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Working Party 8F
Working Group Vision

DG3 POSSIBLE NEW PDNR

WORKING DOCUMENTS FOR FUTURE CONSIDERATION ON POSSIBLE PDNRS

1 Introduction

The working document towards preliminary draft new recommendation on Vision and Objectives of the ongoing enhancement of IMT-2000 and of systems beyond IMT-2000 is being developed. It has been only one working document concerning Question ITU-R 229/8 and volume of contents significantly increases. At the WP8F Stockholm meeting, some contributions proposed to make the working document more concise and one contribution proposed to develop several documents in a series of recommendations that define future systems that are enhancements to IMT-2000 or have capabilities beyond those of IMT-2000. Based on these proposals, it was decided to separate the contents in the working document into several categories that could become individual PDNRs. One of them is “Vision” PDNR that provides high-level view of Vision of the future systems and is drafted as 8F/TEMP/121rev 1. This document includes four attachments that are more detailed considerations to realize the Vision in 8F/121rev. 1. All the contents of the attachments are collected from the former Vision PDNR and contributions to the WP8F Stockholm meeting.

2 Possible new PDNRs

Table 1 shows the possible new recommendations proposed by 8F/297. The contents of the former Vision PDNR are reorganized based on this table. It should be noted that the each possible recommendation listed in the table have not been discussed and it has not yet been decided to develop these in the future. Further contributions are requested to develop appropriate PDNRs.

3 Working Documents

These working documents are produced based on the working documents developed at WP8F Geneva (Attachment 12 to 8F/184) and Rabat (Attachment 17 to 8F/268) meetings and on the contributions to the Stockholm meeting. Information included in the working documents could be used to develop abovementioned possible PDNRs and other PDNRs.

Attachments: 4

TABLE 1

Possible new PDNRs and Reports

Doc Type	ITU-R WP 8Fdocument	Objective	Doc. Identifier	Contents
Rec.	Vision and Objectives of the Ongoing Enhancement of IMT-2000 and of Systems Beyond IMT-2000. High Level concepts and objectives for both the terrestrial and satellite components of systems beyond IMT-2000.	This document should provide only a high-level view of concepts, objectives, services, market trends, spectrum considerations, security, system management, enabling technologies, and developing country requirements for systems beyond IMT-2000. More detailed information and recommendations will be provided in the other ITU-R Reports and Recommendations that are listed in this Work Programme Table.	M.[IMT-VIS]	8F/TEMP/ 121 rev. 1
Rec.	Spectrum considerations, spectrum calculation methodology, and spectrum requirements	This document provides considerations on spectrum implications of the future development and systems beyond IMT-2000. It includes points to be required for the clarification of spectrum requirements. In addition, suitable frequency bands will be discussed, considering spectrum requirements and realization of the future development and systems beyond IMT-2000.	M.[IMT-SPEC]	Attachment 1
Rec.	Framework for services	This document provides a description of the services and capabilities to be provided by the ongoing enhancement of IMT-2000 and systems beyond. It identifies the overall objectives, service requirements, user needs and applications associated with the ongoing enhancement of IMT-2000 and systems beyond, building on the services and capabilities defined in Recommendations ITU-R M.687, M. 816, and M. 1457.	M.[IMT-SVC]	Attachment 2
Rec.	Operational characteristics, management framework, performance, quality of service requirements, and security requirements	TBD	M.[IMT-OPC]	
Rec.	Network architecture	TBD	M.[IMT-NET]	

TABLE 1

Possible new PDNRs and Reports

Rec.	Framework for the radio interface(s) and radio interface requirements	This document provides considerations on framework for the radio interface(s) and radio interface requirements of the future development of IMT-2000 and systems beyond IMT-2000. It includes technical objectives, requirements and capabilities of the radio interface(s) of those systems. These considerations should be used to update the existing radio interface(s) and /or to specify new radio interface(s).	M.[IMT-FRAME]	Attachment 3
Rec.	Evolution and modularity principles	TBD	M.[IMT-EVOL]	
Rec.	Integration of systems (e.g., Bluetooth and wireless terminals) and convergence of services (e.g., broadcasting and mobile services).	TBD	M.[IMT-CON]	
Rec.	Key characteristics	TBD	M.[IMT-KEY-B]	
Rec.	Evaluation guidelines	TBD	M.[IMT-EVAL-B]	
Rec.	Global core specifications	TBD	M.[IMT-RSPC-B]	
Rep. Rep. Rep. Rep.	<u>Technology Trends</u>. This is envisioned to be a series of technical reports on major technology areas that are needed for the development of ongoing enhancement of IMT-2000 and systems beyond IMT-2000. Examples include software defined radio, adaptive antennas, and wireless IP.	This report is designed to provide information on technologies that may be part of the future development of IMT-2000 and systems beyond.	M.[IMT-SDR] M.[IMT-AANT] M.[IMT-W-IP] IMT-Tech(?)	Attachment 4

TBD - To be developed.

Attachment 1

Source Section 2.1 of Informative Attachment I-6, all sections of I-7 and I-13 in Attachment 12 to 8F/184

Section 3 of Annex 3 and Annex 4 in Attachment 17 to 8F/268

8F/304, 8F/307, 8F/326

(Baseline document is Annex 4 in Attachment 17 to 8F/268)

Working Document for future consideration on PDNR [IMT-SPEC]

Considerations on spectrum implications regarding the ongoing development of IMT-2000 and systems beyond

OBJECTIVE: This document provides considerations on spectrum implications of the future development and systems beyond IMT-2000. It includes points to be required for the clarification of spectrum requirements. In addition, suitable frequency bands will be discussed, considering spectrum requirements and realization of the future development and systems beyond IMT-2000.

1 General Considerations

1.1 Mid-Term

In "mid-term" time frame development will utilise frequency bands identified/intended for use by IMT-2000 at WARC-92 and WRC-2000.

In evaluation of these new frequencies as identified by WRC (WRC-92 and WRC-00), factors that relate to the delivery of multimedia applications, such as high downlink data rates, should be taken into account. For this evaluation the traffic asymmetry, uplink and downlink spectrum requirements, regional band plans, global roaming, advances in technology and current or planned future usage of the frequency bands need to be taken into account.

1.2 Longer Term

To meet longer-term requirements for IMT-2000 enhancement and beyond, consideration of new frequency bands may be required. Factors that relate to the delivery of multimedia applications, such as high downlink rates, should be taken into account since this will have a strong impact on the spectrum requirement. Other factors to consider in the determination of spectrum requirements include market forecasts of requirements for new applications and services, technology trends, transmission distance (wide area coverage or short range links), interactivity, mobility, etc.

Because it is envisaged that wireless telecommunication services in the long-term time frame will offer individual users greater than 20-Mb/s data-rates, a broader frequency bandwidth may be required. Considerations to achieve these channels include higher spectrum efficiency, dynamic, flow of traffic, packet data techniques, advanced antenna systems, use of micro/pico cells and others. Therefore, additional radio frequency spectrum above that currently identified for IMT-2000 may be required and therefore there should be considerations for further studies for the systems beyond IMT-2000. However, this will first require a furtherl understanding of the market developments in terms of services, rates of delivery, quality of service and cost of implementation as well as end user costs before estimates of spectrum requirements can be assessed.

2 Traffic Consideration (Section 3 of Annex 3 in Attachment 17 to 8F/268)

(Section 2.1 of Informative Attachment I-6 in Attachment 12 to 184)

When considering the requirements of systems beyond IMT-2000, it is necessary to consider the traffic volume of the period such systems are introduced. The ITU-R Report ITU-R M.2023 "Spectrum Requirements for IMT-2000" projects the traffic in 2010. Annex 1 presents the traffic projection for 2015. The estimation was performed using a method similar to the one described in Report ITU-R M.2023. In the estimation, because very high-speed multimedia services of more than 2 Mb/s are expected, new service categories, i.e., Very High MultiMedia (VHMM) offering 20 Mb/s in the downlink and 2 Mb/s in the uplink and Very High Speed Interactive MultiMedia (VHIMM) offering bi-directional 2-Mb/s links, are defined and taken into account in the traffic calculation in addition to those defined in Report ITU-R M.2023. The annex shows that traffic in 2015 will increase five fold from the level in 2010. Although WRC-2000 identified additional spectrum to be used for IMT-2000 (480 MHz in total in Region 3), a further 1.5 GHz would be required in 2015 if the spectrum efficiency is not enhanced. Therefore, systems beyond IMT-2000 should improve the system capacity and spectrum efficiency further than the current IMT-2000.

3 Factors Influencing Spectrum Requirements

Editor's Note: This section may include the following items:

- *Necessity of global harmonization*
- *Roaming requirements*
- *Global roaming*
- *Inter-system roaming*
- *Satellite communications*
- *High Altitude Platform (HAP) communications*
- *Duplex techniques*
- *Radio propagation*
- *RF technology and spectrum efficiency*

3.1 Spectrum for broadband wireless communications

3.2 Radio propagation

{Note: As per the normal arrangements within ITU-R, WP8F should seek appropriate propagation advice from Study Group 3}

(8F/326)

(a) Urban multi-path propagation characteristics

Propagation in the 3 to 15 GHz band has been studied in urban macrocell environment. With regard to the multi-path effects, analogous characteristics are confirmed over the frequency range from 3 to 15 GHz for urban multi-path propagation characteristics; averaged power delay profiles have similar structures, and delay spread and maximum delay time have similar value over the frequency range from 3 to 15 GHz.

(b) Urban path loss characteristics

Propagation path loss characteristics over the frequency range from 0.4 to 15 GHz has been studied in urban outdoor condition. The frequency dependency of urban path loss is found to follow the free space characteristics, 20log(*f*), where *f* is a carrier frequency, both for macrocell and microcell environments, and also both for high-tier and low-tier cases.

4 Preliminary Spectrum Estimation

Editor's Note: The Spectrum working group in WP 8F will study spectrum requirements.

5 Sharing possibilities with other services

Editor's Note: Aspects are also related to work with the 8F Spectrum Working Group.

5.1 National Cross Border Spectrum Coordination Aspects

6 Regulatory and Standardization Issues

(Section 8 of Attachment 17 to 8F/268 + 8F/307)

In the light of the above, there is clearly a need to ensure that operators can access spectrum to allow operational systems embodying the complete IMT-2000 objectives of seamless services utilising differing technologies in the 2005 to 2010 period. This may require some additional flexibility in allocations and there may be a requirement for additional spectrum (globally harmonised) sometime after 2010. This issue may therefore be included on the WRC-06 agenda. ITU-R WP 8F will undertake studies in this area and will make appropriate proposals to WRC-06.

(8F/304)

Editor's Note: This may contain information of concern to JTG 1-6-8-9.

Reconfigurable radio technology is acknowledged by FCC, the US regulatory authority, as an important mechanism to allow the modernization of spectrum engineering practices to improve spectrum efficiency.

For the longer-term vision of reconfigurable air interfaces, deregulation of spectrum and minimal standardization are key to breaking down the ‘Generation’ cycle in mobile communications, where years of standardization work, resulting in the release of the ‘next’ generation system, may well be already outdated by technology advances. The vision of a flexible, scalable system into which new technology developments may be easily integrated, could potentially minimize standardization requirements, specifying only fundamental communication mechanisms such as:

- An interface for connecting new radio access points to the converged backbone network;
- A communications channel to the terminal over which spectrum access is negotiated, or evolution of an adequate spectrum-access etiquette;
- A mechanism by which spectrum access may be policed (for example, consideration of the case where a software radio pollutes local spectrum, having downloaded and installed software which causes rogue emission).

Furthermore, the role of regulators will require evolution, possibly focussing on :

- Policing user privacy and security in a scheme where user profiles, configuration information, and a significant quantity of personal data is stored and widely distributed. Security and privacy measures must be jointly agreed by industry and regulations to resolve potential conflicts, for example between users and the advertisement industry
- Ensuring fair access to spectrum through real-time policing and prevention of service monopolies

However, the huge investment in legacy systems will ensure that 2G and 3G cellular schemes will be retained for many years. The key is to establish the business model and technologies through which an evolved uniform, scalable system may be adopted as and when segments of spectrum are released.

Annex: 2

ANNEX 1

ESTIMATION OF MOBILE COMMUNICATIONS TRAFFIC AFTER 2010

1 Introduction

In order to discuss system concepts and spectrum requirements for systems beyond IMT-2000, it is important to investigate the mobile communications traffic conditions after 2010. Especially, in the years after 2010, it is anticipated that high-speed services at transmission speeds of greater than 2 Mb/s, which are not supported by IMT-2000, would be available, and the mobile communications traffic, the core of which is likely multimedia communications traffic, are expected to grow substantially.

Using a method similar to the one described in Report ITU-R M.2023, this annex tries to estimate the mobile communications traffic for 2015 with regard to higher-speed mobile communications services.

2 Types and traffic of mobile communication services

The user demand for higher data rate communications services is substantial. With the advent of high-speed fixed networks such as the introduction of Asymmetric Digital Subscriber Lines (ADSLs) and fiber optics subscriber lines, high-speed transmission services ranging from a few tens to a few hundred megabits per second are expected to become available in the near future. These high-speed data transmission services will stimulate ongoing enhancement of applications requiring high-speed data transmission, and will result in an increase in multimedia traffic. To keep apace with this trend, after 2010, mobile communication systems offering transmission rates of more than 2 Mb/s will be introduced, and consequently, the amount of mobile communications traffic will increase significantly.

Report ITU-R M.2023 presents the types of mobile communications services and traffic in 2010. In addition to the mobile communications traffic in 2010, we must consider the traffic generated by the high-speed services at transmission speeds greater than 2 Mb/s. Here, we define a new up/downlink asymmetrical ultra high-speed service called VHMM (Very High MultiMedia, Downlink: 20 Mb/s, Uplink: 2 Mb/s) and a new up/downlink symmetrical ultra high-speed service called VHIMM (Very High Interactive MultiMedia, Up/Downlink: 2 Mb/s). The types of services under consideration are shown in Table 1.

TABLE 1
Mobile communications service types and traffic

Channel Type	**Type of Services**	**Downlink transmission speed (kb/s)**	**Uplink transmission speed (kb/s)**
Asymmetric Up/downlink	VHMM (Very High MultiMedia)	20000	2000
	HMM (High MultiMedia)	2000	128
	MMM (Medium MultiMedia)	384	64
Symmetric Up/downlink	VHIMM (Very High Interactive MultiMedia)	2000	2000
	HIMM (Highly Interactive MultiMedia)	128	128
	SD (Switched Data)	64	64
	SM (Simple Message)	14	14
	S (Speech)	16	16

In this investigation, we define the traffic as the amount of information (bytes) that can be conveyed in a unit time (busy hour). For this purpose, using the calculation method in Report ITU-R M.2023 as the basis, some modifications were made. Specifically, in Report ITU-R M.2023, the required frequency bandwidth is calculated as the final result, while in this investigation, the amount of information (bytes) is calculated by multiplying the Erlang traffic (time unit) per busy hour per cell for each mobile communications service type, which is derived from the calculation process in Report ITU-R M.2023, and the transmission speed of each service type.

