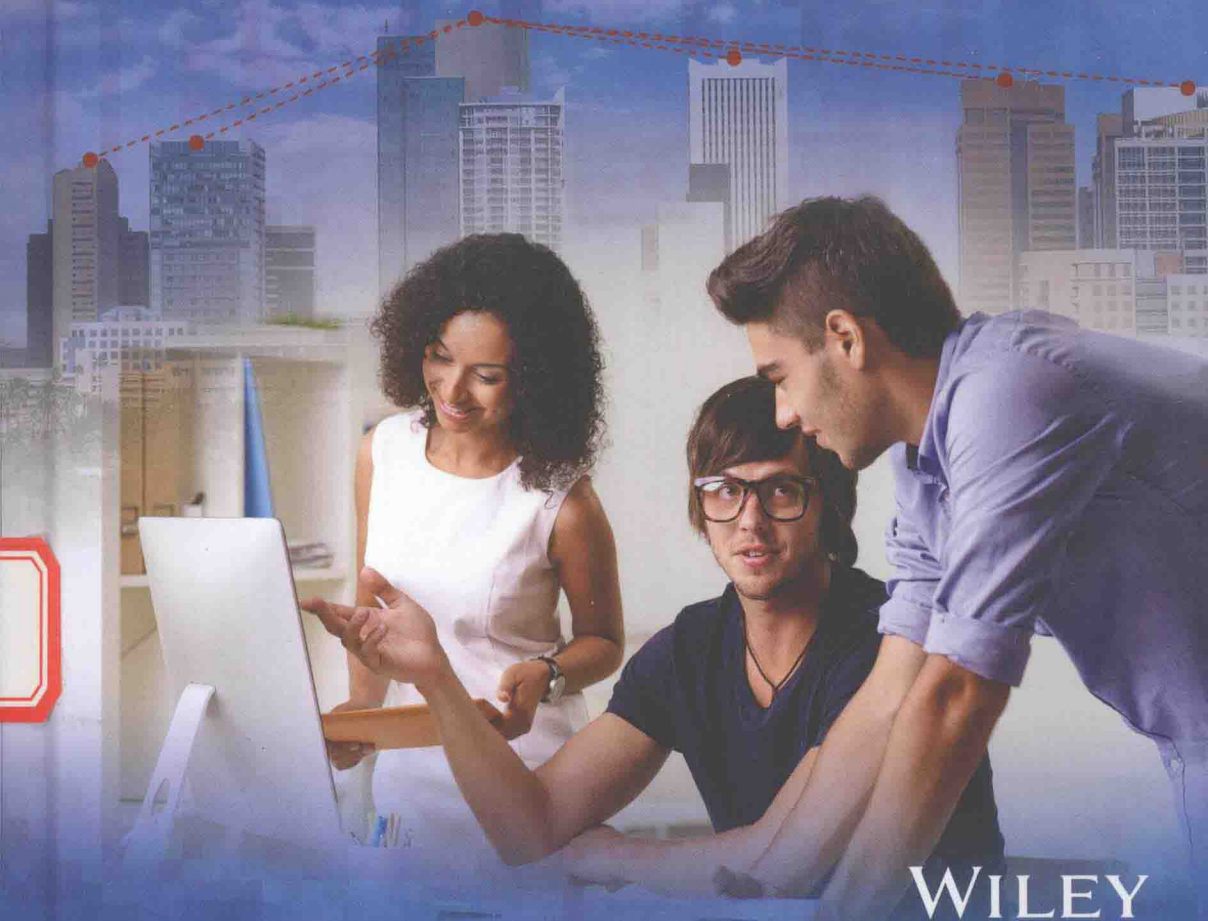
LTE Backhaul

Planning and Optimization

Edited by

Esa Metsälä

Juha Salmelin



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Foreword

With LTE, the mobile network has evolved into a 150+ Mbps per user high-speed always-on packet network. Next we will see high-speed LTE networks becoming available for even larger populations, and solving capacity and speed bottlenecks that users currently experience. For many of us, mobile broadband is the preferred and primary access to the Internet.

