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Introduction

There are fundamental shifts in philosophy and strategy taking place as the wireless industry matures and the power of the internet converges with the world of mobility. That appeal has drawn important new players into wireless with familiar names like Apple, Google, eBay/Skype, Yahoo!, Microsoft, Disney, CNN and ESPN. The success and innovation of social networking sites such as Facebook and MySpace have triggered numerous companies to transport these ideas to the mobile realm. The underpinning for most of these emerging areas is the widespread availability of broadband wireless accessprecisely the capability that High Speed Packet Access (HSPA) promises to deliver.

The wireless industry has reached a true crossroads with packet data services beginning to overtake traditional circuit-switched voice services. Broadband wireless access technologies such as HSPA can bring wired internet performance to the mobile domain. The combination of high data rates, low latencies and mobility enables a new generation of wireless applications not possible or even conceivable with prior technologies. In these emerging broadband wireless systems, voice itself is transported over the packet data interfaces. There are many intermediate steps involved as wireless networks transition from current circuit- to future packet-switched architectures, with HSPA and HSPA+ being two of the critical ones. Mobile service providers must efficiently master these technologies to take full advantage of broadband wireless capabilities.

With this convergence of the internet and wireless industries, the landscape has become dramatically more competitive. Broadband wireless performance is now a serious competitive differentiator in the marketplace. Customer expectations have also markedly risen, with a new generation of consumers expecting wireless systems to deliver mobile performance on par with their fixed-line DSL or cable modem home systems. To step up to that competitive challenge, wireless operators must deploy, optimize and maintain broadband wireless networks achieving dramatically higher data rates and lower latencies. This task involves not just selecting the right

HSPA Performance and Evolution Pablo Tapia, Jun Liu, Yasmin Karimli and Martin J. Feuerstein

air interface, but also having the best possible techniques and tools to elicit optimal performance, while balancing the inevitable network quality, coverage and capacity tradeoffs.

In this book we concentrate on extracting the most from the capabilities offered by 3GPP's HSPA radio technology, consisting of both downlink (HSDPA) and uplink (HSUPA) elements. With data rates on the downlink up to a whopping 8–10 Mbps and latencies of less than 100 milliseconds, HSPA promises to deliver the full wired internet experience to the wireless world. The big data pipe comes courtesy of extremely short time slots, fast channel quality feedback and speedy retransmissions. HSPA enables dramatically faster download times and snappier connections compared to its predecessors EDGE and GPRS, called (E)GPRS, which is great for all applications but especially demanding services like video apps. Ironically in the longer term, the real benefit may lie in the voice domain – namely high-capacity and low-latency wireless Voice over IP (VoIP) services. With technical tricks such as header compression and fast dynamic power sharing, voice could be another data offering while increasing the overall network capacity compared to today's circuit-switched networks.

The wireless industry is currently observing a whirlwind of activity to invent the next big technology. The main standards groups, 3GPP, 3GPP2 and IEEE, are all hard at work on future technologies to get 4G to market – in the form of Long Term Evolution (LTE), and Mobile WiMAX. While many players in the industry are putting efforts into developing future technologies beyond 3G, we believe that the HSPA investment provides a strong and flexible platform for operators to offer highly competitive products for many years to come. In the next few years, Mobile WiMAX will enter the market as a wide area network for offering broadband wireless. From customers' perspectives both HSPA and Mobile WiMAX offer similarly high data rates and low latencies. The key advantages for HSPA are its technical maturity (being based on UMTS) and ubiquitous availability from many operators around the globe and in many devices. What many people do not realize is that for the foreseeable future, the competition for WiMAX is HSPA. Much later, when LTE enters the market in 2010+ it will likely compete with an evolved Mobile WiMAX, but it will take a number of years for LTE to reach mass scale in terms of footprint and devices. Without a doubt, HSPA will be the flag-bearer for broadband wireless services in the 3GPP world for many years to come.

