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Introduction

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1.1 A Book of Visions

This is the third in a series of books, entitled *Technologies for the Wireless Future* and produced by the Wireless World Research Forum (WWRF). The idea is to take the most important outputs from the Working Groups (WGs) and Special-Interest Groups (SIGs) that comprise the Forum, and bring them together in a series of one-volume surveys. The latest of these will give the reader a good overview of the WWRF approach to analysing the future of wireless and mobile communications, as well as an insight into the trends themselves and the key technologies that will be deployed.

Previous volumes were published by Wiley in 2005 [1] and 2006 [2], and this volume should be seen as being mostly complementary to them in terms of the specific research issues raised. The specific technology areas that are featured in the new volume have, in most cases, emerged since the last volume was published. One area in which the present volume builds on the previous ones is in the development of the WWRF system concept, which is described in Chapter 11. This concept is a significant development beyond that expounded in the first volume, and is based on the requirements of the various entities, or stakeholders, that have an interest in the future of mobile communications. It builds on the user-centred approach that was pioneered in the previous volumes.

Each of the volumes comprises the contributions and views of hundreds of researchers from industry and academic institutions, brought together through discussion and the synthesis of white papers from individual contributions at WWRF meetings. The editors would like to acknowledge these contributions.

1.2 The Wireless World Research Forum

The Wireless World Research Forum was established in 2001 to bring together industry and academic researchers to create a clear view of the future of mobile communications and of
the research issues that need to be addressed [3]. The Forum has developed over the years, but has not lost sight of its original mission. New working groups and special interest groups have been formed to tackle new problems and opportunities. Links have been established with new industry, research and standards fora to make sure that our messages are heard by those who will determine the future technology of our industry.

The goal of WWRF is to develop a common global vision for the future of wireless, to drive research and standardization. This is to be used to influence major decision makers’ views of the wireless world to ensure that the right technology is in place to achieve our vision. WWRF also brings together partners to form powerful R&D collaborations. For instance, it played a major role in the establishment of WWI (the Wireless World Initiative), a connected set of projects under the EU’s 6th Framework Programme, which comprised over 100 organizations with a budget of over 100 million euros [4]. Countless smaller projects have also been set up through relationships established at WWRF or through technical discussions that have identified important research issues.

It should never be forgotten that we are advancing the frontiers of wireless technology to better serve our customers, and WWRF has led the way in promoting user-centred design for mobile and wireless telecommunication systems [1].

The objectives of the forum have been established as follows:

- 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 the wireless world.
- 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 simplify future standardization processes by harmonization and dissemination of views.
- To inform a wider audience about research activities that are focussed on the wireless world.

An example of the harmonization of views is the so-called ‘Cross-Forum’ group that WWRF has established with similar regional bodies, including mITF (Mobile IT Forum) (Japan), NGMC (Next-Generation Mobile Communications) (Korea) and the Future Forum (China). The Cross-Forum meets regularly to exchange information and views on the development of new mobile technologies in the different regions. WWRF has also set up liaison agreements with other bodies to ensure a regular flow of information between them. Examples include: the UMTS Forum, IEEE Communication Society, the SDR Forum, the Autonomic Communications Forum (ACF) and the eMobility European Technology Platform.

The WWRF is open to all those who can sign up to our objectives. Different levels of membership are available. Our founder and sponsor members (currently comprising: Alcatel-Lucent, China Mobile, Ericsson, France Telecom, Huawei, Intel, LG Electronics, NEC, Nokia, Nokia Siemens Networks, Nortel, Research in Motion, Samsung and Vodafone) have seats on the Steering Board. Full members make up the remainder. In all, there are over 140 members from five continents, consisting of academic institutions, network operators, manufacturers, regulators and research organizations. All members are represented in the General Assembly, see Figure 1.1 for the structure of WWRF. Executives are elected by the General Assembly, including the Chairman, Treasurer and the Vice-Chairs from three regions: EMEA (Europe, Middle East and Africa), the Americas and Asia. Together with the chairs of the Working Groups and the Special Interest Groups, and the founding and sponsor
members, they form the Steering Board, which runs the Forum in line with the Articles of Association and the decisions of the General Assembly.

The Working Groups and Special Interest Groups are at the heart of WWRF’s activities. Each is responsible for developing white papers and briefings exploring the research agenda in its own area of operation, and for developing a compelling agenda of invited talks and contributions at its meetings. The groups meet during the WWRF plenaries and according to need between them. Collaborative working tools such as Wikis are also used to develop documents.

