COST Technical Committee
"Telecommunications, Information Science and Technology"
(TC-TIST)

COST Action 289

Spectrum and Power Efficient Broadband Communications

PROGRESS REPORT

Period: from 1 July 2003 to 30 June 2004

Start date of the Action: 24 April 2003 Last update: June 2004

1. OVERVIEW: ACTION IDENTIFICATION DATA

COST Action 289
Title: Spectrum and Power Efficient Broadband Communications

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Number of signatories: 16

Signatories and date of signature:

Belgium	05/08/2003	Confirmed
Bulgaria	04/04/2003	Confirmed
Czech Republic	05/08/2003	Confirmed
France	05/08/2003	Confirmed
Germany	02/04/2003	Confirmed
Greece	30/09/2003	Confirmed
Hungary	28/03/2003	Confirmed
Italy	05/08/2003	Confirmed
Norway	05/08/2003	Confirmed
Romania		Confirmed
Serbia and Montenegro	20/11/2003	Confirmed
Slovakia	14/04/2003	Confirmed
Spain	25/09/2003	Confirmed
Sweden	12/08/2003	Confirmed
Switzerland	23/05/2003	Confirmed
Turkey	23/04/2003	Confirmed

Institutes of non-COST countries: None

Area: Mobile Communications

Action web site: http://cost289.ee.hacettepe.edu.tr

Chairperson: Prof. Dr. Mehmet Safak

Prof. Mehmet Safak Hacettepe University Dept. of Electrical and Electronics Eng. 06532 Beytepe, Ankara, Turkey	Tel: +90-312-297 70 70 Fax: +90-312-299 21 25 E-mail: msafak@hacettepe.edu.tr http://www.ee.hacettepe.edu.tr

TC Rapporteur: Prof. G. Brussard
External Evaluator:
External Evaluator:

1. OBJECTIVES

The requirements for higher user mobility and ever increasing data rates seem to act as two major drivers of future communication systems. Based on this observation, the main objective of this Action is to increase the capacity of communication systems with constraints on the transmission bandwidth and the transmitter power, also bearing in mind the cost effectiveness and the practicality of the solution. This imposes serious requirements on communication systems calling for higher data rates, more mobility and, at the same time, a less hazardous electromagnetic environment. To achieve this goal, existing and innovative communication techniques and systems need to be investigated from the viewpoint of the bandwidth and the power efficiency.

This project will contribute to the realization of more spectrum- and power-efficient integrated multimedia communications, thus to minimize the new bandwidth requirements for high data rate services. Reciprocally, the requirements on the transmit power will be reduced for a given transmission bandwidth. The resulting benefits will include the provision of higher data rates, larger coverage areas, more mobility to the users, and longer battery life for mobile terminals. All these will contribute to the provision of better QoS and cost effective services. The systems thus designed will also contribute to the creation of a less polluted electromagnetic propagation environment. Consequently, one may expect reduced electromagnetic compatibility (EMC) problems with other electronic systems and significant reduction in hazardous radiation effects to biological systems. The outcome of the Action is believed to provide valuable contribution to the literature and the technology in the related fields.

2. TECHNICAL DESCRIPTION AND IMPLEMENTATION

The philosophy of the Action is based on close co-operation between the scientists and engineers from the Telecommunication Industry and the Academia. The research efforts will be focused and coordinated, in accordance with the objectives cited above, on the problems discussed below.

The activities of this Action will be conducted in 2 Working Groups (WG’s):

a) WG1: Information Theoretical Description of Radio Systems

The aim of WG1 is to provide an analytical description of mobile systems and related architectures, and to carry out detailed analyses of undiscovered areas of modern communications. The emphasis will be on mathematical studies and simulation rather than on the implementation issues. The output of WG1 can also be used as an input to WG2.

A list of research areas that the WG1 is interested includes, but not limited to:

- *Spectral efficiency (SE) and power efficiency (PE)*
- *Channel capacity (CC)*
- *User capacity (UC)*
- *Modulation*
- *Coding*

b) WG2: Communications Techniques and Systems

The objective of WG2 is to study the implementation of techniques and algorithms for increasing the data rates, the reliability as well as the power and spectrum efficiency of communication systems.

