

Deploying Wireless Networks

Do you want your wireless network to be profitable? Wireless operators will find this practical, hands-on guide to network deployment invaluable. Based on their own extensive experience, the authors describe an end-to-end network planning process to deliver the guaranteed QoS that enables today's wireless IP services such as VoIP, WWW and streaming video. The trade-off between enhanced user experience and operator cost is explored in the context of an example business model, and shown to be a key driver of project value in the planning process.

Comprehensive examples are provided for:

- GSM/GPRS/EDGE
- WCDMA-UMTS/HSDPA
- OFDM-WiMAX/LTE
- mesh WiFi
- packet backhaul

Topics addressed include:

- capacity/peak data rates
- service latency
- link budgets
- lifecycle costs
- network optimisation

With a focus on practical design, the book is ideal for radio and core network planners, designers, optimisers and business development staff at operators and network equipment manufacturers. Extensive references also make it suitable for graduate and postgraduate students.

Andy Wilton is Senior Director and Chief Technologist of Motorola's GSM Systems Division (GSD) and is responsible for technology management of GSM and UMTS products worldwide. His major activities are product innovation, technology sourcing, standards strategy and technical oversight of all GSD programmes.

Tim Charity is Head of Applied Technology at Motorola's Global Networks Services. He has led the creation of a service portfolio for GSM, CDMA, UMTS and WiMAX networks, and holds several patents relating to cellular technologies.

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ANDY WILTON

Motorola Ltd

TIM CHARITY

Motorola Ltd



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 Andy Wilton, Tim Charity
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 One Liberty Plaza, 20th Floor, New York, NY 10006, USA
 477 Williamstown Road, Port Melbourne, VIC 3207, Australia
 314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India
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**To my son Nicholas and to my wife Jenny
for making this and so many other things
possible.**

Andy

To my family.

Tim

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Foreword

Telecommunications networks have always fascinated me. My interest was sparked when, as an engineering student in the late sixties, I was told that the telephone network was the biggest machine on earth yet it was constructed from a few basic building blocks replicated many, many times over. It seemed to me that a machine with those characteristics was both already a remarkable engineering feat and a perfect platform for the rapid development of more sophisticated services. So I decided upon a career in telecommunications engineering.

I soon discovered that there was nothing basic about either the building blocks or the architecture of those networks. They were already engineeringly sophisticated at every layer and in every enabling technology. That sophistication was to lead to the continuing development of telecoms networks at a far greater pace than any of us working in the field three or four decades ago could possibly have imagined.

From voice to data; analogue to digital; terrestrial to satellite; tethered to untethered, the progress has been remarkable. Yet undoubtedly the most remarkable development of all has been in wireless networks. Nearly half of the world's population take it for granted that the purpose of telecoms networks is to connect people, not places. An increasing proportion of them use those connections for exchanging text and images as readily as voice. The transformational effect on national economies, education, health and many other factors that bear upon the quality of life is apparent. Wireless networks are helping us to improve our world in all sorts of ways.

It seems an age ago that my network engineering adventures began. Indeed it was an age ago. It is likely that for those who read this book, the adventure is just beginning. They will take wireless networks to the next high and, along the way, deliver true seamlessness across an increasing diversity of networks, services and devices. They will offer the benefits of that seamlessness to the second half of the world's population. They will transform lives, no less.

I envy them those opportunities and wish them every success. And I thank Andy Wilton and Tim Charity for writing a book that is destined both to become a classic in its field and to inspire all with an interest in wireless networks.

Sir David Brown, FREng
Chairman, Motorola Ltd

Preface

At the time of writing, and to an extent never seen before, there is an expectation that almost any information or service that is available through communication systems in the office or home will be available wherever the user happens to be. This is placing incredible demands on wireless communications and has been the driver for the genesis and deployment of three generations of cellular systems in the space of 20 years. In parallel with this revolution in access technology has come the recognition that any information, whether for communication, entertainment or, indeed, for other purposes as yet unenvisaged, can be stored and transported in a universal digital format. The former technology-driven distinctions of analogue storage and transport for high bandwidth signals, such as video, and digital storage for other content are no more. These changes, together with an increasing international consensus on a ‘light-touch’ regime for regulation to stimulate competition, have enabled the first generation of quad-play multinational companies to become established. Such companies seek to spread a strong base of content and services across what would formerly have been known as broadcast (cable, satellite, terrestrial), fixed telephony, mobile and broadband access channels. However, the ability for such companies to deliver applications and services that operate reliably and consistently, regardless of user location, is ultimately predicated on their ability to design solutions that deliver an appropriate and guaranteed quality of service (QoS) over what will certainly be a finite and potentially narrow-access data pipe. As today’s CEOs know, the delivery of best-effort bit pipes is increasingly a commodity business. Bankers have known since the Battle of Waterloo that the delivery of timely information is the basis on which fortunes are made. The design and deployment of wireless networks that can deliver guaranteed QoS form the focus of this book.