1.3 Current Situation and Trends

At the beginning of 2008 the following situation and short-term trends can be observed:

In Western Europe a saturation point has been reached in terms of the number of mobile phone users, with more than 100% user penetration. However, a majority of voice calls are still generated by fixed-line phones, meaning that there is still significant potential for growth of mobile airtime, if not in terms of number of customers. In addition to ever more competitive tariffs, an important driver might also be the even-better voice quality announced for 2008 with the wideband AMR voice codec for UMTS.

Currently operators and manufacturers also put major efforts into further development of data network performance. Specifically, the HSDPA (High Speed Downlink Packet Access) version currently being deployed at 7.2 Mbps and even higher bit rates will be offered on the downlink, and with HSUPA (High Speed Uplink Packet Access) 1.4 Mbps and more will
be offered on the uplink. Further developments are already planned under the name of LTE (Long Term Evolution), including R&D projects and trials with the aim of achieving significant advances in the up- as well as the downlink during the next few years, as specified by NGMN (Next Generation Mobile Networks) [5].

In terms of growth of number of subscribers, a large increase can be observed in emerging markets such as Africa, China and India. Particularly in Africa, mobile communication, which in many cases means having phone communication for the first time, is a key element in improving the economic situation of countries.

Worldwide, numbers of phones are showing strong growth, and there will be 3.5 billion mobile customers by the end of 2008. In 2007 alone, 1.14 billion mobile terminals were sold worldwide, clearly showing that the mobile market is still one of the largest ‘high tech’ markets.

The appearance of the iPhone from Apple has initiated a lot of discussion on the design, man–machine interface (the touch screen used with fingers and no stylus), future applications and further innovations (such as using sensors for automatic orientation of the screen) of mobile phones. In addition, there are new business models to be considered (where for instance the handheld manufacturer takes a share of the airtime revenue).

Another area with lots of innovation and competition is the operating system (OS) for mobile terminals, and smart phones in particular. The following OSs are amongst those currently competing:

- The market leader, Symbian
- Microsoft Windows Mobile
- Research in Motion
- Various versions of Linux, such as the Android announced by Google or those from the LiMo Foundation (Linux Mobile Foundation)
- MAC OS X
- Palm OS.

When it comes to new applications, the following trends can be seen:

- For navigation in cars, dedicated devices with built-in GPS and maps and a small screen of a few inches in width are becoming more and more successful in the market place. A new trend in Europe is to have a terminal with built-in GPS, so that navigation will also be possible using the mobile terminal. The acquisition of Navteq by Nokia for several billion euros provides evidence for the ever-increasing importance of navigation and related services such as points of interests.
- Mobile television, already a success story in some Asian countries like Korea and Japan, is coming to the European market, facilitated by the standard DVB-H.
- Download of music is becoming more and more important and is already offered by operators as well as handheld manufacturers.
- Push email and PIM functionalities, as pioneered by Blackberry/RIM, are highly valued by many business users.
- Social networks such as MySpace and Facebook are becoming important on mobiles as well.
1.3.1 Next Generation Mobile Networks

Next Generation Mobile Networks (NGMN) is an initiative by a number of mobile network operators to make recommendations for the creation of networks suitable for the competitive delivery of mobile broadband services and cost-efficient eventual replacement of existing networks [5].

It now has 16 network operator members, with a further 26 manufacturer sponsors and two advisor universities.

NGMN is looking for a platform for innovation by moving towards one integrated network for the seamless introduction of mobile broadband services. This network will coexist with other networks while it facilitates smooth migration from them.

The target architecture defined by these recommendations is an optimized Packet Switched (PS) network architecture, which will provide a smooth migration of existing 2G and 3G networks towards an IP network with improved cost competitiveness and broadband performance. This is a further step in the evolution of current industry efforts in HSDPA, HSUPA and EVDO arenas enabling a personalized broadband access experience and consolidating the diversity of networks operated by mobile network operators.

NGMN addresses other issues affecting the mobile industry, such as management of Intellectual Property Rights (IPR), interworking of different technologies and operational aspects of running successful services. Recommendations will be submitted to appropriate standards bodies.

In general NGMN operates on a shorter-term, more focused agenda than WWRF, but there is an ongoing liaison between the two bodies to ensure that information and ideas of significance can be exchanged.

1.3.2 The International Telecommunications Union (ITU)

Since the publication of the last volume, there have been significant developments within the ITU. The World Radio Conference (WRC), held in Geneva in October and November 2007, established the allocation of spectrum for mobile services in the period [6].

In particular, additional spectrum was made available for IMT Advanced or 4G. Over the next 15 years the following spectrum will become available in various countries at varying times:

- 450–470 MHz band
- 698–806 MHz band in Region 2 and nine countries of Region 3
- 790–862 MHz band in Regions 1
- 2.3–2.4 GHz band
- 3.4–3.5 or 3.5–3.6 GHz band (no global allocation, but accepted by many countries).

