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"Signalling Requirements for Smart Pricing in Mobile Telecommunications Systems"

SIGNALLING REQUIREMENTS FOR SMART PRICING IN MOBILE TELECOMMUNICATIONS SYSTEMS

Thesis submitted by

Dat Tien Vo

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School of Electrical and Electronic Engineering

Faculty of Engineering, Computer and Mathematical Sciences

Statement of originality

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Dedication

No house can be built without a good foundation. I am lucky to have a strong and reliable foundation from my family and wife. They are my grounding and sources of motivation. This research has been a long journey and along the way there are many challenges and obstacles. When encountering those, receiving the support and love from my foundation has given me determination to finish this research. This thesis is dedicated to my extended family - the Viens, Vos and Lees.

Abstract

Smart Pricing can be classified as Dynamic Pricing and bears resemblances to Congestion Pricing. It is a pricing scheme that varies prices according to the current users' responses to rising load. *Smart Pricing* is a solution to the problem of under-utilised network resources or to accommodate growing demand within existing network resources. All three pricing schemes necessitates signalling, however, little is known about the signalling requirements. This thesis makes original contributions in this very area whereby it:

- analyses the current 3G mobile telecommunications systems network architecture and shows how *Smart Pricing* can be implemented;
- proposes two models for implementing *Smart Pricing* in 3G mobile telecommunications systems. In these models, a new network element so-called *Dynamic Pricing Engine* is proposed to be added;
- calculates and reports required signalling requirements for *Smart Pricing*; and
- extends the models to more advanced telecommunications systems.

The first model proposed is the *Monte Carlo Simulation* model in which operation of *Smart Pricing* is simulated and the required signalling is calculated. Both small and large *Smart Pricing* systems[1] are investigated and eighteen simulation scenarios are conducted. Highlights[2] of our findings are as follows. When there are more users in the system, the bidding signalling percentage on the uplink increases but decreases on the downlink and on links between network elements. It is not how the level of congestion is defined, it is the user behaviours that dictate the signalling requirements for *Smart Pricing*.

The second model is the *State Space Analysis* model, in which the *Markov Chain* technique is employed. Highlights[3] of our findings are as follows. In the steady-state

[1] A *Smart Pricing* system is defined as a WCDMA UMTS system which adopts *Smart Pricing*.
[2] A complete set of the findings can be found in Section 3.9.
[3] A complete set of the findings can be found in Section 4.12.

condition, the maximum average signalling loads for the uplink, downlink and links between network elements can be accommodated with existing signalling system capacity. With respect to simulation time, this model is significantly faster than the*Monte Carlo Simulation* model. It is recommended that the *Dynamic Pricing Engine* be collocated with the Billing System.

Applicability of the proposed models to more advanced cellular telecommunications systems, such as HSDPA, HSPA+ and LTE is also demonstrated. Then, estimated average signalling loads[4] are reported. Finally, the models are shown to be able to be applied in other resource-constrained and non-cellular telecommunications systems, particularly *Cognitive Radio*[5].

[4]Summary of details can be found in Section 5.6.
[5]Summary of details can be found in Section 6.6.

Publication

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Contents

List of abbreviations

2G	Second Generation
2-WTP	CONF with 2 levels of WTP
3G	Third Generation
3GPP	3rd Generation Partnership Project
4G	Fourth Generation
5-WTP	CONF with 5 levels of WTP
16-QAM	16-Quadrature Amplitude Modulation
64-QAM	64-Quadrature Amplitude Modulation
AMR	Adaptive Multi Rate
AMT	Aeronautical Mobile Telemetry
AoC	Advice of Charge
ASP	Application Service Part
ATM	Asynchronous Transfer Mode
AuC	Authentication Centre
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
BER	Bit Error Rate
BISUP	Broadband ISUP
BLER	Block Error Probability
BSC	Base Station Controller
BSS	Base Station System
BTS	Base Transceiver Station
CAMEL	Customised Applications for Mobile Network Enhanced Logic
C/I	Carrier to Interference Ratio
CCPCH	Common Control Physical Channel
CDF	Charging Data Function
CDMA	Code Division Multiple Access
CDR	Charging Data Record

CGF	Charging Gateway Function
CONF	Video Conferencing Service
CPCH	Control Physical Channel
CQI	Channel Quality Indicator
CR	Cognitive Radio
CR-BCH	CR Broadcast Channel
CR-DCCH	CR Downlink Control Channel
CRE	CR Engine
cr	cost recoverable signalling
CR-RACH	CR Random Access Channel
CRRM	Common Radio Resource Management
CR-UCCH	CR Uplink Control Channel
CRW	Cognitive Radio Gateway
CS-MGW	Circuit Switched-Media Gateway
DL	Downlink
DL-SCH	Downlink Shared Channel
DPA	Dynamic Pricing Adapter
DPDCH	Dedicated Physical Data Channel
DPE	Dynamic Pricing Engine
EDGE	Enhanced Data rates for GSM Evolution
ECR	Effective Coding Rate
eCell_FACH	enhanced Cell_FACH
EIR	Equipment Identity Register
ENG	Electronic News Gathering
EPS	Evolved Packet System
FACCH	Fast Associated Control Channel
FACH	Forward Access Channel
FCC	Federal Communications Commission
FDMA	Frequency Division Multiple Access
FDD	Frequency Division Duplex
FTAM	File Transfer Access and Management
FTP	File Transfer Protocol
GGSN	Gateway GPRS Support Node
GMSC	Gateway Mobile Switching Centre
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
GTP	GPRS Tunnel Protocol
HLR	Home Location Register

