

WWRF—The Wireless World Research Forum

by Werner Mohr

Third generation mobile radio systems are currently being deployed in different regions of the world. Future systems beyond the third generation are already under discussion in international bodies and forums such as ITU, WWRF and R&D programmes of the European Union and in other regions. These systems will determine the research and standardisation activities in mobile and wireless communication in the next years. Based on experience of the third generation, future systems will be developed mainly from the user perspective with respect to potential services and applications including traffic demands. Therefore, the Wireless World Research Forum was launched in 2001 as a global and open initiative of manufacturers, network operators, SMEs, R&D centres and the academic domain. WWRF is focused on the vision of such systems—the Wireless World—and potential key technologies. This paper describes the international context of activities on systems beyond third generation, the goals, objectives and structure of WWRF, the user perspective as the starting point for a future system design and the key enabling technologies for the Wireless World.

1 Introduction

Third generation (3G) mobile radio systems¹⁻³ (IMT-2000 globally and UMTS in Europe) are becoming reality today. The licensing process for the 3G frequency spectrum is ongoing globally. In all major European countries licences have been granted since the year 2000. The network infrastructure is currently being deployed in many countries. Manufacturers, network operators, service and content providers are now focused on the development of new services and applications as well as suitable business models to make third generation mobile communication an economic success. Fig. 1 shows the development towards the third generation and beyond.

The development of 3G systems started in Europe around 1988/89 in the EU RACE I framework research programme nearly two years ahead of the first deployment of GSM. In the beginning, a vision of UMTS was developed including preliminary estimations on the frequency spectrum demand for UMTS. This was the basis for WARC '92 (World Radio Administrative Conference) to allocate the IMT-2000 core band. First radio interface concepts and network architectures were investigated in research projects in the EU RACE II framework programme. The research projects in the EU ACTS program towards radio interface proposals and network architectures had a significant impact on the international standardisation of third generation mobile communication systems.^{1,4,5} At that time the development of 3G systems was mainly driven by technology in terms of supported radio environments, data rates, mobile

speed etc. The development of services, applications, business models and the new value chain started around 1997 close to the decision of ETSI SMG on the selected UTRA concept (UMTS Terrestrial Radio Access) in January 1998. This work was facilitated by the activities of the UMTS Forum, which was established in 1996.

Due to the long time frame for the development and standardisation of new systems, the identification and availability of new spectrum and the regulatory issues such as the licensing process, the research work on systems beyond third generation mobile communications started around 1999 in international projects and bodies (see for example References 6–10). Several projects under the EU IST framework programme are addressing different aspects of future systems. One important lesson from the development of 3G is that potential future services and applications, including the expected user behaviour, should be taken into account from the very beginning to derive technical requirements. This approach is essential to enable the economic success of future systems. The IST WSI project (Wireless Strategic Initiative) is following this approach in the development of a vision of future systems.⁹ On the other hand the mobile community is in the dilemma of developing technical requirements for new systems for an unpredictable future in about ten years time. Therefore, future systems should enable sufficient flexibility to match the operator and user expectations from a service and economic perspective as close as possible. In this environment the Wireless World Research Forum (WWRF) was launched in 2001.¹⁰ Important questions to be answered in the development

