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**Thesis Title**

**Author's full name**

Thesis to obtain the Master of Science Degree in
**Electrical and Computer Engineering**

Supervisor: Prof. Name

**Examination Committee**

Chairperson: Prof. Name

Supervisor: Prof. Name

Members of Committee: Prof. Name

 : Prof. Name

**Month** **Year**

I declare that this document is an original work of my own authorship and that it fulfils all the requirements of the Code of Conduct and Good Practices of the
Universidade de Lisboa.

To...

# Acknowledgements *Note that the Table of Contents is done with these words in blank.*

Acknowledgements

Enter your text

# Abstract

Abstract

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The abstract should have a maximum of 250 words.

The Abstract should state the problem under study, the methods used, and the main conclusions. It should not contain any general statements, or introductory ones, but only very short sentences. The text should be in a single paragraph, without line breaks. One should avoid including acronyms that are not of common knowledge, as well as defining them. It should contain, when it is the case, the main numerical results.

Keywords

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The maximum number of Keywords is 6.

They should represent the main areas of the work, and be listed in a decreasing order of generality.

# Resumo

Resumo

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Palavras-chave

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# List of Acronyms

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*The List* of Symbols should contain all symbols used in the thesis, and their meaning, and it should be sorted. Symbols should be group into three classes (Greek letters, Roman letters, and others) before being sorted.

# List of Software

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Chapter

Introduction

# Introduction

A text with a few lines, up to a maximum of 10 lines, should be put at the beginning if each chapter describing its contents. An example follows.

This chapter gives a brief overview of the work. Before establishing work targets and original contributions, the scope and motivations are brought up. The current State-of-the-Art concerning the scope of the work is also presented. At the end of the chapter, the work structure is provided.

## Overview

The Introduction should start by giving very general information on the system/model, and as it progresses, more specific information should be given, until the topic dealt with in the report is referred. It should describe, in a concise way, the problem under study, and the main methods used in the work. It should also contain the state of the art, with references to previous work, referring other alternatives for the solution of the problem (it is possible to present here just a superficial sate of the art, and then leave a detailed one for a following chapter). After that, a clear identification of the innovative aspects of the work should be given, and it should finish with the description of the contents and structure of the report.

During May 2003, the total number of mobile users has broken the 1.3 billion mark [3GPP01b].

The applications taking into account both application and user requirements, together with the capability of the different networks. It will require higher intelligence in the terminals to make best use of the different applications locally available. At the price of this complexity, the vision brought out by the Wireless Strategic Initiative (WSI) become real, bridging all access technologies from fixed to satellite and from person to person to customised broadcast, Figure 1.1.



Figure 1.1. The multi-technology access network (extracted from [3GPP01a]).

And so on…

## Motivation and Contents

To date, convergence is mainly considered at the core network level, with the use of IP in this context. However, not much attention has been given to how the various wireless standards can be converged at the consumer terminal, if multiple standards are available to the user from a common core network. Under this context, important issues arise, like determining how services map onto certain standards (or even split between standards), and how can this be made to be seamless and appear as a simultaneous connection to the user. Another important issue, still to be analysed, is the impact of convergence on the several access networks performances (and vice-versa).

The current thesis is precisely motivated by this vision of future wireless communication systems where there will be a convergence of wireless standards and an enhancement of services. In particular, the objective is to focus on the capacity of the radio interface of such converged multi-standard systems, and study (by means of a simulation platform developed for this purpose) the overall performance obtained for different scenarios (convergence benefits), using different approaches, namely:

* Analysis of the impact of users traffic variations;
* Analysis of the impact of the number of users in specific scenarios corresponding to different available access technologies;
* Analysis of the impact of the availability of different access technologies for a particular number of users.

This thesis is composed of 5 chapters.

