DEPLOYMENT SCENARIOS AND APPLICATIONS CHARACTERISATION FOR ENHANCED UMTS SIMULATION

Jaime Ferreira*, Fernando J. Velez†,+

* Portugal Telecom Inovação, R. Tenente Valadim, 431, 4100-479 Porto, Portugal
† DEM, University of Beira Interior, Calçada Fonte do Lameiro, 6201-001 Covilhã, Portugal
+ Instituto de Telecomunicações (Lisboa), IST, Av. Rovisco Pais, 1049-001 Lisboa, Portugal
jaime@ptinovacao.pt, fjv@ubi.pt

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Abstract

An overview of E-UMTS deployment scenarios and supported services is presented, based on the views of nowadays-relevant players. Deployment and mobility scenarios include expected population density, and usage of service mix, for each environment. A number of nearly thirty applications are considered. However, a reduced set of applications is needed for simulations purposes, and scenarios were defined with a selection of the most relevant applications. E-UMTS traffic generation and activity models, based on population and service penetration values, are also described and characterised. ON/OFF states have been characterised by appropriate statistical distributions and parameters.

1 Introduction

Enhanced UMTS (E-UMTS) is a UMTS evolution step, which provides bit rates higher than 2 Mbit/s in the uplink and downlink directions over a 5 MHz frequency carrier. It enables the provision of new wideband services and a significant reduction of the price per bit, running over flexible QoS enabled IP based access and core networks, and making possible an effective end-to-end packet based transmission. IST-SEACORN [1] has proposed a set of enhancements to UMTS, which include, among others, advanced modulation and radio transmission techniques, improved strategies for IP routing and QoS assurance.

The effect of the proposed enhancements needs to be evaluated by means of simulation. For that purpose a set of services need to be used, in order to create a complete and realistic simulation framework, impacting directly on traffic generation models. These services will be accessed from a variety of operation environments each with its distinctive set of service preferences, usage patterns, and associated mobility profiles. As an answer to these services and environmental conditions a matching set of deployment strategies need to be studied, adapted, and simulated.

The usage of each application, i.e., the percentage of connections relative to the total number of active applications, is one of the most important aspects to be determined. These data will be essential for multi-service traffic engineering purposes, and it is the main motivation for the realisation of this study. Although there are nowadays few forecast results available for mobile communications, some estimations have already been performed for narrow-, wide- and broadband applications in the residential market of fixed networks [9], [6], as well as for wireless [3], and mobile communications, e.g., UMTS Forum [10] and RACE-MBS [7].

At the same time, a further step is taken in traffic modelling by introducing Long Range Dependence models, better adapted to wireless IP communications. These are based on recent research on field data that has concluded that traditional traffic models produce too optimistic results when used to model some data traffic. This may result in networks that are under dimensioned and therefore under-performing with respect to theoretical expectations.

A range of twenty-eight applications and eight deployment environments is considered for a complete scenario. This number was later integrated and condensed into a smaller set of services and service environments to meet the technical demands of the simulation tools. Without this summarisation effort the framework proposed would pose considerable difficulties to implement due to the amount of computing resources it would require from simulators. A subset of services and environments are therefore selected, with three operation environments, and four or five services.

Section 2 presents a set of scenarios that put together all components of E-UMTS deployment situations. These include expected population density, mobility characteristics and expected usage of service mix for each environment. Section 3 describes the selected set of services, environments, and source traffic models to be used in E-UMTS simulations. They cover voice, interactive data (e.g., Instant Messaging for Multimedia) and streaming based services (Video-telephony, HD Video-telephony). Conclusions are drawn in Section 4.

2 E-UMTS Scenarios Definition

It is still difficult the have a clear view for the deployment scenarios in E-UMTS. However, it is already possible to clearly distinguish the following eight deployment scenarios: i) business city centre, BCC (vehicular or pedestrian), ii) urban residential, URB (vehicular or pedestrian), iii) primary roads, ROA, iv) trains, TRA, v) commercial zones – COM (e.g., airports, railway stations, hospitals, commercial centres, universities), vi) offices, OFF (buildings), vii) industry, IND (large factories plant), and viii) home, HOM.

From the data available for UMTS (data rate from 144 kb/s up to 2 Mb/s) [10, 11], MBS [7], and HIPERLAN (> 2 Mb/s) [3], and based in the views RACE-TITAN project as well, it is possible to perform an updated extrapolation for E-UMTS communications. Broadband applications (> 2 Mb/s) will only be supported in scenarios without relevant mobility; hence, the offices and industry scenarios will be defined separately, Table 1.

