REPORT ITU-R M.2072

World mobile telecommunication market forecast

(Question ITU-R 229/8)

(2005)

Executive Summary

This Report provides a summary of the market analysis and forecast of evolution of mobile market and services for the future development of IMT-2000, systems beyond IMT-2000 and other systems. This Report has derived market related parameters and provided forecasts for 2010, 2015, and 2020 for the mobile market. These parameters are essential inputs in developing a spectrum estimate, for future development of IMT-2000 and systems beyond IMT 2000 in preparation for the World Radiocommunication Conference 2007.

This Report describes analysis results information provided by about thirty administrations and organizations, in response to a request for information from the ITU (Circular Letter CACE/326). The findings of this Report are based on internal and external studies to the year 2020 as well as detailed data on the traffic forecasts in different parts of the world. It also provides examples of potential services and applications of future development of IMT-2000 and systems beyond IMT-2000 from the year 2010 onwards.

The Report consists of nine sections:

Section 1 and 2 provide an introduction and scope that provides context for the market study.

Section 3 provides a reference to ITU Recommendations and Reports that are directly related to the market report.

Section 4 provides market information both on a worldwide and regional level that has been derived from the numerous input contributions. The information includes background information on types of systems used, traffic volume, coverage areas as well as information on subscribers and transition from 2G to 3G.

Year 2004 and first half of 2005 are significant in deployment of IMT-2000 systems. New tariffs (flat rate, large volume) were introduced, which will affect traffic volume (kbytes and minutes) in the future and will facilitate data usage adoption. Handsets capabilities have been enhanced with better operating systems, large memory and multimedia functions (photo, video camera, etc.). In September 2005 there are more than two billion mobile users in the world.

Section 5 covers tendencies in service evolution to the year 2020 that includes applications/services envisaged for the future development of IMT-2000 and systems beyond IMT-2000 and several relevant case studies. High performance, intelligent mobile terminals and rich content will continue to become available. Transmission speed equivalent to those of fixed system is becoming a reality with IMT-2000 systems, which offer transmission speeds of several Mbit/s. Beyond IMT-2000, the enhancements of its technical capabilities, range of services and breadth of applications will be progressively introduced.

Section 6 identifies the key market parameters and provides numerous usage traffic forecasts. The size of the mobile communication market can be estimated from many kinds of parameters. It is also necessary for the market size estimation to take into account some key issues from contexts of the socioeconomic aspects technological, market, service, regulatory and industrial aspects. Traffic forecasts for daily traffic per user in 2020 were provided by several administrations and international organizations, and vary from hundreds of MB/user/day to multiple GB/user/day. These differences result from the variety of environments and assumptions.

Section 7 provides an overview of other radio systems that might interwork with the future development of IMT-2000.

Present mobile communication systems have evolved by adding more and more system capabilities and enhancements, and the user will see a significant increase in capability through the future development of IMT-2000. Systems beyond IMT-2000 will be realized by functional fusion of existing, enhanced and newly developed elements of IMT-2000, nomadic wireless access systems and other wireless systems with high commonality and seamless interworking.

Section 8 provides calculated market attribute values per each service category and service environment for 2010, 2015 and 2020 which is essential input for spectrum estimate effort. The five market attributes are: market scale, number of session attempts, mean service bit rate, average session duration, and mobility ratio. Each service is mapped into the table composed of service type (very low rate data, low rate date and low multimedia, medium multimedia, high multimedia, super high multimedia) and traffic class (conversational, streaming, interactive and background). Six service environments are identified through a table composed of service usage pattern (home, office, public area) and teledensity (dense urban, suburban, rural).

Section 9 identifies items that will impact the markets of the future development of IMT-2000 and systems beyond IMT-2000 and provides some estimates on their impact on the market. The driving forces in the markets of the future development of IMT-2000 and systems beyond IMT-2000 are classified into four categories: technology forces, market, regulatory and idealistic forces.

This Report contains details on regional markets in 2002 and a number of case studies about penetration forecasts up to 2020. The market report highlights strong growth in the wireless market with the share of mobile lines among the total fixed and mobile telecommunications network lines exceeding 50% in 2002 with most regions have higher mobile phone penetration than wireline. The Market Report has been compiled from input received from administrations and organisations worldwide and provides estimates of market growth for 2010, 2015, and 2020.

TABLE OF CONTENTS

1 Introduction

International Mobile Telecommunications-2000 (IMT-2000) systems are third generation mobile systems, which provide access to a wide range of telecommunications services, supported by the fixed telecommunication networks (e.g. PSTN/ISDN/Internet Protocol (IP)), and to other services, which are specific to mobile users.

Key features of IMT-2000 are:

– a high degree of commonality of design worldwide;

– compatibility of services within IMT-2000 and with the fixed networks;

– high quality;

– small terminals suitable for worldwide use;

– worldwide roaming capability;

– capability for multimedia applications within a wide range of services and terminals.

The capabilities of IMT-2000 systems are being continuously enhanced in line with market and technology trends.

The specifications for the initial releases of IMT-2000, which are defined in Recommendation ITU-R M.1457, have been completed, and the commercial deployment of IMT-2000 has begun. Work is already underway in various external organizations to extend the capabilities of the initial releases in line with market expectations and technology trends.

To help meet the ever increasing demands for wireless communication, and the expected higher data rates needed to meet user demands, it is necessary to forecast the evolution of mobile market and services for the future development of IMT-2000 and systems beyond IMT-2000.

In order to produce this Report, the ITU sought information on the analysis and forecast of services and market aspects. This information was gathered by means of a questionnaire, distributed via circular letter (Circular Letter CACE/326) to a range of organizations worldwide, including organizations outside the ITU. Within this Report, the questionnaire is also referred to as the "service view" document, and can be found in Annex 1.

The responses to the questionnaire received by the ITU have been collated and summarized within this Report. Further, data presentations have been harmonized to produce a set of parameters to be used for the purpose of spectrum requirement estimation. A list of responses received is included in Annex 2.

Content within the responses to the questionnaire has been included in the Report in accordance with the original response. Although content and data has been aligned editorially, no changes have been made to the original meaning or values.

2 Scope

This Report provides a summary of the market analysis and forecast of the future market, as well as detailed data on the traffic forecasts, based on internal and external studies to the year 2010 – 2020 as well as detailed data on the traffic forecasts in different parts of the world. It also provides examples of potential services and applications of future development of IMT-2000 and systems beyond IMT-2000 from the year 2010 onwards.

The information involved in this Report will be considered in the methodology and spectrum estimates activities in the preparation for WRC-07.

This Report is structured in six main parts describing:

– Market of pre-IMT-2000 and IMT-2000 mobile systems
– General Trends in Service Evolution
– Usage forecast for future development of IMT-2000 and systems beyond IMT-2000
– Usage forecast for other radio systems
– Market related parameters for spectrum calculation
– Driving forces

3 Related ITU-R documents

3.1 Related Recommendations

Recommendation ITU-R M.1457	Detailed specification of the radio interfaces of International Mobile Telecommunications-2000 (IMT-2000)
Recommendation ITU-R M.1645	Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000
Recommendation ITU-R M.1768	Methodology for calculation of spectrum requirements for the future development of IMT-2000 and systems beyond IMT-2000

3.2 Related Reports

Report ITU-R M.2074	Report on Radio Aspects for the terrestrial component of IMT-2000 and systems beyond IMT-2000

4 Market of pre-IMT-2000 and IMT-2000 mobile systems

Section 4 provides market information both on a worldwide and regional level. The information includes background information on types of systems used, traffic volume, coverage areas as well as information on subscribers and the transition from 2G to 3G.

4.1 Worldwide market overview

Many factors contribute to explain the current mobile penetration levels: some are linked to a country's historical peculiarities such as the nature of the regulatory environment, or the particulars of the operator's offerings – these factors are short-term by nature. Other factors are linked to fundamental social and economic characteristics of the country. Extensive literature exists that describes the historical evolution of the fixed and mobile telecommunication penetration worldwide.

Table 1 compares mobile penetration rates at continent/subcontinent basis between 1995 and 2002. The share of mobile lines among the total fixed and mobile telecommunications network lines grew strongly during the 1995-2002 period to exceed 50% in 2002 as shown in Table 2. Most regions have or shortly will have higher mobile phone penetration than wireline penetration: for high teledensity countries, mainly as a complement, or, for developing countries, as a substitute to expensive fixed infrastructures.

TABLE 1

Mobile penetration evolution per continent/subcontinent 1995-2002
(Source: ITU 2003 – World Telecommunication Indicators)

	Penetration 1995 (%)	**Penetration 2002 (%)**	**CAGR 1995-2002 subscriber growth (%)**
Western Europe	5.9	78.9	45
North America	12.4	47.5	21
Asia/Pacific	3.0	23.9	37
Central & Eastern Europe	0.3	23.5	88
South & Central America and the Caribbean	0.8	18.9	59
Central Asia	0.2	9.4	72
Middle East	0.6	8.2	54
Africa	0.1	4.3	74
Total	**1.8**	**18.6**	**43**

CAGR: Compound annual growth rate

TABLE 2

Mobile share in teledensity evolution per continent/sub-continent 1995-2002
(Source: ITU 2003 – World Telecommunication Indicators)

	1995 (%)	**2002 (%)**	**Growth ratio (%)**
Africa	7.4	61.4	8.3
Western Europe	10.7	58.1	5.4
Asia/Pacific	17.1	56.4	3.3
South & Central America and the Caribbean	8.1	52.9	6.5
Central & Eastern Europe	1.7	48.1	29.0
Central Asia	7.9	47.6	6.0
North America	17.0	42.0	2.5
Middle East	7.3	41.9	5.8
Total	**13.1**	**51.2**	**3.9**

With regard to the mobile global device market, 605.9 million units were shipped globally in 2004 which include both 2G and 3G devices. In the forthcoming years, the highly penetrated markets of Western Europe and Asia-Pacific will experience a slower growth as markets reach saturation and new shipments are driven by replacement sales.

The strongest growth will be in emerging markets, such as China and India. Shipments are expected to increase from 82 million in 2004 to almost 140 million in 2008.

TABLE 3

Device shipment by region in 2003
(Source: Ovum, on behalf of the UMTS Forum, December 2004)

Regions	Devices sold in million units
North America	92
Latin America	43
Western Europe	113
Eastern Europe	43
China/India	85
Asia/Pacific	106
Middle-East and Africa	35
Total	**517**

The total number of global cellular connections reached approximately 1.4 billion generating US$ 422 billion at the end of 2003. Table 4 breaks down cellular connections at a regional level.

TABLE 4

Cellular connections by region in 2003
(Source: Ovum, on behalf of the UMTS Forum, December 2004.)

Region	Cellular connections (millions)	Share (%)
North America	170	12
Latin America	130	9
Western Europe	330	24
Eastern Europe	100	7
China/India	310	22
Asia/Pacific	240	17
Middle-East and Africa	100	7
Total	**1 380**	**100**

In 2004, China and India have already overtaken Western Europe as the largest regional market and their dominance in the coming years is clear. By 2010, most of the growth in new connections will come from the emerging markets.

The transition from 2G to 3G[1] is expected to reach a peak in absolute numbers in 2006 and then to decrease slowly to the favour of migration to 3G. With regard to obtaining an accurate picture of the current mobile market and estimating future developments, several points are worthwhile to keep in mind: 2004 was a significant year in deployment of IMT-2000 systems. New tariffs (flat rate, large

[1] Classifications used by UMTS Forum: 3G = W-CDMA, CDMA2000 EV-DO, CDMA2000 EV-DV, TD-SCDMA, 2.5G = GPRS, EDGE, CDMA2000 2G = GSM, HSCSD, CDMAOne, TDMA, Other.

volume) were introduced, which will affect traffic volume (kbytes and minutes) in the future and will facilitate data usage adoption

Handsets capabilities have been enhanced with better OS, large memory and multimedia functions (e.g., photo, video camera). At the same time, Wifi is now embedded in every new PC laptop: it increases the potential of "wireless usage" in home/business spots.

Convergence of IT, Media and Telecom is just beginning in this digital world (e.g., HTML, XML, and IP). Also, TV on mobile is just starting and attracts customer interest even if, for the moment, streaming is not the adequate mode.

With the introduction of high-speed mobile data, the market is being redefined to give hope for a new trend of P2P relations (text, voice, image, video) and personal empowerment. 2004 can be considered as a turning point in the mobile world as "Year 1 of the Personal and Portable Internet".

4.2 Regional market information

To complement the worldwide overview of the market, the following provides additional information on regional and national markets. Annex 2 provides a list of respondents to the market service survey. The following information is organized using the ITU Regions as defined in the Radio Regulations.

4.2.1 Region 1

Table 5 highlights responses received from some Region 1 participants. Additional information is provided below.

TABLE 5

Example responses related to pre-IMT-2000 and IMT-2000 market

Region 1	Number of 2G Mobile subscribers	Number of 3G subscribers	Volume of traffic	Penetration of mobile (%)	Transition from 2G to 3G
Bulgaria	3 500 869 (2003)			44.9	
Cameroon	1 076 951 (2003)		902.8 million min (2003)	6.47	
Estonia	1 050 000 (2003)		880 million min (2003)	77	See details
Malta	289 992 (2003)		134.4 million min		
Poland	16 058 640 (2003)				

Additional details

Estonia

Traffic volume: for 2003 increased 20% compared to 2002. Volume of mobile traffic was (originated call min) 736 million min for 2002 and increased to 880 million min for 2003. Volume of fixed traffic continuously decreased during last three years time and was 1 313 million min at the end of 2003 (without dial-up connections).

Transition from 2G to 3G: By the seventh year after the issue of the 3G licence, the owner of the licence must operate a third generation mobile telephone network that covers 30% of the population of Estonia and conforms to the third generation mobile network standards of European standardization organizations in terms of network architecture and services.

Mauritius

There are currently three licensed private land mobile network operators in Mauritius. Two mobile operators, namely Emtel Ltd and Cellplus Ltd are currently offering services to the public.

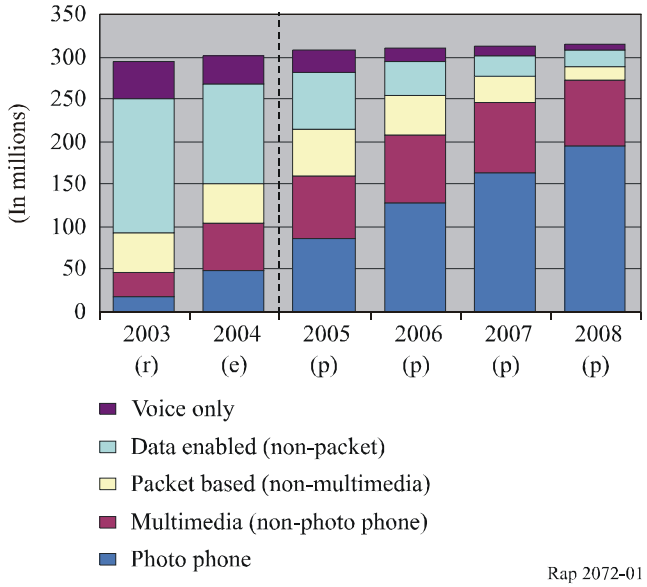
Western Europe

At the end of 2004, Europe had 348 million Sim subscribers with a penetration rate of 88%. Indeed, some countries are beyond 100% due to the increase of multiple data subscriptions per device and the increase in devices a single user may have (personal and professional phones). The expected raise of M2M will emphasise the need to count Sim subscriptions and not population subscribers.

Handset Equipment: At the end of 2003, just 16% of European wireless subscribers had multimedia handsets. By 2008, this share will increase to 86%. Photo phones accounted for 38% of multimedia handset sales in 2003 and will become a standard handset feature, accounting for 76% of multimedia handset sales in 2008, with product differentiation focused on camera quality and features.

FIGURE 1

Wireless subscribers by handset type, 2003 to 2008 in Western Europe
(Source: Jupiter Research, on behalf of the UMTS Forum, December 2004)



Wireless data users: Besides using largely SMS for P2P connections, active wireless users were mainly made up by people downloading ring tones and logos. For the coming years, the growth of active wireless data user base will be driven by the increase in the base of ring tone buyers (thanks to new formats such as ring-back-tones, real audio ring tones) and by the growth of less-developed services (gaming, professional applications, surfing the web, etc.). Especially, the use of mobile operators' portals is expected to grow, as shown in Fig. 2.

4.2.2 Region 2

Table 6 highlights responses received from some Region 2 participants. Additional information and detail is provided below.

FIGURE 2

Mobile portals users (percentage of customers) in Western Europe
(Source: IDC/Orange Badim, on behalf of the UMTS Forum, December 2004)

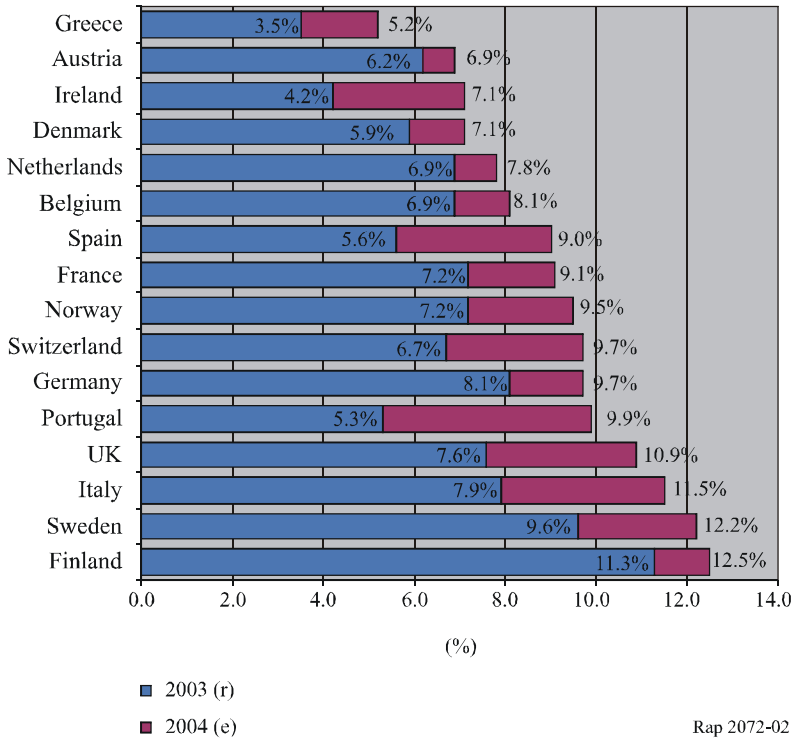


TABLE 6

Example responses related to pre-IMT-2000 and IMT-2000 market

Region 2	Number of 2G subscribers	Number of 3G subscribers	Volume of traffic	Penetration of mobile	Transition from 2G to 3G
Brazil	46 373 266 No distinction given between 3G and 2G subs (2003)		18.459 million min/year		Between 2006 and 2007
Canada	14 984 936 Distinction of subs: digital (13 366 112 M subs) and analogue (1 168 284 M subs)		47 688 425 000 billed min of voice traffic	50% and closer to 60% in urban areas	Ongoing
United States	160 600 000 Distinction of subs based on digital (91%) and analogue (9%)		507 min/ month/user		Significant deployment of 3G systems by major operators in major U.S. markets will continue to occur in the next few years

Additional details

North America

– The North American data services market is beginning to take off and the outlook is expected to push wireless carriers to offer more services, although the United States currently still lags behind adoption of non-voice mobile services.

– Non-voice revenue usage will continue to increase as consumers begin adopting other data services such as IM/chat and ring tones. Voice still accounts for the largest segment within the US mobile market but text messaging, for example, is starting to explode in the US. According to CTIA 25% of all mobile subscribers send text messages, accounting for 2 billion messages/month at the end of 2003, double the 2002 figure. The wireless carriers are also concentrating on delivering music content to their wireless subscribers. Push to Talk could also gain momentum in the United States with several carriers offering this service. Furthermore, wireless downloading of games is gaining momentum. According to CTIA, 12.2 million Americans downloaded or subscribed to wireless games in 2003.

– As the subscriber growth rate diminishes, new applications, such as wireless Internet access, text messaging, instant messaging, ring tones, wireless games, and multimedia messaging services will drive the US market and increase carrier revenues. Going forward the anticipation is that wireless carriers will become much more aggressive in promoting services as revenues of voice flatten out.

– A significant fact regarding the subscribers in the United States is that they are one of the highest users of minutes, averaging 507 min/month for voice calls. Collectively, wireless consumers used more than 449.3 billion billable min in the last half of 2003 – up 37.3% from 327.3 billion min in the second half of 2002 (from CTIA).

United States

– The FCC reports that 283 million people, or 99% of the total U.S. population, live in areas (or counties) where operators offer digital mobile telephone services, including 2G and 3G systems of the types indicated by the technology section above. These areas (or counties) make up 83% of the total land area of the United States.

– Wi-Fi public hot spots (or access points) in U.S. are currently estimated at 21 038 locations. Hot spots include airports, convention centers, hotels, restaurants, coffee shops, schools, libraries, bookstores, retail outlets and city parks and squares. Wi-Fi hot spots subscribers were estimated at about 4.7 million.

4.2.3 Region 3

Table 7 highlights responses received from Region 3 participants. Additional information and detail is provided below.

TABLE 7

Example responses related to pre-IMT-2000 and IMT-2000 market

Region 3	Number of 2G subscribers	Number of 3G subscribers	Volume of traffic	Penetration of mobile	Transition from 2G to 3G
Australia	15 000 000	1 500 000			5 to 7 years from 2005
Bangladesh	4 327 516		170 min/month/user	3.7% (2004)	
China	269 000 000 (2003)		See details below	21% in some developed provinces. Over 50% in Beijing, Guangdong, Shanghai	
Indonesia	18 092 089 (2003)		216 min/month/user		
Japan	71 254 400 (2003) 59 789 200 (2004)	13 756 800 (2003) 25 694 600 (2004)		See details below	Approximately March 2006. See additional details
Korea		36 145 000*			87% of mobile customers are 3G users
Myanmar	122 074				

* Korea does not provide a breakdown of 2G and 3G. See note on transition where most mobile subscribers are 3G subscribers.

Additional details

Australia

Currently GSM reaches about 96% of the population and 12% of the land mass area, CDMA reaches about 98% of the population and about 20% of the land mass and 3G reaches about 12% of the population and over 2% of the land mass area.

Bangladesh

– Average call duration is 2 min/sub (June 2004).
– Teledensity for urban areas is 9.13% and rural areas is 0.142% (2004).

China

Traffic volume: The voice traffic for mobile user was over 630.9 billion min, an increase of 50% compared with 2002 and long-distance voice traffic accounts for 8%. There were 138.6 billion short messages in 2003, an increase of 137% compared with 2002.

Operators: Two mobile operators – China Mobile and China Unicom. China Mobile adopts a GSM/GPRS system, which occupies about 65% of the market. China Unicom adopts GSM and CDMA systems, which occupies about 35% of the market. China Mobile has made roaming contracts with 224 operators in 159 countries. China Unicom has made roaming contracts with 205 operators in 97 countries for GSM systems, and 15 operators in 12 countries for CDMA systems.

China Mobile: Average revenue per user per month (ARPU) was 102 RMB in 2003; in 2002 it was 115 RMB. MOU was 240 min; in 2002, it was 207 min. The mobile data service user accounted for 71% of the mobile users, and new service income accounted for 10.2%, SMS was still the main mobile data service.

China Unicom: ARPU of GSM was 57 RMB; in 2002 it was 59 RMB. ARPU of CDMA is 128 RMB; in 2002 it was 149 RMB. MOU of GSM was 174 min, in 2002, it was 169 min. MOU of CDMA was 338 min; in 2002 it was 350 min.

Japan

– *Traffic Volume:* In fiscal year 2002 (end of March 2003), the number of calls made from mobile phones was at 47.45 billion (a 4.9% increase over the previous fiscal year. Holding time of calls originated by mobile phones and PHS both continued to rise at 1.6 billion hours (a 5.4% increase over the previous fiscal year) and 160 million hours (a 33.9% increase from the previous fiscal year) respectively.

Regional and geographical characteristics: In fiscal year 2003, Japan cellular penetration was about 68% including the penetrations of 92.6% in Tokyo metropolitan district, followed by 78.4% in Aichi Prefecture, and 77.2% in Osaka Prefecture. Japan has 47 prefectures, including Tokyo metropolitan district, Aichi and Osaka Prefectures, divided by geographical characteristics. Table 8 shows a distribution of cellular penetrations among those prefectures:

TABLE 8

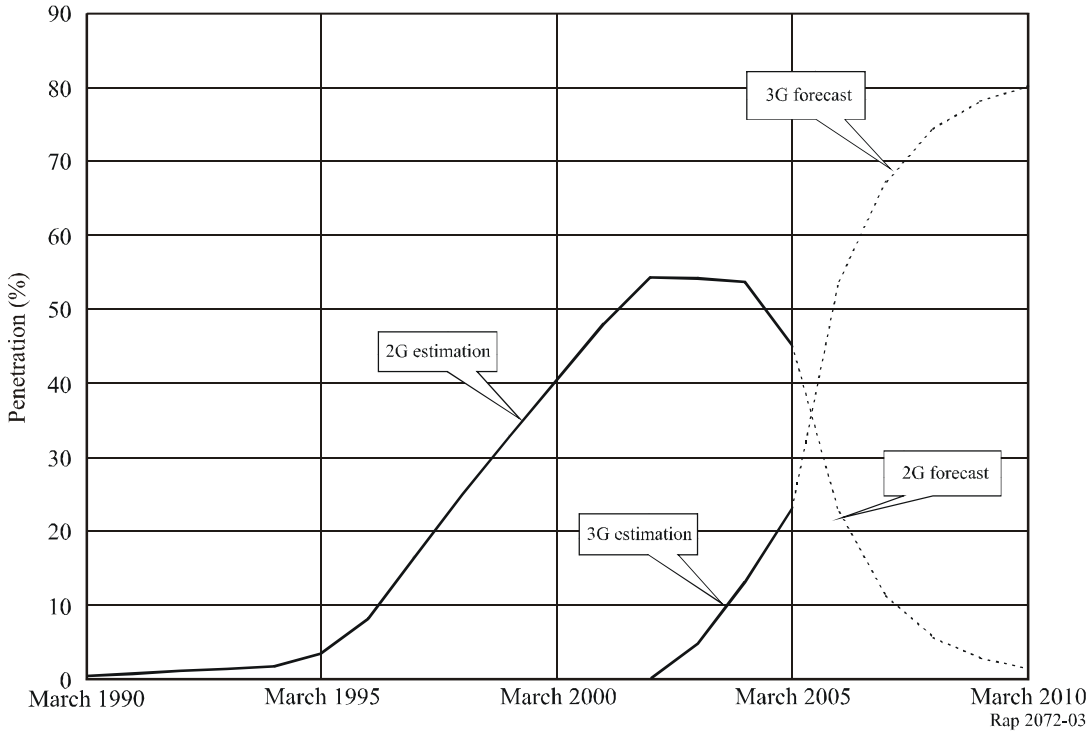
Geographical characteristic of cellular penetration
Cellular penetration vs. number of prefectures
(Source: MIC White Paper FY 2004
http://www.johotsusintokei.soumu.go.jp/whitepaper/ja/h16/pdf/index.html)

Penetration (%)	> 60	60-55	55-50	50-45
Number of prefectures	14	16	12	5

Transition from 2G to 3G: In May 2003, the number of subscribers for 3G cellular systems (WCDMA or cdma2000 1x) reached 10% of the total number of subscribers for 2G cellular systems (PDC or cdmaOne) and 3G systems, in April 2004 it was 20%, in December 2004 it was 30%. It is expected that 3G subscribers will surpass 2G subscribers within fiscal year 2005, i.e., by the end of March 2006 as shown in Fig. 3, which is forecasted by applying a polynomial approximation fitting method based on the previously experienced penetration model in 2G market.

FIGURE 3

Expected time frame for transition from 2G to 3G in Japan forecast based on past 2G experiences



Republic of Korea

– The growth of Wireless Internet (WI) service usage is significantly high in Korea. Figure 4 shows the annual growth of WI usage of SK Telecom's users. Wireless Internet service includes SMS service and wireless data services like ring-tone download, image download, MMS, LBS, news/information, and real multimedia services such as VoD/MoD. With the deployment of new enhanced systems and the growing number of subscribers with new-featured handsets, mobile operators have developed new kinds of services and the users have been active in trying these new services. Therefore, the ratio of WI revenue to the total revenue has increased continuously. During the 3rd quarter of 2004, it amounted to 21.2% of total revenue in SK Telecom.

– Among the total WI revenue, the ratio of SMS usage has decreased from 43.4% in 1st quarter of 2002 to 27.1% in the year 2003. Instead, various types of enhanced non-SMS services are gaining more usage from the users.

FIGURE 4

Annual growth of WI usage of SK Telecom's users
(Source: SK Telecom IR Report)

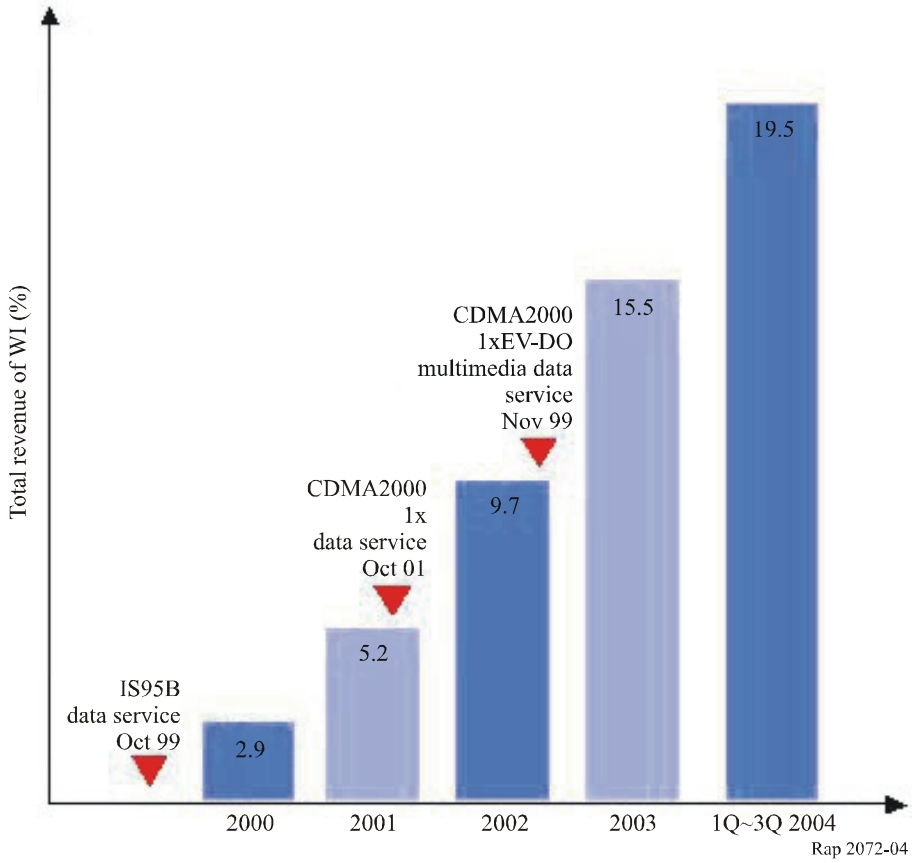
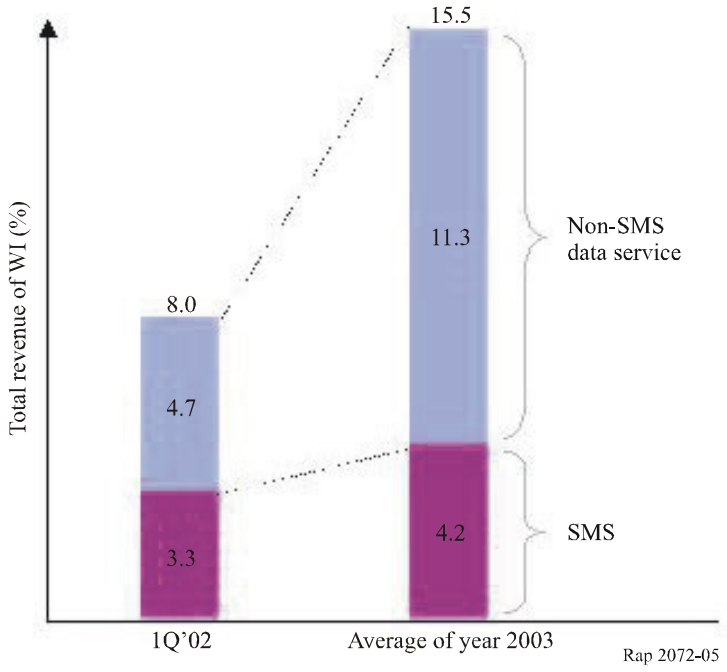


FIGURE 5

Percentage of WI among the total revenue
(Source: SK Telecom)



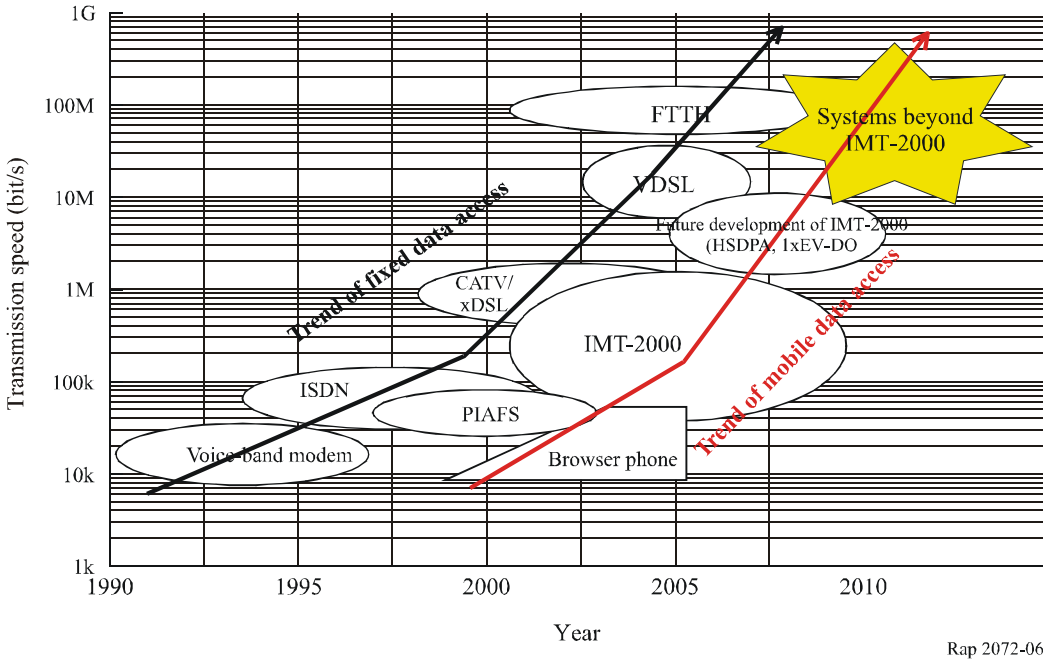
5 General trends in service evolution

The services and markets of the future development of IMT-2000 and systems beyond IMT-2000 must be identified. This is not an easy task as forecasts contain many caveats and exceptions especially for forecasts as far as 2020. There are many issues and types of services that can be considered. A key need is to define the services based on parameters, such as segmentation (e.g. consumer or business, adult or youth, etc.) There is no standard set for defining these services, and different publicly available announcements indicate an inconclusive picture.

The transmission speeds expected for future mobile communications systems are depicted in Fig. 6, based on the projected growth of data access speeds in mobile communications systems and fixed communications systems. In mobile systems, packet data services of several kbit/s to several tens of kbit/s by browser phones (e.g. i-Mode/WAP) started in the late 1990s as the use of the Internet took off following about 5-10 years behind fixed data access services. Although its transmission speed is tantamount to that provided by a voice band modem in the fixed system, it is adequate for content made up mainly of text partly because of the limited display size of mobile terminals. Now that high performance and intelligent mobile terminals and rich content have become available, transmission speeds tantamount to those of fixed system are required. This is becoming a reality with IMT-2000 systems, which offer transmission speeds of several hundred kbit/s to Mbit/s.

FIGURE 6

Changes in bit rate of public data access in the fixed system and the mobile system



Beyond IMT-2000, the enhancements of its technical capabilities, range of available services, and breadth of applications will be progressively introduced in developed countries. Also, there may be a need for new wireless access services to be developed around the year 2010, capable of supporting high data rates with high mobility. It is predicted that through systems beyond IMT-2000 technology, people will be able to enjoy location-based services, mobile shopping, e-mail and multimedia data transfer as well as video streaming via a handheld terminal at reasonable prices.

5.1 List of applications/services envisaged for the future development of IMT-2000 and systems beyond IMT-2000

Table 9 lists representative names of applications/services which are envisaged for the future development of IMT-2000 and systems beyond IMT-2000 in the responses to the questionnaire. The table was obtained through the general process shown in Annex 4. Annex 5 shows the reference to the responses about individual applications/services.

TABLE 9

List of applications/services envisaged for the future development of IMT-2000 and systems beyond IMT-2000

Sequence number	Representative name of application/service	Sequence number	Representative name of application/service
1	Voice telephony	50	Game data download
2	Voice service	51	Download service, e-newspaper
3	VoIP 1	52	Music download
4	VoIP 2	53	Video streaming and download 1
5	VoIP for long distance	54	Video streaming and download 2
6	Videotelephony 1	55	Download media
7	Videotelephony 2	56	Video upload
8	Hi-quality video phone	57	Interactive gaming 1
9	High quality videotelephony	58	Interactive gaming 2
10	Videoconference	59	Slow scan surveillance video/Industrial controls
11	High rate multimedia/Videoconference	60	Low data rate transaction e.g. RFID
12	Video interactive, videoconferencing	61	Medium data rate monitoring and transactions
13	High quality videoconference	62	Machine to machine services
14	Multimedia phone	63	Telemetering
15	SMS	64	Health monitoring
16	Alarms, Voice control	65	Monitoring for uploading video data
17	Voice messaging	66	Telemedicine
18	Low priority e-mail, SMS, MMS	67	Health care/health check, remote diagnostics, medication information, medical data provision
19	Low priority e-mail, SMS, MMS, LBS	68	Exercise monitor and instruction
20	Photo messages 1	69	Exercise monitor, uploading bio-medical or physical data
21	Photo messages 2	70	e-learning, conversational service
22	Communication/messaging (MMS/IMS/SMS)	71	e-learning, video streaming service
23	MMS	72	e-learning, background service
24	Video messaging	73	Life/education//remote monitor/control, information search, e-learning, news/weather

TABLE 9 (*end*)

Sequence number	Representative name of application/service	Sequence number	Representative name of application/service
25	Communication/Web browsing 1	74	P2P file transfer
26	Web browsing 2	75	Collaborative work including multimedia information exchange and file sharing
27	Browsing 3	76	Collaborative working (application sharing) 1
28	Browsing 4	77	Collaborative working (application sharing) 2
29	Browsing 5	78	Collaborative working (application sharing) 3
30	Business intranet/extranet	79	High volume business applications
31	Mobile Internet/intranet/extranet 1	80	High volume business applications and collaborative working (application sharing) 4
32	Mobile Internet/intranet/extranet 2	81	Collaborative working (application sharing) 5
33	Lottery and betting services	82	High volume business applications, file transfer and collaborative working (application sharing) 6
34	Secure M-commerce, M-banking and business applications	83	High rate data transfer (upload/download)
35	M-payment	84	Business applications 1
36	Mobile commerce	85	Business applications 2
37	Public/electric vote, E-government	86	Personal/asset/fleet tracking
38	ITS (navigation)	87	ITS probe, back ground service
39	Location information service	88	ITS probe, interactive service
40	Location based service/location search, navigation, traffic information, point of interest	89	Observation/surveillance by video camera (Network-camera)
41	Location base service/browsing	90	e-emergency rescue, streaming service
42	Mobile TV/broadcast IP TV	91	Emergency/disaster/disaster prediction/notification, emergency information
43	Mobile HDTV and video	92	e-emergency rescue, wideband conversational service
44	Internet radio	93	Robot security
45	Video/audio/TV streaming	94	Consumer and business mobile Internet
46	IP broadcast HDTV and video	95	Low rate data transmit e.g. monitoring
47	High volume streaming	96	Secured transactions (biometrics)
48	Entertainment/movie (video streaming)	97	IP Web radio
49	Entertainment/broadcasting program (video streaming)		

5.2 Market issues

5.2.1 Case Study – Brazil

Using the formula given in Annex 1 of the Questionnaire, we obtained the following trends and tendencies with quantitative information for the Brazilian market for the period between 2005 and 2020.

Population forecast

TABLE 10

The Brazilian population within 2005 to 2020
(Source: IBGE)

Year	2005	2010	2015	2020
Population (millions)	184 184	196 834	208 468	219 077

TABLE 11

Population distribution by environment within 2005 to 2020

Year	Dense urban (%)	Urban (%)	Suburban (%)	Rural (%)
2005	17	6	14	63
2010	19	7	16	58
2015	22	8	17	53
2020	24	9	18	49

Subscriber density

TABLE 12

Mobile subscriber penetration rate in different environments

Year	Dense urban (%)	Urban (%)	Suburban (%)	Rural (%)
2005	50	47	44	42
2010	75	66	55	48
2015	77	68	56	49
2020	78	69	57	50

TABLE 13

Maximum speed of increase
(*in % of maximum penetration*)

Dense urban	Urban	Suburban	Rural
12%	12%	12%	12%

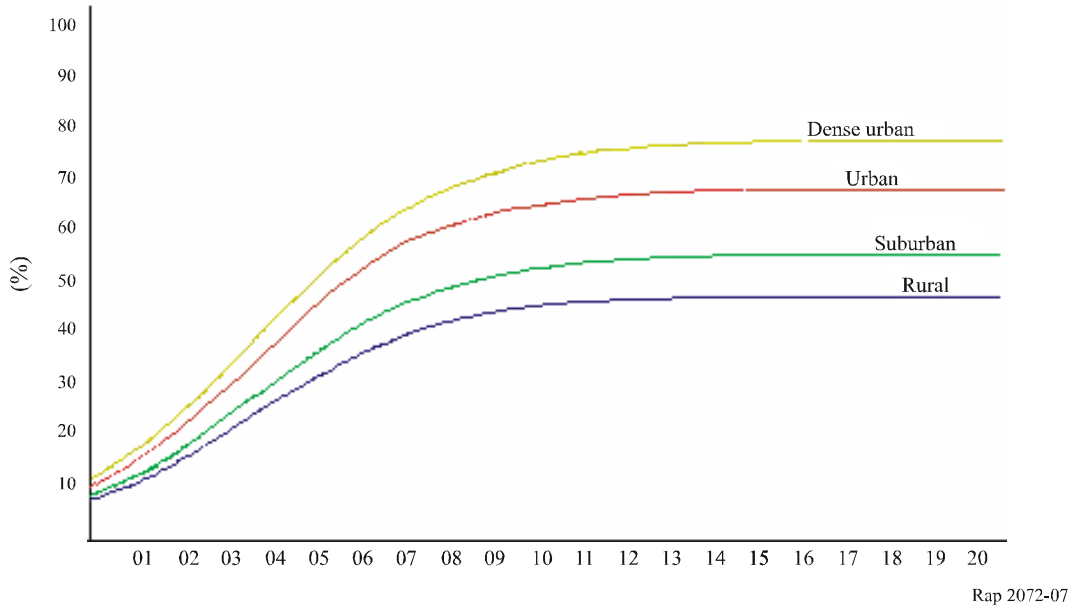
TABLE 14

Subscriber penetration rate in 2001

Dense urban	Urban	Suburban	Rural
19%	17.5%	16.3%	15.8%

FIGURE 7

The subscriber density in different environment (using S-Curve method)



5.2.2 Case Study – Canada

Greater than 100% penetration can be expected by 2015 in Canada. With a population of 34M people growth of 1-2% per annum can be expected over the period.

One of the core communications policies of the administration is to ensure reliable, affordable telecommunications services to all parts of Canada, including rural and remote areas where it is not always economic for commercial operators to provide service.

