FACTA UNIVERSITATIS (NIŠ)
Series: Electronics and Energetics vol. 12, No.2 (1999), 33-43

UDC 621.395

# IMT-2000-3RD GENERATION INTERNATIONAL MOBILE TELECOMMUNICATION: BACKGROUND AND EXPECTATIONS

*This paper is dedicated to Prof. Ilija Stojanović on the occasion of his $75^{th}$ birthday and the $50^{th}$ anniversary of his scientific work*

**Richard C. Kirby**

**Abstract.** This paper summarizes the activities of the international community towards a global standard for mobile communications using digital technology, often referred to as IMT-2000 or third-generation mobile system (3G). It describes the basic objectives of the system, in terms of minimum performance capabilities as specified within the International Telecommunication Union, as well as possible implementation options as discussed within various fora. Finally, it addresses some elements of forthcoming ITU-R Recommendations, which should provide the general framework for 3G networks and which should be free of intellectual property rights problems.

## 1. Background

1985 had ignited global demand for mobile telephony by the success of early Nordic NMT and other analogue systems in Japan, Europe, and North America. The Nordic system had pioneered integration of mobile telephony with national telecom-munication networks, bringing service to vast rural and archipelago regions where land lines and cables were uneconomic. Except for NMT, and AT&T's AMPS in North America, there was little provision for international roaming of terminals. In 1985, ITU (CCIR)'s Working Party 8/13 undertook studies of digital technology for "future global public land mobile telecommunication systems (FPLMTS)".

Manuscript received August 23, 1999.

The author is former Director of the International Radio Consultative Committe (CCIR), 1974-1992, and former Director of the Radiocommunication Bureau of the ITU (1993-1994). Currently, Mr. Kirby is Consultatnt, International Telecommunications, Radio Regulations and Standarization. Postal address: POB 94, CH-1211 Geneva 20, Switzerland; e-mail: Richard.Kirby@ties.itu.int.

The initial effect was mainly catalytic. While meetings were the scenes of seminal discussions of technology and definition of requirements, technology initiatives were pursued in regional settings. By 1993, ITU's Recommendation M.1073 presented seven different regional digital mobile systems, none compatible with another. ETSI had solidified European standardization of digital mobile systems to produce GSM. Japan's Digital Cellular system (JDC) began about the same time. Both used TDMA technology. In North America, competitive TDMA and CDMA were introduced with optional "dual mode" terminals incorporating analogue AMPS to enable wide area "roaming". Europe's GSM system and a North American CDMA system were prominent internationally and were adopted in many countries.

In the circumstances, ITU created a new "Task Group 8/1", reorienting objectives to a third generation concept, "IMT2000" (International Mobile Telecommunication). IMT-2000 is also referred to as UMTS, especially in Europe. By 1997, the need and potential of 3rd generation wireless were recognized, but expectations for timing were different in different regions. Japan, facing growth of demand for domestic wireless communication, urgently required greater system capacity and frequency spectrum. Japan insisted on a deadline for standardization not later than year 2000. Japan's urgency was recognized in setting the ITU deadline for a Recommendation by the end of 1999. Europe might otherwise have accepted 2002-2003 and North American interests saw 2005 as early enough.Sufficient consensus on service requirements and potential technologies enabled ITU to invite proposals of candidate systems in April 1997. A program of evaluation and "harmonization" of proposed technologies was scheduled toward Recommendation of standard(s) by late 1999. TG8/1's program was reinforced by intensive regional and inter-regional activity to meet the schedule.

## 2. Objectives of IMT-2000 and Request for Submission of Candidate Radio Transmission Technologies (RTT's) for IMT-2000/FPLMTS Radio Interface

IMT-2000 was conceived to provide global advanced mobile services with maximum commonality and compatibility. A unique technology seemed unlikely to be achieved; a range of mobile terminal types designed for mobile and fixed use was foreseen. In comparison with the earlier digital mobile capabilities and services, IMT-2000 would include advanced voice and data communication, higher bit-rate capability with "bandwidth on demand" over a wide range of data rates, support for asymmetric data traffic, and improved security. Satellite mobile networks are expected to supplement coverage,

especially in areas not covered economically by the terrestrial component. Paths of evolution for existing systems and migration of users were foreseen, as well as evolution within IMT-2000.

