REPORT ITU-R M.2078

Estimated spectrum bandwidth requirements for the future development of IMT-2000 and IMT-Advanced

(2006)

1 Introduction

To achieve the objectives related to the further development of IMT-2000 and IMT-Advanced, additional spectrum bandwidth beyond that identified for IMT-2000 at WARC-92 and WRC-2000 may be required.

Recommendation ITU-R M.1645 describes in particular the expectations concerning the future development of IMT-2000 and IMT-Advanced:

In the framework of technological advances and introduction of IMT-2000 mobile radiocommunications, agreement on uniform and co-ordinated strategies and approaches in the ITU has been and will continue to be a prerequisite for worldwide success.

A prominent strategic decision by the ITU with regard to the development and introduction of IMT-2000 was the recognition and application of the principle of identifying harmonised frequency bands on a global basis with the aid of footnotes in the Radio Regulations.

The Radiocommunication Assembly 2003 adopted Recommendation ITU-R M.1645 on the "Framework and overall objectives for the future development of IMT-2000 and systems beyond IMT-2000". Special consideration was given to growing demand for wireless communications, which may result in higher data rates to meet user needs.

This Report provides results of technical studies on estimated spectrum requirements for the future development of IMT-2000 and for IMT-Advanced as defined by ITU-R, in accordance with Resolution 228 (Rev.WRC-03). The Report uses market data in the year 2010 onwards from external organisations outside ITU, which are addressed in Report ITU-R M.2072. The estimated spectrum requirements are calculated with the spectrum calculation methodology defined in Recommendation ITU-R M.1768. In the spectrum calculation for the future development of IMT-2000 and IMT-Advanced, new concepts were introduced, including a mix of services, multiple complementary systems, and Radio Access Techniques Groups (RATG). These were not used in the Recommendation ITU-R M.1390 for the additional spectrum calculation for IMT-2000.

The estimated total spectrum bandwidth requirement for both the RATG1 and RATG2 for the year 2020 is calculated in this Report to be 1 280 MHz (including spectrum already in use, or planned to be used, for RATG1). The calculations developed the estimated spectrum bandwidth requirements ranging from 1 280 MHz to 1 720 MHz (including spectrum already in use, or planned to be used, for RATG1) which represented a lower and higher market setting as developed from the data in Report ITU-R M.2072. It should be noted that this lower figure (1 280 MHz) is higher than the anticipated requirements for some countries which may have a need for less or no additional spectrum. In addition there are some countries where the requirement is larger than the higher value (1 720 MHz).

1.1 Service-related elements

User expectations are continually increasing with regard to the variety of services and applications. In particular, users will expect a dynamic, continuing stream of new applications, capabilities and services that are ubiquitous and available across a range of devices using a single subscription and a single identity (number or address). Versatile communication systems offering customized and ubiquitous services based on diverse individual needs will require flexibility in the technology in order to satisfy multiple demands simultaneously.

Multimedia traffic is increasing far more rapidly than speech, and will increasingly dominate traffic flows. There will be a corresponding change from predominantly circuit-switched to packet-based delivery. This change will provide the user with the ability to more efficiently receive multimedia services, including e-mail, file transfers, messaging and distribution services. These services can be either symmetrical or asymmetrical, and real-time or non real-time. They can consume high bandwidths, resulting in higher data rate requirements in the future.

Work has already begun on the convergence of telecommunication services such as digital broadcasting and commercial wireless services. The trend toward integration and convergence can be characterized by:

– connectivity (provision of a pipe, including intelligence in the network and the terminal);

– content (information, including push and pull services);

– commerce (transactions).

These trends may be viewed as the integration and convergence of information technology (IT), telecommunications, and content. This will result in new service delivery dynamics and a new paradigm in telecommunications where value added services, such as those which are location dependent, will provide enormous benefits to both the end users and the service providers.

Convergence of IT, media and telecommunications 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 point-to-point 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”. “(Reference: ITU Internet Reports 2004: The Portable Internet and ITU Internet Reports 2005: The Internet of Things.)”

Furthermore, “always on” communications will enable networked and interconnected devices providing relevant content and information whatever the location of the user. Although mobile data applications have brought Internet-like services to the pockets of many mobile phone users, future systems will not only include personal applications (e.g., cell phones), but also embedded services in inanimate objects that may be pervasive in nature.

1.2 Technology elements

Wireless communications comprises a wide range of technologies, services and applications that have come into existence to meet the particular needs of different market sectors and user environments. Different systems can be broadly characterized by:

– content and services offered;

– frequency bands of operation;

– standards defining the systems;

– data rates supported;

– bidirectional and unidirectional delivery mechanisms;

– degree of mobility;

– regulatory requirements; and

– cost.

Second generation systems were mainly designed for applications such as voice. IMT-2000 and IMT-Advanced will increasingly be designed as a combination of different radio access techniques to complement each other in an optimum way for different service requirements and radio environments. This will enable a common and flexible service platform for different services and applications.

Access to a service or an application may be performed using one system or may be performed using multiple systems simultaneously (e.g. a digital broadcast channel and a return channel using IMT-2000).

In the future operators may deploy a mix of technologies that could, at various stages in time and subject to market and regulatory considerations, incorporate cellular, wireless LAN, digital broadcast, satellite and other access systems. This will require the seamless interaction of these systems in order for the user to be able to receive a variety of content via a variety of delivery mechanisms depending upon the particular terminal capabilities, location and user profile.

Different radio access systems will be connected via flexible core networks. In this way, an individual user can be connected via a variety of different access systems to the networks and services he desires. The interworking between these different access systems in terms of horizontal and vertical handover and seamless service provision with service negotiation including mobility, security and QoS management will be a key requirement.

Such information is one key prerequisite for the estimation of frequency requirements for advanced wireless communications applications. However, most market studies undertaken to date tend to focus on the total communication market to be served by mobile and other advanced wireless services.

2 Scope

This Report:

a) deals only with IMT-relevant future mobile communication RATG(s) focusing on spectrum requirements for the preparation of WRC-07 Agenda item 1.4, while Recommendation ITU-R M.1645 provides the framework of a wider range of future mobile communication RATG(s) in the year 2010 onwards;

b) describes forecast traffic demands for future applications/services in overall mobile communication market in the year 2010 onwards, which may be supported by the capabilities of the future development of IMT-2000 and of IMT-Advanced;

c) duly considers the results of service and market forecast stated in Report ITU-R M.2072 for the traffic demand estimation;

d) determines the distribution ratio amongst RATGs in order to identify IMT-relevant traffic demands, taking into account the Report ITU-R M.2072;

e) identifies the RATG features that will be suitable for the future development of IMT-2000 and IMT-Advanced in the context of WRC-07 Agenda item 1.4;

f) refers to the methodology defined in Recommendation ITU-R M.1768;

g) describes parameters, relating both to market/service and radio aspect, and their values, some of which are provided by Reports ITU-R M.2072 and ITU-R M.2074 respectively;

h) provides the numerical results of the spectrum calculation together with input parameter values;

i) determines the amount of spectrum needed to support applications/services provided by the pre-IMT, IMT-2000, future development of IMT-2000 and IMT-Advanced;

j) this Report does not address the specific spectrum requirements relevant to the scenario of large coverage areas with low teledensity, and parameters relevant to this scenario are therefore not included.

3 Related ITU-R Recommendations and Reports

Recommendations:

ITU-R M.687	International Mobile Telecommunications-2000 (IMT-2000)
ITU-R M.819	International Mobile Telecommunications-2000 (IMT-2000) for developing countries
ITU-R M.1034	Requirements for the radio interface(s) for International Mobile Telecommunications-2000 (IMT-2000)
ITU-R M.1457	Detailed specification of the radio interfaces of International Mobile Telecommunications-2000 (IMT-2000)
ITU-R M.1645	Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000
ITU-R M.1768	Methodology for calculation of spectrum requirements for the future development of the terrestrial component of IMT-2000 and systems beyond IMT-2000
ITU-T Q.1702	Long-term vision of network aspects for systems beyond IMT-2000

Reports:

ITU-R M.2072	World mobile telecommunication market forecast
ITU-R M.2074	Radio aspects for the terrestrial component of IMT-2000 and systems beyond IMT-2000

4 Market trend of future mobile communication

Recommendation ITU-R M.1645 addresses the framework of future development of IMT-2000 and systems beyond IMT-2000.

Present mobile communication systems have evolved by continually adding additional system capabilities and enhancements, and the user will see a significant increase in capability through the future development of IMT-2000. IMT-Advanced 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.

Recommendation ITU-R M.1645 concluded that internationally agreed frequency bands will encourage in particular the adoption of IMT-Advanced systems. Common global spectrum should be the preferred objective to ensure global roaming and equipment-cost reduction through economies of scale.

To fulfil the above mentioned requirement, ITU-R developed and approved Question ITU-R 229/8 on the future development of IMT-2000 and IMT-Advanced. One element of the *decides* of this Question is the technical and operational characteristics needed to meet the requirements (such as utilization of identified frequency bands) for the ongoing enhancement of IMT-2000.

5 Radio access technique group (RATG) approach for spectrum estimation

5.1 RATG definition

Recommendation ITU-R M.1645 considers trends of users as well as of services and applications and identified three focussed capability areas:

a) capability of IMT-2000,

b) capability of new mobile access, and

c) capability of nomadic/local area wireless access, as shown in Fig. 2 of the Recommendation.

The b) and c) capability areas were recognised as new capabilities to be provided by IMT-Advanced systems.

The Recommendation also addresses a mix of services and multiple delivery mechanisms which convey the traffic of the services. Among these delivery mechanisms, some systems like IMT-2000 have detailed specification of their radio interfaces, while some new systems do not yet have detailed specifications for the radio interface(s).

It was decided that the spectrum calculation methodology for the future development of IMT-2000 and IMT-Advanced should have flexibility to handle both emerging technologies and well-characterized systems. Recommendation ITU-R M.1768 sets the guideline that the methodology should be *technology neutral and generic*. Accordingly, the concept of radio access technique groups (RATG) was introduced in Report ITU-R M.2074 in order to address both types of systems: one that does not yet have detailed specifications and others that have detailed specifications. Therefore, RATG can be defined as follows;

Radio access technique group (RATG): *a reference system model* that can best accommodate a particular area of capabilities identified in Fig. 2 of Recommendation ITU-R M.1645.

In other words, a RATG can be a generic reference model with minimum system specifications required to determine spectrum requirements. The RATG will be defined in more detail to be a Global Core Specification (GCS) at a later stage of standardization.

Spectrum requirement estimations need to take into account the relevant technologies. The basis for the grouping is the Agenda item 1.4, Resolution 228 (Rev.WRC-03) and Recommendation ITU-R M.1645.

The RAT Groups are the following:

– *Group 1*: Pre-IMT systems, IMT-2000 and its enhancements.
  – This group covers the cellular mobile systems, IMT-2000 systems and their enhancements.

– *Group 2*: IMT-Advanced as described in Fig. 2 of Recommendation ITU-R M.1645 (e.g., new mobile access and new nomadic/local area wireless access), but not including systems already described in any other RAT groups.

– *Group 3*: Existing radio LANs and their enhancements.

– *Group 4*: Digital mobile broadcasting systems and their enhancements.

– This group covers systems aimed at broadcasting to mobile and handheld terminals.

The justifications for each group are the following:

Group 1: The need for this RAT Group stems directly from the Agenda item 1.4 and Recommendation ITU-R M.1645. The proposal to include IMT-2000 and its future enhancements into a single RAT Group is in line with the M.1645 expectation that "there will be a steady and continuous evolution of IMT-2000 to support new applications, products and services", which is also confirmed by ongoing standardization activities.

Pre-IMT systems are included in RAT Group 1 for the following reasons:

– Pre-IMT systems cover a subset of the IMT-2000 services and therefore the corresponding traffic can be aggregated with IMT-2000 traffic.

– Most bands for pre-IMT-2000 technologies are identified for IMT-2000, and as such those bands will be taken into account in the estimations.

– Presence of pre-IMT systems can technically be taken into account by appropriate adjustments in radio parameters of RAT Group 1, e.g. the spectral efficiency, so that the value of each radio parameter is *representative* for all RATs in the group.

– The time span for the market data is beyond 2015, when significance of the pre-IMT systems may be decreasing in some countries or Regions. However, there will be differences in different countries and Regions with respect to the licensing, market development, migration to IMT-2000, etc. Covering such questions is not in the scope of WRC-07 Agenda item 1.4.

Group 2: The need for this RAT Group stems directly from Agenda item 1.4 and Recommendation ITU-R M.1645. IMT-Advanced will cover new mobile access and new nomadic/local area access capabilities. The motivation for a separate RAT group compared to Group 1 is that IMT-Advanced systems are expected to have significantly differing RAT characteristics and capabilities than IMT-2000 and its future developments.

Group 3: The need for taking this RAT Group into account comes from Recommendation ITU-R M.1645. IMT-2000 and IMT-Advanced are identified to have a relationship with RLAN's. It can be expected that existing RLAN's will share a portion of the relevant total traffic. WRC-03 identified globally common spectrum for RLAN's, which allows considerable capacity for such networks.

Group 4: The need for taking this RAT Group into account comes also from Recommendation ITU-R M.1645 as well as from the fact that new mobile broadcasting services based on technologies such as IP datacast are expected to emerge in the coming years. These services will provide point-to-multipoint services that cover part of the total mobile market.

5.2 RATG approach to determine spectrum requirements

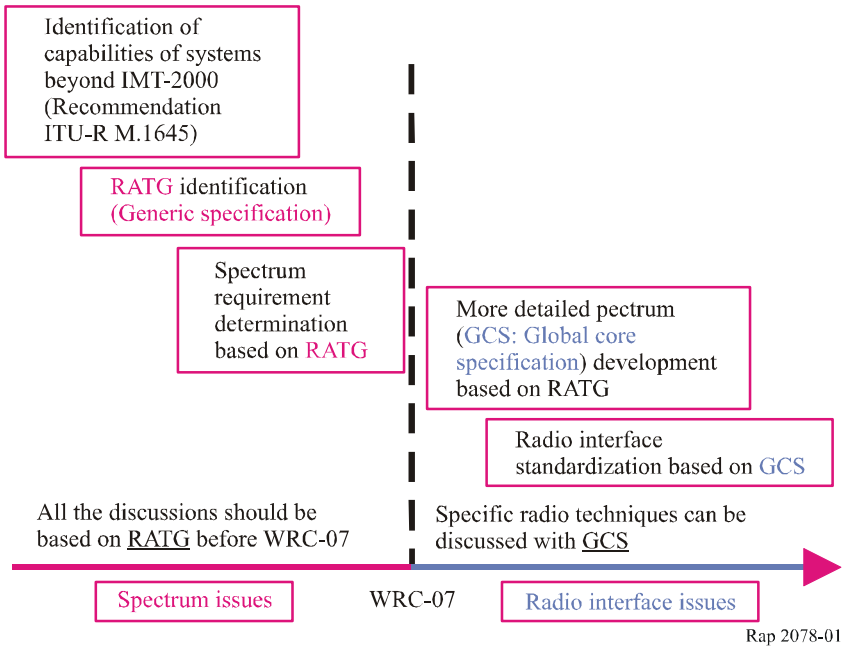
With the introduction of the RATG concept, spectrum requirement issues and radio interface issues, in regards to timeframes can be separately discussed. It is generally known that the amount of spectrum needed for a particular system is based on some system parameters but not all the system parameters which characterise the system. Since a RATG has some system parameters which are technology-neutral but indispensable for spectrum requirements determination, it is possible to consider spectrum requirements for RATG(s) without determining the full set of system parameters (including technology-dependent parameters). This is very beneficial and practical for spectrum requirement considerations, because it may take some time for the identified spectrum to be available and spectrum identification should be performed well in advance of the system deployment.

On the contrary, from the radio interface perspective, it is better to employ the latest technology when developing radio interface standards because the latest techniques would contribute to the improvement of spectrum efficiency. The conflict of the early spectrum identification and the latest technology adoption can be solved by introducing the concept of RATGs, i.e. we can discuss spectrum requirements by using generic and technologically-neutral RATG at first, then we can make the RATG detailed specifications later as a GCS and discuss radio interface techniques with the GCS, as shown in Fig. 1.

Therefore, it was decided to determine spectrum requirements based on RATGs but not specific systems before WRC-07.

FIGURE 1

Two step approach for the future development of IMT-2000 and for IMT-Advanced



6 Time shift approach to global common market

In this Report the spectrum requirements are calculated for RAT Group 1 and RAT Group 2 in three different forecast years, i.e. 2010, 2015 and 2020. The spectrum requirements are calculated with the methodology presented in Recommendation ITU-R M.1768 using the set of input parameter values which is given in § 7.

The spectrum calculation is based on “global common market” presented in Report ITU-R M.2072 which characterises the future mobile market in 2010, 2015 and 2020. Report ITU-R M.2072 defines ranges for the market parameters while the spectrum calculations require unique values for the different input parameters.

There are regional differences in the market development, i.e. in some parts of the world a particular level of market development may be reached earlier or later than in the (average) “global common market”. To characterize the difference in the market development and RAT Group deployment scenarios in different countries, the time shift approach is used to calculate the spectrum requirements. With this approach, unique sets of market parameter values are derived from Report ITU-R M.2072 for 2010, 2015 and 2020. Due to the regional differences in the market

development, the parameter sets are interpreted to be valid in different countries at different time intervals.

Using the unique market prediction sets for 2010, 2015 and 2020, the spectrum requirements can be calculated to a default scenario, called “middle” scenario. From these three Market predictions/ spectrum requirements two different additional scenarios, i.e. “earlier” and “later”, are derived. These two additional scenarios show the time shift market utilisation in different densely populated countries. These additional scenarios “earlier” and “later”, together with “middle” scenario characterise the different speed of system deployment and market development in different areas.

This approach and all the scenarios predict that in different time scale the predicted market will saturate to similar situation in different densely populated countries. The early identification of IMT-Advanced spectrum to support the “saturated” mobile market brings additional benefits. Even if the identification would take place in WRC-07, the time scale of the usage of available spectrum might differ between different administrations e.g. according different chosen time scenarios.

Figure 2 shows the time shift approach on conceptual level. Some countries, wishing to implement future mobile systems as early as possible, would have a view of the system deployment as depicted in blue (top) line. This kind of deployment and market setting would refer to “earlier” market scenario. Some other countries would have deployment and market setting referred “middle” scenario shown in light blue (middle) line. This would be the default setting for spectrum requirement calculations. Those countries whose market development and/or system deployment is assumed to develop slower would have view shown in magenta (bottom) line, this is referred as “later” scenario. The allocation of identified spectrum might differ from market prediction. This difference is assumed to be mostly apparent between year index 2010 and 2015. Thus the trends of spectrum requirements between “2010” and “2020” are marked with dashed line.

FIGURE 2

System deployment scenarios different in time domain and consequential required spectrum (conceptual example)

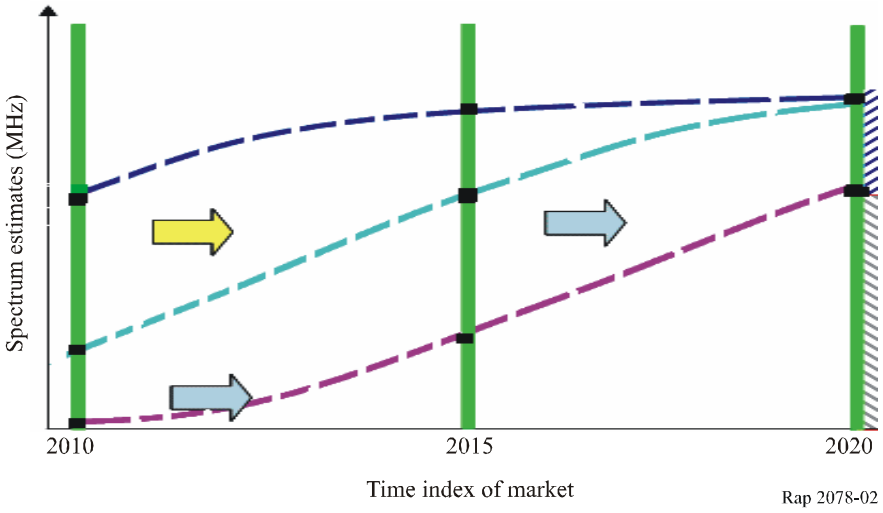


Figure 2 shows how the three example scenarios in three country groups have different shifted time scenarios starting in different time point, e.g. difference by 5 years. All three groups have same system deployment scenario assumption, regardless of starting time, which can be seen in the shape of the curves.

7 Elements to be used for spectrum calculation

7.1 Service elements of the estimate

7.1.1 Service categories

A service category (SC) is defined as a combination of service type and traffic class as shown in Table 1.

TABLE 1

Service categorization

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.

7.1.2 Service environments

Service environments are defined for the following combinations of teledensity and service usage patterns as shown in Table 2.

TABLE 2

The identification of service environments

Teledensity / Service usage pattern	Dense urban	Sub-urban	Rural
Home	SE 1	SE 4	SE6
Office	SE 2	SE 5	
Public area	SE 3		

7.1.3 Service category parameters

Service categories are characterised with parameters which are obtained either from market studies or from other sources. The following parameters are obtained from Report ITU-R M.2072:

1 User density (users/km^2).

2 Session arrival rate per user (sessions/(s*user)).

3 Mean service bit rate (bit/s).

4 Mean session duration (s/session).

5 Mobility ratio.

The first four parameters characterise the demand of different service categories, while the mobility parameter is used in traffic distribution. Terminal mobility is closely related to application usage scenarios. In market studies in Report ITU-R M.2072, the mobility classes are categorized as follows:

1) Stationary (0 km/h)

2) Low (> 0 km/h and < 4 km/h)

3) High (> 4 km/h and < 100 km/h)

4) Super-high (>100 km/h and < 250 km/h)

The range limits of the categories should be related to typical characteristics of cellular radio networks. For application of the mobility classes in the methodology, the mobility classes from market studies are re-interpreted as follows:

1) Stationary/pedestrian (0 – 4 km/h)

2) Low (> 4 km/h and < 50 km/h)

3) High (> 50 km/h)

The traffic of the "high" mobility class obtained from market studies is split into the "low" and "high" mobility classes for the methodology. The splitting needs to take into account the attributes of the considered service environments which can result in different splitting factors J_m in different service environments m. The mapping of traffic to the mobility classes is presented in Tables 3 and 4.

TABLE 3

Mapping of mobility class

Mobility in market study	Mobility in methodology
Stationary	Stationary/pedestrian
Low	
High	Low (fraction J_m)
	(fraction 1 – J_m) High
Super-high	

TABLE 4

***J*-values for mapping of mobility classes in different service environments**

Service environment m	J_m -value
1	1
2	1
3	1
4	1
5	0.5
6	0

The values for the service category parameters that are obtained from market studies are presented in § 7.2. In addition to the market related service category parameters, the methodology's capacity calculation algorithms require parameters which are not obtainable from Report ITU-R M.2072. Different parameters are needed for circuit switched and packet switched service categories. For service categories treated as circuit switched the required parameter values are listed in Table 5.

The quality of service used in the tele-traffic models can have a noticeable impact on the spectrum requirement. The current values chosen must reflect the performance to be expected.

TABLE 5

Service category parameters: Common for traffic class of circuit-switched traffic for years 2010, 2015 and 2020

Parameter	Traffic class	
	Conversational	**Streaming**
	SC1 – SC5	SC6 – SC10
Blocking probability	0.01	0.01

For packet switching the required parameter values are given in Tables 6 to 8, Tables 9 to 11 and Tables 12 to 14 for 2010, 2015 and 2020, respectively. Values are only specified for the service categories that will be subject to the packet-switched capacity calculation as defined by Recommendation ITU-R M.1768, i.e., for service categories 11-20.

TABLE 6

Mean IP packet size per service category for the year 2010 (unit: byte)

Traffic class / **Service type**	**Conversational**	**Streaming**	**Interactive**	**Background**
Super-high multimedia	Treated as circuit-switched	Treated as circuit-switched	1114.00	853.83
High multimedia	Treated as circuit-switched	Treated as circuit-switched	1 345.78	1 111.54
Medium multimedia	Treated as circuit-switched	Treated as circuit-switched	790.59	1 114.00
Low rate data and low multimedia	Treated as circuit-switched	Treated as circuit-switched	92.86	207.00
Very low rate data	Treated as circuit-switched	Treated as circuit-switched	44.76	207.00

TABLE 7

Second moment of the IP packet size per service category for the year 2010 (unit: byte²)

Traffic class / Service type	Conversational	Streaming	Interactive	Background
Super-high multimedia	Treated as circuit-switched	Treated as circuit-switched	1 549 475.00	1 132 635.50
High multimedia	Treated as circuit-switched	Treated as circuit-switched	1 988 453.75	1 545 450.23
Medium multimedia	Treated as circuit-switched	Treated as circuit-switched	1 019 787.76	1 549 475.00
Low rate data and low multimedia	Treated as circuit-switched	Treated as circuit-switched	17 884.41	182 513.50
Very low rate data	Treated as circuit-switched	Treated as circuit-switched	6 381.06	182 513.50

TABLE 8

Mean delay requirements per service category for the year 2010 (unit: s)

Traffic class / Service type	Conversational	Streaming	Interactive	Background
Super-high multimedia	Treated as circuit-switched	Treated as circuit-switched	0.2971	0.0648
High multimedia	Treated as circuit-switched	Treated as circuit-switched	0.0867	0.2131
Medium multimedia	Treated as circuit-switched	Treated as circuit-switched	0.9333	8.9120
Low rate data and low multimedia	Treated as circuit-switched	Treated as circuit-switched	2.7813	4.9444
Very low rate data	Treated as circuit-switched	Treated as circuit-switched	0.4224	44.5000

TABLE 9

Mean IP packet size per service category for the year 2015 (unit: byte)

Traffic class / Service type	Conversational	Streaming	Interactive	Background
Super-high multimedia	Treated as circuit-switched	Treated as circuit-switched	3 271.62	3 054.00
High multimedia	Treated as circuit-switched	Treated as circuit-switched	772.75	3 372.92
Medium multimedia	Treated as circuit-switched	Treated as circuit-switched	1 787.18	3424.00
Low rate data and low multimedia	Treated as circuit-switched	Treated as circuit-switched	103.86	235.50
Very low rate data	Treated as circuit-switched	Treated as circuit-switched	45.74	235.50

TABLE 10

Second moment of the IP packet size per service category for the year 2015 (unit: byte^2)

Traffic class / Service type	Conversational	Streaming	Interactive	Background
Super-high multimedia	Treated as circuit-switched	Treated as circuit-switched	27 378 193.49	20 332 660.50
High multimedia	Treated as circuit-switched	Treated as circuit-switched	5 942 936.47	28 236 339.72
Medium multimedia	Treated as circuit-switched	Treated as circuit-switched	14 849 326.83	28 667 000.00
Low rate data and low multimedia	Treated as circuit-switched	Treated as circuit-switched	154 415.82	1 827 768.50
Very low rate data	Treated as circuit-switched	Treated as circuit-switched	20 157.67	1 827 768.50

TABLE 11

Mean delay requirements per service category for the year 2015 (unit: s)

Traffic class / Service type	Conversational	Streaming	Interactive	Background
Super-high multimedia	Treated as circuit-switched	Treated as circuit-switched	0.1490	0.0648
High multimedia	Treated as circuit-switched	Treated as circuit-switched	0.1019	0.4968
Medium multimedia	Treated as circuit-switched	Treated as circuit-switched	0.7461	13.6960
Low rate data and low multimedia	Treated as circuit-switched	Treated as circuit-switched	4.9444	4.9444
Very low rate data	Treated as circuit-switched	Treated as circuit-switched	0.4224	44.5000

TABLE 12

Mean IP packet size per service category for the year 2020 (unit: byte)

Traffic class / Service type	Conversational	Streaming	Interactive	Background
Super-high multimedia	Treated as circuit-switched	Treated as circuit-switched	3 292.23	3 054.00
High multimedia	Treated as circuit-switched	Treated as circuit-switched	1 847.82	3 307.86
Medium multimedia	Treated as circuit-switched	Treated as circuit-switched	1 021.60	1 369.33
Low rate data and low multimedia	Treated as circuit-switched	Treated as circuit-switched	102.56	235.50
Very low rate data	Treated as circuit-switched	Treated as circuit-switched	47.61	235.50

TABLE 13

Second moment of the IP packet size per service category for the year 2020 (unit: byte²)

Traffic class / Service type	Conversational	Streaming	Interactive	Background
Super-high multimedia	Treated as circuit-switched	Treated as circuit-switched	27 552 481.16	20 332 660.50
High multimedia	Treated as circuit-switched	Treated as circuit-switched	15 349 865.20	27 691 445.33
Medium multimedia	Treated as circuit-switched	Treated as circuit-switched	6 592 429.07	11 523 733.33
Low rate data and low multimedia	Treated as circuit-switched	Treated as circuit-switched	138 595.74	1 827 768.50
Very low rate data	Treated as circuit-switched	Treated as circuit-switched	36 019.39	1 827 768.50

TABLE 14

Mean delay requirements per service category for the year 2020 (unit: s)

Traffic class / Service type	Conversational	Streaming	Interactive	Background
Super-high multimedia	Treated as circuit-switched	Treated as circuit-switched	0.1490	0.0648
High multimedia	Treated as circuit-switched	Treated as circuit-switched	0.1019	0.4968
Medium multimedia	Treated as circuit-switched	Treated as circuit-switched	1.5280	2.9670
Low rate data and low multimedia	Treated as circuit-switched	Treated as circuit-switched	2.7813	4.9444
Very low rate data	Treated as circuit-switched	Treated as circuit-switched	0.4224	44.5000

7.1.4 Radio environment parameters

Tables 15a) and 15b) show the cell/sector area per radio environment, without and with penetration loss respectively. The penetration losses of 18, 15, 12 dB are used for dense urban, sub-urban and rural in the calculation. Table 16 shows the population coverage percentage of the radio environments in each service environment. The population coverage percentage values are given separately for the three different forecast years.