One considers an increase of 15 % on the demand of narrow- plus wideband applications from the residential market to the mixed one, and also from the mixed to the business market, corresponding to a decrease in traditional markets, i.e., sound and voice.

Values for offices and industrial markets [3] have slight differences compared with the business market, Table 2. In the context of these scenarios, new applications, like Control data, Monitoring [3], TV Programme Distribution (MPEG2-4), Wireless LAN Interconnection and Professional Images, are considered. One further assumes that there is a correspondence between deployment scenarios and envisaged markets:

- Residential: URB, and HOM.
- Mixed: ROA, TRA, and COM.
- Business: BCC, OFF, and IND.

Values are proposed for the usage of applications at the eight scenarios, Table 3. The set of applications considered are the ones from [8] plus Broadband, and Sound ones [2].

	Data rates	Demand, % of the market					
		Residential		Mixed		Business	
Sound	-	57		42		27	
High Interact MM	≤ 144	16		16		16	
Narrowband	]144,384]	11	27	18.5	42	26	57
Wideband	]384,2 048]	16		23.5		31	

Table 1: Assumptions for Usage in various E-UMTS Markets.

	Data rates	Demand [%]	
		Offices	Industry
Sound	-	25	15
High Interact. MM	≤ 144	15	10
Narrowband	]144,384]	20	20
Wideband	]384, 2 048]	25	40
Broadband	> 2048	15	15

Table 2: Assumptions for Offices and Industry.

Applications Usage [%]	R_b [kb/s]	BCC	URB	ROA	TRA	COM	OFF	IND	HOM
Sound									
Voice	12	14.0	29.0	21.5	21.5	21.5	13.0	7.5	29.0
Voice over IP	12	10.0	21.0	15.5	15.5	15.5	9.0	6.0	21.0
Audio Streaming	64	3.0	7.0	5.0	5.0	5.0	3.0	1.5	7.0
Total		**27.0**	**57.0**	**42.0**	**42.0**	**42.0**	**25.0**	**15.0**	**57.0**
High Interactive Multimedia (HIMM)									
Interactive remote games	128	1.5	1.5	1.5	1.5	1.5	1.0	0.0	1.5
Still images communication	128	3.0	3.0	3.0	3.0	3.0	3.0	2.5	3.0
Mobile portal	128	3.0	3.0	3.0	3.0	3.0	3.0	2.5	3.0
Micro-movies	128	1.5	1.5	1.5	1.5	1.5	1.0	0.0	1.5
Video-telephony	128	3.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0
HIMM Videoconference, various purposes	128	2.0	2.0	2.0	2.0	2.0	2.0	1.5	2.0
Collaborative working (& tele-presence)	128	2.0	2.0	2.0	2.0	2.0	2.0	1.5	2.0
Total		**16.0**	**16.0**	**16.0**	**16.0**	**16.0**	**15.0**	**10.0**	**16.0**
Narrowband									
Videoconference (Tele-advertising)	384	3.2	1.5	2.2	2.2	2.2	3.0	0.0	1.5
Data File Transfer (ftp)	384	5.5	2.3	3.9	3.9	3.9	4.0	6.0	2.3
Multimedia Web Browsing	384	11.8	4.9	8.4	8.4	8.4	9.0	14.0	4.9
Broadband Videotex (E-commerce)	384	5.5	2.3	4.0	4.0	4.0	4.0	0.0	2.3
Total		**26.0**	**11.0**	**18.5**	**18.5**	**18.5**	**20.0**	**20.0**	**11.0**
Wideband									
Monitoring	480	-	-	-	-	-	-	5.0	-
Instant Messaging for Multimedia	1024	2.2	1.0	1.2	1.5	1.9	8.0	4.0	1.7
Remote Procedure Call	1024	2.2	2.5	1.8	2.0	4.0	2.0	8.0	2.5
Mobile Tele-working	1536	5.4	0.7	2.0	1.5	2.0	2.5	2.5	3.1
Assistance in Travel	1536	2.7	3.5	6.0	2.0	3.0	1.5	1.5	1.0
Urban Guidance	1536	0.8	1.1	2.0	1.5	1.9	0.5	0.5	0.5
Mobile Video Surveillance	1536	0.3	0.2	0.1	-	0.2	0.3	10.0	0.2
Tourist information	1536	2.7	0.3	1.4	2.5	3.5	0.5	0.5	0.3
E-newspaper	1536	3.7	3.2	3.0	8.0	4.0	4.7	5.0	3.2
HD Video-telephony (Tele-education)	2048	11.0	3.5	6.0	4.5	5.0	5.0	3.0	3.5
Total		**31.0**	**16.0**	**23.5**	**23.5**	**23.5**	**25.0**	**40.0**	**16.0**
Broadband									
Control data	3840	-	-	-	-	-		10.0	-
TV program. distribution (MPEG2-4)	12780	-	-	-	-	-	4.5	0.0	-
Wireless LAN Interconnection	12780	-	-	-	-	-	6.5	1.5	-
Professional Images	12780	-	-	-	-	-	4.0	3.5	-
Total							**15.0**	**15.0**	
Density Factor (Number of users / m^2)		0.031	0.012	0.012	0.111	0.150	0.150	0.004	0.015