The research activities of the WG2 include:

- *Adaptive transmission techniques*
- *Software defined radio*
- *Adaptive/reconfigurable networks*
- *Multicarrier systems*
- *Multiple access techniques*
- *Multiuser detection*
- *Multiple-input multiple-output (MIMO) systems*

The two WGs define the framework of the research activities proposed in this Action. In view of the size of the Management Committee (MC), the scientific activities in the two WGs can be monitored in plenary sessions. Therefore, the MC has decided not to appoint heads to these WGs.

c) Project Groups

The MC strongly believes that a COST Action should not provide a platform only for the presentation of individual research products of the participants but rather should act as a means to create synergy in coordinated and cooperative research efforts to find coherent and practical solutions to the problem stated in the MoU.

Accordingly, the MC decided to form the following three project groups, with active participation of a number of institutions listed below, in order to concentrate their efforts and bring solutions to some specific problems of particular importance. The details of the formulation of these projects are presented in Section 4: RESULTS.

- **Pervasive wireless access for 4G**
  ***Coordinator*:** Prof. Armin Wittneben, ETH Zurich
  ***The participating organizations*:** ETH Zurich, Hacettepe University, Norwegian University of Science and Technology, University of Ulm, Budapest University of Technology and Economics, University Carlos III of Madrid.
- **Wide are coverage and high mobility access systems for 4G**
  ***Coordinator*:** Prof. Arne Svensson, Chalmers University of Technology
  ***The participating organizations*:** Chalmers University of Technology, University of Florence, Ramon Llull University, CEI-LETI, University Carlos III of Madrid, Hacettepe University, TU Kosice, Czech Academy of Science, Norwegian University of Science and Technology, DLR.
- **Software defined radio**
  ***Coordinator*:** Prof. Sandor Imre, Budapest University of Technology and Economics.
  ***The participating organizations*:** Budapest University of Technology and Economics, University Carlos III of Madrid, Ramon Llull University, Universitat Politècnica de Catalunya.

The researchers participating to the above projects will cooperate closely and concentrate their efforts to investigate in detail and bring coherent solutions to the formulated problems.

The above research groups were finalized during the 4. MCM, held in Zurich, in 15-16 March 2004. It was desired to organise an inauguration meeting for the above three project groups with the participation of young researchers. However, in view of the large numbers of participation in each of the projects, the project coordinators prepared a description of their project programme and disseminated these programmes to the COST 289 members. Each researcher will freely choose his/her own individual research area, within the framework of the project.

Some of the researches will visit the project coordinators with STSMs for better coordination of the research efforts. These researchers are also encouraged to attend the Seminar to be organized in Budapest 7-9 July 2004 to increase their awareness about the project, to discuss their initial results and for further coordination and cooperation.

Three separate *e-mail groups* are formed for the three research projects, namely Pervasive Wireless Access for 4G, Wide Area Coverage Systems with High Mobility for 4G, and SDR. These e-mail groups will be useful for exchange of information between the young researchers directly involved in these projects and will provide a common platform for discussing the outstanding items. If required, a file uploading system will also be provided for sharing some important documents.

During the course of the Action, new project groups may be formed if there are sufficient numbers of participants interested in a special project in the areas of interest, as defined in the MoU, of the Action.

3. PARTICIPATION AND COORDINATION

3.1 Management Committee

Chairman:

Prof. Dr. Mehmet Safak
Hacettepe University
Department of Electrical and Electronics Engineering
06532 Beytepe, Ankara, Turkey
Tel: +90-312-297 70 70
Fax: +90-312-299 21 25
E-mail: msafak@hacettepe.edu.tr

Vice-Chairman:

Prof. Dr. Hermann Rohling
Technical University of Hamburg-Harburg
Arbeitsbereich Nachrichtentechnik
Eissendorfer Str. 40 D-21073 Hamburg
Tel (+4940) 42878-3028
Fax (+4940) 42878-2281
E-mail rohling@tu-harburg.de

