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The WINNER project: Research for new Radio Interfaces for better Mobile Services

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Summary
Europe has initiated research activity to analyse and prepare the floor for mobile communication beyond 3G. Very recently, around the beginning of 2004, the European commission started together with the main partners in the relevant industry special projects to realize this plan.
The key objective of the WINNER (**W**ireless **W**orld **In**itiative **Ne**w **R**adio [1]) project is to develop an innovative concept in radio access in order to address high flexibility and scalability with respect to data rates and radio environments. 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.). This concept will be derived by a systematic investigation of advanced radio technologies with respect to predicted user requirements and challenging scenarios.
The project will contribute to the global research, regulatory and standardisation communities and processes.

Key words:
Mobile communication, radio, spectrum, WINNER,

I. INTRODUCTION

As the introduction of UMTS has started off in Europe, the question about the future development of this market arises more and more. With the experience from the past on a 10 years research and development phase for a complete new generation of mobile network, the European commission started together with the main partners in the relevant industry special projects to explore the requirements of future mobile networks. These projects – kicked off around the beginning of 2004 - are addressing several segments of the mobile business, and are led by the major players of the relevant industry. Whereas each of these projects has its specific focus in one of the areas of radio, network or services, a coordination action has been started in parallel to cover also "cross issues": the WWI (Wireless World Initiative), an industry founded consortium, offers a common platform to exchange views of the different projects and to contribute to issues related to the end-to-end perspective. All these activities are trimmed to provide a most efficient result of system concept and product guideline for the next generation of mobile network.

II. The WINNER vision

The vision of WINNER for mobile radio communications beyond the 3rd generation is of a ubiquitous radio system concept covering the full range of scenarios from short-range to wide-area which provides a significant improvement to current systems in terms of performance, efficiency, coverage and flexibility. The ubiquitous radio system concept will make efficient use of the radio spectrum to minimise the cost-per-bit by utilising the technologies researched within the WINNER project and combining them in an efficient way. It will be defined in

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such a way that it can be realised through cost competitive infrastructure and terminals.

The system will adapt to and be driven by user requirements and scenarios. To do so the WINNER project has already identified the two key scenarios, the short-range and the wide-area. The main characteristic of short-range scenario is its very high cell throughput up to 1 Gbps for indoor and outdoor connectivity at low mobility. In this domain, besides conventional single-cell single-hop network topology, (ad-hoc) multi-hop structures will evolve to improve coverage and system scalability. This picture will be complemented by the wide-area scenarios expected to provide urban, sub-urban and rural coverage. Expected peak data rates per user will be in the range of less than 1 Mbps up to 100 Mbps for medium to high, and in special cases very high, mobility. Figure-1~~Figure 1~~ summarises the different scenarios with respect to radio environment, mobile speed, deployment concepts and peak data rates.

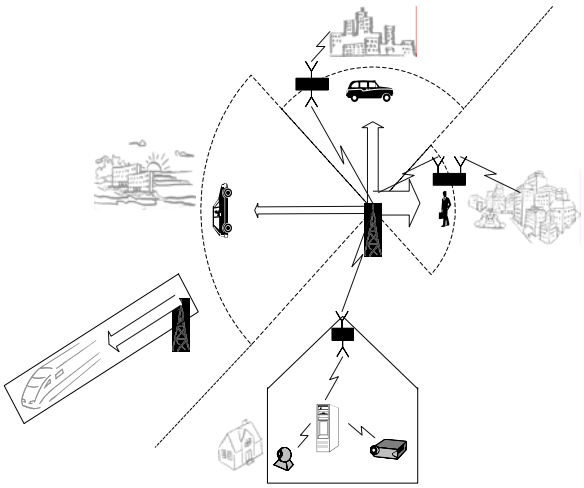


Figure-1: Ubiquitous Radio System Concept for multiple scenarios

The WINNER project is going to develop a radio concept able to fulfil the requirements from wide-area systems to hot spot and short-range scenarios rather than specialised radio interfaces for each different scenario. This will be done with respect to the user's requirements who will not consider the underlying technology but will certainly perceive the "look and feel" of the services, usefulness of contents, the quality of service cost and the user-friendly device (UI, compatibility, power consumption/on time, form factor). The envisioned ubiquitous radio system concept is characterised by