Table 3: Proposal for Applications Usage in each Deployment Scenario.

In Table 3, besides values for usage, the envisaged approximated maximum data rates, R_b, are introduced for all applications, in order to establish the service class (Sound, High Interactive Multimedia, Narrow-, Wide- or Broadband). These data rates 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 ways. The density factors for each of the scenarios are presented as well [7]. In the business market there is a fundamental difference between the BCC scenario, and the OFF and IND ones: applications are movable (not mobile) in the latter, hence, broadband applications, with data rates up to 8 Mb/s, can be supported.
As an example, the following assumptions have been done for the business market (including BCC, OFF and IND scenarios):

- For Sound applications, while the usage is 27 % in BCC it is 25 % in OFF, and 15 % in IND, i.e., slight differences exist among them. As an example, the values for application usage in BCC are the following: Voice, 14 %, Voice over IP, 10 %, and Audio streaming, 3 %.
- High Interactive Multimedia applications have an overall usage of 16 % in BCC, 15 % in OFF, and 10 % in IND. In the case of BCC, the usage is distributed in the following way: Interactive remote games, 1.5 %, Still images communication, 3 %, Mobile portal, 3 %, Micro-movies, 1.5 %, Video-telephony, 3 %, Video-conference, 2% and Collaborative working (& tele-presence), 2%. The slight difference between OFF and IND comes from the lower usage of entertainment applications (Interactive remote games and Micro-movies).
- Narrowband applications have an usage of 26 % in BCC and 20 % both in OFF and IND. As an example, in the BCC scenarios the values for the usage are distributed in the following way: Video-conference for tele-advertising, 3.2 %, Data file transfer (ftp), 5.5 %, Multimedia Web browsing, 11.8 %, and Broadband Videotex for E-commerce, 5.5. %. While the differences to the OFF scenario are slight, there are important differences to the IND scenario [9]: one only considers 6 % of FTP usage and 14 % of Web browsing usage, while the other applications are not used.
- For Wideband applications the usage is 31 % in BCC, 25 % in OFF, and 40 % in IND. Data from the MBS project, Table 4.1 of [7], and from HIPERLAN, Table 9 and 10 of [3], were used, except for Instant Messaging for Multimedia, E-newspaper and Remote procedure call, since data was not available. An example follows on the way that parameters have been obtained for this class of service in the BCC scenario: one considers an usage of 2.2 % of Instant Messaging for Multimedia, 3.7 % for E-newspaper and 2.2 % of Remote procedure call; next, the sum of these values was subtracted from the 31 % of usage of Wideband applications, a value of 22.9 % being obtained; finally, this usage was distributed by the remaining applications in the Wideband service class proportionally to the values of usage extracted from [7], which are used as weights.
- The usage of broadband applications is 15 % in OFF and IND. In OFF, one considers the following values for the usage: TV programmes distribution (MPEG2-4), 4.5 %, Wireless LAN Interconnection, 6.5 %, and Professional images, 4 %. In IND one do not consider TV programme distribution because entertainment is less likely to occur. Instead one introduces an important application: Control data, with a usage of 10 %.

In other types of market, residential (URB and HOM) and mixed (ROA, TRA and COM) the procedure followed to determine the values of the usage was similar. The names of the deployment scenarios are approximately the same from [7], and the data from hotspots has been considered for the Train and Commercial Zones deployment scenarios; the Home scenario was considered as being similar to the Urban one, with slight changes in the usage, except for the one of Tele-working (higher usage at home), Assistance in Travel and Urban Guidance (lower usage at home).
Finally, it is a worth noting that the values presented for maximum data rates are approximate, 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 ways 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, and a statistical multiplexing gain occurs. For a more complete description of the operation environments, the definition of scenarios from mobility is needed. Details are given in [4].