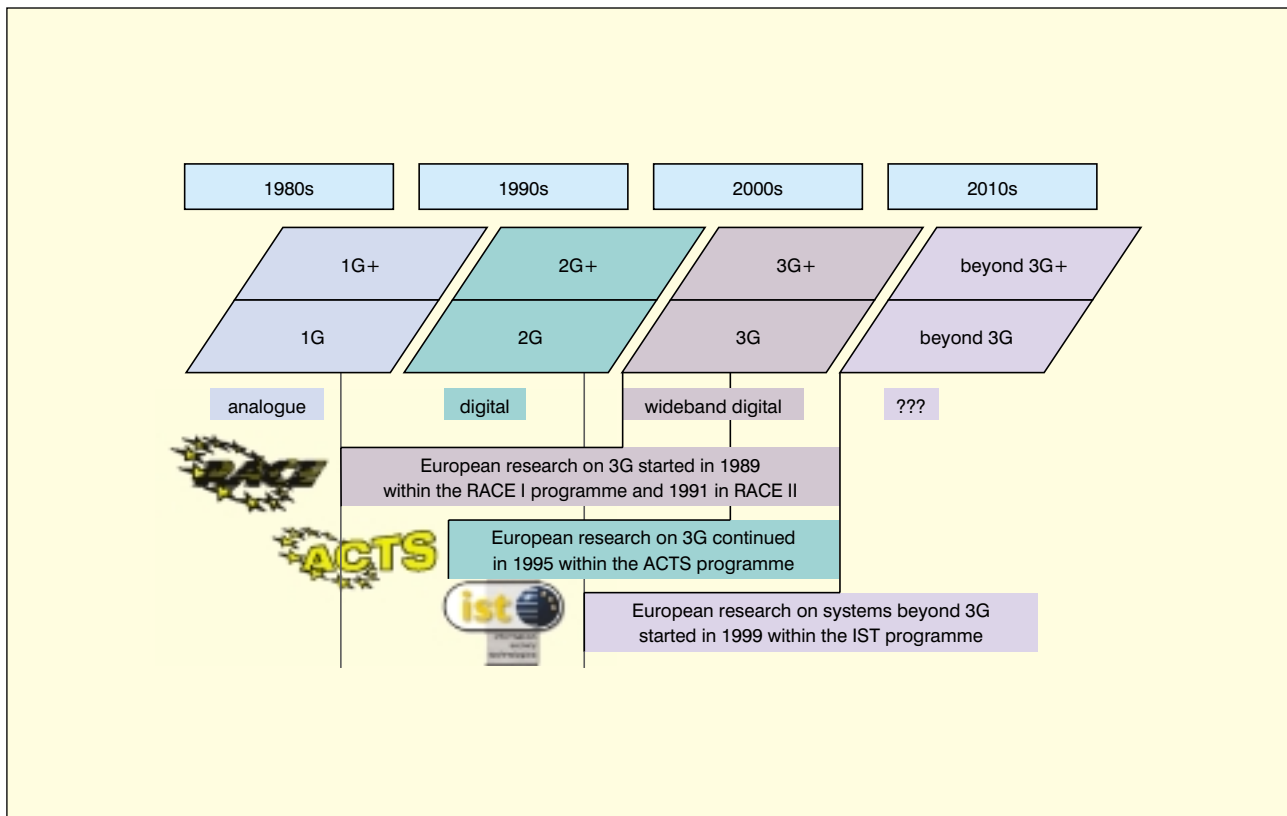


Fig. 1 Evolution of mobile communication systems

of future systems 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 from WWRF is a first step to find the answers to these questions.¹¹

2 International context

The development of visions for future telecommunication systems takes place in a number of bodies and interest groups, which are both standardisation bodies and forums comprising operators of telecommunication networks and equipment manufacturers. Although the messages and projections given by the different groups have different focus, a rather harmonised view on future generation networking exists. The Wireless World Research Forum (WWRF) was established in August 2001 to contribute actively to these international activities towards a global and consistent vision of the Wireless World.^{10,11}

ITU-R WP8F (International Telecommunication Union—Radio Sector, Working Party 8F) and ITU-T SSG (ITU-Telecommunication Sector, Special Study Group) are active in related vision groups to facilitate consensus on basic system concepts.¹² These activities

are a prerequisite for the forthcoming World Radio Conferences (WRC '03 and in particular WRC '07) to discuss and to identify new spectrum for future systems. Its visions and recommendations for technical realisation are those built on expected user requirements on future mobile telecommunication systems. The responsibilities of these bodies include 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, which are currently being discussed by ITU, stress seamless service provisioning across a multitude of wireless systems as being an important feature of future 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 extent.

These activities are accompanied by regional bodies such as the Japanese Telecommunication Council, mITF—mobile IT Forum Japan, the EU framework research programs and forums on particular topics such as the SDR Forum, the OFDM Forum, the IPv6 Forum, the ASMS (Advanced Satellite Mobile Systems) and the 4G Mobile Forum in the US in the context of IEEE. Ongoing research activities are focused on this further development of mobile communications in all relevant areas.

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 and FOMA services. The Japanese TTC (Telecommunications Technology Council) plays a major role in

the discussion on new generation mobile communication systems.¹³ In their recent report¹⁴ the impact of communication and its growing effect on 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.

Research on future generation mobile systems in Europe is strongly influenced by the IST program of the European Union. With the Cluster on Systems beyond 3G, the IST has created a forum to consolidate the results of a number of IST research projects supposed to provide result in relevant fields.¹⁵ The scope of the cluster includes: evolution of access systems, including terrestrial and satellite technologies, both telecomms and interactive broadcasting systems, IP in core and radio access including mobility management, and interworking of existing, evolving and emerging access systems. Major objectives are to develop a vision on 'Systems beyond 3G', evolutionary scenarios based on 3G-systems, and revolutionary scenarios deploying leading-edge access technologies to achieve the integration of mobile and fixed networks, and to allow the seamless transition and service provisioning across heterogeneous access networks.