TABLE 15

Assumed cell area per radio environment (km^2)

a) Without penetration loss

Radio environment	Teledensity		
	Dense urban	Sub-urban	Rural
Macro cell	0.65	0.65	0.65
Micro cell	0.10	0.10	0.10
Pico cell	0.0016	0.0016	0.0016
Hot spot	0.00065	0.00065	0.00065

b) With penetration loss

Radio environment	Teledensity		
	Dense urban	Sub-urban	Rural
Macro cell	0.10	0.15	0.22
Micro cell	0.07	0.10	0.15
Pico cell	0.0016	0.0016	0.0016
Hot spot	0.00065	0.00065	0.00065

TABLE 16

Population coverage percentage (%) of the radio environments in each service environment in 2010, 2015 and 2020, respectively

Service environment	Radio environments 2010			
	Macro cell	Micro cell	Pico cell	Hot spot
1	100	90	0	80
2	100	90	20	80
3	100	95	20	10
4	100	15	0	80
5	100	40	35	20
6	100	0	10	50
Service environment	**Radio environments 2015**			
	Macro cell	**Micro cell**	**Pico cell**	**Hot spot**
1	100	90	10	80
2	100	90	20	80
3	100	95	30	25
4	100	35	0	80
5	100	50	35	20
6	100	0	10	50

TABLE 16 (*end*)

Service environment	Radio environments 2020			
	Macro cell	Micro cell	Pico cell	Hot spot
1	100	90	20	80
2	100	90	20	80
3	100	95	40	40
4	100	35	0	80
5	100	50	35	20
6	100	0	10	50

The radio environments are characterised by the relation between Service environments and radio deployment schemes e.g. micro cellular deployment is considered unfeasible in rural service environment, because no below roof-top-deployment can be accomplished.

7.2 Market overview and forecasted overall traffic

It is recognised that different countries will have different market environments.

These are due to differences in the demographics and differences in the maturity of the markets of the different countries. The differences of demographics of different countries are taken into account by considering the user density values. The differences in the maturity of the markets are taken into account by considering a time shift approach.

The specific values of the parameters below are determined for each service category (SC) and for each service environment (SE) based on Report ITU-R M.2072.

a) Number of subscribers (Market scale) (users/km^2)

b) Number of session attempts per user per time (1/user/s)

c) Mean service bit rate (bit/s)

d) Average session duration (s)

e) Mobility ratio (stationary/low/high/super-high)

These parameters are obtained from the responses to the questionnaire on services and markets from 27 organizations, which can be referenced in Annex 2 of Report ITU-R M.2072. Report ITU-R M.2072 suggests ranges of parameters for each of the following years 2010, 2015, and 2020. The detailed information on these parameters including the ranged values for these parameters can be referenced in § 8 “Market related parameters for spectrum calculation” and Annex 4 of Report ITU-R M.2072. Further information, such as the method to obtain these values, can also be referenced in Report ITU-R M.2072[1].

[1] The averaging process used in the Report ITU-R M.2072 to derive the traffic characteristics for each service category can result in an under-estimation of the spectrum requirement if any of the contributory services have a significantly higher service rate than the average. This will only be important for circuit switched traffic in the highest service category.

The unique values for the market parameters selected from the ranges given in Report ITU-R M.2072 are determined with percentage values (0-100) for parameters a) to d). Percentage value 0 means the minimum value inside the range defined by Report ITU-R M.2072 and 100 means the maximum value inside the range defined by Report ITU-R M.2072. For the mobility ratios three scenarios are considered: lowest (1), medium (2) and highest mobility scenario (3).

Separate tables are given to represent lower user densities and higher user densities. The values for the market settings were chosen to follow a basic approach of using the same percentage value in all service categories for parameters Q: session arrival rate per user, R: mean service bit rate, μ: average session duration, in order to preserve the proportions and between service categories and trends over time foreseen by the Report ITU-R M.2072.

The percentages for the market parameters and the selected mobility scenarios are shown in Tables 17a and 17b. Note that SCs that do not have a range in Report ITU-R M.2072 are not affected by using different market setting values. These are marked with the note "(No range M.2072)" in the tables below. The exact values for the market parameters in Table 17 are shown in Annex 1.

TABLE 17a

Market attributes in year 2010, 2015, 2020 for lower user densities

SC	*U* (%)	*Q* (%)	*R* (%)	*M* (%)	Mobility ratio
1	5	30	30	30	2 (No range M.2072)
2	5	30	30	30	2
3	5	30	30	30	2
4	5	30	30	30	2
5	5	30	30	30	2
6	5	30	30	30	2 (No range M.2072)
7	5	30	30	30	2
8	5	30	30	30	2
9	5	30	30	30	2 (No range M.2072)
10	5	30	30	30	2
11	5	30	30	30	1
12	5	30	30	30	2
13	5	30	30	30	2
14	5	30	30	30	2
15	5	30	30	30	2
16	5	30	30	30	2 (No range M.2072)
17	5	30	30	30	2
18	5	30	30	30	2 (No range M.2072)
19	5	30	30	30	2 (No range M.2072)
20	5	30	30	30	2

TABLE 17b

Market attributes in year 2010, 2015, 2020 for higher user densities

SC	*U* (%)	*Q* (%)	*R* (%)	μ (%)	Mobility ratio
1	25	30	30	30	2 (No range M.2072)
2	25	30	30	30	2
3	25	30	30	30	2
4	25	30	30	30	2
5	25	30	30	30	2
6	25	30	30	30	2 (No range M.2072)
7	25	30	30	30	2
8	25	30	30	30	2
9	25	30	30	30	2 (No range M.2072)
10	25	30	30	30	2
11	25	30	30	30	1
12	25	30	30	30	2
13	25	30	30	30	2
14	25	30	30	30	2
15	25	30	30	30	2
16	25	30	30	30	2 (No range M.2072)
17	25	30	30	30	2
18	25	30	30	30	2 (No range M.2072)
19	25	30	30	30	2 (No range M.2072)
20	25	30	30	30	2

7.3 RATG specification required for spectrum estimation

7.3.1 Radio parameters for spectrum calculation methodology

Tables 18 to 21 introduce input parameters of RAT Groups 1, 2, 3 and 4, respectively.

TABLE 18

Radio parameters for RATG 1

Parameters	Macro cell	Micro cell	Pico cell	Hot spot
Application data rate (Mbit/s)	20	40	40	–
Supported mobility classes	Stationary/ pedestrian, low, high	Stationary/ pedestrian, low	Stationary/ pedestrian	–
Guard band between operators (MHz)	0			–
Minimum deployment per operator per radio environment (MHz)	40	40	40	–
Support for multicast	Yes			–
Number of overlapping network deployment	1			

TABLE 19

Radio parameters for RATG 2

Parameters	Macro cell	Micro cell	Pico cell	Hot spot
Application data rate (Mbit/s)	50	100	1 000	1 000
Supported mobility classes	Stationary/ pedestrian, low, high	Stationary/ pedestrian, low	Stationary/ pedestrian	Stationary/ pedestrian
Guard band between operators (MHz)	0			
Support for multicast	Yes			
Minimum deployment per operator per radio environment (MHz)	20	20	120	120
Number of overlapping network deployment	1			

TABLE 20

Radio parameters for RATG 3

Parameters	Macro cell	Micro cell	Pico cell	Hot spot
Application data rate (Mbit/s)	–	–	50	100
Supported mobility classes	–	–	Stationary/ pedestrian	Stationary/ pedestrian
Support for multicast (yes=1, no=0)	Yes			

NOTE 1 – The above values were taken out of the Report ITU-R M.2074.

TABLE 21

Radio parameters for RATG 4

Parameters	Macro cell
Application data rate (Mbit/s)	2
Supported mobility classes	Stationary/pedestrian, low, high

7.3.2 Spectrum efficiency matrix

The area spectral efficiency is used in the spectrum requirement calculations to convert the capacity requirements in terms of bit/s/cell to the spectrum requirements in Hz. The area spectral efficiency factors should be measured below the IP layer and/or above L2. The spectral efficiency includes all RAT specific overheads, retransmissions load, scheduling, etc. Even though for several teledensities the spectral efficiency might be the same, it is possible that the spectral efficiency will also vary between teledensities.

The spectral efficiency values for RAT Group 1 are shown in Table 22. They are based on figures that have been proposed for the long term evolution of IMT-2000 technologies. The spectral efficiency values for RAT Group 2 are assumed to be dependent on the forecast year. The values for RAT Group 2 in 2010, 2015 and 2020 are shown in Tables 23a to 23e, respectively.

TABLE 22a

Area spectral efficiency RAT Group 1 2010 (bit/s/Hz)

Unicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	1	2	2	–
Suburban	1	2	2	–
Rural	1	2	2	–

Multicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	0.5	1	1	–
Suburban	0.5	1	1	–
Rural	0.5	1	1	–

TABLE 22b

Area spectral efficiency RAT Group 1 2015 (bit/s/Hz)

Unicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	1.5	3	3	–
Suburban	1.5	3	3	–
Rural	1.5	3	3	–

Multicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	0.75	1.5	1.5	–
Suburban	0.75	1.5	1.5	–
Rural	0.75	1.5	1.5	–

TABLE 22c

Area spectral efficiency RAT Group 1 2020 (bit/s/Hz)

Unicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	2	4	4	–
Suburban	2	4	4	–
Rural	2	4	4	–

Multicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	1	2	2	–
Suburban	1	2	2	–
Rural	1	2	2	–

Table 23a is based on simulation results of wireless technologies known in 2006 and expected to be implemented in 2010. Table 23e is derived from theoretical limits (Shannon's Theorem) allowing an estimated margin for implementation. Tables 23b to 23 d represent possible evolution paths within the values shown in Tables 23a and 23e.

TABLE 23a

Area spectral efficiency RAT Group 2 in year 2010

Unicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	2	2.5	3	5
Suburban	2	2.5	3	5
Rural	2	2.5	3	5

Multicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	1	1.2	1.5	2.5
Suburban	1	1.2	1.5	2.5
Rural	1	1.2	1.5	2.5

TABLE 23b

Area spectral efficiency RATG 2 in year 2015 (Set 1)

Unicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	4.25	5.5	7	8.25
Suburban	4.25	5.5	7	8.25
Rural	4.25	5.5	7	8.25

Multicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	2.125	2.75	3.5	4.125
Suburban	2.125	2.75	3.5	4.125
Rural	2.125	2.75	3.5	4.125

TABLE 23c

Area spectral efficiency RATG 2 in year 2015 (Set 2)

Unicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	4	5.25	6.5	7.5
Suburban	4	5.25	6.5	7.5
Rural	4	5.25	6.5	7.5

Multicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	2.0	2.625	3.25	3.75
Suburban	2.0	2.625	3.25	3.75
Rural	2.0	2.625	3.25	3.75

TABLE 23d

Area spectral efficiency RATG 2 in year 2020 (Set 1)

Unicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	4.5	6	7.5	9
Suburban	4.5	6	7.5	9
Rural	4.5	6	7.5	9

Multicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	2.25	3	3.75	4.5
Suburban	2.25	3	3.75	4.5
Rural	2.25	3	3.75	4.5

TABLE 23e

Area spectral efficiency RATG 2 in year 2020 (Set 2)

Unicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	6	8	10	10
Suburban	6	8	10	10
Rural	6	8	10	10

Multicast area spectral efficiency (bit/s/Hz/cell)

Tele-density	Radio environments			
	Macro cell	Micro cell	Pico cell	Hot spot
Dense urban	3	4	5	5
Suburban	3	4	5	5
Rural	3	4	5	5

7.4 Distribution ratios among available RAT groups

The RAT groups distribution ratio depends on the available RATs in each radio environment and service environment. Of the total traffic that goes to a particular radio environment, the distribution to the RAT groups is as defined in Recommendation ITU-R M.1768. This contains the distribution ratios among available RAT groups. The distribution ratios are given separately for each of the 3 years 2010, 2015 and 2020, because with progressing market introduction of RATG members a shift in traffic distribution towards more modern RATGs can be expected. The values are shown in Tables 24a to 24c for 2010, 2015 and 2020.

TABLE 24a

Distribution ratios among available RAT groups in 2010

Available RAT groups	Distribution ratio (%)		
	RATG 1	RATG 2	RATG 3
1	100	–	–
2		100	
3	–	–	100
1, 2	100	0	-
1, 3	30	–	70
2, 3	–	0	100
1, 2, 3	30	0	70

TABLE 24b

Distribution ratios among available RAT groups in 2015

Available RAT groups	Distribution ratio (%)		
	RATG 1	RATG 2	RATG 3
1	100	–	–
2		100	
3	–	–	100
1, 2	50	50	-
1, 3	20	–	80
2, 3	–	30	70
1, 2, 3	20	20	60

TABLE 24c

Distribution ratios among available RAT groups in 2020

Available RAT groups	Distribution ratio (%)		
	RATG 1	RATG 2	RATG 3
1	100	–	–
2		100	
3	–	–	100
1, 2	10	90	-
1, 3	10	–	90
2, 3	–	50	50
1, 2, 3	10	45	45

8 Spectrum requirements of the IMT-related RAT Groups

The spectrum requirements are calculated for RAT Group 1 (i.e. pre-IMT, IMT-2000, and its enhancements) and RAT Group 2 (i.e. IMT-Advanced) in 2010, 2015 and 2020. The spectrum requirements are calculated with the time shift approach described in § 6 using the input parameter values given in § 7. The input parameter values from § 7 are used to calculate the spectrum requirements for default "middle" scenario. The results for "later" and "earlier" scenario are derived by shifting the results from the "middle scenario".

Table 25 shows the spectrum requirements for the average level of market development. There are expected to be regional differences in the market development, i.e. and some parts of the world a particular level of market development may be reached earlier or later than in the (average) "global common market". This is described as the "time shift approach" (see § 6).

TABLE 25

Predicted spectrum requirements for both RATG 1 and RATG 2 (MHz)

Market setting	Spectrum requirement for RATG 1			Spectrum requirement for RATG 2			Total spectrum requirement		
	y2010	y2015	y2020	y2010	y2015	y2020	y2010	y2015	y2020
Higher market metting	**840**	**880**	**880**	**0**	**420**	**840**	**840**	**1 300**	**1 720**
Lower market setting	**760**	**800**	**800**	**0**	**500**	**480**	**760**	**1 300**	**1 280**

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Tables 26a) and b) represent the middle scenario of the time shift approach.

TABLE 26

Ranges of predicted spectrum requirements (MHz)

a) Lower user density market development

	1 network (see Note 3)	2 networks (see Note 1)	3 networks (see Note 1)	4 networks (see Note 1)	5 networks (see Note 1)
RATG 1 (see Note 2)	800	880	840	1 120	1 000
RATG 2	480	560	720	800	1 000
RATG 1 + RATG 2	1 280	1 440	1 560	1 920	2 000

TABLE 26 (*end*)

b) Higher user density market development

	1 network (see Note 3)	**2 networks (see Note 1)**	**3 networks (see Note 1)**	**4 networks (see Note 1)**	**5 networks (see Note 1)**
RATG 1 (see Note 2)	880	880	960	1 120	1 200
RATG 2	840	880	1 020	1 120	1 300
RATG 1 + RATG 2	1 720	1 760	1 980	2 240	2 500

NOTE 1 – When more than one network is present in a country the total spectrum requirement may be higher in order to account for packaging the spectrum (integer multiples of 40 MHz for RATG1).

NOTE 2 – The spectrum estimate for RATG1 for the year 2010 may seem high when considering current network deployments. However, the total estimation was performed using a process established by Recommendation ITU-R M.1768 and technical characteristics predicted for RATG1 in the evolution of IMT-2000 technologies. Furthermore there is not enough statistical market data to predict the exact requirements for RATG1.

NOTE 3 – It should be noted that in Recommendation ITU-R M.1768 and Report ITU-R M.2074 the associated terminology relating to the term 'Network' is the term 'number of overlapping network deployments'.

9 Conclusions

This report presents the results of the calculation of spectrum requirements for RAT Group 1 (i.e. pre-IMT, IMT-2000, and its enhancements) and RAT Group 2 (i.e. IMT-Advanced) in 2010, 2015 and 2020.

This report uses the spectrum calculation methodology presented in the Recommendation ITU-R M.1768 and defines values for all the input parameters needed for spectrum calculations. The spectrum requirements have been calculated for two RAT Groups in the years 2010, 2015 and 2020.

The predicted total spectrum bandwidth requirement for both the RATG 1 and RATG 2 for the year 2020 is calculated in this Report to be 1 280 MHz (including spectrum already in use, or planned to be used, for RATG 1[2]). The calculations developed the spectrum bandwidth requirements ranging from 1 280 MHz to 1 720 MHz (including spectrum already in use, or planned to be used, for RATG 1[2]) which represented a lower and higher market setting as developed from the data in Report ITU-R M.2072. It should be noted that this lower figure (1 280 MHz) is higher than the requirements for some countries. In addition there are some countries where the requirement is larger than the higher value (1 720 MHz).

The deployment scenarios reflect the differences in the quantitative market development and RAT deployment status in different parts of the world.

The results show that additional spectrum is needed, beyond that identified for IMT-2000 at WARC-92 and WRC-2000.

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[2] RATGroup 1: Pre-IMT systems, IMT-2000 and its enhancements.

– This group covers the cellular mobile systems, IMT-2000 systems and their enhancements in accordance with Footnotes 5.317A, 5.384A and 5.388 to the table of frequency allocations.

10 Bibliography

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Development of spectrum requirement forecasts for IMT-2000 and systems beyond IMT-2000 (IMT-Advanced). UMTS Forum Report #40, www.umtsforum.org

Annexes

Annex 1 Market parameter values for spectrum estimation

Annex 2 Basic consideration on spectrum demand estimation for IMT-Advanced from the radio viewpoint and further clarification of the corresponding simplifications for the methodology

Annex 3 Estimation of spectrum for nomadic applications

Annex 4 Sensitivity analysis of spectrum estimate

Annex 1

Market parameter values for spectrum estimation

TABLE 27a

Market attribute in year 2010 (higher user density case)

SC	*U* (%)	*Q* (%)	*R* (%)	μ (%)	Mobility ratio
1	25	30	30	30	2 (No range M.2072)
2	25	30	30	30	2 (No range M.2072)
3	25	30	30	30	2
4	25	30	30	30	2
5	25	30	30	30	2
6	25	30	30	30	2 (No range M.2072)
7	25	30	30	30	2
8	25	30	30	30	2
9	25	30	30	30	2 (No range M.2072)
10	25	30	30	30	2
11	25	30	30	30	1
12	25	30	30	30	2
13	25	30	30	30	2
14	25	30	30	30	2
15	25	30	30	30	2
16	25	30	30	30	2 (No range M.2072)
17	25	30	30	30	2
18	25	30	30	30	2
19	25	30	30	30	2 (No range M.2072)
20	25	30	30	30	2 (No range M.2072)

TABLE 27b

Market attribute in year 2010 for unicast downlink (higher user density case) (part 1 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
1	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	2	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	2	45.0	2.99E-01	20000.0	53.0	100.0	0.0	0.0	0.0
2	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	5	7.0	2.99E-01	20000.0	51.0	100.0	0.0	0.0	0.0
2	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
3	1	6107.8	2.44E-01	496.2	113.5	69.0	21.0	10.0	0.0
3	2	15380.3	3.10E-01	374.9	110.2	69.0	26.0	5.0	0.0
3	3	7812.0	1.64E-01	447.1	71.7	47.0	43.0	10.0	0.0
3	4	1387.5	3.74E-01	290.2	109.2	65.5	22.0	12.5	0.0
3	5	2758.8	4.24E-01	275.2	85.7	49.0	16.0	30.0	5.0
3	6	200.3	9.97E-02	282.4	79.4	46.0	11.5	35.0	7.5
4	1	3475.3	2.86E-01	88.0	249.4	73.8	11.9	9.5	4.8
4	2	3512.8	2.86E-01	88.0	249.4	73.1	16.5	5.7	4.7
4	3	4599.8	2.86E-01	88.0	268.3	50.0	32.4	13.0	4.6
4	4	8.8	2.86E-01	88.0	249.4	69.0	14.3	11.9	4.8
4	5	22.3	2.76E-01	88.0	276.0	53.8	8.5	33.2	4.5
4	6	8.8	2.82E-01	88.0	259.9	50.5	7.8	34.5	7.3
5	1	15616.9	6.48E-01	15.3	221.7	62.6	22.4	9.3	5.6
5	2	34488.8	8.26E-01	15.3	232.7	62.0	25.5	6.9	5.6
5	3	22271.6	7.81E-01	15.3	217.1	37.7	42.5	14.2	5.7
5	4	2240.7	1.38E+00	14.6	208.9	59.0	23.6	11.8	5.7
5	5	4902.9	1.69E+00	11.8	227.1	34.1	23.4	36.6	5.9
5	6	414.2	1.35E+00	15.3	207.5	36.1	18.3	36.1	9.6
6	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	2	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
7	1	11.0	3.00E-03	11230.4	45.0	55.0	25.0	20.0	0.0
7	2	122.8	2.84E-01	10657.1	219.9	65.3	20.5	7.3	6.8
7	3	195.3	8.52E-02	10427.3	190.5	31.7	42.1	18.8	7.4
7	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
7	5	30.8	3.06E-01	8844.2	239.7	48.0	13.2	32.4	6.4
7	6	1.5	6.75E-02	9679.1	197.7	27.9	11.4	45.3	15.4

TABLE 27b

Market attribute in year 2010 for unicast downlink (higher user density case) (part 2 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
8	1	3759.8	1.16E-01	801.9	713.3	72.5	17.5	10.0	0.0
8	2	17338.8	1.19E-01	849.6	1050.5	64.4	20.0	8.4	7.1
8	3	5980.3	2.52E-01	868.8	384.2	46.1	36.9	9.2	7.8
8	4	1131.8	1.41E-01	767.6	449.6	67.5	20.0	12.5	0.0
8	5	2205.5	3.22E-01	868.8	386.3	46.3	18.1	27.8	7.9
8	6	228.0	1.98E-01	832.2	970.1	39.0	16.5	36.7	7.8
9	1	300.0	1.99E-01	144.0	5.0	90.0	10.0	0.0	0.0
9	2	400.0	2.99E-01	144.0	19.0	90.0	10.0	0.0	0.0
9	3	50.0	1.00E-01	144.0	19.0	80.0	10.0	10.0	0.0
9	4	50.0	1.99E-01	144.0	5.0	90.0	10.0	0.0	0.0
9	5	100.0	2.99E-01	144.0	19.0	70.0	10.0	20.0	0.0
9	6	10.0	1.00E-01	144.0	5.0	80.0	10.0	10.0	0.0
10	1	200.0	1.99E-01	16.0	1.0	80.0	20.0	0.0	0.0
10	2	300.0	2.99E-01	16.0	1.0	80.0	20.0	0.0	0.0
10	3	50.0	1.00E-01	16.0	1.0	70.0	20.0	10.0	0.0
10	4	50.0	1.99E-01	16.0	1.0	80.0	20.0	0.0	0.0
10	5	50.0	2.99E-01	16.0	1.0	60.0	20.0	20.0	0.0
10	6	10.0	1.00E-01	16.0	1.0	65.0	20.0	10.0	5.0
11	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	2	20.0	1.99E-01	500000.0	32.0	100.0	0.0	0.0	0.0
11	3	6771.8	3.00E-01	30000.0	2.4	10.0	70.0	20.0	0.0
11	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	5	2511.8	4.39E-01	171000.0	15.2	100.0	0.0	0.0	0.0
11	6	188.0	3.00E-01	30000.0	2.4	5.0	10.0	70.0	15.0
12	1	527.3	5.76E-01	10256.8	92.9	67.5	22.5	10.0	0.0
12	2	1462.0	5.95E-01	9779.8	95.6	67.5	27.5	5.0	0.0
12	3	10978.8	2.33E-01	10532.6	31.1	46.2	44.2	9.5	0.0
12	4	139.5	6.00E-01	9767.9	95.9	62.5	25.0	12.5	0.0
12	5	4061.3	2.31E-01	9820.1	30.8	42.5	20.0	32.5	5.0
12	6	306.0	2.32E-01	9972.0	30.8	40.5	15.0	37.0	7.5
13	1	33827.5	2.24E+00	1371.9	23.6	66.1	23.4	10.4	0.0
13	2	110602.3	2.19E+00	1371.9	32.0	67.0	27.9	5.1	0.0
13	3	66561.0	2.12E+00	1371.9	36.2	36.7	45.2	18.1	0.0
13	4	9558.8	2.30E+00	850.9	22.9	62.5	25.0	12.5	0.0
13	5	24125.8	2.31E+00	859.6	22.9	40.0	20.0	35.0	5.0
13	6	1903.5	2.30E+00	884.1	23.5	36.0	15.0	40.0	9.0
14	1	5763.5	1.07E-01	125.1	21.7	67.2	22.4	10.0	0.5
14	2	5763.5	1.13E-01	126.5	21.7	67.2	27.4	5.0	0.5
14	3	9235.3	1.33E-01	177.4	544.0	25.4	63.7	10.4	0.5
14	4	58.3	1.42E-01	48.8	42.4	61.3	22.1	12.3	4.4
14	5	1622.8	1.38E-01	177.9	1051.0	35.0	60.0	5.0	0.0
14	6	129.5	1.40E-01	177.5	1005.4	32.7	59.8	5.0	2.5

