IST-4-027756 WINNER II

D7.1.5 v1.0

Final Report

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Abstract:
The Final Report provides the available information for publication covering all the work, objectives, results and conclusions.

Keyword list: Final activity report

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List of Abbreviations

AN	**A**mbient **N**etworks (IP name in WWI)
AP	Access Point
BER	Bit Error Rate
B3G	Beyond Third Generation Mobile and Wireless Communications
CBR	Constant Bit Rate
CEPT	Conférence Européene des Administrations des Postes et des Télécommunications
C/I	Carrier/Interference-Ratio
COST	European Co-operation in the field of Scientific and Technical research
CRRM	Common Radio Resource Management
CSI	Channel State Information
Dx	Deliverable No. x
EC	European Commission
ECC	Electronic Communication Commission of the CEPT
ECC PT1	Project Team 1 of ECC. Deals with IMT issues in CEPT.
EG	Quality Evaluation Group
EMF	Electro-Magnetic Field
ERO	European Radiocommunications Office
EU	European Union
FDD	Frequency Division Duplex
FP6	Frame Work Programme 6
FTP	File Transfer Protocol
FuTURE	Future Technologies for Universal Radio Environment
Gbps	Gbit per second
GLL	Generic Link Layer
GSM	Global System for Mobile Communication
HERS	Heterogeneous Relay Station
HO	Handover
HW	Hardware
IEEE	Institute of Electrical and Electronics Engineers
IMT	International Mobile Telecommunication, covers both IMT-2000 and IMT-Advanced
IMT-Advanced	Technologies in the IMT “family” to be standardised by 2011, “Systems beyond 3G”
IMT-2000	International Mobile Telecommunication 2000, “third generation” mobile communication IP Integrated Project
IPR	Intellectual Property Right
IRx	Internal Report No. x
IST	Information Society Technologies
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union, Radio Sector
L	Layer
MAC	Medium Access Control
MCP	Modes Convergence Protocol
MCM	Modes Convergence Manager
MIMO	Multiple Input Multiple Output
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
Px	Partner x

PER	Packet Error Rate
PHY	Physical Layer
PM	Project Manager
PMT	Project Management Team
QEG	Quality Evaluation Group
QoS	Quality of Service
RAN	Radio Access Network
RAT	Radio Access Technique
RF	Radio Frequency
RI	Radio Interface
RRM	Radio Resource Management
R&D	Research and Development
SCM	Spatial Channel Model
SIMO	Single Input Multiple Output
SISO	Single Input Single Output
SME	Small and Medium Enterprise
SNR	Signal/Noise-Ratio
SW	Software
Tx	Task x
TDD	Time Division Duplex
TL	Task Leader
TM	Technical Manager
UMTS	Universal Mobile Telecommunication System
WiFR	Wireless Fixed Routing
WINNER	**W**ireless World **In**itiative **Ne**w **R**adio (IP name in WWI)
WLAN	Wireless Local Area Network
WPx	Work Package x
WPL	Work Package Leader
WP5D	Working Party 5D (IMT Systems) in ITU-R, successor of WP8F
WP8F	Working Party 8F in ITU-R
WRC	World Radiocommunication Conference
WSE	Weighted Spectral Efficiency
WWI	Wireless World Initiative
WWRF	Wireless World Research Forum
3G	Third Generation Mobile Communications
3GPP	Third Generation Partnership Project, based on UMTS

1. Project execution

WINNER project on the web: https://www.ist-winner.org/

1.1 Project objectives

The WINNER II project is part of the Wireless World Initiative (WWI), which is a group of cooperating complementary projects in Framework Programme 6. The key objective of the WINNER II project is to develop and to validate an innovative concept for a wideband radio interface, in response to the research targets for IMT-Advanced as expressed in the ITU-R Recommendation M.1645, in order to provide high flexibility and scalability with respect to achievable throughput, latency and radio environments (wide area, metropolitan, local area). The future converged wireless world requires in the long-term perspective a ubiquitous radio system instead of disparate systems for different purposes (cellular, WLAN, short-range access etc.). The vision of a ubiquitous radio system concept is to provide wireless access for a wide range of services and applications across all environments, from short-range to wide-area, with one single adaptive system concept for all envisaged radio environments. It adapts efficiently to multiple scenarios by using different modes of a common technology basis. The concept comprises an optimised combination of the best component technologies, based on an analysis of the most promising technologies and concepts available or proposed within the research community. The initial development of technologies and their combination in the system concept has been further advanced towards future system realisation. Compared to current and evolving mobile and wireless systems, the WINNER system concept provides significant improvements in peak data rate, latency, mobile speed, spectrum efficiency, coverage, cost per bit and supported radio environments taking into account specified Quality-of-Service requirements.

