The Wireless World Initiative: A Framework for Research on Systems Beyond 3G

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ABSTRACT

The Wireless World Initiative (WWI), a major joint effort from industry, academia and government, has launched its research activities to lay foundations for the long-term future of global wireless communications in January 2004. WWI starts with a series of large Integrated Projects in the European Commission's 6th Framework Programme (FP6) with the overall objective to define mobile systems and functions that provide the users with the best possible user experience while maintaining the lowest possible cost of purchase, use and ownership of the systems.

For WWI, the driving force is user-centricity. In addition to technical viability, future wireless communication systems providing seamless access to electronic services, applications and information anywhere and anytime have to give added value to the users, including all stakeholders from individuals to service providers. This user-centricity means that the users' needs, expectations and requirements must be considered and supported by all system levels from access methods and networks to service platforms and applications.

I. INTRODUCTION

The Wireless World Initiative [1] was established in 2002 to prepare several coordinated FP6 proposals to cover a broad range of research topics for the development of wireless communication technologies for systems beyond 3G, including services and applications, platforms, networking, new radio interfaces and end-to-end reconfigurability. The responsible coordinators of the preparation have been Alcatel, Ericsson, Motorola, Nokia and Siemens.

The Initiative is made up of more than 100 partners. The majority of the global players in wireless communications from the manufacturers, operators, academic and national regulatory agencies domain as well as SME's participate in this initiative. The participants represent almost every European Union member state, as well as Czech Republic, Poland, Hungary Norway, Switzerland, Israel, China, Japan, Singapore, Canada and Australia.

The Integrated Projects within WWI are structured according to a layered model with radio, networking, platforms and application and reconfigurability, providing a complete set of functionalities. These projects are self-contained in each area of research, but complementing each other. To ensure overall consistency of the expected results within this Initiative, Elisa, France Telecom, DoCoMo, Telefonica and Vodafone on behalf of the participating operators are working together with the project coordinators in orchestrating a complete system view and emphasize research issues that are common to all projects such as system architecture, user requirements, quality of service, security, resilience, reconfigurability, operability and validation.

A major objective beyond research is to enable a consensus building process already in the research phase to ease future standardisation. The challenge is to provide technically and commercially viable solutions with a strong user-centric approach.

The collective research efforts amount to several hundreds of person-years yearly and are planned for six years with three phases, each lasting two years. Phase one will concentrate on exploratory research, identifying key technologies and requirements. Phase two will deal with technology development and detailed systems definitions, and phase three with systems synthesis and demonstrations. An essential part of the activity will be dissemination of results and contribution to standards and regulatory bodies. The group of projects reflects the largest

European collaborative research effort to date in the domain of wireless communications.

This paper is organised as follows. Section II describes the WWI in detail and Section III characterises the identified individual WWI Integrated Projects within FP6. Section IV covers cross-research topics, so called Cross Issues, within WWI. Section V is a short conclusion.

II. WWI: THE WIRELESS WORLD INITIATIVE

WWI Motivation

New market opportunities will open up, as wireless technology becomes as pervasive as microprocessors are today, changing the way we live and work. Elementary location sensing is becoming universally available for mobile users, and some devices already carry sensors to scan the surroundings of mobile users, or to sense the physical situation of the users themselves. The development of new high capability radio interfaces will enable a multitude of new services and applications. The personal space will be interconnected automatically and transparently with the surrounding environment through the wireless world using sensors, actuators, multi-modal interfaces and new management and control systems. However, a true understanding of the users context and the provision of suitably adapted services, applications and communications systems have yet to be explored.

The research and development, integration and introduction of such new concepts, technologies and systems provide a major challenge to our whole industry. We must address these challenges and capitalise on these opportunities.

International competition drives the need, in Europe, for critical mass and large scale R&D. The R&D has to thoroughly investigate the full range of issues, and by focusing European resources to provide critical mass, WWI will drive a paradigm shift and the development of economically viable wireless solutions for the world at the beginning of this new century.

The Vision of the Wireless World

Work in the Wireless World Research Forum (WWRF) has laid the foundation for the vision of the Wireless World (see e.g. [6]). From the user's perspective, the notion of "ambient intelligence" provides a vision of natural and enjoyable interactions with applications and services. The user will be put at the centre of attention. All his/her senses will be supported through contextual services and applications. The complexity within these systems is best hidden from the user by consistent, easy to handle, user interfaces and self-learning systems. Many services can be provided without constant user attention, if he or she so wishes. Hence, we can make people's everyday life easier and contribute to wider acceptance and faster uptake of new wireless services.

