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Introduction

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1.1 WCDMA technology and deployment status

The first Third Generation Partnership Project (3GPP) Wideband Code Division Multiple Access (WCDMA) networks were launched during 2002. By the end of 2005 there were 100 open WCDMA networks and a total of over 150 operators having frequency licenses for WCDMA operation. Currently, the WCDMA networks are deployed in Universal Mobile Telecommunications System (UMTS) band around 2 GHz in Europe and Asia including Japan and Korea. WCDMA in America is deployed in the existing 850 and 1900 spectrum allocations while the new 3G band at 1700/2100 is expected to be available in the near future. 3GPP has defined the WCDMA operation also for several additional bands, which are expected to be taken into use during the coming years.

The number of WCDMA subscribers globally was 17 million at the end of 2004 and over 50 million by February 2006. The subscriber growth rate is illustrated in Figure 1.1. WCDMA subscribers represent currently 2% of all global mobile subscribers, while in Western Europe WCDMA's share is 5%, in the UK 8%, in Italy 14% and in Japan over 25%. The reason for the relatively high WCDMA penetrations in the UK and Italy is Three, the greenfield 3G operator, and in Japan NTT Docomo, who are pushing the technology forward. These two operators were also the ones behind the first large-scale commercial WCDMA operation that took place between 2001 and 2003.

The mobile business is driven by the availability of attractive terminals. In order to reach a major market share, terminal offering for all market segments is required. There are currently available over 200 different WCDMA terminal models from more than 30 suppliers launched by 2005. As an example, Nokia WCDMA terminal portfolio evolution is illustrated in Figure 1.2. In 2003, Nokia launched one new WCDMA handset, in 2004 two, and during 2005 more than 10 new WCDMA handsets were launched. It is expected that soon all new medium-price and high-end terminals will support WCDMA.

As WCDMA mobile penetration increases, it allows WCDMA networks to carry a larger share of voice and data traffic. WCDMA technology provides a few advantages for

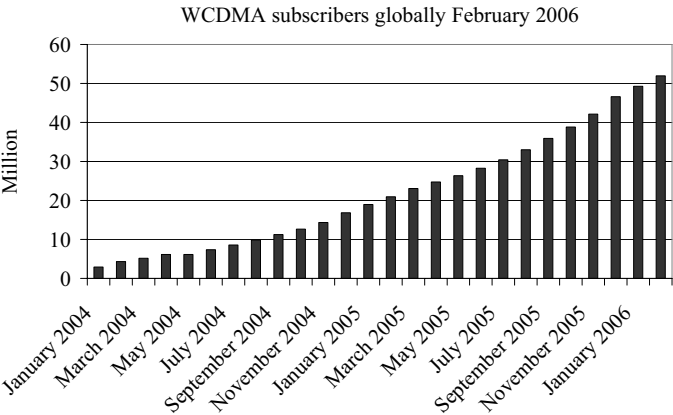


Figure 1.1 3G WCDMA subscriber growth monthly.

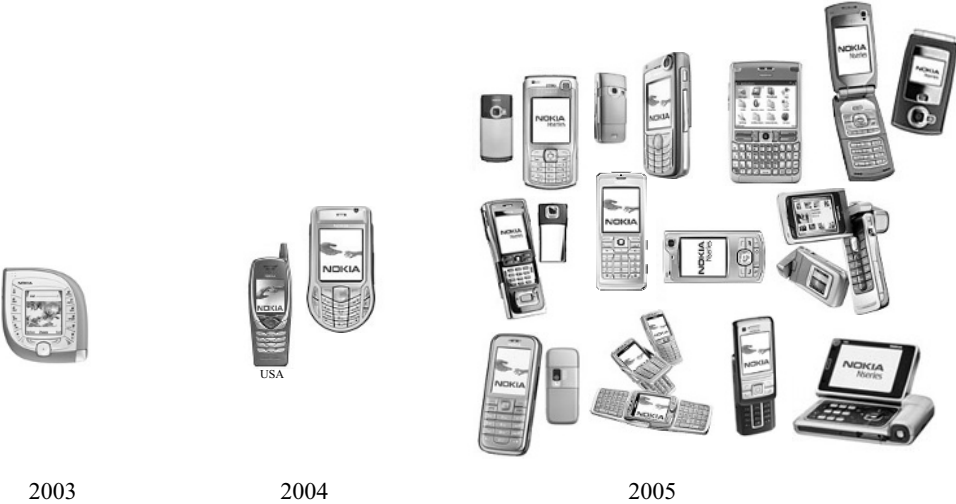


Figure 1.2 Evolution of Nokia 3G terminal offering.
[www.nokia.com]

the operator in that it enables data but also improves basic voice. The offered voice capacity is very high because of interference control mechanisms including frequency reuse of 1, fast power control and soft handover. Figure 1.3 shows the estimated number of voice minutes per subscriber per month that can be supported with a two-carrier, three-sector, $2 + 2 + 2$ WCDMA site depending on the number of subscribers in the site coverage area. Adaptive multi-rate (AMR) 5.9-kbps voice codec is assumed in the calculation. With 2000 subscribers in each base station coverage area, 4300 minutes per month can be offered to each subscriber, while with 4000 subscribers even more than 2100 minutes can be used. These capacities include both incoming and outgoing minutes. Global average usage today is below 300 minutes per month. This calculation shows that