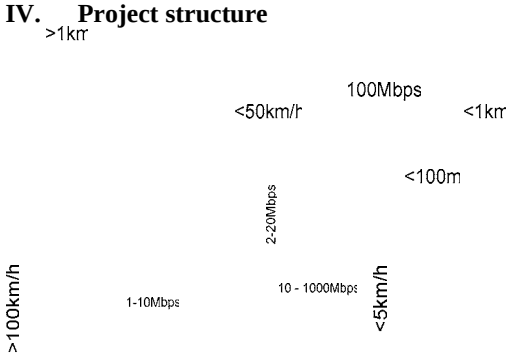
- transmission speed, latency, capacity and range appropriate to the user and service requirements covering, e.g., low data rates up to peak data rates of approximately 1 Gbps. The detailed requirements will be defined in accordance with the user requirements;
- a toolbox of system elements, such as modulation and coding schemes, multiple access scheme, network topology, which can be used in the most appropriate combination to efficiently support any given situation;
- a minimum number of variants for the new radio interface system elements, with high commonality, to exploit synergy in research and ease implementation and reconfigurability;
- flexible and cost efficient RAN deployment concepts;
- high spectral efficiency supported by employing efficient spectrum sharing and flexible spectrum use methods;
- support for precise positioning with the new radio interface;
- efficient point-to-multipoint data distribution;
- low transmission power in order to minimise power consumption of mobile terminals, to reduce interference to other systems and to ensure compliance with EMC and EMF regulations;
- suitable complexity, evaluated with respect to signal processing and power consumption;
- scalable functionality, complexity, implementation effort and performance for innovative wireless services;
- jointly optimised protocol layer within the radio system taking into account core network architecture including Internet Protocols;
- support for mobility management and seamless interworking with various wireless access technologies;
- the capability to be integrated into an overall network and framework including interworking and coexistence with legacy systems.

To get real-life experience, this ubiquitous radio system concept will be proved by trials of key technologies in future phases of the project. Results and concepts will be disseminated globally, e.g. by means of workshops.

III. WINNER consortium

The WINNER consortium comprises 15 manufactures, 5 operators, 13 universities, 4 R&D centres and a project administration partner. This consortium contains most of the major industrial players from the manufacturer and operator domain as well as highly respected research institutes and universities in European and overseas mobile communication and will mobilise the necessary critical mass.

IV. Project structure



The project is structured into the project management and 3 components which are subdivided into seven technical work packages (WP 1..7) along the following subjects.

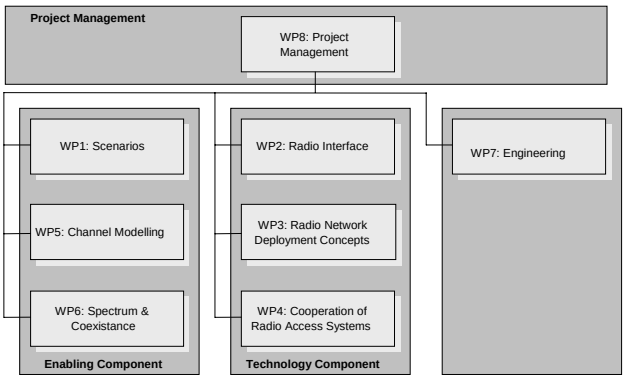


Figure 2: WINNER project structure

WP 1: User scenarios:

The first step in the scenario development approach that is being followed in the WINNER project is the definition of the user scenarios. This is based only on the new user requirements for the future without any reference to the technology. It is only what the user wants to do, where, when and why. The objective is a significant breakthrough in the user experience.

From the user scenarios, some grouping will lead to the usage scenarios, introducing the technology. The key scenario types “wide-area” and “short-range” will probably correspond in part to some of them. But different scenarios, for instance intermediate ones, will probably be defined as well. No general restriction is put on the number or the type of scenarios before the beginning of the project. The "wide-area" scenario group is characterised by wide-area coverage with high mobility and high data rates. The "short-range" scenario group can be described as a limited coverage, with low mobility and very high data rates.

These usage scenarios will be evaluated both in the technical and the economic domain. The performance requirements will be more specific on spectrum, channel propagation, single link throughput and network architecture.

For the ones that are technically realistic and economically promising, precise performance requirements will be derived. The other components of the WINNER project will develop and define the best technologies allowing each scenario. Among the terminals that could be used to allow some of the scenarios here are some examples: multifunction PDAs, integrated digital content recorders, head up displays, location aware devices, virtual pictures, multi device remote controls. Among the applications that would provide a real breakthrough in the user experience these are examples that could be part of some scenarios: location services, video school lessons, home appliance management, health monitoring and management.