Quoted from the invitation for proposals: "A goal for third generation mobile systems is to provide universal coverage and to enable terminals to be capable of seamless roaming between multiple networks.... No longer will the various elements of the radio interface (e.g. channel coder, a modulator, transcoder etc.) have fixed parameters; rather, they will be in the form of a "toolbox" whereby the key parameters of bandwidth, transmission quality and delay can be selected, negotiated, mixed and matched by the requirements of the service, according to the instantaneous capability of the radio channel. IMT-2000 is intended to operate worldwide in bands identified by Radio Regulations provisions."

The number of and differences among interfaces should be minimal. Radio interfaces will serve a variety of radio operating environments, as indoor, out-door pedestrian, and vehicular from stationary to high speed. The request for proposals specified the performance capabilities to qualify for consideration (Table 1 p.36), and provided guidelines for evaluation. A detailed checklist of requirements and desiderata was included to assist the evaluation process.

Besides the requirements of Table 1, a number of guidelines, not all quantified, were provided for the evaluation process:

– *Spectrum efficiency*; consideration of information and voice traffic capacities taking into account frequency reuse and signalling overhead;

– *Flexibility of technology*; concerns adaptability to propagation and traffic environments, ability to balance capacity vs. signal quality, accommodation of fixed wireless architecture; variable bit rate capability, packet data mode;

– *Ability to balance capacity* versus RF signal quality as long as minimum performance requirements are met;

– *Adaptability* of system(s) to different and/or time-varying propagation and traffic environments;

– Ability to accommodate fixed *wireless access* (FWA) architecture;

– *Ease of service* provision including variable bit rate capability, packet data mode transmission and simultaneous transmission of voice and non-voice services;

– Ability to accommodate *mixed-cell (pico, micro, macro, and mega) architecture*;

Table 1. Minimum Performance Capabilities IMT-2000
Candidate Radio Transmission Technologies
From ITU SG8 Circular Letter 8/LCCE/47 April 1997 (slightly compressed)

| Test environments | Indoor Office | Outdoor to Indoor and Pedestrian | Vehicular |
|---|---|---|---|
| Mobility Considerations | Low Mobility | Medium Mobility | High Mobility |
| Handover | Required[1] | Required[1] | Required[1] |
| Packet data | Required | Required | Required |
| Asymmetric services | Required | Required[2] | Required[2] |
| Multimedia | Required | Required | Required |
| Variable bit rate | Required | Required | Required |
| Data services key capabilities | user bit rates and BER | user bit rates and BER | user bit rates and BER |
| Circuit-switched low & long delay | at least 2048 $kb/s$ $\leq 10^{-6}$ | at least 348 kb/s[3] $\leq 10^{-6}$ | at least 144 kb/s $\leq 10^{-6}$ |
| Packet | at least 2 048 kb/s $\leq 10^{-6}$ | at least 348 kb/s[3] $\leq 10^{-6}$ | at least 144 kb/s $\leq 10^{-6}$ |

BER = Bit Error Ratio

[1] Seamless handover required within the environment, for multi-environment technologies proposed for use in more than one test environment seamless inter-environment handovers required for services which can be handled in more than one relevant environment.

[2] The evaluated technologies close but not quite capable to meet the minimum performance capabilities for user bit rates (not less than 64 kbit/s) as specified in the table in one direction for this test environment, but meeting the minimum performance capabilities in the other direction, will also be considered in the consensus building process. See Circular Letter 8/LCCE/47

ITU-R Task Group 8/1 acknowledges advantages of other criteria for evaluation of IMT-2000 technologies such as spectrum efficiency, technology complexity, quality, flexibility, implication on network interfaces, or hand portable performance optimization capabilities.

[3] Maximum user bit rate for data is one of the key criteria for evaluation of IMT-2000 technologies. It is strongly desirable that IMT-2000 technologies are capable of 384 kbit/s or higher user bit rates for data services in the outdoor to indoor and pedestrian test environments. The evaluated technology for this environment which is capable of at least 144 kbit/s user bit rate but not capable of 384 kbit/s will be also considered in the further consensus building process if it is compliant with the requirements and objectives for IMT-2000 which are summarized in Attachment 4 of Circular and if it fulfils the minimum performance capabilities for the vehicular test environment in this table and: ITU-R Task Group 8/1 acknowledges it offers advantages of other criteria for evaluation of IMT-2000 technologies such as spectrum efficiency, technology complexity, quality, flexibility, implication on network interfaces, or hand portable performance optimization capabilities

– *Suitability for multiple operators* in the same/overlapping service areas. Rt. will be compared based on their ability to share efficiently a common spectrum allocation; share network infrastructures (for example in areas of low subscriber density); provide handover between systems run by different operators.

