Deployment Scenarios for Mobile Broadband Communications

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ABSTRACT

The multi-service traffic analysis of a Mobile Broadband System (MBS), with a given mixture of applications, requires the definition of their main operation environments, corresponding to the Residential, the Mixed (half business/half residential), the Business and the Industrial markets. In this work, the respective deployment scenarios are defined by the values for the usage of a set of 26 applications. The usage of broadband applications (> 2 Mb/s) increases from the Residential market (17%) to the Business one (25%), corresponding to a decrease in the usage of wideband (< 2 Mb/s) ones (from 50 down to 42 %), and to a constant value for the usage of low-MBS ([128, 384] kb/s) ones (33%); slight differences exist from the Business to the Industrial market. The actual number of users also depends on the density factor, it varying from 0.004 users/m^2 in the industrial scenario to 0.150 users/m^2 in hotspots, e.g., offices.

I. INTRODUCTION

In the next years, a large demand is foreseen for mobile multimedia services, limitations on achievable data rates and system capacity leading to the use of mobile broadband communication systems operating at millimetre wavebands, e.g., MBS (Mobile Broadband System [1]). MBSs will be deployed mainly in urban areas, to cover hotspots in the centre of large cities, where the highest demand will occur; moreover, they will support several services simultaneously, over the same platform, for different, or even the same, user(s). Owing to the diversity of characteristics of the services to be supported, different requirements arise for resource usage, each application being supported by these services [2] having access to various service components.

The amount of resources that have to be available in each cell depends on the mixture of applications being supported, and also on the total number of users. Because of the sensitivity of system load to application parameters, e.g., average duration, service components characteristics and terminal mobility, an accurate identification of the deployment scenarios of such systems is needed, it being of crucial importance for cellular planning purposes.

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The usage of each application, i.e., the percentage of connections of a given application relatively to the total number of applications, is one of the most important aspects to be determined, there being however, nowadays, few forecast results available for mobile communications. Since one is dealing with applications going beyond the simple voice service the term connection is being used in this paper instead of call. The RACE-TITAN project has already done some estimations for the residential market in fixed networks [3], [4], and ETSI-RES [5], the UMTS Forum [6] and the RACE-MBS project [7] have also presented some forecasts for future mobile broadband systems.

Considering these facts, in this paper one proposes eight deployment scenarios for MBS, and also values for applications usage in each of them. These values were obtained by combining the results available in previous works, mentioned earlier. They are merely an example of a mixture of applications that may exist in MBS; they will however be very useful for multi-service traffic analysis purposes since real data is not yet available in the literature. This is the main motivation for the realisation of this work.

The structure of the paper is as follows. In Section II, the keystone perspectives for the definition of the deployment scenarios are described, and some references to previous work on applications usage for MBS, HIPERLAN and UMTS are given. Because the notation used in each of those references is diverse, in Section III the compatibility of the notation is worked out. In Section IV, a proposal for the deployment scenarios for MBS is described, based on forecasts for narrow-, wide- and broadband applications. In Section V, values for applications usage and for the density factor in each scenario are proposed, and the considered assumptions are analysed. Conclusions are drawn in Section VI.

II. KEYSTONE PERSPECTIVES

A. RACE-MBS Project

In the perspective of the MBS project, mobile applications can be divided into movable, slow (< 36 km/h) and

fast mobile, each of them having different associated data rates, Table 4.1 of [7]. The fast mobile ones are: City Guidance, Freight and Fleet Management, Emergency, Pictorial Data for Travel, Public Transport Information, Electronic Newspaper, Traffic Advice, HDTV Contribution, Audio-visual Library and Surveillance of Property. The ones associated with slow mobility are: Access to Banking Services, Special Needs (health), Repair Assistance, CAD Interconnection and HD Videophone; the movable ones are Tele-consultation and Wireless LAN.

The MBS project has also identified the various user groups and estimated their market penetration: A – Emergency Professionals - 70 %, B – Commuters - 30 %, C – Mobile/On-call Professionals - 50 %, D – Families/ Tourists - 20 %, and E – Specialist Group (not related to other applications) – market penetration not determined. The following five geographical areas have also been identified: Primary roads, City centres, Residential areas, Industrial areas and Hotspots. Estimations have been made for mature MBS on the busy hour rate, i.e., the percentage of total potential users that is active during the busiest hour [7], these values being used here as a basis for the definition of various scenarios in a geographical area.