To estimate the traffic after 2010, first, the amount of information for each service type is calculated using the method aforementioned. The necessary parameters to perform this calculation are based on the values from the pedestrian environment in Region 3 in Report ITU-R M.2023. The calculation results for the amount of information in 2010 are given in Table 2. At the time point of 2010, VHMM and VHIMM need not to be considered; therefore, those rows are intentionally left blank.

TABLE 2

Traffic per cell during busy hour (Mbytes)

Type of Services	Uplink	Downlink
VHMM	-	-
HMM	307	25249
MMM	1023	32319
VHIMM	-	-
HIMM	8379	8379
SD	8092	8092
SM	157	157
S	17477	17477

3 Estimated traffic for 2015

Next, as an example of traffic after 2010, we try to estimate the traffic for 2015 by referring to the values for 2010. First, we assumed that with respect to voice and low-speed data, which comprise the core traffic of 1G and 2G (S, SM, SD) systems, there would be no changes between 2010 and 2015. This assumption is based on the perspective that, (1) the number of voice-based mobile telephone users would nearly saturate by 2010; and, (2), a large increase in the time spared for voice-based communication per user cannot be expected. On the contrary, for multimedia traffic, we can expect significant growth due to higher rate information transmission created by the emergence of VHMM and VHIMM and the development of various applications, etc.

The significant growth in multimedia traffic will mainly be achieved from the improvement in data processing capabilities and memory capacity of information communication devices such as user terminals. In this investigation, we postulate that the rate at which improvements are made in data processing capabilities and memory capacity matches the rate at which multimedia traffic increases, and thereby estimate the rate at which multimedia traffic increases. Moore's law, which is an empirical model that dictates the rate of improvements in CPU processing capacity and memory chip storage capacity, tells us that a two-fold increase will occur in 18 to 24 months[6]. Based on this model, in this investigation we postulate that the multimedia traffic will double on average in

[6] http://www.intel.com/intel/museum/25anniv/hof/moore.htm

21 months (approximately a 49% increase per year). More specifically, we estimate that the total of MMM, HMM, and HIMM in and after 2010 will increase 49% per year. This value is not an unreasonable estimation by any means. As an example, the PHS service in Japan, which provides the highest data transmission service currently available for mobile communications, shows that its ratio of data communication time to total communication time more than doubled during the 12 months from January 1999 from its January 1999 level. Furthermore, the PHS data calls occupied more than 50% of the total outbound calls made by the subscribers as of the end of May 2000, and is still on the increase. There is another example of the Internet traffic trend in Japan. White Paper "Communication in Japan 2000" published by Japanese government shows that the number of the Internet users in Japan, excluding the number of mobile internet users, increases 1.4-fold a year from 1997 to 1999[7]. And traffic of NSPIXP, one of the major Internet exchange points in Japan, increases about 2-fold a year from 1997 to 1999[8]. Therefore, traffic volume per one user, which is given by dividing the total traffic by the number of uses, can be supposed to increase about 43% a year. These facts support our estimation.

When seen by the different mobile communications service types in 2015, we postulate that VHMM and VHIMM will occupy 50% of the up/downlink asymmetrical and up/downlink symmetrical multimedia traffic, respectively. With respect to HMM and MMM, the proportion for up/downlink asymmetrical multimedia traffic other than VHMM will remain unchanged between 2010 and 2015. Moreover, we postulate that the cell size in 2015 will be the same as that of 2010. Under these assumptions, we calculate the traffic per cell during the busy hours.

Table 3 shows the estimated values of multimedia traffic for 2015 and the aforementioned estimate values for 2010. In addition, the respective ratios among the service types are given in Table 4.

TABLE 3

Traffic per cell during busy hour (Mbytes)

Channel Type	Type of Services	2010		2015	
		Uplink	Downlink	Uplink	Downlink
Asymmetric Up/downlink	VHMM	-	-	4820	208567
	HMM	307	25250	1112	91477
	MMM	1023	32320	3708	117090
Symmetric Up/downlink	VHIMM	-	-	30357	30357
	HIMM	8379	8379	30357	30357
	SD	8092	8092	8092	8092
	SM	157	157	157	157
	S	17477	17477	17477	17477

TABLE 4

Respective Rations Among Service Types

Channel Type	Type of Services	2010		2015	
		Uplink	Downlink	Uplink	Downlink
Asymmetric Up/downlink	VHMM	-	-	5%	41%

[7] White paper: Communications in Japan 2000, http://www.mpt.go.jp/eng/Resources/WhitePaper/WP2000/2000-index.html

[8] http://jungle.sfc.wide.ad.jp/NSPIXP/Traffic/

		2010		2015	
	HMM	1%	28%	1%	18%
	MMM	3%	35%	4%	23%
Symmetric Up/downlink	VHIMM	-	-	32%	6%
	HIMM	24%	9%	32%	6%
	SD	23%	9%	8%	2%
	SM	0%	0%	0%	0%
	S	49%	19%	18%	3%

The increase in data traffic from 2010 to 2015 is given in Figure 3. As shown in the figure, the total amount of traffic for 2015 is expected to increase 4.7 fold from 2010. Moreover, the up/downlink traffic ratio for 2010 is 1:2.6, and is estimated to widen to 1:5.2 in 2015. Mobile multimedia traffic is estimated to account for 95% of all downlink traffic.

We believe that VHMM and VHIMM, though not available in 2010, will represent a large percentage of ultra high-speed multimedia traffic by 2015.

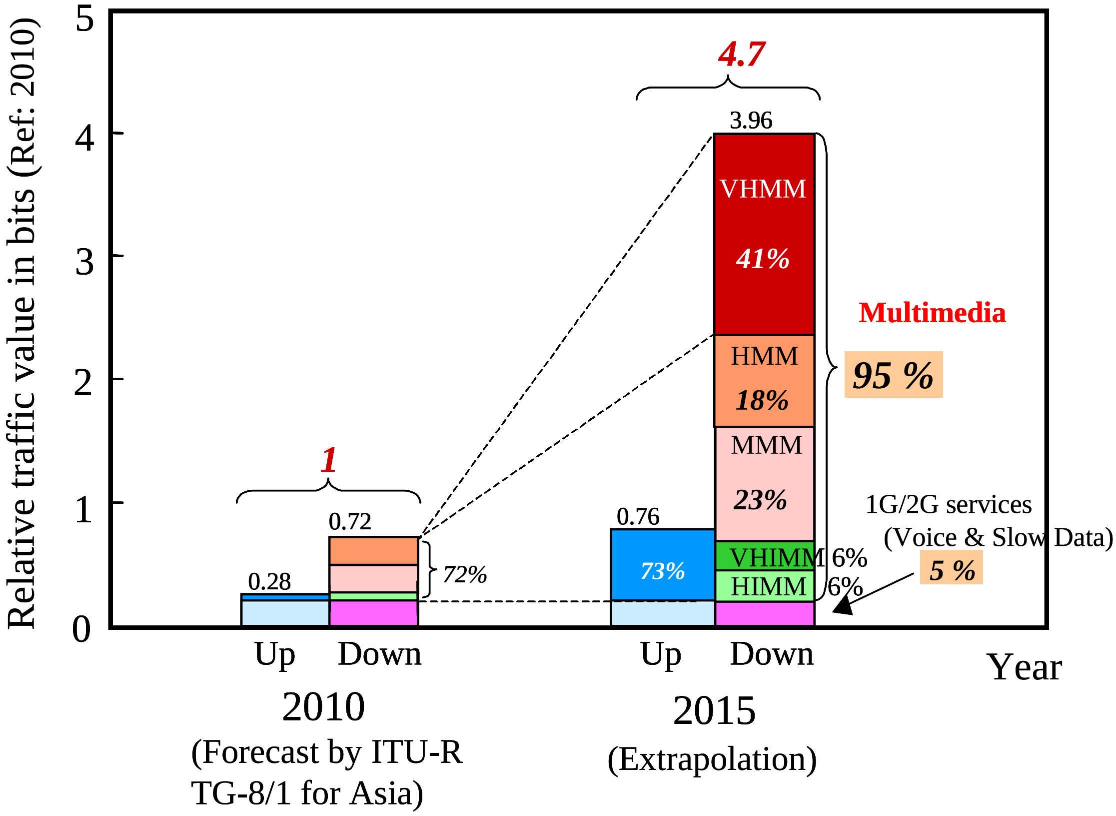

FIGURE 3

Data traffic comparison

Annex 2

PROPAGATION

1 Urban multi-path propagation characteristics issues in the band 3 to 15 GHz

The following text is supplementary information on the issues of urban multi-path propagation characteristics in the band 3 to 15 GHz.

1.1 Summary

Wide-band propagation measurements in 3 GHz band to 15 GHz band are performed in three urban areas using typical macrocellular antenna locations [1]. The comparison of the experimental results show analogous characteristics among the frequency bands 3 to 15 GHz for urban multi-path propagation; averaged power delay profiles have similar structures, and delay spread and maximum delay time have similar value among three frequency bands. These results show that the dominant difference among frequencies in urban multipath propagation characteristics is not found from 3 GHz band to 15 GHz band.

1.2 Measurement procedure and locations

This attachment presents the comparisons of multi-path propagation characteristics at 3 GHz, 8 GHz, and 15 GHz bands based on measurements in three urban areas using typical macrocellular environments. Average surrounding building heights in these three areas are approximately 20 m, 30 m and 20 m, respectively. Base station antenna heights are approximately 30 m, 40 m and 30 m, respectively. The multi-path measurements were performed by using the transmitting waves modulated by 50 Mbps BPSK from a fixed base station to a mobile station. The power delay profiles were obtained by PN code correlation receivers. All base station antennas were 120 degrees beamwidth for horizontal plane and 20 degrees beamwidth for vertical plane. All mobile antennas were omnidirectional and were located on the rooftop of a van.

In all measurements, power delay profiles were received simultaneously for each three frequencies at the van. These profiles were obtained every 30 msec interval. Measured power delay profiles were averaged using 100 profiles. The velocity of the van was set up to 5 km/s, therefore, the averaged power delay profiles correspond to approximately 5m averaged data.

Delay spread and maximum delay time were calculated using the averaged power delay profile. We set the dynamic range for efficient calculation, using the threshold level from the maximum peak level. If the measured delay profile did not have enough dynamic range, the profile was removed for the calculation object. The value of the dynamic range was set to be 15 dB, considering the multi-path influence on receivers for mobile communication system.

1.3 Results

The measured averaged delay profiles for each frequency were received simultaneously at the mobile station. The measured results show the similarity among three frequency bands. The differences among the shape of the profiles in these frequencies are small. Thus, the structures of averaged delay profiles are found to be similar.

Cumulative distributions of measured delay spread and maximum delay time were calculated for all measured data. In the results of cumulative distributions of measured delay spread in one test area, for example, only 0.002 μsec difference of delay spread in 95% point is found between 3 GHz and 15 GHz band. Also in the case of cumulative distributions of maximum delay time, only 0.01 μsec difference of the maximum delay time in 95% point is found between 3 GHz and 15 GHz band. Thus, these are also quite similar results among three frequency bands. The results in other test areas also show the same tendencies.

1.4 Conclusions

Multi-path propagation measurements in 3 GHz band to 15 GHz band were performed in urban macrocell environments. The comparisons of the experimental results show analogous characteristics among frequency bands 3 to 15 GHz for urban multi-path propagation.

The obtained results could be very useful in considering the system requirements of the high bit rate digital mobile communication systems, e.g. further development of IMT-2000 and systems beyond IMT-2000, in which the degradation caused by severe inter-symbol interference due to multi-path propagation could be crucial for reliable radio signal transmission.

1.5 References

[1] Y. Oda, Y. Toki and T. Katagiri, "Frequency characteristics of multipath propagation in urban area," *IEICE of Japan, National Convention*, B-1-40, March, 2000 (in Japanese).

2 Urban path loss characteristics issues in the band 0.4 to 15 GHz

The following text is supplementary information on the issues of urban path loss characteristics in the band 0.4 to 15 GHz.

2.1 Summary

This attachment presents the results of narrowband path loss measurements performed from 0.4 GHz band to 15 GHz band [1]. Focus has been on path loss frequency dependence, particularly above 3 GHz band in urban areas. The measurement campaigns were performed in urban areas using typical macrocellular and microcellular antenna locations. The obtained measurement data shows that the path loss in reference frequency from 0.4 GHz band to 15 GHz band increases in accordance to the free space propagation power law in terms of frequency dependency for both macrocell and microcell environments. Standard deviations of each frequency band exhibit similar values. These measurement results show that the dominant difference among frequencies is found in only free space characteristics from the UHF to microwave frequency bands.

2.2 Measurement procedure and locations

Path loss measurements were carried out in 457.2 MHz, 813 MHz, 2.2 GHz, 4.7 GHz, 8.45 GHz and 15.45 GHz bands in both macrocell and microcell environments to compare at different frequencies under similar conditions. These comparisons were done in four urban areas. Average heights of surrounding buildings in the four urban cities are approximately 25 m, 20 m, 20 m and 30 m, respectively.

In all measurements, antennas at the base and mobile stations were omnidirectional antennas, and were located closely each other to create similar situations for the measurement in all frequencies. The radio waves of the frequencies used in measurements were transmitted simultaneously from the base station. Measurements were taken using a van as the mobile station containing measuring receivers and recording equipment. The radio waves corresponding to the frequencies were simultaneously received by the receivers at the van. The measured data was recorded into the data-recorder with a 0.1 m distance pulse, and averaged for every 100 samples.

We classified the base stations into high-tier or low-tier locations, depending on the antenna height of the base station. Antenna heights of base stations for typical high-tier were more than the average height of surrounding buildings. The antenna heights for low-tier were nearly equal to or less than the average height of surrounding buildings. In addition, measured data were classified by distance R between a base station and a mobile station to compare with previous models, because the Hata model [2] restricts the distance of more than 1 km and the base station antenna height of more than

30 m (high-tier). Measurement scenarios were classified into high-tier (distance R < 1 km), high-tier (R > 1 km), low-tier (R < 1 km) and low-tier (R > 1 km).

