWORKS.....	1005
<i>Oliver Holland, Qi Fan and Hamid Aghvami, King's College London, United Kingdom</i>	
SPLAST: A NOVEL APPROACH FOR MULTICASTING IN MOBILE WIRELESS AD HOC NETWORKS...	1011
<i>Yehuda Ben-shimol, Amit Dvir and Michael Segal, Department of Communication Systems Engineering Ben Gurion University, ISRAEL</i>	
INFLUENCE OF TRANSMISSION POWER CONTROL ON THE TRANSPORT CAPACITY OF WIRELESS MULTIHOP NETWORKS.....	1016
<i>Michael Gerharz, Christian De Waal, Matthias Frank and Peter Martini, Institute of Computer Science IV, University of Bonn, Germany</i>	
AN ACCESS-BASED ENERGY EFFICIENT CLUSTERING PROTOCOL FOR WIRELESS SENSOR NETWORK.....	1022
<i>Xiang Hong and Qilian Liang, University of Texas at Arlington, United States</i>	
TOPOLOGY MANAGEMENT IN DENSE MANET	1027
<i>Zhao Chun-xiao, University, China</i>	
A NOVEL CLUSTER-BASED LOCATION ROUTING ALGORITHM FOR INTER-VEHICULAR COMMUNICATION.....	1032
<i>Raul Aquino and Robert Edwards, University of Sheffield, United Kingdom</i>	
A SIMPLE PERFORMANCE ANALYSIS OF SENSOR LOCALIZATION WITH TWO BEACONS.....	1037
<i>Gianluca Mazzini, University of Ferrara, Italy</i>	
CLOCK DRIFT REDUCTION FOR RELATIVE TIME SLOT TDMA-BASED SENSOR NETWORKS.....	1042
<i>Randolph Tjoa, National University of Singapore, Singapore; Kim Loon Chee, Sivaprasad P. K., S. V. Rao and Joo Ghee Lim, Institute for Infocomm Research, Singapore</i>	
MESH VS. POINT-TO-MULTIPOINT TOPOLOGY: A COVERAGE AND SPECTRUM EFFICIENCY COMPARISON.....	1048
<i>Siamäk Naghian, Nokia, Finland</i>	

SESSION TueAmOR9: Application and Services

-INVITED PAPER- TOPICS IN PROBABILISTIC LOCATION ESTIMATION IN WIRELESS NETWORKS . .	1052
<i>Henry Tirri, Petri Kontkanen, Petri Myllymaki, Teemu Roos, Kimmo Valtonen and Hannes Wettig, University of Helsinki, Finland</i>	
A NOVEL HYBRID PARAMETERS BASED KALMAN LOCATION ESTIMATOR IN CELLULAR NETWORKS	1057
<i>Xiong Jinyu and Zhu Zhongliang, Key Lab. of Southwest Electrics and Telecommunications, China</i>	
SERVICE CREATION WITH A COMMON LANGUAGE	1062
<i>Oliver Rocholl, Vodafone Group RnD - D, Germany</i>	
A FLEXIBLE LOCATION-CONTEXT REPRESENTATION	1065
<i>Filipe Meneses and Adriano Moreira, University of Minho, Portugal</i>	
PROTOTYPE OF CONTEXT-BASED ADAPTIVE COMMUNICATION SYSTEM ON SEAMLESS NETWORKING PLATFORM.....	1070
<i>Masugi Inoue, Khaled Mahmud, Homare Murakami, Mikio Hasegawa, National Institute of Information and Communications Technology, Japan; and Hiroyuki Morikawa, The University of Tokyo, Japan</i>	

SESSION TueAmOR10: 4G or Beyond (2)