Secretary:
Serap Hasimoğlu-Ertas
Researcher
Hacettepe University
Department of Electrical and Electronics Engineering
06532 Beytepe, Ankara, Turkey
Tel: +90-312-297 70 00
Fax: +90-312-299 21 25
E-mail: serap@ee.hacettepe.edu.tr

Members:

Prof. **H. Rohling**, Technical University of Hamburg-Harburg, Germany
Prof. **A. Wittneben**, Swiss Federal Institute of Technology, Switzerland:
Prof. **J. Lindner**, University of Ulm, Germany
Prof. **H. Vinck**, University of Essen, Germany
Prof. **A. Svensson**, Chalmers University of Technology, Sweden
Dr. **S. Kaiser**, German Aerospace Centre, DLR, Germany
Prof. **L. Vandendorpe**, Universite Catholique de Louvain, Belgium
Researcher **M. Dangl**, University of Ulm, Germany
Prof. **A. Polydoros**, University of Athens, Greece
Researcher **K. Nikitopoulos,** University of Athens, Greece
Prof. **D. Kocur**, Technical University of Kosice, Slovakia
Prof. **A. Ahlen**, Uppsala University, Sweden
Prof. **L. Pap**, Budapest University of Technology and Economics, Hungary:
Prof. **S. Imre**, Budapest University of Technology and Economics, Hungary
Researcher **G. Jeney**, Budapest Un. of Technology and Economics, Hungary
Prof. **R. Fantacci**, University of Florence, Italy
Researcher Ing. **D. Tarchi**, University of Florence, Italy
Prof. **J. L. Pijoan**, Ramon Llull University, Spain
Dr. **J. P. Romero**, Polytechnic University of Catalunya, Spain
Researcher **F.A. Freixer**, Polytechnic University of Catalunya, Spain
Dr. **A. Garcia-Armada**, University Carlos III of Madrid, Spain
Researcher **M. P. S. Fernandez**, University Carlos III of Madrid, Spain
Researcher **V. P. G. Jimenez**, University Carlos III of Madrid, Spain
Prof. **M. Safak**, Hacettepe University, Turkey
Researcher **G. Pay**, Hacettepe University, Turkey
Dr. **G. Meyer**, Swiss Federal Institute of Technology, Switzerland
Prof. **G. E. Oien**, Department of Telematics, NTNU, Norway
Prof. **K. J. Hole**, Department of Telematics, NTNU, Norway
Dr. **J. Simsa**, Academy of Sciences, Czech Republic
Prof. **G. Iliev**, Technical University of Sofia, Bulgaria
Prof. Dr. **V. Bota**, Technical University of Cluj-Napoca
Prof. Dr. **A. de Sabato**, Politchnical University of Timisoara
Dr. **H. Sari**, SUPELEC, France
Dr. **R. Visoz**, France Telecom R& D, France
Prof. **D. Bajic**, University of Novi Sad, Serbia and Montenegro
Dr. **W. Teich**, University of Ulm, Germany
Researcher **S. Plass**, German Aerospace Centre, DLR, Germany
Researcher **S. Sand**, German Aerospace Centre, DLR, Germany
Researcher **D. Vukobratovic**, University of Novi Sad, Serbia and Montenegro

Researcher **F. Chiti**, University of Florence, Italy
Researcher **G. Mennuti**, University of Florence, Italy
Dr. **A. Berthet**, SUPELEC, France
Researcher **S. Wendt**, France Telecom R&D, France
Researcher **P. Katsis**, Aristotle University of Thessaloniki, Greece
Researcher **G. Papadopoulos**, Aristotle University of Thessaloniki, Greece
Dr. **M. Drutarovsky**, Technical University of Kosice, Slovakia
Researcher **S. Hasimoglu-Ertas**, Hacettepe University, Turkey
Researcher **F. Balasz**, Budapest Un. of Technology and Economics, Hungary
Researcher **G. Rabai**, Budapest Un. of Technology and Economics, Hungary
Dr. **S. Mayrargue**, CEA-LETI, France
Researcher **C. Vilella**, Ramon Llull University, Spain
Researcher **M. Deumal**, Ramon Llull University, Spain
Researcher **S. Berger**, ETH Zurich, Switzerland
Researcher **I. Hammerstroem**, ETH Zurich, Switzerland
Researcher **B. Rankov**, ETH Zurich, Switzerland
Researcher **J. Cizova**, Technical University of Kosice, Slovakia
Researcher **P. Galajda**, Technical University of Kosice, Slovakia