2.3 Results and analysis

The measured standard deviations of slow fading were calculated. The calculated values are different among measurement scenarios, however similar results were observed among frequency bands in the same scenarios. Standard deviations of small cell scenarios (R < 1 km) are approximately 2~4 dB larger than those for large cell scenarios (R > 1 km) in almost all measurement areas. Generally, there are some line-of-sight (LOS) areas in a small cell scenario, but the area in a large cell scenario is almost non-LOS (NLOS). Therefore, the changing status from LOS to NLOS would cause a greater standard deviation of slow fading in small cell scenario.

The frequency dependency for each path loss measurement was examined. All results for both high-tier and low-tier environments and for both distance ranges are found to follow the free space characteristics of 20log(f). These trends are similar to the Walfisch-Bertoni model [3] in high-tier environments, but differ from the Hata and COST-Walfisch-Ikegami models [2], [4], where the coefficients of the frequency term in the Hata, Walfisch-Bertoni, and COST-Walfisch-Ikegami models are approximately 26, 21 and 26 to 29, respectively. The Hata model is an empirical formula based on the report by Okumura et al. [5]. This measurement was performed in the frequency range from 150 MHz to 1 500 MHz. The COST-Walfisch-Ikegami model was empirically corrected to fit 900 MHz and 1 800 MHz band measurements. Thus, these empirical models are evaluated using a band lower than 2 GHz or closed frequency bands. Therefore, the previously reported frequency dependency of path loss would be inaccurate when taken from the UHF band to microwave frequency band. In our measurements, wide-range frequency bands measurements present valid frequency dependency.

2.4 Conclusion

The frequency dependency of the path loss in these bands can be characterized by the free space propagation power law (20log(f)) for both macrocell and microcell environments. Therefore, when propagation loss at higher frequency is considered in systems design, we can derive the value by adding the above mentioned relative loss (20log(f)) to the traditionally calculated value at lower frequency.

In considering the frequency bands above 3 GHz, the proposed results can be applicable and very useful in the study of the system requirements of further development of IMT-2000 and systems beyond IMT-2000, instead of conventional path loss formulae.

2.5 References

[1] Y. Oda, R. Tsuchihashi, K. Tsunekawa, and M. Hata, "Frequency dependency on urban mobile propagation characteristics," *IEEE Trans. Veh. Technol* , to be published.

[2] M. Hata, "Empirical formula for propagation loss in land mobile radio services," *IEEE Trans. Veh. Technol.*, vol. 29, pp. 317-325, 1980.

[3] J. Walfisch and H. L. Bertoni, "Theoretical model of UHF propagation in urban environments," *IEEE Trans. Antennas and Propagation*, vol. 36, pp. 1788-1796, 1988.

[4] COST 231, "Urban transmission loss models for mobile radio in the 900- and 1,800 MHz bands (Revision 2)," *COST 231 TD(90)119 Rev.2*, The Hague, The Netherlands, September 1991.

[5] Y. Okumura *et al.*, "Field strength and its variability in UHF and VHF land-mobile radio service," *Rev. Elec. Commun. Lab.*, vol. 16, 1968.

Attachment 2

Working Document for future consideration on PDNR [IMT-SVC]

(Source: Attachment 12 to Doc. 8F/184, Attachment 17 to Doc. 8F/268, 8F/304, 8F/315, 8F/319, 8F/331, 8F/336, 8F/365)

Framework of Services for the Future Development of

IMT-2000 and Systems Beyond

(Question ITU-R 229/8)

Editor's Notes*:

- This document represents an attempt to collect and organize all the material that may be relevant to PDNR [IMT-SVC]. An attempt was made to be overinclusive; therefore some material may be included that is more appropriate for other PDNRs. In performing this work, no word edits were made to any of the text, except to incorporate the very few changes proposed in Docs 8F/304, 8F/315, and 8F/319, and to correct typographical errors.

- The document is proposed to be organized according the the following high-level outline :

1. Introduction
2. Market Trends
3. General Considerations
4. Future Development of IMT-2000
5. Systems Beyond IMT-2000

- Placement of text in sections 4 and 5 was done primarily on the basis of headings. In those cases where the headings did not indicate 'Enhancements' or 'Systems Beyond', the text was placed in the 'General Considerations' section. Conversely, the editor considers that some text specifically labelled for 'Systems Beyond' appears much more general in nature. Nonetheless, this text was place in Section 5. Perhaps as a result, there is very little text describing the future development of IMT-2000.

- "Editor's Notes," which are made in revision/strikeout mode, identify the source of each section of text. Likewise, the new section headings proposed above appear as revision marks. The

* Editor: Mr. David Wye, AT&T Wireless Services

relevant section numbers from the original documents were left in so as to facilitate delegates' review of the sections'origin. Corrections to typographical errors do not appear as revisions.

- As requested by the WG-VIS Chair, an "Objective," which appears on the first page, has been drafted.

- Note that there is still much conceptual redundancy within and between the various sections. No attempt was made to reduce this by leaving out any material. In those cases where identical text was discovered in several documents, the editor's notes indicate muliple sources for the text. The document will benefit from further editing.

- The text within each of these sections is organized according to what seemed to facilitate the most orderly flow of thought and text.

- Note that some text may still overlap with the PDNR [IMT-VIS]. This was intentional so as not to lose any information. Once a final determination is made for IMT-VIS, some text may be able to be deleted from this document.

OBJECTIVE: This document provides a description of the services and capabilities to be provided by the ongoing enhancement of IMT-2000 and systems beyond. It identifies the overall objectives, service requirements, user needs and applications associated with the ongoing enhancement of IMT-2000 and systems beyond, building on the services and capabilities defined in Recommendations ITU-R M.687, M. 816, and M. 1457.

1. INTRODUCTION

[Editor's Note: the following material is taken from 8F/184 INFORMATIVE ATTACHMENT I-2.]

1 Introduction

With the approval of Recommendation ITU-R M.1457 (RSPC) at RA-2000 now the emphasis of the work will be on developing enhancements for IMT-2000 and systems beyond IMT-2000. On a global basis planning for the deployment of systems based on ITU Recommendations. Has commenced already.

Considering how second - generation systems have evolved by adding more and more system capabilities and enhancements to make them close to the capabilities of IMT-2000 systems; it is argued that with third generation systems we will also see a continuum of enhancements that will make those systems practically indistinguishable from future generation systems. Indeed, from now on it is expected that it will be more difficult to identify distinct generation gaps and it may only be possible, if possible at all, by looking back at some point in the future.

The evolution aspects are well covered in the ITU-R Handbook on evolution towards IMT-2000. It may now be the right time to develop specific Recommendations on "Evolution from IMT-2000" based on the principles outlined in the handbook. Indeed what is needed is a framework for orderly growth and ongoing technology deployment.

Some of the enhancements that are expected include:

1) Higher speeds (> 10 Mbit/s).
2) Greater spectral efficiencies.
3) Use of a common frequency band world-wide.
4) Moving from a circuit-switched domain to a packet-switched domain.
5) For radio access: adaptive antennas, multi-user detection, multiple access techniques, etc.
6) Better compression techniques; better QoS; better CODECS; higher capacity.
7) Interference mitigation techniques.
8) Innovative services - technical provisioning for the type of information carried.

As new technologies are developed, their application standardized and the corresponding system enhancements are deployed, it will be more difficult to characterize future systems by specific names. Existing Recommendations do not need to be edited because they represent the first instance of IMT, but in the future it would not be practical to refer to IMT-2001, IMT-2002 etc. There is a need to re-focus the work on identifying the evolving user requirements and establish future benchmarks.

Recommendation(s) will be developed based on the ideas in this report including: service/system requirements, evolution roadmap or framework for orderly growth of system capabilities.

Editor's Note: the following material is taken from 8F/184 INFORMATIVE ATTACHMENT I-2.

2 A market perspective of a future converging world

By 2010, digital delivery will largely have replaced analogue delivery, for all services, including broadcasting. The total requirement for information delivery to a home may be tens of Mbit/s (including several channels of television and all other telecommunications services). The majority of speech calls will be tetherless and a cellular device will be installed in almost all new cars, and location services will be used for traffic management.

Societal changes may lead to a significant proportion of the workforce, for example some 25% in the UK, teleworking at least 2 days/week, while the worldwide population of over 65 year olds increases by 1 million a month.

There will be an explosive growth in the number of persons that wish to communicate, and a rapid introduction of machine-to-machine (M2M) communication.

The boundaries between communications and broadcasting will become increasingly blurred. By 2010 there is expected to be an increasing delivery of video and audio to mobile terminals, leading to significant asymmetry in the total traffic.

From a service perspective systems will involve provision of seamless high data rate wireless services over an increasing number of interacting but nevertheless distinct and heterogeneous fixed and wireless platforms and networks operating across multiple frequency bands.

Multiple service solutions that allow service differentiation of content and application providers while respecting data privacy, information integrity and security must be supported.

Wireless mobility control and management, resource management, customization of application program interfaces and software driven user interfaces for wireless terminals, will be required, supported by suitable infrastructure and protocols.

For future telecommunications purposes, it can be anticipated that many of the users will be technology literate, with sophisticated, demanding and personalized requirements. The user may well perceive telecommunications, information exchange, and entertainment / broadcasting as just part of communications. The means of delivering telecommunications may not be considered important, nor will they wish to be aware of it, although the limitations of performance may be tolerated where there is seen to be either a recognized impediment (examples could be in tunnels, or remote regions) which are part of their environment. The user will expect to have access to a wide range of services, and through them, to a wide range of information and opportunities, and have the choice of a variety of delivery mechanisms (fixed, cellular, WLAN, etc).

3 Systems perspective of a future converging world

To fulfill the market vision, the evolution of IMT-2000 and systems beyond will need to offer:

– seamless services provisioning across a multitude of wireless systems and networks, from private to public, from indoor to wide area;
– optimum delivery of the user's wanted service via the most appropriate network available;
– appropriate technologies for the further frequency bands which may be required to support the expected.

This will involve the interaction of fixed, mobile and broadcasting networks, and the identification or improvement of necessary interfaces between IMT-2000 and other networks and technologies to allow new features to develop and grow.

Editor’s Note: the following material is taken from 8F/184 Annex 1

4.5 System Scenario

Figure 2 shows a map of mobile systems from the viewpoints of transmission bit rate and mobility. Initially IMT-2000 achieves transmission bit rates of up to 2 Mb/s. Ongoing enhancement will incrementally increase this transmission bit rates. Systems beyond IMT-2000, transmission bit rates significantly greater than 2 Mb/s are expected. Because an information bit rate of 100 Mb/s by wired LAN is popular now in offices, and wireless LANs achieve information bit rates of several tens Mb/s, a rate greater than 20 Mb/s seems an appropriate long-term target for systems beyond IMT-2000. The target area of service beyond IMT-2000, which should be covered by mobile systems in the long term time frame, is enclosed with a dotted line.

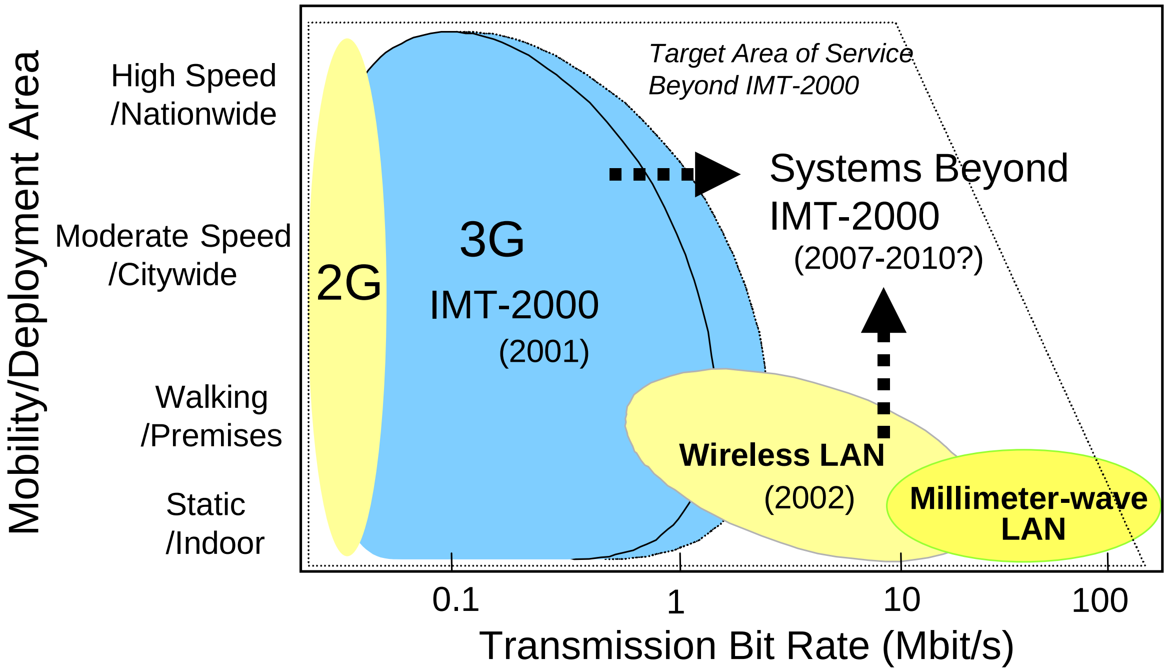

FIGURE 2

Mobile communication systems

Editor's Note: The dates in Figure 2 are to be deleted.

4.6 Deployment Scenarios

The above target area of service beyond IMT-2000 can be covered by a unified system (which may encompass multiple modules) to be developed in the future or multiple systems including the mobile (terrestrial/satellite) systems that already exist today or being developed. The way to cover the service target area is defined as a deployment scenario of systems beyond IMT-2000. The deployment scenario is not identified with the technical capability of the systems. On the same condition of the system capability, there are various deployment scenarios to cover the service target area.

4 Technology perspective

This will involve the interaction of fixed, mobile, satellite and broadcasting networks and rules for distribution and decentralized control of functional entities. It will require the use of protocols that permit the network to adapt dynamically to changing channel conditions (including differences between terrestrial and space delivery mechanisms), that allow the coexistence of low and high-rate users, hand-off of high-data-rate users between base stations, congestion-control algorithms that are cognisant of and adjust to changing channel conditions etc.

It should be noted that technology progress such as new modulation techniques are likely to enable higher bit rates from a given carrier bandwidths. Improved coding (especially of images) may reduce the bit rates required for transmission of information. These may mitigate against the demand for increasing spectrum.

It can be anticipated that there will involve networking on an ad hoc basis, with a myriad of smart and "computational powerful" devices (wireless sensors and actuators embedded in numerous distributed devices, appliances as well as in living beings, capable of monitoring and interacting with the physical world).

Adaptation protocols that permit ad-hoc networks to dynamically self-configure to changing service requirements, that allow the coexistence of low and high-rate wireless devices, including the ability to switch between satellite and terrestrial delivery mechanisms, and that permit better user and application control over such networks will be required.

