REPORT ITU-R M.2038

Technology trends

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TABLE OF CONTENTS

Page

1 Introduction

Recommendation ITU-R M.1645 defines the framework and overall objectives of future development of IMT-2000 and systems beyond IMT-2000 for the radio access network. In defining the framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000, the significant technology trends need to be considered. This Report provides further information on many of the technology trends concerning radio access network foreseen at the time of preparation of Recommendation ITU-R M.1645. Depending on their development, evolution, expected capabilities and deployment cost, each of these technologies may or may not have an impact or be used for the future development of IMT-2000 and systems beyond IMT-2000. It is expected that the research and future development of IMT-2000 and systems beyond IMT-2000 will consider these technologies and provide guidance on the applicability or influence they might have on the future of IMT-2000 and systems beyond IMT-2000.

Technologies described in this Report are collections of possible technology enablers. There is no decision implied at this stage about whether those technologies will be adopted for future mobile communication systems, and this Report does not preclude the adoption of any other excellent technologies that exist or appear in the future.

2 Scope

This Report provides information on many of the technology trends concerning radio access networks foreseen at the time of preparation of Recommendation ITU-R M.1645.

The Report addresses technology topics that appear relevant to some lesser or greater degree to the future development of IMT-2000 and systems beyond IMT-2000. The Report considers these topics in three broad categories:

– technologies which have an impact on spectrum, its utilization and/or efficiency in this context;

– technologies which relate to access networks and radio interfaces;

– technologies which relate to mobile terminals.

3 Overview of major new technologies

This section presents technology topics that appear relevant to some greater or lesser degree to the future development of IMT-2000 and systems beyond IMT-2000. Technologies having an impact on spectrum, its utilization and/or efficiency; technologies related to access networks and radio interfaces; and technologies related to user terminals are described in § 3.1, 3.2, and 3.3, respectively. Further details are provided in the related Annexes.

The demand for mobile multimedia communications has been rapidly increasing. The radio spectrum is, however, a precious and scarce resource. Therefore, novel technologies for efficient spectrum utilization to enhance the capacity of IMT-2000 and systems beyond IMT-2000 are keenly anticipated. Section 3.1 addresses new radio technologies and their impact on spectrum utilization, including technologies for improving spectrum efficiency, those using multiple antennas such as adaptive antennas and multiple-input multiple-output (MIMO), and those for handling traffic asymmetry and time division duplex (TDD).

Advanced radio resource management (RRM) algorithms and flexible frequency sharing methods are beneficial in maximizing and optimizing the frequency resource utilization. In addition, antenna and coding technologies such as smart antennas, diversity techniques, coding techniques, space-time coding, and combined technologies improve the radio link quality in multipath Rayleigh fading channels. Furthermore, efficient multiple access schemes and adaptive modulation improve the bandwidth efficiency of the systems.

Adaptive antennas improve the spectral efficiency of a radio channel, and in so doing, greatly increase the capacity and coverage of most radio transmission networks. This technology uses multiple antennas, digital processing techniques, and complex algorithms to modify the transmitted and received signals at a base station and at a user terminal. In addition, MIMO techniques can provide significant improvements in the radio-link capacity by making positive use of the complex multipath propagation channels found in certain terrestrial mobile communications. MIMO techniques are based on establishing several parallel independent communication channels through the same space and frequency channel by using multiple antenna elements at both ends of the link.

In broadband multimedia communications, asymmetric traffic is envisaged to be dominant. Due to uncertainties in future traffic asymmetry, future mobile communication systems should be adaptable to different ratios of asymmetry especially at the personal-area and the user-access levels in order to deliver the offered traffic asymmetry while simultaneously maintaining high spectrum efficiency. TDD is one of the techniques suitable to support asymmetric high data rate services while providing flexible network deployment including busy urban hotspot and indoor environments as well as wide area applications. TDD systems do not require a duplex frequency pair since both the uplink and downlink transmissions are on the same carrier within the same spectrum band. In future mobile communication systems, flexibility and integration/convergence will be key factors. In section 3.2, technologies related to IP applications and IP broadband wireless access, those related to software-defined radio (SDR), and those achieving wider coverage such as radio on fibre (RoF), multi-hop radio networks, and high altitude platform station (HAPS) are presented.