COMPANDING SYSTEM WITH TIME CLUSTERING	1075
<i>Osamu Takyu, Department of Information and Computer Science, Keio University, Japan; Tomoaki Ohtsuki, Department of Electrical Engineering, Tokyo University of Science, Japan; and Masao Nakagawa, Department of Information and Computer Science, Keio University, Japan</i>	
SIMULATIVE EVALUATION OF LOCATION AIDDED HANDOVER IN WIRELESS HETEROGENEOUS SYSTEMS	1080
<i>Stephan Goebbel, Matthias Siebert, Marc Schinnenburg, Comnets, Germany; and Matthias Lott, Siemens, Germany</i>	
ADVANCED POSITIONING AND LOCATION BASED SERVICES IN 4G MOBILE-IP RADIO ACCESS NETWORKS	1085
<i>Alberto Montilla Bravo, Motorola España S.A., Spain; Jose Ignacio Moreno and Ignacio Soto, Universidad Carlos III de Madrid, Spain</i>	
MEASUREMENT AND USAGE OF POWER CONSUMPTION PARAMETERS OF WIRELESS INTERFACES IN ENERGY-AWARE MULTI-SERVICE MOBILE TERMINALS	1090
<i>Khaled Mahmud, Masugi Inoue, Homare Murakami, Mikio Hasegawa, Communications Research Laboratory, Japan; and Hiroyuki Morikawa, University of Tokyo, Japan</i>	
LOW COMPLEXITY ENERGY EFFICIENT JOINT TRANSMISSION FOR OFDM MULTIUSER DOWNLINKS.....	1095
<i>Tobias Weber, Michael Meurer, Technical University of Kaiserslautern, Germany; and Wolfgang Zirwas, Siemens AG, Germany</i>	

SESSION TueAmOR11: Coding, Modulation and Equalization (5)

FIELD EXPERIMENTS ON LOW-RATE TURBO CODING AND SOFT-DECISION DECODING FOR BROADBAND PACKET DS-CDMA WIRELESS ACCESS IN REVERSE LINK	1100
<i>Shingo Suwa, Nobuhiko Miki, Motohiro Tanno, Kenichi Higuchi and Mamoru Sawahashi, NTT DoCoMo, Inc., Japan</i>	
INCREASING CAPACITY IN A FEC CODED DS-CDMA SYSTEM OVER FREQUENCY-SELECTIVE CHANNELS	1106
<i>Martin Luna, Universidad Autonoma de San Luis Potosi, Mexico; and Emad Al-Susa, University of Manchester Institute of Science and Technology, UK</i>	
PERFORMANCE COMPARISON OF PARALLEL CONCATENATED CODES USING EXIT CHART PREDICTION	1111
<i>Alexander Golitschek Edler von Elbwart, Joachim Loehr and Eiko Seidel, Panasonic European Laboratories GmbH, Germany</i>	
ITERATIVE DECODING ALGORITHM AND TERMINATING CRITERIA FOR INTER-BLOCK PERMUTED TURBO CODES	1116
<i>Yan-Xiu Zheng and Yu T. Su, Dept. of Commun. Eng. NCTU, Taiwan</i>	
AN IMPROVED SOVA ALGORITHM FOR TURBO CODES OVER AWGN AND FADING CHANNELS	1121
<i>Chuan Xiu Huang and Ali Ghayeb, Concordia University, Canada</i>	

SESSION TueAmOR12: MIMO (5)

ANALYSIS OF BER PERFORMANCES USING CHANNEL MATRIX EIGENVALUE IN MIMO SYSTEMS UNDER RAYLEIGH AND RICIAN FADING CHANNELS	1126
<i>Yutaka Murakami, Kiyotaka Kobayashi, Masayuki Orihashi and Takashi Matsuoka, Matsushita Electric Industrial Co., Ltd., Japan</i>	
NON-GRAY LABELING OF ERROR-PRONE FEEDBACK SIGNALS	1131
<i>Olav Tirkkonen, Nokia Research Center, Finland</i>	
PERFORMANCE OF ALAMOUTI SCHEME WITH TRANSMIT ANTENNA SELECTION	1135
<i>Zhuo Chen, the University of Sydney, Australia; Jinhong Yuan, the University of New South Wales, Australia; Branka Vucetic and Zhendong Zhou, the University of Sydney, Australia</i>	
LIKELIHOOD FUNCTION FOR QRM-MLD SUITABLE FOR SOFT-DECISION TURBO DECODING AND ITS PERFORMANCE FOR OFCDM MIMO MULTIPLEXING IN MULTIPATH FADING CHANNEL	1142
<i>Kenichi Higuchi, Hiroyuki Kawai, Noriyuki Maeda, Mamoru Sawahashi, NTT DoCoMo, Inc., Japan; Takumi Itoh, Yoshikazu Kakura, Akihisa Ushirokawa, NEC Corporation, Japan; and Hiroyuki Seki, Fujitsu Laboratories Ltd., Japan</i>	
TRANSMITTER AND RECEIVER DESIGNS FOR THE MIMO FADING BROADCAST CHANNEL	1149
<i>Roya Doostnejad, Teng Joon Lim and Elvino Sousa, University of Toronto, Canada</i>	