The regions can be roughly defined as:

Region 1 – Europe (including all of Russia), Middle East and Africa
Region 2 – North and South America
Region 3 – Asia and Pacific.
In addition, the IMT Advanced concept developed by ITU-R WP8F (Radio Sector Working Party 8F) has progressed, thanks in part to contributions from WWRF, to the stage of inviting candidate technologies to be considered.

1.4 Overview of the Following Chapters

Having introduced this book and the WWRF, we have presented some important aspects of the current situation and short-term trends. Here we give a short overview and discussion of the remaining chapters of the book.

In Chapter 2 the stakeholders, such as users, operators and content providers and their requirements are discussed. This provides the starting point for further discussions about requirements and concepts from more specific viewpoints, as presented in the following chapters. Future trends and the vision of the WWRF are also presented and discussed in this chapter.

Mobile networks have already initiated a very successful revolution in communications. Nevertheless, many – including the WWRF community – are convinced that truly mobile communication is only just starting. This assertion can be put into perspective by looking at some future application scenarios, including a home scenario in California, one in rural China, business activities in Frankfurt and public services in Kenya, as detailed in Chapter 3. The methodology used to derive such scenarios and requirements and innovative business models is also given.

To facilitate innovative services and applications to the end users beyond just voice and connectivity, an appropriate service infrastructure is critical. Key aspects of such an infrastructure presented in Chapter 4 are: a machine-understandable semantic service description, how to create services, and the key requirements as well as concepts of a future service architecture.

The layered structure of the WWI (Wireless World Initiative) reference architecture is described in Chapter 5. This includes the reference points such as the Ambient Network Interface (ANI), the Cognitive Service Provisioning Interface, the Decision Making and Reconfiguration Management Interface, the Self-Configuration and Self-Management Interface, and the Application Interface. Three functional architectures, Heterogeneous Radio Resource Management (HRRM), Mobility Management and Context Awareness, are also discussed.

In Chapter 6 the focus is on physical layer aspects for future air interfaces. A number of aspects are detailed in more depth here. For error correcting codes, LDPC codes that approach the Shannon limit are investigated.

Advanced multi-dimensional radio channel models are needed to meet the requirements of future wireless systems. The requirements include new frequency bands and propagation scenarios, large bandwidth, advanced multi-antenna structures and new network topologies. The state of the art of multi-dimensional radio channel modelling and recent developments in channel model standardization activities are reviewed. Finally, a review and comparison of linear and nonlinear multi-user MIMO precoding techniques is presented.

Another ‘wireless approach’, complementary to the cellular wireless approach and gaining more and more importance is short-range communication, is presented in Chapter 7. Aspects elaborated here are: Ultra Wideband Radio over Optical Fibre, Integrative and Cooperative Aspects, High Data Rate Wireless Communications in the Unlicensed 60 GHz Band, and UWB: Applications and Limitations.
Today a wide variety of air interfaces are in use, including for example: GSM/GPRS/EDGE, UMTS/HSDPA/HSUPA, different standards of WLAN, Bluetooth and others. In the future, this heterogeneity may well increase further as NFC (near field communication) or LTE air interfaces come along. One interesting approach to managing this heterogeneity is to use ‘cognitive networking’. In general, cognitive systems are able to retain knowledge from previous interactions with the environment and to behave according to this knowledge, together with other goals and policies. This enables the system to adapt to external stimuli and optimize its performance.

In Chapter 8, two subjects are presented in more depth:

- The basic characteristics of reconfigurable platforms, with an explanation of how they can support cognitive networks.
- Policy-based management and autonomic radio resource mechanisms that use the cognitive networking paradigm.

One key enabler for mobile communication has been and will always be radio spectrum. Today, spectrum is either used as licensed spectrum, typically allocated to a specific operator, or used in unlicensed bands, as is the case for W-LAN or Bluetooth. In the future, different approaches to spectrum sharing may be used, and a number of such approaches are considered in Chapter 9.

The private home is an important application domain for networking. A deeper analysis of future ultra-broadband Home Area Networks, including requirements and application scenarios for bandwidth greater than 1 Gbps, is presented in Chapter 10.

Finally, in Chapter 11, a combined view of the system concept for the future is summarized. The goal is to specify an environment that can realize our vision of the future wireless world where users are able to access, anytime and anywhere, services that best fit their preferences and environment. Context-aware applications will provide relevant information about users to enable this. The requirements and system concept are discussed. The latter includes all aspects, including applications, services, the IP-based communication subsystem, access networks, reconfigurability and cognitive wireless networks.

References