3 Source Traffic and Simulations

To meet the technical demands of the simulation tools a reduced set of services and environments are therefore selected. Without this summarisation effort the framework proposed would pose considerable difficulties to implement due to the amount of computing resources it would require from simulators. As a result we have three operation environments with four or five services each depending on the environment.
Proposed applications and their relative usage are shown in Table 4. This table is obtained from Table 3 by assuming, as a simplification, that the most significant application accounts or all the traffic usage in that service group. The envisaged approximate data rates are introduced for all applications, in accordance with the service class associated with the application. Here, the ROA scenario is called vehicular (VEH). The population density factors for each of the scenarios are the ones from Table 3. Data rates are aligned to existing standard values in UMTS and HSDPA.

3.1 *Application Traffic*

The amount of generated calls is dependent on the number of potential users and the session arrival rate per user that characterises each service and environment. Call duration, and activity pattern determines traffic behaviour.

Applications Usage [%]	R_b [kb/s]	OFF	BCC	VEH
Sound				
Voice (VOI)	12.2	**25.0**	**27.0**	**42.0**
High Interactive Multimedia				
Video-telephony (VTE)	128	**15.0**	**16.0**	**16.0**
Narrowband				
Multimedia Web Browsing (MWB)	384	**20.0**	**26.0**	**18.5**
Wideband				
Instant Messaging for Multimedia (IMM)	1024	**25.0**		
Assistance in Travel (ATR)	1660			**23.5**
HD Video telephony (HDT)	2048		**31.0**	
Broadband				
Wireless LAN Interconnection (WLI)	12780	**15.0**	-	-
Density Factor (users / m^2)		0.150	0.031	0.012

Table 4: Proposal for Applications Usage in each of the SEACORN Simulation Deployment Scenarios.

User density per environment is defined in Table 4. Penetration rates of E-UMTS services are used to account for different adoption rates between services in each year and evolution of service take-up along the years. Service penetration rates for the year 2010 are estimated, extrapolating and adapting those made for UMTS [10], Table 5. The total number of application j subscribers in a cell, M_j, is given as a function of the penetration, P_j, by

$$M_j = P_j \times M_T, \quad (1)$$

where M_T is the total population of potential users cell.

Applications	OFF	BCC	VEH
Voice	0.3	0.3	0.3
Video-telephony	0.2	0.2	0.2
Multimedia web browsing	0.15	0.15	0.12
Instant Messaging for Multimedia	0.2	-	-
Assistance in Travel	-	-	0.2
HD Video-telephony	-	0.2	-
Wireless LAN Interconnection	0.15	-	-

Table 5: E-UMTS Penetration Rates (2010).

3.2 *Application Traffic*

From the values of usage for OFF, BCC, and VEH scenarios, it is important to obtain, for each considered service, the values of the busy hour call attempts, BHCA, to be used in simulations. BHCA represents in this case the total number of call attempts by all users considered in one simulation. They will correspond the users covered by a radio cell or part of a cell.

$$BHCA_j = \frac{Usage_j}{\overline{\tau}_j} \cdot M_T \cdot \overline{f}, \quad (2)$$

where M_T is the number of users in the cell, $\overline{\tau}_j$ the average call duration, and $\overline{f}$ is the average traffic per user (or, equivalently, the average fraction of active users), which can vary from 0 to 1. From the values for usage from Table 4, and considering a user population of $M_T = 100$, one can obtain, as an example, results for the BHCA, as a function of $\overline{f}$, for the office environment Fig. 1.

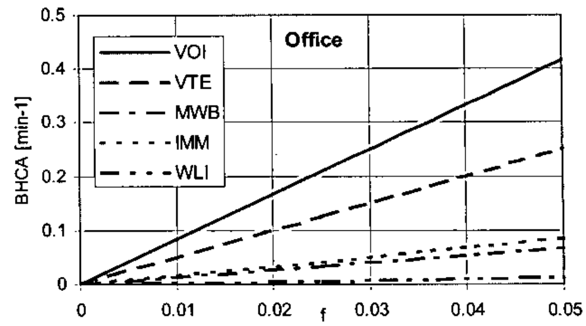

Fig. 1. BHCA for the office environment ($M_T = 100$).