SESSION TueAmOR13: WLAN (5)

MULTI-RATE PERFORMANCE INDEX FOR WIRELESS LANS	1154
<i>Hector Velayos and Gunnar Karlsson, KTH, Royal Institute of Technology, Sweden</i>	

UML 2.0 IMPLEMENTATION OF AN EMBEDDED WLAN PROTOCOL	1158
<i>Petri Kukkala, Väinö Helminen, Marko Hännikäinen and Timo Hämäläinen, Tampere University of Technology, Finland</i>	
TURBO DETECTION AND DECODING FOR SINGLE-CARRIER BLOCK TRANSMISSION SYSTEMS ...	1163
<i>Dongming Wang, Jingyu Hua, Xiqi Gao, Xiaohu You, National Mobile Communication Research Lab., China; Martin Weckerle and Elena Costa, Siemens AG, ICM N PG SP RC FR, Germany</i>	
A FRAMEWORK FOR INTERFERENCE ANALYSIS OF HETEROGENEOUS RADIO NETWORKS	1168
<i>Andre Stranne, Ove Edfors, Lund University, Sweden; and Bengt-Arne Molin, Axis Communications AB, Sweden</i>	
PARALLEL FFT WITH CORDIC FOR ULTRA WIDE BAND	1173
<i>Guoping Zhang and Francois Chin, Institute for infocomm research, Singapore</i>	

SESSION TueAmOR14: Radio Resource Management (4)

PERFORMANCE OF LINK ADMISSION CONTROL IN A WCDMA SYSTEM WITH HS-DSCH AND MIXED SERVICES	1178
<i>Kimmo Hiltunen, Magnus Lundevall and Sverker Magnusson, Ericsson Research, Sweden</i>	
ENHANCING BLUETOOTH PERFORMANCE IN INTERFERENCE ENVIRONMENTS VIA CHANNEL-STATE-DEPENDENT PACKET SCHEDULING WITH ADAPTIVE PACKET SELECTION	1183
<i>Chen-Han Shih, Kuochen Wang and Ae-Yun Liu, National Chiao Tung University, Taiwan</i>	
A PLAYOUT-BUFFER-SENSITIVE TIME SLOT SCHEDULING FOR INTEGRATION OF REAL-TIME AND ELASTIC TRAFFIC IN WIRELESS NETWORKS	1188
<i>Masaki Fukushima, Hajime Nakamura and Shinichi Nomoto, KDDI R&D Laboratories Inc., Japan</i>	
SI2R-DMA: SELF-ORGANIZING INTER- AND INTRA-SITE INTERFERENCE REDUCTION DMA FOR GERAN NETWORKS	1193
<i>Carsten Ball, Kolio Ivanov, Robert Müllner and Hubert Winkler, Siemens AG, Austria</i>	
DYNAMIC CHANNEL ASSIGNMENT FOR SYSTEMS WITH CONSTRAINED DOWNLINK POWER CONTROL	1199
<i>Joseph Kang and Krishna Balachandran, Bell Labs, Lucent Technologies, USA</i>	

SESSION TueAmOR15: OFDM (1)

SYMBOL SPREADING FOR ULTRAWIDEBAND SYSTEMS BASED ON MULTIBAND OFDM	1204
<i>Iyappan Ramachandran, Dept. of EE, Univ. of Washington, U. S. A; Philip Orlik, Yves-Paul Nakache, Andreas Molisch and Jinyun Zhang, Mitsubishi Electric Research Labs, U. S. A</i>	
A NEW SYMBOL TIMING SYNCHRONIZATION FOR OFDM BASED WLANS UNDER MULTIPATH FADING CHANNELS	1210
<i>Liang Zhou and Miyoshi Saito, Advanced Mobile Phones DIV, Mobile Phones Group, Fujitsu Limited., Japan</i>	
COMBINATION OF ADAPTIVE BEAMFORMING AND ADAPTIVE LOADING FOR OFDM PACKET TRANSMISSION	1215
<i>Ming Lei, Hiroshi Harada, Hiromitsu Wakana, Nat. Inst. of Info. and Comm. Tech. of Japan, Japan; and Ping Zhang, Beijing University of Posts and Telecommunications, China</i>	