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

One of those forums dedicated to a technology to be a key component of the Wireless World is the SDR Forum.¹⁶ The SDR Forum is dedicated to supporting the development, deployment, and use of open architectures for advanced wireless systems. To that end, the SDR Forum helps to accelerate the proliferation of enabling software definable technologies necessary for the introduction of advanced devices and services for the wireless Internet, and to develop uniform requirements and standards for SDR technologies to extend capabilities of current and evolving wireless networks.

Further key components of the Wireless World are improved radio access technologies, of which OFDM is regarded as the most important technology for a future public cellular radio access technology. The OFDM Forum¹⁷ is a voluntary association of hardware manufacturers, software firms and other users of orthogonal frequency division multiplexing (OFDM) 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.

The vision of the Wireless World, and similarly the

visions stated by 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.¹⁸ The IPv6 Forum is shaped by a worldwide consortium of leading Internet vendors, and research and 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.

The vision of the Wireless World includes satellite communication as one enabler of ubiquitous communication. In this context the work of the Task Force on Advanced Satellite Mobile Systems (ASMS) relates to the WWRF.¹⁹ ASMS 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.

4Gmobile Forum will be the first international technical body focusing on the next generation broadband wireless mobile communications which converge on wireless access, wireless mobile, wireless LAN and packet-division-multiplexed (PDM) networks.²⁰ This integrated 4Gmobile system provides wireless users with an affordable broadband mobile access solution for the applications of secured wireless mobile Internet services with value-added Quality of Service (QoS) through the application layer all the way to the media-access-control (MAC) layer. This official statement of direction issued by the 4Gmobile Forum already gives some indication on the underlying assumptions on possible future networks. The official kick-off for the Forum was planned for May 2002. Working and study groups were planned to be established as agreed during the kick-off meeting.

3 WWRF—Wireless World Research Forum

The Wireless World Research Forum was started based on the activities in the EU IST project WSI (Wireless Strategic Initiative).⁹ The WSI project started on the 1st May 2000 with the project partners Alcatel, Ericsson, Nokia and Siemens. A major task of the WSI project was to establish an open international discussion on future wireless technologies and business models that may gradually become operational after 2010. These visions are based on the work of a Think Tank of invited experts from network operators, manufacturers, and academia, open calls for contributions and public workshops. A first edition of the 'Book of Visions' was published in December 2000. Due to the success of the Think Tank and increasing request for participation in these activities from groups outside of the WSI project it was decided at the end of 2000 to turn the WSI Think Tank into an open forum with world wide participation with a 1st Call for Contributions in December 2000.