## 3. Process toward Recommendation; Proposals, Evaluation, Harmonisation, "TABD", "OHG" "3GPP", ITU-T, IPR

### 3.1. Proposals, Evaluation

Candidate RTT proposals were submitted to ITU and/or evaluation groups by 30 June 1998. The process was open to all participating entities to evaluate all technologies. Evaluation groups were established largely by regional standardization activities. In practice, self-evaluation against the criteria and guidelines predominated. Completed evaluation reports were sent to ITU-R TG 8/1 by 30 September 1998.

### 3.2. Harmonization (see also sections 3.3. to 3.5.)

ETSI, in January 1998, decided that advanced wideband CDMA would be its candidate for FDD mode. An evolved GSM technology was supported for TDD mode. Similarly in North America, the TDMA candidate was proposed for TDD mode while several CDMA candidates were proposed for FDD. The Japanese proposed a CDMA system. An inter-regional meeting of standards organizations in Japan in February 1998 clarified the array of proposals in process. Some possibilities for common ground were discussed with but it was too early for definitive progress. From the beginning the harmonization process has been constrained by IPR interests, and the understandable goal of "backward compatibility". By 30 September 1998 there would be 8 candidates submitted to ITU. In North America, affinity developed between WCDMA parented by T1P1, and WIMS by TIA 46, both promising candidates. "WPCDMA" resulted as an international candidate offering the additional capability of "connectionless" packet transmission.

### 3.3. Transatlantic Business Dialogue

The Electronics, Electrical, Information Technology, and Telecommunications (EETIS) sectors of the Transatlantic Business Dialogue, in a meeting on 17 Feb 1999 considered Third Generation Wireless Standards and

Regulatory Policy.The meeting included participation of telecommunication operators. It reported:

> "The EETIS group strongly supports the industry-led standards-making process within the ITU. All agreed to support the operators' expressed needs for 1) backward compatibility with existing systems; 2) global roaming; 3) modular deployment to allow the smooth evolution/transition to 3G; 4) cooperation between parties to ensure timely and successful introduction of 3G services; and 5) adherence to the time schedule set by the ITU.
>
> With these factors in mind, there was broad consensus that a *single global standard is not achievable for 3rd generation wireless.* Operators expressed their desire to choose between standards according to their needs, taking into account their business decisions based on the different 2G systems deployed. Therefore, EETIS supports the approach presented by operators to establish a TDMA standard and a CDMA standard with three modes of operation.
>
> With respect to the CDMA standards issue, the operators proposed and the EETIS group supports the establishment of a 3G CDMA standard that provides for three modes of operation (multi-carrier, direct sequence, and TDD); support by each mode for both core networks (i.e., GSM MAP and ANSI-41); provision to maximize commonality among those modes; and network-to-network interfaces. In so doing, operators will be able to choose which of the modes of operation to deploy in their networks that will best serve their needs."

### 3.4. Operators Harmonisation Group

An "Operators Harmonization Group" (OHG), on behalf of more than 30 major network service providers, with the support of more than 10 major manufacturers, intervened in the ITU TG8/1 June 1999 meeting to express its firm goal of a harmonized "Global 3G" CDMA standard. Their recommendation supported 3 modes of CDMA: Multi-carrier (cdma2000 proposal), Direct Sequence (WCDMA proposal) and Time Division Duplex (TDD). OHG made specific recommendations on Inter Base Station Synchronization, various pilot structures, and chip rate (3.84 Mcps). It proposes protocol layers according to a modular system.

OHG objectives relate to customer service, costs and timing for the industry, the recogni-tion of the two well-established core-networks. OHG aims also to minimize cost and complications of IPR elements. OHG's proposal was accepted by ITU Task Group 8/1.