Many wireless communication systems provide users with convenient ways to access the Internet and to communicate with one another or access multimedia content. Wireless technologies are expected to progress in a direction that will allow native support of multimedia and Internet services. The technological implication of the integration of IP and wireless is more prominent in the case of mobile broadband Internet access. To support real-time or multimedia applications using end-to-end IP, all the elements, in general, of a service path must support the requirements of mobile or broadband wireless access. To support efficient IP transport over a broadband mobile environment, we essentially need a set of diverse technologies grouped around the concepts of "seamless", "broadband" and "energy-efficient".

SDR provides reconfigurable mobile communications systems that aim at providing a common platform to run software that addresses reconfigurable radio protocol stacks thereby increasing network and terminal capabilities and versatility through software modifications (downloads). Basically, SDR concerns all communication layers (from the physical layer to the application layer) of the radio interface and has an impact on both the user terminal and network side.

Radio on fibre is defined as a system that enables the transparent interconnection of a base station, or equivalent wireless system radio interface network element, to its associated transmission and reception antennas by means of an optical network. Optical fibre presents very low insertion loss to achieve long cable spans of up to several kilometres and an enormous bandwidth to transport many different RF signals over a single fibre.

Multi-hop wireless access technology utilizes multiple serial wireless connections between the target user terminal and a base station in a homogeneous system or across different systems. In a wireless system with higher frequency bands where a smaller coverage area is available, multi-hop wireless access technology may be a solution for user terminals to gain wireless connectivity to a base station.

Another solution is applying HAPS, which is a new technology based on a flying platform. The HAPS system can provide mobile cellular coverage and fixed wireless services to several regions ranging from a high-density (urban) area to low-density (rural) areas.

Flexibility and integration/convergence are also key factors for user terminals. Section 3.3 addresses technologies for achieving reconfigurable user terminals such as terminal architecture, reconfigurable processors, RF micro-electro-mechanical systems (MEMS) for achieving smaller user terminals, and user interfaces for a flexible user terminal.

Future mobile user equipment may assume characteristics of general-purpose programmable platforms by containing high-power general-purpose processors and provide a flexible, programmable platform that can be applied to an ever-increasing variety of uses. The convergence of wireless connectivity and a general-purpose programmable platform might heighten some existing concerns and raise new ones; thus, environmental factors as well as traditional technology and market drivers influence the architecture of these devices. A well-designed embedded processor with a reconfigurable unit may enable user-defined instructions being efficiently executed, since general-purpose processors such as CPUs or DSPs are not suitable for bit-level operation. This type of processor, which can handle many kinds of bit-level data processes, can be applied to various applications for mobile communication systems with efficient operation.

RF MEMS are integrated micro-devices (or systems) combining electronic and mechanical components fabricated using an integrated circuit (IC) compatible batch-processing technique. This technology can yield compact, light weight, low power, and high performance ICs to replace discrete passive RF components such as VCO, IF, RF filters, and duplexers.

Wearable computing is also a promising technology that will give birth to new ideas of man-machine interfaces applicable to user terminals. So far, many solutions are not standardized but are proprietary methods. There is also a clear need for harmonization and for open use of common open interface standards.

3.1 New radio technologies and impact on spectrum

3.1.1 Technologies for improving bandwidth efficiency

To meet the strong demand for broadband multimedia services to both nomadic and mobile users, it is necessary to increase the maximum information bit rate of systems beyond IMT-2000. To enhance the capacity of IMT-2000 and systems beyond IMT-2000, novel technologies or new concepts for improving bandwidth efficiency are indispensable. Advanced radio resource management (RRM) algorithms will be beneficial for maximizing the resource utilization. In addition, antenna and coding technologies such as smart antenna, diversity techniques, coding techniques, space time coding, and combined technologies will be necessary for systems beyond IMT-2000 to improve the wireless link quality under multipath Rayleigh fading channels. Furthermore, efficient multiple access schemes, adaptive modulation, adaptive downlink modulation, and multi-hopping technology will be needed to improve the bandwidth efficiency of the system.

Technologies for improving bandwidth efficiency which are discussed in this Recommendation include:

– bunched systems;

– ultra-wideband (UWB);

– adaptive modulation and coding (AMC);

– flexible frequency sharing;

High level descriptions of the above technologies are to be found in the following sections, whilst more detailed information is provided in Annex 1.

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