WWRF was launched in March 2001 at the kick-off

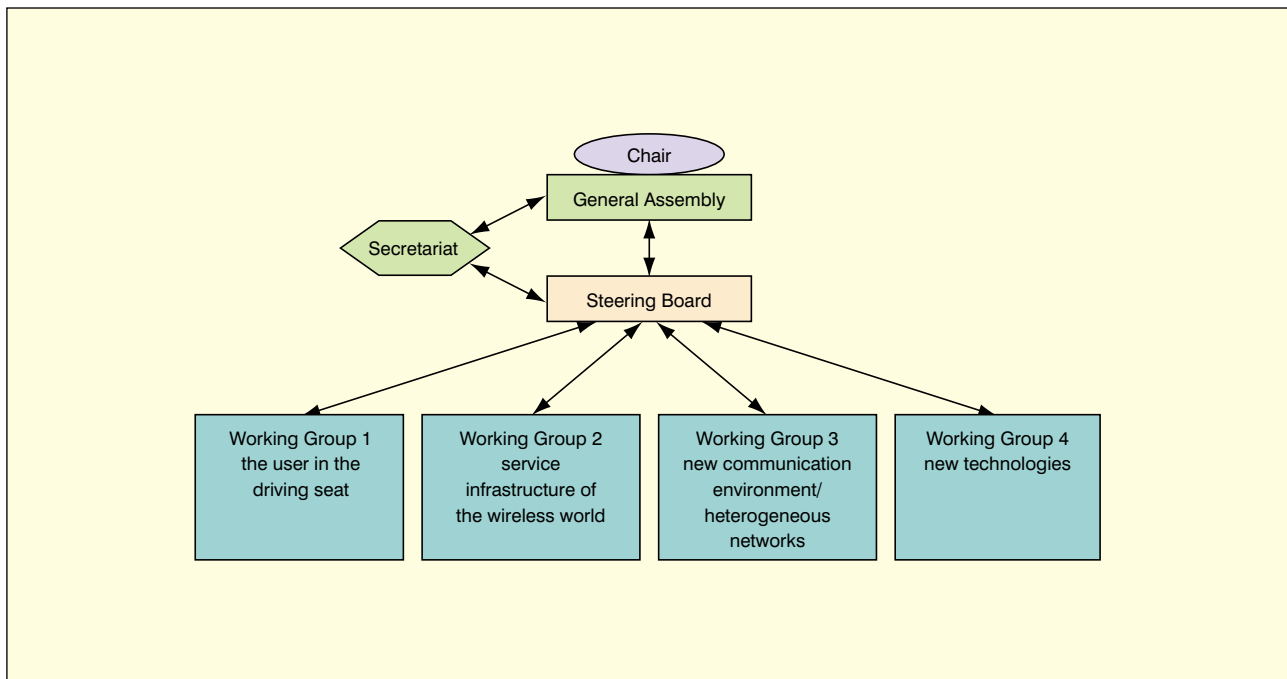


Fig. 2 WWRF organisational structure

meeting in Munich, Germany. A further initial working group meeting took place in May 2001 in Helsinki, Finland. WWRF was legally established on the 14th August 2001 as a non-profit association under Swiss law (article 60 ss. of Swiss Civil Code) as an open and independent organisation by the founding members Alcatel, Ericsson, Motorola, Nokia and Siemens.¹⁰ WWRF organised public working group meetings in September 2001 in Stockholm, Sweden, in December 2001 in Paris, France, in March 2002 in Phoenix, USA, and in June 2002 in London, UK.

Since August 2001 the membership has grown to nearly 130 members (as at November 2002) from the manufacturers domain, the network operators domain and the SME (small and medium enterprises), R&D centre and university domain from America, Asia and Europe.

Goals and objectives

The major objectives of WWRF are:

- to contribute to the vision of the Wireless World
- to develop and maintain a consistent vision of the Wireless World
- to generate, identify, and promote research areas and technical and society trends for mobile and wireless systems towards a Wireless World
- to provide a place where innovative applications and advanced technologies meet
- to identify and assess the potential of new technologies and trends for the Wireless World
- to contribute to the definition of international and national research programmes
- to inform a wider audience about research activities that are focused on the Wireless World

with the scope:

- to contribute to the development of a common and comprehensive vision for the Wireless World
- to concentrate on the definition of research relevant to the future of mobile and wireless communications, including pre-regulatory impact assessments
- to invite world-wide participation and is open to all actors
- to disseminate and communicate Wireless World concepts
- to provide a platform for the presentation of research results.

WWRF will support the UMTS Forum, ETSI, 3GPP, IETF, ITU and other relevant bodies regarding commercial and standardisation issues derived from the research work. However, WWRF is not a standardisation body.

Organisational structure and working groups

Any legal established corporation and individual firm, partnership, university and research institute, governmental body or international organisation supporting the purpose of the WWRF may apply for membership.¹⁰ There are three types of members: Founding Members, Sponsor Members and Full Members. All members are entitled to send representatives to all Working Groups and the General Assembly with the right to vote at the General Assembly (one vote per organisation), to nominate candidates as Executive Board Members of the Steering Board and to access all registered working documents, meeting minutes etc. Each Founding Member appoints a Non-Executive Board Member of the Steering Board and each Sponsor Member is eligible for election to the Steering Board to serve as Non-Executive Board Member. There is an annual membership fee, which is fixed annually by the General Assembly. Fig. 2 shows the organisational structure including all bodies and the current Working Groups.

The main responsibilities of the General Assembly are

to decide on membership issues, to approve the work programme, to approve proposals for research and development issues, to review the work done by the other groups, to approve budget and membership fees, to approve the auditor's report and to approve reports, opinions etc. intended for outside organisations. The General Assembly is convened by the Chair, who is elected for one year. Decisions are generally intended to be based on consensus.

The main responsibilities of the Steering Board are to act on decisions of the General Assembly and to represent WWRF, to address matters of the administration, management and scheduling, to process membership applications and refer them to the General Assembly, to establish/re-organise/dissolve Working Groups and monitor their work, to initiate the development of proposals for research and development issues in the Working Groups and to prepare the balance sheet for approval by the General Assembly. The Steering Board is composed of the Executive Board Members (Chair, Vice Chairs, Treasurer and Working Group Chairs) and Non-Executive Board Members (up to 15), which are nominated representatives from the Founding Members and elected representatives from the Sponsor Members. Decisions are generally intended to be based on consensus.