1.2 Contractors

The consortium comprises 39 partners which are major players in the field from the

- **Manufacturer's domain (16):** Nokia Siemens Networks GmbH & Co. KG (coordinator), Alcatel-Lucent Deutschland AG, Ericsson AB, Fujitsu Laboratories of Europe Ltd, Motorola SAS, Nokia Corporation, Nortel Networks UK Ltd, Philips Electronics UK Ltd, Qualcomm CDMA Technologies GmbH, Samsung Electronics UK Ltd, Siemens AG Österreich, Siemens Program and System Engineering SRO, BenQ (left the consortium on April 30, 2007), Elektrobit Corporation, Nokia Siemens Networks S.p.A., Alcatel-Lucent Telecom Limited, Nokia Siemens Networks Technology (Beijing) Co., Ltd;
- **Network operators domain (6):** DoCoMo Communications Laboratories Europe GmbH, Eurescom GmbH, France Telecom SA, Portugal Telecom Inovação SA, Telefónica Investigación y Desarrollo Sociedad Anónima Unipersonal, Vodafone Group Services Ltd;
- **Academic domain (11):** Aalborg University, Carleton University, Chalmers University of Technology, KTH Stockholm, National Technical University of Athens, Poznan University of Technology, RWTH Aachen University, Technische Universität Dresden, Technische Universität Ilmenau, University of Oulu, The University of Surrey;
- **R&D centre domain (5):** CEA-LETI, CTTC, China Academy of Telecommunication Research, DLR, Technical Research Centre of Finland (VTT).

The WINNER II project is being coordinated by:

Dr. Werner Mohr
Nokia Siemens Networks GmbH & Co. KG

1.3 Progress of work and main results

The WINNER II project focussed its work **in the first year** mainly on conceptual work. The following achievements describe the progress of the project in the first project year:

- Multi-dimensional MIMO radio channel model established.
- WINNER channel model contributions to several standardization organisations like 3GPP and WiMAX Forum.
- Definition and full comparison of convolutional codes, LDPCC and DBTC through extensive simulations with {2, 4, 16, 64,}-QAM and various codeword lengths.
- The WINNER link adaptation scheme for frequency-adaptive transmission has been defined for taking advantage of advanced channel coding.
- In-depth investigations on iterative de-mapping of BICM in conjunction with strong outer codes (LDPC) have been performed highlighting doping of labelling as a suitable candidate.
- Detection techniques for MIMO have been evaluated to identify a solution leading to the best performance-complexity trade-off.
- A decision criterion for switching between frequency-adaptive and non frequency-adaptive transmission has been defined, as well as a model for the channel prediction error which facilitates further evaluations.
- An analytical framework for pilot grid design in non-frequency adaptive down- and uplink WINNER transmission is proposed. Furthermore, iterative channel estimation (ICE) has been shown to be a valuable supplement to pilot-aided channel estimation techniques for all SISO and MIMO modes tested.
- Back-off requirements of B-IFDMA and B-EFDMA have been compared, pointing out that conventional IFDMA needs slightly lower back-off than B-IFDMA, and significantly lower than B-EFDMA.
- Different designs of synchronisation pilot together with synchronisation algorithms utilising their properties were investigated. Correlation schemes provide good trade-off between complexity and performance.
- Biologically inspired “Firefly” synchronization, for network time-synchronization, has been applied.. Since working in a decentralized, self-organized way, this algorithm is thus well suited for local area deployments, as well as to metropolitan area, including relay enhanced cells.
- Based on evaluations, the range of candidate techniques for the generic multi antenna transmitter structure has been narrowed down to a set that allows for optimised performance in all relevant deployment scenarios. Moreover, robust protocol and efficient signalling strategies needed in this context have been investigated, including detailed pilot schemes, measurement types, and preliminary feedback reduction methods. Multi-antenna aspects of relaying have been considered. Finally, spatial adaptation techniques have also been studied.
- Special emphasis was given on relaying related functions, including resource partitioning, micro-mobility, ARQ, segmentation and reassembly, flow control and broadcast/multicast support.
- Relay enhanced Radio Resource Management (RRM) schemes with the goal to mitigate or avoid interference in relay based cellular networks have been investigated and partly assessed.
- Simulations of WINNER I candidate multiple access schemes have been carried out in different evaluation scenarios defined by the Concept Group scenarios.
- An appropriate multiple access schemes for the evolved WINNER system concept including a draft concept for multicasting and broadcasting support is recommended.
- The modelling activity of the inter-cell interference aims at providing methods to simulate the effects of inter-cell interference, in a realistic and computationally affordable way.
- For interference averaging, envisioned solutions are: spreading, frequency hopping, interference cancellation and Random Dynamic Channel Allocation.

