

Quality of Heterogeneous Services with Distributed Resource Management for a WCDMA Uplink

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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.

Pratik Das

*With love and in gratitude to my family for supporting me when I didn't know to ask,
and for encouraging me when I did, this fruit of our labour . . .*

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It is a blessing that none of my family members understand radio resource management. Had that not been true this thesis would have been many times longer. Yet each one of them deserves credit because this thesis exists. They love me so.

List of Abbreviations

3G	3 rd generation
3GPP	3 rd generation partnership project
4G	4 th generation
ACLR	Adjacent channel leakage ratio
ACK	Acknowledgement
ADU	Application data unit
AICH	Acquisition indication channel
AM	Acknowledged mode
AMD	Acknowledged mode data
AMR	Adaptive multi-rate
ARQ	Automatic repeat requests
BCCH	Broadcast control channel
BER	Bit error rate
BLER	Block length error rate
BPSK	Binary phase shift keying
BSR	Bit success rate
CAC	Call admission control
CAGR	Compound annual growth rate
CBR	Constant bit rate
cdf	Cumulative distribution function
CDMA	Code division multiple access
CPCH	Common packet channel
CPI	Cumulative power index
CRC	Cyclic redundancy check
CTIR	Carrier to interference ratio
DCH	Dedicated channel
DPCCH	Dedicated physical control channel
DPDCH	Dedicated physical data channel
DS-CDMA	Direct sequence CDMA

DSL	Digital subscriber line
DTCH	Data transport channel
DTX	Discontinuous transmission
EDGE	Enhanced data rates for GSM evolution
ETSI	European telecommunications standards institute
EUL	Enhanced uplink
FAC	Frame admission control
FACH	Forward access channel
FDD	Frequency division duplex
FEC	Forward error correction
FER	Frame error rate
FIFO	First in first out
FSG	Fixed spreading gain
FSR	Frame success rate
GERAN	GSM/EDGE radio access network
GOP	Group of pictures
GoS	Grade of service
GPRS	General packet radio system
GSM	Global system for mobile communications
HARQ	Hybrid automatic repeat requests
HSDPA	High speed downlink packet access
HSUPA	High speed uplink packet access
ILPC	Inner-loop power control
Inter-SP	Inter-service prioritisation
Intra-SP	Intra-service prioritisation
iRAT	Inter radio access technology
LOS	Line of sight
MAC	Medium access control
MAI	Multiple access interference
MC	Multi-code
MPEG-4	Motion picture experts group 4
MRC	Maximum ratio combining
MSC	Mobile services switching centre
NACK	Negative ACK
NLOS	Non-LOS
OLPC	Outer-loop power control
OVSF	Orthogonal variable spreading factor
PAR	Peak to average ratio

pdf	Probability distribution function
PDU	Protocol data unit
PRACH	Physical RACH
PSK	Phase shift keying
PSTN	Public switched telephone network
QAM	Quadrature amplitude modulation
QoS	Quality of service
QPSK	Quadrature PSK
RAB	Radio access bearer
RACH	Radio access channel
RAN	Radio access network
RLC	Radio link control(ler)
RLE	Run length encoding
RNC	Radio network controller
RoT	Rise over thermal
RRC	Radio resource control(ler)
RRM	Radio resource management
RSVP	Resource reservation protocol
SDU	Service data unit
SGSN	Serving GPRS support node
SIR	Signal to interference ratio
SNIR	Signal to noise and interference ratio
SNR	Signal to noise ratio
TDD	Time division duplex
TFC	Transport format combination
TM	Transparent mode
TPC	Transmission power control
TrCH	Transport channel
TTI	Transmission time interval
UE	User equipment
UM	Unacknowledged mode
UMTS	Universal mobile telecommunication services
UTRAN	UMTS terrestrial RAN
VAD	Voice activity detector
VOP	Video object plane
VSG	Variable spreading gain
WCDMA	Wideband CDMA

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Abstract

A radio resource management scheme for WCDMA uplinks is proposed that manages quality of service (QoS) for heterogeneous services whilst maintaining high channel utilisation efficiency. The proposed system is partitioned into the 3 modules, viz. a QoS-sensitive rate scheduler, an inter-service and intra-service user prioritisation schemes, and a frame admission controller for dynamic resource reallocation. Users are allocated the minimum resources required to manage their QoS requirements through *just-in-time* delivery of payload, leaving more room for best-effort service users. The transmission urgency of each user is estimated by the rate scheduler based on a target transmission delay - a unique parameter used in the proposed resource management strategy to enable just-in-time payload delivery, service differentiation, and uncomplicated mapping of application requirements to QoS parameters. Transmission rate change requests from the rate schedulers are collectively processed through inter-service and intra-service priority queuing in a manner that is shown to exhibit fairness in allocation of resources amongst users of a heavily loaded network. The performance of the proposed strategy is explored through discrete-event simulations for 3 classes of traffic - voice, video and data, over the WCDMA uplink in the presence of short-term Rayleigh fading, ARQ, FEC, target transmission delays and FER targets in a *multi-cell* environment. Two alternatives for distributed resource management have been studied, with the UE or Node-B in control of resource allocation. The UE controlled resource management system is shown to achieve higher channel utilisation efficiency at the cost of fairness. The Node-B controlled resource manager respects the priority of speech, video and data traffic in heavily loaded systems, as reflected in 95 percentile packet transmission delays.

Author's Publications

A list of the author's publications:

- [1] P. Das and J.Y. Khan. MPEG-4 video over packet switched connection of the WCDMA air interface. *IEEE International Symposium on Personal, Indoor and Mobile Radio Communications, 2002 (PIMRC2002)*, 5:2189–2193, 2002.
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