3.2 Participating Institutions

BELGIUM	**Universite Catholique de Louvain**
GERMANY	**Technical University of Hamburg-Harburg**
	University of Ulm
	University of Essen
	German Aerospace Centre, DLR
GREECE	**University of Athens**
	Aristotle University of Thessaloniki
SLOVAKIA	**Technical University of Kosice**
SWEDEN	**Chalmers University of Technology**
	Uppsala University
HUNGARY	**Budapest University of Technology and Economics**
ITALY	**University of Florence**
SPAIN	**Ramon Llull University**
	Polytechnic University of Catalunya
	University Carlos III of Madrid
TURKEY	**Hacettepe University**
SWITZERLAND	**Swiss Federal Institute of Technology, Zurich**
NORWAY	**Department of Telematics, NTNU**
CZECH REPUBLIC	**Academy of Sciencies**
BULGARIA	**Technical University of Sofia**
FRANCE	**Supelec**
	France Telecom R&D
	CEA-CETI
SERBIA and MONTENEGRO	**University of Novi Sad**
ROMANIA	**Technical University of Cluj-Napoca**
	Politchnical University of Timisoara

3.3 Meetings of the Management Committee

Inaugural MCM	24 March 2003, Brussels, Belgium
2. MCM	3-4 July 2003, Hamburg, Germany
3. MCM	30-31 October 2003, Kosice, Slovakia
4. MCM	15-16 March 2004, Zurich, Switzerland
5. MCM (scheduled)	7-9 July 2004, Budapest, Hungary (together with Seminar)
6. MCM (scheduled)	28-29 October 2004, Barcelona, Spain

3.4 Meetings of the Working Groups

No separate Working Group meetings have yet been organised.

3.5 Short-term scientific missions

Several STSM are being organized before the end of June 2004 for the young researchers to visit their project coordinators. At the moment of writing this report, the programmes of the STSM's are not yet finalized.

4. RESULTS

The research efforts resulted in 27 presentations in the last three MCMs, organised during the period 1 July 2003-30 June 2004. The 23 publications are posted in the Action web site. These research outcomes resulted mainly from the individual research efforts of the participants.

It is believed that the following three joint research projects will result in joint publications. The project on *Wide Area Coverage* aims to address the problems of centralized systems with high mobility, thus with correspondingly lower data rates and wider coverage areas. The project on *Pervasive Wireless Access* is mainly concerned with decentralized networks with lower mobility, much higher data rates, and restricted coverage areas. The SDR project aims to bridge these two projects horizontally; the systems coexisting in the same platform are essential for the reconfigurability and adaptivity purposes.

These projects are defined to be sufficiently flexible so that each researcher can choose his particular research topic and thus can make the best use of his/her expertise. As individual researchers complete their parts, the outcome is believed to provide a complete solution to the problem defined by the project.

4.1. Wide Area Coverage and High Mobility Access Systems for 4G

Intense research efforts are currently ongoing towards the definition of physical layers for 4G systems. Several proposals have already been made and some of them are based on OFDM transmission techniques. A national project in Sweden has suggested an adaptive multiplexing and OFDM transmission system for such a downlink [1][2]. NTT DoCoMo has suggested a scheme based on the combination of OFDM and

CDMA [3]. Several other companies are working on their proposals; some of which were presented at a recent 4G forum arranged by Samsung in Jeju Island, Korea.

In the *downlink*, it is all about multiplexing within each cell, while it is multiple access between cells only. In an *uplink* the situation is much more complicated since a combination of multiplexing and multiple access takes place in each terminal when more than one service is transmitted at the same time. The uplink is also normally asynchronous and oscillators in different terminals are not synchronized. This may suggest that OFDM cannot be used due to its sensitivity to frequency synchronization errors. It may also be more difficult to use channel state information in a transmitter in the uplink at least in FDD systems, due to increased overhead.