The user will experience the benefits of more information bandwidth. From the technical perspective, different access systems, including new radio interfaces will be integrated on an IP based platform with seamless interworking. The different interoperable systems will be optimised for particular applications and environments and allow the scalable deployment of system capacity according to the needs of operators and end users. Such an approach will support the societal and economic challenges of building the knowledge society.

A common vision of the participants is inherent in the Wireless World Initiative:

- Easy and seamless access to electronic services, applications and information anywhere and anytime
- End-to-end communication based on an open architecture supporting fast service and content creation boosting end-user acceptance and trust.

Strategic Objectives

The Wireless World Initiative has strategic objectives within two major thrusts:

1. To provide **rich**, high performance communication systems[1] providing ubiquitous access to many new services, professional, personal and multi-media, and
2. To provide **affordable** wireless systems that will enable four billion people and forty billion devices to communicate by 2020. Achieving this will allow many more people to participate in the economic process, thus considerably reducing inequality in the world.

Following both orthogonal paths will lead to ambient communications in the Wireless World.

Technical Objectives

The major technical objectives are:

- To develop systems, from the user perspective, that work seamlessly in different environments: personal, home, vehicular, office, etc.
- To develop open, shared and horizontal software architectures, platforms and tools to enable the widespread development of applications for the ambient Wireless World
- To develop ambient networks then can be easily composed, and utilised in a seamless manner in a wide variety of environments and business contexts
- To develop a ubiquitous radio system concept covering the full range of scenarios from short-range to wide-area and providing wireless access for a wide range of applications and services by an adaptive radio interface
- To develop advanced techniques for delivering mobility, service continuity, end-to-end security and QoS
- To define the evolution paths to the operational Wireless World, showing that the innovations can be introduced and used in a real environment.

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[1] The term "communication system" is used in its widest sense. It includes all people and machines that are able to communicate.

Structure of the Initiative

The structure of the initiative is illustrated in Figure 1 below.

WWI is open for successful projects of Call 2 and following Calls. Currently, Mobilife is under negotiation and will join WWI as soon as it starts.
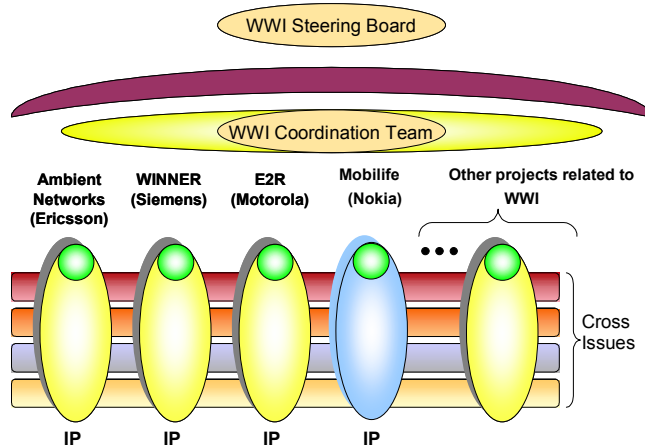

Figure 1: Current Structure of WWI

Timing of the Wireless World Initiative

To achieve the WWI common objectives, it is important to have a commonly agreed overall timetable.

The initiative has 3 phases, lasting 2 years each. The phases are:

Phase I: Technology Exploration and Assessment

During this phase new concepts and technologies will be explored and assessed. Generic user requirements will be identified. **Results** include (i) a set of technologies identified that is compatible and that is capable of fulfilling the overall objectives of the initiative, (ii) first system concepts, improved road maps and evolution scenarios, and (iii) definition of the flexibilities required fulfilling changing user needs.

Phase II: Technology Development and Specification

In this phase collaborative work will result in simulators and first prototypes showing technological feasibility. Specifications are prepared for use in standardisation bodies and forums. **Results** include simulators, prototypes, standards submissions.

Phase III: Validation and Demonstration

In this phase, the concepts developed in the different integrated projects will be verified in larger scale tests, showing system feasibility. Limited verification in collaboration with actual users to validate system flexibilities and concepts in reality is planned. **Results** include (i) overall agreed system concepts and (ii) several demonstrators that show significant aspects of the Wireless World.