A UNIFORM POWER AND CONSTELLATION SIZE BIT-LOADING SCHEME FOR OFDM BASED WLAN SYSTEMS	1220
<i>Davide Dardari, DEIS - University of Bologna, Italy</i>	

SER EVALUATION OF OFDM WITH NYQUIST RATE AND OVERSAMPLED CLIPPING USING ESTIMATED CHANNEL INFORMATION	1225
<i>Bingyang Wu, Shixin Cheng, National Mobile Communications Research Lab., China; Haifeng Wang, Nokia Mobile Phones, Finland; and Ming Chen, National Mobile Communications Research Lab., China</i>	

SESSION TueAmOR16: Mobile Internet (1)

-INVITED PAPER- PROXY SERVICES FOR THE MOBILE INTERNET	1230
<i>Victor Leung, University of British Columbia, Canada</i>	

AN EMPIRICAL 3-D USER SATISFACTION MODEL IN WIRELESS DATA NETWORKS	1236
<i>Milosh Ivanovich, Paul Fitzpatrick, Michael Beresford and Anthony Saliba, Telstra Research Laboratories, Australia</i>	

A NETWORK-BASED SOLUTION FOR TCP IN WIRELESS SYSTEMS WITH OPPORTUNISTIC SCHEDULING	1241
<i>Yi Wu, Zhisheng Niu and Junli Zheng, Department of Electronic Engineering, Tsinghua University,, China</i>	

L7-MOBILITY : A FRAMEWORK FOR HANDLING MOBILITY AT THE APPLICATION LEVEL	1246
<i>Jean Tourrilhes, HP-Labs, USA</i>	

TWO-WAY REGISTRATION: A FAST HANDOFF SCHEME FOR IPV4 MACRO-MOBILITY MANAGEMENT	1252
<i>Ji Zhang, David Pearce and Tim Tozer, University of York, United Kingdom</i>	

SESSION TueAmOR17: Smart Adaptive Antennas (2)

FIELD EXPERIMENTS ON ADAPTIVE ANTENNA ARRAY-BEAM FORMING WITH SIMULTANEOUS PATH TIMING AND ITS DOA ESTIMATIONS EMPLOYING DIRECTIVE BEAM RECEPTION FOR BROADBAND CDMA PACKET ACCESS IN REVERSE LINK	1257
<i>Takashi Kataoka, Hidekazu Taoka, Kenichi Higuchi and Mamoru Sawahashi, NTT DoCoMo, Inc., Japan</i>	

INTEGRATION, MEASUREMENTS AND CALIBRATION OF A UMTS SMART ANTENNA	1263
<i>Manuel Sierra-Perez, Miguel Calvo, Leandro De Haro, Manuel Sierra-Castañer, Ramón Martínez, Laura Garcia, Alberto Martínez, Francisco Javier García-Madrid and José Luis Masa, Universidad Politécnica de Madrid, Spain</i>	

THE EFFECT OF AN ELECTROMAGNETIC BAND-GAP STRUCTURE ON A PIFA ANTENNA ARRAY ...	1268
<i>Luiz Kretly and Alexandre Silva, UNICAMP, Brazil</i>	

A NOVEL BLIND ADAPTIVE BEAMFORMING ALGORITHM FOR SMART ANTENNA IN MC-CDMA UPLINK SYSTEM	1272
<i>Kiattisak Maichalernnukul and Somchai Jitapunkul, Chulalongkorn University, Thailand</i>	

ON CLOSED-LOOP TRANSMIT BEAMFORMING WITH SIMPLE BEAM-CONTROL COMMANDS	1278
<i>Wookwon Lee and Brian Sepko, University of Arkansas, USA</i>	