The Working Groups are established by the Steering Board within the framework of the work programme. Each Working Group elects its chair for one year amongst the member organisations. The current Working Groups are addressing:

- 'The user in the driving seat', with the main identified research tasks: understanding the user, new generic application elements and new interaction techniques.
- 'The service architecture of the Wireless World', with the main identified research tasks: business models, personalisation, adaptability, generic service elements, enabling technologies and architecture for context awareness and ubiquitous computing.
- 'New communication environment and heterogeneous networks', with the main identified research tasks: Wireless World networking architecture, IP mobility architecture for the Wireless World, QoS architecture for the Wireless World, IP multicast architecture for the Wireless World and transport protocols for the Wireless World.
- 'New wireless technologies', with the main identified

research tasks: spectrum issues, antenna arrays and related techniques, new air interfaces and ad hoc networks.

WWRF is issuing open calls for contributions. Technical contributions on ideas and research ideas are presented to the Working Groups and openly discussed. The Working Groups are identifying research issues and draft research tasks. Based on these drafts WWRF is developing research tasks (Fig. 3), which were published in the 2001 edition of the 'Book of Visions'¹¹. The 'Book of Visions' is currently the major deliverable of WWRF.

Timeline

Fig. 4 summarises the WWRF activities in comparison to the global activities, which are ongoing in international standardisation bodies, regulatory bodies and in the industry. Globally, research activities are initiated on systems beyond third generation. ITU is currently working on visions and requirements on future systems. The detailed standardisation work is envisaged not before WRC, '07 (World Radio Conference) in 2006. A first system deployment is expected in ITU-R after 2010. The WWRF activities fit well with the overall global time schedule. The major WWRF milestones for 2002 are the development of an initial system concept and a reference model and based on that an initial WWRF research framework, which will be communicated to national and international research programmes and relevant standardisation bodies.

4 User perspective and MultiSphere level concept

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 that the development of a purely 'technical' vision on new network concepts or radio interfaces will not be sufficient to be successful in future. Such a technical view must address a much wider context:

- a user centred approach, looking at the new ways users will interact with the wireless systems
- new services and applications that become possible