WWI will organise international workshops for dissemination and discussion of results in all phases.
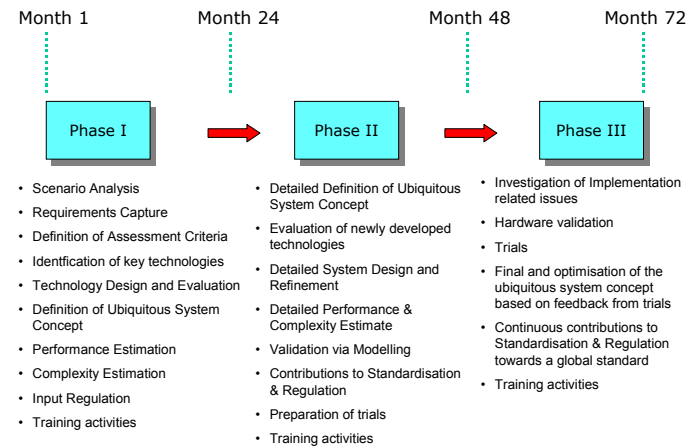
Figure 2 below illustrates the three phases:

Figure 2: The 3 Phases of the Wireless World Initiative

III.   PROJECTS IN THE WWI

The current WWI Projects are presented in the following paragraphs. This represents the start-up set of the initiative. The broad set of objectives will make it necessary to extend this set. WWI is currently in discussions with other projects and a coordination action to be included or related to it.

A   Ambient Networks

The Ambient Networks project (see [2]) will create the network solutions for mobile and wireless systems beyond 3G. It will enable **scalable and affordable** wireless networking while providing rich and easy to use communication services for all. It is geared towards **increasing competition and cooperation** in an environment populated by a multitude of user devices, wireless technologies, network operators and business actors.

Ambient Networks offers a fundamentally new vision based on the **dynamic composition of networks** to avoid adding to the growing patchwork of extensions to existing architectures. This will provide access to any network, including mobile personal networks, through instant establishment of inter-network agreements.

The project adopts the design paradigm of **horizontally structured mobile systems** that offer common control functions to a wide range of different applications and air interface technologies. Such a radical change requires the definition of new interfaces and a multitude of standards in key areas of future media- and context-aware, multi-domain mobile networks.

B   End-to-End Reconfigurability

The End-to-End Reconfigurability (E²R) project (see [3]) aims at bringing the full benefits of the **valuable diversity within the Radio Eco-Space**, composed of a wide range

of systems such as Cellular, Wireless Local Area and Broadcast. The key objective of the E^{2}R project is to **devise, develop and trial architectural design of reconfigurable devices and supporting system functions** to offer an expanded set of operational choices to the users, applications and service providers, operators, regulators in the context of heterogeneous mobile radio systems.

Innovative research, development and proof of concept will be sought in an end-to-end aspect, stretching from user device all the way up to Internet protocol, and services, and in reconfigurability support, intrinsic functionalities such as management and control, download support, spectrum management, regulatory framework and business models.

E²R will thus contribute to the **realisation of the Ambient Space** through which a modern society interacts and communicates with key capabilities of the Radio Eco-System and finally actively influence European industrial and economic competitiveness.

C *MobiLife*

People are used to being able to contact anyone, anywhere, at anytime. However, the challenge of enabling mass-market-scale ubiquitous services and applications remains. The **strategic goal** of the MobiLife project (see [4]) is to bring advances in mobile applications and services within the reach of users in their everyday life by innovating and deploying new applications and services based on the evolving capabilities of 3G systems and beyond.

Future environments give new possibilities, but also new challenges due to increasing heterogeneity of technological environments, user needs and expectations. The **research challenge** of MobiLife is to address the multi-dimensional diversity in end-user devices, available networks, interaction modes, applications, and services. To deal with this complexity and to reach its strategic goal, the MobiLife project has the following **objectives**:

1. Research and develop new applications and services frameworks, and innovative new applications and services
2. Research and develop new enabling technologies for applications and services with the focus on personalisation, privacy & trust, context-awareness and semantic interoperability
3. Integrate and exploit existing and new service components, service enablers and technologies for comprehensive user and industry evaluation
4. Explore and remove hurdles between service development and deployment
5. Demonstrate and disseminate the results

The user-centered research is the motor for the work, around which the technical application development will be undertaken. By taking into account and iterating the research work according to the results of user studies, evaluations and field studies the result will iteratively be refined.

MobiLife will start in early fall 2004.