SESSION TueAmPO2: Coding and Modulation

VARIABLE PACKET SIZE ADAPTIVE MODULATION SR-ARQ SCHEME FOR RAYLEIGH FADING CHANNELS	1283
<i>Junli Wu, Xiaolin Hou, Changchuan Yin and Guangxin Yin, Beijing University of Posts and Telecommunications, China</i>	
COMPLEXITY AND EFFICIENCY OF DATA DETECTION ALGORITHMS FOR TD-SCDMA	1287
<i>Jung-Lin Pan, Jaeyoung Kwak, Aykut Bultan, Yuejin Huang and Donald Grieco, InterDigital Communications Corporation, USA</i>	
FUNCTIONAL STUDY OF FDD EQUALIZER IN THE CONTEXT OF TDD RECONFIGURATION	1292
<i>David Cibaud, France Telecom, France; Genevieve Jourdain, LIS-INPG, France; and Marilyn Arnd, France Telecom, France</i>	
EQUALIZATION SCHEME FOR OFDM SYSTEMS IN LONG DELAY SPREAD CHANNELS	1297
<i>Heejung Yu, Myung-Soon Kim, Taehyun Jeon and Sok-Kyu Lee, ETRI, Korea</i>	
CO-CHANNEL INTERFERENCE SUPPRESSION WITH MODEL SIMPLIFICATION IN TDMA SYSTEMS .	1302
<i>Jiang Li, Qilian Liang and Michael T. Manry, University of Texas at Arlington, USA</i>	
PERFORMANCE EVALUATION OF LINEAR TURBO RECEIVERS USING ANALYTICAL EXIT FUNCTIONS	1307
<i>Cesar Hermosilla, UTFSM, Valparaiso., Chile; and Leszek Szczecinski, INRS-EMT, Canada</i>	
ERROR ANALYSIS OF THE CMOS BASED SOFT GATE FOR ANALOG TURBO DECODER	1312
<i>Kalle Ruttik, Communication Laboratory HUT, Finland</i>	
EFFECT OF THE PHASE ERROR, QUADRATURE ERROR, AND I-Q GAIN MISMATCH ON SYMBOL ERROR PROBABILITY FOR AN M-PSK SYSTEM IN FADING CHANNELS	1317
<i>Seungkeun Park, ETRI, South Korea; Byung Wook Lee and Sung Ho Cho, Hanyang University, South Korea</i>	
A VARIABLE REED-SOLOMON DECODER USING SEPARATE CLOCKS IN ITS PIPELINED STEPS	1322
<i>Moon Kyou Song, Min Han Kong, Wonkwang University, KOREA; and Hee Sun Won, ETRI, KOREA</i>	
ITERATIVE CHANNEL ESTIMATION FOR TURBO EQUALIZATION	1327
<i>Huiheng Mai, Alister Burr and Simon Hirst, Dept of Electronics, Univ. of York, UK</i>	
PERFORMANCE ANALYSIS OF ITERATIVE DETECTION FOR PRE-TRANSFORMED OFDM	1332
<i>Chin Keong Ho, Zhongding Lei, Sumei Sun and Yan Wu, Institute for Infocomm Research, Singapore</i>	
PERFORMANCE OF 2D FFT MODULATED SIGNAL OVER MULTIPATH FADING CHANNELS	1337
<i>Kainan Zhou, National University of Singapore, Singapore; and Yong Huat Chew, Institute for Infocomm Research, A*STAR, Singapore</i>	
AN ITERATIVE ADAPTIVE RECEIVER DESIGN USING THE MULTI-LAYER RLS ALGORITHM WITH APPLICATIONS TO LAYERED SPACE-TIME CODED	1342
<i>Joseph Chueh, Hayoung Yang and Branka Vucetic, University of Sydney, Australia</i>	
AN EQUIVALENCE PRINCIPLE FOR SEPARABLE CPM SIGNALS	1347
<i>Gianfranco Cariolaro and Antonio M. Cipriano, Universita di Padova, Italy</i>	
THRESHOLD CONTROLLING SCHEME FOR ADAPTIVE MODULATION AND CODING SYSTEM	1351
<i>Daisuke Takeda, Toshiba R&D Center, Japan; Yuk Chow, Paul Strauch, Toshiba Research Europe Ltd., United Kingdom; and Hiroshi Tsurumi, Toshiba R&D Center, Japan</i>	