5.2.3 Perspective on market issues – CEPT

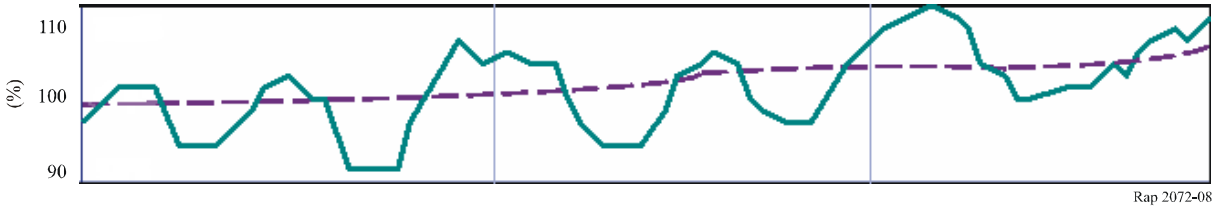
The methodology chosen is a socio-economic analysis which gives the market trends, from the perspective of the basic needs of the customer. Based on this methodology and feedback from a questionnaire[2] we would expect limited economic growth in both total EU economic output and the mean disposable income of an EU citizen, which will influence the market related to mobile communications.

The economic situation is characterized as follows:

Constant changes, up and down with ad hoc growth and recession, often in parallel in different geographic markets, but moderately positive overall – a series of stop-go, with phases of progress and regression as the economic situation is always in strong flux over the period considered, but with geographic and sector pockets of stability, and some of failure, all seems to be randomly distributed across the 25 member countries of the European Union. No real pattern of general progress or coordination can be discerned, but prosperity does increase slowly for many.

FIGURE 8

Changing Regions prosperity



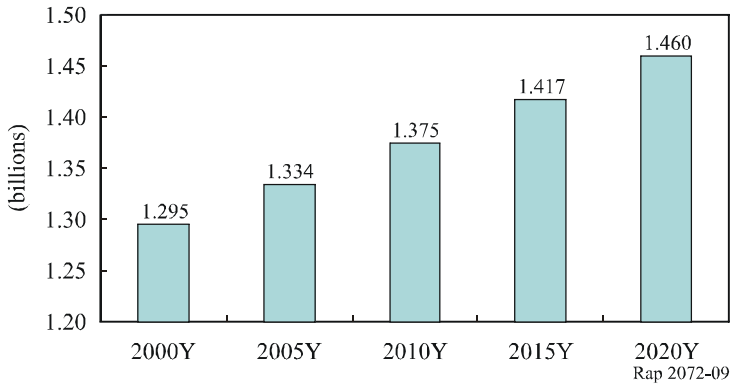
5.2.4 Case Study – China

5.2.4.1 Population forecast and distribution

The nation population grows at a speed of 0.6%. The population within 2005-2020 is estimated as follows.

FIGURE 9

Population forecasts (2005-2020)



[2] This conclusion was reached following a questionnaire survey amongst experts in the industry, economists, sociologists and market players (http://fms.jrc.es/pages/about.htm).

As a developing agricultural country, urbanization is constantly accelerating. At present, national urban population accounts for 40%, the people in rural environments accounts for 60%. Environments could be divided into dense urban, urban, suburban, and rural. The population distributions are estimated as follows.

FIGURE 10

Population distribution by environment (2005-2020)

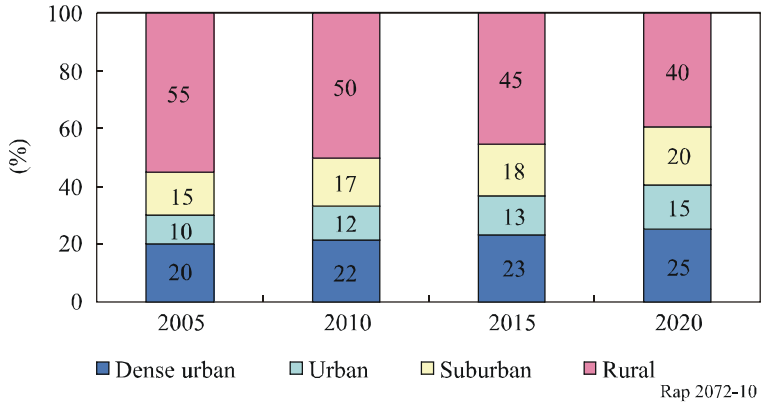


TABLE 15

Population density forecast

(Persons/km^2)	Dense urban	Urban	Suburban	Rural
2010Y	192 000	90 000	21 000	4 000
2015Y	218 000	102 000	24 000	6 000
2020Y	247 000	116 000	27 000	7 000

5.2.4.2 Subscriber forecast

The mobile subscriber penetration rate of China reached 16% in 2002, 21% in 2003, and is estimated to reach 73% in 2020.

The following chart presents the results of the forecast for mobile subscriber penetration rate.

FIGURE 11

Mobile subscriber penetration rate (2005-2020)

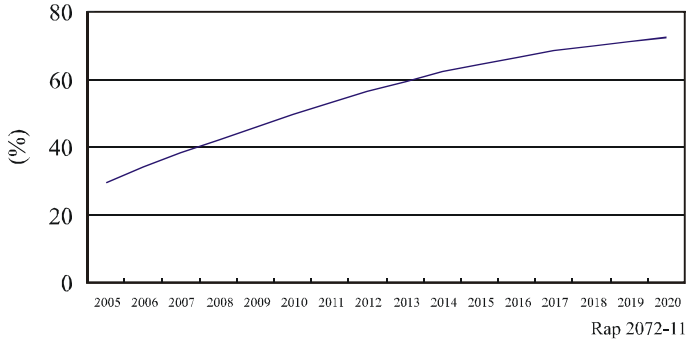


TABLE 16

Mobile subscriber growth

	Subscriber (million)	Penetration rate (%)
2010	646.69	47.0
2015	871.69	61.5
2020	1 071.69	73.4

Using the S-Curve method, the subscriber density under various kinds of environments is shown as follows.

FIGURE 12

Mobile subscriber penetration in different environment

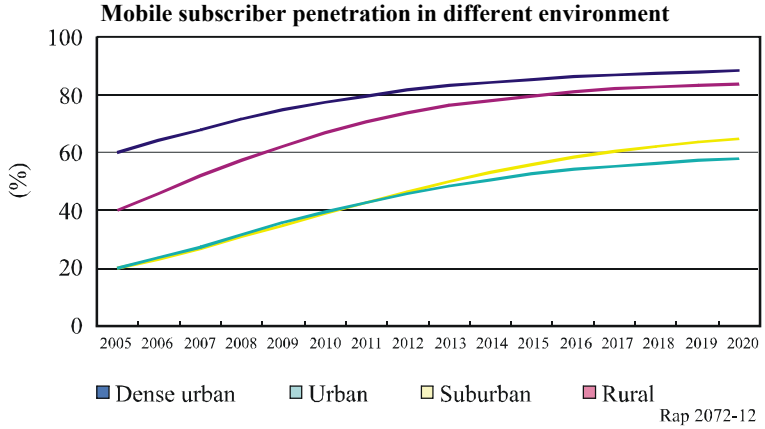


TABLE 17

Mobile subscriber penetration in different environment

	Subscriber penetration rate			
	Dense urban (%)	**Urban (%)**	**Suburban (%)**	**Rural (%)**
2010	77	67	39	39
2015	85	80	56	53
2020	89	84	67	59
	Subscriber density (sub/km^2)			
2010	147 840	60 300	8 190	1 560
2015	185 300	81 600	13 440	3 180
2020	219 830	97 440	18 090	4 130

Furthermore, dense urban could be divided into three environments according to home, office and public. The proportion of user under the three environments is as follows.

TABLE 18

Subscriber distribution in dense urban area

Home	Office	Public
30%	30%	40%

5.2.4.3 Service forecast

The service types needing to be forecasted are listed below.

– Speech
– Low rate service
– Media multimedia
– High multimedia
– Very high multimedia
– Ultra/Super high multimedia.

Speech: All mobile subscribers use speech service.

Low rate service: This service appeared already in the current system. The penetration rate in mobile users was 1.5% in 2003. It is estimated that 80% of users will use such service.

Medium multimedia: The data speed of the service reaches 128 kbit/s. It needs to be supported by CDMA. It is estimated that the penetration rate in mobile subscribers will be 0.5% in 2005 and the maximum penetration rate can reach 60%.

High multimedia: The service needs to be supported by CDMA. It is estimated that the penetration rate in mobile users will be 0.3% in 2007 and the maximum penetration rate can reach 50%.

Very high multimedia: The data speed of the service reaches 10 Mbit/s. It needs to be supported by 3G, such as HSDPA. It is estimated that the penetration rate in mobile subscribers will be 0.1% in the beginning year of 2010, and the maximum penetration rate will reach 30%.

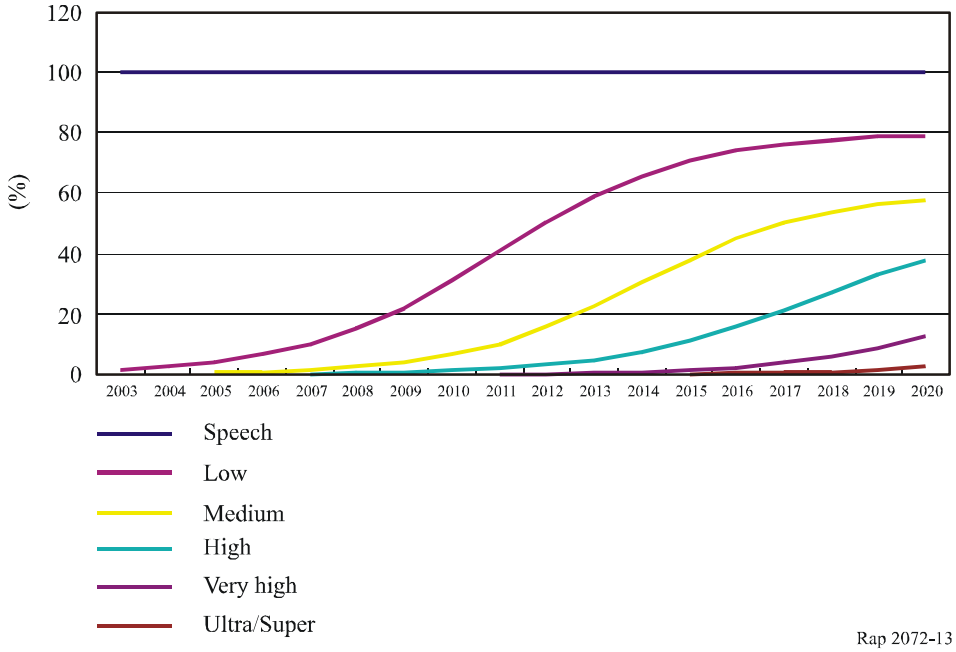
Ultra/Super high multimedia: It needs to be supported by systems beyond IMT-2000. It is estimated that the service will appear from 2015 and the maximum penetration rate will reach 30%.

It is assumed that the penetration rate of each service will be the same in different environment, Dense urban will be considered mainly in the spectrum calculation.

Figure 13 shows the penetration rates of all kinds of services under different environments.

FIGURE 13

Penetration rate of different services



5.2.4.4 User density forecast

The user densities of each service under different environments are listed below.

TABLE 19

User density in different environment

Speech	**Dense urban**	**Urban**	**Suburban**	**Rural**
2010	147 840	60 300	8 190	1 560
2015	185 300	81 600	13 440	3 180
2020	219 830	97 440	18 090	4 130
Low rate	**Dense urban**	**Urban**	**Suburban**	**Rural**
2010	45 836	18 695	2 539	484
2015	131 218	57 784	9 517	2 252
2020	174 011	77 131	14,320	3 269
Medium rate	**Dense urban**	**Urban**	**Suburban**	**Rural**
2010	9 570	3 904	530	101
2015	70 612	31 095	5 122	1 212
2020	126 835	56 220	10 437	2 383
High rate	**Dense urban**	**Urban**	**Suburban**	**Rural**
2010	1 836	749	102	19
2015	20 315	8 946	1 473	349
2020	83 078	36 825	6 837	1 561

TABLE 19 (*end*)

Very high rate	Dense urban	Urban	Suburban	Rural
2010	148	60	8	2
2015	2 553	1 124	185	44
2020	26 989	11 963	2 221	507
Ultra/Super rate	**Dense urban**	**Urban**	**Suburban**	**Rural**
2010	–	–	–	–
2015	371	163	27	6
2020	5 809	2 575	478	109

5.2.5 Case Study – Estonia

As the population is expected to be on the same level (1.4 million), growth of the market volume is possible only together with increase of GDP. At present, Estonian's are spending a considerable amount of their income for communications: 4.5% (this includes both, fixed and mobile) compared with the average European figure of 1.5%. So big changes in structure of expenditure in favour of communications are not envisaged and having in mind 5% annual growth of GDP, the mobile market volume growth can be expected for 2010 by 1.3 times and for 2020 by 2.2 times. As average spending for communications will probably decrease, mobile communications market volume will increase and fixed market will decrease. This will happen because of increasing mobility of telecommunication services and interest of the Estonian population for communication and technical developments.

5.2.6 Case Study – Japan

Japanese market forecast for some typical applications envisaged for the future development of IMT-2000 and systems beyond IMT-2000 which may be pervasive from 2010 to 2020, are shown. Those Japanese market forecasts are adopted from Ministerial white papers or Ministerial policy/vision reports. Those reports are produced by interdisciplinary elaboration of industry experts and/or academia.

TABLE 20

Market trends in Japan

Application	Market trends
Telephony/ Videotelephony	Telephony will play a major role in the future, as today. With the introduction of videotelephony service over IMT-2000 systems, the service is attracting users
e-mail/video-mail	In parallel to telephony, messaging services will also play a major role in the future, as today. With the advent of camera functionality on mobile terminals and the introduction of flat rate high-speed services over IMT-2000, not only users but also traffic may increase more quickly than ever
Web browsing	Upon advent of flat rate service for packet access, web- browsing on mobile terminals will be accelerated further. On the other hand, terminals capable of full browsing have been available on the market since the end of 2004, leading to dissemination of such applications on mobile terminals. Accordingly, it is envisaged that an existing barrier between mobile phone browsing and PC browsing will gradually diminish

TABLE 20 (*continued*)

Application	Market trends
Video streaming	Upon introducing flat rate packet services, web browsing on mobile terminals is increasing, like the trends of the Internet usage on PC. With the dissemination of broadband services, video streaming services over mobile terminals will increase as well. Market forecast of video contents distribution services: FY2001e FY2002e FY2007f Video streaming 13.5 BYen 23.7 BYen 98.4 BYen Video contents include movies, TV programmes, video games, etc.
P2P (peer-to-peer) file transfer	Upon disseminating broadband services over the Internet, P2P file exchange services are increasing. As of today, about 3% of Internet users may enjoy P2P services. Upon introducing and disseminating broadband services over IMT-2000 systems and the future development of IMT-2000 with diversifying applications facilitated on mobile terminals, P2P applications over mobile terminals will increase as well
Multiplayer game	Multiplayer game will increase with introduction of high performance mobile devices and adoption of broadband technology. Users of game download services account about 9 million at the end of 2003. Recently, hit video games are transported to the games for mobile devices. Multiplayer games played over the Internet, which have been increasing rapidly, will be transported to those over mobile devices, as well
e-learning	e-learning may provide lectures to meet trainees' demand and may save time for commutations and costs for facilitating premises, accordingly, e-learning may spread or be widely accepted. e-learning is firstly disseminating in lectures or trainings for IT industry. The trend of estimated gross market size is shown below: FY 2003 FY 2010 Market 169.96 BYen 648.35 BYen
Download services (music, game, e-newspaper, e-book)	Software contents distributed through downloading services will be widely spread in line with spreading of services on e-book terminals or music-data-storable-terminals or advanced mobile terminals. Music download service is becoming a mainstream service in Japan. The number of downloaded music tunes onto mobile terminals is about 120 million in September 2004 since its commencement in December 2002. Game download service is also becoming a mainstream service. Popular video games are being transported to the games for mobile terminals. Trends of estimated market size in B Yen (Billion Yen) is depicted below: FY 2001e FY 2002e FY 2007f Visual 13.5 BYen 23.7 BYen 98.4 BYen Music 28.7 BYen 42.9 BYen 118.3 BYen Text 12.0 BYen 16.2 BYen 49.0 BYen Visual: movie, TV programmes, games, etc. Music: music, radio, etc. Text: newspaper, books, journals, etc.

TABLE 20 (*continued*)

Application	Market trends
ITS probe	ITS industry is expected to enter the 2nd phase around 2007, which means widely spread of ITS devices. Security concern on emergency cases will drive position location and reporting capability on various types of equipment and devices. ITS market size is forecasted by Ministerial telecommunications council: FY 2010: 4.7 Trillion Yen, FY 2015: 7.4 Trillion Yen
Telemetering	Telemetering applications representing Machine-to-Machine telecommunications: Telecommunications may play a central role in ubiquitous network society, and is thought to be disseminated in line with development of not only wireless access technologies, but also business solutions. Japan has already experienced wireless telemetering of consumption of water, gas, and electricity, AVM managements, quality monitoring of water supply, etc. Perceiving more than 5 million AVM machines installed in Japan, a considerable size of market is conceived
Network camera	As like telemetering applications, network-camera applications will also play a central role in ubiquitous network society and will be disseminated in line with development of not only wireless access technologies but also business solutions for applications to private sectors including home security applications. Japan has already experienced wireless network-camera monitoring of car-parks and of construction venues. Recently, application areas are extending to monitor crowdedness of cars or applications for confirmation services of the situation of parked car via network-camera
Medical/health-care/surveillance-service monitoring application	New businesses around home environment are under development with the advent of digital home appliance or home networks. One of typical examples among those is medical/health care/surveillance monitoring applications for elderly people in their home environments. Japan is rapidly getting older; for example, the ratio of people over age 65 will be around 22.5% in 2010 and the ratio of households of such elderly people only will be more than 20%, i.e., 10 million, in 2010. Real-time monitoring systems for biomedical sensing are become available and interest is very high, about 78.1% according to JEITA survey. Real-time monitoring systems with biomedical sensing capability using wireless technology and management system for those are under development in government affiliates and else
e-emergency rescue	For emergency rescue services, immediate preparatory care for a person is very important. Accordingly, not only biomedical data but also video image transmission during ambulance rescue service is very important. Ambulance service is counted about 660 thousand times in Metropolitan Tokyo. Advent of such application will improve remedy ratio under those emergency cases. NiCT, a government affiliate research institute, has been testing pre-market trial towards implementation with transmission capability of high-definition images and/or echo-images over IMT-2000 network, optical cable network, and high speed wireless networks

TABLE 20 (*end*)

Application	Market trends
Exercise-monitor	People are getting awareness of health. To keep health condition, exercise occasions are increasing, the ratio accounting almost 70% of population. Exercise monitor management system will yield efficient exercise practices with ensuring measure in case of urgency, leading strong demands for such applications
ITS (navigation)	Car navigation systems have been accepted widely in the market, the market size of users' devices is around 3 million units per year, and further expansion is envisaged. Media used in the system has been changing from CD-ROM to DVD or HDD with integrating high-level multi-functionality. Car navigation systems with telecommunications capability are emerging, which can afford surrounding information including maps, car parks, restaurants, malls, shops, etc. The most interesting information for users in car navigation services is downloading maps. User's demand to update pre-installed map using telecommunications links is very high

5.2.7 Case Study – Republic of Korea

The market trends and scale of some major services of mobile communication from 2010 to 2020 are discussed in this section. The Korean market forecasts are drawn from reports published by the government or prestigious research centers, which reflect actual growth pattern and trend for each service and some predictions of the application services. Where the actual or projected data for some services are not available, macro trend and forecasts released from press and experts' study results are used.

Driven mainly by the Republic of Korea government's commitment to developing communications technologies and investing in the establishment of an information superhighway infrastructure, there has been very rapid expansion of the communications sector in Korea during the past decade. Korea now boasts one of the world's highest penetration rates in terms of fixed-line and wireless telecommunications. The development and availability of broadband access has also been accelerated in recent years.

The Republic of Korea provides affordable high-speed Internet connections nationwide. The number of Internet users in Korea has been doubling every year since 1998 and this bullish trend is forecast to continue. Korea has the highest broadband penetration rate in the world. More than 70% of all households have a broadband connection at home. The total number of Korean Internet users topped 30 million people, almost 67% of the entire Korean population from the age of six and up, according to the Ministry of Information and Communication.

The Republic of Korea was a late entrant in fixed-line telecom but continues its development in wireless communications from cellular phones to next-generation networks. Korea is the first country to use the the code division multiple access (CDMA) technology in cellular communication and wireless Internet services using the technology in 1999. Thirty-five million mobile subscribers are able to access to wireless Internet as of September, 2004. Video on demand (VoD) and multimedia messaging service (MMS) were also available from 2003.

In 2005 the Republic of Korea initiated the testing of high speed wireless internet technology such as WiBro and Zigbee. WiBro's commercial launch is expected in the first half of 2006. WiBro is capable of providing an access to the Internet at higher speed (1~2 Mbit/s) in a moving vehicle.

The saturation level of WiBro service in Korea is expected to be 10 million subscribers within 5~6 years since its deployment.

Conversational voice

IDC Korea predicts a 12.8% Compound Annual Growth Rate (CAGR) through 2007 for the Korean wireless communications service market, reaching 29 trillion won (about 29 billion dollars) in revenue, from 18 trillion won in 2003. It is expected that revenues from voice communications are slowing down due to market saturation but non-voice sales are expected to moderately expand. It predicts the number of mobile subscribers will reach 37.7 million by 2007, showing an annual 3.1% growth rate. In 2005, the mobile subscribers are 37 million, which is 86% of the country's population.

Messaging (SMS/MMS)

SMS: With the rapid proliferation of cellular phones, the use of SMS has soared over the past years. For example, one mobile operator handled 45 million messages a day in 2001. The number grew to 53 million messages a day 2004. In 2005, daily SMS traffic reached to 70 million messages. The second largest mobile operator carry 30 million SMS traffic a day. Mobile operators said most of the SMS traffic apparently comes from young customers, who use the service as a cheap way to keep in touch with families and friends. But the user is widening toward those in their 20s and 30s. Within 20 years the market will be enlarged to all customers irrespective of age.

MMS: Swapping text-based messages via cellular phones is quickly becoming old-fashioned in the Republic of Korea. MMS enables cellular phone users to swap pictures with sound clips on their handsets or personal digital assistants, or play interactive games featuring colourful graphics and crisp sounds. MMS services that promise pictures, animated characters, user-created content, voice recordings, and video clips are expected to boom with the growing popularity of camera-equipped cellular phones. Currently, monthly camera phones sales account for about 70% of the market. Mobile operators are now expanding the applications of MMS, will reinforce from 2010 to 2020 with the development of technology.

Mobile contents market will rapidly move from one-way and text-based services such as ring-back, ring-tone, SMS, stock information in the early 2000s to interactive multimedia contents like broadcasting, game. IDC Korea said that the MMS market size would be larger than the SMS market from 2005 and the total market size would reach at 630 million dollars by 2007.

LBS (location-based services)

The mobile operators have provided a location-based service (LBS). The service helps its users find another member by identifying geographic coordinates of the base stations and repeaters.

LBS is another compelling capacity allowing the character to search via the wireless Internet for specific locations near the user, such as a restaurant or flower shop. The phone automatically recognizes where users are by picking up the signal of the nearest base station, and then provides menus and maps.

Table 21 shows the LBS market trend in Korea.

TABLE 21

LBS market trend

(Source: Korea Association of Information & Telecommunication, LBS-BSI report, 2005)

	2003	2004	2005	2007
Market size (million dollars)	266.8	521.5	846.0	1 656.1

Telematics is a multimedia service that provides vehicle drivers appending to automobiles with transportation guidance and emergency information, and also gives infortainment service like the Internet, cinema, or game in a vehicle. With the pervasiveness of WiBro and DMB, the growth of leisure activities, telematics will be positioned as a new automobile culture. As the Korean telematics market is expected to grow at 86.2% every year, it will reach at 2.97 billion dollars in 2007.

Entertainment service

Games are not just only for kids but also could mean business. Those working in the game industry think that the potential is immeasurable. Although games are mostly enjoyed by the younger generation at the moment, they will definitely become one of the most popular forms of entertainment in the near future when the youth of today become adults. Korea's cellular phone makers and mobile operators continue to increase their marketing efforts in the online game sector with the goal of winning the support of the nation's younger generation.

Terrestrial DMB enables moving users to enjoy various multimedia contents like audio, video, data through portable devices small sized TV, PDAs. Satellite DMB is a multimedia mobile broadcasting service provided via a handset and it will be converged with various mobile Internet services.

Various types of mobile broadcasting services will be introduced and the mobile broadcasting market will grow up about 27 million subscribers in 2010. (Estimated by sum of forecasts for the individual service type so actual demand would be less than this estimation.)

Mobile game

Mobile game is an online game using a mobile terminal such as a handheld game console, PDA and cellular phone. The Korean mobile game market has been growing rapidly in spite of economic recession and this pattern will continue with the introduction of high-quality devices, the improvement of service environment and affordable flat rate. IDC Korea forecast the mobile game market would grow as in Table 22.

TABLE 22

Mobile game market trend
(Source: 2004 Korea Game White Paper)

	2002	2003	2004	2005	2006
Market size (million dollars)	1 004	1 485	2 187	3 062	4 138
Growth rate (%)	–	45.2	50	40	35

Movie (VOD)

Video-on-demand (VOD) refers to a technology that makes it possible for consumers to control the start of a viewed programme. For example, by remote control a consumer might pick from an on-screen list of movies and start and pause it at their convenience. If fully deployed, it would eliminate the role of video rental stores and change the nature of television services. It would require massive video servers and networks that provide individual video channels from each home to a server location. Cable Hybrid Fiber Coax (HFC) and telephone DSL are possible ways to provide this service.

Mobile VOD can provide movie and value-added content and it has competitive advantage over the Internet service in that hacking or illegal copy can not be made.

Music

Digital music contents has been varied with wireless and wired ring-back and mini homepage background music (BGM). Also, various technologies of streaming, mp3 download, ring-tone download has been developing. The market size of 2 550 million dollars in 2004 has been 5.7 times as 45 million dollars in 2000. The total music market including digital music will reach 500 million dollars in 2005 and will be over 1 000 million dollars in 2009.

Recently, the government set a goal of achieving a music market scale of 1.5 billion dollars by 2010. It concluded a strategy of realizing "21st century music power" with a growth rate of 5% for record, 32% for digital music, 5.4% for music content export every year..

It is expected that the music industry will rapidly recover as the connection with copyright law whole surface rectification and music industry promotion law enactment is maintained, and the new contents circulation channel with DMB is expanded. In 2005, music market size including the record market is estimated to reach 500 million dollars, and to pass one billion dollars in 2009.

5.2.8 Perspective on market issues – UMTS Forum

In this section we review some key emerging services that might be available in line with the technology improvements by the decade 2010-2020. Most likely trends for the year 2010 and probable evolution are presented.

Some of the services quoted in this Report are in continuity with the services currently available in some markets. While customers from advanced regions (e.g. the Republic of Korea) are already experimenting such services, the future of these technologies and the education of the consumer base will widen their usage worldwide.

The services are therefore linked with existing facts and trends, reducing the scope of the prediction for future traffic assumptions, even if consumer trends and service adoptions are difficult to forecast. Because realistic forecasts cannot uniquely be based on prospective trends on each service, these services have been organized and gathered in categories of services by the UMTS forum as reflected in Table 23.

TABLE 23

Categories of services by the UMTS forum

Service Category	Description	Example of emerging mobile services
Mobile Intranet/ extranet access	A business service that provides secure mobile access to corporate local area networks (LANs), virtual private networks (VPNs), and the internet	Intranet access, VPN, access to corporate databases
Customized infotainment services	A consumer mobile service that provides device-independent access to personalized content anywhere, anytime via structured-access mechanisms based on mobile portals	M-commerce: E-commerce sites, online banking and finance, advertising
		Others: Mobile customized portal, blogs, games (download, online), lotteries, bets, personalization of devices (ring tones, logo...)

TABLE 23 (*end*)

Service Category	Description	Example of emerging mobile services
Multimedia Messaging Services	A consumer or business mobile service that offers non-real-time, multimedia messaging with always-on capabilities allowing the provision of instant messaging. Targeted at closed user groups or business communities that are services provider- or user-defined. MMS includes messaging between people and also between machines (telemetry)	SMS, simple email, instant messaging, chat, forum, MMS, photo, video messages, telemetry
Mobile Internet access	A service that offers mobile access to full fixed ISP services with near-wireline transmission quality and functionality. It includes full Web access to the Internet as well as file transfer, email, and streaming video/audio capability	Email, file transfer, streaming and downloading of video/audio clips, Internet-style websites, Internet browsing
Location-based services	A business and consumer mobile service that enables users to find other people, vehicles, resources, services or machines. It also enables others to find users, as well as enabling users to identify their own location via terminal or vehicle identification	Downloading of geo-localized maps, GPS, advertising, people finder, product and service finder, M2M
Simple voice and rich voice services	A mobile service that is real-time and two-way. Simple voice provides traditional voice services including mobile voice features (such as operator services, directory assistance and roaming). Rich voice provides advanced voice capabilities (such as voice over IP (VoIP), voice-activated net access, and Web-initiated voice calls, and mobile videophone and voice enriched with multimedia communications	Voice telephony, voice messages (recording and reading messages), videotelephony, VoIP, videoconference, collaborative work

– **Object identification**

While the power and functionality of end user devices continues to improve, other capabilities are being developed to increase their range of applications. Sensing and actuating technologies such as micro-electromechanical systems (MEMS) will be embedded in a growing number of real-world objects and places, opening a range of new solutions that will quickly impact in activities such as logistic or supply chain (device, car, wagon, truck).

Wireless communication technologies, with radio frequency identification (RFID) leading the charge, will connect first objects directly to data collection environments; further down the line they will connect objects to each other with data collection environments. This will add a new set of capabilities for detection, alerts or online commerce through a set of technical and commercial "bridges" between the physical and online worlds.

By 2010, capabilities will include:

– Some handsets that will be equipped with specialized readers to identify items tagged with barcodes, RFID or other identifiers.

– Handsets that will be also able to read several types of printed tag using just a camera, such as QR codes, Semacodes, Spot Codes and Bango spots. Multiple formats of printed handset readable information will co-exist on products.

These capabilities will be used for accessing Web information about products and locations, and for comparison shopping between various real-world and online outlets. They will be used in conjunction with geo-coding (GeoURLs), which add location information to Web information (e.g., overlaying selected points of interest onto a map, as at maps.yahoo.com). For example, these capabilities will have simple and direct applications such as mapping disease or pollution propagation, harvest problem, temperature measurement etc.

Between 2010 and 2020, wireless tags and beacons (e.g., using active RFID) will be associated with specific objects and locations, which will alert handsets in the vicinity to their location or availability. This will be used to drive more flexible mobile and micro-commerce, as users can be alerted of interesting and relevant business propositions in their vicinity, or search one out based on their current needs.

We can imagine in that future each individual will manage him- or herself a series of personal wireless tags (in his house and personal tags). Remote control of his or her personal life will then be possible.

Inhibitors: The main inhibitors to ubiquitous identification of items and locations will be coverage of the tags in the real world. GPS and geo-coding allow much of the infrastructure to be built up without each location having its own tag, but more fine-grained information access will require item tagging. This is more straightforward with products, particularly for printed codes, as the tags are also required for supply chain management. Grass roots initiatives may drive some coverage of location tagging (e.g., www.yellowarrow.org, where users affix a yellow spot with a unique ID to a real world location, and associated comments with the location via text messaging), as will the desire for merchants and others to broadcast relevant information about their goods and services.

– **Sensor networks and M2M**

At some point in the future (2020 or later) the number of connected points, products or machines might exceed the number of connected people. Even though machine traffic and revenue may not be as large as people-derived revenue, they will be considered as an opportunity. High wireless bandwidth opens up new machine possibilities such as streaming security cameras. Also, there is a basic business principle that you can take a product, add networking, and turn it into a service or a relationship. So M2M will enable some transformational applications.

One major contributor to the growth of connected machines will be sensor nodes. Sensor nodes will exert a major influence on daily life over the next 10 years. So much so that, like PCs and cellular phones, shipments of sensor networks will be measured in billions of units per year.

Miniaturization made possible through nanotechnology and new materials will enable every living and inanimate object to be tagged. Tiny passive chips can be implanted in buildings, on buildings, in machines, in jet engines, in wallets, carpets, fields, deserts, battle zones, road signs, pets and people, for everything from enhanced security to exchange of contact information.

Homes will be “sensorized” with remote monitoring and control of refrigerator inventory, environmental controls and parental control of content. Highways will have sensors that will dramatically reduce accidents by linking to vehicle controls and maintaining safe minimal distances. Contextual information linked to location data will be pervasive. Wide availability of translation devices will enable real-time direct communications in between any of the earth’s languages – in speech or written communications.

Sensor nodes are closely related to RFID tags, but have more intelligence and persistent power. The two technologies will eventually converge, although there will be technical issues to solve first. Sensor technologies in power, radios and networking, for example, are well under way.

However, sensor networks cannot make progress in the market until location sensing becomes more reliable. It is no good deploying billions of sensors if you have to record the location of every node. At the moment, the technologies around location sensing are still somewhat in the early stages of research. There will be tactical deployments, where the number of sensor nodes is small enough that location does not have to be automatic, but the true potential of sensor networks will have to wait.

– **Health monitoring**

Technology for monitoring an individual's vital signs (i.e., "physiological monitoring") will form part of a personal area network, with the mobile device as the hub. The local device will perform a first level analysis, with more sophisticated analysis and long term data capture available through wireless transmission of the health information to a server maintained by individuals or their healthcare providers.

Through 2010, health monitoring linked to wireless capture and analysis will develop but still be primarily a specialist or niche application. The main uses will be during exercise (e.g., advances on today's watches with heart monitors), for patients with chronic conditions and for military applications. Some consumers will use basic health monitoring applications like blood pressure measurement or weight control.

Between 2010 and 2020, adoption will expand to routine monitoring for proactive healthcare by healthy individuals, driven by a personal desire to stay healthy as well as by incentive programs from healthcare and insurance providers and employers. In addition to device-oriented capture, biometric monitoring may also be performed through smart fabrics built into clothing, such as Sensatex's SmartShirt vest. In addition, implanted devices (e.g. similar to today's pacemakers) may become a platform of choice. The biometric information could also be used for other purposes, such as identification or determination of emotional state. As well, sophisticated analysis techniques like "lab on a chip" may exist by 2020, with mobile phones being used to 'sniff' an individual's breath for chemicals that indicate illness. Personal health information on a chip or easily transferable (under privacy control) will be offered.

Inhibitors: Adoption of monitoring technology by healthy individuals will be driven largely by fashion and social norms, which are extremely difficult to predict. Non-implanted devices may not become adopted by 2020 for two reasons: they would not deliver enough accurate data, and they would not be convenient to wear; also "Smart Clothing" may be very expensive even in year 2020, if aiming at providing the same data accuracy as implanted devices.

– **Location discovery**

Every wireless technology can provide some location information as a side effect of its operation. Technologies like GPS and Galileo exist solely to provide location information. Accuracy will be improving in that area for the next coming years.

By 2010 future technologies such as wireless beacons are likely to provide both location and context information (e.g. "this is the door of a shop, this is what we sell"). In the case of mobile transmission technologies such as 3G some location information can be deduced either directly (e.g. by knowing which cell or access point is nearby) or by using additional network equipment measuring signal direction or timing.

By 2020 systems such as GPS and Galileo are expected to provide precision of around 1 m in real-world conditions, near field wireless or RFID tags a few centimetres, beacons a few metres, 2.5G or 3G network based systems such as triangulation tens to hundreds of metres.

Multiple implementations...

Equipment such as MEMS accelerometers which may be installed in electronic devices for purposes such as user interaction or detecting if the user has fallen over, also have a role to play.

These aid location deduction because they might be used for approximate dead reckoning calculations based on the acceleration of the user. Researchers have also demonstrated systems, which can deduce their location by comparing an image of the surroundings with an image database. However even by 2020 this is unlikely to provide mass coverage because of the difficulty of maintaining a sufficiently comprehensive and up to date database.

...through multiple networks

Also by 2020, not only systems dedicated to location discovery but also various other devices will enable location based applications. Many mobile devices will support multiple wireless technologies and multiple ways to deduce location. For example, a future mobile handset might incorporate 3G, GPS, accelerometers and one or more short range wireless technologies. Such a device will therefore have several ways to deduce its location.

In practice not all technologies will be available all the time, e.g. GPS or Galileo will require that the handset can "see" several satellites: fewer satellites provide less precision, and in some situations such as when operating indoors, no satellites may be visible. In the targeted period, a wireless device is likely to maintain a continuous estimate of its location by integrating several estimates from different technologies (e.g. Mitsubishi's PAS (Positioning Augmentation Services) solution combining GPS with a network of electronic reference points on the ground), preferring the most precise source of information at any time.

In the 2010-2020 period, it is assumed that location will always be available, but its precision may vary from around 1 m in the best case to several tens of metres in poor situations.

Inhibitors: Inhibitors to location discovery will be technology and consumer attitude. The main obstacle to location accuracy is indeed location or coverage. Consumer attitudes and reluctance to be located may impede some development in location-based services.

– **M-Payment**

By 2010 the technologies required for initiating the interaction, the mobile transaction authentication and payment reconciliation will have matured. There will be likely several complementary systems in place.

The interaction between a user's device and a merchant's system can be dealt with by 2010 using any type of networks.

For the mobile transaction authentication several alternatives exist. Mobile operators are likely to use the existing authentication to make phone calls. Internet e-payment providers or the European Click&Buy Alliance could leverage the same technologies as in the desktop-Internet world (e.g. cookies) and potentially a third alternative could be another token that interacts with the mobile handset (e.g. a Bluetooth dongle).

Three to four alternatives may exist when it comes to payment reconciliation. There are several models of user, merchant, and payment provider interaction. From the end-user perspective mobile payments could be billed via telephone bill (in that scenario the mobile operators are payment processors), via credit card bill (in that scenario the credit card processors are payment processors), via checking account transfer (in that scenario the retail banks are payment processors), or via the Internet e-payment provider such as PayPal (eBay) or the European Click&Buy Alliance.

The major variable sits in how dominant the different alternatives of the m-payment steps will become, which will also determine the size of the cake mobile operators can potentially own. How will the incumbent banks react? Two main issues will impact future m-payment models: Who will consumers trust most when it comes to payment settling? Who will be most successful in relationship management with the major merchants?

– **Micro-commerce**

Mobile communications provide an alternative channel to access information about desired goods and services and complete the transaction within a secure environment. This ability to complete the retail value chain – from enquiry, to information, selection, and financial payment – is an extremely powerful mechanism that can radically change the nature of personal and business commerce and the use of traditional transaction media such as cash and credit cards.

The logic of micro-purchases (small transactions of less than €5, or even much less e.g. into the cent-arenas) is the increasing penetration and consequentially decreasing transaction cost of electronic payments. This will enable new things to be sold largely centred around (mobile) paid content and location-based-services initially.

By 2010 micro-payments using some form of active device (e.g. smart card with near field wireless, RFID identifier, mobile handset, Internet PC) will be an almost pervasive capability available to anyone with bank account. By 2020 it will be essentially pervasive.

Three largely intersecting major trends are driving micro-commerce:

– Widespread access to physical and social infrastructures providing a marketplace for buyers and sellers to locate each other (today mostly through PC-based e-commerce, increasingly through m-commerce on wireless networks).
– Low cost and trusted models for completing transactions.
– Discovery mechanisms (e.g. electronic publishing) of targeted content and services.

The seeds of the possibilities are already seen in Korea and Japan. In other areas of the world, security concerns and high cost have so far made mobile commerce less popular. It has also been discussed that consumers may not adopt micro-payments because of "mental transaction costs", or lack of trust. These are misguided objections and the best example is the existing business model of the telecommunications industry, which in fact since many decades is a $700 billion business based on micro-purchases (i.e. telephone calls to a large part of less value than €5).

We can observe already today new forms of micro-commerce evolving:

– Apple's iTunes music store has been extremely successful – originally conceived of as a driver of iPod sales – and is now becoming a revenue driver for the whole of Apple Inc.
– In the mobile application domain, European users spent €2 billion on ring tones, logos and screen savers in 2004.
– In the B2B space, online-advertisement got significant traction as evidenced by Amazon's referral program with more than 50K partners and Google's AdSense service.
– The Zingo taxi-hailing service in London uses location tracking and payment through a mobile phone.

Moreover, we can anticipate many more usage of micro-purchases, such as new business opportunities driven by significantly lower direct and hidden transaction costs and that will initially cluster around:

– Paid digital content at new levels or granularity (e.g. ring-tones, music, video, government or transportation information).
– Location-based services (e.g. dispatching, routing services, parking space reservations, pre-booking of fast food, shopping for event tickets, en-route delivery services.)

Consumer's attitudes should not be a major inhibitor to the development of micro-commerce but could slow down its development. By 2010, micro-commerce could grow to at least 10 micro purchases per month for 25% of the adults in OECD nations (e.g. about 1 billion adults). At an

average transaction revenue of €1, this will generate €30 billion in new product and service revenue per year.

By 2015 the commercial world will have changed significantly as a result of micro-purchases and we suppose that micro-commerce opportunities for new products and services below €5 will generate €60 billion in revenue per year by 2015. The assumption behind this trend is that 25% of adult consumers in OECD nations make at least 20 new micro-purchases per month at an average of €1 per transaction.

Some other possible trends are:

– Micro-commerce opportunities for new products and services below €5 will generate €300 billion in revenue per year by 2015. This is assuming that 50% of adult consumers in OECD nations make at least 50 new micro-purchases per month at an average of €1 per transaction.

– Micro-commerce opportunities for new products and services below €5 will generate €780 billion in revenue per year by 2015, based on the assumption that 65% of adult consumers in OECD nations make at least 100 new micro-purchases per month at an average of €1 per transaction.

Micro-commerce will present a significant redirection of cash flow. The major issue of course, is who will be the beneficiaries of micro-commerce from the various stakeholders in the emerging m-payment models.

– **Digital content**

One of the areas that will experience greatest change in the next decade will be the way we deal with information or content, whether as individuals, teams, enterprises or societies. The changes, driven by many technologies, will affect all areas of life. We are now moving into a world where the consumer is demanding rich digital content anytime, anywhere and over any channel.

Within the 2010-2020 timeframe, mobile devices and networks will be in place to meet this demand. The demand for digital content will strengthen the demand for connectivity, but the opportunity for operators to extract value from content will not be unlimited because people will have the possibility to load pirated or cheap content onto personal gadgets via the Internet. This is generally true for stable, non-time-critical content such as e-books and music. However, operators may have a range of opportunities to charge a premium for content which is time-urgent, or location-specific, or where consumers are prepared to pay for the convenience and/or immediacy of instant gratification (impulse buying).

Telecom companies will take advantage of the fact that they are the primary point of contact for customers. Moreover, their historic relationship with the end user has been more one of trust (e.g., confidentiality of communications) than in other newer industries. As the telecom industry evolves to become a major provider of content services, the value of such a trusted environment becomes paramount. The provision of content services carries obligations and responsibilities, particularly in the area of consumer protection.

The old slogan of “Content is King” is expected to be replaced with the new slogan of “Customer Experience is King”. Price-sensitive consumers will endure advertising-rich or pirated content. But many will be prepared to pay for the improved experience of advertising-free content, wrapped in services such as personalisation, recommendation engines, community, ease-of-use and one-click buying.

– **Mobile entertainment**

Mobile technology can also change the nature of entertainment. Whereas entertainment today is externally focused, i.e., an external event one attends or purchases for use in the home,

entertainment will become increasingly internal and personalised, an expression of one's personal interests and needs. The user will have the ability to view, hear, or interact with entertainment media wherever or whenever desired. In addition, the user will increasingly have the ability to adapt and use media elements to create their own personalized entertainment experience.

Users will expect to be able to choose entertainment from a highly diverse selection and control the timing and place of entertainment delivery.

Mobile interactive technology will enable a mobile gaming experience with remote players that emulates "being there". Gamers will be able to join in group games with people all over the world, either peer-to-peer or through a server. Players will be able to interact with each other through voice, video, and or graphic/text in real time, creating an interactive, responsive gaming experience.

Gaming events could be created spontaneously via messaging for virtual or physical games. Mobile video technology will also enable a wider audience.

Being able to watch movies or television only in a fixed time or place will become a thing of the past. Users might order, select and pay for a movie on one device (on mobile for instance) and watch it on another one (TV or PC). The media industry will expand the use of portable messaging to allow viewers an increasingly interactive experience. The integration of television shows with mobile data technology can already be seen with viewers voting via SMS. The accessibility and personalisation of mobile devices will enable a level of interactivity between the media and audience not possible before. The new "reality shows" will likely include the audience experience as well.