B. ETSI-HIPERLAN

ETSI has identified the following three deployment scenarios for HIPERLAN [5]: Office, Industry and Studio (TV, radio or recording). The usage of applications deployed on those scenarios is presented in Tables 9-11 of [5], as well as their average data rate; different sets of applications exist in each of the scenarios. In this work, these values are the basis for the cases of MBS deployment scenarios with movable or low mobility terminals.

C. UMTS Forum

The UMTS Forum has identified six operational environments [6]: i) CBD – City business district (in building), ii) Suburban (in building or on street), iii) Home (in building), iv) Urban (pedestrian), v) Urban (vehicular) and vi) Rural in- & outdoor. The density of potential users per km^2 and the foreseen cell types have also been identified, assuming that no user occupies two operational environments at the same time. The distinction between low (pedestrian), medium and full (high) mobility scenarios is done.

It was assumed, at least initially, that services are deployed on a platform based on the existing DECT and GSM. UMTS capability will be higher than for GSM, depending also on service bit rates / classes and on the use of low / high mobility terminals. By 2010 the cell radii will be on the limit, e.g., 75 m for CBD, 2 km for suburban cells and 600 m for urban cells, and further reduction may not be economically feasible [6]. UMTS penetration figures for years 2005 and 2010 in each operating environment, and for each service class, can be extracted from these reports, Table 3.3 of [6]. The considered service classes are High Interactive Multimedia (MM), High MM, Medium MM, Switched Data, Simple Messaging and Speech. These figures are based on extensive market research within Europe and represent the fraction of the density of potential users for each of the operation environments given in Table 3.1 of [6].

Nevertheless, it should be noted that the use of each service is not exclusive. Each penetration figure, P_j, refers to the penetration of service j as a proportion of the total potential users, i.e., it is the percentage of the total number of users who potentially can use applications from this service. Since users can have simultaneous access to more than one service it is possible for the *total penetration rate* in an environment (across all services) to exceed 100 %, if a high proportion of users are using more than one service. The CBD environment is assumed to be the only one with offices, meaning that the penetration rate in the CBD area comes primarily from people in those offices.

To achieve the number of active users it is necessary to know the busy hour connection attempt, *BHCA*, which is defined as the ratio between the total number of connections and the total number of subscribers in the considered area, measured during the busy hour [8], values being presented in Table 3.4 of [6]. It is however worthwhile noting that these traffic characteristics are hard to predict, mainly for MM type of services. New services will have different temporal characteristics so that the relative spectrum balance between speech and other services will vary through the day. Besides that, different tariffs during the day will change traffic characteristics drastically. Furthermore the assumed *BHCA* for MM services have a lack of proper comparison material due to the fact that similar charged services do not exist in public use today.

III. NOTATION AND DEFINITIONS

Different notations are adopted in the various sources [5], [6], [7]. In order to have a common notation some definitions follow. The total number of application j subscribers during the busy hour, M_j, is given as a function of the penetration, P_j, by $M_j = P_j \cdot M$, where M is the total number of potential users.

The application j *BHCA* is given by the ratio between the total number of active connections, $N_{conns\,j}$, and the total number of subscribers using it in the considered area, measured during the busy hour, i.e.,

$$BHCA_j = \frac{N_{conns\,j}}{M_j}, \qquad (1)$$

the total number of application j active connections being

$$N_{conns\,j} = BHCA_j \cdot P_j \cdot M . \qquad (2)$$

The application j usage, U_j, is defined by the percentage

of that application use relatively to the total number of active applications, and can be obtained as a function of the $BHCA_j$, in a given deployment scenario, by

$$U_j = \frac{N_{comms\,j}}{\sum_i N_{comms\,i}} = \frac{BHCA_j \cdot P_j}{\sum_i BHCA_i \cdot P_i}, \quad (3)$$

where the sum is done for all applications operating in the considered scenario. Another measure for application j "usage" is the busy hour rate, BHR_j, given by the ratio between the total number of active application j connections and the total number of potential users, i.e.,

$$BHR_j = \frac{N_{comms\,j}}{M} = \frac{N_{comms\,j} \cdot P_j}{M_j}. \quad (4)$$

From this, the following relation exits

$$BHR_j = BHCA_j \cdot P_j \quad (5)$$

leading to the following equation for the usage of application j as a function of the busy hour rate

$$U_j = \frac{BHR_j}{\sum_i BHR_i}. \quad (6)$$

These definitions allow using data from each of the references in a uniform manner.