COMPUTATION OF THE FREE DISTANCE AND LOW WEIGHT DISTRIBUTION OF TURBO CODES WITH CONVOLUTIONAL INTERLEAVERS	1356
<i>Sina Vafi and Tadeusz Wysocki, University of Wollongong, Australia</i>	
AN EFFICIENT ESTIMATOR FOR OFDM INTEGER FREQUENCY OFFSET SYNCHRONIZATION	1360
<i>Chen Chen, Jiandong Li and Linjing Zhao, Information Science Institute, Xidian University, China</i>	
ROBUST NON DATA-AIDED FREQUENCY OFFSET ESTIMATION TECHNIQUE FOR OFDM SYSTEMS IN RAYLEIGH FADING CHANNELS	1365
<i>Arafat Al-Dweik, Etisalat College of Engineering, UAE</i>	
A FREQUENCY OFFSET COMPENSATION METHOD FOR ULTRA-NARROWBAND DIGITAL WIRELESS MODEMS	1370
<i>Young-Jun Chong, Sung-Jin You, Min-Soo Kang, Myung-Sun Song, ETRI, KOREA; and Seung-Hyeub Oh, Chung-nam National University, KOREA</i>	

SESSION TuePmOR1: 4G or Beyond (3)

NON-REAL TIME CONTENT SCHEDULING IN WIRELESS DATA NETWORKS	1375
<i>Samrat Ganguly, Nan Tu, NEC Laboratories America, USA; Mainak Chatterjee, University of Central Florida, USA; and Rauf Izmailov, NEC Laboratories America, USA</i>	
A COMBINED APPROACH OF SCHEDULING AND POWER DISTRIBUTION STRATEGIES FOR MIMO MOBILE COMMUNICATIONS SYSTEM.	1380
<i>Xinsheng Zhao, Tao Ju, National Mobile Communications Research Lab., Southeast University, China; and Hui Li, 3,4,5Information & Communications Mobile Network, Siemens AG., Munich</i>	
SYSTEM LEVEL PERFORMANCE OF OFDMA FORWARD LINK WITH PROPORTIONAL FAIR SCHEDULING	1384
<i>Seokhyun Yoon, Youngkwon Cho, Chan-Byoung Chae and Hyunwoo Lee, Samsung Electronics, Co. Ltd, South Korea</i>	
EFFICIENT RESOURCE ALLOCATION FOR STATISTICAL QOS ASSURANCES IN HDR BASED WIRELESS PACKET DATA	1389
<i>Ferit Ozan Akgul and Oguz Sunay, Koc University, Turkey</i>	
RMP: RECONFIGURATION MANAGEMENT PLANE FOR THE SUPPORT OF POLICY-BASED NETWORK RECONFIGURATION	1394
<i>Nancy Alonistioti, Aristotelis Glentis, Fotis Foukalas and Alexandros Kaloxylos, UoA, Greece</i>	

SESSION TuePmOR2: Coding, Modulation and Equalization (6)

PERFORMANCE OF ADAPTIVE EQUALIZERS FOR SYSTEMS WITH CODE-MULTIPLEXED PILOT	1398
<i>Ivan Fernandez and Srikant Jayaraman, Qualcomm Inc, USA</i>	
PERFORMANCE OF LDPC BASED TURBO EQUALIZATION FOR SPATIAL MULTIPLEXING	1404
<i>Takaaki Zakoji, Hidekazu Murata and Kiyomichi Araki, Graduate School of Science and Engineering, Tokyo Institute of Technology, Japan</i>	
SINR MAXIMIZATION APPROACH FOR PARTIAL EQUALIZATION IN OFDM SYSTEMS	1409
<i>Hossein Zamiri jafarian and Subbarayan Pasupathy, University of Toronto, Canada</i>	

FREQUENCY-DOMAIN SC/MMSE ITERATIVE EQUALIZER WITH MF APPROXIMATION IN LDPC-CODED MIMO TRANSMISSIONS.....	1414
--	------

Toshiaki Koike, Kyoto University, Japan; Hidekazu Murata, Tokyo Institute of Technology, Japan; and Susumu Yoshida, Kyoto University, Japan