In this project, **partners will design and analyze physical layer solutions for 4G uplinks**. We should restrict ourselves to systems with wide area coverage and high mobility. We do not need to restrict ourselves to OFDM transmission techniques and to CDMA, but every transmission and multiple access technique is allowed. So in principle any physical layer technique can be used and combined in such a way that a high bandwidth and power efficient downlink is obtained. Based on recent assumptions on 4G system uplinks, we propose the following common parameters (used by DoCoMo):

- Available uplink bandwidth is 40 MHz
- Carrier frequency likely around 5 GHz
- Maximum speed is 250 km/h

If some partners are interested in a further comparison between spread and nonspread OFDM schemes for the downlink, this is also possible as a subtask within the cooperation. A fair comparison between those systems in a multi-cellular environment with also complexity taken into account is believed to be still missing. Recent parameters for the downlink include (used by DoCoMo):

- Available downlink bandwidth is 100 MHz
- Carrier frequency likely around 5 GHz
- Maximum speed is 250 km/h

It should also be kept in mind that the requirement for high mobility by ITU is 100 Mbps, which might be difficult to obtain with a 40 MHz bandwidth.

All performance evaluation should be done using the UMTS channel models. Preferably, performance should be evaluated in a multi-cell environment, but single cell performance and single link performance is acceptable as a starting point.

References

[1] M. Sternad, T. Ottosson, A. Ahlén, A. Svensson, “Attaining both coverage and high spectral efficiency with adaptive OFDMA downlinks,” in *Proc. IEEE VTC 2003 Fall*, Orlando, USA, October 2003.

[2] W. Wang, T. Ottosson, M. Sternad, A. Ahlén, A. Svensson, “Impact of multiuser diversity and channel variability on adaptive OFDM,” in *Proc. IEEE VTC 2003 Fall*, Orlando, USA, October 2003.

[3] H. Atarashi, N. Maeda, S. Abeta, M. Sawahashi, “Broadband packet wireless access based on VSF-OFCDM and MC/DS-CDMA,” in *Proc. IEEE PIMRC 2002*, Lisbon, Portugal, pp. 992-997, Sept. 2002.

4.2. Pervasive Wireless Access for 4G

Next generation WLANs will provide ubiquitous wireless connectivity for a variety of heterogeneous nodes, e.g., RFID tags for object identification, sensors and computers, with data rate requirements ranging from 1Mbps to 1Gbps. We refer to this breed of networks as pervasive wireless access networks, which are believed to have a tremendous impact on our lifestyle. It is anticipated by many analysts that, in the future, pervasive wireless access systems will generate the bulk of the data traffic in the Internet.

For complexity reasons low end user nodes will have a single antenna. High end user nodes will feature multiple antennas to improve throughput and coverage. The extended use and range of deployment will lead to a high node density. This makes cooperative signaling schemes an extremely attractive option. Channel adaptive scheduling, adaptive modulation and spatial multiplexing (MIMO) will be indispensable to achieve the required scalability and spectral efficiency. The heterogeneous QoS requirements would facilitate channel adaptive scheduling, but typical user nodes in WLANs have low mobility and the channel may not vary sufficiently over time to make fair channel adaptive scheduling efficient. For spectral reasons next generation WLANs will operate beyond 5 GHz (e.g. at 17/24GHz). Here we face a *poor scattering/rich array* situation as opposed to the *rich scattering/poor array* situation at 5GHz [1]. Recent work [2]-[4] has shown the potential of cooperative signalling (in particular linear multi-node relaying) to exploit spatial multiplexing on poor scattering channels. **The main motivation of this project is to open up the benefits of cooperative diversity, channel adaptive scheduling and spatial multiplexing (MIMO) in a low mobility environment with poor scattering and with heterogeneous nodes.** This area is essentially unexplored to date and requires fundamental new work ranging from multinode/multihop channel modeling to efficient cooperative spatial multiplexing, cooperative medium access and cooperative channel adaptive scheduling schemes. In this project we will constrain our attention to linear but possibly *time-variant* processing at the cooperating nodes. This has the major advantage that the cooperation is transparent to an adaptive modulation scheme (symbol alphabet) used by the source. We are explicitly interested in schemes, that allow a seamless integration of multi-antenna nodes and that remain efficient in a poor scattering environment. This work includes a number of deliverables, which will be produced by the participants of the project group (multihop/multinode channel model implementation, cooperative space-time code design criteria and evaluation SW, cooperative WLAN simulation framework). The proposed research will benefit substantially from the RACOON Laboratory and the testbed infrastructure [5][6], which is currently being finalized in ETH Zurich. RACOON constitutes a heavy investment of ETH Zurich in cooperative wireless. Within COST289, RACOON will be made available to the other partners for verification and demonstration activities.

