Wireless World Research Forum

The Book of Visions 2001

Visions of the Wireless World

An invitation to participate in the making of the future of wireless communications

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The Book of Visions 2001 – Visions of the Wireless World

An invitation to participate in the making of the future of wireless communications

PREFACE

The Book of Visions 2001 is the outcome of the first year's work of the Wireless World Research Forum, WWRF.

Alcatel, Ericsson, Motorola, Nokia, and Siemens founded the "Wireless World Research Forum (WWRF)" in early 2001. The objective of the forum is to formulate visions on strategic future research directions in the wireless field, involving industry and academia, and to generate, identify, and promote research areas and technical trends for mobile and wireless system technologies. The timeframe of reflection is in the range 10 –15 years from now. Membership in the forum is open to all interested parties. Members are expected to contribute papers and ideas.

In 2001, the forum organised three working sessions and a workshop. The WWRF kick-off session was held in Munich, Germany on March 6 – 7, the second session in Helsinki on May 10-11, 2001, and the third session in Stockholm on September 18 and 19. A workshop will be held in Paris on December 6 and 7, 2001.

Many written contributions were received for all working sessions identifying important research areas for wireless communication systems beyond the third generation.

The work was distributed among four working groups:

- WG1 The Human Perspective of the Wireless World
- WG2 The Service Architecture for the Wireless World
- WG3 New Communication Environment and Heterogeneous Networks
- WG4 Spectrum, New Air Interfaces and Ad-hoc Networking.

The Working Groups were chaired by academics, elected by the WG members. Rapporteurs from the founding members of the WWRF support the chairpersons in producing reports.

The Book of Visions 2001 is entirely based on the contributions received and reflects the status of discussions in the working groups. Therefore, the Book of Visions 2001 does not yet represent a harmonised view of all WWRF members. This draft is a summary of ideas and contributions that are currently being discussed.

The main parts of the Book of Visions 2001 is structured along the lines of the forum's four working groups.

The Book of Visions 2001 has 6 major parts.

- Section 1 introduces the Wireless World and attempts to set the scene for what follows.
- Section 2 represents a first stab at synthesising the results of the working groups into models and timelines.
- Section 3 describes the "Visions and Issues" as produced by the working groups. This section, together with section 5, is the heart of the document.
- Section 4 is a summary of the research proposed. It consists of a table made up from extracts of the "Expected Results" section in the individual tasks from section 5.
- Section 5 defines some possible research tasks that address the issues from the previous section.
- Section 6 lists the experts that have contributed the text for sections 3 and 5. The experts are referenced and linked from the corresponding headings in the text sections.
- Section 7 is a list of references to all contributions received during 2001. These are linked to the corresponding pdf files on the web or the CD respectively.

Sections 3 and 5 should be linked: The possible research tasks defined in section 5 should emanate from the issues described in section 3. However, there may be issues identified in section 3 that have not found a champion to produce the corresponding research task for section 5.

The WWRF steering board thanks all contributors.

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The Book of Visions 2001 - Visions of the Wireless World

1. Introduction

The introduction will provide a short description of the context in which the Book of Visions 2001 has been produced. It outlines the general vision of the WWRF and describes a set of activities on systems beyond third generation that go on elsewhere in the world but relate to the work in the WWRF.

1.1 Times of Change

History seems to indicate that mobile systems pass through a paradigm shift roughly in a 10-year cycle. First generation systems were introduced in the early eighties, followed by GSM in the early nineties and UMTS at the beginning of the new millennium. This implies that now is the time to begin conceptual work for the Wireless World, which is the name given to the systems that will succeed 3G. This report is a contribution to this conceptual work.

The Book of Visions 2001 has been conceived and written during a period of profound change, not only in telecommunications but also in industry in general, in commerce and in daily life. Many principles, considered sound up to very recently, are now questioned.

There has been a general downturn in the communications and IT industry. Many dot.com companies have gone out of business, and the process has not yet come to an end. As sales and profits have been lower than expected, even the large telecommunication companies have had to re-structure their operations.

At the same time, mobile communication is seeing the advent of the third generation of mobile cellular systems, UMTS. With UMTS it will be possible to use high bit-rate data communication on the move and ubiquitously.

UMTS will enable mobile Internet access with its information and e-commerce transaction services. It is expected that mobile access to the Internet will outnumber fixed access within two to five years.

However, the transition from a voice-orientated system to a data-orientated system is not going as smoothly as anticipated by the industry. In Europe the market for GSM type communication is stagnant, and new applications that could attract significantly more traffic, while one is waiting for UMTS, are hard to find. Consumer behaviour is likely to be affected for a long time after the events of September 11, 2001, positively and negatively.

In front of such a backdrop one has to see the efforts of the industry to start defining the Wireless World, the systems that will be introduced into the market after 2011.

Important questions to be answered are:

- What essential demand will a Wireless World address?
- How can advances in technologies be combined in a consistent manner?
- How can wireless communications become universally available for both people and things?
- What business models will drive the Wireless World (what are its fundamental laws)?

The Book of Visions 2001 is a first step to find the answers to these questions.

1.2 A Vision of the Wireless World

In a world that gets ever smaller a global driving and shared vision of the future of mobile telecommunication is needed. The success of mobile communications so far has been made possible only by shared and stable visions and principles at the system level, among a wide set of players.

It has become clear in the discussions in the WWRF that the development of a purely “technical” vision, debating, say, new network concepts or radio interfaces, will not be sufficient. Rather, such a technical view must be put into a much wider context:

- an user centred approach, looking at the new ways users will interact with the wireless systems
- new services and applications that become possible with the new technologies, and
- new business models that may prevail in the future, overcoming the by now traditional user, service provide, network provider hierarchy.

It is expected that the major innovative thrust will come from new ways of interaction with the system or among systems.

An example for a vision of the Wireless World is the emerging need to bridge the real and the personal virtual world and to continuously stay in contact with both. The Wireless World therefore has to address communications amongst things, humans and cymans (our synthetic counterparts in the virtual cyber-world – a sort of autonomous avatars). As such, a Wireless World of the future will become our natural enhanced living environment.

This report defines a target – the Wireless World – not the way to get there. It is assumed that many of the components required for the implementation of the Wireless World will evolve from previous systems.

Some people believe that there will be a paradigm shift in the way the Wireless World will be defined. They believe that the Wireless World would rather be based on policies, rules and principles than on standards as we know them today. Such a new system approach would need a firm and well-constructed foundation requiring continuous monitoring.

1.3 Activities outside the WWRF

The work of the WWRF cannot be seen in isolation. The development of visions for future telecommunications systems takes place in a number of bodies and interest groups, which are both standardisation bodies and fora comprising operators of telecommunication networks and equipment manufacturers. Although the messages and projections given by the different groups have different foci, a rather harmonised view on future generation networking exists. This chapter provides a list of such interest groups and explains how they relate to the visions developed within the WWRF.

1.3.1 Activities on the System Level

Some of the activities are at a global system level, intending to embrace the entire system beyond 3G.

1.3.1.1 Japanese Telecommunications Technology Council (TTC)

Strong drivers of a vision for future generation telecommunication can be found in Japan. Operators in Japan have already pushed for third generation networks and services, which is most vividly reflected in the I-Mode services and the FOMA, DoCoMo's first commercial offering of 3G services. The Japanese TTC (http://www.soumu.go.jp/joho_tsusin/eng/index.html) plays a major role in the discussion on new generation mobile communication systems. In their recent report "Future Prospect of the New Generation Mobile Communication System" the impact of communication and its growing impact on the society is acknowledged. Similar to the notion of the Wireless World, it is stated that ubiquitous access to information will play an increasing importance for modern societies. IP and Internet technology are expected to be cornerstones of a new generation mobile communications system, which is supposed to realise

- ultra high-speed, high quality transmission
- flexible, diverse services
- open services.

1.3.1.2 ITU-R WG8F

The ITU-R Working Party 8F is planned as international focal point for the continuing vision of next generation wireless services and systems. Its visions and recommendations for technical realisation of those built on expected user requirements on future mobile telecommunication systems. It is responsible for the overall system aspects of IMT-2000 with a focus on wireless terrestrial components. Included in the work assigned to WP8F are issues such as spectrum needs, higher data rate capabilities, Internet Protocol (IP)-based service needs of mobile systems such as IMT-2000, and the development of systems beyond IMT-2000.

The visions published by this forum stress seamless service provisioning across a multitude of wireless systems as being an important feature of next generation systems. In this aspect the correspondence to the WWRF is most visible. In general the views of ITU-R and WWRF are aligned to a large extend.

1.3.1.3 4Gmobile Forum

4Gmobile Forum (http://4Gmobile.com) is an IEEE initiative, not yet set up. There have been no meetings up to now. The forum is intended to be an international technical body focusing on the next generation broadband wireless mobile communications which converge wireless access, wireless mobile, wireless LAN and packet-division-multiplexed (PDM) networks. The envisaged integrated 4Gmobile system provides wireless users an affordable broadband mobile access solutions for the applications of secured wireless mobile Internet services with value-added quality-of-service (QoS) through application layer all the way to the media-access-control (MAC) layer.

This statement of direction issued by the 4Gmobile Forum gives some indication on the underlying assumptions on possible future networks. The official kick-off of the forum is planned for May 2002. Working and study groups will be established as agreed during the kick-off meeting.

1.3.1.4 Cluster on Systems beyond 3 G (IST initiative)

Research on future generation mobile systems in Europe is strongly influenced by the IST programme of the European Union. With the “Cluster on Systems beyond 3G” the IST programme has created a forum to consolidate the results of a number of IST research projects working in relevant fields. (http://www.cordis.lu/ist/ka4/mobile/beyond3g.htm). The scope of the cluster includes:

- Evolution of access systems, including terrestrial and satellite technologies, both telecom and interactive broadcasting systems
- IP in core and radio access including mobility management
- Interworking of existing, evolving and emerging access systems.

1.3.2 Technically Focussed Work

Apart from the activities aiming at the establishment of visions and views on complete future generation networks, a number of fora exist, which aim at driving single technologies.

1.3.2.1 Software Defined Radio (SDR) Forum

One of those fora dedicated to a technology, which has been identified by the WWRF to be a key component of the Wireless World is the SDR Forum (http://sdrforum.org). The SDR Forum is dedicated to supporting the development, deployment, and use of open architectures for advanced wireless systems. To that end, the Forum helps to:

- Accelerate the proliferation of enabling software definable technologies necessary for the introduction of advanced devices and services for the wireless Internet

- Develop uniform requirements and standards for SDR technologies to extend capabilities of current and evolving wireless networks.

1.3.2.2 Orthogonal Frequency Division Multiplexing (OFDM) Forum

Further key components of the Wireless World are improved radio access technologies, whereof OFDM is regarded as the most important technology for a future public cellular radio access technology. The OFDM Forum (http://www.ofdm-forum.com) is a voluntary association of hardware manufacturers, software firms and other users of orthogonal frequency division multiplexing technology in wireless applications. The OFDM Forum was created to foster a single, compatible OFDM standard, needed to implement cost-effective, high-speed wireless networks on a variety of devices. OFDM is a cornerstone technology for the next generation of high-speed wireless data products and services for both corporate and consumer use. With the introduction of the IEEE 802.11a, ETSI BRAN, and multimedia applications, the wireless world is ready for products based on OFDM technology.

1.3.2.3 IPv6 Forum

The vision of the Wireless World and in the same way the visions stated by the ITU and TTC assume that the future mobile telecommunication system will be based on Internet technology. Apart from the standardisation work carried out in the IETF, the IPv6 Forum is dedicated to develop IP towards a technology for the next generation Internet, which is supposed to be an integral part of the Wireless World.

The IPv6 Forum (http://www.ipv6forum.com) is shaped by a world-wide consortium of leading Internet vendors and research & education networks. The forum has a clear mission to promote IPv6 by dramatically improving the market and user awareness of IPv6, creating a quality and secure Next Generation Internet and allowing world-wide equitable access to knowledge and technology, embracing a moral responsibility to the world.

1.3.2.4 Taskforce on Advanced Satellite Mobile Systems (ASMS)

The vision of the wireless world includes satellite communication as one enabler of ubiquitous communication. In this context the work of the ASMS relates to the WWRF. The Task Force on Advanced Satellite Mobile Systems (http://www.cordis.lu/ist/ka4/mobile/satcom.htm) is an independent, industry-led body, committed to the successful introduction and development of advanced (including 3G and beyond) mobile satellite communications systems and services.

2. FIRST ATTEMPTS AT A SYNTHESIS

The present Book of Visions 2001 is a collection of ideas that will play a role in the Wireless World. Nevertheless attempts have been made to synthesise the material into models:

1. the "MultiSphere", a reference model that, taking a user-centred approach, shows the Wireless World as a succession of concentric spheres (from the Book of Visions 2000)

2. the "Building Blocks of the Wireless World", a collection of system elements and functions that are believed to play a prominent part in the systems of the Wireless World

3. a "Timeline" providing view of the coming of the Wireless World and the actions that the WWRF is planning to undertake.

These models are described below.

2.1 The MultiSphere Reference Model

During the discussions in preparation of the Book of Visions 2000 it became apparent that we needed a reference model for the Wireless World we were talking about. As a result the MultiSphere model was sketched out. It is too early to call it a common model. It should, however, assist in putting the issues and ideas into a common context. Driven by the horizontalisation introduced by 3G's mobile Internet, future vertical applications and services will draw together a multitude of wireless technologies in an ad-hoc manner. Those elements will be around us like a number of spheres in which we live.

In the following paragraphs the various spheres of this model are introduced. As model is intended to reflect our current thinking, no particular technology is mentioned here. Furthermore the reference presented here reflects largely the discussions and opinions in the Think Tank of 2000 and are not bound to a particular company's view.

2.1.1 MultiSphere Level ➀: The PAN

Figure 2.1-1: MultiSphere Level 1: The PAN

The closest interaction with the Wireless World will happen with the elements that are the nearest to us or might even be part of our body. Communication facilities will be contained in clothes and wearable items. On request they will start to discover each other and distribute a common virtual terminal over us.

This Personal Area Network (PAN) vision is certainly feasible in today's technology but needs much closer integration with the overall concept. As electronic communication will happen "at" our body power issues will be critical for PANs together with fast, flexible and automatic configuration and privacy protection. We believe that much additional research is needed for the evolution of PANs to full constituents of the Wireless World of tomorrow.

2.1.2 MultiSphere Level ➁: The Immediate Environment

Figure 2.1-2: MultiSphere Level 2: The Immediate Environment

At the next level we find the elements of the real world around us. Currently we do not interact with them but in future we will expect that they take notice of us, that they start to interact with us and turn into personalised items rather than general purpose devices. TV sets should know what programmes we are interested in, toasters might want to deliver toast with the right level of toasting and fridges might want to tell us what we probably would like to re-order as we might run out of milk over the weekend.

As the difficulty of using current technologies is irritating to many people, learning and adapting environments will start to address real and fundamental user needs. While personalisation as a technology might become part of nearly all devices in the future what will be important is the possibility to personalise several devices with a common approach or at the same time rather than individually. For example, a non-smoker or vegetarian will not want to explain his preferences 100 times in different ways, to his different devices. Similarly a user will expect at least consistent errors when interacting with devices using speech. Therefore, we believe the immediate ad-hoc environment to be an important part of the Wireless World model.

2.1.3 MultiSphere Level ③: Instant Partners

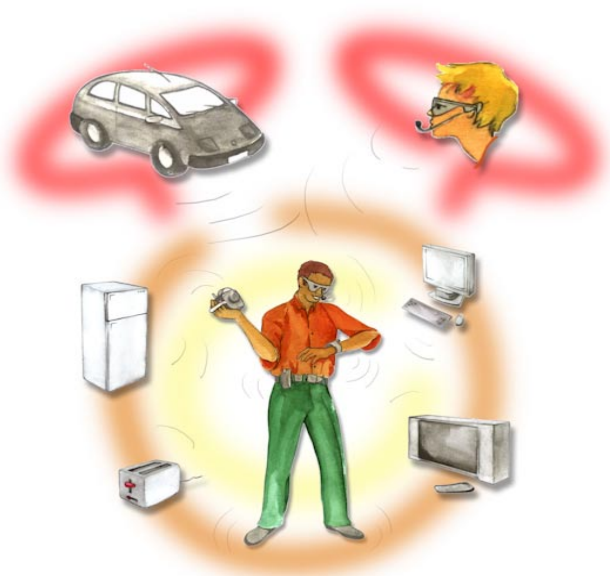

Figure 2.1-3: MultiSphere Level 3: Instant Partners

One step further we interact with people around us as well as with more complex systems like cars. We may want to talk to them or just relay information through them. It is believed, that in the future our wireless possibilities should enable an easier and maybe richer interaction with close-by people than with people on the other continent. On the other hand, “closeness” can also be seen as being part of a close net of people with whom we want to be closely interconnected and where we would like to be kept informed about their wishes and thoughts quickly. Current chat communities are just a glimpse of what people might desire and enter into in the future.

2.1.4 MultiSphere Level ④: Radio Accesses

Figure 2.1-4: MultiSphere Level 4: Radio Accesses

What has made mobile communication so successful was the possibility to rely on ubiquitous coverage of a wide area system. This will certainly remain a fundamental requirement. Either directly from the PAN or via the instant partners publicly accessible radio interfaces must be reachable.

Current infrastructures might be supplemented by a host of additional commercial ventures like flying base stations (e.g., HAPS), high-speed local media points or dedicated road technologies. For these new infrastructure types it will be vital to provide adaptivity to various terminals, simple inter-action with the backbone and low, close to zero, operational cost. One might expect to see more specialised radio interfaces that have short innovation cycles. One of the critical issues will be to determine how those can fit into the backbone structures and the legacy of terminals.

2.1.5 MultiSphere Level ⑤: Interconnectivity

Figure 2.1-5: MultiSphere Level 5: Interconnectivity

The value of communications technologies is sometimes said to grow proportionally to the square of the number of the connected devices. Therefore, it will be a crucial task to maintain universal wireless interconnectivity, as in today's mobile Internet core networks. To offer the right level of support for the various specialised radio interfaces and terminals will be a key requirement. One can therefore see an emerging need for both a radio convergence layer and a number of APIs beside the evolved IP transport and networking layers. Evolutions of interconnectivity in the Wireless World will convey radio interface state specific information to applications and also allow for seamless integration of synchronous direct communication services with asynchronous message based services.

2.1.6 MultiSphere Level ⑥: CyberWorld

Figure 2.1-6: MultiSphere Level 6: Cyberworld

The outmost sphere, most remote from our immediate real world, represents our CyberWorld. It is soon likely that presence in our self- created CyberWorld will be as important to us as presence in the real world. This trend is already visible if we look at today's explosion of services and the perceived realism of advanced games. In the CyberWorld we can stay in touch with our (semantic) agents, knowledge bases, communities, services and transactions. The Wireless World will be the way for us to become permanent residents in the CyberWorld. A deep understanding of this world is necessary to develop Wireless World technologies that really satisfy our fundamental needs.

This is what we set out to do!

2.2 The Building Blocks of the Wireless World

The previous sections described a user-centric view of the Wireless World, using the sphere model. A system view emerged when analysing the visions and issues presented in this report.

We were able to start identifying the major system elements or functions that could characterise and make up the Wireless World.

Figure 2.2-1: The 9 building blocks of the Wireless World

The nine potential building blocks of the Wireless World are described below.

Augmented Reality/Cyberworld

New types of user interactions will characterise the Wireless World in the peoples mind, more than any implementation orientated feature. Wearable communication terminals and deviceless interactions will become fashionable. The communication space of the user will be populated by avatars, and the reality he sees will be augmented by useful information.

Key Words:

- wearables
- deviceless communication
- avatars
- augmented reality

Semantic Aware Services

The services provided in the Wireless World will have to understand what the user wants, based on past observation of the user and, maybe, some common sense. The service has to remember, to deduce, to think and to propose appropriate actions.

Key Words:

- context aware services

- location aware services
- extensive use of artificial intelligence to assist in information retrieval
- personalisation.

Peer Discovery

Convenient solutions for locating service providers and users in the Wireless World are a key building block, which will have strong impacts of the potential users perception of service quality. Addressing schemes need to be found which work across network boundaries and harmonise access to the broad range of conceived services.

Key Words:

- User Addressing
- Service Discovery

End-to-end Security & Privacy

In the Wireless World users are expected to rely to a much higher degree on the communication system than now. This implies high system availability and integrity of communication. Payments via mobile devices will be commonplace, exceeding other methods of payment, implying the provision of universal, easy to use, secure and cheap payment services.

Key Words:

- ensuring privacy and security.

Co-operative Networks & Terminals

The Wireless World is supposed to comprise a number of heterogeneous technologies, which have to be co-ordinated such that they provide a seamless service to the user. Network details and differences in the access means are to be hidden. A continuous service area needs to be guaranteed ensuring service continuity among technology borders. Both the network and the terminals need to co-operate to achieve this goal. An all-IP architecture could be the common basis for co-operation.

Key Words:

- reliable transport among heterogeneous networks and terminals
- all IP

Heterogeneous Ad-hoc Networking

The communication network of the Wireless World will include Ad-hoc elements which collaborate to construct network islands of increased direct communication needs. Such configurations are supposed to appear at hot-spots such as airports or shopping malls. Additionally ad-hoc communication links can be used to ensure access to the Wireless World for remote mobile stations without direct link to the Wireless World. Such a link can also comprise heterogeneous communication means to achieve global connectivity for terminals supporting only short-range communication by themselves, too.

Key Words:

- Ad-hoc networks among homogeneous and heterogeneous communication nodes

4G Radio Interfaces

Different radio technologies, which are tailored to certain environments need to be defined for application in the Wireless World network. Their spectral co-existence needs to be guaranteed by defining appropriate rules for frequency etiquette. Technologies, such as ultra-wideband (UWB) and Multi-carrier solutions, need to be investigated and mechanisms for spectrum sharing are required.

- Spectral Coexistence and frequency etiquette
- Positioning
- Multi-carrier
- New air interface

Smart Antennas & Basestations

New concepts of cellular networks should not hold off from new architectural concepts deviating from the traditional views. Interesting concepts such as HAP (High Altitude Platforms) should be evaluated for the Wireless World. Antenna technology such as smart antennas have similarly high potential to contribute significantly to the future radio access technology.

- HAPs
- beamforming
- MIMO, Space Time Coding
- Radio heads and optical fibre

Software Defined Radio

This technology is a key enabler for a flexible network architecture, allowing an easy adaptation to the application's demands. Thus, it ensures a future proof network architecture, which can keep pace with the application innovation process by changing the mobile station’s protocol stacks remotely. The research in this area includes software architectures and an investigation of the hardware impacts.

- reconfigurable, downloadable Protocol Stacks.

2.3 Timeline

As part of the work in the WWRF, a first tentative timeline was developed for the coming of the Wireless World.

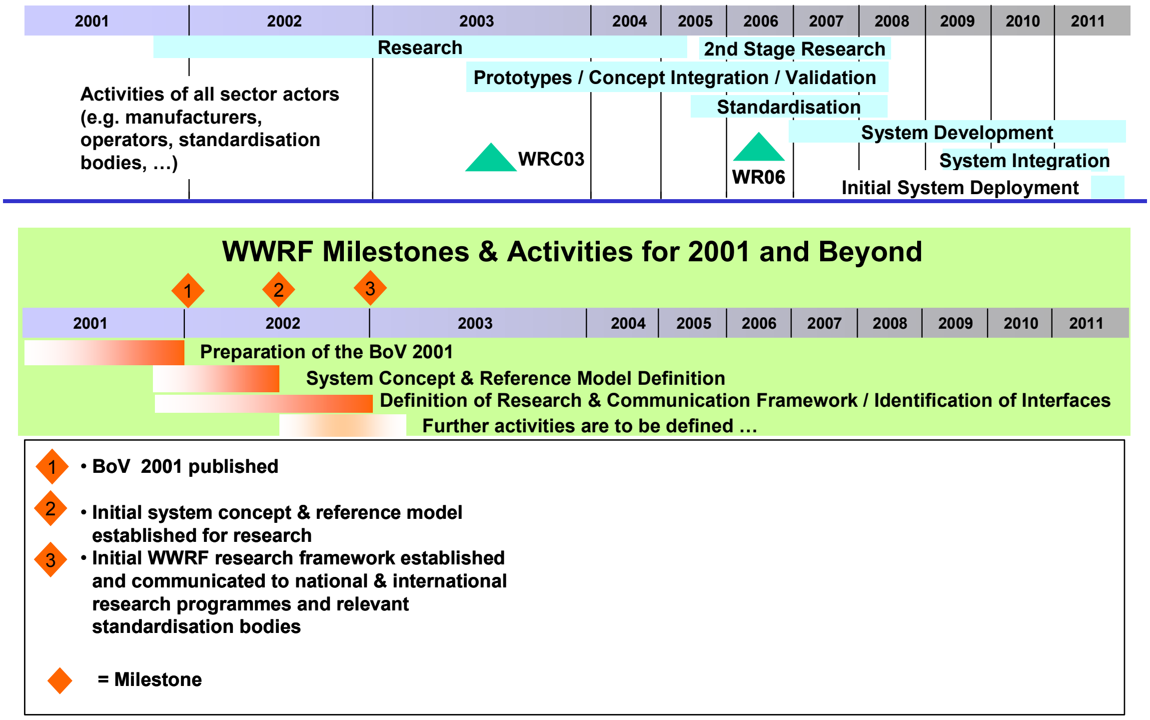

Figure 2.3-1: Timeline for the coming of the Wireless World.

In the figure above a distinction is drawn between the activities that go on in the industry world-wide and the activities that will be undertaken by the WWRF. In this way it can be shown that the activities of the WWRF fit in well with an overall schedule.

Activities of Sector Actors and the WWRF

Research into the items that are crucial to the Wireless World has started in the late 90s. The 5th Framework Programme of the European Commission is one of the instruments used. Future research for the Wireless World will get considerably more focus through the work on the Books of Visions 2000 and 2001 and on the fundamentals (reference model and system concept, research framework and roadmap).

It is expected that a second wave of research activities will start around 2005. Because being closer to deployment, this research will be more directed to applications and trials.

The forum expects that first bread-board models and prototypes will become available in 2003 already. The activities of trial, integration and validation will become ever more important.

Parallel to the trial and integration activities standardisation is predicted to start in 2005, based on pre-standardisation research work preceding it.

System development and integration will start at the end of 2006, leading to first commercial deployment around 2011.

3. THE VISION AND THE ISSUES

In this section the 4 working groups of the WWRF describe how they see the Wireless World - its possibilities and some of the options available. The issues related to those choices are analysed and possible research proposed to address those issues. The picture presented is quite wide in scope but neither monolithic nor even harmonised yet. It is a step in arriving at a consensus on a common system view.

3.1 WG 1 - The Human Perspective of the Wireless World

It is generally believed that the development of the Wireless World will be truly user centred, and that it will provide the user with new sensations and experiences opening up new possibilities especially in the close vicinity of the human user. Only by satisfying the user beyond his expectations will it be possible to generate the revenue required to economically produce, install and operate the new systems.

3.1.1 The Visions and the Issues {32}

Basic Needs of the User

The evolution of communication solutions has a deep impact on our society, if basic human needs are addressed.

Being able to talk to human beings outside the audio range of the speaker satisfied a basic human need, in an era when travelling was not easy and might have taken weeks or months. Fixed-line telephony is today an every-man's asset in some parts of the world. Still, every third human being has not made a telephone call.

The ability to communicate even when not nearby the fixed-line telephone was the next natural step. One hundred years later, voice mobility, e.g. a telephone in our cars or pockets, is used by some 5% of the Earth's population. However, 6 billion humans do not yet own a mobile telephone subscription.

A big evolutionary step offered to the high-end mobile users was the ability to be reached on the same mobile terminal and number independently of the location in Europe, Australia and some parts of Asia and North America. As our society is developing into the information and communication era, global access to information and media is developing into a basic requirement of advanced users. Therefore, global mobility of voice and data forms the development basis for mobile communication solutions known as Third Generation.

It is our belief that information and communication systems belonging to different generations will co-exist for a long while. Users will also have different requirements, all across the range from making a first, basic fixed-line telephone call to watching a video clip advertising the next Hollywood movie when relaxing on the beaches of the Mediterranean Sea.

This Book of Visions is about addressing the needs of this user population. Due to the quick growth rate, this population will expand step-by-step into the "masses". During the next hundred years, probably most human beings will be able to belong to it.

Where do we come from

During its first century of existence, the development of communication systems has experienced a serious degradation of end user's ease of use. In the early years of telephony, calls used to be placed with the help of an intelligent, voice-activated communication agent, the Operator (Figure 3.1-1). As the number of users increased, so did the degree of complexity and cognitive load put on the end users. Technology needed to solve the typical mass market problems, leading to today's 20-digit long telephone numbers to be punched on a keyboard, representing the address of devices (not even people) in most cases.

Figure 3.1-1: Operator Ladies (Courtesy of End User Applications, Mobile Enterprise Solutions, Ericsson Enterprise AB, Sweden)

A key issue, not focused so far, is the creation of communication interaction experiences resembling Human-to-Human communication, exploiting the strengths of this well-known, classical model. As the underlying technology is becoming increasingly complex, the need for a simple and generic way to communicate and interact is becoming more important. The gap between how we communicate person-to-person, in real life and the artificial way we communicate using technology *must* be reduced. The unique and fascinating capabilities of humans must be involved and utilised to meld impressions from several senses and analyse them, based on our previous experiences. This is the only way to ensure that new, emerging technologies will support intuitive and scalable human-system interaction.

Our Vision

Our simple and basic vision of communication solutions for the Wireless World is that they will meet and hopefully exceed user expectations by means of simplicity and functionality. This will only happen if development will take well understood user behaviour into account, based on awareness of how people communicate and interact, what they want to do and achieve, thoroughly understanding their tasks and requirements.

Looking into the world of future wireless communication certain evolutionary steps are predictable. Some characteristics have been asked for even of the systems we have today. From the users' perspective we would like to have truly usable systems that provide easy, efficient and effortless interaction and use. We would like to see natural interfaces that are based on, for instance, natural language speech recognition, gesture interpretation or even controlled by our brain waves. The systems should be able to, if not read our minds, know what we want. Information browsing and retrieval should be intuitive and effortless. The user experience should be built upon more senses than sight and hearing. Our environment should be constantly tailored and personalised to our likes, habits and situation. All services of the future wireless should be provided with the highest integrity and security in mind.

The solutions must offer holistic, converged communication appliances for fixed as well as mobile information and communication. Devices, systems and applications must operate in harmony, seamless to but taking full advantage of available technologies. By building the development of information and communication systems for the Wireless World, quality of life and an enhanced user experience can be offered.

This can only be achieved by addressing the three main topics identified as key areas of the end user perspective in this book: understanding the user, new generic interaction elements and new interaction techniques.

Let's do it, together, for our children!

The Issues

Following the vision described above and the discussions at the WWRF meetings held over the year, a set of main topics has been identified within WG1. In order to be able to create systems and services for the future Wireless World from the users point of view (e.g. that are both useful and usable) there is a need to better understand the user and what identifies the user interaction experience.

Most of the system and application design today is technology driven only because we don't have the tools to incorporate user behaviour as a parameter in the product development process. In order to do this there is also a need to create new development processes that incorporates the end-user in a clear way. The future Wireless World will also deliver new enabling technologies that give birth to new types of applications and services (e.g. situation and context awareness, augmented and virtual realities). We need to understand how these services will affect the users' behaviour in different situations as well as what requirements the user will put on them before they will be used.

The user's experience is always influenced by the technology for user interaction. The user interface outlines (and limits) the possibilities and capabilities of future communication systems. To investigate, develop and understand new interaction technologies will be crucial in defining the use of the future Wireless World.

Thus we have identified the following main topics for research;

1. Understanding the user
2. New generic application elements

3. New interaction techniques

The topics are not isolated but interdependent of each other as shown in Figure 3.1-2.

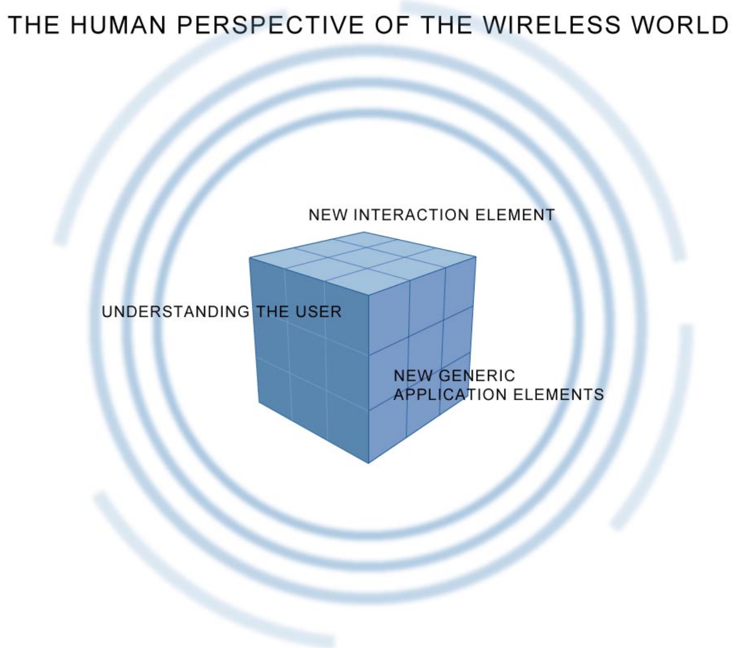

Figure 3.1-2: The set of research tasks for the Human Perspective of the Wireless World working group.

Understanding the user

Exploratory user research has been used successfully over the years to guide the development of new technology. It is fairly easy to let users judge whether they like a product or don't, if it's easy to use and if they feel they have a need for it. It's much harder to let users express their needs for the future, to judge technology not yet implemented or visualised. Sometimes it is even hard for the users to explain their own behaviour and why they do what they do in a certain situation. To this extent a commonly used method to gather user data is by observing their behaviour in their own natural context. These methods are unfortunately mainly used in academic research today. Within the industry there is a great need to gather observational data on users' behaviour as input into product development. The methods of today are however not easily applicable into product development. They must be fine-tuned to be able to meet with the industries needs in order for them to be widely used for data collection.

As the research issues described in this book illustrate, potential research aimed at increasing our understanding of the user runs the gamut from the realms of abstract concepts to that of specific applications.

At the more abstract level is research designed to explore models of human behaviour. Unified methods and tools that are based on well-known models for the physical system often rule product and service creation of today. To introduce user behaviour data into the creation process is hard since there are no satisfactory models to use for the human being. A next step may be to create a solid unified user behavioural model.

Next, we can consider new methodologies for introducing the user perspective into product and service design processes. Only a few companies creating services for the future Wireless World actively work with user centred design and address usability issues through the complete product lifecycle. The main argument not to do it is mostly time. Even in the research community one can find examples where usability and understanding of the intended end-user is put aside in order to focus solely on technological issues. But the main obstacle is probably not time but rather the lack of efficient tools to drive a user centred approach to application and/or concept development. If we had methods and tools to create novel use situations, these could be used both for initial concept development as well as for validation of the usefulness of already realised products.

One method of generating plausible use cases is to construct and analyse a number of reference scenarios. These scenarios must be designed to encompass societal, economic as well as technologic developments and form a logical framework in which use cases can be fitted. They should involve a mixture of in-depth analysis and imaginative thinking, sketching out potential trajectories by modelling relevant actors and factors and the projected impact of trends upon them.

Finally, our understanding of the user role in the wireless future can be expanded greatly through the use of both new and existing methodologies to study user behaviour across classes of applications (e.g. context-awareness), broad user groups (segmented by age, culture, geographic region, special accessibility needs, etc) and in specific application domains. Interesting domains include healthcare, fire fighting, extended enterprise logistics, education/learning, government administration and entertainment. This list of application domains, while not comprehensive, represents an appropriate cross section to show the usability of mobile solutions. In any application domain, it is essential to understand the unique user requirements to improve the chances of success for the introduction and launch of new mobile solutions.

Thus, we conclude that user research has a strong role to play in answering several key questions, the answers to which will help to drive the research and development of the wireless future. These include: Is there a way we can model the user the same way we today model technology? What are the use cases and scenarios of the future for both the consumer and business world? What are the users' needs and requirements that future wireless systems need to satisfy?

New generic application elements

New applications for the future generation of wireless systems will have different evolution paths. One path will be functional and quality improvements of 3G services and applications. Fixed network broadband applications will go wireless and become mobile. The third evolution path will be when new enabling technology makes it possible to create wireless and mobile specific services that are not possible either in 3G or in fixed networks e.g. situation and context awareness, virtual assistants, augmented and virtual realities (see Figure 3.1-3 and Figure 3.1-4).

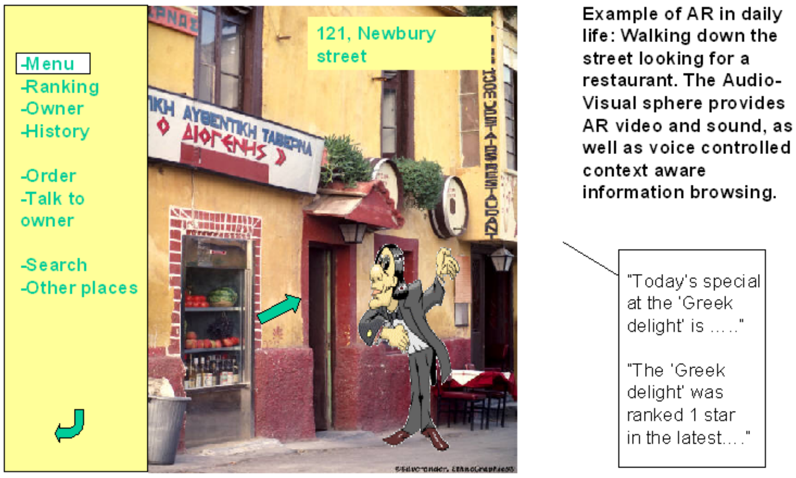

Figure 3.1-3: An AR scenario. The location and direction info (combined with distance information from the restaurant and possibly user preferences) triggers the AR scenario. The real view (restaurant) is enhanced with info that is overlaid to the real world. An animated body is the virtual guide. Web browsing is part of the scenario. Conversational MM is also part ("talk to the owner"). (Courtesy of Media Lab, Ericsson Research, Sweden)

In the future computers will not only be increasingly mobile, but information will be accessible from any mobile position. Devices will recognise who we are and obtain information about us. There will be a mixture of interoperable fixed and mobile devices. A device will also be more aware of its user and more aware of its own environment. The terminal will be able to sense the presence of a user and calculate his/her current situation. Throughout the environment, bio-sensing will be used not only for entertainment and medical reasons, but also to enhance person-to-person and person-to-device communication

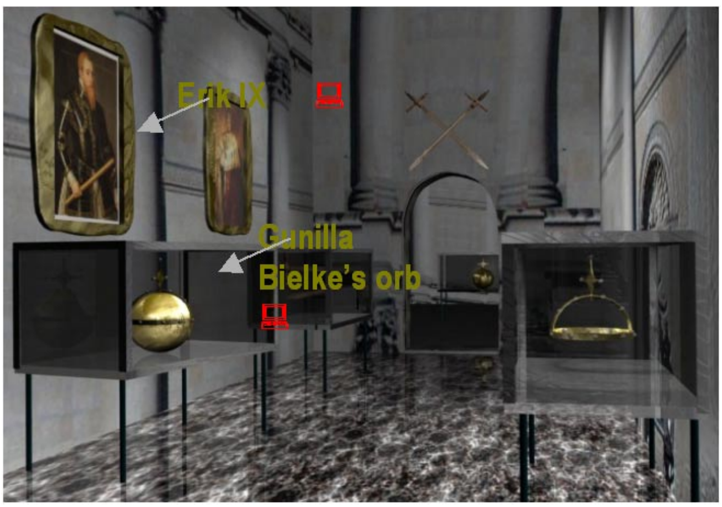

Figure 3.1-4: A scenario of indoor AR (Courtesy of Media Lab, Ericsson Research, Sweden)

New technology enables new types of application and services. Figure 3.1-4 shows a possible scenario of the near future where an augmented reality system guides a visitor within a museum. Together with advances in new interaction techniques these types of systems might be integrated in our everyday life in the future of wireless systems. We still need to put the user in the foreground and ask us the question – Do we want this?

New interaction techniques

Looking at wireless application and services of today one can say that the user interface defines the user experience and charts out the possible uses of all the services and capabilities of the computer or communication system. It is therefore very likely that the introduction of new interaction techniques will be the trigger of major disruptive leaps in the use of new technology. Recent advances in wearable computing and intelligent fabrics hints at future directions of ways to realise truly ubiquitous computing. But how will the user interact with the disappearing devices? What is the user interface of tomorrow?

Figure 3.1-5: The phone glove. A study of the fragmentised terminal concept (Courtesy of Usability and Interaction Lab, Ericsson Research, Sweden)

There are several major trends within the area of User Interaction that have the potential of causing this type of disruptive change.

- **Ubiquitous Computing (or Communication)** – Surrounding people with intelligent intuitive interfaces that are embedded in all kinds of objects.
- **Augmented Reality** – Using a semi-transparent visor or head up display, to enhance the users' perception of the reality by embedding objects such as 3D images, videos, text, computer graphics, sound, etc.
- **Conversational Interfaces** – Using conversation (i.e. speech) effectively and unobtrusively in solutions for users' everyday problems
- **Multi-modal Interaction** – Using a combination of several interaction techniques (or senses) to interact or communicate
- **Human Supervised Computing** – Automation allows humans to be above the system control loop, using sensors and actuators to both monitor and shape their physical surroundings

A common aspect for all these trends is the need to address the fact that while the complexity of technology used in everyday life has exploded, the basic human capabilities (sensory and motor limits, short and long term memory, the brains processing power etc.) have evolved very slowly. In order to fully exploit these capabilities we need to extend the interaction with more senses (touch, smell, and taste) and at the same time make better use of the senses used today (hearing and vision) by exploring peripheral vision and ambient listening. With even a longer perspective we need also to consider inventing "new senses" by combining current senses and extending them with new technology. In the future *All Senses Communication* would be a way to enhance the communication with other entities (humans or machines) using a combination of several of our present or future senses.

The total user experience or the user satisfaction is determined by how well we meet some or all of the users needs. Given the increasing bandwidth of the new Broadband networks, applications will gradually start to exploit new ways of interaction. Soon the bandwidth bottleneck will not be in the transport of data but rather be determined by the “Bandwidth to the Brain”. Adapting the interaction to the way we have been trained to absorb and analyse information will allow us to maximise the throughput of these “channels”.

3.1.2 Proposed Research {33}

In this section the individual research tasks that WG1 is proposing are put into context. The task references refer to the tasks numbers used in section 1.

3.1.2.1 Understanding the user

In many fields of science and engineering, models of physical behaviour are used as important tools in the analysis and design of new systems and products. Likewise, models of human behaviour exist, but are considered too crude for use in product and service design. Task 1.1 addresses this by proposing research that would develop improved models of human behaviour so that it might become possible to introduce user behaviour data into the creation process.

As new concepts are developed for applications in the wireless future, it is useful to consider methods and tools for creating novel use situations. Task 1.2 describes one method of generating plausible use cases by constructing and analysing a number of reference scenarios designed to encompass societal, economic and technologic developments. It proposes a mixture of in-depth analysis and imaginative thinking, sketching out potential trajectories by modelling relevant actors and factors and the projected impact of trends upon them.

Tasks 1.3-1.5 address employing techniques of user study to explore the requirements and needs of users in various dimensions. Task 1.3 provides an example of studying user behaviour relevant to a broad class of applications enabled by capabilities of future wireless networks. The specific capability addressed here is context awareness, a key aspect of the vision and research within the domain of the WWRF Working Group 2. Task 1.4 offers an example of study user requirements for a broad user group. In this case, the focus is on enabling universal access to the wireless future by uncovering unique user requirements for assistive technologies. Finally, Task 1.5 proposes research to gather user behaviour data in one or more vertical application domains from which to inform application development. The task includes brief summaries of several potential target application domains drawn from many contributions received by the working group.

The set of research tasks presented here is clearly not a comprehensive list of interesting research relevant to understanding user issues for the wireless future.

They do, however, represent an excellent set of initial research proposals and exemplify a structure for future contributions to this important area.

3.1.2.2 New Generic Application Elements

A key part of discovering the Wireless World of the future is to understand what the user is going to do with the capabilities provided by new technology. The user centred research process calls for a study of human behaviour and users within their domains of activity. Such research is addressed in Understanding the User. Having studied the user, capabilities and their underlying enablers can be identified as areas of technology research, which are addressed by the technological focussed working groups within the vision and the associated research tasks. However, there is a class of research that lies between the pure user research and the pure technology research. This research is characterised by having a dual focus; both a user dimension and a technological dimension. These research topics are termed generic application enablers. The research tasks are either the study of technologies that are closely bound to the interaction with the user, or the study of a class of human related issues that require a solution in order for the technology to be truly useful. A good example of the former is user interaction technologies, and an example of the later is the need for technologies for the user to manage the complexity of future systems. In fact, the study of interaction technologies is so important that they have been separated into a section of their own.

Generic application enablers are then those technologies that will make the Wireless World a truly useable and useful tool of the future. Four generic topics have been identified for study:

- User requirements and technologies for managing the complexity of future wireless systems. This is addressed in Task 1.6.

- User requirements, architectures and technologies for augmented and virtual spaces. This is addressed in Task 1.7.

- User interaction paradigms; the identity of the user in the Wireless World. This is addressed in Task 1.8.

- User requirements and technologies for body area networks. This is addressed in Task 1.9.

3.1.2.3 New Interaction Techniques

As mentioned earlier many regard the user interface as the true bottleneck of efficient information technology usage in general and Mobile Internet services in particular. The user interface defines the user experience and charts out the possible uses of all the services and capabilities of the computer or communication system. It is therefore very likely that the introduction of new interaction techniques will be the trigger of major disruptive leaps in the use of new technology.

The WWRF area New Interaction Techniques will focus on research that involves new user interface technologies that promise to achieve these disruptive leaps. We have outlined a few major trends that have the potential of causing this type of disruptive change and several proposed research topics plans to explore these areas.

Figure 3.1-6: New Interaction Techniques will probably provide the user with a combination of way to interact with the real and virtual world. (Courtesy of LinLab Research and Innovation, Ericsson Research, Sweden)

Several contributions (described in Tasks 1.5, 1.7, 1.8, 1.10 and 1.11) suggest Augmented User Interfaces to create interfaces that are portable, deviceless and extensible. Deviceless means that the interface between user and an information appliance has no mechanical interference with the user and extensible means that the interface can re-shape itself for different purposes. Even if the proposed applications for Augmented Reality vary, the contributions could benefit from a common architecture, test bed and usage scenarios.

There are also several contributions (Tasks 1.6, 1.7 and 1.10) that propose Avatars as a way to improve the user interaction. Avatars can offer a consistent interaction metaphor across different modalities. This is especially important under mobile circumstances where the context-of-use changes all the time, and where the user should be able to switch between visual and auditory interaction without having to switch applications. It may also reduce the amount of interaction needed by the user to actually get what he or she wants, at the right moment.

Other areas of research that are outlined (primarily) in Task 1.10 are: Haptic Interfaces, Multi-modal Interaction, Conversational Interfaces and Ambient Interfaces.

In order to conduct joint (but distributed) research we need to establish a common test and prototype environment with a set of test cases for service developers that allow us to explore selected aspects of New Interface Techniques. This could be conducted as collaboration with other WWRF research areas or in the framework of other research initiatives.

3.2 WG 2 - The Service Architectures for the Wireless World

In the last years, a variety of concepts for service integration and corresponding systems have gained momentum. On the one hand, they aim for the inter-working and integration of classical telecommunications and data communications services. On the other hand, they are focusing on universal service access from a variety of end user systems. All these systems are driven by the concept of providing several technologies to users by keeping the peculiarity of each service. From the service point of view, the participants of WG2 believe that the service architectures of the Wireless World will be based on service personalisation, service integration, and IP-based reachability.

3.2.1 The Vision and the Issues

3.2.1.1 Service Architectures – an I-centric communications approach

We believe that future services will adapt to individual requirements (I-centric). The communication system will provide the intelligence required for modelling the communication space of each individual adapting to his interests, environment and life stage.

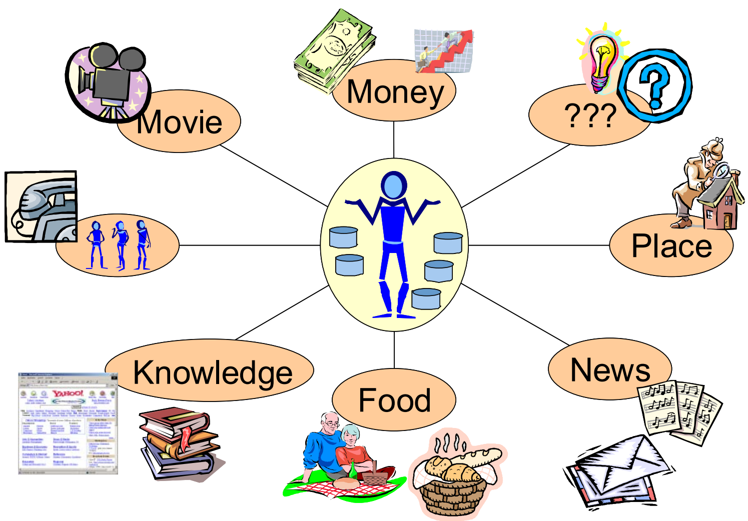

Figure 3.2-1: Individual communication space

I-centric communication considers the human behaviour as a starting point to adapt the activities of communication systems to it. Human beings do not want to employ technology, they rather want to communicate with their environment. They may meet with others to talk, to celebrate, they read and travel, they are listening to news or to music, they take decisions, etc. As Figure 3.2-1 illustrates, people interact with several ‘things of interest’ to solve the problems of daily life: money and bank accounts need to be managed, food has to be bought and to be prepared for eating, movies can be watched for entertainment, places are visited and news are consumed to increase knowledge, other people are met for discussions.

All these contexts and the related objects define the communication space of a human being. A context represents a certain “universe of discourse” in an individual communication space at a certain point in time. In general, human beings communicate with ‘objects’ in their environment in a certain context. Note that the same objects may pertain to different contexts and to different communication spaces. Objects pertaining to a certain context can be active or passive at certain moment in time depending on the situation of the user. They can be activated or deactivated by the user or environmental condition. They can be directly addressable or represent a set of physical entities performing a certain service as a whole.

A user might have different preferences under different situations. Sitting alone in a silent room might indicate that the user is willing to receive incoming phone calls. However, the same user can take it as a disturbance to be involved in a conversation with other people. To be I-centric requires knowledge of the actual situation of a user. An active context defines the relationship of a human being to a particular number of objects of its communication space at a moment in time, in a certain environment. I-centric communication systems have to be aware of the context a user is in and have to adapt their service provisioning to that very context in a certain temporal and environmental situation.

The multitude of devices, wearables, different telecommunication technologies, positioning and sensing systems, location-aware or context-aware applications etc. can be seen as enabling technologies for I-centric communications. Universal information access (including service inter-working, media conversion), flexible control of equipment and facilities (e.g. smart homes), and personal communications (supporting personal mobility and terminal mobility) form the basis of such systems.

I-centric Services describe the ability to define and to manage contexts that are tailored to the preferences of single users, in its individual way to interact with the communication system. Based on the evaluation of ‘profiles’ that describe user preferences, service capabilities, and on sensing information about its actual environment, the user can be provided with individualised services adapted to his present environment. Self-learning capabilities are used to profile the behaviour of users, numerous services or several features of different services are combined on-demand, and appropriate terminals and conversion strategies are evaluated.

Interaction with the environment is required for a certain context to sense the environment in order to be able to adapt to it. Temporal and spatial characteristics are only two examples of information, which may affect the context. Temperature, noise level, light intensity, presence of other people and objects in the vicinity, are additional parameters which may help to adapt the applications to the user needs and profiles. Note that a certain environment can restrict the functionality provided by a certain context. Interacting in a TV context while driving a car may reduce the functionality to ”record the movie for later viewing”. Sensing the environment provides the information necessary for the choice from several types of equipment which have to be controlled (presentation terminals, handhelds, microelectronic controlled devices), their quality of service (volume, brightness etc) that are connected via an access network (Infranets, Intranets, Internet, Extranets, telecommunication networks) to create an dynamic I virtual private network.

A Service Platform will be responsible for shaping the communication system, based on the contexts identified and the actual sensed environment information. It activates the objects involved in the context, identifies causalities between them based on sensed environmental data, controls the services offered by these objects, and converts data structures and operations for inter-working between (possibly unrelated) services. The equipment is configured dynamically, its state is profiled, distributed objects are controlled, service creation and deployment is supervised, and the inter-working among domains is enabled by the platform.

The aim of the service architectures in the Wireless World is to devise a framework that models the communication behaviour of human beings. This will lead to an expandable system that is almost invisible to the user, that requires no time-consuming configuration, and provides customised interfaces to each single user based on its own preferences and situations in time. Combining off-the-shelf developments for the area of microelectronic controlled devices, handhelds, wearables, Infranets, the Internet and the World Wide Web, mobile telecommunication networks, E-Commerce, and context-awareness, complex and intelligent services can be provided to human beings in an easy, for them understandable and therefore acceptable way.

A further aspect of I-centric technology is the empowerment of any user to act as a service provider in a paradigm shift from a provider centric paradigm to a decentralised peer-to-peer paradigm.

Significant technological advances in recent years in the areas of palm-sized computers and wireless communications, accompanied by an infiltration of the Internet in all aspects of our lives have given reason to analysts world-wide to forecast that as early as 2003 almost half of the Internet population will consist of mobile access devices. By that time, a variety of different wireless network platforms with different properties, capable of transporting Internet traffic will be available. IP-based technologies that allow the integration of available heterogeneous and homogenous networks into a single platform capable of supporting user roaming between them, while not interrupting active communications, are already gaining importance. This development will be assisted by the rise of new mobile devices capable of maintaining various access interfaces that will allow simultaneous connectivity over a range of providers and technologies. Finally, the emergence of a plethora of access devices will dictate the liberation of users from a single device (i.e. mobile phone) and allow mobility between devices even as the user is communicating.

The paradigm shift addressed here however does not only concern the user as a provider of network related services. An integrated network platform allowing true global mobility and transparent access to other nodes over a common IP platform can function as the basis for a technology that will allow everyone to provide a wide range of services ranging from typical Internet services to “traditional goods” like physical products as well as conventional services to other customers. Main characteristics of peer-to-peer systems as they are starting to emerge today are:

- All nodes are equal – there is no distinction between client and server nodes.
- There is no central element of control (and thus no central authority).
- Robust protocols that allow for flexible ad-hoc management of nodes and services.

- Strong sense of “locality”, “proximity” or “community” in which a node operates.

The technology needed to support the aforementioned shift to an I-centric model were every node can function as a provider or a customer is a dynamic service discovery mechanism that can locate any available service according to criteria defined by the user and regardless of availability of internet connectivity, physical position of the user or the service provider as well as virtual position in respect to network bearer technology or segment of the network.

State-of-the-art

Higher processor speed and large storage capacity are as normal today as broadband networks and value-added services. New services, like distributed office, tele-working, and video-conferencing, initiated new trends in the society. Ubiquitous & context aware computing can be seen as the technology that deals with the society’s demand for ‘universal connectivity’. Already applications and systems available on the market: mobility in fixed and wireless networks, unification of service access and service delivery (at least for a particularly described set of services), and interoperability of services and interfaces. Whilst most of the technological foundations are convenient, new trends and developments can be identified (see Figure 3.2-2):

Telecommunications – The era of monolithic telecommunication networks with only centralised intelligence (like Intelligent Networks) is coming to an end. The integration of IP-based services from the Internet community, like Voice over IP, and the advantages of packet-switched networks are going to change the characteristics of telecommunication networks. Looking at 3rd generation mobile networks, Parlay/OSA and VHE, new approaches are in the phase of standardisation or already on the market. The inter-working of formerly separated signalling protocols and the adaptation of information streams by Media Gateways indicate this development. The convergence of telecommunication networks and IP-based networks is no longer a buzzword, but commonly accepted reality.

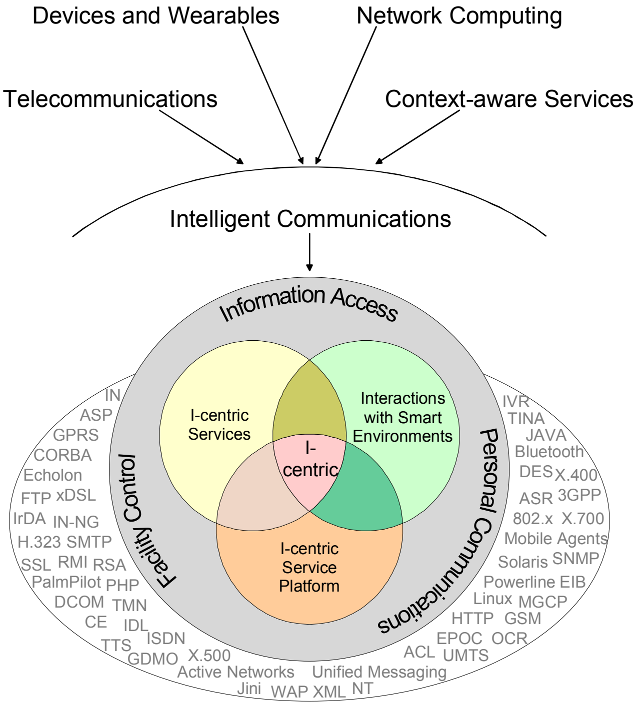

Figure 3.2-2: Enabling Technologies

The Internet has altered from a scientific network for technical specialists to a commonly used market place and information place. The Internet Protocol is going to be extended to overcome its original restrictions regarding, for instance, real-time transmission and quality of service demands. The Internet is now a business driver effecting all parts of global economy. Today, the most challenging task is to model real world business processes with Internet technology. This is known as E-Commerce (business-to-user as well as business-to-business). Beside the global network, local area networks are also based on the Internet Protocol. Using an all IP platform is the prerequisite to develop an I-centric service platform.