WP2: Radio interface

The radio interface is one of the major components of the new ubiquitous radio system concept, which comprises leading-edge technologies for the physical layer, medium access, data link control and radio resource management. The future broadband radio interface should enable the provision of service opportunities to the user far exceeding those in present heterogeneous wireless systems with optimised and adequate QoS at any time, anywhere, in any situation. Variations in data rate of supported services need to be taken into account. Efficient support for low data rate per user is important, as this seems likely to continue to form a significant part of traffic. Furthermore, the asymmetric nature of traffic in the uplink and downlink should be considered when designing the future broadband radio interface.

Many individual elements of radio interfaces, such as modulation, coding, hybrid ARQ and antenna diversity, are well understood today. The highest potential of the future radio interface is expected to come from an efficient combination of the available elements. Therefore, the aim of this project is to achieve this by a close cooperation between the individual technology investigations.

The future radio interface, as part of a ubiquitous radio system concept, will be based on common radio interface technologies able to fulfil the requirements in a wide range of scenarios such as wide-area, hot spot and short-range. An intermediate step towards this goal is the investigation of potential key technologies in suitable scenarios, which is a major initial phase of the WINNER project. Those key technologies with high performance according to the assessment criteria will be selected and combined in an appropriate way to suitable radio interface concepts that form the elements of the ubiquitous radio system concept.

WP 3 Radio network deployment concepts

Future radio access network deployment concepts will take advantage of a reduced mutual interference resulting from coordination of the shared radio medium across base stations (BSs). Rather than being an admission control only, this coordination is expected to result in an improved overall system capacity under centralised or decentralised control. The coordination will comprise the domains time, frequency, space and code and will take the overall traffic load and its geographical distribution into account.

Broadband radio interface technologies with high multiplexing bit rates are characterised by a very limited transmission range and QoS characteristics unevenly

distributed over distance between terminal and BS. One of the most important factors for high data rate communication is the existence of sufficiently low signal attenuation. In today's cellular systems obstacles like buildings and hilly terrain, in general, introduce high path loss, which affects communication robustness and throughput adversely. An improvement of the path loss would be possible by using sophisticated antennas and/or setting up a high number of pico cellular BSs which will result in high deployment costs. A more cost efficient and innovative candidate solution is to trade the capacity of a BS against the range of the service area. Thereby, the capacity of a BS is partly utilised by a number of relay stations acting as wireless BS in some desirable configuration. The path between the original BS and its terminal is them segmented into consecutive links. This would also allow to communicate around or over any obscuring object. Compared to pico cellular BSs the relay stations do not need a wired network connection and this would reduce cost substantially. A relay station can be either fixed or mobile and serve to cover otherwise shadowed areas and to enlarge the limited coverage range of a BS. This solution appears very attractive taking into account that it is deemed unlikely that the high traffic capacity of a broadband BS will be used up by the user terminals roaming in its cell. The relaying concept applies to wide-area as well as to short-range systems.
New deployment concepts will be developed taking conventional single-hop concepts as well as relay based concept into account. The new radio interface technology will be scalable in terms of capacity and can be either homogeneous or heterogeneous on the different hops of a multi-hop link. To find an optimum solution applicable to different scenarios the conventional and relay based concepts will be combined into one common concept. Co-operative relaying will be investigated to exploit signal diversity gains resulting from relaying. To support all of these new deployment concepts WINNER will develop highly efficient multi-hop capable protocols.

1.1 WP 4 Cooperation of Radio Access Systems

Current deployed Radio Access Networks (RANs) support only one single Radio Access Technology (RAT), due in their conception cooperation with other RANs was not a primary issue. Existing RANs can at this moment be modified or updated for cooperation only at a high level layers of the mobile network, which translates into routing (and other functions) taking place at the Radio Network Controllers (RNC), or RAN equivalent network element, and above.
The main innovation that the WINNER project brings to this field lies in the fact that cooperation mechanisms will be proposed and developed not only at the high-level layers, but at the radio segment level of new RANs. They will become built-in features of the WINNER interfaces, and will be implemented at network elements comparable to Node B's in current systems (or equivalent) and below. Moreover, even mobile terminals will comprise respective features that support the process of cooperation.
Concerning their activation, the cooperation mechanisms will be capable of being activated from the radio access level. Additionally, they will also be activated by other entities of the overall mobile network; for example by a user specified application. In the scope of WINNER most relevant Radio Resource Management (RRM) cooperation mechanisms will be: Mobility management (handover and location based RRM), Joint RRM (admission control and scheduling/load balance) and Policy based management.
In the WINNER project, different RRM cooperation schemes will be proposed and analysed; Combined RRM , Concurrent RRM and Layered / Cross Layered RRM.
The WINNER cooperation scheme and associated mechanisms will enhance the functionality, performance, flexibility and radio coverage with respect to current isolated RANs.