- For interference avoidance, solutions are: restricted use of resources, power control according to frequency patterns, scheduling schemes (cooperative/inter-cell or not, centralized/hybrid/distributed) and interference based Dynamic Channel Allocation.
- Mechanisms and techniques are identified for the efficient cooperation among WINNER and the legacies RANs and especially for the cooperation of WINNER modes namely; mobility management, congestion avoidance control and QoS based management. The applicability of fuzzy logic to mobility is also studied.
- Flexible Spectrum Use and spectrum sharing related spectrum functionalities covering both Short Term and Long Term functionalities were defined together with their interactions.
- System architectural locations of the required spectrum functionalities were defined.
- 27 Contributions were submitted to CEPT and ITU-R. They were addressing WINNER capabilities and spectrum requirements (3), spectrum estimations and the tool (9), service and radio parameters for IMT-Advanced, to be used in the Estimate Report (10), technical parameters for IMT-Advanced, to be used in the sharing studies (2) and content of sharing studies between IMT-Advanced and systems in the Fixed satellite service (FSS) (3).
- The spectrum requirements calculation tool (“Speculator”) developed by WINNER became the ITU tool for doing the spectrum requirements calculations for WRC-07 Agenda Item 1.4. It is downloadable from the ITU-R WP8F website.
- Strong influence to the Report ITU-R M.2078 (Spectrum requirements for the future development of IMT-2000 and IMT-Advanced). WINNER contributed about the input parameters and the text. The CEPT tentative input parameter set originated from WINNER. Active participation in meetings, chairing of a drafting group. The results of the report show that a significant amount of additional spectrum is needed by year 2020.
- Strong influence to ITU-R WP8F working document IMT.SHARING. The results show that sharing between FSS and IMT-Advanced is feasible under certain conditions. Significant part of content originates from WINNER.
- Impact on Report ITU-R M.2079 (Technical and operational information for identifying Spectrum for the terrestrial component of future development of IMT-2000 and IMT-Advanced).
- Impact on draft CPM text of WRC-07 Agenda Item 1.4 (ITU-R document CPM07-2/1).
- The description of the WINNER logical node architecture has been completed by defining system functions, their interaction, grouping, and assignment to logical nodes as detailed in D6.13.8 "Intermediate WINNER II system concept".
- Baseline simulation and design assumptions for the test scenarios "base coverage urban", "microcellular, and "indoor" of the three concept groups have been derived via project-wide co-ordination and original contributions of WP6.
- In D6.13.6 "Cost models for different deployment scenarios" focus is on cost assessment of future wireless systems like WINNER. This deliverable provides cost models and a cost assessment methodology for different WINNER deployment scenarios.
- The demonstration and trial activities concentrate on improved user experience due to advanced technical solutions (like handover, adaptive spatial processing). In the RRM demo activity the first integration of the RRM platform has been achieved.
- The physical layer centric hardware trial will show adaptivity (link and spatial scheme adaptation). The baseline SISO version is implemented and will be upgraded to an adaptive switching between two 2x2 MIMO transmission modes based on diversity and spatial multiplexing in the final implementation.

During the second year the WINNER II project focussed its work mainly on the detailed design, optimisation and validation of the system concept and on demonstrations of the WINNER demonstrator at international events. The following achievements describe the progress of the project in the second year:

- Final WINNER Channel Models were produced and published as the deliverable D1.1.2. Channel models were based on WINNER II Interim Channel Models These were updated and complemented by some new models, like macro-cellular Outdoor to Indoor model.
- Channel model implementation was updated to contain the features specified in the deliverable D1.1.2.
- Channel model standardization was participated, e.g. following and influencing IEEE802.16m standardization body.
- ITU-R regulation was followed by contributing two ITU-R / 8F meetings: In Yaoundé Cameroon, January 2007 and Kyoto Japan in May 2007. In both meetings WP1 could influence the output document.
- Design and performance results for QC-BLDPC codes: Lifting procedure targeting very high Codeword Lengths (due to Finalization study requirements) whilst maintaining good performance, and backward compatibility with former investigations and results.
- Evaluation of performance robustness to SNR estimation for LDPC codes: Enhancement of End-to-End evaluation.
- Evaluation of Detection Capability of LDPC Codes: feasibility study for getting rid of CRC with ARQ.
- Low rate (R = 1/4) Optimum Discrete Spectrum (ODS) convolutional codes for encoding very short broadcast and signalling messages (K = 25 inf. bits) - literature studies and performance evaluation for the WINNER reference design.
- Encoding of the broadcast modulation and coding scheme table for the non-frequency adaptive control channel.
- Link adaptation with prediction error.
- Link adaptation using QC-BLDPC codes - fine tuning of MI-ACM (a.k.a. Stiglmayr's) algorithm.
- HARQ with partial CSI.
- Completed final specification of pilot design, channel estimation, measurement and signalling, RF and synchronization imperfections, link-level and self-organized network synchronisation.
- Developed full pilot grid design for the WINNER system concept.
- A list of measurement metrics required by components of the WINNER system, in order to carry out their functionality, is produced.
- The impact of different signalling on multi-antenna transmission techniques is studied.
- The candidate techniques for the generic multi-antenna transmitter was narrowed down to a limited set. The set included the multi-antenna techniques that optimise the system spectral efficiency for all relevant deployment scenarios.
- Robust protocol, efficient signalling strategies, including detailed pilot schemes, measurement types, and preliminary feedback reduction methods; have been suggested and included in the performance metric of multi-antenna techniques.
- Multi-antenna aspects of relaying were studied and evaluated.
- New spatial techniques increasing the system performance and providing at least two of the well known multi-antenna gains (e.g. beam forming and spatial multiplexing) were proposed.
- The WINNER relaying concept was further developed and integrated in the overall system concept.
- The WINNER relaying concept was assessed in all three concept group scenario, i.e. the metropolitan, the wide area and the local area scenarios, through system-level simulations. Thereby different technical implementations have been assessed in terms of radio resource management and the idea of cooperative relaying.
- Cost assessments show that relays are very likely to be a cost efficient alternative in urban scenarios.
- Two basic transmission modes are now part of the WINNER System Concept: frequency-adaptive transmission and non-frequency-adaptive transmission. Performance evaluations have been made for both transmission modes.