The aim of this book is to share practical implementation methods and tradeoffs for deploying, optimizing and maintaining networks using the HSPA air interface. The imperative word is 'practical', as opposed to standards, research and theory. That means we focus on real-world performance in operator's networks. We will not dive too deeply into simulation results, and we will not present theoretical derivations that you might read in research papers or in many other books written by research and development teams. Instead we will focus on lessons learned from, and techniques for optimally deploying HSPA in the field from an operator's viewpoint. We identify areas where standards have left items open for interpretation, which causes significant differences between vendor implementations. We will do so without divulging vendor proprietary algorithms, but in a way that explains what operators can expect. We also explain the essential distinctions between rolling out HSPA compared to earlier UMTS and GSM technology, because there are many issues that must be handled differently.

1.1 Services and Applications for HSPA

Before diving into the technology of HSPA itself, it's worthwhile examining first the evolving data services, applications and the related ecosystem. As noted, the search is still on for a killer application for wireless data – the proverbial 'Holy Grail' that will make wireless data services as necessary to the user as the current voice service. Meanwhile, mobile operators around the world are experiencing steady increases in their networks' data usage and more importantly the associated revenues [1], driven by the launches of new network technologies and the availability of advanced Smartphone and Personal Digital Assistant (PDA) devices. This trend can clearly be seen from the growth in Figure 1.1, which shows trends in both total data revenues and the percentage of data revenues out of Average Revenue per User (ARPU).

More than relying on a single killer application, a wider adoption of data services is instead dependent on other factors, including the handset usability (user interface, processing power and speed), the capabilities of the network technology (e.g. throughput and latency), the price of the data plans, and the operators' openness to accepting new applications and partners. HSPA can certainly plan an important role in driving this adoption.

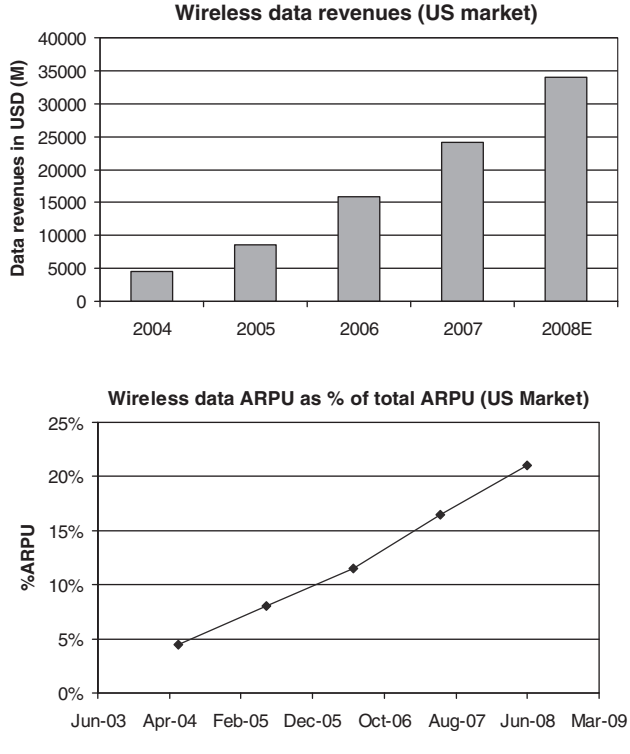

Figure 1.1 Data traffic revenue in the US 2004–2008: absolute (top) and relative to total ARPU (bottom) (data from Ref. 1)

When introducing a new air interface technology, we have found that the laggard has typically been the handset capabilities rather than the network. The reasons for this have been the severe restrictions on size, complexity, battery power, and ultimately price, which handset devices face compared to the network infrastructure. UMTS was no exception. UTRAN networks had been deployed around the world for five to six years before feature rich and stable handsets made it into the consumer hands on a mass scale.