References

[1] A. Wittneben, B. Rankov, "MIMO Signaling for Low Rank Channels, " URSI International Symposium on Electromagnetic Theory (2004 URSI EMT-S), Pisa, Italy (Invited Paper).
[2] A. Wittneben and B. Rankov; "Distributed Antenna Arrays versus Cooperative Linear Relaying for Broadband Indoor MIMO Wireless," *International Conference on Electromagnetics in Advanced Applications, ICEAA'03*, Torino, Italy, Sept. 2003, (*invited paper*).
[3] M. Kuhn, I. Hammerstroem, and A. Wittneben, "Linear Scalable Dispersion Codes for Frequency Selective Channels," *Proc. of the 8th International OFDM-Workshop*, Sept. 2003.
[4] A. Wittneben and B. Rankov, "Impact of Cooperative Relays on the Capacity of Rank-Deficient MIMO Channels," *Proceedings of the 12th IST Summit on Mobile and Wireless Communications*, Aveiro, Portugal, pp. 421-425, June 2003.
[5] R. Kueng: "STORADIO, Repeater RF Unit, Specification, Design, Test", Version 1.1, 14.10.2001. Elektrobit, Bubikon.
[6] M. Wattinger: "STORADIO, Storage Unit, Specification", Version 1.0, 17.10.2003, Elektrobit, Bubikon.

4.3. Software Defined Radio

The adaptive modulation and coding techniques require logical functions, coordination mechanisms and systems architectures better suited for adaptation. On the other hand, nowadays subscribers of wireless systems suffer the great number of networks operating according to different standards. Inter-system roaming (e.g. GSM-IS95) and vertical handover (e.g. UMTS-WLAN) would require the implementation of many different standards in a single radio terminal/base station.

In order to avoid the usage of multi-multi-mode terminals, the so-called software defined radio (SDR) concept has been proposed. Reconfigurable equipment with universal hardware and downloaded software can solve roaming/handover problem efficiently. Furthermore modifications or even new techniques related to the air interface can be realized without effort enabling cost-efficient system upgrades. Therefore, SDR fits into the newly emerging “reconfigurable networks” concept.

The software-defined radio (SDR) implies a radio with enough programmability, thus easy and inexpensive modification of the signal processing steps, and thereby provides different communication schemes. Thanks to the developments in digital signal processing (DSP), field programmable gate arrays (FPGAs), application specific integrated circuits (ASICs) and digital signal processors (DSPs), we now have new options for the SDR. The ability to work across a wide range of frequency spectrum is believed to be a requirement for next generation SDR’s. Hardware architectures, for both baseband and RF sides, continue to improve. The SDR technology continues to evolve and is expected to be one of the key technologies of the future systems.

Within COST 289 the following research topics are considered:

- Hardware strategies to efficiently design reconfigurable radios (implementation independent methods). The efforts can be focused in:

- The physical layer organization (distributed-DSP or centralized INTEL-type approaches) [1], [2]
  - More general approaches, including higher layer protocols, networking, services, interfaces, call admission control, etc
- Software strategies for downloading software modules and efficient reconfiguration algorithms.
- Specific hardware architectures that allows reconfiguration with a minimum power consumption penalty [3] or dynamic adaptation to the variations in user traffic
- Experiences that partially implement multiple standards as GSM, EDGE, WCDMA-FDD, Bluetooth using some strategies on any platform ([2], [4], [5], etc.)