– **Corporate services**

Companies will benefit from improved communication tools in order to share more efficiently information and knowledge among workers. Especially, professional experiences will be shared through corporate blogs. Mobile instant messaging will also be a tool enabling workers to better communicate. Moreover, corporations will have the opportunity to manage supply chains and inventories more efficiently: the access to corporate data bases as inventory state will enable companies to have advantages in cost, efficiently and flexibility.

Actually, mobile technologies like VPNs or M2M services will enable the increased blurring of home and work life. Not only is one always accessible for work-related responsibilities, technology provides the increased ability to manage one's personal life from a remote work location. The questions of where one is located physically when earning income become irrelevant as everyone balances work hours between home and a number of business sites. The "office" becomes the mobile technology one carries to any physical location. Working hours are likely to become more flexible as a result.

– **M-Government**

Government will encourage adoption of technology by proactively using networks and technology to disseminate information, provide services and mandate and encourage citizen participation in government.

Government mandates to foster use of networks could take the form of required electronic filing of all government forms. Thanks to mobile technologies, these forms would be available anywhere and any time. Electronic voting is also expected to take advantage from mobility, by enabling each citizen to proceed to a vote, whatever his or her location is on polling day.

– **M-Education**

M-Education would represent a second step in the digitalization of education that was decided by many governments.

New devices such as the Tablet PC would represent a complementary way to improve a student's knowledge, although they are not expected to replace current teachers. They would provide tools, anywhere and anytime, to check his or her knowledge. For instance, university and school students will carry with them an always-on screen to manage their work.

5.2.9 Case Study – United States of America

The services and markets of the future development of IMT-2000 and systems beyond IMT-2000 must be identified. This is not an easy task as forecasts contain many caveats and exceptions especially for forecasts as far as 2020. There are many issues and type of services which can be considered. A key need is to define the services based on parameters, such segmentation (e.g. consumer or business, adult or youth, etc.) There is no set standard for defining these services, and different publicly available announcements indicate an inconclusive picture.

According to the USA Census website (www.census.gov) the USA is expected to have the following number of inhabitants from the years 2010 to 2020:

This information prepared by the U.S. wireless industry since the U.S. Administration does not make recommendations specific to wireless services or make forecasts regarding market size.

TABLE 24

US population forecasts

Population	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
USA 1000s	308 936	311 601	314 281	316 971	319 668	322 366	325 063	327 756	330 444	333 127	335 805

Source: census.gov

TABLE 25

Expected wireless subscriber and penetration for voice and data

Subscribers	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
USA wireless subs 1000 s	244 382	246 694	252 202	257 433	262 739	268 136	273 623	278 925	284 306	289 481	294 726
Wireless Penetration											
Penetration – USA	78.00%	79.17%	80.25%	81.22%	82.19%	83.18%	84.18%	85.10%	86.04%	86.90%	87.77%

Source: Bell-Labs Business Modeling Group

Applying specific take rates for data usage will yield the number of wireless data subscribers.

Data subscriber is segmented by usage type. Casual data subscriber are defined as subscriber most of whom use short message service (text) and some of whom also use multimedia messaging (MMS, picture mail), download ring tones or do simple web surfing.

These subscribers will use their data-capable handsets. Heavy data subscribers use the wireless data access for heavy web surfing, emailing, videoconferencing etc. In essence, heavy users will demand broadband access speeds (like DSL and cable) from their wireless connection. The following are estimates for both casual and heavy data users:

TABLE 26

Growth of U.S. wireless data users (casual and heavy users)

Data – Heavy + Casual Subscribers	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
USA casual data users % of population	25.7%	26.1%	26.5%	26.8%	27.1%	27.4%	27.8%	28.1%	28.4%	28.7%	29.0%
USA wris casual data subscribers 1000 s	79 424	81 409	83 227	84 953	86 704	88 485	90 296	92 045	93 821	95 529	97 259
USA heavy data users % of population	7.7%	8.9%	9.9%	10.8%	11.9%	12.9%	14.0%	15.0%	16.0%	17.1%	18.1%
USA heavy wris data subscribers 1000 s	23 788	27 732	31 114	34 233	38 040	41 682	45 379	49 131	52 937	56 798	60 713
USA – total data subscribers 1000 s	103 212	109 142	114 340	119 186	124 744	130 167	135 674	141 176	146 758	152 327	157 973

Source: Bell-Labs Business Modeling Group

TABLE 27

Expected US wireless voice and data revenues

Revenues – Voice + data	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Revenues – USA billions	$167 086	$166 768	$168 575	$170 116	$171 626	$173 119	$174 596	$175 138	$177 138	$178 216	$179 286
Revenues – Data											
Data revenues – USA billions	$52 588	$58 369	$67 430	$68 046	$66 934	$67 517	$68 092	$65 075	$65 541	$65 940	$62 750
ARPU – Data											
ARPU data – USA (per data user)	$42.46	$44.57	$49.14	$47.58	$44.71	$43.22	$41.82	$38.41	$37.22	$36.07	$33.10
ARPU data – USA (per overall subscribers)	$17.93	$19.72	$22.28	$22.03	$21.23	$20.98	$20.74	$19.44	$19.21	$18.98	$17.74

Source: Bell-Labs Business Modeling Group

Note that data ARPU is measured per actual data subscriber and per overall subscribers (some who do not use data service at all.)

For the USA there are forecasted to be nearly 157 million wireless data subscriber by 2020, 60 million of which are heavy users and 97 million of which are casual (and not negligible) wireless data users.

The NAR wireless data market is expected to be worth $62 billion by 2020 with each data subscriber using more than $33 worth of data services per month.

6 Usage forecast for future development of IMT-2000 and systems beyond IMT-2000

6.1 Key market parameters

Note that these key market parameters may also be relevant for other radio systems, such as those described in § 7.

6.1.1 Introduction

According to the classic economics, the market size is determined by factors from different aspects: the Desire to consume, and the capability to consume. The market size of IMT-2000 and systems beyond IMT-2000 can be estimated from many kinds of parameters. It is also necessary for the

market size estimation to take account of key issues from contexts of the socio economic, technical and so on. These parameters and issues can be categorized by factors from several aspects.

For example, total population is one of the key parameters to determine consume. The more the total population is, the more the total capability is under the situation of same average income. The concentration of population in urban areas, urbanization, is also an important driver of cellular penetration. In these areas, life styles are more favourable to mobile expansion, and the high density of population lowers the cost of providing the services.

Income can be the other key market parameter for the market estimation. It can be considered as an approximation for the average citizen's capacity to buy mobile telecommunication services. Human development can be added to assess the general stage of development of each country, because the information for income such as Gross National Income (GNI) does not show what kind of goods and services the country produces, nor how equitable income is distributed among the population. It is obvious that telecommunication growth is highly correlated to the level of fulfillment of other primary social needs such as health and literacy rate.

Technology which will be available to users at a certain point of time, technology progress, is highly involved to the market because new technology will lead to new services and demand creation which are indicated by parameters such as content, QoS and security.

6.1.2 List of parameters

Table 28 describes the parameters and issues and also their impact to the market trend forecast from the view of several aspects.

TABLE 28

List of the key market parameters and their impact

Parameter/issue	Impact
Social and economical aspect	
Population	*Population density, Population growth:* The larger the analysed population, the larger the market is expected for high-speed wireless data services
Economic indicators	GDP, GNP, economic growth
Income	Overall income level is a factor in usage of high-speed wireless data services, the higher the level of income, the higher the usage and adoption is expected
Human development	*Health, Education/Literacy rate:* Telecommunication growth is highly correlated to the level of fulfilment of other primary social needs. The more educated the population is, the more likely it is to use high-speed wireless data services
Teledensity	*Mobile penetration:* Higher teledensity points to higher adoption of high-speed wireless data services although, a country with low teledensity may "leap-frog" ahead with wireless services availability

TABLE 28 (*continued*)

Parameter/issue	Impact
Social and economical aspect (continued)	
Usage pattern (current/forecasted)	*Wireless data users/penetration, industry specific adoption of high-speed wireless data services, number of active subscriptions for each service category in a given area, urbanization, habit:* Current usage is indicative of future usage – MOU, busy hour times, peak usage etc. What is the expected usage, using public available info and private research
Government adoption	Government usage of high-speed wireless data services in its own agencies (Military, law enforcement, healthcare, etc.) will affect usage by business and consumers
Business adoption of wireless	Business adoption of wireless is indicative of future propensity to invest in high-speed wireless data services
Early adopters	How big is the early adopter segment of total usage-early adopters are good indicators of technology's success
Technological aspect	
Technology progress	*Technology evolution (standards, products etc.), technology affinity:* New technology will lead to new services and demand creation
Market aspect	
Time-to-market (a.k.a. first to market advantage)	First operator to market with high-speed wireless data services, will have the first mover advantage and expected larger share of high-speed wireless data services users
Scenario planning	Using sensitivities on all assumption and inputs (parameters/issues) to derive "what-if" scenarios
Probability analysis	Like scenario planning, assigning probabilities to outcomes (e.g. what if one more carrier enters market – what happens to high-speed wireless data services demand)
Device availability	What technology will be available to user at what point in time
Market segmentation	Business and consumer traffic differs significantly Comment: Whilst there are a myriad of market segmentation schemes and hundreds of possible variations, the simple separation of business and consumers handles most of the traffic considerations
Service aspect	
Existing wireless coverage	More coverage will translate to more potential users
Current mobile data status	Take rates of SMS, WAP, GPRS, 1X etc. services indicate users' acceptance of wireless data services
Tariff	*$ per transaction, $ per month, $ per traffic (kb/min):* Tariff is important factor of attraction for new services, especially in developing countries
Average revenue per user (ARPU)	Higher prices would lead to lower demand (demand elasticity)
Minutes of use (MOU)	The higher MOUs would be indicative of higher high-speed wireless data services demand, although voice centric markets may see less data uptake due to large voice usage

TABLE 28 (*continued*)

Parameter/issue	Impact
Service aspect (continued)	
Device cost	Higher device cost would indicate that user demand will be less then actual demand may be, unless a device becomes a "must have" trend
Content	Content is one of the most important factors to attract consumers
QoS	QoS is important for consumers' satisfaction degree
Security	*Possibility of content stolen, Possibility of data lost:* The more we rely on the mobile systems, the more importance of security is
Traffic volumes and types	
File sizes for non-real time services	Larger files and traffic per user will require improved capacity management techniques to maintain cost effective network
Bandwidth/speed for real time services	Increasing use of video conferencing and other "Rich Voice" services will consume significantly more spectrum that today's voice traffic
Session/call frequency	Increasing session/call frequency is expected to increase traffic volumes
Session/call duration	Call duration is expected to be flat and will not offset traffic volume increases
Contact type – one to one, one to many	There will be more one to many applications in the future and these can significantly increase traffic volumes Comment: Policy issues related to broadcasting in a mobile environment are an issue
Time varying traffic factor	*Call/session duration in busy hour:*
Machine to machine connections in public mobile networks	Large growth is expected. New ways of thinking about penetration rates are needed
Mobility	*Maximum required mobility support:*
Internet/personal computer penetration	Higher personal computer penetration and Internet usage would translate to higher usage of high-speed wireless data services, although "leapfrogging" is possible for less developed countries (by deploying wireless)
TV/media usage	The higher the users familiarity and comfort with different media sources the more likely they will be to use high-speed wireless data services for media and other access
Post and prepaid penetration	Advanced wireless services are used more by postpaid users
Regulatory aspect	
Government regulation	Government regulation (including taxes) will affect usage of high-speed wireless data services. It is usually assumed that too much intervention adversely affects demand unless there are laws to encourage high-speed wireless data services uptake
Spectrum availability	Cost and availability of spectrum, government regulation of spectrum

TABLE 28 (*end*)

Parameter/issue	Impact
Industrial aspect	
Carriers/operators	Current and planned wireless operators indicate overall expected demand for high-speed wireless data services, a market with more high-speed wireless data services carriers is anticipated to have more demand
Number of business establishments	A vibrant business environment indicates more users of high-speed wireless data services
Enterprise size	Small/medium/large will impact overall segmentation and number of high-speed wireless data services users
Workforce size	A larger workforce will lead to larger demand
Workforce skills	Higher skills mean higher usage and adoption of high-speed wireless data services

6.2 Traffic forecast

This section contains forecast information relating to IMT-2000 and systems beyond IMT-2000, primarily as solicited in Questions 2, 3.3 and 3.4 of the "Service View" document, Annex 1.

6.2.1 Results from CEPT

Table 29 sums up the European forecast:

TABLE 29

Traffic forecast results in 2020

Results in minutes (x 1 000) of 1 Mbit/s per day					**Volume per day (Gbits)**	**Volume per user per day (Gbits)**
Communications	**Entertainment**	**Lifestyle**	**Business**	**Total**		
24 453 394	34 545 271	28 723 034	244 907 863	332 629 563		
Results with activity ratio factored in						
Communications (60%)	Entertainment (70%)	Lifestyle (20%)	Business (20%)			
14 672 037	24 181 690	5 744 607	48 981 573	93 579 906	5 614 794 347	11.7

This leads to 1.46 GBytes/day/mobile/user in 2020.

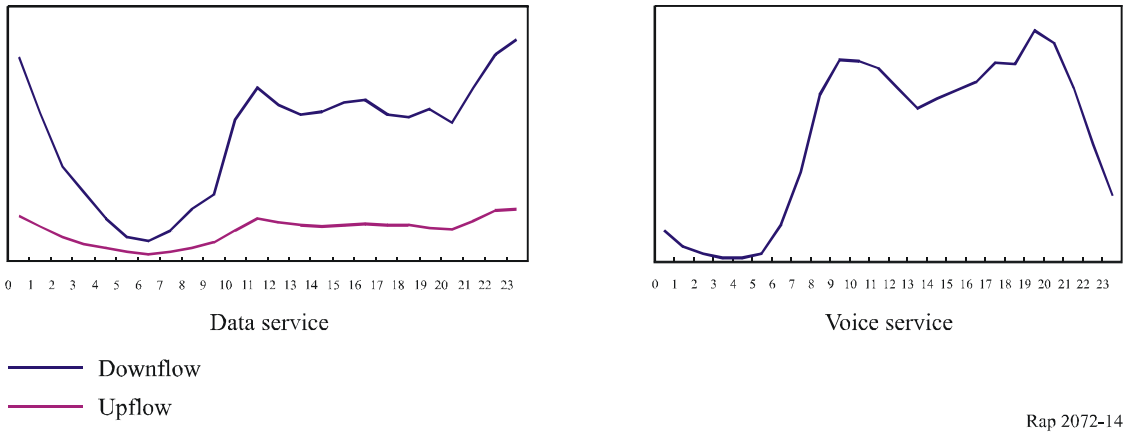
6.2.2 Results from China

Different services have different busy hours. They can be categorized into voice and data from present traffic statistics.

The following charts show how voice and data service's traffic volumes change within 24 h.

FIGURE14

Traffic volume during 24 h



The busy hour of voice service occurs at 0800-1100 h and 1900-2100 h, and the busy hour of data service occurs in 2200-2400 h.

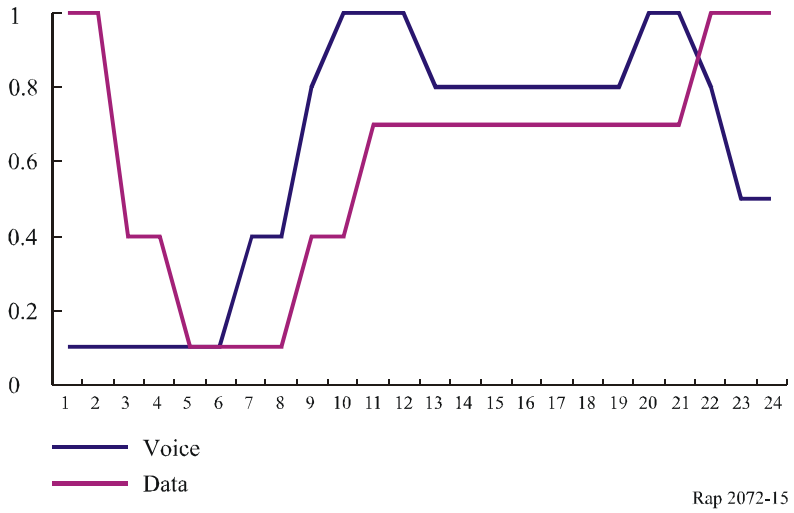
The time varying factor $F_{n,BH}$ is introduced.

$F_{n,BH}$ = user traffic volume in the n-th hour/user traffic volume in busy hour.

The time varying factors for voice and data services are set as below.

FIGURE 15

Time varying factor for voice and data



The reference population density, for Tables 30 and 31, is dense urban.

TABLE 30

Traffic volume 2000-2100 h in 2020Y (Mbits/BH/km^2)

	Service type	Downlink	Uplink	Total
1900-2200 h	CBR+VBR	9 092 261	1 740 698	10 832 959
	ABR+UBR	6 510 155	1 302 031	7 812 186
	Sum	15 602 417	3 042 729	18 645 146
2100 h	CBR+VBR	7 273 809	1 392 558	8 666 367
	ABR+UBR	9 300 222	1 860 044	11 160 266
	Sum	16 574 031	3 252 603	19 826 634

TABLE 31

User density forecast

(Persons/km^2)	Dense urban	Urban	Suburban	Rural
2020Y	**219 830**	**97 440**	**18 090**	**4 130**

If we take into account the population density corresponding to a dense urban density: the data volumes per user, per busy hour are:

TABLE 32

Traffic volume per user, per busy hour

SUM	(Mbits/BH/user)	2020Y
1900-2000 h	Sum	85
2100 h	Sum	90

If the time varying factor is taken into account, we can assume that a entire day is equivalent to 15.6 BH.

TABLE 33

Total traffic volume

SUM	(Mbytes/day/user)	2020Y
DAY	Sum	**166**

6.2.3 Results from France Telecom

6.2.3.1 Country categories

The results from France Telecom are based on country categorization. Considering the available data, all countries have been divided into six groups presenting similar evolution perspectives:

Group A: the most developed countries, with high income and high development index. This group mainly includes North-American and West-European nations, as well as the richest of Asia/Pacific and petrol exporting countries. Current high penetration rates (average around 65%) indicate that their mobile market will be mature in the short term, with reduced room for growth of their subscriber base.

Group B: countries with middle income (mainly upper middle), high or middle HDI and a present telecommunication penetration (fixed and mobile) over 36%. Most of them are potential leaders in technology. This group typically includes future EC members, most developed areas of South and Central America and some major tourism-based economies. They have an average mobile penetration rate of around 30% in 2002 and large progression perspectives in the short and middle term.

Group C: countries with middle income (mainly lower middle), medium HDI and current telecom penetration level between 36% and 17% (fixed + mobile). They rank today among averagely developed economies with a significant potential. Most of them are Dynamic Adopters in technologies. All geographic areas, apart from Western Europe and North America, are represented in this category. Their current mobile penetration is close to 20% and is awaited to grow significantly over and after the forecast period.

Group D: less wealthy among the middle income countries, with medium HDI and a telecom penetration under 17%. Additionally, this category also includes some emerging countries, despite their low income, because of their Dynamic Adopter position in technology. Their current mobile penetration is low but should take off within the 2003-2020 period.

Group E: developing countries with low income but long term growth capabilities linked to their investment in health and education (middle HDI). Their current mobile penetration is low but will progress moderately over the period.

Group F: least developed countries, with low income, low HDI and/or Technologically Marginalized. Due to conflicts, agricultural centric economy, export dependence, poor infrastructure, or demographic problems, their mobile penetration will remain very low, though a significant growth rate of their subscriber base.

6.2.3.2 Characterization of the services in 2006: duration session, number of session per user

The first set of hypotheses concern the basic characteristics of the services, in terms of average session duration and data volume, where a session corresponds for instance to a phone call for voice services, an email for simple email services, etc.

The data volume indicated corresponds to the *downstream volume* only: the volume of data uploaded from the user terminal to the network is not taken into account.

Voice, videotelephony services and collaborative work services average durations are expressed in minutes. Additionally, the volume for an average session is computed from the duration using the following data rate assumptions:

– Voice: 10 kbit/s

– Videotelephony and collaborative work: 128 kbit/s

All other services are only characterized in terms of average session volume in kbytes.

Table 34 is set once, for all environments and all country categories:

TABLE 34

2006 Service characteristics assumptions sheet

Service Category	Services	Average duration	Unit of use	Session volume/ duration
Voice Communication	Voice telephony - Incoming and outgoing calls	2 Min	Kbyte	150 KB
	Voice messages - Listening and recording	30 s	Kbyte	38 KB
Multimedia Communication	Videotelephony and videoconference	2 Min	Kbyte	1920 KB
	Collaborative work	-	Kbyte	4800 KB
Simple messaging and community services	SMS and simple email	-	Kbyte	5 KB
	Instant messaging	-	Kbyte	10 KB
	Chat, forum	-	Kbyte	10 KB
Multimedia messaging	MMS, photo, video messages	-	Kbyte	200 KB
Simple information and entertainment	Internet-style web sites (information, entertainment, games, eeducation)	-	Kbyte	100 KB
	Simple games, lotteries, bets	-	Kbyte	50 KB
	Downloading of geo-localized maps, location-based services	-	KByte	100 KB
Rich Multimedia information and entertainment	Streaming and downloading of audio/ video clips	-	KByte	1000 KB
	Game downloads, network games	-	KByte	1000 KB
M-Commerce and finance	Browsing and buying on E-commerce sites (retail, tourism, …)	-	KByte	100 KB
	On-line banking and finance	-	KByte	50 KB
	M-Payment	-	KByte	0 KB
	Advertising	-	KByte	5 KB
Corporate services	Intranet access, VPN	-	KByte	100 KB
	Access to corporate databases	-	Kbyte	100 KB

The next set of hypotheses concerns the penetration and usage of the services in each environment for a **Category A country**.

As mentioned above, at this stage in the assumptions the usage profiles assume that in every environment a high-data rate network is available, meaning that the available bandwidth is similar to that available with an IMT-2000 network.

Each service's penetration estimates are given as a percentage of service users among the total mobile-equipped population. It is assumed that all services within a given category have the same penetration level. For each service category, a different penetration assumption can be given for each type of environment: dense urban, urban and rural (service penetration and usage are not estimated for desert areas).

The usage estimates are expressed as an average number of sessions per month per service user.

TABLE 35

2006 Service penetration and usage input sheet for Country Category A
(for users using a high-data rate network)

		Dense Urban		Urban		Rural	
Service Category	Services	Service penetration on customer base	Session per month per costumer	Service penetration on customer base	Session per month per customer	Service penetration on customer base	Session per month per customer
Voice Communication	Voice telephony - Incoming and outgoing calls	100%	100	100%	100	100%	100
	Voice messages - Listening and recording		10		10		10
Multimedia communication	Videotelephony and videoconference	15%	20	10%	20	8%	20
	Collaborative work		2		2		2
Simple messaging and community services	SMS and Simple Email	80%	50	80%	50	80%	50
	Instant messaging		30		30		30
	Chat, forum		30		30		30
Multimedia messaging	MMS, photo, video messages	60%	15	50%	15	30%	15
Simple information and entertainment	Internet-style web sites (information, entertainment, games, eeducation)	50%	100	50%	100	40%	100
	Simple games, lotteries, bets		10		10		10
	Downloading of geo-localised maps, location-based services		10		10		10
Rich multimedia information and entertainment	Streaming and downloading of audio/ video clips	60%	5	50%	5	30%	5
	Game downloads, network games		2		2		2
M-commerce and finance	Browsing and buying on E-commerce sites (retail, tourism, …)	60%	10	50%	10	25%	10
	On-line banking and finance		5		5		5
	M-Payment		5		5		5
	Advertising		20		20		20
Corporate services	Intranet access, VPN	10%	30	7%	30	2%	30
	Access to corporate databases		30		30		30

6.2.3.3 Characterization of the services in 2010 and 2020

For every country category, the assumptions for the evolution of service penetration and usage estimates for the years 2003, 2010 and 2020 are expressed as a ratio relative to the corresponding 2006 value, as in the following example:

TABLE 36

2010 Service penetration and usage input sheet for Country Category A

	Dense Urban			Urban			Rural		
Service category	Service penetration on customer base	Averagesession volume	Sessions per month per service user	Service penetration on customer base	Average session volume	Sessions per month per service user	Service penetration on customer base	Average session volume	Sessions per month per service user
Voice communication	*x 1.00*	*x 1.00*	x 1.10	*x 1.00*	*x 1.00*	x 1.10	*x 1.00*	*x 1.00*	x 1.10
Multimedia communication	x 1.50	x 1.20	x 1.20	x 1.50	x 1.20	x 1.20	x 1.40	x 1.20	x 1.10
Simple messaging and community services	x 1.00	x 1.00	x 1.20	x 1.00	x 1.00	x 1.20	x 1.00	x 1.00	x 1.20
Multimedia messaging	x 1.20	x 1.20	x 1.50	x 1.20	x 1.20	x 1.50	x 1.20	x 1.20	x 1.50
Simple information and entertainment	x 1.20	x 1.00	x 1.20	x 1.20	x 1..	x 1.20	x 1.20	x 1.00	x 1.20
Rich multimedia information and entertainment	x 1.20	x 1.20	x 1.20	x 1.20	x 1.20	x 1.20	x 1.10	x 1.20	x 1.10
M-commerce and finance	x 1.20	x 1.00	x 1.20	x 1.20	x 1.00	x 1.20	x 1.20	x 1.00	x 1.20
Corporate services	x 1.10	x 1.20	x 1.20	x 1.00	x 1.20	x 1.20	x 1.00	x 1.20	x 1.10

The acceleration effect of the different communication technologies is expressed by means of ratios comparing the service penetration and usage per service category to the reference high data rate service penetration and usage estimates.

Only one such table of inputs is specified. It covers every country category and every year in the 2003-2020 timeframe:

TABLE 37

Effect of communication technology on service penetration and usage

	Low data ratio		High data ratio		Very high data ratio	
Service category	Service penetration	Service usage	Service penetration	Service usage	Service penetration	Service usage
Voice communication	x 1.00	x 1.00	***x 1.00***	***x 1.00***	x 1.00	x 1.00
Multimedia communication	x 0.00	x 0.00	***x 1.00***	***x 1.00***	x 1.50	x 2.00
Simple messaging and community	x 0.80	x 1.00	***x 1.00***	***x 1.00***	x 1.00	x 1.00
Multimedia messaging	x 0.80	x 0.50	***x 1.00***	***x 1.00***	x 1.00	x 1.00
Simple information and entertainment	x 0.80	x 0.10	***x 1.00***	***x 1.00***	x 1.00	x 2.00
Rich multimedia information and entertainment	x 0.00	x 0.00	***x 1.00***	***x 1.00***	x 1.50	x 2.00
M-Commerce and finance	x 0.50	x 0.50	***x 1.00***	***x 1.00***	x 1.00	x 1.00
Corporate services	x 0.50	x 0.10	***x 1.00***	***x 1.00***	x 1.50	x 3.00

The following assumptions characterize the forecast spread of the new communication technologies. They are set per country category, for every environment (dense urban, urban and rural) and for the years 2003, 2006, 2010 and 2020:

TABLE 38

Assumptions for the level of adoption of communication technology

		2003			2006			2010			2020		
Network Mix		Low data rate	High data rate	Very high data rate	Low data rate	High data rate	Very high data rate	Low data rate	High data rate	Very high data rate	Low data rate	High data rate	Very high data rate
Country Class A	Dense urban	100%			80%	20%		20%	80%			60%	40%
	Urban	100%			80%	20%		40%	60%			80%	20%
	Rural	100%			90%	10%		70%	30%			100%	
Country Class B	Dense urban	100%			90%	10%		40%	60%			80%	20%
	Urban	100%			100%			60%	40%		30%	70%	
	Rural	100%			100%			100%			80%	20%	
Country Class C	Dense urban	100%			90%	10%		60%	40%		20%	70%	10%
	Urban	100%			100%			80%	20%		50%	50%	
	Rural	100%			100%			100%			100%		
Country Class D	Dense urban	100%			90%	10%		70%	30%		45%	50%	5%
	Urban	100%			100%			90%	10%		70%	30%	
	Rural	100%			100%			100%			100%		
Country Class E	Dense urban	100%			90%	10%		80%	20%		55%	40%	5%
	Urban	100%			100%			100%			80%	20%	
	Rural	100%			100%			100%			100%		
Country Class F	Denseurban	100%			90%	10%		80%	20%		65%	30%	5%
	Urban	100%			100%			100%			85%	15%	
	Rural	100%			100%			100%			100%		

6.2.3.4 Results of the service penetration and usage forecasts

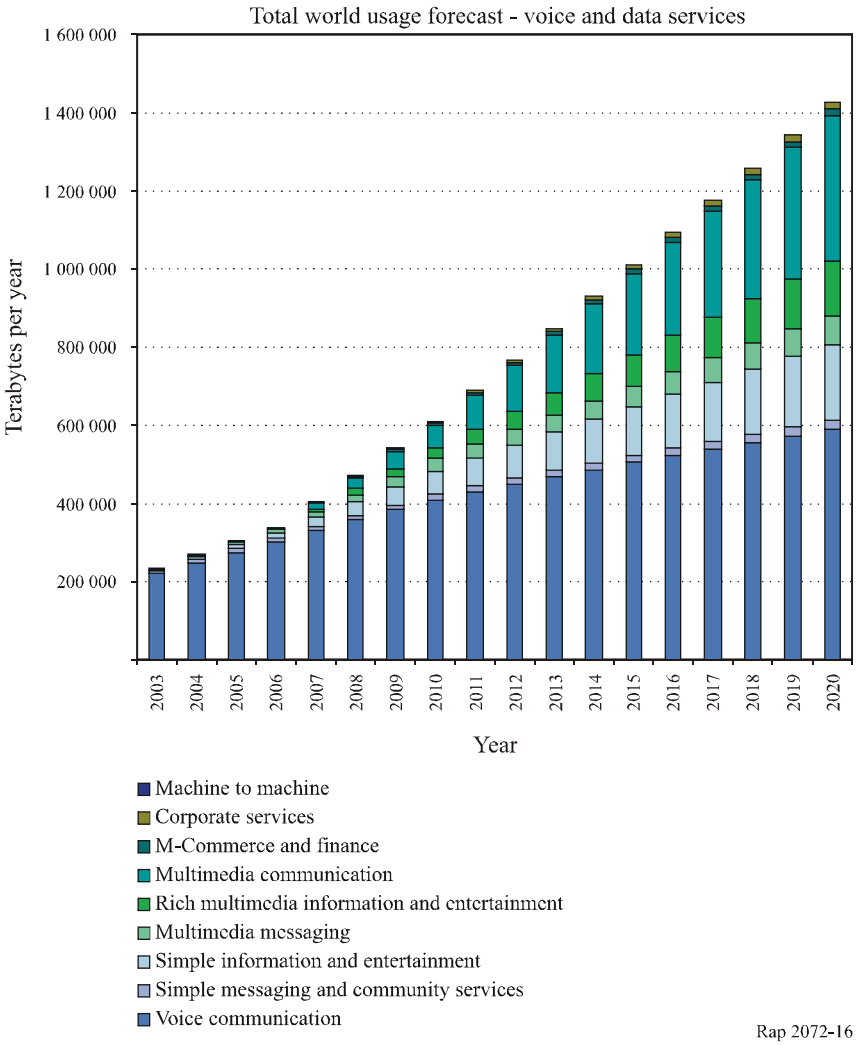
Forecast of service penetration (percentage and total number of users), and service usage in terms of number of service sessions and volume of transported data (average usage per user, and total usage) for each combination of:

– Service category
– Country
– Environment (dense urban, urban, rural – penetration and usage are not computed in desert areas)
– Any year, between 2003 and 2020.

The following graph shows the 2003-2020 forecast for the total world traffic per service category. This graph shows how voice traffic will remain dominant globally until approximately 2015, although the situation is very different in the various country categories: data traffic becomes dominant as soon as 2010 in A category countries, whereas voice remains dominant throughout the forecast period in C, D, E and F category countries.

FIGURE 16

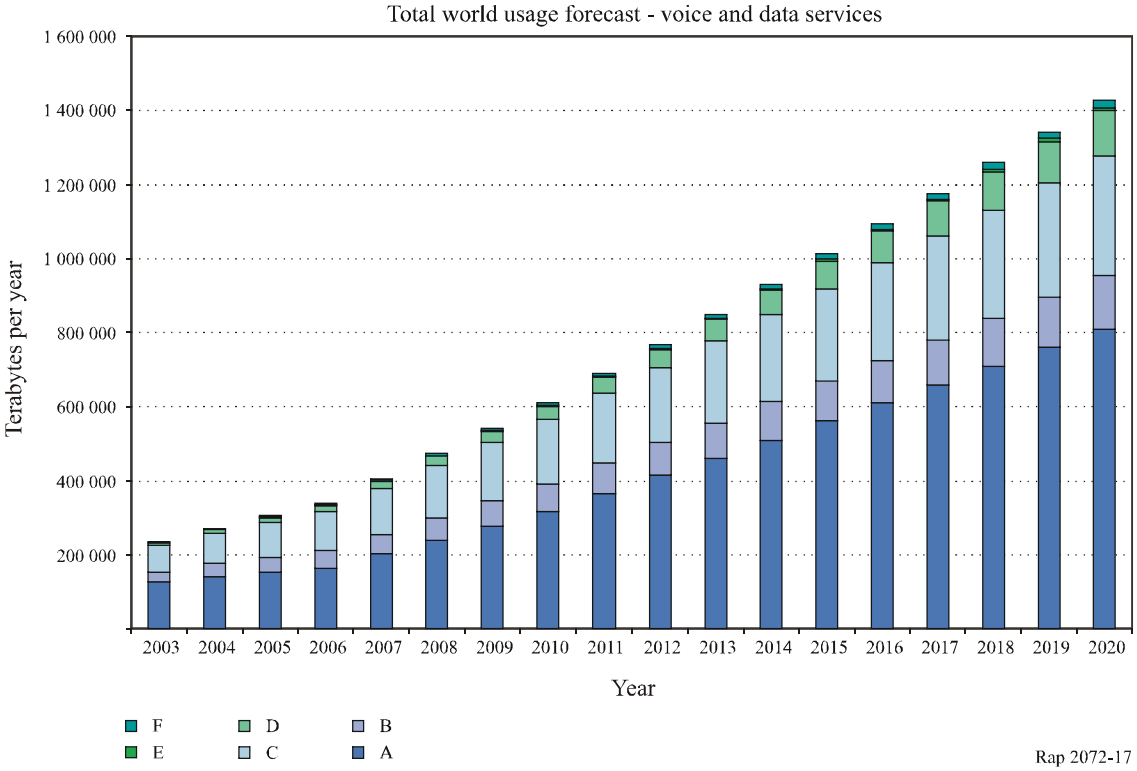
World usage forecast per service category



The following graph presents the contribution of the different country categories to the total world traffic. This shows clearly the great weight of A category countries in terms of traffic, which is due entirely to the high level of penetration and usage of high-volume multimedia services such as videotelephony and rich multimedia entertainment. In contrast, countries in other categories use less bandwidth-intensive services such as voice communication, and Internet-style simple information and services.

FIGURE 17

World usage forecast per country category



6.2.4 Results from Japan

Typical market/traffic related parameters of representative environments classified by user density, dense urban (DU), suburban (S), and rural (R) areas, for identified potential applications in the year 2020 are shown below:

TABLE 39

Values of typical market/traffic related parameters

No	Applications	Environ-ment User density	Symme-tricity	Penetra-tion	Busy hour session attempt	Mean service bit rate (kbit/s)	Session volume (Kbytes)	Average session duration
1-1	Telephony	DU	Up/down	0.860	3.316	16	420	210
		S	links	0.860	0.884	16	420	210
		R		0.860	0.442	16	240	120
1-2	TV-tel	DU	Up/down	0.5	0.854	768	20 160	210
		S	links	0.5	0.854	768	11 520	120
		R		0.5	0.067	768	11 520	120
2-1	e-mail	DU	Up/down	0.860	3.150	4	2	4
		S	links	0.860	3.150	4	2	4
		R		0.860	3.150	4	2	4
2-2	Picture-mail	DU	Up/down	0.860	0.435	4 096	4 000	8
		S	links	0.860	0.435	4 096	4 000	8
		R		0.860	0.435	4 096	4 000	8

TABLE 39 (*continued*)

No	Applications		Environ-ment User density	Symme-tricity	Penetra-tion	Busy hour session attempt	Mean service bit rate (kbit/s)	Session volume (Kbytes)	Average session duratio n
2-3	Video-mail		DU	Up/down	0.860	0.148	8 000	24 000	24
			S	links	0.860	0.148	8 000	24 000	24
			R		0.860	0.148	8 000	24 000	24
3	Web browsing		DU	Up/down	0.86	22.827	3 360	420	1
			S	links	0.86	22.827	3 360	420	1
			R		0.86	22.827	3 360	420	1
4	Video streaming		DU	Up/down	0.378	0.481	3 200	480 000	1 200
			S	links	0.378	0.481	3 200	480 000	1 200
			U		0.378	0.481	3 200	480 000	1 200
5	P2P		DU	Up/down	0.2050	2.8833	20 000	720 000	288
			S	links	0.2050	2.8833	20 000	720 000	288
			U		0.2050	2.8833	20 000	720 000	288
6	Multiplayer (player's data)		DU	Uplink	0.1197	29.0777	224	0.28	0.01
			S		0.1197	29.0777	224	0.28	0.01
			R		0.1197	29.0777	224	0.28	0.01
	Multiplayer (Other players data)		DU	Downlink	0.1197	29.0777	4 800	5.6	0.01
			S		0.1197	29.0777	4 800	5.6	0.01
			R		0.1197	29.0777	4 800	5.6	0.01
7	e-Learning	Conversational	DU	Up/down	0.2549	0.1717	16	60	30
			S	links	0.2445	0.4500	16	60	30
			R		0.2445	0.4500	16	60	30
		Video streaming	DU	Downlink	0.2549	0.0286	3 000	1 350 000	3 600
			S		0.2445	0.0750	3 000	1 350 000	3 600
			R		0.2445	0.0750	3 000	1 350 000	3 600
		File downloading	DU	Downlink	0.2549	0.8586	4 000	4 000	8
			S		0.2445	2.2500	4 000	4 000	8
			R		0.2445	2.2500	4 000	4 000	8
8-1	e-Newspaper		DU	Downlink	0.4387	1.0000	60 000	60 000	8
			S		0.4387	1.0000	60 000	60 000	8
			R		0.4387	1.0000	60 000	60 000	8
8-2	e-Game		DU	Downlink	0.2560	1.0000	100 000	512 000	41
			S		0.2560	1.0000	100 000	512 000	41
			R		0.2560	1.0000	100 000	512 000	41
8-3	e-Music		DU	Downlink	0.3549	0.0815	10 00	43 200	35
			S		0.3549	0.0815	10 00	43 200	35
			R		0.3549	0.0815	10 00	43 200	35
9-1	ITS (Probe)		DU	Downlink	0.061	6.000	300	1 000	30
			S		0.061	3.000	600	2 000	30
			R		0.061	2.000	1 00	6 000	30

TABLE 39 (*end*)

No	Applications	Environment User density	Symmetricity	Penetration	Busy hour session attempt	Mean service bit rate (kbit/s)	Session volume (Kbytes)	Average session duration
9-2	ITS (Probe)	DU	Uplink	1.560	60	6.4	0.8	1
		S		1.560	61	6.4	0.8	1
		R		1.560	61	6.4	0.8	1
10	Telemetering	DU	Uplink	0.0420	1	12	1.28	1
		S		0.0420	1	12	1.28	1
		R		0.0420	1	12	1.28	1
11	Network camera	DU	Uplink	0.5250	1.0	3 200	480 000	1 200
		S		0.5250	1.0	3 200	480 000	1 200
		R		0.5250	1.0	3 200	480 000	1 200
12-1	Healthcare monitor	DU	Uplink	0.222	1	10.4	4 680	3 600
		S		0.222	1	10.4	4 680	3 600
		R		0.222	1	10.4	4 680	3 600
12-2	Health care surveillance	DU	Uplink	0.222	0.0658	3 200	120 000	300
		S		0.222	0.0658	3 200	120 000	300
		R		0.222	0.0658	3 200	120 000	300
13	e-Rescue (image data)	DU	Uplink	0.00015	0.2190	24 000	6 300 000	2 100
		S		0.00015	0.2190	24 000	6 300 000	2 100
		R		0.00015	0.2190	24 000	6 300 000	2 100
	e-Rescue (instruction)	DU	Downlink	0.00015	0.2190	256	67 200	2 100
		S		0.00015	0.2190	256	67 200	2 100
		R		0.00015	0.2190	256	67 200	2 100
14	e-Exercise (biomedical-data)	DU	Uplink	0.286	0.222	69	31 050	3 600
		S		0.286	0.222	69	31 050	3 600
		R		0.286	0.222	69	31 050	3 600
	e-Exercise (instruction)	DU	Downlink	0.286	0.222	256	115 200	3 600
		S		0.286	0.222	256	115 200	3 600
		R		0.286	0.222	256	115 200	3 600
15	ITS (car-navigation)	DU	Downlink	0.2993	0.128	4 000	10 000	20
		S		0.2993	0.128	6 000	20 000	30
		R		0.2993	0.390	9 000	71 000	90

6.2.5 Results from Korea

TABLE 40

Traffic forecast results in 2020

Services	Peak bit rate (Mbits)	Number of access per user	Average usage duration per access	Average traffic volume (Mbits) per hour per user	Average traffic volume(MBits) per day per user
		2020	2020	2020	2020
Conversational voice	0.016	5.73	4.72	0.43	10.32
Conversational video	0.144	3.06	7.11	3.13	75.12
Web browsing	0.016	4.05	9.87	0.64	15.36
Messaging	2	3.88	1.98	15.38	369.12
Location-based service	0.144	3.48	6.84	3.43	82.32
Financial commerce	0.144	0.80	3.14	0.36	8.64
Life education	30	0.90	15.54	419.05	10 057.12
Health	30	0.72	6.88	148.74	3 569.76
Game	2	1.27	21.89	55.74	1 337.76
Music	2	1.69	20.86	70.61	1 694.64
Movie	30	0.17	29.56	150.66	3 615.84
TOTAL					20 836.00

6.2.6 Results from UMTS Forum

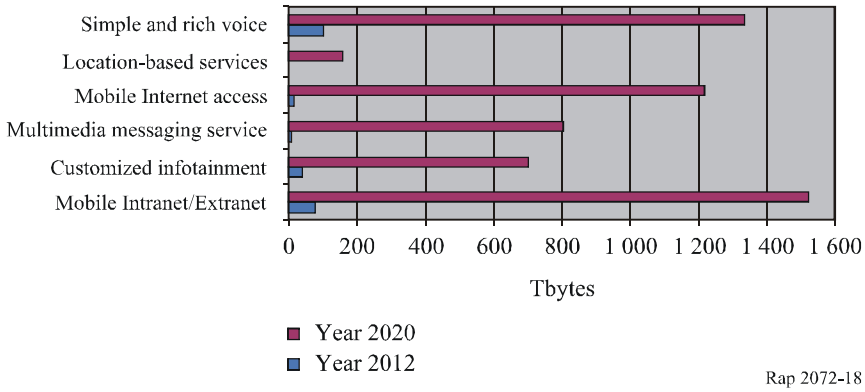
TABLE 41

Offered traffic in 2020

Application	Offered traffic in 2020
MMS	33.66 Mb/day/user
Simple and rich voice	95.55 Mb/day/user
Customized infotainment	77.07 Mb/day/user
Mobile Internet access	169.23 Mb/day/user
Mobile Intranet Extranet access	120.04 Mb/day/user
Location-based services	5.14 Mb/day/user
TOTAL	500.69 Mb/day/user

FIGURE 18

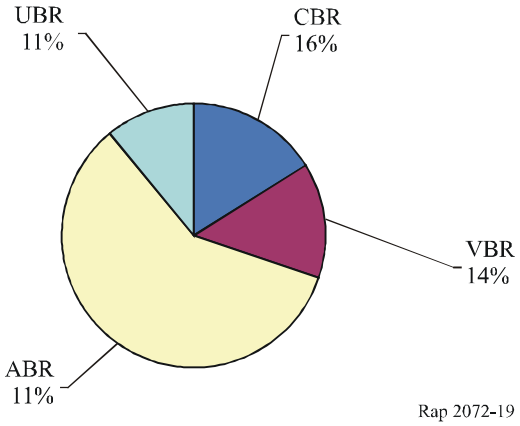
Total daily traffic forecast by service category for a representative Western European country: 2012 vs 2020



From 2012 to 2020, total daily traffic raises from 250 Tbytes to 5 744 Tbytes (e.g. *a* + 2 200% growth).