The competition for the hearts and minds of LTE subscribers makes the user experience increasingly critical. Understanding the technology behind the service is the key to business success. Delving into the details of LTE technology soon reveals many items that affect performance, allowing room for optimization—and differentiation—in the market.

In general, operators today have more choice and support than ever in choosing their strategy for LTE planning and optimization tasks, including IP and backhaul tasks. The myriad challenges operators face can be addressed by specific professional services, purchased from an expert organization, or issues can be solved by in-house professionals. Many large networks are operated as a service, and a continuum of possibilities exists, from traditional in-house operation to fully managed service operations, and everything in between.

Whatever the technology and business strategy of the operator, high-bandwidth LTE radio needs to be reflected in the IP backhaul. For the LTE backhaul, a number of new areas call for special attention, namely security, synchronization, availability, end-user QoS and dimensioning, to name a few.

LTE IP planning professionals depend on both LTE and IP knowledge, and greatly benefit from realistic guidance for their projects. This book is of great help when assessing technical and economical alternatives and when creating solid and reliable real-life backhaul designs for LTE success.

Igor Leprince
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We are grateful for comments and suggestions for improvements or changes that could be implemented in forthcoming editions of this book. This feedback can be sent to the editors' email addresses: esa.metsala@nokia.com and juha.salmelin@nokia.com.

Esa Markus Metsälä and Juha T.T. Salmelin
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List of Abbreviations

2G	second generation (mobile system)
3G	third generation (mobile system)
3GPP	Third Generation Partnership Program
ASN.1	Abstract Syntax Notation One
ABS	almost blank subframe
ACK	acknowledgement signal
AFxx	assured forwarding behavior group xx
AH	Authentication Header
AM	acknowledged mode
AMBR	Aggregate Maximum Bit Rate
AMR	adaptive multi-rate coding
ANR	automatic neighbor relation
AOM	administration of measurements
AP	Application Protocol
APN-AMBR	Access Point Name–Aggregate Maximum Bit Rate
AQM	active queue management
ARP	Address Resolution Protocol
ATM	asynchronous transfer mode
BBF	Broadband Forum
BC	boundary clock
BCMP	Baskett, Chandy, Muntz and Palacios
BE	best effort
BFD	bidirectional forwarding detection
BH	Backhaul, Busy Hour
BITW	bump in the wire
BMAP	batch Markovian arrival processes
BMCA	best master clock algorithm
BSC	base station controller
BSHR	bidirectional self-healing ring

BTS	base station
CA	carrier aggregation, certification authority
CAC	connection admission control
capex	capital expenditure
CBS	committed burst size
CDF	cumulative distribution function
CDMA	Code Division Multiple Access
CE	customer equipment
CET	carrier Ethernet
CIR	committed information rate
CLI	command line interface
CM	configuration management
CMP	Certificate Management Protocol
CoDel	controlled delay
CoMP	coordinated multi-point
CORBA	Common Object Request Broker Architecture
CoS	class of service
C-plane	control plane
CPE	customer premises equipment
CPU	central processing unit
CRC	cyclic redundancy check
CRL	certificate revocation list
CRS	common reference signals
CSFB	Compact Small Form-factor Pluggable
CSV	comma-separated values
CUBIC	TCP with cubic window increases function
CWDM	coarse wavelength division multiplexing
DC	dual connectivity
DCF	discounted cash flows
DCH	dedicated channel
DCN	data communications network
DHCP	Dynamic Host Configuration Protocol
DL	downlink
DNS	domain name system
DNU	do not use
DOCSIS	data over cable service interface specification
DoS	denial of service
DPD	dead peer detection
DSCP	differentiated services code point
DSL	digital subscriber line
DWDM	dense wavelength division multiplexing
DWRR	deficit weighted round robin
EAPS	Ethernet Automatic Protection Switching
EBS	excess burst size
ECMP	equal cost multipath
eCoMP	enhanced CoMP