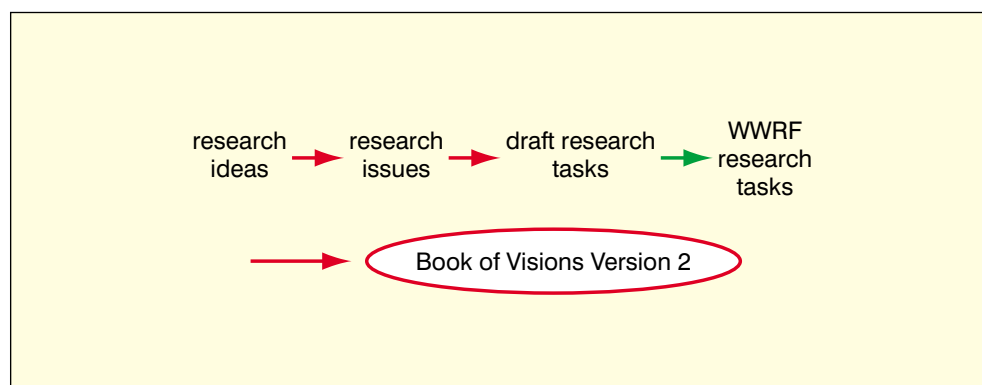


Fig. 3 Approach of work

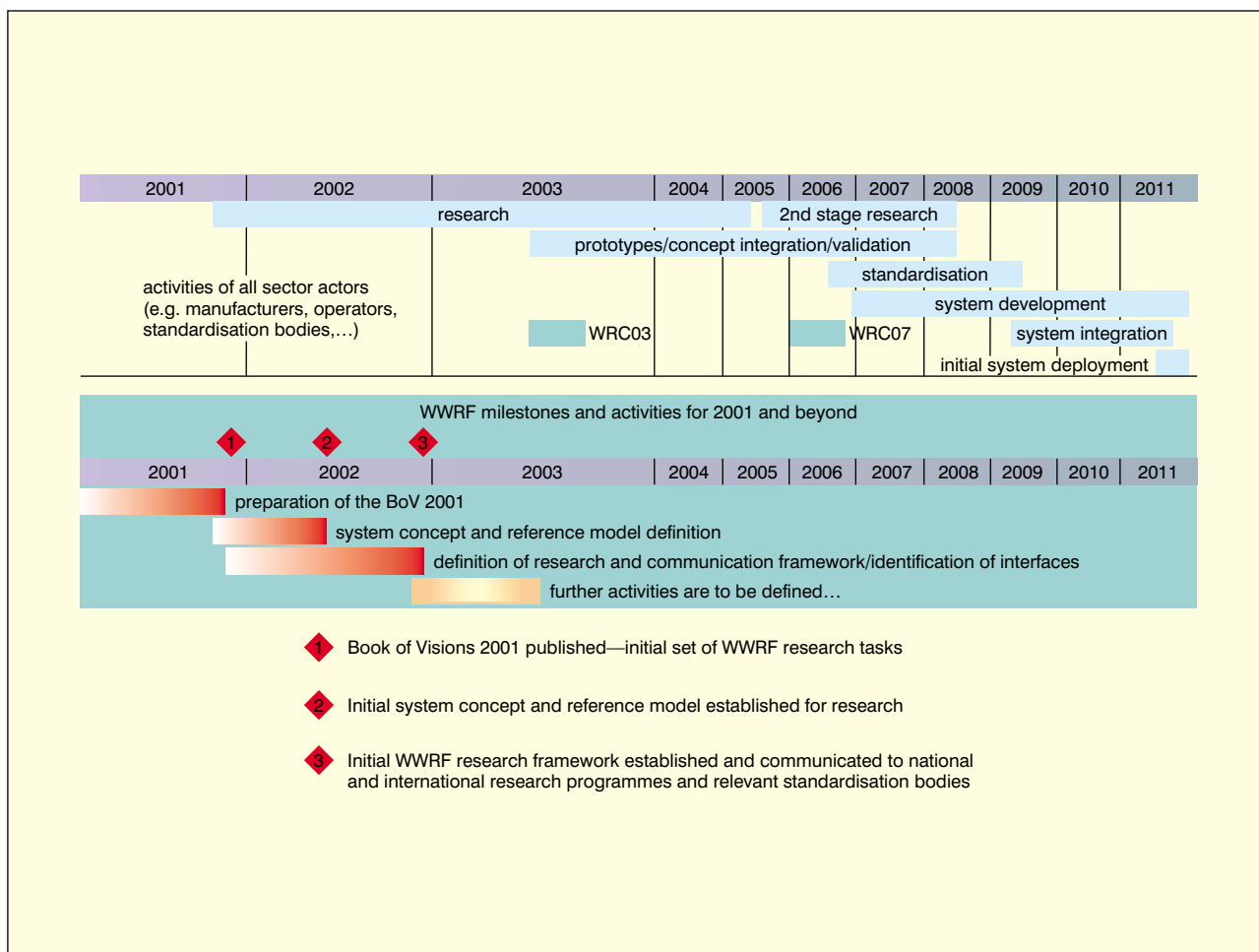


Fig. 4 WWRF timeline in a global context

with the new technologies

- new business models that may prevail in the future, overcoming the by now traditional user, server and 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 of 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 among things, humans and 'cymans' (our synthetic counterparts in the virtual cyber-world—a sort of autonomous avatar). As such, a Wireless World of the future will become our natural enhanced living environment.

The development to future systems will be significantly determined by general shaping factors such as society, politics, economy, environment, technology, customers and competition, which are affecting the regulatory environment, user behaviour and potential future services and applications. The living spaces where future systems will be operated are at home, in public places, at work and in transportation systems. All these living spaces require different technical capabilities of systems. Potential areas for services and applications are education and learning, electronic commerce, leisure and entertainment, health, knowledge based business, green

processes and products. This list is not exhaustive. The introduction of data systems like GPRS, EDGE and 3G does not provide a single 'killer application'. Many different services and applications can be expected, which will be provided on the available technical platform.

Users want to get personalised mobile multimedia services with any content, anywhere and anytime, via any device and any access system. On the other hand, users are not interested in the technology. Therefore, the necessary system complexity has to be hidden from the user via easy to handle user interfaces. From the user perspective the vision for mobile communications can therefore be described as a MultiSphere level concept, which was developed in the IST WSI project and further detailed in the WWRF 'Book of Visions'^{14,15} (Fig. 5).