D *WINNER*

The Winner Project ("Wireless World Initiative New Radio", see [5]) will develop a new radio interface with significantly improved capabilities that enables a new mobile user experience and makes the international visions on mobile communications reality. The ubiquitous radio system concept will cover the full range of scenarios from short-range to wide-area and provide significant improvement compared to current systems in terms of performance, efficiency, coverage and flexibility.

The concept is based on a common radio interface technology that will adapt to user needs and scenarios by utilizing advanced and flexible network topologies, physical layer technologies and frequency sharing methods. The radio system will make efficient use of the radio spectrum to minimize the cost-per-bit by combining the enabling technologies researched in an efficient way to realize a future system through cost competitive infrastructure and terminals.

The WINNER project has created already in this early research phase a tight network of cooperation to support the international harmonization and consensus building process. For that purpose relations to other international bodies are currently being established, especially to ease future standardization.

The WINNER Project will stimulate the next step of industrial revolution towards a more convenient and user-oriented mobile communication around the world.

IV. THE WWI CROSS ISSUES – A NOVEL APPROACH FOR INTER-PROJECT RESEARCH

A prerequisite to generating additional value from a group of projects is the exchange of information and joint development of key topics. The Integrated Projects are structured according to a layered model with radio, networking, platforms and application and reconfigurability, providing a complete set of functionalities. These projects are self-contained in each area of research, but complement each other. Therefore, they needed a mechanism to allow close inter-project collaboration on common topics. The Cross Issues are the special inter-project coordination instruments to which all WWI projects have committed. The mechanism is outlined below and the individual Cross Issues are then described in more detail to allow a better understanding of the approach.

A *The Cross Issue Mechanism*

Cross Issues are coordination efforts for issues impacting on more than one project. The Cross Issues research ensures that certain common system characteristics, requirements and assumptions are viewed consistently in all WWI projects.

The Cross Issues related work is carried out in the WWI projects, via activities and manpower in their existing Workpackages. Each Cross Issue has a home project, which takes responsibility for organising work on the Cross Issue for which they are responsible. In each of the

other Integrated Projects, there are specific contact persons for each Cross Issue.

The persons involved in the Cross Issue will form a virtual team. Workshops will be organized as needed to reach consensus on issues may be faced. The agreements reached on the issues will be documented and communicated to all relevant parties.

Key objectives of the Cross Issues are to:

- facilitate information exchange between the projects in the mobile area and with other Initiatives,
- synchronise selected research work,
- create the system-level requirements, concepts and architectural frameworks,
- manage the information created (i.e. know-how)

The Cross Issues identified so far, including their leaders and home project are shown in Table 1:

User Requirements	Motorola	MobiLife
Operability	Elisa	MobiLife
E2e Quality of Service	DoCoMo	AN
Security and Trust	Vodafone	AN
Resilience	Telefonica	E2R
Validation	France Telecom	WINNER
Reconfigurability	Motorola	E2R
System Architecture	Nokia	MobiLife

Table 1: Active WWI Cross Issues

It is anticipated that new Cross Issues will be added to the WWI, allowing the flexibility to investigate issues as they emerge. Some of the Cross Issues are explained in more detail here to better visualise the mechanisms and type of results which are aimed to be achieved.

B   Specific Cross Issues
User Requirements
The future promises technology which will enable a staggering number of possibilities, and so the question for researchers is no longer how to advance the capability of technology along traditional technology axes, but how technology can support and enrich the lives of people through delivering valuable services and applications. The key, then, to success is to ensure that they have the appropriate links to scientific user research. Creating these linkages between the WWI IPs is the purpose of the user requirements cross issue.   The overall objectives are to achieve:

- The consolidation of system-level user requirements for B3G systems and services and their dissemination to the related integrated projects
- The consolidation of technology specific user requirements for B3G systems and services and their dissemination to the related integrated projects
- The consolidation of technology and system evaluations in the context of user based requirements
- The appropriate dissemination of user centred techniques and methodologies to ensure a user centred research process to ensure a scientific approach to user requirements

System Architecture
The System Architecture Cross Issue has been set up to create, evaluate and maintain a system-level architecture for the new Wireless World, where all building blocks (subsystems) shall be consistent with each other and interoperable at all stages of the system evolution. It will define the requirements for architecture-related issues that are meaningful on an end-to-end basis, and coordinate the work in each WWI Integrated Project where the dependencies and interfaces between the different Building Blocks of the System need to be agreed jointly. The migration paths from the existing 2G/3G systems towards the B3G target system will be a special concern of this Cross Issue.