FIGURE 19

Traffic allocation into ATM traffic classes in 2020



6.2.7 Other information

Several countries (Estonia, Australia) assume that voice traffic will have become mainly or fully VoIP by 2020. Standard telephony will have disappeared.

UMTS forum forecasts still to have 35% of standard voice versus 65% VoIP.

7 Usage forecast for other radio systems

7.1 Introduction

This section contains information relating to other radio systems, primarily as solicited in question 4 of the "Service View" document (Annex 1). The classification used in this section of this Report is based only on that used in the responses to the "service view" document. An overview of the other radio systems identified is given, followed by more detailed information on the radio systems, and finally the parameter forecasts are included.

It is estimated that almost all users can access multiple systems and accordingly any forecasts of traffic and demand for services and applications need to reflect that the demand can be partially satisfied by these other radio systems. In such an environment, the percentage of users subscribing to each radio access technology will not be fixed, but it will fluctuate. Initial values for the subscription to different access technologies may be derived from current systems.

Note that § 6.1 describes key market parameters that may be relevant for market analysis and forecasting of other radio systems.

7.2 Overview of other systems identified

TABLE 42

Grouped by radio system

Other radio systems	Source of relevant questionnaire responses
WLAN (including IEEE 802.11 family)	China (People's Republic of), United States of America, APT Wireless Forum (AWF), Japan, Intel Corp., Estonia (Republic of), 3G Americas, UMTS Forum, WWRF, Brazil, Canada, Korea, Cameroon
BWA, MANs, BRANs (including IEEE 802.16 family and IEEE 802.20 family)	IEEE, United States of America, Intel Corp., Estonia (Republic of), 3G Americas, UMTS Forum, WWRF, Brazil, Canada, Korea
Broadcast systems (terrestrial and satellite)	APT Wireless Forum (AWF), Japan, UMTS Forum, WWRF, Brazil, Canada, Korea, Cameroon
Digital home appliances	APT Wireless Forum (AWF), Japan, Cameroon
Intelligent transportation system (ITS)	APT Wireless Forum (AWF), Japan
Satellite systems (non-broadcast)	UMTS Forum, Brazil
Sensor networks	UMTS Forum, WWRF, Canada, Korea
PANs	UMTS Forum, WWRF, Brazil, Canada, Korea

7.3 Detailed information on other radio systems

Framework overview and general information

As described in Recommendation ITU-R M.1645 – Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000, it is widely acknowledged that systems beyond IMT-2000 and other radio systems will be integrated into a more broadly defined system of complementary elements based on a hierarchical set of layers interconnected via a broadband packet data core (anticipated to be largely IP technology). It is further expected that almost all mobile terminals will have multiple radio access capabilities and operators will provide multiple radio accesses. Even when offering only one radio access, tie-up or cooperation with other operators may enable provision of the same services as multiple access providers.

WLAN (including IEEE 802.11 family)

Use of WLAN is already widespread, in the home, enterprise and public access (both commercial and community based) environments. It is anticipated that all new portable computers will have integrated WLAN capability by 2006. Future extensions to WLAN will enable new capabilities, which may include mobility.

Broadcast systems (terrestrial and satellite)

Presently perceived emerging systems/services, which are envisaged to interwork with the future development of IMT-2000 and systems beyond IMT-2000, include digital broadcasting, including digital terrestrial video/audio broadcasting and satellite radio and television.

Digital home appliances

Digital home appliances include:

– Audiovisual equipment such as television, CD-player and DVD-recorder

– Appliances such as airconditioner, electronic oven, refrigerator, cleaner and washing machine

– Personal computer and peripheral equipment such as printer and scanner

– Digital information equipment such as digital camera

– Home automation such as lighting and door lock system.

Enhanced home appliances create new and diversified services, which provide more convenience, by connecting to each other, and being operated and controlled through external networks.

Intelligent transportation system (ITS)

ITS are systems which exchange information between humans, roads and vehicles, for the purpose of resolving various problems such as traffic accidents, congested roads, related environmental issues, waste of energies and distribution system efficiency. Such systems are anticipated to become a vital part of the transportation infrastructure, and it is believed that wide ranging development opportunities for related organizations and the creation of various ITS applications will help to drive economic growth in the 21st century.

Satellite systems (non-broadcast)

Today, we know some of the other radio systems expected to interwork with IMT-2000 and systems beyond IMT-2000, and these include satellite systems (VSAT, satellite radio and TV).

Sensor networks

Systems beyond IMT-2000 encompassing new mobile access and new nomadic/local area wireless access will interwork with sensor networks.

Personal area networks (PANs)

Systems beyond IMT-2000 encompassing new mobile access and new nomadic/local area wireless access will interwork with wireless PANs.

7.4 Parameter forecasts for other radio systems

7.4.1 Service issues

Information on service issues is not presented in this section. Within this Report, the relevant general service trends are detailed in § 5, in a technology independent manner.

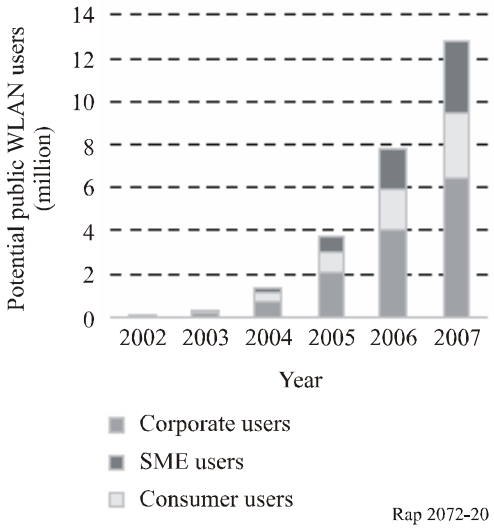
7.4.2 Market forecasts

7.4.2.1 WLAN (including IEEE 802.11 family) in 2007-

There is an optimistic forecast of about 12 million hotspot subscribers by 2007[3] (0) The number who will require interworking function will be a fraction of WiFi hotspot subscribers.

FIGURE 20

U.S. WiFi Hot spot subscriber forecast
(Source: 2003 Analysis Research)



7.4.2.2 BWA, MANs, BRANs (including IEEE 802.16 family and IEEE 802.20 family)

Korea

The saturation level of WiBro service in Korea is expected to be 10 million subscribers, and it will take 5~6 years to reach that matured stage.[4]

Latin America

Short term forecasts (conservative and optimistic) are available for broadband fixed wireless subscribers in Latin America.[5]

TABLE 43

Broadband fixed wireless subscriber lines (in thousands)
(Source: 2003 pyramid research)

	2003	2004	2005	2006	2007	2008
Conservative	56	92	125	154	175	193

[3] Source: 3G Americas

[4] Source: Korea

[5] Source: 3G Americas

Global parameters[6]:

It is important to note that the following tables containing subscriber forecasts do not include highly-mobile applications. These tables reflect the incremental growth in 802.16 fixed and nomadic services traffic some of which would interwork with IMT-2000 systems and beyond.

Table 44 shows the growth forecast for 802.16 subscribers by region[7]. Table 44 includes not only subscriber forecasts of systems based on the IEEE Standard 802.16-2004, but also subscriber forecasts for nomadic applications of systems based on the future 802.16 standard addressing new mobile capabilities.

TABLE 44

802.16 Subscribers by Region (in millions)

	2005	2006	2007	2008	2009	CAGR (05-09)
Asia Pacific	0.00879	0.09454	0.51842	1.53808	4.44115	374%
North America	0.00429	0.04476	0.27103	0.79567	1.99506	364%
Latin America	0.00199	0.01456	0.10119	0.27613	0.70602	334%
Europe	0.00437	0.05135	0.35957	1.10485	2.64515	396%
Rest of World	0.00150	0.01068	0.08358	0.24608	0.69671	365%
Total	0.02093	0.21588	1.33379	3.96081	10.48409	373%

This subscriber growth is not uniform among various environments or market segments. Residential/SOHO users are expected to grow at a much faster pace that other segments.

Table 45 through Table 47 contain subscriber growth forecast information on various market segments for IEEE 802.16-2004.

TABLE 45

IEEE 802.16-2004 Residential/SOHO subscribers by Region (in millions)

	2005	2006	2007	2008	2009	CAGR (05-09)
Asia Pacific	0.00242	0.02080	0.23235	0.64774	1.71812	416%
North America	0.00140	0.01258	0.15546	0.46941	0.99099	415%
Latin America	0.00129	0.00645	0.06394	0.16439	0.37658	313%
Europe	0.00187	0.02268	0.24657	0.75308	1.55050	437%
Rest of World	0.00092	0.00302	0.04330	0.11175	0.27765	317%
Total	0.00791	0.06552	0.74162	2.14637	4.91385	399%

6 Source: IEEE

7 Tables 1-5 from *WiMAX/802.16: Opportunities for High Speed Wireless Data in Enterprise, SOHO, Residential and Portable (802.16e) Markets*. ABI Research. © 2004 All Rights Reserved. Used by permission granted to IEEE and ITU.

TABLE 46

IEEE 802.16-2004 Small Medium Business (SMB) subscribers by Region (in millions)

	2005	2006	2007	2008	2009	CAGR (05-09)
Asia Pacific	0.00587	0.04940	0.11235	0.22319	0.40459	188%
North America	0.00283	0.02127	0.04446	0.08259	0.15029	170%
Latin America	0.00064	0.00548	0.01654	0.03252	0.05414	203%
Europe	0.00239	0.01902	0.04147	0.07952	0.14353	178%
Rest of World	0.00048	0.00418	0.01287	0.02569	0.04437	210%
Total	0.01222	0.09935	0.22769	0.44351	0.79692	184%

TABLE 47

IEEE 802.16-2004 Enterprise subscribers by Region (in millions)

	2005	2006	2007	2008	2009	CAGR (05-09)
Asia Pacific	0.00050	0.00270	0.00659	0.01259	0.02147	157%
North America	0.00005	0.00022	0.00044	0.00074	0.00130	126%
Latin America	0.00005	0.00030	0.00079	0.00159	0.00288	176%
Europe	0.00011	0.00055	0.00128	0.00233	0.00391	145%
Rest of World	0.00009	0.00068	0.00197	0.00419	0.00817	205%
Total	0.00080	0.00446	0.01107	0.02144	0.03773	162%

Table 48 contains subscriber growth forecast information across various market segments for nomadic applications of systems based on the future 802.16 standard addressing new mobile capabilities, referred to as 802.16e.

TABLE 48

802.16e Subscribers by Region (in millions)

	2005	2006	2007	2008	2009	CAGR (06-09)
Asia Pacific	–	0.02	0.17	0.65	2.30	374%
North America	–	0.01	0.07	0.24	0.85	330%
Latin America	–	0.00	0.02	0.08	0.27	389%
Europe	–	0.01	0.07	0.27	0.95	371%
Rest of World	–	0.00	0.03	0.10	0.37	408%
Total	–	0.05	0.35	1.35	4.74	367%

In addition to the growth rate, subscriber penetration among various market segments is certainly not the same. Table 49 contains subscriber penetration data for residential/SOHO, business subscribers using a fixed CPE station, as well as stand-alone laptops with their own embedded station[8]. The following data is based on observations in the United States.

TABLE 49

Subscriber penetration for 802.16 services

Penetration	2006	2007	2008	2009
Residential/SOHO	3.94%	8.74%	14.13%	19.56%
SMB	0.75%	1.62%	2.56%	3.52%
Laptops	–	0.34%	0.78%	1.26%

7.4.2.3 Intelligent transportation system (ITS)

The systems categorized in this market may interwork with systems beyond IMT-2000, and the development of this industry may further increase traffic demand expected in systems beyond IMT-2000.

ITS forecasted market trends in Japan is depicted in Table 50, which is adopted from a MIC report on envisaged information communication technology:

TABLE 50

Japan market forecast for ITS related equipment (unit: 100 million yen)

Market segment	FY 2000	FY 2005	FY 2010	FY 2015	Cumulative total
ITS info-services	768	9 449	24 950	47 729	309 903
ITS vehicle mounted platform	4 452	10 182	15 068	17 417	186 705
ITS system infra-equipment	3 594	6 500	7 470	8 470	106 546
Total	8 814	26 131	47 488	73 616	603 154

7.4.2.4 Digital home appliance

Digital home appliances may interwork with mobile communications systems and digital broadcasting to provide highly integrated service and applications, and propulsion of networking may be one of the key elements to realise a ubiquitous network society.

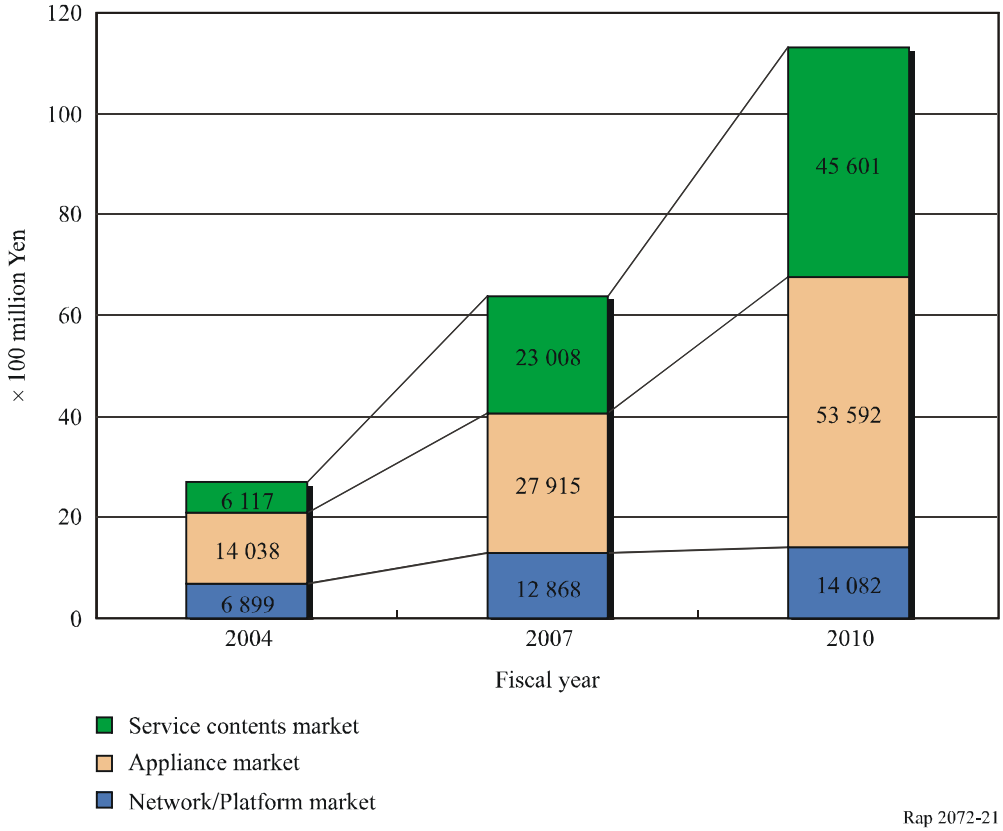
In a MIC report on the Japanese market size of digital home appliance released in August 2004, it is forecasted to be 6.4 Trillion Yen in 2007, 11.3 Trillion Yen in 2010, which is depicted in Fig. 21.

---

[8] *Executive Summary July 22, 2004* by LCC © 2004 All Rights Reserved. Used by permission granted to IEEE and ITU.

FIGURE 21

Japan market forecast for digital home appliance



Network/Platform market includes CATV, xDSL, and optical fibre markets. It is difficult to separate network markets for digital home appliance and for others, so whole markets are considered as for digital home appliance, in those figures. The mobile telephone market is not included in the figure, but if that market is included it becomes much bigger market.

The appliance market is a basic market and includes equipments such as network router, modem, WLAN equipments, home gateway, digital video recorder, game, PC, white appliances, digital TV tuner, robot, censor, digital camera, digital video, and web camera.

The service contents market had been provided for PC applications in the past, but may create new services market for networked and digitalized home appliances. It may contain online music, home security, e-learning, health related services, information distribution, data centre, etc.

(Source: MIC Study Report on Networking of Digital Home Appliance, August 2004)

7.4.3 Traffic forecasts

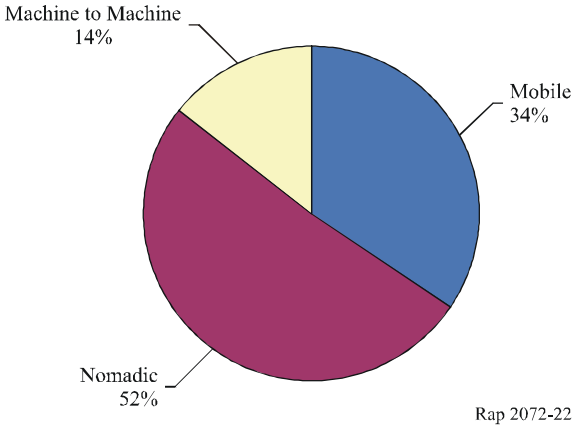
7.4.3.1 WLAN (including IEEE 802.11 family) in 2020[9]

As shown in Fig. 22, traffic in 2020 will be a combination of mobile and nomadic. In addition, a significant portion of the traffic will be between machines and not people. Nomadic, and also machine to machine, traffic may be carried by WLAN, BWA, MAN, or BRAN. Other technologies (e.g. PAN) may also carry machine to machine traffic. The high percentage of traffic shown for nomadic application is largely driven by the greater use of applications such as Internet access in nomadic situations. While the traffic is higher, the number of subscribers is lower.

[9] Source: UMTS Forum

FIGURE 22

Type of traffic that will be offered to networks in a representative Western European county in 2020
(Source: Telecompetition Inc., on behalf of UMTS Forum, November 2004)



Based on the UMTS Forum's studies, 23% of users in 2020 will use nomadic services and may have multiple subscriptions for this traffic. For mobile subscribers, 100% in Western Europe will have multiple service subscriptions. Table 51 shows how traffic will be distributed between voice, data and machine to machine traffic.

TABLE 51

Mobile traffic by service type in 2020
(Source: Telecompetition Inc., on behalf of UMTS Forum, November 2004)

Traffic by service type (%)	**Total BH Traffic UL (%)**	**Total BH Traffic DL (%)**	**Total BH Traffic per Subscriber (%)**
Mobile voice	50	16	23
Mobile data	40	81	72
Machine to machine	10	3	5

Figure 23 shows the applications a business user is predicted to use in a nomadic situation.

Figure 24 shows the consumer traffic by activity in a nomadic environment in 2020.

FIGURE 23

Business traffic generated in a nomadic environment in a representative Western European country in 2020
(Source: Telecompetition Inc., on behalf of UMTS Forum, November 2004)

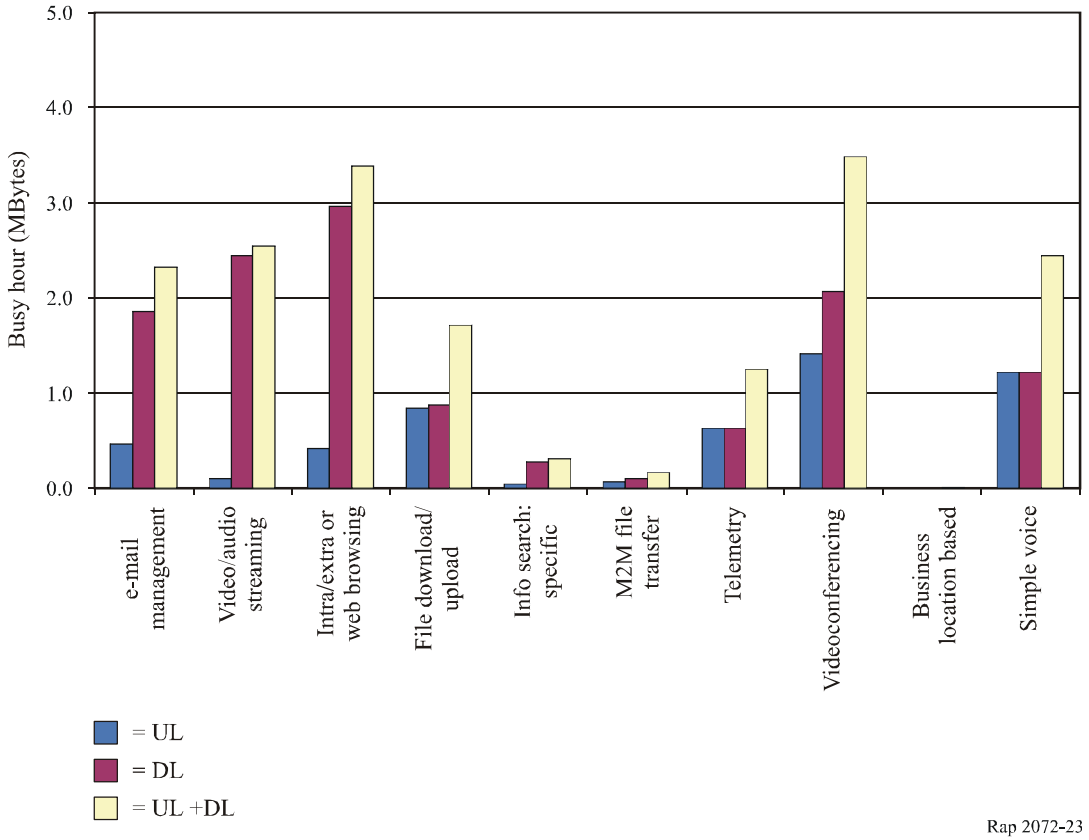
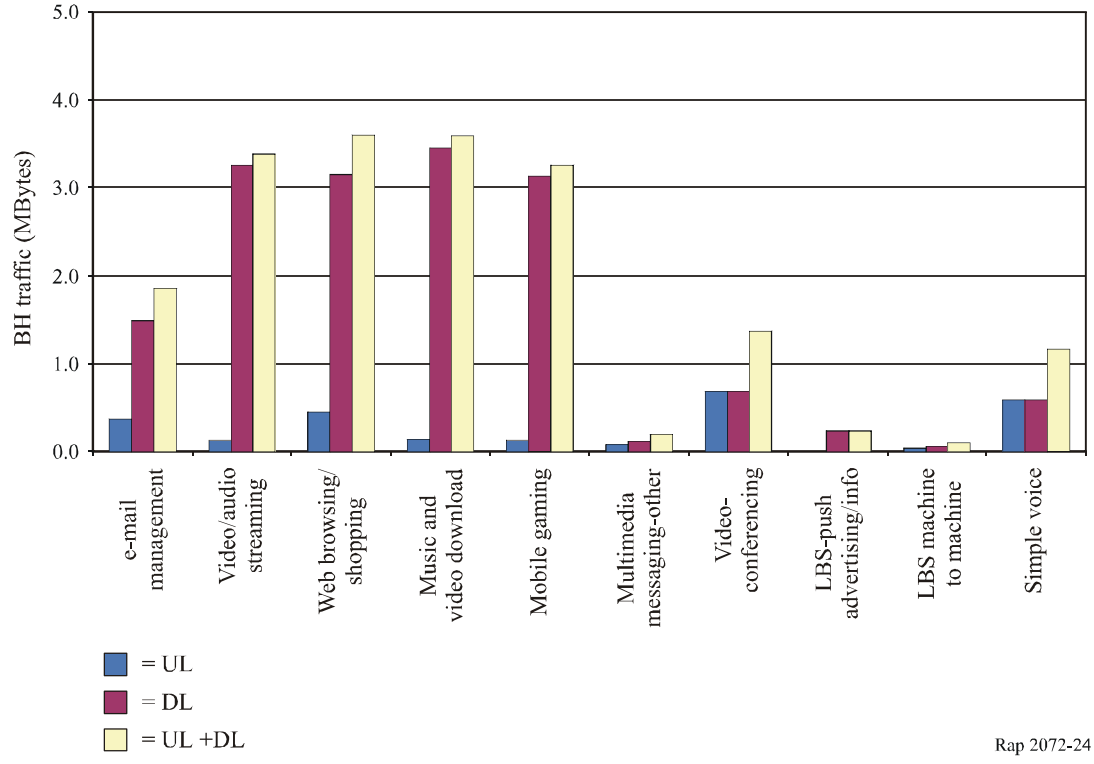


FIGURE 24

Consumer traffic by activity in a representative Western European country in 2020
(Source: Telecompetition Inc., on behalf of UMTS Forum, November 2004)



8 Market related parameters for spectrum calculation

This section describes the specific values of the five parameters to be used in spectrum calculation method, as described in Recommendation ITU-R M.1768, for IMT-2000 and systems beyond IMT-2000. The market related parameters are aggregated across applications served by both emerging technologies and well characterized systems such as those defined in Recommendation ITU-R M.1457. The five market attributes are market scale, number of session attempts per user, mean service bit rate, average session duration, and mobility ratio.

The method to analyse the responses to questionnaire and derive the results shown in this section are described in Annex 4 in detail.

The service categories used in this section and their numbers are shown in Table 52. Table 53 shows the identification of service environments.

TABLE 52

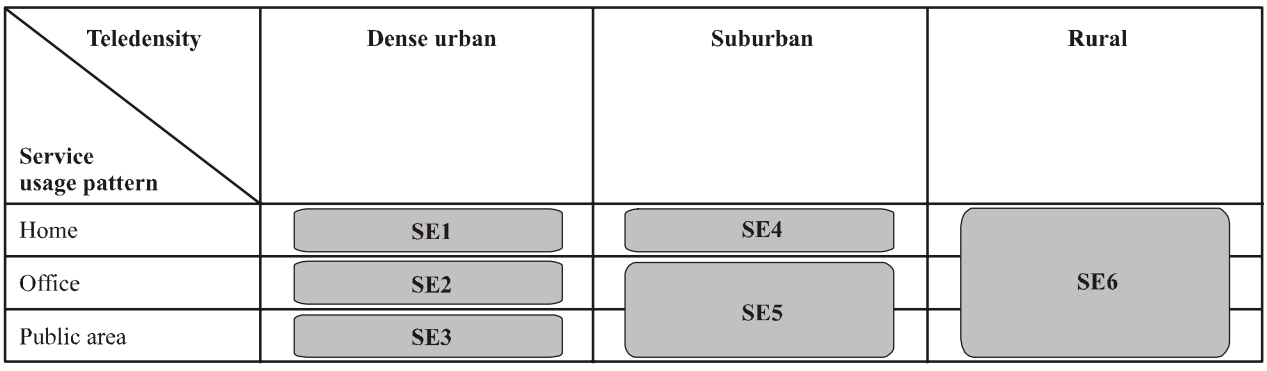
Service category number

Traffic class / Service type	Conversational	Streaming	Interactive	Background
Super high multimedia	SC 1	SC 6	SC 11	SC 16
High multimedia	SC 2	SC 7	SC 12	SC 17
Medium multimedia	SC 3	SC 8	SC 13	SC 18
Low rate data and low multimedia	SC 4	SC 9	SC 14	SC 19
Very low rate data(1)	SC 5	SC 10	SC 15	SC 20

(1) This includes speech and SMS.

TABLE 53

The identification of Service Environments



Rap 2072-tab53

8.1 Traffic classes for service categorization

Recommendation ITU-R M.1079 defines four QoS classes for IMT-2000 from the user perspective:

– conversational class of service

– interactive class of service

– streaming class of service
– background class of service.

The main distinguishing factor between these classes is how delay-sensitive the application is:

– conversational class refers to applications which are very delay-sensitive while background class is the most delay-insensitive QoS class.

For traffic classes based on Recommendation ITU-R M.1079 the conversational and streaming class are served with circuit switching and the background and interactive class with packet switching.

8.1.1 Conversational class

The most well-known use of this scheme is telephony speech. But with Internet and multimedia a number of new applications will require this scheme, for example VoIP and videoconferencing tools. Real-time conversation is always performed between peers (or groups) of live (human) end users. The real-time conversation scheme is characterized by the transfer time that must be low because of:

– the conversational nature of the scheme;
– at the same time the time relation (variation) between information entities of the stream must be preserved in the same way as for real-time streams.

The maximum transfer delay is given by the human perception of video and audio conversation. Therefore the limit for acceptable transfer delay is very strict, as failure to provide low enough transfer delay will result in unacceptable lack of quality. The transfer delay requirement is therefore both significantly lower and more stringent than the round trip delay of interactive applications.

8.1.2 Interactive class

When the end-user, that is either a machine or a human, is online requesting data from remote equipment (e.g. a server) this scheme applies. Examples of human interaction with the remote equipment are: Web browsing, database retrieval, server access. Examples of machine interaction with remote equipment are: polling for measurement records and automatic database enquiries (tele machines).

Interactive traffic is the other classical data communication scheme that on an overall level is characterized by the request response pattern of the end-user. At the message destination there is an entity expecting the message (response) within a certain time. Round-trip delay time is therefore one of the key attributes. Another characteristic is that the content of the packets must be transparently transferred (with low BER).

Interactive traffic – fundamental characteristics for QoS:

– request response pattern;
– preserve payload content.

8.1.3 Streaming class

When the user is looking at (listening to) real-time video (audio) the scheme of real-time streams applies. The real-time data flow is always aiming at a live (human) destination. It is a one-way transport.

This scheme is one of the newcomers in data communication, raising a number of new requirements in both telecommunication and data communication systems. It is characterized by the time relations (variation) between information entities (i.e. samples, packets) within a flow which must be preserved, although it does not have any requirements on low transfer delay.

The delay variation of the end-to-end flow must be limited, to preserve the time relation (variation) between information entities of the stream. But as the stream normally is time aligned at the receiving end (in the user equipment), the highest acceptable delay variation over the transmission media is given by the capability of the time alignment function of the application. Acceptable delay variation is thus much greater than the delay variation given by the limits of human perception.

Real-time streams – fundamental characteristics for QoS:

– unidirectional continuous stream;

– preserve time relation (variation) between information entities of the stream.

8.1.4 Background class

When the end-user, that typically is a computer, sends and receives data-files in the background, this scheme applies. Examples are background delivery of e-mails, SMS, download of databases and reception of measurement records.

Background traffic is one of the classical data communication schemes where an overall level is characterized by the absence of a parameter at the destination expecting to receive the data within a certain time limit, with the exception that there is still a delay constraint, since data is effectively useless if it is received too late for any practical purpose. The scheme is thus more or less delivery time insensitive. Another characteristic is that the content of the packets must be transparently transferred (with low BER).

Background traffic – fundamental characteristics for QoS:

– the destination is not expecting the data within a certain time;

– preserve payload content.

A background application is one that does not carry delay information. In principle, the only requirement for applications in this category is that information should be delivered to the user essentially error free. However, it is emphasized that there is still a delay constraint, since data is effectively useless if it is received too late for any practical purpose.

8.2 Map the services into service category (SC) table per each service environment (SE)

Each service can be mapped into the table composed of service type and traffic class as shown in Table 54. Note that some services in the table may not be found in some service environments. We can identify this from teledensity, which is one of the parameters shown in Table 53.

TABLE 54

Mapping services onto service categories

Traffic class / Service types	Conversational	Streaming	Interactive	Background
Super high multimedia (30 Mbit/s to 100 M/ 1 Gbit/s)		High volume streaming	Browsing 5	Mobile Internet/Intranet/Extranet 2
			Game data download	High volume business applications, file transfer and collaborative working (application sharing) 6
			Download service, e-newspaper	High rate data transfer (upload/download)
			Collaborative working (application sharing) 5	Business applications 2

TABLE 54 (*continued*)

Traffic class / Service types	Conversational	Streaming	Interactive	Background
High multimedia (<30 Mbit/s)	High quality videoconference	Entertainment/movie (video streaming)	Video messaging	Mobile Internet/Intranet/Extranet 1
	Multi-media phone	Entertainment/broadcasting program (video streaming)	Browsing 4	ITS (navigation)
	Mobile HDTV and video	High volume business applications	Mobile commerce	Health care/health check, remote diagnostics, medication information, medical data provision
	IP broadcast HDTV and video	e-emergency rescue, streaming service	Music download	Life/education//remote monitor/control, information search, e-learning, news/weather
	Collaborative working (application sharing) 3		Video streaming and download 2	P2P file transfer
			Interactive gaming 1	Business applications 1
			Collaborative working (application sharing) 2	
			High volume business applications and collaborative working (application sharing) 4	
			Emergency/disaster// disaster prediction/ notification, emergency information	
Medium multimedia (<2 Mbit/s)	Videotelephony 1	Video interactive, videoconferencing	High rate multimedia/ videoconference	Photo messages 2
	Hi-quality video phone	Video/audio/TV streaming	Photo messages 1	Business Intranet/Extranet
	Videoconference	Interactive gaming 2	Communication/messaging (MMS/IMS/SMS)	e-learning, background service
	Mobile TV/broadcast IP TV	Monitoring for uploading video data	Web browsing 2	Consumer and business mobile Internet
	Telemedicine	Exercise monitor and instruction	Secure M-commerce, M-banking and business applications	
	Secured transactions (biometrics)	e-learning, video streaming service	Public/electric -vote, e-government	
	IP Web radio	Observation/surveillance by video camera (network-camera)	Location-based service/browsing	
			Video streaming and download 1	
			Collaborative working (application sharing) 1	
			ITS probe, interactive service	

TABLE 54 (*end*)

Traffic class / Service types	Conversational	Streaming	Interactive	Background
Multimedia and Low rate data (<144 kbit/s)	VoIP 1	Internet radio	MMS	Low priority e-mail, SMS, MMS, LBS
	Videotelephony 2	Medium data rate monitoring and transactions	Browsing 3	Machine to machine services
	Slow scan surveillance video/industrial controls		Lottery and bettting services	
	e-emergency rescue, wideband conversational service		M-payment	
			Location-based service/location search, navigation, traffic information, point of interest	
			Exercise monitor, uploading bio-medical or physical data	
			Collaborative work including multimedia information exchange and file sharing	
Very low bit rate (e.g. speech and SMS) (<16 kbit/s)	Voice telephony	Low data rate transaction e.g. RFID	VoIP 2	Low priority e-mail, SMS, MMS
	VoIP for long distance	Health monitoring	SMS	Telemetering
	e-learning, conversational service		Voice messaging	
			Communication/Web browsing 1	
			ITS probe, back ground service	
			Low rate data transmit e.g. monitoring	

8.3 Market attribute values per SC and SE

Table 55 shows the market attribute values per each SC and SE.

Each parameter value is described with a range, if necessary, based on the descriptions in plural responses to the questionnaire. In particular, some reasons have been specified on the value deviations on two parameters. As for user density (market scale), some responses show average value while others describe the values considering user concentration usually seen in railway station and office. Traffic concentration in time is also considered in some responses and reflected in number of session attempts per user.

TABLE 55

Calculated market attribute values per each SC and SE

SC *n*	SE *m*	User density (users/km^2)		Session arrival rate per user (session arrivals/h/users)		Mean service bit rate (kbit/s)		Average session duration (s/session)		Mobility ratio (%)							
										Stationary		Low		High		Super-High	
2010, Uplink																	
1	1	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
1	2	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
1	3	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
1	4	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
1	5	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
1	6	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
2	1	50	50	0.100	0.100	20 000	20 000	1 793	1 793	100	100	0	0	0	0	0	0
2	2	55	55	0.281	0.281	20 000	20 000	64	64	100	100	0	0	0	0	0	0
2	3	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
2	4	20	20	0.100	0.100	20 000	20 000	1 793	1 793	100	100	0	0	0	0	0	0
2	5	10	10	0.299	0.299	20 000	20 000	9	9	100	100	0	0	0	0	0	0
2	6	1	1	0.100	0.100	20 000	20 000	1 793	1 793	100	100	0	0	0	0	0	0
3	1	3 400	15 371	0.100	0.579	66	1 468	90	208	55	83	17	25	0	20	0	0
3	2	5 000	47 871	0.159	0.661	65	910	111	120	55	84	16	35	0	10	0	0
3	3	200	30 828	0.100	0.314	70	1 081	79	120	10	83	17	70	0	20	0	0
3	4	700	3 750	0.228	0.700	64	768	79	210	45	87	13	30	0	25	0	0
3	5	400	10 000	0.350	0.573	64	768	91	120	10	88	12	20	0	60	0	10
3	6	20	750	0.055	0.199	64	768	74	120	5	87	10	13	0	70	0	15
4	1	50	13 751	0.100	0.720	64	144	100	2 390	55	100	0	25	0	20	0	10
4	2	100	13 751	0.100	0.720	64	144	100	2 390	55	100	0	35	0	12	0	10
4	3	20	18 339	0.100	0.720	144	1 391	127	2 390	8	100	0	70	0	28	0	10
4	4	5	20	0.100	0.720	64	144	100	2 390	45	100	0	30	0	25	0	10
4	5	20	29	0.100	0.688	144	1 778	138	2 390	7	100	0	17	0	66	0	9
4	6	5	20	0.100	0.707	144	893	115	2 390	4	100	0	16	0	71	0	15
5	1	2 ,000	92 779	0.129	1.860	15	16	60	599	54	80	20	28	0	20	0	12
5	2	2 000	218 592	0.103	2.513	15	16	71	610	54	80	20	35	0	15	0	12
5	3	500	145 644	0.139	2.278	15	16	50	607	10	70	20	70	10	20	0	12
5	4	300	13 ,238	0.491	3.454	14	16	37	610	45	80	20	30	0	25	0	12
5	5	114	32 040	0.800	3.760	10	16	60	617	10	60	20	28	15	60	0	12
5	6	20	2 648	0.446	3.454	15	16	35	610	5	70	10	28	5	70	5	15
6	1	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
6	2	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
6	3	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
6	4	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
6	5	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
6	6	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
7	1	0	44	0.000	0.010	2 000	30 000	0	150	55	55	25	25	20	20	0	0
7	2	97	200	0.192	0.498	2 000	30 000	18	635	53	90	10	35	0	16	0	15
7	3	0	781	0.000	0.284	2 106	29 543	0	635	10	54	16	69	17	21	0	15
7	4	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
7	5	30	33	0.224	0.498	2 602	26 386	18	701	8	90	10	17	0	66	0	13
7	6	0	6	0.000	0.225	2 279	28 326	0	659	5	51	9	14	20	71	15	16
8	1	50	15 797	0.100	0.527	384	812	10	1 147	55	90	10	25	0	20	0	0
8	2	100	48 039	0.299	0.656	384	850	10	1 170	55	90	10	35	0	10	0	1
8	3	10	31 826	0.100	0.647	384	902	10	1 161	10	90	10	70	0	20	0	1
8	4	20	3 713	0.100	0.658	384	810	10	1 170	45	90	10	30	0	25	0	0
8	5	50	9 953	0.199	0.657	384	813	10	1 168	10	90	10	20	0	60	0	10
8	6	5	752	0.100	0.656	384	816	10	1 165	5	80	10	10	10	70	0	15
9	1	300	300	0.199	0.199	144	144	7	7	90	90	10	10	0	0	0	0

TABLE 55 (*continued*)

SC *n*	SE *m*	User density (users/km^2)	Session arrival rate per user (session arrivals/h/users)	Mean service bit rate (kbit/s)	Average session duration (s/session)	Mobility ratio (%)			
						Stationary	Low	High	Super-High
2010, Uplink (*continued*)									
9	2	400 - 400	0.299 - 0.299	144 - 144	29 - 29	90 - 90	10 - 10	0 - 0	0 - 0
9	3	50 - 50	0.100 - 0.100	144 - 144	29 - 29	80 - 80	10 - 10	10 - 10	0 - 0
9	4	50 - 50	0.199 - 0.199	144 - 144	7 - 7	90 - 90	10 - 10	0 - 0	0 - 0
9	5	100 - 100	0.299 - 0.299	144 - 144	29 - 29	70 - 70	10 - 10	20 - 20	0 - 0
9	6	10 - 10	0.100 - 0.100	144 - 144	7 - 7	80 - 80	10 - 10	10 - 10	0 - 0
10	1	200 - 4 500	0.199 - 1.000	3 - 16	2 - 3 600	55 - 80	20 - 25	0 - 20	0 - 0
10	2	300 - 16 200	0.299 - 1.000	3 - 16	2 - 3 600	55 - 80	20 - 35	0 - 10	0 - 0
10	3	50 - 9 720	0.100 - 1.000	3 - 16	2 - 3 600	10 - 70	20 - 70	10 - 20	0 - 0
10	4	50 - 1 350	0.199 - 1.000	3 - 16	2 - 3 600	45 - 80	20 - 30	0 - 25	0 - 0
10	5	50 - 3 600	0.299 - 1.000	3 - 16	2 - 3 600	10 - 60	20 - 20	20 - 60	0 - 10
10	6	10 - 270	0.100 - 1.000	3 - 16	2 - 3 600	5 - 65	10 - 20	10 - 70	5 - 15
11	1	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
11	2	20 - 20	0.199 - 0.199	500 ,000 - 500 000	4 - 4	100 - 100	0 - 0	0 - 0	0 - 0
11	3	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
11	4	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
11	5	5 - 5	0.199 - 0.199	500 000 - 500 000	4 - 4	100 - 100	0 - 0	0 - 0	0 - 0
11	6	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
12	1	200 - 331	0.100 - 1.382	6 306 - 30 000	4 - 230	57 - 80	20 - 24	0 - 18	0 - 1
12	2	300 - 709	0.100 - 1.626	1 877 - 30 000	4 - 276	55 - 80	20 - 35	0 - 10	0 - 0
12	3	10 - 837	0.100 - 1.432	8 719 - 30 000	4 - 211	25 - 80	20 - 57	0 - 17	0 - 2
12	4	50 - 55	0.100 - 1.736	1 759 - 30 000	4 - 278	46 - 80	20 - 30	0 - 25	0 - 0
12	5	50 - 152	0.100 - 1.720	2 125 - 30 000	4 - 274	12 - 75	20 - 20	5 - 58	0 - 10
12	6	5 - 14	0.100 - 1.659	3 812 - 30 000	4 - 254	11 - 75	11 - 20	5 - 64	0 - 14
13	1	2 000 - 84 572	0.100 - 0.165	881 - 1 659	17 - 26	47 - 80	20 - 23	0 - 18	0 - 4
13	2	2 000 - 292 780	0.162 - 0.299	881 - 1 576	14 - 26	52 - 80	20 - 34	0 - 10	0 - 1
13	3	100 - 180 170	0.100 - 0.175	881 - 1 733	20 - 26	9 - 63	20 - 66	17 - 19	0 - 7
13	4	200 - 24 048	0.100 - 0.162	881 - 1 547	12 - 26	45 - 80	20 - 30	0 - 25	0 - 1
13	5	100 - 64 163	0.163 - 0.299	881 - 1 567	13 - 26	10 - 70	20 - 20	10 - 60	0 - 11
13	6	25 - 4 822	0.100 - 0.166	753 - 1 616	14 - 28	5 - 66	10 - 20	10 - 70	4 - 15
14	1	3 000 - 19 293	0.100 - 4.936	24 - 144	1 - 2	55 - 80	20 - 25	0 - 20	0 - 1
14	2	3 000 - 14 054	0.100 - 0.142	24 - 144	2 - 63	55 - 80	20 - 35	0 - 10	0 - 1
14	3	200 - 36 341	0.100 - 0.209	68 - 151	2 - 1 804	1 - 50	30 - 98	1 - 20	0 - 1
14	4	200 - 1 583	0.100 - 17.728	29 - 144	0 - 2	45 - 80	20 - 30	0 - 25	0 - 5
14	5	100 - 6 191	0.100 - 0.227	69 - 145	2 - 3 494	0 - 70	20 - 100	0 - 10	0 - 0
14	6	15 - 788	0.100 - 7.266	69 - 146	2 - 65	0 - 65	20 - 99	0 - 10	0 - 5
15	1	3 000 - 115 178	0.498 - 14.016	2 - 16	1 - 29	55 - 80	20 - 25	0 - 20	0 - 0
15	2	3 000 - 414 308	0.996 - 14.026	2 - 16	1 - 36	55 - 80	20 - 35	0 - 10	0 - 0
15	3	200 - 249 535	0.299 - 15.275	3 - 16	1 - 24	10 - 60	20 - 70	20 - 20	0 - 1
15	4	200 - 34 520	0.598 - 14.028	2 - 16	1 - 29	45 - 80	20 - 30	0 - 25	0 - 0
15	5	100 - 92 082	0.996 - 15.327	2 - 16	1 - 29	10 - 80	10 - 20	10 - 60	0 - 10
15	6	10 - 6 910	0.598 - 15.319	2 - 16	1 - 29	5 - 65	10 - 20	10 - 70	5 - 15
16	1	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
16	2	50 - 50	0.199 - 0.199	20 000 - 20 000	6 - 6	80 - 80	20 - 20	0 - 0	0 - 0
16	3	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
16	4	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
16	5	10 - 10	0.199 - 0.199	20,000 - 20,000	6 - 6	80 - 80	20 - 20	0 - 0	0 - 0
16	6	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
17	1	0 - 1 142	0.000 - 1.501	5 175 - 10 140	0 - 286	55 - 55	25 - 25	20 - 20	0 - 0
17	2	50 - 3 631	0.199 - 1.682	5 273 - 20 000	12 - 289	55 - 80	20 - 35	0 - 10	0 - 0
17	3	0 - 2 392	0.000 - 1.548	5 745 - 10 596	0 - 292	10 - 12	68 - 70	20 - 20	0 - 0
17	4	0 - 298	0.000 - 1.707	5 100 - 10 080	0 - 288	45 - 45	30 - 30	25 - 25	0 - 0