3.3 Call Generation and Traffic Parameters

Call generation and traffic parameters describe service behaviour in terms of traffic generation. They include average data-rate, session arrival rate per user during the busy hour, average call duration, burstiness, and asymmetry factor. The term call usually refers to conversational services while session refers to data connections. Because in E-UMTS both entities are similarly supported on PDP con-text establishment the concept is basically the same. It must be referred that, since uplink and downlink data-rates are not necessarily equal, the data-rate parameter value refers to the higher value between the two, which in all exemplified cases is the downlink. The set of parameters that describe these services from the traffic modelling perspective are defined in Table 6. Call and session related parameters are used to model the birth and death of calls and sessions.

Session arrival rate represents the average number of calls generated per service subscriber during the busy hour. The Poisson process is used to model session arrivals. Values for session arrival rate are derived from service penetration and session duration values, considering $\overline{f} = 0.03$. These parameters are tightly associated for each application, and deployment scenario, as formulated below. Usage, U_j, is ex-pressed as a ratio between the traffic for service j, (derived from session arrival rate, duration and number of subscribers), and the total produced traffic, during the busy hour. The conversion to BHCA can be done by using (2).

$$U_j = \frac{SessArrRate_j \cdot M_T \cdot P_j \cdot \tau_j}{\sum_i SessArrRate_i \cdot M_T \cdot P_i \cdot \tau_i} \quad (3)$$

Applica-tions	Data ra-te [kb/s]	Session arrival rate[min]$^{-1}$ OFF	BCC	VEH	τ [min]	Sym. UL/DL
VOI	12	0.50	0.54	0.84	3	1
VTE	128	0.45	0.48	0.48	3	1
MWB	384	0.16	0.21	0.19	15	0.25
IMM	1024	0.15	-	-	15	0.05
ATR	1536	-	-	0.11	20	0.07
HDT	2048	-	0.09	-	30	1
WLI	12780	0.03	-	-	60	0.25

Table 6: Call generation & traffic parameters.

3.4 Session Activity Parameters

Session activity parameters describe the detailed aspects of traffic within a call. This is accomplished by means of an alternating active/inactive state model (ON/OFF). The activity within a call is modelled by defining an average duration of each period, together with an adequate statistical distribution. Video telephony applications are always active in both directions and so do not have OFF periods. The basic model for application data normally uses a web session as a paradigm, although the model may be used for all types of data. A session is composed of a set of active periods made of packet sequences (packet calls) separated by inactivity periods. A packet call is a sequence or burst of packets, corresponding, e.g., to a web page or other data item. Inactivity periods between packet call arrivals are often called reading or inactivity time.
Table 7 describes average active versus inactive durations, the corresponding file sizes of activity packet call periods and statistical distributions of the active and inactive durations. It may be noted that streaming services do not exhibit inactive states therefore the ON state is equal to call duration and OFF state duration is zero.
Further details on traffic source models and their parameters are given in [5]. Concerning streaming services, a model for streaming video is also outlined in [5], based on MPEG-4 trace statistics.

Applica-tions	Active state (ON)			Inactive state (OFF)	
	Avg.[s]	Filesize[KB]	Distrib.	Avg.[s]	Distrib.
VOI	1.4s	2.14	Expon.	1.7 s	Expon.
VTE	τ			0	
MWB	5	240	Pareto	13	Pareto
IMM	5	640	Weibull	90	Pareto
ATR	60	11520	Weibull	14	Pareto
HDT	τ			0	
WLI	5	7988	Weibull	1	Pareto

Table 7: Application activity parameters.

4 Conclusions

Future 3.5 G systems have to be able to support nowadays applications and new ones, with different capacity and requirements. A set of scenarios was drawn by associating values of service usage with each of the eight deployment scenarios. Nearly thirty services were considered, grouped into Sound, High Interactive Multimedia, Narrow-, Wide- and Broadband. They are an example of a mixture of applications that may exist in E-UMTS. However, a reduced set of applications is needed for simulations purposes. A selection of the most relevant service environments and applications is then brought to the foreground and proposed as the key scenarios, thus responding to the necessity of diminishing the burden on simulation work. A traffic generation model was described in order to allow quantification and description of traffic offered to the E-UMTS network. This model is based on population and service penetration values in order to determine call generation rates for the constituent services within each of the selected scenarios. For each service an activity model was presented, and the ON and OFF states were characterised by appropriate statistical distributions. This completes the basic output to the SEACORN simulation work, whose objective is to determine the E-UMTS network behaviour and QoS response under these service assumptions.

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