TABLE 27b

Market attribute in year 2010 for unicast downlink (higher user density case) (part 3 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
15	1	12294.5	1.20E+00	8.3	8.5	67.2	22.4	10.0	0.5
15	2	38327.0	1.55E+00	7.6	10.0	67.5	27.5	5.0	0.0
15	3	22530.3	1.08E+00	32.8	9.0	33.5	38.9	26.6	1.0
15	4	3155.0	1.27E+00	7.6	8.5	62.5	25.0	12.5	0.0
15	5	8279.3	1.55E+00	39.4	9.2	44.3	13.4	37.8	4.5
15	6	624.0	1.27E+00	61.3	9.2	34.5	14.5	40.5	10.5
16	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	2	50.0	1.99E-01	20000.0	54.0	80.0	20.0	0.0	0.0
16	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	5	10.0	1.99E-01	20000.0	54.0	80.0	20.0	0.0	0.0
16	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
17	1	1953.5	0.00E+00	5521.6	86.4	55.0	25.0	20.0	0.0
17	2	6950.5	1.99E-01	6530.6	120.0	67.5	27.5	5.0	0.0
17	3	4201.0	0.00E+00	5594.0	86.7	10.0	70.0	20.0	0.0
17	4	574.8	0.00E+00	5512.7	86.4	45.0	30.0	25.0	0.0
17	5	1537.5	1.99E-01	6513.5	120.0	45.0	20.0	30.0	5.0
17	6	115.3	0.00E+00	5539.2	86.4	5.0	10.0	70.0	15.0
18	1	1468.8	7.45E-01	701.8	11.6	67.5	22.5	10.0	0.0
18	2	8490.0	6.77E-01	716.5	16.7	67.5	27.5	5.0	0.0
18	3	20.0	1.00E-01	990.0	6.0	60.0	20.0	20.0	0.0
18	4	380.8	7.45E-01	1009.0	10.7	62.5	25.0	12.5	0.0
18	5	70.0	9.96E-01	653.0	36.0	60.0	20.0	20.0	0.0
18	6	68.8	7.45E-01	1009.0	10.7	32.5	15.0	42.5	10.0
19	1	500.0	1.00E-01	144.0	5.0	80.0	20.0	0.0	0.0
19	2	1000.0	2.99E-01	144.0	5.0	80.0	20.0	0.0	0.0
19	3	50.0	1.00E-01	144.0	5.0	60.0	20.0	15.0	5.0
19	4	50.0	1.00E-01	144.0	5.0	80.0	20.0	0.0	0.0
19	5	50.0	1.00E-01	144.0	5.0	60.0	20.0	20.0	0.0
19	6	10.0	1.00E-01	144.0	5.0	60.0	20.0	15.0	5.0
20	1	1000.0	1.00E-01	16.0	6.0	80.0	20.0	0.0	0.0
20	2	1000.0	2.99E-01	16.0	10.0	80.0	20.0	0.0	0.0
20	3	100.0	1.00E-01	16.0	6.0	60.0	20.0	20.0	0.0
20	4	100.0	1.00E-01	16.0	6.0	80.0	20.0	0.0	0.0
20	5	50.0	2.99E-01	16.0	10.0	60.0	20.0	20.0	0.0
20	6	10.0	1.00E-01	16.0	6.0	60.0	20.0	15.0	5.0

TABLE 27c

Market attribute in year 2010 for unicast uplink (higher user density case) (part 1 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
1	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	2	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	1	50.0	1.00E-01	20000.0	1793.0	100.0	0.0	0.0	0.0
2	2	55.0	2.81E-01	20000.0	64.0	100.0	0.0	0.0	0.0
2	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	4	20.0	1.00E-01	20000.0	1793.0	100.0	0.0	0.0	0.0
2	5	10.0	2.99E-01	20000.0	9.0	100.0	0.0	0.0	0.0
2	6	1.0	1.00E-01	20000.0	1793.0	100.0	0.0	0.0	0.0
3	1	6392.8	2.44E-01	486.6	125.4	69.0	21.0	10.0	0.0
3	2	15717.8	3.10E-01	318.5	113.7	69.5	25.5	5.0	0.0
3	3	7857.0	1.64E-01	373.3	91.3	46.5	43.5	10.0	0.0
3	4	1462.5	3.70E-01	275.2	118.3	66.0	21.5	12.5	0.0
3	5	2800.0	4.17E-01	275.2	99.7	49.0	16.0	30.0	5.0
3	6	202.5	9.82E-02	275.2	87.8	46.0	11.5	35.0	7.5
4	1	3475.3	2.86E-01	88.0	787.0	73.8	11.9	9.5	4.8
4	2	3512.8	2.86E-01	88.0	787.0	73.1	16.5	5.7	4.7
4	3	4599.8	2.86E-01	518.1	805.9	50.0	32.4	13.0	4.6
4	4	8.8	2.86E-01	88.0	787.0	69.0	14.3	11.9	4.8
4	5	22.3	2.76E-01	634.2	813.6	53.8	8.5	33.2	4.5
4	6	8.8	2.82E-01	368.7	797.5	50.5	7.8	34.5	7.3
5	1	15616.9	6.48E-01	15.3	221.7	62.6	22.4	9.3	5.6
5	2	34488.8	8.26E-01	15.3	232.7	62.0	25.5	6.9	5.6
5	3	22271.6	7.81E-01	15.3	217.1	37.7	42.5	14.2	5.7
5	4	2240.7	1.38E+00	14.6	208.9	59.0	23.6	11.8	5.7
5	5	4902.9	1.69E+00	11.8	227.1	34.1	23.4	36.6	5.9
5	6	414.2	1.35E+00	15.3	207.5	36.1	18.3	36.1	9.6
6	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	2	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
7	1	11.0	3.00E-03	10400.0	45.0	55.0	25.0	20.0	0.0
7	2	122.8	2.84E-01	10400.0	203.1	65.3	20.5	7.3	6.8
7	3	195.3	8.52E-02	10337.1	190.5	31.7	42.1	18.8	7.4
7	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
7	5	30.8	3.06E-01	9737.2	222.9	48.0	13.2	32.4	6.4
7	6	1.5	6.75E-02	10093.1	197.7	27.9	11.4	45.3	15.4

TABLE 27c

Market attribute in year 2010 for unicast uplink (higher user density case) (part 2 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
8	1	3986.8	2.28E-01	512.4	351.1	72.5	17.5	10.0	0.0
8	2	12084.8	4.06E-01	523.8	358.0	72.1	22.4	5.0	0.5
8	3	7964.0	2.64E-01	539.4	355.3	49.8	39.8	10.0	0.5
8	4	943.3	2.67E-01	511.8	358.0	67.5	20.0	12.5	0.0
8	5	2525.8	3.36E-01	512.7	357.4	50.0	15.0	30.0	5.0
8	6	191.8	2.67E-01	513.6	356.5	42.5	10.0	40.0	7.5
9	1	300.0	1.99E-01	144.0	7.0	90.0	10.0	0.0	0.0
9	2	400.0	2.99E-01	144.0	29.0	90.0	10.0	0.0	0.0
9	3	50.0	1.00E-01	144.0	29.0	80.0	10.0	10.0	0.0
9	4	50.0	1.99E-01	144.0	7.0	90.0	10.0	0.0	0.0
9	5	100.0	2.99E-01	144.0	29.0	70.0	10.0	20.0	0.0
9	6	10.0	1.00E-01	144.0	7.0	80.0	10.0	10.0	0.0
10	1	1275.0	3.19E-01	8.2	1081.4	67.5	22.5	10.0	0.0
10	2	4275.0	4.04E-01	8.2	1081.4	67.5	27.5	5.0	0.0
10	3	2467.5	2.35E-01	8.2	1081.4	40.0	45.0	15.0	0.0
10	4	375.0	3.19E-01	8.2	1081.4	62.5	25.0	12.5	0.0
10	5	937.5	4.04E-01	8.2	1081.4	35.0	20.0	40.0	5.0
10	6	75.0	2.35E-01	8.2	1081.4	35.0	15.0	40.0	10.0
11	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	2	20.0	1.99E-01	500000.0	4.0	100.0	0.0	0.0	0.0
11	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	5	5.0	1.99E-01	500000.0	4.0	100.0	0.0	0.0	0.0
11	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
12	1	232.8	4.85E-01	13414.2	71.8	68.5	22.0	9.0	0.5
12	2	402.3	5.58E-01	10313.9	85.6	67.5	27.5	5.0	0.0
12	3	216.8	5.00E-01	15103.3	66.1	52.2	38.3	8.5	1.0
12	4	51.3	5.91E-01	10231.3	86.2	62.7	24.9	12.4	0.0
12	5	75.5	5.86E-01	10487.5	85.0	43.5	20.0	31.5	5.0
12	6	7.3	5.68E-01	11668.4	79.0	43.0	15.5	34.5	7.0
13	1	22643.0	1.20E-01	1114.4	19.7	66.1	22.4	9.4	2.1
13	2	74695.0	2.03E-01	1089.5	17.6	67.0	27.4	5.1	0.5
13	3	45117.5	1.23E-01	1136.6	21.8	35.8	42.8	17.9	3.5
13	4	6162.0	1.19E-01	1080.8	16.2	62.2	24.9	12.4	0.5
13	5	16115.8	2.04E-01	1086.8	16.9	39.8	19.9	34.8	5.5
13	6	1224.3	1.20E-01	1011.9	18.2	35.5	15.0	40.0	9.5
14	1	7073.3	1.55E+00	60.0	1.3	67.2	22.4	10.0	0.5
14	2	5763.5	1.13E-01	60.0	20.3	67.2	27.4	5.0	0.5
14	3	9235.3	1.33E-01	92.9	542.6	25.4	63.7	10.4	0.5
14	4	545.8	5.39E+00	63.5	0.6	61.0	24.4	12.2	2.4
14	5	1622.8	1.38E-01	91.8	1049.6	35.0	60.0	5.0	0.0
14	6	208.3	2.25E+00	92.1	20.9	32.7	59.8	5.0	2.5

TABLE 27c

Market attribute in year 2010 for unicast uplink (higher user density case) (part 3 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
15	1	31044.5	4.55E+00	6.2	9.4	67.5	22.5	10.0	0.0
15	2	105827.0	4.91E+00	6.2	11.5	67.5	27.5	5.0	0.0
15	3	62533.8	4.79E+00	6.9	7.9	34.8	44.8	19.9	0.5
15	4	8780.0	4.63E+00	6.2	9.4	62.5	25.0	12.5	0.0
15	5	23095.5	5.30E+00	6.2	9.4	45.0	15.0	35.0	5.0
15	6	1735.0	5.01E+00	6.2	9.4	35.0	15.0	40.0	10.0
16	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	2	50.0	1.99E-01	20000.0	6.0	80.0	20.0	0.0	0.0
16	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	5	10.0	1.99E-01	20000.0	6.0	80.0	20.0	0.0	0.0
16	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
17	1	285.5	0.00E+00	5671.5	85.8	55.0	25.0	20.0	0.0
17	2	945.3	1.99E-01	6745.7	95.1	67.5	27.5	5.0	0.0
17	3	598.0	0.00E+00	6230.1	87.6	11.0	69.0	20.0	0.0
17	4	74.5	0.00E+00	5598.0	86.4	45.0	30.0	25.0	0.0
17	5	203.0	1.99E-01	6607.1	95.1	45.0	20.0	30.0	5.0
17	6	15.3	0.00E+00	5806.8	87.0	5.5	10.0	69.5	15.0
18	1	600.0	1.00E-01	574.0	8.0	80.0	20.0	0.0	0.0
18	2	1300.0	9.96E-01	595.0	16.0	80.0	20.0	0.0	0.0
18	3	20.0	1.00E-01	990.0	2.0	60.0	20.0	20.0	0.0
18	4	100.0	1.00E-01	1030.0	7.0	80.0	20.0	0.0	0.0
18	5	70.0	9.96E-01	653.0	15.0	60.0	20.0	20.0	0.0
18	6	10.0	1.00E-01	1030.0	7.0	60.0	20.0	15.0	5.0
19	1	500.0	1.00E-01	144.0	5.0	80.0	20.0	0.0	0.0
19	2	1000.0	2.99E-01	144.0	5.0	80.0	20.0	0.0	0.0
19	3	50.0	1.00E-01	144.0	5.0	60.0	20.0	15.0	5.0
19	4	50.0	1.00E-01	144.0	5.0	80.0	20.0	0.0	0.0
19	5	50.0	1.00E-01	144.0	5.0	60.0	20.0	20.0	0.0
19	6	10.0	1.00E-01	144.0	5.0	60.0	20.0	15.0	5.0
20	1	1000.0	1.00E-01	16.0	6.0	80.0	20.0	0.0	0.0
20	2	1000.0	2.99E-01	16.0	10.0	80.0	20.0	0.0	0.0
20	3	1209.0	3.70E-01	13.2	2.5	35.0	45.0	20.0	0.0
20	4	100.0	1.00E-01	16.0	6.0	80.0	20.0	0.0	0.0
20	5	457.5	5.09E-01	13.2	3.7	35.0	20.0	40.0	5.0
20	6	39.0	3.70E-01	13.2	2.5	32.5	15.0	42.5	10.0

TABLE 27d

Market attribute in year 2010 for multicast downlink (higher user density case)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
2	1	50.0	0.1	20000.0	3585.4	100	0	0	0
2	2	10.0	0.4	20000.0	1344.5	100	0	0	0
2	3	0.0	0.0	0.0	0.0	0	0	0	0
2	4	20.0	0.1	20000.0	3585.4	100	0	0	0
2	5	3.0	0.4	20000.0	597.6	100	0	0	0
2	6	1.0	0.1	20000.0	3585.4	100	0	0	0
3	1	380.0	0.4	1424.2	273.6	83	17	0	0
3	2	450.0	0.6	922.7	384.1	84	16	0	0
3	3	60.0	0.4	1192.0	149.4	82	18	0	0
3	4	100.0	1.3	731.7	248.5	86	14	0	0
3	5	55.0	1.4	623.4	336.1	87	13	0	0
3	6	2.8	0.8	679.9	223.3	87	13	0	0

TABLE 28a

Market attribute in year 2015 (higher user density case)

SC	*U* (%)	*Q* (%)	*R* (%)	μ (%)	Mobility ratio
1	25	30	30	30	2 (No range M.2072)
2	25	30	30	30	2 (No range M.2072)
3	25	30	30	30	2
4	25	30	30	30	2
5	25	30	30	30	2
6	25	30	30	30	1
7	25	30	30	30	2
8	25	30	30	30	2
9	25	30	30	30	2 (No range M.2072)
10	25	30	30	30	2
11	25	30	30	30	1
12	25	30	30	30	2
13	25	30	30	30	2
14	25	30	30	30	2
15	25	30	30	30	2
16	25	30	30	30	2 (No range M.2072)
17	25	30	30	30	2
18	25	30	30	30	2
19	25	30	30	30	2 (No range M.2072)
20	25	30	30	30	2

TABLE 28b

Market attribute in year 2015 for unicast downlink (higher user density case) (part 1 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
1	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	2	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	2	46.0	5.98E-01	20000.0	106.0	100.0	0.0	0.0	0.0
2	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	5	7.0	5.98E-01	20000.0	102.0	100.0	0.0	0.0	0.0
2	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
3	1	11981.0	2.54E-01	505.3	162.5	69.0	21.0	10.0	0.0
3	2	24526.8	4.02E-01	379.1	147.3	69.0	26.0	5.0	0.0
3	3	16618.5	2.15E-01	467.4	107.1	47.0	43.0	10.0	0.0
3	4	1771.5	5.60E-01	290.2	156.1	65.5	22.0	12.5	0.0
3	5	3764.0	6.27E-01	275.2	126.6	49.0	16.0	30.0	5.0
3	6	275.3	1.65E-01	282.4	121.2	46.0	11.5	35.0	7.5
4	1	9879.5	5.81E-01	88.0	428.5	73.8	11.9	9.5	4.8
4	2	9917.8	5.81E-01	88.0	428.5	73.1	16.5	5.7	4.7
4	3	13139.3	6.03E-01	99.2	449.5	50.0	32.4	13.0	4.6
4	4	10.3	6.43E-01	88.0	428.5	69.0	14.3	11.9	4.8
4	5	26.5	6.09E-01	96.4	443.2	53.8	8.5	33.2	4.5
4	6	11.0	6.29E-01	91.5	434.8	50.5	7.8	34.5	7.3
5	1	31362.5	7.97E-01	15.3	231.5	62.6	22.4	9.3	5.6
5	2	63240.3	9.93E-01	15.3	231.0	62.0	25.5	6.9	5.6
5	3	42105.5	9.15E-01	15.3	252.1	37.7	42.5	14.2	5.7
5	4	4062.0	1.56E+00	15.3	205.9	59.0	23.6	11.8	5.7
5	5	8689.0	2.02E+00	11.8	255.1	34.1	23.4	36.6	5.9
5	6	781.5	1.54E+00	15.3	205.2	36.1	18.3	36.1	9.6
6	1	111.0	2.00E-02	321000.0	150.0	0.0	0.0	0.0	0.0
6	2	111.0	2.00E-02	321000.0	150.0	0.0	0.0	0.0	0.0
6	3	148.0	2.20E-02	321000.0	150.0	0.0	0.0	0.0	0.0
6	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
7	1	2229.0	2.10E-02	2009.6	1054.8	55.0	25.0	20.0	0.0
7	2	9524.8	3.16E-01	7400.0	1092.6	65.3	20.5	7.3	6.8
7	3	439.0	9.45E-02	10571.5	309.9	31.7	42.1	18.8	7.4
7	4	611.3	2.25E-02	2000.0	1080.0	0.0	0.0	0.0	0.0
7	5	37.3	5.42E-01	9570.7	368.4	48.0	13.2	32.4	6.4
7	6	124.8	2.40E-02	2200.2	1014.9	27.9	11.4	45.3	15.4

TABLE 28b

Market attribute in year 2015 for unicast downlink (higher user density case) (part 2 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
8	1	6857.8	1.60E-01	700.8	413.9	72.5	17.5	10.0	0.0
8	2	13632.5	5.83E-01	868.8	413.9	64.4	20.0	8.4	7.1
8	3	9314.0	4.61E-01	868.8	412.4	46.1	36.9	9.2	7.8
8	4	1142.5	2.52E-01	700.8	413.9	67.5	20.0	12.5	0.0
8	5	3053.5	6.02E-01	868.8	413.6	46.3	18.1	27.8	7.9
8	6	230.8	4.63E-01	868.8	413.6	39.0	16.5	36.7	7.8
9	1	306.0	3.98E-01	144.0	10.0	90.0	10.0	0.0	0.0
9	2	408.0	5.98E-01	144.0	38.0	90.0	10.0	0.0	0.0
9	3	51.0	1.99E-01	144.0	38.0	80.0	10.0	10.0	0.0
9	4	51.0	3.98E-01	144.0	10.0	90.0	10.0	0.0	0.0
9	5	102.0	5.98E-01	144.0	38.0	70.0	10.0	20.0	0.0
9	6	10.0	1.99E-01	144.0	10.0	80.0	10.0	10.0	0.0
10	1	204.0	3.98E-01	16.0	2.0	80.0	20.0	0.0	0.0
10	2	306.0	5.98E-01	16.0	2.0	80.0	20.0	0.0	0.0
10	3	51.0	1.99E-01	16.0	2.0	70.0	20.0	10.0	0.0
10	4	51.0	3.98E-01	16.0	2.0	80.0	20.0	0.0	0.0
10	5	51.0	5.98E-01	16.0	2.0	60.0	20.0	20.0	0.0
10	6	10.0	1.99E-01	16.0	2.0	65.0	20.0	10.0	5.0
11	1	27.8	2.40E-02	321000.0	18.0	0.0	0.0	0.0	0.0
11	2	42.8	1.75E-01	321000.0	61.5	100.0	0.0	0.0	0.0
11	3	14092.8	2.99E-01	36825.4	3.3	10.0	70.0	20.0	0.0
11	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	5	5209.5	5.79E-01	175503.1	27.2	100.0	0.0	0.0	0.0
11	6	390.5	3.00E-01	36433.0	3.3	5.0	10.0	70.0	15.0
12	1	13253.5	9.39E-01	9869.7	19.2	67.5	22.5	10.0	0.0
12	2	41696.3	2.13E-01	9450.9	73.1	67.5	27.5	5.0	0.0
12	3	32679.0	2.02E-01	10141.0	70.1	46.2	44.2	9.5	0.0
12	4	3899.0	9.51E-01	9425.3	18.5	62.5	25.0	12.5	0.0
12	5	11992.0	2.01E-01	9465.8	70.1	42.5	20.0	32.5	5.0
12	6	985.3	7.82E-01	9599.7	19.2	40.5	15.0	37.0	7.5
13	1	29994.5	2.65E+00	1372.5	62.3	66.1	23.4	10.4	0.0
13	2	85808.5	3.24E+00	1372.5	53.9	67.0	27.9	5.1	0.0
13	3	56159.5	2.89E+00	1372.5	64.4	36.7	45.2	18.1	0.0
13	4	6601.8	3.45E+00	870.3	44.8	62.5	25.0	12.5	0.0
13	5	17283.8	3.72E+00	888.5	44.8	40.0	20.0	35.0	5.0
13	6	1312.5	3.44E+00	936.2	46.0	36.0	15.0	40.0	9.0
14	1	12245.5	1.60E-01	125.8	23.8	67.2	22.4	10.0	0.5
14	2	12245.5	1.74E-01	126.5	23.8	67.2	27.4	5.0	0.5
14	3	19735.8	2.07E-01	176.5	352.9	25.4	63.7	10.4	0.5
14	4	63.0	2.68E-01	48.8	51.4	61.3	22.1	12.3	4.4
14	5	2293.8	2.10E-01	177.2	1021.6	35.0	60.0	5.0	0.0
14	6	180.8	2.15E-01	178.1	938.2	32.7	59.8	5.0	2.5

TABLE 28b

Market attribute in year 2015 for unicast downlink (higher user density case) (part 3 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
15	1	13082.0	1.60E+00	9.7	14.9	67.2	22.4	10.0	0.5
15	2	40999.5	2.29E+00	8.3	17.2	67.5	27.5	5.0	0.0
15	3	24818.8	1.35E+00	35.2	16.6	33.5	38.9	26.6	1.0
15	4	3376.0	1.74E+00	7.6	14.2	62.5	25.0	12.5	0.0
15	5	9081.0	2.29E+00	54.7	15.6	44.3	13.4	37.8	4.5
15	6	684.5	1.72E+00	85.3	15.6	34.5	14.5	40.5	10.5
16	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	2	51.0	3.98E-01	20000.0	108.0	80.0	20.0	0.0	0.0
16	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	5	10.0	3.98E-01	20000.0	108.0	80.0	20.0	0.0	0.0
16	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
17	1	1771.5	6.49E-01	8136.4	86.4	55.0	25.0	20.0	0.0
17	2	6184.3	9.49E-01	9623.9	153.9	67.5	27.5	5.0	0.0
17	3	3778.0	6.58E-01	8426.8	87.3	10.0	70.0	20.0	0.0
17	4	510.3	6.72E-01	8061.6	86.4	45.0	30.0	25.0	0.0
17	5	1362.5	9.53E-01	9553.9	153.9	45.0	20.0	30.0	5.0
17	6	102.8	6.69E-01	8178.7	86.7	5.0	10.0	70.0	15.0
18	1	2496.5	8.14E-01	1001.8	17.6	67.5	22.5	10.0	0.0
18	2	10152.3	1.07E+00	1016.5	27.8	67.5	27.5	5.0	0.0
18	3	20.0	1.99E-01	990.0	11.0	60.0	20.0	20.0	0.0
18	4	687.8	8.14E-01	1321.0	16.1	62.5	25.0	12.5	0.0
18	5	71.0	1.99E+00	653.0	72.0	60.0	20.0	20.0	0.0
18	6	129.8	8.14E-01	1321.0	16.1	32.5	15.0	42.5	10.0
19	1	510.0	1.99E-01	144.0	10.0	80.0	20.0	0.0	0.0
19	2	1020.0	5.98E-01	144.0	10.0	80.0	20.0	0.0	0.0
19	3	51.0	1.99E-01	144.0	10.0	60.0	20.0	15.0	5.0
19	4	51.0	1.99E-01	144.0	10.0	80.0	20.0	0.0	0.0
19	5	51.0	1.99E-01	144.0	10.0	60.0	20.0	20.0	0.0
19	6	10.0	1.99E-01	144.0	10.0	60.0	20.0	15.0	5.0
20	1	1020.0	1.99E-01	16.0	12.0	80.0	20.0	0.0	0.0
20	2	1020.0	5.98E-01	16.0	20.0	80.0	20.0	0.0	0.0
20	3	102.0	1.99E-01	16.0	12.0	60.0	20.0	20.0	0.0
20	4	102.0	1.99E-01	16.0	12.0	80.0	20.0	0.0	0.0
20	5	51.0	5.98E-01	16.0	20.0	60.0	20.0	20.0	0.0
20	6	10.0	1.99E-01	16.0	12.0	60.0	20.0	15.0	5.0

TABLE 28c

Market attribute in year 2015 for unicast uplink (higher user density case) (part 1 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
1	1	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
1	2	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
1	3	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
1	4	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
1	5	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
1	6	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
2	1	51	1.99E-01	20000	3586	100.0	0.0	0.0	0.0
2	2	56	5.61E-01	20000	129	100.0	0.0	0.0	0.0
2	3	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
2	4	20	1.99E-01	20000	3586	100.0	0.0	0.0	0.0
2	5	10	5.98E-01	20000	17	100.0	0.0	0.0	0.0
2	6	1	1.99E-01	20000	3586	100.0	0.0	0.0	0.0
3	1	12272	2.54E-01	495.7	187	69.0	21.0	10.0	0.0
3	2	24871	4.01E-01	322.7	150.6	69.5	25.5	5.0	0.0
3	3	16664.25	2.15E-01	393.6	130.4	46.5	43.5	10.0	0.0
3	4	1848	5.50E-01	275.2	173.6	66.0	21.5	12.5	0.0
3	5	3806	6.14E-01	275.2	138.3	49.0	16.0	30.0	5.0
3	6	277.5	1.62E-01	275.2	128.4	46.0	11.5	35.0	7.5
4	1	9879.5	5.81E-01	88	1504.3	73.8	11.9	9.5	4.8
4	2	9917.75	5.81E-01	88	1504.3	73.1	16.5	5.7	4.7
4	3	13139.25	6.03E-01	992.1	1525.3	50.0	32.4	13.0	4.6
4	4	10.25	6.43E-01	88	1504.3	69.0	14.3	11.9	4.8
4	5	26.5	6.09E-01	782.7	1519	53.8	8.5	33.2	4.5
4	6	11	6.29E-01	417.9	1510.6	50.5	7.8	34.5	7.3
5	1	31362.5	7.97E-01	15.3	231.5	62.6	22.4	9.3	5.6
5	2	63240.25	9.93E-01	15.3	231	62.0	25.5	6.9	5.6
5	3	42105.5	9.15E-01	15.3	252.1	37.7	42.5	14.2	5.7
5	4	4062	1.56E+00	15.3	205.9	59.0	23.6	11.8	5.7
5	5	8689	2.02E+00	11.8	255.1	34.1	23.4	36.6	5.9
5	6	781.5	1.54E+00	15.3	205.2	36.1	18.3	36.1	9.6
6	1	111	2.00E-02	302293.9	150	0.0	0.0	0.0	0.0
6	2	111	2.00E-02	302293.9	150	0.0	0.0	0.0	0.0
6	3	148	2.20E-02	302293.9	150	0.0	0.0	0.0	0.0
6	4	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
6	5	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
6	6	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
7	1	191.5	6.00E-03	10400	45	55.0	25.0	20.0	0.0
7	2	335	4.14E-01	10400	388.2	65.3	20.5	7.3	6.8
7	3	439	9.45E-02	10438.5	309.9	31.7	42.1	18.8	7.4
7	4	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
7	5	37.25	5.42E-01	10529.4	334.8	48.0	13.2	32.4	6.4
7	6	2.5	1.06E-01	10457.1	302.1	27.9	11.4	45.3	15.4