- Significant gains from multi-user scheduling and frequency-adaptive link adaptation have been demonstrated.
- A MAC control structure has developed and overhead is shown feasible. Both transmission modes have been shown feasible and are integrated in a MAC Reference Design.
- For interference averaging, envisioned solutions investigated are: spreading, frequency hopping, interference cancellation and Random Dynamic Channel Allocation.
- For interference avoidance solutions investigated are: restricted use of resources, power control according to frequency patterns, scheduling schemes (cooperative/inter-cell or not, centralized/hybrid/distributed) and interference based Dynamic Channel Allocation.
- It has been shown that efficient interference mitigation could be obtained from various ways such as: interference rejection schemes, advanced schedulers, use of grid of beams. The more appropriate method highly depends on the deployment and the context.
- Mechanisms and techniques for the efficient cooperation among WINNER and the legacies RANs have been assessed.
- Cooperation mechanisms among WINNER modes have been described and evaluated; namely; mobility management, congestion avoidance control and QoS based management.
- IP convergence layer and radio resource control layer have been described.
- A location determination method in cooperation has been developed and evaluated.
- Flexible Spectrum Use and spectrum sharing related sub-functionalities were defined and algorithms were developed both for the Short Term and Long Term Assignment. Negotiation procedures were defined. Work was done on MAC to include spectrum sharing and on Multi-band scheduler to enable operation in multiple transmission bands.
- RMM simulator was prepared with the aim to verify the spectrum related algorithms and investigate the performance of the advanced functionalities. The work included definition, coding and implementation of the simulator.
- 12 Contributions were submitted to ITU-R. The contributions addressed:
    - channel model approach and parameters (3 contributions),
    - evaluation method, test environments and simulation parameters for evaluations of IMT-Advanced technology candidates (1 contribution),
    - technical, service and spectrum related minimum requirements of IMT-Advanced technology candidates (6 contributions) and
    - sharing study between FSS and IMT-Advanced in the C-band and mitigation techniques for the sharing between FSS and IMT (2 contributions).

  All contributions were taken into account in the work of ITU-R. WINNER channel model inputs were the first ones to address that particular topic.
- WINNER inputs formed a significant portion of the IMT part of the report M.2109 on sharing between IMT and FSS which was finalised in the ITU-R meeting in Kyoto.
- Main results and conclusions of WINNER have also been exchanged with results from Chinese activities in a meeting hosted by CATR in Beijing, China, on October, 15 – 16, 2007.
- The two WINNER trials focussing on RRM and PHY aspects have been successfully integrated into one demonstration, which was presented live at the Wireless World Research Forum Meeting 18, Espoo, Finland, 13 – 15 June, 2007, at the IST Mobile Summit (Budapest, Hungary, 02. – 05.07.2007), at WRC 07 (Geneva, Switzerland, 22. – 31.10.2007) and the WINNER ALL meeting, (Munich, Germany, 11. – 12.12.2007). It is important to note that the total number of demonstration events exceeds the original plan, leading to significant effort and expenses.
- The cost assessment work has been driven further using additionally absolute cost examples that show the suitability of the proposed methodology. In the urban scenario a relay-enhanced network is cheaper than a micro-BS-enhanced system although higher costs for the RN that for the micro BS were considered. Due to

higher line-of-sight probability, this benefit is not as obvious in the rural scenario. On the other hand even higher benefits are expected in built-up areas (investigations using a Manhattan grid).

- According to the deployment assumptions of D6.13.7 the following spectral efficiency requirements were set for WINNER in the downlink for a minimum average user throughput of 2 Mbps for 95 % of the users: 2 bps/Hz/cell in wide area, 3 bps/Hz/cell in metropolitan area, and 10 bps/Hz/cell in local area. Spectral efficiencies in the uplink shall be 50 % thereof. Simulation results prove that the WINNER final system concept and design is able to fulfil these requirements.
- The logical node and protocol architecture of WINNER has been finalized including the design of transport and physical data and control channels, the quality of service concept, RLC and MAC services and functions, and user plane processing. A multi-table approach for the downlink resource mapping and transport format indication allows to keep overhead small while enabling high flexibility of scheduling. The latest status of the WINNER system concept and reference design has been compiled in D6.13.14 "WINNER II system concept description". Main architectural features of WINNER include:
    - Flat architecture
    - Relay logical nodes integral part of the architecture
    - Spectrum Server
    - Cross-layer optimization of protocols
    - Connection via BS or RN is transparent to the user terminal
    - Pool concepts avoids single point of failure
    - Focus on scalability and flexibility
- The end-to-end performance evaluation methodology has been harmonised. Basic spectral efficiency values have been generated using this unified methodology thus enabling comparability. A compilation of correction factors that allow estimating the impact of, e.g., non-ideal channel estimation or of non-ideal link adaptation has been provided.
- The reference design is an exemplary implementation using vendor-specific algorithms. Based on such exemplary assumptions a proof-of-concept was established by means of evaluations. Apart from the reference design T14 has delivered D6.13.10-12 containing the final results and conclusions from the investigations in the three concept groups, "wide area", "metropolitan area", and "local area", respectively. The basic conclusion is that the WINNER II requirements can be met with the final status of the concept and reference design.

The work performed was the basis for a consensus building process in a wide community in an early stage well ahead of future standardisation. In particular, the project impacted the regulatory process in CEPT PT1 and ITU-R WP8F in the preparatory phase of WRC 2007. The WINNER II project developed a radio interface for challenging requirements for systems beyond 3G in order to establish a harmonised system concept. Results from the project will be used by project partners for the forthcoming standardisation process for IMT-Advanced, which is starting in 2008. The project achieved these objectives based on the involvement of major players from the manufacturer, network operator and research domain.

