

Radio Access Network Design for the Evolved UMTS Network

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I hereby certify that the work embodied in this thesis is the result of original research and has not been submitted for a higher degree to any other University or Institution.

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Abstract

The Radio Access Network (RAN) accounts for the major proportion of the UMTS system operating cost. Transmission from radio base station sites contributes a larger part of the RAN operating costs. Selection of suitable transport technologies and proper allocation of network resources are vital from an operator cost optimisation and the Quality of Experience (QoE) points of view. This thesis extensively investigated the performance of a RAN to support multimedia traffic on a HSDPA air interface. Transport network layer of a future RAN could be based on a number of transport protocols such as ATM, IP and Ethernet. With the increasing traffic volume and diversity the efficiencies of IP and Ethernet based RAN could increase significantly due to the use of larger payloads and simpler resource allocation techniques. Also, on IP and Ethernet based links relatively fewer overhead bits are transmitted compared to an ATM based link. Both the IP and Ethernet based links appear to perform better under heavy traffic load conditions. An IP based link could perform better than an Ethernet based link when an IP header compression technique is used. An Ethernet based link is an alternative transport technique for the UTRAN transport network due to its flexibility, economy and bandwidth efficiency.

The HSDPA (High Speed Downlink Packet Access) is considered to be one of the initial evolutionary steps to enhance the data rate, and QoS of downlink data and multimedia services for the evolved UMTS network. It can provide high data rate up to 28.8 Mbps on the downlink shared channel using the packet access technique. A HSDPA network can dynamically adjust a connection data rate to match radio conditions to ensure the highest possible data rate for different type of traffic. Inappropriate RAN capacity allocation could lead to low radio resource or RAN resource utilizations. In this thesis, a Markov chain based analytical model has been developed to study the interaction between the air interface and the RAN for a HSDPA network. The analytical model was used to study interactions of RAN transport protocols, flow control techniques and the air interface transmission conditions. Further a simulation model was developed to investigate the relationship between the HSDPA air interface and its RAN

parameters. Another important issue in the HSDPA network design is the scheduling algorithm used at the Node-B. A scheduling algorithm plays a key role in allocating a RAN's network resources. Impacts of scheduling algorithms are studied in this work using a simulation model. Based on the study of the HSDPA air interface and its RAN parameter interactions this work has developed an adaptive resource management algorithm, which uses the measured air interface information to allocate the corresponding connection data rate on the I_{ub} link. The developed algorithm reduces RAN resource requirements while increasing the air interface resource utilization and QoS of connections.

Abbreviations

3GPP	3rd Generation Partnership Project
AAL2	ATM Adaptation Layer type 2
AAL5	ATM Adaptation Layer type 5
ACK	Acknowledgement
ALCAP	Access Link Control Application Part
AM	Acknowledged Mode
AMD	Acknowledged Mode Data
AMR	Adaptive Multi-rate (speech codec)
ARQ	Automatic Repeat Request
ATM	Asynchronous Transfer Mode
BCCH	Broadcast Channel (logical channel)
BCH	Broadcast Channel (transport channel)
BCFE	Broadcast Control Functional Entity
BCH	Broadcast Channel (transport channel)
BER	Bit Error Rate
BLER	Block Error Rate
BMC	Broadcast/Multicast Control Protocol
BS	Base Station
BSS	Base Station Subsystem
BSC	Base Station Controller
CCCH	Common Control Channel (logical channel)
CCH	Common Transport Channel
CCH	Control Channel
CDF	Cumulative Distribution Function
CDMA	Code Division Multiple Access
CFN	Connection Frame Number
CIR	Carrier to Interference Ratio
CIP	Composite IP
CM	Connection Management
CN	Core Network