End-to-end QoS
QoS (Quality of Service) is commonly considered as one of the key issues in future communication networks. In general, QoS is a very broad term and may cover all the perceived QoS by the user, which includes not just bandwidth, delay, etc but also service availability, service disruptions, and user assistance in case of problems.

In general, Quality of Service (QoS) includes QoS that is directly perceived by the customers or transport QoS, which is characterized by network parameters like bandwidth, delay, etc. Usually the different QoS parameters on different layers could not directly be mapped onto each other. In this way, solutions are required for an integrated QoS handling including network aspects as well as service and business aspects. This is especially challenging in heterogeneous environments where the information exchange crosses network and domain borders like in next generation mobile systems.

Due to its importance and manyfoldness, the issue of QoS will be researched in all projects of the WWI. This cross issue character is satisfied by a number of interfaces and interdependencies between the activities within the projects.

The technical approach for Cross Issue QoS is based on agreements between the projects regarding requirements and mutual interfaces. This establishes the requirement and capability exchange between the projects, as well as the agreement needed in order to achieve an overall solution. Another issue regarding QoS is reconfigurability. Reconfigurability mechanisms can be use to improve QOs, but also the software download for reconfiguration requires QoS. Hence an overall system approach to QoS has to consider both of these dependencies. The main coordination task for the overall solution shall be taken by the Ambient Network project.

Operability
One of the major technical objectives of the WWI is to define the evolution paths to the operational Wireless World, showing that the innovations can be introduced and used in a real environment. The future ambient world will be built on a heterogenous system including several new network technologies, service and application platforms

and enablers and terminals. Due to its ubiquitous nature and the emergence of new players, business models and applications, there is a risk of the increase of the overall complexity of the operability related functions.

This challenge is faced by the Operability Cross Issue work aiming to create the requirements for the cost-effective deployment and management of the new services and systems. The work will also cover the operability related functions and create the overall operability architecture to be incorporated into the system-level architecture. Requirements that are specific to particular building blocks will be derived and taken into account in the Integrated Projects.

Security and Trust

Issues of trust and security are critical to the development of technically and commercially successful systems. Individual components, subsystems and databases all need to be protected, as do end-to-end or peer-to-peer services and applications.

Within WWI, aspects of security, privacy and trust are addressed in all the projects. It is important that there is not a mismatch between requirement and implementation, or between layers of the overall architecture.

This Cross Issue coordinates security and trust issues for the family of WWI projects, and also communicates with security and trust related projects outside WWI. Deployment issues will be specifically studied in later project phases, but for the present the objectives are to:

- Develop an outline trust model that is applicable across WWI projects
- Provide a high-level view of the complete WWI security and privacy architecture, identifying a common set of security and privacy requirements.
- Identify gaps and inconsistencies regarding the way security and privacy is dealt with across WWI
- Identify commonalities between the solutions proposed by the individual IPs
- Identify and define the required security interfaces between WWI IPs
- Enable communication on security issues between WWI IPs and with the outside world

C   Other Cross Issues

The Cross Issue "**Resilience**" creates user and system requirements for the system availability (the views of all players in the Value Chain to be considered), and translates them to the technical requirements for all building blocks to be taken into account in the Integrated Projects.

The Cross Issue "**Validation**" defines the system-level (architectures, functions) validation process and targets for the WWI, defines the methods and needed infrastructures needed in each cross-IP validation activity, and the schedule and responsibilities. The actual implementation of the system-level -validation will take place via detailed modelling in Phase 2, and system validation during the Phase 3 of the WWI.

The Cross Issue "**Reconfigurability**" will facilitate technical discussions and information exchange on

Reconfigurability within the WWI. It will create White Papers on Reconfigurability topics, such as scenarios, requirements, architecture and reference model, management and control.

V.   CONCLUSIONS

Wireless World Initiative (WWI) is a major joint research effort containing a series of large Integrated Projects in the European Commission's 6th Framework Programme (FP6) Information Society Technology. The Integrated Projects are structured according to a layered model with radio, networking, platforms and application and reconfigurability, providing a complete set of functionalities.

A major objective beyond research is to enable a consensus building process already in the research phase to ease future standardisation. The challenge is to provide technically and commercially viable solutions with a strong user-centric approach.

ACKNOWLEDGEMENTS

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