ADAPTIVE SCHEME FOR JOINT FREQUENCY AND TIME OFFSET CORRECTION OVER OFDM SYSTEMS	1419
--	------

Yeheskel Bar-Ness and Rubén Solá, CCSPR, United States

SESSION TuePmOR3: MIMO (6)

BER PERFORMANCE OF SPACE-TIME BLOCK CODED MIMO SYSTEM IN THE PRESENCE OF INTERFERENCE.....	1424
--	------

Zhuo Wu, Alister Burr, department of electronics, University of York, UK; and Simon Hirst, Communications Group, Department of Electronics, UK

VARYING INTERLEAVE PATTERNS WITH ITERATIVE DECODING FOR IMPROVED PERFORMANCE IN MIMO SYSTEMS	1429
--	------

Kiyotaka Kobayashi, Yutaka Murakami, Masayuki Orihashi and Takashi Matsuoka, Matsushita Electric Industrial Co., Ltd., Japan

IMPACT OF RF FRONT-END IMPAIRMENTS AND MOBILITY ON CHANNEL RECIPROCITY FOR CLOSED-LOOP MULTIPLE ANTENNA TECHNIQUES	1434
--	------

Alexandre Ribeiro Dias, David Bateman and Karine Gosse, Motorola Labs, France

MIMO CAPACITY LOSS FOR REAL WORLD SIGNAL CONSTELLATIONS AND CHANNEL DEGRADATIONS	1439
--	------

Gerhard Bauch, DoCoMo Euro-Labs, Germany

NOVEL REDUCED COMPLEXITY ALGORITHM BASED ON GROUP DETECTION IN MULTIPLE ANTENNA SYSTEMS	1444
---	------

Tsuguhide Aoki, Hidehiro Matsuoka and Hiroki Shoki, TOSHIBA, Japan

SESSION TuePmOR4: WLAN (6)

-INVITED PAPER- COGNITIVE TRENDS IN MAKING: FUTURE OF NETWORKS	1449
--	------

Petri Mahonen, Aachen University, Germany

TRACKING OF MOVING WIRELESS LAN TERMINALS	1455
---	------

Michael Wallbaum, RWTH Aachen University, Germany

PERFORMANCE EVALUATION FOR IEEE802.11G HOT SPOT COVERAGE USING SECTORISED ANTENNAS	1460
--	------

Arif Otyakmaz, Ulrich Fornefeld, Jelena Mirkovic, Daniel Schultz and Erik Weiss, ComNets, Aachen University, Germany

NOVEL ARCHITECTURE FOR RELIABLE H.26L VIDEO TRANSMISSION OVER IEEE 802.11E	1466
--	------

Ksentini Adlen, LICP, France; Gueroui Abdelhak, PRISM, France; and Naimi Mohamed, LICP, France

CAPTURE EFFECT IN WIRELESS LANS WITH RAKE RECEPTION OF DSSS/DPSK SIGNALS	1471
--	------

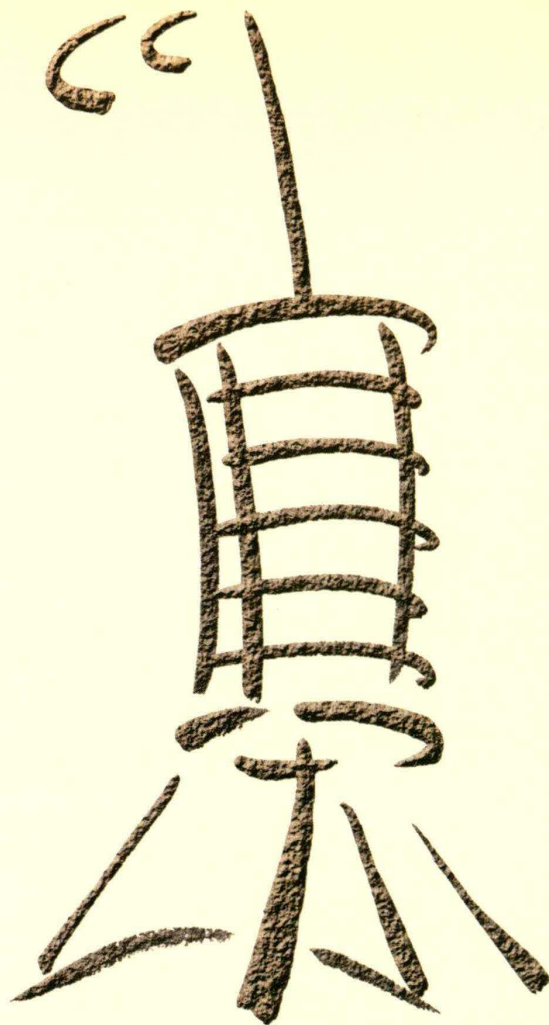
Zoran Hadzi-Velkov and Boris Spasenovski, Ss. Cyril and Methodius University, Faculty of Electrical Engineering, Macedonia