Handsets are definitely evolving though. Today, the most basic phones have a color screen or even an embedded camera and are able to perform packet data communications. New industry players, such as Apple or Google, are creating a revolution in the market, with application rich phones that facilitate the access to applications through the wireless internet. Convergence is the word. Converged devices are starting to blossom because of the complex apps being envisioned in the future. Wireless operator's services will no longer be 'voice' or 'data', but instead a multi-media blending. Recent years have clearly demonstrated that iconic handset devices, such as the Google Phone, Apple iPhone and Motorola RAZR, can play a dramatic role in driving demand, adoption and heavy usage of new technologies. The right pairing of a handset with advanced features can indeed deliver an impressive surge in 3G penetration and data usage, as we have witnessed after launching the Google Phone in the USA. The T-Mobile G1 is an HSDPA capable phone based on the new Android operating system, creating an open mobile platform which permits users to download and install a vast array of applications created by a community ecosystem of developers across the globe. The desirable result was the generation of data traffic by the G1 that was several multiples larger than the total amount of data traffic generated by existing 3G terminals. The G1 created this impressive data dominance in an extremely short time period after its launch, handily beating out some existing handsets with embedded HSDPA capabilities, which had been launched several months before. A similar effect was experienced by the industry with the launch of the Apple iPhone, which in roughly one year has become the world's no. 2 vendor of smartphone devices, with approximately 20% of the market share (see Figure 1.2).

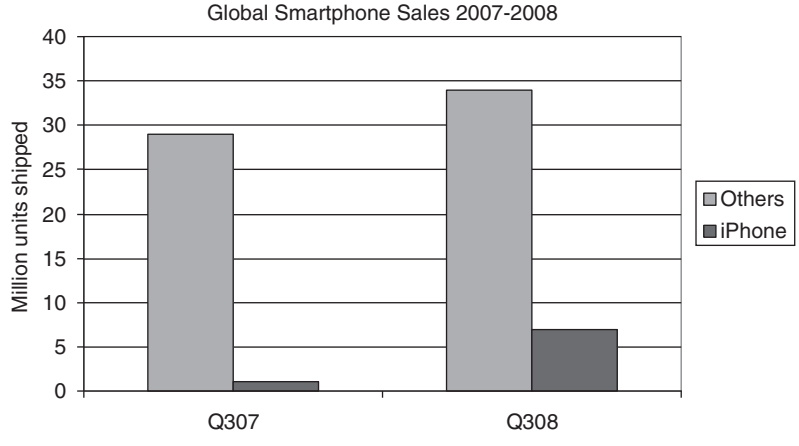

Figure 1.2 Apple iPhone sales volume since its launch in June 2007 as compared to the rest of the smartphone industry (from Ref. 2)

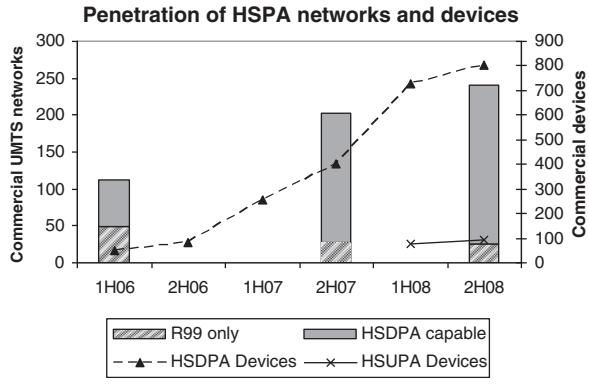

Figure 1.3 Commercial availability of HSPA 2006–2008 (from Ref. 3)

The chipset technology has also evolved and for the same price newer and more complex modems and processors are available. Following the trend of GPRS and EDGE, soon the basic chipsets for manufacturers of the 3GPP family will have HSPA modem capabilities by default. Remarkably, handsets' screen sizes are getting larger, their memory is growing and at the same time prices for those components are cheaper, which will ultimately translate into increasing demands on handsets' data transmission capabilities. As Figure 1.3 illustrates, the adoption of HSPA by both networks and handsets has been extremely rapid. Only two years after the technology was launched, 86% of the UMTS networks have HSPA capabilities with more than 800 HSDPA capable devices available in the marketplace [3,4].