Devices – The miniaturisation of microelectronics has enabled small and powerful handheld devices. Two different approaches rule the market, the PalmPilot and the family of Windows CE terminals. Additionally, a new type of edge devices gained momentum – wearables. Those are small devices with a minimum power consumption that can be easily carried by human beings. The idea behind wearables is to design gadgets out of simple electronic components in place of ‘computers’. Thus, wearable computers can be seen as propagations of the human senses. The third type of devices is microelectronic controlled equipment. Target environments today are mainly in the in-house, business area and home area with wireline and wireless systems. In addition to ‘classical’ Customer Premises Equipment, such as telephone, fax, PC, etc., today many microelectronic controlled devices (stereo/video products, home theatre, white goods, light control, burglar alarm, person identification/location systems, etc.) are applied in a household. Most of these systems are currently stand-alone. Integrating theses devices in an integrated communication environment using existing or easy-to-install networks (e.g. power-line, wireless systems) will allow major enhancements to existing and the creation of completely new applications and services and thus provide a significant push to all players in the field.

Context-aware Services – Topics like service inter-working and service personalisation are already covered by recent development activities. The evaluation of the later one has shown, that just personalisation of services is not enough to match user requirements. Service personalisation considers factors like time (periods of time), costs, media conversion, and intelligibility to deliver information. However, there is no access to implicit situational information or context. Communication systems, which are not able to react on changes in their environment, cannot support users sufficiently. Context-aware applications can provide completely new functionality to users. Electronic sensors can be used to measure the temperature, the noise level, or the illumination conditions of the environment of a user. This information can be used to introduce context-aware applications that react on the user's current environment with regard to the user's preferences.

3.2.1.2 WWRF WG2 Organisation of work

Following the vision of I-centric communication, WWRF' WG2 has identified the main topics for service architectures for the Wireless World. The work program of WG2 reflects these topics. Figure 3.2-3 illustrates the relationship between WG2 work items.

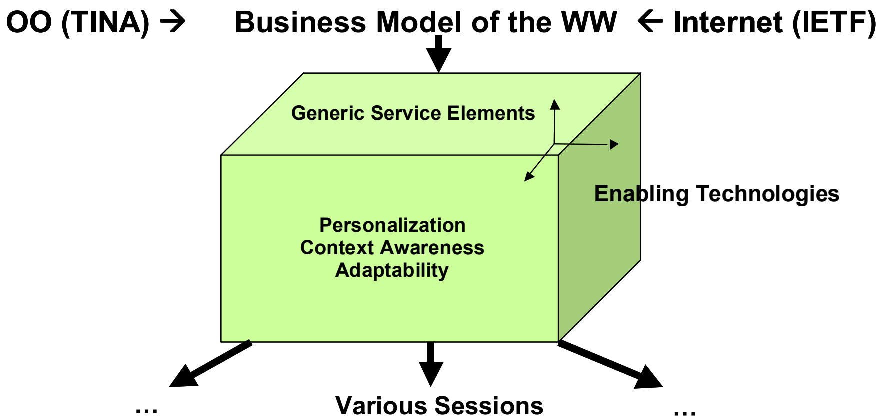

Figure 3.2-3: WG2 Organisation – Open Service Architecture for context awareness & ubiquitous computing

A business model is required in order to identify the major roles and reference points for implementing the I centric paradigm and to fit the requirements of the Wireless World. Based on this business model, WG2 will work on open service architectures and services that feature I-centric communication (context awareness and ubiquitous communications). The work will be backed by the development of concepts of service personalisation, context awareness, and adaptability for the Wireless World. Generic service elements like discovery or management will be developed. In parallel, enabling technologies will be analysed in order to identify the most suitable and the future technologies for implementing the service architecture. Based on the developed service architecture, a set of requirements for the underlying communication network, will be derived. These requirements will be used as input for WG3 and WG4.

3.2.2 Propose Research

3.2.2.1 Business Model

The convergence of traditional telecommunication systems, internet based systems and the emergence of new application scenarios (based on ubiquitous wireless connectivity) needs new kinds of business models.

The first objective of the required research is a model for the description of relationships between involved parties in a global business community. Based on these relationships, a business model defining roles and reference points should be developed. This allows the participation of each business partner on a global business on one side and provides the freedom in development and integration on the other side. Reference points provide standardised points of contact and information exchange between business partners. The roles are used to specify who contacts whom, for what purpose, regarding permissions or prohibitions. Such a business model for the Wireless World is a prerequisite for the definition of a service architecture that supports the required functionalities of the whole business life cycle.

Beside this, WG2 will also investigate in business models from a more value chain oriented viewpoint. Potential scenarios, including the whole process from service creation up to accounting and billing will be analysed. New applications and ideas of how to make money in the Wireless World will indicate whether the proposed architectures will be capable to satisfy all, the equipment manufactures, the service and network providers and the customers.

3.2.2.2 Personalisation

One of the major trends in the current information society is personalisation. Personalisation is the concept of adapting (mobile) services to the context, such as user preferences, user location, network and terminal capabilities. The concept of personalisation is somewhat abstract, and will be discussed in this section. The implementation of personalisation (how and to what do services get adapted) is described in the section on context awareness.

Personalisation is considered as being the key factor for success/failure of mobile devices and services. Information and services become increasingly tailored to individual user preferences and characteristics. The primary goal behind this kind of personalisation is to make usage easier and the perception of these information services more pleasant to users, and to enable personalised filtering of the enormous amount of available data. Another goal of personalisation, in a more commercial context, is to increase the perceived value of offered services.

Currently for UMTS, an implementation concept for personalisation focused on the portability of personalised information across network boundaries and between terminals is specified in the Virtual Home Environment. The concept of VHE is such that users are consistently presented with the same personalised features. Augmenting the Personal Service Environment (PSE) concept as formulated within the VHE, research projects exist that add service discovery and service adaptation as key functionality's of such an environment. Furthermore, the concept of personalisation should not be limited to merely the UMTS, or any other network technology. Network independence, IP-based networks, and global roaming need to be realised for systems in the Wireless World.

The wire-line Internet and mobile telecommunications worlds are converging and the next-generation mobile Internet arises. In a converged world, an extended personalisation concept is needed that enables value networks (e.g. value chains) of content providers, network providers and service providers to offer personalised services to mobile users in a way that suits their individual needs, at a specific place and time. These personalised services provide, next to data and content, emotions and experiences to the user. Especially in mobile environments this trend is prominent. The mobile device is considered as a personal assistant that offers unique opportunities such as real-time adaptation of services to a dynamic user environment.

In the Wireless World GSM-evolved networks will be integrated with WLANs (wireless local-), PANs (personal-), BANs (body- area networks), and other wireless technologies to form a ubiquitous all-IP environment. In such a world multi-channelling is common practice where personalised services are delivered to wire-line devices, wireless terminals and to broadcasting sets (e.g. EPGs, electronic program guides, in personal digital recorders or in home media servers, which are successors of the set-top boxes). Solutions and services are designed from the user perspective and no longer from the service or content providers. The service infrastructure (from physical to presentation layers) is hidden for users. The user is always connected to the backbone network ("always on") and uses personalised services according to his present location, role, needs, and time, etceteras. The architecture that provisions this must be neutral to the serving network and terminal technologies, allowing users to roam freely between networks and providers, world-wide. Further the open service architecture is of a distributed nature, and the user has optimal control over the use of his personal information. Issues around security, privacy and trust are solved.

In general, a further development of the distributed personalised service architecture is needed. All the personalisation aspects like e.g. user preferences, role/task, location, time, network, and terminal have to be integrated and the relation between the aspects must be studied. Further user studies are needed to know what user's experience as useful and added value services and this knowledge should be used in the personalisation concept.

Personalisation related to the different aspects has to evolve for example as follows:

Next-generation mobile terminals are expected to be capable of multimedia (voice, data, text, images and slow scan video) and based on a combination of functions seen in laptops, Pads, mobile phones, and even for example radios and remote controls for a wide variety of devices. This means that for next-generation services and applications, a large variety of mobile terminals targeted at various market segments and user groups will emerge, with voice being only one of many features. As a result, adaptation and tailoring of functions and services to the specific terminal characteristics has to be realised, hidden to the user of course. In addition, when multimedia becomes more important, the need for guaranteeing certain levels of Quality of Service (QoS) becomes imminent. In mobile environments, where users are in the influence-range of changing networks, QoS guarantees will lead to the need for dynamic personalisation functionality (e.g. content tailoring) and mechanisms on a networking and service level. Finally, the changing location of a mobile user opens the way for a completely new range of services and applications, which use location dependent information to offer users personalised services.

3.2.2.3 Context Awareness

Services become personalised when they are tailored to the context and adapting to the changing situation. The context in this sense consists of many aspects, like the needs, preferences, history, and behaviour of the user, location-related aspects, like physical co-ordinates and velocity, but also ambient conditions, technical aspects like bandwidth of the network and capabilities of the terminal, business rules that apply etc. Context information can thus be defined as any information that can be used to characterise the situation of an entity.

One of the most appealing and typical mobile services of today are based on location-awareness. Services can be delivered to users everywhere. Moreover, the location of the user influences the service (what is delivered, e.g. a map of a, for the user unknown city that dynamically changes in accordance with the user's movement or of which the scale dynamically changes upon the user's velocity). Context awareness goes far beyond location awareness. Technical periphery is part of it (what bandwidth is available, which terminal capabilities does the user have). Also all kinds of user-related circumstances (does he prefer classical music or house, can and should he be disturbed in his present activity for a certain service, what language does he prefer, what is the current time for the user), but also emotions play a role. What mood is the user in: does he need to be comforted after an anxious, stress-full, experience? The context-awareness extends to adapting the I/O characteristics of devices. For example, while driving a car an incoming mail message should be preferable directed to the car's audio system instead of being displayed on the driver's mobile phone, thereby avoiding the driver to concentrate on browsing through the phone menus.

Currently, the context factors that are implemented in personalised services are limited. Examples are the user's history (which services did he use before, which products did he buy before, e-commerce, etc), user's location (e.g. by GPS in USA), user's network and device capabilities, etceteras. Different stakeholders gather, store, use and manage context information from the interaction with users. By its nature context information is distributed and incomplete. Several efforts exist on building an open architecture based on web services using SOAP (simple object access protocol), UDDI (universal authority mark-up language), and WSDL (web service description language). Efforts exist that relate to exchanging context-information. Examples for end-devices are the CC/PP (composite capabilities/preferences profile) framework and the UAProf (user agent profile) specification. Examples for networks are e.g. OPES (open pluggable edge services), CDI (content distribution internetworking), WEBI (web intermediaries) from IETF who develop frameworks and standards for communication between intermediaries within the network, especially for content peering and adaptation purposes. The MPEG-7 standard deals with multimedia content schemes (metadata) with possibilities of tailoring content to terminal characteristics and user preferences (presentation, language, etc), and enables personalised filtering and searching and browsing of AV content. OSA/Parlay specifications define a.o. mobility API's, and PAM formulated specifications for managing the presence and availability of entities. In the video and audio entertainment sector issues are addressed of controlling functionality's across a network, like in HAVi (Home Audio Video Interoperability) and UPnP (Universal Plug and Play). UPnP is an architecture for pervasive peer-to-peer network connectivity of PCs of all form factors, intelligent appliances, and wireless devices. HAVi is a digital AV networking initiative that provides a home networking software specification for seamless interoperability among home entertainment products. Examples are TV with voice recognition capability, or a video camera that automatically starts a recording when a visitor arrives unexpectedly during the night. Further exploration of techniques such as used by HAVi to enable devices previously unknown by the network to be used could give interesting options for application interfaces with low complexity.

In a decade time the wireless services will be tailored to the integrated aspects that form the user-context. Furthermore, the services will automatically, in real time, adapt themselves to changes in the context. The mobile user moves around, and thus the services deal with a dynamic user environment. The adaptation to the context is hidden for the user and provides him with optimal experiences and added value. Vice versa, the environment of the user can be influenced by the presence's and activities of the user and adapt itself accordingly.

The context will consist of the following categories, following the profile data that is gathered, used, stored and managed by several parties and at several locations:

- User-related category, typically consisting of user preferences, user history, user interest, user role, user priorities.
- Mobility and location-related category, typically embedding physical co-ordinates, velocity, direction of movement, ambient conditions (indoor, outdoors, temperature, humidity, etc),
- Network and terminal characteristics, like bandwidth, graphic capabilities, screen size, etc,
- Non-user-related information that e.g. contains content-related preferences (like presentation format, encoding, etc), but also business rules that applies.
- Service-related information, e.g. describing what the service delivers, pricing information, requirements the service poses on network and terminal, etceteras.

In the mobility and location-related category sensory input will play a major role in providing the information. Sensor technologies are embedded in the mobile equipment and networks and services will sense who the user is, where he is, what he is doing, what the environmental conditions are, etc. The environment itself will also be equipped with sensors that perceive users and communicate with their devices.

Context information -gathering and -adaptation is obtained from a profile learning functionality. Possibly, in the future smart intelligent agent technologies will be used for it. Another option is using an automated learning functionality as described under adaptability (see the next section). The profile data typically has a distributed nature and parts will be available for different stakeholders. Furthermore, it has static and dynamic parts. Data management and incomplete profile data issues are solved.

Advances in sensor technology are conditions to reach further adaptation of services to - and co-operation with - the environment of users. Many devices in our current world already adapt in some form to their operating environment. One example is the television set that adjusts its image contrast to the ambient lighting level. Miniaturisation and integration between sensors and wireless devices has to proceed further. ‘Intelligent I/O behaviour’ can be used to adapt the output characteristics depending on the situational context (e.g. mail message to car audio system or textual on cellular phone), but also the input characteristics should change in many situations (do not bother the user with long lasting search interaction, but combine the context information with the basic intention that was beforehand communicated by a few interactions). This intelligent I/O behaviour would demand the development of multi-mode user interfaces and corresponding support functions in the various consumer devices as well as in the service adaptation network.

An integrated approach that takes into account all aspects of the context categories in relation to the communication and computation capabilities of the environment is needed.

Consensus about the context and profile categories is needed (1), as well as about the format of the profile data (2), standards to exchange the context information and generic support for this exchange (3) and standards to secure protection of sensitive data (4). This accommodates extensibility, interoperability and security and can win the user’s trust. Generic support for distributed context information needs to be developed further. The perceived privacy of the user is a business enabler: without access to user-related context data many mobile services will not exist. Further, the issue of incomplete context-information (or profile data) must be solved. And different types of processing must be served (human and machine involvement, (semi-) automatic, and interactive processing).

The viability of context-aware services must be analysed from a business-point-of-view.

User acceptance will be an issue that needs to be dealt with. Insight in the user’s perception and requirements of context-aware services is needed.

3.2.2.4 Adaptability

Adaptability is one of the key research areas in nomadic computing. The basic principle of adaptability is simple. When the circumstances change, then the behaviour of an application changes according to the desires of a user—or more precisely according to principles ascribed to her. Services and context information should be dynamically adapted in the future to the context by the use of an automated learning functionality.

An important research topic is how to translate the wishes of users, which are almost always inaccurate, incomplete and sometimes even contradictory, into a set of rules precise enough for processing to be automated with sufficient reliability?

Learning the wishes and desires of a user is a crucial part of adaptability. Fully automated learning may be a utopia. Starting from an empty set of knowledge would take too much time. The learning path would necessarily contain too many malfunctions that upset the user who will be ready to discard the gadget.

Instead, starting from teaching is much more fruitful. In the same way as a child in a family is taught the habits of the family in a matter of years, the personal agents are taught the habits of the user in a few days. In this process the user interface is crucial: How and in which forms are users willing to give feedback? Most probably the feedback system cannot be unified but must be personalised for each user. The common attitude of a layman user—“I give feedback as I will”—must be the starting point of the user interface design. In particular, obtaining positive feedback is problematic. In some cases, missing feedback can be interpreted as a correct selection of action. However, in other cases that interpretation is questionable or even misleading.

Another crucial problem is the size and computational complexity of the knowledge base. Most probably the knowledge needs to be partitioned so that each subset is small enough. The partitioning, however, is not alone sufficient. The models presenting the subsets of the knowledge must be combined in different ways for different purposes. It should be noted that this is not the only application of partitioning in nomadic computing.

Adaptability cannot only be reactive. When the battery dies or the connectivity breaks, many actions are impossible. However, something could have been done beforehand. Therefore, adaptation must also be proactive, which, in turn, requires predictability of the near future. An important question in predictions is to distinguish between the situations in which the user behaviour seems to be predictable and those being unpredictable.

The objective should not be a perfect system since that would take forever. Instead, the goal must be a system that often (or at least sometimes) behaves correctly but almost never behaves incorrectly. Doing nothing is quite often a lesser evil than taking the wrong action.

3.2.2.5 Generic Service Elements

The service architectures for the Wireless World will have to cope with things like numerous service providers, always connected users, automatic service adaptation, context awareness and new IP devices. Aspects like dynamic service discovery and service provisioning in (for users) unknown environments and the personalised services usage requires new mechanisms inside Wireless World service architectures.

The most interesting tasks in this area are the development of concepts for:

- Service Discovery (a mechanism to discover service features dynamically)
- Service Management (massive numbers of parallel services will need new kinds of management)
- Service Creation (to provide a variety of services the fast creation of them has to be enabled)
- Service Deployment

- Service Composition (dynamic inter-working of services will help to create value added services)
- Service Logic (the evaluation of the current situation a user is in → decision what have to be done)
- Service Control (the process to control all the recourses needed for a specific service)
- Environment Monitoring

These functionalities will enable providers to make their products and services available in a flexible way. The same will make it possible for users to transparently discover the desired service. Assembly and configuration of complex service packages composed of various products needed to achieve the requirements stated explicitly or implicitly by the user. Last but not least this infrastructure will be used to deliver the service to the mobile user in the same I-centric manner. Consequently new technologies will emerge that will enable users to locate resources and services within their physical and network environment regardless of the underlying Internet bearer.

3.2.2.6 Enabling Technologies

In the Wireless World services and applications must offer ever-increasing levels of value and differentiation (i.e. they have to be attractive, intuitive and easy-to-use, with personalisation and ubiquitous access.). These services must also be developed easily, deployed quickly and, if necessary, altered efficiently.

Advanced software technologies are needed to enable this vision of an open service architecture for context-aware and ubiquitous computing. Within WG 2 it is a research task to apply existing software technologies with regard to the proposed service architecture, rather than to do research into completely new enabling technologies. This effort should be done clearly in cooperation with WG 3 which proposes to look at similar enabling technologies (section 3.3.2: agent technology, open APIs), particularly in the area of software-defined radio (section 3.3.3: research on software architecture [APIs, middleware technologies, re-configuration management]).

Open interfaces

The traditional telecommunication environments have some limitations in the areas of service portability and fast service deployment. Several initiatives have been started to overcome these limitations and constraints by opening and making the networks accessible for 3rd party service providers. The main objective of this work is to provide access to the network resources and network capabilities for innovative and creative 3rd party service providers and application designers in addition to the traditional network operators. This opening could lead to new business opportunities for the involved parties and also to an increase of network usage as well as higher revenues for the network operators.

Different solutions have been adopted to achieve this goal, including Parlay, OSA and JAIN. These solutions are more or less based on an open application programming interface (API) method. This API is defined as a set of technology-independent interfaces in terms of procedures, events, parameters and their semantics and it is based on distributed computing concepts such as CORBA, Java RMI and other technologies.

While open interfaces at the application level are the prerequisite for an open service architecture, it is important that applications' requests can be mapped appropriately onto the behaviour of the wireless network. Therefore open APIs are needed also at lower layers to enable customisations. Programmable networking aims at opening low-level access to network elements (routers, switches, base stations) by defining appropriate interfaces (e.g. IEEE P 1520). These interfaces can then be accessed by various entities (protocols, agents) to offer advanced, customisable and collaborative network services. This concept can then be extended with mechanisms for distributing and executing code which programs the interfaces on behalf of individual applications (including those running on end systems). The new paradigm has been called active networking.

These approaches require a lot of agreement between the involved roles, business systems and used technologies. Therefore a new trend has been coming up in the application space: The move from tightly coupled monolithic system towards systems of loosely coupled, dynamically bound components.

Software technologies

An open service architecture with open interfaces requires much more flexibility of the underlying software technologies. Therefore we propose to further do research in the applicability of the following technologies:

Agent technology

Intelligent software agent technology, one of the most important emerging IT-technology of the last years, plays the role of an important enabler for highly distributed and complex solutions, self-organising, and collaborative systems, solutions, and services. In particular agent technology is predestined for the integration of Web-Services (e.g. Microsoft's .NET or Sun's SunOne) being supported by suppliers. It is the ability to communicate, co-ordinate, and cooperage and associate the usage of learning, scheduling and other advanced techniques like matchmaking, or the migration of agents to other platforms, that makes agents and multi agent systems a worthwhile metaphor in computing and that makes them attractive when it comes to tackling some of the requirements in next-generation telecommunications systems.

Aspect-oriented Programming (AOP)

Aspect oriented Programming is a new programming methodology which extends the modularisation of software (realised today with object oriented programming) to also include "crosscutting concerns": instead of spreading parts of code implementing certain aspects of e.g., error-checking or resource sharing all over the code, those aspects are formulated as separate aspect programs and are integrated with the main code body by the compiler instead of the programmer. Thus, different aspects can be reflected much more cleanly in the code as with current approaches.

Event-based programming

Event-based programming means that the actions a program performs are triggered by something that happens, either in the program, or external to the program (e.g., by the user). This is called an "event". For instance a simple mouse click is an event. This is the usual way of programming user interfaces, however in the meantime also Java and other programming languages use this kind of programming for efficient communication between different components.

XML and beyond

The Extensible Mark-up Language (XML) is a mark-up language for documents containing structured information. It enables operations to be performed on content. New languages can thus be defined more easily. Several extensions, like RDF(s), or domain specific XML dialects (like ebXML) exist or are under development. Moreover SOAP, simply speaking remote procedure call over XML, is predestined to overcome the different component based architectures and supporting open infrastructures.

P2P

Peer-to-peer computing is the sharing of computer resources and services by direct exchange between systems. These resources and services include the exchange of information, processing cycles, cache storage, and disk storage for files. Peer-to-peer computing takes advantage of existing desktop computing power and networking connectivity, allowing economical clients to leverage their collective power to benefit the entire enterprise.

In a peer-to-peer architecture, computers that have traditionally been used solely as clients communicate directly among themselves and can act as both clients and servers, assuming whatever role is most efficient for the network. This reduces the load on servers and allows them to perform specialised services (such as mail-list generation, billing, etc.) more effectively.

Plug and Play Technologies

Plug and play technologies like Jini or UPnP, enables ad-hoc networking of different devices. It is based on existing technologies like TCP/IP, HTML, Java VM or XML. Using such an architecture, users will be able to plug printers, storage devices, speakers, and any kind of device directly into a network and every other computer, device, and user on the network will know that the new device has been added and is available. Each pluggable device will define itself immediately to a network device registry. The operating system will know about all accessible devices through some network registry.

3.3 WG 3 - New Communication Environment and Heterogeneous Networks

Infrastructures for cellular systems have traditionally been based on circuit-switched architectures. As mobile communications systems transitions from 2G to 3G and other generations, packet-switched architectures based on IP technologies are being explored to more flexibly position these future cellular systems as major (and driving) components of mobile networks. The Internet is a good example here. At the same time, other wireless technologies such as wireless LAN (WLAN), wireless PAN (WPAN), DVB, and DAB are emerging as other means of wireless access to the Internet. Such mobile access to the Internet has characterised the initial definition of mobile Internet, with the scope of mobility subject to the coverage of the relevant wireless network. This vision is certainly limited.

3.3.1 A Vision for Networking in the Wireless World {1}

Seamless Mobile Networking

Compared to the evolution of access technologies, the concept of the Wireless World is complementary. Using enhanced IP networking technologies to integrate hybrid systems (current and future systems) as a unified network, it enables a truly seamless mobile Internet beyond simply wireless access to the Internet. Thus, “Wireless World” does not merely mean generations after 3G, more significantly, it means surpassing 3G by extending beyond the scope of a monolithic system.

IPv6 offers not only virtually unlimited address space, but also sounder technical foundation for networking evolution with respect to security, mobility, QoS, etc. It serves therefore naturally as the basis of networking in the Wireless World.

Enhanced IPv6 allows for a unified open networking evolution independent of access technology evolution. This is significant because it enables networks in the Wireless World to exploit existing systems rather than abandoning them; to embrace new systems when they become available; and to leverage Internet application innovations rather than seeking desperately for killer applications.

The following figure illustrates the vision of a Wireless World network, which is composed of 3 aspects: integrated networking support, integrated radio resource/spectrum management, and enhanced applications. The integrated networking support of networking in the Wireless World allows more flexible network designs to encompass heterogeneous wired and wireless technologies, more innovative applications, less expensive deployment, and faster technology adoption. Thus in Wireless World networks, opportunities are created for integrated management of scarce radio spectrum shared between different access technologies to more efficiently serve users’ needs. Besides, there are also new opportunities for composite radio applications as well as location-, context- and QoS-aware applications.

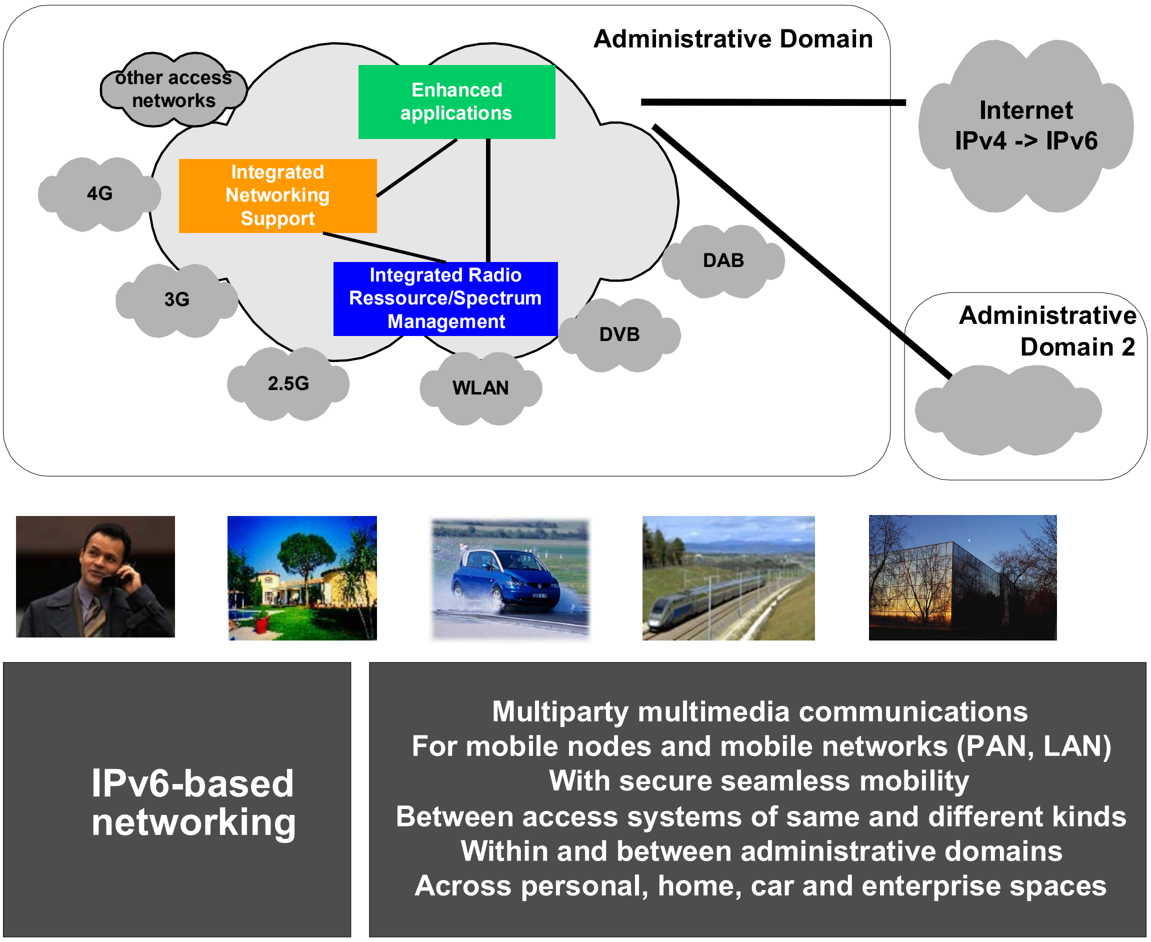

Figure 3.3-1: Networking in the Wireless World

The goal of networking for the Wireless World is to significantly enhance IPv6 networking technologies. This will enable mobile users to conduct multiparty multimedia communications with secure seamless mobility, as individual mobile nodes or in-house mobile networks, between access systems of the same and different kinds, within and between administrative domains, spanning across the person, home, auto and work spaces. Networking in the Wireless World also needs to be scalable, deployable, manageable and resilient.

Cellular network architectures

Mobile telecommunications networks, such as 2G, 2.5G and 3G, define complete network architectures with specific Core Networks to incorporate mobility and QoS support. The users' demand for mobile access to the Internet and the operators' increasing preference to provide IP-based application services have suggested that it is both logical and beneficial that cellular network architectures evolve towards embracing a purely IP networking approach.

With networking in the Wireless World, one possible evolution is that radio access networks or base stations could be directly attached to the IPv6 infrastructure, without any traditional mobile-telecommunications Core Networks. This allows future radio network developments to concentrate on link-level mobility, QoS and radio resource management, leaving network-level mobility, QoS and network management to networking.

Administrative domains

In Wireless World networking, the AAA-based administrative domains serve as a foundation for network administration and management. Such an administrative domain is typically owned and administered by an organisation that can be an operator, an ISP, a content provider, a company, a university, etc.

An administrative domain is made of an IPv6 infrastructure. Depending on the requirements of the organisation, the IPv6 infrastructure in an administrative domain may incorporate various wired and wireless access systems, such as Ethernet, 802.11, W-CDMA, HiperLAN, etc.

AAA provides a secure administration framework essential for IP-based mobile communications. A mobile user has only access to, and is charged for, the services that his profile allows. Whenever a user moves into a foreign administrative domain, some kind of AAA signalling between the visited domain and the home domain is required to allow the visited domain to serve the user. Typically, the AAA server is in charge of first authenticating a user in an access system in an administrative domain, then authorising him to access some specific services with certain QoS characteristics, in accordance with his profile, and also maintaining billing data charging purposes. In the context of Wireless World networking, it is necessary to integrate AAA into mobility and QoS operations so that a mobile user can effectively enjoy continuous access to the Internet with the expected QoS support. Specifically, one primary challenge is to minimise its signalling overheads (especially with the AAA server) during mobility between access systems within and between administrative domains, without compromising with the security measures in authentication and authorisation.

IP mobility

IP mobility support is primarily concerned with handover between IP-subnets for a mobile node, which has been addressed in Mobile-IPv6. However, it is increasingly important that mobility of a leaf-set of one or more IP-subnets as a whole be supported as well, especially in the case of LANs inside moving vehicles and PANs on mobile users. Moreover, IP mobility has to co-operate with AAA mechanisms efficiently to allow secure mobility between access systems within and between administrative domains.

In all cases, IP mobility needs to be enhanced to exhibit the following characteristics:

- Low handover delay: In order to support real-time applications, the handover delay must be minimised between the moment when link layer connectivity to an access point in a new networks is established and the moment when the mobile node can effectively receive IP datagrams through the new access point.

- Low handover packet loss: In order to support loss-sensitive applications, switching point of attachment from one network to another must be accomplished with little or no loss of IP packets. Typical techniques involve make-before-break strategies and bi-casting mechanisms.

- Efficient signalling: Even though the amount of available bandwidth is rapidly increasing, wireless bandwidth will remain a scarce resource. Another scare resource is the battery power available to a mobile node. The mobility support must therefore minimise the amount of (over-the-air) signalling and allow a mobile node to enter power-saving mode when it is not communicating.

- Scalable support: Proliferation of mobile devices and emergence of pico-cell architectures requires that mobility support is scalable for a large number of mobile nodes and mobile IP-subnets.

Seamless handover often refers to handover with low delay and low packet loss. As examples, the following approaches could help enhance Mobile-IPv6 to support seamless handover:

- Early address configuration: When a mobile node enters a new IP-subnet it needs to obtain a topologically correct IP address (as its care-of address). This can be achieved through either stateful or stateless address allocation mechanisms. This step could add significant delay due to the effort needed to ensure that duplicate addresses are not used. Mechanisms such as sending advanced handover initiate messages to generate a new address in the new IP-subnet could reduce such delay.

- Reduced signalling path: A mobile node needs to update its home agent and its correspondent nodes every time it obtains a new care-of address. Frequent changes in this address can potentially cause significant disruption in traffic. In general, two mobility contexts according to network hierarchy can be identified, namely, macro-mobility and micro-mobility. Based on network hierarchy, macro-mobility management handles mobility between distant access points whereas micro-mobility is concerned with mobility between neighbouring access points. Using some hierarchical mobility support for local mobility management in micro-mobility could reduce the signalling delay.

- Reduced packet loss: When a mobile node changes its IP-subnet, packets transmitted to the old IP-subnet will be lost. Techniques such as small group single source multicast routing can be used to route packets to multiple locations thereby reducing packet loss.

Providing mobility support at the network layer has the advantages of being independent of the link layer used in an access system. However, information from the link layer is essential for more effective and efficient support of seamless handover. For example, link-layer information could be used to predict the need for handover between access systems, and thus prepare handover at an optimal moment and condition.

QoS

QoS is typically based on intserv, diffserv, or a hybrid architecture of both. While intserv supports per-flow QoS, it suffers from concerns of scalability. On the other hand, diffserv is a more scalable approach but it supports only aggregated QoS. A hybrid architecture of both could offer the best of both worlds but it remains a challenge to support a end-to-end QoS architecture, which relies mainly on RSVP for end-to-end QoS signalling.

In a QoS architecture, a QoS policy framework could be established in which a QoS Manager serves as a Policy Decision Point (PDP) to co-ordinate resource allocation within a QoS domain, and access routers serve as Policy Enforcement Points (PEPs). In such framework, QoS requests transmitted through the network (e.g., using RSVP) are intercepted by the PEPs which then communicate with the PDP (e.g., using COPS) to determine how to honour these QoS requests. This concerns decisions in admission control, bandwidth allocation on a pre-flow basis, assignment to a diffserv BA, etc.

The provision and maintenance of QoS for mobile nodes adds even more challenge. Until now, IP technologies for QoS and mobility have been developed essentially independently, and little effort has been made to integrate their approaches. An established QoS session across the routers in a network needs to be maintained through a different path of routers as the node moves between different IP-subnets. This requires that QoS states, such as the diffserv BA assignment to the flow or the interserv bandwidth reservation, be re-negotiated and re-established by the QoS policy framework according to new constraints due to change in routing path. At the same time, the operation of QoS policy framework needs to be in accordance with seamless handover; otherwise, seamless mobility cannot be achieved for IP sessions with QoS requirements.

The Internet QoS architecture is independent of any specific access system. Thus, proper QoS mapping between IP- and access-system-specific QoS parameters is very important. Such mapping is indeed required between all protocol layers to eventually support an application's QoS requirement.

Multimedia applications are capable of being adaptive in its operations, for example by changing between coding techniques. This is a particularly valuable feature to be exploited when a mobile node traverses dissimilar access systems during the course of a session. Thus the application QoS interface and the QoS policy framework need to be enhanced accordingly.

Network management

In order to allow efficient and reliable deployment of a Wireless World system, access routers and access points (or base stations) need to be capable of both self-configuration and self-healing. When a new access router is added to an existing network, it should operate without manual configuration, possibly with the help of some network management server. When an element of the infrastructure fails, other elements should take up the function of the failed element. For example, when an access point fails, surrounding access points should detect the failure and increase their coverage to accommodate the affected users. While the failure would be reported to the system operator, users of the system should notice minimal disruption.

Wireless World systems must also accommodate the Internet's transition from IPv4 to IPv6. While a Wireless World administrative domain is based on IPv6, the wealth of content and services in the IPv4-based Internet must be available to Wireless World users. During the transition, there will effectively be two domains of IP networking capability. Although there are basic approaches addressing how to interconnect IPv4 and IPv6 networks, little work has been done with respect to AAA, mobility and QoS issues across the two domains. IPv4-IPv6 interworking technologies need to be developed to minimise adverse impact on the seamless mobility experience for Wireless World users when an IPv4 domain is involved in the users networking activities.

Conclusion

The vision of the Wireless World is a means to achieve total mobile communications convergence and to develop a seamless mobile network like the Internet. This vision is enabled by Wireless World networking, which undertakes enormous challenge to make the necessary evolution and enhancements of IPv6 networking technologies. Plenty of research needs to be conducted in the coming years. The following tasks could serve as a research framework for Wireless World networking:

Wireless World networking architecture

- AAA and charging for administrative domains
- Network management
- Wireless systems incorporation
- IPv4 and IPv6 co-existence
- Interaction with integrated radio resource management
- Enhanced services for applications

IP mobility architecture for the Wireless World

- Scalable mobility architecture
- Secure mobility with respect to IPsec and AAA architecture
- Seamless handover between access systems of same or different kinds
- Seamless handover within and between administrative domains
- Network mobility (mobile IP-subnet)

QoS architecture for the Wireless World

- End-to-end QoS architecture
- Mobility-enabled QoS policy framework

IP Multicast architecture for the Wireless World

- Mobility-enabled IP multicast
- QoS-enabled IP multicast

Transport protocols for the Wireless World

- Wireless-adapted transport protocols
- QoS-enabled transport protocols

3.3.2 Enabling Technologies for Systems in the Wireless World {2}

Issues

Researchers have noticed already that word 3G has suffered a lot of inflation and now it is trendy to speak about 4 or even 5G. To get some perspective it is useful to look to the past. It can be seen that each of the wireless Wide Area Network (WAN) generations has taken a decade to mature. Moore´s Law says that processing power doubles every 18 months. That gives the result that every 10 years, approximately, features should be 100 times more advanced than in the previous phase. This does not necessary mean that the bandwidth will increase that much but other features are improved. If most of the new processing power will be dedicated for the increase of the bandwidth, transmission speed in the Wireless World should reach 100 Mbit/s, and at the same time the price per bit has to drop to 1:1000 part.

However, bandwidth itself is not the driving force towards the Wireless World, but new user interactions and services are required. The inventive step has to be large enough to persuade for the new generation. There has been a lot of talk about the so-called Killer Application. Is it coming, does it exist or is it even needed? Another term used is Mass Murderer. It highlights the idea that there will be several new services that, combined, provide the incentive for the user, and not only a single one. As the future is always difficult to predict, it is better to concentrate on developing the infrastructure such that it enables a bright and rich future.

Possible Approaches

<u>Access Convergence</u>

Access to the Internet today is very dispersed. Each access environment has its dedicated means to access the core networks. Each of those have their own functionalities to authenticate and charge the usage, and interworking of networks is very limited. Surely this architecture is not optimal. Everybody should have seamless access to all services independently of their location and terminal type. Usage of the networks should be also very simple, so simple and seamless the user does not even recognise that the access network has changed. Charging principles should be unified and fair for easy usage. Security has to be confirmed whenever the service is used. Terminals may support multimode access technologies to achieve the best usage comfort and minimising the cost structure. An important technology to make that happen is Software Defined Radio. It enables the creation of open APIs for the radio interface and reduces the number of radio components. This is very essential to increase the battery life and make the seamless operations simpler. Intelligent terminals may benefit a lot from the multimode features.

<u>Enabling technologies</u>

Software development process

Different type of processes could be applied for the new generation development. One idea is that the focus of standardisation is moved from various interface specifications towards open APIs, on top of which almost anybody could create his or her own applications. This type of liberalised service creation has worked pretty well with GSM ring tones and logos. The number of service provides ensures the wide selection of attractive applications and the probability to find the killer applications will be multiplied. This approach can be taken even further. Software developers may learn a lot of how the Linux operating system was created. Fast, open and free code are the key words here. Linux is a living sample that software can be developed efficiently and on high quality in uncontrolled environment.

Architecture

The current 3G architecture is the direct result of an evolution strategy from GSM. This path was reasonable but it can be anticipated that the new architecture alternatives will get more momentum. Already for some time there has been a strong push towards internet centric solutions. It has been called Full IP in some papers, [1] and [2]. The major idea is to have one common internet core for all different access networks. One driver for this set-up is also the trend that terminal intelligence is expected to increase while the core network IQ will drop. Services are provided partly by mobiles themselves and the Service Domain while the Network Domain is responsible for the bit pipe management.

Protocols

Internet Protocol version 6

One thing is sure: IP will play major role in the future networks. IP will be like a water or electricity; it is everywhere and easy to access. The visions where even dogs and fridges will have their own IP addresses will inevitably require IPv6 update for all the IP networks. Surely there will be a transition period between IPv4 and v6 networks, but IPv6 will provide the long term solution. The enhanced address space is not the only advantage but the built-in security, QoS support and extension headers are almost as important new features.

Session Initiation Protocol

This protocol was specified by IETF year 1999 as one element of the multimedia protocol set. See more details from [3]. The novelty of SIP relies in the flexible structure. The basic protocol can be easily extended without any major standardisation need. SIP is a true multimedia protocol which can control and transport emails, pictures, WEB links, videos, service scripts, speech and finally the most important – any arbitrary combinations of all above. Useful built-in feature is also the support of multiparty sessions which enables various group services. As a summary it can be stated that SIP is the enabler for the future services and just the imagination of engineers sets the limits for the new ideas.

Mobility Management

Mobility control is the core part of the mobile system. In 2G and 3G systems MM has been tackled by dedicated protocols which have been incorporated deeply into the system specifications. These protocols provide the very best system inside performance but do not work across the different access networks. Although internet has not been designed for the mobile environment, it includes some useful weapons to control movement. SIP can be applied to locate one or more IP addresses where a user can receive media streams, given only a generic, location-independent address identifying a domain. This type of MM provides *personal mobility*, e.g. user can change the device without notifying the callers. But that does not work during the call and for that purpose we need something else. IETF defined Mobile IPv6 (MIPv6) to cover *device mobility* challenge. Unfortunately MIPv6 was not specified to support real time services and that is why the service disruption can be fairly long during the handover procedure. MIPv6 is called also *macromobility* protocol to illustrate the fact that it is targeted for services where a break of few seconds is not critical. To meet the real time requirements IETF started several paths to solve the *micromobility* challenge. There are now a few alternatives on the table, see [4], but the long term solution is still missing. It is self evident that MM has to support both device and personal mobility for seamless operations.

Services

Agent technology

Among the research community there is general consensus about the need for agent technology. Intelligent agents can save a lot of time, a fact most people have experienced when surfing the web. Agents may search information on behalf of the user according to preference lists. That may happen automatically and during the night, when charges are lower. Combined with push service technology agents can fetch accurate information and deliver them without user interaction.

An important future service will be instant messaging combined with the location information gathered from different systems. In the offices telephone, cellular and email systems can be integrated to improve reachability. During the free time instant messaging implemented by SIP type of protocol will replace SMS services and also enable fascinating group sessions. Individual preferences can be easily programmed according to personal needs.

Location

One input for the presence information are the location co-ordinates. Location tracking accuracy will increase a lot in the future and the current variation of around 100 meter can shrink to meters. It is another story if a user wants this kind of accuracy or location tracking at all. Regulators try to sell this feature as an Emergency service requirement but public opinion should not be underestimated.

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3.3.3 Software Defined Radio (SDR) {3}

The Vision

The evolution of telecommunications in the next decade will be characterized by the convergence toward an IP-based core network and ubiquitous seamless access (2G, 3G, broadband, broadcast, etc.) in the context of hierarchical and self-organizing networks (Figure 3.3-2; [5]).

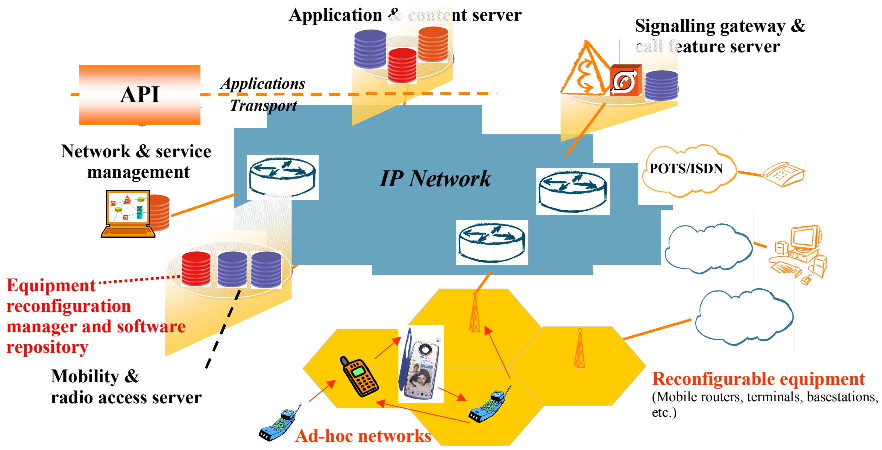

Figure 3.3-2: Convergence in Telecommunications {1}

The interworking, mobility management, and roaming will be handled via medium access systems and the IP based core network. Software Defined Radio (SDR) will have a key role in such a seamless network convergence. Mobile users will only benefit from this global telecommunication environment if they are equipped with a single re-configurable multi-mode multi-band terminal. These terminals have to be capable of operating in several or all of the different access environments and to support the whole range of applications available on the specific devices in the heterogeneous networks.

Issues

The main issues to be solved for SDR and re-configurable equipments beyond 3G are:

- Business models,
- Regulatory issues,
- User perspectives,
- Radio resource and spectrum management,
- System level issues (including interactions between terminals and networks, centralized and decentralized networks supporting re-configurable terminals, security, etc.),

- Enabling technologies.

To achieve the success of this promising communications evolution it is fundamental to realise that the definition of SDR, its design and development will require huge amount of efforts and research at all levels. In this chapter it is proposed to focus on the research relative to the SDR architecture of mobile devices.

State of the Art in the Area

Research in SDR has been initiated for military and civilian applications [5]. In 1996, a non-profit organization called the SDR Forum (ex, MMITS Forum: Modular Multifunction Information Transfer System) was founded to develop technical specifications and mobile standards requirements for its realization. Representatives from defence, commercial wireless, and civil government are present in this forum. Membership also includes service providers, network operators, equipment manufacturers, component manufacturers, regulatory authorities, and academia and research organisations. The activities of the SDR Forum have helped to raise the awareness of this emerging technology.

In addition, the sponsored research of European Commission in the domain of SDR also has been significant. Some of the past projects are the 4th generation ACTS and ESPRIT initiatives such as FIRST (Flexible Integrated Radio Systems Technology), SORT (Software Radio Technology), and SLATS (Software Libraries for Advanced Terminal Solutions). The current wave of 5th framework projects includes TRUST (Transparently Re-configurable UbiquitouS Terminal), CAST (Configurable radio with Advanced Software Technology), MOBIVAS (downloadable MOBIle Value Added Services through software radio & switching integrated platforms), SODERA (re-configurable radio for SOftware DEfined RAdio for 3rd generation mobile terminals), and PASTORAL (Platform And Software for Terminals Operationally Re-configurAbLe).

The majority of the published papers on SDR technology were originally and are still focused on aspects related to the digital front-end of the SDR terminals and functionalities of the radio interface. This is due to the difficult problems that are still unsolved in this field. On the other hand, very important and interesting issues such as the co-operation of the SDR terminal with the supporting networks were scarcely covered by the international bibliography.

Potential Approach

The research on SDR is at the confluent of three main research domains depending on each other as illustrated in Figure 3.3-3:

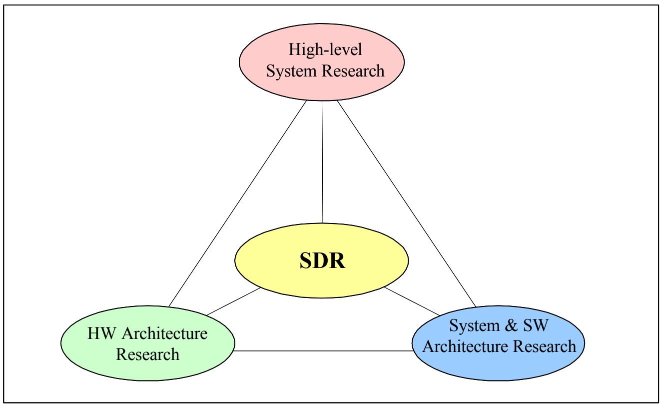

Figure 3.3-3: SDR Research

The themes of the actual research can be structured as follows:

- High-level System Research (Task 3.9):
  - Analysis of technical requirements and constraints associated to the different radio access technologies
  - Analysis of the feasibility requirements, considering the concurrent technological road-maps of HW and System/SW evolution.
- Research on Hardware Architecture (Task 3.10):
  - Analysis of partitioning between analog and digital baseband
  - Research on re-configurable RF Front-End and analog baseband
  - Research on re-configurable digital baseband.
- Research on System and Software Architectures (Task 3.11):
  - Analysis of the reconfigurability requirements
  - Research on System and network architectures supporting re-configurable equipments
  - Research on Network-centric re-configuration support
  - Research on Terminal-centric re-configuration support.

The high-level system research is the upper-layer research, and has to interact tightly with the two other research domains that are HW and System/Software architectures research.

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3.4 WG 4 - Spectrum, New Air Interfaces and Ad-hoc Networking

In order to provide continuous connectivity for “everybody and everything” to personalised services, systems in the Wireless World should be the integration of (second generation), IMT-2000, its enhancements, other systems such as WLAN type systems, short range connectivity, broadcast systems and new radio interface concepts on a common IP-based platform.

3.4.1 WWRF WG4 Structure of Work

Wireless technology plays a vital role in providing “continuous connectivity” between (end user) nodes and a variety of services. In a scenario where “everybody and everything is always connected to access personalised services,” several types of ‘human to human’, ‘human to machine’ and ‘machine to machine’ communication links can exist, see Figure 3.4-1.

Applications for wireless communication

Receiver		Transmitter: Human	Transmitter: Machine
Receiver	Human	Voice communications (VoIP) Video phone/conference Interactive games Chat Visual mail/audio mail Text mail	Video relay broadcasting Video supervising Human navigation Internet browsing Informatin service Music download
Receiver	Machine	Remote control Recording to storage devices: voice, video, etc.	Location information services, distribution systems, etc. Data transfer Consumer electronic device maintenance

↑ Real time — Permit delay ↓

Support of real time and non-real time services

Figure 3.4-1: Applications and users of future mobile and wireless services [Source: NTT DoCoMo, WWRF meeting Paris 2000]

The majority of presently used ‘human to human’ information exchange is voice based. A clear shift to data services is observed. In ‘human to machine’ and ‘machine to machine’ dialogue, the volume of information exchanged is small and a short duration ‘call’ at a low bit rate is usually sufficient. For ‘human to human’ and ‘machine to human’ Interaction for work or leisure, the situation is quite the opposite.

Intelligent Spaces in the future Wireless World shall contain a very large number of “intelligent” devices like wireless sensors, actuators embedded in appliances and/or carried by the living beings and interacting between themselves as well as their physical environment. In such cases, the spontaneous information exchange would be based on dynamically configurable ad-hoc networks of low/very low power transceivers located in appliances with varying information-processing capabilities.

The transceivers might be connected to sensors and/or actuators, e.g., micro and speaker but also visual and bio-sensors and related actuators are envisaged. The very high concentration of such transceivers would need large spectrum bandwidth. Also, some of the envisaged future mobile applications and services will be "location aware". This requires suitable new air interface technology capable of combining the functions of data transmission with that of precise location determination and position tracking.

Additionally, the existence of Moore's Law for bandwidth is more and more perceptible – the end users tend to embrace services and applications utilising ever faster data rates. The service bandwidth (offered/required) is doubling every 12 months or so. The constant increase in "users" injects further positive feedback in to the system – thus sending the BANDWIDTH demand spiralling up.

This potential growth scenario needs to be evaluated in the light of the following;

1. The extent of good quality radio coverage is inversely proportional to the transmitted bit rate. The cost of 'continuous' and 'all time everywhere' radio coverage increases very sharply with the transmitted bit rate. Spectrum will be necessary in low frequency range which provides the required coverage in sparsely populated areas.

2. The higher service bit rate, the larger is the required BANDWIDTH and the higher is the frequency range where some additional spectrum might be available to go on offering the required capacity.

3. The frequency spectrum assigned to radio services is used with a very different spectrum efficiency of the systems operated there. The regulation authorities appear to be especially restrictive when assigning spectrum for mobile radio use, resulting in high sophisticated air-interfaces like those of 3G systems and respective costs of development and deployment.

4. The economic value of a mobile radio service compared to that of other radio services, and the respective bandwidth capacity assigned, currently appear not to be key criteria for spectrum allocation.

5. The present (systems and service providers) users of the already allocated frequency bands would like to make the most out of their allocation. As a result, the sophistication of standardised air-interfaces, e.g., by introducing space-time coding, smart antenna systems and multi-hop links to improve the radio coverage, appear to be the direct consequence of frequency spectrum shortage for mobile radio use.

6. Proliferation of competing information services.

7. The variety of networks for provision of seamless services in private to public and short range localised coverage to wide area coverage will be limited by the necessity of cost effectiveness of the corresponding business case.

8. The requirement of a very wide consensus (much more extensive than technology standardisation) shall be motivated by the globalisation of markets. The international regulatory frame needs to be enhanced to handle the co-

existence of wireless networks operating in distinct, adjoining and partially overlapping frequency bands and the inter working of permanently established and spontaneously created networks.

Based on the usually employed artefacts for improving the situation of spectrum congestion, the research topics proposed by this working group have been divided in the following categories:

Improved bits/Hz/sec/km2

This is achievable through improved signal design i.e. modulation and channel coding. Well-known methods for a vast majority of wireless channels are available. The theoretical limit of channel capacity (Shannon Limit) can be very closely approached through the use of existing mechanisms of channel coding in single input single output (SISO) channels. The system performance in multiple input – multiple output (MIMO) channels, commonplace in wireless communications, can be greatly enhanced by use of Space Time coding, multi-user detection and smart antenna techniques. Moreover, signal design for very high bit transmission (100Mb/sec) in difficult wireless channels (e.g., for fast moving mobiles) is still an open issue. So is the case of providing throughput like 1Gb/sec for the “hot spots”.

Information Compression i.e. signal processing and source coding techniques useful to reduce the source output bit rate so that a larger number of simultaneous calls be accommodated per unit BANDWIDTH, is well mastered for voice sources. More efficient algorithms for multi-media services are currently being developed.

Refined Multiple Access Techniques:

The ability to accommodate several users, accessing a given service, simultaneously in a communication channel can go a long way to improve the situation of spectrum usage. The presently deployed ‘contention free schemes’ are well mastered. Further improvement through the use of ‘contention based (or tolerating) multiple access schemes’ for packet mode communication are possible. Simultaneous implementation of adaptation mechanisms at different layers of the protocol stack should be helpful in improving the system performance all the while allowing for fine granularity of spectrum usage for different mix of services (channel or packet switched).

Short Range Spontaneous Networking;

A naturally existing trade-off between the transmitted power and the improvement of efficiency in the use of the radio spectrum can be exploited through applications of ad-hoc networking of wireless capable nodes. Body Area Networks (BAN), Personal Area Networks (PAN), networking between appliances at home and office and wide area networks of permanently installed and/or mobile nodes shall be instrumental in bringing about the success of “everything, everybody always connected” idea.

Also, technical issues for all the protocol layers need to be considered. A non-exhaustive list is provided below:

- Network Layer: Addressing, Routing, Mobility and Topology Management

- Medium Access Control Layer; Centralised vs. Distributed, Fairness, Quality of Service Support, Varying Node Capabilities
- Management of Spectrum vs. Device Resources (Transmit Power, Processing)
- Auto – configuration: Service Discovery, Network Dynamics
- AAA and Information Security and User Privacy.

Additionally, it can be expected that such an evolved Wireless World would require new arrangements for managing the rare physical resource namely the radio spectrum. Hence the following category of topics needs to be duly addressed.

System Co-existence and Network Inter-working;

A large number of wireless technologies for varied applications exist and several new technologies are being developed. Moreover, multiple existing wireless technologies are being improved for their field of application. The introduction of DAB and DVB or the introduction of EDGE are a few examples.

It is proposed to develop an approach based on dynamic spectrum re-farming so that the use of radio spectrum < 1GHz for cellular and mobile communications be maximised simultaneously more efficient use of spectrum through system overlay and temporary allocation is achieved. Recommendations for spectrum sharing for the co-existence of several technologies and different applications shall be formulated through the comparison of efficiency / complexity trade-offs.

3.4.2 The Vision and the Issues

3.4.2.1 Spectrum Issues

Asymmetric traffic characteristics of uplink and downlink usage

The higher the transmit rate of a service the higher is the expected asymmetry of usage of the uplink and downlink channels, making the downlink a bottleneck in IMT 2000 systems. Both, UMTS Forum and ITU-R have published a projection of the future usage of IMT 2000 systems and have identified the spectrum needed for the specific services, see Figure 3.4-2. A substantial asymmetry of the expected average traffic has been predicted there especially for medium and high rate multimedia traffic.