IV. DEPLOYMENT SCENARIOS

A. Types of Environments

It is still difficult the have a clear view of all operation environments in MBS. However, it is already possible to clearly distinguish the following ones, Fig. 1:

a) Business City Centre - BCC (vehicular or pedestrian)
b) Urban Residential Areas - URB (vehicular or pedestrian)
c) Primary Roads - ROA (including highways)
d) Trains - TRA
e) Commercial Zones - COM (large public places)
f) Offices - OFF (buildings, not residential)
g) Industry - IND (large factories plant)
h) Home - HOM (rooms in residences)

Besides the Residential market one also considers the Business, the Mixed (half-business / half-residential) and the Industrial ones, with different assumptions for the demand.

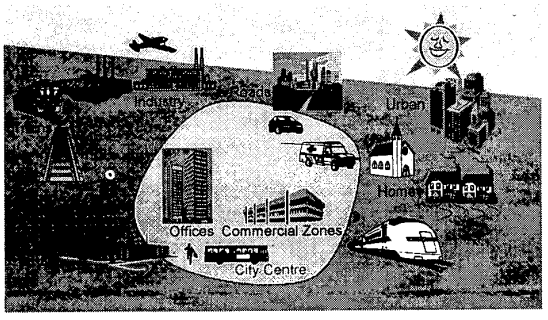

Fig. 1 –MBS deployment scenarios

B. RACE-TITAN Forecasts

Forecasts have been extracted from the RACE-TITAN project for the demand in the Residential market, defined as a percentage of the total Residential market, for the years 2005 and 2010, Table 1. From these forecasts, one can assume that applications with data rates in the range [128, 384] kb/s will be supported by MBS, they being designated by low-MBS ones. Consequently, one has considered as an approximation that, in 2010, from the 25 % of ISDN applications, 2/5 of the total demand, i.e., 10 %, can be included as low-MBS applications, the remaining 3/5, i.e., 15 %, being ISDN-data applications.

Table 1 - RACE-TITAN Project Forecasts

Demand as percentage of the residential market		2005	2010
ISDN	< 144 kb/s	20 %	25 %
Wideband	< 2 Mb/s	10 %	15 %
Broadband	< 8 Mb/s	2 %	5 %

Although TITAN has defined 8 Mb/s as an upper value for the data rate, one can assume that higher data rates can be achieved in MBS, up to 32 Mb/s in the examples presented in this work. Even higher data rates, up to 155 Mb/s, will be achieved in the future, e.g., with the ABR (available bit rate) service class, i.e., a variable bit rate service class with a minimum bandwidth guarantee. It allows the ATM system to fill the resources to the maximum capacity when there are periods when CBR and VBR (constant / variable bit rate) traffics are low.

From the UMTS forecasts for 2005 one can also conclude that in the mobile market, from ISDN applications, 18 % are going to be ISDN-data ones (< 128 kb/s), whereas only around 2 % are going to be low-MBS applications ([128, 384] kb/s). This means that in 2010 the usage of these applications (10%) relatively to others in the mobile market will be five times larger than in 2005. However, as the demand is normalised to the total usage of whole applications, these quantities do not reflect exactly the increase in the total number of users, which will possibly lead to an additional increase.

C. Proposal for Mobile Broadband Communications

From the data available for MBS and HIPERLAN (data rates higher than 2 Mb/s) and UMTS (applications with data rates from 128 up to 2 Mb/s), in the cases presented, it is possible to do an updated extrapolation for mobile broadband communications. Because the data from the RACE-TITAN project is for the Residential market, some changes had to be done for the Business and the Mixed (half-business / half-residential) ones, Table 2. The demand of wide- and broadband applications increases 5 % from the Residential market to the mixed one and also from the Mixed to the Business one, corresponding to a decrease in traditional markets, mainly voice. Consequently, the respective forecasts for MBS-alone usage are the ones from Table 3.