TABLE 28c

Market attribute in year 2015 for unicast uplink (higher user density case) (part 2 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
8	1	13073.5	2.51E-01	750.9	335.2	72.5	17.5	10.0	0.0
8	2	29299	6.57E-01	780	365.5	72.1	22.4	5.0	0.5
8	3	22739.75	3.96E-01	801.3	363.7	49.8	39.8	10.0	0.5
8	4	1879.75	3.51E-01	749.7	365.8	67.5	20.0	12.5	0.0
8	5	5030.75	4.91E-01	750	365.2	50.0	15.0	30.0	5.0
8	6	380.25	3.52E-01	750.9	364.6	42.5	10.0	40.0	7.5
9	1	306	3.98E-01	144	14	90.0	10.0	0.0	0.0
9	2	408	5.98E-01	144	57	90.0	10.0	0.0	0.0
9	3	51	1.99E-01	144	57	80.0	10.0	10.0	0.0
9	4	51	3.98E-01	144	14	90.0	10.0	0.0	0.0
9	5	102	5.98E-01	144	57	70.0	10.0	20.0	0.0
9	6	10	1.99E-01	144	14	80.0	10.0	10.0	0.0
10	1	2103	5.79E-01	8.3	1082.8	67.5	22.5	10.0	0.0
10	2	7249.5	7.19E-01	8.3	1082.8	67.5	27.5	5.0	0.0
10	3	4250.25	4.39E-01	8.3	1082.8	40.0	45.0	15.0	0.0
10	4	623.25	5.79E-01	8.3	1082.8	62.5	25.0	12.5	0.0
10	5	1598.25	7.19E-01	8.3	1082.8	35.0	20.0	40.0	5.0
10	6	124.5	4.39E-01	8.3	1082.8	35.0	15.0	40.0	10.0
11	1	27.75	2.40E-02	304587.8	18	0.0	0.0	0.0	0.0
11	2	42.75	1.75E-01	304587.8	22.9	100.0	0.0	0.0	0.0
11	3	37	3.00E-02	304587.8	18	0.0	0.0	0.0	0.0
11	4	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
11	5	5	3.98E-01	500000	7	100.0	0.0	0.0	0.0
11	6	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
12	1	11217.5	1.54E-01	10435.7	25	68.5	22.0	9.0	0.5
12	2	39423.25	1.50E-01	8246.3	23.8	67.5	27.5	5.0	0.0
12	3	23809.25	1.56E-01	11734.9	25.9	52.2	38.3	8.5	1.0
12	4	3288.25	1.51E-01	8176.6	23.8	62.7	24.9	12.4	0.0
12	5	8707	1.51E-01	8344.5	23.8	43.5	20.0	31.5	5.0
12	6	654.75	1.52E-01	9145.3	24.4	43.0	15.5	34.5	7.0
13	1	20780.75	2.12E-01	1149.5	35.2	66.1	22.4	9.4	2.1
13	2	48677.25	3.85E-01	1180.1	26.1	67.0	27.4	5.1	0.5
13	3	34998	2.29E-01	1181.9	37.3	35.8	42.8	17.9	3.5
13	4	3380.5	2.37E-01	1229.3	21.9	62.2	24.9	12.4	0.5
13	5	8693.75	4.10E-01	1227.8	22.6	39.8	19.9	34.8	5.5
13	6	668.25	2.41E-01	1135.5	25.9	35.5	15.0	40.0	9.5
14	1	13650	1.02E+00	60	3.6	67.2	22.4	10.0	0.5
14	2	12245.5	1.74E-01	60	22.4	67.2	27.4	5.0	0.5
14	3	19735.75	2.07E-01	94.3	351.5	25.4	63.7	10.4	0.5
14	4	578.25	6.91E+00	68.4	1.5	61.0	24.4	12.2	2.4
14	5	2293.75	2.10E-01	92.1	1020.2	35.0	60.0	5.0	0.0
14	6	265	2.46E+00	93	23.9	32.7	59.8	5.0	2.5

TABLE 28c

Market attribute in year 2015 for unicast uplink (higher user density case) (part 3 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
15	1	32207	8.69E+00	7.6	17.8	67.5	22.5	10.0	0.0
15	2	109849.5	9.40E+00	6.9	22.3	67.5	27.5	5.0	0.0
15	3	65052.75	8.76E+00	8.3	15.1	34.8	44.8	19.9	0.5
15	4	9113.5	8.84E+00	6.9	17.8	62.5	25.0	12.5	0.0
15	5	23982.5	9.78E+00	7.6	17.8	45.0	15.0	35.0	5.0
15	6	1802	9.22E+00	7.6	17.8	35.0	15.0	40.0	10.0
16	1	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
16	2	51	3.98E-01	20000	12	80.0	20.0	0.0	0.0
16	3	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
16	4	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
16	5	10	3.98E-01	20000	12	80.0	20.0	0.0	0.0
16	6	0	0.00E+00	0	0	0.0	0.0	0.0	0.0
17	1	298.25	5.06E-01	9044.5	85.8	55.0	25.0	20.0	0.0
17	2	880.75	9.02E-01	10442.9	105.9	67.5	27.5	5.0	0.0
17	3	596	5.50E-01	11004.2	93.9	11.0	69.0	20.0	0.0
17	4	68.25	6.35E-01	8482.3	87.3	45.0	30.0	25.0	0.0
17	5	184	9.31E-01	9920.7	104.4	45.0	20.0	30.0	5.0
17	6	14.25	6.17E-01	9351.5	89.7	5.5	10.0	69.5	15.0
18	1	612	1.99E-01	574	17	80.0	20.0	0.0	0.0
18	2	1326	1.99E+00	595	32	80.0	20.0	0.0	0.0
18	3	20	1.99E-01	990	5	60.0	20.0	20.0	0.0
18	4	102	1.99E-01	1030	15	80.0	20.0	0.0	0.0
18	5	71	1.99E+00	653	31	60.0	20.0	20.0	0.0
18	6	10	1.99E-01	1030	15	60.0	20.0	15.0	5.0
19	1	510	1.99E-01	144	10	80.0	20.0	0.0	0.0
19	2	1020	5.98E-01	144	10	80.0	20.0	0.0	0.0
19	3	51	1.99E-01	144	10	60.0	20.0	15.0	5.0
19	4	51	1.99E-01	144	10	80.0	20.0	0.0	0.0
19	5	51	1.99E-01	144	10	60.0	20.0	20.0	0.0
19	6	10	1.99E-01	144	10	60.0	20.0	15.0	5.0
20	1	1020	1.99E-01	16	12	80.0	20.0	0.0	0.0
20	2	1020	5.98E-01	16	20	80.0	20.0	0.0	0.0
20	3	1210.5	4.39E-01	13.2	4.3	35.0	45.0	20.0	0.0
20	4	102	1.99E-01	16	12	80.0	20.0	0.0	0.0
20	5	458.25	7.19E-01	13.2	6.7	35.0	20.0	40.0	5.0
20	6	39	4.39E-01	13.2	4.3	32.5	15.0	42.5	10.0

TABLE 28d

Market attribute in year 2015 for multicast downlink (higher user density case)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
2	1	51.0	0.2	20000.0	7172.1	100.0	0.0	0.0	0.0
2	2	10.2	0.8	20000.0	2689.6	100.0	0.0	0.0	0.0
2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	4	20.4	0.2	20000.0	7172.1	100.0	0.0	0.0	0.0
2	5	3.1	0.8	20000.0	1195.4	100.0	0.0	0.0	0.0
2	6	1.0	0.2	20000.0	7172.1	100.0	0.0	0.0	0.0
3	1	387.6	0.8	1424.2	547.3	83.0	17.0	0.0	0.0
3	2	459.0	1.2	922.7	768.4	84.0	16.0	0.0	0.0
3	3	61.2	0.8	1192.0	298.8	82.0	18.0	0.0	0.0
3	4	102.0	2.6	731.7	497.0	86.0	14.0	0.0	0.0
3	5	56.1	2.8	623.4	672.4	87.0	13.0	0.0	0.0
3	6	2.7	1.6	679.9	446.7	87.0	13.0	0.0	0.0

TABLE 29a

Market attribute in year 2020 (higher user density case)

SC	*U* (%)	*Q* (%)	*R* (%)	μ (%)	Mobility ratio
1	25	30	30	30	2 (No range M.2072)
2	25	30	30	30	2
3	25	30	30	30	2
4	25	30	30	30	2
5	25	30	30	30	2
6	25	30	30	30	2 (No range M.2072)
7	25	30	30	30	2
8	25	30	30	30	2
9	25	30	30	30	2 (No range M.2072)
10	25	30	30	30	2
11	25	30	30	30	1
12	25	30	30	30	2
13	25	30	30	30	2
14	25	30	30	30	2
15	25	30	30	30	2
16	25	30	30	30	2 (No range M.2072)
17	25	30	30	30	2
18	25	30	30	30	2 (No range M.2072)
19	25	30	30	30	2 (No range M.2072)
20	25	30	30	30	2

TABLE 29b

Market attribute in year 2020 for unicast downlink (higher user density case) (part 1 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
1	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	2	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	1	4730.0	1.44E-01	11240.0	360.0	0.0	0.0	0.0	0.0
2	2	17062.5	7.07E-01	11240.0	513.3	100.0	0.0	0.0	0.0
2	3	10216.8	1.44E-01	11240.0	360.0	0.0	0.0	0.0	0.0
2	4	1419.0	1.44E-01	11240.0	360.0	0.0	0.0	0.0	0.0
2	5	3789.3	7.07E-01	11240.0	508.4	100.0	0.0	0.0	0.0
2	6	283.8	1.44E-01	11240.0	360.0	0.0	0.0	0.0	0.0
3	1	18096.0	3.84E-01	506.0	231.3	69.0	21.0	10.0	0.0
3	2	35528.0	6.30E-01	379.8	214.8	69.0	26.0	5.0	0.0
3	3	26291.5	3.01E-01	470.9	146.9	47.0	43.0	10.0	0.0
3	4	2338.5	8.88E-01	290.2	229.2	65.5	22.0	12.5	0.0
3	5	5266.3	1.04E+00	275.2	172.2	49.0	16.0	30.0	5.0
3	6	387.8	2.99E-01	282.4	161.1	46.0	11.5	35.0	7.5
4	1	13089.8	9.95E-01	88.0	810.7	73.8	11.9	9.5	4.8
4	2	13128.0	9.95E-01	88.0	810.7	73.1	16.5	5.7	4.7
4	3	17421.0	1.02E+00	123.0	833.8	49.8	32.3	13.4	4.6
4	4	14.3	1.21E+00	88.0	810.7	69.0	14.3	11.9	4.8
4	5	33.8	1.13E+00	105.0	819.8	54.3	9.5	31.7	4.5
4	6	14.5	1.18E+00	95.3	814.2	50.7	8.2	33.8	7.2
5	1	37575.8	9.25E-01	16.0	229.0	62.6	22.4	9.3	5.6
5	2	68203.0	1.33E+00	16.0	227.2	62.0	25.5	6.9	5.6
5	3	45589.3	1.00E+00	15.3	252.1	37.7	42.5	14.2	5.7
5	4	4373.8	1.70E+00	15.3	204.3	59.0	23.6	11.8	5.7
5	5	8709.5	2.34E+00	11.8	255.1	34.1	23.4	36.6	5.9
5	6	842.8	1.68E+00	15.3	203.6	36.1	18.3	36.1	9.6
6	1	1743.0	2.50E-02	321000.0	150.0	55.0	25.0	20.0	0.0
6	2	1743.0	2.50E-02	321000.0	150.0	55.0	35.0	10.0	0.0
6	3	2324.0	3.00E-02	321000.0	150.0	10.0	70.0	20.0	0.0
6	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
7	1	5080.5	0.00E+00	3075.0	892.8	55.0	25.0	20.0	0.0
7	2	13683.0	3.10E-02	8075.5	1136.3	72.1	22.4	5.0	0.5
7	3	2971.8	0.00E+00	10963.1	480.0	32.0	42.5	18.0	7.5
7	4	917.0	0.00E+00	3000.0	1080.0	45.0	30.0	25.0	0.0
7	5	44.3	5.92E-01	9992.8	533.6	48.5	13.7	30.9	6.9
7	6	187.0	0.00E+00	3409.7	988.2	5.5	10.0	69.5	15.0

TABLE 29b

Market attribute in year 2020 for unicast downlink (higher user density case) (part 2 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
8	1	15782.5	1.74E-01	700.8	123.0	72.5	17.5	10.0	0.0
8	2	15861.0	9.32E-01	868.8	486.2	63.9	19.8	8.8	7.5
8	3	21320.3	7.93E-01	868.8	486.2	46.1	36.9	9.2	7.8
8	4	21.0	4.11E-01	384.0	158.0	67.5	20.0	12.5	0.0
8	5	68.5	1.03E+00	868.8	493.1	46.3	18.1	27.8	7.9
8	6	9.0	7.39E-01	868.8	493.1	38.5	17.6	36.2	7.7
9	1	309.0	8.23E-01	144.0	20.0	90.0	10.0	0.0	0.0
9	2	412.0	1.23E+00	144.0	79.0	90.0	10.0	0.0	0.0
9	3	52.0	4.11E-01	144.0	79.0	80.0	10.0	10.0	0.0
9	4	52.0	8.23E-01	144.0	20.0	90.0	10.0	0.0	0.0
9	5	103.0	1.23E+00	144.0	79.0	70.0	10.0	20.0	0.0
9	6	10.0	4.11E-01	144.0	20.0	80.0	10.0	10.0	0.0
10	1	206.0	8.23E-01	16.0	4.0	80.0	20.0	0.0	0.0
10	2	309.0	1.23E+00	16.0	4.0	80.0	20.0	0.0	0.0
10	3	52.0	4.11E-01	16.0	4.0	70.0	20.0	10.0	0.0
10	4	52.0	8.23E-01	16.0	4.0	80.0	20.0	0.0	0.0
10	5	52.0	1.23E+00	16.0	4.0	60.0	20.0	20.0	0.0
10	6	10.0	4.11E-01	16.0	4.0	65.0	20.0	10.0	5.0
11	1	27.8	3.00E-02	321000.0	18.0	55.0	25.0	20.0	0.0
11	2	43.5	3.17E-01	321000.0	81.9	100.0	0.0	0.0	0.0
11	3	18793.8	2.99E-01	90141.2	6.0	10.0	70.0	20.0	0.0
11	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	5	6950.8	8.76E-01	212984.6	53.9	100.0	0.0	0.0	0.0
11	6	521.0	3.00E-01	89978.0	6.0	5.0	10.0	70.0	15.0
12	1	35244.0	2.84E+00	11059.6	33.1	67.5	22.5	10.0	0.0
12	2	120974.5	2.57E+00	10725.9	75.5	67.5	27.5	5.0	0.0
12	3	82235.8	2.28E+00	11344.8	75.2	46.0	44.0	10.0	0.0
12	4	10549.5	2.85E+00	9835.8	21.2	62.5	25.0	12.5	0.0
12	5	30422.0	2.31E+00	9858.5	21.2	42.5	20.0	32.5	5.0
12	6	2373.3	2.56E+00	9953.7	21.2	40.5	15.0	37.0	7.5
13	1	14325.3	2.43E-01	1360.5	149.3	65.1	23.3	11.6	0.0
13	2	14293.5	5.03E-01	1360.8	148.6	64.7	29.9	5.4	0.0
13	3	17566.0	3.29E-01	1359.6	156.3	36.5	45.7	17.8	0.0
13	4	75.5	9.70E-01	1358.1	176.6	62.5	25.0	12.5	0.0
13	5	110.8	1.76E+00	1358.1	175.2	40.0	20.0	35.0	5.0
13	6	24.5	1.14E+00	1249.6	177.9	36.0	15.0	40.0	9.0
14	1	15514.5	2.40E-01	120.2	30.6	67.2	22.4	10.0	0.5
14	2	15514.5	2.54E-01	121.6	30.3	67.2	27.4	5.0	0.5
14	3	26031.8	3.12E-01	177.0	314.1	26.0	62.5	11.0	0.5
14	4	67.3	5.28E-01	48.8	66.9	61.3	22.1	12.3	4.4
14	5	2977.3	2.97E-01	177.8	981.0	35.0	60.0	5.0	0.0
14	6	233.3	3.23E-01	177.6	852.6	32.7	59.8	5.0	2.5

TABLE 29b

Market attribute in year 2020 for unicast downlink (higher user density case) (part 3 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
15	1	13139.8	2.06E+00	11.5	30.0	66.5	22.2	9.9	1.5
15	2	41089.8	3.15E+00	7.9	33.2	67.2	27.4	5.0	0.5
15	3	25608.0	1.23E+00	20.1	35.9	33.3	38.2	26.5	2.0
15	4	3382.0	2.47E+00	7.0	27.2	62.5	25.0	12.5	0.0
15	5	9313.8	3.14E+00	30.1	29.3	44.0	12.5	39.5	4.0
15	6	702.8	2.47E+00	36.5	30.7	34.5	14.0	41.0	10.5
16	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	2	52.0	8.23E-01	20000.0	222.0	80.0	20.0	0.0	0.0
16	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	5	10.0	8.23E-01	20000.0	222.0	80.0	20.0	0.0	0.0
16	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
17	1	4493.3	7.13E-01	10056.5	32.7	55.0	25.0	20.0	0.0
17	2	16242.8	1.01E+00	9931.2	179.5	67.5	27.5	5.0	0.0
17	3	2969.5	8.24E-01	10911.4	90.6	10.5	69.5	20.0	0.0
17	4	1309.8	7.28E-01	9481.7	32.1	45.0	30.0	25.0	0.0
17	5	1044.0	1.43E+00	9733.7	224.9	45.0	20.0	30.0	5.0
17	6	262.5	7.27E-01	9816.7	32.7	5.0	10.0	70.0	15.0
18	1	618.0	4.11E-01	574.0	82.0	67.5	22.5	10.0	0.0
18	2	1339.0	4.11E+00	595.0	153.0	67.5	27.5	5.0	0.0
18	3	21.0	4.11E-01	990.0	23.0	60.0	20.0	20.0	0.0
18	4	103.0	4.11E-01	1030.0	72.0	62.5	25.0	12.5	0.0
18	5	72.0	4.11E+00	653.0	148.0	60.0	20.0	20.0	0.0
18	6	10.0	4.11E-01	1030.0	72.0	32.5	15.0	42.5	10.0
19	1	515.0	4.11E-01	144.0	21.0	80.0	20.0	0.0	0.0
19	2	1030.0	1.23E+00	144.0	21.0	80.0	20.0	0.0	0.0
19	3	52.0	4.11E-01	144.0	21.0	60.0	20.0	15.0	5.0
19	4	52.0	4.11E-01	144.0	21.0	80.0	20.0	0.0	0.0
19	5	52.0	4.11E-01	144.0	21.0	60.0	20.0	20.0	0.0
19	6	10.0	4.11E-01	144.0	21.0	60.0	20.0	15.0	5.0
20	1	1030.0	4.11E-01	16.0	25.0	80.0	20.0	0.0	0.0
20	2	1030.0	1.23E+00	16.0	41.0	80.0	20.0	0.0	0.0
20	3	103.0	4.11E-01	16.0	25.0	60.0	20.0	20.0	0.0
20	4	103.0	4.11E-01	16.0	25.0	80.0	20.0	0.0	0.0
20	5	52.0	1.23E+00	16.0	41.0	60.0	20.0	20.0	0.0
20	6	10.0	4.11E-01	16.0	25.0	60.0	20.0	15.0	5.0

TABLE 29c

Market attribute in year 2020 for unicast uplink (higher user density case) (part 1 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
1	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	2	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	1	4730.0	1.44E-01	11240.0	360.0	100.0	0.0	0.0	0.0
2	2	17062.5	7.07E-01	11240.0	513.3	100.0	0.0	0.0	0.0
2	3	10216.8	1.44E-01	11240.0	360.0	0.0	0.0	0.0	0.0
2	4	1419.0	1.44E-01	11240.0	360.0	100.0	0.0	0.0	0.0
2	5	3789.3	7.07E-01	11240.0	508.4	100.0	0.0	0.0	0.0
2	6	283.8	1.44E-01	11240.0	360.0	100.0	0.0	0.0	0.0
3	1	18096.0	3.84E-01	506.0	231.3	69.0	21.0	10.0	0.0
3	2	35528.0	6.30E-01	379.8	214.8	69.5	25.5	5.0	0.0
3	3	26291.5	3.01E-01	470.9	146.9	46.5	43.5	10.0	0.0
3	4	2338.5	8.88E-01	290.2	229.2	66.0	21.5	12.5	0.0
3	5	5266.3	1.04E+00	275.2	172.2	49.0	16.0	30.0	5.0
3	6	387.8	2.99E-01	282.4	161.1	46.0	11.5	35.0	7.5
4	1	13089.8	9.95E-01	88.0	810.7	73.8	11.9	9.5	4.8
4	2	13128.0	9.95E-01	88.0	810.7	73.1	16.5	5.7	4.7
4	3	17421.0	1.02E+00	123.0	833.8	49.8	32.3	13.4	4.6
4	4	14.3	1.21E+00	88.0	810.7	69.0	14.3	11.9	4.8
4	5	33.8	1.13E+00	105.0	819.8	54.3	9.5	31.7	4.5
4	6	14.5	1.18E+00	95.3	814.2	50.7	8.2	33.8	7.2
5	1	37575.8	9.25E-01	16.0	229.0	62.6	22.4	9.3	5.6
5	2	68203.0	1.33E+00	16.0	227.2	62.0	25.5	6.9	5.6
5	3	45589.3	1.00E+00	15.3	252.1	37.7	42.5	14.2	5.7
5	4	4373.8	1.70E+00	15.3	204.3	59.0	23.6	11.8	5.7
5	5	8709.5	2.34E+00	11.8	255.1	34.1	23.4	36.6	5.9
5	6	842.8	1.68E+00	15.3	203.6	36.1	18.3	36.1	9.6
6	1	1743.0	2.50E-02	321000.0	150.0	55.0	25.0	20.0	0.0
6	2	1743.0	2.50E-02	321000.0	150.0	55.0	35.0	10.0	0.0
6	3	2324.0	3.00E-02	321000.0	150.0	10.0	70.0	20.0	0.0
6	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
7	1	5080.5	0.00E+00	3075.0	892.8	55.0	25.0	20.0	0.0
7	2	13683.0	3.10E-02	8075.5	1136.3	65.9	20.7	7.4	6.0
7	3	2971.8	0.00E+00	10963.1	480.0	32.0	42.5	18.0	7.5
7	4	917.0	0.00E+00	3000.0	1080.0	0.0	0.0	0.0	0.0
7	5	44.3	5.92E-01	9992.8	533.6	48.5	13.7	30.9	6.9
7	6	187.0	0.00E+00	3409.7	988.2	28.5	12.0	44.0	15.5

TABLE 29c

Market attribute in year 2020 for unicast uplink (higher user density case) (part 2 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
8	1	15782.5	1.74E-01	700.8	123.0	72.5	17.5	10.0	0.0
8	2	15861.0	9.32E-01	868.8	486.2	70.0	21.7	6.3	1.9
8	3	21320.3	7.93E-01	868.8	486.2	48.3	38.6	9.7	3.4
8	4	21.0	4.11E-01	384.0	158.0	67.5	20.0	12.5	0.0
8	5	68.5	1.03E+00	868.8	493.1	50.0	15.0	30.0	5.0
8	6	9.0	7.39E-01	868.8	493.1	42.5	10.0	40.0	7.5
9	1	309.0	8.23E-01	144.0	20.0	90.0	10.0	0.0	0.0
9	2	412.0	1.23E+00	144.0	79.0	90.0	10.0	0.0	0.0
9	3	52.0	4.11E-01	144.0	79.0	80.0	10.0	10.0	0.0
9	4	52.0	8.23E-01	144.0	20.0	90.0	10.0	0.0	0.0
9	5	103.0	1.23E+00	144.0	79.0	70.0	10.0	20.0	0.0
9	6	10.0	4.11E-01	144.0	20.0	80.0	10.0	10.0	0.0
10	1	206.0	8.23E-01	16.0	4.0	67.5	22.5	10.0	0.0
10	2	309.0	1.23E+00	16.0	4.0	67.5	27.5	5.0	0.0
10	3	52.0	4.11E-01	16.0	4.0	40.0	45.0	15.0	0.0
10	4	52.0	8.23E-01	16.0	4.0	62.5	25.0	12.5	0.0
10	5	52.0	1.23E+00	16.0	4.0	35.0	20.0	40.0	5.0
10	6	10.0	4.11E-01	16.0	4.0	35.0	15.0	40.0	10.0
11	1	27.8	3.00E-02	321000.0	18.0	55.0	25.0	20.0	0.0
11	2	43.5	3.17E-01	321000.0	81.9	100.0	0.0	0.0	0.0
11	3	18793.8	2.99E-01	90141.2	6.0	10.0	70.0	20.0	0.0
11	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	5	6950.8	8.76E-01	212984.6	53.9	100.0	0.0	0.0	0.0
11	6	521.0	3.00E-01	89978.0	6.0	0.0	0.0	0.0	0.0
12	1	35244.0	2.84E+00	11059.6	33.1	68.3	22.1	9.0	0.5
12	2	120974.5	2.57E+00	10725.9	75.5	67.5	27.5	5.0	0.0
12	3	82235.8	2.28E+00	11344.8	75.2	50.0	40.5	9.0	0.5
12	4	10549.5	2.85E+00	9835.8	21.2	62.5	25.0	12.5	0.0
12	5	30422.0	2.31E+00	9858.5	21.2	43.0	20.0	32.0	5.0
12	6	2373.3	2.56E+00	9953.7	21.2	41.8	15.4	35.3	7.5
13	1	14325.3	2.43E-01	1360.5	149.3	68.5	21.2	7.9	2.4
13	2	14293.5	5.03E-01	1360.8	148.6	67.4	25.8	5.1	1.7
13	3	17566.0	3.29E-01	1359.6	156.3	38.6	39.7	17.4	4.3
13	4	75.5	9.70E-01	1358.1	176.6	61.9	24.8	12.4	1.0
13	5	110.8	1.76E+00	1358.1	175.2	39.8	19.9	34.8	5.5
13	6	24.5	1.14E+00	1249.6	177.9	35.3	14.9	39.8	10.0
14	1	15514.5	2.40E-01	120.2	30.6	67.2	22.4	10.0	0.5
14	2	15514.5	2.54E-01	121.6	30.3	67.2	27.4	5.0	0.5
14	3	26031.8	3.12E-01	177.0	314.1	26.0	62.5	11.0	0.5
14	4	67.3	5.28E-01	48.8	66.9	60.7	23.8	12.1	3.4
14	5	2977.3	2.97E-01	177.8	981.0	35.0	60.0	5.0	0.0
14	6	233.3	3.23E-01	177.6	852.6	32.7	59.8	5.0	2.5

TABLE 29c

Market attribute in year 2020 for unicast uplink (higher user density case) (part 3 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
15	1	13139.8	2.06E+00	11.5	30.0	67.5	22.5	10.0	0.0
15	2	41089.8	3.15E+00	7.9	33.2	67.5	27.5	5.0	0.0
15	3	25608.0	1.23E+00	20.1	35.9	35.0	45.0	19.5	0.5
15	4	3382.0	2.47E+00	7.0	27.2	62.5	25.0	12.5	0.0
15	5	9313.8	3.14E+00	30.1	29.3	45.0	15.0	35.0	5.0
15	6	702.8	2.47E+00	36.5	30.7	35.0	15.0	40.0	10.0
16	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	2	52.0	8.23E-01	20000.0	222.0	80.0	20.0	0.0	0.0
16	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	5	10.0	8.23E-01	20000.0	222.0	80.0	20.0	0.0	0.0
16	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
17	1	4493.3	7.13E-01	10056.5	32.7	56.6	24.2	19.2	0.0
17	2	16242.8	1.01E+00	9931.2	179.5	67.5	27.5	5.0	0.0
17	3	2969.5	8.24E-01	10911.4	90.6	13.9	66.2	19.4	0.5
17	4	1309.8	7.28E-01	9481.7	32.1	45.3	29.9	24.9	0.0
17	5	1044.0	1.43E+00	9733.7	224.9	45.0	20.0	30.0	5.0
17	6	262.5	7.27E-01	9816.7	32.7	7.0	10.0	68.0	15.0
18	1	618.0	4.11E-01	574.0	82.0	80.0	20.0	0.0	0.0
18	2	1339.0	4.11E+00	595.0	153.0	80.0	20.0	0.0	0.0
18	3	21.0	4.11E-01	990.0	23.0	60.0	20.0	20.0	0.0
18	4	103.0	4.11E-01	1030.0	72.0	80.0	20.0	0.0	0.0
18	5	72.0	4.11E+00	653.0	148.0	60.0	20.0	20.0	0.0
18	6	10.0	4.11E-01	1030.0	72.0	60.0	20.0	15.0	5.0
19	1	515.0	4.11E-01	144.0	21.0	80.0	20.0	0.0	0.0
19	2	1030.0	1.23E+00	144.0	21.0	80.0	20.0	0.0	0.0
19	3	52.0	4.11E-01	144.0	21.0	60.0	20.0	15.0	5.0
19	4	52.0	4.11E-01	144.0	21.0	80.0	20.0	0.0	0.0
19	5	52.0	4.11E-01	144.0	21.0	60.0	20.0	20.0	0.0
19	6	10.0	4.11E-01	144.0	21.0	60.0	20.0	15.0	5.0
20	1	1030.0	4.11E-01	16.0	25.0	80.0	20.0	0.0	0.0
20	2	1030.0	1.23E+00	16.0	41.0	80.0	20.0	0.0	0.0
20	3	103.0	4.11E-01	16.0	25.0	35.0	45.0	20.0	0.0
20	4	103.0	4.11E-01	16.0	25.0	80.0	20.0	0.0	0.0
20	5	52.0	1.23E+00	16.0	41.0	35.0	20.0	40.0	5.0
20	6	10.0	4.11E-01	16.0	25.0	32.5	15.0	42.5	10.0