EDGE	enhanced data rates for GSM evolution
EF	expedited forwarding
eICIC	enhanced inter-cell interference coordination
EIR	excess information rate
E-LAN	Ethernet service, multipoint-to-multipoint
E-line	Ethernet service, point-to-point
EMS	element management system
eNB	evolved NodeB
e2e	end-to-end
EPC	evolved packet core
ERP	Ethernet ring protection
ESM	EPS session management
ESP	Encapsulating Security Payload
E-tree	Ethernet service, point-to-multipoint
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
EXP	experimental bits
FCAPS	fault, configuration, accounting, performance, security
FCFS	first come, first served
FDD	frequency division duplex
FD-LTE	full duplex LTE
FeICIC	further enhanced inter-cell interference coordination
FIFO	first in, first out
FTP	File Transfer Protocol
GbE	gigabit Ethernet
GBR	guaranteed bit rate
GE	gigabit Ethernet
G.Fast	up to Gigabit/s fast short distance digital subscriber line
GLONASS	Global Navigation Satellite System, Russia
GNSS	global navigation satellite system
GPON	gigabit-capable passive optical network
GPRS	general packet radio service
GPS	Global Positioning System
GSM	Global System for Mobile communications
GTP	general packet radio service Tunneling Protocol
GTP-U	general packet radio service Tunneling Protocol user
HARQ	hybrid automatic repeat request
HetNet	heterogeneous networks
HRM	hypothetical reference model
HSPA	high-speed packed access
HSRP	Hot Standby Router Protocol
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
ICIC	inter-cell interference coordination
ICMP	Internet Control Message Protocol
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force

IKE	Internet key exchange
IMS	IP Multimedia Subsystem
IMT-A	international mobile telecommunications advanced
impex	implementation expenditure
IP	Internet protocol
IPsec	Internet Protocol Security architecture
IRC	interference rejection combining
IRR	internal rate of return
ISD	inter-site distance
itag	video parameter classification
ITU	International Telecommunication Union
ITU-T	ITU Telecommunication Standardization Sector
IU	indoor unit
KPI	key performance indicator
L1	Layer 1 in Open Systems Interconnection data link layer
L2	Layer 2 in Open Systems Interconnection data link layer
L2 VPN	Layer 2 virtual private network
L3 VPN	Layer 3 virtual private network
LAG	link aggregation group
LAN	local area network
LDF	load distribution factor
LFA	loop-free alternate
LOS	line of sight
LSP	label switched path
LTE	long-term evolution
LTE-A	long term evolution advanced
M/G/R-PS	M/G/R Processor Sharing model
MAC	media access control
MAN	metropolitan area network
MAP	Markovian arrival processes
MBH	mobile backhaul
MBMS	Multimedia Broadcast Multicast Service
MEF	Metro Ethernet Forum
MeNB	master eNB
MGW	media gateway
MIB	management information base
MIMO	multiple input, multiple output
MLO	multilayer optimization
ML-PPP	multilayer point-to-point protocol
MME	mobile management entity
MPEG4	Moving Pictures Experts Group
M-plane	management plane
MPLS	multiprotocol label switching
MPLS TC	multiprotocol label switching traffic class
MPLS-TP	multiprotocol label switching traffic profile
MSP	multiplex section protection

MS-SPRING	multiplex section protection ring
MSTP	Multiple Spanning Tree Protocol
MTBF	mean time between failures
MTTR	mean time to repair
MTU	maximum transfer unit
MVI	multi-vendor interface
MWR	microwave radio
NaaS	network management system as a service
NAS	network application server
NETCONF	Network Configuration Protocol
NGMN	Next Generation Mobile Network
NG-SDH	Next Generation Synchronous Digital Hierarchy
nLOS	near line of sight
NLOS	non line of sight
NMS	network management system
non-GBR	non-guaranteed bit rate
NP	non-protected
NPV	net present value
NTP	Network Time Protocol
O&M	operation and maintenance
OAM	operations administration and maintenance
OC-3	optical carrier level 3
ODU	outdoor unit
OID	object identifier
opex	operational expenditure
OSPF	Open Shortest Path First
OSS	operation support system
OTDOA	observed time difference of arrival
OTT	over the top
OU	outdoor unit
P	protected (IPsec)
PDF	probability distribution function
PDH	plesiochronous digital hierarchy
PDN	public data network
PDP	packet data protocol
PDU	protocol data unit
PE	provider edge
PE–PE	provider edge to provider edge
P-GW	packet data network gateway
PHB	per-hop behaviors
PHY	physical layer
PKI	public key infrastructure
PLMN	public land mobile network
PM	performance monitoring
PON	passive optical network
ppb	parts per billion