### 3.5. "3GPP" 3rd Generation Partnership Project

Regional and national Standards Development Organizations have agreed to cooperate in a "$3^{rd}$ generation partnership project" for the production of Technical Specifications for 3G mobile systems to be based on the evolved GSM and ANSI-41 core networks and the CDMA radio access technologies supported by the "organizational partners". The organizational partners are ETSI, Europe; ANSI (TIA and ATIS T1P1), North America; TTC and ARIB, Japan; TTA, Korea; CWTS, China.

Specifications for radio access network are dealt with in 3GPP_TSG_RAN, where Working Group 1 is responsible for Layer 1 and Working Group 2 is responsible for Layers 2 and 3.

3GPP, at a meeting in July 1999, fully accepted the recommendations of the Operators' Harmonization Group. The 3G press release says:

> "At a meeting held in Sophia Antipolis, 6-7 July 1999, the Third Generation Partnership Project (3GPP) accepted the recommendations of the Operators' Harmonization Group (OHG) and agreed to produce standards for the Direct Sequence and Time Division Duplex (TDD) modes as recommended by OHG. The results form part of the ongoing work on the ITU IMT-2000 recommendations.
>
> According to the agreement, 3GPP will cover the technical issues relating to the development of the Direct Sequence and Time Division Duplex (TDD) modes that form part of the harmonized global 3G CDMA standard. The work will also include the inter-working between the evolved ANSI-41 and GSM MAP platforms.
>
> Towards global harmonization, 3GPP has changed the chip rate of its proposed standard from 4.096 to 3.840 Mcps and adopted a new downlink pilot structure. These two changes come in addition to the asynchronous/synchronous base station operation previously adopted. The complete 3G standards will ensure global roaming and seamless service provisioning"

The focus is now on 3GPP to construct and submit to ITU the final technical specifications for IMT2000. Some 250 documents will have been addressed to constitute "Release 99", for incorporation in the ITU Recommendation as of October 1999.

### 3.6. ITU Telecommunication Standards Sector

While ITU's Task Group 8/1 focus is primarily Radio layer 1, Radio layers 2 and 3 require cooperation with, and ultimate standardization by, ITU's Telecommunication Standardization Sector, responsible for network studies and standards. Primary liaison is with ITU-T Study Group 11 on behalf of network support of mobile services. Study Group 11 continues intensive work scheduled to meet the requirements of the radio access standardization. Considerable work remains to be done on the network side.

### 3.7. Intellectual Property Rights.

ITU has a long standing "Patent Policy" requiring that a patent holder for technology essential to implementation of an ITU Recommendation must declare agreement to license use of the patented element on "reasonable and non-discriminatory terms". Failure to agree unconditionally with this requirement arrests approval of an ITU Recommenda-tion. In December 1998, two companies declared conditions inconsistent with the ITU patent policy. A potential crisis ensued making uncertain the continuation of work toward an IMT-2000 Recommendation. An ad hoc ITU meeting in February 1999 averted a crisis. Subsequent review of ITU Patent Policy reaffirmed the require-ment for declaration of agreement to license IPR, and eliminated mandatory disclosure of specific patents and details.

In any case, ITU has no mandate to administer licensing or to control cost. In deployment of digital cellular systems up to now, manufacturers and service providers have been concerned with substantial and long-term cost of patent licenses. Anxiety on this issue provoked development of an industry IPR policy and practice for 3G standards.

The UMTS Intellectual Property Association (UIPA) was formed early in 1999. Members propose a comprehensive "UMTS 3G Patent Platform" aimed to control ("cap") the cost of patent licenses for implementation of 3G mobile systems "consistent with commercial viability of providing service". While not part of ITU policy, and theoretically a "voluntary" measure, wide support of manufacturers provides a forceful guideline. The UIPA may also oversee or administer licensing. The extent to which provisions of the platform comply with national "anti-trust" laws remains to be seen.

## 4. The Future

Specifications from 3GPP for IMT-2000, "Release 99", and other material required for the Recommendation are scheduled to be available to Task

Group 8/1 at its Helsinki Meeting 25 October - 5 November 1999. Approval by Study Group 8 is scheduled for 11-12 November.[4] Assuming that the Study Group agrees to submit by correspondence to Administrations, final approval of the Recommendation could be effective by end of March 2000.