WP5 Channel Modelling

It has been widely understood that the radio propagation environment has a significant impact on the performance of wireless communication systems. The impact on future broadband systems is even more important. Thus, radio channel models and simulations have to be more accurate than in earlier systems. Research organizations have studied the propagation phenomena for several decades. Various models for path loss, large-scale and small-scale fading have been proposed. They are more or less accurate models based on measurements and theoretical analysys of the environment and mostly valid for current wireless systems and applications, in particular frequency ranges. Nevertheless, they are not adequate for future B3G systems.
Modelling of wideband MIMO channel is the key challenge in propagation research of future wireless systems. Multidimensional spatial channel models include not only path magnitude, phase, delay and Doppler information, but also direction of departure and direction of arrival as well as polarisation. From them, it is also possible to compose stochastic and correlative channel models based on the spatial information about the channel to simplify the model.
In this work package, a set of multidimensional channel models will be developed. Channel models are created based on channel measurements and existing data, putting effort on keeping the modelling as simple as possible without loosing reliability and accuracy. Channel models are formed for other work packages, where common models are needed for reliable evaluation and comparison of transmitter and receiver algorithms. Different models

have to be defined for each frequency band. Channel models will be independent of modulation and coding schemes, and they should also be independent of antenna geometry.

WP6 Spectrum and coexistence

In the international domain ITU-R approved the Recommendation ITU-R M.1645 "Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000“ in June 2003 as a basis of the future activities [2]. This recommendation is also important in the preparation for the forthcoming World Radiocommunication Conference WRC-2007.

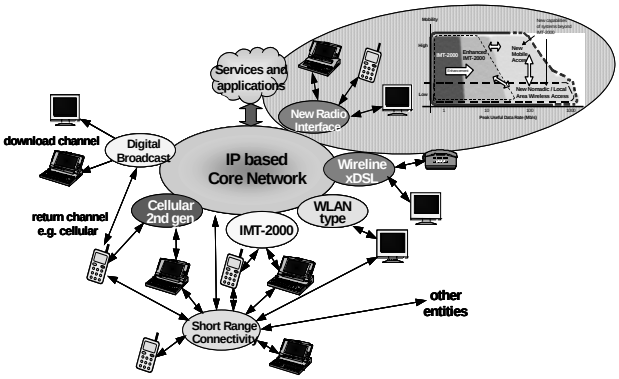


Figure -3: ITU-R Vision for Systems Beyond 3G

The ITU-R vision for systems beyond 3G comprises two major paths (**Fehler! Verweisquelle konnte nicht gefunden werden.**). On one hand existing and evolving access systems will be integrated on a packet-based platform to enable cooperation and interworking in the sense "optimally connected anywhere, anytime". On the other hand the radio access system for new mobile access and new nomadic/local area wireless access will be developed to provide significantly improved performance compared to today's systems. The focus of the WINNER project is the development of this radio access system taking into account interworking with other systems.

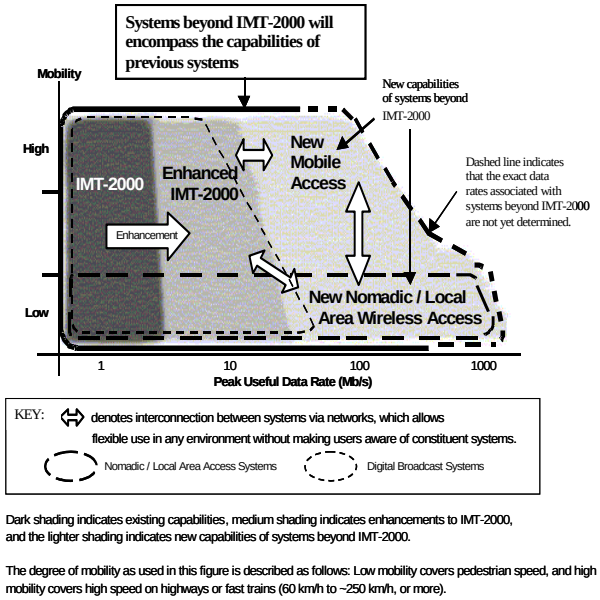


Figure -4: Illustration of capabilities of IMT-2000 and systems beyond IMT-2000. Source: [2]