CPCH	Common Packet Channel
CPICH	Common Pilot Channel
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
CRNC	Controlling RNC
CS	Circuit Switched
CTCH	Common Traffic Channel
DCCH	Dedicated Control Channel (logical channel)
DCFE	Dedicated Control Functional Entity
DCH	Dedicated Channel (transport channel)
DL	Downlink
DPCCH	Dedicated Physical Control Channel
DPDCH	Dedicated Physical Data Channel
DRNC	Drift RNC
DRX	Discontinuous Reception
DSCH	Downlink Shared Channel
DTCH	Dedicated Traffic Channel
DTX	Discontinuous Transmission
E-UTAN	Evolved Universal Terrestrial Radio Access Network
FACH	Forward Access Channel
EDF	Earliest Deadline First
FIFO	First In First Out
FP	Frame Protocol
FTP	File Transfer Protocol
GFP	Generic Framing Procedure
GGSN	Gateway GPRS Support Node
GMSC	Gateway MSC
GPRS	General Packet Radio System
GSM	Global System for Mobile Communications
GTP-U	User Plane Part of GPRS Tunnelling Protocol
HARQ	Hybrid Automatic Repeat Request
HDTV	High-definition Television

HDLC	High-Level Data link Control
HLR	Home Location Register
HSDPA	High Speed Downlink Packet Access
HS-DPCCH	Uplink High Speed Dedicated Physical Control Channel
HS-DSCH	High Speed Downlink Shared Channel
HSS	Home Subscriber Server
HS-SCCH	High Speed Shared Control Channel
HSUPA	High Speed Uplink Packet Access
HSS	Home Subscriber Server
IETF	Internet Engineering Task Force
IMA	Inverse Multiplexing for ATM
IMS	IP Multimedia Sub-system
IMT-2000	International Mobile Telephony, 3rd Generation Networks are referred as IMT-2000 within ITU
IP	Internet Protocol
ITU	International Telecommunications Union
L1	Layer 1 (Physical Layer)
L2	Layer 2 (Data Link Layer)
L3	Layer 3 (Network layer)
LAN	Local Area Network
LAPS	Link Access Procedure for SDH
LIPE	Lightweight IP Encapsulation
MAC	Medium Access Control
MBMS	Multimedia Broadcast Multicast Service
ME	Mobile Equipment
MEF	Metro Ethernet Forum
MGCF	Media Gateway Control Function
MGW	Media Gateway
MMoIP	multimedia over IP
MPEG	Motion Picture Experts Group
MS	Mobile Station
MSC/VLR	Mobile Services Switching Centre/Visitor Location Register

MT	Mobile Termination
NBAP	Node B Application Part
NRT	Non-real Time
ODMA	Opportunity Driven Multiple Access
OFDMA	Orthogonal Frequency Division Multiple Access
PAD	Padding
PCCCH	Physical Common Control Channel
PCCH	Paging Channel (logical channel)
PCCPCH	Primary Common Control Physical Channel
PCH	Paging Channel (transport channel)
PCPCH	Physical Common Packet Channel
PDCP	Packet Data Converge Protocol
PDP	Packet Data Protocol
PDH	Plesiochronous Digital Hierarchy
PDSCH	Physical Downlink Shared Channel
PDU	Protocol Data Unit
PHY	Physical Layer
PICH	Paging Indicator Channel
PRACH	Physical Random Access Channel
PS	Packet Switched
PSCH	Physical Shared Channel
PSTN	Public Switched Telephone Network
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
RAB	Radio Access Bearer
RACH	Random Access Channel
RAN	Radio Access Network
RANAP	Radio Access Network Application Part
RB	Radio Bearer
RLC	Radio Link Control
RNC	Radio Network Controller