PPP	point-to-point protocol
ppm	pulse per minute
pps	pulse per second
PRC	primary reference clock
PS HO	packet service handover
PSK	pre-shared key
PTP	Precision Time Protocol
QCI	quality of service class indicator
QNA	queuing network analyzer
QoE	quality of experience
QoS	quality of service
RA	radio access
RBID	radio bearer identification
RC	resource coordination
RE	range extension
RED	random early detection
RF	radio frequency
RFCs	request for comments
RLC	radio link control
RN	relay node
RNC	radio network controller
ROI	return on investment
RRC	radio resource control
RRH	remote radio head
RRM	radio resource management
RSTP	Rapid Spanning Tree Protocol
RTO	retransmission timeout timer
RTP	Real-time Transport Protocol
RTT	round trip time
RX	receive, receiver
S1	Interface between eNB and MME/S-GW
S1-AP	S1 Application Protocol
S1-MME	interface between eNB and MME
S1-U	interface between eNB and S-GW
SA	security association
SACK	selective acknowledgment
SCEP	Simple Certificate Enrollment Protocol
SCF	Small Cell Forum
SCTP	Stream Control Transmission Protocol
SDH	synchronous digital hierarchy
SEG	security gateway
SeNB	slave eNB
S-GW	serving gateway
SLA	service level agreement
SMS	short message service

SMTP	Simple Mail Transfer Protocol
SNMP	Single Network Management Protocol
SOA	service-oriented architecture
SOAP	Simple Object Oriented Access Protocol
SON	self-organizing network
SONET	synchronous optical network
SP	strict priority scheduling
SP-GW	combined node of S-GW and P-GW
S-plane	synchronization plane
SPQ	strict priority queuing
SRLG	shared risk link group
SRVCC	single radio-voice call continuity
SS7	signaling system 7
SSH	secure shell
SSL	secure sockets layer
SSM	synchronization status messages
STM	synchronous transport module
STP	Spanning Tree Protocol
SyncE	Synchronous Ethernet
TCP	Transmission Control Protocol
TDD	time division duplex
TD-LTE	time division duplex LTE
TDM eICIC	time domain enhanced inter-cell interference coordination
TFRC	Transmission Control Protocol-friendly rate control
TLS	Transport Layer Security protocol
TMN	Telecom Management Network
TTI	transmission time interval
TTL	Time to Live
TWAMP	Two-Way Active Measurement Protocol
TX	transmit, transmitter
UDP	User Datagram Protocol
UE	user equipment
UL	Uplink
U-plane	user plane
USB	universal serial bus
VDSL	very high bit rate digital subscriber line
VLAN	virtual local area network
VLL	virtual leased line
VoIP	voice over Internet protocol
VoLTE	voice over long-term evolution
VPLS	virtual private local area network service
VPN	virtual private network
VPWS	virtual private wire service
VRF	virtual routing and forwarding
VRRP	Virtual Router Redundancy Protocol

WACC	weighted average cost of capital
W-CDMA	Wideband Code Division Multiple Access
WDM	wavelength division multiplexing
WFQ	weighted fair queuing
WRR	weighted round robin
X2-AP	X2 application protocol
X2-U	interface between eNB and eNB
xDSL	"any kind of" digital subscriber line
XG-PON	10 gigabits/passive optical network
XML	Extensible Markup Language
XPIC	cross-polarization interference cancellation

Contents