A broad range of wireless network interfaces that will be capable of transmitting a wide range of data rates over a wide range of average transmission output power levels and operating frequency bands, again supported by suitable infrastructure.

5 Cellular component within the converging world

In the broader context of convergence, it must be recognized that there are other systems beside IMT-2000 that exist today (e.g. broadcasting, WLAN, Satellite, etc). Convergence within the market place in some form in the future is likely, as discussed in the previous sections, and that this will have an associated impact on the technology.

IMT-2000 and Systems Beyond, within the context of a future converging world, could be described as the cellular component of the "converging world". It can be anticipated that there will also be other components such as Broadcast, WLAN, etc. IMT-2000 & Systems Beyond will have a significant part to play.

6 External interfaces and interactions

This section will address the identification of the necessary interfaces between IMT-2000 & Systems Beyond, and the interactions with external bodies necessary to achieve these.

The activities of JTG 1-6-8-9, concerning technical and regulatory requirements of terrestrial wireless interactive multimedia applications, should be relevant to Working Party 8F activities, and vice versa.

2. MARKET TRENDS

[Editor’s Note: The Following Text Is From 8f/268 Annex 3]

Detailed Considerations on market requirements for ongoing development of IMT-2000 and systems beyond

1 Market Trends

The number of subscribers for mobile communications has increased much faster than expected. Annual growth rates in important markets increased from 1998 with about 60 % to expected 100 % per year in 2002. In 2000 the number of mobile subscribers is higher than 400 million worldwide and for 2010 more than 1700 million mobile subscribers are expected worldwide. With third generation systems the combination and convergence of the different worlds IT industry, media industry and telecommunications will integrate communication with information technology. It is expected by the UMTS Forum that in Europe in 2010 more than 90 million mobile subscribers will use mobile multimedia services and will generate about 60 % of the traffic in terms of transmitted bits. These different types of services can be subdivided into individual services like multimedia, e-mail, file transfer etc., symmetrical and asymmetrical services, real-time and non real-time services and distribution services like radio, TV and software provision. The major step from the second to the third generation was the ability to support advanced and wideband multimedia services. The user expectations are increasing with regard to a large variety of services and applications with different degree of quality of service (QoS), which is related to delay, data rate and bit error requirements. Therefore, seamless services and applications via different access systems will be the driving forces for future developments. It is expected that due to the dominating role of mobile radio access the number of portable handsets will exceed the number of PCs connected to the Internet around 2004. Therefore, mobile terminals will be the major man machine interface in the future instead of the PC. Due to the dominating role of IP based data traffic in the future the networks and systems have to be designed for economic packet data transfer. The expected new data services are highly bandwidth consuming. This results in high data rate requirements for future systems.

3. GENERAL CONSIDERATIONS

[Editor’s Note: the following material is taken from Doc. 8F/268 Annex 2]

4 Service Objectives

One key aspect of IMT-2000 systems is that they will be based on defined “service capabilities”, rather than on defined services. These standardised capabilities will provide a defined platform enabling the support of speech, video, multi-media, messaging, data, user applications and supplementary services, while enabling the market for services to be driven by users. This approach will ensure that operators will be capable of rapid development and deployment of competitive service offerings

Support IP-packet data for both real time and non-real time applications for "mid-term" developments.

Editor’s Note: the following material is taken from Doc. 8F/268

4.1 Services Context [*editor’s note: includes changes from Doc. 8F/304*]

The trends from a service perspective include integration of services and convergence of service delivery mechanisms. In particular, there are three pillars for future service integration (CCC):

1 Connectivity (provision of a pipe, including intelligence in the network and the terminal)

2 Content (information, including push-pull)

3 Commerce (transactions)

These market trend swill result in new service delivery dynamics and a new paradigm in telecommunications where value added services such as those which are location dependent will provide enormous benefits to both the end users and the service providers. The convergence will lead to more intelligent use of the communications media, where IMT-2000 will be able to offer the users what they need in any specific mobile environment. The range of applicability of IMT-2000 is very much wider than earlier mobile systems and is expected to include future enhancements which will offer increasingly superior capabilities and performance in low mobility environments, however, also for high mobility applications as well.

Hence, IMT-2000 systems will need to support these service trends in an integrated manner (e.g., suitable QoSs for a service mix, content-dependent characteristics, and secure transaction capabilities). Furthermore, IMT-2000 will complement other means of service delivery, including other mobile and fixed wireless access, wireline, broadcasting, etc., hence convergence of all these systems will need to be considered. There are also many emerging embedded applications and machine-to-machine communications, which will increase the demand for IMT-2000 systems.
In the original version of Recommendation ITU-R M.816 (prior to revision 1) service bit rates of up to 20 Mbit/s were originally envisaged to be supported under favourable circumstances. It is expected that systems beyond IMT should also be able to support spot coverage and 100 Mbit/s+. In the meantime there will be a choice of WLAN chips, based on IEEE 802.11 and HIPERLAN 2 standards, which could be included in mobile terminals to extend their capabilities in certain areas.

[Editor’s Note: the following text is from 8F/184, Informative Attachment I-3 and 8F/268 Annex 1]

2. Services and Applications

Multimedia services and applications with various information speeds will be widely used in the future. Considering the accessibility to services on the Internet in the future, support of IPv6, Voice over IP (VOIP), Quality of Service (QoS), multicast, and real time applications end to end will be required. This should take into account the Quality of Service (QoS) requirements of both real time and non-real time applications. A system capability that enables users to access either the 3G, systems beyond IMT-2000 and wireless private networks such as wireless LANs and also enable seamless roaming between heterogeneous networks without interruption will be requested as well. In addition, geo-location services using air-interface signals and its applications will play an important role in future mobile services. [Following text was moved to this location from 8F/315]

The future mobile applications may be expected as follows;

1) The enhanced services
   - Location information service offering multimedia geographical information in detail
   - Wireless Internet education service
   - Mobile computing service dealing with the multimedia data processing
   - Emergency service : vehicles repair and life rescue
   - Remote health care service
   - Internet videophone service
   - Wireless Internet home shopping and banking service
   - Wireless Internet broadcasting and news service
   - VOD service.
2) The new services
   - High quality image service : HDTV broadcasting service
   - Wireless services according to various QoS
   - Multimedia services transmitted over communication satellites
   - Wireless interface selection service according to the user terminal capability.

[Editor’s Note: the following text comes from 8F/268 Annex 2]

1.2 Objectives [*editor's note: includes changes from 8F/304*]

It is highly expected that the enhanced systems of IMT-2000 and systems beyond may offer the integrated services of broadcasting and wireless communication. Since many advanced wireless communication technologies have been being developed, the implementation issues of systems to launch the new services might be easier. Thus, prior to determination of the future system features, it is valuable to consider what kind of services are going to be provided in the future.

According to the trend of services, the future systems such as terrestrial wireless interactive multimedia systems, which arises with the terrestrial components of enhanced systems of IMT-2000 and systems beyond, is expected to have to consider the following items:

– seamless services across various wireless systems and networks;
– global roaming service between existing systems and the future systems including the fixed network;
– appropriate technologies to employ the future services.

When the future system is developed, items mentioned above have to be considered. In current Vision PDNR, there are many requirements and considerations of system features. On the other hand, the contents of future services are insufficient in the current PDNR. Thus, it is required to discuss the future services in Vision Working Group.

When launching future systems, enhanced and new services will appear. After several years from now, it is expected that there are many enhanced services using the future systems in the world. For example:

[Editor's Note: the text that was found here was moved to Annex 1 according to Doc. 8F/315 and is now found directly above.]

[*Editor's Note: following text is from 8F184 Annex 1 and 8F/268]*

7.1 General Requirements

– Support terminal and personal mobility
– Usability on variable environments (high/low tier movement, indoor, satellite, etc.)
– Roaming and hand-over support to other different systems [and networks]
– Guarantee comparable quality with wire-line network
– Global seamless support
– Support of data rate from [2 Mbps] (full movement) to [20 Mbps] (Still) in new mobile systems

[Editor's Note: following text is from 8F/184, Informative Attachment I-3]

2.5 Coverage

From the user's viewpoint, it is important to cover a wide service area equivalent to the present cellular systems. It is also necessary to cover vehicular environments. There are several radio operating environments, and radio systems are designed taking into account of the assumed operating environments. By taking advantage of seamless service, service area in different environments can be covered complementarily by several systems. The satellite component may be used in conjunction with the terrestrial component to facilitate global coverage, particularly in large geographical areas. In the longer term cell size is [TBD].

2.6 Security

Authentication protocols are required between public and private networks to support a seamless service.

[Editor’s Note: the following text is from 8F/268 Annex 1]

3. System capabilities

Initially IMT-2000 achieves transmission bit rates of up to 2Mbit/s. Ongoing enhancement will incrementally increase these transmission bit rates.

A peak data rate of 100 Mbit/s by wired LAN is now common in offices, and wireless LANs achieve information bit rates of several tens Mbit/s. Data rates significantly greater than 2Mbit/s seems an appropriate medium-term target for IMT-2000 systems working co-operatively with these and other delivery platforms as the mobile element of a convergence scenario.

The evolution of mobile communication systems beyond 3G will include continuous improvements of the systems and their integration into a “network of networks“, including systems for short range connectivity as well as broadcast systems.
The mobile elements of systems beyond IMT-2000 might need to offer data rates significantly greater than 20Mbit/s, otherwise they will not really fulfil the definition of "systems beyond".

[Editor’s Note: the following text is from 8F/268 Annex 1]

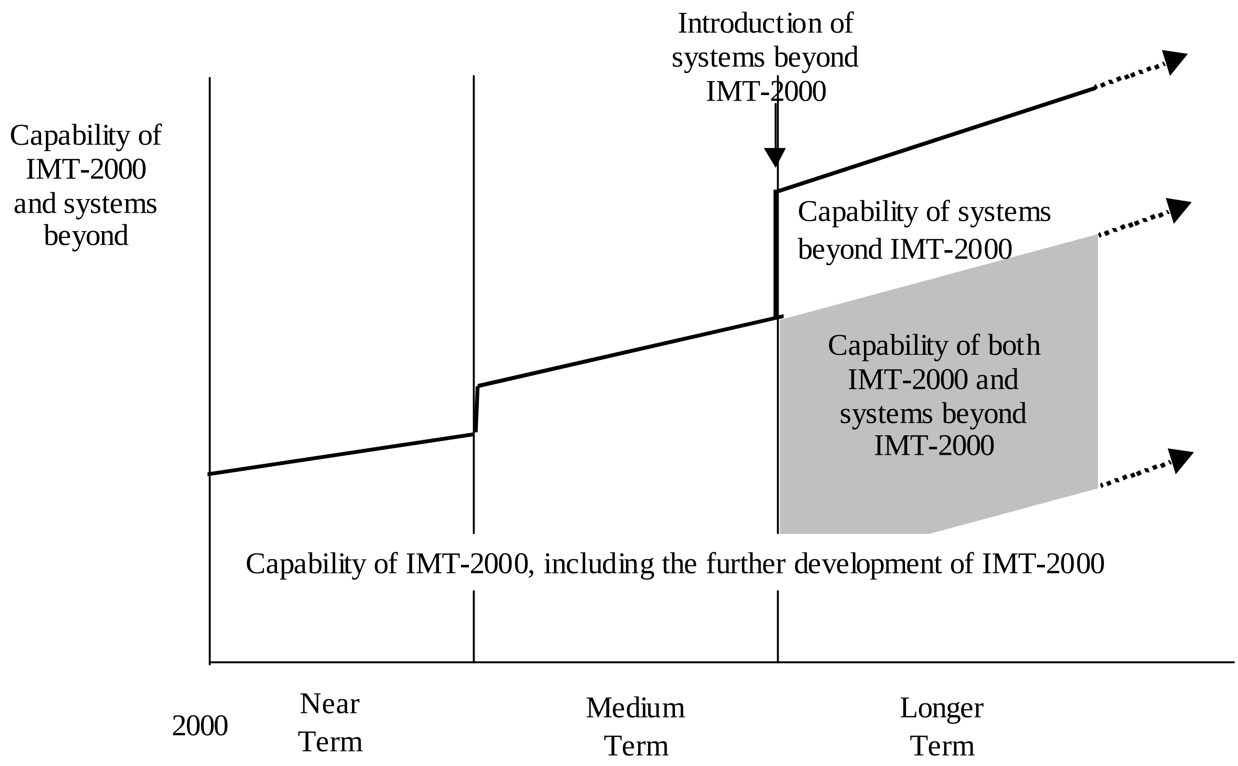

FIGURE 1

Capability of IMT-2000 and systems beyond

[Editor's Note: the following material is taken from 8F/184 Annex 1]

4.7 Developing Country

Editor's Note: The following recommendation and Handbook should be utilized in the development on the subject area of Developing Country (M.819-2).

4. FUTURE DEVELOPMENT OF IMT-2000

[Editor's Note: the following text is from 8F/184 IA I-6]

4 An example of Focus Area: IP Broadband Wireless Access

Wireless communications has created a generation of users who are entirely dependent on portable devices for personal connectivity. The underlying technologies have matured to a level where portable telephony is ubiquitous, and a very large and dynamic market has formed. One promising new area for the transparent convergence of the Internet and wireless is portable broadband Internet access.

The advent of the Internet into personal and commercial communications is creating new opportunities as well as new challenges for telecommunication system planners, operators and equipment designers and manufacturers. In particular, it is agreed that wireless access to the Internet will soon represent an enormous market (Fig. 2). Satisfying the needs of the wireless users, while continuing to meet the requirements of the myriad service providers who are offering their wares on the fixed or wired Internet creates additional challenges. Wireless providers may not be able to meet these challenges with today's offerings, and will be hard-pressed to meet even with the next generation of wireless networks that are in various stages of planning. However, new enabling technologies such as packet radio, adaptive antenna systems and Internet-derived architectures may make access to the rich content (streaming video, etc.) of the Internet as pervasive as cellular telephony today.