This would require the further development of 3G systems to be able to support higher bit rate services on the downlink than on the uplink that could be realised by allowing a variable duplex spacing and multiple FDM channels for parallel usage on the downlink.

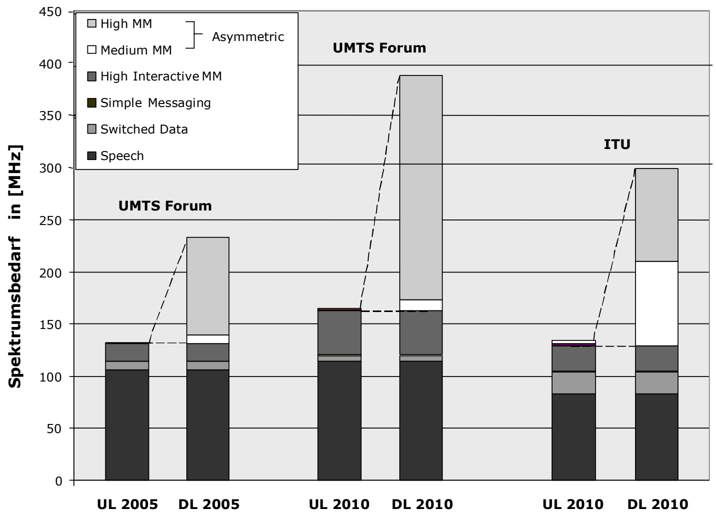

Figure 3.4-2: Projection of the future usage of IMT 2000 systems (Source: UMTS-Forum, Report No.6 and ITU-R Report M.[IMT.SPEC])

It has been proposed to combine cellular radio and digital broadcast services into an integrated system to make use of the high downlink capacity of broadcast systems as part of communication sessions initiated via cellular radio. Experiments have proven the design to be feasible but to have a limited flexibility owing to the MPEG-2 container used for data transmission in the DVB-T standard. Per DVB-T (8MHz) channel even at very high speed a total data rate of 12 Mbit/s appears to be possible. A capacity improvement of the combined system could be realised, especially, for broadcast applications in UMTS but not for point-to-point communications owing to the large TV broadcast cells and the resulting small capacity.

A homogeneous system where UMTS instead of DVB-T is applied on the 8 MHz TV-channels appears much more attractive, since no multi-mode terminals would be needed then.

The downlink in the broadcast band could be provided from all the base stations of a cellular operator in the coverage area, instead from the TV-towers only, allowing a much higher capacity gain through cellular spectrum re-use. Dynamic channel allocation to provide UMTS downlinks on TV-channels needs a concept called co-farming of spectrum [Bernhard Walke, Spectrum Issues for Next Generation Cellular, Proc. Visions of the Wireless World, Workshop of the Wireless Strategic Initiative, December 12, 2000, Brussels, Belgium] to guarantee both, the broadcast operator and the cellular operator a mutual benefit from this. Further, the UMTS standard would need to be extended to allow various duplex spacing and multiple downlink channels.

Radio LANs for broadcast and asymmetrical traffic support

Radio LANs (RLANs) have been proposed to complement the service capacity of 3G systems and have been studied, e.g., in the IST/BRAIN project [WK, UWB]. The co-operation of cellular and RLAN is by means of access to a common core network using a multi-mode terminal controlled by a mobility management function comprising both access systems to provide the user the best service possible at a given location, see Figure 3.4-3.

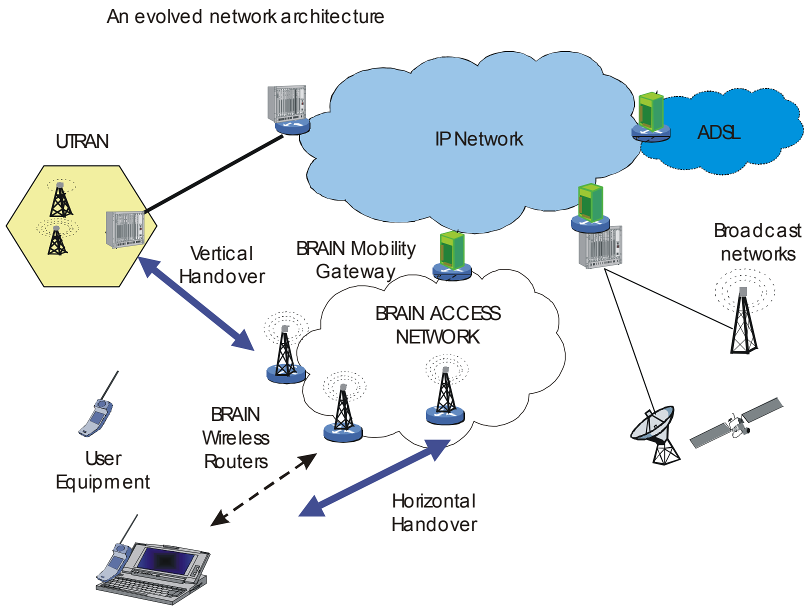

Figure 3.4-3: Hybrid network architecture studied in the BRAIN project

The idea behind BRAIN is to provide broadband services in so-called hot spots where a RLAN based pico-cellular radio coverage is provided, including horizontal handover across access points providing broadband access and vertical handover between the two different access networks.

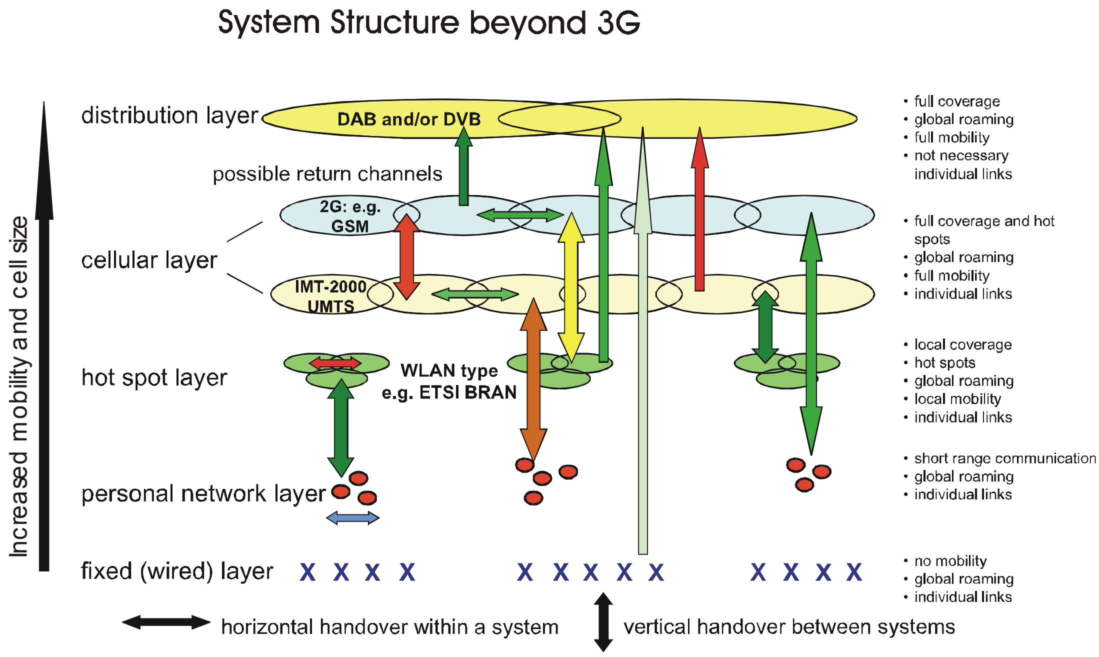

Figure 3.4-4: Layered architecture of an integrated radio network comprising digital broadcasting, 2G and 3G cellular, WLANs in hot spots and personal area networks [WK]

The RLAN technology might be based on ETSI/BRAN HiperLAN/2 (H/2) or IEEE 802.11. Systems combining 3G (UMTS) and RLANS are expected to come into operation in Europe in the year 2003, according to announcements in 2001 of some network manufacturers.

This would complement the integration of radio based systems like digital audio broadcast (DAB) and DVB-T, besides personal area networks (PAN) like Bluetooth into a common network architecture as shown in Figure 3.4-4 [WK]. An architecture like this is close to implementation since the elements are available already and an integration on the network layer into a common system (by means of inter-working) appears feasible. Then, radio interfaces developed specifically for the various speeds of mobility and classes of service will be combined as access networks to become a common core network to provide universal mobile access for all services known from fixed networks. This system would be able to support any class of traffic (point-to-point, point-to-multipoint, broadcast) by using the most appropriate air interface in a most spectrum- and cost-efficient way.

Air Interfaces

Experience from the past has shown that the idea of an universal system able to cover all the needs in a given application area cannot be realised. Instead, a multitude of air-interfaces will be needed in the future to cover the quite different needs of mobile and wireless (slow-mobile) communicating users.

Multi-mode terminals will be a must that are able to hook-on whatever air-interface that is best suited from a number of available interfaces in a given environment, seen from traffic performance and cost considerations. The way to realise such a terminal is described in the Chapter 2.3 on reconfigurable radio terminals.

To get an understanding of the issue, Figure 3.4-5 from [BW] shows some of the criteria to be considered when applying a multi-mode terminal to serve a mobile user in an optimum way.

The characteristics of service provisioning and the class of service will be the main decision criteria for the use of one of a multiple air-interfaces available from the same or a number of competing operators, namely

- availability under the current conditions of terminal movement, e.g., radio coverage
- timeliness of the service to be performed, e.g. instantaneous when demanded, semi-instantaneous, e.g., provisioning within a given time window
- cost of service per time unit
- quality of service, e.g., real-time requirements in terms of delay and delay jitter for an interactive service, transmit data rate required,
- service management, i.e. ease of use services across different radio networks, supported from the terminal and the operators.

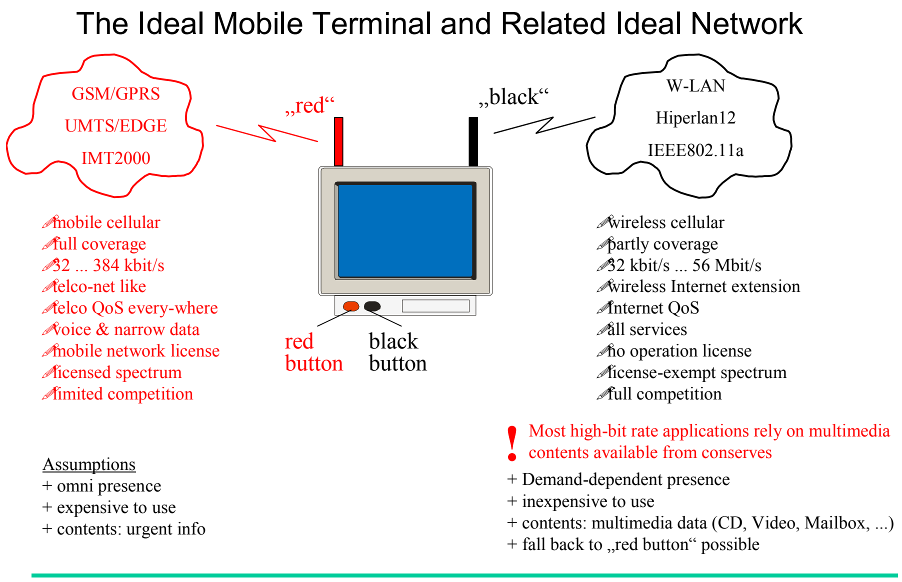

Figure 3.4-5: Multi-mode terminal of a radio network with multiple air-interfaces [23]

The two buttons shown at the terminal serve only to make visible the internally contained functions that decide what radio network to use for what service under what conditions.

The multitude of air-interfaces addressed as natural representations of the systems shown in Figure 3.4-4 motivates to engage in research towards more unification to simplify the terminals using these services. This would require air-interfaces able to cover two or more application areas in a specific cost-efficient way.

Besides this goal a demand for higher speed data transmission with mobile radio systems of 100 Mbps or even 1 Gbps has been expressed, see the submissions to the WWRF meetings, collected in the appendix.

Spectrum related characteristics

At present, strategies for handling interference between different radio systems typically assume a fixed allocation of frequency bands to operators and/or services, with sufficient guard band (Minimum Frequency Separation) [16] between neighbouring spectra, and a set of rules for spectrum usage (Frequency Sharing Rules) [17] [19] in cases where a common spectrum is used. Based on this assumption, the evaluation of the efficiency of these strategies is done by modelling the interference phenomenon together with statistical analysis of the models, to obtain, for example, a prediction of the probability that remaining interference will cause unacceptable degradation to either service. Under the assumption of fixed spectrum allocation, such studies have been performed for special cases (UMTS / DECT, GSM / TETRA) [20], where for example analysis of the interference situation allowed prediction of the GoS for a given guard band.

Present strategies may be improved with regard to the following aspects:

- Almost all radio systems face time-dependent load characteristics. Most services, for example, have a certain, predictable load pattern over the course of a day, with peak times and low-load periods. With statically assigned spectrum, these systems will try to prepare for peak load by reserving bandwidth as close to the expected maximum load as possible, in order to guarantee QoS even during peak times. However, most of the reserved spectrum will be unused for long periods of time. Dynamic allocation of spectrum may enable use of these unused resources for other services, which might face a shortage of bandwidth at that moment.

- Spectrum efficiency may be increased by choosing the optimal transmission technology for a given load scenario. For example, data may be transmitted both via a point-to-point UMTS link and a broadcast DAB link. In a scenario where several mobile users are requesting the same data, transmission via the broadcast service will be more efficient, as otherwise several point-to-point links will use bandwidth to transmit the same data over different dedicated radio channels.

- Instead of allocating fixed guard bands between services, intelligent systems may, at least to some extent, be able to detect or predict interference, and avoid impaired channels only in situations were interference actually occurs. Thus spectrum that was reserved for guard bands can partially be used, thereby freeing additional spectrum for communication use.

- Existing systems cannot exchange information on their respective spectrum usage. It can be expected that co-operative allocation of spectrum can significantly decrease the need for guard bands, by allowing the systems to negotiate what parts of the impaired spectrum between the two services is used by which service.

These advances and the impact of dynamic spectrum allocation on the interference between the different radio technologies are studied in the *DRiVE* project. It can be expected that the type of radio technology using a given part of the spectrum strongly influences the level and spatial distribution of the interference emanating from this portion of the spectrum. So far, interference has been studied only in the traditional, static frequency environment. It is proposed to extend the existing interference models to cover flexible spectrum allocation and spectrum usage co-ordination. In order to optimise spectrum allocation strategies and to assess the need for guard bands, extensive studies on the statistical properties of these algorithms have to be performed.

Dynamic allocation of spectrum to radio services may be investigated instead of a fixed allocation as it takes place today.

Overall, the multi-radio approach to use spectrum resources more efficiently addresses the co-operation of different radio systems, preferably in a common frequency range combined with dynamic spectrum allocation and de-allocation.

In future research work, all these issues may be addressed within one approach because it is already predicted that the existing spectrum allocation for mobile communication services is not sufficient in face of the tremendous growth rates for this type of communication. Hence a future option is to open new spectrum. However, a fixed and world-wide allocation is difficult if not impossible to achieve; instead a dynamic allocation could possibly open a lot of regional spectrum capacity.

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3.4.2.2 Antenna Arrays and Related Techniques

The Vision and the Issues

Smart antennas are essential to increase the spectral efficiency of wireless communication systems. They can be realised by an antenna array at the base station and sophisticated baseband signal processing. Thereby, adaptive directional reception is achieved on the uplink and adaptive directional transmission on the downlink. Hence, an increased antenna gain and an increased diversity gain are realised towards the desired user. At the same time, less interference is received from the other directions on the uplink or transmitted in the other directions on the downlink. Therefore, more users can be accommodated by the system and a corresponding increase of the spectral efficiency is achieved.

Due to the fact that the uplink and the downlink operate on the same frequency in time division duplex (TDD) systems, channel parameters (e.g., spatial covariance matrices) estimated on the uplink can also be used to calculate the weights for *downlink* beamforming techniques. This is more difficult in frequency division duplex (FDD) systems, since the uplink and the downlink operate on different frequencies and some kind of frequency transformation or feedback from the mobile might become necessary. If no channel knowledge is available at the transmitter, space-time coding techniques can be used to increase the diversity gain.

Even higher spectral efficiencies can be achieved if antenna arrays are not only used at the base station but also at the mobile to create multiple-input-multiple-output (MIMO) systems. The achievable spectral efficiency, however, depends on the propagation and interference environment. If a rich scattering environment is available, an enormous spectral efficiency can be obtained via spatial multiplexing.

Current research efforts focus on idealistic channel models and simplified interference scenarios, which do not properly describe real-world channels. The spatial dimension of the propagation environment is particularly important to the suitability and success of different space-time multiplexing techniques, as well as to the mapping between the uplink and downlink channels. Moreover, the time-varying properties of the MIMO space-frequency channel are also crucial to the design of efficient MIMO transceivers. Therefore, MIMO channel-sounding campaigns are required at the frequencies and in the environments of interest. Depending on the chosen radio interface, suitable space-time processing techniques should be developed and evaluated by using realistic channel and interference models.

The integration of space-time signal processing to a variety of existing and future air interfaces is a topic that will deserve close attention. The ability of the employed techniques to work across a variety of propagation environments, traffic patterns, user and base station locations, number of employed antennas on each side of the link, while meeting their QoS targets, will be key to their successful implementation. Moreover, the ability of wireless networks and air interfaces to accommodate such re-configurable space-time processing techniques, further allowing the user to experience transparent operation amongst them, is another demanding task. Eventually, any given user terminal should be able to communicate with any base station (macro/micro/pico cellular, indoor / outdoor etc.), and any given base station should be able to communicate with any user terminal (mobile phone / PDA / laptop computer etc.).

Finally, future research efforts should also concentrate on the evaluation of the overall value of MIMO systems at the level of network performance. Novel schemes that allow the maximisation of the overall network capacity as well as the quality of service should be investigated and their comparative technical and financial values should be evaluated.

3.4.2.3 New Air Interfaces

The Vision and the Issues

Whereas 1G and 2G mobile systems were initially designed mainly for Channel Switched (CS) communication (like voice), in 3G efficient solutions to handle both CS and Packet Switched (PS) services have received a great deal of attention. As PS services are in general e.g. more delay tolerant but require better residual error rates than CS services, new air interface and network solutions must have been developed in order to specify cellular systems with good spectral efficiency. In addition to ability to efficiently handle both CS and PS services, another important design target of 3G systems has been to provide efficient support for applications requiring simultaneous transmission of several bit streams with possibly different Quality of Service (QoS) targets. All this has called for very flexible air interface and network solutions.

Although 3G systems represent clear improvements over 2G systems in terms of spectral efficiency, peak data rates, QoS control etc., work is already on-going on developing the systems even further. One of the first steps has been to define innovative solutions for improved packet access performance especially in downlink (from network to user terminal) direction. This is quite natural as it is anticipated that traffic volumes in downlink will be bigger than in the opposite (uplink) direction. An example service which follows this assumption is web browsing which is more downlink intensive. At the same time there has also been a lot of attention on network evolution which is heading towards IP-protocol based solutions.

Even though 3G and its evolution is expected to continue for several years, there is still a need to consider other (possibly) revolutionary air interface. By dropping out the backwards compatibility requirements with current and future 3G systems there is more room for new innovations which could lead to quantum leap in system capabilities. It should be noted, however, that any revolutionary solution must be clearly better than evolved 3G in order to justify any technical or commercial interest. Therefore, the targets for future wireless research must be set considerably higher than the anticipated capabilities of evolved 3G systems.

State-of-the art

The two most prominent 3G systems, WCDMA as specified by 3GPP and cdma2000 as specified by 3GPP2, are both based on Direct-Sequence Code Division Multiple Access (DS-CDMA) access scheme [1]. Thus it is quite natural that they employ very similar radio transmission solutions. The key features that contribute to the overall good performance of those 3G systems include:

- Efficient channel coding, rate matching and channel multiplexing solutions
- Various diversity techniques
- Beamforming
- Link adaptation techniques
- Shared channels for packet switched communication (only in WCDMA)

Flexible combination of channel encoding, rate matching and channel multiplexing allows the radio interface to efficiently utilise only the necessarily needed radio channel resources to get the desired QoS. Different transport channels[1] with (possibly) different QoS characteristics can be efficiently multiplexed into either single or multiple physical channels. Varying energy-per-bit requirements of different transport channels are handled by rate matching function which, by using repetition or puncturing, matches the channel encoded bit stream to the available bit rate of the physical channel. As a result the physical layer can efficiently handle various bit rates with no (repetitions) or little loss (puncturing) in performance.

Partly due to inherent properties of CDMA 3G systems can utilise various different diversity techniques including:

- Multipath diversity
- Macro diversity (soft handover)
- Time diversity (ARQ)
- Rx diversity (mainly uplink, but can be used also in downlink)
- Site Selection Diversity Transmit power control (SSDT, only in WCDMA)
- Both open and closed loop Tx diversity techniques

Use of wide variety of diversity techniques is one key reason for improved performance of 3G radio when compared to 2G radio.

3G air interfaces have got built-in support both for fixed and steerable beam concepts. In e.g. WCDMA network tells to the mobile terminal which signal (primary common pilot, secondary common pilot or dedicated pilot) can be used for channel estimation in downlink. As dedicated pilots are specified even user specific beams are efficiently supported.

There are two main link adaptation techniques in 3G systems: Transmit Power Control (TPC) and ARQ. TPC includes both open loop and closed loop solutions with an obvious goal of trying to minimise the Tx power yet keeping the target received signal quality level. The closed loop TPC can be further split into inner and outer loop control. The maximum rate of closed loop TPC depends on the frame structure of the physical channels. For example in cdma2000, TPC rate is 800 Hz.

Another (implicit) link adaptation technique included in the current 3G systems is Type I ARQ operating between data link layer protocol entities. Erroneously received data packets are discarded at the receiver end and retransmitted from the transmitter side. This provides automatic adaptation to local channel conditions as only “bad” packets need to be transmitted again.

Finally, WCDMA system employs also so called shared channel concept both in downlink and uplink (TDD mode only) directions. The basic idea is to schedule several packet users simultaneously on a single physical channel. This leads to efficient utilisation of channelisation code space and also improved throughput for packet switched services.

[1] In WCDMA standard *transport channels* define the interface between L1 and Medium Access Control (MAC) of L2

Research for future wireless

When 3G was initially envisioned in the early 90's it was not very clear what its breakthrough characteristics would be. The only self-evident requirement was that 3G must offer much higher data rates and higher traffic capacity than 2G. Soon after the initial deployment of 2G the goals and targets of 3G were better understood and the research and later on standardisation work could really start.

Now that the first 3G systems are being built it is natural to start asking what could be the next big step. The situation today with respect to 3G and what might come after it is not quite the same as with 2G and its successor 3G ten years ago. In many ways step from 2G to 3G was bigger than step from 1G to 2G. In 3G there is a lot of built in flexibility and extension possibilities so that it can evolve for long time and be able to provide a wide variety of different kind of services to the end users. Therefore, it is not clear what any system in the Wireless World could or should offer. In fact, it is a possibility that we will not see a full blown new mobile system generation after 3G. Maybe we will only witness the emergence of new radio access scheme that can then be connected to a 3G network.

As the present evolution seems to be going towards 10 Mbps/100 Mbps peak data rates any air interface for the Wireless World should be clearly better in order to justify its technical and commercial feasibility. Figure 3.4-6 shows the mobility vs. data rate both for different mobile system generations and also the research target for a possible revolutionary air interface for the Wireless World. There are several reasons why we should set the challenging research targets for the Wireless World of up to 100 Mbps and 1 Gbps peak data rates for wide area coverage full mobility and local area coverage low mobility cases, respectively. They include:

- 3G will go towards 10/100 Mbps (wide/local area) – beyond 3G should be clearly better
- No application may need that high continuous bit rates but the system may need it in order to
    - Serve many high bit rate users simultaneously
    - Maximise throughput/capacity
    - Minimise latencies
- There may be an optimum bandwidth which will maximise the spectral efficiency of a wireless system
    - Research target must be set high to "capture" that optimum
- Short distance radio bit rates will go towards 1 Gbps and users expect wide area coverage service level to be fairly close

Even though 100 Mbps/1 Gbps peak data rate target is very challenging it should not be impossible to achieve. Given the very challenging goals and expected long evolution path of 3G schedule wise we should target the year 2010 or later for possible commercial launch of any air interface in the Wireless World.

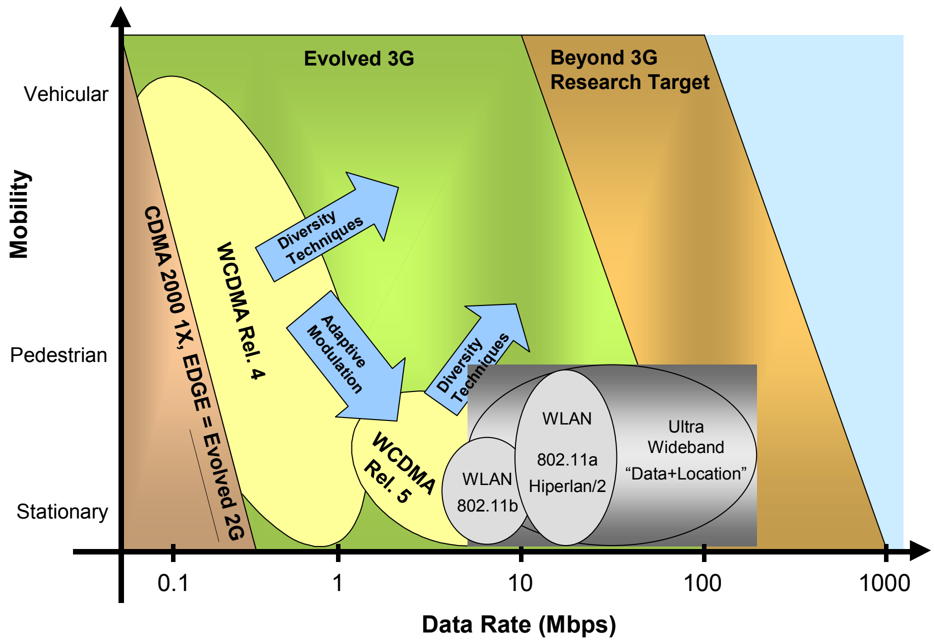

Figure 3.4-6: Mobility vs. data rate

How to reach the challenging goals presented here for an air interface in the Wireless World is a question for international research community to answer. Yet, we can list some potential research areas that need to be covered as part of beyond 3G air interface research including:

- Spatial domain solutions including Tx/Rx diversity, beamforming, MIMO
- Multidimensional adaptation (time, frequency, space)
- Multidimensional radio resource allocation (code, time, frequency, space)
- Error correction coding

Spatial domain solutions are very important if considerable improvements to wireless system performance are targeted for. Thus, techniques like Tx/Rx diversity, beamforming and MIMO should be studied carefully both with shorter (e.g. evolution of 3G) and longer term goals (possible beyond 3G solutions) in mind. In terms of capacity improvement spatial domain processing is probably the most important research area to consider.

Adaptation in general tries to optimise the performance of a single radio link. Well-known adaptation in time domain could be further extended to frequency and spatial domains. Expected gains in system (and link) level performance are quite likely less prominent than those reachable by multi-antenna solutions, though.

Already in 2G/3G radio interfaces it is possible to perform radio resource allocation in code, frequency and time domains. Note that in 3G systems like WCDMA spatial domain can be indirectly involved as cellular throughput depends on the scheduler algorithm and decisions to allocate resources to a mobile terminal may depend on its location. Further improvements could be available by adding the possibility for fast scheduling also in the frequency domain.

With the advent of Turbo coding the performance of error correction coding solutions have got quite near the Shannon channel capacity limits. Thus, big improvements from a single link point of view are not expected. However, combining channel encoding with various diversity and multidimensional adaptation techniques could yield bigger gains.

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3.4.2.4 Ad Hoc Networks {4}

The Vision and the Issues

Mobile ad hoc networks are formed by wireless[2] devices that communicate without necessarily using a pre-existing network infrastructure. Ad hoc networks are self-configuring, i.e. there is no (central) management system with configuration responsibilities. Some, if not all, nodes in an ad hoc network are capable of assuming router functionality when needed. This enables terminals to communicate with each other when they are out of (radio) range, provided they can reach each other via intermediate hosts acting as routers that relay the packets from source to destination. The structure of the network can change constantly because of the movement of the nodes. Ad hoc networks can be viewed as stand-alone groups of mobile terminals, but they may also be connected to a pre-existing network infrastructure and use it to access hosts which are not part of the ad hoc network.

What is the motivation behind research on ad hoc networking? It can be expected that in the near future there will be a proliferation of wireless devices. Ad hoc network functionality such as self-configurability and independence of existing infrastructures are key issues in this context. Examples are Personal Area Networks (PANs)[1], Body Area Networks (BANs)[2], home networks, networks of sensors and actuators (e.g. at home, cars, or those for ambient intelligence), or vehicle to vehicle networks.

Not less important, the multi-hop communication capabilities of ad hoc networks can be used to extend the coverage of existing wireless access technologies. Not only is this an interesting approach for cellular networks, but particularly in the case of high-frequency Wireless Local Area Networks (WLANs) due to opacity problems [3].

A third interesting aspect of ad hoc networking has to do with the intrinsic characteristics of ad hoc networks such as self-configurability [12] and neighbour discovery, which imply that these networks will be a key element for enhancing the interoperability among different wireless technologies.

[2] Stricttly speaking, ad hoc networks can make use of other technologies. However, wireless is the natural choice for spontaneous networking.

Finally, it is observed that network management and data routing in ad-hoc networks will be substantially facilitated if the underlying air interface is capable of delivering location information – in addition to transmitting data. (see references in task 4.6)

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4. EXPECTED RESULTS FROM THE RESEARCH

The table in this section is a synopsis of the “Expected Results” from the proposed research tasks specified in section 5.

4.1 WG 1 the Human Perspective of the Wireless World

Research Task	Expected Outcome
WG 1	*The Human Perspective of the Wireless World*
Task 1.1 - Modelling the structure and function of the Human User	• composite model for the inner control system of the human being
Task 1.2 – Scenario-based Service Development Methodology	• forum of highly qualified multi-disciplinary experts • deeper insights into potential contexts of use for new services, indicating possible end user demands and limitations. • identify bottlenecks in the development of new wireless technologies. Specific new research areas will be defined, like: • Services which are easy-to-handle, human friendly, personalised, situation-aware, low-rate services • Socially reconcilable solutions such as no-service environments (“recreation zones”), solutions for electromagnetic tolerance and applicable business models • Extended transmission carrier techniques such as non-electromagnetic, skin, water, soil, streets, animals, gravity waves, telepathy • Biological receivers, transmitters, networks, and interfaces; and • New understanding of information, knowledge handling, emotion transmission, and data security.
Task 1.3 - User-Centred Requirements for Contextually Aware Systems	• user-centred ontology of context comprising abstract and elemental context data types • standard data definition for abstract context types and elemental cues. • Requirements and recommendations for dynamic context definitions within service environments.
Task 1.4 – User Requirements for Universal Access and Assistive Technologies	• ICT products and services accessible and usable for all users, including elderly users and those with disabilities. • user requirements for people with special needs, including elderly, disabled and children • roadmap for the design and development of appropriate user interfaces and presentation techniques, based on a service platform in line with the requirements of people with special needs

Task 1.5 - User Behavioural Research for Applications in the Wireless World	• ethnographies, written, photo and video diaries, interview transcripts • abstracted analysed data: Personae, representative user descriptions, user scenarios, and “day-in-the-life” amalgams • user models, contextual design “work” models.
Task 1.6 - User Requirements and Technologies for Managing the Complexity of Future Wireless Systems	• user requirements and criteria for system to adapt to user preferences • HCI prototypes and user evaluations. • overall guidelines for implementation. • service platform for natural interaction between the user and the Internet. • guidelines for wireless networks architectures.
Task 1.7 - User Requirements, Architectures and Technologies for Augmented and Virtual Spaces	• improve the use of existing infrastructures (e.g. roads, parking places, etc.) • facilitate context-dependent commercial advertisement, and improve safety • enable new ways of enriching users experience • support virtual training partners that pace with the user.
Task 1.8 – User Interaction Paradigms; the Identity of the User in the Wireless World	• practicality of the service architecture • service interaction metaphors • requirements of the supporting technology, network and usability.
Task 1.9 – User Requirements and Technologies for Body Area Networks	• user requirements for wearable electronics • formal description of a generic BAN • systems architecture for generic BAN • software Architecture for BAN applications Insight into network layer requirements for heterogeneous networks. Application interfaces with low complexity. Physical layers for short-range communications around the body. Further insight into security issues for BANs, taking into account the need for flexibility and ease of use. • prototype of generic open extensible customisable BAN for patients/citizens • prototypes of BAN applications.
Task 1.10 - All Senses Communication	• test and prototype environment with a set of test cases for service developers.

Task 1.11 – Augmented User Interfaces	• basic layout for a small user interface based on Augmented Reality techniques • interface/application separation (hardware mock-up • identification of the core functions and how to separate and access them from the applications • simulate and prototype the devices and see how the functions map on the current applications and how the users feel about using a deviceless interface.

4.2 WG 2 - Service Infrastructure of the Wireless World

WG 2	*The Service Architecture of the Wireless World*
Task 2.1 - Wireless World Business Models	• generic business model that can be easily mapped to different scenarios of the wireless world • methodology for the definition of: o organisational models o process maps and flows o functional decomposition o requirements definitions o technology models o Use Case models.
Task 2.2 - Business Evaluation Tools	• in-depth market analysis, after the full definition of 4G services scenario
Task 2.3 - Profiling & Preferences	• format for profile data • profile categorisation and terminology • specifications to exchange profile information.
Task 2.4 - Personalisation Support for Mobile Services	• broad architectural view combined with a better understanding of user needs.
Task 2.5 - Context-Awareness of Mobile Services	• generic support for exchanging context information • specifications that describe specific types of context data such as user activity, geographical location and mobility, and physical circumstances • insight in the user's perception and requirements of context-aware services.
Task 2.6- Agent-based Profile Learning and Brokerage	• develop and deploy proper profile learning functions.
Task 2.7 – Generic Service Elements	• Concepts for: o Service Discovery (a mechanism to discover service features dynamically) o Service Management (massive numbers of parallel services will need new kinds of management) o Service Creation (to provide a variety of services the fast creation of them has to be enabled) o Service Deployment o Service Composition (dynamic inter-working of services will help to create value added services) o Service Logic (the evaluation of the current situation a user is in → decision what have to be done) o Service Control (the process to control all the recourses needed for a specific service) o Environment Monitoring.

<table>
<tr><td>Task 2.8 - Enabling Service Technologies</td><td>Agent technology
identification and specification of the necessary extensions to existing agents and agent platforms required to support seamless mobility
specification of the necessary local network element interfaces for the transfer of (IP) network state and objects
identification of a transition path from today towards a wide-spread deployment of agents applied to networking
specification of an interface to allow for programmability and customisation.
Open service architecture/open interfaces
definition of open service architecture based on the Web Services technology
analysis of how the Web Service concept could be used by defining so-called VHE components
verification if the Web service concept.</td></tr>
</table>

4.3 WG 3 - New Communication Environment and Heterogeneous Networks

WG 3	*New Communication Environment and Heterogeneous Networks*
Task 3.1 - Reliable Transport in Heterogeneous Wireless Networks: Do we need new end-to-end transport protocols?	• Design transport protocols that: o guarantee Quality of Service on an end-to-end basis o provide a new socket supporting QoS features as interface for application protocols (http, ftp, smtp).
Task 3.2 - Mobile Internet Integrated Network Platforms	• internet integrated network platforms.
Task 3.3 – Enhanced IP	• IP networking solutions to enable the Wireless World.
Task 3.4 - Wireless IP set of protocols, Wireless TCP/IP, Unified set of QoS parameters and QoS Aware End-to-End Transport	• definition of the set of QoS parameters • definition of a generic "IP over wireless" interface to specify the way information should be exchanged between IP and radio layers so that layer 2 can enforce QoS policy according to its own characteristics • application to specific convergence layers (e.g. IP over HiperLAN 2) • mapping of this set of parameters to UTRAN QoS parameters • enforcement of these parameters in a DVB distribution network • mapping of this set of parameters to xDSL QoS parameters • transport protocols allowing to handle Quality of Service on an end-to-end basis • new socket supporting QoS features as interface for application protocols (http, ftp, smtp).
Task 3.5 - Network and Services Management	• efficient network and service management strategies in a heterogeneous radio access systems context.

Task 3.7 - Optical Radio Access Networks - beating distance with capacity	• Future radio base stations need to meet a micro/pico cell scenario. Important issues include o Architecture, security, scalability, radio resource management, traffic modelling and characterisation, etc o Performance/cost efficiency achieved e.g. by using re-configurable logic and designed for test o Packaging and interconnects for low cost and power efficient HF and microwave components with high reliability (maintenance free) for in-/out-door environment. • At the terminal end – small lightweight intelligent terminals are needed. For these the following issues need to be addressed. o Efficient architectures, design tools, processes, interconnect structures and material systems for both chip and packaging o Small sized, light-weight radio systems with extremely high performance/cost ratio to the end user o Highly power efficient microelectronic solutions working at relatively high frequency o Flexible solutions, e.g. in system re-configurable logic o Built in security features and positioning possibilities o Backed up by a high capacity, fine meshed fixed (optical) network infrastructure. • To meet the combined capacity and flexibility requirement fibre optic developments are needed. Critical issues include: o Low cost optical modules and fibre installation technologies o High-capacity, flexible optical network components like optical add-drop multiplexers, optical cross-connects and optical wavelength routers o Future optical network architectures and efficient signalling schemes o Correct partitioning between optical and electrical functions for cost effective solutions.
Task 3.8 - The Security and Privacy Layer	• provide customers with the means to decide their security policies in a simple way • security definition language and protocols for secure interoperability.
Task 3.9 – SDR – High-level System Research	• consolidated road-map which ensures a complementary approach for SDR reconfigurable equipments research on both HW and System/SW sides.
Task 3.10 - SDR Hardware Architecture	• SDR architecture with well-defined building blocks and interfaces.

Task 3.11 - SDR System and Software Architectures	• platform-independent structure and re-configuration management scheme for re-configurable nodes in wireless networks. • resolution of issues: issues o Definition of minimum requirements for global connectivity, o Network reconfiguration management, o Definition of a software interfaces architecture to enable access and use of the re-configurable features within mobile networks. • architecture supporting re-configuration, based on an application programming interface (API) architecture for software definable radios • interface architectures for both terminal and system capable to enable and support re-configuration

4.4 WG 4 - Spectrum, New Air Interfaces and Ad-hoc Networking

WG 4	*Spectrum, New Air Interfaces and Ad-hoc Networking*
Task 4.1 - Spectral Coexistence of TDMA/FDMA and CDMA Systems	• identify the kind of services that are best-suited to be provided in each of the coexistent systems • identify methods to optimally place the base stations of the co-existent systems in order to ensure the required traffic capacity and service quality (this would be another research item) • compare the spectrum efficiency gain and the complexity and power consumption in mobile terminals.
Task 4.2 - Frequency Etiquettes and Spectrum Sharing Rules	• define Frequency Sharing Rules (FSR) • define measures to enable self-organising NG systems to make efficient use of spectrum for interference-free operation.
Task 4.3 - Spectrum Exploration for Mobile Radio	• in depth investigation of the practicability of the time-shared use, i.e., “co-farming“, of spectrum assigned by WRC, NATO, EC, and national governments to the defence community and to broadcasters • validation of the practicability: o candidate bands have to be identified o the practicability of the proposed co-farming has to be validated o the engineering of a service that is partly based on co-farming of frequency bands to be able to guarantee some service quality even when a borrowed band is withdrawn has to be investigated. This includes the definition of the relation of licensed and borrowed band of a public operator under the conditions of its service mix o commercial and competitions aspects have to be studied o the regulators views have to be taken into account and to be further developed to allow the shared spectrum usage o commercial models have to be developed that motivate broadcasters and defence community members to offer bands for shared usage to mobile operators. • The main RRM research topics identified are the following: o Spectrum management for asymmetric regular traffic and solutions for SDR to maximise asymmetry performance, o Inter-system handovers measurement and criteria, considering cellular (UMTS/FDD, UMTS/TDD, GSM, unlicensed TDD), WLAN (Hiperlan/2), PAN (Bluetooth) RATs, and use of broadcast in cellular systems, o Flexible spectrum allocation and design of potential collaborative RRM schemes considering solutions of spectrum sharing between operators, o Flexible spectrum allocation in a context of re-configurable equipment and self-organising networks.

Task 4.4 - Smart Antennas	• provide techniques for: o blind/non-blind/semi-blind multi-user detection (MUD) / multi-signal-stream detection techniques o beamforming techniques o high–frequency aspects of smart antennas in handsets o multi-input multi-output (MIMO) systems, including studies on advanced space-time coding/decoding schemes, (optimum) spatial multiplexing and eigenbeamforming concepts.
Task 4.5 - Location–Sensitive Radio Resource Management	• Concepts and methods for location sensitive handover and radio resource management.
Task 4.6 - Ultra Wideband (UWB) Radio Technology (UWB-RT): Short-Range Communication and Location Tracking	• contributions in defining representative applications and user scenarios and the deduction of requirements on qualitative and quantitative PHY and MAC specifications, particularly in the area of (joint) data transmission and location tracking applications • contributions in the areas of performance evaluation, algorithmic design, implementation of practical procedures for position determination, and location tracking of mobile stations in ad-hoc networks (tag-type and/or transponder-type systems) • contributions in the area of comparative performance evaluation (simulation and experimental measurements) of various coding and modulation schemes for UWB radio devices. Comparison of pulse-based UWB radio signalling with alternate (ultra) wideband modulation methods • demonstration (proof of concept) of selected hardware and software prototype functions required in UWB radio devices (e.g., joint data communication and location tracking) • broad consensus on: o Radio regulatory matters concerning UWB radio devices, and o submissions to international standard bodies dealing with UWB-RT.
Task 4.7 - Multi-Carrier based Air Interface	• development of OFDM-based multiple access technology that possesses the network flexibility of CDMA and the spectral efficiency of OFDM.
Task 4.8 - Multi-Hop Ad-hoc Networks	• provide: o scenarios o mobility Models o system requirements o active network concepts o prototypes o large-scale trials.

5. PROPOSED RESEARCH TASKS

5.1 WG 1 – The Human Perspective of the Wireless World

5.1.1 Understanding the User

Task 1.1 - Modelling the structure and function of the Human User {5}

Objectives of the proposed research

- Building and validating models of human behaviour for the purpose of predicting user acceptance or rejection of new communication services.

Rationale

There are almost 10^{10} human beings in the world. Most of them will be the users of the Wireless World described in the “Book of Visions 2001”. The present situation in the global wireless business emphasizes the need for new genuinely user-centred methods and tools for the selection, design, and optimisation of wireless products and services. Every business transaction requires a voluntary decision of a human being. Companies that know the user best will be the winners of the global competition.

State of the art in the area

The understanding of the user means describing him/her with proper and useful models. Presently, scenarios describing typical users and user situations are the main tools for modelling and understanding the variety of users. They are based on the mental models (tacit knowledge) of the product developers and selected users (as models for other users).

On a more general level, the present state of the art of wireless product and service creation can be compared to the engineering design of wireless devices and systems. As an example, there is a unified composite model for the GSM phone but there is no corresponding general model for the user of a GSM phone. The unified model makes it possible to carry out the engineering design as a co-operation of experienced people by systematically using methods and tools that are based on models for the physical systems.

The reason for the fundamental difference is that there is no unified model for describing the human being. Man is an extremely complex biological system in comparison to physical systems. For understanding the human being, the 6.1 billion people on earth unconsciously and consciously use everyday mental models, which are deficient and differ greatly from one individual to the other. The scientific disciplines use hundreds of different models suggested by individual people for describing and understanding the human being. Most of the models are partial models, corresponding only to parts of the real-world system and/or only during part of the time. Typically the models embody little or no structure. Some of the models are wrong: they do not correspond to the real system.

The Maslow hierarchy is an example of the partial models for the human. The list of references contains examples of the rapid advances taking place in areas useful for compiling a unified user behavioural model. During the 1990s, psychology has taken a turn towards modelling the human as a whole, integrating emotions with human cognitive characteristics. In marketing, Professor Gerald Zaltman at Harvard Business School has developed a method for measuring and understanding the customer behaviour on the deeper emotional level. In the field of artificial intelligence, Professor Marvin Minsky at MIT and Professor Aaron Sloman at University of Birmingham have developed complex system structures useful as the basis of a unified model.

Possible approach

The solution to the prevailing situation is intensive scientific research aimed at the inner structure of the human being. Systems engineering and hierarchical model thinking offer the most promising possibility for achieving the goal of the research. The new approach would mean extending the successful operating mode of engineers from the field of physical systems to the realm of biological systems. The work would cross the divide between engineering and humanism, requiring close cooperation of engineers with specialists in humanistic disciplines and fields.

The new approach would attempt to understand the human user by describing him/her as a complex living system. It would be based on the construction of a unified model for the fundamental structure and function of the human being. Recent results of AI research suggest that a 3-dimentional serial, parallel, and hierarchical network of networks could serve as the basic structure for the human inner control system.

The structure, consisting of hundreds of specialized networks competing and cooperating in a biologically parallel and hierarchical way, would make it possible to incorporate the complexity of human behaviour into the structure of the model. Examples of the inner functions are the pre-processing of the sensory signals and the creation of different types of representations (abstractions, concepts) on different hierarchical levels. The structure could also include the systems for biological survival, continuous individual development, and contribution to other people, which generate the human needs on different hierarchical levels from the basic biological needs to the higher unconscious and conscious human cognitive/ethical needs. The model would also explain the basic qualitative (constructive, maintaining, destructive) modes of human living. During the whole lifetime, the structure and the parameters of the genetically programmed system continuously develop and change in close interaction with the environment.

The inner control system drives the behaviour of all humans. Human behaviour results from the fundamental operation mode which continuously drives the system towards elevating the level of the inner emotional state through a combination of two mechanisms. The first mechanism aims at minimizing and eliminating negative feelings (pain) and the second mechanism at generating positive feelings (pleasure).

With the exception of the lowest-level functions (e.g. reflexes), this fundamental structure of the control system effectively decouples specific output behaviours from specific input events. This mode of operation destroys the direct cause-effect relationship, which is central in present science and engineering. Even so, there is an overall structure which can be discovered and modelled.

The inner mechanism explains the fundamental similarity and, at the same time, the great diversity of the cultures of the people of the world. The concept of the dynamical emotional state is also central to the development and marketing of wireless products and services. They can be regarded as instruments for elevating the emotional state. The increase caused by the product/service must exceed the decrease caused by the loss of money and by any negative consequences associated with the transaction. This kind of engineering approach leads to a fundamental definition of modern business: the purpose of the corporations is to raise the “feeling meter” of the customers by using the available resources.

The research would consist of basic scientific work in connection with experimental work, including the collection of important results of relevant disciplines and fields for incorporating them into a structured form useful for the Wireless World. The research program would employ a core team of systems engineers and humanists cooperating with a network of scientists and experts in the relevant disciplines and fields. The latest results in e.g. artificial intelligence, brain research, neurobiology, biology, and genetics would provide knowledge about the structure of the model. At the same time, knowledge in e.g. marketing, usability research, industrial design, cognitive science, psychology, psychiatry, educational science, sociology, and philosophy would be used to model the function of the system. The work would utilize modern tools, e.g. the self-organizing map by Prof. Teuvo Kohonen, for processing the experimental results and combining them with the theoretical work.

Expected results

The fundamental outcome of the research task would be a composite model for the inner control system of the human being with the emphasis on structures and functions important to the Vision of the Wireless World. The model could be divided into the model for the input system, model for the system for the emotional state, and model for the system for output behaviour. It would be a combination of graphical models, language models, analog models, and mathematical models. Initially, the models would be separated e.g. according to age and the emotional region (negative, neutral, positive). The work would proceed from static models during relatively stable situations towards dynamical behaviour. It would include real-time estimation/measurement of the emotional state in situations relevant to Wireless World products and services.

The models resulting from the basic research would allow systematic methods and tools to be developed for e.g. user segmentation and for the selection, design, and optimisation of wireless products and services. An example is the enhancement of the products to satisfy the higher human needs and/or multiple human needs simultaneously. Also, systems level products and services (wholes for raising the emotional state) based on combining advanced wireless technology with other technologies are possible. They would be designed and implemented e.g. as cooperation of brand companies.

The intrinsic advantage of the new approach is that the structures of the resulting models would correspond to the human structure more accurately that present models. Therefore, the underlying assumption of the research plan is that even the first relatively simple methods and tools would be useful to the WWRF partners. On a more general level, there is a historical analogy to describing and understanding the structure and function of mechanical systems. The universal adoption in science and engineering of the unified composite model (combination of Newton's laws with the models of the forces in nature) for mechanical systems has had a great impact on the world.

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Task 1.2 – Scenario-based Service Development Methodology {6}

Objectives of the proposed research

- To create, collect and analyse a comprehensive and manifold set on future communications scenarios with the goal to identify new research topics on wireless communications.

Rationale

The radical uncertainty and fast pace of developments in the wireless domain require researchers to turn to non-traditional ways to envisage future developments. Scenarios constitute a powerful way of doing this. Scenarios refer to creative, collective exercises, based on an analysis of crucial trends and uncertainties. Their purpose is to construct visions of future developments characterised by the interdependence of many, largely unknown factors. Over the past twenty years, a large and diverse body of expertise has been built up regarding the use of scenarios for different purposes and in different sectors. Generally, these tend to concentrate on technological development and diffusion or acceptance patterns, and to be rather oblivious of the impact of, for instance, strategic developments on service development.

What is lacking, therefore, is an integrated scenario method incorporating technological, user as well as business perspectives and combining the macro, meso and micro level. Based on an integrated scenario method, a potpourri of future scenarios has to be collected. These will be analysed considering various viewpoints to, finally, draw conclusions for future trends and future research topics.

State of the art in the area

There is abundant business and, to a lesser extent, scientific literature on future 3G services. These analyses and predictions are generally lacking on some, or indeed all, of the following three accounts:

- They are technology-centric, or fail to assess the interdependencies between business roles and strategies, user practices and technological innovations.

- They focus on individual users, or very generically defined groups of users, and their supposed needs or demands for services, instead of on different daily practices and potential contexts of use of established and new services.

- They don't have a clear vision on the integration of different mobile and wireless environments.

A notable exception is the work by ISTAG (IST Advisory Group) on "Scenarios for Ambient Intelligence". The report of the group [9] gives 4 scenarios including an analysis and overall conclusions. The report also covers in some detail the requirements for industrial applications.

Further research in this field would have to present and analyse additional rich reference scenarios, which integrate the aspects mentioned above. These scenarios must provide a framework of reference for more detailed and specific use cases and business models in the Wireless World.

Possible approach

Figure 5.1-1 gives an idea of the possible approach of creating and collecting scenarios with the objective to derive future research topics for the Wireless World.

The first step is to form a team of inter-disciplinary experts and to find appropriate ways and procedures on how to create, discuss and analyse scenarios. Scenarios from the past, lessons learnt from previous predictions and market successes and failures may also to be considered. The diversity of experts from different fields will certainly be of great importance. It may be desirable that a number of inherently different possible scenarios are constructed, instead of positive vs. negative scenarios or fast adoption vs. slow adoption scenarios.

The next step is to analyse the collection of scenarios. This will certainly imply extensive work, since it is not only based on the potential interaction between user and technology. Specific attention needs to be paid to barriers to adoption or production of a service, potential turning points, and critical dependencies between factors. The benefits for both individuals and the society should by scrutinised.

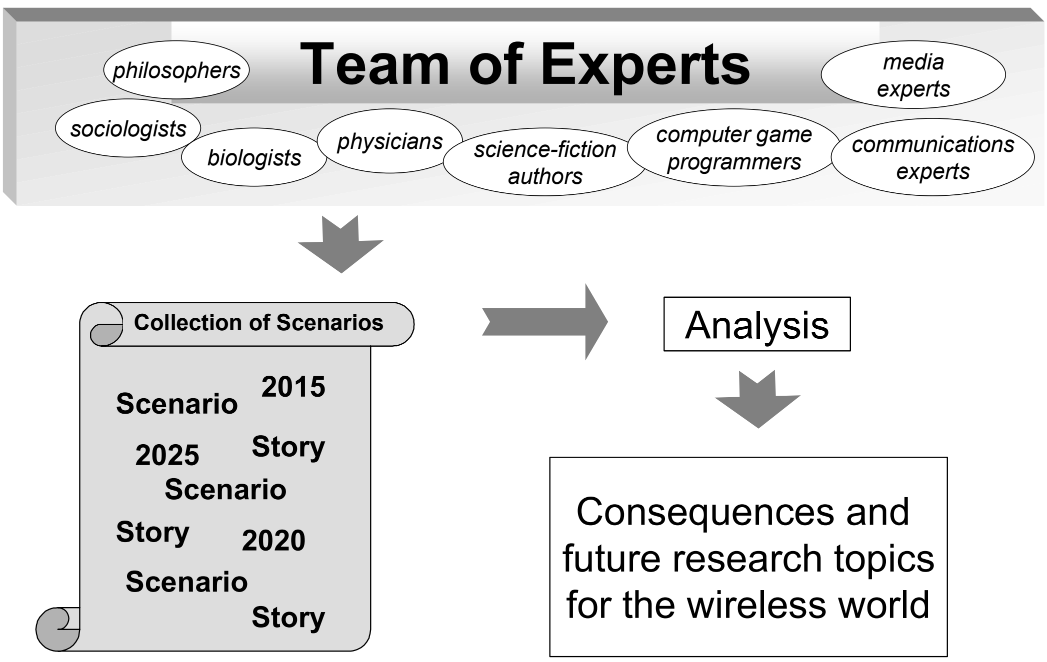

Figure 5.1-1: A team of multi-disciplinary experts creates and collects a suite of stories and scenarios, analyses it and derives consequences for the wireless research.

The final step will be to draw the conclusions from the analysis, to identify the technology needed to push and to avoid scenarios. This leads to the identification of future research topics in the Wireless World and possibly also for other domains.

Expected results

As general results we expect:

- A forum of highly qualified multi-disciplinary experts who are able to ask the right questions and to develop visions and future stories of the Wireless World under manifold views.
- To get deeper insights into potential contexts of use for new services, indicating possible end user demands and limitations.
- To see many facets of the future Wireless World, to identify bottlenecks in the development of new wireless technologies and to conclude with innovative consequences for the research in the Wireless World.

Specific new research areas will be defined. Without anticipating the results of the team of experts, new focuses may be unveiled like:

- Services which are easy-to-handle, human friendly, personalised, situation-aware, low-rate services (e.g. for older people), emotion carrying services;
- Socially reconcilable solutions such as no-service environments (“recreation zones”), solutions for electromagnetic tolerance and applicable business models;
- Extended transmission carrier techniques such as non-electromagnetic, skin, water, soil, streets, animals, gravity waves, telepathy;
- Biological receivers, transmitters, networks, and interfaces; and
- New understanding of information, knowledge handling, emotion transmission, and data security.

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Task 1.3 - User-Centred Requirements for Contextually Aware Systems {7}

Objectives of the proposed research

- Development of a user-centred system of description for context information

Rationale

In the wireless future, applications will use data from sensors and personal histories or preferences to enhance the user experience through situational or context awareness. An application will sense who and where the user is, the conditions in their environment, and/or what they are trying to do and adapt its operation and the information provided to the task. Two critical needs in this space are development of the application environment and an understanding of the user experience issues.

The application environment should be architected to encourage widespread development, portability, and interoperability of context-aware applications. In order to realise this vision of ubiquitous, context-aware systems, the environment needs to support the following aims:

- Applications should be portable

- Applications should be able to work with abstract representations of context

- Abstract context should be derived from sets of elemental context cues

- Details of this abstraction should be hidden from the applications

An important step in creating systems which facilitate the wide deployment and interoperability of context-aware applications is the development of a user-centred system of description for context information that can be common to the various system elements (e.g., the user, the application, the service environment (middleware), services, and sensors) dealing with contextual information. Such a language should facilitate the application level representation of and adaptation to context in a way that corresponds to human perception of context. The specific research objectives are:

- develop a user-centred systematic description of contextual information

- identify elemental context cues and their relevant data attributes

- identify an initial set of common abstract context types and their relevant elemental context cues

- investigate and recommend means to personalise and adapt context information

State of the art in the area

There has not been much research on how to describe and represent contextual information. The Knowledge Query Mark-up Language (KQML) and the eXtensible Markup Language (XML) are languages that can be used to define and express ontologies. The ontologies expressed with them have largely been created in an *ad hoc* fashion, focusing on issues of location, identity and time.

The ParcTab system, the seminal work in context-aware computing, divided the space of contextual information into three categories: users, devices and locations. Schilit et al. list the important aspects of context to be where you are, whom you are with and what resources are near by. The Context Toolkit work takes the approach that there are four primary pieces of context: identity, location, time and activity. Similarly, Ryan et al. suggest context types of location, environment, identity and time. In other work, Ryan defined a set of context metadata, including spatial and temporal coverage of contextual information.

An alternative to these *ad hoc* approaches is the more theoretical work from Öztürk and Aamodt. Here, contextual information is split into internal context (user's goals, hypotheses and expectations) and external context (situational information). This theoretical model stops short of specifying an ontology or representing contextual information.

