Radio Access Network Design for the Evolved UMTS Network

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M.Eng

A thesis submitted in partial fulfilment
of the requirements for the degree of

Doctor of Philosophy

February, 2010

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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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Acknowledgements

First I would like to acknowledge Australian Research Council and Singtel OPTUS to provide me Australian Postgraduate Award Industry (APAI) to support my research in the University of Newcastle.

I would like to thank my research supervisor, Dr. Jamil Y. Khan, for his wise advice and encouragement during the completion of this Ph.D. works. I also would like to thank my research co-supervisor, A/Prof. Steve Weller, for his well organization of my research upgrade.

I also would like to give thanks to Dr. Brendan Jones, at Singtel OPTUS, for his technical direction to this work.

Foremost, I am profoundly grateful to my family, especially my wife, Wei Dai, who have always expressed me her unconditional support and love; my Cathy and Janet, their smile give me inspiration.

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 increases 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

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