TABLE 55 (*continued*)

SC *n*	SE *m*	User density (users/km^2)	Session arrival rate per user (session arrivals/h/users)	Mean service bit rate (kbit/s)	Average session duration (s/session)	Mobility ratio (%)			
						Stationary	Low	High	Super-High
2010, Uplink (*end*)									
17	5	10 - 782	0.199 - 1.731	5 119 - 20 000	12 - 289	10 - 80	20 - 20	0 - 60	0 - 10
17	6	0 - 61	0.000 - 1.670	5 313 - 10.251	0 - 290	5 - 6	10 - 10	69 - 70	15 - 15
18	1	600 - 600	0.100 - 0.100	574 - 574	8 - 8	80 - 80	20 - 20	0 - 0	0 - 0
18	2	1 300 - 1 300	0.996 - 0.996	595 - 595	16 - 16	80 - 80	20 - 20	0 - 0	0 - 0
18	3	20 - 20	0.100 - 0.100	990 - 990	2 - 2	60 - 60	20 - 20	20 - 20	0 - 0
18	4	100 - 100	0.100 - 0.100	1 030 - 1.030	7 - 7	80 - 80	20 - 20	0 - 0	0 - 0
18	5	70 - 70	0.996 - 0.996	653 - 653	15 - 15	60 - 60	20 - 20	20 - 20	0 - 0
18	6	10 - 10	0.100 - 0.100	1 030 - 1.030	7 - 7	60 - 60	20 - 20	15 - 15	5 - 5
19	1	500 - 500	0.100 - 0.100	144 - 144	5 - 5	80 - 80	20 - 20	0 - 0	0 - 0
19	2	1 000 - 1 000	0.299 - 0.299	144 - 144	5 - 5	80 - 80	20 - 20	0 - 0	0 - 0
19	3	50 - 50	0.100 - 0.100	144 - 144	5 - 5	60 - 60	20 - 20	15 - 15	5 - 5
19	4	50 - 50	0.100 - 0.100	144 - 144	5 - 5	80 - 80	20 - 20	0 - 0	0 - 0
19	5	50 - 50	0.100 - 0.100	144 - 144	5 - 5	60 - 60	20 - 20	20 - 20	0 - 0
19	6	10 - 10	0.100 - 0.100	144 - 144	5 - 5	60 - 60	20 - 20	15 - 15	5 - 5
20	1	1 000 - 1 ,000	0.100 - 0.100	16 - 16	6 - 6	80 - 80	20 - 20	0 - 0	0 - 0
20	2	1 000 - 1 000	0.299 - 0.299	16 - 16	10 - 10	80 - 80	20 - 20	0 - 0	0 - 0
20	3	100 - 4,536	0.100 - 1.000	12 - 16	1 - 6	10 - 60	20 - 70	20 - 20	0 - 0
20	4	100 - 100	0.100 - 0.100	16 - 16	6 - 6	80 - 80	20 - 20	0 - 0	0 - 0
20	5	50 - 1 680	0.299 - 1.000	12 - 16	1 - 10	10 - 60	20 - 20	20 - 60	0 - 10
20	6	10 - 126	0.100 - 1.000	12 - 16	1 - 6	5 - 60	10 - 20	15 - 70	5 - 15
2010, Downlink									
1	1	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
1	2	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
1	3	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
1	4	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
1	5	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
1	6	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
2	1	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
2	2	45 - 45	0.299 - 0.299	20 000 - 20 000	53 - 53	100 - 100	0 - 0	0 - 0	0 - 0
2	3	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
2	4	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
2	5	7 - 7	0.299 - 0.299	20 000 - 20 000	51 - 51	100 - 100	0 - 0	0 - 0	0 - 0
2	6	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
3	1	3 020 - 15 371	0.100 - 0.579	66 - 1 500	73 - 208	55 - 83	17 - 25	0 - 20	0 - 0
3	2	4 550 - 47 871	0.160 - 0.661	65 - 1 098	106 - 120	55 - 83	17 - 35	0 - 10	0 - 0
3	3	140 - 30 828	0.100 - 0.314	70 - 1 327	51 - 120	10 - 84	16 - 70	0 - 20	0 - 0
3	4	600 - 3 750	0.234 - 0.700	64 - 818	66 - 210	45 - 86	14 - 30	0 - 25	0 - 0
3	5	345 - 10 000	0.350 - 0.595	64 - 768	71 - 120	10 - 88	12 - 20	0 - 60	0 - 10
3	6	17 - 750	0.055 - 0.204	64 - 792	62 - 120	5 - 87	10 - 13	0 - 70	0 - 15
4	1	50 - 13 751	0.100 - 0.720	64 - 144	100 - 598	55 - 100	0 - 25	0 - 20	0 - 10
4	2	100 - 13 751	0.100 - 0.720	64 - 144	100 - 598	55 - 100	0 - 35	0 - 12	0 - 10
4	3	20 - 18 339	0.100 - 0.720	64 - 144	127 - 598	8 - 100	0 - 70	0 - 28	0 - 10
4	4	5 - 20	0.100 - 0.720	64 - 144	100 - 598	45 - 100	0 - 30	0 - 25	0 - 10
4	5	20 - 29	0.100 - 0.688	64 - 144	138 - 598	7 - 100	0 - 17	0 - 66	0 - 9
4	6	5 - 20	0.100 - 0.707	64 - 144	115 - 598	4 - 100	0 - 16	0 - 71	0 - 15
5	1	2 000 - 92 779	0.129 - 1.860	15 - 16	60 - 599	54 - 80	20 - 28	0 - 20	0 - 12
5	2	2 000 - 218 592	0.103 - 2.513	15 - 16	71 - 610	54 - 80	20 - 35	0 - 15	0 - 12
5	3	500 - 145 644	0.139 - 2.278	15 - 16	50 - 607	10 - 70	20 - 70	10 - 20	0 - 12
5	4	300 - 13 238	0.491 - 3.454	14 - 16	37 - 610	45 - 80	20 - 30	0 - 25	0 - 12
5	5	114 - 32 040	0.800 - 3.760	10 - 16	60 - 617	10 - 60	20 - 28	15 - 60	0 - 12
5	6	20 - 2 648	0.446 - 3.454	15 - 16	35 - 610	5 - 70	10 - 28	5 - 70	5 - 15

TABLE 55 (*continued*)

SC *n*	SE *m*	User density (users/km^2)			Session arrival rate per user (session arrivals/h/users)			Mean service bit rate (kbit/s)			Average session duration (s/session)			Mobility ratio (%)								
														Stationary			Low			High		
2010, Downlink (*continued*)																						
6	1	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
6	2	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
6	3	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
6	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
6	5	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
6	6	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
7	1	0	-	44	0.000	-	0.010	2 000	-	32 768	0	-	150	55	-	55	25	-	25	20	-	20
7	2	97	-	200	0.192	-	0.498	2 000	-	30 857	42	-	635	53	-	90	10	-	35	0	-	16
7	3	0	-	781	0.000	-	0.284	1 949	-	30 210	0	-	635	10	-	54	16	-	69	17	-	21
7	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
7	5	30	-	33	0.224	-	0.498	1 709	-	25 493	42	-	701	8	-	90	10	-	17	0	-	66
7	6	0	-	6	0.000	-	0.225	1 865	-	27 912	0	-	659	5	-	51	9	-	14	20	-	71
8	1	50	-	14 889	0.065	-	0.235	384	-	1 777	38	-	2 289	55	-	90	10	-	25	0	-	20
8	2	100	-	69 055	0.019	-	0.352	384	-	1 936	38	-	3 413	55	-	90	10	-	35	0	-	19
8	3	10	-	23 891	0.100	-	0.606	384	-	2 000	38	-	1 192	10	-	90	10	-	70	0	-	20
8	4	20	-	4 467	0.100	-	0.235	335	-	1 777	38	-	1 410	45	-	90	10	-	30	0	-	25
8	5	50	-	8 672	0.199	-	0.610	384	-	2 000	38	-	1 199	10	-	90	10	-	29	0	-	60
8	6	5	-	897	0.085	-	0.463	384	-	1 878	38	-	3 145	5	-	80	10	-	26	10	-	70
9	1	300	-	300	0.199	-	0.199	144	-	144	5	-	5	90	-	90	10	-	10	0	-	0
9	2	400	-	400	0.299	-	0.299	144	-	144	19	-	19	90	-	90	10	-	10	0	-	0
9	3	50	-	50	0.100	-	0.100	144	-	144	19	-	19	80	-	80	10	-	10	10	-	10
9	4	50	-	50	0.199	-	0.199	144	-	144	5	-	5	90	-	90	10	-	10	0	-	0
9	5	100	-	100	0.299	-	0.299	144	-	144	19	-	19	70	-	70	10	-	10	20	-	20
9	6	10	-	10	0.100	-	0.100	144	-	144	5	-	5	80	-	80	10	-	10	10	-	10
10	1	200	-	200	0.199	-	0.199	16	-	16	1	-	1	80	-	80	20	-	20	0	-	0
10	2	300	-	300	0.299	-	0.299	16	-	16	1	-	1	80	-	80	20	-	20	0	-	0
10	3	50	-	50	0.100	-	0.100	16	-	16	1	-	1	70	-	70	20	-	20	10	-	10
10	4	50	-	50	0.199	-	0.199	16	-	16	1	-	1	80	-	80	20	-	20	0	-	0
10	5	50	-	50	0.299	-	0.299	16	-	16	1	-	1	60	-	60	20	-	20	20	-	20
10	6	10	-	10	0.100	-	0.100	16	-	16	1	-	1	65	-	65	20	-	20	10	-	10
11	1	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
11	2	20	-	20	0.199	-	0.199	500 000	-	500 000	32	-	32	100	-	100	0	-	0	0	-	0
11	3	0	-	27 087	0.000	-	1.000	30 000	-	30 000	0	-	8	10	-	10	70	-	70	20	-	20
11	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
11	5	5	-	10 032	0.199	-	1.000	30 000	-	500 000	8	-	32	10	-	100	0	-	20	0	-	60
11	6	0	-	752	0.000	-	1.000	30 000	-	30 000	0	-	8	5	-	5	10	-	10	70	-	70
12	1	200	-	1 509	0.100	-	1.685	1 795	-	30 001	14	-	277	55	-	80	20	-	25	0	-	20
12	2	300	-	4 948	0.100	-	1.749	1 114	-	30 000	14	-	286	55	-	80	20	-	35	0	-	10
12	3	10	-	43 885	0.100	-	0.543	2 945	-	28 237	14	-	71	12	-	80	20	-	68	0	-	19
12	4	50	-	408	0.100	-	1.765	1 097	-	30 000	14	-	287	45	-	80	20	-	30	0	-	25
12	5	50	-	16 095	0.100	-	0.537	1 955	-	28 172	14	-	70	10	-	75	20	-	20	5	-	60
12	6	5	-	1 209	0.100	-	0.539	2 166	-	28 186	14	-	70	6	-	75	10	-	20	5	-	69
13	1	2 000	-	129 310	0.100	-	7.226	1 083	-	2 046	2	-	74	47	-	80	20	-	25	0	-	20
13	2	2 000	-	436 409	0.162	-	6.931	1 083	-	2 046	14	-	74	52	-	80	20	-	35	0	-	10
13	3	100	-	265 944	0.100	-	6.835	1 083	-	2 046	20	-	74	9	-	64	20	-	70	16	-	20
13	4	200	-	37 635	0.100	-	7.441	373	-	1 966	1	-	74	45	-	80	20	-	30	0	-	25
13	5	100	-	96 203	0.299	-	6.986	385	-	1 967	1	-	74	10	-	70	20	-	20	10	-	60
13	6	25	-	7 539	0.100	-	7.432	420	-	1 967	1	-	76	5	-	67	10	-	20	10	-	70
14	1	3 000	-	14 054	0.100	-	0.123	117	-	144	4	-	63	55	-	80	20	-	25	0	-	20
14	2	3 000	-	14 054	0.100	-	0.142	119	-	144	4	-	63	55	-	80	20	-	35	0	-	10
14	3	200	-	36 341	0.100	-	0.209	142	-	260	4	-	1 804	1	-	50	30	-	98	1	-	20

SC *n*	SE *m*	Mobility ratio (%)								
		High			Super-High					
2010, Downlink (*continued*)										
6	1	0	-	0	0	-	0			
6	2	0	-	0	0	-	0			
6	3	0	-	0	0	-	0			
6	4	0	-	0	0	-	0			
6	5	0	-	0	0	-	0			
6	6	0	-	0	0	-	0			
7	1	20	-	20	0	-	0			
7	2	0	-	16	0	-	15			
7	3	17	-	21	0	-	15			
7	4	0	-	0	0	-	0			
7	5	0	-	66	0	-	13			
7	6	20	-	71	15	-	16			
8	1	0	-	20	0	-	0			
8	2	0	-	19	0	-	16			
8	3	0	-	20	0	-	17			
8	4	0	-	25	0	-	0			
8	5	0	-	60	0	-	17			
8	6	10	-	70	0	-	17			
9	1	0	-	0	0	-	0			
9	2	0	-	0	0	-	0			
9	3	10	-	10	0	-	0			
9	4	0	-	0	0	-	0			
9	5	20	-	20	0	-	0			
9	6	10	-	10	0	-	0			
10	1	0	-	0	0	-	0			
10	2	0	-	0	0	-	0			
10	3	10	-	10	0	-	0			
10	4	0	-	0	0	-	0			
10	5	20	-	20	0	-	0			
10	6	10	-	10	5	-	5			
11	1	0	-	0	0	-	0			
11	2	0	-	0	0	-	0			
11	3	20	-	20	0	-	0			
11	4	0	-	0	0	-	0			
11	5	0	-	60	0	-	10			
11	6	70	-	70	15	-	15			
12	1	0	-	20	0	-	0			
12	2	0	-	10	0	-	0			
12	3	0	-	19	0	-	0			
12	4	0	-	25	0	-	0			
12	5	5	-	60	0	-	10			
12	6	5	-	69	0	-	15			
13	1	0	-	20	0	-	0			
13	2	0	-	10	0	-	0			
13	3	16	-	20	0	-	0			
13	4	0	-	25	0	-	0			
13	5	10	-	60	0	-	10			
13	6	3	-	15						
14	1	0	-	20	0	-	1			
14	2	0	-	10	0	-	1			
14	3	1	-	20	0	-	1			

TABLE 55 (*continued*)

SC *n*	SE *m*	User density (users/km^2)			Session arrival rate per user (session arrivals/h/users)			Mean service bit rate (kbit/s)			Average session duration (s/session)			Mobility ratio (%)											
														Stationary			Low			High			Super-High		
2010, Downlink (*end*)																									
14	4	11	-	200	0.100	-	0.240	8	-	144	4	-	132	45	-	80	15	-	30	0	-	25	0	-	9
14	5	100	-	6,191	0.100	-	0.227	144	-	257	4	-	3 494	0	-	70	20	-	100	0	-	10	0	-	0
14	6	15	-	473	0.100	-	0.234	143	-	258	4	-	3 342	0	-	65	20	-	99	0	-	10	0	-	5
15	1	3 000	-	40 178	0.498	-	2.845	5	-	16	4	-	19	55	-	80	20	-	25	0	-	20	0	-	1
15	2	3 000	-	144 308	0.996	-	2.848	4	-	16	4	-	24	55	-	80	20	-	35	0	-	10	0	-	0
15	3	200	-	89 521	0.299	-	2.900	16	-	72	6	-	16	8	-	60	20	-	59	20	-	34	0	-	2
15	4	200	-	12 020	0.598	-	2.849	4	-	16	4	-	19	45	-	80	20	-	30	0	-	25	0	-	0
15	5	100	-	32 817	0.996	-	2.851	16	-	94	5	-	19	9	-	80	10	-	17	10	-	66	0	-	9
15	6	10	-	2 466	0.598	-	2.826	16	-	167	5	-	19	4	-	65	9	-	20	10	-	71	5	-	16
16	1	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
16	2	50	-	50	0.199	-	0.199	20 000	-	20 000	54	-	54	80	-	80	20	-	20	0	-	0	0	-	0
16	3	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
16	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
16	5	10	-	10	0.199	-	0.199	20 000	-	20 000	54	-	54	80	-	80	20	-	20	0	-	0	0	-	0
16	6	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
17	1	0	-	7 814	0.000	-	1.731	5 022	-	10 018	0	-	288	55	-	55	25	-	25	20	-	20	0	-	0
17	2	50	-	27 652	0.199	-	1.758	5 034	-	20 000	48	-	288	55	-	80	20	-	35	0	-	10	0	-	0
17	3	0	-	16 804	0.000	-	1.738	5 096	-	10 076	0	-	289	10	-	10	70	-	70	20	-	20	0	-	0
17	4	0	-	2 299	0.000	-	1.762	5 013	-	10 010	0	-	288	45	-	45	30	-	30	25	-	25	0	-	0
17	5	10	-	6 120	0.199	-	1.765	5 015	-	20 000	48	-	288	10	-	80	20	-	20	0	-	60	0	-	10
17	6	0	-	461	0.000	-	1.757	5 040	-	10 032	0	-	288	5	-	5	10	-	10	70	-	70	15	-	15
18	1	600	-	4,075	0.100	-	2.250	574	-	1,000	8	-	20	55	-	80	20	-	25	0	-	20	0	-	0
18	2	1 300	-	30 060	0.540	-	0.996	595	-	1 000	8	-	37	55	-	80	20	-	35	0	-	10	0	-	0
18	3	20	-	20	0.100	-	0.100	990	-	990	6	-	6	60	-	60	20	-	20	20	-	20	0	-	0
18	4	100	-	1 223	0.100	-	2.250	1 000	-	1 030	8	-	17	45	-	80	20	-	30	0	-	25	0	-	0
18	5	70	-	70	0.996	-	0.996	653	-	653	36	-	36	60	-	60	20	-	20	20	-	20	0	-	0
18	6	10	-	245	0.100	-	2.250	1 000	-	1 030	8	-	17	5	-	60	10	-	20	15	-	70	5	-	15
19	1	500	-	500	0.100	-	0.100	144	-	144	5	-	5	80	-	80	20	-	20	0	-	0	0	-	0
19	2	1 000	-	1 000	0.299	-	0.299	144	-	144	5	-	5	80	-	80	20	-	20	0	-	0	0	-	0
19	3	50	-	50	0.100	-	0.100	144	-	144	5	-	5	60	-	60	20	-	20	15	-	15	5	-	5
19	4	50	-	50	0.100	-	0.100	144	-	144	5	-	5	80	-	80	20	-	20	0	-	0	0	-	0
19	5	50	-	50	0.100	-	0.100	144	-	144	5	-	5	60	-	60	20	-	20	20	-	20	0	-	0
19	6	10	-	10	0.100	-	0.100	144	-	144	5	-	5	60	-	60	20	-	20	15	-	15	5	-	5
20	1	1 000	-	1 000	0.100	-	0.100	16	-	16	6	-	6	80	-	80	20	-	20	0	-	0	0	-	0
20	2	1 000	-	1 000	0.299	-	0.299	16	-	16	10	-	10	80	-	80	20	-	20	0	-	0	0	-	0
20	3	100	-	100	0.100	-	0.100	16	-	16	6	-	6	60	-	60	20	-	20	20	-	20	0	-	0
20	4	100	-	100	0.100	-	0.100	16	-	16	6	-	6	80	-	80	20	-	20	0	-	0	0	-	0
20	5	50	-	50	0.299	-	0.299	16	-	16	10	-	10	60	-	60	20	-	20	20	-	20	0	-	0
20	6	10	-	10	0.100	-	0.100	16	-	16	6	-	6	60	-	60	20	-	20	15	-	15	5	-	5
2015, Uplink																									
1	1	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
1	2	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
1	3	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
1	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
1	5	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
1	6	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
2	1	51	-	51	0.199	-	0.199	20 000	-	20 000	3 586	-	3 586	100	-	100	0	-	0	0	-	0	0	-	0
2	2	56	-	56	0.561	-	0.561	20 000	-	20 000	129	-	129	100	-	100	0	-	0	0	-	0	0	-	0
2	3	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
2	4	20	-	20	0.199	-	0.199	20 000	-	20 000	3 586	-	3 586	100	-	100	0	-	0	0	-	0	0	-	0
2	5	10	-	10	0.598	-	0.598	20 000	-	20 000	17	-	17	100	-	100	0	-	0	0	-	0	0	-	0

TABLE 55 (*continued*)

SC *n*	SE *m*	User density (users/km^2)		Session arrival rate per user (session arrivals/h/users)		Mean service bit rate (kbit/s)		Average session duration (s/session)		Mobility ratio (%)							
										Stationary		Low		High		Super-High	
2015, Uplink (*continued*)																	
2	6	1	1	0.199	0.199	20 000	20 000	3 586	3 586	100	100	0	0	0	0	0	0
3	1	3 468	38 684	0.199	0.382	79	1 468	181	201	55	83	17	25	0	20	0	0
3	2	5 100	84 184	0.319	0.593	71	910	120	222	55	84	16	35	0	10	0	0
3	3	204	66 045	0.199	0.251	99	1 081	119	157	10	83	17	70	0	20	0	0
3	4	714	5 250	0.455	0.773	64	768	158	210	45	87	13	30	0	25	0	0
3	5	408	14 000	0.386	1.146	64	768	120	181	10	88	12	20	0	60	0	10
3	6	20	1 050	0.061	0.398	64	768	120	148	5	87	10	13	0	70	0	15
4	1	51	39 365	0.110	1.680	64	144	100	4 781	55	100	0	25	0	20	0	10
4	2	102	39 365	0.110	1.680	64	144	100	4 781	55	100	0	35	0	12	0	10
4	3	20	52 497	0.141	1.680	144	2 971	130	4 781	8	100	0	70	0	29	0	10
4	4	7	20	0.199	1.680	64	144	100	4 781	45	100	0	30	0	25	0	10
4	5	20	46	0.199	1.565	144	2 273	121	4 781	8	100	0	19	0	63	0	9
4	6	8	20	0.199	1.632	144	1,057	109	4,781	5	100	0	17	0	70	0	15
5	1	2 040	119 330	0.153	2.299	15	16	74	599	54	80	20	28	0	20	0	12
5	2	2 040	246 841	0.120	3.031	15	16	69	609	54	80	20	35	0	15	0	12
5	3	510	166 892	0.148	2.705	15	16	100	607	10	70	20	70	10	20	0	12
5	4	306	15 330	0.475	4.081	15	16	34	607	45	80	20	30	0	25	0	12
5	5	132	34 360	0.842	4.770	10	16	100	617	10	60	20	28	15	60	0	12
5	6	20	3 066	0.449	4.081	15	16	33	607	5	70	10	28	5	70	5	15
6	1	111	111	0.020	0.020	3 277	1 000 000	150	150	55	55	25	25	20	20	0	0
6	2	111	111	0.020	0.020	3 277	1 000 000	150	150	55	55	35	35	10	10	0	0
6	3	148	148	0.022	0.022	3 277	1 000 000	150	150	10	10	70	70	20	20	0	0
6	4	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
6	5	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
6	6	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
7	1	0	766	0.000	0.020	2 000	30 000	0	150	55	55	25	25	20	20	0	0
7	2	161	857	0.164	0.996	2 000	30 000	36	1 210	53	90	10	35	0	16	0	13
7	3	0	1 756	0.000	0.315	2 118	29 853	0	1 033	10	54	15	70	16	20	0	15
7	4	0	0	0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0
7	5	31	56	0.348	0.996	2 808	28 546	36	1 032	9	90	10	18	0	63	0	14
7	6	0	10	0.000	0.353	2 358	29 355	0	1 007	5	52	10	14	18	70	15	16
8	1	51	52 141	0.199	0.372	384	1 607	19	1 073	55	90	10	25	0	20	0	0
8	2	102	116 890	0.598	0.793	384	1 704	19	1 174	55	90	10	35	0	13	0	4
8	3	10	90 929	0.199	0.856	384	1 775	19	1 168	10	90	10	70	0	20	0	7
8	4	20	7 459	0.199	0.706	384	1 603	19	1 175	45	90	10	30	0	25	0	0
8	5	51	19 970	0.398	0.707	384	1 604	19	1 173	10	90	10	20	0	60	0	10
8	6	5	1 506	0.199	0.708	384	1 607	19	1 171	5	80	10	10	10	70	0	15
9	1	306	306	0.398	0.398	144	144	14	14	90	90	10	10	0	0	0	0
9	2	408	408	0.598	0.598	144	144	57	57	90	90	10	10	0	0	0	0
9	3	51	51	0.199	0.199	144	144	57	57	80	80	10	10	10	10	0	0
9	4	51	51	0.398	0.398	144	144	14	14	90	90	10	10	0	0	0	0
9	5	102	102	0.598	0.598	144	144	57	57	70	70	10	10	20	20	0	0
9	6	10	10	0.199	0.199	144	144	14	14	80	80	10	10	10	10	0	0
10	1	204	7 800	0.398	1.000	5	16	4	3 600	55	80	20	25	0	20	0	0
10	2	306	28 080	0.598	1.000	5	16	4	3 600	55	80	20	35	0	10	0	0
10	3	51	16 848	0.199	1.000	5	16	4	3 600	10	70	20	70	10	20	0	0
10	4	51	2 340	0.398	1.000	5	16	4	3 600	45	80	20	30	0	25	0	0
10	5	51	6 240	0.598	1.000	5	16	4	3 600	10	60	20	20	20	60	0	10
10	6	10	468	0.199	1.000	5	16	4	3 600	5	65	10	20	10	70	5	15
11	1	0	111	0.000	0.080	6 554	1 000 000	0	60	55	55	25	25	20	20	0	0
11	2	20	111	0.080	0.398	6 554	1 000 000	7	60	55	100	0	35	0	10	0	0

TABLE 55 (*continued*)

SC *n*	SE *m*	User density (users/km^2)			Session arrival rate per user (session arrivals/h/users)			Mean service bit rate (kbit/s)			Average session duration (s/session)			Mobility ratio (%)											
														Stationary			Low			High			Super-High		
2015, Uplink (*continued*)																									
11	3	0	-	148	0.000	-	0.100	6 554	-	1 000 000	0	-	60	10	-	10	70	-	70	20	-	20	0	-	0
11	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
11	5	5	-	5	0.398	-	0.398	500 000	-	500 000	7	-	7	100	-	100	0	-	0	0	-	0	0	-	0
11	6	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
12	1	204	-	44 258	0.134	-	0.199	5 249	-	22 538	7	-	67	56	-	80	20	-	24	0	-	18	0	-	1
12	2	306	-	156 775	0.129	-	0.199	2 498	-	21 659	7	-	63	55	-	80	20	-	35	0	-	10	0	-	0
12	3	10	-	95 207	0.137	-	0.199	6 898	-	23 021	7	-	70	20	-	80	20	-	61	0	-	18	0	-	1
12	4	51	-	13 000	0.130	-	0.199	2 419	-	21 611	7	-	63	45	-	80	20	-	30	0	-	25	0	-	0
12	5	51	-	34 675	0.130	-	0.199	2 631	-	21 676	7	-	63	11	-	75	20	-	20	5	-	59	0	-	10
12	6	5	-	2 604	0.132	-	0.199	3 643	-	21 984	7	-	65	9	-	75	11	-	20	5	-	66	0	-	15
13	1	2 040	-	77 003	0.199	-	0.241	881	-	1 776	28	-	52	33	-	80	15	-	20	0	-	13	0	-	4
13	2	2 040	-	188 589	0.293	-	0.598	881	-	1 878	15	-	52	40	-	80	20	-	26	0	-	9	0	-	3
13	3	102	-	139 686	0.199	-	0.298	881	-	1 884	31	-	52	8	-	63	20	-	53	15	-	17	0	-	8
13	4	204	-	12 910	0.199	-	0.327	881	-	2 042	9	-	52	45	-	80	20	-	30	0	-	25	0	-	2
13	5	102	-	34 469	0.330	-	0.598	881	-	2 037	10	-	52	10	-	70	20	-	20	10	-	60	0	-	11
13	6	25	-	2 598	0.199	-	0.339	753	-	2 028	13	-	56	5	-	66	10	-	20	10	-	70	4	-	16
14	1	3 060	-	45 420	0.199	-	2.943	24	-	144	3	-	5	55	-	80	20	-	25	0	-	20	0	-	1
14	2	3 060	-	39 802	0.163	-	0.199	24	-	144	5	-	63	55	-	80	20	-	35	0	-	10	0	-	1
14	3	204	-	78 331	0.199	-	0.226	67	-	158	5	-	1 160	2	-	50	30	-	95	2	-	20	0	-	1
14	4	204	-	1 701	0.199	-	22.570	36	-	144	0	-	5	45	-	80	19	-	30	0	-	25	0	-	7
14	5	102	-	8 869	0.199	-	0.235	69	-	146	5	-	3 389	0	-	70	20	-	100	0	-	10	0	-	0
14	6	15	-	1 015	0.199	-	7.732	69	-	149	5	-	68	0	-	65	20	-	99	0	-	10	0	-	5
15	1	3 060	-	119 648	0.996	-	26.655	4	-	16	1	-	57	55	-	80	20	-	25	0	-	20	0	-	0
15	2	3 060	-	430 218	1.992	-	26.685	3	-	16	1	-	72	55	-	80	20	-	35	0	-	10	0	-	0
15	3	204	-	259 599	0.598	-	27.820	5	-	16	1	-	48	10	-	60	20	-	70	19	-	20	0	-	1
15	4	204	-	35 842	1.195	-	26.691	3	-	16	1	-	57	45	-	80	20	-	30	0	-	25	0	-	0
15	5	102	-	95 624	1.992	-	27.960	4	-	16	1	-	57	10	-	80	10	-	20	10	-	60	0	-	10
15	6	10	-	7 178	1.195	-	27.936	4	-	16	1	-	57	5	-	65	10	-	20	10	-	70	5	-	15
16	1	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
16	2	51	-	51	0.398	-	0.398	20 000	-	20 000	12	-	12	80	-	80	20	-	20	0	-	0	0	-	0
16	3	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
16	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
16	5	10	-	10	0.398	-	0.398	20 000	-	20 000	12	-	12	80	-	80	20	-	20	0	-	0	0	-	0
16	6	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
17	1	0	-	1 193	0.000	-	1.685	6 187	-	15 712	0	-	286	56	-	56	24	-	24	19	-	19	0	-	0
17	2	51	-	3 370	0.398	-	2.078	6 347	-	20 000	24	-	297	55	-	80	20	-	35	0	-	10	0	-	0
17	3	0	-	2 384	0.000	-	1.834	8 414	-	17 048	0	-	313	10	-	18	63	-	70	19	-	20	0	-	1
17	4	0	-	273	0.000	-	2.115	5 548	-	15 329	0	-	291	45	-	46	30	-	30	25	-	25	0	-	0
17	5	10	-	706	0.398	-	2.176	5 601	-	20 000	24	-	292	10	-	80	20	-	20	0	-	60	0	-	10
17	6	0	-	57	0.000	-	2.055	6 536	-	15 921	0	-	299	5	-	9	10	-	10	66	-	70	15	-	15
18	1	612	-	612	0.199	-	0.199	574	-	574	17	-	17	80	-	80	20	-	20	0	-	0	0	-	0
18	2	1 326	-	1 326	1.992	-	1.992	595	-	595	32	-	32	80	-	80	20	-	20	0	-	0	0	-	0
18	3	20	-	20	0.199	-	0.199	990	-	990	5	-	5	60	-	60	20	-	20	20	-	20	0	-	0
18	4	102	-	102	0.199	-	0.199	1 030	-	1 030	15	-	15	80	-	80	20	-	20	0	-	0	0	-	0
18	5	71	-	71	1.992	-	1.992	653	-	653	31	-	31	60	-	60	20	-	20	20	-	20	0	-	0
18	6	10	-	10	0.199	-	0.199	1 030	-	1 030	15	-	15	60	-	60	20	-	20	15	-	15	5	-	5
19	1	510	-	510	0.199	-	0.199	144	-	144	10	-	10	80	-	80	20	-	20	0	-	0	0	-	0
19	2	1,020	-	1 020	0.598	-	0.598	144	-	144	10	-	10	80	-	80	20	-	20	0	-	0	0	-	0
19	3	51	-	51	0.199	-	0.199	144	-	144	10	-	10	60	-	60	20	-	20	15	-	15	5	-	5
19	4	51	-	51	0.199	-	0.199	144	-	144	10	-	10	80	-	80	20	-	20	0	-	0	0	-	0
19	5	51	-	51	0.199	-	0.199	144	-	144	10	-	10	60	-	60	20	-	20	20	-	20	0	-	0

TABLE 55 (*continued*)

SC *n*	SE *m*	User density (users/km^2)			Session arrival rate per user (session arrivals/h/users)			Mean service bit rate (kbit/s)			Average session duration (s/session)			Mobility ratio (%)											
														Stationary			Low			High			Super-High		
2015, Uplink (*end*)																									
19	6	10	-	10	0.199	-	0.199	144	-	144	10	-	10	60	-	60	20	-	20	15	-	15	5	-	5
20	1	1 020	-	1 020	0.199	-	0.199	16	-	16	12	-	12	80	-	80	20	-	20	0	-	0	0	-	0
20	2	1 020	-	1 020	0.598	-	0.598	16	-	16	20	-	20	80	-	80	20	-	20	0	-	0	0	-	0
20	3	102	-	4 536	0.199	-	1.000	12	-	16	1	-	12	10	-	60	20	-	70	20	-	20	0	-	0
20	4	102	-	102	0.199	-	0.199	16	-	16	12	-	12	80	-	80	20	-	20	0	-	0	0	-	0
20	5	51	-	1 680	0.598	-	1.000	12	-	16	1	-	20	10	-	60	20	-	20	20	-	60	0	-	10
20	6	10	-	126	0.199	-	1.000	12	-	16	1	-	12	5	-	60	10	-	20	15	-	70	5	-	15
2015, Downlink																									
1	1	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
1	2	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
1	3	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
1	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
1	5	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
1	6	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
2	1	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
2	2	46	-	46	0.598	-	0.598	20 000	-	20 000	106	-	106	100	-	100	0	-	0	0	-	0	0	-	0
2	3	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
2	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
2	5	7	-	7	0.598	-	0.598	20 000	-	20 000	102	-	102	100	-	100	0	-	0	0	-	0	0	-	0
2	6	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
3	1	3 080	-	38 684	0.199	-	0.382	79	-	1 500	146	-	201	55	-	83	17	-	25	0	-	20	0	-	0
3	2	4 641	-	84 184	0.320	-	0.593	71	-	1 098	120	-	211	55	-	83	17	-	35	0	-	10	0	-	0
3	3	143	-	66 045	0.199	-	0.251	99	-	1 327	102	-	119	10	-	84	16	-	70	0	-	20	0	-	0
3	4	612	-	5 250	0.468	-	0.773	64	-	818	133	-	210	45	-	86	14	-	30	0	-	25	0	-	0
3	5	352	-	14 000	0.386	-	1.190	64	-	768	120	-	142	10	-	88	12	-	20	0	-	60	0	-	10
3	6	17	-	1 050	0.061	-	0.407	64	-	792	120	-	124	5	-	87	10	-	13	0	-	70	0	-	15
4	1	51	-	39 365	0.110	-	1.680	64	-	144	100	-	1 195	55	-	100	0	-	25	0	-	20	0	-	10
4	2	102	-	39 365	0.110	-	1.680	64	-	144	100	-	1 195	55	-	100	0	-	35	0	-	12	0	-	10
4	3	20	-	52 497	0.141	-	1.680	80	-	144	130	-	1 195	8	-	100	0	-	70	0	-	29	0	-	10
4	4	7	-	20	0.199	-	1.680	64	-	144	100	-	1 195	45	-	100	0	-	30	0	-	25	0	-	10
4	5	20	-	46	0.199	-	1.565	76	-	144	121	-	1 195	8	-	100	0	-	19	0	-	63	0	-	9
4	6	8	-	20	0.199	-	1.632	69	-	144	109	-	1 195	5	-	100	0	-	17	0	-	70	0	-	15
5	1	2 040	-	119 330	0.153	-	2.299	15	-	16	74	-	599	54	-	80	20	-	28	0	-	20	0	-	12
5	2	2 040	-	246 841	0.120	-	3.031	15	-	16	69	-	609	54	-	80	20	-	35	0	-	15	0	-	12
5	3	510	-	166 892	0.148	-	2.705	15	-	16	100	-	607	10	-	70	20	-	70	10	-	20	0	-	12
5	4	306	-	15 330	0.475	-	4.081	15	-	16	34	-	607	45	-	80	20	-	30	0	-	25	0	-	12
5	5	132	-	34 360	0.842	-	4.770	10	-	16	100	-	617	10	-	60	20	-	28	15	-	60	0	-	12
5	6	20	-	3 066	0.449	-	4.081	15	-	16	33	-	607	5	-	70	10	-	28	5	-	70	5	-	15
6	1	111	-	111	0.020	-	0.020	30 000	-	1 000 000	150	-	150	55	-	55	25	-	25	20	-	20	0	-	0
6	2	111	-	111	0.020	-	0.020	30 000	-	1 000 000	150	-	150	55	-	55	35	-	35	10	-	10	0	-	0
6	3	148	-	148	0.022	-	0.022	30 000	-	1 000 000	150	-	150	10	-	10	70	-	70	20	-	20	0	-	0
6	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
6	5	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
6	6	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
7	1	0	-	8 916	0.000	-	0.070	2 000	-	2 032	0	-	3 516	55	-	55	25	-	25	20	-	20	0	-	0
7	2	204	-	37 487	0.024	-	0.996	2 000	-	20 000	84	-	3 446	55	-	90	10	-	35	0	-	10	0	-	1
7	3	0	-	1 756	0.000	-	0.315	1 978	-	30 623	0	-	1 033	10	-	54	15	-	70	16	-	20	0	-	15
7	4	0	-	2 445	0.000	-	0.075	2 000	-	2 000	0	-	3 600	45	-	45	30	-	30	25	-	25	0	-	0
7	5	31	-	56	0.348	-	0.996	1 849	-	27 588	84	-	1 032	9	-	90	10	-	18	0	-	63	0	-	14
7	6	0	-	499	0.000	-	0.080	1 998	-	2 672	0	-	3 383	5	-	6	10	-	10	69	-	70	15	-	15
8	1	51	-	27 278	0.068	-	0.376	144	-	2 000	77	-	1 200	55	-	90	10	-	25	0	-	20	0	-	0

TABLE 55 (*continued*)

SC *n*	SE *m*	User density (users/km^2)			Session arrival rate per user (session arrivals/h/users)			Mean service bit rate (kbit/s)			Average session duration (s/session)			Mobility ratio (%)											
														Stationary			Low			High			Super-High		
2015, Downlink (*continued*)																									
8	2	102	-	54 224	0.371	-	1.079	384	-	2 000	77	-	1,200	55	-	90	10	-	35	0	-	20	0	-	17
8	3	10	-	37 226	0.199	-	1.072	384	-	2 000	77	-	1 195	10	-	90	10	-	70	0	-	20	0	-	17
8	4	20	-	4 510	0.199	-	0.376	144	-	2 000	77	-	1 200	45	-	90	10	-	30	0	-	25	0	-	0
8	5	51	-	12 061	0.398	-	1.079	384	-	2 000	77	-	1 199	10	-	90	10	-	29	0	-	60	0	-	17
8	6	5	-	908	0.199	-	1.078	384	-	2 000	77	-	1,199	5	-	80	10	-	29	10	-	70	0	-	17
9	1	306	-	306	0.398	-	0.398	144	-	144	10	-	10	90	-	90	10	-	10	0	-	0	0	-	0
9	2	408	-	408	0.598	-	0.598	144	-	144	38	-	38	90	-	90	10	-	10	0	-	0	0	-	0
9	3	51	-	51	0.199	-	0.199	144	-	144	38	-	38	80	-	80	10	-	10	10	-	10	0	-	0
9	4	51	-	51	0.398	-	0.398	144	-	144	10	-	10	90	-	90	10	-	10	0	-	0	0	-	0
9	5	102	-	102	0.598	-	0.598	144	-	144	38	-	38	70	-	70	10	-	10	20	-	20	0	-	0
9	6	10	-	10	0.199	-	0.199	144	-	144	10	-	10	80	-	80	10	-	10	10	-	10	0	-	0
10	1	204	-	204	0.398	-	0.398	16	-	16	2	-	2	80	-	80	20	-	20	0	-	0	0	-	0
10	2	306	-	306	0.598	-	0.598	16	-	16	2	-	2	80	-	80	20	-	20	0	-	0	0	-	0
10	3	51	-	51	0.199	-	0.199	16	-	16	2	-	2	70	-	70	20	-	20	10	-	10	0	-	0
10	4	51	-	51	0.398	-	0.398	16	-	16	2	-	2	80	-	80	20	-	20	0	-	0	0	-	0
10	5	51	-	51	0.598	-	0.598	16	-	16	2	-	2	60	-	60	20	-	20	20	-	20	0	-	0
10	6	10	-	10	0.199	-	0.199	16	-	16	2	-	2	65	-	65	20	-	20	10	-	10	5	-	5
11	1	0	-	111	0.000	-	0.080	30 000	-	1 000 000	0	-	60	55	-	55	25	-	25	20	-	20	0	-	0
11	2	20	-	111	0.080	-	0.398	30 000	-	1 000 000	60	-	65	55	-	100	0	-	35	0	-	10	0	-	0
11	3	0	-	56 371	0.000	-	0.998	36 424	-	37 762	0	-	11	10	-	10	70	-	70	20	-	20	0	-	0
11	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
11	5	5	-	20 823	0.398	-	1.000	36 433	-	500 000	11	-	65	10	-	100	0	-	20	0	-	60	0	-	10
11	6	0	-	1 562	0.000	-	1.000	36 433	-	36 433	0	-	11	5	-	5	10	-	10	70	-	70	15	-	15
12	1	204	-	52 402	0.199	-	2.664	1 872	-	28 531	15	-	29	55	-	80	20	-	25	0	-	20	0	-	0
12	2	306	-	165 867	0.199	-	0.246	1 281	-	28 514	29	-	176	55	-	80	20	-	35	0	-	10	0	-	0
12	3	10	-	130 686	0.199	-	0.209	2 362	-	28,292	29	-	166	12	-	80	20	-	68	0	-	20	0	-	0
12	4	51	-	15 443	0.199	-	2.706	1 253	-	28 494	14	-	29	45	-	80	20	-	30	0	-	25	0	-	0
12	5	51	-	47 815	0.199	-	0.204	1 424	-	28 230	29	-	166	10	-	75	20	-	20	5	-	60	0	-	10
12	6	5	-	3 926	0.199	-	2.143	1,617	-	28 226	15	-	29	6	-	75	10	-	20	5	-	69	0	-	15
13	1	2 040	-	113 858	0.199	-	8.359	1 083	-	2 048	26	-	147	32	-	80	15	-	25	0	-	20	0	-	0
13	2	2 040	-	337 114	0.293	-	10.131	1 083	-	2 048	14	-	147	39	-	80	20	-	35	0	-	10	0	-	0
13	3	102	-	224 332	0.199	-	9.170	1,083	-	2 048	29	-	147	8	-	64	20	-	70	15	-	20	0	-	0
13	4	204	-	25 795	0.199	-	11.020	366	-	2,047	1	-	147	45	-	80	20	-	30	0	-	25	0	-	0
13	5	102	-	68 829	0.598	-	11.015	392	-	2,047	1	-	147	10	-	70	20	-	20	10	-	60	0	-	10
13	6	25	-	5 175	0.199	-	10.993	461	-	2,045	1	-	151	5	-	67	10	-	20	10	-	70	3	-	15
14	1	3 060	-	39 802	0.143	-	0.199	118	-	144	7	-	63	55	-	80	20	-	25	0	-	20	0	-	1
14	2	3 060	-	39 802	0.163	-	0.199	119	-	144	7	-	63	55	-	80	20	-	35	0	-	10	0	-	1
14	3	204	-	78 331	0.199	-	0.226	139	-	264	7	-	1,160	2	-	50	30	-	95	2	-	20	0	-	1
14	4	16	-	204	0.199	-	0.430	8	-	144	7	-	155	45	-	80	15	-	30	0	-	25	0	-	9
14	5	102	-	8 869	0.199	-	0.235	143	-	257	7	-	3,389	0	-	70	20	-	100	0	-	10	0	-	0
14	6	15	-	678	0.199	-	0.253	143	-	260	7	-	3,111	0	-	65	20	-	99	0	-	10	0	-	5
15	1	3 060	-	43 148	0.996	-	2.996	7	-	16	5	-	38	55	-	80	20	-	25	0	-	20	0	-	3
15	2	3 060	-	154 818	1.992	-	2.999	5	-	16	4	-	48	55	-	80	20	-	35	0	-	10	0	-	1
15	3	204	-	98 663	0.598	-	3.119	16	-	80	10	-	32	8	-	60	20	-	58	20	-	34	0	-	4
15	4	204	-	12 892	1.195	-	2.999	4	-	16	4	-	38	45	-	80	20	-	30	0	-	25	0	-	0
15	5	102	-	36 018	1.992	-	2.998	16	-	145	6	-	38	8	-	80	10	-	15	10	-	69	0	-	8
15	6	10	-	2 708	1.195	-	2.952	16	-	247	6	-	38	4	-	65	8	-	20	10	-	72	5	-	16
16	1	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
16	2	51	-	51	0.398	-	0.398	20 000	-	20 000	108	-	108	80	-	80	20	-	20	0	-	0	0	-	0
16	3	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
16	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0