Possible approach

We propose creating a user-centred context definition that focuses on understanding what abstract context types are important to people. Abstract context is defined as consisting 'of the *description* of different observable dimensions (or attributes) characterising a situation'. For example, observable attributes or elemental cues such as location and time can be combined to form an abstract context type that represents being in a meeting. Abstract context types can be composed of a set (or sets) of elemental context cues, for which standard data definitions can be created.

A preliminary step in defining abstract context types is to build a list from known context-aware applications and ad hoc context descriptions suggested by previous researchers. However, the main research work will manifest itself in a series of observational studies of people to determine a common set of abstract context types from the user perspective. The studies should focus on user behaviour in specific environments (e.g. at home) or during well-defined activities (e.g. shopping). Each situation will have a set of abstract context types that are important to understand or affect that given situation. The research will seek to discover what abstract context types are being used and gauge their importance to the user in the given environment.

Results from the secondary research and observational studies can then be combined to create a database of common abstract context types, including canonical descriptions, details of their constituent elemental context cues and data on the relative frequency of relevance to user behaviour. This information can be used to populate one or more ontological models of context information.

The definition and use of context information will likely vary on an individual or cultural basis. Based on the knowledge of variation in context cues and abstract context types gained from this research, it should be possible to generate requirements and recommendations for ways to personalise and evolve specific instantiations of the context description language.

It will not be possible to research all possible contextually aware application domains. However, the research data can be analysed to suggest requirements for the service environment to discover and share context whilst being flexible to changes or additions to the set of context types.

Expected results

The expected results from the approach list above are:

- A user-centred ontology of context comprising abstract and elemental context data types
- A standard data definition for abstract context types and elemental cues.
- Requirements and recommendations for dynamic context definitions within service environments

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Task 1.4 – User Requirements for Universal Access and Assistive Technologies {8}

Objectives of the proposed research

- to define and specify agreed-upon interfaces that enable users to use one and the same assistive device on a large range of devices.
- To develop methods and concepts for the design of adaptive mobile applications and services which are most appropriate for realising universal access, regarding especially the limitations of people with special needs

Rationale

Motivated by the trend towards regulatory requirements and the changing world view of people with special needs such as elderly and disabled users or children, the European ICT industry is preparing for developing solutions for making their products usable for all users. Although the range of users who are confronted with accessibility problems extends beyond the population of people with special needs, to include all people. Since products and service require particular skills and abilities on part of the human user, universal access for all is a critical quality target in the context of the emerging information society.

Where a *Design for All* solution is not readily achievable, one-solution manufacturers may choose to offer technical interfaces for so called assistive devices that fill the gap between the user interface of the device and the abilities of the user. Elderly and disabled users would benefit from (de-facto) standards for these interfaces so that one assistive device, e.g. a display for the presentation of information in large letters, can be used for the widest possible range of products from different manufacturers. The manufacturers themselves benefit by complying with European and international regulations if they offer a compatible interface even if they leave the production of the assistive devices to third party manufacturers.

The output of the proposed work may turn out to pave the way for agreed-upon solutions that benefit both users and manufacturers.

As outlined above, there currently is an opportunity to define and specify agreed-upon interfaces that enable users to use one and the same assistive device on a large range of devices. If the consensus is not achieved, manufacturer-specific, or worse, no interfaces will be developed and implemented. As a consequence, elderly and disabled people would have to purchase different assistive devices (e.g. displays or keyboards) for use on different products and services.

Although, it must be considered that universal access is much more than direct access or access through assistive technologies. It overall must relate to the contents developed, to the functionality supported by different services, and to the physical syntactic and semantic characteristics of interaction. One of the methods of providing universal access was in developing adaptive techniques, which are capable of identifying those circumstances that necessitate adaptation, and eventually select and effect an appropriate course of action. Different from traditional solutions which involve static applications providing the same page and content and the same set of links to all users, adaptive systems should monitor user interaction and use the monitoring data for a basis to draw assumptions, continuously verifying, refining, revising, and if necessary, withdrawing them from the set of assumptions which are known to be valid for a given user group. Early attempts to employ adaptation techniques were driven by the specific requirements of communities such as disabled and elderly people. Especially blind people attracted the most attention due to the visual orientation of network based facilities and graphical user interfaces (operating systems such as Windows) which limited their opportunities to make use of computers and handheld devices. Usually these problems were treated as soon as they appeared, rather than to prevent them from occurring.

In consideration, which data is to be adapted, it is reasonable to distinguish between:

- *user data*: comprises the traditional adaptation target adapting to various characteristics of the user
- *usage data*: describes data about user interaction with the system
- *environment data*: comprises all aspects of the user environment

State of the art in the area

- A majority of adaptive systems for serving on-line information were developed after 1996, some of which are e.g. classic online information systems, electronic encyclopaedias, information kiosks, virtual museums, handheld guides, e-commerce- and performance support systems
- Adaptive techniques are presently limited to stationary systems in fixed networks, and are not applicable to mobile devices due to their small screens.

Considering the design of communication interfaces, ETSI HF have produced three very significant deliverables that provide guidance to the designers of communications products and services:

- ETR 116: Human Factors (HF); Human factors guidelines for ISDN Terminal equipment design;
- ETR 029: Human Factors (HF); Access to telecommunications for people with special needs; Recommendations for improving and adapting telecommunication terminals and services for people with impairments
- ETR 166: Human Factors (HF); Evaluation of telephones for people with special needs; An evaluation method

All of these documents are, or have been used, by major European companies to help them in the design of their telecommunications products and services. The first of these documents provides a very comprehensive set of guidelines related to the design of telecommunications terminals and services, however at the time of its creation a *Design for All* approach was not common and some of the guidelines do not take account of people with special needs and disabilities. In contrast, the other two deliverables are specifically targeted at people with disabilities and suffer from being much more restricted in scope. A *Design for All* approach makes it imperative that a revised document integrating the best elements of these documents into a coherent whole is produced to replace these separate documents.

These deliverables were produced in 1994, 1991 and 1995 respectively and since then the technologies to which the guidelines relate have changed significantly.

Possible approach

The proposed research item will need to bring about a consensus among key manufacturers in order to obtain a basis for the technical specification of open interfaces. The steps required for the proposed work include:

- To identify and document the user requirements for assistive technology solutions in ICT,
- To identify technical solutions considering different technologies (e.g. Bluetooth™, Wireless LAN/HiperLAN)
- Survey on technical solutions (considering e.g. safety, reliability, efficiency, costs, etc.)
- To try to initiate and build a consensus among the key manufacturers
- To develop methods and concepts for the design of adaptive mobile applications and services which are most appropriate for realising universal access, regarding especially the limitations of people with special needs
- Survey on societal impacts

Expected results

- ICT products and services accessible and usable for all users, including elderly users and those with disabilities.
- Deeper insights of user requirements of people with special needs, including elderly, disabled and children
- Roadmap for the design and development of appropriate user interfaces and presentation techniques, based on a service platform in line with the requirements of people with special needs

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Task 1.5 - User Behavioural Research for Applications in the Wireless World {9}

Objectives of the proposed research

The objectives of this research are:

- Gather detailed observational data on users' activities in specific domains that can then be used to inform application design and resulting technological requirements in those domains.

- Gather this data in several socio-cultural settings, both inside and outside of the EU, so that cultural differences in technology design and deployment can be explicitly identified.

The results of this work may be applied to identify well-grounded future applications of emerging wireless technology and develop requirements for this technology as well. By conducting this research across cultures we explicitly recognise the significant role that nationality and local culture often plays in technology adoption. The work may also inform novel uses of existing technology, such as 2.5 and 3G wireless systems.

Target application domains

There are, of course, a great many potential application domains for the wireless future. In this section, we briefly overview a few domains that may be of interest as targets for user behavioural research.

Mobile Enterprise Triggered by the continuously growing degree of innovation in communication technologies, a new set of frameworks has evolved for working in mobile environments. This leads to a great increase in flexibility and dynamics in the B2B (Business-to-Business) field, as well as to a new dimension of "information transcendence" of the employees of an enterprise. The extension of the worker's role in enterprises and the higher degree of information from customers and business partners are tightly connected to the business processes. As business processes are increasingly integrated, improvements can be considered through the employment of wireless communication technologies such as UMTS, Wireless LAN, Bluetooth, etc. In this manner we can speak of a migration from the e-process to the m-process with its accordant increase in flexibility. Among the specific enterprise areas that may benefit from this are Supply Chain Management (SCM), Enterprise Resource Planning (ERP), Customer Relationship Management (CRM) and production processes.

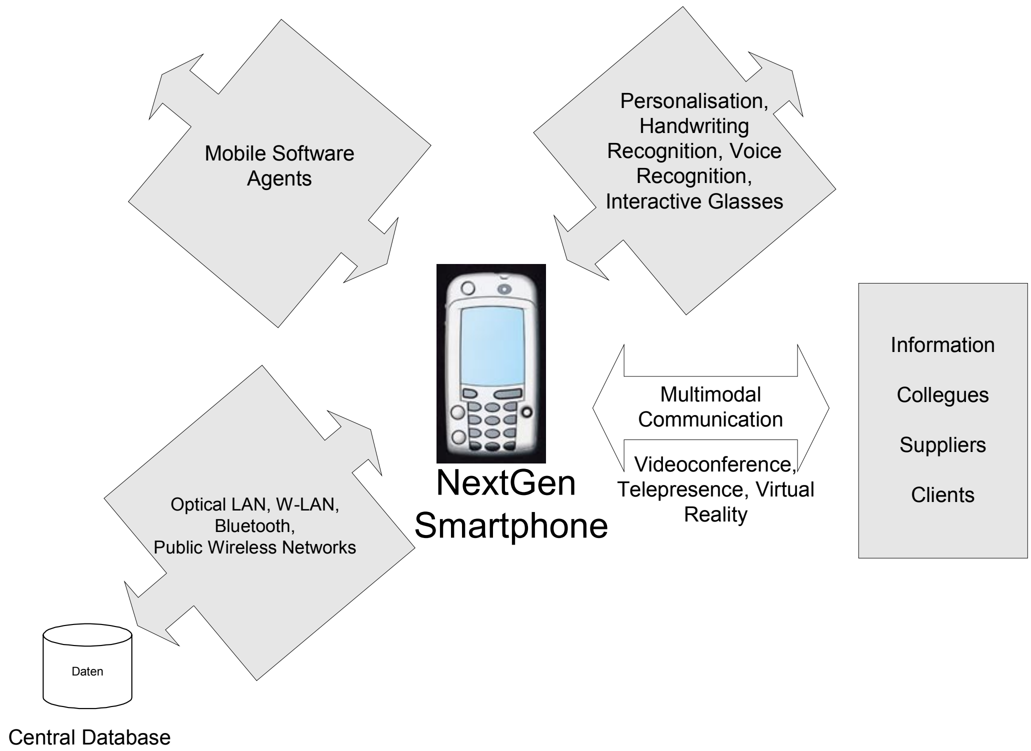

Figure 5.1-2: The mobile office of the future: time management, mobility planning and -support, availability- and communication Management, contact administration and information search

In the area of SCM, it is important to have a holistic view of the whole transport chain in order to quickly overcome changes due to unknown situations, for example accidents or traffic jams. With the knowledge of the whole chain, available transport and handling resources including infrastructure networks could be better used and managed. Integrated services have to be developed which take into account the different requirements of the different partners involved in intermodal transport like suppliers, shipping companies, forwarders, customers, etc. User research might focus on extended services and applications for intermodal transport that meet future requirements. The results will contribute to managing the intermodal transport flows and promoting better co-ordination and co-operation so that all parties realise gain from optimisation.

ERP and CRM processes might benefit from mobile access to databases, as mobile decision support and mobile workplaces will become important success factors for companies. This might include context-sensitive solutions for highly personalised scenarios and services for mobile and ubiquitous B2C and C2C e-Commerce. In these areas, user research might focus on requirements for applications that use the full bandwidth of mobile devices to support business processes and to integrate enterprise systems, creating open environments and seamless information integration.

A final area of interest for the enterprise is production systems. Here research might focus on the development of new user centred application scenarios and concrete applications that will be based on new communication environments as well as on the impact on existing production-structures in terms of change. The main objective will consist in the improvement of existing production structures by the application of combined ICT technologies, ad hoc networks, etc. to obtain increased usability and improved information access for the user.

M-Commerce Moving from the internal view of the enterprise (above) to the external view of the consumer, the adoption decisions of individual end-users must be better understood to predict and explain the adoption of services in general, and mobile commerce in particular. Understanding the end-user context may provide a set of context specific adoption requirements. To understand these requirements, the end-user may be viewed as a technology user, a consumer, and as a member of a network. By combining the three perspectives in a demand side adoption framework, operators, service providers and application developers will get a better foundation for designing, evaluating and timing mobile commerce end-user services.

Health Care The healthcare sector today still offers high potentials for IT integration in the work processes. Two specific target areas for new applications include mobile nursing and virtual health care teams. A number of problems have been identified in mobile nursing that might be solved through the provision of tailored applications for mobile devices, including specialist hardware and software. The technologies required to realise the vision of Virtual Health Care Teams (VHCTs) involves a number of areas including wireless transmission systems supporting broadband access, wide-area networks, Body Area Networks (BANs), Personal Area Networks (PANs) and ambient intelligent environments. User research in this domain would focus on gathering data from which to develop applications and services based on these new technologies that meet the needs of the patients and healthcare providers.

Fire Services The duty of fire brigades is very spontaneous and difficult to plan. Most of the problems during action are unforeseeable. Therefore, it is very necessary for fire fighters to work very flexibly and tightly together with secondary organisations to quickly and directly get all the information needed. New applications based on communications technologies of the wireless future may enable greater and more timely access to key sources of information, including building maps, floor plans and information about hazardous materials. Significant public benefit can come from understanding unique user behaviours in these situations, leading to improved interactive information and communication system for public authorities.

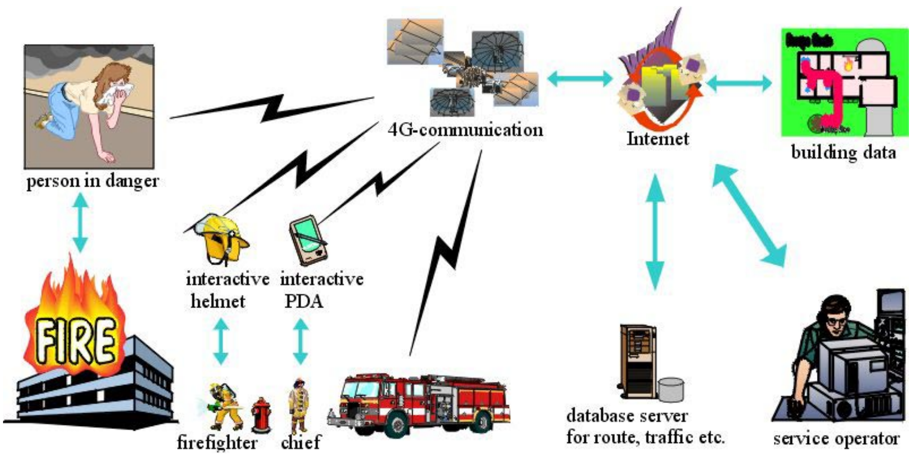

Figure 5.1-3: Scenario of future fire fighting and rescue operations

State of the art in the area

The literature on innovation indicates that new technology development can be and has successfully been guided by exploratory user research. The power of this method lies in the fact that users are poor at articulating needs that are not met by current technology, and are particularly unable to say, when explicitly questioned, whether or how they would make use of new technology. Users are, however, expert at their own behaviour, although again they are poor at articulating why they do what they do. This so-called *paradox of the expert* is a primary motivation for eliciting user needs by observing their behaviour and actions in the users' natural environments. Recognising these facts, several methods have been developed for gathering observational data in a natural setting, all of them variations on the anthropological technique of *ethnography*. Methods such as diary and beeper studies, contextual inquiry, and various forms of "rapid" ethnography have all been successfully used to this end, often in combination.

A recent example of an application of these methodologies is the EU Intelligent Information Interfaces (I^3)-funded Maypole Project. In this effort, a joint industrial and academic team of sociologists, psychologists, interaction designers and electronics engineers conducted a comprehensive two year research program to identify and explore possible uses of visual communication in family settings across several EU member countries.

Possible approach

We posit that research in this area will be focused in one or a very few application domains, *e.g.* health care, care of the elderly, family communication, enterprise communication, *etc.,* as described above. As such, the first work items will likely be identification of the domains to research, and the research participants.

Two main tracks of research are contemplated. The more straightforward will be to study in detail the effects of existing technology on the affected domain; for example, as 3G systems roll out, it will be instructive to examine the effects and uses upon users in the selected domain. Methods that may be useful here include diary studies, contextual inquiry and other observational methods, as well as focus groups, surveys and quantitative analyses, *e.g.* adoption rates and sales.

At the same time, similar methods such as contextual inquiry and more traditional ethnographic methods can be applied as described above to study users' behaviours in the selected research domain(s), with a focus of identifying areas where future wireless technology can help solve real and anticipated user problems.

As stated earlier, to maximise the scope of coverage, research should be conducted in several countries. This can be accomplished by setting up cross-disciplinary teams by geographic region and utilising similar data gathering and analysis methods to identify cross-cultural differences.

Expected results

Concrete results of this research will be embodied in the following forms:

- Ethnographies, written, photo and video diaries, interview transcripts. These are the written analyses and raw observational data, and contain a wealth of detailed information.

- Abstracted analysed data: Personae, Representative user descriptions, user scenarios, and "day-in-the-life" amalgams. These analysed representations of the data are useful as a bridge from raw data to design implications, and also serve as communication vehicles for those without the time, interest or expertise to digest the more raw forms of data.

- User models, contextual design "work" models. Formalisms for capturing communication flow, roles and relationships among individuals, and interplay between individuals and their socio-political environments have proven useful in representing data from multiple observations in a standardised way, affording comparison and contrast. The best examples are the "work models" in contextual design.

These results will catalogue the detailed user understanding that can facilitate development of truly useful, culturally sensitive and indispensable applications for future wireless technology. Once identified, follow-on prototyping, testing and refinement of application concepts can help validate the application concepts and provide more detailed requirements on the underlying technology.

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5.1.2 New Generic Application Elements

Task 1.6 - User Requirements and Technologies for Managing the Complexity of Future Wireless Systems {10}

Objectives of the proposed research

The objective of the research is to gather requirements and further technologies, which help the user to manage the underlying complexity of future wireless systems and the services that they enable. The ultimate goal is to make the future Wireless World and all that it enables useable.

Rationale

In the Wireless World a wide range of services and applications will be available to end-users. It is critical for the success and usability of the future Wireless World that the user can manage this complexity in an intuitive and easy way. Easy use of complex systems prompts research then in two areas.

- Investigation of the implementation of intelligent service automation.
- Assess the feasibility and develop artificial entities called *Virtual Assistants* to aid mobile users apply networked resources to take appropriate decisions.

Intelligent Service Automation

The objective of this research will be to investigate the implementation of intelligent service automation. The desired result will be the automatic integration of multiple services from the wide range likely to be available to meet the user's needs. There is a need for an agreed method of actively managing the complexity and quantity of services or combination of services available to the end user, in an intelligent and seamless way. A series of questions has been identified that should be answered by the research:

1. Understand user requirements for intelligent service automation.
   - How can users access combinations of services without having to understand the way in which those services are partitioned?
   - How accurate could Intelligent Service Automation be, and what are the boundaries of user acceptance?
   - Would users trust the device to select the best services
2. Implementation of service automation, particularly adaptive user profiles.
   - To what extent can adaptive user profiles provide a solution?
   - What are the criteria for adaptation, and how does the system learn behaviour?

- Does the profile reside in the network or device and how be security and trust be established?
- How will the user set up their initial profile, and how generic should it be?
- Should the user be able to override their profile?
- How can intelligent user profiles be modelled and implemented?

The results from this research will be applied to develop technological requirements for delivering an agreed means of service automation across wireless systems.

Virtual Assistants.

In the mobile environment, Virtual Assistants provide the following advantages;

- Consistent interaction metaphor across different modalities. This is especially important under mobile circumstances where the context-of-use constantly changes, and where the user will use visual and auditory interaction.
- Reduction of the amount of interaction needed by the user to actually get what he or she wants, at the right moment. This does not only apply to information but also to on-the-move entertainment.

State of the art in the area

The subject may be divided in three major research domains with existing bodies of research; human interfaces, artificial Intelligence, and human behavioural study and user centred design methods. One possibility is the use of Avatars as human interfaces. Simplified facial animation is already included in the MPEG-4 standard. A list of references is provided below for more art in these areas.

Possible approach

The user centred approach for research is to study the user requirements, prototype solutions and evaluate against user needs. This research will complement technology research into service automation. The following stages are envisaged:

1. Gather end user requirements for intelligent service automation, including: boundaries of use, accuracy, user privacy; generic vs. context-specific profiles; user acceptance; usability; where the profile resides; overriding the automation.
2. Investigate possible criteria for system adaptation.
3. Explore options for implementation, e.g. user models and agent architectures.
4. Develop options for user interfaces. Identify current HCI guidelines for mobile devices and develop suitable representations of the outputs of the Intelligent Service Automation systems. Develop and evaluate interface prototypes.
5. Develop simulations of Intelligent Service Automation in suitable application area and evaluate to determine accuracy and relevance of system predictions and service delivery. Investigate user acceptance.

6. Investigate ‘softer’ issues, such as user trust in automated service delivery, either by primary or secondary research with users.

Expected results

- User requirements and criteria for system to adapt to user preferences
- HCI prototypes and user evaluations.
- Overall guidelines for implementation.
- Service platform for natural interaction between the user and the Internet.
- Guidelines for wireless networks architectures

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Task 1.7 - User Requirements, Architectures and Technologies for Augmented and Virtual Spaces {11}

Objectives of the proposed research

The objective of the research is to investigate the potential of augmented and virtual realities when coupled to a wireless system to enable new mobile applications and to enhance the user’s experience.

Rationale

Augmented realities and Mobile Augmented Reality (MAR) are a natural step of evolution for mobile users and a natural step for enhancing communication and information presentation to the user based on factors like location and direction of view, user situation/context aware (day of the time, holidays of business related, etc), user preferences (i.e. preference in terms of content and interests), terminal capabilities and network capabilities. Virtual objects can supplement real-world information. These multimedia objects may be visual, auditory, haptic and even olfactory. New applications will be enabled once the technical challenges are overcome. MAR can be used for current services (like MMS) as well as upcoming services (like Conversational Multi Media - CMM) to enhance user experience. MAR can be combined with Virtual Reality, leading to the ultimate user experience.

Figure 5.1-4 shows the concept or a museum-based application. Information is overlaid on top of his real world. The technique can be used for information assistance, virtual advertisement based on user preferences, virtual decoration, etc.

Figure 5.1-4: "Smart signs” give information about my world

A further example is shown in Figure 5.1-5. Location, direction of view, distance from the objects that the user is viewing, user preferences, animation, voice interaction, virtual object insertion, the database of information, etc are some of the issues

Figure 5.1-5: The virtual guide. The users location, direction of view and distance from a certain objects is used to show information about the various objects in the scene.

Videoconferencing combined with AR applications is probably among the most challenging and difficult applications. Figure 5.1-6 shows an example of AR.

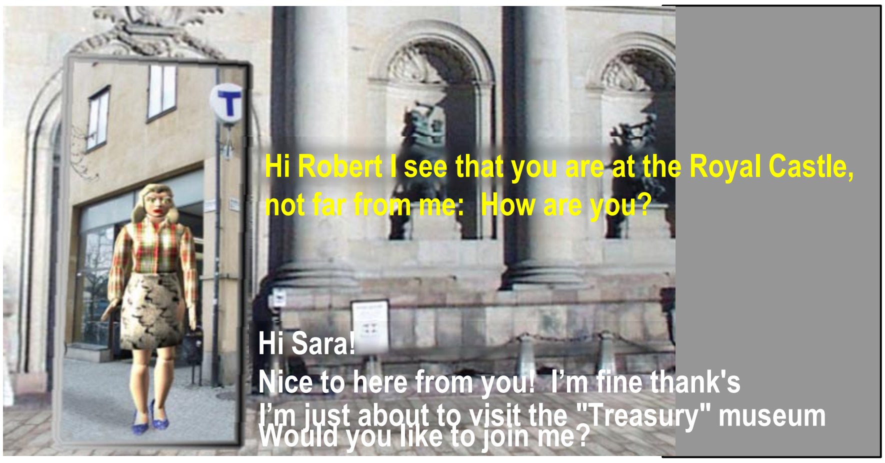

Figure 5.1-6: Advanced AR scenario combined with 3D information and video-conference application

Many more applications are imaginable, such as games, maintenance of industrial products, or free parking places in a crowded downtown.

The results of this research item will be used to develop open platforms (Hardware + Software) allowing the Internet Service Providers (ISPs) to implement context and location-dependent mobile applications.

State of the art in the area

Prof. Steve Mann is one of the pioneers in this area. He produced one of the earliest examples of a wireless, visually augmented system. Columbia University has designed a wireless system that allows a user having appropriate see-through glasses to read the name of a specific building within the campus. The University of Oulu has developed a computer-aided navigation system for tourists. Evidently, MAR include aspects as wireless communications, MM databases, position and orientation tracking systems, wearable computers, interaction techniques, wireless networking technologies, information presentation aspects, pattern recognition, etc. Much of the work that has been done now has focused in some of the aspects of MAR, while very little work has been related to the wireless aspects. MIT and Berkeley have done important work in this area. Other important references are given at the end of this task description.

Possible approach

Evaluation of this technology requires concurrent work in the following fields:

- MAR/VR application description, architecture and device requirements analysis
- Perception research into usefully and safely merging virtual and real objects.
- Design of unobtrusive see-through devices including position and attitude sensors enabling seamless integration of virtual and real scenes.
- Radio systems with sufficient performance to allow usable superposition.
- Internet Servers for sourcing content
- Experimental evaluation of service platforms and reference applications.
- Definition or roadmap for delivering MAR services.

Technical issues, which will enable these capabilities include, Personal Area Networks, real-time video object insertion, mapping of real 3D world with synthetic 3D world, personalisation information, location and orientation tracking technologies, range finding, content management, wearable computers, virtual interfaces, head mounted displays, radio and core networks and systems.

Expected results

This research will improve the use of existing infrastructures (e.g. roads, parking places, etc.), facilitate context-dependent commercial advertisement, and improve safety. It will enable new ways of enriching users experience, for example, promoting tourism and facilitating the appreciation of cultural objects in the user's language. It will support virtual training partners that pace with the user. Due to the fact that the number of potential applications is probably endless, the accent should be put on the design of open platforms allowing ISPs to create their own service proposals.

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Task 1.8 – User Interaction Paradigms; the Identity of the User in the Wireless World {12}

Objectives of the proposed research

The objective of this research is to investigate how the user perceives him or herself within the capabilities afforded by the Wireless World. The research will identify the most useable models which users can relate to, the best interaction paradigms and common means of identifying the user within those models and paradigms.

Rationale

Whenever a human being interacts with technology or more specifically with services enabled by technology, he or she has a model of themselves within the interaction. The individual is able to use the technology because the model hides the complexity of the implementation. As services and systems become more complex, interaction with the technology becomes more complex and the delivery mechanisms become more diverse, the user needs to hold on to a limited number of models and interaction paradigms so that remain comfortable using the technology. Of particular interest are the impact of Augmented Reality and Tele- Existence metaphors on the mobile user, and a single universal identifier and a common method of setting up, receiving and managing communications in a multi-modal communications system.

It is anticipated that Mixed Reality devices, like Head Mounted Displays (HMD), will become commercially available within the next 5 to 10 years. It will solve the problem of small screen sizes. By combining these devices with Augmented Reality and tele-Existence technology, there is a potential to provide new services. The purpose of this topic is to study the impact these technologies will have on the mobile user and develop suitable service architectures for them. An in-depth study can be carried out on the user interface metaphors/devices resulting from this change of interface technology. Lastly, the requirements on the underlying communication/security architecture necessary to support this technology can be determined.

Currently, users of communications systems are presented with a large number of methods of establishing a communication with a potential receiver. Determining a communication strategy to contact an intended receiver can become a non-trivial task. Solutions are available to enable users to control their different communication systems and to present a potentially simpler interface to the calling party. However, current solutions differ in their method of operation and in solving one problem they may create others. There is a very clear need for an accurate and fundamental understanding of users' requirements both in setting-up and receiving communications. The availability of more sophisticated communications tools is changing peoples expectations and creating different communication needs, but these needs are still evolving slower than the rate of change of technology and they usually represent a modification of some more fundamental, but well established, communication needs. These communication requirements need to be captured in an implementation-free form that enables them to be interpreted in specific ways in different communications systems in order to achieve a common integrated solution.

An effective and efficient multi-modal communications system would have a choice of terminals, a single universal identifier and a common method of setting up, receiving and managing communications.

State of the art in the area

There are a number of important and relevant fields that pertain to this research topic. The most prominent technologies include Augmented Reality and tele-existence. Additionally there are necessary communication technologies of interest such as Personal Area Networks, Wireless LAN's and cellular systems (e.g. GSM). Both AR and tele-existence are similar in a number of respects. They are both based on the 'real world'. The main difference between these technologies, from a service point of view, is that AR users are physically located in the area providing services and tele-existence users are virtually present. Initial research has taken place, describing potential services using these technologies such as Location based services and meetings. However the service architecture itself has not been developed extensively. References are given below.

Possible approach

The approach proposed is to build a system based on a Service MultiSphere Model, a user centric approach. The user is surrounded by 3 geographically-based service layers, the Personal User Service, Local Environment Services, Global Services Network.

The advantage of a service layer structure is that it divides services according to the area and needs of the user. With personal services, the user has total control to customise their settings to match their own needs. Area services provide additional user information e.g. company announcements, shop advertising etc. Global services can be accessed at anytime anywhere. The service layers outlined are not without some problems. Too much information can be presented to the user. There is always the risk of a big brother feeling or that people may get access to services that they are not entitled to e.g. restricted areas. Hence some services could be placed on different levels of security access.

In order to propose a new identifier, it is necessary to understand the user requirements, which will underpin it. Refining these requirements, assumptions about the types of networks in which a UCI might be used must be made. For instance, a common theme amongst all emerging architectures is the concept of a software entity or entities that manages the user's communications (a "Personal User Agent" or PUA). The set of the user requirements will provide the criteria against which any proposed new UCI (or solutions not involving new identifiers) must be compared.

A new identifier will be proposed, consisting of:

- an alphabetic label that is the name by which the person or organisation usually wishes to be known. This label would be used to access the complete UCI from the user's address book, and would be used to show who a communication was from;

- a numeric string that is globally unique. Under most circumstances it would not be necessary for a user to memorise or enter this string as it would be "captured" from incoming communications, business cards or from a directory service, and stored in an address book function;

- an additional part of the label which imparts extra information in the form of flags. These flags would not be directly visible but could indicate to the receiver's PUA whether the communication was from a business source or a private individual, and whether alphabetic label was a real name or an alias. This information could be used to make filtering/routing decisions for incoming communications or could be passed on to the receiver for information.

Expected results

The expected results from this research are:

1. Study the practicality of the service architecture.

2. Experiment with the service interaction metaphors. These metaphors include user – network interaction and user –user interaction/collaboration.

3. Determine the requirements of the supporting technology, network and usability.

4. Standardisation in several areas. Naturally, the format of the UCI itself will require standardisation but additionally, standardisation covering PUA intercommunication and directory structures will be needed.

5. Although it will be an overlay system, the setting up of a UCI/PUA based communications architecture will be a large undertaking. However, the rewards, in terms of increased user satisfaction and increased network usage and revenue would also be great. The UCI derived as a result of this study offers a practical way forward to a very effective way of managing communications in an increasingly complex environment.

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Task 1.9 – User Requirements and Technologies for Body Area Networks {13}

Objectives of the proposed research

The objective of this research is to study user requirements, user interactions and supporting technologies for Body Area Networks (BANs). A particular focus of the research is to investigate the different aspects of the BAN, especially the relation to Personal Area Networks (PANs).

Rationale

There has been some lack of clarity surrounding the definitions of and distinction between BANs and PANs. We define a Body Area Network (BAN) as a collection of communicating devices that are worn on the body, providing an integrated set of personalised services to the user. The BAN provides the closest interaction with the Wireless World. As electronic communication will happen “at” our body, power issues will be critical for BANs together with fast, flexible and automatic configuration and protection. We envisage the BAN to be level 1 of the WWRF MultiSphere reference model.

A Personal Area Network consists of interacting devices in the proximity (around 10m) of the user, creating a personalised environment. The interacting devices are ordinarily general-purpose devices, but turn into personalised items the moment they take notice of us. We envisage the PAN to be level 2 of the WWRF MultiSphere reference model.

One sector where BANs may also have widespread applicability in future is the healthcare sector. We envisage BANs worn by healthcare professionals and by patients [6]. For a patient BAN, devices are worn on the body, perhaps embedded in clothing, jewellery, glasses, perhaps attached directly to the body (e.g. a cardiac monitor) or implanted. The BAN is intended to be an open, extensible platform which can be personalised not only to a class of patients (e.g. diabetic patients) but also to the particular set of (chronic and acute) problems of the individual person/patient.

State of the art in the area

The first version of a body area network consisted of wearable electronics that addressed the entertainment and leisure sector and reached the market during the year 2000. These early examples, directly connected together within a jacket, represent the first examples of the BAN. Some integration between devices was achieved so that, for instance, the music was muted when the phone rang and control of both phone and MP3 player was possible with a separate, easily accessible, controller. Connection between the devices was achieved by wires integrated into the garment, but in future we might expect both conducting materials and wireless links being used to make inter-device connections.

An important application area for BANs is healthcare. Examples are the *Virtual Trauma Team* and *Virtual Homecare Team*. These two instances of the wider concept of *Virtual Health Care Teams* are applications based on emerging and future wireless communication technologies. The technical research required to realise the vision of Virtual Health Care Teams involves a number of areas including: wireless transmission systems supporting broadband access, vehicle-based (fast roaming) networks (thus Vehicle Area Networks or VANs), BANs, and ambient intelligent environments (PANs), with ad hoc networking enabling communication between (roaming) professionals, clients and patients. References are given below

Possible approach

The possible approach to this area is one of user centred research identifying the basic need for BANs, and specifying the requirements for the enabling technologies. Such a process would involve:

- gathering user requirements for services and applications
- survey existing standalone and proprietary solutions
- specifying technology solutions
- use state of the art emerging technologies to build BANs from existing platforms.

For the technology enablers, in order to ensure interoperability, it is crucial that each device uses the same protocols. The important layers are physical, data link and some of the higher layers, and standard based implementations are required.

On the application level, a common application interface needs to be defined. This would specify what happens when for instance a button is pressed, or the phone should ring and so on. It would be interesting to investigate techniques such as used by HAVi to enable devices previously unknown by the network to be used.

To summarise, a BAN will consist of the following components:

- One or more physical layers. Each physical layer will have different capabilities and therefore the network layer to co-ordinate data transfers.

- A network performing addressing and routing of data, which initially will be IP based.

- An application interface. In a BAN the emphasis is on simplicity and low power.

Expected results

The outcome of the research carried out in this area should be:

- Increased understanding of user requirements for wearable electronics

- Formal description of a generic BAN

- Systems architecture for generic BAN

  - Software Architecture for BAN applications

  - Insight into network layer requirements for heterogeneous networks.

  - Application interfaces with low complexity.

  - Physical layers for short-range communications around the body.

  - Further insight into security issues for BANs, taking into account the need for flexibility and ease of use.

- Prototype of generic open extensible customisable BAN for patients/citizens.

- Prototypes of BAN applications

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5.1.3 New Interaction Techniques

Task 1.10 - All Senses Communication {14}

Objectives of the required research

The goal of the research project is to explore the concept of *All Senses Communication* as a way to enhance the communication with other entities (humans or machines) using a combination of several of our present or future senses.

Rationale

All Senses Communication address the fact that while the complexity of technology used in everyday life has exploded, the basic human capabilities (sensory and motor limits, short and long term memory, the brains processing power etc.) have evolved very slowly. In order to fully exploit these capabilities we need to extend the interaction with more senses (touch, smell, and taste) and at the same time make better use of the senses used today (hearing and vision) by exploring peripheral vision and ambient listening. With even a longer perspective we need also to consider inventing "new senses" by combining current senses and extending them with new technology.

The basic concept is to combine input and output from several senses to:

- Minimise the gap between how we communicate person-to person in real life and the artificial way we communicate using technology
- Fully utilise the unique capabilities of humans to meld impressions from several senses and analyse based on previous experiences
- To enhance the communication and (by choice) communicate more than is possible by normal face-to-face communication (i.e. sensors will tell you is the person in front of you is angry, sad or nervous)

State of the art in the area / Important research areas

Many new interaction techniques are emerging based on the availability of new "channels" connected to our senses. A growing importance for the role of aesthetics is reinforced by the use of new interaction techniques such as visual, audio, haptics etc. Some important research areas are:

Multi-modal enabler – many interaction techniques are problematic when they are used as the single communication channel. For example the problem of "the Midas Touch" in speech interfaces and eye tracking (e.g. everything is interpreted as commands) can be avoided by adding direction. If you are looking at a human you are making conversation, and if you focus on the computer you are probably entering commands.

Invisible service interfaces – in a ubiquitous environment where everything is networked and intelligent, the services become the centre of everything. The problem is that this environment will be evolving organically. New services will be downloaded to the devices automatically and different combinations of devices will produce a new set of services. It will become very hard to show the user what services are available, and the capabilities of each service. It will also difficult for the user to find out where to direct their interaction if services are embedded in stuff around us.

Ambient interfaces – a new type of interfaces are starting to emerge that are focusing on user's ability to process information in the background. Using variations in background lighting or sound the system can transfer information about for example the situation on the stock market or the load on the computer network. Another way of subliminal interaction is to use body sensors and actuators. The user can be guided in the right direction just by the actuators getting warmer or colder.

Haptic interfaces – are emerging as an important new way of interacting. Two recent examples are the Microsoft SideWinder Freestyle Pro and the Ericsson Rhythm Stick.

Conversational Interfaces – A driving force is to create a style of interaction with technology that resembles Human-to Human communication. As the underlying technology is becoming increasingly complex the need for a simple and common way to interact with the environment will increase. Making the way we communicate with machines resemble the way we communicate with humans, will make the interaction more "intuitive" and scaleable as new technology emerges.

Artificial or superhuman senses – Our current senses could be extended with, for example, infrared sight, sensitive hearing aids or a low-power radar that will give us a sense of being aware possible dangers we would face walking down a dark alley and allow us to feel safe.

Adaptability – A key aspect of All Senses Communication is that it allows the user (and the system) to change between different sets of senses for the interaction. The system can adapt and choose senses based on variety of aspects such as technological constraints, the physical conditions, or the context (position or task) of the users.

Another interesting research area is to exploit the passive communication or consummation of information. We can keep track of friends by just being aware of their location and actions, without the need to be actively engaged in the activity. Passive (or ambient) ways of keeping track of what is happening in your *interest sphere*, will also give the service providers an opportunity to charge for a constant stream of data.

Possible approach – Expected Results

The project needs to establish a test and prototype environment with a set of test cases for service developers that take All Senses Communication into account. This could be conducted as collaborations with other WWRF projects or IST projects such as "The Disappearing Computer".

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Task 1.11 – Augmented User Interfaces {15}

Objectives of the proposed research

Development of a new user interface appliance paradigm and to focus research on the application level and how to apply the design to the mobile devices like media phones.

Rationale

There is a need of structured information for mobile devices. They are small and they have many side applications that create a hazardous user interfaces. Wireless Application Protocol was trying to place the things in order but the emphasis was on protocol and not on the interface level (it was some how tackled but not really seriously). Also, we want to have an interface that is portable, deviceless, and extensible.

By the term *portable* we mean a device that allows the user to easily carry it out or move. A *deviceless interface* of an information appliance has no mechanical interference with the user. An *extensible* or *expandable* interface has the ability to re-shape, or morph, itself for different purposes than the ones originally defined.

State of the art in the area

Several projects have been identified in the area. Most of them are emphasising the user interface dynamics and construction. The hand interface is described as a menu system. A combination of image processing technique and Augmented Reality is used in order to augment the user hands with a menu system.

Another system is developed by using Pinch Gloves in order to achieve 3D interaction techniques for travel, way-finding, selection, manipulation, and system control.

Researchers from MIT have addressed the area by focussing on the wearable issue of the interface and how it can be applied to wearable computer interfaces (but they were thinking mainly as keyboard an not as Interface Appliance integrating other input methods). A more focused approach on human computer interfaces is also done when the research topic is emphasising on mouse devices for Virtual Environments.

Possible approach

We are concentrating on the device separation. How well can we separate the user interface from the applications and how to achieve that at the hardware level? The interfaces are regarded as part of the operating system or, at least, part of the applications. The way to separate them it was achieved mostly when changing the look-and-feel, but nobody has addressed the problem on the functions level. We are looking even more far away, on the hardware level, a “*deviceless interface*”. How to implement a user interface appliance that will embed the functions used within normal user interfaces. This appliance could be instanced by the applications in order to communicate and interact with the user. We call that approach a “interface class" approach, and we are trying to define its "abstract methods". Once that we achieve this, a device that runs an application will need only to instance the interface class in order to access the user interaction.

Figure 5.1-7: The example of using the interface separation to place a call. From left to right, how the user sees the hand, description of the interface and the prototype. (Prototype available courtesy of NAIST – Nara Institute of Science and Technology, Hiroshi Sasaki et. al)

Expected results

We expect to define a basic layout for a small user interface based on Augmented Reality techniques. A JNI package will be deployed for testing. Second phase will deal with the interface/application separation (hardware mock-up). Identification of the core functions is needed and how to separate and access them from the applications. Another step will be to simulate and prototype the devices and see how the functions map on the current applications and how the users feel about using a deviceless interface.

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5.2 WG 2 - Service Infrastructure of the Wireless World

5.2.1 Business Model

Task 2.1 - Wireless World Business Models {16}

Objectives of the proposed research

- Development of a model for the description of relationships between the parties involved in a global business community.

Rationale

The world of communication systems is changing rapidly, so there has been an increasing need for people to understand their systems in a more integrated manner (e.g. systems to be designed for the wireless world). Business leaders are asking, “How? When? Where? Why? Who does what? What tools do they need to do it?” The answers to these questions form the basis of an Business Modelling. An communication systems may be considered as a complex system of cultural, process and technology components engineered to accomplish organisational goals.

The objective of the proposed research therefore is a model for the description of relationships between involved parties in a global business community. Based on these relationships, a business model defining roles and reference points should be developed. This allows the participation of each business partner on a global business on one side and provides the freedom in development and integration on the other side. Reference points provide specified points of contact and information exchange between business partners. The roles are used to specify who contacts whom, for what purpose, regarding permissions or prohibitions.

Such a business model for the wireless world is a prerequisite for the definition of a service architecture that supports the required functions of the entire business life cycle.

State of the art in the area

Many business modelling mechanisms (see References to CIMOSA, GRAI-GIM, PERA, ARIS, GERAM, ODP, TINA, IETF) are available today. They have to be analysed, whether they are suitable in the context of the Wireless World.

We think, that the convergence of traditional telecommunication systems, internet based systems and the emergence of new application scenarios (based on ubiquitous wireless connectivity) needs new kinds of business models. Within WWRF there is the potential to develop such models, because all necessary partners come together (vendors, operators, research community).

Possible approach

Based on the analysis of existing 2G / PSTN / Internet services and their underlying business models a framework for new models should be defined that

- can be validated against wireless world scenarios
- can be checked for rigor & robustness
- capture and communicates ideas
- can be changed.

Finally, mechanisms can be specified, that map these business models to concrete service architectures that can build the basis for the wireless world.

Expected results

- A generic business model that can be easily mapped to different scenarios of the wireless world.

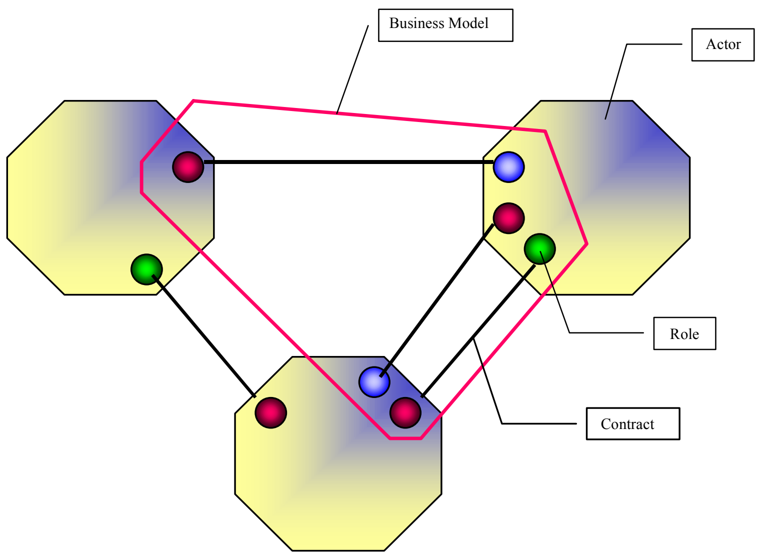

Figure 5.2-1: Generic Business Model

- A methodology for the definition of:
    - Organisational models.
    - Process maps.
    - Process flows.
    - Functional decomposition.
    - Requirements definitions.
    - Technology models.
    - Use Case models.

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Task 2.2 - Business Evaluation Tools

Objectives of the proposed research

- Definition of Business Roles, Scope, Purpose, Policies
- Conceptual Framework, identify main revenue drivers
- Mapping of business model to the application

Rationale

A fundamental issue is to think long term scenarios and to provide true market projections for the mobile next generation wave. To this purpose we have to create specific tools and business models with a particular stress on the economics and revenues drivers. The use of simulators will facilitate the understanding of the initial situation and its possible evolutions, as well the identification of the future economical potentialities.

Consultants predicts major trends in mobile markets (e.g. they forecast mobile data growth and decreasing voice revenues). Available analysis provide us with medium term forecasts covering GPRS and UMTS growth until 2005. Forecasts are based on past experience and trends estimation. Beyond 2005, only rough estimations are available.

Possible approach

The main issues covered in this topic are related to applications /services market forecasts and evaluation issues. The scope of this wireless business model is to provide a tool to evaluate the future wireless market evolution in Europe.

The market assumptions are based on the future scenario taking in consideration the next generation wireless services. A smooth evolution is envisaged from 3G mobile generation to next 4G wireless wave: a learning process from the customers' side is highlighted and business visions are derived and crossed with other sources (e.g. ITU). The research outputs are new 4G market figures to be used as a starting point for evaluation. As a consequence the creation of this business evaluation tool may provide a better understanding on the future market demand..

Expected results

Test bed software release is already scheduled only for 4G core applications; after the full definition of 4G services scenario, more depth market analysis will be available. As a consequence a more complete software tools will be designed and therefore will be ready to be implemented.

As an example, consider the WWRF contribution "Beyond third generation wireless communications The European market Business Case modelling" by G. Gasbarrone, where business modelling techniques with an output for European market have been proposed .

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5.2.2 Personalization

Task 2.3 - Profiling & Preferences {18}

Objectives of the proposed research

- Provide solutions for profile data with respect to storage, format, coding, exchange, and interoperability.

Rationale

Personalisation is recognised as being one of the most important factors in determining whether or not a mobile service stands a change to become successful (viability of a mobile service). The implementation of the concept of personalisation is partly done by means of using *profiles*. All this profile data means you have to store and manage this data in a user-acceptable way (perceived privacy is important). At the same time, profile data-exchange and accessibility must not be restricted too much in order to enable attractive and personalised mobile services (tailored to the user). Thus, we need solutions for profile data with respect to storage, format, coding, exchange, standards, and interoperability. And we need the same terminology and interoperable profile schemes that are supported by a distributed architecture.

Furthermore, gathering of profile data and keeping it up-to-date with the changing needs and context of the user is an important issue. Thus another objective should be a profile learning functionality to give solutions for profile gathering, updating profile data, and dynamically adapting the profile data to new situations (location, time, user needs, and network capabilities).

State of the art in the area

A common way of categorising personalisation factors is [1]:

- *User factors*: those factors that are about the interests of users, their preferences, usage behaviour, user and task characteristics. The user factors determine how the information should be personalised.

- *Information or content factors*: those factors that are about the properties of the information, e.g. the media type and whether there is content and/or associated meta-data. The information factors determine how the information can be personalised and these factors are more technology based.

- *Context factors*: all factors in the surrounding of the personalised information system and the user (e.g. current location, hardware, software, application domain, etc).

The personalisation factors are stored in profiles. Due to the nature of mobile services and use, the profile is gathered by multiple parties, stored in multiple places and used and managed by multiple stakeholders. The distributed nature of profiles must be supported by the architecture. Further, both globalisation and virtualisation of society have contributed to a greater privacy risk. With the perceived privacy being a mobile business enabler, protection of profile data and trust cannot be neglected in designing a service architecture for the next generation mobile setting.

Work on (semi-) standards that incorporate profiles is e.g.:

- 3GPP/VHE [2]: They specify a distinction into *two groups of profiles*: User_Interface_Profile, User_Services_Profile. Profiling is still ongoing work within 3GPP.

- MPEG Community: MPEG-7 [3]: Multimedia content schemes (metadata) with possibilities of tailoring content to terminal characteristics and user preferences (presentation, language, etc), personalised filtering and searching and browsing of AV content. MPEG7 AHG Mobile [4]: Study of mobile-specific requirements.

- PAM Forum [5]: Has defined a set of specifications for Presence and Availability Management, with the goal of reaching a standard on digital identities, characteristics and presence's status of agents, capabilities and state of entities, and availability of entities for various forms of communication. An identity is a limited electronic representation of entities. Profiles (named set of attribute and attribute value pairs) are used to associate data with identities. Programmatic interfaces to define profiles are part of the specs.

- Cameleon [6]: A European project named CAMELEON (carried out between 1998-2000, VHE concept compatible) worked on a prototype of personalised service portability (and made use of agent technology). They covered adaptive profile management, advanced directory service, virtual address book, flexible financial services, and personal telecommunication assistant. Use was made of *four sub-profiles*, being (1) communications management, (2) user environment personalisation, (3) application personalisation, and (4) security.

A language to ensure interoperability and offer extensibility is XML (standard of W_3C), and Secure-XML (XML-S, standard under construction by W_3C).

Possible approach

Since in mobile services location-awareness offers much additional functionality and opportunities, it seems logical to define a separate group of profile data on mobility/location-related information. Furthermore, network & terminal information also deserves a specific profile category. Within the WWRF forum we should get consensus about a suitable profile categorisation, accommodating the relevant and tailorable parameters for mobile applications. We propose to use the following profile categories:

1) User-related profile data:

    - preferences, history, interest, role, priorities,

2) Mobility & location -related profile data:

    - physical co-ordinates, velocity, direction of movement, ambient conditions (indoor, outdoors, etc.)

3) Network & terminal profile data:

- characteristics about network and terminal capabilities like bandwidth, graphics, etc.

4) Other remaining profile data:

- non-user related information that is not in a separate profile group, like content-related preferences (e.g. presentation format, encoding, language), query (formulation), business rules that apply, etc.

The approach would be to put the profile data in a semi-structured data format, thereby offering extendibility and enabling distributed storage and management of the data. This requires a distributed architecture. An approach for a language for the semi-structured data can be to use Secure-XML (XML-S; ongoing work on encryption technologies can be implemented in the keys and encryption that is used at the different levels that determine the different access rights for specific data parts).

The practical situation will be that the profile data is stored and managed in multiple places and by multiple stakeholders. XML as a language offers the extensibility and interoperability needed. The architecture should deal in a proper way with distributed gathering, storing, using and managing of profile data.

Expected results

The expected results are consensus about/definition of:

(1) format for profile data
(2) profile categorisation and terminology
(3) specifications to exchange profile information.

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Task 2.4 - Personalisation Support for Mobile Services {19}

Objectives of the proposed research

- Provide generic support for personalisation that covers different networks and various device types and accommodates the needs of users, providers and suppliers ("personalisation middleware").

Rationale

A major trend in the current information society is personalisation. Information and services become increasingly tailored to individual user preferences and characteristics. Personalisation is considered a key factor for mobile services [1], because the mobile device is a personal assistant that offers unique opportunities such as real-time adaptation of services to a dynamic user environment.

It is expected that value networks will arise in which service providers, content providers, and network operators co-operate to offer personalised services to mobile users in a way that suits their *individual preferences and needs*, at a specific place and time. At the same time, next-generation mobile terminals are expected to be capable of multimedia (voice, data, text, images and slow scan video) and based on a combination of functions seen in laptops, PDAs, mobile phones, and even for example radios and remote controls for a wide variety of devices. As a result, adaptation and tailoring of functions and services to the specific *terminal capabilities* and *network characteristics* become essential. Finally, the *mobility* of a user opens the way for a completely new range of services and applications, which use location-dependent information to offer users personalised services.

State of the art in the area

The Virtual Home Environment (VHE) [2] and Open Service Architecture (OSA) [3, 4] included in the UMTS specifications introduce an implementation concept for personalisation focussed on portability of personalised information across network boundaries and between terminals. The concept of VHE is such that users are consistently presented with the same personalised features.

The VHE concept provides little or no integration with the existing Internet world. In the wireless world beyond 3G, it will not only be GSM-evolved networks such as GPRS and UMTS, but also wireless LAN's, personal area networks, and other wireless technologies that have to be integrated to form a ubiquitous all-IP environment.

In the Internet world, Microsoft's Hailstorm [5], part of the .NET architecture, aims to provide a single point-of-access for information on identity, security, preferences, notification, inbox, wallet and other personal data, all accessible through XML Web services. However, Hailstorm is proprietary and does not provide an open API, making it an unlikely candidate for adoption by the telecommunications world.

Several projects already work towards a distributed, loosely coupled personalisation architecture based on Internet standards. Within the I-centric Communications initiative [6], an architectural framework has been defined that includes a service platform that supports personalised services and interaction with smart environments [7]. The VESPER project [8] aims to validate the VHE concept by defining and implementing an architecture based on Web services, using common Internet technologies such as SOAP, UDDI and WSDL. The GigaMobile project [9] is also working towards a loosely coupled personal service environment, which will be implemented using Web services.

It is expected that different architectures and middleware solutions for personalisation will arise. Currently, many equipment vendors provide service platforms that offer some degree of personalisation, e.g. Nokia's mPlatform [10] and Ericsson's WISE Portal [11]. It is reasonable to assume that these telecommunication-centric solutions will evolve towards open all-IP middleware. On the Internet, limited forms of personalisation are also prevalent, especially in e-commerce settings where the contents of Web pages are tailored to the (expected) interests of the user, e.g. using rule-based approaches or techniques such as collaborative filtering (for an overview, see [12]).

Possible approach

An architecture for personalisation should be concerned with more than just gathering and managing user profiles. Service discovery and adaptation are equally important aspects of providing personalised services. The integration of services, possibly from different providers, should be accommodated by such an architecture. Furthermore, the architecture should be neutral to the serving network and terminal technology, allowing the user to roam freely between different networks and providers, and bridging the gap between the telecommunications and Internet worlds. To this end, the use of open Internet standards within the telecommunications community should be promoted. Finally, the architecture should have a distributed nature. User preferences, service characteristics, and information about network and terminal will be provided and used by different parties, and may be located on the user's device, with the network or service provider, or with a trusted third party. This distributed character poses additional requirements on consistency, security and privacy protection, which should allow the user optimal control over the use of his personal information.

Expected results

Current personalisation solutions are rather shallow and lack true integration of all personalisation aspects mentioned before. A broad architectural view that encompasses all these aspects, combined with a better understanding of user needs will drive the evolution and convergence of existing products and will lead to the emergence of new solutions.

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5.2.3 Context Awareness

Task 2.5 - Context-Awareness of Mobile Services {19}

Objectives of the proposed research

- Development of integrated concepts and strategies for context aware systems.

Rationale

An essential element in the provisioning of personalised services is context-awareness. Services not only need to adapt to the user's needs and preferences, but must also be aware of the user's *behaviour* (e.g., tasks, habits), and of the *device and network characteristics* (e.g. available interfaces, bandwidth). Furthermore, the evolution of mobile devices and networks will be accompanied by an increasing awareness of the *physical environment* (e.g., geographical location, ambient conditions). All these aspects should be taken into account in the (admittedly, rather vague) notion of 'context'.

A first step in context-awareness is the emergence of location-based services. However, location is only a relatively simple form of contextual information. Various sensor technologies will be included in mobile equipment and networks; services may sense who the user is, where he is, what the environmental conditions are, and what the user is doing. Moreover, the environment itself may be furnished with sensors that perceive users and communicate with their devices. All this sensory information can be used by a service to adapt its operation in order to enhance the user experience. Conversely, the environment can be influenced by the presence and activities of users and adapt itself accordingly. In the end, we foresee a world in which services adapt themselves to the user's needs, preferences and circumstances, and cooperage with their environment to provide an optimal user experience.

State of the art in the area

Many devices perform some form of adaptation to their operating environment. For example, television sets that adjust their image contrast to the ambient lighting level have been on the market for several years now. Advances in sensor technology are impressive, and miniaturisation and integration between sensors and wireless communications is producing interesting results (see e.g. the Esprit project TEA [1, 2], the work on "smart dust" [3], the smart environment described by Dey et. al. [4], or the service platform of Van der Meer et al. [5]). In the field of mobile communications, location-based services are of course the prime example of context-awareness that is already commercially available.