Table 2 – Assumptions for the various markets

Services	Data rates [kb/s]	Demand [%] Residential		Mixed		Business	
Voice	-	55		40		25	
ISDN-data	< 128	15		15		15	
Low-MBS	[128,384]	10	30	15	45	20	60
Wideband	< 2 000	15		20		25	
Broadband	> 2 000	5		10		15	

Table 3 – MBS-alone usage for each of the markets

MBS usage (percentage of the market)		Residential	Mixed	Business	Industrial
Low-MBS	[128,384] kb/s	33 %	33 %	33 %	22 %
Wideband	< 2 Mb/s	50 %	45 %	42 %	53 %
Broadband	> 2 Mb/s	17 %	22 %	25 %	25 %

Values are included for the Industrial market, assuming that broadband applications have the same usage as in the Business market, whereas low-MBS applications have lower usage, resulting in a higher usage for wideband ones. Again it does not reflect the difference in the number of potential users, but only the "mixture" of services operating simultaneously. Besides, one further considers that the Residential market corresponds to the URB and HOM deployment scenarios, the Mixed market corresponds to the ROA, TRA and COM ones, while the Business market corresponds to the BCC and OFF ones.

V. APPLICATIONS USAGE

Values for the usage of each application are proposed for the eight deployment scenarios, Table 4. The envisaged maximum data rates are also presented in order to establish the service class associated with the application (low-MBS, wide- or broadband). The density factors (number of users per net area, e.g., total area of the streets to be covered or the actual coverage area in a commercial zone) are also proposed for every scenario [7]. The following assumptions are considered:

- For low-MBS applications the usage is 33 %, except in the industrial scenario where it is 22%. For the former, 15 % are from Desktop MM (because of the importance of Web Browsing), 7 % from Data Transfer, 7 % from Broadband Videotex for E-commerce (because of the increasing importance of this kind of applications), and the remaining 4 % from ISDN Videoconference, (e.g., for tele-advertising, e-commerce and tele-education). In the industrial deployment scenario it was considered that 15 % of the usage is from Desktop MM (because of the importance of Web Browsing) and 7 % from Data Transfer.

Table 4 – Proposal for applications usage in each of the deployment scenarios

Applications Usage [%]	Data Rate [kb/s]	BCC	URB	ROA	TRA	COM	OFF	IND	HOM
Low-MBS									
ISDN Videoconference	384	4	4	4	4	4	5.6	-	4
Data File Transfer (ftp)	384	7	7	7	7	7	5.6	7	7
Desktop Multimedia (Web browsing)	384	15	15	15	15	15	14.8	15	15
Broadband Videotex (E-commerce)	384	7	7	7	7	7	7	-	7
total		**33**	**33**	**33**	**33**	**33**	**33**	**22**	**33**
Wideband									
Monitoring	500	-	-	-	-	-	-	11	-
Configuration Data	600	-	-	-	-	-	-	1	-
E-mailbox for Multimedia	1 500	3	3	2	3	4	7.5	7.5	4
Remote Procedure Call	1 500	3	8	3	8	8	14	7.5	8
HD Videotelephony	2 000	15	11	9.8	8	9.2	0.9	1	15
Mobile Tele-working	2 000	7.3	2.2	3.3	3.2	3.7	4.7	5	10
Assistance in Travel	2 000	3.6	11	16.3	4.8	5.5	3	-	1
Urban Guidance	2 000	1.1	3.3	3.3	3.2	3.7	1	-	0.5
Mobile Video Surveillance	2 000	0.4	0.5	0.2	-	0.4	0.5	15	0.5
Tourist information	2 000	3.6	1.0	2.1	4.8	5.5	1	-	1
E-newspaper	2 000	5	10	5	10	5	9.4	-	10
Video Multi-point Monitoring	2 000	-	-	-	-	-	-	5	-
total		**42**	**50**	**45**	**45**	**45**	**42**	**53**	**50**
Broadband									
Freight and Fleet Management	2 200	0.7	0.2	2.3	6	-	0.2	-	0.2
Mobile Repair Assistance	2 400	0.2	0.1	0.3	-	1	-	3	0.1
Multimedia Library	2 400	7.4	4.4	5.6	-	6	6	3	3.5
Mobile Emergency Services	2 800	1.8	0.1	1.6	-	-	-	-	0.1
TV-programmes (MPEG2-4)	8 000	7.4	9	5	12	10.9	4.8	-	10
High BW Video Multi-point Monitoring	8 000	-	-	-	-	-	-	0.5	-
Professional images	8 000	2	1	1.5	2	2	4	2	1
HDTV Outside Broadcast	8 000	0.1	0.1	0.1	-	0.1	3	-	0.1
Control Data	21 000	-	-	-	-	-	-	12.5	-
Wireless LAN Interconnection	32 000	5.4	2.1	5.6	2	2	7	4	2
total		**25**	**17**	**22**	**22**	**22**	**25**	**25**	**17**
Density Factor (Number of users/m^2)		0.031	0.012	0.012	0.111	0.150	0.150	0.004	0.015