TABLE 29d

Market attribute in year 2020 for multicast downlink (higher user density case)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
2	1	51.5	0.4	20000.0	14812.0	100.0	0.0	0.0	0.0
2	2	10.3	1.7	20000.0	5554.5	100.0	0.0	0.0	0.0
2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	4	20.6	0.4	20000.0	14812.0	100.0	0.0	0.0	0.0
2	5	3.1	1.7	20000.0	2468.7	100.0	0.0	0.0	0.0
2	6	1.0	0.4	20000.0	14812.0	100.0	0.0	0.0	0.0
3	1	391.4	1.7	1424.2	1130.4	83.0	17.0	0.0	0.0
3	2	463.5	2.5	922.7	1587.0	84.0	16.0	0.0	0.0
3	3	61.8	1.7	1192.0	617.2	82.0	18.0	0.0	0.0
3	4	103.0	5.4	731.7	1026.4	86.0	14.0	0.0	0.0
3	5	56.7	5.8	623.4	1388.6	87.0	13.0	0.0	0.0
3	6	2.7	3.3	679.9	922.5	87.0	13.0	0.0	0.0

TABLE 30a

Market attribute in year 2010 (lower user density case)

SC	*U* (%)	*Q* (%)	*R* (%)	μ (%)	Mobility ratio
1	5	30	30	30	2 (No range M.2072)
2	5	30	30	30	2 (No range M.2072)
3	5	30	30	30	2
4	5	30	30	30	2
5	5	30	30	30	2
6	5	30	30	30	2 (No range M.2072)
7	5	30	30	30	2
8	5	30	30	30	2
9	5	30	30	30	2 (No range M.2072)
10	5	30	30	30	2
11	5	30	30	30	1
12	5	30	30	30	2
13	5	30	30	30	2
14	5	30	30	30	2
15	5	30	30	30	2
16	5	30	30	30	2 (No range M.2072)
17	5	30	30	30	2
18	5	30	30	30	2
19	5	30	30	30	2 (No range M.2072)
20	5	30	30	30	2 (No range M.2072)

TABLE 30b

Market attribute in year 2010 for unicast downlink (lower user density case) (part 1 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
1	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	2	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	1	0.0	0.00E+00	0.0	0.0	55.0	25.0	20.0	0.0
2	2	45.0	2.99E-01	20000.0	53.0	77.5	17.5	5.0	0.0
2	3	0.0	0.00E+00	0.0	0.0	10.0	70.0	20.0	0.0
2	4	0.0	0.00E+00	0.0	0.0	45.0	30.0	25.0	0.0
2	5	7.0	2.99E-01	20000.0	51.0	55.0	10.0	30.0	5.0
2	6	0.0	0.00E+00	0.0	0.0	5.0	10.0	70.0	15.0
3	1	3637.6	2.44E-01	496.2	113.5	69.0	21.0	10.0	0.0
3	2	6716.1	3.10E-01	374.9	110.2	69.0	26.0	5.0	0.0
3	3	1674.4	1.64E-01	447.1	71.7	47.0	43.0	10.0	0.0
3	4	757.5	3.74E-01	290.2	109.2	65.5	22.0	12.5	0.0
3	5	827.8	4.24E-01	275.2	85.7	49.0	16.0	30.0	5.0
3	6	53.7	9.97E-02	282.4	79.4	46.0	11.5	35.0	7.5
4	1	735.1	2.86E-01	88.0	249.4	73.8	11.9	9.5	4.8
4	2	782.6	2.86E-01	88.0	249.4	73.1	16.5	5.7	4.7
4	3	936.0	2.86E-01	88.0	268.3	49.3	32.3	13.8	4.6
4	4	5.8	2.86E-01	88.0	249.4	69.0	14.3	11.9	4.8
4	5	20.5	2.76E-01	88.0	276.0	54.8	9.5	30.7	5.0
4	6	5.8	2.82E-01	88.0	259.9	50.7	8.2	33.8	7.2
5	1	15616.9	6.48E-01	15.3	221.7	62.6	22.4	9.3	5.6
5	2	34488.8	8.26E-01	15.3	232.7	62.0	25.5	6.9	5.6
5	3	22271.6	7.81E-01	15.3	217.1	37.7	42.5	14.2	5.7
5	4	2240.7	1.38E+00	14.6	208.9	59.0	23.6	11.8	5.7
5	5	4902.9	1.69E+00	11.8	227.1	34.1	23.4	36.6	5.9
5	6	414.2	1.35E+00	15.3	207.5	36.1	18.3	36.1	9.6
6	1	0.0	0.00E+00	0.0	0.0	55.0	25.0	20.0	0.0
6	2	0.0	0.00E+00	0.0	0.0	55.0	35.0	10.0	0.0
6	3	0.0	0.00E+00	0.0	0.0	10.0	70.0	20.0	0.0
6	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
7	1	2.2	3.00E-03	11230.4	45.0	55.0	25.0	20.0	0.0
7	2	102.2	2.84E-01	10657.1	219.9	70.0	21.7	5.8	2.4
7	3	39.1	8.52E-02	10427.3	190.5	33.3	42.3	17.9	6.5
7	4	0.0	0.00E+00	0.0	0.0	45.0	30.0	25.0	0.0
7	5	30.2	3.06E-01	8844.2	239.7	48.5	14.1	30.1	7.3
7	6	0.3	6.75E-02	9679.1	197.7	6.5	10.0	68.5	15.0

TABLE 30b

Market attribute in year 2010 for unicast downlink (lower user density case) (part 2 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
8	1	792.0	1.16E-01	801.9	713.3	72.5	17.5	10.0	0.0
8	2	3547.8	1.19E-01	849.6	1050.5	63.9	19.8	8.8	7.5
8	3	1204.1	2.52E-01	868.8	384.2	46.1	36.9	9.2	7.8
8	4	242.4	1.41E-01	767.6	449.6	90.0	10.0	0.0	0.0
8	5	481.1	3.22E-01	868.8	386.3	47.6	16.7	28.6	7.1
8	6	49.6	1.98E-01	832.2	970.1	39.7	15.4	37.4	7.5
9	1	300.0	1.99E-01	144.0	5.0	90.0	10.0	0.0	0.0
9	2	400.0	2.99E-01	144.0	19.0	90.0	10.0	0.0	0.0
9	3	50.0	1.00E-01	144.0	19.0	80.0	10.0	10.0	0.0
9	4	50.0	1.99E-01	144.0	5.0	90.0	10.0	0.0	0.0
9	5	100.0	2.99E-01	144.0	19.0	70.0	10.0	20.0	0.0
9	6	10.0	1.00E-01	144.0	5.0	80.0	10.0	10.0	0.0
10	1	200.0	1.99E-01	16.0	1.0	80.0	20.0	0.0	0.0
10	2	300.0	2.99E-01	16.0	1.0	80.0	20.0	0.0	0.0
10	3	50.0	1.00E-01	16.0	1.0	70.0	20.0	10.0	0.0
10	4	50.0	1.99E-01	16.0	1.0	80.0	20.0	0.0	0.0
10	5	50.0	2.99E-01	16.0	1.0	60.0	20.0	20.0	0.0
10	6	10.0	1.00E-01	16.0	1.0	65.0	20.0	10.0	5.0
11	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	2	20.0	1.99E-01	500000.0	32.0	100.0	0.0	0.0	0.0
11	3	1354.4	3.00E-01	30000.0	2.4	10.0	70.0	20.0	0.0
11	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	5	506.4	4.39E-01	171000.0	15.2	100.0	0.0	0.0	0.0
11	6	37.6	3.00E-01	30000.0	2.4	5.0	10.0	70.0	15.0
12	1	265.5	5.76E-01	10256.8	92.9	67.5	22.5	10.0	0.0
12	2	532.4	5.95E-01	9779.8	95.6	67.5	27.5	5.0	0.0
12	3	2203.8	2.33E-01	10532.6	31.1	46.2	44.2	9.5	0.0
12	4	67.9	6.00E-01	9767.9	95.9	62.5	25.0	12.5	0.0
12	5	852.3	2.31E-01	9820.1	30.8	42.5	20.0	32.5	5.0
12	6	65.2	2.32E-01	9972.0	30.8	40.5	15.0	37.0	7.5
13	1	8365.5	2.24E+00	1371.9	23.6	66.1	23.4	10.4	0.0
13	2	23720.5	2.19E+00	1371.9	32.0	67.0	27.9	5.1	0.0
13	3	13392.2	2.12E+00	1371.9	36.2	36.7	45.2	18.1	0.0
13	4	2071.8	2.30E+00	850.9	22.9	62.5	25.0	12.5	0.0
13	5	4905.2	2.31E+00	859.6	22.9	40.0	20.0	35.0	5.0
13	6	400.7	2.30E+00	884.1	23.5	36.0	15.0	40.0	9.0
14	1	3552.7	1.07E-01	125.1	21.7	67.2	22.4	10.0	0.5
14	2	3552.7	1.13E-01	126.5	21.7	67.2	27.4	5.0	0.5
14	3	2007.1	1.33E-01	177.4	544.0	25.4	63.7	10.4	0.5
14	4	20.5	1.42E-01	48.8	42.4	61.3	22.1	12.3	4.4
14	5	404.6	1.38E-01	177.9	1051.0	35.0	60.0	5.0	0.0
14	6	37.9	1.40E-01	177.5	1005.4	32.7	59.8	5.0	2.5

TABLE 30b

Market attribute in year 2010 for unicast downlink (lower user density case) (part 3 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
15	1	4858.9	1.20E+00	8.3	8.5	67.2	22.4	10.0	0.5
15	2	10065.4	1.55E+00	7.6	10.0	67.5	27.5	5.0	0.0
15	3	4666.1	1.08E+00	32.8	9.0	33.5	38.9	26.6	1.0
15	4	791.0	1.27E+00	7.6	8.5	62.5	25.0	12.5	0.0
15	5	1735.9	1.55E+00	39.4	9.2	44.3	13.4	37.8	4.5
15	6	132.8	1.27E+00	61.3	9.2	34.5	14.5	40.5	10.5
16	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	2	50.0	1.99E-01	20000.0	54.0	80.0	20.0	0.0	0.0
16	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	5	10.0	1.99E-01	20000.0	54.0	80.0	20.0	0.0	0.0
16	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
17	1	390.7	0.00E+00	5521.6	86.4	55.0	25.0	20.0	0.0
17	2	1430.1	1.99E-01	6530.6	120.0	67.5	27.5	5.0	0.0
17	3	840.2	0.00E+00	5594.0	86.7	10.0	70.0	20.0	0.0
17	4	115.0	0.00E+00	5512.7	86.4	45.0	30.0	25.0	0.0
17	5	315.5	1.99E-01	6513.5	120.0	45.0	20.0	30.0	5.0
17	6	23.1	0.00E+00	5539.2	86.4	5.0	10.0	70.0	15.0
18	1	773.8	7.45E-01	701.8	11.6	67.5	22.5	10.0	0.0
18	2	2738.0	6.77E-01	716.5	16.7	67.5	27.5	5.0	0.0
18	3	20.0	1.00E-01	990.0	6.0	60.0	20.0	20.0	0.0
18	4	156.2	7.45E-01	1009.0	10.7	62.5	25.0	12.5	0.0
18	5	70.0	9.96E-01	653.0	36.0	60.0	20.0	20.0	0.0
18	6	21.8	7.45E-01	1009.0	10.7	32.5	15.0	42.5	10.0
19	1	500.0	1.00E-01	144.0	5.0	80.0	20.0	0.0	0.0
19	2	1000.0	2.99E-01	144.0	5.0	80.0	20.0	0.0	0.0
19	3	50.0	1.00E-01	144.0	5.0	60.0	20.0	15.0	5.0
19	4	50.0	1.00E-01	144.0	5.0	80.0	20.0	0.0	0.0
19	5	50.0	1.00E-01	144.0	5.0	60.0	20.0	20.0	0.0
19	6	10.0	1.00E-01	144.0	5.0	60.0	20.0	15.0	5.0
20	1	1000.0	1.00E-01	16.0	6.0	80.0	20.0	0.0	0.0
20	2	1000.0	2.99E-01	16.0	10.0	80.0	20.0	0.0	0.0
20	3	100.0	1.00E-01	16.0	6.0	60.0	20.0	20.0	0.0
20	4	100.0	1.00E-01	16.0	6.0	80.0	20.0	0.0	0.0
20	5	50.0	2.99E-01	16.0	10.0	60.0	20.0	20.0	0.0
20	6	10.0	1.00E-01	16.0	6.0	60.0	20.0	15.0	5.0

TABLE 30c

Market attribute in year 2010 for unicast uplink (lower user density case) (part 1 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
1	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	2	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	1	50.0	1.00E-01	20000.0	1793.0	100.0	0.0	0.0	0.0
2	2	55.0	2.81E-01	20000.0	64.0	100.0	0.0	0.0	0.0
2	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	4	20.0	1.00E-01	20000.0	1793.0	100.0	0.0	0.0	0.0
2	5	10.0	2.99E-01	20000.0	9.0	100.0	0.0	0.0	0.0
2	6	1.0	1.00E-01	20000.0	1793.0	100.0	0.0	0.0	0.0
3	1	3998.6	2.44E-01	486.6	125.4	69.0	21.0	10.0	0.0
3	2	7143.6	3.10E-01	318.5	113.7	69.5	25.5	5.0	0.0
3	3	1731.4	1.64E-01	373.3	91.3	46.5	43.5	10.0	0.0
3	4	852.5	3.70E-01	275.2	118.3	66.0	21.5	12.5	0.0
3	5	880.0	4.17E-01	275.2	99.7	49.0	16.0	30.0	5.0
3	6	56.5	9.82E-02	275.2	87.8	46.0	11.5	35.0	7.5
4	1	735.1	2.86E-01	88.0	787.0	73.8	11.9	9.5	4.8
4	2	782.6	2.86E-01	88.0	787.0	73.1	16.5	5.7	4.7
4	3	936.0	2.86E-01	518.1	805.9	50.0	32.4	13.0	4.6
4	4	5.8	2.86E-01	88.0	787.0	69.0	14.3	11.9	4.8
4	5	20.5	2.76E-01	634.2	813.6	53.8	8.5	33.2	4.5
4	6	5.8	2.82E-01	368.7	797.5	50.5	7.8	34.5	7.3
5	1	15616.9	6.48E-01	15.3	221.7	62.6	22.4	9.3	5.6
5	2	34488.8	8.26E-01	15.3	232.7	62.0	25.5	6.9	5.6
5	3	22271.6	7.81E-01	15.3	217.1	37.7	42.5	14.2	5.7
5	4	2240.7	1.38E+00	14.6	208.9	59.0	23.6	11.8	5.7
5	5	4902.9	1.69E+00	11.8	227.1	34.1	23.4	36.6	5.9
5	6	414.2	1.35E+00	15.3	207.5	36.1	18.3	36.1	9.6
6	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	2	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
7	1	2.2	3.00E-03	10400.0	45.0	55.0	25.0	20.0	0.0
7	2	102.2	2.84E-01	10400.0	203.1	65.3	20.5	7.3	6.8
7	3	39.1	8.52E-02	10337.1	190.5	31.7	42.1	18.8	7.4
7	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
7	5	30.2	3.06E-01	9737.2	222.9	48.0	13.2	32.4	6.4
7	6	0.3	6.75E-02	10093.1	197.7	27.9	11.4	45.3	15.4

TABLE 30c

Market attribute in year 2010 for unicast uplink (lower user density case) (part 2 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
8	1	837.4	2.28E-01	512.4	351.1	72.5	17.5	10.0	0.0
8	2	2497.0	4.06E-01	523.8	358.0	72.1	22.4	5.0	0.5
8	3	1600.8	2.64E-01	539.4	355.3	49.8	39.8	10.0	0.5
8	4	204.7	2.67E-01	511.8	358.0	67.5	20.0	12.5	0.0
8	5	545.2	3.36E-01	512.7	357.4	50.0	15.0	30.0	5.0
8	6	42.4	2.67E-01	513.6	356.5	42.5	10.0	40.0	7.5
9	1	300.0	1.99E-01	144.0	7.0	90.0	10.0	0.0	0.0
9	2	400.0	2.99E-01	144.0	29.0	90.0	10.0	0.0	0.0
9	3	50.0	1.00E-01	144.0	29.0	80.0	10.0	10.0	0.0
9	4	50.0	1.99E-01	144.0	7.0	90.0	10.0	0.0	0.0
9	5	100.0	2.99E-01	144.0	29.0	70.0	10.0	20.0	0.0
9	6	10.0	1.00E-01	144.0	7.0	80.0	10.0	10.0	0.0
10	1	415.0	3.19E-01	8.2	1081.4	67.5	22.5	10.0	0.0
10	2	1095.0	4.04E-01	8.2	1081.4	67.5	27.5	5.0	0.0
10	3	533.5	2.35E-01	8.2	1081.4	40.0	45.0	15.0	0.0
10	4	115.0	3.19E-01	8.2	1081.4	62.5	25.0	12.5	0.0
10	5	227.5	4.04E-01	8.2	1081.4	35.0	20.0	40.0	5.0
10	6	23.0	2.35E-01	8.2	1081.4	35.0	15.0	40.0	10.0
11	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	2	20.0	1.99E-01	500000.0	4.0	100.0	0.0	0.0	0.0
11	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	5	5.0	1.99E-01	500000.0	4.0	100.0	0.0	0.0	0.0
11	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
12	1	206.6	4.85E-01	13414.2	71.8	68.5	22.0	9.0	0.5
12	2	320.5	5.58E-01	10313.9	85.6	67.5	27.5	5.0	0.0
12	3	51.4	5.00E-01	15103.3	66.1	52.2	38.3	8.5	1.0
12	4	50.3	5.91E-01	10231.3	86.2	62.7	24.9	12.4	0.0
12	5	55.1	5.86E-01	10487.5	85.0	43.5	20.0	31.5	5.0
12	6	5.5	5.68E-01	11668.4	79.0	43.0	15.5	34.5	7.0
13	1	6128.6	1.20E-01	1114.4	19.7	66.1	22.4	9.4	2.1
13	2	16539.0	2.03E-01	1089.5	17.6	67.0	27.4	5.1	0.5
13	3	9103.5	1.23E-01	1136.6	21.8	35.8	42.8	17.9	3.5
13	4	1392.4	1.19E-01	1080.8	16.2	62.2	24.9	12.4	0.5
13	5	3303.2	2.04E-01	1086.8	16.9	39.8	19.9	34.8	5.5
13	6	264.9	1.20E-01	1011.9	18.2	35.5	15.0	40.0	9.5
14	1	3814.7	1.55E+00	60.0	1.3	67.2	22.4	10.0	0.5
14	2	3552.7	1.13E-01	60.0	20.3	67.2	27.4	5.0	0.5
14	3	2007.1	1.33E-01	92.9	542.6	25.4	63.7	10.4	0.5
14	4	269.2	5.39E+00	63.5	0.6	61.0	24.4	12.2	2.4
14	5	404.6	1.38E-01	91.8	1049.6	35.0	60.0	5.0	0.0
14	6	53.7	2.25E+00	92.1	20.9	32.7	59.8	5.0	2.5

TABLE 30c

Market attribute in year 2010 for unicast uplink (lower user density case) (part 3 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
15	1	8608.9	4.55E+00	6.2	9.4	67.5	22.5	10.0	0.0
15	2	23565.4	4.91E+00	6.2	11.5	67.5	27.5	5.0	0.0
15	3	12666.8	4.79E+00	6.9	7.9	34.8	44.8	19.9	0.5
15	4	1916.0	4.63E+00	6.2	9.4	62.5	25.0	12.5	0.0
15	5	4699.1	5.30E+00	6.2	9.4	45.0	15.0	35.0	5.0
15	6	355.0	5.01E+00	6.2	9.4	35.0	15.0	40.0	10.0
16	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	2	50.0	1.99E-01	20000.0	6.0	80.0	20.0	0.0	0.0
16	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	5	10.0	1.99E-01	20000.0	6.0	80.0	20.0	0.0	0.0
16	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
17	1	57.1	0.00E+00	5671.5	85.8	55.0	25.0	20.0	0.0
17	2	229.1	1.99E-01	6745.7	95.1	67.5	27.5	5.0	0.0
17	3	119.6	0.00E+00	6230.1	87.6	11.0	69.0	20.0	0.0
17	4	14.9	0.00E+00	5598.0	86.4	45.0	30.0	25.0	0.0
17	5	48.6	1.99E-01	6607.1	95.1	45.0	20.0	30.0	5.0
17	6	3.1	0.00E+00	5806.8	87.0	5.5	10.0	69.5	15.0
18	1	600.0	1.00E-01	574.0	8.0	80.0	20.0	0.0	0.0
18	2	1300.0	9.96E-01	595.0	16.0	80.0	20.0	0.0	0.0
18	3	20.0	1.00E-01	990.0	2.0	60.0	20.0	20.0	0.0
18	4	100.0	1.00E-01	1030.0	7.0	80.0	20.0	0.0	0.0
18	5	70.0	9.96E-01	653.0	15.0	60.0	20.0	20.0	0.0
18	6	10.0	1.00E-01	1030.0	7.0	60.0	20.0	15.0	5.0
19	1	500.0	1.00E-01	144.0	5.0	80.0	20.0	0.0	0.0
19	2	1000.0	2.99E-01	144.0	5.0	80.0	20.0	0.0	0.0
19	3	50.0	1.00E-01	144.0	5.0	60.0	20.0	15.0	5.0
19	4	50.0	1.00E-01	144.0	5.0	80.0	20.0	0.0	0.0
19	5	50.0	1.00E-01	144.0	5.0	60.0	20.0	20.0	0.0
19	6	10.0	1.00E-01	144.0	5.0	60.0	20.0	15.0	5.0
20	1	1000.0	1.00E-01	16.0	6.0	80.0	20.0	0.0	0.0
20	2	1000.0	2.99E-01	16.0	10.0	80.0	20.0	0.0	0.0
20	3	321.8	3.70E-01	13.2	2.5	35.0	45.0	20.0	0.0
20	4	100.0	1.00E-01	16.0	6.0	80.0	20.0	0.0	0.0
20	5	131.5	5.09E-01	13.2	3.7	35.0	20.0	40.0	5.0
20	6	15.8	3.70E-01	13.2	2.5	32.5	15.0	42.5	10.0

TABLE 30d

Market attribute in year 2010 for multicast downlink (lower user density case)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
2	1	50.0	0.1	20000.0	3585.4	100	0	0	0
2	2	10.0	0.4	20000.0	1344.5	100	0	0	0
2	3	0.0	0.0	0.0	0.0	0	0	0	0
2	4	20.0	0.1	20000.0	3585.4	100	0	0	0
2	5	3.0	0.4	20000.0	597.6	100	0	0	0
2	6	1.0	0.1	20000.0	3585.4	100	0	0	0
3	1	380.0	0.4	1424.2	273.6	83	17	0	0
3	2	450.0	0.6	922.7	384.1	84	16	0	0
3	3	60.0	0.4	1192.0	149.4	82	18	0	0
3	4	100.0	1.3	731.7	248.5	86	14	0	0
3	5	55.0	1.4	623.4	336.1	87	13	0	0
3	6	2.8	0.8	679.9	223.3	87	13	0	0

TABLE 31a

Market attribute in year 2015 (lower user density case)

SC	*U* (%)	*Q* (%)	*R* (%)	μ (%)	Mobility ratio
1	5	30	30	30	2 (No range M.2072)
2	5	30	30	30	2 (No range M.2072)
3	5	30	30	30	2
4	5	30	30	30	2
5	5	30	30	30	2
6	5	30	30	30	1
7	5	30	30	30	2
8	5	30	30	30	2
9	5	30	30	30	2 (No range M.2072)
10	5	30	30	30	2
11	5	30	30	30	1
12	5	30	30	30	2
13	5	30	30	30	2
14	5	30	30	30	2
15	5	30	30	30	2
16	5	30	30	30	2 (No range M.2072)
17	5	30	30	30	2
18	5	30	30	30	2
19	5	30	30	30	2 (No range M.2072)
20	5	30	30	30	2

TABLE 31b

Market attribute in year 2015 for unicast downlink (lower user density case) (part 1 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
1	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	2	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	2	46.0	5.98E-01	20000.0	106.0	100.0	0.0	0.0	0.0
2	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	5	7.0	5.98E-01	20000.0	102.0	100.0	0.0	0.0	0.0
2	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
3	1	4860.2	2.54E-01	505.3	162.5	69.0	21.0	10.0	0.0
3	2	8618.2	4.02E-01	379.1	147.3	69.0	26.0	5.0	0.0
3	3	3438.1	2.15E-01	467.4	107.1	47.0	43.0	10.0	0.0
3	4	843.9	5.60E-01	290.2	156.1	65.5	22.0	12.5	0.0
3	5	1034.4	6.27E-01	275.2	126.6	49.0	16.0	30.0	5.0
3	6	68.7	1.65E-01	282.4	121.2	46.0	11.5	35.0	7.5
4	1	2016.7	5.81E-01	88.0	428.5	73.8	11.9	9.5	4.8
4	2	2065.2	5.81E-01	88.0	428.5	73.1	16.5	5.7	4.7
4	3	2643.9	6.03E-01	99.2	449.5	49.8	32.3	13.4	4.6
4	4	7.7	6.43E-01	88.0	428.5	69.0	14.3	11.9	4.8
4	5	21.3	6.09E-01	96.4	443.2	54.3	9.5	31.7	4.5
4	6	8.6	6.29E-01	91.5	434.8	50.7	8.2	33.8	7.2
5	1	7904.5	7.97E-01	15.3	231.5	62.6	22.4	9.3	5.6
5	2	14280.1	9.93E-01	15.3	231.0	62.0	25.5	6.9	5.6
5	3	8829.1	9.15E-01	15.3	252.1	37.7	42.5	14.2	5.7
5	4	1057.2	1.56E+00	15.3	205.9	59.0	23.6	11.8	5.7
5	5	1843.4	2.02E+00	11.8	255.1	34.1	23.4	36.6	5.9
5	6	172.3	1.54E+00	15.3	205.2	36.1	18.3	36.1	9.6
6	1	111.0	2.00E-02	321000.0	150.0	55.0	25.0	20.0	0.0
6	2	111.0	2.00E-02	321000.0	150.0	55.0	35.0	10.0	0.0
6	3	148.0	2.20E-02	321000.0	150.0	10.0	70.0	20.0	0.0
6	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
7	1	445.8	2.10E-02	2009.6	1054.8	55.0	25.0	20.0	0.0
7	2	2068.2	3.16E-01	7400.0	1092.6	72.1	22.4	5.0	0.5
7	3	87.8	9.45E-02	10571.5	309.9	32.0	42.5	18.0	7.5
7	4	122.3	2.25E-02	2000.0	1080.0	45.0	30.0	25.0	0.0
7	5	32.3	5.42E-01	9570.7	368.4	48.5	13.7	30.9	6.9
7	6	25.0	2.40E-02	2200.2	1014.9	5.5	10.0	69.5	15.0