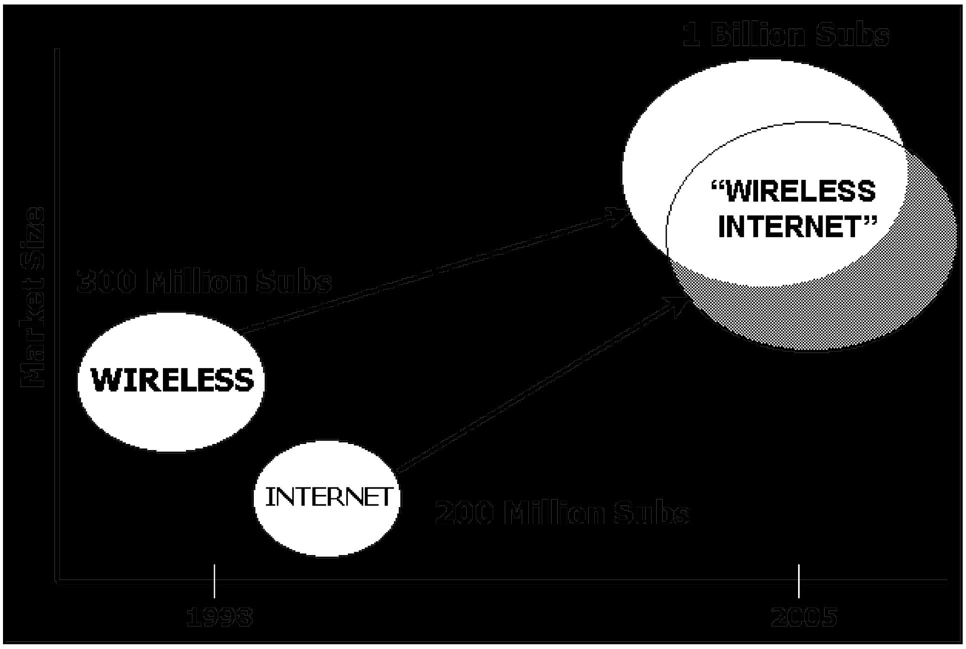

FIGURE 2

The entire Internet industry has grown due, in part, to the low entry barrier for a vast variety of content and services. But whereas in many markets wired residential consumers have seen bandwidth rise from 9.6 kbits/s to over 1 Mbit/s at somewhat affordable prices, the same consumers still have great difficulty to gain web-browsing access to the Internet when they leave their fixed, wired connections. Although an industry has evolved around "broadband wireless" systems as identified on Figure 1, these are targeted at providing high-speed connections to fixed locations and buildings, not people.

Historically, despite the mobile wireless industry's repeated attempts at providing wireless data services, customers were often reluctant, though there are now some widespread consumer success stories: for example, the numerous applications and end-user devices in the Personal Handiphone and i-Mode networks in Japan, and the enormous adoption of short messaging service in GSM networks. But the adoption of packet-based networks for wireless systems has so far been gated by the need to provide circuit-switched voice services on these networks. Consequently, the adoption of end-to-end packet networks has been slowed in the past by the lack of consumer demand. In addition, most end-user devices are based on telephony concepts rather than designed as Internet appliances. Only recently have portable Internet appliances designed for wireless connectivity started to emerge.

Mobile wireless data applications can be categorized into segments that become increasingly more demanding in complexity, bandwidth and transparency to Internet content and protocols:

- Basic Internet content (e.g., weather, stocks, and news) is widely available today in most commercial mobile networks, using the Wireless Application Protocol (WAP) and other Web clipping techniques, and is delivered to mobile phones in text form.
- Over the next few years, network-enhanced applications - those that require some level of intelligence and transactional capability in the network - such as geolocation-ready applications, will emerge on these devices. Those applications have real value and are not demanding of bandwidth - only of network intelligence and preprogrammed interaction between the network and the user.
- Next, there is a variety of applications that require some level of security and reliability, such as mobile secure commerce and corporate access to intranets. Here, the issue is more complex in that the end-user has some specific and very demanding needs, such as security and encryption; those problems are being solved today.
- Undoubtedly, the IMT-2000 family of systems will allow for a considerably enhanced Internet user experience. However, from a practical standpoint it could be argued, given the ever increasing needs for voice access, that unless VoIP on a packetized network will be available, wireless access would still lag behind wireline access in terms of transparent Internet access ease, quality and affordability. Thus there is a case for specifications and standards for wireless system architectures that would enable providing business users and consumers very fast data-rate connection to the Internet, with freedom to move, and an always-on experience. Such a standard would, alongside the main components of the IMT-2000 family, focus on the arguably vast niche of data-only access mechanisms, and be wholly complementary of the other IMT-2000 family components.

The growth of the Internet is the key engine behind the need for such a standard. The greater the use of the Internet in day-to-day life and the greater the breadth of applications on the Internet, which users will experience at fixed stations, the greater will be the need for a service that allows them the same unfettered access while at a different, but un-served location. One of the goals of establishing such a standard would be to offer to all an "untethered multimedia experience". A new breed of application developers will extend broadband applications to the portable domain, as well as invent them specifically for that domain, such as broadband geolocation services and content. Such services would include tele-work, tele-health, tele-education, entertainment, tourism, gaming, and instructional content.

[Editor’s Note: the following text is from 8F/184 Annex 1 and 8F/268]

5.2.1.1 Target of Mobility and Information Bit Rate

Ongoing enhancements will increase the information bit rates beyond that current envisioned for IMT-2000 for all classes of mobility. It is envisioned that peak AMBR[1] will be less than [20 Mb/s] in multi-user and multi-cell environments.

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[1] Recent systems under development are supposed to apply adaptive modulation/coding techniques. These systems change information bit rates according to the propagation conditions, interference, and congestion. Because of this, there may be areas where the maximum possible bit rate cannot be achieved. Therefore, a new definition of throughput will be necessary to evaluate the systems. For example, the area averaged maximum possible bit rate (AMBR) as shown in Equation (1) is a candidate for such a definition.

$$AMBR = \frac{1}{S}\int MBR(s)ds \qquad (1)$$

MBR(s) represents the maximum possible bit rate at a particular geographic point, s is the cell area surrounding that particular point, and S is the total service area under consideration.

[Editor's Note: the following text is from 8F/184 Annex 1 and 8F/268]

5.2.1.2 Coverage

The satellite component may be used in conjunction with the terrestrial component to facilitate global coverage, particularly in large geographical areas. For "mid-term", coverage support same wide-area cell-size as in IMT.RSPC.

[Editor's Note: the following text is from 8F/184 Annex 1 and 8F/268]

2.1.3 Security

Authentication protocols are required between public and private networks to support a seamless service. These authentication and security services will address both the needs of the user and the network itself. The protocols must also support a single user having multiple IMT-2000 devices that are in use simultaneously.

5. SYSTEMS BEYOND IMT-2000

[Editor's Note: the following text is from 8F/268 Annex 2]

2.2 Systems Beyond IMT-2000

From the user perspective the vision for mobile communications can be described as a multi sphere level concept. 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. Level three ensures the direct communication to instant partners as other users and vehicles. Different radio access systems like terrestrial systems, satellite systems and HAPS (High Altitude Platform Stations) are provided in level four for full area coverage. These levels are surrounded by the Cyber World (services and applications domain) in level five, where games, access to databases and the Internet, communication etc. are provided. Therefore, the different communication relations person to person and mainly machine to person and vice versa and machine to machine will determine mobile and wireless communications in future.

This vision from the user perspective is the driving force for seamless services and applications via different access systems for future developments. Due to the future dominating role of IP-based data traffic and applications, networks and systems have to be designed for economic packet data transfer. The fixed Internet penetration is growing in parallel to the mobile radio access penetration. About 80 % of fixed Internet users are also using mobile communications. Therefore, these users want to get the same services also on mobile terminals. These services require a high degree of asymmetry between uplink and downlink especially for Internet type services with much higher expected capacity on the downlink.

Several access technologies are evolving and emerging. In addition to second and third generation mobile communication systems, broadband WLAN type systems as HIPERLAN 2, IEEE 802.11 and broadcast systems as DAB and DVB-T are becoming available. For short-range connectivity systems like Bluetooth are being developed. In the fixed access, systems as xDSL and in particular ADSL are increasing the user data rate significantly on the last mile. All these technologies will be part of systems beyond third generation, which are applicable to data communications. The WLAN type systems are designed in particular for high data rate access, low range and in general for low mobility. They are applicable for corporate networks and public access for hot spot applications as complement to cellular mobile radio systems (e.g. GSM and IMT-2000 / UMTS). Fixed wireless access or wireless local loop systems are developed to replace or complement wired access systems. DAB and DVB-T can be applied to wideband broadcasting data services in the downlink. These systems can be combined with cellular mobile radio systems as GSM and UMTS and the PSTN and ISDN for the uplink as return channel for user requests and highly asymmetrical services. The combination of these technologies represents a very flexible and powerful platform to support future requirements on services and applications, which will be part of mobile communications beyond third generation. In addition, research activities are starting to develop new radio interface concepts, which may support higher data rates with higher mobility than current third generation systems.

This vision from the user perspective can be implemented by integration of these different evolving and emerging access technologies in a common flexible and expandable platform to provide a multiplicity of possibilities for current and future services and applications to users in a single terminal. The available, emerging and evolving access technologies have basically been designed in the classical vertical communication model that a system has to provide a limited set of services to users in an optimized manner. Systems beyond third generation will mainly be characterized by a horizontal communication model, where different access technologies as cellular, cordless, WLAN type systems, short range connectivity and wired systems will be combined on a common platform to complement each other in an optimum way for different service requirements and radio environments. These access systems will be connected to a common, flexible and seamless core network. The mobility management will be part of a new Media Access System as interface between the core network and the particular access technology to connect a user via a single number for different access systems to the network. This will correspond to a generalized access network. Global roaming for all access technologies is required. The interworking between these different access systems in terms of horizontal and vertical handover and seamless services with service negotiation including mobility, security and QoS will be a key requirement, which will be handled in the newly developed Media Access System and the core network.

[Editor’s Note: the following text was moved here from 8F/268 Annex 5]

1.2 Requirements for Future Mobile Communications from the User Perspective

Given the increasing demand of flexibility and individuality in the society, the mean for the end-user must be assessed. Potentially, the value would be in the diversity of mobile applications, hidden from the complexity of the underlying communications schemes. This complexity would be abstracted into an intelligent personality management mechanism, learning and understanding the needs of the user, and controlling the behavior of their reconfigurable terminal accordingly in terms of application behavior and access to the supporting services.

Collaborative research work attempts to rationalize this ‘seamless wireless utopia’ by studying the ‘real’ requirements for reconfigurable terminals and creating realistic working scenarios. Technology research will identify the system support concepts, enabling technologies and standardization required to realize the scenarios, and through subjective evaluation, system modelling and simulation, will evaluate the feasibility of the proposed solutions.

Table 1 shows the dominant high-level requirements for reconfigurable radio from the perspectives of users, application/content providers, service providers, network operators and equipment manufacturers. Based on these requirements, the demands on the end-to-end system concepts and corresponding enabling technologies may be derived.

TABLE 1

End user high level requirements

END USER HIGH LEVEL REQUIREMENTS	
Ubiquitous mobile access	Robust connection is essential *Access to mobile-specific web, multimedia, broadband and broadcast content: seamless handoff between radio access modes (user not interested in which ones).* Service discovery and transparent dynamic adaptation of applications to match available services and preference profiles; home country roaming will become an issue for users Global roaming (important for only a small subset of potential users)
Quality expectations vary with task	Service degradation and dropped service (e.g. broadcast TV, interactive games, voice telephony) must be managed. Similar levels of service are expected on the train as in the home. User must have high-level control where cost is concerned.
Ease of access to applications and services	Current technologies will set benchmarks (e.g. Internet download) Transparent discovery and switching between services and radio access modes, based on an intelligent establishment and interpretation of user preferences and application requirements. However, some users will require more control for private vs. business use.
Low cost and relevant services and meaningful billing	Intelligent discovery, presentation and selection of service options and billing schemes; distribution of application processing between network and terminal to reduce terminal resource requirement. Billing should hide some of the inherent system complexity, i.e. only one bill. Set cost constraints for services
Technology comfort	User friendly consumer product model versus computer (PC) model: computer-literacy should not be required but may be useful. Intelligent client-server management schemes must offer freedom from complex PC-like application installation and configuration; but users may still want some control; User-friendly handling of delays, disconnections and new connections via meaningful feedback to the user; Transparent handling of version/configuration control for application and system software (including radio access stack software) and accountability of system to user for reconfiguration changes. Support expected from the service provider and operator in finding services and updating software. Intelligent use of battery resource, both locally (local application, display, sound) and in network access Simple UI and appealing aesthetic.
Reasonable equipment life	Expectation that terminal equipment will offer support for fast-evolving complexity and diversity of applications and services
APPLICATION DEVELOPER/CONTENT PROVIDER	
Common Execution Environment	Allowing development of applications and associated content independently of underlying network services and terminal capabilities: self-configuration via capability exchange
Application Diversity	Terminals capable of supporting fast-evolving complexity and diversity of applications and services; Utilization of increasing terminal resources to enrich application (e.g. spare DSP processing capacity)
SERVICE PROVIDER	
Fast, open service creation, validation and provisioning	Allowing development of services independently of underlying network services; Provisioning of validated services configured to underlying network and terminal capabilities
Inform user of services available	Requirement for an effective scheme to ‘advertise’ available services in a service discovery negotiation
Maintain connections and adapt to required QoS	*Ability to seamlessly switch connections to alternate radio access schemes or alternate network operators both in call and in standby* *Dynamically modify resource allocation to maintain desired QoS over radio channels*

NETWORK OPERATOR	
Maximize utilization of allocated spectrum	Flexible allocation of spectrum according to differing user demands. Radio resource and network management to support coexistence of access schemes within allocated bands and spectrum sharing between operators.
Maintaining QoS	Maintenance of Quality of Service is a fundamental measure of network operator performance
Longevity and flexibility of network equipment	Supporting reconfiguration in the radio access equipment and the media access fabric interfacing to the core network
Owning customers	Mechanisms to support operator control of terminals, at all levels
TERMINAL AND COMPONENT MANUFACTURER	
Economies of scale	Consolidation of product variants onto reconfigurable product platforms
Bug fix and software enhancement provisioning	Ability to download and install software to overcome bugs and enhance functionality/performance reduces recall costs and increases differentiation and revenue stream
Fast product creation	Reconfigurable IP authoring fostering maximized reuse, hardware/software codesign and platform-based IP integration methodology

[Editor's Note: The Following Text Is From 8f/268 Annex 5]

Detailed Considerations on capabilities of ongoing development of IMT-2000 and systems beyond

1 Capabilities for the System Beyond IMT-2000

1.1 General Requirements

– Support terminal and personal mobility
- Flexible allocation of required system capacity
– Usability on variable environments (high/low tier movement, indoor, satellite, etc.)
– Seamless service via different technologies. Global roaming and hand-over support to other different systems
– Provision of QoS for real time services and efficient transport of packet oriented services. Guarantee comparable quality with wire-line network
– Global seamless support of a wide range of services including symmetrical and asymmetrical services
– Support of a wide range of data rates according to economic and service demands from [2 Mbit/s] (full movement) up to about [20 Mbit/s] and beyond (stationary or nearly so) in new mobile systems
- Requirements for Future Mobile Communications from the End-User Perspective
- Efficient support of broadcast and distribution services
- Economic deployment of systems in the entire coverage area with optimized radio interfaces for macro cells, micro cells, indoor, hot spots and broadcast
- Allocation of significant parts of the system complexity to the base station to simplify terminal implementation
- Reconfigurability of network entities and terminals

Systems beyond IMT-2000 will have to support a wide range of symmetrical and asymmetrical services. QoS for real time services and efficient transport of packet oriented services is required, as well as the efficient support of broadcast and distribution services. Seamless service will have to be provided via different technologies, supported by global roaming, as well as the efficient support of broadcast and distribution services.