RNL	Radio Network Layer
RNS	Radio Network Sub-system
RNSAP	Radio Network Subsystem Application Part
RRC	Radio Resource Control
RRM	Radio Resource Management
RT	Real Time
RTP	Real Time Protocol
SAP	Service Access Point
SCCPCH	Secondary Common Control Physical Channel
SCH	Synchronisation Channel
SDH	Synchronous Digital Hierarchy
SDU	Service Data Unit
SF	Spreading Factor
SFD	Start of Frame Delimiter
SGSN	Serving GPRS Support Node
SHO	Soft Handover
SID	Silence Indicator
SINR	Signal-to-Noise Ratio where noise includes both thermal noise and interference
SIP	Session Initiation Protocol
SIR	Signal to Interference Ratio
SNR	Signal to Noise Ratio
SRB	Signalling Radio Bearer
SRNC	Serving RNC
SRNS	Serving RNS
TCH	Traffic Channel
TCP	Transport Control Protocol
TCRTP	Tunnelled multiplexed compressed RTP
TCTF	Target Channel Type Field
TE	Terminal Equipment
TF	Transport Format
TFCI	Transport Format Combination Indicator

TFCS	Transport Format Combination Set
TFI	Transport Format Indicator
TFRC	Transport Format and Resource Combination
TNL	Transport Network Layer
TPC	Transmission Power Control
TR	Transparent Mode
TTI	Transmission Time Interval
UDP	User Datagram Protocol
UE	User Equipment
UL	Uplink
UM	Unacknowledged Mode
UMTS	Universal Mobile Telecommunication Services
UNI	User Network Interface
USCH	Uplink Shared Channel
USIM	UMTS Subscriber Identity Module
UTRA	UMTS Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network
VoIP	Voice over IP
WCDMA	Wideband CDMA
WiMAX	Worldwide interoperability for Microwave Access
WLAN	Wireless Local Area Network
WRR	Weighted Round Robin

TABLE OF CONTENTS

Chapter 1 Introduction	1
1.1 HIGH DATA RATE MOBILE COMMUNICATION NETWORKS	1
1.2 RESEARCH MOTIVATION	4
1.3 SUMMARY OF CONTRIBUTIONS	6
1.4 THESIS OUTLINE	7
1.5 PRIOR PUBLICATIONS	8
Chapter 2 UMTS Radio Access Network Architecture, Protocol and QoS.....	10
2.1 INTRODUCTION.....	10
2.2 UMTS SYSTEM ARCHITECTURE OVERVIEW	11
2.3 UTRAN ARCHITECTURE.....	13
2.3.1 Radio Network Controller	13
2.3.2 Node-B.....	14
2.4 UTRAN PROTOCOLS	14
2.5 RADIO INTERFACE PROTOCOL.....	18
2.5.1 RLC Protocol.....	19
2.5.2 MAC Protocol.....	21
2.5.3 Channels Mapping.....	23
2.6 QUALITY OF SERVICE.....	26
2.6.1 QoS Architecture	27
2.6.2 UMTS QoS Classes.....	28
2.7 SUMMARY	31
Chapter 3 High Speed Downlink Packet Access	32
3.1 INTRODUCTION.....	32
3.2 HSDPA PRINCIPLE.....	33
3.3 HSDPA PROTOCOL ARCHITECTURE	34
3.4 HSDPA CHANNEL STRUCTURE.....	36
3.5 HSDPA TERMINAL CAPABILITY	38
3.6 FLOW CONTROL BETWEEN RNC AND NODE-B	40
3.7 SUMMARY	42
Chapter 4 Performance Analysis of the UTRAN for Multimedia Services	43
4.1 INTRODUCTION.....	43
4.2 THE I _{UB} LINK PROTOCOL STRUCTURE	47
4.3 TRANSPORT LAYER PROTOCOL.....	51
4.3.1 AAL2/ATM Protocol	51
4.3.2 IP Protocol	53
4.3.3 IP/Ethernet Protocols	54
4.4 TRAFFIC MODEL.....	55
4.4.1 Voice Traffic	56
4.4.2 Web Data Traffic	58
4.4.3 Streaming Video Traffic.....	59
4.5 SIMULATOR ARCHITECTURE	62
4.6 PERFORMANCE ANALYSIS AND COMPARISON	64
4.6.1 AAL2/ATM performance analysis.....	64
4.6.2 Performance Comparison.....	70
4.7 SUMMARY	75
Chapter 5 Performance Analysis of the HSDPA Radio Access Network	77
5.1 INTRODUCTION.....	77
5.2 HSDPA AIR INTERFACE AND RAN PARAMETRIC INTERACTIONS	80