In the first level the user connects all carried devices like a camera, phone, mirror glasses for images, watch etc. in a PAN (personal area network) by short-range connectivity systems. The second level links the immediate environment like a TV, a PC, a refrigerator etc. to the user. Currently, the user does not interact with them but in future she will expect that they take notice of her, that they start to interact with her and turn into personalised items rather than general-purpose devices. Level three ensures the direct communication with instant partners as other users and vehicles. Users may want to talk to them or just to relay information through them. In the future wireless possibilities should enable

an easier and maybe richer interaction with people close by than with people on another continent. What has made mobile communication so successful is the possibility to rely on ubiquitous coverage of a wide area system. Either directly from the PAN or via the instant partners, publicly accessible radio interfaces must be reachable.

Different wireless access systems like terrestrial systems, satellite systems and HAPS (High Altitude Platform Stations) are, therefore, provided in level four for full area coverage. Universal wireless interconnectivity emerging from today's mobile Internet core networks will be one of the crucial tasks. To offer the right level of support for the various specialised radio interfaces and terminals will be a key requirement. Evolutions of interconnectivity (level five) 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. These levels are surrounded by the Cyber World (services and applications domain) in level six, where the user can stay in touch with his agents, knowledge bases, communities, services and transactions. This vision from the user perspective is the driving force for seamless services and applications via different access systems for future development.¹⁵

5 Building blocks for the Wireless World

The previous section describes a user-centric view of the Wireless World, using the MultiSphere Level concept.

Based on this concept WWRF started to identify the major system elements or functions that could characterise and make up the Wireless World. As such these building blocks represent a first attempt at a system view of the Wireless World (Fig. 6). These nine potential building blocks of the Wireless World are briefly described in the following:

- *Augmented reality/Cyberworld:* New types of user interactions will characterise the Wireless World in the people's 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 are wearables, deviceless communication, avatars and augmented reality.
- *Semantic aware services:* The services provided in the Wireless World will have to understand what the user wants, based on past observations of the user and, maybe, some common sense. The service has to remember, to deduce, to think and to propose appropriate actions. Key words are context aware services, location aware services, and extensive use of artificial intelligence to assist in information retrieval and 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 on