TABLE 55 (*continued*)

SC *n*	SE *m*	User density (users/km^2)			Session arrival rate per user (session arrivals/h/users)			Mean service bit rate (kbit/s)			Average session duration (s/session)			Mobility ratio (%)								
														Stationary			Low			High			Super-High		
2015, Downlink (*end*)																									
16	5	10	-	10	0.398	-	0.398	20 000	-	20 000	108	-	108	80	-	80	20	-	20	0	-	0	0	-	0
16	6	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
17	1	0	-	7 086	0.000	-	2.162	5 155	-	15 093	0	-	288	55	-	55	25	-	25	20	-	20	0	-	0
17	2	51	-	24 584	0.398	-	2.234	5 177	-	20 000	96	-	289	55	-	80	20	-	35	0	-	10	0	-	0
17	3	0	-	15 112	0.000	-	2.192	5 485	-	15 291	0	-	291	10	-	11	69	-	70	20	-	20	0	-	0
17	4	0	-	2 041	0.000	-	2.239	5 070	-	15 042	0	-	288	45	-	45	30	-	30	25	-	25	0	-	0
17	5	10	-	5 420	0.398	-	2.248	5 077	-	20 000	96	-	289	10	-	80	20	-	20	0	-	60	0	-	10
17	6	0	-	411	0.000	-	2.230	5 203	-	15 122	0	-	289	5	-	5	10	-	10	70	-	70	15	-	15
18	1	612	-	8 150	0.199	-	2.250	574	-	2 000	8	-	40	55	-	80	20	-	25	0	-	20	0	-	0
18	2	1 326	-	36 631	0.680	-	1.992	595	-	2 000	8	-	74	55	-	80	20	-	35	0	-	10	0	-	0
18	3	20	-	20	0.199	-	0.199	990	-	990	11	-	11	60	-	60	20	-	20	20	-	20	0	-	0
18	4	102	-	2 445	0.199	-	2.250	1 030	-	2 000	8	-	35	45	-	80	20	-	30	0	-	25	0	-	0
18	5	71	-	71	1.992	-	1.992	653	-	653	72	-	72	60	-	60	20	-	20	20	-	20	0	-	0
18	6	10	-	489	0.199	-	2.250	1 030	-	2 000	8	-	35	5	-	60	10	-	20	15	-	70	5	-	15
19	1	510	-	510	0.199	-	0.199	144	-	144	10	-	10	80	-	80	20	-	20	0	-	0	0	-	0
19	2	1 020	-	1 020	0.598	-	0.598	144	-	144	10	-	10	80	-	80	20	-	20	0	-	0	0	-	0
19	3	51	-	51	0.199	-	0.199	144	-	144	10	-	10	60	-	60	20	-	20	15	-	15	5	-	5
19	4	51	-	51	0.199	-	0.199	144	-	144	10	-	10	80	-	80	20	-	20	0	-	0	0	-	0
19	5	51	-	51	0.199	-	0.199	144	-	144	10	-	10	60	-	60	20	-	20	20	-	20	0	-	0
19	6	10	-	10	0.199	-	0.199	144	-	144	10	-	10	60	-	60	20	-	20	15	-	15	5	-	5
20	1	1 020	-	1 020	0.199	-	0.199	16	-	16	12	-	12	80	-	80	20	-	20	0	-	0	0	-	0
20	2	1 020	-	1 020	0.598	-	0.598	16	-	16	20	-	20	80	-	80	20	-	20	0	-	0	0	-	0
20	3	102	-	102	0.199	-	0.199	16	-	16	12	-	12	60	-	60	20	-	20	20	-	20	0	-	0
20	4	102	-	102	0.199	-	0.199	16	-	16	12	-	12	80	-	80	20	-	20	0	-	0	0	-	0
20	5	51	-	51	0.598	-	0.598	16	-	16	20	-	20	60	-	60	20	-	20	20	-	20	0	-	0
20	6	10	-	10	0.199	-	0.199	16	-	16	12	-	12	60	-	60	20	-	20	15	-	15	5	-	5
2020, Uplink																									
1	1	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
1	2	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
1	3	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
1	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
1	5	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
1	6	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
2	1	52	-	52	0.411	-	0.411	20 000	-	20 000	7 406	-	7 406	100	-	100	0	-	0	0	-	0	0	-	0
2	2	57	-	57	1.160	-	1.160	20 000	-	20 000	265	-	265	100	-	100	0	-	0	0	-	0	0	-	0
2	3	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
2	4	21	-	21	0.411	-	0.411	20 000	-	20, 000	7 406	-	7 406	100	-	100	0	-	0	0	-	0	0	-	0
2	5	10	-	10	1.234	-	1.234	20 000	-	20 000	35	-	35	100	-	100	0	-	0	0	-	0	0	-	0
2	6	1	-	1	0.411	-	0.411	20 000	-	20 000	7 406	-	7 406	100	-	100	0	-	0	0	-	0	0	-	0
3	1	3 502	-	63 051	0.372	-	0.411	80	-	1 468	201	-	373	55	-	83	17	-	25	0	-	20	0	-	0
3	2	5 150	-	128 051	0.617	-	0.658	72	-	910	120	-	457	55	-	84	16	-	35	0	-	10	0	-	0
3	3	206	-	104 734	0.254	-	0.411	104	-	081	119	-	324	10	-	83	17	-	70	0	-	20	0	-	0
3	4	721	-	7 500	0.854	-	0.940	64	-	768	210	-	327	45	-	87	13	-	30	0	-	25	0	-	0
3	5	412	-	20 000	0.427	-	2.366	64	-	768	120	-	374	10	-	88	12	-	20	0	-	60	0	-	10
3	6	19	-	1 500	0.067	-	0.823	64	-	768	120	-	305	5	-	87	10	-	13	0	-	70	0	-	15
4	1	52	-	52 203	0.110	-	3.060	64	-	144	100	-	9 875	55	-	100	0	-	25	0	-	20	0	-	10
4	2	103	-	52 203	0.110	-	3.060	64	-	144	100	-	9 875	55	-	100	0	-	35	0	-	12	0	-	10
4	3	21	-	69 621	0.141	-	3.059	144	-	6 320	133	-	9 875	7	-	100	0	-	70	0	-	30	0	-	10
4	4	12	-	21	0.411	-	3.060	64	-	144	100	-	9 875	45	-	100	0	-	30	0	-	25	0	-	10
4	5	21	-	72	0.411	-	2.823	144	-	2 949	113	-	9 875	9	-	100	0	-	19	0	-	61	0	-	10
4	6	13	-	19	0.411	-	2.960	144	-	1 307	105	-	9 875	5	-	100	0	-	17	0	-	70	0	-	15

TABLE 55 (*continued*)

SC *n*	SE *m*	User density (users/km^2)			Session arrival rate per user (session arrivals/h/users)			Mean service bit rate (kbit/s)			Average session duration (s/session)			Mobility ratio (%)											
														Stationary			Low			High			Super-High		
2020, Uplink (*continued*)																									
5	1	2 060	-	144 123	0.162	-	2.706	16	-	16	70	-	600	54	-	80	20	-	28	0	-	20	0	-	12
5	2	2 060	-	266 632	0.135	-	4.114	16	-	16	64	-	608	54	-	80	20	-	35	0	-	15	0	-	12
5	3	515	-	180 812	0.148	-	3.002	15	-	16	100	-	607	10	-	70	20	-	70	10	-	20	0	-	12
5	4	309	-	16 568	0.470	-	4.561	15	-	16	33	-	604	45	-	80	20	-	30	0	-	25	0	-	12
5	5	146	-	34 400	0.884	-	5.730	10	-	16	100	-	617	10	-	60	20	-	28	15	-	60	0	-	12
5	6	19	-	3 314	0.450	-	4.561	15	-	16	32	-	604	5	-	70	10	-	28	5	-	70	5	-	15
6	1	1 743	-	1 743	0.025	-	0.025	3 277	-	1 000 000	150	-	150	55	-	55	25	-	25	20	-	20	0	-	0
6	2	1 743	-	1 743	0.025	-	0.025	3 277	-	1 000 000	150	-	150	55	-	55	35	-	35	10	-	10	0	-	0
6	3	2 324	-	2 324	0.030	-	0.030	3 277	-	1 000 000	150	-	150	10	-	10	70	-	70	20	-	20	0	-	0
6	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
6	5	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
6	6	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
7	1	0	-	45 467	0.000	-	0.598	3 191	-	3 226	0	-	1 168	55	-	55	25	-	25	20	-	20	0	-	0
7	2	206	-	142 763	0.691	-	2.057	3 190	-	20 000	74	-	1 184	55	-	90	10	-	35	0	-	10	0	-	0
7	3	0	-	92 606	0.000	-	0.718	3 171	-	4 896	0	-	1 196	10	-	13	69	-	70	20	-	20	0	-	1
7	4	0	-	11 211	0.000	-	0.722	3 192	-	3 200	0	-	1 176	45	-	45	30	-	30	25	-	25	0	-	0
7	5	31	-	29 980	0.722	-	2.057	3 191	-	20 000	74	-	1 176	10	-	90	10	-	20	0	-	60	0	-	10
7	6	0	-	2 257	0.000	-	0.721	3 187	-	3 366	0	-	1 177	5	-	5	10	-	10	70	-	70	15	-	15
8	1	52	-	62 974	0.072	-	0.411	76	-	2 000	39	-	108	55	-	90	10	-	25	0	-	20	0	-	0
8	2	103	-	63 135	0.608	-	1.689	384	-	2 000	39	-	1 252	55	-	90	10	-	35	0	-	20	0	-	17
8	3	10	-	85 251	0.411	-	1.684	384	-	2 000	39	-	1 252	10	-	90	10	-	70	0	-	20	0	-	17
8	4	21	-	21	0.411	-	0.411	384	-	384	39	-	39	90	-	90	10	-	10	0	-	0	0	-	0
8	5	52	-	118	0.823	-	1.505	384	-	2 000	39	-	1 275	10	-	90	10	-	25	0	-	60	0	-	15
8	6	5	-	21	0.411	-	1.505	384	-	2 000	39	-	1 275	5	-	80	10	-	23	10	-	70	0	-	16
9	1	309	-	309	0.823	-	0.823	144	-	144	30	-	30	90	-	90	10	-	10	0	-	0	0	-	0
9	2	412	-	412	1.234	-	1.234	144	-	144	118	-	118	90	-	90	10	-	10	0	-	0	0	-	0
9	3	52	-	52	0.411	-	0.411	144	-	144	118	-	118	80	-	80	10	-	10	10	-	10	0	-	0
9	4	52	-	52	0.823	-	0.823	144	-	144	30	-	30	90	-	90	10	-	10	0	-	0	0	-	0
9	5	103	-	103	1.234	-	1.234	144	-	144	118	-	118	70	-	70	10	-	10	20	-	20	0	-	0
9	6	10	-	10	0.411	-	0.411	144	-	144	30	-	30	80	-	80	10	-	10	10	-	10	0	-	0
10	1	206	-	11 120	0.823	-	1.000	10	-	16	9	-	3 600	55	-	80	20	-	25	0	-	20	0	-	0
10	2	309	-	40 032	1.000	-	1.234	10	-	16	9	-	3 600	55	-	80	20	-	35	0	-	10	0	-	0
10	3	52	-	24 019	0.411	-	1.000	10	-	16	9	-	3 600	10	-	70	20	-	70	10	-	20	0	-	0
10	4	52	-	3 336	0.823	-	1.000	10	-	16	9	-	3 600	45	-	80	20	-	30	0	-	25	0	-	0
10	5	52	-	8 896	1.000	-	1.234	10	-	16	9	-	3 600	10	-	60	20	-	20	20	-	60	0	-	10
10	6	10	-	667	0.411	-	1.000	10	-	16	9	-	3 600	5	-	65	10	-	20	10	-	70	5	-	15
11	1	0	-	111	0.000	-	0.100	6 554	-	1 000 000	0	-	60	55	-	55	25	-	25	20	-	20	0	-	0
11	2	21	-	111	0.100	-	0.823	6 554	-	1 000 000	15	-	60	55	-	100	0	-	35	0	-	10	0	-	0
11	3	0	-	148	0.000	-	0.120	6 554	-	1 000 000	0	-	60	10	-	10	70	-	70	20	-	20	0	-	0
11	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
11	5	5	-	5	0.823	-	0.823	500 000	-	500 000	15	-	15	100	-	100	0	-	0	0	-	0	0	-	0
11	6	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
12	1	206	-	87 656	0.313	-	0.411	5 494	-	22 283	15	-	34	56	-	80	20	-	25	0	-	19	0	-	1
12	2	309	-	312 797	0.311	-	0.411	3 241	-	21 547	15	-	31	55	-	80	20	-	35	0	-	10	0	-	0
12	3	10	-	189 039	0.316	-	0.411	6 890	-	22 718	15	-	35	18	-	80	20	-	63	0	-	18	0	-	1
12	4	52	-	26 001	0.311	-	0.411	3 181	-	21 514	15	-	31	45	-	80	20	-	30	0	-	25	0	-	0
12	5	52	-	69 348	0.311	-	0.411	3 352	-	21 569	15	-	31	11	-	75	20	-	20	5	-	59	0	-	10
12	6	5	-	5 206	0.312	-	0.411	4 173	-	21 828	15	-	32	8	-	75	11	-	20	5	-	67	0	-	15
13	1	2 060	-	57 105	0.411	-	3.201	764	-	1 799	4	-	107	24	-	80	11	-	20	0	-	10	0	-	5
13	2	2 060	-	50 994	0.189	-	1.234	706	-	1 789	82	-	107	23	-	80	13	-	20	0	-	8	0	-	5
13	3	103	-	69 955	0.294	-	0.411	881	-	1 883	93	-	107	7	-	63	19	-	48	13	-	17	0	-	9

TABLE 55 (*continued*)

SC *n*	SE *m*	User density (users/km^2)	Session arrival rate per user (session arrivals/h/users)	Mean service bit rate (kbit/s)	Average session duration (s/session)	Mobility ratio (%)			
						Stationary	Low	High	Super-High
2020, Uplink (*end*)									
13	4	206 - 1 827	0.411 - 28.612	881 - 1 901	0 - 107	43 - 80	20 - 30	0 - 25	0 - 15
13	5	103 - 134	1.234 - 2.994	881 - 2 000	107 - 120	10 - 70	20 - 21	10 - 60	0 - 16
13	6	24 - 386	0.411 - 27.278	753 - 1 980	1 - 115	5 - 66	10 - 21	10 - 70	4 - 16
14	1	3 090 - 52 788	0.167 - 0.411	23 - 144	10 - 67	55 - 80	20 - 25	0 - 20	0 - 1
14	2	3 090 - 52 788	0.187 - 0.411	23 - 144	10 - 66	55 - 80	20 - 35	0 - 10	0 - 1
14	3	206 - 103 509	0.270 - 0.411	67 - 174	10 - 1,012	3 - 50	30 - 92	3 - 20	0 - 2
14	4	21 - 206	0.411 - 0.800	8 - 144	10 - 188	45 - 80	15 - 30	0 - 25	0 - 9
14	5	103 - 11 600	0.248 - 0.411	69 - 148	10 - 3,235	0 - 70	20 - 99	0 - 10	0 - 0
14	6	15 - 888	0.285 - 0.411	69 - 155	10 - 2,807	1 - 65	20 - 97	1 - 10	1 - 5
15	1	3 090 - 121 289	2.057 - 39.712	7 - 16	1 - 118	55 - 80	20 - 25	0 - 20	0 - 1
15	2	3 090 - 435 889	4.114 - 39.774	7 - 16	1 - 148	55 - 80	20 - 35	0 - 10	0 - 0
15	3	206 - 263 674	1.234 - 40.123	9 - 16	2 - 99	10 - 60	20 - 70	17 - 20	0 - 3
15	4	206 - 36 310	2.469 - 39.787	6 - 16	1 - 118	45 - 80	20 - 30	0 - 25	0 - 0
15	5	103 - 96 894	4.114 - 40.407	7 - 16	1 - 118	10 - 80	10 - 20	10 - 60	0 - 10
15	6	10 - 7 277	2.469 - 40.359	7 - 16	1 - 118	5 - 65	10 - 20	10 - 70	5 - 15
16	1	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
16	2	52 - 52	0.823 - 0.823	20 000 - 20 000	25 - 25	80 - 80	20 - 20	0 - 0	0 - 0
16	3	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
16	4	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
16	5	10 - 10	0.823 - 0.823	20 000 - 20 000	25 - 25	80 - 80	20 - 20	0 - 0	0 - 0
16	6	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
17	1	0 - 1 265	0.000 - 1.815	11 467 - 22 587	0 - 312	59 - 59	22 - 22	17 - 17	2 - 2
17	2	52 - 2 792	0.823 - 2.538	9 390 - 21 756	49 - 328	55 - 80	20 - 35	0 - 10	0 - 1
17	3	0 - 2 193	0.000 - 2.151	14 293 - 23 717	0 - 388	10 - 31	50 - 70	17 - 20	0 - 3
17	4	0 - 226	0.000 - 2.566	7 340 - 20 936	0 - 303	46 - 47	29 - 29	24 - 24	0 - 1
17	5	10 - 559	0.823 - 2.718	7 108 - 20 843	49 - 306	10 - 80	20 - 20	0 - 60	0 - 10
17	6	0 - 48	0.000 - 2.497	9 917 - 21 967	0 - 333	5 - 17	10 - 11	58 - 70	14 - 15
18	1	618 - 618	0.411 - 0.411	574 - 574	35 - 35	80 - 80	20 - 20	0 - 0	0 - 0
18	2	1 339 - 1 339	4.114 - 4.114	595 - 595	66 - 66	80 - 80	20 - 20	0 - 0	0 - 0
18	3	21 - 21	0.411 - 0.411	990 - 990	10 - 10	60 - 60	20 - 20	20 - 20	0 - 0
18	4	103 - 103	0.411 - 0.411	1 030 - 1 030	31 - 31	80 - 80	20 - 20	0 - 0	0 - 0
18	5	72 - 72	4.114 - 4.114	653 - 653	63 - 63	60 - 60	20 - 20	20 - 20	0 - 0
18	6	10 - 10	0.411 - 0.411	1 030 - 1 030	31 - 31	60 - 60	20 - 20	15 - 15	5 - 5
19	1	515 - 515	0.411 - 0.411	144 - 144	21 - 21	80 - 80	20 - 20	0 - 0	0 - 0
19	2	1 030 - 1 030	1.234 - 1.234	144 - 144	21 - 21	80 - 80	20 - 20	0 - 0	0 - 0
19	3	52 - 52	0.411 - 0.411	144 - 144	21 - 21	60 - 60	20 - 20	15 - 15	5 - 5
19	4	52 - 52	0.411 - 0.411	144 - 144	21 - 21	80 - 80	20 - 20	0 - 0	0 - 0
19	5	52 - 52	0.411 - 0.411	144 - 144	21 - 21	60 - 60	20 - 20	20 - 20	0 - 0
19	6	10 - 10	0.411 - 0.411	144 - 144	21 - 21	60 - 60	20 - 20	15 - 15	5 - 5
20	1	1 030 - 1 030	0.411 - 0.411	16 - 16	25 - 25	80 - 80	20 - 20	0 - 0	0 - 0
20	2	1 030 - 1 030	1.234 - 1.234	16 - 16	41 - 41	80 - 80	20 - 20	0 - 0	0 - 0
20	3	103 - 4 536	0.411 - 1.000	12 - 16	1 - 25	10 - 60	20 - 70	20 - 20	0 - 0
20	4	103 - 103	0.411 - 0.411	16 - 16	25 - 25	80 - 80	20 - 20	0 - 0	0 - 0
20	5	52 - 1 680	1.000 - 1.234	12 - 16	1 - 41	10 - 60	20 - 20	20 - 60	0 - 10
20	6	10 - 126	0.411 - 1.000	12 - 16	1 - 25	5 - 60	10 - 20	15 - 70	5 - 15
2020, Downlink									
1	1	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
1	2	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
1	3	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
1	4	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0
1	5	0 - 0	0.000 - 0.000	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0

TABLE 55 (*continued*)

SC *n*	SE *m*	User density (users/km^2)			Session arrival rate per user (session arrivals/h/users)			Mean service bit rate (kbit/s)			Average session duration (s/session)			Mobility ratio (%)									
														Stationary			Low			High			Super-High		
2020, Downlink (*continued*)																									
1	6	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
2	1	0	-	18 920	0.000	-	0.481	3 200	-	30 000	0	-	1 200	55	-	55	25	-	25	20	-	20	0	-	0
2	2	46	-	68 112	0.481	-	1.234	3 200	-	30 000	219	-	1 200	55	-	100	0	-	35	0	-	10	0	-	0
2	3	0	-	40 867	0.000	-	0.481	3 200	-	30 000	0	-	1 200	10	-	10	70	-	70	20	-	20	0	-	0
2	4	0	-	5 676	0.000	-	0.481	3 200	-	30 000	0	-	1 200	45	-	45	30	-	30	25	-	25	0	-	0
2	5	7	-	15 136	0.481	-	1.234	3 200	-	30 000	212	-	1 200	10	-	100	0	-	20	0	-	60	0	-	10
2	6	0	-	1 135	0.000	-	0.481	3 200	-	30 000	0	-	1 200	5	-	5	10	-	10	70	-	70	15	-	15
3	1	3 111	-	63 051	0.372	-	0.411	80	-	1 500	201	-	302	55	-	83	17	-	25	0	-	20	0	-	0
3	2	4 687	-	128 051	0.617	-	0.660	72	-	1 098	120	-	436	55	-	83	17	-	35	0	-	10	0	-	0
3	3	144	-	104 734	0.254	-	0.411	104	-	1 327	119	-	212	10	-	84	16	-	70	0	-	20	0	-	0
3	4	618	-	7 500	0.854	-	0.967	64	-	818	210	-	274	45	-	86	14	-	30	0	-	25	0	-	0
3	5	355	-	20 000	0.427	-	2.457	64	-	768	120	-	294	10	-	88	12	-	20	0	-	60	0	-	10
3	6	17	-	1 500	0.067	-	0.841	64	-	792	120	-	257	5	-	87	10	-	13	0	-	70	0	-	15
4	1	52	-	52 203	0.110	-	3.060	64	-	144	100	-	2 469	55	-	100	0	-	25	0	-	20	0	-	10
4	2	103	-	52 203	0.110	-	3.060	64	-	144	100	-	2 469	55	-	100	0	-	35	0	-	12	0	-	10
4	3	21	-	69 621	0.141	-	3.059	114	-	144	133	-	2 469	7	-	100	0	-	70	0	-	30	0	-	10
4	4	12	-	21	0.411	-	3.060	64	-	144	100	-	2 469	45	-	100	0	-	30	0	-	25	0	-	10
4	5	21	-	72	0.411	-	2.823	87	-	147	113	-	2 469	9	-	100	0	-	19	0	-	61	0	-	10
4	6	13	-	19	0.411	-	2.960	74	-	145	105	-	2 469	5	-	100	0	-	17	0	-	70	0	-	15
5	1	2 060	-	144 123	0.162	-	2.706	16	-	16	70	-	600	54	-	80	20	-	28	0	-	20	0	-	12
5	2	2 060	-	266 632	0.135	-	4.114	16	-	16	64	-	608	54	-	80	20	-	35	0	-	15	0	-	12
5	3	515	-	180 812	0.148	-	3.002	15	-	16	100	-	607	10	-	70	20	-	70	10	-	20	0	-	12
5	4	309	-	16 568	0.470	-	4.561	15	-	16	33	-	604	45	-	80	20	-	30	0	-	25	0	-	12
5	5	146	-	34 400	0.884	-	5.730	10	-	16	100	-	617	10	-	60	20	-	28	15	-	60	0	-	12
5	6	19	-	3 314	0.450	-	4.561	15	-	16	32	-	604	5	-	70	10	-	28	5	-	70	5	-	15
6	1	1 743	-	1 743	0.025	-	0.025	30 000	-	1 000 000	150	-	150	55	-	55	25	-	25	20	-	20	0	-	0
6	2	1 743	-	1 743	0.025	-	0.025	30 000	-	1 000 000	150	-	150	55	-	55	35	-	35	10	-	10	0	-	0
6	3	2 324	-	2 324	0.030	-	0.030	30 000	-	1 000 000	150	-	150	10	-	10	70	-	70	20	-	20	0	-	0
6	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
6	5	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
6	6	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
7	1	0	-	20 322	0.000	-	0.055	2 991	-	3 271	0	-	2 976	55	-	55	25	-	25	20	-	20	0	-	0
7	2	206	-	54 114	0.031	-	2.057	2 965	-	20 000	173	-	3 384	55	-	90	10	-	35	0	-	12	0	-	5
7	3	0	-	11 887	0.000	-	0.555	1 991	-	31 898	0	-	1 600	10	-	57	15	-	70	16	-	20	0	-	13
7	4	0	-	3 668	0.000	-	0.075	3 000	-	3 000	0	-	3 600	45	-	45	30	-	30	25	-	25	0	-	0
7	5	31	-	84	0.592	-	2.057	1 930	-	28 806	173	-	1 375	10	-	90	10	-	19	0	-	62	0	-	15
7	6	0	-	748	0.000	-	0.085	2 942	-	4 501	0	-	3 294	5	-	8	10	-	10	67	-	70	15	-	15
8	1	52	-	62 974	0.072	-	0.411	144	-	2 000	108	-	158	55	-	90	10	-	25	0	-	20	0	-	0
8	2	103	-	63 135	0.608	-	1.689	384	-	2 000	158	-	1 252	55	-	90	10	-	35	0	-	20	0	-	17
8	3	10	-	85 251	0.411	-	1.684	384	-	2 000	158	-	1 252	10	-	90	10	-	70	0	-	20	0	-	17
8	4	21	-	21	0.411	-	0.411	384	-	384	158	-	158	90	-	90	10	-	10	0	-	0	0	-	0
8	5	52	-	118	0.823	-	1.505	384	-	2 000	158	-	1 275	10	-	90	10	-	25	0	-	60	0	-	15
8	6	5	-	21	0.411	-	1.505	384	-	2 000	158	-	1 275	5	-	80	10	-	23	10	-	70	0	-	16
9	1	309	-	309	0.823	-	0.823	144	-	144	20	-	20	90	-	90	10	-	10	0	-	0	0	-	0
9	2	412	-	412	1.234	-	1.234	144	-	144	79	-	79	90	-	90	10	-	10	0	-	0	0	-	0
9	3	52	-	52	0.411	-	0.411	144	-	144	79	-	79	80	-	80	10	-	10	10	-	10	0	-	0
9	4	52	-	52	0.823	-	0.823	144	-	144	20	-	20	90	-	90	10	-	10	0	-	0	0	-	0
9	5	103	-	103	1.234	-	1.234	144	-	144	79	-	79	70	-	70	10	-	10	20	-	20	0	-	0
9	6	10	-	10	0.411	-	0.411	144	-	144	20	-	20	80	-	80	10	-	10	10	-	10	0	-	0
10	1	206	-	206	0.823	-	0.823	16	-	16	4	-	4	80	-	80	20	-	20	0	-	0	0	-	0
10	2	309	-	309	1.234	-	1.234	16	-	16	4	-	4	80	-	80	20	-	20	0	-	0	0	-	0

TABLE 55 (*continued*)

SC *n*	SE *m*	User density (users/km^2)			Session arrival rate per user (session arrivals/h/users)			Mean service bit rate (kbit/s)			Average session duration (s/session)			Mobility ratio (%)											
														Stationary			Low			High			Super-High		
2020, Downlink (*continued*)																									
10	3	52	-	52	0.411	-	0.411	16	-	16	4	-	4	70	-	70	20	-	20	10	-	10	0	-	0
10	4	52	-	52	0.823	-	0.823	16	-	16	4	-	4	80	-	80	20	-	20	0	-	0	0	-	0
10	5	52	-	52	1.234	-	1.234	16	-	16	4	-	4	60	-	60	20	-	20	20	-	20	0	-	0
10	6	10	-	10	0.411	-	0.411	16	-	16	4	-	4	65	-	65	20	-	20	10	-	10	5	-	5
11	1	0	-	111	0.000	-	0.100	30 000	-	1 000 000	0	-	60	55	-	55	25	-	25	20	-	20	0	-	0
11	2	21	-	111	0.100	-	0.823	30 000	-	1 000,000	60	-	133	55	-	100	0	-	35	0	-	10	0	-	0
11	3	0	-	75 175	0.000	-	0.998	89 936	-	90 620	0	-	20	10	-	10	70	-	70	20	-	20	0	-	0
11	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
11	5	5	-	27 788	0.823	-	1.000	89 978	-	500 000	20	-	133	10	-	100	0	-	20	0	-	60	0	-	10
11	6	0	-	2 084	0.000	-	1.000	89 978	-	89 978	0	-	20	5	-	5	10	-	10	70	-	70	15	-	15
12	1	206	-	140 358	0.411	-	8.520	1 891	-	32 453	22	-	59	55	-	80	20	-	25	0	-	20	0	-	0
12	2	309	-	482 971	0.411	-	7.614	1 413	-	32 456	59	-	114	55	-	80	20	-	35	0	-	10	0	-	0
12	3	10	-	328 913	0.383	-	6.721	2 307	-	32 433	59	-	113	10	-	80	20	-	70	0	-	20	0	-	0
12	4	52	-	42 042	0.411	-	8.530	1 749	-	28 705	5	-	59	45	-	80	20	-	30	0	-	25	0	-	0
12	5	52	-	121 532	0.411	-	6.733	1 850	-	28 545	5	-	59	10	-	75	20	-	20	5	-	60	0	-	10
12	6	5	-	9 478	0.411	-	7.577	1 986	-	28 545	5	-	59	5	-	75	10	-	20	5	-	70	0	-	15
13	1	2 060	-	51 121	0.171	-	0.411	1 083	-	2 008	83	-	304	24	-	80	11	-	20	0	-	10	0	-	5
13	2	2 060	-	50 994	0.189	-	1.234	1 083	-	2 009	82	-	304	23	-	80	13	-	20	0	-	8	0	-	5
13	3	103	-	69 955	0.294	-	0.411	1 083	-	2 005	93	-	304	7	-	64	19	-	48	13	-	16	0	-	9
13	4	32	-	206	0.411	-	2.275	1 083	-	2 000	122	-	304	43	-	80	20	-	30	0	-	25	0	-	16
13	5	103	-	134	1.234	-	2.994	1 083	-	2 000	120	-	304	10	-	70	20	-	21	10	-	60	0	-	16
13	6	24	-	26	0.411	-	2.856	928	-	2 000	120	-	313	5	-	67	10	-	21	10	-	70	3	-	17
14	1	3 090	-	52 788	0.167	-	0.411	110	-	144	15	-	67	55	-	80	20	-	25	0	-	20	0	-	1
14	2	3 090	-	52 788	0.187	-	0.411	112	-	144	15	-	66	55	-	80	20	-	35	0	-	10	0	-	1
14	3	206	-	103 509	0.270	-	0.411	135	-	275	15	-	1,012	3	-	50	30	-	92	3	-	20	0	-	2
14	4	21	-	206	0.411	-	0.800	8	-	144	15	-	188	45	-	80	15	-	30	0	-	25	0	-	9
14	5	103	-	11 600	0.248	-	0.411	143	-	259	15	-	3,235	0	-	70	20	-	99	0	-	10	0	-	0
14	6	15	-	888	0.285	-	0.411	141	-	263	15	-	2,807	1	-	65	20	-	97	1	-	10	1	-	5
15	1	3 090	-	43 289	2.057	-	3.156	11	-	16	9	-	79	55	-	80	19	-	25	0	-	20	0	-	6
15	2	3 090	-	155 089	3.152	-	4.114	7	-	16	5	-	99	55	-	80	20	-	35	0	-	11	0	-	3
15	3	206	-	101 814	1.234	-	3.356	16	-	57	23	-	66	8	-	60	20	-	62	20	-	29	0	-	7
15	4	206	-	12 910	2.469	-	3.151	6	-	16	5	-	79	45	-	80	20	-	30	0	-	25	0	-	1
15	5	103	-	36 946	3.143	-	4.114	16	-	157	8	-	79	7	-	80	10	-	15	10	-	70	0	-	8
15	6	10	-	2 781	2.469	-	3.080	16	-	221	10	-	79	4	-	65	9	-	20	10	-	71	5	-	16
16	1	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
16	2	52	-	52	0.823	-	0.823	20 000	-	20 000	222	-	222	80	-	80	20	-	20	0	-	0	0	-	0
16	3	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
16	4	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
16	5	10	-	10	0.823	-	0.823	20 000	-	20 000	222	-	222	80	-	80	20	-	20	0	-	0	0	-	0
16	6	0	-	0	0.000	-	0.000	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0
17	1	0	-	17 973	0.000	-	2.377	5 948	-	19 643	0	-	109	56	-	56	24	-	24	20	-	20	0	-	0
17	2	52	-	64 815	0.823	-	1.435	5 616	-	20 000	172	-	197	55	-	80	20	-	35	0	-	10	0	-	0
17	3	0	-	11 878	0.000	-	2.748	6 721	-	20 689	0	-	302	10	-	14	66	-	70	19	-	20	0	-	1
17	4	0	-	5 239	0.000	-	2.426	5 255	-	19 344	0	-	107	45	-	45	30	-	30	25	-	25	0	-	0
17	5	10	-	4 146	0.823	-	2.861	5 285	-	20 114	197	-	290	10	-	80	20	-	20	0	-	60	0	-	10
17	6	0	-	1 050	0.000	-	2.423	5 659	-	19 518	0	-	109	5	-	7	10	-	10	68	-	70	15	-	15
18	1	618	-	618	0.411	-	0.411	574	-	574	82	-	82	80	-	80	20	-	20	0	-	0	0	-	0
18	2	1 339	-	1 339	4.114	-	4.114	595	-	595	153	-	153	80	-	80	20	-	20	0	-	0	0	-	0
18	3	21	-	21	0.411	-	0.411	990	-	990	23	-	23	60	-	60	20	-	20	20	-	20	0	-	0
18	4	103	-	103	0.411	-	0.411	1 030	-	1 030	72	-	72	80	-	80	20	-	20	0	-	0	0	-	0
18	5	72	-	72	4.114	-	4.114	653	-	653	148	-	148	60	-	60	20	-	20	20	-	20	0	-	0
18	6	10	-	10	0.411	-	0.411	1 030	-	1 030	72	-	72	60	-	60	20	-	20	15	-	15	5	-	5
19	1	515	-	515	0.411	-	0.411	144	-	144	21	-	21	80	-	80	20	-	20	0	-	0	0	-	0
19	2	1 030	-	1 030	1.234	-	1.234	144	-	144	21	-	21	80	-	80	20	-	20	0	-	0	0	-	0
19	3	52	-	52	0.411	-	0.411	144	-	144	21	-	21	60	-	60	20	-	20	15	-	15	5	-	5
19	4	52	-	52	0.411	-	0.411	144	-	144	21	-	21	80	-	80	20	-	20	0	-	0	0	-	0

TABLE 55 (*end*)

SC *n*	SE *m*	User density (users/km^2)	Session arrival rate per user (session arrivals/h/users)	Mean service bit rate (kbit/s)	Average session duration (s/session)	Mobility ratio (%)			
						Stationary	Low	High	Super-High
2020, Downlink (*end*)									
19	5	52 - 52	0.411 - 0.411	144 - 144	21 - 21	60 - 60	20 - 20	20 - 20	0 - 0
19	6	10 - 10	0.411 - 0.411	144 - 144	21 - 21	60 - 60	20 - 20	15 - 15	5 - 5
20	1	1 030 - 1 030	0.411 - 0.411	16 - 16	25 - 25	80 - 80	20 - 20	0 - 0	0 - 0
20	2	1 030 - 1 030	1.234 - 1.234	16 - 16	41 - 41	80 - 80	20 - 20	0 - 0	0 - 0
20	3	103 - 103	0.411 - 0.411	16 - 16	25 - 25	60 - 60	20 - 20	20 - 20	0 - 0
20	4	103 - 103	0.411 - 0.411	16 - 16	25 - 25	80 - 80	20 - 20	0 - 0	0 - 0
20	5	52 - 52	1.234 - 1.234	16 - 16	41 - 41	60 - 60	20 - 20	20 - 20	0 - 0
20	6	10 - 10	0.411 - 0.411	16 - 16	25 - 25	60 - 60	20 - 20	15 - 15	5 - 5
2010, Traffic data which are clearly described as downlink multicast									
2	1	50.00	0.10	20000	3585.394	100	0	0	0
2	2	10.00	0.40	20000	1344.523	100	0	0	0
2	3	0.00	0	0	0	0	0	0	0
2	4	20.00	0.10	20000	3585.394	100	0	0	0
2	5	3.00	0.40	20000	597.5657	100	0	0	0
2	6	1.00	0.10	20000	3585.394	100	0	0	0
3	1	380.00	0.40	1424.184	273.6222	83	17	0	0
3	2	450.00	0.60	922.6667	384.1494	84	16	0	0
3	3	60.00	0.40	1192	149.3914	82	18	0	0
3	4	100.00	1.29	731.7468	248.4615	86	14	0	0
3	5	55.00	1.39	623.4074	336.1307	87	13	0	0
3	6	2.75	0.80	679.8873	223.3009	87	13	0	0
2015, Traffic data which are clearly described as downlink multicast									
2	1	51.00	0.20	20000	7172.142	100	0	0	0
2	2	10.20	0.80	20000	2689.553	100	0	0	0
2	3	0	0.00	0	0	0	0	0	0
2	4	20.40	0.20	20000	7172.142	100	0	0	0
2	5	3.06	0.80	20000	1195.357	100	0	0	0
2	6	0.98	0.20	20000	7172.142	100	0	0	0
3	1	387.60	0.80	1424.184	547.3477	83	17	0	0
3	2	459.00	1.20	922.6667	768.4438	84	16	0	0
3	3	61.20	0.80	1192	298.8393	82	18	0	0
3	4	102.00	2.59	731.7468	497.0169	86	14	0	0
3	5	56.10	2.79	623.4074	672.3884	87	13	0	0
3	6	2.70	1.59	679.8873	446.6861	87	13	0	0
2020, Traffic data which are clearly described as downlink multicast									
2	1	51.50	0.41	20000	14812.04	100	0	0	0
2	2	10.30	1.65	20000	5554.514	100	0	0	0
2	3	0	0.00	0	0	0	0	0	0
2	4	20.60	0.41	20000	14812.04	100	0	0	0
2	5	3.09	1.65	20000	2468.673	100	0	0	0
2	6	0.97	0.41	20000	14812.04	100	0	0	0
3	1	391.40	1.65	1424.184	1130.392	83	17	0	0
3	2	463.50	2.47	922.6667	1587.004	84	16	0	0
3	3	61.80	1.65	1192	617.1682	82	18	0	0
3	4	103.00	5.35	731.7468	1026.448	86	14	0	0
3	5	56.65	5.76	623.4074	1388.628	87	13	0	0
3	6	2.67	3.29	679.8873	922.5041	87	13	0	0

9 Driving forces

The contents of this section come mainly from responses to Q.5 and Q.6 in Annex 1.

9.1 Overview

This section lists items which will be the driving forces in the markets of the future development of IMT-2000 and systems beyond IMT-2000, and estimates their impact and timing.

All driving forces are classified into four categories:

– Technology
– Market
– Regulatory
– Idealistic.

9.2 Technology forces

The advancement of technology is always an important aspect of the driving force in the Telecom industry. For the future development of IMT-2000 and systems beyond IMT-2000, the following new advancements of technology in the future would be driving forces.

– Broadband

Quality and speed should be as good as wired broadband network

With the increase in bandwidth due to the development of fiber optics and high-frequency radio technology, packet size and total throughput will also increase as high volume contents such as high-quality video, 3d audio and hologram video contents are introduced.

Demand for service on wireless environment, both frequency and necessity, should increase as unification of wired-wireless contents, migration of off-line contents to on-line, and emergence of convergence device with diverse network-cable devices.

– VoIP

Services such as voice to multiple tiers of VoIP defined by QoS and price.

– Mobile voice communication

In the market of the Republic of Estonia or other similar developing countries, the driving force (and success of GSM for example) has been the possibility for mobile voice communication until now. Additional services like SMS and MMS were contributing to that but it seems that it is not enough for the next step of comparable development.

– Distributed computing (web services, grid)

Distributed computing technologies such as web services allow computers to collaborate to deliver services. As the number and power of web services increase they will replace other methods of computation and go beyond. Key enablers include: network bandwidth, software application development tools and middleware, standards. Leading indicators: Web service adoption, grid applications, and complex service composition.

– The target applications/services

The target applications/services include: peer-to-peer video/image sharing (digital TV phones), location based services (LBS), multi-party gaming (MPG), fixed mobile convergence, integrated biometrics in handsets, telemetry, remote monitoring, integrated telematic (such as driver's logbook solution, self-billing/provisioning refrigerators or coffee machines, automatic meter reading, transport and logistics solution, etc.).

Ideally this will be done to integrate within personal lifestyles and business workflows. Examples include: Supply chain management with GPS/RFID tracking, multi-party gaming, dating services; TV with digital rights management; integrated sensors in phones for diseases, bad breath, leading to integrated biometrics.

– Amalgamation of technologies

Information technology, Internet, wireless communication and overall general communication tools are growing at an astounding rate worldwide as the access to these technologies combined with the capabilities becomes more affordable for all demographics.

The amalgamation of these technologies converging provides the opportunity for new services that require increasing device processing power and higher wireless data speeds to deliver these new services to subscribers. Thus, the key to delivering these new future services lies in the allocation of the required spectrum.

– Network reconfiguration

Includes terminal reconfiguration and network elements reconfiguration, in terms of radio access technology selection, antenna tilting and/or power allocation. Such aspects are under investigation.

9.3 Market forces

The market requirements are the major driving forces for the future development of IMT-2000 and systems beyond IMT-2000. The following items would be included:

– Economic development

Economic development controls consumption. It is important to comprehend the real utility of understanding the influence of affordability, and accessibility to the user's decision. Therefore the driving forces for the future development of IMT-2000 and systems beyond IMT-2000 should take into account socio-economic factors and consumer demand.

– Ubiquitous access to Internet

The growth of the Internet and the requirement to provide cost effective access to the Internet regardless of place or time will also be a key driving force for IMT-2000 and systems beyond IMT-2000. As explained in the general introductory remarks, Recommendation ITU-R M.1645 overlooks the role IMT-2000 and systems beyond IMT-2000 can and should play in the near and medium term with respect to providing cost effective broadband wireless access to the Internet in all markets including rural. This will increasingly be done by facilitating broadband packet data wireless access to nomadic computing platforms, in addition to hand held terminal devices. Resolution 228 (Rev.WRC-03) contains a broader perspective on IMT-2000 than the one contained in Recommendation ITU-R M.1645.

The Internet is growing, adding more information, providing more services, reaching more people on more devices, in more places, at lower cost, all the time. This is a fundamental driving force that enables many of the other services mentioned above. Key enablers: backbone networks, ISPs, broadband.

– Business model changing

Several factors will change future business model running over IMT-2000 and beyond. For example: more flat rate services, enterprise solution requirements, and convergence and competition between mobile communication and broadcast, etc.

