Self Configurable Air Interface

The project aims at studying and evaluating the performance of a novel generalised air interface capable of self-reconfiguring in order to satisfy global network Quality of Service requirements, based on channel and traffic knowledge.

At A Glance: *SURFACE*

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Duration: *01/2006 – 12/2008*

Total Cost: *€2,84m*

EC Contribution: *€1,7m*

Main Objectives:

SURFACE aims at studying and evaluating the performance of a novel generalised air interface capable of self-reconfiguring in order to satisfy global network Quality of Service requirements, based on channel and traffic knowledge. It considers Multiple Input Multiple Output (MIMO) technologies as an option and develops a general framework that includes as specific cases standardised access technologies like DS-CDMA (Direct Sequence Code Division Multiple Access), MC-CDMA (Multi-Carrier Code Division Multiple Access) and OFDM (Orthogonal Frequency Division Multiplexing) to develop a physical layer, completely reconfigurable to match the global instantaneous, but imperfect, channel state, mobility, traffic information and terminal capabilities. The project is organised into System Requirements, Research, Technological Development and Dissemination and Assessment activities and its expected duration is 36 months.

The System Requirement objectives include the specification of global QoS requirements of the services to be supported and the definition of the strategy for channel state information estimation and prediction. The Research objectives entail optimisation of the air-interface in single-user, multi-user and multi-cellular environments.

The Technological Development activities involve the development of appropriate transmission and reception architectures and will be evaluated by means of link and system level simulations. An Air-Interface emulator will be developed showing the impact of the optimized physical layer on the end-to-end QoS. These activities will also identify a roadmap for utilisation of the SURFACE concept.

The Dissemination and Internal Assessment activities will propagate project results in conferences, workshops and by a constant updating of the project web page. Finally, these activities incorporate internal verification instruments in order to guarantee project progress towards envisioned objectives.

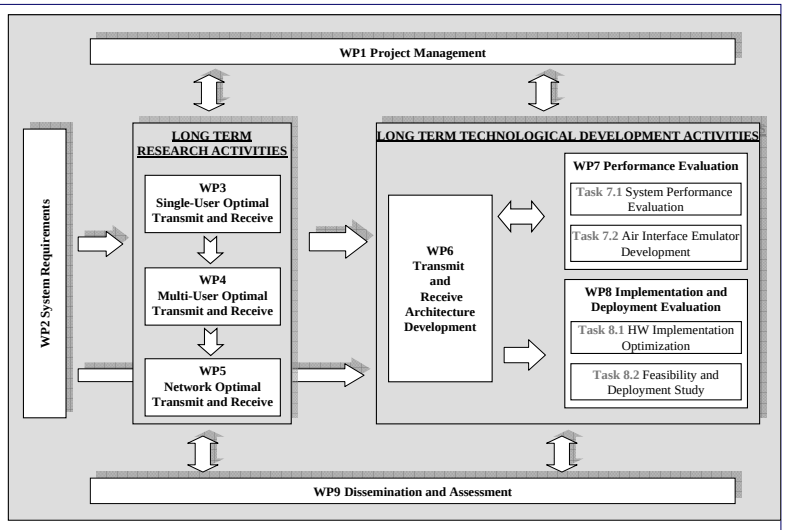
Technical Approach

Activities have been classified into Management, Research, Technological Development, Dissemination and Assessment Activities. Additionally WP2 is devoted to System Requirements that aims at studying the common tools required by the Research WPs and the Technological ones.

The Research Activities starts considering the single-user scenario in WP3, which concentrates on the best transmission schemes for a single-user system, under given service requirements and channel state information. The focus is on MIMO technologies, even though the analysis does not preclude the possibility of having some single antenna transceivers. One of the specific tasks of WP3 is to quantify the performance improvement achievable by exploiting the availability of state information at the transmit side. Building on the results of WP3, the extension to the multi-user configuration is considered in detail in WP4, under multi-user QoS requirements. In this context, it will be analyzed how to optimally share the physical resources among the users, taking into account the availability of MIMO technologies and partial state information. The result of this WP will be to choose the most appropriate multiplexing and coding strategy, for each user. In WP4, the scenario is composed of a single cell, so that there is intra-cell interference, but no inter-cell interference. In WP5, the analysis will be extended to the whole heterogeneous network, composed of many contiguous

cells. The goal of WP5 is to identify the best way of adapting the coding/multiplexing strategy, in each cell, in each cell, in order to cope with both intra- and inter-cell interference, posing a global QoS optimisation problem. Besides, WP2 first provides a flexible bandwidth allocation channel model and channel prediction strategies to the research workpackages, i.e. WP3, WP4 and WP5.

Technological Development Activities start with WP6 in which transmit and receive architectures are developed for the evolution of cellular and wireless Beyond 3G Systems. The development of a common signalling and data representation appropriate for the unified air interface formulation under multi-vendor interoperability requirements is also provided by WP2. Performance analysis of the architectures developed in WP6 is carried out in WP7. This WP also includes the development of an Air Interface Emulator, which shows the impact of the unified air inter-face on the end user QoS perception. Detailed hardware implementation analysis, including optimisation issues for parallelism, power consumption and algorithm locality, is carried out in WP8 with emphasis addressed to for future (foreseeable) hardware platforms. This topic is complemented within the same WP by deployment studies of the evolution beyond 3G.



Graphical representation of project components.

Dissemination and Assessment Activities are covered in WP9, which is devoted to the dissemination of project results and to monitor the project tasks to ensure progress towards the envisioned objectives.

Key Issues

One of the key aspects in the design of a self-configurable air interface is the use of a unified formulation of the transmission scheme. A unified formulation is fundamental in the conception of an adaptive scheme capable of changing the transmission strategy as a function of the QoS requirements, channel status, and traffic information. Nowadays, a plethora of different wireless transmission schemes suitable for multi-user systems are available. Some of them are DS-CDMA, OFDMA, or Multi-Carrier CDMA, primarily devised for single-antenna 3G cellular, wireless LAN, and MAN systems. The number of available interfaces further increases if we allow the possibility of adopting different strategies for the downlink and uplink channels or if we consider MIMO systems. In such a case, it is necessary to combine CDMA or MC-CDMA schemes with well-known techniques that exploit the benefits of MIMO channels, such as spatial multiplexing, beamforming, or space-time coding. The multiplicity of degrees of freedom and the variety of transmission schemes available in the design of the air interface points out a real need for a unified formulation of the air interface. Since there is not a unique best interface, the choice should result from a trade-off among several objectives, like QoS, ease of adaptation, energy consumption at the mobile hand-set and so on.

Expected Impact

In summary, SURFACE focus-es on how to effectively optimise wireless systems taking into account QoS requirements, channel conditions and terminal capabilities and exploit a wide range of access technologies. To solve all the large number of optimisation problems to be faced, we will establish a procedure based on the theory of NP-completeness. Intuitively, this theory provides a notion about the difficulty of the problem at hand before solving it. If appropriate, it also provides procedures to solve the problem whenever a solution exists. If not, a suboptimal solution for the problem is completely justified. We are therefore confident that the different components produced by SURFACE will impact on the development of a new air interface for the evolution of enhanced 3G Systems.