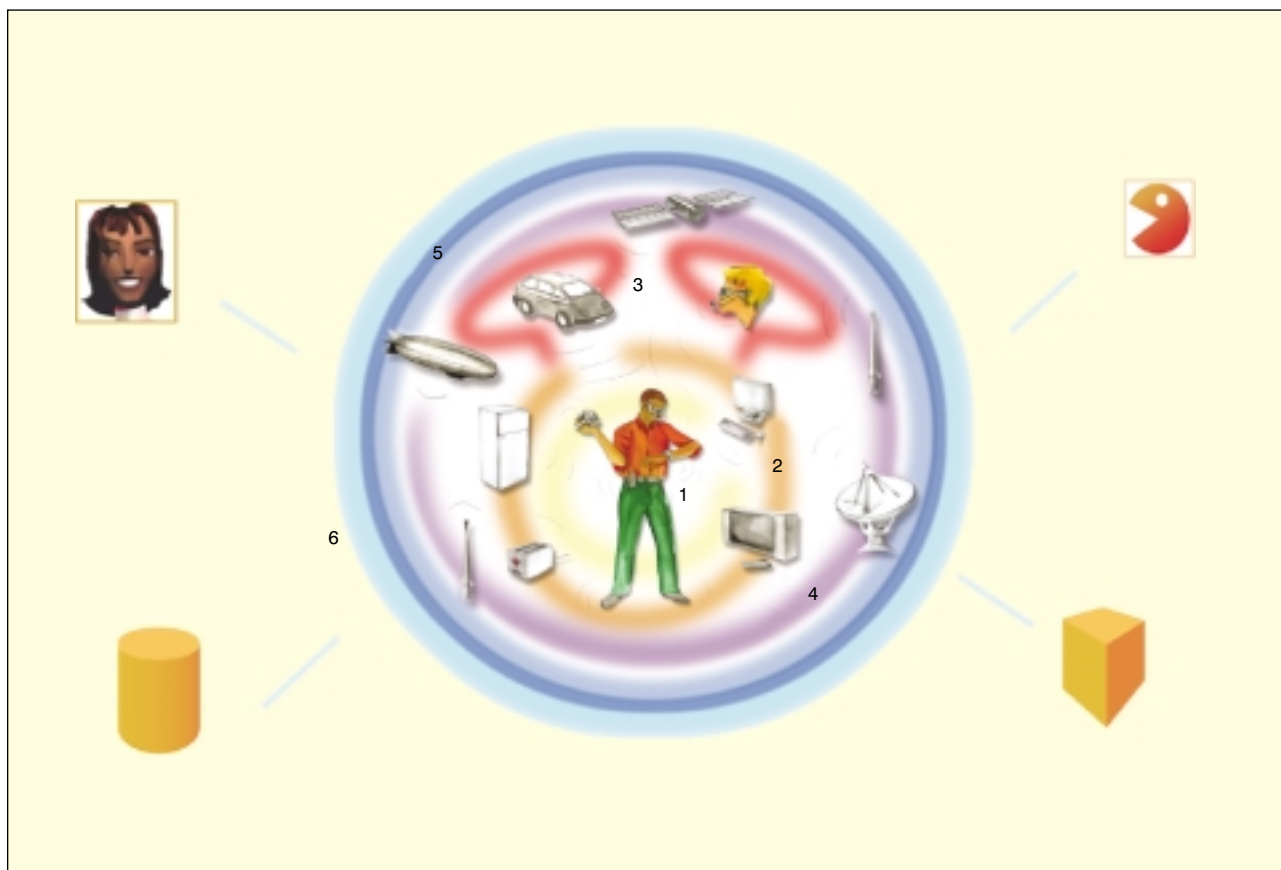


Fig. 5 MultiSphere level concept: Level 1: The PAN; Level 2: The immediate environment; Level 3: Instant partners; Level 4: Radio accesses; Level 5: Interconnectivity; Level 6: CyberWorld



Fig. 6 The nine building blocks of the Wireless World

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 are user addressing and service discovery.

- *End-to-end security and privacy:* In the Wireless World users are expected to rely to a much higher degree on the communication system than today. 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 are ensuring privacy and security.
- *Co-operative networks and 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 are reliable transport among heterogeneous networks and terminals and 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 hotspots 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 are 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 etiquettes. Technologies, such as UWB (ultra wide band) and multi-carrier solutions, need to be investigated and mechanisms for spectrum sharing are required. Key words are spectral coexistence and frequency etiquettes, positioning, multi-carrier and new air interface.
- *Smart antennas and base stations:* New concepts of cellular networks should not hold off from new architectural concepts deviating from the traditional views. Interesting concepts such as HAPS (high altitude platform systems) should be evaluated for the Wireless World. Antenna technology such as smart

antennas has similarly high potential to contribute significantly to the future radio access technology. Key words are beamforming, MIMO, space-time coding, (high altitude platform systems), 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. Key words are reconfigurable, downloadable protocol stacks.

These are major areas of investigation and discussion in WWRF to enable the necessary research for the Wireless World.

6 Conclusions

Third generation mobile communication systems are currently being deployed in different regions of the world. Due to the long time frame for the development of future systems, research and standardisation work on initial system requirements and concepts for systems beyond 3G has already started in parallel to the first deployment of third generation systems, e.g. in EU research framework programs, ITU-R, ITU-T and related forums such as WWRF. Therefore, WWRF was launched in 2001 as a global initiative and is focused on the vision of such systems and potential key technologies. The forum is open to manufacturers, network operators, SMEs, R&D centres and the academic domain. WWRF is addressing the key issues, which are impacting the further development of the Wireless World. The open discussion on a global level requires liaisons with other forums and initiatives, which are active in particular areas and towards similar goals. The timeline of WWRF is synchronised with the global context, which is related to the activities in ITU and the forthcoming World Radio Conferences in 2003 and 2006.

Systems beyond third generation will be designed mainly from the user perspective to ensure an economic success as far as possible. The developed MultiSphere level concept shows the different interaction modes from the user perspective. WWRF is working on a reference model and the identification of the main building blocks of the Wireless World. These are augmented reality/cyberworld, semantic aware services, peer discovery, end-to-end security and privacy, co-operative networks and terminals, heterogeneous ad hoc networking, 4G radio interfaces, smart antennas and base stations and software defined radio. WWRF is working on the research tasks needed for future research programmes and projects and will address these areas to national and international framework research programmes.

The References give details of the achievements of the different WWRF Working Groups.

Acknowledgment

The author is a member of the Wireless World Research Forum-WWRF. He would like to acknowledge the contributions of the colleagues from WWRF member organisations, and in particular the Editorial Group for the 'Book of Visions', and meeting participants. This paper is however, based on the personal opinion of the author.

This paper was first published in *Computer Communications*, an Elsevier Science publication.

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