TABLE 31b

Market attribute in year 2015 for unicast downlink (lower user density case) (part 2 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
8	1	1412.4	1.60E-01	700.8	413.9	72.5	17.5	10.0	0.0
8	2	2808.1	5.83E-01	868.8	413.9	63.9	19.8	8.8	7.5
8	3	1870.8	4.61E-01	868.8	412.4	46.1	36.9	9.2	7.8
8	4	244.5	2.52E-01	700.8	413.9	67.5	20.0	12.5	0.0
8	5	651.5	6.02E-01	868.8	413.6	46.3	18.1	27.8	7.9
8	6	50.2	4.63E-01	868.8	413.6	38.5	17.6	36.2	7.7
9	1	306.0	3.98E-01	144.0	10.0	90.0	10.0	0.0	0.0
9	2	408.0	5.98E-01	144.0	38.0	90.0	10.0	0.0	0.0
9	3	51.0	1.99E-01	144.0	38.0	80.0	10.0	10.0	0.0
9	4	51.0	3.98E-01	144.0	10.0	90.0	10.0	0.0	0.0
9	5	102.0	5.98E-01	144.0	38.0	70.0	10.0	20.0	0.0
9	6	10.0	1.99E-01	144.0	10.0	80.0	10.0	10.0	0.0
10	1	204.0	3.98E-01	16.0	2.0	80.0	20.0	0.0	0.0
10	2	306.0	5.98E-01	16.0	2.0	80.0	20.0	0.0	0.0
10	3	51.0	1.99E-01	16.0	2.0	70.0	20.0	10.0	0.0
10	4	51.0	3.98E-01	16.0	2.0	80.0	20.0	0.0	0.0
10	5	51.0	5.98E-01	16.0	2.0	60.0	20.0	20.0	0.0
10	6	10.0	1.99E-01	16.0	2.0	65.0	20.0	10.0	5.0
11	1	5.6	2.40E-02	321000.0	18.0	55.0	25.0	20.0	0.0
11	2	24.6	1.75E-01	321000.0	61.5	100.0	0.0	0.0	0.0
11	3	2818.6	2.99E-01	36825.4	3.3	10.0	70.0	20.0	0.0
11	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	5	1045.9	5.79E-01	175503.1	27.2	100.0	0.0	0.0	0.0
11	6	78.1	3.00E-01	36433.0	3.3	5.0	10.0	70.0	15.0
12	1	2813.9	9.39E-01	9869.7	19.2	67.5	22.5	10.0	0.0
12	2	8584.1	2.13E-01	9450.9	73.1	67.5	27.5	5.0	0.0
12	3	6543.8	2.02E-01	10141.0	70.1	46.0	44.0	10.0	0.0
12	4	820.6	9.51E-01	9425.3	18.5	62.5	25.0	12.5	0.0
12	5	2439.2	2.01E-01	9465.8	70.1	42.5	20.0	32.5	5.0
12	6	201.1	7.82E-01	9599.7	19.2	40.5	15.0	37.0	7.5
13	1	7630.9	2.65E+00	1372.5	62.3	65.1	23.3	11.6	0.0
13	2	18793.7	3.24E+00	1372.5	53.9	64.7	29.9	5.4	0.0
13	3	11313.5	2.89E+00	1372.5	64.4	36.5	45.7	17.8	0.0
13	4	1483.6	3.45E+00	870.3	44.8	62.5	25.0	12.5	0.0
13	5	3538.4	3.72E+00	888.5	44.8	40.0	20.0	35.0	5.0
13	6	282.5	3.44E+00	936.2	46.0	36.0	15.0	40.0	9.0
14	1	4897.1	1.60E-01	125.8	23.8	67.2	22.4	10.0	0.5
14	2	4897.1	1.74E-01	126.5	23.8	67.2	27.4	5.0	0.5
14	3	4110.4	2.07E-01	176.5	352.9	26.0	62.5	11.0	0.5
14	4	25.4	2.68E-01	48.8	51.4	61.3	22.1	12.3	4.4
14	5	540.4	2.10E-01	177.2	1021.6	35.0	60.0	5.0	0.0
14	6	48.2	2.15E-01	178.1	938.2	32.7	59.8	5.0	2.5

TABLE 31b

Market attribute in year 2015 for unicast downlink (lower user density case) (part 3 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
15	1	5064.4	1.60E+00	9.7	14.9	66.5	22.2	9.9	1.5
15	2	10647.9	2.29E+00	8.3	17.2	67.2	27.4	5.0	0.5
15	3	5127.0	1.35E+00	35.2	16.6	33.3	38.2	26.5	2.0
15	4	838.4	1.74E+00	7.6	14.2	62.5	25.0	12.5	0.0
15	5	1897.8	2.29E+00	54.7	15.6	44.0	12.5	39.5	4.0
15	6	144.9	1.72E+00	85.3	15.6	34.5	14.0	41.0	10.5
16	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	2	51.0	3.98E-01	20000.0	108.0	80.0	20.0	0.0	0.0
16	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	5	10.0	3.98E-01	20000.0	108.0	80.0	20.0	0.0	0.0
16	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
17	1	354.3	6.49E-01	8136.4	86.4	55.0	25.0	20.0	0.0
17	2	1277.7	9.49E-01	9623.9	153.9	67.5	27.5	5.0	0.0
17	3	755.6	6.58E-01	8426.8	87.3	10.5	69.5	20.0	0.0
17	4	102.1	6.72E-01	8061.6	86.4	45.0	30.0	25.0	0.0
17	5	280.5	9.53E-01	9553.9	153.9	45.0	20.0	30.0	5.0
17	6	20.6	6.69E-01	8178.7	86.7	5.0	10.0	70.0	15.0
18	1	988.9	8.14E-01	1001.8	17.6	67.5	22.5	10.0	0.0
18	2	3091.3	1.07E+00	1016.5	27.8	67.5	27.5	5.0	0.0
18	3	20.0	1.99E-01	990.0	11.0	60.0	20.0	20.0	0.0
18	4	219.2	8.14E-01	1321.0	16.1	62.5	25.0	12.5	0.0
18	5	71.0	1.99E+00	653.0	72.0	60.0	20.0	20.0	0.0
18	6	34.0	8.14E-01	1321.0	16.1	32.5	15.0	42.5	10.0
19	1	510.0	1.99E-01	144.0	10.0	80.0	20.0	0.0	0.0
19	2	1020.0	5.98E-01	144.0	10.0	80.0	20.0	0.0	0.0
19	3	51.0	1.99E-01	144.0	10.0	60.0	20.0	15.0	5.0
19	4	51.0	1.99E-01	144.0	10.0	80.0	20.0	0.0	0.0
19	5	51.0	1.99E-01	144.0	10.0	60.0	20.0	20.0	0.0
19	6	10.0	1.99E-01	144.0	10.0	60.0	20.0	15.0	5.0
20	1	1020.0	1.99E-01	16.0	12.0	80.0	20.0	0.0	0.0
20	2	1020.0	5.98E-01	16.0	20.0	80.0	20.0	0.0	0.0
20	3	102.0	1.99E-01	16.0	12.0	60.0	20.0	20.0	0.0
20	4	102.0	1.99E-01	16.0	12.0	80.0	20.0	0.0	0.0
20	5	51.0	5.98E-01	16.0	20.0	60.0	20.0	20.0	0.0
20	6	10.0	1.99E-01	16.0	12.0	60.0	20.0	15.0	5.0

TABLE 31c

Market attribute in year 2015 for unicast uplink (lower user density case) (part 1 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
1	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	2	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	1	51.0	1.99E-01	20000.0	3586.0	100.0	0.0	0.0	0.0
2	2	56.0	5.61E-01	20000.0	129.0	100.0	0.0	0.0	0.0
2	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	4	20.0	1.99E-01	20000.0	3586.0	100.0	0.0	0.0	0.0
2	5	10.0	5.98E-01	20000.0	17.0	100.0	0.0	0.0	0.0
2	6	1.0	1.99E-01	20000.0	3586.0	100.0	0.0	0.0	0.0
3	1	5228.8	2.54E-01	495.7	187.0	69.0	21.0	10.0	0.0
3	2	9054.2	4.01E-01	322.7	150.6	69.5	25.5	5.0	0.0
3	3	3496.1	2.15E-01	393.6	130.4	46.5	43.5	10.0	0.0
3	4	940.8	5.50E-01	275.2	173.6	66.0	21.5	12.5	0.0
3	5	1087.6	6.14E-01	275.2	138.3	49.0	16.0	30.0	5.0
3	6	71.5	1.62E-01	275.2	128.4	46.0	11.5	35.0	7.5
4	1	2016.7	5.81E-01	88.0	1504.3	73.8	11.9	9.5	4.8
4	2	2065.2	5.81E-01	88.0	1504.3	73.1	16.5	5.7	4.7
4	3	2643.9	6.03E-01	992.1	1525.3	49.8	32.3	13.4	4.6
4	4	7.7	6.43E-01	88.0	1504.3	69.0	14.3	11.9	4.8
4	5	21.3	6.09E-01	782.7	1519.0	54.3	9.5	31.7	4.5
4	6	8.6	6.29E-01	417.9	1510.6	50.7	8.2	33.8	7.2
5	1	7904.5	7.97E-01	15.3	231.5	62.6	22.4	9.3	5.6
5	2	14280.1	9.93E-01	15.3	231.0	62.0	25.5	6.9	5.6
5	3	8829.1	9.15E-01	15.3	252.1	37.7	42.5	14.2	5.7
5	4	1057.2	1.56E+00	15.3	205.9	59.0	23.6	11.8	5.7
5	5	1843.4	2.02E+00	11.8	255.1	34.1	23.4	36.6	5.9
5	6	172.3	1.54E+00	15.3	205.2	36.1	18.3	36.1	9.6
6	1	111.0	2.00E-02	302293.9	150.0	55.0	25.0	20.0	0.0
6	2	111.0	2.00E-02	302293.9	150.0	55.0	35.0	10.0	0.0
6	3	148.0	2.20E-02	302293.9	150.0	10.0	70.0	20.0	0.0
6	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
7	1	38.3	6.00E-03	10400.0	45.0	55.0	25.0	20.0	0.0
7	2	195.8	4.14E-01	10400.0	388.2	65.9	20.7	7.4	6.0
7	3	87.8	9.45E-02	10438.5	309.9	32.0	42.5	18.0	7.5
7	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
7	5	32.3	5.42E-01	10529.4	334.8	48.5	13.7	30.9	6.9
7	6	0.5	1.06E-01	10457.1	302.1	28.5	12.0	44.0	15.5

TABLE 31c

Market attribute in year 2015 for unicast uplink (lower user density case) (part 2 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
8	1	2655.5	2.51E-01	750.9	335.2	72.5	17.5	10.0	0.0
8	2	5941.4	6.57E-01	780.0	365.5	70.0	21.7	6.3	1.9
8	3	4556.0	3.96E-01	801.3	363.7	48.3	38.6	9.7	3.4
8	4	392.0	3.51E-01	749.7	365.8	67.5	20.0	12.5	0.0
8	5	1047.0	4.91E-01	750.0	365.2	50.0	15.0	30.0	5.0
8	6	80.1	3.52E-01	750.9	364.6	42.5	10.0	40.0	7.5
9	1	306.0	3.98E-01	144.0	14.0	90.0	10.0	0.0	0.0
9	2	408.0	5.98E-01	144.0	57.0	90.0	10.0	0.0	0.0
9	3	51.0	1.99E-01	144.0	57.0	80.0	10.0	10.0	0.0
9	4	51.0	3.98E-01	144.0	14.0	90.0	10.0	0.0	0.0
9	5	102.0	5.98E-01	144.0	57.0	70.0	10.0	20.0	0.0
9	6	10.0	1.99E-01	144.0	14.0	80.0	10.0	10.0	0.0
10	1	583.8	5.79E-01	8.3	1082.8	67.5	22.5	10.0	0.0
10	2	1694.7	7.19E-01	8.3	1082.8	67.5	27.5	5.0	0.0
10	3	890.9	4.39E-01	8.3	1082.8	40.0	45.0	15.0	0.0
10	4	165.5	5.79E-01	8.3	1082.8	62.5	25.0	12.5	0.0
10	5	360.5	7.19E-01	8.3	1082.8	35.0	20.0	40.0	5.0
10	6	32.9	4.39E-01	8.3	1082.8	35.0	15.0	40.0	10.0
11	1	5.6	2.40E-02	304587.8	18.0	55.0	25.0	20.0	0.0
11	2	24.6	1.75E-01	304587.8	22.9	100.0	0.0	0.0	0.0
11	3	7.4	3.00E-02	304587.8	18.0	10.0	70.0	20.0	0.0
11	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	5	5.0	3.98E-01	500000.0	7.0	100.0	0.0	0.0	0.0
11	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
12	1	2406.7	1.54E-01	10435.7	25.0	68.3	22.1	9.0	0.5
12	2	8129.5	1.50E-01	8246.3	23.8	67.5	27.5	5.0	0.0
12	3	4769.9	1.56E-01	11734.9	25.9	50.0	40.5	9.0	0.5
12	4	698.5	1.51E-01	8176.6	23.8	62.5	25.0	12.5	0.0
12	5	1782.2	1.51E-01	8344.5	23.8	43.0	20.0	32.0	5.0
12	6	135.0	1.52E-01	9145.3	24.4	41.8	15.4	35.3	7.5
13	1	5788.2	2.12E-01	1149.5	35.2	68.5	21.2	7.9	2.4
13	2	11367.5	3.85E-01	1180.1	26.1	67.4	25.8	5.1	1.7
13	3	7081.2	2.29E-01	1181.9	37.3	38.6	39.7	17.4	4.3
13	4	839.3	2.37E-01	1229.3	21.9	61.9	24.8	12.4	1.0
13	5	1820.4	4.10E-01	1227.8	22.6	39.8	19.9	34.8	5.5
13	6	153.7	2.41E-01	1135.5	25.9	35.3	14.9	39.8	10.0
14	1	5178.0	1.02E+00	60.0	3.6	67.2	22.4	10.0	0.5
14	2	4897.1	1.74E-01	60.0	22.4	67.2	27.4	5.0	0.5
14	3	4110.4	2.07E-01	94.3	351.5	26.0	62.5	11.0	0.5
14	4	278.9	6.91E+00	68.4	1.5	60.7	23.8	12.1	3.4
14	5	540.4	2.10E-01	92.1	1020.2	35.0	60.0	5.0	0.0
14	6	65.0	2.46E+00	93.0	23.9	32.7	59.8	5.0	2.5

TABLE 31c

Market attribute in year 2015 for unicast uplink (lower user density case) (part 3 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
15	1	8889.4	8.69E+00	7.6	17.8	67.5	22.5	10.0	0.0
15	2	24417.9	9.40E+00	6.9	22.3	67.5	27.5	5.0	0.0
15	3	13173.8	8.76E+00	8.3	15.1	35.0	45.0	19.5	0.5
15	4	1985.9	8.84E+00	6.9	17.8	62.5	25.0	12.5	0.0
15	5	4878.1	9.78E+00	7.6	17.8	45.0	15.0	35.0	5.0
15	6	368.4	9.22E+00	7.6	17.8	35.0	15.0	40.0	10.0
16	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	2	51.0	3.98E-01	20000.0	12.0	80.0	20.0	0.0	0.0
16	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	5	10.0	3.98E-01	20000.0	12.0	80.0	20.0	0.0	0.0
16	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
17	1	59.7	5.06E-01	9044.5	85.8	56.6	24.2	19.2	0.0
17	2	217.0	9.02E-01	10442.9	105.9	67.5	27.5	5.0	0.0
17	3	119.2	5.50E-01	11004.2	93.9	13.9	66.2	19.4	0.5
17	4	13.7	6.35E-01	8482.3	87.3	45.3	29.9	24.9	0.0
17	5	44.8	9.31E-01	9920.7	104.4	45.0	20.0	30.0	5.0
17	6	2.9	6.17E-01	9351.5	89.7	7.0	10.0	68.0	15.0
18	1	612.0	1.99E-01	574.0	17.0	80.0	20.0	0.0	0.0
18	2	1326.0	1.99E+00	595.0	32.0	80.0	20.0	0.0	0.0
18	3	20.0	1.99E-01	990.0	5.0	60.0	20.0	20.0	0.0
18	4	102.0	1.99E-01	1030.0	15.0	80.0	20.0	0.0	0.0
18	5	71.0	1.99E+00	653.0	31.0	60.0	20.0	20.0	0.0
18	6	10.0	1.99E-01	1030.0	15.0	60.0	20.0	15.0	5.0
19	1	510.0	1.99E-01	144.0	10.0	80.0	20.0	0.0	0.0
19	2	1020.0	5.98E-01	144.0	10.0	80.0	20.0	0.0	0.0
19	3	51.0	1.99E-01	144.0	10.0	60.0	20.0	15.0	5.0
19	4	51.0	1.99E-01	144.0	10.0	80.0	20.0	0.0	0.0
19	5	51.0	1.99E-01	144.0	10.0	60.0	20.0	20.0	0.0
19	6	10.0	1.99E-01	144.0	10.0	60.0	20.0	15.0	5.0
20	1	1020.0	1.99E-01	16.0	12.0	80.0	20.0	0.0	0.0
20	2	1020.0	5.98E-01	16.0	20.0	80.0	20.0	0.0	0.0
20	3	323.7	4.39E-01	13.2	4.3	35.0	45.0	20.0	0.0
20	4	102.0	1.99E-01	16.0	12.0	80.0	20.0	0.0	0.0
20	5	132.5	7.19E-01	13.2	6.7	35.0	20.0	40.0	5.0
20	6	15.8	4.39E-01	13.2	4.3	32.5	15.0	42.5	10.0

TABLE 31d

Market attribute in year 2015 for multicast downlink (lower user density case)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
2	1	51.0	0.2	20000.0	7172.1	100.0	0.0	0.0	0.0
2	2	10.2	0.8	20000.0	2689.6	100.0	0.0	0.0	0.0
2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	4	20.4	0.2	20000.0	7172.1	100.0	0.0	0.0	0.0
2	5	3.1	0.8	20000.0	1195.4	100.0	0.0	0.0	0.0
2	6	1.0	0.2	20000.0	7172.1	100.0	0.0	0.0	0.0
3	1	387.6	0.8	1424.2	547.3	83.0	17.0	0.0	0.0
3	2	459.0	1.2	922.7	768.4	84.0	16.0	0.0	0.0
3	3	61.2	0.8	1192.0	298.8	82.0	18.0	0.0	0.0
3	4	102.0	2.6	731.7	497.0	86.0	14.0	0.0	0.0
3	5	56.1	2.8	623.4	672.4	87.0	13.0	0.0	0.0
3	6	2.7	1.6	679.9	446.7	87.0	13.0	0.0	0.0

TABLE 32a

Market attribute in year 2020 (lower user density case)

SC	*U* (%)	*Q* (%)	*R* (%)	μ (%)	Mobility ratio
1	5	30	30	30	2 (No range M.2072)
2	5	30	30	30	2
3	5	30	30	30	2
4	5	30	30	30	2
5	5	30	30	30	2
6	5	30	30	30	2 (No range M.2072)
7	5	30	30	30	2
8	5	30	30	30	2
9	5	30	30	30	2 (No range M.2072)
10	5	30	30	30	2
11	5	30	30	30	1
12	5	30	30	30	2
13	5	30	30	30	2
14	5	30	30	30	2
15	5	30	30	30	2
16	5	30	30	30	2 (No range M.2072)
17	5	30	30	30	2
18	5	30	30	30	2 (No range M.2072)
19	5	30	30	30	2 (No range M.2072)
20	5	30	30	30	2

TABLE 32b

Market attribute in year 2020 for unicast downlink (lower user density case) (part 1 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
1	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	2	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	1	946.0	1.44E-01	11240.0	360.0	55.0	25.0	20.0	0.0
2	2	3449.3	7.07E-01	11240.0	513.3	77.5	17.5	5.0	0.0
2	3	2043.4	1.44E-01	11240.0	360.0	10.0	70.0	20.0	0.0
2	4	283.8	1.44E-01	11240.0	360.0	45.0	30.0	25.0	0.0
2	5	763.5	7.07E-01	11240.0	508.4	55.0	10.0	30.0	5.0
2	6	56.8	1.44E-01	11240.0	360.0	5.0	10.0	70.0	15.0
3	1	6108.0	3.84E-01	506.0	231.3	69.0	21.0	10.0	0.0
3	2	10855.2	6.30E-01	379.8	214.8	69.0	26.0	5.0	0.0
3	3	5373.5	3.01E-01	470.9	146.9	47.0	43.0	10.0	0.0
3	4	962.1	8.88E-01	290.2	229.2	65.5	22.0	12.5	0.0
3	5	1337.3	1.04E+00	275.2	172.2	49.0	16.0	30.0	5.0
3	6	91.2	2.99E-01	282.4	161.1	46.0	11.5	35.0	7.5
4	1	2659.6	9.95E-01	88.0	810.7	73.8	11.9	9.5	4.8
4	2	2708.0	9.95E-01	88.0	810.7	73.1	16.5	5.7	4.7
4	3	3501.0	1.02E+00	123.0	833.8	49.3	32.3	13.8	4.6
4	4	12.5	1.21E+00	88.0	810.7	69.0	14.3	11.9	4.8
4	5	23.6	1.13E+00	105.0	819.8	54.8	9.5	30.7	5.0
4	6	13.3	1.18E+00	95.3	814.2	50.7	8.2	33.8	7.2
5	1	9163.2	9.25E-01	16.0	229.0	62.6	22.4	9.3	5.6
5	2	15288.6	1.33E+00	16.0	227.2	62.0	25.5	6.9	5.6
5	3	9529.9	1.00E+00	15.3	252.1	37.7	42.5	14.2	5.7
5	4	1122.0	1.70E+00	15.3	204.3	59.0	23.6	11.8	5.7
5	5	1858.7	2.34E+00	11.8	255.1	34.1	23.4	36.6	5.9
5	6	183.8	1.68E+00	15.3	203.6	36.1	18.3	36.1	9.6
6	1	1743.0	2.50E-02	321000.0	150.0	55.0	25.0	20.0	0.0
6	2	1743.0	2.50E-02	321000.0	150.0	55.0	35.0	10.0	0.0
6	3	2324.0	3.00E-02	321000.0	150.0	10.0	70.0	20.0	0.0
6	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
7	1	1016.1	0.00E+00	3075.0	892.8	55.0	25.0	20.0	0.0
7	2	2901.4	3.10E-02	8075.5	1136.3	70.0	21.7	5.8	2.4
7	3	594.4	0.00E+00	10963.1	480.0	33.3	42.3	17.9	6.5
7	4	183.4	0.00E+00	3000.0	1080.0	45.0	30.0	25.0	0.0
7	5	33.7	5.92E-01	9992.8	533.6	48.5	14.1	30.1	7.3
7	6	37.4	0.00E+00	3409.7	988.2	6.5	10.0	68.5	15.0

TABLE 32b

Market attribute in year 2020 for unicast downlink (lower user density case) (part 2 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
8	1	3198.1	1.74E-01	700.8	123.0	72.5	17.5	10.0	0.0
8	2	3254.6	9.32E-01	868.8	486.2	63.9	19.8	8.8	7.5
8	3	4272.1	7.93E-01	868.8	486.2	46.1	36.9	9.2	7.8
8	4	21.0	4.11E-01	384.0	158.0	90.0	10.0	0.0	0.0
8	5	55.3	1.03E+00	868.8	493.1	47.6	16.7	28.6	7.1
8	6	5.8	7.39E-01	868.8	493.1	39.7	15.4	37.4	7.5
9	1	309.0	8.23E-01	144.0	20.0	90.0	10.0	0.0	0.0
9	2	412.0	1.23E+00	144.0	79.0	90.0	10.0	0.0	0.0
9	3	52.0	4.11E-01	144.0	79.0	80.0	10.0	10.0	0.0
9	4	52.0	8.23E-01	144.0	20.0	90.0	10.0	0.0	0.0
9	5	103.0	1.23E+00	144.0	79.0	70.0	10.0	20.0	0.0
9	6	10.0	4.11E-01	144.0	20.0	80.0	10.0	10.0	0.0
10	1	206.0	8.23E-01	16.0	4.0	80.0	20.0	0.0	0.0
10	2	309.0	1.23E+00	16.0	4.0	80.0	20.0	0.0	0.0
10	3	52.0	4.11E-01	16.0	4.0	70.0	20.0	10.0	0.0
10	4	52.0	8.23E-01	16.0	4.0	80.0	20.0	0.0	0.0
10	5	52.0	1.23E+00	16.0	4.0	60.0	20.0	20.0	0.0
10	6	10.0	4.11E-01	16.0	4.0	65.0	20.0	10.0	5.0
11	1	5.6	3.00E-02	321000.0	18.0	55.0	25.0	20.0	0.0
11	2	25.5	3.17E-01	321000.0	81.9	100.0	0.0	0.0	0.0
11	3	3758.8	2.99E-01	90141.2	6.0	10.0	70.0	20.0	0.0
11	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	5	1394.2	8.76E-01	212984.6	53.9	100.0	0.0	0.0	0.0
11	6	104.2	3.00E-01	89978.0	6.0	5.0	10.0	70.0	15.0
12	1	7213.6	2.84E+00	11059.6	33.1	67.5	22.5	10.0	0.0
12	2	24442.1	2.57E+00	10725.9	75.5	67.5	27.5	5.0	0.0
12	3	16455.2	2.28E+00	11344.8	75.2	45.0	45.0	10.0	0.0
12	4	2151.5	2.85E+00	9835.8	21.2	62.5	25.0	12.5	0.0
12	5	6126.0	2.31E+00	9858.5	21.2	42.5	20.0	32.5	5.0
12	6	478.7	2.56E+00	9953.7	21.2	40.0	15.0	37.5	7.5
13	1	4513.1	2.43E-01	1360.5	149.3	69.3	20.7	6.7	3.3
13	2	4506.7	5.03E-01	1360.8	148.6	69.1	22.1	5.4	3.4
13	3	3595.6	3.29E-01	1359.6	156.3	40.3	38.1	16.5	5.1
13	4	40.7	9.70E-01	1358.1	176.6	57.5	23.4	11.7	7.5
13	5	104.6	1.76E+00	1358.1	175.2	38.6	19.8	33.8	7.7
13	6	24.1	1.14E+00	1249.6	177.9	35.5	15.3	39.4	9.9
14	1	5574.9	2.40E-01	120.2	30.6	67.2	22.4	10.0	0.5
14	2	5574.9	2.54E-01	121.6	30.3	67.2	27.4	5.0	0.5
14	3	5371.2	3.12E-01	177.0	314.1	26.5	61.0	11.5	1.0
14	4	30.3	5.28E-01	48.8	66.9	61.3	22.1	12.3	4.4
14	5	677.9	2.97E-01	177.8	981.0	35.2	59.8	5.0	0.0
14	6	58.7	3.23E-01	177.6	852.6	33.0	58.5	5.5	3.0

TABLE 32b

Market attribute in year 2020 for unicast downlink (lower user density case) (part 3 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
15	1	5100.0	2.06E+00	11.5	30.0	65.9	21.5	9.8	2.9
15	2	10690.0	3.15E+00	7.9	33.2	66.2	27.0	5.4	1.5
15	3	5286.4	1.23E+00	20.1	35.9	33.0	39.8	23.8	3.4
15	4	841.2	2.47E+00	7.0	27.2	62.2	24.9	12.4	0.5
15	5	1945.2	3.14E+00	30.1	29.3	43.5	12.5	40.0	4.0
15	6	148.6	2.47E+00	36.5	30.7	34.5	14.5	40.5	10.5
16	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	2	52.0	8.23E-01	20000.0	222.0	80.0	20.0	0.0	0.0
16	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	5	10.0	8.23E-01	20000.0	222.0	80.0	20.0	0.0	0.0
16	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
17	1	898.7	7.13E-01	10056.5	32.7	56.0	24.0	20.0	0.0
17	2	3290.2	1.01E+00	9931.2	179.5	67.5	27.5	5.0	0.0
17	3	593.9	8.24E-01	10911.4	90.6	12.0	68.0	19.5	0.5
17	4	262.0	7.28E-01	9481.7	32.1	45.0	30.0	25.0	0.0
17	5	216.8	1.43E+00	9733.7	224.9	45.0	20.0	30.0	5.0
17	6	52.5	7.27E-01	9816.7	32.7	6.0	10.0	69.0	15.0
18	1	618.0	4.11E-01	574.0	82.0	80.0	20.0	0.0	0.0
18	2	1339.0	4.11E+00	595.0	153.0	80.0	20.0	0.0	0.0
18	3	21.0	4.11E-01	990.0	23.0	60.0	20.0	20.0	0.0
18	4	103.0	4.11E-01	1030.0	72.0	80.0	20.0	0.0	0.0
18	5	72.0	4.11E+00	653.0	148.0	60.0	20.0	20.0	0.0
18	6	10.0	4.11E-01	1030.0	72.0	60.0	20.0	15.0	5.0
19	1	515.0	4.11E-01	144.0	21.0	80.0	20.0	0.0	0.0
19	2	1030.0	1.23E+00	144.0	21.0	80.0	20.0	0.0	0.0
19	3	52.0	4.11E-01	144.0	21.0	60.0	20.0	15.0	5.0
19	4	52.0	4.11E-01	144.0	21.0	80.0	20.0	0.0	0.0
19	5	52.0	4.11E-01	144.0	21.0	60.0	20.0	20.0	0.0
19	6	10.0	4.11E-01	144.0	21.0	60.0	20.0	15.0	5.0
20	1	1030.0	4.11E-01	16.0	25.0	80.0	20.0	0.0	0.0
20	2	1030.0	1.23E+00	16.0	41.0	80.0	20.0	0.0	0.0
20	3	103.0	4.11E-01	16.0	25.0	60.0	20.0	20.0	0.0
20	4	103.0	4.11E-01	16.0	25.0	80.0	20.0	0.0	0.0
20	5	52.0	1.23E+00	16.0	41.0	60.0	20.0	20.0	0.0
20	6	10.0	4.11E-01	16.0	25.0	60.0	20.0	15.0	5.0