Allocation of significant parts of the system complexity to the base station shall be envisaged in order to simplify terminal implementation. Reconfigurability of network entities and terminals will be necessary.

[*Editor's Note: following text is from 8F184 Annex 1*

5.4 Service Objectives

Support IP-packet data for both real time and non-real time applications for "mid-term" developments.

[Editor's Note: the following text is from 8F/184 IA I-6]

2.3 Target of service

Figure 1 shows a map of mobile systems from the viewpoints of information speed and mobility. IMT-2000 achieves information bit rates of up to 2 Mb/s. Ongoing enhancement to IMT-2000 will incrementally increase this information rate, systems beyond IMT-2000 the information bit rates significantly greater than 2 Mb/s are expected. Because an information bit rate of 100 Mb/s by wired LAN is popular now in offices, and wireless LANs achieve information bit rates of several tens Mb/s, a rate greater than 20 Mb/s seems an appropriate long-term target for systems beyond IMT-2000.

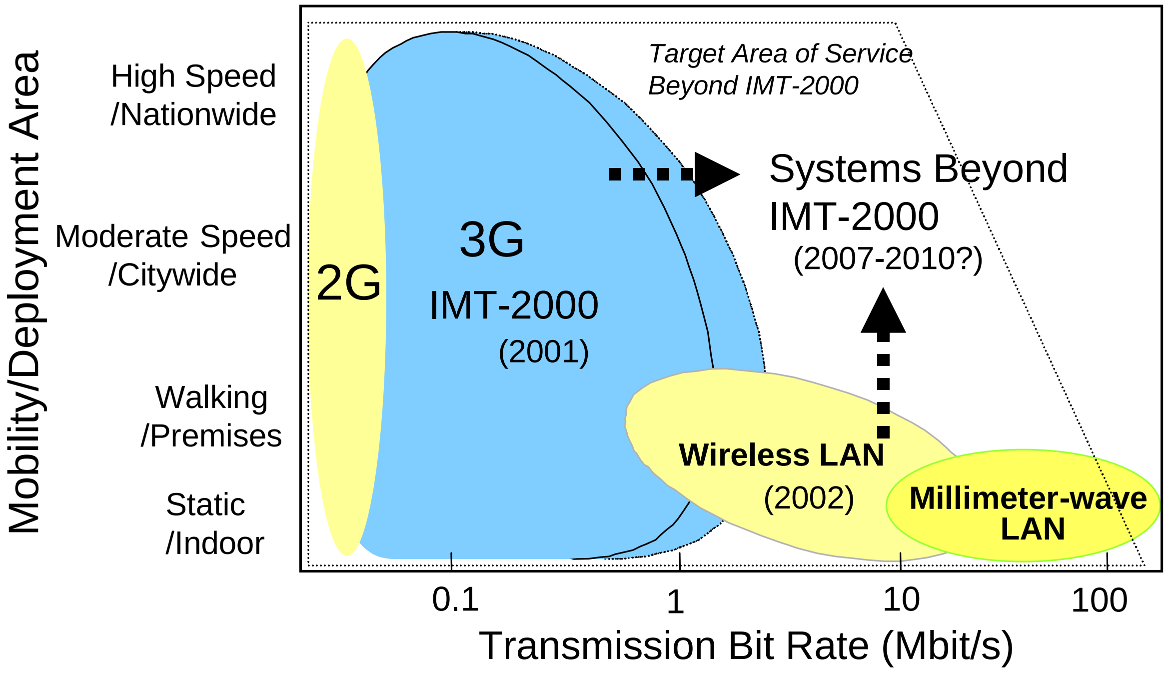


FIGURE 1

Mobile communication systems

[Editor's Note: the following material is from 8F/184 IA I-9. This placement is roughly consistent with the movement proposed in 8F/319.]

1 Discussion A

As a base for further consideration regarding technical requirements of the systems beyond IMT-2000, we consider two types of basic deployment scenarios, which are referred as an all-round-type scenario and a complement-type scenario. In the all-round-type scenario, the systems beyond IMT-2000 cover the whole ranges of the mobility and the transmission rate. On the other hand, in the complement-type scenario, the systems beyond IMT-2000 are located in the position not covered by the other mobile systems. The positions of the systems in the all-round-type scenario and the complement-type scenario are shown in Figures I-9.1 and I-9.2, respectively. Representative technical requirements for the systems beyond IMT-2000 in the two types of deployment scenarios are as follows;

i) In the all-round-type scenario, the systems beyond IMT-2000

– supports a wide range of transmission bit rate,

– supports a wide range of mobility,

– provides various types of service as a unified system,

– has functions of 2G, 3G and the other mobile systems,

– deploys base stations in whole areas,

– can replace 2G, 3G and the other mobile systems, and

ii) In the complement-type scenario, the systems beyond IMT-2000

– supports a higher transmission bit rate,

– supports a cellular range of mobility,

– provides various types of service with 2G, 3G and the other mobile systems,

– has function to interface with 2G, 3G and the other mobile systems,

– deploys base stations only in cellular areas,

– exists together with 2G, 3G and the other mobile systems.

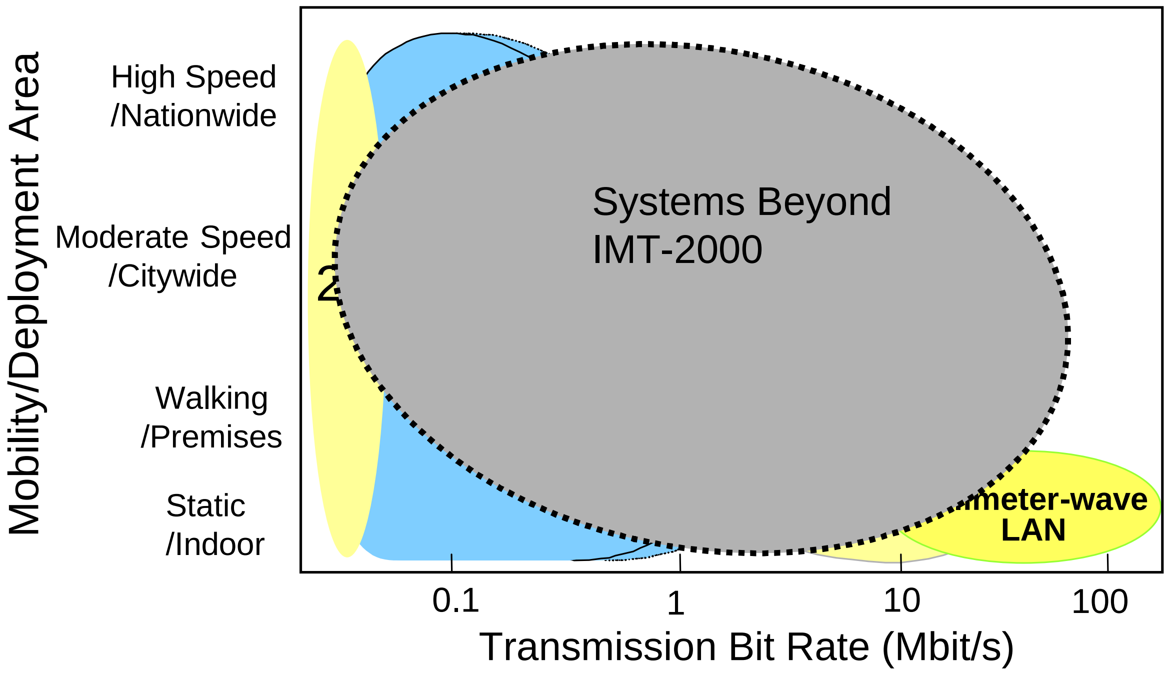


FIGURE I-9.1

All-round-type scenario

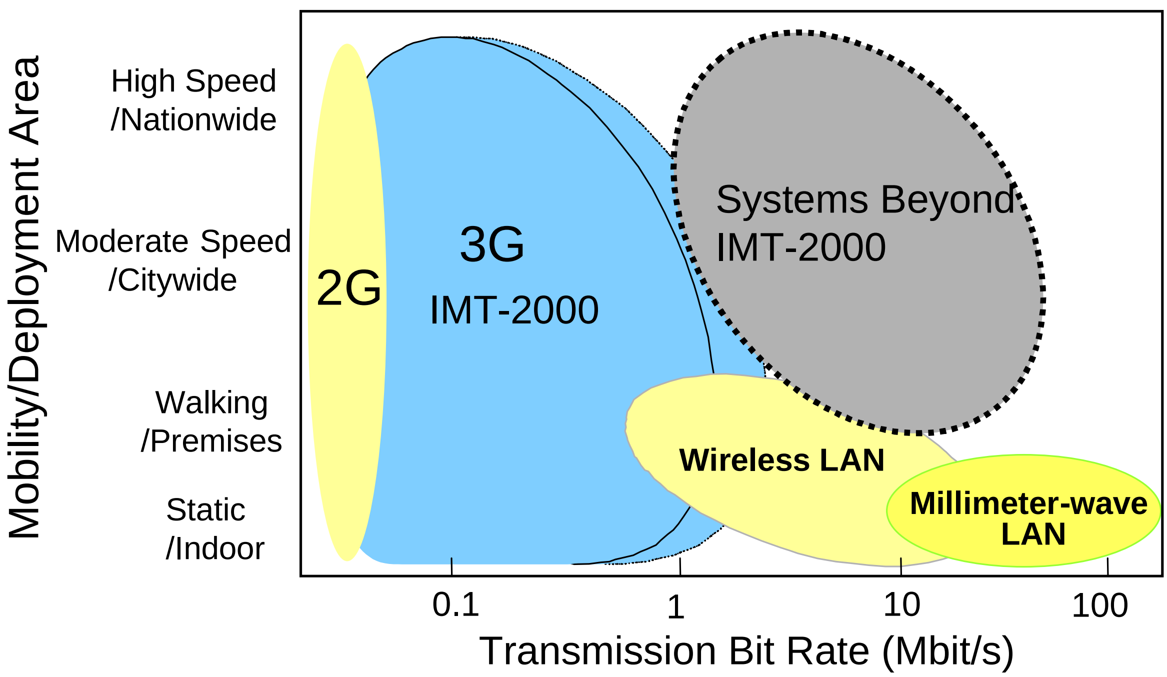


FIGURE I-9.2

Complement-type scenario

[Editor's Note: the following text is from 8F/184 IA I-9]

1.1 Position of systems beyond IMT-2000

As one interpretation to various targets of mobile communication and wireless access services, the service targets are defined on a plane consisting of vertical and horizontal axes indicating mobility speed and transmission rate, respectively. According to the definition, a target of service beyond IMT-2000 is illustrated with that of each mobile communication and wireless access service in Figure 1. The service target beyond IMT-2000 covers a wide area, both in terms of mobility speed and transmission rate, and the upper right coverage of the area is closely related to the maximum specifications of the systems beyond IMT-2000.

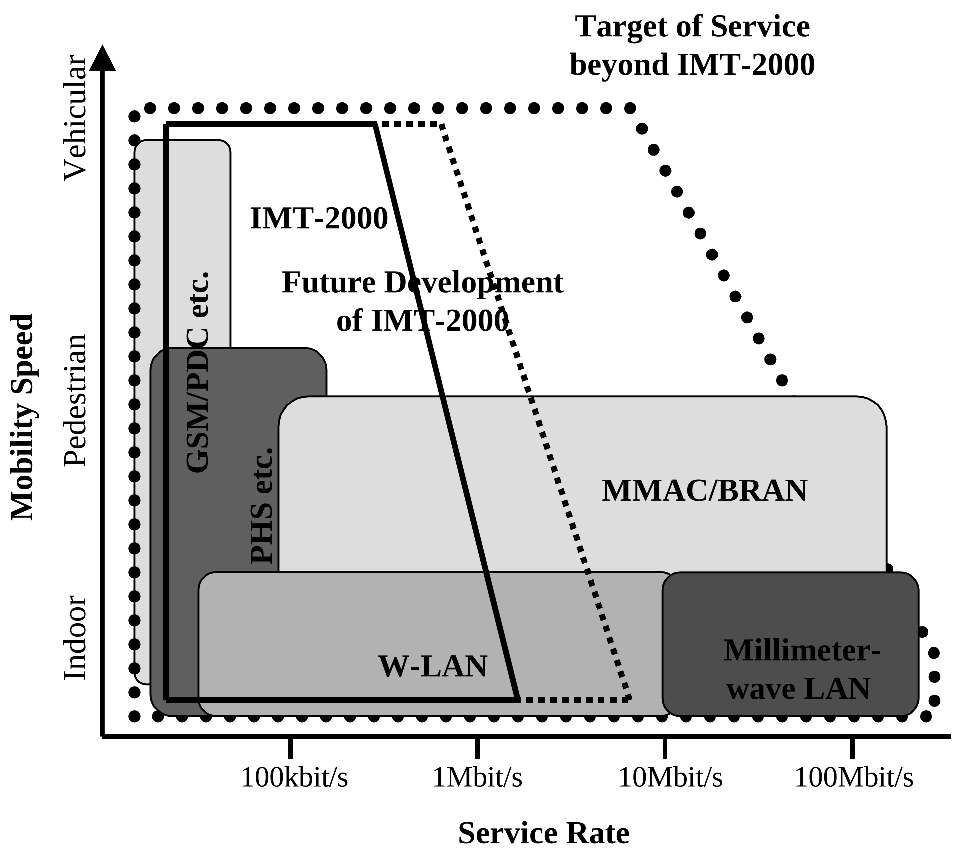


FIGURE 1

Position of Systems beyond IMT-2000

1.2 Deployment scenarios of systems beyond IMT-2000

The above target area of service beyond IMT-2000 can be covered by a unified system to be developed in the future or multiple systems including the mobile communication and wireless access systems that already exist today or being developed. The way to cover the service target area is defined as a deployment scenario of systems beyond IMT-2000. The deployment scenario is not identified with the technical capability of the systems. On the same condition of the system capability, there are various deployment scenarios to cover the service target area. As examples of the deployment scenarios, we propose four scenarios for the systems beyond IMT-2000 from a viewpoint of deployment area and service rate. The deployment scenarios are as follows:

1) Scenario I: All-round-type

   The systems beyond IMT-2000 cover the whole ranges of the deployment area and the transmission rate. The position of the systems is shown in Figure 2(a).