A possible general structure for the Thesis can be:

* Chapter 1 – Introduction (around 5 pages)
* Chapter 2 – Basic concepts and state of the art of the problem under study (around 20 pages)
	+ 2.1 – Basic description of the system
	+ 2.2 – Description of specific items related to the system
	+ 2.3 – State of the art
* Chapter 3 – Theoretical development of the problem, and computer algorithms implementation and assessment (around 25 pages)
	+ 3.1 – Development of the theoretical model
	+ 3.2 – Description of the implementation in to program/simulator
	+ 3.3 – Assessment of program/simulator
* Chapter 4 – Analysis of results (around 25 pages)
	+ 4.1 – Scenarios description
	+ 4.2 – Analysis of parameter A
	+ 4.3 – Analysis of parameter B
* Chapter 5 – Conclusions (around 5 pages)



Figure 1.2. Test figure.

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Chapter

Title Chapter

# Title Chapter

This chapter provides an overview of the GSM/GPRS, UMTS and HIPERLAN/2 systems, mainly focussing on the capacity aspects of the radio interfaces.

## The GSM/GPRS system

### Introduction

In June 1982, CEPT (European Conference of Postal and Telecommunications Administrations) decided to develop and standardise a Pan-European cellular mobile radio network [3GPP01b]. The aim was for the new system to operate in the 900 MHz frequency band allocated to land mobile radio. A working group, called *Group Spéciale Mobile* (GSM), was set up under the direction of CEPT, to develop and standardise the so-called GSM mobile radio system. The GSM objectives for its Public Land Mobile Network (PLMN) included offering [3GPP01b]: a broad set of speech and data services, cross-border system access for all mobile phone users, automatic roaming and handover, highly efficient use of frequency spectrum, supplier-independence, etc..

GSM networks, either in the original GSM conception or as an evolution of it, are currently spread worldwide and are unanimously considered a very successful project.

### System architecture

The GSM/GPRS system can be divided into the following three subsystems [3GPP01a]: Radio SubSystem (RSS), Network and Switching SubSystem (NSS) and Operation SubSystem (OSS).

These subsystems and their components are represented in the simplified version of the functional architecture in [3GPP01a].

The following network elements are part of the OSS: Operation and Maintenance Centre (OMC), Authentication Centre (AuC) and Equipment Identity Register (EIR).

### Radio interface capacity aspects

The radio interface is located between the MS and the rest of the GSM/GPRS network. Physically, the information flow takes place between the MS and the BTS. But, viewed logically, the MSs are communicating with the BSC, MSC and the SGSN. The gross transmission rate over the radio interface is 270.833 kbps.

Currently there are several frequency bands defined for the operation of GSM, Table 2.1. Operators may implement networks that operate on a combination of these frequency bands to support multi band MSs.

Table 2.1. GSM frequency bands (based on [3GPP01a]).

|  |  |  |  |
| --- | --- | --- | --- |
| **Band** | **Uplink [MHz]** | **Downlink [MHz]** | **Duplex interval [MHz]** |
| GSM 450 | 450.4-457.6 | 460.4-467.6 | 10 |
| GSM 480 | 478.8-486 | 488.8-496 | 10 |
| GSM 850 | 824-849 | 869-894 | 45 |
| Primary GSM 900 or P-GSM | 890-915 | 935-960 | 45 |
| Extended GSM 900 or E-GSM | 880-915 | 925-960 | 45 |
| Railways GSM 900 or R-GSM | 876-915 | 921-960 | 45 |
| GSM 1800 | 1710-1785 | 1805-1880 | 95 |
| GSM 1900 | 1850-1910 | 1930-1990 | 80 |

Text.

Table 2.2. New table.

|  |  |  |  |
| --- | --- | --- | --- |
| **Band** | **Uplink [MHz]** | **Downlink [MHz]** | **Duplex interval [MHz]** |
| GSM 450 | 450.4-457.6 | 460.4-467.6 | 10 |
| GSM 480 | 478.8-486 | 488.8-496 | 10 |
| GSM 850 | 824-849 | 869-894 | 45 |
| Primary GSM 900 or P-GSM | 890-915 | 935-960 | 45 |

## The HIPERLAN/2 system

### Introduction

The increasing demand for "anywhere, anytime" communications and the merging of voice, video and data communications has created a demand for broadband wireless networks. Under this scope, ETSI created the BRAN [3GPP01a] project to develop standards and specifications for broadband radio access networks that cover a wide range of applications and are intended for different frequency bands (licensed and license exempt use). The BRAN project covers the following systems: HIPERLAN/1, HIPERLAN/2, HIPERACCESS and HIPERLINK [3GPP01b]. In the present report, one will concentrate on the HIPERLAN/2 system, which basically acts as a WLAN system offering high bitrates.