Several standards are already available or being developed for exchanging information about the device and network context. For end-devices, important examples are the resource description framework (RDF, [6]), the composite capabilities/preferences profile framework (CC/PP, [7]), and the user agent profile specification (UAProf, [8]). For networks, examples are the Open Pluggable Edge Services (OPES, [9a]), the Content Distribution Internetworking (CDI, [9b]), and the

Web Intermediaries (WEBI, [9c]) working groups of the IETF, who develop frameworks and standards for communication between intermediaries within the network, especially for content peering and adaptation purposes. Also important are the OSA/Parlay specifications, most notably the mobility APIs [9]. However, for exchanging other, ‘higher-level’ types of context information, standards are still mostly lacking.

Possible approach

Although many projects and initiatives are concerned with elements of context-awareness, be they focussed on sensor technology, smart environments, infrastructure, or other aspects, what is still needed is an integrated approach, which takes into account the physical context of the user, his behaviour, needs and preferences, characteristics of the networks and devices being used, and the communication and computation capabilities of the environment. In-depth research is needed into the relation between the user’s preferences or habits, his tasks, the other users, services, and objects available in his context, and the way in which these may influence the behaviour of services.

A user-centred approach is envisaged, in which both user studies are conducted and the definition of architectures and infrastructure for an all-encompassing context-awareness support is pursued. Furthermore, the viability of context-aware services must be analysed from a business point of view, by defining suitable business models and studying user acceptance. An interesting approach is taken by Fikouras et al. [10], who propose an approach to m-commerce that seamlessly integrates mobile products and services into a single business model, focussing on user centricity and mobility awareness.

Expected results

To facilitate the context-awareness of services, generic support for exchanging context information is needed. As stated above, standards already exist on the levels of networks and devices. Closer to the application level, an important contribution would be the definition of specifications that describe specific types of context data such as user activity, geographical location and mobility, and physical circumstances.

Furthermore, insight in the user’s perception and requirements of context-aware services would be an important result. How should services behave in order to optimise the user experience, and how can these services maximally profit from interaction or Cupertino with the environment?

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5.2.4 Adaptability

Task 2.6- Agent-based Profile Learning and Brokerage {17}

Objectives of the proposed research

- Provide solutions, at application level, for gathering, updating and dynamically adapting user profiles to new situations (location, time, user needs, network and end-device capabilities, and provided services) to achieve optimal brokerage of personalised mobile services.

Rationale

In personalisation, essential determinants are the representation of all the relevant information involved in personalised mobile service delivery [4]. How does one obtain network, end-device, user and mobile service profiles? And how does one keep the data up-to-date with the changing needs and context of network, end-device, user and service providers? All this should be done as automatically as possible, because the user and other stakeholders don't want to be bothered with profile nor brokerage issues during mobile service delivery. Therefore, it is clear that profile learning and brokerage mechanisms must be developed and deployed to ensure mobile service personalisation for the Wireless World. Almost inevitably this will require use, development and deployment of latest agent technologies.

State of the art in the area

To dynamically obtain, update and adapt profiles of users, end-devices, fixed or wireless networks and (mobile) services there are and have been several standardisation bodies and consortia active among which the most influential will be probably the Foundation of Intelligent Agents, FIPA [1], and Cameleon [2]. Both of them consider agent technologies in particular to gather, refresh and change profile information for several (mobile) application domains. Profiles occur in the context of their used agent technologies as a part of the agent (meta)-ontology including agent communication languages/protocols. These (mobile) agents can act on behalf of all individual or group of users, end-device manufacturers, network operators and service providers heading for:

- Enabling centralised or distributed intelligent matching, negotiation, adaptation, initialisation and conclusion of mobile services against acceptable or optimal perceived quality of service, in which e.g. user preferences, price and available bandwidth form essential issues.

To satisfy and enable profile specifications and personalisation architecture, respectively, a (semi-) automatic agent-based profile learning and brokerage management system appears to be indispensable. Requests and offerings of users, device manufacturers, network operators and providers should be matched such that their perceived quality of service levels are optimised or acceptable (sub-optimal). Besides functionality for integral representation of profiles, negotiating and matching profiles, service demands and offerings, such a brokerage system needs deductive or inductive inferential structures capable to *learn, anticipate, adapt and introduce* service changes in next-generation mobile settings. Therefore, the envisioned implementation of the profile learning and brokerage schemes and adaptation mechanisms will have to be based on an agent development and deployment environment with learning, anticipating as well as adaptive capabilities [4].

A possible agent platform that can serve as a profile learning system is a service-oriented negotiating agent system with case–based reasoning or fuzzy rule architectures subjected to genetic algorithms to find the best breed agents making use of profiles [3]. Reasons for advocating evolutionary negotiating agent platforms are two-fold. Time-, resource- and behaviour-dependent tactics and strategies in service-oriented agent negotiations together with their profiles also appear in mobile service delivery negotiation problems, and the service-oriented agent's mental state captures beliefs of a stakeholder and knowledge about and attitudes towards other service delivery issues, which are in the represented by profiles.

Possible approach

To realise a possible evolutionary system of automated negotiating agents selecting best-breed learning agents, we foresee the following steps to be necessary:

- An evolutionary database management system of genetic algorithms:
    - Codification of the agents (meta)-ontology's including communication languages.
    - Codification of the agents behaviour, in terms of applied rules, with respect to relevant (mobile) service delivery issues that are at stake like price etceteras.
    - Codification of the cases of agent negotiation threads together with the quality of service perceived by the individual or group of stakeholders (necessary to derive the relevant inferential structures for learning).
    - Genetic algorithms to find the most suitable agent to serve as profile communicator and mobile service negotiator, initiator or adapter.
- Empirical identification of profiles with the above codification's and genetic algorithms.

Note that the profiles also relate to agent behaviour aspects, the involved negotiation threads and possibly even characteristics of the genetic algorithms like the measures of fitness (suitability) in order to find the best strategies to be followed by the stakeholders' agents.

A generic automated evolving agent brokerage system could make next-generation mobile-services a success by making the mobile service logical, explicit and formally operational. In order to set up such a system, particular frameworks, environments and systems are needed. An agent system architecture is needed that supports creation of negotiation strategies and assessment of their fitness (success) in achieving optimal perceived quality of service. For this purpose, case-based and/or fuzzy architectures seem most promising [4].

As a generic multi-agent-modelling framework one can apply the Agent Unified Modelling Language, AUML [5] in combination with a step transition system. For development and deployment of agents, many environments are available, such as IKV++'s Grasshopper platform [6] and Tryllian's Agent Development Kit [7].

Because our envisioned architecture requires a representation of various profiles of users, devices, networks and servers, ultimately a multi-context system should also be integrated in the brokerage system. Multi-context systems such as DESIRE [8] can be used to represent different components of agent architecture and specify the interactions between the components by means of so-called bridge rules coinciding with (meta-) ontology's. The agent in these systems may have units for theories of belief, desire and intention, whereas the architecture may have units for co-operation, assessment and plan execution at the level of the evolutionary computing of the best breed agents in negotiating mobile service delivery issues.

Expected results

We expect to develop and deploy a proper profile learning functionality within our architecture. Novel (mobile) service businesses and markets of agent-service providers will pop up looking after the interests of the stakeholders. These businesses and markets then support a distributed intelligent negotiation and collaboration of stakeholders before, during and after (mobile) service delivery. Because the brokerage agents remain communicating with the envisioned genetic agent environment enabled by the next-generation mobile service providers, they can reproduce and mutate to counteract static and dynamic (mobile) service changes.

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5.2.5 Generic Service Elements

Task 2.7 – Generic Service Elements {16,20}

Objectives of the proposed research

- Specification of functional components that can be used by a variety of services. This will improve service development by reusing these components, and service deployment by providing well defined service infrastructures.

Rationale

The service architectures for the Wireless World will have to cope with things like numerous service providers, always connected users, automatic service adaptation, context awareness and new IP devices. Aspects like dynamic service discovery and service provisioning in (for users) unknown environments and the personalised services usage requires new mechanisms inside Wireless World service architectures.

Possible approach

The administration of services including tasks like creation, composition and deployment will make heavy use of standardised service profiles in order to allow for seamless service discovery and provision and to promote interoperability between different systems as well as different service types. In this sense service creation is based on functionality that is able to generate or update service profiles possibly as part of an automated machine2machine communication interface. The profiles created are then deployed to an appropriate middleware responsible for supporting the service discovery process by making the profiles available to potential users.

Deployment of the information describing the services (i.e. the service profiles themselves) is heavily based on the paradigm used for service discovery. A centralized approach requiring specific entities to manage the available services will inevitably require a complex system for handling the logistics of this issue. On the other hand a simpler system based on dynamic service discovery in a peer2peer paradigm will reduce the need for specific service deployment functionality by relying heavily on the available service discovery infrastructure described in the previous paragraphs.

Structuring services into constructs composed of various components (that are in themselves viable services) based an object oriented paradigm will allow for the provision of complex service packages to the end-user. Such packages will be configured by intelligent clients performing queries and handling service discovery in the end-users device. Packages of complex services composed of a number of clearly defined elementary service components can thus be made available to the end-user. A meta definition language for the description of composite services could even allow for the dynamic creation, composition and even discovery of services previously undefined by the user or the service provider.

A technology capable of addressing the aforementioned issues and providing a realistic and user-centric solution will have to integrate technologies from the areas of user and service profiling as well as positioning systems and other sensors. The deployment, discovery, assembly and provision of services on integrated network platforms require standardised methods and structures for the representation of user and service data. A way to profile services, and an appropriate meta-data representation for use in mobile service discovery scenarios needs to be investigated. The availability of common profiling techniques and conventions is of utmost importance to the creation of a working service infrastructure. Furthermore readily available and accurate means of acquiring positioning data have to be developed and integrated in both the profiling mechanisms and the service handling technologies. Special considerations include integration of mobility and location dependent aspects that can only be achieved with the help of sensor input that will enable context aware reactions. Finally it is of utmost importance to realise that the implementation of a solution capable of realistically achieving widespread acceptance depends on the utilisation of widely accepted and open Internet standards as building blocks.

Expected results

The most interesting results in this area are concepts for:

- Service Discovery (a mechanism to discover service features dynamically)
- Service Management (massive numbers of parallel services will need new kinds of management)
- Service Creation (to provide a variety of services the fast creation of them has to be enabled)
- Service Deployment
- Service Composition (dynamic inter-working of services will help to create value added services)
- Service Logic (the evaluation of the current situation a user is in → decision what have to be done)
- Service Control (the process to control all the recourses needed for a specific service)
- Environment Monitoring

These functionalities will enable providers to make their products and services available in a flexible way. The same will make it possible for users to transparently discover the desired service. Assembly and configuration of complex service packages composed of various products needed to achieve the requirements stated explicitly or implicitly by the user. Last but not least this infrastructure will be used to deliver the service to the mobile user in the same I-centric manner. Consequently new technologies will emerge that will enable users to locate resources and services within their physical and network environment regardless of the underlying Internet bearer.

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5.2.6 Enabling Technologies

Task 2.8 - Enabling Service Technologies {20}

Objectives of the proposed research

- Analysis of the advanced software technologies that are needed to enable the vision of an open service architecture for context-aware & ubiquitous computing.

Rationale

The next generation (beyond 3G) of mobile services and applications must offer ever increasing levels of value and differentiation (i.e. they have to be attractive, intuitive and easy-to-use, with personalization and ubiquitous access.). These services must also be developed easily, deployed quickly and, if necessary, altered efficiently.

The recent trends of telecommunication such as

- converging networks (telecommunication, Internet, TV and local area networks),
- new kinds of devices (more powerful, more intelligent, multi-mode / reconfigurable, etc.),
- new solution areas (electronic and mobile business; communities and entertainment; etc.),
- importance to provide content (location dependent, personalization, etc.),
- always on behaviour of users,
- characterise the increased mobility in our global society: the mobility of humans, devices, and software.

These trends and the necessity to provide services, which fulfil the requirements of the users, make the elaboration of an open service architecture for context-aware & ubiquitous computing necessary. Figure 5.2-2 shows the different aspects (business model, service management, personalisation, enabling technologies) of such an architecture.

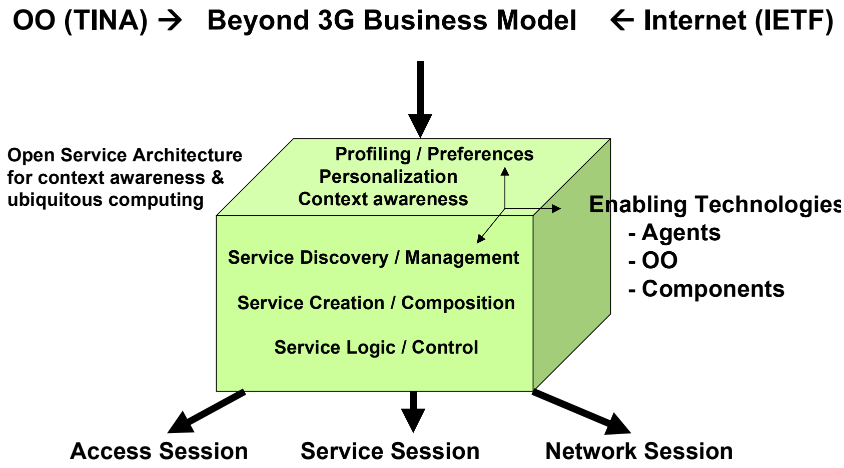

Figure 5.2-2: Open Service Architecture for context-awareness and ubiquitous computing

The main objectives of this research task is to focus on software technologies to realise the service architecture of the wireless world, which includes, e.g.::

- Elaboration of new architectural and functional concepts and models according to the above stated thesis.
- Models for the distribution of processing capabilities, data storage and data management to terminals and network elements.
- Usage of agents to be downloaded to intelligent environments (network elements, smart terminals).
- Usage of open interfaces for service creation.
- Usage of web based technologies for service provisioning.

The harmonisation and coordination of these parallel trends and views may lead to the identification of challenging scenarios and new business models for the definition and offer of advanced services, but the definition of new concepts in terms of architectures and functionalities is mandatory.

State of the art in the area

The challenges and opportunities associated with the evolution beyond 3G have as a prerequisite a fundamental transformation of current networks in terms of intelligence, service logic and distribution of processing capabilities. This is due to the expected heterogeneity for beyond 3G networks: several different radio technologies as well as several classes of mobile devices running a variety of applications will be deployed, while the Internet Protocol (IP) will play the role of the unifying architectural component. To cope with the described diversity, networking paradigms like programmable networking should be incorporated into the vision of wireless / mobile networks “beyond 3G”.

Agent technology

Programmable networking aims at opening low-level access to network elements (routers, switches, base stations) by defining appropriate interfaces. These interfaces can then be accessed by various entities (protocols, agents) to offer advanced and customisable network services. This concept can then be extended with mechanisms for distributing and executing code which programs the interfaces on behalf of individual applications (including those running on end systems). The new paradigm has been called active networking. Until now, however, research work in the literature either considers existing wireless / IP networks to demonstrate the viability of active network or agent-based concepts themselves (proof-of-concept) or aims at demonstrating potential benefits for the particular existing network scenario. We, in contrast, want to outline some thoughts on how agent-based active networking could influence the design of the next generation of wireless packet networks.

An intelligent agent is “*a computer system, situated in some environment, that is capable of flexible, autonomous action in order to meet its design objectives*.” [10]. *“A multi agent system is a dynamic federation of software agents that are coupled through shared environments, goals, or plans, and that cooperate and coordinate their actions”* [11]. It is this ability to communicate, coordinate, and cooperate that makes agents and multi agent systems a worthwhile metaphor in computing and that makes them attractive when it comes to tackling some of the requirements in next-generation telecommunications systems.

A very interesting type of agents are mobile agents, i.e., software agents that are able to migrate between multiple hosts and to carry out computations on different hosts, following an itinerary. In [12], the authors present an analysis of current trends in the Internet which in their opinion opens the path for the deployment of mobile agent technology. Mobile agents distribute code to proxies at the edge of the wireless network as well as to the mobile device. Thus the number of necessary network transactions to provide a service can be reduced by local processing as well as local service customisation. This in turn might lead to less bandwidth consumption and lower latency. Examples for mobile agent platforms, i.e. the software for managing the mobility and task execution of the agents, are MOLE, IBM Aglets, Objectspace Voyager, the OMG-MASIF initiative, Grashopper, Semoa and Swarm. The ACTS (Advanced Communications Technologies and Services) EU program has featured a cluster of agent-based telecommunications projects (CLIMATE: Cluster for Intelligent Mobile Agents for Telecommunication Environments).

The area of active, self-organizing networks is e.g. represented by the DARPA-sponsored Active networks program, the Active Networks project at MIT and the self-organizing network activities at EPFL. The EU-sponsored project FAIN (Future Active IP Networks) aims at developing an open, flexible and reliable network architecture based on active networks. However, only few research work has been done with particular emphasis on wireless / mobile networks: Kulkarni and Minden [13] provide a taxonomy for active protocol components called “protocol classes”. They also propose to deploy such components to the edges of the wireless network. In particular, the usefulness of adaptive error control as well as application-specific filtering is highlighted. Providing adaptive QoS support for wireless / mobile hosts is also the focus of the middleware toolkit Mobiware [14]. Adaptivity is particularly important because of the time-varying link quality. The work covers active networks in the sense that objects providing adaptive transport can be injected into network nodes. Lower layers in the protocol stack (down to the MAC layer) offer programmable interfaces. Besides providing an introduction to programmable / active networks in the context of wireless / mobile networking, Chin [15] emphasizes the potential benefits of active networking for mobile hosts, particularly in the context of mobile IP.

Open service architecture/ open interfaces

The traditional telecommunication environments have some limitations in the areas of service portability and fast service deployment. Several initiatives have been started to overcome these limitations and constraints by opening and making the networks accessible for 3rd party service providers. The main objective of this work is to provide access to the network resources and network capabilities for innovative and creative 3rd party service providers and application designers in addition to the traditional network operators. This opening could lead to new business opportunities for the involved parties and also to an increase of network usage as well as higher revenues for the network operators.

Different solutions have been adopted to achieve this goal, including Parlay [1], OSA [2] and JAIN [4]. These solutions are more or less based on an open application programming interface (API) method. This API is defined as a set of technology-independent interfaces in terms of procedures, events, parameters and their semantics and it is based on distributed computing concepts such as CORBA, Java RMI and other technologies.

These approaches require a lot of agreement between the involved roles, business systems and used technologies. Therefore a new trend has been coming up in the application space: The move from tightly coupled monolithic system towards systems of loosely coupled, dynamically bound components.

The IST project VESPER [17] [18] analyses, defines, demonstrate and validate a service architecture which is based on these approaches and solutions for the provision of selected services across heterogeneous communication networks and the support of the multi-provider approach. Therefore VESPER provides an architectural solution which could be used as starting point.

Possible approach

Agent technology

We propose to exploit some key properties of agents to cope with the anticipated heterogeneity of a beyond 3G wireless network. Our approach should enable seamless mobility independently of a particular (wireless) access technology thus offering seamless service provisioning.

Agent mobility is the capability of transporting objects which include code and state[3] to a network element. We see the major advantages in the rapid deployment of new network protocols and mechanisms. (Mechanisms in our definition cover local processing, like queue management, scheduling, link quality measurement, etc.). It should be emphasized that this specifically also covers only partial deployments. That means that on one hand also proprietary protocols could be deployed and tested to some extent in a live network. On the other hand, protocols which have been widely accepted could be deployed on-the-fly to network domains where they are currently needed, leading to less resources being consumed in the network nodes.

However, we also clearly see the problems associated with agent mobility. The access to internal network resources must be very well secured. Security has to play a major role in the design of the software environment supporting the agent deployment (the agent platform, see above). Also, cost in terms of agent migration overhead and local processing needs to be taken into account. Finally, the compatibility of agent platforms in terms of code and interfaces needs to be assured, as it is the basis for the simplicity of protocol deployment outlined above.

As an example agent mobility can enable the transfer of objects to support host mobility. If only protocol state is transferred, agents can help to improve the efficiency of a deployed protocol like Mobile IP. If state and code is transferred and executed, an active networking approach to support mobility is realised.

The second key property we would like to emphasize is agent autonomy and intelligence. We define this property as the capability of autonomous decisions particularly as a reaction to events in the network. In the context of networking we believe that autonomy and intelligence are interconnected: if an agent is intelligent but cannot or must not make local decisions, remote entities need to be contacted. This then undermines the appealing properties of agents to reduce network control traffic, to react quickly in response to local network behaviour and to sustain some level of operation under adverse network conditions. If an agent is capable of decision making, however its local intelligence is not sufficient, a similar problem arises.

Again, we need to emphasize the security risks associated with agents: giving an agent a great degree of autonomy and intelligence also increases the risk of damage in the event of a malfunction or when such an agent is used for an attack.

An example for the described property of autonomy and intelligence is an agent which, having carried and deployed air interface software for one radio technology, may autonomously requests software from a repository for another technology before a vertical handover.

Both described properties point to the general trade-off of a local versus a centralized network organization. If more emphasis is put on local aspects, the needed network resources for control traffic are lower, customisation is easier and a relatively high local processing power is needed (the opposite arguments apply to a

[3] "State" in our definition could cover e.g. the state of a process, a protocol state machine or information on active connections.

centralized approach). For the local approach, the available processing power then dictates the degree to which functionality in a node can be active, programmable or needs to be fixed.

Open service architecture/ open interfaces

A concept supporting the current trend towards systems of loosely coupled, dynamically bound or assembled components is the concept of Web Services [5].

Web Services reflect a new service-oriented architectural approach, based on the notion of building applications by discovering and orchestrating network-available services, or just-in-time integration of applications. Web Services systems promote significant decoupling and dynamic binding of components: All components in a system are services, in that they encapsulate behaviour and publish a messaging API to other collaborating components on the network. Services are marshalled by applications using service discovery for dynamic binding of collaborations.

Web Services are self-contained, modular applications that can be described, published, located, and invoked over a network; generally, the Web. The Web Services architecture is the logical evolution of object-oriented analysis and design, and the logical evolution of components geared towards the architecture, design, implementation, and deployment of e-business solutions. As in object-oriented systems, some of the fundamental concepts in Web Services are encapsulation, message passing, dynamic binding, and service description and querying. Fundamental to Web Services, then, is the notion that everything is a service, publishing an API for use by other services on the network and encapsulating implementation details.

The concept of Web Services will be supported by "common" Internet-related technologies, such as XML and HTTP and by Web Service specific technologies. These Web Service specific technologies include among others:

SOAP (Simple Object Access Protocol) [6] an XML-based protocol that has three major parts for defining a message exchanged between two components. The envelope defines a framework for describing message content and how to process it. The encoding rules define a serialization mechanism used to exchange application-defined data types. The remote procedure call (RPC) convention enables basic request/response interactions.

WSDL (Web Services Description Language) [7] an XML vocabulary that provides a standard way of describing web services and its interfaces. It provides a simple way for service providers to describe the format of request and response messages for remote method invocations. WSDL addresses this topic of service interfaces independent of the underlying protocol and encoding requirements. In general, WSDL provides an abstract language for defining the published operations of a service with their respective parameters and data types. It also addresses the definition of the location and binding details of the service.

UUDI (Universal Description, Discovery, and Integration) [8] provides a common set of SOAP APIs that enable the implementation of a service broker. The UDDI specification defines an open, platform-neutral, XML-based service description or business description formats.

Expected results

Agent technology

We aim at exploring the potential of agent-based active networking in a beyond 3G network scenario. The focus is on the support of seamless mobility independently of a particular (wireless) access technology thus offering seamless service provisioning. In particular the following research tasks have been identified:

- Identification and specification of necessary extensions to existing agents and agent platforms (with regard to agent mobility, autonomy/intelligence and communication) required to support seamless mobility
- Specification of the necessary local network element interfaces for the transfer of (IP) network state (context transfer, [9]) and objects (protocols, mechanisms)
- Identification of a transition path from today towards a wide-spread deployment of agents applied to networking
- Specification of an interface to the realised network-internal functionality via the open service architecture to allow for programmability and customisation

Open service architecture/ open interfaces

We aim to evaluate how the Web Services technology could be used in the area of Service Provisioning in beyond 3G network. The main focus is to identify the possible usage of the Web Services concept at the open interfaces between network and service provider and the realisation of common functionality which could be used by the all third party applications.

Three main results are expected within this area:

- Definition of open service architecture based on the Web Services technology, outcome of the standardisation (e.g. 3GPP, W3C, IETF) and the results of research projects (e.g. VESPER) . Usage of Web Services for the definition/implementation of the open interface between network capabilities and third party application developers as a complement to or replacement of OSA/Parlay.
- Analysis how the Web Service concept could be used by defining so-call VHE components (common functionality which could be used by all applications) [18].
- Verification if the Web service concept could be used for the definition / implementation of the so-called resource interface (interface between VHE components and underlying network) [1], [2].

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5.3 WG 3 - New Communication Environment and Heterogeneous Networks

5.3.1 Networking in the Wireless World

Task 3.1 - Reliable Transport in Heterogeneous Wireless Networks: Do we need new end-to-end transport protocols?

Objectives of the proposed research

- Clarifying the need for new (not TCP/IP based) end-to-end transport approaches
- Proposing a framework for end-to-end related QoS in a heterogeneous network environment
- Designing reliable transport protocols with QoS guarantees
- Migration of the new approaches into the IP world

State of the art in the area

- General (theoretical) QoS approaches
- QoS frameworks for ATM which do not consider the end-to-end transport layer
- QoS frameworks for IP network domains (IntServ, DiffServ) which do not consider the end-to-end transport layer
- Several approaches for end-to-end transport protocols based on Best Effort strategy (UDP, TCP and its enhancements, SCTP)
- Detailed analysis of the behaviour of TCP in heterogeneous networks with and without wireless links
- Several approaches to improve its performance in heterogeneous networks.

Possible approach

- New QoS aware transport protocol suite including protocols for reliable and unreliable end-to-end transport

Expected results

Design transport protocols that:

- guarantee Quality of Service on an end-to-end basis
- provide a new socket supporting QoS features as interface for application protocols (http, ftp, smtp).

Task 3.2 - Mobile Internet Integrated Network Platforms {21}

Objectives of the proposed research

- Development of multi-bearer, ad-hoc, multi-hop platforms.

Rationale

The recent years have brought significant technological advances in the areas of palm-sized computers and wireless communications, accompanied by a penetration of the Internet in all aspects of our lives. Mobile Internet access accounts today for only a tiny proportion of the Internet users. However, it is forecasted that as early as 2003 almost half of the Internet population will consist of mobile access devices. By that time, a variety of different wireless bearers including multi-hop ad hoc networks, capable of transporting Internet traffic will be available. This development will give rise to a new generation of access devices equipped with multiple access interfaces that will allow simultaneous connectivity over a range of providers and technologies. Consequently, a technology that allows the integration of heterogeneous networks into a single platform capable of supporting user roaming between them will gain importance.

Overcoming the aforementioned problem is considered as a significant milestone in the evolution of modern communication systems because it will lead to the liberation of users from individual providers and bearers (i.e. UMTS).

State of the art in the area

The Internet Protocol was originally designed to interconnect heterogeneous wireline networks. This property of IP to integrate, is inherited by its Mobile IP [3] extension that focuses on mobile environments. Consequently, *the key enabling technology that will form the basis of integrated network platforms is the Internet Protocol and its extensions.*

The Mobile IP [1] is an extension to the basic protocol design for Internet mobile host support. Mobile IP provides functions similar to the post-office forwarding service in order to provide network connectivity to roaming mobile hosts. In that manner, it is possible for a mobile node to vary its point of attachment to the Internet while remaining reachable on a permanent Internet address and without having to interrupt active communications.

Mobile IP introduces new overheads such as network layer hand-offs, triangle routing and tunnelling that bring new challenges in the provision of quality of service (QoS), protocol performance as well as security and privacy. In addition, Mobile IP does not provide any facilities for the management of multiple access interfaces [5]. It is considered that a mobile node with multiple attachment points to the Internet should be able to distinguish between networks with individual properties and intelligently determine on a per flow basis, the most appropriate network [4].

Possible approach

The transparent manner in which Mobile IP provides mobility support to the Internet protocol suite has been considered as one of its most important advantages. As a result of this transparency, neither of other protocols or layers need to be changed. However, the transition from stationary to mobile environments has introduced new overheads such as wireless loss or hand-offs that can affect the performance of other protocols [2]. Moreover, the fundamental assumption of layer independence prohibits the existence of an inter-layer communication that might enable protocols to recover from such events based on information acquired from other layers. From this it is determined that integrated network platforms can only be efficiently realised through establishment of a inter-layer communication. This would provide the means for layers to communicate information about the status of the link, QoS and other network properties, across the stack. Individual protocols or even applications may utilise this information in order to adapt to mobility.

A key issue in integrated network platforms is the capacity of a mobile ode equipped with multiple access interfaces to manipulate and utilise them simultaneously in order to either aggregate resources or to search for the network that best matches the requirements of individual flows. In order for this to occur the Mobile IP protocol would have to be extended. Initially the protocol would have to be brought to recognise the individual attributes of each network made available through its access interfaces. In addition, Mobile IP would have to be able to distinguish between individual flows and according to their QoS requirements associate certain flows with certain interfaces.

Integrated network platforms provide new challenges in the areas of users privacy and security. Such environments provide news ways of attacking a communication and violating a user’s privacy. The shortcomings of existing protocols for the provision of security and privacy in integrated network platforms, needs to be investigated and new extensions need to be identified.

Expected results

The result of this work would be to provide considerations for Internet integrated network platforms whereby a mobile user may roam between homogeneous and heterogeneous wireless as well as wireline bearers without compromising its identity and without interrupting active communications. The mobile node would be able to evaluate available networks of different providers and bearers to determine the best for its communications on a per flow basis. Finally, all communications will be completed in a secure manner and with respect to the user’s privacy requirements.

List of References

[1] Perkins CE. *IP Mobility Support*, RFC 2002, October 1996

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Task 3.3 – Enhanced IP {22}

Objectives of the proposed research

- To enhance IP networking technologies to support innovative multiparty multimedia applications to mobile users seamlessly across heterogeneous wired and wireless environments for interactive communications, contents streaming, real-time games, etc.

- To offer an alternative to the IP-oriented evolution of cellular systems, opening the possibility of attaching 3G UTRAN's and/or 3G Node-B's directly to the IP backbone.

- To explore how IP networking technologies can collaborate with and take advantage of composite radio resource management to optimise the use of radio resources.

Rationale

One trend of evolution in wireless communications positions various wireless technologies, such as 2G, 2.5G, 3G, wireless LAN (WLAN), wireless PAN (WPAN), DVB-T, DAB, etc, as a means of mobile access to the Internet. However it is Beyond-3G, the integration of current and future radio systems by means of enhanced IP networking technologies, that will enable a truly seamless mobile Internet across the personal, home, car, and enterprise spaces.

As IP-based technologies allow more flexible network designs, lower barrier to service provision, and faster offering of innovative applications, Beyond-3G will enhance the overall capability and appeal of any wireless system, facilitating the market adoption of new wireless technologies, in particular 3G and the Wireless World.

State of the art in the area

Beyond-3G is a concept being nurtured in Europe, especially in the context of the 5th Framework European projects. It is still in its infancy as far as the enhancement of IP networking technologies are concerned. The most pertinent projects include WINE GLASS, Moby Dick, WSI, etc. The "System Beyond 3G" cluster and WWRF are the major fora in which the Beyond-3G concept can be further explored.

As for the IETF, little has been done to enable Beyond-3G. However, issues such as QoS mobility support for mobile users, inter-administrative-domain mobility, AAA support for Mobile-IPv6, fast/smooth/seamless handover, etc are recently being discussed. New working groups, such as SeaMoby, were also set up to tackle relevant issues. Progress is at the infancy stage. It is hoped that the European projects researching into Beyond-3G will become major contributors in IETF to help establish the necessary standards to enable Beyond-3G.

Possible approach

Beyond-3G creates a whole new challenge in the enhancement of IP networking technologies. Substantial research is needed to develop, experiment, validate, and assess new solutions and their limitations.

Specifically, integrated support of mobility, end-to-end QoS, multicast, and value-added service provision for both wired and wireless environments in a secure, adaptive, scalable, reliable and self-configuring manner is required. IPv6, due to its relative advantages with respect to address space, mobility and security, shall be adopted as the basis of this enhancement of IP networking capability.

Standard mechanisms should be employed wherever possible. Unfortunately, current standards do not yet fully uphold the Beyond-3G objectives. Mobile IPv6 advantages in mobility should be extended to provide low latency, low loss handover across IP-subnets. Besides, seamless vertical handover between radio networks (of same and different types) within and between administrative domains should be supported. IPv6 QoS mechanisms for Beyond-3G are another significant area of research. In particular, QoS mechanisms should adapt dynamically to particular link characteristics and support adaptive applications. Beyond-3G should also offer QoS to mobile users with appropriate enhancement of QoS policy frameworks.

Besides, research should be conducted so that IP protocol signalling can effectively accompany the particular radio resource establishment procedures, in view of attaching 3G UTRAN's and/or 3G Node-B's directly to the IP backbone. Similarly, IP protocol signalling should also accompany effectively composite radio resource management of heterogeneous radio systems.

Although Beyond-3G systems will be deployed as IPv6-based edge networks, the Internet will remain largely IPv4-based for some time, while evolving gradually towards IPv6. Thus, efficient IPv4 and IPv6 translation must be supported to facilitate evolution towards IPv6.

Expected results

Ultimately, it is hoped that this research will offer IP networking solutions to enable Beyond-3B, thereby creating a truly seamless mobile Internet.

List of References

[1] WINE GLASS
[2] Moby Dick
[3] WSI
[4] WWRF

Task 3.4 - Wireless IP set of protocols, Wireless TCP/IP, Unified set of QoS parameters and QoS Aware End-to-End Transport {23}

Objectives of the proposed research

- clarify the need for new (not TCP based) end-to-end transport approaches and their integration in into the IP world. The objective is to design reliable transport protocols with QoS guarantees.

Rationale

One of the topics to be investigated to serve wireless applications efficiently is the definition of a basic unified set of Quality of Service (QoS) parameters over wireless access. Several QoS parameters have been defined by the IP community but without taking into account the specificity of a wireless access and of a mobile user. Since QoS management is progressing in IP core networks, it is very important to solve the QoS issue in the wireless access in order to provide end-to-end QoS. These parameters should be defined in a generic way with the following requirements;

- *For future all-IP wireless access networks*; the studied set of QoS parameters should take into account wireless specificities, so that any radio layer (layer 2) can interpret them via a generic "IP over wireless" interface.

- *For existing wireless access networks*; one should be able to map the studied set of QoS parameters onto QoS parameters of existing wireless access networks (e.g. UMTS, DVB).

- *For fixed IP networks;* IP is also spreading to fixed access networks. The studied set of QoS parameters should also be able to describe the QoS policy of a fixed IP access network.

To complete this, end-to-end QoS has to be considered, not only for single links, systems (UMTS, WLAN) or IP domains, but also between the communicating devices themselves, even through a heterogeneous environment. Research is required to clarify the need for new (not TCP based) end-to-end transport approaches and their integration in into the IP world. The objective is to design reliable transport protocols with QoS guarantees.

State of the art in the area

Three QoS models are currently defined by the IETF (Internet Task Force).

- Best Effort
- Integrated Services (IntServ)
- Differentiated Services (DiffServ)

Best effort applies when no QoS is defined. It is a very simple model where all applications receive a share of the available bandwidth. It is commonly used in current IP networks. However, QoS is needed to successfully deliver real time applications such as audio or video conferencing.

With IntServ [1], an application sends a request to obtain a type of service prior to emitting data. The request is handled by a signalling protocol such as RSVP (Resource ReserVation Protocol) [2]. The application informs the network about its traffic profile. Once the network has verified that it could reserve the resource the application needs, it sends a confirmation to the application. Then the application can start sending data. It is a connection-oriented model.

DiffServ [3], as opposed to IntServ, does not use a signalling mechanism before sending data. The importance of a packet, its class, is directly conveyed in the IP header in a field called DSCP (Differentiated Service Code Point). For each class of service, the network manages a number of queues in a hop-by-hop manner. Three types of service class are defined;

- best effort (default service class)
- assured services where some bandwidth is reserved for each class (albeit not for each individual connection)
- expedited services for which no bandwidth is reserved, but whose maximum delay, jitter and packet loss rate can be specified.

Until recently, QoS issues in a wireless/mobile context have received little attention within the IETF. Recent groups are investigating the transport of IP over HiperLAN, 802.11 and Bluetooth – their work on QoS has to be monitored. Research also started recently in Europe, with IST projects such as BRAIN, WINE, WINE GLASS. Within BRAIN [4], an IP to Wireless interface has been defined a, as well as an architecture designed to handle mobility and QoS ; however, there is still work to be done especially by defining a unified set of QoS parameters that take into account the possibility that the route include wireless links.

Concerning end-to-end QoS, we can mention;

- General (theoretical) QoS approaches
- QoS frameworks for ATM which do not consider the end-to-end transport layer
- QoS frameworks for IP network domains (IntServ, DiffServ, see above) which do not consider the end-to-end transport layer.
- Several approaches for end-to-end transport protocols based on Best Effort strategy (UDP, TCP and its enhancements, SCTP)
- Detailed analysis of the behaviour of TCP in heterogeneous networks with and without wireless links and several approaches to improve its performance
- Definition, in IST project BRAIN, of an "enhanced socket" that takes into account QoS parameters.

Possible approach

Taking into account the specificity of wireless links

Wireless access differs from wired access by the severity and the duration of changes in available bandwidth, due to handover – after a handover, the new path may have less (or more) capacity. Furthermore, a wireless link is subject to greater bit error rate and consequently to greater packet loss rate. This packet loss should not be interpreted as congestion by the higher layer (TCP). To decrease this packet loss rate, most wireless accesses implement special mechanisms such as Automatic Repeat reQuest (ARQ) or Forward Error Correction (FEC). These mechanisms result in a trade-off between delay, target error rate and throughput, i.e. the "local" QoS parameters of the wireless link; clearly, this trade-off should be adjusted according to the QoS profile. The relationship between the QoS profile and the wireless link error protection options still needs studying.

It is proposed to define a set of QoS parameters that take all the wireless issues into account and also to study QoS-related information exchange between IP and wireless layers. Particular attention should be paid to the fact that specific mechanisms are required to ensure a certain stability of the wireless link QoS in spite of the fluctuations of transmission quality.

Compatibility with existing access networks

QoS policies of existing access networks should be studied so that the defined QoS parameters are compatible with these policies, i.e. can be conveniently mapped to these access networks' own QoS parameters. Identified access networks are;

- UMTS – specific QoS
- DVB – downlink only, based on IP over MPEG2 transport stream encapsulation should be taken into account
- xDSL – ATM-based today, but may evolve towards IP

End-to-end QoS

The proposed approach consists in studying a new QoS-aware transport protocol suite, including protocols for reliable and unreliable end-to-end transport. These protocols operating below socket level, applications would not be affected.

Expected results

Expected results are:

- A definition of the set of QoS parameters described above.
- A definition of a generic "IP over wireless" interface to specify the way information should be exchanged between IP and radio layers so that layer 2 can enforce QoS policy according to its own characteristics.
- Application to specific convergence layers (e.g. IP over HiperLAN 2)
- Mapping of this set of parameters to UTRAN QoS parameters
- Enforcement of these parameters in a DVB distribution network

- Mapping of this set of parameters to xDSL QoS parameters
- Transport protocols allowing to handle Quality of Service on an end-to-end basis
- Provisioning of a new socket supporting QoS features as interface for application protocols (http, ftp, smtp).

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[3] S. Blake, D. Black, M. Carlson, E. Davies, Z. Wang,W. Weiss, “An Architecture for Differentiated Services,” IETF RFC 2475, December 1998.

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Task 3.5 - Network and Services Management {24}

Objectives of the proposed Research

- To develop integrated resource management strategies for heterogeneous networks including both fixed and wireless segments.
- To progress in the definition of joint network and services management.
- To define tools to establish virtual private networks (VPN) over heterogeneous networks (including QoS parameter translation) among different domains and different technologies.
- To use efficiently and propose enhancement to existing management protocols.
- To liaise management techniques and rules related to dynamic spectrum assignment.

New business model must be taken into account since some technologies may use unlicensed spectrum in an un-operated environment.

Rationale

The explosive growth in the number of mobile subscribers and their increasing demand for flexible access to diverse services with various quality of services has motivated significant research, standardisation and development effort in the area of future wireless access systems, and especially on UMTS, the IMT-2000 framework, Mobile Broadband System (MBS) such as HiperLAN, and Digital Broadcasting Systems (DBS), such as DVB and DAB. These future wireless access systems form what it is widely called 3G systems.

The vision for the Wireless World is that UMTS, Digital Broadcast Systems and WLAN will be three co-operating and complementary components. Through this integrated infrastructure operators will be enabled to provide users with efficient (in terms of cost and QoS) wireless access, and service providers with the means for offering sophisticated services.

The diversification of the services, the need to have scalable management techniques as well as the available radio technologies lead inexorably to the requirement of having advanced network and services management platforms.

State of the Art

Recent IST projects illustrate the trend towards co-operation and integration of different radio access systems: BRAIN [1] proposes an open architecture to integrate WLAN and UMTS, DRIVE [2] addresses the convergence between cellular and broadcast networks, WINEGLASS [3] integrates UMTS and WLAN from a user perspective, MOBYDICK [4] concentrates on a common Ipv6-based network architecture to handle mobiles and WLAN systems, and MONASIDRE defines [5] the first blocks for management of heterogeneous networks.

Because IP networks were traditionally best effort, network and service management is limited in current networks. Of course IP network management uses protocols such as SNMP or COPS.

Similarly, management in telecommunication networks uses TMN approach described in the M.30 series of ITU-T.

Approach

With the advent of IP networks supporting Quality of Service, the need to have advanced management techniques is appearing. However, the TMN model from telecommunication world is hierarchical and a bit rigid, i.e. not very adapted to the IP world.

In addition, because an end-to-end connection often goes through different IP domains, a pure centralised management is not feasible. More decentralised and collaborative management schemes should be developed. This trend is even more strengthened by the use of multiple radio access technologies. Indeed, each radio access system requires specific but co-ordinated radio resource management.

The research might take into account various scenarios, from the simplest one where a single operator owns the various radio technologies as well as the core IP network to more complex ones where the different IP domains are separately managed.

The network and service management system should be able to:

- Monitor and analyse the requirements originating from the service area, in terms of traffic volume, mobility levels, etc., and the corresponding statistical performance and QoS levels provided by the network elements (segments) of the managed infrastructure.
- Inter-work with service provider mechanisms, so as to allow service providers to dynamically request the reservation (release, etc.) of network resources.
- Perform dynamic reconfigurations on the (radio and fixed network segments of the) overall managed radio access systems infrastructure, as a result of resource management strategies, for handling new environment conditions and service provider requests in a cost-efficient manner.

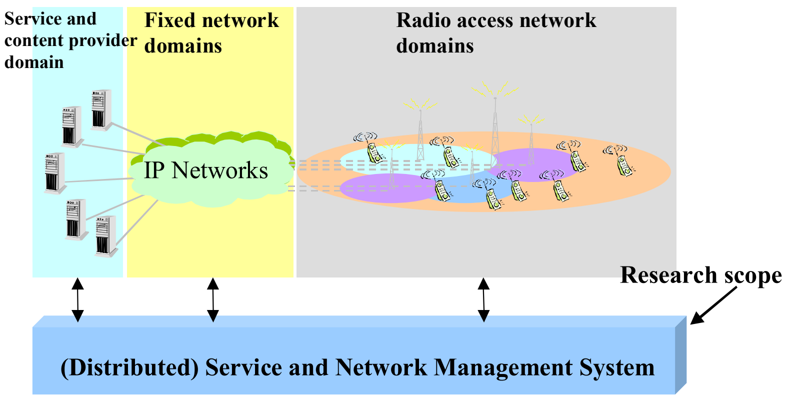

Figure 5.3-1: Scope of Network and Service Management

Resource management strategies are seen as means for improving statistical performance indicators (e.g., blocking or outage probability, average delay, etc.). Schemes that are targeted to the accommodation of individual events (e.g., channel requests corresponding to a new call or handover) are seen as part of the control domain. The management system acts in a manner that is complementary to the control domain, by incorporating (management) strategies that will be targeted to the activation (cessation, etc.) of resources and resource control schemes within time periods of the system operation. Nevertheless, no constraint is imposed on the time-scale on which management actions may be applied. Hence, these may be sought in the short, or medium, term depending on the specific problem that is addressed. Both automatic (in accordance with the *self-organised system* paradigm) and human-driven reconfiguration of the network is envisaged.

The management system is realised as an open, distributed, component-based management architecture. CORBA might be used as a mean to easily distribute the management platform. An even more distributed and autonomous management platform might use software agents. Software agents are autonomous piece of software able to move in the network and to communicate with other agents.

Expected Results

This research should lead define efficient network and service management strategies in a heterogeneous radio access systems context, widely named beyond 3G system. These strategies should basically rely on existing management protocols if they are adapted to this new context. If not, improvements or new protocols should be defined.

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[2] DRIVE: Dynamic Radio for IP-Services in Vehicular Environments, http://www.ist-drive.org/

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[4] MOBYDICK: Mobility and Differentiated Services in a Future IP Network, http://www-int.berkom.de/~mobydick/

[5] MONASIDRE: Management Of Networks And Services In a Diversified Radio Environment, http://www.monasidre.com/

Task 3.7 - Optical Radio Access Networks - beating distance with capacity {25}

Objectives

- To develop the technology necessary for cost-effective optical radio access systems.

Rationale

A trend for coming generations of wireless communication systems is to have higher data-rates in the air-interface. Given the same penetration and usage as today combined with the restrictions on available frequencies, much more information (up to 10.000 times or more for 100 Mb/s in the air interface) has to be handled both in the wireless and in the fixed network. The total network solution should provide capacity, mobility and flexibility at a cost-effective price for the end user, presumably not higher than telephony today. Due to the higher frequencies and bandwidth needed, the density of radio base stations needs to increase. Thus the radio base stations need to be smaller and cheaper to provide cost effective solutions.

On the transmission side the rapid development of optical technology has replaced copper with fibres in the transport and metro networks for capacity and cost reasons. Thus optical fibres would be interesting also further out towards the edges of the network, e.g. to the office, home, and radio base station. This would then solve the need for high capacity. One of the major obstacles in these situations where cost sharing is limited, is the high price of the installation and optical link and microwave components.

Given that low cost optical and RF technologies evolve, it will give the opportunity to bridge distance with capacity. A high transmission capacity almost “for free” also opens new possibilities to new and more efficient network architectures.

The optical networks of today have a limited flexibility. When the optical signal needs to be switched or routed it is generally converted to the electrical domain – and then after switching again converted back to the optical domain. There are evolving technologies to allow for optical (or more correctly electro-optical) switching. Thus the signal can be kept in the optical domain. These technologies are, however, still sophisticated and expensive restricting their use to the central parts of the network.

The overall challenge is to find solutions, which make real-time interactive communication with multimedia services available at the same cost to the end user as telephony today.

Today we are confronted technically with system/network issues including partitioning between optical and electrical switching and routing, flexible optical switching or routing components and mechanisms, extremely low cost optical modules and optical fibre installation technologies, low cost microwave photonics development including small efficient antennas. Another issue is to achieve good power efficiency in the complete network, from battery fed mobile terminals (PDA:s) to the optical switching and routing nodes.

Possible Approach – Expected Results

From this brief introduction we can extract several critical developments that need to be solved for coming generations of mobile systems. Future radio base stations need to meet a micro/pico cell scenario. Important issues include

- Architecture, security, scalability, radio resource management, traffic modelling and characterisation, etc
- Performance/cost efficiency achieved e.g. by using re-configurable logic and designed for test
- Packaging and interconnects for low cost and power efficient HF and microwave components with high reliability (maintenance free) for in-/out-door environment.

At the terminal end – small lightweight intelligent terminals are needed. For these the following issues need to be addressed.

- Efficient architectures, design tools, processes, interconnect structures and material systems for both chip and packaging
- Small sized, light-weight radio systems with extremely high performance/cost ratio to the end user
- Highly power efficient microelectronic solutions working at relatively high frequency
- Flexible solutions, e.g. in system re-configurable logic
- Built in security features and positioning possibilities
- Backed up by a high capacity, fine meshed fixed (optical) network infrastructure.

To meet the combined capacity and flexibility requirement fibre optic developments are needed. Critical issues include:

- Low cost optical modules and fibre installation technologies
- High-capacity, flexible optical network components like optical add-drop multiplexers, optical cross-connects and optical wavelength routers
- Future optical network architectures and efficient signalling schemes
- Correct partitioning between optical and electrical functions for cost effective solutions.

Task 3.8 - The Security and Privacy Layer {26}

Objectives of the proposed research

- Development of a Security and Privacy layer for co-operative network

Rationale

Introduction

Service Discovery, Ad-Hoc networking, automatic reconfiguration and interfacing are powerful technologies. Nowadays IP protocols may be misused to achieve information about people. Traceroute or the DNS can reveal where the user is, sendmail can give information about the real affiliation of people. Virus, worms and intrusions are terrible dangers that affect all the computers directly connected to the Internet. The perspective presented in the Book of Visions is very attractive, everybody and everything are fully connected with any other thing or person: full connection, high bandwidth. In the meanwhile your wrist watch becomes feasible to hackers attacks (maybe paid by your competitor) that want you to reach an appointment too late.

Discussion

Existing technology in the field of protection of security and privacy is not really suited for the MultiSphere model. A PAN level firewall can protect the wrist watch from attacks but at the same time it is also a useless barrier when we are at home, that is usually a reliable and trusted environment, even from the perspective of the data privacy and security. Other layers of firewalls should be needed for the house itself, the car, etc. This would be a wrong solution for at least a couple of reasons: the communication would get fragmented by these ’check points’ on the network, each firewall needs maintenance: log control, software update etc. otherwise the user has only the illusion of security which is worse than having no security at all.

From another perspective the MultiSphere model appears to generate a widely distributed integrated data network including wireline and wireless equipment. All the developments in communication protocols will be evolutions of the IP (v4 and v6) families. In some sense all the wireless devices will be nodes of a single world wide network. The specific functionality of each single device is determined by the services it is able to provide. It is similar to what happens in the Internet today: each directly connected node has its own IP address and a Web server is different from a News or ftp server depending on its open ports.

Today all the packet routing done by cellular companies (e.g. for GSM) is invisible to users. Information like the current cell used by the user’s terminal is secretly kept by the phone company. There is a danger that in the future with some catalogues of addresses and a traceroute it will be possible to track all the moves of a user. If some workaround can be done to prevent the routers to discover their identities a localisation is always possible: some devices in the environment can try to leave some information on the user’s portable devices (e.g. by using a spontaneous network), like the cookies for the browsers. These cookies can be a hint about where the user is (or has been recently).

Research Directions

The convergence to IP protocols for wireless applications guarantees a wide compatibility with existing applications, protocols and networks. At the same time this choice potentially exposes wireless users to the same security dangers of a direct Internet connection.

Existing technologies such as firewalls, VPN sandboxes cannot be directly applied to the wireless mobile world.

Security for our purposes means *protecting user data and information from damages or changes and from denial of service due to either accidental or voluntary events.*

Privacy means *protecting user data, user identity, location and other sensible information from the view of other users when there is not a specific permission to read this data.*

Security and Privacy are two folds of the same problem. A malicious user can access private data by changing access rights or he can change your data by breaking some authentication methods provided he can read your private passwords (sensible data).

In the wireless domain services may change but also access methods, media, frequencies, access protocols, etc. Security models must protect the user independently form hand-offs even between different communication channels (provider, media and so on).

Security must be a shared layer in the whole architecture. This approach is clearly different from what has happened in the cellular communications for all generations up to the third. In a basically single provider/single medium approach (as in cellular networks today), security and privacy of the users can be protected by enforcing strict policies on the network infrastructure. Clearly this approach is unfeasible when applied to a multiple provider (maybe no provider)/multiple media device. When two users are communicating each others by using infrared, Bluetooth or some other LPD like channel there is no infrastructure at all, thus any constraint on the infrastructure trivially cannot be applied.

The new devices will be directly connected to several communication networks both local and wide-range. Today the user can trust nation-wide cellular network providers, tomorrow with a 3++ device she will have to deal with several untrusted attempt of communication, the most of them are related to useful, interesting and well behaved services but she will have to face also to some malicious hacking attacks.

Concepts like trusted domains, hierarchy of trusted networks, degree of trusting, limited trusting in time and space must be included in the security model.

Today in the Internet, firewalls are used to create barriers between public untrusted networks and private trusted ones. Firewalls, as known today, are not suited for the multitech integrated network envisioned for the fourth generation of wireless devices. In fact, a firewall protects a private network by enforcing the policy of a single point of connection to the untrusted rest-of-the-world. This requirement collides both with the idea of mobility and with the possibility of partitioning in the system. If we protect with a firewall the trusted domain of all the devices owned by a specific user it may happen that the user is away from home with his/her portable computer, watch, pda and cellular, far from his/her home located pc, car and microwave oven. This problem could be solved in principle by creating a private extranet (a.k.a. VPN) [4] that extends the firewall protected domain, i.e. the trusted network, to all the device that are temporarily outside the firewall. In practice this solution is not suited for partitionable systems. In fact, to preserve the security of the systems all communications towards a foreign device (not owned by the user of the example) must be redirected to pass through the firewall at home. This behaviour leads also to a very inefficient routing (the communication packets between two users standing one in front of the other may need to travel across the world) and to a system extremely fragile for partitioning (if the firewall is unreachable it is not possible to communicate at all).

Another approach to the security is the concept of sandbox. The user defines a set on information that can be visible by foreign requests. All the service queries, downloaded code or foreign agents cannot access data outside the box. The Java Virtual Machine uses a sandbox to protect the user data from malicious action of applets. Sandboxes are safe if the related code is update as soon as a security hole has been discovered.

The challenge is to find an integration between distributed firewalls, sandboxes, automatic software upgrade methods to preserve the safety and privacy of the user personal data. The tools to configure the degree of relevance and the sensibility of data should permit to the user to define security policies effectively. Most of the authentication and authorisation work should be done in an automatic way, following the policy requested by the user: changes in connectivity, spontaneous connections for local info exchange will be too frequent events to be considered one by one. The user, that in the general case will not be a computer security expert, must receive alerts for possible breakthroughs or for security dangers both runtime and from the tool used to define the policy.

Information is subject to partitions when it is two times critical: it is critical both in the meaning that it is *needed* and that it is *private*. Sensible data can be replicated through the network, on untrusted servers, provided it is encrypted, in this way it is possible to preserve privacy and increase availability at the same time. When the network get partitioned data can be slightly outdated, but in very many cases it is more than no data. Actually there are classes of attacks that make use of data forced to be outdated, but also in this case the challenge is to give the user the right to choose in a simple way if it worth risking. The replication of data, maybe using partitionable group services [5], could also be used to store data on resources available at the base stations rather than on palmtop or wearable computers that can have limited resources due to their size and to the need of low power consumption.

State of the art in the area

Very few work has been done to address this problem. The technology today provides two different classes of wireless devices, about no integration of services is possible between different classes.

- Public (or private) cellular networks (all the generations up to the third) provide voice and data connectivity, usually on virtual circuits. The user need a terminal to access the cellular network, all the problems related to security, privacy, routing, availability are managed by the provider.

- Short range cordless devices. Bluetooth, 802.11 and all similar technologies [3] provide user desk, home or campus wide networks. Security is a matter of the user, not only in the meaning that he/she has to choose the right implementation (e.g. the correct number of encryption bits for WEP) but the user is also responsible for the configuration that may give unauthorised access to computers or access to private information like the location of the user within the local network (e.g. by analysing the signal strength at the base stations). In this latter case the user is also the owner of the communication infrastructure, it means that the user is also responsible for software upgrades, bug fixes and all the maintenance actions required to preserve the security of the system.

These two classes of networking device and protocols have been designed for different set of users. Cellular networks are for the general public, the topology is designed by providers. Short range cordless devices are for close sets of trusted users, the topology may change (ad-hoc networks [1]). The Book of Visions presents a complete integration between these two worlds. An entirely new approach to security is needed.

Possible approach

We have to define twofold standard: a language/protocol for interoperability and a graphic interface to help the user to define her policies.

The research has to move in several directions:

- languages for security rule definitions. it must be extensible, general purpose, flexible in terms of bandwidth, delay and support from connectivity providers, etc. It must be also light: it can be executed on a laptop as well as on a palmtop or embedded computer;

- aggregate safety certification when several communication channels are in use;

- integration of a security layer in the system;

- strong authentication methods also for automatic software updates;

- log analysis methods;

- natural abstractions and metaphors for the user interface;

- proposal of a standard for secure communications and secure interoperability among heterogeneous appliances connected by heterogeneous networks.

Expected results

The challenge is to give the users who are not communication or security specialists in the general case, the way to decide their policies in a simple way.

The challenge is also to define a security definition language and protocols for secure interoperability. This is the way to create a single safe infrastructure where different equipments can interoperate with different networks sharing and correctly managing security policies.

Each trusted domain (set of equipments under the same administrative control e.g. the set of tools owned by a single user or her family) must be connected to untrusted domains in very few (ideally one) well configured, software updated and very controlled points.

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5.3.2 Software Defined Radio

Task 3.9 – SDR – High-level System Research

As mentioned in the Vision chapter, the evolution of telecommunications in the next decade will be characterized by the convergence toward an IP-based core network and ubiquitous seamless access (2G, 3G, broadband, broadcast, etc.) in a context of hierarchical and self-organizing networks and **Software Defined Radio (SDR)** will have a key role in this seamless network convergence. Mobile users will only benefit from this global telecommunication environment if they are equipped with a single re-configurable multi-mode multi-band terminal. These terminals have to be capable to operate in several or all of the different access environments and to support the whole range of applications available on the specific devices in the heterogeneous networks.