– Group collaboration

A group could be a family, a business team or a group of friends with common interests. The driving factor is the human desire to interact with others with a common bond or purpose. One to one and broadcast technologies do not address this need but new technology developments support it to an increasing extent. The collaboration would include video and audio conferencing, online game play, sharing rich media content and possibly other forms of collaboration. Services that support the new forms of collaboration will become increasingly important. Key enablers: network

convergence and collaboration services, new terminal device technologies (high definition displays, cameras, computational power, storage, new batteries, etc.) bandwidth, addressing, security. Leading indicators: Peer-to-peer file sharing, picture/video sharing, affinity groups, social networks, web-logs.

– Feature transparency with landline

How important is single number services, handover, full access to landline services, etc. With high-speed wireless links: Is there a fixed access network in 2010? Is mobility/handover across networks/carriers with seamless continuity of high-speed applications required?

– Carrier roaming between high-speed data networks

Will there be a plethora of high-speed wireless access methods/protocols in multiple carriers or just one: WiMAX? Will consumers expect seamless continuity across networks?

– Pricing model

What will be the future pricing models, free, pay-per-use, or subscription-based? Free with advertisements or with location-based services shared to ASPs? User pays for services not 100+ Mbit/s. Will cities become wireless hubs? How are carriers paid? In a word, the innovation of the pricing model will be another driving force.

– Complex business models

The driving forces for today's telecommunication world have been the growth of Internet (especially broadband Internet access at home) and 2G mobile telecommunication. Both are now converging around the 2.5 and 3G networks and services. The telecommunications industry is characterized by complex business models caused by the following drivers:

– Services realized by the integration and cooperation of services from a number of players (network operators, Internet service providers, content providers, etc.).
– Co-existence of Internet based and traditional telecommunication services.
– The ongoing integration of pure data, voice, video and value-added services into a single service stream.
– Demand for mobility with unified service access offering guaranteed QoS.
– Cost-effective delivery of service (irrespective of access technology).

From a service perspective, the main difference between 2G/2.5G and 3G telecommunication systems is the new air interface enabling higher transmission data rates. For 3G beyond systems a global consensus exists that new system architecture needs to be developed. However, this development does not depend on a specific radio access technology (RAT). This system architecture has to support a number of new features that have been identified already:

Blurring business roles (nearly everyone can be a provider, operator, customer, and user).

– Personalized, ambient-aware, adaptive end user services.
– Move from a network centric approach (the user actively knows the network) to an I-centric paradigm ("it just happens").
– Augmented environments as part of the ubiquitous communication system (smart-IP devices and sensor networks).
– New applications.
– New networking services are becoming more important: ad-hoc, peer-to-peer, content aware, secure and QoS aware services. These systems will be tied with cellular/fixed infrastructure support.

– All IP services: Always best connected, packet switched, broadband multimedia applications.
– Flexible platform supporting diverse access technologies, global coverage, global roaming.
– Further convergence of voice, data, and mobile communications.
– New wireless links (high/low data rate, long/short range communication) to serve different application domains.
– Socio-economic changing in developing countries

In recent years Bulgaria's economy has been characterized by stability and predictability. The economic growth is substantial and the anticipations for development and accession to the EU are positive. The gradual transformation of mobile services from a natural necessity for the population into means of data exchange and use by a wide circle of applications for business and entertainment strengthens the role of the income growth which is the main factor for the intensive increase in consumption in the future.

For the period 2010-2020, the telecommunication market in Bulgaria can be expected to reach the level of its counterparts in the developed European countries. The anticipated preservation of the economic growth and the increase in the volume of investments, and the access to international resources and technologies will gradually smoothen the cycles of technological and product upgrade in the telecommunications sector with those of the developed countries, and the Bulgarian mobile market will follow the trends of the international development of mobile communications.

Socio-economic changing in developing countries like Bulgaria will be a growing driving force of IMT-2000 and beyond.

9.4 Regulatory forces

Regulation is another driving force. Five elements are discussed.

– **Policies upon carriers**

It includes policies about possible new entrant MNOs, mobile number portability, and usage of location reporting systems.

– **Policies upon unlicensed mobile access technologies**

With unlicensed mobile access technologies, how will regulatory concerns be addressed? Will a UNE-P legal entity be created for newer wireless ISPs to piggy-back over existing networks?

– **Policies upon spectrum management**

Flexible spectrum usage is one key-factor as it may be useful to support efficiently the seamless provisioning of services needed in a multiple access environment. Consequently, efficient spectrum management is an important aspect of future systems. The basic research framework includes:

– Facilitating opportunities for flexible, efficient, and reliable spectrum use.
– Establishment of means to quantify and manage interference.
– Licensed and license-exempt operation in fixed, mobile broadcast and satellite frequency bands.

– **Cooperation among network providers (NP)**

The competitive way in which NPs coexist today must be replaced by the willingness for cooperation. Towards this direction, a starting point is the establishment of common agreements, on which traffic partitioning will be based. Cost changes and traffic forecast are under research today and can guarantee only the networks' efficiency. The realization of such a concept includes techno-economic studies, in order to persuade NPs to act in such a way.

– **Competition**

To keep and enlarge the market share, the operators will try to use new technologies to provide new services with cheaper price.

At this stage, there are more than three mobile operators in many countries, but in China, there are only two operators. To create a full competition environment, the government will allow new mobile operators.

The fixed network operators have strong willing to run mobile services. In the last two years, the fixed network voice traffic volume has increased only 7.4% and 2.6%, and MOU kept decreasing. But the mobile network voice traffic volume increased 44.3% and 41.1%, and MOU kept increasing. 3G license will be a new chance for the fixed network operators to provide mobile service.

9.5 Idealistic forces

During the process to get the application examples, a number of free ranging discussions have taken place across a variety of high and low level topics. Some of these impact the relationship between service concepts and parameters, and are briefly summarized as follows. These idealistic changes will impact the markets of the future development of IMT-2000 and systems beyond IMT-2000 in a subtle but maybe huge way.

– Communication systems vs. communication services

Traditionally when people have considered communication systems, they have considered communication services. Increasingly this can no longer be taken to be the case. Communications systems are a tool to get data from one place to another, and typically that data can be seen to meet some higher level need or motivation of the user. For example: to gain assistance or reassurance, or to enable information retrieval, or to provide entertainment. All the possibilities for communications systems should be considered, not only those related to communication services.

– Service delivery to terminal vs. services delivery to user

It may be possible and useful, to consider service delivery of comprising of two parts: service delivery to the terminal, and service delivery to the user. In terms of user experience, what is important is the service delivery from the terminal to the user. Of course the user is not completely isolated from the service delivery to the terminal, as there may be impacts on aspects such as cost and terminal choice. However, it is important to recognize that genuine user scenarios will mostly provide information on the service delivery from the terminal to the user, and assumptions on the service delivery to the terminal should be minimized when analysing these scenarios. It is also useful to recognize when external service or traffic classes/models are developed according to one or other of these parts.

– Storage vs. communication

The relationship between storage and communications is an interesting one, with potential implications for both technology and economics.

Conceptually, given sufficient communications capability (speed, availability, reliability) there is no need for local storage – everything can be stored remotely and accessed as if it were available locally. Advantages to this approach include having a storage capacity which is not limited by e.g. device form factor, which can be accessed independently of device, which can be shared, and which can be resilient to environmental factors (loss, damage, heat, cold etc.).

Conversely, given sufficient local storage, and pre-loading of appropriate data, communications capability is only needed to obtain data which has changed since the last opportunity to update the storage.

In practice, a trade-off between storage and communications capability will be required.

The cost and size of storage media is continually reducing, and will provide a more cost effective mechanism for providing a bit to the user than communications for many years to come.

However, being able to successfully predict what data will be required, so it can be preloaded onto storage (e.g. at home or in the office) is not a trivial activity.

Therefore it seems reasonable that a combination of storage and communications, where communications is used to provide information which was not predicted, or which has changed (e.g. context related or interactive) is the most suitable to meet the need of most users. Given the disparate cost of the two technologies, it seems necessary for the communications systems to focus on the provision of timely data, rather than just large amounts of data, in order to maximize the value to the user.

– Data source vs. data sink

Traditionally end user communications terminals have been seen as data sinks when considering larger amounts of data (e.g. web browsing, multimedia downloads). Particularly with the advent of camera phones, but also with activities such as mob logging, the role of the terminal as a data source is also becoming increasingly relevant.

This has obvious implications for the relative dimensioning of uplink and downlink in a radio system, but also has deeper implications on QoS issues.

For example, if one is watching a (downlink) streaming video clip, some degree of distorting is typically no more than a nuisance. However, if one is creating a streaming archival recording of an important event, such as a wedding, to remote storage, it is important that this is transferred "perfectly" – it must be able to withstand repeated consumption, and there is no second chance to obtain another copy in the event of errors.

– Streaming vs. download/upload

The question here is to establish if streaming is really different from download (also upload). In fact, if the average download-speed is sufficient, and there is an adequate memory buffer to smooth out any variability in the instantaneous download speed, what difference remains?

Some topics are possible in the case of streaming and not for download, such as protecting content, providing one copy of content to multiple users or to provide synchronization of the streaming content with other activity. Furthermore, downloading of content may also place demands on storage which may become restrictive for large content. On the other hand, error correction is only possible with download.

– Local vs. remote vs. distributed processing

Depending on the type of service being used, the location of processing can also impact on the communications requirements. In this context, location of processing refers to its location with respect to the communications link – for example, whether it is carried out within the user's terminal, or within the service provision equipment, or within some network entity.

For example, when considering voice control, the location of processing has an impact on the amount of processing and storage at the terminal and on the radio link capability:

– *Local processing:* voice recognition is used at the terminal to identify commands, and generate –control data: this solution requires a higher amount of processing power and storage but probably a low capability radio link

– *Remote processing:* streaming audio carries the voice from the terminal to a remote location, where the voice recognition and control data generation takes place: this solution requires a low amount of processing and storage but a higher capability radio link

– *Distributed processing:* feature recognition is used in the terminal to extract features of the voice, which can be used remotely to identify the actual words, and generate the control data: this is an intermediate solution

Annex 1

Questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000

Q.1 Services and market survey for existing mobile services

Regarding the 2G and 3G mobile communication services and market, including mobile satellite and wireless LAN services, please list information on the following parameters as they existed at the end of 2003.

– Number of subscribers
– Traffic volume
– Expected time frame for transition from 2G to 3G
– Regional and geographical characteristics
– System type
– Area covered
– Commencement of operation
– Economics of network deployment.

Q.2 Key market parameters

The market size of the future development of IMT-2000 and systems beyond IMT-2000 can be estimated from parameters such as density of potential users, call/session duration, service bandwidth and so forth. It is also necessary for the market size estimation to take account of key issues such as services usage and usage environments. Please list the key parameters and issues you consider necessary for the market size estimation, and comment on the impact of each parameter and issue on the market.

For example, the market study could provide the following parameters:

– the number of mobile voice service subscribers;
– the traffic volume for data service from mobile subscribers density of potential users in urban area during a specific time of day;
– density of potential users in a rural/remote area for specific time of day;
– average call duration of voice service during a specific time of day;
– session activation rate of web browsing service by heavy users;

– services and related QoS parameters; guaranteed/best-effort, real time/non-real time, fixed/variable bit rate;

– usage environments; high/low mobility, indoor/outdoor, business/private, urban/non-urban.

For these parameters the following reporting units could be used:

– The number of service requests per unit time and area, i.e. session arrivals/s/m^2. The service request density is assumed to be identical in uplink and downlink direction. The value of this parameter could be provided for appropriate time intervals during the day, and separately for working days and non-working days, in order to account for non-simultaneously occurrence of the peak offered traffic of different service types.

– Percentage of users in a set of mobility classes (stationary, pedestrian and vehicular)

– Maximum required mobility support (km/h)

– Mean service duration (s or amount of data)

– Required minimum, average and maximum bit rate measured at the application layer (bit/s), for uplink and downlink

– Required end-to-end delay (s).

Q.3 Service and market forecast for future development of IMT-2000 and systems beyond IMT-2000

Regarding services and markets of the future development of IMT-2000 and systems beyond IMT-2000, please provide forecasts on the future status of the parameters listed in Q.2. Future trends of the parameters should be described in this question. When answering this question, please qualify the forecast. The evolution of service capabilities should also be described.

Q.3.1 Service issues

Please describe the applications envisaged for the future development of IMT-2000 and systems beyond IMT-2000, which may be pervasive from 2010 to 2020. Examples of potential future applications are shown in Attachment 1.

Q.3.2 Market issues

Please describe the trends and scale of the market related to mobile communication from 2010 to 2020. Regarding the market scale, quantitative information is desirable. Please state how this information was obtained (e.g., methods and parameter values). An example of a method that can be used for market evolution forecast is given in Attachment 3.

Q.3.3 Preliminary traffic forecast

Please provide information related to service traffic to be provided by the future development of IMT-2000 and systems beyond IMT-2000 from the year 2010 to 2020 (e.g. 2010, 2015 and 2020). The volume of traffic may be derived from information such as the number of service subscribers, service activation rate, service duration, transferred data size taking into account affordable expenses of the subscribers for this service. It may also be derived from information such as uplink and downlink speed, traffic class, service environment and economics of network deployment.

Examples of parameters that may be used to characterize the volume of traffic of these applications are shown in Attachment 2. It is preferable that the information related to traffic volume be provided for each service listed in the answer to Q.3.1.

Q.3.4 Related information

Please provide any related information such as:

– impact of the number of operators;
– peak hour/peak ratio of traffic volume;
– expected affordable expenses in average per subscriber for the services;
– economics of network deployment.

Q.4 Service and market forecast for other radio systems

The future development of IMT-2000 and systems beyond IMT-2000 are envisaged to interwork with other radio systems such as wireless LAN and broadcasting systems. Please list any radio systems that might interwork with the future development of IMT-2000 and systems beyond IMT-2000, and forecast the future status of the parameters from Q.3. Please indicate the percentage of users that subscribe to multiple systems/operators.

Q.5 Driving forces of the future market

Please list any items which will be the driving forces in the markets of the future development of IMT-2000 and systems beyond IMT-2000, and estimate their impact and timing. There may be different drivers for different market areas, e.g., urban vs. rural/remote, in respective countries.

Q.6 Any other views on future services

If there are any other views on the services to be provided by the future development of IMT-2000 and systems beyond IMT-2000, which are not described in the Recommendation ITU-R M.1645, please express and elaborate on them.

Attachment 1
to Annex 1

Examples of applications envisaged for the future development of IMT-2000 and systems beyond IMT-2000

It is expected that there will be a large number of applications which will be provided by future development of IMT-2000 and systems beyond IMT-2000. The applications may be grouped into service categories. They could differ on a region or country basis.

Table 56 provides examples of potential future applications and their allocation to service categories and gives guidance to be used in the elaboration of answers to the Questionnaire. Respondents are encouraged to provide information according to this guidance.

TABLE 56

Service categories	Examples of applications
Speech	Voice
Multimedia messaging	Mobile ordering enabling easy purchase of products or obtainment of information simply by holding a mobile terminal toward printed materials (magazines, brochures, posters, etc.) or images. Information pertaining to the product (video, CM, specifications) may be automatically delivered to the mobile terminal from the product centre, and displayed in 3D images, which can be viewed from multiple angles. Users, if they like, can order the product on the spot, make the payment and settle the accounts from a mobile terminal. Sales status in the areas nearby, and other related information on the product could also be obtained
Low rate data	
Low multimedia	Navigation System: users accessing information services from inside moving vehicles. The information should be provided adequately depending on time, location and properties of user. Users may also be able to receive discounts at shops by presenting the information retrieved through the above
Medium multimedia	Location information service (locating service, route guide, traffic information, etc.) Vehicle information service (automobile information, vehicle tune-up information, etc). Entertainment service (radio, TV programmes, etc.). Control service (vehicle control in the event of earthquake, accident, etc). Emergency service (accident, sudden illness, etc.). Logistics service (parcel delivery, etc.). Entertainment: Simply by instructing the name of video (which does not necessarily have to be precise; ambiguous input will do) of users' choice (TV programs broadcast in the past, news, dramas, movies, or concerts, etc.) through voice input, etc., users will be able to watch it on a mobile terminal through streaming from the network anytime and anywhere they like. The charges for the content – which should be decided taking into account the requests of the rights holder, the number of accesses from users (popularity), video quality, the number of copies, the time of viewing, location, etc. – will be presented on the spot, and if the user agrees, the video will be made available for viewing. Also, when the user wants to see a movie using some spare time, for instance, during a trip, he/she can search information concerning the movies currently on show and see a preview on the player. If he/she decides to watch the whole movie in a cinema, it is possible to search the theatre that can be reached from the current location before the start of the movie, and if necessary, make a seat reservation and purchase electronic tickets, too. The videos can be viewed in trains on a spectacles-type display, which can be suspended for a moment when changing trains
High multimedia	
Very high multimedia	
Ultra high multimedia	
Super high multimedia	

Note that there is presently limited understanding as to the specific applications that will fit within the very high, ultra high or super high categories. It is therefore proposed that these categories be reviewed once further information is available.

Attachment 2
to Annex 1

Examples of parameters for answers to Q.3.3

In order to establish spectrum requirements estimates, it is essential that the services envisaged are described in terms of technical characteristics. Therefore it is encouraged to establish a list of parameters and the values of these parameters for the various services. This attachment lists examples of parameters that may be used to describe the characteristics of the various services.

1 Traffic class

The different services can be divided into four traffic classes as follows:

– *Constant bit rate (CBR)* – CBR is a traffic class in which the peak bit rate takes a constant fixed value and is guaranteed. CBR is used for services that require a very low end-to-end delay as well as a low level of delay variation (jitter).

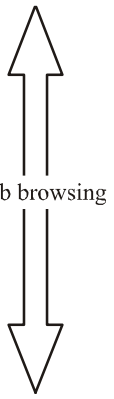
– *Variable bit rate (VBR)* – VBR class allows its bit rate to dynamically vary in response to the throughput actually required for the service. This class guarantees at least its sustainable bit rate and provides up to its peak bit rate if possible. The VBR has two subclasses according to its real-time nature; rtVBR (real-time VBR) and nrtVBR (non real-time VBR). In rtVBR, the peak bit rate is allowed to vary but real-time transmission is guaranteed, in which a tightly constrained delay and delay variations are required. The rtVBR is used for real-time applications, such as a voice and video communication. The nrtVBR is required to achieve a low packet loss ratio and mainly user for the applications of reliable and quick response like an electronic transaction. No delay bounds are defined in this category

– *Available bit rate (ABR)* – The ABR has no delay or delay variation requirements. This class is not intended for the use of real time applications. In this class, only peak bit rate and minimum usable bit rate are specified when establishing its connection. The minimum usable bit rate can be set to zero. The available bit rate may vary according to its network condition.

– *Unspecified bit rate (UBR)* – This class specifies no traffic related service guarantees. This class is intended for non-real-time applications, such as conventional computer communication applications; file transfer, or E-mail.

TABLE 57

Example mapping of potential applications on to service types

Service Categories	CBR	VBR	ABR	UBR
Speech	Voice	–	VoIP	–
Multimedia messaging	–	–	High/Medium priority MMS	Low priority MMS
Low rate data	–	–	Organizer Sync Simple transactions	–
Low multimedia	–	–	Mobile commerce	–
Medium multimedia	Micro movies	Video telephony	Mobile commerce Location-based advertising	
High multimedia	–	HD video telephony Videoconferencing	Mobile commerce Downloads	
Very high multimedia	–	–	Desk top applications	
Ultra high multimedia	–	Streaming video Multiplayer gaming	Spooling video	
Super high multimedia	–	–	High volume applications	

2 Bit rates

Bit rates are extremely important within the spectrum calculation and each service is likely to have different requirements. The peak bit rates are used here to categorize the services. For the purposes of modelling, however, it is possible to group together services demanding similar rates into a common category. To aid understanding of the hierarchy of categories, they are defined in terms of their peak user rate. This is distinct from the effective user rate which represents all services within the category for the purposes of spectrum calculation. Average bit rate may also be a parameter used to describe the characteristics of the service. For some services the delay may be relevant in addition to or instead of the peak bit rates.

3 Degree of asymmetry

A driving parameter for categorization is the degree of asymmetry for the service. Precise asymmetries will vary between services, however, it is possible to group together services having similar asymmetry. The representative asymmetry for each group is subject to market assessment, but it is likely that there will be at least three variants to represent whether the service is fundamentally upload, download or symmetric. Download services are expected to use high bit rates on the down link and low bit rates on the uplink or even no uplink data. Up load services use the reverse.

4 QoS parameters

QoS parameters such as delay may be used to describe the characteristics of the various applications and services.

5 Mobility

Terminal mobility is closely related to application usage scenarios. The requirements depend upon the relative speed between the mobile stations and the stations in the radio access network with which they are interacting. For example, the mobility may be categorized as follows:

- stationary (0 km/h);
- pedestrian (>0 and <10 km/h);
- vehicular (>10 km/h);
  - Low/medium (>10 and <100 km/h)
  - High (>100 and <250 km/h)
  - Super-high (>250 km/h)

6 Service usage patterns

A service usage pattern may be categorized according to an area where users exploit similar services and expect similar QoS.

- Home
- Office
- Public area
- Wide area.

The service usage pattern may be further categorized according to the time of day. The time-of-day variation of traffic volume depends on the type of application, which might have different usage such as:

- busy time
- non-busy time.

7 Teledensity

Teledensity may be categorized into the following:

- Dense Urban
- Urban
- Suburban
- Rural
- Remote.

8 Relations between the different parameters

Detailing all the combinations of parameters for each service would lead to very big amount of possibilities. Since not all these combinations reflect real cases, and in order to simplify the studies, a limited set of combinations of parameters may be used. The following tables provide some possible sets of combinations.

TABLE 58

Summary of service categories

Peak bit rate	Service categories
< 16 kbit/s	Speech
< 128 kbit/s	Multimedia messaging, Low multimedia, low rate data
< 384 kbit/s	Medium multimedia
< 2 Mbit/s	High multimedia
< 10 Mbit/s	Very high multimedia
< 30 Mbit/s	Ultra high multimedia
< 100 Mbit/s	Super high multimedia
Unspecified bit rate	Background

Note that there is presently limited understanding as to the specific applications that will fit within the very high, ultra high or super high categories. It is therefore proposed that these categories be reviewed once further information is available. Similarly, it is premature to define the asymmetry associated with the up load and down load multimedia categories until further market data is available and the likely applications are better understood. Indeed it would be prudent to review all parameters associated with service categories in the light of market input before finalising the definition of each service category.

Table 59 describes the parameters that may be needed for the various traffic classes.

Note that all services which will be handled on a best effort basis are collected together under the service category Background. Thus the UBR traffic class is not required as a parameter in the definition of the other service categories.

TABLE 59

Additional parameters needed in addition to traffic class

Traffic class	CBR	VBR	ABR	UBR
Information required	QoS Average bit rate Delay requirement	QoS Average bit rate Peak bit rate	QoS Average bit rate Minimum bit rate (or maximum delay)	None

Attachment 3
to Annex 1

An example of a method to forecast market evolution

Anticipating the evolution of the worldwide mobile communication penetration for the next twenty years is a challenging work. In this timeframe, as the world population increases by 22% (from 6.2 Billion in 2002 up to 7.6 Billion in 2020)[10], many factors will influence the particular situation of each country and their telecommunication development. The forecasts for the evolution of telecommunication penetration developed from this method are based on the general socio-economic context and perspectives of each country.

For example, the penetration forecast could be set in two steps:

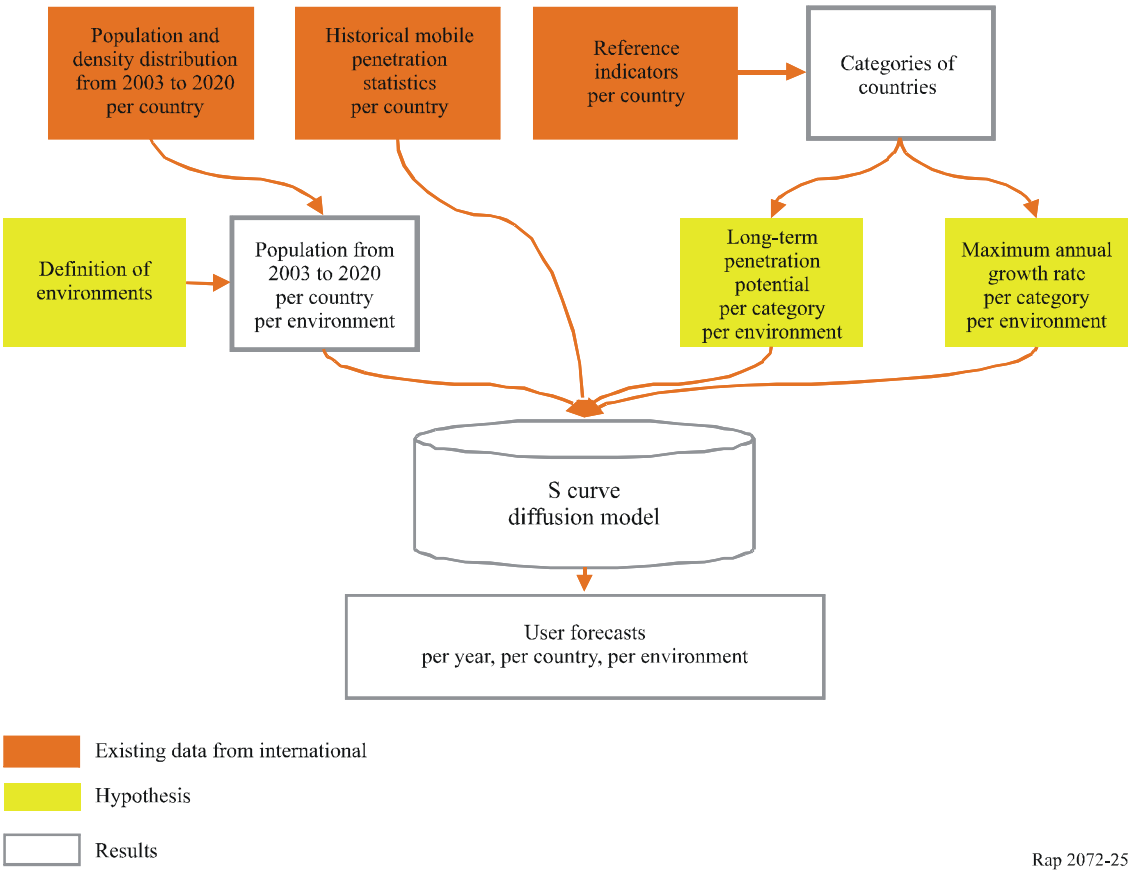
Step 1: the long-term mobile penetration levels that the countries are expected to reach in 2020 are determined, as well as the maximum speed of penetration increase over the timeframe.

Step 2: the penetration evolution for every country, and for every year in the period 2003-2020 is computed using the so called S-Curve model.

An example of a particular method is presented in Fig. 25.

FIGURE 25

Synopsis of the mobile penetration forecast method



[10] Source: UNO, World Population Prospect – 2001 Revision

Four major reference indicators could be considered to estimate the future mobile telecommunication market in each country:

– Income
– Human development
– Technology affinity
– Urbanization.

The evolution of the mobile penetration could be modelled per country and per environment as an S-curve diffusion process with the following parameters:

– the historical mobile penetration in the country;
– the long-term mobile penetration potential for the country;
– the maximum year-on-year penetration growth rate (which occurs at the inflexion point of the penetration curve).

Annex 2

List of responses to "Service View" document

Document No.	Source	Name of document or comments
1	France Telecom	Preliminary answers to questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
2	Brazil (Federative Republic of)	Partial responses on the questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
3	IEEE	Response to Radiocommunication WP 8F questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
4	Australia	Response to questionnaires on the services and market and possible terrestrial candidate frequency bands for the future development of IMT-2000 and systems beyond IMT-2000
5	China (People's Republic of)	Document to make answer towards "WG service/market" questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
6	China (People's Republic of)	Method of analysing responses to questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
7	United States of America	Initial response to the "Questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000"

Document No.	Source	Name of document or comments
8	APT Wireless Forum (AWF)	The Initial AWF response to the Questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
9	Japan	Initial response to "Questionnaire on services and market for the future development of IMT-2000 and systems beyond IMT-2000"
10	Intel Corp.	Initial response to Question 4 of the “Questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000”
11	WINNER Project	Input to the ITU-R "Questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000" from winner project
12	CEPT	Information about the planned european response to the Radiocommunication WP 8F questionnaire on future mobile services and markets from 2010 onwards (CACE/326)
13	Bulgaria (Republic of)	Response to the questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
14	Estonia (Republic of)	Response to the questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
15	3G Americas	Response to the questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
16	UMTS Forum	Initial response from the UMTS Forum on the questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
17	DECT	Answers from DECT Forum to the Radiocommunication WP 8F “Questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000”
18	WWRF Forum	WWRF answers on the questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
19	Malta	Response to the questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
20	Poland (Republic of)	Response to the questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
21	Azerbaijani Republic	Response to the questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
22	UMTS Forum	Magic mobile future 2010-2020
23	CEPT	European response to the Radiocommunication WP 8F questionnaire on future mobile services and markets from 2010 onwards (CACE/326)

Document No.	Source	Name of document or comments
24	Japan	Final response to "Questionnaire on services and market for the future development of IMT-2000 and systems beyond IMT-2000"
25	Brazil (Federative Republic of)	Responses on the questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
26	Canada	Response to the questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
27	Korea (Republic of)	Response to Radiocommunication WP 8F questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
28	CDMA Development Group	Initial response to the "Questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000"
29	APT Wireless Forum (AWF)	The final AWF response to the questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000
30	Cameroon	Initial response to the "Questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000"
31	Mauritius	Initial response to the "Questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000"
32	Japan	Update of the preliminary traffic forecast shown in the final response to "Questionnaire on services and market for the future development of IMT-2000 and systems beyond IMT-2000" for the section 8, "Market related parameters for spectrum calculation" of working document towards market report
33	United States of America	Additions to the response to the "Questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000"
34	UMTS Forum	Proposal for an executive summary of the working document towards market report
35	CEPT	Addendum to the european response to the Radiocommunication WP 8F questionnaire on future mobile services and markets from 2010 onwards (CACE/326)

Annex 3

Market size estimation and traffic forecast methodologies

1 Market size estimation methodology

1.1 Guideline

a) Basic viewpoint of market size estimation

According to the classic economics, the market size is determined by factors from two aspects: the DESIRE to consume, and the CAPABILITY to consume. To estimate the future market size of IMT-2000 and systems beyond IMT-2000, the CAPABILITY aspect should be considered seriously as well as the DESIRE aspect, because generally more luxuriant services are always followed by higher prices.

b) Consideration of economic inequality in inhabitants (Gini Coefficient)

The Gini coefficient (or Gini ratio) G is a summary statistic of the Lorenz curve and a measure of inequality in a population. The Gini coefficient is most easily calculated from unordered size data as the "relative mean difference," i.e., the mean of the difference between every possible pair of individuals, divided by the mean size μ:

$$G = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} \left| x_i - x_j \right|}{2n^2 \mu}$$

The Gini coefficient ranges from a minimum value of zero, when all individuals are equal, to a theoretical maximum of one in an infinite population in which every individual except one has a size of zero.

Gini coefficient reflects the inequality of income among inhabitants. It affects consumption capability a lot, especially in developing countries.

c) Consideration of content aspect in future mobile communications

Content running over IMT-2000 and systems beyond is the most important factor to attract subscribers. The attraction of content could be described in two aspects: extent and depth.

1.2 General market size estimation process

As described above, market size estimation must consider two aspects: CAPABILITY and DESIRE. The estimation process is made up of two steps:

Step 1: Calculate the total capability of consumption in future mobile communications.

Step 2: Determine the proportion of capability that subscribers desire to consume.

In the first step, the capability of consumption can be obtained from macroeconomic indicators, such as Gross National Income, Gini coefficient, and population. It may be expressed in form of formula:

Capability_of_consumption = Function (GNI, Gini_coef, Population, etc.)

Capability_of_consumption: xxx dollars

GNI: xxx dollars per capital

Gini_coef: a number between 0 and 1

Population: an integer number considering the roaming part

This formula only gives an open form of capability calculation, which needs more detailed analysis in parameters and their effect on calculation result according to in-depth study on economic aspects of mobile communication industry. In a word, capability of consumption gives maximum volume of market size in a certain country.

In the second step, the desire of consumption in radio communication may be affected by a lot of factors more or less. These factors include:

– Content
– QoS
– Tariff
– Habit
– Security, etc.

It also can be expressed as follows:

Proportion of capability consumed = Function (Content, Qos, Tariff, Habit, Security, etc.)

The result is a percentage. If the result is 0%, it means all subscribers have no desire to consume. On the other hand, if the result is 100%, it means all capability of consumption is used up. Similarly, the form of formula is not fixed due to lack of thorough research on these key market parameters which would affect future mobile communication.

Further consideration

The forms of functions that are used in market size estimation is still unfixed. And it is believed that confirmation on these forms should base on a lot of historical data analysis. Further discussion on this subject should be encouraged.

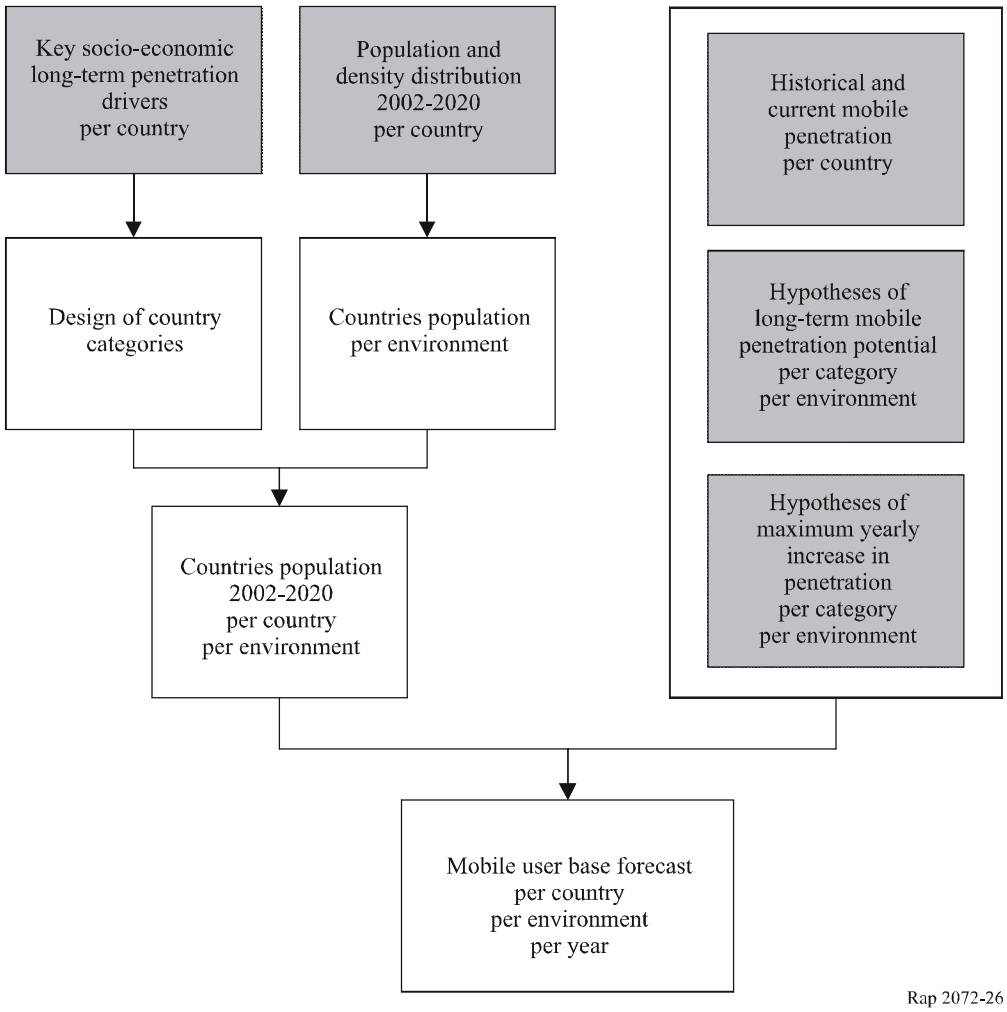
1.3 Mobile user forecast method

We propose the following **methodology** to be used to specify hypotheses for the mobile penetration level, and the "shape" of the penetration evolution for each country, within the forecast timeframe. The figure below shows a simplified view of the methodology. Grey boxes depict inputs (available data and specified hypotheses), white boxes describe results.

The forecasts for the number of users can then be combined with average penetration and usage per user forecasts, to compute estimates for the total number of users and the total volume of traffic per country.

FIGURE 26

Synoptic of the mobile penetration forecast methodology (Inputs are in Grey, Outputs are in White)



The penetration forecasts are set in two steps:

Step 1: The long-term mobile penetration levels are set that the countries are expected to reach or approach in 2020, as well as the maximum speed of penetration increase over the timeframe.

Step 2: The penetration evolution for every country, and for every year in the period 2003-2020 is then computed using a special type of forecast method based on S-Curves.

The evolution of the mobile penetration is modelled per country as a standard S-Curve diffusion process, using a minimal set of hypotheses:

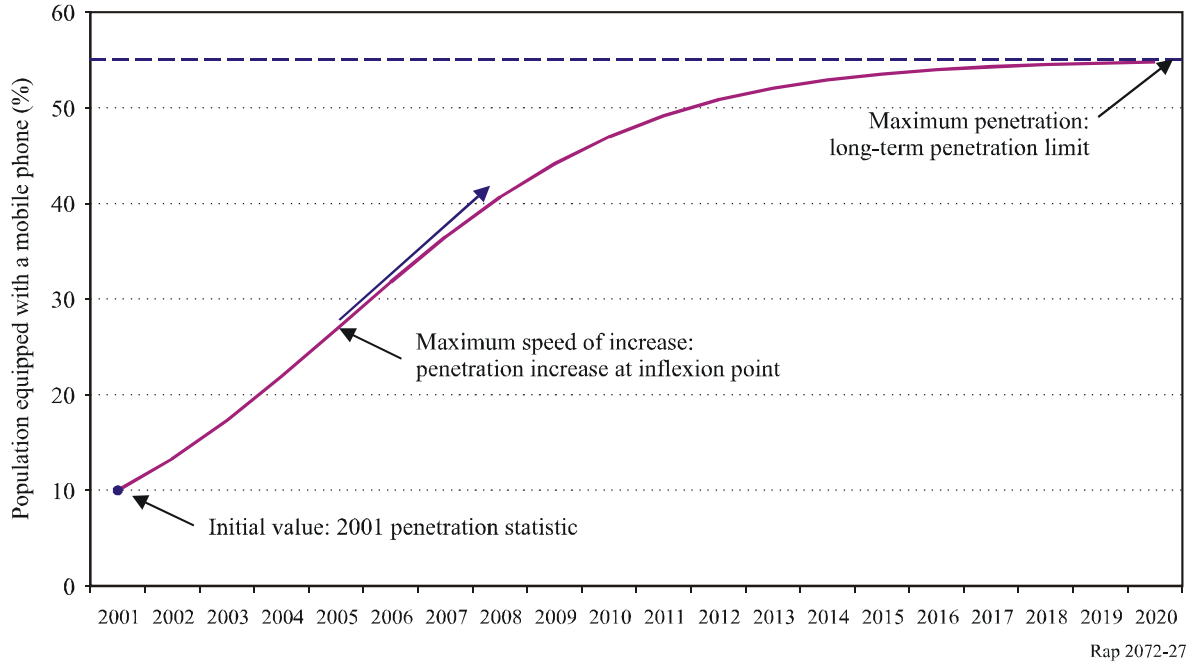
– *Maximum penetration:* the long-term penetration potential for the country,

– Maximum speed: the maximum year-on-year penetration increase (which occurs at the inflexion point of the penetration curve) in percentage of the maximum penetration.

The maximum penetration and maximum speed of penetration increase parameters are both set globally for each country category, then for every country the initial point of the penetration curve is set equal to the country's 2002 mobile penetration level. Figure 27 shows an example of a penetration curve modelled using an S-Curve method:

FIGURE 27

Example of a penetration evolution modelled using an S-Curve formula



2 Service usage and traffic forecast methodology

2.1 General traffic forecast method

Figure 28 shows a simplified view of the methodology used for the service penetration and usage forecast. Grey boxes depict inputs, where hypotheses are specified; white boxes are results derived from the hypotheses. This methodology is designed to strike a balance between taking into account all the main drivers of services penetration and usage, and the simplifications needed to enable the rapid specification of forecast scenarios.

The outputs of this methodology are services penetration and usage forecasts at the following level of detail:

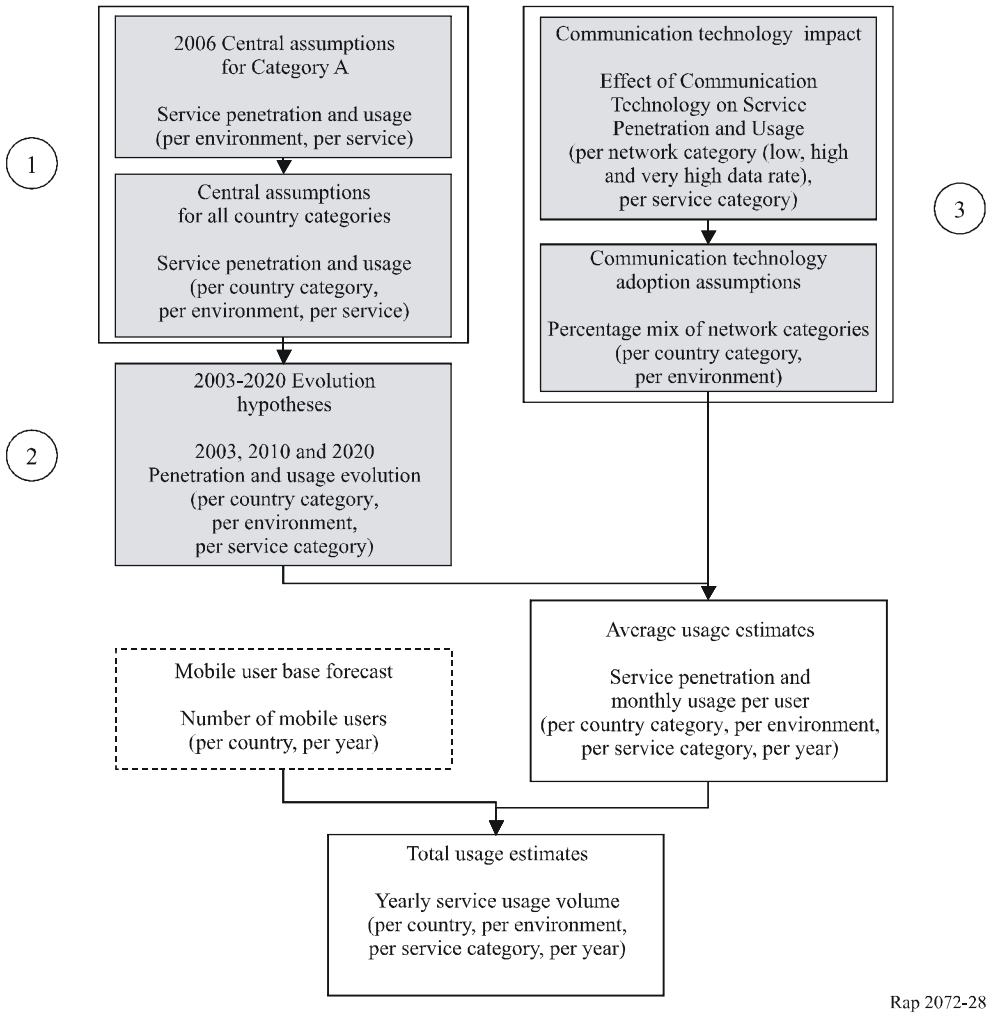
– per service category
– per country
– per environment (dense urban, urban, rural)
– for every year, between 2003 and 2020.

The services penetration is expressed as a percentage of the mobile-equipped population. By definition, we assume that every mobile user uses voice services: voice service penetration on the user base is assumed to be 100% in every case. All the other data services' penetrations are expressed as a percentage on the total mobile user base. The penetration rates expressed in this manner do not take into account the number of terminals per user: only the number of owners and users of mobile terminals is taken into account.

The service usage per user is expressed in terms of number of sessions per user per month. Combined with additional assumptions on the average duration of voice calls, and the average volume of data sessions the service usage can then be expressed either as a number of minutes (for voice services) or number of Kilobytes for data services.