The ITU Recommendation should provide early in the year2000 a basis for the industry to implement third generation mobile systems. If Japan accomplishes its timetable; it would be the first to launch 3G mobile services. But "Release 99" is not the end of the road. 3GPP continues a substantial agenda and program of meetings for the year 2000. Besides formal texts, technical topics are to be addressed, as for example:

– Combined GSM and Mobile IP handling in UMTS

– UMTS core network based ATM transport

– Base Station Conformance Testing

– Technical Specification for Tandem Free

– Quantitative performance evaluation of real-time packet switched multimedia

– Broadcast and multicast services

– Further work will be needed on the inter-working between the evolved ANSI-41 and GSM MAP platforms

– Enhanced position location and emergency communications features.

The import of and methods of response to changes incorporated in "Release 2000", etc. remains to be seen.

Japan's early entry may be significant to the international market and to Europe and North America's calendar for implementation. Europe is developing significant momentum toward 3G in spite of more relaxed targets earlier. Worldwide there is an important link with wireless fixed network strategies. 3G technology has inspired fixed applications, indeed a wave of high capacity, high bit rate (10-25 Mbps) LAN's, some labeled "$4^{th}$ Generation". Regions, which are actively expanding or upgrading their terrestrial network, will wish to incorporate advanced mobile systems or technology.

In any case, there remains a certain dependence on available frequency bands being considered for allocation in ITU's "WRC-2000"

[4]Study Group 8 must also identify ITU responsibility and organisation for maintenance and future revisions of the Recommendation; it appears likely that Task Group 8/1, having carried out its mission, would be replaced.

Most references are cited in the body of the text. Additional source information is given below:

## REFERENCES


1. 3GPP Organization and Background: *http://www.3gpp.org.*
2. ITU-R Recommendation M.1073-1: *Digital Cellular Land Mobile Telecommunication Systems.*, 1994-1997
3. ITU-R Recommendation M.1225: *Guidelines for Evaluation of Radio Transmission Technologies for IMT-2000.*, 1997
4. International Telecommunication Union: *ITU-R Task Group 8/1, Doc. 424, Report of the seventeenth meeting.* (Beijing, 31 May-11 June 1999), *http://www.itu.-int/itudoc/itu-r/sg8/docs/tg8-1/1998-99/17report/index.html*
5. UMTS Intellectual Property Association: *Secretary c/o Alcatel 54.*, rue La Boetie F-75411 PARIS CEDEX


## Appendix

**Acronyms**

| | |
|---|---|
| 3GPP | Third Generation Partnership Project (standards development organizations) |
| AMPS | Advanced Mobile Phone System |
| ANSI | American National Standards Institute |
| ARIB | Association of Radio Industries and Businesses (Japan) |
| ATM | Asynchronous Transfer Mode |
| CCIR | ITU's Former International Radio Consultative Committee; Radiocommunication Sector integrated from 1993 |
| CDMA | Code Division Multiple Access |
| CWTS | China Wireless Telecommunication Standards |
| DECT | Digital Enhanced Cordless Telephone |
| ETSI | European Telecommunication Standards Institute |
| FDD | Frequency-Division Duplex |
| GSM | ETSI's "Global System Mobile" |
| IP | Internet Protocol |
| ITU-R | ITU's Radiocommunication Sector |
| ITU-T | ITU's Telecommunication Standardization Sector |
| JDC | Japan's Digital Cellular system |
| LAN | Local Area Network |
| NMT | Nordic Mobile Telephony |
| T1P1 | Sub-Committee of ANSI/ATIS Standards Committee T1 |
| TDD | Time Division Duplex |
| TDMA | Time Division Multiple Access |
| TG8/1 | Task Group 1 of ITU-R's Study Group 8 |
| TIA | Telecomunications Industry Association |

| | |
|---|---|
| TIA46 | ANSI/TIA Technical Committee 46 |
| UIPA | UMTS Intellectual Property Association |
| UMTS | Universal Mobile Telecommunication System |
| UTRA | UMTS Radio Access |
| UTRAN | UMTS Radio Access Network |
| WCDMA | Wideband Direct Sequence CDMA |
| WPCDMA | Wideband Packet Direct Sequence CDMA |
| WIMS | Wideband Multi-media and Messaging Service |
| WRC2000 | World Radiocommunication Conference, 2000 |