The main issues to be solved for SDR and re-configurable equipments beyond 3G are:

- Business models,
- Regulatory and legal issues,
- User and operator perspectives,
- Radio resource and spectrum management,
- System-level issues and integration of re-configurable SDR equipments in beyond 3G Systems,
- Enabling technologies.

Objectives of the Required Research

The research on SDR is at the confluent of three main research domains, depending on each other: High-level system research, HW architecture research (Task 3.10) and System & SW architectures research (Task 3.11).

The High-level system research is the SDR upper layer research and includes the three following objectives:

- Provide the main conceptual inputs to HW and System/SW architectures research, regarding the technical requirements coming from the different existing and future standards, from physical to application layer. This will guarantee the 'open platform' feature of the future SDR reconfigurable equipments,
- Ensure the coherence of the overall SDR research, linking and developing synergies between the two different areas of HW and System/Software. This will facilitate the achievement of the de-correlation between SW and HW, only possible if both research domains exchange and build common understanding,

- Develop homogeneous R&D SDR reconfigurable equipments road-maps, built on technological information coming from HW and System/SW domains. This will ensure the feasibility of the developed concepts and guide the orientation of the overall SDR research.

State of the Art in the Area

TRUST [5, 13, 19, 29] addresses research on SDR and important focus is placed on the terminal re-configuration, following a top-down approach, from a system perspective down to the potential terminal implementation solutions. TRUST analyses the technical requirements and constraints associated to the different RATs to be supported by the reconfigurable equipments, considering Cellular (2G/3G), WLAN (HiperLan2) and PAN (Bluetooth) RATs. This analysis is done from application layer to physical layer. TRUST has also initiated analysis on the feasibility requirements, considering the technological (RF, Baseband…) and regulatory (new spectrum allocation policies, security…) road-maps.

Potential Approach

Research on the High-level system requirements will directly feed into the HW & System/SW research efforts but it will also gain from the developments in hard and software technology. At the first stage of SDR technology research, the technical requirements and constraints associated to the existing and possible future RATs, to be supported by the SDR reconfigurable equipments, have to be taken into account. Thereby, the High-level system research will provide inputs and should review and orientate the identification of requirements realised in the SDR-HW and System/SW research fields. This procedure will guarantee the open platform nature of the equipments for both existing and future RATs.

The analysis of the feasibility requirements, considering the concurrent technological road-maps, is also fundamental to support the research on HW and System/SW Architectures and the possible realization of SDR applications. Using this feedback, the High-level system research will ensure the feasibility of the developed concepts and will help to orientate and foster the overall SDR research efforts.

The major focal points for High-level system research are:

- The analysis of technical requirements and constraints associated to the different existent and possible future radio access technologies (RATs),

- Analysis of the feasibility requirements, considering both the concurrent technological road-maps and the emerging evolutions in SDR HW and System/SW architecture technologies.

The High-level system research should finally be seen as a mean to develop and foster synergies between the two different research domains of SDR HW and System/SW architectures.

Expected Results

The main expected result is the delivery of a consolidated road-map which ensures a complementary approach for SDR reconfigurable equipments research on both HW and System/SW sides. Furthermore, the feedback loop between High-level system and SDR HW & System/SW research may be expected to accelerate the evolution of SDR technology in the HW, System and SW domains.

Time Frame to get the Expected Results

An evolution path for future SDR reconfigurable equipments developments has been identified in the TRUST project [5]. The vision (Figure 5.3-2) addresses terminals, networks and regulation issues and can be seen as a framework for federated SDR research.

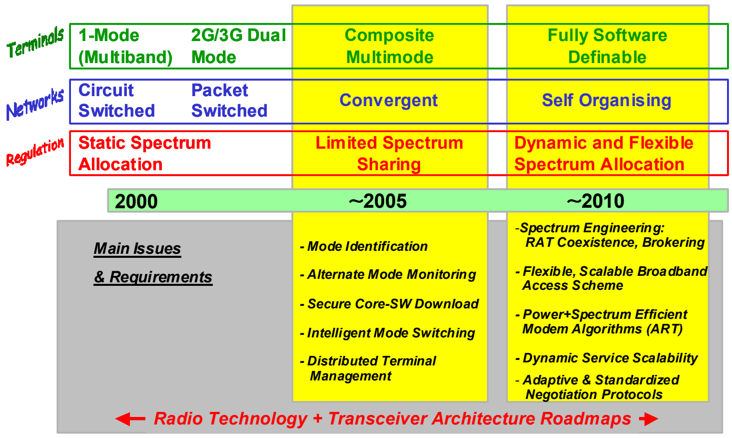


Figure 5.3-2: Time Frame for Re-configurable Equipments

Task 3.10 - SDR Hardware Architecture

Mobile radio communication systems beyond 3G will hierarchically integrate a variety of wireless access networks into a common structure encompassing the 3rd generation WCDMA-based cellular mobile systems, broadband OFDM-based radio LANs such as IEEE 802.11a and Hiperlan-2, and inexpensive personal-area networks like Bluetooth [2, 5, 25, 27]. Users will only benefit from this future mobile communication system if they are equipped with a single mobile terminal capable to operate in several or all different access environments. Thus, small-size, multi-mode, and multi-band terminals with low-power consumption are required. Combining dissimilar and complex access schemes and transmission techniques in a single device requires a re-configurable and programmable hardware platform or a so-called Software-Defined Radio (SDR). The architecture of the SDR equipment has to be sufficiently generic to support these various radio access technologies, differently constrained in frequency band, channel bandwidth, modulation scheme, output RF spectrum, linearity, etc.

Objectives of the Required Research

The feasibility to design and implement a SDR as enabling platform for several advanced wireless access systems is intimately linked to the rapid advances made in analog and digital circuit technology.

The implementation of a SDR with programmable digital circuits only is not yet possible today. However, due to the technological push, the processor speed nearly doubles every three years and the integration density also increases exponentially. Analog circuits will thus be more and more replaced by hardwired digital circuits and finally by software running on digital signal processors (DSPs) and embedded controllers. The portion of software or firmware based components is growing continuously and going to replace hardware oriented microelectronic architectures. This will shift the hardware/software split towards the antenna with increasing processing power of future digital processors.

Moreover, thanks to the advances in modern circuit technology, the time is rapidly approaching when the complete set of digital signal processing and control functions required for an advanced cellular or radio LAN transceiver can be implemented on a single chip. In particular, the cell size of a chip will soon allow that several digital signal processors, dedicated signal processing functions implemented as hardware cores, and embedded controllers together with large memories can be integrated on a single chip.

This very fast evolution of microelectronics requires the development of a hardware architecture, which can be continuously adapted to the respective state of the art. Ideally, this should be an open architecture which is not owned or controlled by a single company. Today, forced by technological limitations, the circuits for radio frequency and intermediate frequency are distributed over separate dyes. For economical reasons, the baseband is joined with the applications. To support the speed of evolution, this current strategy has to be given up. Future microelectronic integration should separate the components by technical functions to get a modular concept for a flexible ‘SDR construction kit’. This could be part of a fully object-oriented design approach and increase the re-configurability capabilities of the SDR terminal. In comparison to the modem (modulator/demodulator) functions, applications are changing more often. The separation of applications from the integrated circuit with the modem functions will allow an easier adaptation to trends with no modification of other hardware components.

On the way to the SDR, transitional solutions will be necessary The baseband functions and firmware cores for several complex standards can be either implemented by means of ‘configurable silicon’, i.e. multiple cores which are switched on and off on demand, or by means of ‘programmable silicon’, i.e. digital processors that first download and then run a required set of functions corresponding to a particular standard or protocol [2]. Because no digital solution for the RF front end is available yet, a parameter controlled analog radio frequency front end is proposed [3].

The objectives of this research project can be listed as follows:

- Definition of a flexible and efficient hardware architecture for an SDR, which is well-suited for
  - the execution of wireless communication systems beyond 3G [2, 25, 27] and
  - adaptable to the evolution of microelectronic circuit technology [4, 8, 12, 26, 30].
- Strategy for Hardware/Software split adaptive to the evolution of microelectronics [8],
- Development of a modular concept for a flexible ‘SDR construction kit’ with
  - re-configurable RF front end and analog baseband, and
  - re-configurable digital baseband, and
  - re-programmable digital signal processing and control engines.

State of the Art in the Area

An SDR is not feasible using state of the art technology because sufficient processing power is not available today. Simulating the function of digital hardware by software, the RF component of UMTS alone would require a processing power of 10000 GIPS (Giga Instructions per Second). This is much more than the equivalent 20 GIPS offered by current ASICs (Application Specific Integrated Circuit).

However, the rapid evolution of microelectronics will make the SDR feasible in the future.

Potential Approach

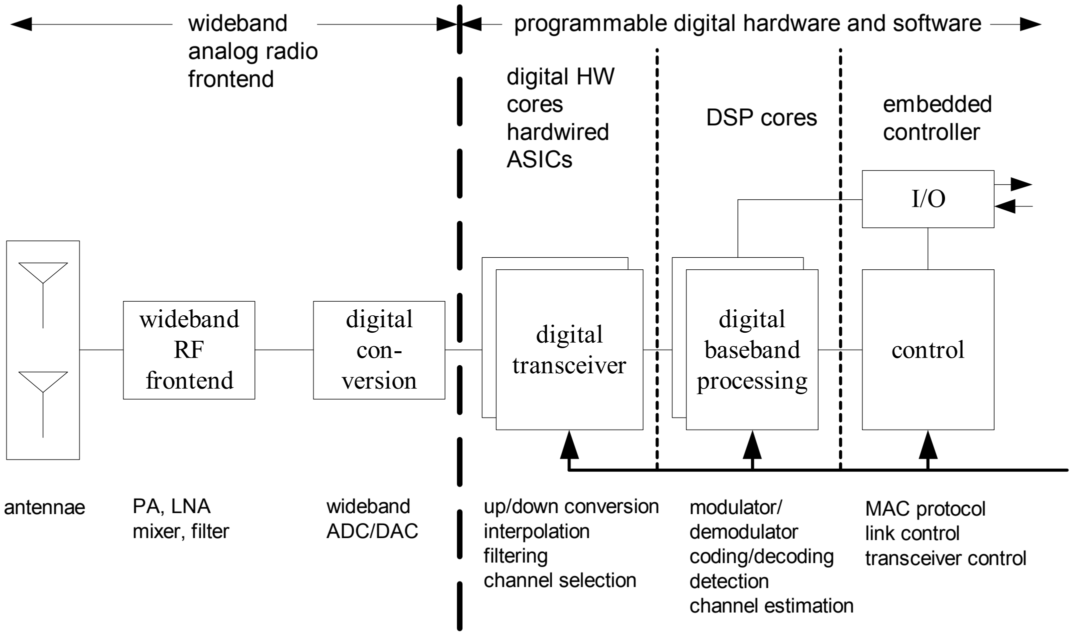


Figure 5.3-3: Functional Block Diagram of a Software Defined Radio

Figure 5.3-3 illustrates the building blocks of a SDR. Its functionality can be split into an reconfigurable analog radio front-end and a programmable digital part. The analog part consists of antennae, power amplifier (PA), low-noise amplifier (LNA), mixers, filters, and wideband analog-to-digital converter (ADC) / digital-to-analog converter (DAC). The digital part is programmable and consists of several hardware cores, DSPs and embedded controller(s). Depending on the selected wireless access system, various hardwired ASIC cores are powered on or off, and software is downloaded for execution on the DSP cores and embedded controller. Hardware cores are typically employed for up/down conversion, interpolation, filtering etc., while DSP cores are used for the digital baseband functions, e.g., modulation, coding, and detection. The embedded controller executes protocol and control software, while the I/O module exchanges data at a high rate with the service user.

In this research project, the analog and digital processing functions of a 3G+ wireless access system need to be identified and efficiently mapped onto the analog and digital building blocks of the SDR.

The architecture of the analog radio front-end can encompass either a heterodyne or homodyne receiver [30] and should incorporate the use of emerging smart antenna concepts. The re-configurability of different RF front-end architectures can only be judged by taking into account system level aspects. The design of the identified parameter-controlled front-end will be specified, simulated, and prototyped in a proper circuit technology.

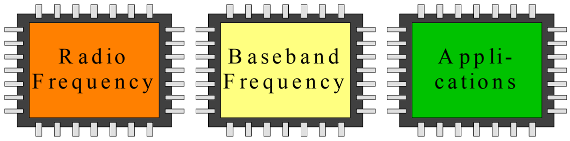
The digital functions need to be assigned either to special-purpose hardwired ASICs or to a suitable DSP or embedded controller. The implementation complexity and processing requirements of the functions have to be assessed taking into account the capabilities of the circuit technology (CMOS, SiGe, etc.). For the digital components power consumption, chip size, and programmable ICs are the criteria, whether to use ASICs, FPGAs (Field Programmable Gate Array), DSPs, CISC-(Complex Instruction Set Computer) or RISC-processors (Reduced Instruction Set Computer). ASICs are intended for a specific purpose and offer highest integration densities and lowest power consumption, but they are not programmable and cannot be modified. FPGAs are standard components and are programmable once. Using such devices with low power consumption and small chip size allow a shorter time to market.

DSPs for signal processing and CISC/RISC-processors for handheld application are programmable. Therefore, their use is much more flexible. Standardized interfaces and standard processors allow the development of hardware independent software, which is transferable to different mobile terminals. However, their power consumption is higher and their chip sizes are larger than those of ASICs and FPGAs.

As shown in Figure 5.3-4, GSM requires for the RF functionality a processing power of approximately 1000 GIPS and about 100 GIPS for the IF functionality [12]. Furthermore, a processing power of 10 GIPS is necessary for the baseband (BB). In this table, corresponding figures are also given for GSM combined with EDGE (Enhanced Data Rates for GSM Evolution) and for UMTS.

The comparison of Figure 5.3-4 and Figure 5.3-5 clearly shows, that only ASICs provide the required processing power of 10 GIPS for the BB of UMTS. Therefore, the signal processing of RF, IF, and parts of BB still have to be realised by analog hardware. For an interim solution, the SDR receiver can be split into an re-configurable (parameter controlled) analog radio front end and a programmable digital part [3, 4]. The following research items are yielding from this:

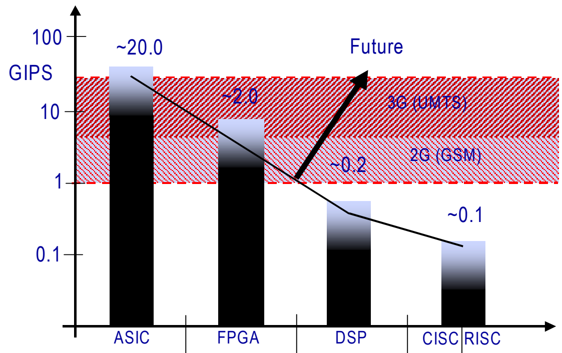
- Development of dedicated hardware cores for switching,
- System level considerations of different RF front-end architectures to elucidate their potential towards reconfigurability,
- Specification, simulation and design of parameter controlled front-ends,
- Choice of a suitable semiconductor technology (CMOS, SiGe, Si bipolar),
- Evaluation of ADC implementations,
- Development of wideband tuneable RF components (filters, mixers, amplifiers [30]), and
- Use of field programmable gate arrays (FPGA) for software download [4].



Estimates given in billion instructions per second (GIPS)	RF section	IF section	analog BB	Digital FE[1]	DSP[2]	Appli-cations
UMTS @ 400 kbit/s	≈10 000	≈1 000	≈100	≈10	≈1	Typ. 0.001 to 1
GSM/ EDGE	≈2 000	≈200	≈30	≈3	≈0.3	
GSM	≈1 000	≈100	≈10	≈1	≈0.1	

[1] FE: Front End
[2] DSP: Digital signal processing = mod. & demod., channel codec

Figure 5.3-4: Required Processing Power



	ASIC	FPGA	DSP	CISC	RISC
Battery Lifetime	++	+	±	-	--
Integration Density	++	+	-	-	-
Programmable	--	±	++	++	++

Figure 5.3-5: Performance of Modern Digital Microelectronic Devices compared with required Processing Power for BB

Of course, the final goal will be an SDR terminal with fully programmable digital hardware. The development of a flexible, future-proof hardware architecture adaptable to the respective state of the art will be required allowing a permanent modification according to the needs of the market. Furthermore a strategy for hardware/software split adaptive to microelectronics evolution has to be devised and a modular concept for a flexible 'SDR construction kit' will be needed.

The following research items have been identified:

- Develop a flexible and efficient hardware architecture for a SDR, which is well-suited for the implementation of wireless access systems beyond 3G.
- Derive a modular concept for a flexible 'SDR construction kit' that can be adapted to the future state of the art of microelectronics [8].

- Partition the hardware into a re-configurable analog radio front-end, a re-configurable digital baseband processing engine, and an embedded controller for executing control and protocol software.

- Exploit the progress made in semiconductor technologies to design, simulate, and implement

    - a re-configurable RF front end with analog components (LNA, PA, mixer, filter, etc)

    - a high-resolution wide-band ADC/DAC,

    - a re-configurable digital baseband with ASIC cores, FPGAs and/or DSPs.

- Select an embedded controller suitable for

    - configuring and controlling the SDR via a system bus, and

    - executing the lower layer protocol software of the wireless access system.

- Verify the flexibility of the architecture by creating a SDR reference design, which can execute terminal functions of the FDD and TDD mode of the 3G-WCDMA cellular system as well as an OFDM based radio LAN.

Expected Results (Hardware Architecture)

The ambitious goal of the envisaged research effort is to develop a SDR architecture with well-defined building blocks and interfaces. Since an implementation of a fully digital SDR is not feasible with today's available technology, the objective of this research is to design a SDR consisting of a re-configurable RF front-end to be realised by analog circuits with switchable parameters [3, 4, 30], re-configurable digital circuits, and programmable processors. The proposed architecture will be verified with the help of a reference design, which targets wideband CDMA-3G and OFDM-802.11a.

In the long term, a fully digital mobile device is desirable, which is able to integrate itself into existing and also coming heterogeneous networks by automatic software download (reconfiguration by software download) without the need for manual interaction of the user.

The SDR architecture developed within the framework of the WWRF will be open and it will remain extendable, i.e., allow the addition of future building blocks for next-generation wireless systems.

Task 3.11 - SDR System and Software Architectures

Objectives of the Required Research

The 'beyond 3G' system is commonly agreed and characterised as the convergence of systems, where different networks will cooperatively work with each other to deliver a mix of services and applications cost-effectively and transparently to the roaming users. The fundamental requirements to enable the cooperation between networks is provision of software configurable terminals and networks, which can efficiently and intelligently configure themselves to different air-interface standards, applications and faster/easier accommodation of technological advances.

Re-configuration of mobile SDR terminals will require complex interactions between the terminal and the network entities, including download of new software modules to be installed on the terminal and the discovery of services. In order to facilitate the implementation of the standardized distributed interfaces, required for the interactions between the SDR Terminal and entities in the fixed network; a general distributed application framework must be provided. The interworking, mobility management and roaming will be handled via the medium access systems and the IP based core network and will impact the current existing signalling.

To support the development of software defined and re-configurable radio and networks, the research on SDR Software Architectures will have to address the following main areas:

- System and network architectures supporting re-configurable equipment,
- Network-centric re-configuration support,
- Terminal-centric re-configuration support.

An immediate impact is expected on:

- Efficient use of the existing network resources,
- Enhancing the capabilities for adaptable wireless service provision,
- Adaptive and customisable QoS provision by using 'the right network for the required service',
- Global access, roaming and service availability.

The three main research areas include a number of technical, regulatory and business issues to be addressed. On the technical side these are:

1) System and network architectures for re-configuration management: Based on IP-based RAN and CN architectures and the architectures already defined in TRUST and VCE Core Project [13,14], the requirements for a network infrastructure supporting terminal re-configuration should be assessed. Distributed architectures for such an infrastructure as well as particular additional components required in the network should be developed. The infrastructure has to provide support for several *functions, in particular for enabling distributed mode negotiation and mode switching decision making, efficient strategies for user-centric mode selection based on context information, and ensuring QoS of software download. Furthermore, new efficient handover procedures for software download need to be defined.*

2) Network-centric support re-configuration. The terminal re-configuration can be at the initiative either of the terminal or the network. A local intelligence on the terminal must interact with the network, other terminals, or new software on another terminal. Procedures and signalling between communicating entities must be defined. There is also a need for specification of a minimum set of signalling for the purpose of controlling reconfiguration procedures namely, request, control and management processes. The research should also include the following points:

- Analysis of service discovery in support of the re-configuration process and implication of agent technology from the terminal point of view,
- Development of standardized and adaptive protocols for vertical handover negotiations,
- Identification of requirements and constraints on wireless middleware. Definition of wireless middleware services as transaction management or interaction management.

3) Terminal-centric support re-configuration. The terminal re-configuration manager as part of the local intelligence on the terminal takes care of the successful re-configuration tasks. The research will have to focus on the following technical issues:

- Management of mapping of software on the hardware platform. Management of lock-up, crash, reset and recovery mechanisms,
- Definition of open APIs necessary for re-configuration processes,
- Development of Hardware Abstraction Layer (HAL) de-correlating HW platform from application software,
- Development of object-oriented approach for platform design and realization.

Global circulation and issues like standard compliance testing of software re-configurable terminals are the initial topics that need to be addressed by the regulatory/standardisation bodies. Furthermore, the provision of a global connectivity channel for software radios and its implications could be investigated and finally research areas as usage of competitors network infrastructure, unified billing and global roaming support have to be explored.

Cross network integration and global software radio connectivity and support will have various beneficiaries, the results of this research, the implementation and application of these technologies will influence:

- Global mobility and connectivity to wireless communication systems,
- Service specific choice of networks,
- Flexible application execution platform and network adaptation and

- Global regulation and standardisation.

State of the Art in the Area

The SDR Forum has lead research on software download, open platform development and the definition of functional description and Application Programming Interfaces (APIs) of software components for Software Defined Radios.

Important middleware technologies (like CORBA, Java/RMI, JINI, UDDI, SOAP, WSDL, SLP, Bluetooth, SDP, and DCOM) and their significance for the implementation of reconfigurable systems are acknowledged.

Network and functional architectures supporting re-configurable terminals have been proposed by TRUST [13]. A re-configuration management architecture has been proposed by Mobile VCE, as part of the core 2 Software Based Systems research area, see [14] and [29] for further details. And a terminal architecture, based on the JTRS initiatives SCA, have been proposed by ITRI [15]. The three cornerstones for re-configurable software architectures enabling seamless vertical roaming are re-configuration management, software radio connectivity and cross network signalling (i.e. enabling interworking between networks), the current state of the art in these areas is documented in the remainder of this section.

Reconfiguration Management

Software re-configurable radios and re-configurable mobile communication networks require intrinsically an additional degree of freedom which enables them to provide the well-known 'anywhere, anytime, anything' communication. Software definability of terminals and network nodes introduces this freedom to communication platforms, however reconfigurability causes the problem that nodes within a network may assume different configurations. Additionally, the configuration (i.e. the currently active implementation of an access scheme) of a re-configurable terminal (or network node) needs also to be monitored and if necessary adjusted, e.g. a terminal may be configured to either standard A (e.g. GSM) or standard B (e.g. UMTS), it must not dwell in a transition between two states (configurations).

An architecture to manage and control the configurations and re-configuration procedures within terminals and also within the nodes of the access networks is required. Such a re-configuration management architecture needs to provide mechanisms that enable the terminal to detect available radio access networks and prevent both reconfigurable terminal and the complete access network to slip into undefined or unwanted states/configurations. So far, reconfiguration management has not been widely addressed and literature documenting this important research topic is rather scarce (see also references [13, 14, 15, 16]) The TRUST project has introduced functional and network-centric architectures supporting re-configurable terminals [5, 13, 29], whilst Mobile VCEs efforts have been concentrated on investigations in a distributed reconfiguration management architecture [14, 21]. These architectures have to be extended and developed on the network side (to go up to the overall system architecture) and on the terminal and base/station side (to go down to the physical implementation architecture).

Software Radio Connectivity and Cross Network Signalling

Reconfiguration and in particular provision of the initial connectivity for software definable terminals is an increasingly important research topic. Assuming a terminal configured to an access standard different from the one provided within the current coverage area, the terminal first needs to determine the appropriate access scheme and may then perform a reconfiguration process to assume the required access standard.

This problem reappears with every movement of a terminal from the coverage area of one to those of another radio access network. With every migration, the terminal requires or find (blind or assisted mode identification and monitoring investigated in TRUST [13]) information about the type, frequency range, quality, etc. of the available access scheme/s. Assuming that the required reconfiguration software (i.e. to the target access scheme) is not already resident within the terminal, the network and terminal then require the infrastructural means to provide basic connectivity which enables the download of the required configuration software and supports reconfiguration of terminals to the target access scheme. One proposed alternative is the use of the boot protocol investigated in TRUST [13]. Basic connectivity is one aspect for software reconfigurable terminals, evolving of this reconfigurability however is the possibility for vertical handovers to any other radio access system, therefore, the second major research area in the field of 'SDR connectivity' is the provision of cross signalling to facilitate interoperability between the different access networks. Therefore, one of the aims of the system beyond 3G has to be the provision of means to enable interoperability between and cooperation of existing and future wireless access networks. An example for such cooperation has not been foreseen in the original design of legacy networks, the exception to this is the 3G specification for unidirectional handovers ('hand-downs') from UMTS to GSM.

Solutions for possible interactions between terminal and network regarding vertical handovers have been proposed in TRUST [13]. A complementary approach to support vertical handover is currently pursued by Mobile VCE, these efforts include both the Reconfiguration Management Architecture (RMA) and an Universal Reconfiguration Signalling Architecture (URSA) as introduced in the remainder of this section.

The role of this a common (universal) access channel is to support seamless roaming throughout the coverage areas of different access (traffic) systems and also to inform the user/terminal about availability and accessibility of local access networks (i.e. to facilitate basic connectivity). Additionally such a universal signalling architecture has to support and control the reconfiguration procedures in reconfigurable network nodes (e.g. software definable terminals). An URSA, based on a distributed object platform could provide the basis for such a software radio reconfiguration support – connectivity and network interworking channel. An URSA network infrastructure will provide an universal signalling backbone and signalling bridge between the different types of traffic networks. URSA requires a network infrastructure, various network entities and appropriate protocol stacks for these entities have to be defined.

The major tasks of the URSA are:

- Provision of basic and continuous connectivity for reconfigurable mobile terminals,

- Cross system connection management (CM) i.e. establishment, maintenance and release of connections to enable access to the various (traffic) networks,
- Cross system mobility management (MM) i.e. location management and support of vertical handoff signalling,
- Reconfiguration software download signalling.

Literature provides a number of proposals aiming to introduce a connectivity channel, the schemes suggested range from a Network Access and Connectivity Channel (NACCH), via a Bootstrap channel to a Global Pilot Mechanism (ETSI) or Global Radio Control Channel (ITU), see references [20, 22, 23, 24, 25, 26, 27]. General cross system signalling and the definition of a suitable signalling platform are initially documented in [28], whilst [14] provides and overview of the associated RMA.

Links with other research initiatives

A number of projects and forums are engaged in reconfigurability and software radio research, including various projects of the European IST programme, organised in the cluster for reconfigurability (http://www.cordis.lu/ist/ka4/mobile/reconfigurability2.htm):

- TRUST: (http://www.ist-trust.org)
- MOBIVAS: (http://mobivas.cul.di.uoa.gr)
- PASTORAL: (http://www.ist-pastoral.org)

Other efforts on the definition, specification and standardisation of software defined radios and wireless distributed object computing platforms are documented at:

- Mobile VCE: (http://www.mobilevce.com)
- SDR-Forum: (http://www.sdrforum.org)
- Object Management Group: (http://www.omg.org)

These research projects and standardisation efforts may provide valuable inputs and possibly standardised mechanisms capable to support the specification of an integrated heterogeneous network environment which will facilitate cooperation between different access networks, management of network and terminal reconfiguration and global roaming of software definable radios.

Potential Approach

System and network architectures supporting re-configurable equipment

The architectural research [14, 15, 29] will cover:

- An investigate and proposal of adequate system architectures,

- Research into efficient handover procedures in mobile networks supporting terminal re-configuration management, software download and peer to peer interaction,
- The facilitation of distributed mode selection,
- Support of QoS for reconfiguration software download, based on IP-based transport.

Network-centric re-configuration support

The research will address the following areas [1, 5, 6, 7, 9, 10]:

- Interactions between terminal and centralized and decentralized networks,
- Discovery of the environment and its capabilities. Adaptation to changes in the environment,
- Self-configuration and self-organization,
- Network procedures for terminal re-configuration,
- Solutions for routing and configuration management,
- Novel signalling mechanisms,
- Universal Reconfigurable Signalling Architecture (URSA),
- Mode switching negotiation and vertical handover,
- Standardized negotiation methods between user, terminal and network. Flexible and adaptive negotiation protocols,
- Mobile agents and agent technology,
- Re-configuration management as a part of configuration management,
- Secure software download including authentication, capability exchange and integrity assurance,
- Radio resource dedicated to software download,
- Minimal set of terminal and network functionalities to be standardized as e.g. reset and recovery procedures for terminals,
- Wireless middleware.

Terminal-centric re-configuration support

The research will address the following areas [5, 17, 30, 32]:

- Management of SW mapping on HW platform,

- Definition of open APIs,
- Development of Hardware Abstraction Layer de-correlating HW platform from application SW,
- Development of object-oriented approach for platform design and realization,
- Re-configurable signal processing algorithms to enhance the performance of re-configurable terminal in the use of the spectrum resource, efficiency of transceiver implementation and power management.

The re-configurability support and domains are synthesized in Figure 5.3-6:

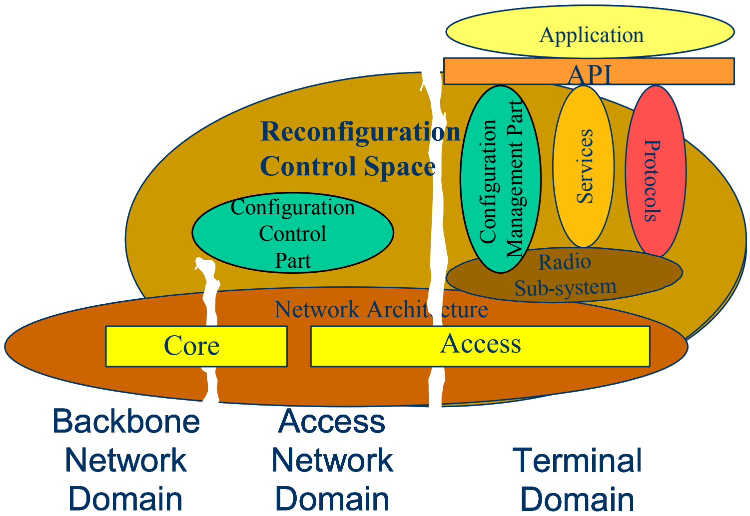


Figure 5.3-6: Re-configuration Support in Re-configurable Access Networks and Terminals

It is inevitable, for potential research into the software architecture for Software Defined Radio systems, to include complete access networks into the re-configuration processes and also to introduce reconfiguration management techniques that cover the complete re-configurable communication system. Figure 5.3-6 illustrates the co-operation and interaction of network and terminal reconfiguration management; the principle distinguishes between network and terminal reconfiguration management parts (i.e. Configuration Control Part and Configuration Management Part, respectively) but combines them in a 'Reconfiguration Control Space'.

Expected Results

Basic connectivity, software radio re-configuration support and interworking of access networks (i.e. for vertical handoffs) are to be achieved. Therefore, a platform-independent structure has to be developed and a re-configuration management scheme for re-configurable nodes in wireless networks have to be educed.

Following issues will need further exploration:

- Definition of minimum requirements for global connectivity,
- Network reconfiguration management,
- Definition of a software interfaces architecture to enable access and use of the re-configurable features within mobile networks.

Architecture supporting re-configuration, based on an application programming interface (API) architecture for software definable radios will provide an open re-configurable communication platform.

Eventually this will deliver interface architectures for both Terminal and System capable to enable and support re-configuration. Additionally the research will deliver the definition of procedures and protocols for terminal re-configuration in hierarchical and decentralized networks.

In the future, a broad variety of radio access technologies and networks will be surrounding us. These networks will be combined together and will appear to the user as a seamless single network.

Equipped with an automatically self-configuring mobile device, the user will just apply this SDR terminal without worrying about technical details. The complexity of the heterogeneous network will be hidden for the user.

Time Frame to get the Expected Results

The System and SW architectures research road-map is part of the overall road-map presented in Figure 5.3-6.

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5.4 WG 4 - Spectrum, New Air Interfaces and Ad-hoc Networking

5.4.1 Spectrum Issues {27}

Task 4.1 - Spectral Coexistence of TDMA/FDMA and CDMA Systems

Objectives of the proposed research

- to explore methods to provide cost- and spectrum efficient radio services.

Rationale

The objective of the proposed research is to explore methods to provide cost- and spectrum efficient 3G services by operating systems using different multiple access methods in the same frequency band. These methods, especially, appear valuable to ease the migration from one generation to the next but are not limited to this. The capacity in Erlang/(MHz*km^2) is the criterion for the success of the work. The proposed coexistence would allow to exploit the signal space better than is possible now.

It might be that coexistence of systems is favourable in terms of cost, power consumption and spectrum efficiency, compared to the application of more advanced signal processing techniques, e.g., using smart antennas and MIMO techniques, applied to CDMA systems, operated in their own bands.

State of the art in the area

Most of the wideband 3G systems use CDMA as the multiple access method, e.g. UMTS, TD-SCDMA, and CDMA2000. Furthermore, some IMT-2000 family member systems use TDMA or FDMA or both as the multiple access method, e.g. UWC-136/GSM EDGE, and COFDMA systems are under discussion to be integrated with 3G systems.

CDMA systems, owing to its spreading gain, are able to suppress narrowband disturbers and narrowband TDMA systems could be affected only to a certain degree by CDMA systems coexisting in the same band depending in both cases to the spectrum usage density. [1-5].

CDMA systems use spreading methods to spread a narrowband signal into a wideband signal. Since the spreading process does not change the power of the signal, the spectral power density of the spread signal is lower than the power density of the narrowband signal.

Figure 5.4-1 shows the principle of the spreading and the de-spreading process. The narrowband useful signal is spread, the spread signal is transmitted over a wideband channel and de-spread in the receiver. Typically, CDMA systems don't need clustering, i.e. the same frequency can be used in all cells.

As visible from Figure 5.4-1, the de-spreading process in the CDMA receiver operates as a spreading process for narrowband interfering signals. In terms of co-existence of TDMA/FDMA and CDMA systems, the narrowband FDMA channels act as narrowband interferers for the CDMA system if they exist in the same frequency band as the CDMA carrier.

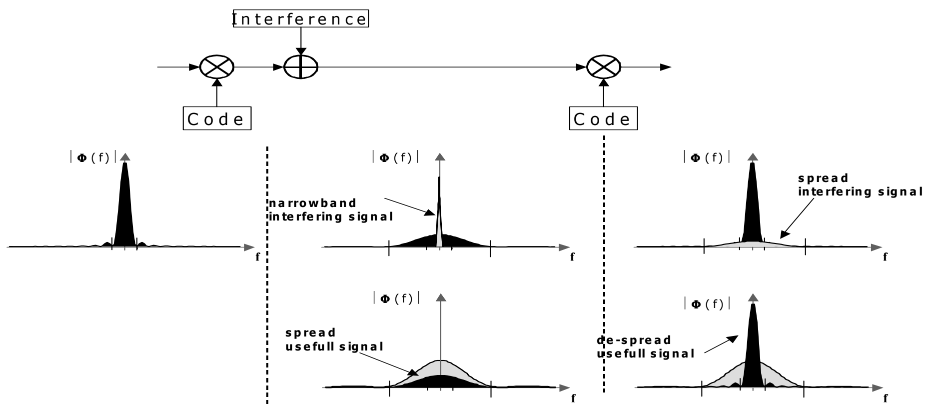

Figure 5.4-1: Spectral Characteristics of DS-CDMA-Systems

Figure 5.4-2 shows an example spectrum usage if a TDMA and a CDMA system are operated at the same time in the same frequency band. Due to the clustering in the TDMA system only some of the TDMA frequency channels are used in one TDMA cell while the whole wideband frequency channel is used in the CDMA system in all cells.

From the TDMA system's point of view, the CDMA system acts like a noise-like interferer with a low spectral power density. The receiver filter in the TDMA receiver will make sure that the noise like interfering signal will only be received in the narrow bandwidth of the TDMA system. Thus, only a small part of the interference power originating in the CDMA system will be received.

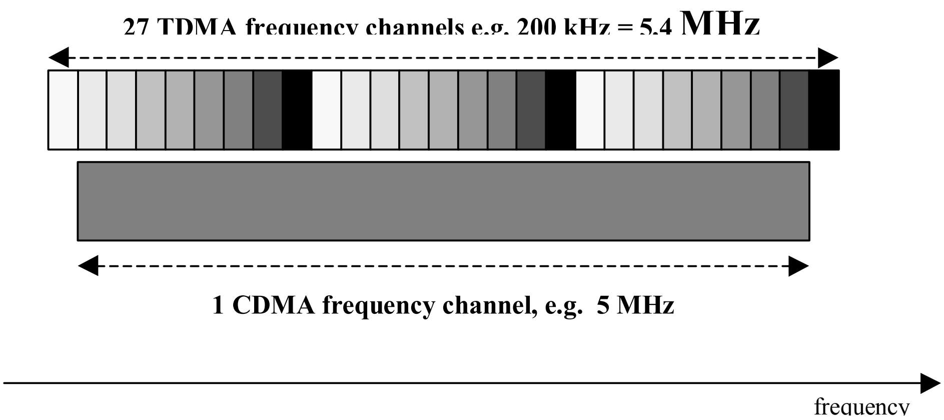

Figure 5.4-2: Spectrum usage in the coexistence case

From the CDMA-system's point of view, the TDMA system acts like a narrowband interferer that is de-spread in the CDMA system's receiver into a wideband noise-like signal while the useful signal is de-spread into a narrowband signal with high spectral power density. Furthermore, due to the clustering in the TDMA/FDMA system, only a small part of the narrowband frequency channels are used in one cell and thus acting as interferers.

Figure 5.4-3 shows an example co-existence scenario. TDMA and CDMA base stations are co-sited. Both systems are operated in the same area and in the same frequency band.

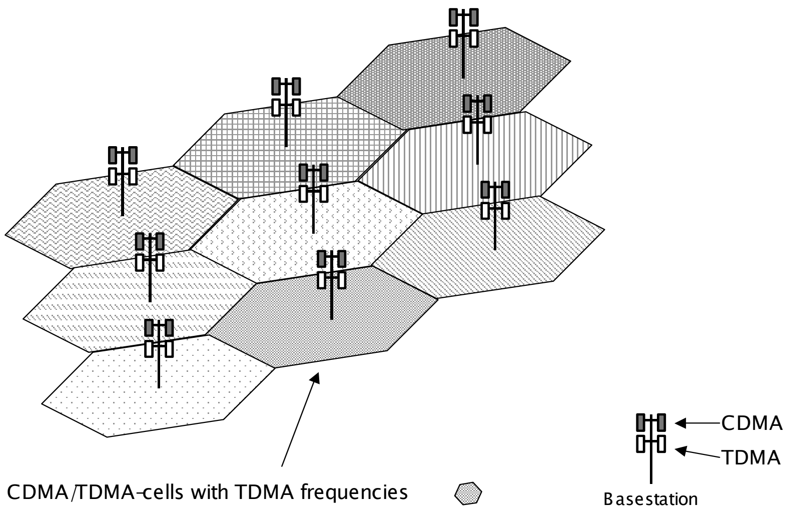

Figure 5.4-3: Coexistence Scenario

The proposed overlay of systems appears promising also for the current GSM bands, where a CDMA could improve the capacity.

It is worth mentioning that CDMA has been invented to be jamming resistant, e.g., to be able to survive under heavy narrowband signal interferencies. This property is not exploited in the current 3G CDMA systems designs, since the whole spectrum allocation will be necessary in urban high density areas to offer the required traffic capacity and quality since the bands used are exclusively assigned and no interference from narrowband systems is existent at all. The ability of CDMA to operate under narrowband disturbers is re-interpreted here as operation under the co-existence of a TDMA system, say GSM/(E)GPRS that is operating some narrowband (200 kHz) channels in the 5 MHz band assigned to, say, UMTS.

Research – Expected Results

Investigations are proposed to identify the kind of services that are best-suited to be provided in each of the coexistent systems. A packet switched service could, e.g., be best suited for the TDMA system since then the interferer's position to the CDMA base station changes with time allowing to exploit a diversity gain to reduce the near-far effect.

A high spreading factor of the CDMA system would allow to suppress the interfering narrow-band signals. Low bit rate circuit-switched services might be best suited to be served by the CDMA system. It is probable that this coexistence could rather apply in low traffic density areas under certain conditions that would need to be addressed in a further step, such as the way to optimally place the base stations of the co-existent systems in order to ensure the required traffic capacity and service quality (this would be another research item).

The spectrum efficiency gain and the complexity and power consumption in mobile terminals will have to be compared with that resulting for more advanced CDMA systems.

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Task 4.2 - Frequency Etiquettes and Spectrum Sharing Rules

Objectives of the proposed research

- Development of generally accepted methods and rules for spectrum sharing.

Rationale

An uncoordinated operation of radio systems co-existing in the spectrum such as in the ISM bands (e.g., 2.4 GHz) has been extended in the 5 to 6 GHz band to license-exempt bands with 300 MHz opened by the FCC for the U-NII, 445 MHz for HiperLANs by CEPT and 100 MHz for MMAC in Japan, respectively.

HiperLAN/2 systems at 5 GHz being a transparent wireless extension of ATM, UMTS, IEEE 1394, and IP-based networks to wireless terminals aim to support quality of service (QoS) requirements as known from fixed ATM networks. IEEE 802.11a operating at 5 GHz contains the PCF enabling the support of QoS requirements to some extent. There is no concept known how to guarantee fairness of spectrum usage across systems and how to enable the individual systems to guarantee a QoS contracted to a communications session throughout a communication phase.

Next Generation (NG) systems will use high bandwidth channels, they may have to use frequency bands that are spread over several compounds that are sufficiently free of interference. Further, to allow systems to share the spectrum with forthcoming or existing systems, the new systems should be able to survive in extreme load situations where a limited amount of free spectrum is available only with the required QoS.

State of the art in the area

The 5GIAG (5GHz Industry Advisory Group) [1] group has undertaken to harmonise inter-working and has also considered the operation of different WLAN standards licensed to operate in the same spectrum. The results are a progress but are not very convincing to solve the problems resulting from uncoordinated co-existence [1], [2], [3].

Expected Results

Frequency Sharing Rules (FSR) are to define to allow different radio standards to co-exist in the same spectrum. All systems applying a defined etiquette and the respective FSRs, would increase the QoS to their user terminals.

Since the forthcoming ad-hoc and infrastructure-based systems are likely to operate without synchronisation to other systems operating in their vicinity, e.g., HiperLAN/2 and IEEE 802.11a systems must be protected against each other, and against across-standards interference. Without supporting measures, any system will be selfish and try to get as much radio resources as possible (if required by its user terminals) and all the other systems will be interpreted as competitors. This would lead to a non-co-operative non spectrum-efficient operation.

It would be advantageous if wireless systems following different standards would be multilingual in the sense that they could co-operate across standards and interact with other systems in their own air-interface language.

Measures to enable self-organising NG systems to make efficient use of spectrum for interference-free operation are to develop. Further, strategies to enable a system to survive under extreme spectrum load situations with the required quality of service are needed.

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Task 4.3 - Spectrum Exploration for Mobile Radio {28}

Objectives of the proposed research

Two non-conventional methods are proposed to be investigated:

- co-farming of spectrum, where two operators agree to share a given frequency band time-alternating for different radio services under predefined conditions and
- co-operation, where two organisations agree to make available parts of their licensed spectrum to be used in a way that a new radio service can be operated there by both together.

Both methods substantially contribute to make available spectrum for economically meaningful usage and to reduce the scarcity of spectrum in general.

Rationale

The reason for the proposal is that both, the defence community and the broadcasters are assigned excessive parts of the frequency spectrum that would be best suited for cellular operators to extend their existent services. It is proposed to identify suitable frequency bands and to study the conditions that would allow co-farming of these bands.

It is proposed to develop measures to motivate operators that are licensed large amounts of spectrum by the government to actively contribute to raise a revenue from parts of their spectrum by opening it for commercial services against usage fees.

It is expected that national governments in Europe might agree that both, the defence community organisations and the broadcasters working under public law, would open parts of their licensed spectrum to raise money, thereby lowering the financial contributions requested by this organisations from the government.

Today many Radio Access Technologies (RAT) are available through different systems such as cellular (GSM, UMTS…), broadcast (DVB-T), WLAN (Hiperlan/2, IEEE 802.11), and PAN (Bluetooth). Each of those systems has been initially designed for specific services and applications in identified operating areas. SDR represents the mean to achieve the full interoperability between all those technologies. However, to maximise the benefits associated to SDR technology, more flexibility is also needed in current spectrum management rules and practices need to evolve in parallel with the technological evolution [R1]. Thus, an additional challenge for SDR success will also reside in the design of new rules for a more flexible spectrum allocation management.

State of the art in the area

ITU-R WP8F currently is discussing the implementation and usage of the spectrum identified by WARC-92 and WRC-2000 for IMT-2000 family members to develop recommendations for the national regulation authorities of the different regions and countries. The main goal is to reach a maximum of international harmonisation to prepare for global roaming and to achieve economy of scale on terminal equipment production.

The frequency bands under discussion internationally are not available for IMT2000 throughout all the regions. A consequence of this will be the demand for multiband and multimode terminals. In the view of UMTS Forum the spectrum planned for 3G systems is not sufficient to allow a cost efficient provision of the multimedia services foreseen [6].

Figure 5.4-4 gives an overview on the frequency bands identified by WARC-92 and by WRC-2000 for IMT 200 systems. ITU-R WP8F - Spectrums Group currently is discussing the usage of these bands. The bands shown are not available in all the member regions internationally:

The IMT 2000 extension band 2500 to 2690 MHz – devoted for terrestrial radio services in the range from 2520 to 2670 MHz – is not available in some countries of Asia and in North America. This band will become available in other countries between the years 2005 and 2010, e.g., in Germany the band will be available from January 2008 on.

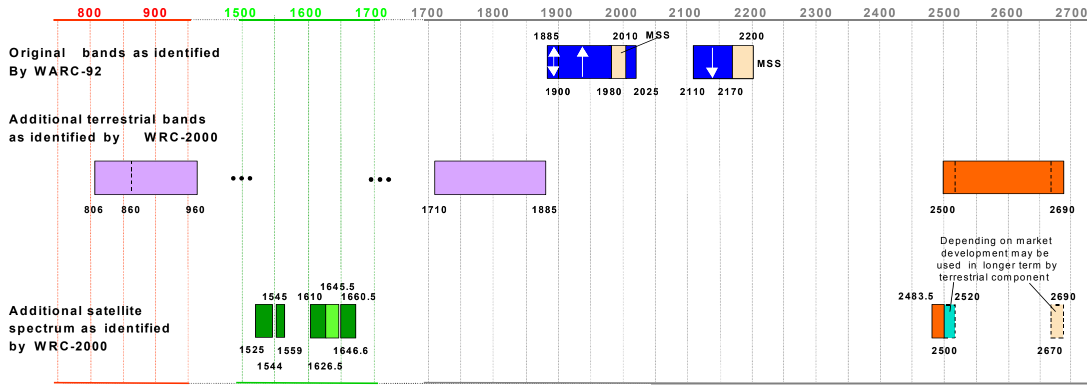

Figure 5.4-4: Overview on the frequency bands identified by WARC-92 (Source: ITU)

Frequency bands in use today for second generation mobile radio services, e.g., 806 to 960 MHz dependent on region and country (GSM900) and 1710 to 1885 MHz (GSM1800) will be available for IMT 2000 after the respective licenses will have expired or after the regulation conditions will have been changed accordingly. New assignments of these bands will be possible in Germany for the GSM bands from the year 2015 on.

Most of the spectrum allocated to mobile service is used with FDD (frequency duplex division) while the asymmetrical multimedia services will develop (part of the spectrum is used with TDD (time duplex division) allowing asymmetrical transmission): The higher the transmit rate of a service the higher is the expected asymmetry of usage of the uplink and downlink channels, making the downlink a bottleneck in IMT 2000 systems. The UMTS Forum and ITU-R have published projections of the future usage of IMT 2000 systems and have identified the spectrum needed for the specific services, see Figure 5.4-5. A substantial asymmetry of the expected average traffic has been predicted there especially for Medium and High Multimedia traffic.

Facts on spectrum allocation and examples how to improve the efficient use of spectrum

From the Detailed Spectrum Investigation (DSI) Process Phase III (862-3400 MHz) of ERO of July 1998, (available from http://www.ero.dk/eroweb/DSIinfo.html)

- it is clear that in the fixed network the relative load by data has exceeded that of voice in 1998 (see page 21), a development that experts expect to happen a number of years later also to wireless and mobile radio networks

- „Trends and Developments for the Military Services“ within the DSI range can be found (NATO unclassified), see page 106-114.

The Green Paper on Radio Spectrum Policy (distributed by EC, Brussels, 09.12.98 COM(1998) final) distinguishes

- five radio-based sectors and activities (see Table 1 on page 5)
  - Telecommunications
  - Broadcasting
  - Transport
  - Government (including Defence, Emergency, Law enforcement, Space science, Applications under international commitments)
  - Research & Development

- three parts of the spectrum owned, e.g., in UK by "Defence"

three parts of the spectrum	owned, e.g., in UK by "Defence"
1. 9 kHz to 1 GHz	29%,
2. 1 GHz to 3 GHz	31%,
3. 3 GHz to 30 GHz	38%.

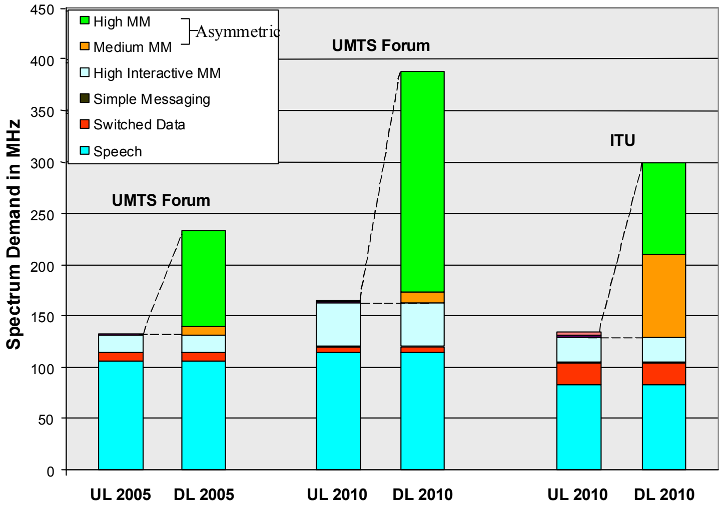

Figure 5.4-5: Projection of the future usage of IMT 2000 systems by UMTS-Forum, Report No.6 and ITU-R Report M.[IMT.SPEC])

The situation is similar in other member states of the EC. Figure 5.4-6 gives an example of the proposed sharing of spectrum assigned to the defence community for use by mobile radio operators as long, as the defence community has no current need to use the band itself, e.g., for manoeuvre. The shared band at 1260 to 1340 MHz might be used as an FDD band or as a pure down-link, either.

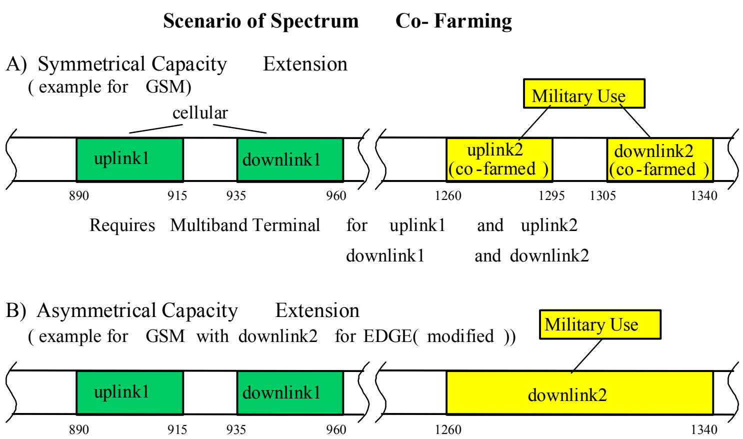

Figure 5.4-6: Example of spectrum co-farming by defence community and mobile operator

Broadcasters have been assigned in the 40s excessive spectrum for radio and television broadcasting, namely for television services

Band I: 47-68 MHz (21 MHz)

Band III: 174-230 MHz (56 MHz)

Band IV/V: 470-863 MHz (412 MHz) according to ITU-R and WARC Recommendations to operate analogue transmission systems.

Some channels out of these bands, according to national regulation decisions, are not available in some European countries.

Today it is apparent that broadcasters are not able to use the spectrum efficiently: In most places of a country, especially outside cities, substantial parts are being not used. This spectrum is especially well suited for mobile radio services in rural areas.

In many European countries a high percentage of the subscribers have decided to substitute terrestrial TV access that they had used before by TV-access via cable or satellite.

The economic value of the spectrum usage by broadcasters became from this behaviour of their subscribers more and more questionable. The spectrum is licensed to broadcasters in many countries for free, lacking any motivation for broadcasters to make efficient use of the spectrum.

It is a fact that in most European countries

- broadcasters are assigned much more frequency spectrum than all the mobile radio operators together
- the number of users subscribed to the mobile radio operators of a country is very much higher than that with a subscription to the TV broadcasting services
- broadcasters are licensed spectrum that, owing to the radio propagation conditions, is much better suited for use by mobile radio systems than the spectrum that is licensed for mobile radio services

Mobile radio operators extract large economic value out of the spectrum they are licensed against substantial fees.

Since much more spectrum is needed for mobile radio operation to allow for high bit rate multimedia services, incentives have to be developed to motivate broadcasters to make more efficient use of their spectrum, thereby freeing spectrum for new uses.

The spectrum allocation for television services between 470 and 863 MHz, see first row in Figure 5.4-7 will be reconsidered in 2003 and 2006 by WRC for the years beyond 2010. The TV-channel width is 8 MHz that is also well suited to host one or two UMTS channels. Figure 5.4-7 reflects as an example the spectrum usage in Germany, where the channels from 814 to 838 MHz (licensed to the defence community) are used for experimental transmission via the new DVB-T standard.

Some governments in Europe are aiming to re-allocate the current TV-spectrum to be used from 2010 on for digital video broadcast transmission based on the DVB-T standard. The cellular industry should participate in this process with a well-developed argumentation basis.

The scenarios 1 to 3 of Figure 5.4-7 have been developed by the COMCAR [11] and DRIVE [12] projects that research the integration of services offered via the TV-bands with that offered from public cellular operators. Since it would be optimum for a radio terminal to make use of spectrum bands that are closely neighboured, in

Scenario 1 an example is shown where the cellular radio band (shown in dark/blue) is operated in channels of the military band 814 - 862 MHz.

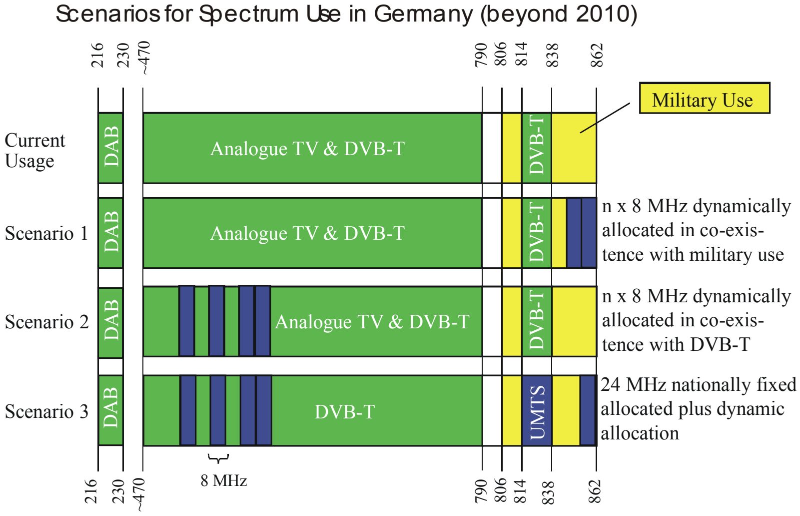

Figure 5.4-7: Scenarios for cellular and broadcast co-operation studied in DRIVE and COMCAR

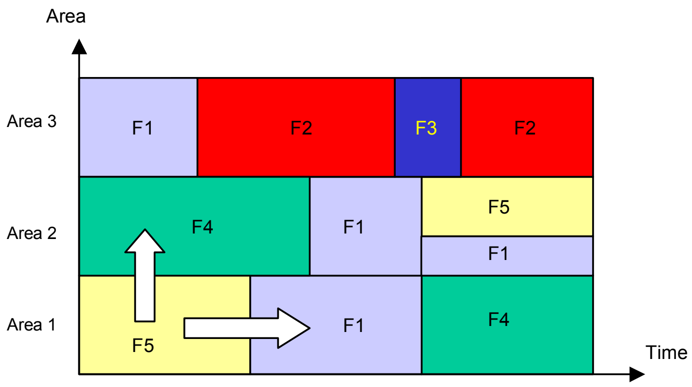

Figure 5.4-8: Temporal and location (area) dependent usage of TV-channels for mobile radio services

A Scenario 2 shows alternate spectrum usages to operate the public cellular radio system somewhere in channels of the spectrum currently allocated for television broadcasting. Usually the usage of the television band is different, dependent on the location. The proposal to use time-wise TV-channels for cellular radio could be either country-wide or location dependent (called dynamic channel allocation), see Figure 5.4-8.