In particular, the envisioned capabilities of the new components of future mobile and wireless communication systems were agreed with the following peak aggregate user data rates (Figure 2 [2]): Up to approximately

- 1 Gbps for new nomadic / local area
- 100 Mbps for the new mobile wireless access.

The work on spectrum and coexistence will comprise of the following parts:
A methodology will be developed for estimating the spectrum requirements for “further developments of IMT-2000 and systems beyond IMT-2000”, suitable for the ITU-R in it’s preparations towards the WRC-2007. The current work in ITU and relevant earlier research results will be taken into account. The developed methodology will be used to prepare an estimation of the spectrum requirements for the systems beyond IMT-2000. This requires that available information and estimations of future services, their characteristics and usage and knowledge about future technologies such as those evolving from the current technologies and the technical characteristics of the system concept being developed in the WINNER project is applied. The spectrum requirements for WINNER system concept will also be determined.
Sharing and coexistence issues will be investigated to ensure that they are properly taken into account in the WINNER system concept in order to improve the overall spectrum efficiency and to make the spectrum

identification easier. Flexible spectrum use methods to be utilised in the WINNER system concept are studied and determined in order to improve the overall spectrum efficiency and to simplify the network implementation under varying conditions. Capability for flexible spectrum use may also help in the spectrum identification process and in making sufficient bands available.
The relevant results will be contributed to the international regulatory process in due time for the preparations for the WRC-2007. This means that contributions will be submitted to the CEPT and to the ITU-R.

WP7 system engineering

The system engineering or the integrative component is the "driving force" that generates the common understanding of the *beyond 3G ubiquitous radio system concept* within the whole consortium. This will be the key for getting a consistent and harmonised system approach encompassing all other work packages. It will receive scenarios, radio access technologies and radio network topologies, spectrum and coexistence issues, identified in other work packages, as an input. Based on these inputs, it will identify a system concept, envisaged as an optimised trade off between usage scenarios and system performance and network infrastructure and terminal complexity.
Contemporary activities usually concentrate on one or few individual aspects of mobile communications, failing to account for a "big picture". Taking into account a scenario driven approach, technologies will be investigated in the context of their respective usage scenarios and network topologies allowing the exploitation of potential synergies, which will be key to the creation of a *ubiquitous radio system concept*.
System Engineering will define the system requirements mainly based on input of the Scenario work package and will define a set of technical assessment criteria. These will be used by the technology work packages to assess systematically potential key technologies. Based on this, the key task of System Engineering will be to define a harmonised ubiquitous radio system concept that will fulfil the user requirements and scenarios and to drive the WINNER project into this technical direction. After having an initial system concept, this will be fed back to the technology work packages to derive performance and complexity of the key components. System Engineering will provide the estimated performance and complexity figures for the initial system concept.
System Engineering will encompass all other WINNER work packages with a technical coordination to ensure a consistent approach within the whole project. This includes the maintenance of a common technical assumptions register. Common design methodologies will be employed across the WINNER project to ensure the compilation of a harmonised ubiquitous radio system concept.

V. WINNER as part of the WWI

Wireless World Initiative (WWI) [3] – a major joint effort from industry, academia and government – is investing several hundred million Euros in research to lay the foundations for the long-term future of global wireless communications. This endeavour contains a series of FP6 (Framework Program 6, set-up and coordinated by European Commisision) IST (Information Society Technologies) Integrated Projects – WINNER being one of them – and a Coordination Action. They are planned to run over the six-year period towards 2010. The majority of the global players in wireless communications from the manufacturers, operators and academic domain as well as SME's participate in this initiative.

VI. Conclusions

In summary, WINNER is aiming to a comprehensive solution of future-proof radio-technologies for mobile services showing up the next decade. The overall goal is to make communication more easy and convenient for the end user and therefore generate additional business opportunities for the operators and vendors.

VII. Acknowledgements

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