With the appropriate networks and handsets ready for a true wired internet data experience, it is important to understand the characteristics of the traffic being carried because, as will be explained in more detail, this has a significant impact on how the network should be planned and dimensioned. For example, operators targeting broadband competition need to be ready to absorb a much higher demand for traffic than those with a handheld voice-centric strategy. Also, operators may decide to restrict the usage of certain services that are resource intensive, such as video streaming, in which case the capacity planning can be relaxed.

The data traffic carried by a wireless network can be further divided depending on the device used during the communication, which are typically laptops with wireless cards or handheld devices with data capabilities. In the case of computers the data traffic carried is similar to what can be found in wired broadband data networks, which is mainly based on typical internet applications like web browsing or email. Ultimately, the particular share of data traffic depends on the operator's strategy with regards to data services. For example, if the strategy is to compete in the broadband market, then more laptop-type traffic will be found, and the various parts of the networks have to be scaled accordingly. On the other hand, with a handheld-centric strategy the demand for resources will be lower in all parts of the network. In most of the cases, wireless operators carry both kinds of traffic and certain trade-offs will have to be applied, such as establishing limits to data consumption on heavy laptop users.

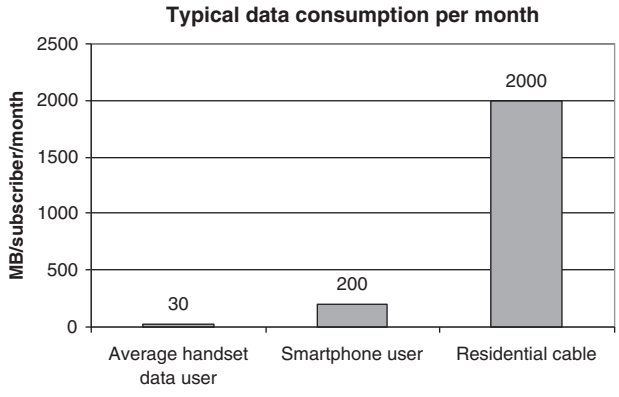

Figure 1.4 Typical data consumption depending on customer profile (type of device) compared against wired residential cable internet service

The data traffic generated by handheld devices (excluding smartphones) is typically WAP/HTML, Blackberry email or small file transfers (e.g., MMS, ringtones, etc.), with the demand for audio and video streaming traffic remarkably increasing. The total data consumption in handheld devices is significantly lower compared to that of typical computer users, as can be seen from Figure 1.4. The figure compares average monthly data usage for wireless customers with handhelds and smartphones compared to wired internet users with residential cable service. The trend is clearly for dramatically increased wireless data usage as devices evolve and wireless broadband reaches laptops and even desktop computers.

1.2 Organization of the Book

Our goal with this book is to help network planning and optimization engineers and managers, who work on real live networks. This is done first by setting the right performance expectations for the technology and second by sharing solutions to common problems that crop up during deployment and optimization. The book also serves as a reference for higher level managers and consultants who want to understand the real performance of the technology along with its limitations.

In the second chapter we discuss the basics of UMTS and HSPA system functionality, including the standards, features, architectures and network elements. The third chapter covers typical data application performance requirements and the closely related Quality of Service (QoS) aspects of HSPA. Radio resource management, together with many of the fundamental algorithms in HSPA, are presented in Chapter 4. Chapter 5 tackles the must-know issues in the planning and optimizing of HSPA, including the key tools and techniques for rolling out networks. Radio performance of HSPA is detailed in Chapter 6, relying on numerous results from actual lab and field tests. Chapter 7 addresses management of HSPA capacity growth after initial network deployment, focussing on strategies for handling UMTS/HSPA carrier frequency expansion. The technology evolution into HSPA+ is discussed in Chapter 8, with

many architecture and feature upgrades to enable better performance and longer life for HSPA. Finally, Chapter 9 presents technology strategies for UMTS/HSPA operators going forward, examining many potential evolution paths with tie-ins to LTE.

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