TABLE 32c

Market attribute in year 2020 for unicast uplink (lower user density case) (part 1 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
1	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	2	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
1	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
2	1	946.0	1.44E-01	11240.0	360.0	100.0	0.0	0.0	0.0
2	2	3449.3	7.07E-01	11240.0	513.3	100.0	0.0	0.0	0.0
2	3	2043.4	1.44E-01	11240.0	360.0	100.0	0.0	0.0	0.0
2	4	283.8	1.44E-01	11240.0	360.0	100.0	0.0	0.0	0.0
2	5	763.5	7.07E-01	11240.0	508.4	100.0	0.0	0.0	0.0
2	6	56.8	1.44E-01	11240.0	360.0	100.0	0.0	0.0	0.0
3	1	6108.0	3.84E-01	506.0	231.3	69.0	21.0	10.0	0.0
3	2	10855.2	6.30E-01	379.8	214.8	69.5	25.5	5.0	0.0
3	3	5373.5	3.01E-01	470.9	146.9	46.5	43.5	10.0	0.0
3	4	962.1	8.88E-01	290.2	229.2	66.0	21.5	12.5	0.0
3	5	1337.3	1.04E+00	275.2	172.2	49.0	16.0	30.0	5.0
3	6	91.2	2.99E-01	282.4	161.1	46.0	11.5	35.0	7.5
4	1	2659.6	9.95E-01	88.0	810.7	73.8	11.9	9.5	4.8
4	2	2708.0	9.95E-01	88.0	810.7	73.1	16.5	5.7	4.7
4	3	3501.0	1.02E+00	123.0	833.8	49.3	32.3	13.8	4.6
4	4	12.5	1.21E+00	88.0	810.7	69.0	14.3	11.9	4.8
4	5	23.6	1.13E+00	105.0	819.8	54.8	9.5	30.7	5.0
4	6	13.3	1.18E+00	95.3	814.2	50.7	8.2	33.8	7.2
5	1	9163.2	9.25E-01	16.0	229.0	62.6	22.4	9.3	5.6
5	2	15288.6	1.33E+00	16.0	227.2	62.0	25.5	6.9	5.6
5	3	9529.9	1.00E+00	15.3	252.1	37.7	42.5	14.2	5.7
5	4	1122.0	1.70E+00	15.3	204.3	59.0	23.6	11.8	5.7
5	5	1858.7	2.34E+00	11.8	255.1	34.1	23.4	36.6	5.9
5	6	183.8	1.68E+00	15.3	203.6	36.1	18.3	36.1	9.6
6	1	1743.0	2.50E-02	321000.0	150.0	55.0	25.0	20.0	0.0
6	2	1743.0	2.50E-02	321000.0	150.0	55.0	35.0	10.0	0.0
6	3	2324.0	3.00E-02	321000.0	150.0	10.0	70.0	20.0	0.0
6	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	5	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
6	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
7	1	1016.1	0.00E+00	3075.0	892.8	55.0	25.0	20.0	0.0
7	2	2901.4	3.10E-02	8075.5	1136.3	72.5	22.5	5.0	0.0
7	3	594.4	0.00E+00	10963.1	480.0	11.3	68.5	19.7	0.5
7	4	183.4	0.00E+00	3000.0	1080.0	45.0	30.0	25.0	0.0
7	5	33.7	5.92E-01	9992.8	533.6	50.0	15.0	30.0	5.0
7	6	37.4	0.00E+00	3409.7	988.2	5.0	10.0	70.0	15.0

TABLE 32c

Market attribute in year 2020 for unicast uplink (lower user density case) (part 2 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
8	1	3198.1	1.74E-01	700.8	123.0	72.5	17.5	10.0	0.0
8	2	3254.6	9.32E-01	868.8	486.2	63.9	19.8	8.8	7.5
8	3	4272.1	7.93E-01	868.8	486.2	46.1	36.9	9.2	7.8
8	4	21.0	4.11E-01	384.0	158.0	90.0	10.0	0.0	0.0
8	5	55.3	1.03E+00	868.8	493.1	47.6	16.7	28.6	7.1
8	6	5.8	7.39E-01	868.8	493.1	39.7	15.4	37.4	7.5
9	1	309.0	8.23E-01	144.0	20.0	90.0	10.0	0.0	0.0
9	2	412.0	1.23E+00	144.0	79.0	90.0	10.0	0.0	0.0
9	3	52.0	4.11E-01	144.0	79.0	80.0	10.0	10.0	0.0
9	4	52.0	8.23E-01	144.0	20.0	90.0	10.0	0.0	0.0
9	5	103.0	1.23E+00	144.0	79.0	70.0	10.0	20.0	0.0
9	6	10.0	4.11E-01	144.0	20.0	80.0	10.0	10.0	0.0
10	1	206.0	8.23E-01	16.0	4.0	67.5	22.5	10.0	0.0
10	2	309.0	1.23E+00	16.0	4.0	67.5	27.5	5.0	0.0
10	3	52.0	4.11E-01	16.0	4.0	40.0	45.0	15.0	0.0
10	4	52.0	8.23E-01	16.0	4.0	62.5	25.0	12.5	0.0
10	5	52.0	1.23E+00	16.0	4.0	35.0	20.0	40.0	5.0
10	6	10.0	4.11E-01	16.0	4.0	35.0	15.0	40.0	10.0
11	1	5.6	3.00E-02	321000.0	18.0	55.0	25.0	20.0	0.0
11	2	25.5	3.17E-01	321000.0	81.9	100.0	0.0	0.0	0.0
11	3	3758.8	2.99E-01	90141.2	6.0	10.0	70.0	20.0	0.0
11	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
11	5	1394.2	8.76E-01	212984.6	53.9	100.0	0.0	0.0	0.0
11	6	104.2	3.00E-01	89978.0	6.0	100.0	0.0	0.0	0.0
12	1	7213.6	2.84E+00	11059.6	33.1	67.7	22.4	9.5	0.5
12	2	24442.1	2.57E+00	10725.9	75.5	67.5	27.5	5.0	0.0
12	3	16455.2	2.28E+00	11344.8	75.2	49.0	41.5	9.0	0.5
12	4	2151.5	2.85E+00	9835.8	21.2	62.5	25.0	12.5	0.0
12	5	6126.0	2.31E+00	9858.5	21.2	43.0	20.0	32.0	5.0
12	6	478.7	2.56E+00	9953.7	21.2	41.3	15.4	35.8	7.5
13	1	4513.1	2.43E-01	1360.5	149.3	69.3	20.7	6.7	3.3
13	2	4506.7	5.03E-01	1360.8	148.6	69.1	22.1	5.4	3.4
13	3	3595.6	3.29E-01	1359.6	156.3	39.8	38.1	17.0	5.1
13	4	40.7	9.70E-01	1358.1	176.6	57.7	23.5	11.7	7.0
13	5	104.6	1.76E+00	1358.1	175.2	38.6	19.8	33.8	7.7
13	6	24.1	1.14E+00	1249.6	177.9	35.1	15.3	39.6	9.9
14	1	5574.9	2.40E-01	120.2	30.6	67.2	22.4	10.0	0.5
14	2	5574.9	2.54E-01	121.6	30.3	67.2	27.4	5.0	0.5
14	3	5371.2	3.12E-01	177.0	314.1	26.5	61.0	11.5	1.0
14	4	30.3	5.28E-01	48.8	66.9	61.3	22.1	12.3	4.4
14	5	677.9	2.97E-01	177.8	981.0	35.2	59.8	5.0	0.0
14	6	58.7	3.23E-01	177.6	852.6	33.0	58.5	5.5	3.0

TABLE 32c

Market attribute in year 2020 for unicast uplink (lower user density case) (part 3 of 3)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
15	1	5100.0	2.06E+00	11.5	30.0	67.2	22.4	10.0	0.5
15	2	10690.0	3.15E+00	7.9	33.2	67.5	27.5	5.0	0.0
15	3	5286.4	1.23E+00	20.1	35.9	35.0	45.0	18.5	1.5
15	4	841.2	2.47E+00	7.0	27.2	62.5	25.0	12.5	0.0
15	5	1945.2	3.14E+00	30.1	29.3	45.0	15.0	35.0	5.0
15	6	148.6	2.47E+00	36.5	30.7	35.0	15.0	40.0	10.0
16	1	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	2	52.0	8.23E-01	20000.0	222.0	80.0	20.0	0.0	0.0
16	3	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	4	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
16	5	10.0	8.23E-01	20000.0	222.0	80.0	20.0	0.0	0.0
16	6	0.0	0.00E+00	0.0	0.0	0.0	0.0	0.0	0.0
17	1	898.7	7.13E-01	10056.5	32.7	59.0	22.0	17.0	2.0
17	2	3290.2	1.01E+00	9931.2	179.5	67.2	27.4	5.0	0.5
17	3	593.9	8.24E-01	10911.4	90.6	20.4	59.7	18.4	1.5
17	4	262.0	7.28E-01	9481.7	32.1	46.5	29.0	24.0	0.5
17	5	216.8	1.43E+00	9733.7	224.9	45.0	20.0	30.0	5.0
17	6	52.5	7.27E-01	9816.7	32.7	11.0	10.5	64.0	14.5
18	1	618.0	4.11E-01	574.0	82.0	80.0	20.0	0.0	0.0
18	2	1339.0	4.11E+00	595.0	153.0	80.0	20.0	0.0	0.0
18	3	21.0	4.11E-01	990.0	23.0	60.0	20.0	20.0	0.0
18	4	103.0	4.11E-01	1030.0	72.0	80.0	20.0	0.0	0.0
18	5	72.0	4.11E+00	653.0	148.0	60.0	20.0	20.0	0.0
18	6	10.0	4.11E-01	1030.0	72.0	60.0	20.0	15.0	5.0
19	1	515.0	4.11E-01	144.0	21.0	80.0	20.0	0.0	0.0
19	2	1030.0	1.23E+00	144.0	21.0	80.0	20.0	0.0	0.0
19	3	52.0	4.11E-01	144.0	21.0	60.0	20.0	15.0	5.0
19	4	52.0	4.11E-01	144.0	21.0	80.0	20.0	0.0	0.0
19	5	52.0	4.11E-01	144.0	21.0	60.0	20.0	20.0	0.0
19	6	10.0	4.11E-01	144.0	21.0	60.0	20.0	15.0	5.0
20	1	1030.0	4.11E-01	16.0	25.0	80.0	20.0	0.0	0.0
20	2	1030.0	1.23E+00	16.0	41.0	80.0	20.0	0.0	0.0
20	3	103.0	4.11E-01	16.0	25.0	35.0	45.0	20.0	0.0
20	4	103.0	4.11E-01	16.0	25.0	80.0	20.0	0.0	0.0
20	5	52.0	1.23E+00	16.0	41.0	35.0	20.0	40.0	5.0
20	6	10.0	4.11E-01	16.0	25.0	32.5	15.0	42.5	10.0

TABLE 32d

Market attribute in year 2020 for multicast downlink (lower user density case)

SC	SE	User density (users/km^2)	Session arrival rate per user (sessions/h/users)	Mean service bit rate (kbit/s)	Average session duration (s)	Mobility ratio			
						Stationary	Low	High	Super-high
2	1	51.5	0.4	20000.0	14812.0	100.0	0.0	0.0	0.0
2	2	10.3	1.7	20000.0	5554.5	100.0	0.0	0.0	0.0
2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	4	20.6	0.4	20000.0	14812.0	100.0	0.0	0.0	0.0
2	5	3.1	1.7	20000.0	2468.7	100.0	0.0	0.0	0.0
2	6	1.0	0.4	20000.0	14812.0	100.0	0.0	0.0	0.0
3	1	391.4	1.7	1424.2	1130.4	83.0	17.0	0.0	0.0
3	2	463.5	2.5	922.7	1587.0	84.0	16.0	0.0	0.0
3	3	61.8	1.7	1192.0	617.2	82.0	18.0	0.0	0.0
3	4	103.0	5.4	731.7	1026.4	86.0	14.0	0.0	0.0
3	5	56.7	5.8	623.4	1388.6	87.0	13.0	0.0	0.0
3	6	2.7	3.3	679.9	922.5	87.0	13.0	0.0	0.0

Annex 2

Basic consideration on spectrum demand estimation for IMT-Advanced from the radio viewpoint and further clarification of the corresponding simplifications for the methodology

1 Behavior of a real radio network and its performance

1.1 Basic radio performance

The investigation of the basic performance of a real radio network is based on a technology-independent description of the radio interface and of a simplified hexagonal model for the network deployment with omni directional antennas.

1.1.1 Generic description of performance of the radio interface

The theoretical limit of the channel capacity for communication systems is given by the Shannon channel capacity in the sense of information theory [3]. The Shannon channel capacity is given by

$$\frac{C_s}{W} = \log_2\left(1 + \frac{C}{I+N}\right) \quad (1)$$

with:

C_s: Shannon channel capacity

W: system carrier bandwidth

C: carrier power

I: interference power

N: noise power.

The Shannon bound in equation (1) describes the link level in terms of spectral efficiency versus $CIR = C/(I + N)$. The achievable CIR depends on the system level according to the bullet list in § 1. It is assumed that the interference signal follows a Gaussian distribution, which is a sufficiently accurate assumption for the case of several independent interferers according to the Central Limit Theorem [3]. For realistic signals with limited signal amplitude the achievable capacity is smaller than in equation (1).

In addition, experience shows that the envelope of the physical layer modes for feasible radio interface concepts provide a basic performance in terms of spectral efficiency versus CIR, which can be approximated by a parallel shift of Shannon's performance function according to Fig. 3, which takes into account the degradation of feasible systems compared to the Shannon bound. The maximum available spectral efficiency ε_{max} (bit/s/Hz) of a feasible radio interface depends on the physical layer concept with the highest modulation order and coding rate. ε_{max} corresponds to the maximum data rate related to the aggregate throughput T including overhead for coding, channel estimation, protocols, signalling, etc. in relation to the carrier bandwidth W. ε_{max} will be a design parameter of a particular radio interface. For $\varepsilon < \varepsilon_{max}$ the spectral efficiency ε follows a shifted Shannon formula versus CIR. In this approach a fully loaded system is assumed, when the entirely available throughput T is used.

The spectral efficiency for the feasible radio interface follows as:

$$\varepsilon = \frac{T}{W} = \log_2\left(1 + \frac{CIR}{\Delta CIR}\right) \qquad \text{for} \quad \varepsilon \le \varepsilon_{max} \quad \text{and} \quad CIR \le CIR' \tag{2}$$

$$\varepsilon = \frac{T}{W} = \varepsilon_{max} = \text{const} \qquad \text{for} \quad CIR > CIR'$$

with the degradation ΔCIR with respect to the Shannon bound:

$$\frac{CIR}{\Delta CIR} = \frac{C}{I + N} \tag{3}$$

in equation (1). This formula is valid in the CIR-range:

$$CIR(\text{dB}) \le CIR'(\text{dB}) = 10 \cdot \log\left(2^{\varepsilon_{max}} - 1\right) + \Delta CIR(\text{dB}) \quad . \tag{4}$$

The degradation of the feasible radio interface ΔCIR compared to the Shannon bound is the second design parameter. Basically, a generic radio interface is completely characterized in this generic form by equation (2) and the two design parameters:

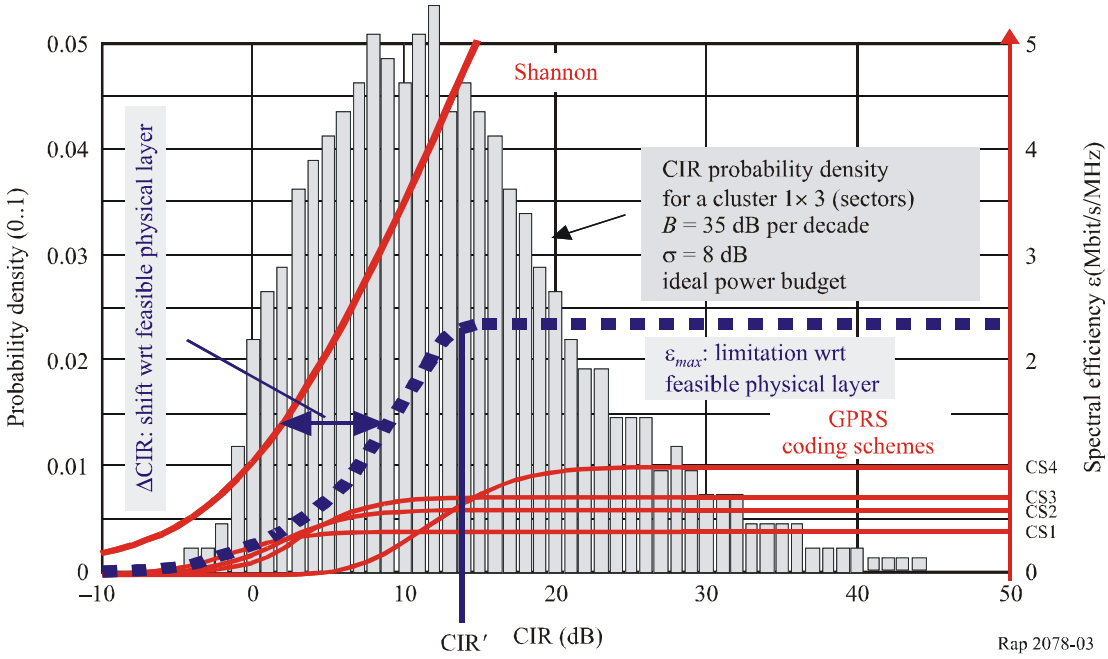
ε_{max}: maximum available spectral efficiency (bit/s/Hz)

ΔCIR: degradation with respect to the Shannon formula (dB).

For ΔCIR = 0 dB the spectral efficiency ε approaches the Shannon capacity with $\varepsilon \rightarrow C_s/W$.

FIGURE 3

Generic performance of an adaptive radio interface (example GPRS) versus carrier/interference-ratio compared to Shannon's channel capacity



1.1.2 Description of the deployment scenario

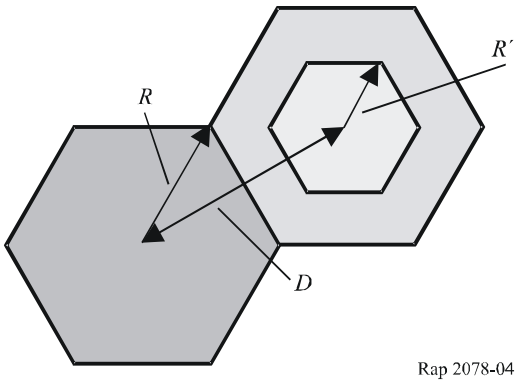
Figure 4 shows two adjacent cells in a cellular layout including the parameters to characterize the layout. The basic relation between cluster size K, cell range R and re-use distance D is given by:

$$\frac{D}{R} = \sqrt{3 \cdot K} \tag{5}$$

for a fully loaded network and a certain CIR_{cov} requirement of e.g. 95 % satisfied users. If a physical layer mode with a higher CIR_{cov} requirement is used, the cell range will shrink to R'.

FIGURE 4

Relation between re-use distance D, cell range R and effective cell range R' per physical layer (ε'_{max} and ΔCIR)



The relation between cluster size, required *C*/*I*-ratio CIR_{cov} and coverage for the case of cellular environment for ubiquitous coverage for a fully loaded network and constant modulation and coding can approximately be described by [4]:

$$CIR_{COV}[\text{dB}] \approx 0.5 \cdot \beta \cdot \log(3 \cdot K) - \Gamma \quad (6)$$

with:

K: cluster size

β: propagation loss per decade and

Γ: correction term, which depends essentially on

– required area coverage (e.g. 95 %)

– standard deviation σ of long term fading

– antenna diagram

– hand-over algorithm

– used method for interference reduction (e.g. power control).

The frequency re-use in the deployment area is given by the cluster size *K*. *K* corresponds to the number of needed carrier frequencies, which ensure full area coverage for a given physical layer mode.

Table 33 shows basic values for Γ and the dependency versus the standard deviation σ of the long-term fading according to equation (6):

$$\Gamma(\sigma)(\text{dB}) = \Gamma(\sigma = 6\ \text{dB}) + 2 \cdot \Delta\sigma(\text{dB}) \quad (7)$$

TABLE 33

Correction factor Γ for different coverage requirements cov and long-term fading standard deviation σ

For σ = 6 dB	Omni cells		
Coverage cov	90 %	95 %	98 %
Γ	12 dB	14 dB	16 dB

The further evaluations will be performed for the following parameters:

K = 1 (for most of the cases)

β = 40 dB/decade

σ = 6 or 8 dB respectively.

1.2 Spectrum demand for a radio interface with constant physical layer mode

In the case with constant physical layer mode the necessary CIR_{cov} value for the quality criterion of e.g. 95 % satisfied users follows from equation (6) and Table 33. The carrier bandwidth corresponds to *W* and the carrier spacing is determined by $W(1 + q)$, where the parameter *q* represents the required normalized guard band with respect to adjacent channel separation. This leads to the

necessary entire system bandwidth $B_{necessary}$ and cluster size K for ubiquitous coverage based on the equations (1), (2) and (6):

$$\frac{B_{necessary}}{T\cdot(1+q)}=\frac{K\cdot W}{T}\approx\frac{1}{3}\times 10^{\frac{CIR_{cov}(\varepsilon_{max},\Delta CIR)\big|_{\mathrm{dB}}+\Gamma}{0.5\cdot\beta}}\cdot\frac{1}{\log_2\left(1+\frac{CIR_{COV}}{\Delta CIR}\right)}$$

For $\varepsilon\le\varepsilon_{max}$ and $CIR\le CIR'$

$$\frac{B_{necessary}}{T\cdot(1+q)}=\frac{K\cdot W}{T}\approx\frac{1}{3}\times 10^{\frac{CIR'_{cov}(\varepsilon_{max},\Delta CIR)\big|_{\mathrm{dB}}+\Gamma}{0.5\cdot\beta}}\cdot\frac{1}{\varepsilon_{max}} \qquad (8)$$

For $CIR > CIR'$

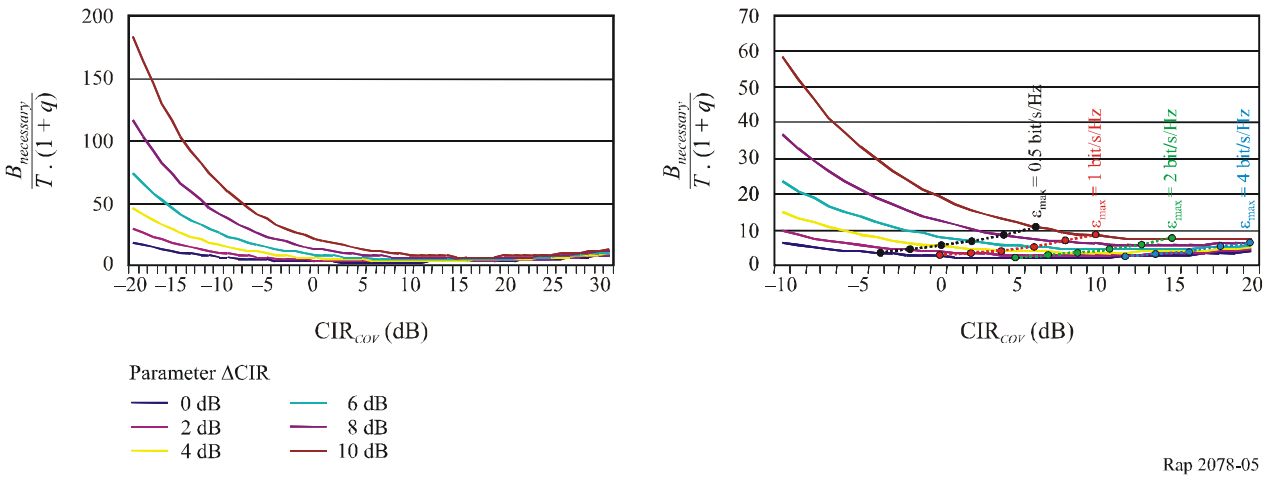
$$K=\frac{B_{necessary}}{W\cdot(1+q)}=\frac{B_{necessary}}{T\cdot(1+q)}\cdot\varepsilon_{max}$$

In the case of CIR > CIR′ an increase of the CIR does not improve the spectral efficiency due to the limitation ε_{max} of the physical layer mode in the radio system.

The Fig. 5 shows the evaluation of equation (8) with respect to coverage requirements and propagation conditions. The minimum spectrum demand in this case is achieved for CIR values above 10 dB, which would mean a cluster size K > 7.

FIGURE 5

Necessary normalized system bandwidth for: coverage 95 %, standard deviation of long-term fading 8 dB, path loss slope 40 dB, parameters ΔCIR – degradation compared to Shannon bound and for maximum spectral efficiency ε_{max} of physical layer mode



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1.3 Spectrum demand for a radio interface with adaptive physical layer modes

In this case of cellular environment for ubiquitous coverage for a fully loaded network and adaptive modulation and coding that physical layer mode is used, which is available according to Figure 3 with respect to the available CIR value. Depending on the needed CIR value an "effective cluster size" K' can be calculated. These different physical layer modes correspond to different parameters ε'_{max} (bit/s/Hz). For each of these modes with a certain minimum CIR'_{cov} requirement and the necessary CIR-range the effective cluster size $K' \geq K$ can be calculated with equation (6). This results for a given re-use distance D in the effective cell range $R' \leq R$, where the particular physical layer can be used with the required coverage performance (Fig. 4):

$$K' \approx \frac{1}{3} \times 10^{\frac{CIR'_{COV}(\varepsilon'_{max}, \Delta CIR)\big|_{\mathrm{dB}} + \Gamma}{0.5 \cdot \beta}} \quad \text{and} \quad \frac{D}{R'} = \sqrt{3 \cdot K'} \tag{9}$$

The average normalized aggregate throughput (corresponding to the area spectral efficiency) in the deployment area as expectation value of T/W with the probability density for K' [4] corresponds to the expectation value depending on the radio interface, the deployment scenario and the cluster size K. This average is calculated under the assumption of uniform user distribution in the deployment area.

1.3.1 Evaluation of the average aggregate throughput for a given radio interface with adaptive modulation and coding

The Figures 6 to 7 show the average throughput normalized to the carrier bandwidth W for different peak spectral efficiencies, the maximum throughput T_{max}, the probability of the availability of the maximum throughput in the coverage area as well as the necessary overall spectrum demand for ubiquitous coverage for the parameter 1 bit/s/Hz and 4 bit/s/Hz for the exemplary given propagation conditions and coverage requirements. The mathematical background for the average values is available in [4]. With increasing degradation ΔCIR with respect to the Shannon capacity the average throughput is degrading significantly, which results in increasing spectrum demand. The probability to achieve the peak throughput is decreased significantly for small cluster size. However, the spectrum demand is minimal for a cluster size $K = 1$. This allows different trade-offs between the aggregate average throughput, the availability of the peak aggregate throughput and the overall spectrum demand.

Therefore, the estimation of the spectrum demand needs to take into account deployment reference scenarios and quality criteria for the achievable average aggregate throughput in relation to the peak aggregate throughput of the radio interface and the probability to support the peak aggregate throughput in the deployment area.