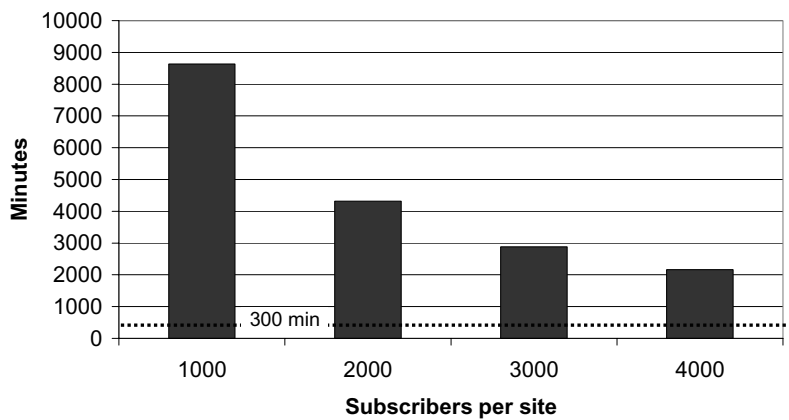


Figure 1.3 Voice minutes per subscriber per month (minutes of usage, mou).

WCDMA makes it possible to offer substantially more voice minutes to customers. At the same time WCDMA can also enhance the voice service with wideband AMR codec, which provides clearly better voice quality than the fixed land line telephone. In short, WCDMA can offer more voice minutes with better quality.

In addition to the high spectral efficiency, third-generation (3G) WCDMA provides even more dramatic evolution in terms of base station capacity and hardware efficiency. Figure 1.4 illustrates the required base station hardware for equivalent voice capacity with the best second-generation (2G) technology from the early 2000s and with the latest 3G WCDMA base station technology. The high integration level in WCDMA is achieved because of the wideband carrier: a large number of users are supported per carrier, and fewer radio frequency (RF) carriers are required to provide the same capacity. With fewer RF parts and more digital baseband processing, WCDMA can take benefit of the fast evolution in digital signal processing capacity. The high base

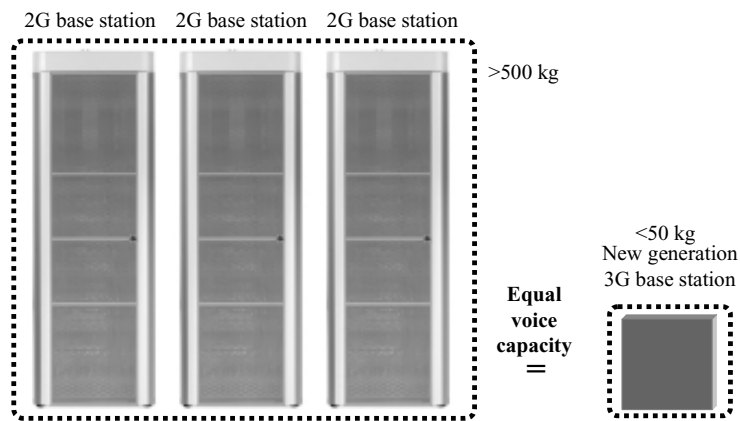


Figure 1.4 Base station capacity evolution with 3G WCDMA.

station integration level allows efficient building of high-capacity sites since the complexity of RF combiners, extra antennas or feeder cables can be avoided.

WCDMA operators are able to provide interesting data services including browsing, person-to-person video calls, sports and news video clips and mobile-TV. WCDMA enables simultaneous voice and data which allows, for example, browsing or emailing during voice conferencing, or real time video sharing during voice calls. The operators also offer laptop connectivity to the Internet and corporate intranet with the maximum bit rate of 384 kbps both in downlink and in uplink. The initial terminals and networks were limited to 64–128 kbps in uplink while the latest products provide 384-kbps uplink.