Beside the above research activities it is planned to cooperate with the other two COST 289 projects, namely, Pervasive Wireless Access for 4G and Wide Area Coverage and High Mobility Access Systems for 4G, which consider vertical approaches in wireless networks in two different environments (low and high mobility, centralized-distributed). The SDR project aims to bridge these two COST 289 projects horizontally, concentrating in the reconfigurability of different systems.

A white paper will be prepared surveying the state of the art concepts and solutions for reconfigurable air interfaces.

References

[1] S. Srikanteswara, J.H Reed, P. Athanas; Boyle, R, "A soft radio architecture for reconfigurable platforms", IEEE Communications Magazine, vol. 38, no. 2, pp. 140–147, Feb. 2000.

[2] S. Srikanteswara, J. Neel, J.H Reed, P. Athanas, **"**Soft radio implementations for 3G and future high data rate systems**"**, IEEE Global Telecommunications Conference, GLOBECOM 2001, 25-29 November 2001, vol. 6, pp. 3370–3374.

[3] S. Srikanteswara, R.C. Palat, J.H Reed, P. Athanas, **"**An overview of configurable computing machines for software radio handsets", IEEE Communications Magazine, vol. 41, no. 7, pp. 134–141, July 2003.

[4] A. A. Kountouris, C. Moy, L. Rambaud, P. Le Corre, "A software radio approach for the transceiver transition from 2G to 2.5G to 3G", Sixth International, Symposium on Signal Processing and its Applications, 13-16 Aug. 2001, vol. 2, pp. 485–488.

[5] F. Jondral, A. Wiesler, R. Machauer, "A software defined radio structure for 2nd and 3rd generation mobile communications standards", 2000 IEEE Sixth International Symposium on Spread Spectrum Techniques and Applications, 6-8 Sept. 2000, vol. 2, pp. 637-640.

5. DISSEMINATION OF RESULTS

5.1 Publications and Reports

During this period, COST Action 289 organized three Management Committee Meetings. The number of presentations made during these MCMs is listed below:

2. MCM in Hamburg, 3-4 July 2003: 7

3. MCM, Kosice, 30-31 October 2003: 8
4. MCM, Zurich, 15-16 March 2004: 12

The detailed list of publications is presented below and they are also posted in the web site of the Action: http:// cost289.ee.hacettepe.edu.tr.

1. M. A. Dangl, W.G. Teich, J. Lindner and J. Egle; Joint Iterative Equalization, Demapping and Decoding with a Soft Interference Canceller
2. D. Galda and H. Rohling; A Low Complexity Transmitter Structure for OFDM-FDMA Uplink Systems
3. B. Chen and H. Rohling; Joint Layer Optimization for OFDM based Radio Systems
4. L. G. Alonso Zarate; MAC/RLC Protocol Design in Heterogeneous Networks
5. S. Bozay and M. Safak; Performance Analysis of Spatial Multiplexing and Maximal Ratio Combining Systems in the Presence of Polarization Diversity
6. A. Svensson, A. Ahlen, A. Brunstrom, T. Ottosson and M. Sternad; An OFDM based System Proposal for 4G Downlinks
7. M. Sternad, T. Ottosson, A. Ahlen and A. Svensson; Attaining both Coverage and High Spectral Efficiency with Adaptive OFDM Downlinks
8. W. Wang, T. Ottosson, M. Sternad, A. Ahlen and A. Svensson; Impact of Multiuser Diversity and Channel Variability on Adaptive OFDM
9. M. des Noes and D. Ktenas; MC-CDMA vs DS-CDMA
10. Stephan Sand; Two Dimensional Pilot Symbol Aided Channel Estimation for a Broadband MC-CDMA System with High Mobility
11. A.J. Han Vinck; Pulse Position Access Codes
12. Pavol Švac, Martin Piekov; CC-CDMA for B3G Wireless Communications: An overview and some open issues
13. Dušan Kocur, Jana Cízová, Stanislav Marchevsky; The Piece-Wise Linear Microstatistic Multi-User Receiver
14. F. Chiti, R. Fantacci, G. Mennuti, and D. Tarchi; A Novel Admission Control Algorithm for UMTS System
15. Arne Svensson; Joint project on ”Wide area coverage and high mobility access systems for 4G”
16. F. Adelantado, O. Sallent, J. Pérez-Romero, R. Agustí; Traffic Hotspots in UMTS networks: influence on RRM strategies
17. Simon Plass; Rank-Codes for OFDM
18. Victor P.Gil Jimenez and Ana Garcia Armada; Bit-loading in Hybrid OFDM (H-OFDM)
19. Stefan Wendt; A tapped Delay Line Model of Multipath Channel for CDMA Systems
20. Sami Chtourou, Raphael Visoz, and Antoine O. Berthet; A Class of Low Complexity Iterative Equalizers for Space-Time BICM over MIMO Block Fading Multipath AWGN Channel
21. Lorenzo Caponi, Francesco Chiti, Romano Fantacci; A Dynamic Rate Allocation Technique for Wireless Communication Systems
22. Gabor Jeney, Janos Levendovszky, Sandor Imre and Laszlo Pap; Quadratic Optimization with Stochastic Recurrent Neural Networks.