- For wideband applications the usage varies between 42 and 53 %. Data from the MBS project [7] and from HIPERLAN [5] has been used, except for E-mailbox for MM, E-newspaper and Remote Procedure Call, since data was not available. The names of the deployment scenarios are approximately the same from [7], the data from *Hotspots* being considered for the Train and the Commercial Zones scenarios; the Home scenario is considered as being similar to the Urban one, with slight changes in the usage, except for Tele-working (higher usage at home), Assistance in Travel and Urban Guidance (lower usage at home). In the Office and Industrial deployment scenarios one used data from HIPERLAN (Tables 9-10 from [5]). It follows an example on the way that parameters have been obtained for this class of service in the BCC scenario: one considered an usage of 3% for E-mail-box for MM, 5 % for E-newspaper and 3 % for Remote Procedure Call; next, the sum of these values was subtracted from the 42 % of usage of wideband applications, a value of 31 % being obtained; finally, this usage was distributed by the remaining applications in the wideband service class proportionally to the values for usage extracted from Table 4.1 of [7], which were used as weights.
- For broadband applications the methodology is similar to the one presented for wideband ones. Data from [7] was used, except for Professional Images and TV-programmes. Whereas Professional Images has a high demand in Business like scenarios, as the office one, TV-programmes have a higher demand in Residential and Mixed-type of markets, where entertainment is more likely to occur (e.g., in the urban, the home or the commercial zones deployment scenarios).

In the industrial deployment scenario, from the applications used in other scenarios, fewer applications are used, while some specific new ones are considered. Thus, the values for the usage of applications common to other scenarios were adapted from the office scenario, according to what one expects on what their relative importance will be in the industrial scenario.

Finally, it is worthwhile noting that the values presented for the maximum data rates are approximated ones and refer to the link with higher bit rate (either the up- or the downlink). Asymmetric applications (e.g., FTP) will only need such high bit rates in one of the directions whereas, for bursty VBR applications (e.g., Desktop MM), the average bit rate can be much lower, leading to an improvement of the resource usage.

VI. CONCLUSIONS

The multi-service traffic analysis in MBS involves a lot of variables, the establishment of the foreseen deployment scenarios being of huge importance in the definition of the mixture of applications to be considered. Based on the available data for UMTS, B-ISDN and HIPERLAN, as well as some data from TITAN and MBS RACE projects one has identified the following eight environments: primary roads, business city centres, urban residential areas, trains, commercial zones, offices, industries and homes. Moreover, they correspond to four types of market, i.e., the Residential, the Mixed, the Business and the Industrial ones, for which the usage of low-MBS ([128, 384] kb/s), wide- (data rates up to 2 Mb/s) and broadband (data rates higher than 2 Mb/s) applications was defined. The usage of broadband applications increases from the residential market (17%) to the business one (25%), corresponding to a decrease in the usage of wideband applications (from 50 down to 42 %), and to a constant value for the usage of low-MBS (33%); slight differences exist from the business to the industrial market. However, it is not enough to define the applications usage in each scenario, the actual number of users also depending on the density factor, which varies from 0.004 users/m^2 in the industrial scenario to 0.150 users/m^2 in hotspots, e.g., commercial zones and offices.

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