1.4 Expected impact

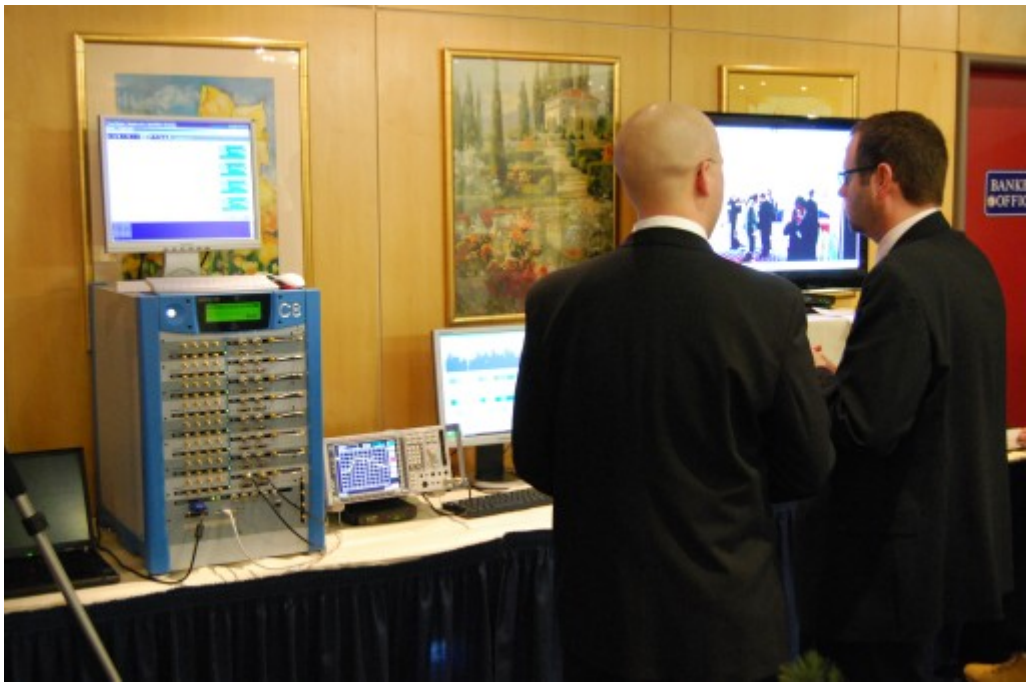
The developed radio interface system concept will enable contributions to the forthcoming international standardisation process for IMT-Advanced. This supports the development towards the information society in line with the i2010 Initiative of the EU Commission. The system concept was developed based on a systematic approach by investigating advanced radio technologies with respect to expected user requirements and challenging scenarios. Respective standardisation bodies have started to review, extend and adapt technical system requirements, where WINNER results will be used. The project has contributed extensively to the global research, regulatory and standardisation process. Major players in the mobile and wireless communications domain are cooperating in this project towards common objectives. This enabled the development of a consistent system concept, which is based on a consensus building process in the consortium.

2. Dissemination and use

2.1 Dissemination activities

Wide and targeted dissemination and exploitation is of particular importance for WINNER II. The Project has been very active in ensuring that public awareness is raised and results of the WINNER II project become widely disseminated to a targeted audience in the scientific and industrial community. Means of dissemination are:

- **WINNER Web site:** The WINNER Web site has two parts: a public part and a secure part for WINNER II members only. The public part ensures that anybody interested can access the publicly available results of the WINNER II project (e.g. public deliverables, press releases, etc.). The secure part is for keeping the Consortium members always up-to-date of all internal documents and activities.
- **Presentations to conferences:** WINNER II contributed extensively to events with a high scientific standard and high visibility. To ensure the quality of such submissions, all papers submitted are passed via the PMT for technical approval and via the entire consortium for approval according to the contract. More than 160 presentations to international conferences were given or will still be given after the end of the project.
- **Publications:** WINNER II also submitted papers to reputated scientific publications. In total 34 papers have been accepted. Several other submitted papers are still pending and being processed by publishers and will be published after the end of the project.
- **Contributions to standards and regulatory bodies:** The WINNER II project contributed to the ITU-R WP8F as well as to relevant specification bodies such as 3GPP and the WiMAX Forum. In total, 83 contributions have been submitted to these fora. Additional five contributions have been prepared based on WINNER II results and submitted after project end to ITU-R WP5D meeting end of January 2008.
- **IST Concertation and Cluster Meetings:** These events are organised by the European Commission and are important means to exchange results amongst IST projects. WINNER II continuously participated at these meetings and has presented 14 contributions during project lifetime.
- **Public Workshops:** The WINNER II project has organised a workshop with Chinese organisations on October 12, 15 and 16, 2007 in Beijing. A WINNER technical workshop has been held as part of the WWI Innovation Day in Brussels on November 13, 2007. A final WINNER Workshop has been held in Munich on December 11, 2007 with invited speakers from relevant standardisation bodies from different regions of the world.



WINNER demo at the public workshop, Munich, 11 December 2007

Further details can be found on the project Web site https://www.ist-winner.org which is hosted by Eurescom.

2.2 Publishable results

Already during the **first 12 months** of the project a number of results have been achieved. All deliverables are accessible via the WINNER public web at https://www.ist-winner.org. In the following the abstracts of three major important deliverables are provided.

D3.4.1 The WINNER II Air Interface: Refined Spatial-Temporal Processing Solutions

In this report, the generic multi-antenna concept is revisited, further developed and optimised. Different options are investigated and compared. The emphasis is on radio network system aspects of multi-antenna techniques in the various deployment environments, i.e. wide, metropolitan and local areas. Conventional co-located antennas, distributed antennas and relaying are analysed and evaluated. Optimised spatial-temporal processing techniques solutions are provided for each of the deployment and propagation scenario.