23. Matilde Sanchez Fernandez, Ma del Pilar Cantarero Recio and Ana Garcia Armada; Study of MIMO channel capacity for IST METRA models

5.2 Conferences and Workshops

The Seminar will take place in Budapest during 7-9 July 2004 together with the 5th MCM. The detailed information about the program of the seminar is available in the web site of the Action. The Seminar is aimed to serve the purpose of bringing together the young researchers from the COST nations, increase the spirit of cooperation between them; coordinate their research efforts under the guidance of the project coordinator; and to improve their background scientific level about the joint projects. For this purpose, Dr. H. Atarashi from DoCoMo will give a lecture on the uplink design in 4G systems. Similarly, Prof. L. Hanzo from Southampton University is invited as an expert to the Seminar to lecture on 4G systems. In addition to these experts, there will be lectures by some of the COST members about the specifics of the projects.

5.3 Web site

The web site is used to present the activities of the Action. The web site address is http://cost289.ee.hacettepe.edu.tr. The site is divided into two sections: an open section and a section restricted to the to the participants of the Action only. In the open section the following information is available: Status, MoU, Chair, Participating Organisations, Meetings, Signatories and Related Links. The part accessible only through password is Publications, which contains the working documents of the WGs and some electronic copies of the papers presented at the meetings.

5.4 Scientific and Technical Co-operation

During this phase of the Action, the priority was given to the establishment of coordination and cooperation between the participants. Noting that the participation of the members to the Action took place in an extended time, cooperation between the Action members was considered to be more important. During the next phases, close scientific and technical cooperation is desired to be established with other relevant COST Actions, scientific institutions, and research programmes, especially in the EU framework programme.

5.5 Transfer of results

The transfer of the results of the research is considered a key issue and a number of target groups have been identified, e.g., technology developers and providers, scientists, industry representatives and standardisation bodies as the key recipients of information. The actual dissemination is implemented based on the Action web site. Other means will include

- Electronic media in which the research results is/will be entered in the Internet for easy retrieval by researchers and other professionals.
- Specific contacts with already established agencies, initiatives and programmes.

- Traditional means such as reports, academic journals, conferences, seminars and workshops.

5.6 Contacts in the ERA

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6. ECONOMIC DIMENSION

Currently, 16 countries signed the MoU and 26 institutions from 16 different countries participates the Action.

It is therefore realistic to assume that the Action will be operated with at least 16 countries during the period 1 July 2004- 30 June 2005 with, on the average, 2 representatives per country. As also suggested in the MoU, the economic value of the research conducted by each country per year can be estimated from the following

½ engineer/researcher/secretary	50 000 Euros
½ technician	30 000 Euros
2 Ph.D. students	70 000 Euros
Equipment and material costs	30 000 Euros
Travel	20 000 Euros
Total per signatory per year	**200 000 Euros**

The total cost per signatory will be about 200 000 Euros per year and 800 000 Euros in four years, the duration of the Action. The total economic dimension over four years for 16 nations is predicted to be approximately 12.8 Million Euros.

The total budget for the period 1 July 2003-30 June 2004, including the yearly grants and the meeting expenses, which was directly reimbursed by the COST Secretariat in Brussels, was 51.2 kEURO. At the moment of reporting this grant period has not ended.