2) Scenario II: Complement-type

   The systems beyond IMT-2000 are located in the position not covered by the other mobile communication and wireless access systems, both in terms of the deployment area and the transmission rate. The position of the systems is shown in Figure 2(b).

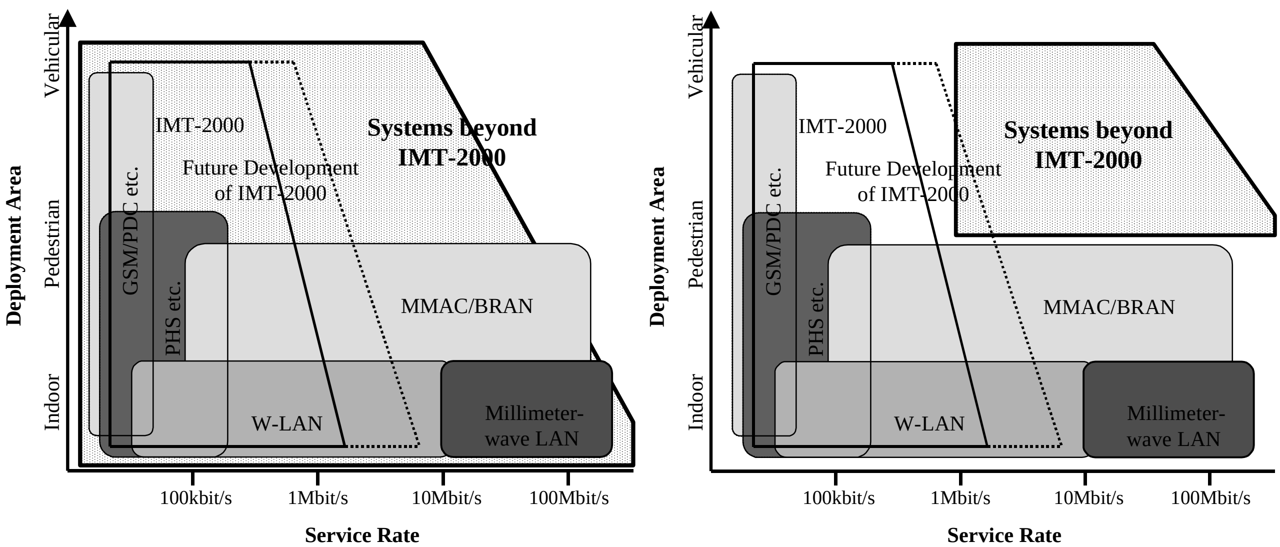
3) Scenario III: Area-complement-type

   The systems beyond IMT-2000 cover the whole range of the transmission rate and are located in the position not covered by the other mobile communication and wireless access systems in terms of the deployment area. The position of the systems is shown in Figure 2(c).

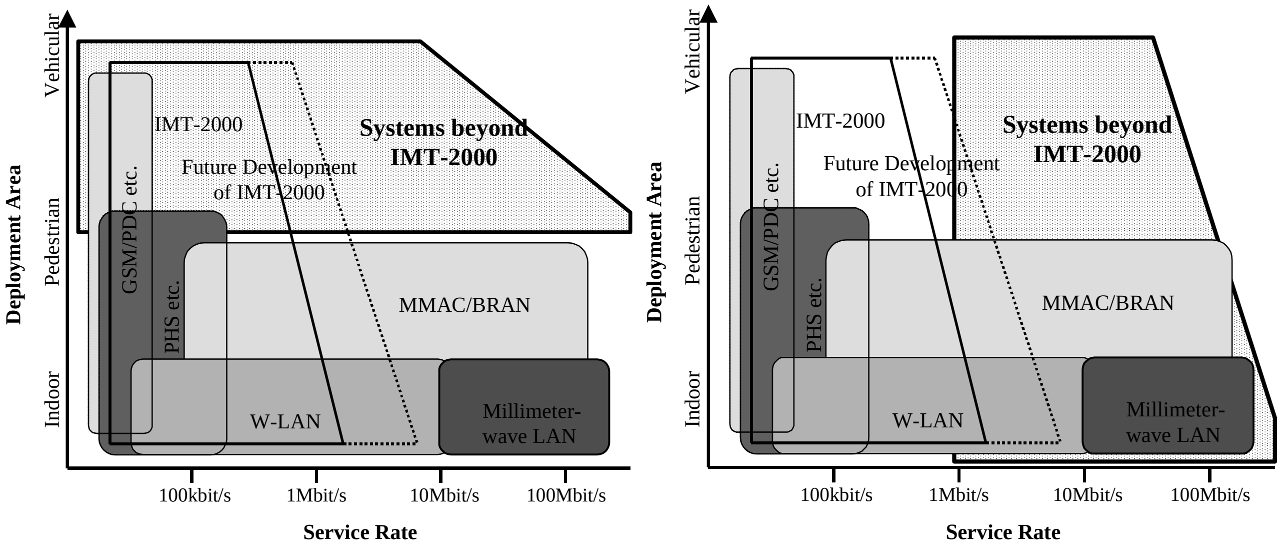
4) Scenario IV: Rate-complement-type

   The systems beyond IMT-2000 cover the whole range of the deployment area and are located in the position not covered by the other mobile communication and wireless access systems in terms of the transmission rate. The position of the systems is shown in Figure 2(d).

Regarding all scenarios, the systems beyond IMT-2000 need to have high mobility and wide-band transmission capability in order to cover the service target area. Furthermore, the systems in the complement-type scenarios II, III and IV require system roaming capability to support seamless service across the other mobile communication and wireless access systems. Such requirements of the systems beyond IMT-2000 and their necessity and importance to achieve the service target depend on the deployment scenarios of the systems. Table 1 shows differences between the all-round-type scenario and the complement-type scenarios from several technical viewpoints.



(a) Scenario I: All-round-type (b)Scenario II: Complement-type



(c) Scenario III: Area-complement-type (d) Scenario IV: Rate-complement-type

FIGURE 2

Scenarios of systems beyond IMT-2000

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2 Discussion B

2.1 The Scope of the System Beyond IMT-2000

The system beyond IMT-2000 can be composed of two stages with different time frame. We like to think that the system beyond IMT-2000 should be developed at first as "converging stage" and then the next as "mature stage". These two stages can be diagrammed as shown in Figure I-9.3 and I-9.4.

As shown in Figure I-9.3, converging stage in dark shades in the background, provides an integrated network to support various network technologies. Specifically the evolved IMT-2000 system to support up to 10 Mbps, and the evolved Wireless LAN capable of more than 54 Mbps support are expected to be integrated with Wireless PAN and Broadband Wireless Access System in this stage.

In Figure I-9.4, mature stage, describes the advent of new system, in the darkest shade, which provides high data rate in mobile telecommunication network up to 20 Mbps. With more evolved Wireless LAN, Broadband Wireless Access systems and IMT-2000 system, new system encompasses a integrated convergence network, which is broader than that of converging stage.

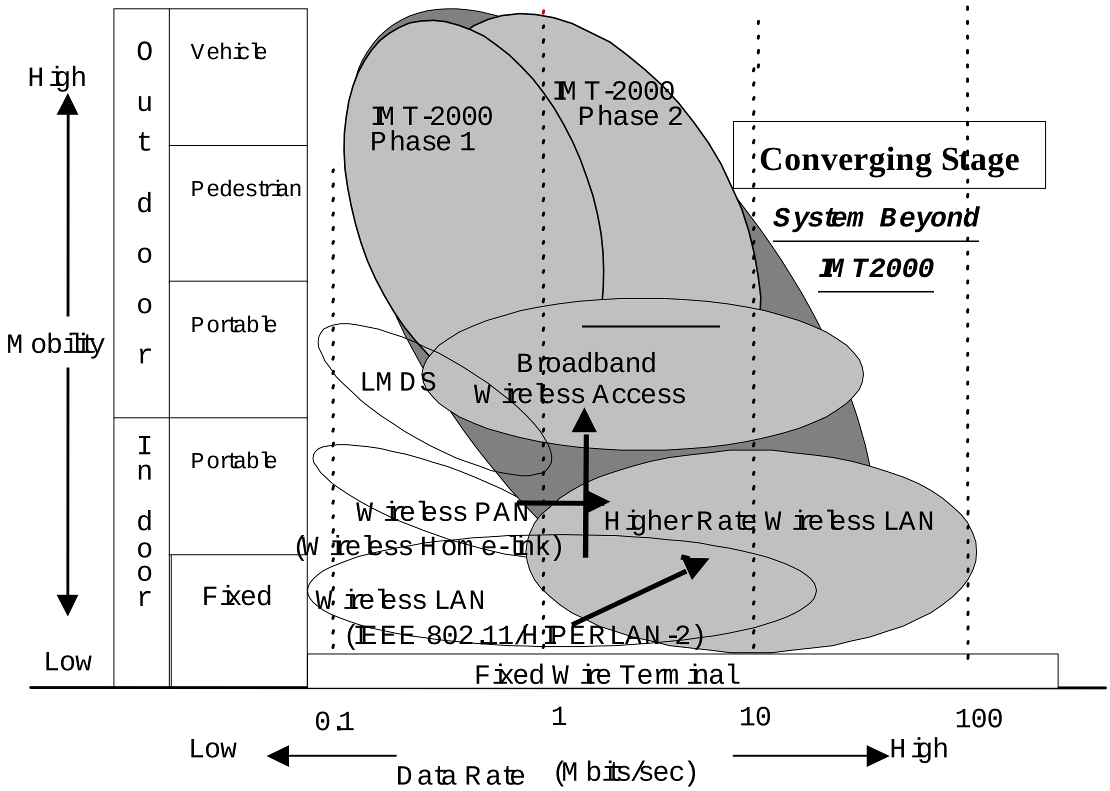

FIGURE I-9.3

Diagram of Converging Stage

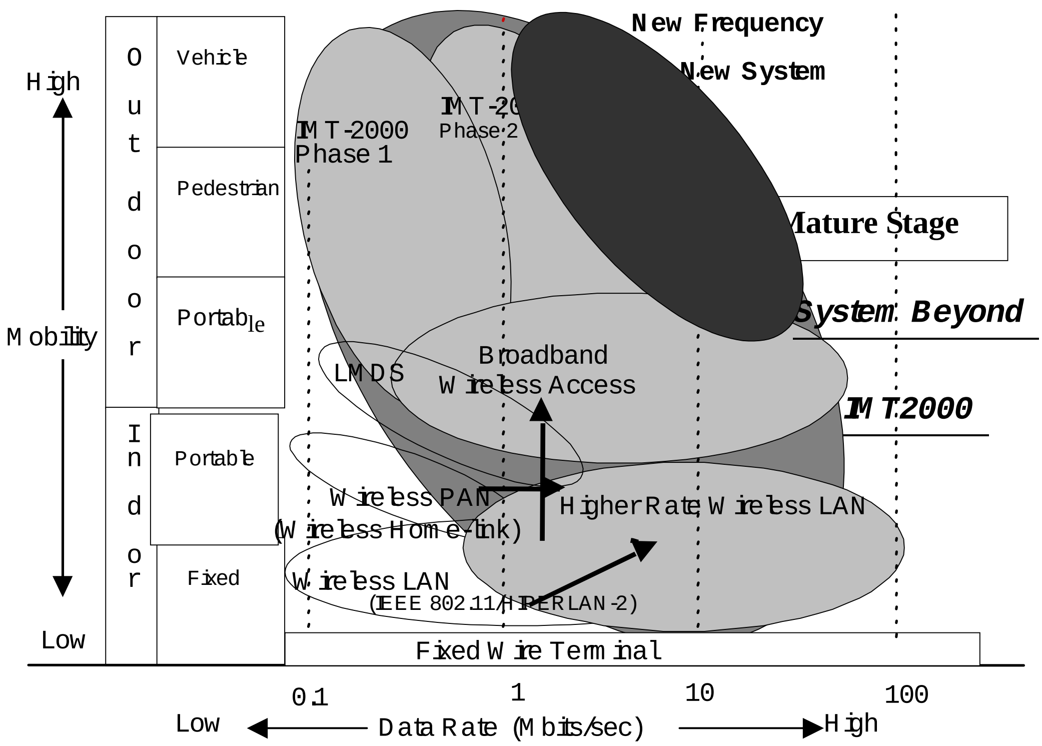

FIGURE I-9.4

Diagram of Mature Stage

2.1.1 Converging Stage (Integrated Digital Convergence, 2010~)

In the first "converging stage", all kinds of existing 3G telecommunication service networks will be integrated as a convergence network, which encompasses fixed, mobile, satellite and broadcasting networks. With only one type of terminal, a user can connect to the integrated convergence network. Depending on the area, data speed and services desired, 3G mobile telecommunication network can be used when a user is walking or moving in a vehicle, or in still-position. Whereas FWA and Wireless LAN can be used when a user wants to have high speed data rate service in fixed area such as in-building or in a spot coverage area. This system focuses on providing an integrated telecommunication service for users.

2.1.2 Mature Stage (New System, 2015~)

In order to support the high mobility and high data rate service which can not be handled in the "converging stage", the "mature stage" kicks in. In this stage, a single new wireless system with new spectrum should be developed with a backward compatibility with 3G networks and the integrated convergence network.

The new system gives freedom from spatial and mobility restriction to users. When a user wants to use a certain service, he or she can select the best system that will deliver the required service with highest performance. In this stage, the choice of a system and a service is up to users, neither operators nor manufacturers. The more individualized and diversified users are, the more personalized service they require. The users drive this stage, and their demands would be the key elements to decide what the system beyond IMT-2000 is to be like. True personalization and more emotional perception of the services will be the key driving force of "mature stage", in which the optimum service delivery via the most appropriate network must be guaranteed.

2.2 Capabilities for the system beyond IMT-2000

2.2.1 Converging Stage

– Variable (partial) integrated convergence network, dependent on service
– Support of wireless access technology up to 155 Mbps (in case of using FWA)
– Support of services with data rate more than 54 Mbps (in case of using Wireless LAN)
– Integrated All-IP network
– Content based billing (micro payment).

2.2.2 Mature Stage

– Backward compatibility with converging stage
– More evolved wireless access system and wireless LAN than in converging stage.