5.2.1.	<i>I_{ub} link Flow Control Algorithm</i>	80
5.2.2.	<i>HSDPA Air Interface Transmission Efficiency</i>	82
5.2.3.	<i>Analytical Model</i>	82
5.2.4.	<i>Air Interface Model</i>	85
5.2.5.	<i>Example Calculation</i>	89
5.3	SIMULATION MODEL.....	92
5.3.1.	<i>Simulator Architecture</i>	92
5.3.2.	<i>I_{ub} Link Simulation</i>	94
5.3.3.	<i>Traffic Model</i>	94
5.4	INTERDEPENDENCY BETWEEN RAN AND AIR INTERFACE	95
5.4.1.	<i>Impact of RAN Capacity on the HSDPA Connection QoS</i>	95
5.4.2.	<i>Effect of Transport Protocols on the HSDPA Connections</i>	99
5.5	SUMMARY	101
Chapter 6 Effect of Scheduling and Adaptive Joint Resource Allocation Technique for the HSDPA RAN		102
6.1	INTRODUCTION.....	102
6.2	PACKET SCHEDULING TECHNIQUE	104
6.2.1.	<i>HSDPA Packet Scheduling Algorithms</i>	105
6.2.2.	<i>Impact of Node-B scheduling algorithms on the I_{ub} Link Performance</i>	107
6.3	JOINT RESOURCE MANAGEMENT TECHNIQUE	112
6.3.1.	<i>Proposed Joint Resource Management Technique</i>	113
6.3.2.	<i>Performance Evaluation of the Proposed Algorithm</i>	117
6.4	SUMMARY	123
Chapter 7 Conclusion and Further Works		125
7.1	CONTRIBUTIONS AND CONCLUSIONS: A REVIEW.....	125
7.2	FURTHER WORKS	128
References		131

LIST OF FIGURES

Figure 1.1 Mobile telecommunications network capacity evolution	3
Figure 2.1 The UMTS System Architecture	11
Figure 2.2 General protocol structure for UTRAN interfaces [17].....	15
Figure 2.3 The UTRAN protocol architecture (User Plane – PS).....	18
Figure 2.4 Radio interface protocol architecture [22].....	19
Figure 2.5 The RLC layer architecture [3]	20
Figure 2.6 Mapping between logical channels and transport channels [3].....	24
Figure 2.7 Mapping between transport channels and physical channels [25].....	25
Figure 2.8 End to end QoS architecture [29].....	28
Figure 3.1 HSDPA protocol architecture.....	35
Figure 3.2 HSDPA channel structure	37
Figure 3.3 HSDPA flow control on the Iub interface	41
Figure 4.1 User plane protocol stack for the Iub interface.....	48
Figure 4.2 Downlink FP data frame structure.....	49
Figure 4.3 HS-DSCH FP data frame structure	50
Figure 4.4 AAL2 multiplexing structure	53
Figure 4.5 CIP/UDP/IP/PPP/HDLC multiplexing structure.....	54
Figure 4.6. CIP/IP/Ethernet/GFP multiplexing structure.....	55
Figure 4.7 Traffic source model.	56
Figure 4.8 Video FP data frame generation.....	62
Figure 4.9 Transmitter side of Simulator (RNC side).....	63
Figure 4.10 Receiver side of Simulator (Node-B side).....	63
Figure 4.11 an example of packet over DCH	63
Figure 4.12 Filling ratio of CPS-PDU vs. no of voice stream	66
Figure 4.13 95-percentile delay of voice Data Frame.....	66
Figure 4.14 Mean voice Data Frame transmission delay.....	66
Figure 4.15 AAL2 packet and ATM loss ratio	67
Figure 4.16 Performance comparison of FIFO vs. Priority transmission techniques.	69
Figure 4.17 Mean delay for different priorities at 10% re-transmission ratio.....	70
Figure 4.18 99.9 percentile of voice FP frame delay	70
Figure 4.19 Mean delay of voice FP frame	71
Figure 4.20 Standard deviation of voice FP frame	71
Figure 4.21 99.9 percentile of 64 kbps data FP frame delay	71
Figure 4.22 Mean delay of 64kbps data FP frame	72
Figure 4.23 Standard deviation of 64kbps data FP frame.....	72