1.2 HSPA standardization and deployment schedule

High-speed downlink packet access (HSDPA) was standardized as part of 3GPP Release 5 with the first specification version in March 2002. High-speed uplink packet access (HSUPA) was part of 3GPP Release 6 with the first specification version in December 2004. HSDPA and HSUPA together are called ‘high-speed packet access’ (HSPA). The first commercial HSDPA networks were available at the end of 2005 and the commercial HSUPA networks are expected to be available by 2007. The estimated HSPA schedule is illustrated in Figure 1.5.

The HSDPA peak data rate available in the terminals is initially 1.8 Mbps and will increase to 3.6 and 7.2 Mbps during 2006 and 2007, and potentially beyond 10 Mbps. The HSUPA peak data rate in the initial phase is expected to be 1–2 Mbps with the second phase pushing the data rate to 3–4 Mbps. The expected data rate evolution is illustrated in Figure 1.6.

HSPA is deployed on top of the WCDMA network either on the same carrier or – for a high-capacity and high bit rate solution – using another carrier, see Figure 1.7. In both cases, HSPA and WCDMA can share all the network elements in the core network and

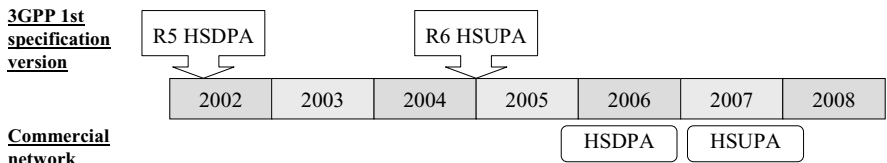


Figure 1.5 HSPA standardization and deployment schedule.

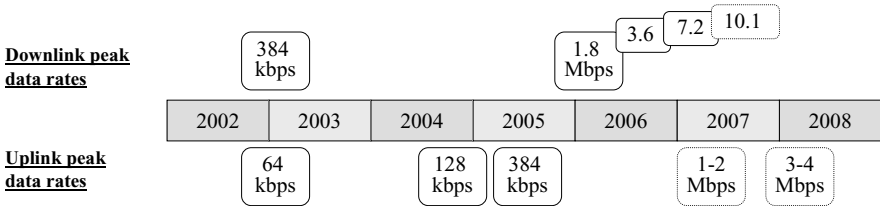


Figure 1.6 Data rate evolution in WCDMA and HSPA.

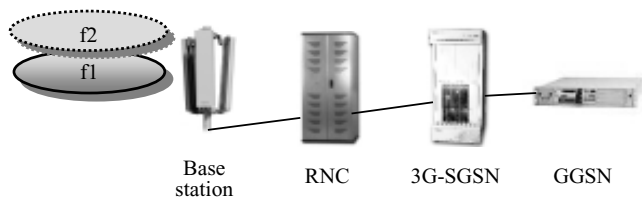


Figure 1.7 HSPA deployment with (f2) new carrier deployed with HSPA and (f1) carrier shared between WCDMA and HSPA.

in the radio network including base stations, Radio Network Controller (RNC), Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN). WCDMA and HSPA are also sharing the base station sites, antennas and antenna lines. The upgrade from WCDMA to HSPA requires new software package and, potentially, some new pieces of hardware in the base station and in RNC to support the higher data rates and capacity. Because of the shared infrastructure between WCDMA and HSPA, the cost of upgrading from WCDMA to HSPA is very low compared with building a new standalone data network.

The first HSDPA terminals are data cards providing fast connectivity for laptops. An example terminal – Sierra Wireless AirCard 850 – is shown in Figure 1.8 providing 1.8-Mbps downlink and 384-kbps uplink peak data rates.

HSDPA terminal selection will expand beyond PCMCIA cards when integrated HSDPA mobile terminals are available during 2006. It is expected that HSPA will be a standard feature of most 3G terminals after some years in the same way as Enhanced Data Rates for GSM Evolution (EDGE) capability is included in most GSM/GPRS terminals. HSDPA will also be integrated to laptop computers in the future, as is indicated already by some of the laptop manufacturers.



Figure 1.8 Example of first-phase HSDPA terminal.
[Courtesy of Sierra Wireless]

1.3 Radio capability evolution with HSPA

The performance of the radio system defines how smoothly applications can be used over the radio network. The key parameters defining application performance include data rate and network latency. There are applications that are happy with low bit rates of a few tens of kbps but require very low delay, like voice-over-IP (VoIP) and real time action games. On the other hand, the download time of a large file is only defined by the maximum data rate, and latency does not play any role. GPRS Release 99 typically provides 30–40 kbps with latency of 600 ms. EGPRS Release 4 pushes the bit rates 3–4 times higher and also reduces latency below 300 ms. The EGPRS data rate and latency allow smooth application performance for several mobile-based applications including Wireless Application Protocol (WAP) browsing and push-to-talk.