FIGURE 28

Synoptic of the service penetration and usage forecast methodology (Inputs are in Grey, Outputs are in White)



Average usage is in general presented as an average over the number of persons using the service: in that case the term "average usage per service user" is used. Often, the average usage is computed over the total mobile user base (which is equivalent to the average usage per service user weighted by the service penetration): in that case, the tem "average usage per mobile user" is used.

The forecast model is necessarily quite complex, due to the number of different dimensions that must be taken into account (2 outputs for each of 9 service categories x 192 countries x 3 environments x 18 years). In order to reduce the complexity, the forecasts are generated from a smaller set of simplified assumptions.

The assumptions are set in three main steps:

Step 1: Detailed service penetration and usage assumptions for the year 2006 (identified as representative of a reference market potential), per service, per category of country, and per environment.

The service penetration and usage hypotheses assume that a high-data rate, multimedia network is available in all environments and for all services. Step 3 takes into account the effect of the availability of different communication technologies on the service penetration and usage.

Step 2: Assumptions concerning the evolution of the service penetration and usage over the full time-frame, compared with the 2006 estimates.

The evolution hypotheses are specified for the years 2003, 2010 and 2020, separately for each country category. For the intermediate years, penetration and usage is linearly interpolated.

Step 3: Assumptions concerning the effect of the available network technology on service penetration and usage and the mix of network technology per country category.

This set of assumptions takes into account the mix of available network technologies over time, per country category and per environment, and the effect that the availability of different communication technologies can have on service penetration and usage.

2.2 Other considerations

a) Regionalization

Due to the diversity of development of civilization and economies, different countries and regions may be in different phases of mobile communications. So traffic forecast in the future development of IMT-2000 and systems beyond IMT-2000 in these countries are recommended to be considered respectively.

b) Effect of population who roam in/out

With the further cooperation among the international society, more and more people will travel to the locations outside of their home city, at the same time many visitor and tourists will visit their own city. Assuming that international seamless roaming should be implemented in most area of the world, the network deployment of operator companies in future development of IMT-2000 should consider the effect of population roaming.

c) Voice/Data analysis respectively

The teletraffic volume of voice service is traditionally measured by Erlang, which means the occupied period per line per time unit, for example 0.2 Erlang = 12 min/line/h. But data services usually are measured by bits transmitted per time unit, such as 128 kbit/s. In spite of packet-switching dominating future communication, traffic volume of voice services measured by Erlang will always be friendly to operators and consultants. And it may be transformed into bit/s given exact link data rate of one voice channel or line.

d) Consideration of impact of income per inhabitant

As described above in § 2, economic situation may play an important role in the subscribers' consumption ability. Many consumers are sensitive to the pricing policy of services in most developing countries. And inequality of income (Gini coefficient) will affect traffic volume forecast.

e) Consideration of redundancy part of services traffic volume

Packet switching networks may cause information loss in communications, so redundancy is sometimes essential to satisfy the need of customers, which leads a little more volume compared to normal cases.

NOTE 1 – Retransmitting in the lower layers of radio access network, such as ARQ, is only a part of information redundancy. In the future networks redundancy part in application and session layer will come into consideration as well.

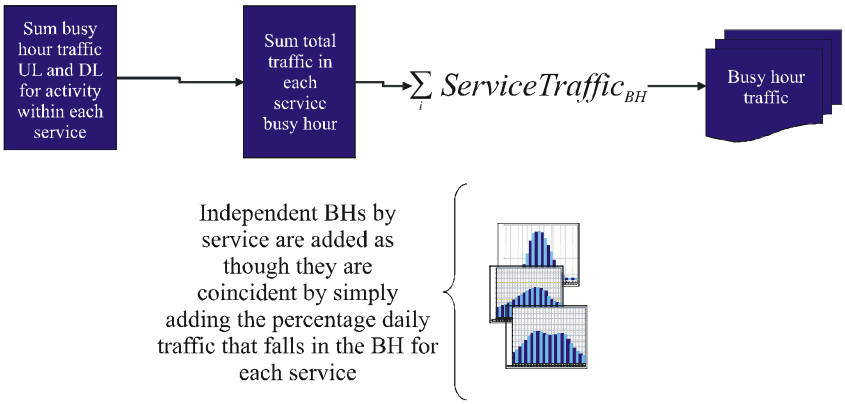
2.3 Busy hour traffic calculation

As mobile traffic migrates from a single symmetric service (voice) to a complex aggregation of many different data services, applications and activities, the busy hour traffic characteristics are the primary drivers for network design and capacity management.

A significant amount of research was done to determine the appropriate way to measure busy hour traffic in a multi-service environment. It was determined that the key parameter is the percentage of traffic in the busy hour. This individual traffic can then be simply summed. The difference between this approach and a more detailed aggregate busy analysis is negligible. Figure 29 shows how the busy hours were summed to arrive at the total busy hour traffic.

FIGURE 29

Calculation of the total busy hour traffic
(Source: Telecompetition, Inc. on behalf of the UMTS Forum, December 2004)



<2% Difference was found between this approach and a more complex calculation of an aggregate busy hour.

Rap 2072-29

Annex 4

Method to analyse responses

1 Data analysis

Terminology for market data analysis

Application: an application which is general and essential enough to categorize all the collected services concisely and appropriately

Service: The service is basic element, of which an application is composed. The services composed of an application have the assumption that they independently happen. For example, use of VoD service does not depend on the use of AoD service. The second assumption is that all services mapped to the same service category have identical and independent properties in market attributes.

Market attribute parameters: Related with users' perspective. These values could be obtained from the market data

Traffic attribute parameters: Related with traffic characteristics of the service. These values could be obtained by analysing technical trends.

1.1 General process

Figure 30 shows the general process for the market data analysis.

FIGURE 30

General process for the market data analysis

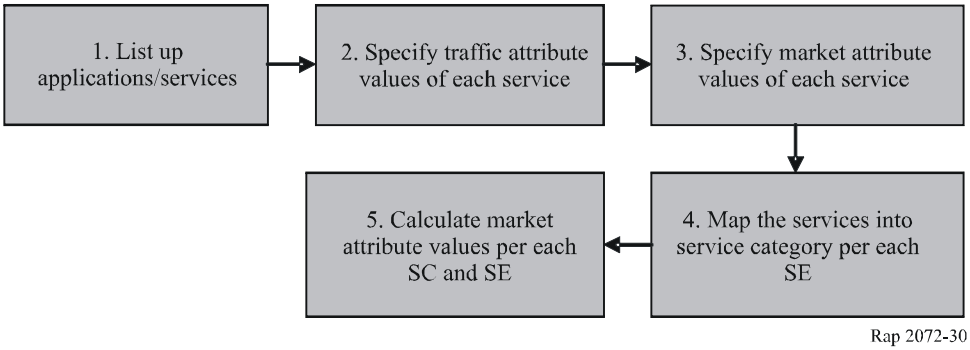


Figure 31 illustrates the practical flow for the general process to analyse plural responses to the questionnaire.

1.2 List applications/services

All foreseeable applications/services of the future listed up. Since the list of applications and services is one of the important factors to calculate spectrum SWG Market should choose the services not to be overlapped from an application which be general and essential enough to categorize all the collected services concisely and appropriately.

In this step, the lists of applications and services must be fixed and filled up the first and second columns of Table 60. The obtained application list into application/ service categories shown in Table 60 should be categorized by considering their attributions. These categories should cover all foreseeable application categories in order to make estimation reliable.

In practice, every response is determined whether it includes an individual list of applications and services. When the response includes a list, every item is merged in the list of applications and services with concise and appropriate categorization by considering the attribution of individual items.

Note that the document number describing an item should be affixed with the individual item in the list, in order to make the following steps faster and simpler. If an item in the list of applications and services is a name of application and does not have any names of service to extract traffic attributes, it would be hard for the item to execute Step 2 in Figure 60. Such an item should specify practical services to proceed to following steps; otherwise it should be removed from the list of applications and services.

Table 61 shows a practical worksheet that is basically able to include the same contents as Table 60. Table 61 has four additional columns. Three columns would be respectively filled with the sequence number of service in the same application/service category, the sub sequence number of service to be merged under the same sequence number of service, and the document number for the above purpose. The other column of SC *n* defined in Table 52 is used for mapping to Table 63.

The only representative name of application/service under the same sequential number of service might be used to fill the relevant columns in Tables 60, 62, 63, and 64.

FIGURE 31

Practical flow for general process to summarize responses

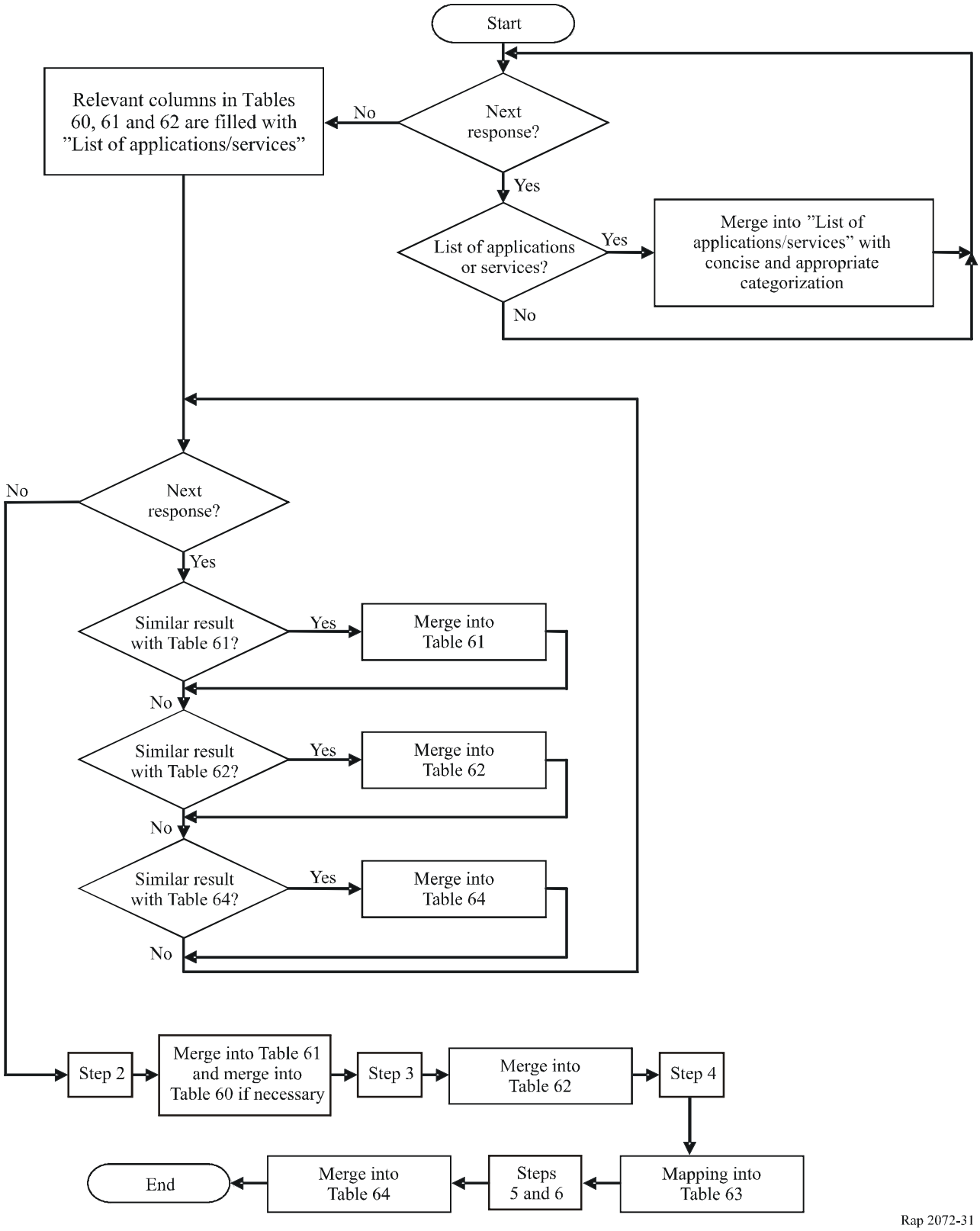


TABLE 60

Example application/service category and their traffic attributes

Applications	Services		Traffic attributes	
			Mean service bit rate	Average session duration
Existing applications	Voice (multimedia and low rate data/conversational)		64 kbit/s	
	Video phone (medium multimedia/conversational)		384 kbit/s	
	Packet	IM, e-mail (very low rate data/ background)	1 kbit/s	
		Video mail (medium multimedia/background)	512 kbit/s	
		Mobile broadcasting (high multimedia/streaming)	5 Mbit/s	
		Internet access (high multimedia)	10 Mbit/s	
Town monitoring systems	Voice (multimedia and low rate data/conversational)		64 kbit/s	
	Video communication (medium multimedia/conversational)		384 kbit/s	
	Medium rate data transmission for town information monitoring (medium multimedia/interactive)		384 kbit/s	
	Low rate data transmission for reservation of restaurants, etc. (very low rate data/interactive)		1 kbit/s	
	File transfer (super high multimedia/background)		50 Mbit/s	

TABLE 61

Application/service category and their traffic attributes

Sequence number of service	Sub-sequence number in same service sequence number	Name of application/service	Doc. No.	SC *n*	Mean service bit rate (kbit/s)	Average session duration
1	1	Voice telephony	D1		10	2-3 min
1	2	Speech	D3			
1	3	Telephone	D4	5	16	120-210 s
1	4	Voice messages	D1	5	10	30 s
2	1	Videotelephony	D1		128	2min
2	2	TV-telephone	D4	3	384	
2	3	Videoconference	D1			2 min
2	4	Videoconference	D2			
2	5	Videoconference	D4	3	768	120-210 s

TABLE 62

Expected response to questionnaire on market and services

Applica-tions	Services *s*: index	SC *n*	SE *m*	Market Attributes							
				User density $U_{m,t,s}$ (users/ km^2)	Session arrival rate per user $Q_{m,t,s}$ (session/ (s*user))	Mean service bit rate r_s (bits/s)	Average session duration $\mu_{m,t,s}$ (second/ session)	Mobility ratio (%) $MR_{m,s}$			
								Stationary	Low	High	Super - high
Town Monitoring systems	Town information monitoring $s = 1$	18	1		~	~	~				
			2		~	~	~				
			3								
					~	~	~				
					~	~	~				
	Reservation $s = 2$										

Table 63

Mapping services onto service categories

Traffic class / Service type	Conversational	Streaming	Interactive	Background
Super high multimedia				File transfer
High multimedia				
Medium multimedia	Videophone			
Low rate data and low multimedia				
Very low rate data	Voice		Low data transmission for restaurant reservation in town monitoring system	Low priority e-mail. Low data transmission for town monitoring

TABLE 64

Market data for service category in a service environment

SC *n*	SE *m*	Market attributes							
		Market scale $N_{s,m}$ (users/km^2)	Number of session attempts per user $A_{s,m}$ (1/h/user)	Mean service bit rate (kbits/s)	Average session duration $D_{n,m}$ (s)	Mobility ratio (%) $MR_{s,m}$			
						Stationary	Low	High	Super high
SC1	SE1	0	–	–	–	80	20	0	0
	SE2	...	...	...	...	...	...	...	...
	...	...	...	...	...	...	...	...	...
	SE6								
SC20									

1.3 Merge well-analysed results which are ready to merge into Tables 61, 62 and 64

Frames of Tables 62 and 64 are prepared respectively for merger of the results from individual responses. Every response is determined whether it includes one or more of Tables 61, 62 and 64 (or similar results). When the response includes one or more tables (or similar results), they are merged in the above tables. Note that the document number describing an item to be merged should be affixed with the item in the tables and the document number should be listed with the respective table as well.

When plural responses describe different values in number, the range of those values could be described in the table if necessary.

This is an additional procedure between Step 1 and Step 2 in the general process in Fig. 30, to include the well-analysed results in the tables in a straightforward manner.

1.4 Specify traffic attribute values of each service

With the lists of applications and services developed in Step 1, the values of the traffic attributes parameters such as mean service bit rate, average session duration per each service are specified in this step.

By examining services developed in Step 1, the traffic attributes as shown in Table 60 are extracted. This table gives typical values for:

– mean service bit rate,

– average session duration.

These values can be used for the decomposition of the collected market data of applications, if they are not specified in the collected market data.

In practice, the list of applications and services in § 1.2 is utilized for input in Step 2 and the result of the step is merged into Table 61 that may already include some results from some responses. In this step, the item with the document number that is listed with Table 61 could be skipped, because the table already includes the result from the document. When plural services in same sequential number of service describe different values in number, the range of those values could be described in Table 60 if necessary.

1.5 Specify market attribute values of each service

The time-varying and regionally-varying natures of traffic on different RATGs provide an opportunity to increase the efficiency of spectrum usage made from the use of coordinated networks and a flexible spectrum usage (FSU) scheme. The basic idea behind this concept is to no longer have fixed and geographically equal amounts of spectrum allocated to each RATG, but to allow the RATGs to give spectrum to each other, during times when it is unused. If a perfect FSU scheme was being used then only as much spectrum as required for the traffic demand would be allocated to the RAN. These time varying patterns are seen on most RATs, as a consequence of user behaviour changing depending on the time of day.

In order to calculate the dynamic spectrum requirement of a RATG, the market attribute values need to be provided for individual time interval *t*. The achievable spectrum savings from applying FSU will increase with the time resolution with which the market attribute values can be provided.

For analysing the market data, the values of user density and session arrival rate per user for each service in each service environment and time interval need to be specified. In addition, the mobility ratios are needed in the traffic distribution. Table 62 shows a example of the expected response to Questionnaire on market and services.

In practice, Table 60 is utilized for input in Step 3 and the result of the step is merged into Table 62 that may already include some results from some responses. In this step, the item with the document number that is listed with Table 62 could be skipped, because the table already includes the result from the document. When plural services in same sequential number of service describe different values in number, the range of those values could be described in Table 62 if necessary.

1.6 Map the services into service category (SC) table per each service environment

According to Table 62, each service can be mapped into the table composed of service type and traffic class as shown in Table 63. All the services listed in Table 62 should be mapped into Table 63. This table will be developed per each Service environment, so that we can establish six tables for all service environments.

1.7 Calculate market attribute values per each SC and SE

Table 63 shows the market attribute values of each service. In this step, we will calculate market attribute values of each SC, SE and time interval, using the following calculation. The result is shown in Table 64. Market attribute values are provided separately for uplink and downlink.

Required values for SE *m*, time interval *t*, and SC *n* are derived from the values of parameters of each service as follows:

User density (users/km^2) of a certain service category is the summation of the user densities of each service mapped into the service category.

Mathematical expression is as follows:

$$U_{m,t,n} = \sum_{s \in n} U_{m,t,s}$$

where $U_{m,t,n}$ and $U_{m,t,s}$ denote the user density of service category n and the user density of service s inside service category n, respectively.

Session arrival rate per user (sessions/(s*user)) of a certain service category is the weighted average of session arrival rate per user of each service mapped to this service category. The weight of each service is the user density.

Mathematical expression is as follows:

$$Q_{m,t,n} = \frac{\sum_{s \in n} U_{m,t,s} Q_{m,t,s}}{U_{m,t,n}}$$

where $Q_{m,t,n}$ and $Q_{m,t,s}$ denote the session arrival rate per user of service category n and the session arrival rate per user of service s inside service category n, respectively.

Average session duration (second/session) of a certain service category is the weighted average of average session duration of each service mapped to this service category. The weight is the session arrival rate per area. We distinguish the time unit "second" for the session duration from the time unit "s" for the simple time interval.

Mathematical expression is as follows:

$$\mu_{m,t,n} = \sum_{sen} w_{m,t,s} \mu_{m,t,s}$$

where

$$w_{m,t,s} = \frac{U_{m,t,s} Q_{m,t,s}}{U_{m,t,n} Q_{m,t,n}}$$

where $\mu_{m,t,n}$ and $\mu_{m,t,s}$ denote the average session duration of service category n and the average session duration of service s inside service category n, respectively.

Mean service bit rate (bits/s) of a certain service category is the weighted average of the mean service bit rates of each service mapped to this service category. The weight is the traffic volume (sum of the average durations of all sessions that arrive during a unit time) per area.

Mathematical expression is as follows:

$$r_{m,t,n} = \sum_{s \in n} \overline{w}_{m,t,s} r_{m,t,s}$$

where

$$\overline{w}_{m,t,s} = \frac{U_{m,t,s} Q_{m,t,s} \mu_{m,t,s}}{U_{m,t,n} Q_{m,t,n} \mu_{m,t,n}}$$

where $r_{m,t,n}$ and $r_{m,t,s}$ denote the service data rate of service category n and the service data rate of service s inside service category n, respectively.

Mobility ratio of a certain service category is the weighted average of each mobility ratio for a user of a service category of each service mapped to the service category. It is assumed that the mobility ratio is not time dependent. The weighting of each service is calculated as ratio of offered traffic of a service to total offered traffic of the service category in the service environment.

Mathematical expression is as follows:

$$MR\_market_{m,t,n} = \sum_{s \in n} \overline{w}_{m,t,s} MR\_market_{m,s}$$

where $MR\_market_{m,t,n}$ and $MR\_market_{m,s}$ denote the mobility ratio of service category n and the mobility ratio of service s inside service category n, respectively.

In practice, Tables 62 and 63 are utilized for input in Step 5 and the result of the step is merged into Table 64 that may already include some results from some responses. In this step, the item with the document number that is listed with Table 64 could be skipped, because the table already includes the result from the document. When plural services in same sequential number of service describe different values in number, the range of those values could be described in Table 64 if necessary.

Annex 5

Worksheet towards list of applications/services

Table 65 shows the applications/services seen in the responses to the questionnaire.

TABLE 65

List of applications/services seen in the responses to the questionnaire

Sequence number of service	Sub sequence number in same service sequence number	SC of the service	Representative name of application/ service	Name of application/service	Doc. No. in Annex 2	SC *n*	Mean service bit rate	Average session duration
1	1	5	Voice telephony	Phone	13			
1	2			Voice	26		16 kbit/s	120-210 s
1	3			Voice service	22		< 16 kbit/s	
1	4			Voice service	23			
1	5			Voice service	25			
1	6			Voice	5		16 kbit/s	100 s
1	7			Voice service	12			
1	8			Voice telephony	1, 14		10 kbit/s	2-3 min
1	9			Simple voice	20, 32	5	16 kbit/s	120-617 s
1	10			Telephone	29	5	16 kbit/s	120-210 s
1	11			Communication/ Conversational voice	24		<16 kbit/s	
1	12			Voice telephony	20			
1	13			Voice telephony (Simple voice)	14		8 kbit/s	3 min

TABLE 65 (*continued*)

Sequence number of service	Sub sequence number in same service sequence number	SC of the service	Representative name of application/ service	Name of application/service	Doc. No. in Annex 2	SC *n*	Mean service bit rate	Average session duration
1	14			Speech	16			
1	15			Speech	28			
2	1		Voice service	Voice service	22		< 144 kbit/s	
3	1	4	VoIP 1	VoIP	22		< 144 kbit/s	
3	2			VoIP	26		< 144 kbit/s	
3	3			VoIP	23			
3	4			VoIP	14		128 kbit/s	1.5-7.5 min
4	1	15	VoIP 2	VoIP	20, 32	15	16 kbit/s	65.83-148.12 s
5	1	5	VoIP for long distance	VoIP for long distance	5		16 kbit/s	100 s
6	1	3	Video telephony 1	Rich voice with video	13			
6	2			Video interactive	20, 32	3		
6	3			TV-telephone	29	3	384 kbit/s	
6	4			Video telephony (medium quality)	9		64-512 kbit/s	
6	5			Rich voice	14		384 kbit/s	30 min
6	6			Medium multimedia/video calls	28			
7	1	4	Video telephony 2	Video phone	5		64 kbit/s	100 s
7	2			Videotelephony, videoconference	1, 14		128 kbit/s	2 min
7	3			Collaborative work including group videoconference (exchange of multimedia information, and the sharing of files)	1, 14		128 kbit/s	
7	4			Voice telephony	9		8-64 kbit/s	
7	5			Communication/ conversational video, videoconference	24		<144 kbit/s	
7	6			Video telephony	23			
8	1	3	Hi-quality video phone	Hi-quality video phone	5		384 kbit/s	100 s
9	1		High quality video telephony	High quality video telephony	9		2-5 Mbit/s	
10	1	3	Videoconference	Videoconferencing	25			
10	2			Videoconference	29	3	768 kbit/s	120-210 s
10	3			Video-conference	14			
10	4			Videoconference	22		<2 Mbit/s	
11	1	13	High rate multimedia/ Videoconference	High rate multimedia/ videoconference	5		2 048 kbit/s	500 s
11	2			Video interactive	20			

TABLE 65 (*continued*)

Sequence number of service	Sub sequence number in same service sequence number	SC of the service	Representative name of application/ service	Name of application/service	Doc. No. in Annex 2	SC *n*	Mean service bit rate	Average session duration
12	1	8	Video interactive, videoconferencing	Video interactive, videoconferencing	20, 32	8		
13	1	2	High quality videoconference	High quality videoconference	9		10-50 Mbit/s	
13	2			Videoconference	22		< 30 Mbit/s	
14	1	2	Multi-media phone	Multi-media phone	26			
14	2			Rich data call	9		2-5 Mbit/s	
15	1	15	SMS	SMS	23			
15	2			SMS	12			
15	3			SMS	29			
15	4			email, text-message	29	15	4 kbit/s	4 s
15	5			Chat, forum	1, 14			
15	6			Text-based Web access and short messaging	13			
15	7			SMS (including push advertising)	1, 14			
15	8			Advertising	14			
15	9			SMS	32	15		
16	1		Alarms, voice control	Alarms	9		8-64 kbit/s	
16	2			Voice control	9		8-64 kbit/s	
17	1	15	Voice messaging	Voice messaging	22		< 16 kbit/s	
17	2			Voice messages	1, 14		10 kbit/s	30 s
17	3			Voice messages	20			
18	1	20	Low priority e-mail, SMS, MMS	Low priority e-mail, SMS, MMS	9			
18	2			SMS and simple email	1, 14			
18	3			email management	14			
18	4			SMS	30			
18	5			Low priority e-mail, SMS, MMS	32	20		
19	1	19	Low priority e-mail, SMS, MMS, LBS	Low priority e-mail, SMS, MMS, LBS	20, 32	19		
19	2			Instant messages	9		8-64 kbit/s	
19	3			Messaging (data/voice/media)	9		8-64 kbit/s	
19	4			Instant messaging	14			
19	5			Instant messaging	1, 14			
20	1	13	Photo messages 1	Picture messaging	23			
20	2			MMS	25			
20	3			Multimedia messaging	12			

TABLE 65 (*continued*)

Sequence number of service	Sub sequence number in same service sequence number	SC of the service	Representative name of application/ service	Name of application/service	Doc. No. in Annex 2	SC *n*	Mean service bit rate	Average session duration
20	4			e-mail, with image	29	13	512 kbit/s	7.8 s
20	5			Multimedia messaging services	16			
20	6			Multimedia messaging	28			
21	1	18	Photo messages 2	MMS, photo (Video) messages	1, 14			
21	2			e-mail, business applications	20, 32			
22	1	13	Communication/ messaging(MMS/ IMS/SMS)	Communication/ messaging (MMS/IMS/SMS)	24		<2 Mbit/s	
23	1	14	MMS	MMS	5		128 kbit/s	60 s
23	2			MMS	20, 32	14		
23	3			MMS	30			
24	1	12	Video messaging	Video messaging	23			
24	2			MMS, (photo) video messages	1, 14			
24	3			e-mail, with video clip	29	12	4 Mbit/s	24 s
25	1	15	Communication/ Web browsing 1	Communication/ Web browsing	24			
26	1	13	Web browsing 2	Public information distribution	26			
26	2			Browsing	5		2 048 kbit/s	60 s
26	3			Web browsing	22		<2 Mbit/s	
26	4			Public safety service	22		<2 Mbit/s	
26	5			Internet-style web sites	1, 14			
26	6			Web browsing, shopping	14			
26	7			Web browsing	29	13	1.68 Mbit/s	1 s
26	8			Browsing (and buying) on E-commerce sites	1, 14			
26	9			Information search and retrieval	14			
26	10			Public information distribution	26			
26	11			Consumer and business mobile Internet	20			
26	12			Web browsing	9		144-512 kbit/s	
26	13			Medium multimedia/Web browsing	28			
26	14			Internet browsing	30			
27	1	14	Browsing 3	Browsing	5		128 kbit/s	60 s
28	1	12	Browsing 4	Browsing	5		32 768 kbit/s	60 s
28	2			Web browsing	22		< 30 Mbit/s	

TABLE 65 (*continued*)

Sequence number of service	Sub sequence number in same service sequence number	SC of the service	Representative name of application/ service	Name of application/service	Doc. No. in Annex 2	SC *n*	Mean service bit rate	Average session duration
28	3			Public safety service	22		< 30 Mbit/s	
29	1	11	Browsing 5	Browsing	5		32 768 kbit/s	60 s
29	2			Web browsing	22		30 to 100 Mbit/s/ 1 Gbit/s	
30	1	18	Business intranet/extranet	Business intranet/extranet	20, 32	18		
30	2			Medium multimedia/data access	28			
31	1	17	Mobile internet/intranet/ extranet 1	Mobile Internet/intranet/ extranet	20, 32	17		
32	1	16	Mobile internet/intranet/ extranet 2	Mobile Internet/intranet/ extranet	20, 32	16	20 Mbit/s	11.95-222.18 s
33	1	14	Lottery and bettting services	Simple games,lotteries, bets	1, 14			
33	2			Lottery and bettting services	26			
33	3			Bets and gambling	9		8-64 kbit/s	
34	1	13	Secure M-commerce, M-banking and business applications	Secure M-commerce, M-banking and business applications	20, 32	13		
34	2			Mobile commerce	22		<2 Mbit/s	
35	1	14	M-payment	Mobile payment	23			
35	2			Payment using mobile phone	12			
35	3			(Browsing and) buying on E-commerce sites	1, 14			
35	4			On-line banking and finance	1, 14			
35	5			e-market services	16			
35	6			M-payment	1, 14			
35	7			M-payment	14			
35	8			Financial commerce	24		<144 kbit/s	
35	9			M-Government	14			
35	10			Authentication (m-payment, m-wallet, m-ticket, m-key etc.)	9		8-64 kbit/s	
35	11			e-commerce	25			
35	12			M-banking	20, 32	14		
36	1	12	Mobile commerce	Mobile commerce	22		< 30 Mbit/s	
37	1	13	Public/electric-vote, E-government	Public/electric-vote, E-government	24		<2 Mbit/s	
38	1	17	ITS (navigation)	Location service	23			

TABLE 65 (*continued*)

Sequence number of service	Sub sequence number in same service sequence number	SC of the service	Representative name of application/ service	Name of application/service	Doc. No. in Annex 2	SC *n*	Mean service bit rate	Average session duration
38	2			Location-based service	25			
38	3			ITS (navigation)	29	17	4-9 Mbit/s	20-90 s
38	4			Navigation systems for vehicles	16			
38	5			Localized map download	9		2-5 Mbit/s	
38	6			Telematics (vehicle)	14			
38	7			Medium multimedia/ location-based services	28			
38	8			Location-based service	22		< 30 Mbit/s	
39	1		Location information service	Location information service	22		30 to 100 Mbit/s/ 1 Gbit/s	
40	1	14	Location based service/location search, navigation, traffic information, point of interest	Location discovery	14			
40	2			Navigation system	22		< 144 kbit/s	
40	3			Location-based service/location search, navigation, traffic information,point of interest	24		<144 kbit/s	
40	4			Downloading of geolocalized maps	1, 14			
40	5			Location based service/push advertising/Info	14			
40	6			Navigation/travel	14			
40	7			Location-based service/LBS	30			
41	1	13	Location base service/browsing	Location-based service/browsing	5		384 kbit/s	60 s
41	2			Navigation system	22		<2 Mbit/s	
41	3			Presence driven transfer	9		64-512 kbit/s	
41	4			Interactive geographical maps	9		64-512 kbit/s	
41	5			Localized datacast/beacons	9		64-512 kbit/s	
42	1	3	Mobile TV/Broadcast IP TV	Low resolution mobile TV	20, 32	3		
42	2			Mobile TV	20, 32	3		
42	3			IPTV broadcast TV	20, 32	3		

TABLE 65 (*continued*)

Sequence number of service	Sub sequence number in same service sequence number	SC of the service	Representative name of application/ service	Name of application/service	Doc. No. in Annex 2	SC *n*	Mean service bit rate	Average session duration
43	1	2	Mobile HDTV and video	Mobile HDTV and video	20, 32	2	20 Mbit/s	35 86.07-14 812.04 s
44	1	9	Internet radio	Internet radio	9		64-144 kbit/s	
44	2			Audio streaming	9		64-144 kbit/s	
44	3			Entertainment	22		< 144 kbit/s	
44	4			Listening to radio	30			
45	1	8	Video/audio/TV streaming	Listening to radio/ watching live TV	13			
45	2			Music listening, image viewing	13			
45	3			Online video services	12			
45	4			Streaming and downloading of audio/video	1, 14			
45	5			Internet radio	9		144-512 kbit/s	
45	6			Audio streaming	9		144-512 kbit/s	
45	7			Streamed video (sports events)	20			
45	8			IP radio	20			
45	9			Streaming	5		384 kbit/s	100 s
45	10			Audio/video on demand	16			
45	11			Video/audio/TV streaming	14			
45	12			Digital content	14			
45	13			Mobile entertainment	14			
45	14			Video streaming	29	8	1.6 Mbit/s	20 min
45	15			Multicast capabilities	16			
45	16			TV broadcast	14			
45	17			High-rate streaming	5		2 048 kbit/s	150 s
45	18			Entertainment	22		<2 Mbit/s	
45	19			Streaming service	22		<2 Mbit/s	
45	20			Medium multimedia/video streaming	28			
45	21			Video streaming	20			
45	22			Entertainment/ music (music streaming)	24		<2Mbit/s	
45	23			Watching live TV	30			
46	1	2	IP broadcast HDTV and video	IP broadcast HDTV and video	20, 32	2		
47	1	6	High volume streaming	High volume streaming	5		32 768 kbit/s	150 s
47	2			Entertainment on demand	22		30 to 100 Mbit/s/ 1 Gbit/s	

TABLE 65 (*continued*)

Sequence number of service	Sub sequence number in same service sequence number	SC of the service	Representative name of application/ service	Name of application/service	Doc. No. in Annex 2	SC *n*	Mean service bit rate	Average session duration
48	1	7	Entertainment/ movie (video streaming)	Real time video streaming	9		2-5 Mbit/s	
48	2			Entertainment/ movie (video streaming)	24		<30 Mbit/s	
48	3			Video streaming (normal)	9		5 Mbit/s	
48	4			Entertainment on demand	22		< 30 Mbit/s	
48	5			Video streaming and mobile TV	23			
48	6			Video streaming	20			
48	7			High volume streaming	5		32 768 kbit/s	150 s
48	8			Streaming service	22		< 30 Mbit/s	
49	1	7	Entertainment/ broadcasting programme (video streaming)	Entertainment/ broadcasting programme (video streaming)	24		<30 Mbit/s	
49	2			Video broadcasting	9		2-5 Mbit/s	
49	3			TV broadcast	25			
50	1	11	Game data download	Game downloads	1, 14			
50	2			Data downloading	16			
50	3			Download service, games	29	11	45 Mbit/s	17 s
51	1	11	Download service, e-Newspaper	Data downloading	16			
51	2			Download service, e-Newspaper	29	11	30 Mbit/s	8 s
52	1	12	Music download	Requesting single songs/albums	13			
52	2			Downloading of movies	12			
52	3			Data downloading	16			
52	4			Download service, music	29	12	10 Mbit/s	35 s
52	5			video and audio download	25			
52	6			MP3 transfer	25			
52	7			Music and video download	14			
52	8			Requesting single songs/albums	30			
53	1	13	Video streaming and download 1	Video streaming and download	20, 32	13		
54	1	12	Video streaming and download 2	Video streaming and download	20, 32	12	20 Mbit/s	7.17-59.25 s
54	2			Video streaming (archival)	9		30 Mbit/s	
54	3			Video download	9		<5 Mbit/s	

TABLE 65 (*continued*)

Sequence number of service	Sub sequence number in same service sequence number	SC of the service	Representative name of application/ service	Name of application/service	Doc. No. in Annex 2	SC *n*	Mean service bit rate	Average session duration
55	1	1	Download media	Download media	20			
56	1		Video upload	Video upload	9		<5 Mbit/s	
57	1	12	Interactive gaming 1	Gaming	13			
57	2			Network games	1, 14			
57	3			Mobile gaming	14			
57	4			Real time gaming	9		1-10 Mbit/s	
57	5			Multiplayer game	29	12	2.4 Mbit/s	0.01 s
57	6			Medium multimedia/online gaming	28			
58	1	8	Interactive gaming 2	Entertainment/ game(interactive game)	24		<2 Mbit/s	
58	2			Games download and networking	20	8		
59	1	4	Slow scan surveillance video/Industrial controls	Slow scan surveillance video/Industrial controls	20, 32	4		
60	1	10	Low data rate transaction e.g. RFID	Low data rate transaction e.g. RFID	20, 32	10		
61	1	9	Medium data rate monitoring and transactions	Medium data rate monitoring and transactions	20, 32	9		
62	1	19	Machine to machine services	Machine to machine services	1, 14			
62	2			Machine to machine services	14			
62	3			Sensors	9		8-64 kbit/s	
62	4			Telemetry service	22		< 144 kbit/s	
63	1	20	Telemetering	Telemetry and other machine to machine communications	14			
63	2			Sensor Networks and M2M	14			
63	3			Telemetering	29	20	12 kbit/s	1 s
63	4			Object Identification	14			
63	5			Low bandwidth M2M	23			
64	1	10	Health monitoring	Health monitoring	14			
64	2			Medical/ healthcare (surveillance) – Service monitoring application, interactive service for uploading medical data	29	10	5.2 kbit/s	60 min

TABLE 65 (*continued*)

Sequence number of service	Sub sequence number in same service sequence number	SC of the service	Representative name of application/ service	Name of application/service	Doc. No. in Annex 2	SC *n*	Mean service bit rate	Average session duration
65	1	8	Monitoring for uploading video data	(Medical/ healthcare/) Surveillance – Service monitoring application, for uploading video data	29	8	800 kbit/s	5 min
65	2			Medical monitoring service	22		<2 Mbit/s	
66	1	3	Telemedicine	Telemedicine	20, 32	3		
67	1	17	Health care/health check, remote diagnostics, medication information, medical data provision	Health care/health check, remote diagnostics, medication information, medical data provision	24		<30 Mbit/s	
67	2			Medical monitoring service	22		< 30 Mbit/s	
68	1	8	Exercise monitor and instruction	Exercise monitor, downloading exercise instruction or background music	29	8	256 kbit/s	60 min
69	1	14	Exercise monitor, uploading bio-medical or physical data	Exercise monitor, uploading bio-medical or physical data	29	14	69 kbit/s	60 min
69	2			Medical monitoring service	22		< 144 kbit/s	
70	1	5	e-learning, conversational service	M-education	14			
70	2			e-learning, conversational service	29	5	16 kbit/s	3 s
71	1	8	e-learning, video streaming service	M-education	14			
71	2			e-learning, video streaming service	29	8	2 Mbit/s	60 min
72	1	18	e-learning, background service	M-education	14			
72	2			e-learning, background service	29	18	2 Mbit/s	8 s
73	1	17	Life/education// remote monitor/control, information search, e-Learing, news/weather	Life/education// remote monitor/control, information search, e-Learing, news/weather	24		<30 Mbit/s	
74	1	17	P2P file transfer	P2P file transfer/ Background	29	17	15 Mbit/s	288 s
74	2			Peer-to-peer file sharing	9		<5 Mbit/s	
74	3			Access to databases and file systems	9		<5 Mbit/s	

TABLE 65 (*continued*)

Sequence number of service	Sub sequence number in same service sequence number	SC of the service	Representative name of application/ service	Name of application/service	Doc. No. in Annex 2	SC *n*	Mean service bit rate	Average session duration
75	1	14	Collaborative work including multimedia information exchange and file sharing	Collaborative work including (group videoconference,) exchange of multimedia information, and the sharing of files	1, 14		128 kbit/s	
75	2			Intranet access,VPN// Access to corporate databases	1, 14			
75	3			Corporate services	14			
75	4			Collaborative working (application sharing)	26			
75	5			File transfer	22		< 144 kbit/s	
75	6			Collaborative working (application sharing)	26			
76	1	13	Collaborative working (application sharing) 1	Collaborative working (application sharing)	26			
76	2			File transfer	22		<2 Mbit/s	
76	3			Access to corporate database (lightweight)	9		64-512 kbit/s	
76	4			Collaborative working (application sharing)	26			
76	5			Business applications	32	13		
77	1	12	Collaborative working (application sharing) 2	Collaborative work	9		2-5 Mbit/s	
77	2			Collaborative working (application sharing)	26			
77	3			High volume business applications	20, 32	12		
77	4			High bit rate data exchange	12			
77	5			File transfer	14			
77	6			File Transfer	22		< 30 Mbit/s	
77	7			Telepresence	9		1-10 Mbit/s	
77	8			P2P file transfer/ interactive	29	12	15 Mbit/s	288 s
78	1	2	Collaborative working (application sharing) 3	Collaborative working (application sharing)	26			
78	2			High volume business applications	20, 32	2		

TABLE 65 (*continued*)

Sequence number of service	Sub sequence number in same service sequence number	SC of the service	Representative name of application/ service	Name of application/service	Doc. No. in Annex 2	SC *n*	Mean service bit rate	Average session duration
79	1	7	High volume business applications	High volume business applications	20, 32	7		
80	1	12	High volume business applications and collaborative working (application sharing) 4	Collaborative working (application sharing)	26			
80	2			High volume business applications	20			
81	1	11	Collaborative working (application sharing) 5	Collaborative working (application sharing)	26			
81	2			Collaborate working	22		30 to 100 Mbit/s/ 1 Gbit/s	
81	3			Virtual computer networks	12			
81	4			High volume business applications and file transfer	32	11		
82	1	16	High volume business applications, file transfer and collaborative working (application sharing) 6	Collaborative working (application sharing)	26			
82	2			High volume business applications and file transfer	20, 32		500 Mbit/s	7.17-133.31 s
82	3			Database service	9		< 50 Mbit/s	
82	4			File system service	9		< 50 Mbit/s	
82	5			File Transfer	22		30 to 100 Mbit/s/ 1 Gbit/s	
83	1	16	High rate data transfer (upload/ download)	Delivery large numbers of presentation while mobile	13			
83	2			High rate data transfer (upload/download)	9		<50 Mbit/s	
84	1	17	Business applications 1	Business applications	20, 32	17		
85	1	16	Business applications 2	Business applications	20, 32	16		
85	2			Telematics with full multi-media in vehicle systems	23			
85	3			Remote office	12			
85	4			Collaborative work	9		10-50 Mbit/s	

TABLE 65 (*end*)

Sequence number of service	Sub sequence number in same service sequence number	SC of the service	Representative name of application/ service	Name of application/service	Doc. No. in Annex 2	SC *n*	Mean service bit rate	Average session duration
86	1		Personal/asset/ fleet tracking	Personal tracking	14			
86	2			Asset/fleet tracking	14			
87	1	15	ITS probe, back ground service	ITS probe, back ground service	29	15	3.2 kbit/s	1 s
88	1	13	ITS probe, interactive service	ITS probe, interactive service	29	13	300 k-1.6 Mbit/s	30 s
89	1	8	Observation/ surveillance by video camera (network-camera)	Tracking of moving objects and surveillance using imaging , multimedia downloading and viewing from mobile device	12			
89	2			Observation/ surveillance by video camera (network-camera)	29	8	1.6 Mbit/s	20 min
90	1	7	e-emergency rescue, streaming service	e-emergency rescue, streaming service	29	7	12 Mbit/s	2 100 s
91	1	12	Emergency/ disaster/disaster prediction/ notification, emergency information	Emergency/ disaster/disaster prediction/ notification, emergency information	24		<30 Mbit/s	
92	1	4	e-emergency rescue, wide-band conversational service	e-emergency rescue, wide-band conversational service	29	4	64 kbit/s	2 100 s
93	1		Robot security	Robot security	9		2-5 Mbit/s	
94	1	18	Consumer and business mobile Internet	Consumer and business mobile Internet	32	18		
95	1	15	Low rate data transmit e.g. monitoring	Low rate data transmit e.g. monitoring	20, 32	15		
96	1	3	Secured transactions (biometrics)	Secured transactions (biometrics)	20, 32	3		
97	1	3	IP Web radio	IP Web radio	32	3		