D4.6.1 The WINNER II Air Interface: Refined multiple access concepts

This deliverable aims at refining the definition of suitable multiple access schemes for the WINNER system concept. Simulations of WINNER I candidate multiple access schemes have been carried out in different evaluation scenarios defined by the Concept Group scenarios. Based on the insights from these simulations, reference design of multiple access schemes for frequency-adaptive and non-frequency adaptive transmission in uplink and in downlink are proposed. Investigations on the benefit of a Direct Access Channel in the uplink and further work on integration of Space Division Multiple Access are reported. Co-existence and adaptation mechanisms of the multiple access solutions are also discussed. In addition, an initial concept for multicast and broadcast support is described. Finally, the MAC layer from WINNER I is evolved, and protocol mechanisms needed to achieve an adaptive MAC layer with low protocol overhead are discussed.

D6.13.7 Test Scenarios and Calibration Cases Issue 2

This report provides the baseline assumption related to environment, deployment, system design, and algorithms for the three test scenarios "base coverage urban", "microcellular", and "indoor" in which the WINNER system is exemplified and evaluated. Associated key assessment criteria are defined**.**

Below table gives an overview of major project results achieved during the **second period** of the project (i.e. month 13 - month 24).

Result description	Possible market applications	Stage of development	Collaboration sought or offered	Collaborator details	Intellectual property rights granted or published	Contact details
Downlink MIMO- and beamforming schemes for throughput and coverage enhancement of wireless base stations, incl. efficient multi-user scheduling algorithms	LTE and WiMAX based mobile wireless infrastructure; future IMT-Advanced systems	Algorithm implementation in simulators and demonstrators	-	-	-	Alcatel-Lucent, Bell Labs Germany, Stuttgart
Pilot design to support various flavours of MU-MIMO schemes	IMT-advanced, B3G systems	Concept	-	-	Published at WCNC 2007, Hong Kong, China, ICC 2007, Glasgow, UK, and	DoCoMo Euro-Labs, Munich, Germany

Result description	Possible market applications	Stage of development	Collaboration sought or offered	Collaborator details	Intellectual property rights granted or published	Contact details
					EURASIP JWCN Journal, to appear in 2008	
Channel estimation error model	Wireless systems	Model for link to system interface	-	-	-	DoCoMo Euro-Labs, Munich, Germany
Threshold controlled iterative channel estimation	OFDM receiver	Algorithm	-	-	Published at VTC 2007 spring, Dublin, Ireland	DoCoMo Euro-Labs, Munich, Germany
Self-organized slot synchronisation for wireless networks	IMT-advanced, B3G systems, Ad hoc and multi-hop networks	Algorithm implemented in simulator and demonstrator	-	-	Published at VTC 2007 spring, Dublin, Ireland	DoCoMo Euro-Labs, Munich, Germany
Synchronisation in the presence of narrow-band interference	IMT-advanced, B3G systems, Ad hoc and multi-hop – networks	Algorithm	-	-	Published at Globecom 2007, Washington, USA	DoCoMo Euro-Labs, Munich, Germany
Decentralised interference management	IMT-advanced, B3G systems, Ad hoc and multi-hop networks	Concept and algorithm	-	-	Published at PIMRC 2007, Athens, Greece	DoCoMo Euro-Labs, Munich, Germany
RRM platform – a platform to monitor and manage the intersystem interworking between WINNER and legacy networks	Mobile and Wireless Operators	Demonstrator	Information exchange	Universities	no	NTUA
Methodology for evaluating radio access networks containing multiple types of node	Cellular wireless	Approaching maturity for relay-based networks	n/a	Nortel	Published	n/a
1. Link level synchronisation scheme	In 4G mobile and base stations	Model and simulation results available and submitted to conferences	None	None	Papers published, public deliverable	PUT

Result description	Possible market applications	Stage of development	Collaboration sought or offered	Collaborator details	Intellectual property rights granted or published	Contact details
2. Efficient interference modelling for microcellular systems	In simulation packages for 4G concept testing	Model and simulation results available and submitted to conferences	None	None	Papers published, public deliverable	PUT
3. MI-ACM algorithm optimisation with RCP-BLDPC codes	In simulation packages for 4G concept testing	Evaluation and simulation results published in D2.2.3 and submitted to a conference	None	None	Papers published, public deliverable	PUT
4. Cooperative relaying in WINNER local area scenario	Future mobile cellular systems	Performance simulations, algorithm	None	None	2 papers published (one co-authored), 2 papers submitted (one co-authored)	PUT
5. Throughput maximization in Manhattan scenario	Future mobile cellular systems	Performance simulations, algorithm	None	None	1 papers published	PUT
6. Multimedia Broadcast Multicast Service	Future mobile cellular systems	Concept description and initial simulation analysis	None	None	To be published (partly reported in the deliverables)	PUT
Channel model implementation	Channel simulators, Channel emulators	Finished	NA	NA	Published	Elektrobit, TUI, UOULU, Nokia
1. Pilot Optimization for Single WINNER Chunk	Optimized channel estimation performance for WINNER and WiMax systems.	MATLAB-based simulator			-	The University of Surrey
2. Bit and Power Allocation for Relay Networks	All OFDM-based networks, such as WiFi, WiMax.	MATLAB-based simulator			-	The University of Surrey
3. Short Term (ST) and Long Term (LT) Spectrum assignment in WINNER	Spectrum gain based on short term variations in RAN traffic in IMT-Advanced	MATLAB-based simulator			-	The University of Surrey