The Scenario 3 is going beyond Scenario 2: a number of TV-channels has been permanently allocated to serve cellular radio. In addition, the ideas presented in the other two scenarios are kept as part of Scenario 3, namely co-farming of military spectrum and of television spectrum by cellular radio.

The scenarios 1 to 3 in Figure 5.4-7 would especially well cover the high demand for more down-link capacity of mobile radio systems to serve asymmetrical communications.

Co-operation in this context would mean a combined operation of cellular mobile services by TV-broadcasters and mobile radio operators in an effort to join the forces, say, by means of a common subsidiary company to operate the combined service in former TV-bands.

Figure 5.4-8 shows that in a given area and in the course of time different numbers of TV-channels might be used for cellular mobile radio, dependent on the needs of TV-operators.

The current spectrum allocation is based on dedicated frequency bands (licensed or not) associated to specific RATs, depending in some cases of the deployment region. The TRUST project [R2] initiates research on flexible spectrum allocation, seamlessly and transparently for the user, considering the re-configurability capacities of SDR terminals and starting to introduce some flexibility in the spectrum allocation, by allowing load balancing between different RATs on the same geographical area. This is be done, keeping the spectrum bandwidth allocated per RAT fixed but correlating the RATs operation and managing the radio resource (codes, slots and frequency carriers) in a concerted way. Spectrum efficiency is not anymore linked with a given RAT but envisaged globally, considering all available RATs. The research lead in TRUST focuses on a dynamic UMTS simulation platform, RAT1 and RAT2 being UMTS TDD and FDD RATs, both RATs belonging to the same operator.

This TRUST study is the first step in a more ambitious approach consisting at final stage in collaboration and spectrum sharing between operators, overall result being a maximisation of the spectrum efficiency for operators involved.

Expected Results

It is proposed to perform an in depth investigation of the practicability of the time-shared use, i.e., “co-farming“, of spectrum assigned by WRC, NATO, EC, and national governments to the defence community and to broadcasters. Under what conditions could cellular operators be allowed to use the bands in a time-shared mode of operation and what are the motivations for the current licensees to open their spectrum for commercial use by mobile operators.

Possible ways of co-operation between cellular and broadcast operators are to investigate the establishment of new services in bands licensed to one of them.

The proposed co-operations need a validation of the practicability before introducing it into practice. This validation and measures to secure the guarantee of full control of the licensee over its bands, needs deep investigations and experimentation.

Besides others,

- candidate bands have to be identified
- the practicability of the proposed co-farming has to be validated
- the engineering of a service that is partly based on co-farming of frequency bands to be able to guarantee some service quality even when a borrowed band is withdrawn has to be investigated. This includes the definition of the relation of

licensed and borrowed band of a public operator under the conditions of its service mix

- commercial and competitions aspects have to be studied
- the regulators views have to be taken into account and to be further developed to allow the shared spectrum usage
- commercial models have to be developed that motivate broadcasters and defence community members to offer bands for shared usage to mobile operators.

Co-farming of spectrum should be planned on a mutual benefit basis to be advantageous to the involved parties. If successful, spectrum would be used in a much more efficient way as in these days. Scarcity of spectrum could be overcome by this. As the main result, more spectrum would be available to cellular mobile services.

The research initiated on TRUST should serve as a basis to develop RRM policies in flexible spectrum allocation associated to SDR terminals [R2]. It is clear now that the full benefit of SDR technology will only be reached if new spectrum engineering practices are developed to maximise efficient and effective use of the scarce radio spectrum resource, taking into account the diversity of RATs, the multiplicity of operators (fully licensed or virtual) and the existence of regulator rules across the different regions.

The main RRM research topics identified are the following:

- Spectrum management for asymmetric regular traffic and solutions for SDR to maximise asymmetry performance,
- Inter-system handovers measurement and criteria, considering cellular (UMTS/FDD, UMTS/TDD, GSM, unlicensed TDD), WLAN (Hiperlan/2), PAN (Bluetooth) RATs, and use of broadcast in cellular systems,
- Flexible spectrum allocation and design of potential collaborative RRM schemes considering solutions of spectrum sharing between operators,
- Flexible spectrum allocation in a context of re-configurable equipment and self-organising networks.

The research will require co-ordination of operators and regulators.

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5.4.2 Antenna arrays and related Techniques

Task 4.4 - Smart Antennas

Objectives of the proposed research

Future mobile and wireless applications will require significantly higher data rates and significantly reduced costs per transmitted bit as compared to 3G. These requirements on data rate, link quality, spectral efficiency, and mobility cannot be met with conventional single antenna systems. Therefore, antenna arrays have to be used at least on the base station side. Thereby, an increased antenna gain and/or an increased diversity gain are realised towards the desired user. At the same time, less interference is received from the other directions (on the uplink) or transmitted in the other directions (on the downlink). Hence, more users can be accommodated by the system and a corresponding capacity increase is achieved.

In case of very high data rates and/or high mobile velocities, multiple antennas should also be used on the terminal side. Such MIMO (multiple-input-multiple-output) channels have an increased capacity.

An immediate impact is expected:

- on the efficient use of the spectrum (increased spectral efficiency),
- on decreasing the cost of establishing new wireless networks,
- on the service quality provided by those networks, and
- on the potential physiological impact on humans.

A wide range of wireless communication systems may benefit from advanced space-time processing:

- high-mobility cellular systems,
- low-mobility short-range systems,
- broadband fixed wireless access systems,
- satellite systems, and
- wireless LAN.

State of the art in the area

Multi-user detection techniques for CDMA systems

These techniques attempt to separate the signals of multiple users sharing the spectrum resources. Some of them use pilot signals known by both the transmitter and receiver (non blind techniques), whereas other ones only employ a priori knowledge of the received signals (blind techniques).

Depending on the multiple access technique, different strategies have been proposed, from theoretically optimal strategies to practical ones like Parallel or Successive Interference Cancellation (PIC or SIC), decorrelation, and Joint Detection.

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Beamforming techniques

Beamforming techniques are generally used at the base station for uplink reception and downlink transmission with multiple antennas. Beamforming allows spatial access to the radio channel by means of different approaches, e.g., based on directional parameters or by exploiting the second order spatial statistics of the radio channel. Thus, space-time processing minimises interference and maximises the intended signal. Moreover, adaptive antennas can exploit long-term and/or short-term properties of the mobile radio channel to achieve improved channel estimation accuracy and reduced computational complexity.

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High-Frequency Aspects of Smart Antennas in Handsets

The integration of smart antennas into mobiles is difficult and is not realised yet. Obviously, the limited space in handsets is a major challenge. The lack of space in a mobile terminal forces to offend against the golden rule, that the spacing between the array elements should not be smaller than half of the used wavelength of the transmitted or received radiation. With a wide spacing a better directivity can be obtained.

The integration of smart antennas into mobiles results in many very attractive features Thus, their implementation is worthwhile even in spite of some difficult technical challenges:

- Due to the increasing number of subscribers, the limited resources of the air interfaces in the current cellular networks are measured too short for the future. Smart antennas will increase these resources by adding an additional degree of freedom to diversity. Integrated into handsets, they will allow the usage of this additional diversity for the uplink as well.

- Electromagnetic radiation can be significantly reduced by forming a 'beam' into the opposite direction of the human body. Two different kinds of effects are suspected to cause harm: on the one hand there is the conversion of the radiation into heat and on the other there might be a direct effect to biological tissue. Negative effects on the brain, on the ear, and on the intraocular pressure, caused by localized heating, are in discussion [1, 2]. The other direct effects of electromagnetic waves on biological tissue has not been understood completely yet. A damage of animal DNA strands by even low-level exposure of radio frequency radiation have been reported [3]. Obviously, the directivity of suitable smart antennas can reduce the risk caused by both effects of electromagnetic radiation.

- A smart antenna focuses its transmission power towards the base station. By this, either the range will be increased for fixed transmission power, or the power can be reduced for a fixed range. This will result in a reduced power consumption.

Thus, three major objectives of research can be summarized as follows:

- increase of the capacity of cellular networks

- reduction of electromagnetic radiation

- reduction of the power consumption of handhelds.

Antennas in current handsets are omni-directional. This means, that the transmitted power is more or less the same for all directions. By this it is achieved, that a connection to a base station is retained, even if the user is turning around during a telephone call. The exposure to electromagnetic radiation is just accepted or, sometimes, reduced by radio screening. Obviously, a significant protection of the user cannot be achieved by this method.

An important aspect is the increasing number of subscribers. The resources of the air interfaces currently used will be depleted sometimes in the future. If the vision is to be realised, that everybody will be able to use extensive wireless services everywhere and at any time, the spectrum resources must be increased.

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Multi-Input Multi-Output (MIMO) transmission systems

Multiple antennas at both links of the wireless channel can be used to increase the data rate via spatial multiplexing and to improve the link quality through diversity.

Further improvements brought by the use of several transmit and/or receive antennas in wireless telecommunications are:

- Increase of channel capacity. Investigations show a capacity that grows as much as linearly with $\min\{M_R, M_T\}$, which is the maximum number of spatial eigenmodes and where M_R and M_T denote the number of antennas at the receiver and the transmitter, respectively.

- Decrease of the Bit Error Rate (BER) without any bandwidth expansion when RX diversity and space-time codes, i.e., TX diversity, are used jointly.

- Decrease of the impact of fading effects.

Different strategies have been developed in order to achieve increased spectral efficiencies:

- Space-time codes in the form of Space-Time Trellis Codes (STTC) or Space-Time Block Codes (STBC) achieve space diversity (for STTC and STBC) and coding gain (for STTC).

- The BLAST technology takes advantage of several parallel channels. In the original BLAST proposal, an independent data stream is sent through each transmit antenna.

The key points to take into account when dealing with MIMO techniques are:

- channel knowledge: what are the assumptions (narrowband, frequency selective, long-term properties, short-term properties)
- experimental environment: picocell, macrocell, etc.
- correlation of fading processes seen by the antenna elements on both transmit and receive antennas.

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Incorporation of MIMO techniques into multi-technology radio networks

Adaptive or smart antennas at base stations and mobile terminals have been recognised as a powerful tool for capacity enhancement. Such MIMO (Multiple-Input-Multiple-Output) channels require advanced space-time processing. A standard approach to study the advantages of MIMO technology is to adopt simplified assumptions such as: "N signals with orthogonal training data from N transmit antennas plus white Gaussian noise". These kinds of simplifications may be useful for analysis of the potential performance, which is limited by the properties of the propagation media. From a technical point of view, the main problem here is the applicability of such assumptions and corresponding results in realistic scenarios. It is worth emphasising that the techniques and results based on simplified assumptions often cannot be considered as "the first step in the right direction" under conditions where these assumptions may be violated. Robust, non-optimal techniques may show better results.

An illustration of the application of MIMO techniques in the TDMA interference-limited scenario is presented in [1]. The single and multi-stage training-based and semi-blind algorithms from [2] are applied in the downlink EDGE (Enhanced Data for GSM Evolution) scenario. The conclusions are as follows:

- Multiple transmit antennas in an adjacent cell create a multi-component structure in the co-channel interference (CCI) even in the single interference case. The complicated structure of the CCI requires an increased number of receive antennas.

- Semi-blind algorithms are required to address the problem of insufficient amount of training data.

- Training sequences designed under the interference-limited assumption may provide significant performance improvement compared to the conventional noise limited approach.

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Re-configurable and robust signal processing techniques

Wireless systems "beyond 3G" require signal processing techniques that would be capable of operating under highly variable scenarios, with respect to:

- propagation environment (indoor / outdoor, rich-scattering / specular etc.),

- traffic environment (hot-spot / spotty, uniform / directional, dense / sparse etc.),

- interference environment (intra-cell / inter-cell, same system / other system etc.),

- system mobility (static / mobile users, speed of interference etc.),

- antenna configuration (number of antennas at the terminal / base, antennas correlation/ bandwidth, antenna topology etc.).

There are two main approaches to allow wireless communication transceivers to operate in a multi-parametric, continuously changing environment:

- re-configurable, adaptive techniques for adjusting the structure and parameters of the transceivers to allow them to demonstrate the best performance in a variety of the particular situations,

- robust techniques, which can demonstrate reasonable (required) performance in a variety of the unspecified situations.

The first approach assumes that the particular scenario can be identified, the optimal solution is known and the required transceiver configuration can be provided. Multiple Input Multiple Output (MIMO) receivers, which are capable of re-configuring themselves by switching automatically between a “beamforming” and a “spatial multiplexing” [1,2] can be considered as an example of the first approach.

The second approach can be illustrated by “short-burst” systems [3], which allow avoiding nonstationarity tracking. Another example are MIMO and interference cancellation techniques [4,5] based on the semi-blind estimation algorithms without explicit estimation of the propagation channel for all signals received by an antenna array.

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Realistic Channel Models and Interference Scenarios to Evaluate the Performance of Smart Antennas

MIMO techniques are expected to enhance the capacity of future wireless communication systems by achieving higher data rates and by reducing the interference. Nevertheless, their efficiency depends on the characteristics of a highly variable environment in terms of propagation, antenna array configuration, user behaviour, traffic patterns, service profiles, and interference scenarios. It is therefore critical to develop realistic spatio-temporal models for the characterisation of the MIMO channel in a highly variable propagation environment and of representative interference models for adequate evaluation of base-band signal processing techniques in multiple antenna, multi-user, multi-service, multi-technology radio networks.

Spatio-temporal channel modelling has been based on theoretical analysis, i.e., stochastic and/or geometrical representation of the scattering environment. The accuracy and flexibility of such a model rely on high parameterisation, and the latter requires a number of statistical data to be provided by vector channel measurements in the environments of interest. MIMO channel measurement campaigns have been carried out in order to statistically characterise the power-delay spectrum, the powerazimuth spectrum and the spatial correlation at the frequencies of interest (see [1]-[5] and references therein).

Vector channel modelling is required in order to sufficiently assess the performance of MIMO techniques at a link level and in the single user case, but Quality of Service evaluation in a multi-user, multi-service and multi-technology environment requires adequate modelling of interference. System level simulators have been employed (e.g. see [1]), which generate certain traffic within a network of cells and statistically measure interference in terms of Signal-to Interference-Ratio (SIR). A mapping between link and system level results is performed in order to extrapolate the system level gains from the link level [1], [6]-[8].

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Links with the IST Programme of the 5th Framework

Several European projects of the IST Programme, in the 5th Framework, are dealing with the abovementioned techniques:

- ASILUM (http://www.ist-asilum.org)
- METRA (http://www.ist-metra.org)
- SATURN (http://www.ist-saturn.org)
- FITNESS (Fourth-generation Intelligent Transparent Networks Enhanced through Space-time Systems, IST-2000-30116, Action Line IV.5.1, starting date: September 2001)

These projects are organised into an IST cluster entitled "adaptive antennas". A first report comparing the channel measurements and models in the various projects has been published and is available on the previous web sites.

The results of these projects could be relevant inputs to this research item.

Possible approach

Beamforming & Space-Time Processing

Depending on the chosen radio interface, suitable space-time processing techniques should be developed and evaluated with realistic channel models.

High-Frequency Aspects of Smart Antennas in Handsets

It was already mentioned above, that it is much more difficult to integrate a smart antenna into a handheld than into a base station. In the following, the technical challenges are listed more in detail and suggestions for possible solutions are given:

The limited space in handhelds forces to make the smart antennas very small. As a consequence, an unfavourable narrow spacing between the array elements of approx. $\lambda/4$ or less must be accepted, resulting in a limited directivity. This means, that the angle of aperture will be rather broad. This fact is dictated by the laws of physics and there is no way for a work around. Thus, the function of the antenna array will be mainly reduced to the control of the beam direction (steering).

To improve the directivity and to enhance the sensitivity of the smart antenna simultaneously, active antenna elements with a certain individual directivity are proposed. The basic idea is not new: For example, arrays of parabolic antennas are used in radio astronomy since a long time period. This increases the angle resolution significantly compared with that of the singe parabolic antennas. Of course, such antennas are not feasible for handhelds. The diameters necessary for typical wavelengths are not small enough. Furthermore, the direction of the main beam of the separate antenna elements must be tracked to that of the whole array. For parabolic antenna elements this would be much to complicated. Active antenna elements feature both properties at the same time. They can be realised by two pads on a printed circuit board with a switching transistor connecting both electrically. This transistor provides a feedback. However, the small dimensions will limit the directivity. A pragmatic compromise has to be found, giving priority to an optimum signal to noise ratio over any other criteria.

A severe problem will be caused by the uncertainty of the ambient environment of an antenna. How an user will hold the mobile in his hand is not predictable. Even rather small changes may change the impedances of the antenna element feeding points significantly. The unpredictable coupling between the human body and a smart antenna in a mobile will affect its most important function, i.e. the beam forming to the desired direction. Intensive research work has to be done in the field of antenna hardware and also in the field of signal processing to find a solution for this problem.

A subscriber will not accept any limitation for his mobility during a telephone call. Thus, in contrast to a base station, the directivity of a smart antenna has to be managed in three dimensions. Again, intensive research work will be necessary here.

A problem, very often underestimated, is that of scan blindness, which happens especially in the case of narrow spaced antenna elements. This is caused by the change of the input impedance of each antenna element according to the change of the beam direction. As a result of this mismatch, at certain angles of scanning the antenna array cannot form a beam to these particular directions. The effect of 'blind angles' can be minimized by choosing appropriate arrangements of the array elements and by modifying the ambient environment of the antenna. Intensive experimental work has to be carried out to find a good compromise.

From these problems the following list of research items can be extracted:

- development of active antenna elements with controllable directivity
- development of antennas and of signal processing methods being tolerant of changes of the ambient environment
- development of smart antennas with controllable 3D directivity
- development of antenna geometries with minimized scan blindness.

Multi-Input Multi-Output (MIMO) transmission systems

There are additional research requirements on

- adaptive modulation schemes,
- the significance of diversity & antenna gain in realistic environments
- MIMO concepts for non-correlated, semi-correlated, and fully correlated radio channels
- how to use partial knowledge of the channel (e.g., long-term properties)
- the role of beamforming for multi-signal-stream concepts
- the impact of MIMO on the wireless link management
- the extension of known and future MIMO concepts to frequency-selective channels

The development of a testbed

- to evaluate the discussed concepts of channel Modeling in MIMO systems
- to demonstrate the performance of the proposed algorithms and concepts

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Incorporation of MIMO techniques into multi-technology radio networks

Initial investigations with EDGE illustrate the general problems with MIMO techniques in interference limited scenarios. Especially interesting could be a similar study of MIMO for advanced access schemes, such as OFDM, TDD/FDD CDMA and their combinations. Particular problems for investigation can be formulated as follows:

- Development of MIMO and interference cancellation techniques under complicated interference environments, such as asynchronous and sparse interference scenarios.

- Development of semi-blind MIMO and interference cancellation techniques, taking into account a restricted amount of training data available in each time-frequency slot and the increased number of receive antennas required because of the multi-component structure of the interference (see Note).

- Optimisation of the training data sequences in the interference-limited scenarios.

Note: MIMO schemes with an equal number of transmit and receive antennas are likely to be not effective in interference limited scenarios.

References

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[3] M. Kuzminskiy, P. Strauch, "Sparse interference cancellation with an antenna array for OFDM", Wireless World Research Forum, Helsinki, May 2001.

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Re-configurable and robust signal processing techniques

The current vision of systems "beyond 3G" (everything is connected everywhere at anytime with high frequency reuse and high mobility) suggests that complicated system / interference scenarios will be important, which cannot be reduced to a fixed set of the situations with the known optimal solutions. Thus, a combination of re-configurable and robust techniques is required.

The specific target areas within that context are as follows:

- On-line classification and estimation of the wireless signal / interference environment,
- Development of base-band signal processing algorithms that make a robust (the best if possible) use of the identified class of environment / system situation,
- Development of smart switching algorithms between the identified classes of environment / system situations.

Moreover, the development of low-cost integrated multiple-chain radio solutions has become a research topic of the utmost importance.

Realistic Channel Models and Interference Scenarios for to Evaluate the Performance of Smart Antennas

The current vision of smart antennas, multi-service, multi-technology, future wireless systems suggests that a more realistic approach to channel and interference modelling is required.

The specific target areas within that context are as follows:

- MIMO channel modelling based on statistical formulation of the scatterers' distribution and measurement campaigns for a variety of antenna array configurations, air interfaces, user mobility patterns and service profiles.

- Realistic interference modelling based on system level simulations taking under consideration the intra- and inter-cell impact of smart antenna techniques, non-uniformity of traffic (e.g. hot spots), mixed services scenarios and interoperability between different air interfaces.

- Accurate mapping between link and system level results based on more realistic interference models.

Expected results

The following techniques will be investigated:

- blind/non-blind/semi-blind multi-user detection (MUD) / multi-signal-stream detection techniques,

- beamforming techniques

- high–frequency aspects of smart antennas in handsets

- multi-input multi-output (MIMO) systems, including studies on advanced space-time coding/decoding schemes, (optimum) spatial multiplexing and eigenbeamforming concepts.

These techniques could be combined to achieve improved interference mitigation performance concurrently with high hardware efficiency. Their robustness to various environments should be evaluated, as well as their ability to track and adapt themselves in real time to channel variations.

Techniques similar to the ones applied in MIMO for EDGE in [1] should be developed for other access schemes. Their efficiency should be compared to the MIMO techniques designed under the noise-limited scenario [2].

Depending on the chosen radio interface, suitable space-time processing techniques with multiple antennas at the base station and/or mobile terminal should be developed and evaluated using realistic channel and interference models. These models will be reliably used to assess the performance of smart antenna techniques at the link level, and the mapping between system and link level results will allow for more accurate capacity enhancement evaluation at the system level.

Practicable hardware design methods in combination with corresponding signal processing methods are necessary for smart antennas in handsets. It is clearly emphasized at this point, that an approach must be pragmatic enough, and nobody should expect figures of merit, which are derived from smart antennas in base stations. The signal to noise should be in the focus of attention for smart antennas in handsets, not the directivity.

References

[1] A. M. Kuzminskiy, H. R. Karimi, C. Luschi, "MIMO transceivers under interference limited scenarios", Wireless World Research Forum, Stockholm, September 2001.

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5.4.3 New Air Interfaces

Task 4.5 - Location–Sensitive Radio Resource Management

Objectives of the proposed Research

If subscribers are moving around in a cellular network, handover is an essential mean to guarantee the users mobility. Moving from one cell to another, a new connection with the target cell has to be set up and the connection with the old cell has to be released. Conventional handover execution criteria rely on the signal quality. Mobile location information is not used.

If handover execution criteria are extended by additional location assistance data - based on real-time position measurement of the mobiles - a predictive channel reservation approach will be possible. By an extrapolation of the movement, the next cell for each mobile can be predicted.

State of the Art in the Area

The conventional handoff execution criteria rely mainly on the signal quality, user mobility, traffic distribution, bandwidth, and so forth. Essentially, the signal strength of the target cell is compared with the present cell, and if the former is superior to the latter, then a handoff event is triggered.

Potential Approach

For interference-limited systems like Wideband CDMA, the location information alone is not enough for a reliable handover application. Location Sensitive Handoff (LSH) is recommended for an improvement. This method is using both, mobile location information and signal strength.

The location information may be extracted either periodically or it can be gathered on demand. By using the mobile’s two most recent co-ordinates, its velocity can be calculated, thus providing information about the speed and the direction of motion.

Soft handoff is an inherent feature of CDMA based cellular systems causing more signalling and processing load to the system. Thus minimising unnecessary handover procedures is a desirable objective.

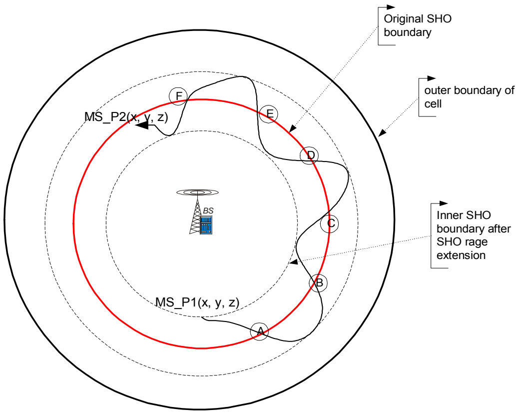

Figure 5.4-9: Soft handoff range optimisation by utilising mobile positioning assistance data

The example in Figure 5.4-9 shows, how this can be achieved with LSH: from the path of the mobile a threshold hysteresis can be calculated (here the distance of two consecutive turning points). By this, unnecessary handover procedures at points A, B, C, D, E and F can be avoided.

Of course, the extraction of location information creates some additional system load. Computer simulations show, that for moderate positioning frequencies (10-30 /s) there is still a reasonable gain in the overall performance [1].

Expected Results

Concepts and methods for location sensitive handover and radio resource management.

References

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Task 4.6 - Ultra Wideband (UWB) Radio Technology (UWB-RT): Short-Range Communication and Location Tracking {30}

Objectives of the proposed research

- Define operational contexts and user scenarios for wireless applications requiring data communication and location tracking, or a combination of both. For selected scenarios, determine the requirements in terms of communication needs (e.g., data rate, link distance, ad-hoc or centralised network) and location information (e.g., distance, direction, position accuracy) and then deduce the requirements for the physical layer (PHY) and medium access control (MAC) of UWB radio devices.

- Define and evaluate system concepts (PHY, MAC) for UWB radio devices that enable separate modes for data communication and location tracking as well as for UWB devices that support efficient joint operation of both modes.

- Assess the performance and complexity (simulation, experiment) of the different possible approaches to generate and receive UWB radio signals.

- Compare the performance of different wide-band radio systems (e.g. chirp modulation, pulse distance modulation, pulse compression techniques, etc.) and narrow-band OFDM systems (e.g., IEEE802.11a), in terms of transmission and location aspects as well as channel access complexity (e.g., “mono-channel” versus multiple narrow-band channels).

The trend and efforts currently observed in the US to regulate and commercialise wireless devices based on the principles of pulse-based ultra wide-band (UWB) radio technology (UWB-RT) are increasingly also taking hold in Europe [1]–[3]. The CEPT/SE24 and ETSI study groups are currently investigating how to accommodate UWB radio devices within the range of 1 – 40 GHz to ensure that UWB radio systems can coexist with other radio services [3]. It is important to note, however, that neither the US-based Federal Communications Commission (FCC) nor the CEPT/ETSI groups pursue a standard for a functional UWB radio system; the latter will be the ultimate objective of this proposed research.

The FCC proposes a definition of UWB signals similar to that established by the OSD/DARPA UWB radar review panel [1]. An UWB device is any device where the fractional bandwidth of the emitted signal, i.e., the ratio between absolute bandwidth and centre frequency, is greater than 0.25 (25%) or occupies at least 1.5 GHz of spectrum. The absolute bandwidth is measured at the upper and lower –10 dB power points, f_H and f_L, respectively, and the centre frequency, f_C, is defined as the average of the upper and lower –10 dB power points, i.e. $f_C = (f_H + f_L)/2$. It should be noted that the radio regulatory authorities have not yet decided whether this definition should indeed be adopted as it stands. In addition, it is also left open whether one should limit this definition of UWB devices to devices that solely emit pulsed signals where the bandwidth is directly related to the (narrow) pulse width [1]. This latter approach will be the primary focus of this task. However, it is recognised that other than pulse-based modulation techniques can be equally employed to produce UWB equipment, such as spectral spreading techniques based on pseudorandom or maximum-length binary sequences (PRBS/MLBS), chirp- or noise-based techniques, and possibly others.

UWB-RT holds the promise for a large array of new or improved (short-range) radio devices and services that could have enormous benefits for public safety, consumers as well as businesses alike, through potentially sharing spectrum space with other radio services. Clearly, it will be important to develop and deploy (license-free) wireless technologies in the future that allow a more efficient use of the radio spectrum resources [1].

In addition, it could also be of interest to consider other spectrally efficient candidate systems, such as those based on so-called “mono-channel” wide bandwidth technologies, where a short fixed-frequency header combines with a data-modulated, linear-frequency ramp signal covering the entire allocated frequency band [4], [5]. In the case of unexpected difficulties with the regulatory acceptance of pulse-based UWB-RT, these alternate wideband technologies may be of particular interest since they also offer efficient use of the spectrum resources through the joint use of frequency and time domains.

The ongoing regulatory procedures in the US and Europe and the significant technological advances by several US-based pioneering developers of UWB-RT are matched by an increasing interest within the European industry and research organizations [2], [3], [7]. This situation suggests that UWB-RT deserves a broad research and discussion podium such as provided within the framework of the WWRF. This new technology creates some significant technical challenges when attempting to realise its full potential benefits and advantages. It is foreseeable that the benefits the users and the enabling industries can possibly derive from this new technology could be realised on a larger scale provided that the technological development, the regulatory processes, and standardisation issues are dealt with in an international (global) forum. We observe that both the current commercial status and the world-wide regulatory status of UWB-RT are still at a fairly premature level such that only in a few cases – if any – hard precedence cases exist. After all, the legal use of UWB radio devices is not yet authorised anywhere today (10/2001) and the exact technical terms under which legalisation will occur are still not known:

- This situation suggests calling now for co-ordinated research and development initiatives with the long-term but ultimate objective to achieve broadly supported standardisation of certain systems using primarily pulse-based UWB-RT [6].

- This co-ordinated research would also take into consideration certain different alternative wideband technologies (such as the “mono-channel” wide bandwidth concept [4], [5] or PRBS/MLBS-based techniques [8]–[10]) to clearly determine the advantages and disadvantages compared to pulse-based UWB-RT.

UWB-RT provides the potential for implementing short-range radio devices that can inherently and effectively support applications based on data communication (potentially at high data rates) as well as precise measurement of distances or locations [6]. Thus, UWB-RT provides the opportunity to develop and define (standardise) *new short-range wireless systems capable of combining the functions for data communication and location tracking*. This latter feature is useful for network management and data routing in ad-hoc networks or to support location-aware applications and services, or both [11]. These capabilities make UWB-RT also potentially useful in hand-held devices (e.g., cell phone, PDA, laptop computer) to enable high data rate access and location tracking in areas with high user density (“hot-spot” scenario).

The results and conclusions from this work will be directly applicable towards the ultimate target objective of the proposed research agenda; namely, facilitating co-ordinated initiatives for broadly supported standardisation of certain systems using UWB-RT.

State of the art in the area

Within the main scope of the proposed research, UWB radio devices will transmit sequences of (possibly frequency shifted and) appropriately (envelope) shaped, wide-spaced, modulated pulses of short duration (e.g., 0.1 – 2 ns) such that the waveform's observed duty cycle is significantly less than unity (e.g., 1/100 – 1/1000). The very nature of this type of UWB radio signal (i.e., narrow and relatively wide-spaced pulses) leads to inherently good receiver robustness in environments subject to multi-path propagation conditions. This property and the fact that pulsed UWB signals are ideal for ranging applications enable one to conceive mobile short-range radio devices that inherently support the functions for (potentially high rate) data communication as well as precise location determination and tracking. Therefore, it appears realistic to think of certain future short-range wireless devices featuring scalable (high-performance) data communication combined with precise location tracking of mobile terminals. Location-aware ad-hoc networks such as described in [11] would greatly benefit from the availability of wireless devices capable of precise location tracking, even more so, when the latter is coupled with joint data transmission capabilities. Devices using pulse-based UWB-RT offer a high degree of operating flexibility in terms of data rate selection and transmission range, since these devices typically operate with a single transmitted pulse waveform. For example, changes in data rate and/or transmission range are accomplished by simply changing the transmitter’s pulse repetition frequency (PRF) and/or the data redundancy of the transmitted pulse (i.e., number of information bits carried by a single pulse; see also [6]).

The UWB technique mentioned above using wide spaced pulses shall demonstrate only one possible solution. Other principles may also refer to UWB impulse compression methods allowing other types of signals than impulses (chirp, PRBS or others). They can be designed for a low crest factor, which leads to the use of low level signals. This benefits the application of semiconductor integration and a large bandwidth.

Existing and future short-range wireless systems based on narrow-band carrier modulation are often inadequate or incapable to provide sufficiently accurate location information of mobile terminals to support, for example, location-aware network management (routing mechanisms) and applications. On the other hand, there is a growing need for these capabilities [11]–[14]. The first-order estimates shown in Figure 5.4-10 indicate that devices based on UWB-RT can potentially outperform conventional radio devices based on achievable spatial capacity – measured in terms of aggregate data rate per unit area or (Kb/s)/m^2 – as well as achievable average location error [6], [12]–[15]. However, note that the indicated potential operating points in Figure 5.4-10 for the devices based on UWB-RT are only "speculative" at this time; it is an objective of this research proposal to determine a set of realistic operating parameters.

Early US-based developers and adopters of UWB-RT are already well advanced in developing the basic technologies required to realise application scenarios based on data communication combined with (indoor) location tracking of the mobile terminals [6]. Some of the known published European UWB-RT research – having only a small spread up to now – was mainly directed to digital pulse compression techniques for UWB-radar applications up to 5 GHz bandwidth and 10 GHz internal clock where some basic SiGe-circuits were implemented and successfully tested [9]. However, there exists a large gap between the demonstrated base technology and the availability of complete and widely deployable (standardised) systems and applications using these base technologies. In particular, high-level device integration and power efficiency are not yet proved. Also, the feasibility of a "scalable (high-performance) communication system" offering a large spatial capacity (see Figure 5.4-10) requires proof but leaves a high degree of flexibility in the possible choices of relevant PHY and MAC functions. Concerning localisation, even if the distance measurement performance between UWB radio terminals is theoretically excellent, the degradation depending on the network load and other effects have to be estimated. Moreover, direction estimation is a subject to be developed in addition to simple distance measurement methods. Ultimately, however, effective methods enabling two- (2D) and three-dimensional (3D) location tracking capabilities need to be investigated and developed (see also [6]).

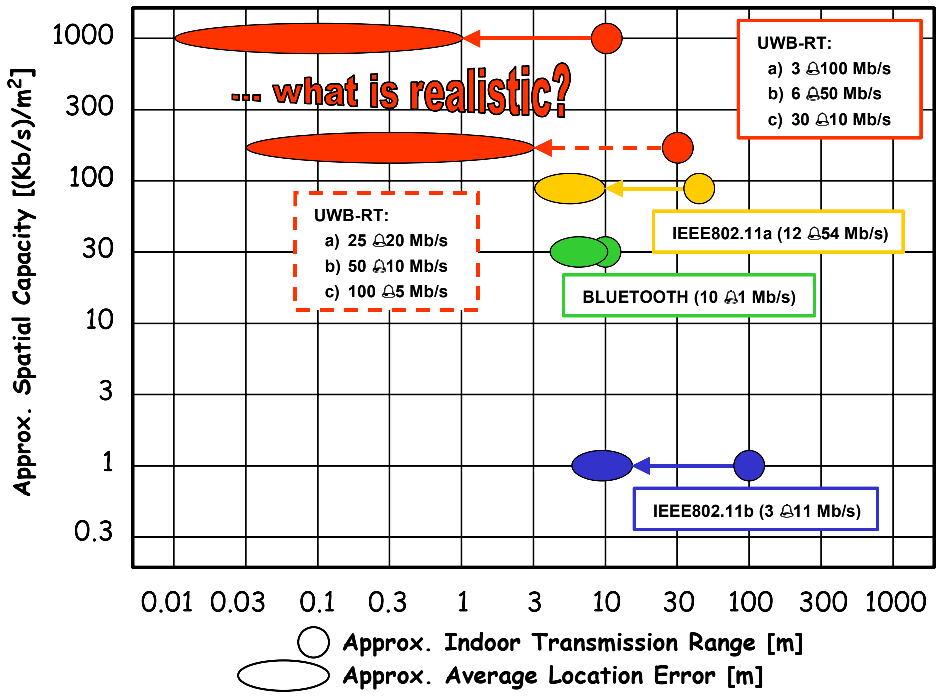

Figure 5.4-10: Comparison of assumed UWB radio devices and conventional short-range wireless systems in terms of spatial capacity (first-order estimate), i.e., aggregate data rate of N active devices per unit area or (Kb/s)/m2, as a function of approximate transmission range and average location error. For example, the notation "IEEE802.11b (3 % 11 Mb/s)" means that three (N = 3) IEEE802.11b devices communicate with three different access points at the

same time with 11 Mb/s data rate at a radial distance of maximal 100 m. In the case of UWB-RT, it is assumed that N devices – each belonging to a different piconet – communicate simultaneously at some data rate using a scheme enabling code division multiple access (e.g., N = 6, data rate: 50 Mb/s over a 10 m range [15]).

Finally, the efficiency of the MAC function in a highly loaded network has to be investigated, preferably in co-operation with other programs and studies trying to solve this problem. While UWB-RT promises also to deal well with the basic requirements for data communication and location tracking, detailed workable solutions need to be evaluated and defined. Note that the FCC's NPRM document [1] lists further examples on the potential applications and uses of UWB radio devices. These devices will have a variety of technical characteristics depending upon the intended application. In particular, the US-based pioneering companies who developed UWB-RT thus far have already demonstrated that UWB radio devices are inherently capable to enable functions for 1) data communication, 2) location tracking, and 3) sensing.

Possible approach

It is proposed to select technical work items based on the following ordered list of principal sub-tasks:

Sub-Task 1 Investigation and definition of realistic application scenarios and requirements for short-range wireless devices, with a particular emphasis on scenarios based on (combined) data communication and location tracking. The potential capabilities of short-range wireless devices based on UWB-RT will provide the key assumptions when defining these scenarios.

Sub-Task 2 Investigation, design, and demonstration of PHY and MAC concepts that enable the realisation of selected application scenarios based on UWB-RT. Performance comparison of different ultra wideband schemes (mainly at PHY level) as well as design and demonstration of selected hardware and software prototype functions. Deduction of "optimal" applications for UWB-RT and comparison with other radio technologies.

Sub-Task 3 Achieve and respond with a consolidated view to the proposals and actions taken by regulators and standardisation bodies concerning radio regulatory matters of UWB-RT.

Sub-Task 4 Submission of broadly supported standard proposals for PHY and MAC functions for devices based on UWB-RT to appropriate standardisation committees.

It will be necessary that a sufficiently representative number of experts (teams) from relevant industrial and academic institutions contribute and share the proposed research work, thus:

- *The active participation of further interested parties is encouraged; in particular, the constructive participation of the US-based industrial pioneers and leaders in the field of UWB-RT is solicited.*

The following items – without claim for completeness – are possible topics to be addressed in each of the task areas (note that the present expert teams plan to cover only some of the listed items):

Sub-Task 1

- Definition of realistic user scenarios for (indoor) short-range wireless systems for which UWB-RT seems to be a good candidate technology.
- PHY and MAC requirements of applications for data communication.
- PHY and MAC requirements of applications for location tracking (e.g., distance measurement only or combined with direction estimation; methods for 2D and 3D location tracking).
- PHY and MAC requirements of applications based on combined data communication and location tracking.
- Selection of representative application scenarios suited for study under Sub-Task 2.

Sub-Task 2

- Determine sets of requirements for PHY and MAC layers for the different application scenarios chosen under Sub-Task 1; in particular, consider systems supporting joint data communication and location tracking.
- Perform analysis and performance comparisons by means of simulations and experiments for different approaches to implementing UWB radio devices. As topics of interest for this comparison we can identify:
    - Spreading efficiency,
    - power spectral density,
    - ease of adaptation considering available carrier and corresponding bandwidth,
    - achievable data rates and aggregate data rate per unit area (spatial capacity),
    - robustness against multipath effects,
    - macro-diversity capability,
    - access modes (centralised and/or distributed),
    - throughput performances (of each link, of the network),
    - capability to deal with QoS constraints,
    - capability to satisfy a variety of services classes,
    - capability to provide relay or transit functions,
    - localisation and positioning capabilities,
    - manufacturing technology/system costs,
    - and possibly others.
- Compare the performance and the complexity trade-offs between systems based on UWB-RT and narrow-band radio systems based on (coded) orthogonal frequency division multiplexing (COFDM/OFDM). The topics of comparison could

be the same as listed above. In addition, other than pulse-based modulation techniques producing UWB signals may be investigated.

- Define system concepts at PHY and MAC levels for selected scenarios; in particular, consider systems supporting joint data communication and location tracking (e.g., definition of packet frame formats for data communication and location tracking).
- Coding and error correction strategies for the UWB radio channel.
- Antenna technologies for UWB radio devices.
- Definition of MAC functions to support ad-hoc network architectures (location-based routing mechanisms).
- Co-operative routing capability and associated protocols and their influence on the network load.
- Investigation of multiple access schemes for UWB radio devices such as code division multiple access (CDMA).
- Coexistence and integration of UWB radio devices with existing (short-range) wireless systems.
- Propagation characteristics of UWB radio signals and UWB radio channel models.
- Recovery of multi-path components: RAKE receivers.
- Required semiconductor technology (e.g., CMOS, SiGe, others).
- Methods to determine location information (e.g., distance estimation without and with combined direction information, centralised and distributed triangulation, 2D and 3D location tracking systems).
- Address schemes for unique and universal device identification.
- Means for quality of service (QoS) assurance (e.g., for real-time applications).
- Security and privacy issues related to location information.

Sub-Task 3

- Investigate conformance of the various UWB signalling formats in relation to regulatory constraints by considering results obtained under Sub-Tasks 1 and 2.
- Formulation and submission of consolidated comments and recommendations in response to proposals and actions taken by regulators and standardisation bodies concerning radio regulatory matters of UWB-RT.

Sub-Task 4

- Under consideration of the results obtained under Sub-Tasks 1–3, select and propose suitable standard solutions for PHY and MAC functions based on UWB-RT to appropriate standardisation committees; such submissions should be endorsed by a majority of the participants.

Expected results

- Contributions in defining representative applications and user scenarios and the deduction of requirements on qualitative and quantitative PHY and MAC specifications, particularly in the area of (joint) data transmission and location tracking applications.

- Contributions in the areas of performance evaluation, algorithmic design, implementation of practical procedures for position determination, and location tracking of mobile stations in ad-hoc networks (tag-type and/or transponder-type systems).

- Contributions in the area of comparative performance evaluation (simulation and experimental measurements) of various coding and modulation schemes for UWB radio devices. Comparison of pulse-based UWB radio signalling with alternate (ultra) wideband modulation methods.

- Demonstration (proof of concept) of selected hardware and software prototype functions required in UWB radio devices (e.g., joint data communication and location tracking).

- Achievement of a broad consensus on:

    - Radio regulatory matters concerning UWB radio devices, and
    - submissions to international standard bodies dealing with UWB-RT.

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[6] Partial list of US-based companies and organisations active primarily in pulse-based UWB-RT (alphabetical order):

- *Aetherwire & Location*, *Inc*. (http://www.aetherwire.com): localisers
- *Fantasma Networks*, *Inc*. (http://www.fantasma.net): wireless home networking (see also *Pulse~Link, Inc*., (http://www.pulselink.net))
- *Lawrence Livermore National Laboratory* (LLNL) (http://www.llnl.gov): micro-power radar
- *Multispectral Solutions*, *Inc*. (http://www.multispectral.com): communication, radar, location
- *Time Domain*, *Corp*. (http://www.time-domain.com): communication, radar, location
- *UWB Working Group* (UWBWG; http://www.uwb.org): industry consortium
- *XtremeSpectrum*, *Inc*. (http://www.xtremespectrum.com): communication

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- Dresden University of Technology, Germany (http://www.tu-dresden.de)
- OMAN-UWB Group, University of Rome, Rome , Italy (INFOCOM Department)
- *MEODAT GmbH* (http://www.meodat.de)
- TU Ilmenau (http://www.tu-ilmenau.de)
- Robert Bosch GmbH, Germany
- Siemens/Roke Manor Research, England (http://www.roke.co.uk)

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Task 4.7 - Multi-Carrier based Air Interface

Objectives of the proposed Research

Multi-carrier based systems have proven to be well suited for high bit rate wireless communications in multipath fading channels. Orthogonal frequency division multiplexing (OFDM) [1] when combined with a coding scheme offers simple technical implementation. The use of OFDM in cellular networks is promising because of high spectrum and power efficiencies by reduced signalling overhead, a broadband access (with up to 100 Mbit/s) and a support of asymmetric traffic.

The disadvantages of OFDM, aside from the well-known linearity requirement, are its coarse granularity and limited radio networking (multiple-access) flexibility. This poses a major technical hurdle in providing rich-media services in wide-area network (WAN) environment where a base station communicates with a large number of dynamic subscribers. The development of OFDM-based multiple access technology that possesses the network flexibility of CDMA and the spectral efficiency of OFDM is of high importance [7].

Of particular interest is the combination of OFDM based systems together with adaptive or smart antennas because of their interference rejection capability.

Known interference cancellation algorithms for OFDM can be put into two groups:

- Techniques based on a Spatial Division Multiple Access (SDMA) belong to the first group. This concept assumes, that the data model is known at the receiver, and that all propagation channels can be estimated for the desired signal and for all co-channel signals (users). The main problem with this approach is that un-modelled co-channel interference (CCI) may cause uncontrollable performance degradation.

- The second group of techniques is based on instantaneous correlation moments estimation and assumes that the data model of the desired signal is known up to the propagation channel which can be estimated using pilot symbols. These techniques are quite robust against un-modelled CCI. The underlying assumption for these algorithms is that the training data for the desired signal is representative in the sense that the CCI overlaps (in time and in frequency) with the pilot symbols of the desired signal. This is normally the case for synchronous CCI, which has the same time-frequency structure as the desired user.

Asynchronous cells, discontinuous transmission mode, adaptive frequency allocation or a fast frequency hopping scheme, different sub-carriers and symbols of the CCI belonging to different users - lead to more complicated asynchronous or sparse interference scenarios (sparse co-channel interference = SCCI). The known training-based algorithms may fail in these situations, because the training data may not be representative.

A solution for the above mentioned problem would be based on the combined use of multi-carrier communications together with smart antennas. This approach can offer new services on wireless systems.

State of the Art in the Area

State of the art in multi-carrier communications are the broadcasting standards DAB, DRM and DVB-T, as well as the wireless LAN standards HIPERLAN/2, IEEE 802.11a and MMAC.

In the past years, intensive research work has started to investigate the potential of different multi-carrier based multiple access techniques [2], such as multi-carrier CDMA (MC-CDMA), multi-carrier direct-sequence CDMA (MC-DS-CDMA), spread-spectrum multi-carrier multiple access (SS-MC-MA), generalised MC-CDMA (GMC-CDMA), MC-TDMA , MC-FDMA (also known as OFDMA) and interleaved FDMA (IFDMA)[3]. All these multiple access techniques promise to be highly spectral efficient multiple access schemes for future mobile radio systems

Possible Approach

By allowing subscribers to transmit signals through a subset of sub-carriers in OFDM, OFDMA (orthogonal frequency division multiple access) presents a generic platform for multi-carrier based multiple access techniques. The inclusive nature of OFDMA allows it to subsume all the benefits of all other OFDM/CDMA approaches. For example, MC-CDMA is a special case of OFDMA where each subscriber spreads his signals over a cluster of OFDM sub-carriers. A major advantage of OFDMA over regular OFDM is its finer granularity, and more importantly, the ability to capture the so-called *multi-user diversity* which can potentially lead to 2-3 times capacity increase over regular OFDM [7].

A first proposal is the extension of modern OFDM techniques by a reconfigurable multi-carrier approach. The concept of a "Hybrid Multi-Carrier multiple access" would allow dynamic sub-carrier and access methods. By this, different access technologies may coexist in the same link, adapted to the needs for data rate and error protection of each individual user. Furthermore, different access technologies can be applied for a better support of asymmetric traffic [4].

A second proposal is the addition of antenna diversity to OFDM based systems. Joint transmitter and receiver antenna diversity concepts can be adapted to OFDM systems. It is known that significant performance improvements can be achieved with receiver antenna diversity in order to improve the signal-to-noise ratio (SNR). This can be helpful in combating correlated error distribution before channel decoding too. The latter can be handled by adequate transmitter diversity techniques. The combination of both diversity schemes is one of the new research topics.

A promising candidate to address the SCCI cancellation problem in OFDM is a semi-blind algorithm based on the usual dual Least Squares – Constant Modulus (LS-CM) optimisation criterion [5,6]. The dual LS-CM semi-blind algorithm is proposed in [6] for a short burst TDMA system. An application of this technique to OFDM requires joint interpolation and antenna array coefficients estimation [7].

When thinking of new air interfaces - the antenna diversity concepts can further be improved by adapting the channel coding to these techniques, resulting in new multi-carrier based space-time coding concepts [4].

Expected Results

- development of OFDM-based multiple access technology that possesses the network flexibility of CDMA and the spectral efficiency of OFDM.

OFDM can improve the spectrum efficiency and flexibility of wireless systems and can be the basis for the definition of new wireless techniques with data rates and mobility beyond that of existing technologies.

The LS-CM based semi-blind algorithms should have a sparse interference rejection capability similar to or even better than training-based algorithms in the synchronous scenario [7].

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5.4.4 Ad-hoc Networking

Task 4.8 - Multi-Hop Ad-hoc Networks {31}

Objectives of the proposed research

The main objectives of research in ad hoc networks are two:

a) To enable ubiquitous communications.

It can be expected that in the near future there will be a proliferation of wireless devices. Ad hoc network functionality such as self-configurability and independence of existing infrastructures are key issues in this context. Examples of future networks can be Personal Area Networks (PANs)[1], Body Area Networks (BANs)[2], home networks, networks of sensors and actuators (e.g. at home, cars, or those for ambient intelligence), or vehicle to vehicle networks.

b) Complementing and enhancing wireless access networks.

Ad hoc networking and in particular multi-hop communication capabilities can be used to extend the coverage of existing wireless access technologies. Not only is this an interesting approach for cellular networks, but particularly in the case of high-frequency Wireless Local Area Networks (WLANs) due to capacity problems [3]. In general, direct communication between neighbouring terminals without intervention of relatively remote base stations results in a decreased interference level, which implies that the general capacity of the system will be increased. This can represent a reduction in the cost of wireless access infrastructures, at the expense of some additional networking complexity.

Intrinsic characteristics of ad hoc networks such as self-configurability [12] and neighbour discovery imply that these networks will be a key element for enhancing the interoperability among different wireless technologies.

Rationale

Mobile ad hoc networks are formed by wireless[4] devices that communicate without necessarily using a pre-existing network infrastructure. Ad hoc networks are self-configuring, i.e. there is no (central) management system with configuration responsibilities. Some, if not all, nodes in an ad hoc network are capable of assuming router functionality when needed. This enables terminals to communicate with each other when they are out of (radio) range, provided they can reach each other via intermediate hosts acting as routers that relay the packets from source to destination. The structure of the network can change constantly because of the movement of the nodes. In contrast with traditional cellular networks, there is no need to build up a network infrastructure with base stations. Ad hoc networks can be viewed as stand-alone groups of mobile terminals, but they may also be connected

[4] Stricttly speaking, ad hoc networks can make use of other technologies. However, wireless is the natural choice for spontaneous networking.

to a pre-existing network infrastructure and use it to access hosts which are not part of the ad hoc network. In conclusion, ad hoc networking is about supporting spontaneous (multimedia) communication among mobile, wireless and fixed terminals whenever there is the physical possibility to do so.

Detailed issues include:

- Network layer issues:
  - Routing
  - Micro-mobility support and topology management. The basic idea of micro-mobility, which is to confine mobility associated signalling to a small geographical area, can be useful in the context of relatively large ad hoc networks with one or more access points to the Internet
  - Addressing: addressing hierarchy, address assignment mechanisms
  - Interoperability among different wireless access networks
- Medium access control (MAC):
  - Efficiency, fairness, centralised/distributed MAC, dealing with terminals with different ranges
- Physical layer issues, e.g. new radio technologies (e.g. diversity, or adaptive modulation and reception).
- Location and context awareness and methods.
- Quality of Service (QoS) support
- Resource management and sharing, e.g. power, bandwidth
- Autoconfiguration
- Service discovery, including service availability beyond the first hop
- Administration, authentication and accounting (AAA) aspects, including security and privacy
- Ad hoc techniques for enhancing fixed network infrastructures
- Applications issues:
  - Application adaptability
  - Application interface
- Interoperability and interworking, e.g. with fixed infrastructure
- Co-existence of different wireless technologies (although this is not specific of ad hoc networks).

State of the art

A few experimental ad hoc networks are already being built these days. These experiments mainly focus on the implementation and the operation of already proposed routing protocols for ad hoc networks. We find an overview of research activities within this field in [4].

Because of the unique characteristics of ad hoc networks, other issues such as QoS, security and multicasting are being re-considered too.

Several examples of on-going research in specific contexts are:

- Wireless sensor networks. These networks interconnect sensors, actuators and processors. They are characterised by a large number of nodes, mainly static, with highly constrained energy resources. Protocols for self-organisation in combination with energy-aware routing and co-operative information processing have been proposed in [13]. The Sensit project [15] is investigating the technology for building self-organising sensor networks using reconfigurable smart sensor nodes. Networked embedded sensor packs for critical applications are being studied in the ESP project [16].

- The WIND project [14] is developing middleware and protocols to enable applications networks of devices, sensors, and computers to communicate with each other with minimal manual or a priori configuration.

- Smart spaces, where the environment adapts to the needs of the information consumer while moving, are studied in [17].

- Ad hoc networking as a complement of cellular networks [18].

- Ad hoc can be useful for providing network interoperability. The use of software radio aware architectures is studied in [19].

- Multi hop communication is studied in, e.g., [20]

- Mobility Modeling

The modelling of a user's movement is an essential building block in analytical and simulation-based studies of wireless systems. In cellular networks, e.g., a user's mobility behaviour directly affects the signalling traffic needed for handover and location management, the channel holding time, and the call blocking and dropping probability. The choice of the mobility model has a significant effect on the obtained results. If the model is unrealistic, invalid conclusions may be drawn. A categorisation and survey of mobility models used in current wireless research can be found in [25].

With the increasing number of subscribers and the decreasing cell size in future wireless networks, the mobility pattern of users will even more influence the performance of the network. Smaller cells result in an increased mobility-related signalling load and more database queries. Models that proved to be a good choice in simulation of macro-cellular environments show some drawbacks when being applied in micro- and pico-cellular environments. This is especially true for analysis of protocols for self-organising wireless ad hoc networks. Whereas in cellular networks there exists a number of approaches that model the macroscopic movement behaviour of users (e.g., random walk from cell to cell, description of the cell residence time), in these cases we need a “microscopic” model. Furthermore, the mobility of users directly affects important network parameters, such as the connectivity, routing performance, and effectiveness of power control.

Possible Approach

- Development of scenarios and their implications:
    - BAN/PAN.
    - Home, car and office environments.
    - Ambient intelligence/smart environments.
    - Wide-area access.
- Define a set of simulation scenarios with their respective mobility models: user type, parameters, and different levels of detail.

  This set could be similar to the test environments defined by ETSI/3GPP for system-level simulation of UMTS [2]. If possible give a precise mathematical formulation of these models. · Investigate e.g. the following questions: Which parameters have most significant impact on results? Which level of detail is required?
- Derive requirements from scenarios
- Study the application of new techniques and paradigms, such as:
    - Active network concepts.
    - Artificial intelligence algorithms.
    - Self-organising networks aspects.

Expected Results

- Scenarios
- Mobility Models
- System requirements
- Active network concepts
- Prototypes
- Large-scale trials

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7. Contributions Received

The following is a list of links to all contributions received in 2001 before August 1st.