HSDPA	High Speed Downlink Packet Access
HS-DPCCH	High Speed-Dedicated Physical Control Channel
HS-DSCH	High Speed-Downlink Shared Channel
HSPA+	High Speed Packet Access Evolution
HS-PDSCH	High Speed-Physical Downlink Shared Channel
HS-SCCH	High Speed-Shared Control Channel
HSS	Home Subscriber Server
IETF	Internet Engineering Task Force
IMT	International Mobile Telecommunications
IN	Intelligent Network
IP	Intelligent Peripheral
ISDN	Integrated Service Digital Network
ISDN-UP	ISDN-User Part
ISUP	ISDN-UP
ITU	International Telecommunication Union
ITU-T	ITU-Telecommunication Standardization Sector
LAPD	Link Access Protocol on D Channel
LAPDm	Link Access Protocol on Dm Channel
LRT	Likelihood Ratio Test
LTE	Long Term Evolution
MAC	Medium Access Control
MAC-hs	Medium Access Control-high speed
MAP	Mobile Application Part
MCS	Monte Carlo Simulation
ME	Mobile Equipment
MIMO	Multiple Input Multiple Output
MMI	Man Machine Interface
MS	Mobile Station
MSC	Mobile Switching Centre
MTP	Message Transfer Part
NBAP	Node B Application Part
Netw2Netw	Between Network Elements
OCS	Online Charging System
OFCS	Offline Charging System
OFDM	Orthogonal Frequency Division Multiplexing
OMC	Operations and Maintenance Centre
OSF	Operations System Function
P-CCPCH	Primary-Common Control Physical Channel

PCH	Paging Channel
PCEF	Policy and Charging Enforcement Function
PCRF	Policy and Charging Resource Function
PDN	Packet Data Network
PDN-GW	Packet Data Network Gateway
PDSCH	Physical Downlink Shared Channel
P-GW	Packet Data Network Gateway
PLMN	Public Land Mobile Network
P-SCP	Prepaid Service Control Point
PSTN	Public Switched Telephone Network
PU	Primary User
QAM	Quadrature Amplitude Modulation
QCI	QoS Class Identifier
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
RACH	Random Access Channel
RANAP	Radio Access Network Application Part
RAT	Radio Access Technology
RF	Radio Frequency
RLC	Radio Link Layer
RNC	Radio Network Controller
RNS	Radio Network System
RNSAP	Radio Network Subsystem Application Part
RRC	Radio Resource Control
SAE	System Architecture Evolution
SAT	SIM Application Toolkit
SCCP	Signalling Connection Control Part
S-CCPCH	Secondary-Common Control Physical Channel
SC-FDMA	Single Carrier - Frequency Division Multiple Access
SCP	Service Control Point
SCTP/IP	Stream Control Transmission Protocol/Internet Protocol
SDR	Software Defined Radio
SGSN	Serving GPRS Support Node
S-GW	Serving Gateway
SGW	Signalling Gateway Function
SIM	Subscriber Identity Module
SIR	Signal-to-Interference Ratio
SINR	Signal-to-Interference-plus-Noise Ratio

SIT CRC	Smart Internet Technology Cooperative Research Centre
SMS	Short Message Service
SMS–GMSC	SMS–Gateway MSC
SMS–IWMSC	SMS–Interworking MSC
SMS–SC	SMS–Service Centre
SNR	Signal-to-Noise Ratio
SPR	Subscription Profile Repository
SR	Software Radio
SS7	Signalling System #7
SSA	State Space Analysis
SSP	Service Switching Point
STP	Signal Transfer Point
TCAP	Transaction Capabilities Application Part
TCP/IP	Transmission Control Protocol/Internet Protocol
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TFTP	Trivial File Transfer Protocol
TOU	Time-Of-Use
TSS	Tariff Setting System
TUP	Telephone User Part
TVOB	Television Outside Broadcast Network
uc	uplink signalling
UE	User Equipment
UHF	Ultra High Frequency
UL	Uplink
UMTS	Universal Mobile Telecommunication Systems
USAT	USIM Application Toolkit
USIM	Universal SIM
USSD	Unstructured Supplementary Service Data
UTRAN	UMTS Terrestrial Radio Access Network
VHF	Very High Frequency
VLR	Visitor Location Register
WCDMA	Wideband Code Division Multiple Access
WIN	Wireless Intelligent Network
WTP	Willingness To Pay
WTP1	Lowest WTP
WTP5	Highest WTP