Result description	Possible market applications	Stage of development	Collaboration sought or offered	Collaborator details	Intellectual property rights granted or published	Contact details
systems	systems.					
4. SEAMCAT implementation of WINNER and ITU propagation models	Spectrum sharing between WINNER and FSS systems, European Radiocommunictaions Office (ERO)				-	The University of Surrey

Additional information

Poznan University of Technology (PUT)

1. Link level synchronisation scheme (A. Langowski)

1. Results description
   The low-PAPR synchronisation preamble consisting of one OFDM symbol was designed. The coarse timing synchronisation and fractional frequency offset estimation algorithms making use of preamble structure were developed. The main advantages of the proposed method are the short acquisition time and accurate offsets estimates.
   - Possible market applications
   - The concept is an adequate technique for link level synchronisation in mobile radio systems
   - State of development
   - Simulation results available and published in public deliverables and conferences.
   - Collaboration sought or offered (manufacturing agreement, financial support or investment, information exchange, training, consultancy, other)
   - None
   - Collaborator details (type of partner sought and task to be performed)
   - None
   - Intellectual property rights ***granted*** or published
   - *The following paper was published:*
     - Langowski, "Szybka, dokładna synchronizacja czasu i częstotliwości w systemie OFDM", KKRRiT 2007, Gdańsk, Poland, June 2007
   - A. Langowski, "Fast and Accurate OFDM Time and Frequency Synchronisation", IEEE ISWCS 2007, Trondheim, Norway, October 2007Contact details

2. Efficient interference modelling for microcellular systems (P. Sroka, Z. Długaszewski)

- Result description
  We proposed an efficient interference modelling approach for the microcellular environment simulations using Manhattan grid. It has been optimized and evaluated through simulations and proved to be an adequate solution for system-level simulations. The proposed approach can be easily adapted and optimized to work for other microcellular systems.
  - Partner(s) involved in the exploitation, role and activities
  - PUT
  - Possible market applications or how they might be used in further research

- Further additional research and development work, including need for further collaboration and who they may be;
- Research on the uplink to downlink and vice-versa interference modelling.
- Further simplification of the existing model for uplink interference.
- Intellectual Property Rights protection measures (patents, design rights, database rights, plant varieties, etc – include references and details);
- The concept was published in the public WINNER Deliverable and was submitted as a paper publication to the conference KKRRiT 2008 (Polish).

- Any commercial contacts already taken, demonstrations given to potential licensees and/or investors and any comments received (market requirements, potential etc.);
  None

- Investigation of the performance of various scheduling algorithms in both MIMO and SISO microcellular systems
  - Result description
  - We have evaluated the performance of a microcellular system in the Metropolitan Area when using various scheduling algorithms by the means of system simulation. 9 scheduling methods have been investigated to find the best solution for the WINNER system.
  - Partner(s) involved in the exploitation, role and activities
  - PUT
  - Possible market applications or how they might be used in further research
  - Further additional research and development work, including need for further collaboration and who they may be;
  - Research on the the influence of scheduling on system performance when interference cancellation algorithm is employed.
  - Intellectual Property Rights protection measures (patents, design rights, database rights, plant varieties, etc – include references and details);
  - The concept was published in the public WINNER Deliverable.

- Any commercial contacts already taken, demonstrations given to potential licensees and/or investors and any comments received (market requirements, potential etc.);
  None

3. MI-ACM algorithm optimisation with RCP-BLDPC codes (A. Piątyszek)

Results description: This topic includes optimisation aspects of *modulation and coding schemes* (MCS) used in one of the WINNER adaptation strategies, namely frequency-adaptive transmission, taking into account certain design constraints (signalling overhead, adaptation algorithm properties, etc.). The analysis and evaluation through intensive computer simulations assume the use of *mutual information-based adaptive coding and modulation* (MI-ACM a.k.a. Stiglmayr's) algorithm with *rate-compatible punctured block-circulant low-density parity-check* (RCP-BLDPC) codes. The output of this work is an optimised set of MCS, which is a part of the final WINNER reference design.

Possible market applications: The concept is an adequate technique for link level adaptation scheme in mobile radio systems

State of development: Simulation results available and published in public deliverables and submitted to a conference.

Publication:
A. Piątyszek, "Fine Tuning of MI-ACM Algorithm in LDPC Coded OFDM Transmission", submitted to *17th ICT Mobile and Wireless Communications Summit 2008*, Stockholm, Sweden, June 2008

4. Cooperative relaying in WINNER local area scenario

The performance of cooperative relaying in an indoor environment of an office type was evaluated with respect to conventional relaying and direct transmission. Due to a specific characteristic of this scenario, where numerous walls exist over the whole area, it was necessary to find an optimum deployment of the radio access points, i.e. the base station and the relay nodes. To this end a number of different positioning schemes were analysed by means of simulation and the conclusions regarding a more relevant approach to radio access point deployment were drawn.