[*Editor's Note: following text is from 8F184 Annex 1 and 8F/268 as modified by 8F/304*

2.2.1 Target of mobility and information bit rate

Systems beyond IMT-2000 may handle a wide range of supported data rates according to economic and service demands with an AMBR of greater than 20 Mb/s for systems in multi-user and multi-cell environments and with terminals moving at vehicular speeds. The following ranges of data rates are envisaged:

100 Mbps @ 3km/h

20 Mbps @ 60km/h

2 Mbps @ 250km/h

X Mbps @ 500 km/h (train)

(total shared data rate in one cell with 20 MHz bandwidth when operating in a cellular network applying frequency-reuse factor 1).

Flexible allocation of the required system capacity will be provided.

[*Editor's Note: following text is from 8F184 Annex 1*

5.2.2.2 Coverage

From the user's viewpoint, it is important to cover a wide service area equivalent to the present IMT-2000 systems. It is necessary to cover vehicular environments as well as local area (indoor offices, homes and business premises). There are several radio operating environments, and radio systems are designed taking into account of the assumed operating environments. By taking advantage of seamless service, service area in different environments can be covered in a complementary manner by several systems. The satellite component may be used in conjunction with the terrestrial component to facilitate global coverage, particularly in large geographical areas. In the longer term cell size is [TBD].

[Editor's Note: the following text is from 8F/268 Annex 2

2.2.2 Coverage

From the user's viewpoint, it is important to cover a wide service area equivalent to the present IMT-2000 systems. It is necessary to cover vehicular environments as well as local area (indoor offices, homes and business premises). There are several radio operating environments, and radio systems are designed taking into account of the assumed operating environments. By taking advantage of seamless service, the service area in different environments can be covered in a complementary manner by several systems. The satellite and terrestrial components may operate in conjunction with one another to facilitate global coverage. The possibility to use of a common frequency band worldwide is a desirable goal. Economic deployment of systems in the entire coverage area with optimized radio interfaces for

- macro cells
- micro cells
- indoor, hot spots and
- broadcast

will be required.

[*Editor's Note: following text is from 8F184 Annex 1 as modified in 8F/264 Annex 2]*

2.2.3 Security

Authentication protocols are required between public and private networks to support a seamless service. These authentication and security services will address both the needs of the user and the network itself. The protocols must also support a single user having multiple IMT-2000 devices that are in use simultaneously.

[Editor's Note: following text is from 8F/184, IA I-6]

2.1 Projection of traffic in the era of the systems beyond IMT-2000

When considering the requirements of systems beyond IMT-2000, it is necessary to consider the traffic volume of the period such systems are introduced. The ITU-R Report ITU-R M.2023 "Spectrum Requirements for IMT-2000" projects the traffic in 2010. Informative Attachment I-7 presents the traffic projection for 2015. The estimation was performed using a method similar to the one described in Report ITU-R M.2023. In the estimation, because very high-speed multimedia services of more than 2 Mb/s are expected, new service categories, i.e., Very High MultiMedia (VHMM) offering 20 Mb/s in the downlink and 2 Mb/s in the uplink and Very High Speed Interactive MultiMedia (VHIMM) offering bi-directional 2-Mb/s links, are defined and taken into account in the traffic calculation in addition to those defined in Report ITU-R M.2023. The annex shows that traffic in 2015 will increase five fold from the level in 2010. Although WRC-2000 identified additional spectrum to be used for IMT-2000 (480 MHz in total in Region 3), a further 1.5 GHz would be required in 2015 if the spectrum efficiency is not enhanced. Therefore, systems beyond IMT-2000 should improve the system capacity and spectrum efficiency further than the current IMT-2000.

[Editor's Note: the following text is from 8F/184, IA I-7]

ESTIMATION OF MOBILE COMMUNICATIONS TRAFFIC AFTER 2010

1 Introduction

In order to discuss system concepts and spectrum requirements for systems beyond IMT-2000, it is important to investigate the mobile communications traffic conditions after 2010. Especially, in the years after 2010, it is anticipated that high-speed services at transmission speeds of greater than 2 Mb/s, which are not supported by IMT-2000, would be available, and the mobile communications traffic, the core of which is likely multimedia communications traffic, are expected to grow substantially.

Using a method similar to the one described in Report ITU-R M.2023, this annex tries to estimate the mobile communications traffic for 2015 with regard to higher-speed mobile communications services.

2 Types and traffic of mobile communication services

The user demand for higher data rate communications services is substantial. With the advent of high-speed fixed networks such as the introduction of Asymmetric Digital Subscriber Lines (ADSLs) and fiber optics subscriber lines, high-speed transmission services ranging from a few tens to a few hundred megabits per second are expected to become available in the near future. These high-speed data transmission services will stimulate ongoing enhancement of applications requiring high-speed data transmission, and will result in an increase in multimedia traffic. To keep apace with this trend, after 2010, mobile communication systems offering transmission rates of more than 2 Mb/s will be introduced, and consequently, the amount of mobile communications traffic will increase significantly.

Report ITU-R M.2023 presents the types of mobile communications services and traffic in 2010. In addition to the mobile communications traffic in 2010, we must consider the traffic generated by the high-speed services at transmission speeds greater than 2 Mb/s. Here, we define a new up/downlink asymmetrical ultra high-speed service called VHMM (Very High MultiMedia, Downlink: 20 Mb/s, Uplink: 2 Mb/s) and a new up/downlink symmetrical ultra high-speed service called VHIMM (Very High Interactive MultiMedia, Up/Downlink: 2 Mb/s). The types of services under consideration are shown in Table 1.

TABLE 1
Mobile communications service types and traffic

Channel Type	Type of Services	Downlink transmission speed (kb/s)	Uplink transmission speed (kb/s)
Asymmetric Up/downlink	VHMM (Very High MultiMedia)	20000	2000
	HMM (High MultiMedia)	2000	128
	MMM (Medium MultiMedia)	384	64
Symmetric Up/downlink	VHIMM (Very High Interactive MultiMedia)	2000	2000
	HIMM (Highly Interactive MultiMedia)	128	128
	SD (Switched Data)	64	64
	SM (Simple Message)	14	14
	S (Speech)	16	16

In this investigation, we define the traffic as the amount of information (bytes) that can be conveyed in a unit time (busy hour). For this purpose, using the calculation method in Report ITU-R M.2023 as the basis, some modifications were made. Specifically, in Report ITU-R M.2023, the required frequency bandwidth is calculated as the final result, while in this investigation, the amount of information (bytes) is calculated by multiplying the Erlang traffic (time unit) per busy hour per cell for each mobile communications service type, which is derived from the calculation process in Report ITU-R M.2023, and the transmission speed of each service type.

To estimate the traffic after 2010, first, the amount of information for each service type is calculated using the method aforementioned. The necessary parameters to perform this calculation are based on the values from the pedestrian environment in Region 3 in Report ITU-R M.2023. The calculation results for the amount of information in 2010 are given in Table 2. At the time point of 2010, VHMM and VHIMM need not to be considered; therefore, those rows are intentionally left blank.

TABLE 2
Traffic per cell during busy hour (Mbytes)

Type of Services	Uplink	Downlink
VHMM	-	-
HMM	307	25249
MMM	1023	32319
VHIMM	-	-
HIMM	8379	8379
SD	8092	8092
SM	157	157
S	17477	17477

3 Estimated traffic for 2015

Next, as an example of traffic after 2010, we try to estimate the traffic for 2015 by referring to the values for 2010. First, we assumed that with respect to voice and low-speed data, which comprise the core traffic of 1G and 2G (S, SM, SD) systems, there would be no changes between 2010 and 2015. This assumption is based on the perspective that, (1) the number of voice-based mobile telephone users would nearly saturate by 2010; and, (2), a large increase in the time spared for voice-based communication per user cannot be expected. On the contrary, for multimedia traffic, we can expect significant growth due to higher rate information transmission created by the emergence of VHMM and VHIMM and the development of various applications, etc.

The significant growth in multimedia traffic will mainly be achieved from the improvement in data processing capabilities and memory capacity of information communication devices such as user terminals. In this investigation, we postulate that the rate at which improvements are made in data processing capabilities and memory capacity matches the rate at which multimedia traffic increases, and thereby estimate the rate at which multimedia traffic increases. Moore's law, which is an empirical model that dictates the rate of improvements in CPU processing capacity and memory chip storage capacity, tells us that a two-fold increase will occur in 18 to 24 months[6]. Based on this model, in this investigation we postulate that the multimedia traffic will double on average in 21 months (approximately a 49% increase per year). More specifically, we estimate that the total of MMM, HMM, and HIMM in and after 2010 will increase 49% per year. This value is not an unreasonable estimation by any means. As an example, the PHS service in Japan, which provides the highest data transmission service currently available for mobile communications, shows that its ratio of data communication time to total communication time more than doubled during the 12 months from January 1999 from its January 1999 level. Furthermore, the PHS data calls occupied more than 50% of the total outbound calls made by the subscribers as of the end of May 2000, and is still on the increase. There is another example of the Internet traffic trend in Japan. White Paper "Communication in Japan 2000" published by Japanese government shows that the number of the Internet users in Japan, excluding the number of mobile internet users, increases 1.4-fold a year from 1997 to 1999[7]. And traffic of NSPIXP, one of the major Internet exchange points in Japan, increases about 2-fold a year from 1997 to 1999[8]. Therefore, traffic volume per one user, which is given by dividing the total traffic by the number of uses, can be supposed to increase about 43% a year. These facts support our estimation.

When seen by the different mobile communications service types in 2015, we postulate that VHMM and VHIMM will occupy 50% of the up/downlink asymmetrical and up/downlink symmetrical multimedia traffic, respectively. With respect to HMM and MMM, the proportion for up/downlink asymmetrical multimedia traffic other than VHMM will remain unchanged between 2010 and 2015. Moreover, we postulate that the cell size in 2015 will be the same as that of 2010. Under these assumptions, we calculate the traffic per cell during the busy hours.

Table 3 shows the estimated values of multimedia traffic for 2015 and the aforementioned estimate values for 2010. In addition, the respective ratios among the service types are given in Table 4.

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[6] http://www.intel.com/intel/museum/25anniv/hof/moore.htm

[7] White paper: Communications in Japan 2000, http://www.mpt.go.jp/eng/Resources/WhitePaper/WP2000/2000-index.html

[8] http://jungle.sfc.wide.ad.jp/NSPIXP/Traffic/

TABLE 3
Traffic per cell during busy hour (Mbytes)

Channel Type	Type of Services	2010		2015	
		Uplink	Downlink	Uplink	Downlink
Asymmetric Up/downlink	VHMM	-	-	4820	208567
	HMM	307	25250	1112	91477
	MMM	1023	32320	3708	117090
Symmetric Up/downlink	VHIMM	-	-	30357	30357
	HIMM	8379	8379	30357	30357
	SD	8092	8092	8092	8092
	SM	157	157	157	157
	S	17477	17477	17477	17477

TABLE 4
Respective Rations Among Service Types

Channel Type	Type of Services	2010		2015	
		Uplink	Downlink	Uplink	Downlink
Asymmetric Up/downlink	VHMM	-	-	5%	41%
	HMM	1%	28%	1%	18%
	MMM	3%	35%	4%	23%
Symmetric Up/downlink	VHIMM	-	-	32%	6%
	HIMM	24%	9%	32%	6%
	SD	23%	9%	8%	2%
	SM	0%	0%	0%	0%
	S	49%	19%	18%	3%

The increase in data traffic from 2010 to 2015 is given in Figure 3. As shown in the figure, the total amount of traffic for 2015 is expected to increase 4.7 fold from 2010. Moreover, the up/downlink traffic ratio for 2010 is 1:2.6, and is estimated to widen to 1:5.2 in 2015. Mobile multimedia traffic is estimated to account for 95% of all downlink traffic.

We believe that VHMM and VHIMM, though not available in 2010, will represent a large percentage of ultra high-speed multimedia traffic by 2015.

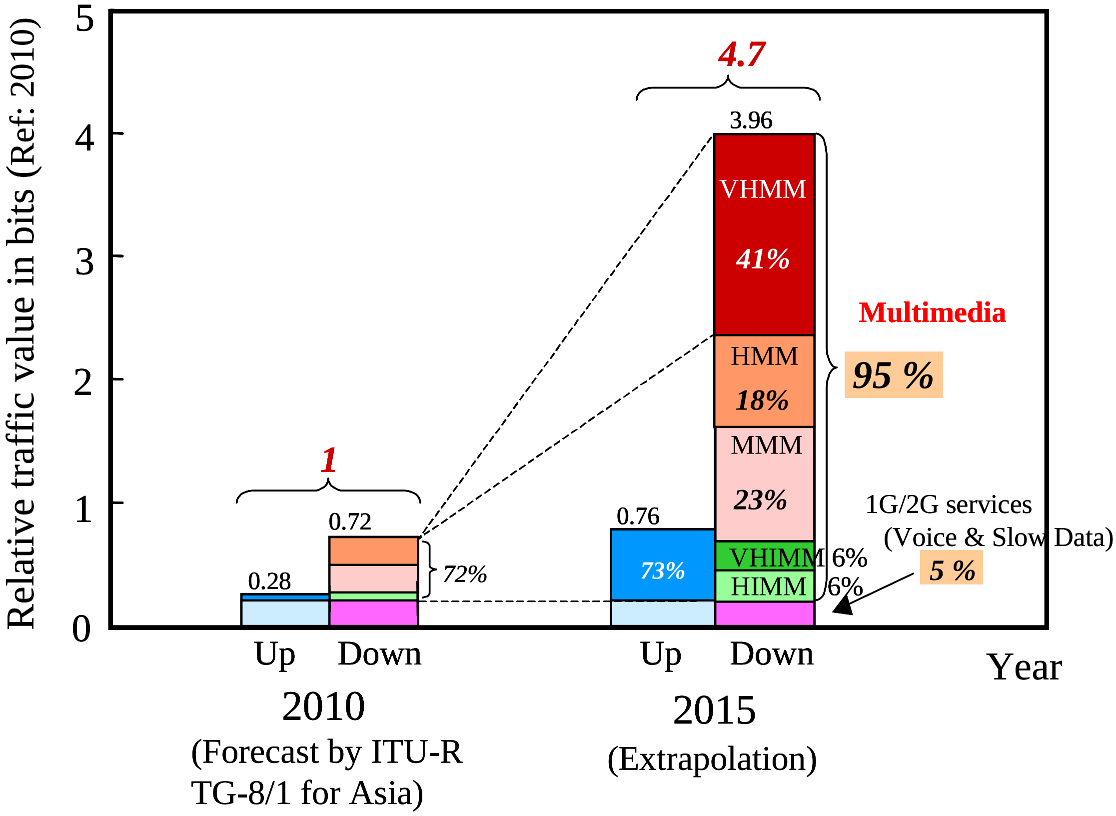

FIGURE 3

Data traffic comparison