7.1 Contributions Received prior to the Kick-off Meeting in Munich

Nr.	Title	Author(s), Affiliation	Original Contribution
01-1-01	Creating a unified basis for the technological research work of the WSI	Simo Lehto, Helsinki Polytechnic	01_1_01_Helsinki_Lehto.pdf
01-1-02	Shaping the Future of Mobile Devices	Bruno von Niman, Satu Ruuska-Dalliokulju, Matthias Schneider-Hufschmidt, Kaisa Väänänene-Vainio-Mattila, Ericsson, Nokia, Siemens	01_1_02_Erik-Nok-Siem_von-Niman.pdf
01-1-03	New communication technologies for forest management	Karel Charvat, Lesprojekt Sluzby	01_1_03_Lesprojekt_Charvat.pdf
01-1-04	Wireless system for Cycle Tourism	Karel Charvat, Lesprojekt Sluzby	01_1_04_Lesprojekt-Sluzby_Charvat.pdf
01-1-05	On the Move, over the Air, on Paper	Harald Fischer, mCare Services	01_1_05_mCare_Fischer.pdf
01-1-06	Human Interface for the Wireless World: The Virtual Assistant	Raul Bruzzone, Philips	01_1_06_Philips_Bruzzone.pdf
01-1-07	Body Area Networks: Towards a Wearable Future	Karin van Dam, Steve Pitchers, Mike Barnard, Philips Research Laboratories	01_1_07_Philips_van-Dam.pdf
01-1-08	Developing a User Centric MultiSphere Service model for Mobile Users Using a Visual Cell Platform	Seamus Hickey, Petri Pulli, University of Oulu	01_1_08_Uni-Oulu_Hickey.pdf
01-1-09	Wireless Micropayment Systems	Jari Karvonen, Petri Pulli, University of Oulu	01_1_09_Uni-Oulu_Karvonen.pdf
01-1-10	Wireless enabled Networked Communities	Nikolaus A. Dietrich, Ulf Eichner, Blue C	01_1_10_BlueC_Dietrich.pdf
01-1-11	Beyond 3G: What will the user want?	Kate Cook, Motorola UK Research Labs	01_1_11_Motorola_Cook.pdf
01-1-12	European Heritage promotion through wireless technology	Eric Delalonde, Cap Gemini Ernst & Young	01_1_12_Ernst&Young.Delalonde.pdf
01-2-01	UMTS: Beyond or Behind GSM?	Curley Fraser, C-Quential	01_2_01_c-quential_fraser.pdf

01-2-02	Towards I-centric Communications	Radu Popescu-Zeletin, GMD Fokus	01_2_02_GMD-Fokus_Popescu-Zeletin.pdf
01-2-03	Beyond third generation wireless communications: The European market Business Case modelling	Giovanni Gasbarrone, Telecom Italia	01_2_03_Telecom-Italia_Gasbarrone.pdf
01-2-04	Seamless Integration of Mobile Products and Services - User Centricity and Mobile Awareness for mCommerce	Ioannis Fikouras, M. Wunram, F. Weber, Bremen Institute of Industrial Technology and Applied Work Science (BIBA)	01_2_04_BIBA_Fikouras.pdf
01-2-05	Personalization of Next-Generation Mobile Services	Marc Lankhorst, Gerard van Eijkel, Herma van Kranenburg, M.E. Bijlsma, Telematica Instituut	01_2_05_Telematica-Instituut_Lankhorst.pdf
01-2-06	Open Communication as Transactions	Johan Hjelm, Ericsson	01_2_06_Ericsson_Hjelm.pdf
01-2-07	Application Issue for the Wireless Future	Ken Crisler, Larry Marturano, Motorola Labs	01_2_07_Motorola_Crisler.pdf
01-2-08	Usability and Systems Architecting the MultiSphere	Matthew Johnson, Agilent Technologies Laboratories	01_2_08_Agilent-Techn_Johnson.pdf
01-2-09	Relaying in Wireless Access Networks - A Capacity and Energy-Efficiency Perspective	Holger Karl, Technical University Berlin	01_2_09_Uni-Berlin_Karl.pdf
01-2-10	Adaptive Multimedia Messaging: Application Scenario and Technical Challenges	Jörg Heuer, André Kaup, Uwe Rauschenbach, Siemens Corporate Technology	01_2_10_Siemens_Rauschenbach.pdf
01-2-11	Towards Ubiquitous Multimedia Services	Stuart Goose, Rune Hjelsvold, Dr. Georg Schneider, Siemens Corporate Research	01_2_11_Siemens_Goose.pdf
01-2-12	Here, There and Every-Ware: Some applications of mobile and wireless technology in future healthcare	Val Jones, Centre of Telematics and Information Technology	01_2_12_Telematics_Jones.pdf
01-3-01	Trends in Mircölectronic Solutions for Wireless Communication of 3G and Beyond	Peter Jung, Jörg Stammen, Dieter Greifendorf, Fraunhofer-Institut für Mikrölektronische Schaltungen und Systeme	01_3_01_Fraunhofer-Institut_Jung.pdf
01-3-02	Active Routing in Mobile Ad Hoc Networks	Kön Cooreman, Thijs Lambrecht, Bart Duysburgh, Peter Backx, Bart Dhödt, Piet Demeester, Ghent University - INTEC	01_3_02_Uni-Ghent_Cooreman.pdf

01-3-03	Adaptive Wireless Transceivers: A Step Closer to Wireline Quality and Capacity Over Wireless Channels	Lajos Hanzo, University of Southampton	01_3_03_UniSouthampton_Hanzo.pdf
01-3-04	Unified Error-Control Procedure for Global Telecommunication Systems Using Redundant Residue Number System Codes	Lie-Liang Yang, Lajos Hanzo, University of Southampton	01_3_04_Uni-Southampton_Hanzo.pdf
01-3-05	Preliminary Directions for 4th Generation Systems	Edward Tiedemann, Qualcomm	01_3_05_Qualcomm_Tiedemann.pdf
01-3-06	Some FAQ about the 4G	José Jimenéz, Telefonica I+D	01_3_06_Telefonica_Jimenez.pdf
01-3-07	Enabling Technologies for the System Beyond 3G	Yrjö Raivio, Nokia Networks	01_3_07_Nokia_Raivio.pdf
01-3-08	Comparison of wideband technologies for 4G Wireless Communications	Serge Hethuin, Joseph Lasante, Thales Communications	01_3_08_Thales_Hethuin.pdf
01-3-09	Wireless Access Technology Beyond 3G	Pierre R. Chevillat, Wolfgang Schott, IBM Zurich Research Laboratory	01_3_09_IBM_Chevillat.pdf
01-4-01	Instant response systems for wireless media	Irek Defée, Tampere University of Technology	01_4_01_Uni-Tampere_Defee.pdf
01-4-02	On the Role of Satellites in the Wireless Future	Harald Ernst, Erich Lutz, DLR, German Aerospace Centre	01_4_02_DLR_Ernst.pdf
01-4-03	What do we call 4G?	Pierre Combelles (Presenter: Philippe Bertin), France Télécom	01_4_03_France-Telecom_Combelles.pdf
01-4-04	Basic Concept of Personal Area Network	Ramjee Prasad, Aalborg University	01_4_04_Uni-Aalborg_Prasad.pdf
01-4-05	Security and Privacy in the MultiSphere model	Renzo Davoli, University of Bologna	01_4_05_Uni-Bologna_Davoli.pdf
01-4-06	Enabling Smart Networks - Distributed Data Management and Synchronization	Markku Oivo, Timo Hotti, Solid Information Technology	01_4_06_Solid-Inf-Tech_Markku.pdf
01-4-07	Portable Broadband Internet Access	Nitin J. Shah, Arnaud Saffari, ArrayComm	01_4_07_Array-Comm_Shah.pdf

01-4-08	4G: The framework for the convergence of evolutionary trends in the distribution of intelligence	Giorgio Gallassi, Siemens AG	01_4_08_Siemens_Gallassi.pdf
01-4-09	4G network Interconnection Issues	Nikolaos A. Mylonopoulos, Ioanna Constantiou, George Polyzos, Athens University of Economics and Business	01_4_09_Uni-Athen_Mylonopoulos.pdf
01-4-10	Role of Satellite in 3G and beyond	B. G. Evans and R. Tafazolli, University of Surrey	01_4_10_Uni-Surrey_Evans.pdf
01-4-11	Achieving Integrated Network Platforms through IP	N.A. Fikouras, C. Görg, I.Fikouras, ComNets, University of Bremen and BIBA	01_4_11_ComNets-BIBA_Fikouras.pdf
01-4-12	Synergies between WWRF and the Mobile VCE Research Programs	Barry Evans, Keith Baughan & Walter Tuttlebee, Mobile VCE R&D	01_4_12_VCE-Mobile_Evans.pdf
01-4-13	Spectrum Engineering Options for Software Definable Radio	Doru Calin, Lucas Elicegui, David Grandblaise, Motorola Labs	01_4_13_Motorola_Elicegui.pdf

7.2 Contributions Received prior to the Helsinki Meeting

Nr	Title	Author(s), Affiliation	Original Contribution
02-1-01	Virtual Assistants	Raul Bruzzone, Philips Consumer Communications Route d'Angers, 72000 Le Mans France raul.bruzzone@philips.com	02_1_01-Virtual Assistant Item.pdf
02-1-02	Augmented Reality	Raul Bruzzone, Philips Consumer Communications Route d'Angers, 72000 Le Mans France raul.bruzzone@philips.com	02_1_02-Augmented Reality Item.pdf
02-1-03	From PAN to BAN: Why Body Area Networks	Karin van Dam, Steve Pitchers, Mike Barnard Philips Research Laboratories, Cross Oak Lane, Redhill RH1 5HA, United Kingdom Karin.van.Dam@philips.com, Steve.Pitchers@philips.com, Mike.Barnard@philips.com)	02_1_03-wwrf2BAN.pdf
02-1-04	4G Healthcare Services	José Esteban Sema Group sae Albarracin 25 28037 Madrid, Spain jfernando.esteban@sema.es	02_1_04-210415 v1.0 JES 4G_HEALTHCARE_SERVICES.pdf
02-1-05	Modeling the Structure and Operation of the Human User	Simo Lehto Department of Electrical Engineering POB 4020, 00099 City of Helsinki Helsinki Polytechnic Helsinki, Finland Tel: + 358 9 31083421 E-mail: Simo.Lehto@stadia.fi	02_1_05-Contribution_Simo_Lehto_WWRF_Helsinki.pdf
02-1-06	Metaphors for Mobile Tele-Existence	Seamus Hickey, Prof. Petri Pulli Dept. of Information Processing Science, Uiversity of Oulu, FIN-90570 OULU, Finland	02_1_06-WSIhelsinki2001.pdf
02-1-07	Augmented Reality	Raul Bruzzone, Philips Consumer Communications Route d'Angers, 72000 Le Mans France raul.bruzzone@philips.com	02_1_07-Augmented Reality Item Version2.pdf

02-1-08	Visions, Scenarios and Their Consequences	Thaddäus Dorsch, Uwe Fiebig, German Aerospace Center (DLR), Institute for Communications and Navigation Site Oberpfaffenhofen P.O.Box 1116, D-82230 Wessling, Germany E-mail: Uwe.Fiebig@DLR.de, Thaddaeus.Dorsch@DLR.de	02_1_08-WWRF_VisionsScenariosConsequences.pdf
02-1-09	Usability enhanced Applications in production environments by the usage of seamless and ubiquitous communication	Wolfgang Echelmeyer, Ernesto Morales, BIBA, Hochschulring 20, 28359 Bremen, Germany ech@biba.uni-bremen.de	02_1_09-WWRF_IPS_Contribution_Production_v1.1.pdf
02-1-10	Integrated services for intermodal supply chains	Thomas Schmidt, Carsten Westerholt, Pierre Kirisci BIBA, Hochschulring 20, 28359 Bremen, Germany smd@biba.uni-bremen.de, wes, kir	02_1_10-WWRF thema intermodal plt.pdf
02-1-11	Understanding mobile commerce end-user adoption: a triangulation perspective	Per E. Pedersen Agder University College / The Foundation for Research in Economics and Business Administration Grooseveien 36, 4890 Grimstad, Norway per.pedersen@hia.no	02_1_11-WWRF_paper1.pdf
02-1-12	User-driven Intelligent Service Automation	Kate Cook and Andy Aftelak Motorola Labs Jays Close, Viables Industrial Estate, Basingstoke, Hants. RG22 4PD. UK Kate.Cook@motorola.com	02_1_12-WWRF_service_automation.pdf
02-1-13	User Behavioral Research for Applications Beyond 3G	Larry Marturano Motorola Labs 1301 E. Algonquin Road, Room 2230, Schaumburg, IL 60196 USA larry.marturano@motorola.com	02_1_13-010409-ethno-wwrf2-v1.pdf

02-1-14	A Systematic, User-Centered Description of Contextual Information	Ken Crisler Motorola Labs 1301 E. Algonquin Road Schaumburg, IL 60196, USA Ken.Crisler@motorola.com Guy Romano Motorola Labs 1301 E. Algonquin Road Schaumburg, IL 60196, USA Guy@motorola.com Dr. Anind K. Dey Graphics, Visualization and Usability Research Center Georgia Institute of Technology Atlanta, GA 30332, USA anind@cc.gatech.edu	02_1_14-WWRF_WG2_input.pdf
02-1-15	Optimized services in mobile nursing through new wireless applications	Joachim Kaebler, Thomas Bruns BIBA, Hochschulring 20, 28359 Bremen, Germany kae@biba.uni-bremen.de bru@biba.uni-bremen.de	02_1_15-WWRF – mobile nursing kae bru final 2001-04-16.pdf
02-1-16	Informal Communication with Ubiquituous Devices	Tapio Takala Professor - Helsinki University of Technology Dept. of Computer Science Konemiehentie 2, 02150 Espoo tapio.takala@hut.fi or research fellow Nokia Ventures Organization Itälahdenkatu 22, Helsinki tapio.takala@nokia.com	02_1_16-Informal Communication.pdf
02-1-17	Advanced telematic platform to support alternative powered vehicles	Marc C. Lemmel, Dr. Gerald Ströbel BIBA, Hochschulring 20, 28359 Bremen, Germany lem@BIBA.uni-bremen.de str@BIBA.uni-bremen.de	02_1_17-BIBA-MAQ WWRF-CALL-LEM-STR-V5.pdf
02-1-18	3D City Info – a Near-future Application of 4G Services	Ismo Rakkolainen Signal Processing Laboratory, Tampere University of Technology, P.O.BOX 553, 33101Tampere, Finland ira@cs.tut.fi	02_1_18-WWRF2001.pdf

02-1-19	Virtual Trauma Team	1. Dr Val Jones, Dept. of Computer Science, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands, tel: +31 53 489 4018, fax: +31 53 489 4524 jones@cs.utwente.nl 2. Richard Bults, Manager ANTC Netherlands, Email: bults@ctit.utwente.nl, tel: +31 53 4893743, fax: +31 53 489 4524 3. Prof Dr PAM Vierhout, Medisch Spectrum Twente and Department of Technology and Management, University of Twente, tel: +31 53 489 3825	02_1_19-contrib2.pdf
02-1-20	Wireless Service Scenarios: Use and Business Cases	Pieter Ballon Researcher and Advisor TNO-Institute for Strategy, Technology and Policy P.O.Box 6030, 2600 JA Delft, The Netherlands Ballon@stb.tno.nl http://www.stb.tno.nl	02_1_20-WWRF contribution by TNO.pdf
02-1-21	The Wireless Impact on Humanitarian Aspects	Nikolaus A. Dietrich, MSc (Business Administration) Ulf Eichner, MSc (Psychology) BLUE C New Economy Consulting Deutschland GmbH Neusser Straße 93, D-50670 Köln Phone: +49-175-224 9038 Office: +49-221-13050 Fax: +49-221-130 55 99 Email: Nikolaus.Dietrich@blue-c.com Ulf.Eichner@blue-c.com http://www.blue-c.com	02_1_21-Wireless Impact Humanitarian Aspects1.pdf

02-1-22	MobiCom - Evolution Scenarios for emerging M-Commerce services: New Policy, Market Dynamics, Methods of Work and Business Models	University of Jyvaskyla, Finland Sonera Corporation, Finland University of Cologne, Germany Vodafone Pilotentwicklung GmbH, Germany Creditreform, Germany Athens University of Economics and Business, Greece Lambrakis Research Foundation, Greece Stet Hellas / Telestet, Greece University of Brighton, Great Britain	02_1_22-IST MobiCom - JyU contribution.pdf
02-1-23	Upper Bounds for Memory Requirements in Virtual Assistants	Raul Bruzzone, Philips Consumer Communications Route d'Angers, 72000 Le Mans France raul.bruzzone@philips.com	02_1_23-Memory Capacity Rev2.pdf
02-1-24	On the Applicability of Reconfigurable Devices for Multi-mode, Multi-services Multimedia-enabled Terminals	Fadi Kurdahi (fk@morphotech.com) Behzad Mohebbi (behzad@morphotech.com) Todd Nash (tnash@morphotech.com) Morpho Technologies 2301 Campus Drive, Suite 240 Irvine, CA 92612, USA	02_1_24-abstract finland paper draft tnash01-fjk02.pdf
02-1-25	Mobile Internet Without Fuzz	Dick Schefström, CDT, *http://www.cdt.luth.se* Mäkitalo Research Centre http://www.mrc.cdt.luth.se/	02_1_25-WithoutFuzz.pdf
02-1-26	Mobile data management and data access (m-data management)	Karel Charvat Lesprojekt sluzby Brdickova 1916 charvat@lesprojekt.cz	Late Arrival
02-1-27	Mobile customers segments and end user requirements	Karel Charvat Lesprojekt sluzby Brdickova 1916 Praha 5 155 00 charvat@lesprojekt.cz	Late Arrival
02-2-01	Ubiquitous Mobile Discovery of Knowledge	Bernd Bredehorst, Ioannis Fikouras, Michael Wunram BIBA, Hochschulring 20, 28359 Bremen, Germany bre@biba.uni-bremen.de fks@biba.uni-bremen.de wun@biba.uni-bremen.de	02_2_01-Ubiquitous Mobile Discovery of Knowledge.pdf

02-2-02	Wireless Micro-Payments in the Networked Markets	Jari Karvonen University of Oulu Deparment of Economics P.O.Box 4600, FIN-90014 Oulu, Finland Jari.T.Karvonen@oulu.fi Toni Komu University of Oulu Dept of Information Processing & Infotech Research Center P.O. Box 1100, FIN-90571 Oulu, Finland tkomu@rieska.oulu.fi Petri Pulli University of Oulu Dept of Information Processing & Infotech Research Center P.O. Box 1100, FIN-90571 Oulu, Finland Petri.Pulli@oulu.fi	02_2_02-wwrfhelsinki.pdf
02-2-03	Privacy protection related issues in the design of a personal service environment for personalised mobile services	Herma van Kranenburg, Marc Lankhorst, Gerard van den Eijkel Telematica Instituut, PO Box 589, 7500 AN Enschede, Netherlands kranenburg@telin.nl	02_2_03-WWRF privacy legislation.pdf
02-2-04	An Architecture for Personalisation of Mobile Services	Marc Lankhorst, Herma van Kranenburg, Gerard van den Eijkel Telematica Instituut, PO Box 589, 7500 AN Enschede, Netherlands lankhorst@telin.nl	02_2_04-WWRF PSE architecture.pdf
02-2-05	Pricing for Efficient Quality of Service Support in Wireless Packet Networks	Prof. George C. Polyzos & Prof. Costas Courcoubetis Mobile Multimedia Laboratory Department of Informatics Athens University of Economics and Business 76 Patission, 10434 Athens, Greece polyzos@aueb.gr, courcou@aueb.gr	02_2_05-WWRF-2-Pricing-QoS.pdf
02-2-06	Service Location in Integrated Networks	Dipl. Inform. Ioannis Fikouras BIBA, Hochschulring 20, 28359 Bremen, Germany fks@biba.uni-bremen.de N. A. Fikouras BSc MSc, Prof. Dr. rer. nat. habil. C. Görg ComNets, Kufsteiner Str. NW1, 28359 Bremen, Germany {niko, cg}@comnets.uni-bremen.de	02_2_06-Service Location in Integrated Networks v03.pdf

02-2-07	Distribution of Intelligence and Processing Capabilities	G.Gallassi Siemens ICN S.p.A., Milan giorgio.gallassi@icn.siemens.it	02_2_07-WWRF2.pdf
02-2-08	Key Research Areas in Adaptive Middleware for Mobile Computing Beyond 3G	Kimmo Raatikainen Nokia Research Center P.O. Box 407, FIN-00045 NOKIA GROUP, Finland Kimmo.raatikainen@nokia.com	02_2_08-WWRF_MWresearch.pdf
02-2-09	Application of agent technology to next generation wireless/mobile networks	Henning Sanneck Siemens Information and Communication Mobile - Networks, D-81359 Munich, Germany henning.sanneck@icn.siemens.de Michael Berger, Bernhard Bauer§ Siemens Corporate Technology, Intelligent Autonomous Systems, D-81730 Munich, Germany {michael.berger,bernhard.bauer}@mchp.siemens.de	02_2_09-agents-wwrf-submission.pdf
02-2-10	Service and Mobility Modeling for the 4G	Mathias Schweigel Technische Universität Dresden Telecommunications Laboratory schweige@ifn.et.tu-dresden.de	02_2_10-Mobility.pdf
02-2-11	Exploitation of heterogeneous networks for mobile services and mobility management	Klaus Strohmenger, Dr. Jörg Brakensiek, Dr. Mohsen Darianian Nokia Research Center Meesmannstraße 103 44807 Bochum, Germany klaus.strohmenger@nokia.com	02_2_11-WWRF_HeteroMobility.pdf
02-2-12	Memory intensive applications for affordable infrastructure	Jens Zander Wireless@KTH KTH/S3 100 44 Stockholm jens.zander@wireless.kth.se	02_2_12-WWRF_Zander.pdf
02-2-13	How can image compression enable next generation applications?	Michael Chui Founder, AirZip, Inc. 650 S. Winchester Boulevard, Suite 101 San Jose, CA 95128 USA michael@airzip.com Phone 408-243-8184	02_2_13-WWRF AirZip contribution.pdf

02-2-14	Communication Privacy in IP-based Architectures	D. Westhoff NEC Europe Ltd., Adenauerplatz 6, D-69115 Heidelberg, Germany Phone: +49/(0) 6221/13708-20, Fax: -28 Email: dirk.westhoff@ccrle.nec.de G. Schäfer[2] Department of Electrical Engineering, TKN-Group, Technical University of Berlin, Einsteinufer 25, D-10587 Berlin, Germany, Phone: +49 30 314 23836, Fax: -23818, Email: schaefer@ee.tu-berlin.de	02_2_14-WWRFPrivacy.pdf
02-2-15	Modelling Future Wireless Multimedia Services	Nigel Jefferies Vodafone Group R&D, The Courtyard, 2-4 London Road, Newbury, Berks, RG14 1JX, UK nigel.jefferies@vf.vodafone.co.uk Alistair Munro University of Bristol, Merchant Venturers Building, Woodland Road, Bristol BS8 1UB, UK A.Munro@bristol.ac.uk	02_2_15-Modelling Future Wireless Multimedia Services AM_.pdf
02-2-16	VESPER, Virtual Home Environment for Service Personalization and Roaming Users	See 20	02_2_16-WWRF_Submission_VESPER.pdf
02-2-17	VHE Web Services Architecture	Erwin Postmann Standards and Technology Manager SIEMENS AG Austria A-1210 Vienna, Autokaderstraße 29 Tel: +43-51707-21398, Email: erwin.postmann@siemens.at Hans Portschy Innovation and Technology Manager SIEMENS AG Austria A-1101 Vienna, Gudrunstraße 11, Tel: +43-51707-45331, hans.portschy@siemens.at	02_2_17-WWRF_Submission_VHE_WebServices.pdf
02-2-18	The Mobile Commerce Quest for Value-Added Products & Services	Christer Carlsson and Pirkko Walden IAMSR / Abo Akademi University DataCity B 6734, 20502 Abo, Finland Christer.carlsson@abo.fi	Late Arrival

02-3-01	Reconfigurable RF and Baseband Architectures for Mobile Radio Transceivers	Linus Maurer, Robert Weigel Institute for Communications and Information Engineering, University of Linz Altenbergerstr. 69, 4040 Linz, Austria {linus.maurer@ieee.org, weigel@ieee.org}	02_3_01-Maurer_1.pdf
02-3-02	RF Front-End Design for Software Defined Radio	Linus Maurer, Robert Weigel Institute for Communications and Information Engineering, University of Linz Altenbergerstr. 69, 4040 Linz, Austria {linus.maurer@ieee.org, weigel@ieee.org}	02_3_02-Maurer_2.pdf
02-3-03	Ad-Hoc Networks	D. Remondo Bueno University of Twente Postbus 217, 7521 ZA Enschede, The Netherlands remondo@cs.utwente.nl K. Cooreman Ghent University Sint-Pietersnieuwstraat 41, B-9000 Gent, Belgium koen.cooreman@intec.rug.ac.be R. Tafazolli University of Surrey R.Tafazolli@surrey.ac.uk	02_3_03-Draft_WWRF_adhoc_research_issues_submitted.pdf
02-3-04	Future microelectronic hardware concepts for wireless communication beyond 3G	Peter Jung, Jörg Stammen, Dieter Greifendorf Fraunhofer-Institut für Mikroelektronische Schaltungen und Systeme (IMS) Finkenstrasse 61, D-47057 Duisburg, Germany {jung, stammen, greif}@ims.fhg.de	02_3_04-WWRF2nd-FHG.pdf
02-3-05	Interconnection and Regulation in Heterogeneous Wireless Networks: An Economic Perspective	Ioanna Constantiou Project Manager MobiCom Athens University of Economics and Business - eLTRUN, The eBusiness Center Evelpidon 47a & Lefkados 33 11362 Athens, Greece ioanna@aueb.gr	02_3_05-WWRF-2-Interconnect.pdf

02-3-06	The Security and Privacy Layer	Renzo Davoli Department of Computer Science, University of Bologna, Mura Anteo Zamboni, 7 I40127 Bologna (Italy). renzo@cs.unibo.it Philippe Charas Corporate Marketing and Business Development Ericsson SE-126 25 Stockholm (Sweden) philippe.charas@lme.ericsson.se	02_3_06-wwrf2.pdf
02-3-07	Reliable Transport in Heterogeneous Wireless Networks, Do we need new end-to-end transport protocols?	Jörg Schüler Chair for Telecommunications, Dresden University of Technology	02_3_07-contri1.doc
02-3-08	Personal Area Networks	Ignas G. Niemegeers University of Twente P.O.B 217, 7500AE Enschede, The Netherlands Niemegee@cs.utwente.nl Ramjee Prassad University of Aalborg Address prasad@cpk.auc.dk Ciaran Bryce Université de Genève 24, rue Général-Dufour, CH-1211 Genève 4, Switzerland Ciaran.Bryce@cui.unige.ch	02_3_08-WWRF_PAN_Contribution_final-version.pdf
02-3-09	Self-organizing networks	Sonia Heemstra de Groot, Ericsson ELN/ University of Twente, Enschede, The Netherlands Ignas G.M.M. Niemegeers, David Remondo Bueno University of Twente, Enschede, The Netherlands Rogier VIssers Ericsson ELN, Enschede, The Netherlands	02_3_09-self-organizing-networks.pdf

02-3-10	Hardware Architecture of a Software-Defined Radio for Mobile Communication Systems Beyond 3G	Pierre R. Chevillat and Wolfgang Schott IBM Research Division Zurich Research Laboratory Säumerstrasse 4 CH-8803 Rüschlikon/Switzerland pch@zurich.ibm.com, sct@zurich.ibm.com	02_3_10-WWRF_Helsinki_2001_SoftwareDefinedRadio_IBM.pdf
02-3-11	Wireless IP set of protocols	QoS End-to-end Transport Jörg Schüler Technical University of Dresden G.Schumann Str. 9, Barkhausen Bau, D-01062 Dresden schuelj@ifn.et.tu-dresden.de QoS parameters : Servane Bonjour, Philippe Bertin, Pierre Combelles France Telecom R&D Rue du Clos Courtel, BP59 35512 Cesson-Sevigne Cedex servane.bonjour@francetelecom.com philippe.bertin@francetelecom.com pierre.combelles@francetelecom.com	02_3_11-ContribFTRD-TUDresden-WWRF2-v2.pdf
02-3-12	Design principles for Future Generation systems	Norbert Niebert Ericsson Eurolab Deutschland GmbH Ericsson Allee 1, D-52134 Herzogenrath, Germany Norbert.Niebert@ericsson.com	02_3_12-WWRF_template.pdf
02-3-13	Mobility Management in Integrated Network Platforms	N. A. Fikouras, C. Görg ComNets, Universität Bremen Kufsteiner Str. NW1, 28359 Bremen, Germany {niko, cg}@comnets.uni-bremen.de W. Zirwas ICN, Siemens AG 2ICN M RP 1, Hofmannstr. 51, D-81359 Munich, Germany wolfgang.zirwas@icn.siemens.de	02_3_13-Mobility Management in Integrated Networks.pdf

02-3-14	Trends in Microelectronic Solutions for Wireless Communication of 3G and Beyond	Peter Jung, Jörg Stammen, Dieter Greifendorf Fraunhofer-Institut für Mikroelektronische Schaltungen und Systeme (IMS) Finkenstrasse 61, D-47057 Duisburg, Germany {jung, stammen, greif}@ims.fhg.de	02_3_14-Talknumber_301009.pdf
02-3-15	Satellites in a Wireless World	Jean Bouin Alcatel Space Standards Manager Satellite Systems 31037 Toulouse Cedex 1, France jean.bouin@space.alcatel.fr Harald Ernst DLR, Institute for Communications and Navigation D-82234 Wessling Harald.Ernst@dlr.de Prof. Barry Evans University of Surrey Centre for Communication Systems Research Surrey GU2 7XH, UK B.Evans@surrey.ac.uk	02_3_15-WWRF_satellite.pdf
02-3-16	Hybrid Ad Hoc and Cellular Architectures	Mathias Schweigel Technische Universität Dresden Telecommunications Laboratory schweige@ifn.et.tu-dresden.de	02_3_16-hybNetw.pdf
02-3-17	Ultra Wideband (UWB) Radio Technology (UWB-RT) - Short-Range Communication and Location Tracking	Walter Hirt IBM Research, Zurich Research Laboratory CH-8803 Rüschlikon, Switzerland Tel.: +41-1-724 8477 hir@zurich.ibm.com	02_3_17-IBM_WWRF_UWB_CONTRIBUTION.pdf
02-3-18	Self-Organizing Wireless Broadband Networks with Guaranteed Quality of Service	Bernhard Walke, Bangnan Xu Communication Networks, Aachen University of Technology, D-52074 Aachen, Germany, walke@comnets.rwth-aachen.de.	02_3_18-WWRF_template_WCHAMB.pdf

02-3-19	Joint source-channel coding for 4G multimedia streaming	Leonardo Camiciotti, Catherine Lamy, Lisa Meilhac, Stefano Olivieri, PierGiorgio Verdi Philips Research, Via G. Casati 23, 20052 Monza (MI) – Italy. Stefano.olivieri@philips.com	02_3_19-JSCC4WWRF.pdf
02-3-20	Beyond 3G	Hong-Yon Lach Motorola (Centre de Recherche de Motorola Paris) Espace Technologique Commune de Saint Aubin 91193 Gif-sur-Yvette, Cedex, France hong-yon.lach@crm.mot.com	02_3_20-WWRF_Beyond3G.pdf
02-3-21	Multi-Hop Ad-hoc Networks	Joerg Habetha, Dr.-Ing. Wolfgang O. Budde Philips Research Laboratories, Aachen Weisshausstr. 2, D-52066 Aachen E-mail: joerg.habetha@philips.com, wolfgang.o.budde@philips.com	02_3_21-WWRF2_multihop_adhoc.pdf
02-3-22	Broadcasting multimedia streams in future mobile systems	Cristian Hesselman, Henk Eertink, Telematica Instituut PO Box 589, 7500 AN Enschede, The Netherlands {hesselman,eertink}@telin.nl	02_3_22-wwrf_contribution_ch_he.pdf
02-3-23	Re-configurable Terminals Beyond 3G	M. Beach University of Bristol; D. Bourse, K. Cook Motorola Labs; M. Dillinger Siemens AG; T. Farnham Toshiba Research Europe Ltd; T. Wiebke Panasonic European Laboratories	02_3_23-WWRF_Helsinki.pdf

02-3-24	Network and Services Management in context of Heterogeneous Radio Access Networks	1. Motorola Labs – CRM Paris, Espace technologique de St Aubin, 91193 Gif sur Yvette Cedex, France Tel. : +33 1 69352568, Fax: +33 1 6935 2501, E-mail: vivier@crm.mot.com 2. National Technical University of Athens, GREECE 3. Motorola Technology Center of Italy, Torino, ITALY 4. Telefonica Investigation y Desarollo, Madrid, SPAIN 5. Institut National des Telecommunications, Paris, FRANCE 6. University of Applied Sciences Valais, Sion, SWITZERLAND 7. ShineLINE srl, Venezia, ITALY 8. OMNYS srl, Vicenza, ITALY	02_3_24-Monasidre_to_WWRF.pdf
02-3-25	See 02-3-17	See 02-3-17	02_3_25-IBM_WWRF_UWB_PAPER.pdf
02-3-26	Towards 4G	Hamid Aghvami, Paul Anthony Pangalos King's College London (University of London) Centre for Telecommunications Research Strand London WC2R 2LS, UK hamid.aghvami@kcl.ac.uk	02_3_26-WWRF.pdf
02-3-27	Asymmetric UMTS: Driving 3G Ahead	Ralf Keller, Stefan Wager Ericsson Eurolab Deutschland GmbH, Ericsson Allee 1, D-52134 Herzogenrath, Germany {Ralf.Keller, Stefan.Wager}@eed.ericsson.se	02_3_27-AsymUMTS_WWRF.doc1.pdf
02-3-28	Communication Platform Reconfiguration	Klaus Moessner, Rahim Tafazolli Centre for Communication Systems Research University of Surrey Guidlford, Surrey United Kingdom – GU2 7XH {k.moessner/r.tafazolli}@eim.surrey.ac.uk	Late Arrival

02-4-01	Multi-Carrier based Air Interface	Stefan Kaiser, Michael Schnell, Armin Damman, Erik Haas, Ronald Raulefs German Aerospace Center (DLR) Institute of Communications and Navigation 82234 Wessling Germany stefan.kaiser@dlr.de	02_4_01-WWRF_Kaiser.pdf
02-4-02	Portable Broadband Internet Access: Predicting and Analysing Service, Content, Network and Customer Experience Parameters	Joanne Wilson, Vice President Standards, Arnaud Saffari, Co-founder ArrayComm, Inc. Address: 2480 North First Street San Jose, California, USA 95131-1014 Tel: + 1 202-835-1925 joanne@arraycomm.com, arnaud@arraycomm.com	02_4_02-WWRF_Helsinki-01-Research Item.pdf
02-4-03	Smart Antennas	Martin Haardt Siemens AG D-81359 Munich, Germany haardt@ieee.org Laurent Herault leti F-38054 Grenoble, France Laurent.Herault@cea.fr Rahim Tafazolli University of Surrey Guildford, UK R.Tafazolli@eim.surrey.ac.uk Wolfgang Utschick Munich University of Technology D-80333 Munich, Germany wout@nws.e-technik.tu-muenchen.de	02_4_03-WWRF_smart_antennas_3.pdf
02-4-04	Requirements, System Design and Optimisation Priniciples	Irek Defée Tampere University of Technology P.O. Box 553, FIN-33101 Tampere, Finland. E-mail: irk@cs.tut.fi	02_4_04-WWRFcontr.pdf

02-4-05	4G Nano/pico-cell architectures: their impact on mobility handling protocols	Hannes Hartenstein and Ralf Schmitz Computer & Communication Research Lab NEC Europe Ltd. 69115 Heidelberg, Germany {ralf.schmitz|hannes.hartenstein}@ccrle.nec.de Hiroshi Furukawa, Koichi Ebata and Kazuhiro Okanoue Networking Research Laboratories NEC Corporation Miyazaki 4-1-1, Miyamae, Kawasaki 226-8555, Japan furuhiro@cw.jp.nec.com	02_4_05-wwrf_contrib_nec.pdf
02-4-06	Spectrum Exploration for Mobile Radio	Bernhard H. Walke Communication Networks, Aachen University of Technology, Kopernikusstr. 16, D-52074 Aachen, Germany, walke@comnets.rwth-aachen.de	02_4_06-WWRF_template_Cofarm.pdf
02-4-07	The Way Forward on Spectrum Allocation	S Ghaheri-Niri, P leaves, R Tafazolli University of Surrey Centre for Communication Systems Research (CCSR) Mobile Communications Research Group, University of Surrey Guildford, Surrey GU2 5XH, England Tel: +44 1483 259484 Fax: +44 1483 259504 E-mail: S.Ghaheri-Niri@eim.surrey.ac.uk J Huschke, W Stahl, R Tonjes Ericsson Eurolab Germany	02_4_07-wwrf_dsa_1.pdf
02-4-08	Location-Sensitive Radio Resource Management in Future Mobile Systems	Siamäk Naghian, NOKIA, IP Mobile Networks	02_4_08-LS_HO_WWRF_Final.pdf

02-4-09	Sparse interference cancellation with an antenna array for OFDM	Alexandr M.Kuzminskiy and Paul Strauch Bell Laboratories, Lucent Technologies Optimus, Windmill Hill Business Park, Swindon, Wiltshire SN5 6PP, UK ak9@lucent.com, pstrauch@lucent.com	02_4_09-wwrf.pdf

7.3 Contributions Received prior to the Stockholm Meeting

Nr.	Title	Author(s), Affiliation	Original Contribution
03-1-01	Scenarios and Their Consequences, Part II	Thaddäus Dorsch, Uwe Fiebig German Aerospace Center (DLR), Institute for Communications and Navigation Site Oberpfaffenhofen P.O.Box 1116, D-82230 Wessling, Germany E-mail: Uwe.Fiebig@DLR.de, Thaddaeus.Dorsch@DLR.de	03_1_01_Thaddaus_Dorsch.pdf
03-1-02	All Senses Communication	Martin Rantzer, Ericsson Research Datalinjen 4, P.O.Box 1248, SE-581 12 Linköping, Sweden E-mail: martin.rantzer@ericsson.com	03_1_02_Martin_Rantzer.pdf
03-1-03	Mobile Augmented Reality (MAR) and Virtual Reality	Charilaos Christopoulos, Media Lab, Ericsson Research, Ericsson, Sweden	03_1_03_Charilaos_Christopoulos.pdf
03-1-04	Interactive information and communication system for fire brigades	Marc C. Lemmel BIBA Hochschulring 20, 28359 Bremen, Germany E-mail:lem@BIBA.uni-bremen.de	03_1_04_Marc_C_Lemmel_(BIBA).pdf
03-1-05	Mobile Personal Services for the elderly and disabled	Pierre T. Kirisci Affiliation: BIBA Hochschulring 20, 28359 Bremen, Germany E-mail: kir@biba.uni-bremen.de	03_1_05_Pierre_T_Kirisci_(BIBA).pdf

03-1-06	Body Area Networks for Healthcare	Dr. Val Jones, Dept. of Computer Science, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands, tel: +31 53 489 4018, fax: +31 53 489 4524, email: jones@cs.utwente.nl Ing. Richard Bults, manager ANTC Netherlands®, University of Twente dept. CTIT, PO Box 217, 7500 AE Enschede, Email: bults@cs.utwente.nl, tel: +31 53 4893743, fax: +31 53 489 4524 Prof. Dr. Dimitri Konstantas, Dept. of Computer Science, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands, tel: +31 53 489 4018, fax: +31 53 489 4524, email: dimitri@cs.utwente.nl Prof. Dr. P.A.M. Vierhout, Medisch Spectrum Twente and Department of Technology and Management, University of Twente, tel: +31 53 489 3825.	03_1_06_Val_Jones_Richard_Bults.pdf
03-1-07	Mobile Broadband for Emergency and Safety Applications (MESA)	Steffen Ring - Chairman Project MESA Steering Committee www.projectmesa.org Contact: Kjell Strandberg: Kjell.Strandberg@etsi.fr	03_1_07_Steffen_Ring_MESA.pdf
03-2-01	Peer-to-peer Computing in Wireless Networks	Friedhelm Ramme, Axel Busboom Ericsson Eurolab Deutschland GmbH Ericsson Allee 1 D-52134 Herzogenrath firstname.lastname@eed.ericsson.se	03_2_01_Friedhelm_Ramme_Axel_Busboom_v2.pdf
03-2-02	A Semantic Web Environment for Context-Aware Mobile Services	Prof. Norman M. Sadeh Human Computer Interaction Institute & eCommerce Institute School of Computer Science Carnegie Mellon University 5000 Forbes Avenue Pittsburgh, PA 15213-3891 USA sadeh@cs.cmu.edu Tel: (+1-412) 268-8144 Fax: (+1-412) 291-1110	03_2_02_Norman_M_Sadeh_v2.pdf

03-2-03	Beyond third generation wireless communications The European market Business Case modelling	Giovanni Gasbarrone Telecom Italia Headquarters, Rome E-Mail: giovanni.gasbarrone@telecomitalia.it	03_2_03_Giovanni_Gasbarrone_Businessm.pdf
03-2-04	Future M2M in mobile networks	Johan Hjelm, Nippon Ericsson KK	03_2_04_Johan_Hjelm.pdf
03-2-05	A User-Centric Design of a Personal Service Environment	Michael van Bekkum, Jan de Jongh, Celeste Ponsioen TNO Physics and Electronics Laboratory P.O. Box 96864 NL 2509 JG The Hague The Netherlands J.F.C.M.DeJongh@FEL.TNO.NL	03_2_05_M_Bekkum_Jan_de_Jongh.pdf
03-2-06	Understanding business models in mobile commerce	Leif B. Methlie Norwegian School of Economics and Bus. Adm./ The Foundation for Research in Economics and Business Administration Breiviksveien 40, 5045 BERGEN, Norway leif.methlie@nhh.no Per E. Pedersen Agder University College / The Foundation for Research in Economics and Business Administration Grooseveien 36, 4890 Grimstad, Norway per.pedersen@hia.no	03_2_06_Leif_Methlie_Per_Pedersen.pdf
03-2-07	A service system architecture for context-aware service	Shigetoshi Sameshima, Katsumi Kawano, Motohisa Funabashi Hitachi Ltd. 1099 Ohzenji, Asao, Kawasaki, Kanagawa Japan {samesima | kawano | funa}@sdl.hitachi.co.jp	03_2_07_Shigetoshi_Sameshima_others.pdf
03-3-01	Re-configurable Terminals Beyond 3G Radio Research	J.R. MacLeod, M.A. Beach, P.A. Warr Centre for Communications Research, University of Bristol	03_3_01_JR_MacLeod_Others.pdf

03-3-02	Re-configurable Terminals Beyond 3G and Supporting Networks System Aspects	M. Beach[1], D. Bourse[2], R. Navarro[2], M. Dillinger[3], T. Farnham[4], T. Wiebke[5] [1] University of Bristol; [2] Motorola Labs; [3] Siemens AG; [4] Toshiba Research Europe Ltd; [5] Panasonic European Laboratories	03_3_02_M_Beach_TRUST-contribution.pdf
03-3-03	Seamless Interoperability of Wireless Technologies and Smart Environments with SEEWIN (Smart Environments with Embedded Wireless Internet)	Peter Jung, Jörg Stammen, Dieter Greifendorf Fraunhofer Institut für mikroelektronische Schaltungen und Systeme Finkenstraße 61, 47057 Duisburg {peter.jung, joerg.stammen, dieter.greifendorf}@ims.fhg.de	03_3_03_Peter_Jung_Frauenhof.pdf
03-3-04	An Adaptive Hardware Platform for SDR	[1]Pangan Ting , [1]Benjamin H. Wang , [1]Charles S. Tsao , [1]Nanson Huang , [1]Hung-Lin Chou , [2]Wern-Ho Sheen , [1]Chia-Lin Hu , [1]Cathy H. Hsieh , [1]Hsuan-Ling Chen , [1]Hung-Chih Chen Wireless Communications Department Computer & Communications Research Laboratories (CCL) Industrial Technology Research Institute (ITRI) [2] National Chiao-Tung University M300 Bldg. 14, 195-11 Sec. 4, Chung Hsing Rd. Chutung, Hsinchu, Taiwan 310, R.O.C pating@itri.org.tw	03_3_04_Pangan_Ting_AdaptiveHW.pdf
03-3-05	Integration of Software Platform and Hardware Platform of SDR Technology	[1]Benjamin H. Wang[†], [1]Pangan Ting[†], [1]Charles S. Tsao[†], [1]Hung-Lin Chou[†], [1]Nanson Huang[†], and [2]Wern-Ho Sheen[‡] [†1]Wireless Communications Department Computer & Communications Research Laboratories Industrial Technology Research Institute; [‡2]National Chiao-Tung University, bhwang@itri.org.tw	03_3_05_Benjamin_H_Wang.pdf

03-3-06	Mobile MPLS	Hans-Peter Huth Siemens AG, Corporate Technology Siemens AG, CT IC 2 Otto-Hahn-Ring 6 D-81730 Munich Germany E-mail : Hans-Peter.Huth@mchp.siemens.de	03_3_06_Hans-Peter_Huth.pdf
03-3-07	Mobile MPLS - a MPLS based Micro Mobility Concept	J. Grimminger, H.-P. Huth Siemens AG, Corporate Technology, Information & Communication	03_3_07_J_Grimminger_H-P_Huth.pdf
03-3-08	A Framework for Quality of Service (QoS) Provisioning in Wireless Networks	Manickam R. Sridhar & Steve Cook Sitara Networks Inc. 52, Second Ave. Waltham, MA 02451. Msridhar@sitaranetworks.com Scook@sitaranetworks.com	03_3_08_Manickam_R_Sridhar.pdf
03-3-09	The Security and Privacy Layer	Renzo Davoli Department of Computer Science University of Bologna renzo@cs.unibo.it Philippe Charas Corp. Marketing and Business Development Ericsson philippe.charas@lme.ericsson.se	03_3_09_Renzo_Davoli_Philippe_Charas.pdf
03-3-10	Bridges between the fixed and wireless network (Optical Radio Access Networks beating distance with capacity)	Gunnar Edwall, Ericsson Radio Systems, Generic Technologies Research, SE-164 80 Stockholm	03_3_10_Gunnar_Edwall.pdf
03-3-11	Radio Resource Management and Flexible Spectrum Allocation for Re-configurable SDR Terminals	David Grandblaise, L. Elicegui, D. Bourse Motorola Labs - CRM Paris	03_3_11_David_Grandblaise_motorola.pdf

03-3-12	Ultra Wideband (UWB) Radio Technology (UWB-RT): Short-Range Communication and Location Tracking	Pierre Chevillat (email: pch@zurich.ibm.com) Walter Hirt (email: hir@zurich.ibm.com) IBM Research, Zurich Research Laboratory, CH-8803 Rüschlikon, Switzerland Serge Hethuin Serge.HETHUIN@fr.thalesgroup.co m Isabelle Bucaille isabelle.bucaille@fr.thalesgroup.com) THALES Communications, F-92704 Colombes Cedex, France Jean-René Lequepeys (email: lequepeys@chartreuse.cea.fr) LETI/CEA, Grenoble, France	03_3_12_Pierre_Chevillat.pdf
03-4-01	Ultra Low Power transmission with braodband backward channels	Zirwas Wolfgang Siemens AG, ICM N MR ST 8 Technopark II, Werner-von-Siemens-Ring 20, 85630 Grasbrunn E-mail: wolfgang.zirwas@icn.siemens.de	03_4_01_Wolfgang_Zirwas_low power.pdf
03-4-02	Broadband MultiHop Networks for Public Hot Spot Scenarios	Wolfgang Zirwas[1)], Tobias Giebel[2)], Norbert Esseling[3)], Egon Schulz[1)], Josef Eichinger[1)] 1) Siemens AG, ICM N MR ST 8, xxx, 2) TU Hamburg Harburg 3) RWTH Aachen Phone: ++49 (0)89 722 34369 Fax: ++49 (0)89 722 26478 email: wolfgang.zirwas@icn.siemens.de	03_4_02_Wolfgang_Zirwas_Multihop.pdf
03-4-03	MIMO Transceivers under Interference Limited Scenarios	Alexandr M.Kuzminskiy, Hamid Reza Karimi and Carlo Luschi Bell Laboratories, Lucent Technologies The Quadrant, Stonehill Green, Westlea, Swindon, Wiltshire SN5 7DJ, UK E-mail: ak9@lucent.com	03_4_03_Alexandr_Kuzminskiy_others.pdf

03-4-04	Radio-Access Technologies for Next Generation High-Speed Mobile Data Networks	Name: Hui Liu, Chief Technology Office; Alex Li, VP of Technology Affiliation: Broadstorm Telecommunications Inc. Address: 400 112th Ave NE, Suite 250, Bellevue WA, 98004-5545, USA Tel: + 1 *425-646-8800; Fax: +1 425-451-3765* E-mail: hliu@broadstorm.com	03_4_04_Hui_liu_broadstorm.pdf
03-4-05	Ad Hoc Networks Interest Group	Editor: D. Remondo-Bueno Affiliation: University of Twente Postbus 217 - 7500AE - Enschede - The Netherlands E-mail: remondo@cs.utwente.nl	03_4_05_D_Remondo_Bueno_v2.pdf
03-4-06	Implementing The RadioSphere	Dick Schefström & Fredrik Johansson, CDT, http://www.cdt.luth.se & Mäkitalo Research Centre http://www.mrc.cdt.luth.se/ 97187 Luleå, Sweden	03_4_06_Dick_Schefstrom.pdf
03-4-07	Smart Antennas	Martin Haardt, Siemens AG D-81359 Munich, Germany E-mail: haardt@ieee.org Norbert Geng, Siemens AG D-81667 Munich, Germany E-mail: Norbert.Geng@mch.siemens.de Laurent Herault, CEA-LETI F-38054 Grenoble, France E-mail: Laurent.Herault@cea.fr Rahim Tafazolli, University of Surrey Guildford, UK E-mail: R.Tafazolli@eim.surrey.ac.uk Wolfgang Utschick, Munich University of Technology D-80333 Munich, Germany E-mail: wout@nws.e-technik.tu-muenchen.de	03_4_07_Martin_Haardt_smartantennas6.pdf

7.4 New and Updated Contributions Received after the Stockholm Meeting

Nr.	Title	Author(s), Affiliation	Original Contribution
04-1-01	Modelling the Structure and Function of the Human User	Simo Lehto, Lic.Tech., Project Manager Helsinki Polytechnic University Department of Electrical Engineering Address: POB 4020, 00099 City of Helsinki Helsinki, Finland E-mail: Simo.Lehto@stadia.fi	04_1_01_Simo_Lehto.pdf
04-1-02	Access for All and Assistive Technologies	Bruno von Niman Ericsson Ericsson Enterprise AB 13189 Stockholm Bruno.vonniman@ericsson.com Dr. Matthias Schneider-Hufschmidt SIEMENS AG ICM MP TI 3 msch@mch.siemens.de	04_1_02_Bruno v Niman, Access for all and assistive technologies.pdf
04-1-03	User Addressing in Converging Networks	Bruno von Niman Ericsson Ericsson Enterprise AB 13189 Stockholm Bruno.vonniman@ericsson.com	04_1_03_Bruno v Niman, User addressing in Converging networks.pdf
04-1-04	User-driven Intelligent Service Automation	Kate Cook and Andy Aftelak Motorola Labs Jays Close, Viables Industrial Estate, Basingstoke, Hants. RG22 4PD. UK Kate.Cook@motorola.com	04_1_04_Kate Cook User-driven Intelligent Service Automation .pdf

04-1-05	User-Centered Description of Contextual Information	Ken Crisler Motorola Labs 1301 E. Algonquin Road Schaumburg, IL 60196 USA Ken.Crisler@motorola.com Guy Romano Motorola Labs 1301 E. Algonquin Road Schaumburg, IL 60196 USA Guy@motorola.com Dr. Anind K. Dey GVU Research Center Georgia Institute of Technology Atlanta, GA 30332 USA anind@cc.gatech.edu	04_1_05_Ken Crisler A Systematic, User-Centered Description of Contextual Information.pdf
04-1-06	User Behavioural Research for Applications Beyond 3G	Larry Marturano Motorola Labs 1301 E. Algonquin Road, Room 2230, Schaumburg, IL 60196 USA larry.marturano@motorola.com	04_1_06_Larry Marturano User Behavioural Research for Applications Beyond 3G.pdf
04-1-07	All Senses Communication	Martin Rantzer Ericsson Research Datalinjen 4, P.O.Box 1248, SE-581 12 Linköping, Sweden martin.rantzer@ericsson.com	04_1_07_Martin Rantzer, All Senses Communication.pdf
04-1-08	Understanding mobile commerce end-user adoption: a triangulation perspective.	Per E. Pedersen Agder University College Grooseveien 36, 4890 Grimstad, Norway per.pedersen@hia.no	04_1_08_Per Pedersen Understanding mobile commerce end-user adoption.pdf
04-1-09	User Interface Appliance for Mobile Devices.	Peter Antoniac, Tomohiro Kuroda, Petri Pulli University of Oulu, Deparment of Information Processing Science P.O.Box 3000, FIN-90014 Oulu, Finland {peter, tomo, ppulli}@paula.oulu.fi	04_1_09_Peter Antoniac User Interface Appliance for Mobile Devices.pdf
04-1-10	Wireless Service Scenarios: Use and Business Cases	Pieter Ballon Researcher and Advisor TNO-Institute for Strategy, Technology and Policy P.O.Box 6030, 2600 JA Delft, The Netherlands Ballon@stb.tno.nl	04_1_10_Pieter Ballon, Wireless Service Scenarios.pdf

04-1-11	Virtual Assistants Cluster: New Application Domains - Horizontal	Raul Bruzzone Philips Consumer Communications Route d'Angers 72000 Le Mans France raul.bruzzone@philips.com	04_1_11_Raul Bruzzone Virtual Assistant Item.pdf
04-1-12	A User Centric MultiSphere Service model based on Augmented Reality and Tele- Existence metaphors	Seamus Hickey, Prof. Petri Pulli Dept. of Information Processing Science, Uiversity of Oulu, FIN-90570 OULU, Finland	04_1_12_Seamus Hickey Metaphores for mobile tele existence.pdf
04-1-13	Modeling the Structure and Operation of the Human User	Simo Lehto, Lic.Tech. Helsinki Polytechnic Department of Electrical Engineering POB 4020, 00099 City of Helsinki Helsinki, Finland Simo.Lehto@stadia.fi	04_1_13_Simo Lehto, Modeling the Structure and Operation of the Human User.pdf
04-1-14	Visions, Scenarios and Their Consequences	Thaddäus Dorsch, Uwe Fiebig German Aerospace Center (DLR), Institute for Communications and Navigation Site Oberpfaffenhofen P.O.Box 1116, D-82230 Wessling, Germany Uwe.Fiebig@DLR.de, Thaddaeus.Dorsch@DLR.de	04_1_14_Thaddaeus Dorsch, Visions, Scenarios and Their Consequences.pdf
04-1-15	Research proposal: Virtual Trauma Team	Dr Val Jones, Coordinator Application Protocol Systems Group, Manager CTIT Web Development Team, Dept. of Computer Science, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands jones@cs.utwente.nl Richard Bults, Manager Advanced Networking Technology Centre, Netherlands, bults@ctit.utwente.nl Prof Dr PAM Vierhout, General Surgeon, Medisch Spectrum Twente (general hospital and regional trauma centre) and Department of Technology and Management, University of Twente.	04_1_15_Val Jones Virtual Trauma Team.pdf

04-1-16	Examples of vertical application domains	Joachim Kaebler, Thomas Bruns kae@biba.uni-bremen.de, bru@biba.uni-bremen.de Marc C. Lemmel lem@BIBA.uni-bremen.de Thomas Schmidt, Carsten Westerholt smd@biba.uni-bremen.de, wes@biba.uni-bremen.de Marcus Seifert, Jens Eschenbächer sf@biba.uni-bremen.de, eb@biba.uni-bremen.de Wolfgang Echelmeyer, Ernesto Morales ech@biba.uni-bremen.de Wolfgang Echelmeyer, Christian Gorldt, Ernesto Morales ech@biba.uni-bremen.de BIBA Hochschulring 20, 282359 Bremen	04_1_16_BIBA_new_inputs.pdf
04-2-01	Enabling Technologies - Open Service Architecture for context-aware & ubiquitous computing	Bernhard Bauer Michael Berger Hans Portschy Erwin Postmann Henning Sanneck	04_2_01_Henning_Sanneck_Enabling_technologies.pdf
04-2-02	Business Models	Giovanni Gasbarrone Telecom Italia I-0166 Valcannuta 182 Roma, Italy Giovanni.Gasbarrone@TelecomItalia.it	04_2_02_Gasbarrone_Business Models1.pdf
04-3-01	Mobility Management for fast technology - independent Handovers	Hans-Peter Huth Siemens AG, Corporate Technology D-81730 Munich, Otto-Hahn Ring 6 Hans-Peter.Huth@mchp.siemens.de	04_3_01_Huth_Mobility_Management.pdf
04-3-02	Bridges between the fixed and wireless network (Optical Radio Access Networks beating distance with capacity)	Gunnar Edwall Ericsson Radio Systems Generic Technologies Research SE-164 80 Stockholm	04_3_02_Edwall_Bridge_between_optical_and_wireless_rev_B.pdf

04-3-03	Network Planning and Traffic Engineering	J. Eberspächer, A. Riedl Institute of Communication Networks, Technische Universität München Arcisstr. 21, 80290 München, Germany {Eberspaecher, Anton.Riedl}@ei.tum.de R. Lehnert, J. Schüler Chair for Telecommunications, Dresden University of Technology 01062 Dresden, Germany {lehnert, schuelj}@ifn.et.tu-dresden.de	04_3_03_Eberspacher_Network_Planning.pdf
04-3-04	A Search Engine for a Wireless Internet	David Cleary, Ericsson Ireland Daryl Parker Ericsson Ireland Diarmuid O'Donoghue NUI Maynooth Ericsson Software Campus Athlone Co. Westmeath Ireland [David.Cleary, Daryl.Parker]@eei.ericsson.se Department of Computer Science, NUI Maynooth Ireland. dod@cs.may.ie	04_3_04_David_Cleary_Wireless_searching.pdf
04-3-05	High Altitude Platform Station (HAPS) for Delivery of Mobile Communications and Broadcasting Services	Woo Lip Lim University of Surrey Guildford, UK W.Lim@eim.surrey.ac.uk Yu Chiann Foo University of Surrey Guildford, UK Y.Foo@eim.surrey.ac.uk Rahim Tafazolli University of Surrey Guildford, UK R.Tafazolli@eim.surrey.ac.uk	04_3_05_Tafazolli_high_altitude_platform_3.pdf
04-4-01	Radio Propagation and Network Planning	Tommi Jämsä Elektrobit Ltd. Tutkijantie 8, FIN-90570 Oulu, FINLAND Tommi.Jamsa@elektrobit.fi	04_4_01_Jamsa_Propagation.pdf
04-4-02	Single Frequency Networks for communication systems	Zirwas Wolfgang Siemens AG, ICM N MR ST 8 Technopark II, Werner-von-Siemens-Ring 20, 85630 Grasbrunn wolfgang.zirwas@icn.siemens.de	04_4_02_Zirwas_SFN.pdf