Relevant publications:

- Michał Wódczak, "Extended REACT - Routing information Enhanced Algorithm for Cooperative Transmission," 16th IST Mobile and Wireless Communications Summit, 2007, 1-5 June 2007
- Klaus Doppler, Afif Osseiran, Michał Wódczak, Peter Rost, „On the Integration of Cooperative Relaying into the WINNER System Concept," 16th IST Mobile and Wireless Communications Summit, 2007, 1-5 lipiec 2007
- Michał Wódczak, "Cooperative relaying in an indoor environment," submitted to ICT Mobile Summit 2008
- Klaus Doppler, Simone Redana, Michał Wódczak, Peter Rost, " In-Band Relays for Next Generation Communication Systems," submitted to JSAC

5. Throughput maximization in Manhattan scenario

The idea and results of the throughput maximization oriented approach to interference management were presented. The research was based on the Manhattan scenario deployment concept presented in and the achieved results proved that the performance of this system can be further optimised with the aid of the proposed adaptation strategy. It was shown that while the deployment scenario kept the interference at minimum it was still possible to maximize the overall system throughput by proper service time assignment.

Relevant Publications:

- M. Głąbowski, M. Wódczak, "On throughput maximization oriented approach to buffer memory management in context of the relay-based Manhattan-type deployment concept," *IST Mobile and Wireless Communications Summit*, June 2006.

University of Surrey

Our exploitation results are mainly for research and teaching purposes and also for Hi-Tech journal and conference publications. UniS have and will use WINNER results in multiple ways, part of the findings have and will flow into the syllabuses and thus directly into the teaching of communication engineering degrees at undergraduate and postgraduate MSc courses(examples include the advanced coding and modulation techniques and radio resource management mechanisms, spectrum sharing).

The produced knowledge from results 1 to 3 has been and is currently being published in scientific journals, presented at conferences and workshops. Concerning the 4 result, development of SEAMCAT propagation module and supporting documentation and verifications are submitted for the usage of European Radiocommunictaions Office (ERO) SEAMCAT activities. Also these SEAMACT modules are used in the evaluation study of spectrum sharing between WINNER and FSS systems for the presentation and reporting in ITU preparation activities for WRC 2007 Conference.

Participating in WINNER enabled UNIS to remain competitive in new FP7 projects such as ROCKET, and WHERE as well as other related national project initiatives.

1. Pilot Optimization for Single WINNER Chunk

Optimum pilot placement has been investigated for chunk-based OFDMA uplink. The pilot optimization takes into account of both noise and interpolation error. The best fixed pilot placement has been proposed for various practical wireless environment; e.g., consideration of channel time-frequency selectivity and MIMO. This is the first proposal that consider interpolation error in pilot optimization.

- Possible market applications (sectors, type of use...) or how they might be used in further research (including expected timings)
  The proposed pilot pattern can offer optimized channel estimation performance for WINNER and WiMax systems.
- Stage of development (laboratory prototype, demonstrator, industrial product...)
  MATLAB-based simulator
- Intellectual property rights granted or published

2. Bit and Power Allocation for Relay Networks

We have proposed a class of novel bit and power allocation algorithms for the three-node cooperative relay network. The proposed algorithms can offer significant performance gain for the relay operating in various relaying protocols, e.g., ideal selecting detection-forward, outage selection detection-forward, and amplify-forward.

- Possible market applications (sectors, type of use...) or how they might be used in further research (including expected timings)

The proposed algorithm can be implemented in all OFDM-based networks, such as WiFi, WiMax.

- Stage of development (laboratory prototype, demonstrator, industrial product...)

MATLAB-based simulator

3. Short Term (ST) and Long Term (LT) Spectrum assignment in WINNER systems

Performance evaluation based on a system level simulation study based on WINNER spectrum functionalities is investigated. Scenarios covered are WINNER TDD mode considered within metropolitan area (MA) and local area (LA) deployment. In each scenario traffic demand distribution based on MA and LA deployment are deployed within RANs for ST spectrum assignment at cell level. In the case of ST assignment spectrum assignment between multiple WINNER RANs are investigated based on two different cell selection algorithms. Namely the cell pair selection for spectrum assignment is investigated based on "least satisfaction algorithm" and the "maximum flexibility algorithm". Apart from that the impact of traffic variance and correlation on the performance of ST assignment is also investigated.

- Possible market applications (sectors, type of use...) or how they might be used in further research (including expected timings)

The proposed spectrum assignment schemes can offer spectrum gain based on short term variations in RAN traffic in IMT-Advanced systems.

- Stage of development (laboratory prototype, demonstrator, industrial product...)

MATLAB-based simulator

4. SEAMCAT implementation of WINNER and ITU propagation models

SEAMCAT implementation of the following WINNER and ITU propagation models are developed and evaluated within WINNER Spectrum activities in UniS.

WINNER Propagation models

- *WINNER C1 LOS model*
- *WINNER C1 – NLOS model*
- *WINNER C2 NLOS model*
- *WINNER D1 LOS model*
- *WINNER D1 NLOS model*

Note C1 – SUBURBAN, C2 – URBAN, D1 – RURAL

ITU P 452 model with the following features

- *Line-of-sight propagation (including short-term effects) source*
- *Clutter loss calculation: source height-gain model*
- *Sub path diffraction model*

- Possible market applications (sectors, type of use...) or how they might be used in further research (including expected timings)
  - *These models are used in the evaluation study of spectrum sharing between WINNER and FSS systems for the presentation and reporting in ITU preparation activities for WRC 2007 Conference.*
  - *SEAMCAT propagation module and supporting documentation and verifications are submitted for the usage of European Radiocommunictaions Office (ERO) SEAMCAT activities.*
- Stage of development (laboratory prototype, demonstrator, industrial product...)

ITU and WINNER propagation module in SEAMCAT Java plug-in models and verification of the Java plug-in in MATLAB script