FIGURE 6

Average aggregate throughput normalized to the carrier bandwidth and the maximum aggregate throughput and the probability of the maximum aggregate throughput for the parameters: coverage 95%, omni cells, standard deviation of the long-term fading 6 dB, path loss slope 40 dB, ε_{max} = 1 bit/s/Hz for the parameter ΔCIR – degradation compared to the Shannon bound

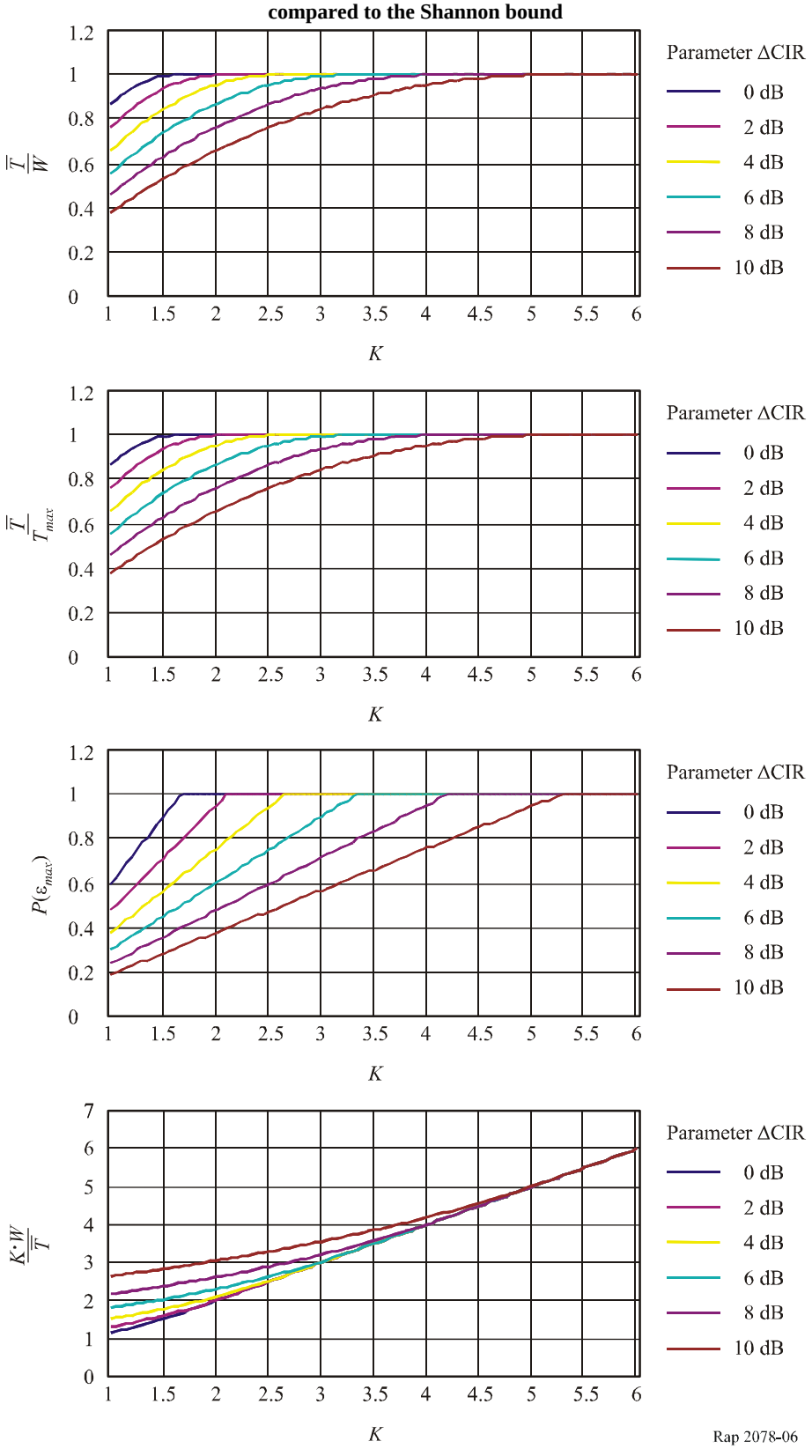
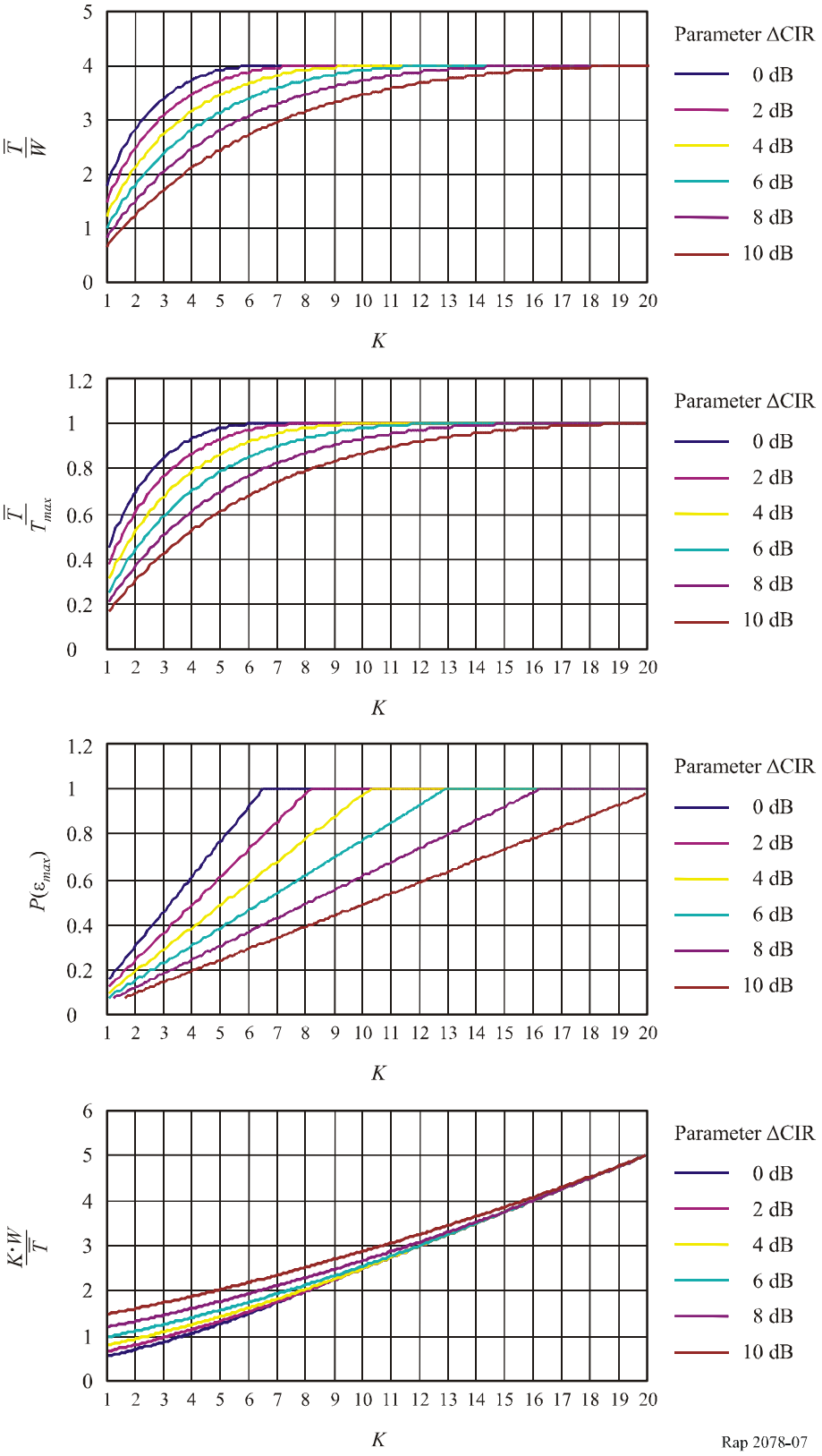


FIGURE 7

Average aggregate throughput normalized to the carrier bandwidth and the maximum aggregate throughput and the probability of the maximum aggregate throughput for the parameters: coverage 95%, omni cells, standard deviation of the long-term fading 6 dB, path loss slope 40 dB, ε_{max} = 4 bit/s/Hz for the parameter ΔCIR – degradation compared to the Shannon bound



1.3.2 Aggregate throughput versus distance and at the cell edge for a given radio interface with adaptive modulation and coding

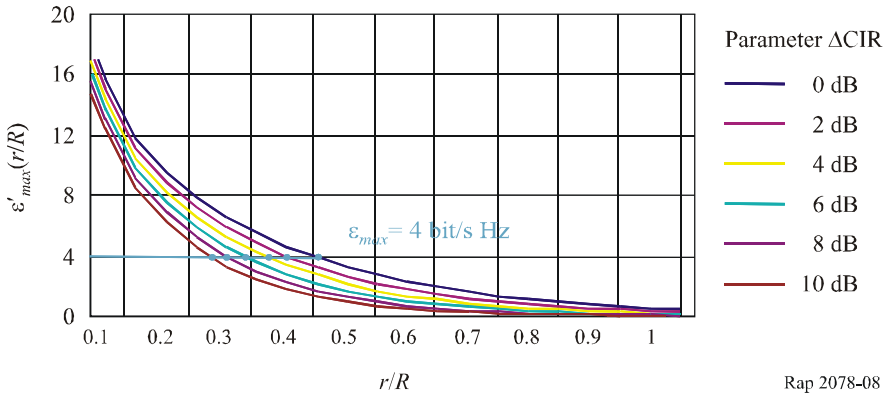
The theoretically available aggregate throughput depends on the available carrier/interference-ratio and is decreasing with increasing distance r to the serving base station. The available aggregate throughput at the cell edge is an important requirement from the user's perspective in terms of quality of service (QoS). The normalized aggregate throughput versus distance r is given by [4]:

$$\varepsilon'_{max}(r) = \frac{T(r)}{W} = \frac{\ln\left(1 + \frac{\sqrt{3 \cdot K}^{\beta/10}}{10^{\frac{\Delta CIR|_{dB} + \Gamma}{10}}} \cdot \left(\frac{R}{r}\right)^{\beta/10}\right)}{\ln 2} \leq \varepsilon_{max} \quad (10)$$

The available aggregate throughput is significantly reduced with distance r. Therefore, a minimum guaranteed aggregate available throughput up to the cell edge is also an important quality criterion to take into account in determining the overall spectrum demand. Figure 8 presents the available aggregate throughput versus distance.

FIGURE 8

Normalized aggregate throughput versus normalized distance r/R for the parameters: cluster size K = 1, coverage 95%, omni cells, standard deviation of the long-term fading 6 dB and path loss slope 40 dB for the parameter ΔCIR – degradation compared to the Shannon bound, the maximum normalized aggregate throughput ε_{max} is indicated



At the cell edge with $r = R$ the aggregate throughput is given as [4]:

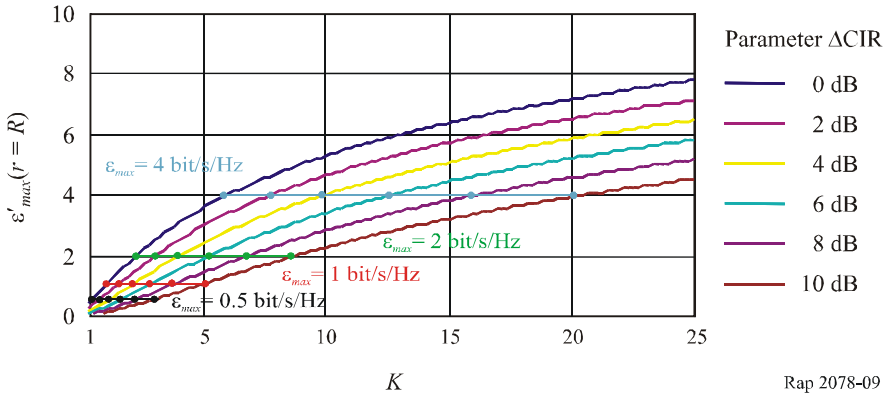
$$\varepsilon'_{max}(r = R) = \frac{T(R)}{W} = \frac{\ln\left(1 + \frac{\sqrt{3 \cdot K}^{\beta/10}}{10^{\frac{\Delta CIR|_{dB} + \Gamma}{10}}}\right)}{\ln 2} \quad (11)$$

which is independent of the peak aggregate throughput of the radio interface for the highest physical layer mode.

The aggregate throughput at the cell edge according to equation (11) is presented in the Fig. 9 for the exemplary parameters as used before. The aggregate throughput is increasing with increased cluster size, however, at the expense of increasing spectrum demand (c.f. Figs. 6 and 7). Especially for small cluster sizes the degradation ΔCIR has a significant impact on the spectral efficiency. In practical systems the functions are limited by ε_{max} of the maximum available physical layer mode.

FIGURE 9

Normalized aggregate throughput at the cell edge for the parameters: coverage 95%, omni cells, standard deviation of the long-term fading 6 dB and path loss slope 40 dB for the parameter ΔCIR – degradation compared to the Shannon bound, the maximum normalized aggregate throughput ε_{max} is indicated



1.4 Example of system parameters for different system design

The following example shows the basic impact of the system design on the performance versus provided available spectrum.

In the following a system with adaptive modulation and coding is assumed. Propagation conditions with a path loss slope of 40 dB/decade are considered. The overhead for signalling and coding is in the order of 20 % of the useful data rate. The peak useful aggregate throughput of the system should be 100 Mbit/s. Two system designs with peak aggregate spectral efficiencies of 1 bit/s/Hz and 4 bit/s/Hz are assumed. The frequency re-use is K = 1. This results in the following general parameters:

– $T_{max,\ useful}$ = 100 Mbit/s
– signalling overhead 20 %
– T_{max} = 120 Mbit/s
– K = 1
– ε_{max} = 1 bit/s/Hz or 4 bit/s/Hz respectively
– degradation with respect to Shannon bound ΔCIR = 4 dB
– path loss slope 40 dB/decade.

Based on earlier sections the following system performance according to Table 34 is achieved.

TABLE 34

Comparison of a more narrowband and a more wideband system design

Parameter	Narrowband system approach	Wideband system approach
ε_{max} (bit/s/Hz)	4	1
$T_{max,\ useful}$ (Mbit/s)	100	100
T_{max} (Mbit/s) including overhead	120	120
$\overline{T}_{useful}$ (Mbit/s)	30.9	65
$T_{cell\ edge}$ (Mbit/s)	4.8	19.2
W (MHz)	30	120
$K\ W$ (MHz)	30	120
Probability for T_{max}	0.0975	0.377

The more wideband system provides better QoS to users due to its better robustness towards co-channel interference. Therefore, an overall trade-off between spectrum demand and quality is needed. The general assumption should be that IMT-Advanced should provide a good QoS to users.

1.5 Factors influencing the spectrum demand estimation

This Report shows that the overall spectrum demand depends on many parameters and in particular on the performance of the radio interface and the deployment concept. For early estimations, when no detailed and generally accepted concept for new radio interface systems is available, a more generic description of the radio interface according to § 3.1 can be used to perform a technology-independent spectrum estimation. In the spectrum calculation methodology in Recommendation ITU-R M.1768 the radio interface is represented by an average spectral efficiency per cell, which corresponds to the inverse of the overall spectrum demand normalized to the average throughput in Figs. 6 and 7.

1.5.1 Peak aggregate throughput

The basic radio interface is characterized by the possible peak aggregate throughput depending on the carrier bandwidth *W*, the coding scheme and the highest available modulation order and physical layer mode as well as the flexibility in data rate allocation with lower throughput for other available physical layer modes.

There are several possible technical solutions in terms of combinations between carrier bandwidth, coding scheme and modulation order to provide a given peak throughput. However, a narrowband system with higher-order modulation requires a much higher signal/noise-ratio than a wideband system for the same peak aggregate throughput.

Due to these relations the definition of the peak aggregate throughput is not sufficient to estimate the overall spectrum demand for systems with adaptive physical layers. The overall spectrum demand depends on the carrier bandwidth, the number of needed carrier frequencies *K* for full area coverage, the needed guard bands and deployment concept and the required QoS. Therefore, the definition of QoS parameters such as the aggregate average cell throughput and the aggregate throughput at cell edge influence the spectrum demand estimation.

1.5.2 QoS criterions

In addition to the peak aggregate throughput the definition of QoS criterions is important for spectrum demand estimation under more realistic conditions.

The radio interface is characterized by the following parameters:

– The available aggregate peak data rate or throughput T_{max} is a design parameter and depends on the modulation order and coding scheme.

– The flexibility of the radio interface in terms of throughput adaptation depends on the set of available modulation and coding schemes.

– The relation between the available signal/(noise plus interference)-ratio and throughput determines the performance of the radio interface.

– The available signal/(noise plus interference)-ratio depends on the propagation conditions, deployment scenario and antenna concepts.

Other important QoS criteria for spectrum demand estimation are:

– The average aggregate cell throughput $\bar{T}$ in the deployment area, e.g. for uniform user distribution, and under reference deployment scenario conditions. This determines the average spectral efficiency of the radio interface under system-level conditions.

– The remaining available aggregate minimum throughput at the cell edge T_{edge}.

– A satisfied user criterion based on:
  – percentage of users (e.g. 95%),
  – who get a minimum throughput (e.g. 10% of peak throughput)
  – during a specified percentage of the session duration (e.g. 95% of the session time).

The average throughput $\bar{T}$ depends on:

– the design parameters ε_{max} and ΔCIR of the radio interface,

– the deployment scenario with K and Γ,

– the propagation conditions β and σ and finally on

– the antenna concepts.

The difference to the remaining throughput at the cell edge T_{edge} is that the design parameter ε_{max} of the radio interface has no impact on it.

The satisfied user criterion can only be evaluated in simulations. The dependency of the throughput versus distance should be as small as possible, which is supported by more wideband systems.

1.6 Summary of basic relations

The investigations in this document show basic relations between the different parameters of the radio interface and the deployment scenario. The theoretical background used in this Annex is more explained in [4]. The basic relations of different parameters are summarized in the following:

– The available peak aggregate throughput of the radio interface is determined by the maximum physical layer mode and is only available for high carrier/interference-ratios.

– Reduced cluster size K reduces spectrum demand $B_{necessary}$ for given carrier bandwidth W however at the expense of average aggregate throughput.

– The spectrum demand for systems with adaptive modulation and coding for given peak aggregate throughput normalized to the average aggregate cell throughput is minimal for cluster $K = 1$.

– However, under this condition the probability is low to get this peak aggregate throughput due to the impact of co-channel interference.

– A requested peak aggregate throughput can basically be achieved with any spectrum efficiency ε_{max} in combination with the modulation order.

– The available aggregate throughput is significantly decreasing versus distance from the base station.

– The cell edge aggregate throughput does not depend on the available peak throughput of the radio interface. It does only depend on the available carrier/interference-ratio and the carrier bandwidth.

– The aggregate average traffic, which can be supported, depends on the available aggregate average cell throughput.

– The average aggregated throughput depends on the design of the radio interface (peak aggregate throughput, degradation to Shannon bound, flexibility of physical layer modes), the propagation and deployment scenario and in particular on the system bandwidth.

– The propagation conditions including the path loss coefficient β and standard deviation σ of shadow fading have to be accepted dependent on the deployment scenarios.

– High values for β reduce the impact of inter-cell interference at the expense of range and vice versa.

– Small values for β improve the range and an economic network deployment for sufficient cell size scalability. However, also the co-channel interference is increasing. The impact of inter-cell interference in that case has to be reduced by antenna concepts and deployment of access points below roof top level to use inherent shadowing in the deployment area.

– Antenna concepts reduce co-channel interference and may improve range.

– The impact of adjacent channel interference should be minimized to reduce the necessary guard bands between adjacent carriers.

– However, the biggest impact results from intra-cell co-channel interference compared to inter-cell co-channel interference and a lower impact from adjacent channel interference.

2 Adaptation of the real radio network to Recommendation ITU-R M.1768 and this Report

Section 2 described the basic behavior of a real radio network under interference limited conditions and listed issues that influence the spectrum demand. The agreed spectrum requirement calculation methodology presented in Recommendation ITU-R M.1768 provides a simplified description of the real radio network. Simplifications were needed because one of the requirements for the methodology was to be “no more complex than justified by the uncertainty of the input data”.

In the spectrum requirements calculation methodology in Recommendation ITU-R M.1768 many of the influential factors listed in § 3 are modelled with the input parameters to the methodology. These radio related input parameters include cell area, application data rate, minimum deployment per operator per radio environment, and area spectral efficiency. The meaning and usage of these parameters in the methodology is described in the following subsections. In addition, it is explained how the derivation of the values for these input parameters should take into account the issues of real radio networks listed in § 3.

2.1 Cell area

The cell area parameter is used to calculate the offered traffic load in the different radio environments in different teledensities based on the traffic figures from market studies. Realistic values for the cell area parameter should be obtained with link budget calculations.

Values for the cell area parameter take into account the operating environment (such as propagation conditions in the given deployment, interference situation), QoS criteria (such as target data rates like peak data rate and cell edge user data rate), and system characteristics (such as antenna configurations, transmitter and receiver performance, and carrier bandwidths which depend on the data rate). The values for cell area should also take into account the requirements for mobility support in different cell types. For example, the macro cell is defined to support all mobility classes from stationary to high mobility in Recommendation ITU-R M.1768 which sets a lower limit on the available cell size for macro cell deployment.

2.2 Application data rate

The application data rate parameter is used in the methodology in the distribution of traffic to RAT groups and radio environments. The application data rate represents a bit rate which is basically available for applications in a particular cell type. The application data rate may be smaller than the available peak bit rate and may not be available throughout the whole cell.

The estimation tool is currently using the following values for the application data rate for traffic distribution to different RAT groups:

– macro-cell scenarios 50 Mbit/s

– micro-dell scenarios 100 Mbit/s

– indoor scenarios 1 Gbit/s.

In **macro- and micro-cellular environment** the system is operated under **interference-limited conditions**. There the available aggregate throughput is decreasing significantly with increased range (c.f. § 3.3.2). Therefore, the application data rate – especially in macro-cellular environment – corresponds to an expected average aggregate throughput, which is smaller than the peak aggregate throughput of the system. The Figs. 6 and 7 show that the average aggregate throughput for a deployment with frequency re-use 1 in macro-cellular environment is in the order of 50% of the peak aggregate throughput depending on the peak spectral efficiency, the degradation compared to the Shannon bound and the propagation conditions. In macro-cells the application data rate of 50 Mbit/s corresponds to 50% of the required peak aggregate throughput of 100 Mbit/s for IMT-Advanced. In micro-cellular environment potentially higher physical layer modes can be applied compared to macro-cells due to higher expected carrier/interference-ratios, which enable a higher application data rate of 100 Mbit/s.

It is assumed that in **indoor scenarios** the system is operated under **noise-limited conditions** well above the noise level. Therefore, the application data rate of 1 Gbit/s corresponds to the required peak aggregate throughput of the system, which is available in the entire indoor cell with high probability with respect to the expected short range under realistic assumptions for indoor applications.

These values of the application data rate compared to the required peak aggregate throughput values fit to the area spectral efficiency values for the different scenarios.

The application data rate in Recommendation ITU-R M.1768 determines whether a service category can be supported by a given RAT group in a given radio environment by comparing the requirements of the service categories with the RAT group capabilities. The market studies in Report ITU-R M.2072 characterise the service categories with only one type of data rate parameter which is the mean service bit rate. The mean serviced bit rate of the service category presents an

average data rate requirement which is obtained as the weighted average of different services belonging to the same service category as described in Recommendation ITU-R M.1768. Therefore, only one type of data rate parameter is used in the methodology to model the RAT group to reduce the complexity. This was chosen to be the application data rate which needs to be sufficiently large to accommodate the service categories from the market studies which can be supported by the future systems. However, this bit rate may not be available throughout the cell.

2.3 Minimum deployment per operator (= per network) per radio environment

Minimum deployment per operator per radio environment parameter is the minimum amount of spectrum needed for one operator to build a practical working network in the given radio environment. Minimum deployment per operator per radio environment is a spectrum granularity unit related to the carrier bandwidth.

The derivation of the values for minimum deployment parameter needs to ensure that the application data rate can be supported in the given radio environment. In addition, the minimum deployment should consider the cell edge bit rate to ensure reasonable user satisfaction also for the users who are located at cell edge.

2.4 Area spectral efficiency

In Recommendation ITU-R M.1768 the area spectral efficiency parameter is used to calculate the raw spectrum requirements per cell by dividing the capacity requirement in bit/s/cell with the spectral efficiency values in bit/s/Hz/cell. In Recommendation ITU-R M.1768 and Report ITU-R M.2074 the spectral efficiency is defined to be calculated from the mean data throughput achieved over all users, which are homogenously distributed in the area of the radio environment, on IP layer for packet switched services and on application layer for circuit switched services.

The capacity requirement in the methodology presents the aggregate capacity requirement for UL and DL and thus the corresponding spectral efficiency is independent of the link direction. The capacity requirement is the average aggregate capacity required in the cell which is calculated from traffic figures which present the average aggregate traffic over the cell. Therefore, also the spectral efficiency is presented in a single figure per cell in an average sense which characterises the situation over the whole cell. The calculation of the spectral efficiency values is based on the average aggregate throughput of all users in the cell normalised with the bandwidth of the cell.

Spectral efficiency values should consider the QoS criteria (sufficient user satisfaction, data rates), operating environment (propagation conditions, interference situation), and system characteristics (antenna characteristics, transmitter and receiver performance).

2.5 Achievable bit rate over the cell

In practice the available bit rates will not be constant over the whole cell, as they depend e.g. on the distance from the base station due to S/N variations in the noise limited case and due to $S/(I + N)$ in the interference limited case. As modeling this properly would require a rather complex algorithm, and as the spectrum requirements estimation tool was required to be as simple as possible so that the calculations could be done by a normal PC with standard software programs an alternative, simplified approach is used in the methodology.

For traffic distribution purposes, the application data rate used in the methodology is assumed constant over the whole cell area. This approach is an conservative approximation as it assumes that the application data rate for the majority of users is always available. However, the variability of the available data rates over the cell area is taken into account by considering the area spectral efficiency i.e. the spectral efficiency averaged over the entire cell area.

2.6 Relations of the radio parameters

The radio parameters from § 4.1 to 4.4, which are used as input parameters in Recommendation ITU-R M.1768 to model the real network in a simplified manner, are closely inter-related. Therefore, the derivation of the values for these input parameters to be used in this Report should be conducted in the same framework. The input parameter values should take into account the operating environment (such as propagation conditions, interference situation), QoS criteria (such as data rate requirements, user satisfaction) and system characteristics (antenna configurations, transmitter and receiver characteristics). It is important that the same situation is considered when deriving the values for the different input parameters due to the interrelations.

3 Conclusions

This Annex 2 describes the behavior of a real radio network with the basic relations, and lists issues that influence the spectrum demand. The agreed spectrum calculation methodology in the Recommendation ITU-R M.1768 presents a simplified model to characterize the real radio network. The factors influencing the spectrum demand of the real radio network presented in § 3 are captured in the spectrum calculation methodology in the input parameters and derivation of their values as described in § 4. These input parameters include cell area, application data rate, minimum deployment per operator per radio environment, and area spectral efficiency.

It is important that the values for these input parameters to be used in this Report are derived in the same framework with the same assumptions because the individual parameters are interrelated.

4 References

[1] Recommendation ITU-R M.1645 – Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000.

[2] Recommendation ITU-R M.1768 – Methodology for calculation of spectrum requirements for the future development of the terrestrial component of IMT-2000 and systems beyond IMT-2000.

[3] THOMAS, J.B. [1969] *An Introduction to Statistical Communication Theory*, John Wiley & Sons, New York, United States of America.

[4] MOHR, W. [2003] Spectrum demand for Systems Beyond IMT-2000 Based on Data Rate Estimates. *Wiley J. Wireless Comm.* and *Mobile Computing*; **3**, p. 1-19.

Annex 3

Estimation of spectrum for nomadic applications

There was considerable discussion on the estimation of spectrum for nomadic applications that need to be provided by RATG 2. Some Administrations believe that there was no need to separately estimate this spectrum, whereas others are of the view that this spectrum should be separately estimated so that administrations can be informed on how to accommodate such use in available frequency bands.

The nomadic applications are based on large data rates up to 1 Gbit/s and will be provided by pico cells and hot spot cells. The radio characteristics for nomadic applications may be different from mobile applications i.e., the carrier bandwidths may be large (for example 100 MHz), other cell interference is less etc.

The spectrum estimation tool does not allow the separate estimation of spectrum for nomadic applications. There was not enough time to complete this work in time for inclusion in the CPM-07 Report. One Administration has made some estimates of nomadic spectrum and has shown that this could be more than 50% of the total spectrum estimate. Some other administrations support the trend of this analysis, but some administrations do not support this analysis. Since the tool cannot estimate the nomadic spectrum, this estimation of nomadic spectrum may not be accurate.

Annex 4

Sensitivity of spectrum estimates

Figure 10 below shows the sensitivity of spectrum estimates to the parameters *U*, *Q*, *R* and μ. These parameters were individually varied from minimum (equals zero) to maximum (equals 1) and then collectively varied.

The results showed that spectrum requirements rapidly rise beyond about 50% (i.e mid range) of the values of the variables.

FIGURE 10

The sensitivity of spectrum estimates to the parameters, *U, Q, R* and μ