SESSION TuePmOR5: Radio Resource Management (5)

PERFORMANCE COMPARISON OF FRACTIONAL GUARD CHANNEL POLICIES IN MOBILE CELLULAR NETWORKS	1476
<i>José Vázquez-vila, Felipe Cruz-Pérez, CINVESTAV-IPN, Mexico; and Lauro Ortigoza-Guerrero, WFI, USA</i>	
POWER CONTROL WITH OUTAGE PROBABILITY SPECIFICATIONS FOR WIRELESS CELLULAR SYSTEMS IN Rician/Rician FADING CHANNELS	1481
<i>Chin Choy Chai, Institute for Infocomm Research, Singapore; Ying Lu, National University of Singapore, Singapore; Yong Chew and Tjeng Thiang Tjhung, Institute for Infocomm Research, Singapore</i>	
CHANNEL ALLOCATION AND HANDOVER FOR THE HSCSD SERVICE IN SDMA SYSTEMS	1486
<i>Christian Hartmann, Technische Universität München, Institute of Communication Networks, Germany</i>	
SELECTIVE LOAD SHARING FOR HANDOVER ADMISSION IN OVERLAPPING COVERAGE	1491
<i>Ki-Dong Lee, Deock Gil Oh and Ho-Jin Lee, ETRI, KOREA</i>	
IMPLEMENTATION OF A QOS MANAGEMENT MECHANISM TO SUPPORT APPLIED ALGORITHMS ON AN IEEE 802.11 WLAN TEST-BED	1496
<i>Marc Portoles, Jose Luis Valenzuela and David Perez, Universitat Politecnica de Catalunya, Spain</i>	

SESSION TuePmOR6: OFDM (2)

ON LINEAR PREDISTORTION TECHNIQUES FOR SINGLE-CARRIER AND OFDM SD/CDMA SYSTEMS	1501
<i>Christoph Degen and Lars Brühl, IHF, RWTH Aachen University, Germany</i>	
NONLINEAR DISTORTION CANCELLATION IN OFDM SYSTEMS USING AN ADAPTIVE LINC STRUCTURE	1506
<i>Paloma Garcia, Alfonso Ortega, Jesús De Mingo and Antonio Valdovinos, University of Zaragoza, Spain</i>	
JOINT ADAPTIVE TRANSMITTER/RECEIVER IQ IMBALANCE CORRECTION FOR OFDM SYSTEMS ..	1511
<i>Jian Lin and Ernest Tsui, Intel Corporation, USA</i>	
LATTICE-REDUCTION-AIDED RECEIVERS FOR MIMO-OFDM IN SPATIAL MULTIPLEXING SYSTEMS	1517
<i>Inaki Berenguer, Jaime Adeane, Ian Wassell, University of Cambridge, UK; and Xiaodong Wang, Columbia University, United States</i>	
PERFORMANCE AND IMPLEMENTATION COMPLEXITY OF RECEIVER ALGORITHMS FOR MIMO-OFDM BASED WIRELESS LAN SYSTEMS	1522
<i>Julian Penketh and Manel Collados, Philips Research, The Netherlands</i>	
Author Index	xxix



PIMRC 2004



BARCELONA

5/8 September

2004 IEEE 15th
INTERNATIONAL SYMPOSIUM
ON PERSONAL, INDOOR
AND MOBILE RADIO COMMUNICATIONS

PROCEEDINGS VOLUME 2 of 4



UNIVERSITAT POLITÈCNICA
DE CATALUNYA



KING'S
College
LONDON
University of London