WCDMA enables peak data rates of 384 kbps with latency 100–200 ms, which makes Internet access close to low-end digital subscriber line (DSL) connections and provides good performance for most low-delay Internet Protocol (IP) applications as well.

HSPA pushes the data rates up to 1–2 Mbps in practice and even beyond 3 Mbps in good conditions. Since HSPA also reduces network latency to below 100 ms, the end user experienced performance is similar to the fixed line DSL connections. No or only little effort is required to adapt Internet applications to the mobile environment. Essentially, HSPA is a broadband access with seamless mobility and extensive coverage. Radio capability evolution from GPRS to HSPA is illustrated in Figure 1.9.

HSPA was initially designed to support high bit rate non-real time services. The simulation results show, however, that HSPA can provide attractive capacity also for low bit rate low-latency applications like VoIP. 3GPP Releases 6 and 7 further improve the efficiency of HSPA for VoIP and other similar applications.

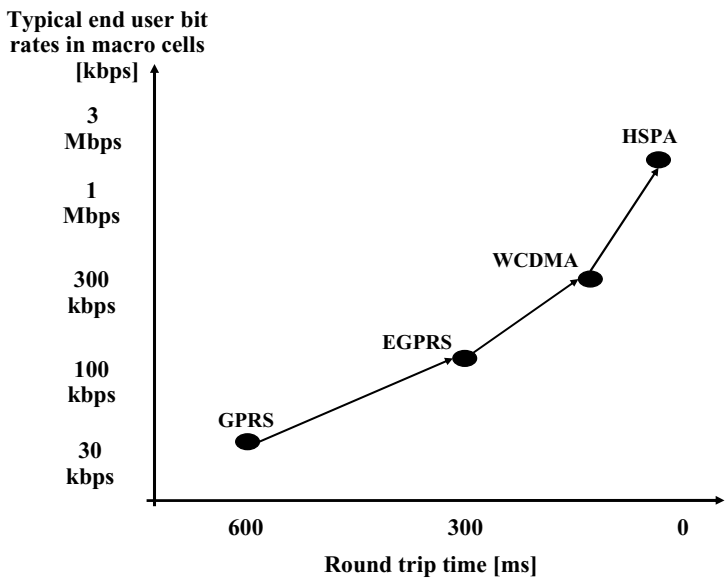


Figure 1.9 Radio capability evolution.

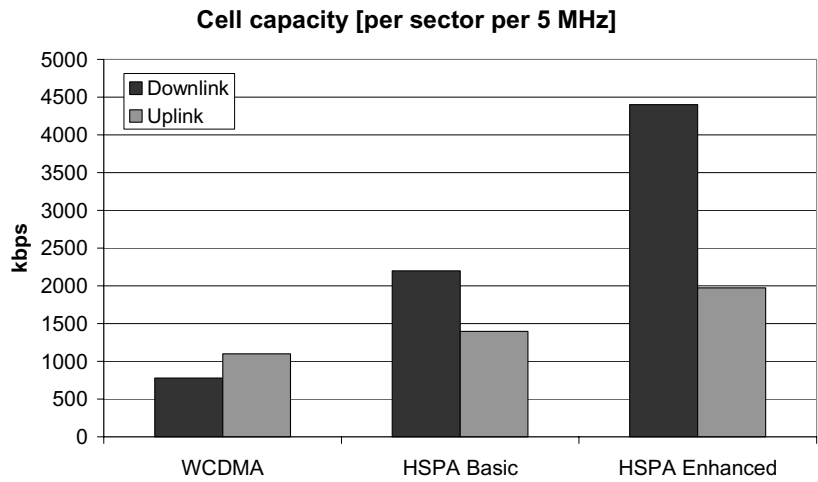


Figure 1.10 Capacity evolution with HSPA.

Higher cell capacity and higher spectral efficiency are required to provide higher data rates and new services with the current base station sites. Figure 1.10 illustrates the estimated cell capacity per sector per 5 MHz with WCDMA, with basic HSPA and with enhanced HSPA in the macro-cell environment. Basic HSPA includes a one-antenna Rake receiver in the terminals and two-branch antenna diversity in the base stations. Enhanced HSPA includes two-antenna equalizer mobiles and interference cancellation in the base station. The simulation results show that HSPA can provide substantial capacity benefit. Basic HSDPA offers up to three times WCDMA downlink capacity, and enhanced HSDPA up to six times WCDMA. The spectral efficiency of enhanced HSDPA is close to 1 bit/s/Hz/cell. The uplink capacity improvement with HSUPA is estimated between 30% and 70%. HSPA capacity is naturally suited for supporting not only symmetric services but also asymmetric services with higher data rates and volumes in downlink.