The book is organised into ten chapters. Chapter 1 provides an overview of the factors currently at work in the communications marketplace worldwide; it also reacquaints the reader with *Shannon’s Law*, which drives the architecture of many of the solutions discussed. Chapter 2 aims to establish an understanding of the way most cellular networks operate, using the ubiquitous GSM system as a baseline, and highlights the key differences that can be expected in networks providing fixed or ‘nomadic’ wireless access. The concept of *contexts* – central to the timely and efficient delivery of packet data in GSM and UMTS – is also introduced. Factors that contribute to cellular network operating expense are explored to highlight activities that significantly impact the operator’s profit

and loss account and, finally, the profit and loss account is used as an agenda to identify wireless network technologies that are likely to change in the future.

Chapter 3 is a key chapter for any reader new to wireless network planning. It introduces the processes to be followed when planning the wireless network segment of most cellular networks. Particular attention is paid to techniques that can be adopted to maximise return on investment through intelligent network rollout. A review of the different approaches that are adopted when planning voice and multimedia networks is provided and there is emphasis on the planning of wireless packet networks. A technique is introduced that may be used to plan such networks so that the delivery of QoS is assured. Such techniques will assume increasing importance as it becomes necessary to ensure the correct operation of the new classes of applications, which tend to have arbitrary traffic burst distributions. The chapter concludes with a methodology that may be used to assess the commercial viability of new wireless network proposals. Chapter 4 provides a more extensive discussion of propagation models and introduces a framework for capturing the requirements of multimedia traffic. Insight is provided into the sources of information that are needed together with a discussion of the key steps in the generic aspects of the RAN planning process.

Chapters 5, 6, 7 and 8 adhere to a common format. A description of the key features and principles of a particular radio access network (RAN) is followed by a discussion of the factors that influence the system sensitivity and, hence, coverage and capacity. Additional functionality that can be configured to influence performance is then reviewed. The intention of these sections is to provide the reader with a good understanding of the factors that drive performance for the wireless network in a given scenario. The second part of each of these chapters features a worked example, which addresses one of the deployment scenarios detailed in Chapter 4. The worked example template is consistent across the four chapters and serves to illustrate the strengths and weaknesses of the air interface under discussion. Chapter 5 addresses GSM and GPRS/EDGE, Chapter 6 UMTS, Chapter 7 UMTS long-term evolution (LTE) and WiMAX and Chapter 8 Wi-Fi mesh networks.

Chapter 9 addresses core network and transmission, which typically forms the other major element of a wireless network deployment. An overview of core network evolution is followed by a more comprehensive discussion of two specific core network configurations. The first of these is the Release 98 MSC-based core network with its separate circuit and packet network elements and MSC or IN-based services. This is included because it represents the overwhelming majority of network deployments to date. The second configuration is a core network comprising the Release 8 evolved packet core (EPC) augmented by an IMS-hosted application solution. Over a period of time, this architecture is likely to be widely deployed because it represents a single media-independent solution. The chapter concludes with a summary of transmission systems and a worked example, which addresses the packet transport requirements necessary to connect the SAE and PDN gateways via a shared packet transport link, whilst preserving application QoS.

Chapter 10, the concluding section of the book, aims to provide insight into the activities that take place during the initial deployment of the planned network and

subsequent day-to-day operations. The importance of network optimisation in assuring the ongoing quality of the network is highlighted along with a detailed discussion of the way optimisation is carried out for GSM/GPRS and UMTS networks.

Deploying Wireless Networks was written to appeal to a broad audience. It will be an invaluable resource for system architects, radio and core network planning staff, deployment and optimisation teams and mobile network business development staff. The extensive references and worked examples mean that the text may also be attractive to graduate and undergraduate students.

Andy Wilton
Tim Charity
Swindon, UK

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Authors' disclaimer

Note that the views and opinions presented in this book are those of the authors and not necessarily of the organisations which employ them. These views should in no way be assumed to imply any particular strategic direction or policy recommendation within the organisations thus represented.