Chapter

Conclusions

# Conclusions

This chapter finalises this work, summarising conclusions and pointing out aspects to be developed in future work.

Conclusions are supposed to have the main results from the work, presenting numbers for the main results, orders of magnitudes, which techniques or models were the best, a critical analysis of the limitations. It should start by formulating the problem addressed in the work, after which conclusions from the various chapters should be presented, and it should finish by indicating possible directions for future work.

The current thesis intended to analyse the overall performance of a converged multi-technology system (convergence benefits), mainly focussing on capacity aspects of the radio interface. Three technologies have been considered for this purpose: GSM/GPRS, UMTS and HIPERLAN/2.

Annex 1

Validation of Random Number Generators

1. Validation of Random Number Generators

Brief description of annex.

* 1. Theory

For the implementation of statistical traffic source models, Random Number Generators (RNG) are essential. In the case of the traffic source models considered in the present report, 10 different RNGs were necessary for their implementation. More specifically, RNGs for the following statistical distributions were used: Uniform, Gamma, Beta, Exponential, Geometrical, Normal, LogNormal, Pareto, Poisson and Weibul.

, (A.1)

where *noc*[*n*] corresponds to the number of occurrences within interval *n*.

The MSE obtained for the data of each RNG is presented in Table A1.1 and was calculated as:

 (A.2)

* + 1. Practical examples

Annex tables’ captions are inserted using the “Table\_Appendix” caption type.

Table A.1. Observation parameters and MSE of each RNG.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **RNG** | ***xmin*** | ***xmax*** | ***I*** | **MSE** |
| Uniform (min=0, max=1) | 0 | 1 | 0.01 | 1.90×10-3 |
| Gamma (*β*=9, *λ*=100) | 0 | 2500 | 25 | 3.58×10-10 |
| Beta (*p*=1, *q*=8) | 0 | 1 | 0.01 | 1.40×10-3 |
| Exponential (1/*μCD* =3) | 0 | 25 | 0.25 | 3.35×10-6 |
| Geometric (*PPC*=0.2) | 0 | 35 | 1 | 3.84×10-7 |
| Normal (*μN*=0, *σN*=1) | -4 | 4 | 0.1 | 3.28×10-5 |
| LogNormal (*μLN*=0.97, *σLN*2=4.38) | 0 | 100 | 1 | 1.90×10-5 |
| Pareto (*αp*=1.1, *k*=81.5) | 0 | 1200 | 10 | 3.90×10-8 |
| Poisson (*λc*=60) | 30 | 90 | 1 | 4.16×10-7 |
| Weibul (*λk*=0.45, *βk*=0.80) | 0 | 25 | 0.25 | 2.49×10-4 |



Figure A.1. Comparison between the Gamma PDF and the PDF equivalent modified histogram obtained from the Gamma RNG (*β*=9, *λ*=100).

Annex Figures’ captions are inserted using the “Figure\_Appendix” caption type.

Annex 2

User Scenarios Variation Results

1. User Scenarios Variation Results

Brief description of the Annex.



Figure B.1. BR versus User Scenario (G).

# References

References

This list should be sorted.

[3GPP01a] 3GPP, *Digital cellular telecommunications system (Phase 2+); Physical layer on the radio path*; *General description (Release 1999)*, TSG GERAN Technical Specification, No. 05.01, Ver. 8.6.0, Nov. 2001 (http://www.3gpp.org).

[3GPP01b] 3GPP, *Packet switched conversational multimedia applications; Default codecs (Release 5)*, TSG SSA Technical Specification, No. 26.235, Ver. 5.0.0, June 2001 (http://www.3gpp.org).