Figure 4.24 . CDF of delay on ATM, IP and Ethernet based Iub link for HSDPA	74
Figure 5.1 flow control between Node-B and RNC	81
Figure 5.2 Probability distribution of the air interface transmission rate represented in number of MAC-d PDUs for UE Category 12.....	87
Figure 5.3 HSDPA bit-rate: stationary during good radio conditions [69].....	88
Figure 5.4 HSDPA bit-rate: stationary during poor radio conditions [69]	88
Figure 5.5 state transition diagram	90
Figure 5.6 The simulator structure.....	94
Figure 5.7 the interdependency between the Iub effective link bandwidth and the HSDPA air interface efficiency.	96
Figure 5.8 HSDPA efficiency for different values of p.	98
Figure 5.9 Relationship between the HSDPA average throughput (RLC layer) and Iub link utilization.....	98
Figure 5.10 Distribution number of PDUs in the Node-B buffer for UE Cat.12.....	98
Figure 5.11 Distribution of PDU number in node-B buffer for UE Cat.5/6 (calculation vs. simulation).....	99
Figure 5.12 Efficiency comparison of transport layer protocols	100
Figure 5.13 HSDPA air interface efficiency for different Iub physical link data rate.	100
Figure 6.1 Potential and actual HSDPA cell throughput.	109
Figure 6.2 Average cell throughput; comparing potential and actual throughput	110
Figure 6.3 HSDPA efficiency distribution for different scheduling algorithms	110
Figure 6.4 Average cell throughput (UE Category 10).....	112
Figure 6.5 HSDPA air interface efficiency (UE category 10)	112
Figure 6.6 the variance of average throughput	114
Figure 6.7 Instantaneous air interface throughput and the running average throughput value.	115
Figure 6.8 Adaptive bandwidth allocation.....	116
Figure 6.9 HSDPA air interface efficiency for different channel conditions and Iub link allocation techniques.	117
Figure 6.10 Iub link effective bandwidth utilization for different channel conditions and link allocation techniques	118
Figure 6.11 HSDPA air interface efficiency and Iub link bandwidth utilization for the adaptive resource allocation vs. peak rate allocation techniques.	119
Figure 6.12 Iub link bandwidth requirements for peak rate and adaptive allocation techniques using three transport protocols.....	120
Figure 6.13 CDF of cell throughput (potential vs. actual)	120
Figure 6.14 Iub link bandwidth utilization (UE category 10).....	122
Figure 6.15 HSDPA air interface efficiency (UE category 10)	122
Figure 6.16 The required Iub link physical bandwidth for three transport techniques (UE category 10).....	123

LIST OF TABLES

Table 2.1 Traffic classes in UMTS.....	29
Table 3.1 HSDPA terminal capability categories.....	39
Table 3.2 RLC layer data rate for different UE categories	39
Table 4.1 Number of bits in Classes A, B, and C for each AMR codec mode	57
Table 4.2 Parameters for voice traffic for the 12.2 kbps AMR in ON state	58
Table 4.3 Parameters for web data traffic.....	59
Table 4.4 the simulator parameters.....	64
Table 4.5 Combined traffic parameters	68
Table 4.6 FP Frame Fields (byte)	73
Table 5.1 Calculation Results (UE Cat.12).....	91
Table 5.2 Calculation Results (UE Cat.5/6)	92
Table 5.3 Key Simulation Parameters	93