



White Paper

3G evolution – the trusted road ahead

NOKIA

 **vodafone™**

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Introduction

Mobile network operators are faced with important capital expenditure decisions regarding which wireless broadband technology is the most appropriate to fulfill their strategic business objectives and network evolutionary paths. Consequently, a clear understanding is needed of the prevailing strengths, weaknesses and tradeoffs among leading alternatives for mass-market implementation.

The purpose of this paper is to comparatively evaluate key commercial and technical criteria of 3G WCDMA/HSPA (Wideband CDMA/High Speed Packet Access) technology with other emerging wireless broadband alternatives as a mainstream, mass market technology for delivering next generation mobile content and services to consumers and businesses. The term HSPA is used in this document to combine two standardized developments to 3G WCDMA, HSDPA (High Speed Downlink Packet Access) and HSUPA (High Speed Uplink Packet Access).

A comparative evaluation of wireless broadband alternatives must be multi-dimensional. Evaluated in this paper are leading technologies' revenue generation capability, cost efficiency, time-to-market, technical performance and ability to address new business domains. Also considered is the most optimal evolution path for existing 2G operators when choosing among the various alternative technologies.

There are a number of different wireless broadband technologies available, with different performance characteristics and operating in a variety of frequency variants. These include, for example, WiMAX, WLAN, TDD-solutions, and a number of proprietary solutions.



This document provides analysis of such technologies in comparison to 3G from the perspective of established mobile operators. The focus in the analysis is on the business impacts and business fundamentals, which relate to the basic choice between a standardized, globally adopted 3G-technology and less widely adopted alternative technologies. Performance overview of different technology categories is a part this document, however the goal is not to provide detailed technology performance of particular technologies. Further, technologies discussed in this paper focus on real-world, field delivery results rather than theoretical or laboratory results.

Nokia and Vodafone believe there is a clear demarcation among wireless broadband technologies that are best suited for mainstream, mass-market implementation versus complementary implementation, but view a multi-access wireless future as a reality. It is the conclusion of this paper that 3G WCDMA/HSPA is clearly the preferred mass-market technology providing the maximum cost and performance benefit, and clearest evolutionary path forward for mobile network operators.

Executive summary

The mobile industry is on the verge of delivering to consumers and businesses a new generation of rich content and services made possible by wireless broadband technologies. At the forefront of this opportunity are operators currently owning 2G networks and rolling out 3G technology to enable delivery of these services.

While some operators have made their technology choices and have embarked on their network evolution paths, others are weighing which alternative will become their mainstream, mass-market wireless broadband selection.

The criteria upon which each technology is evaluated and compared are many, but this paper recognizes five of the most important aspects that influence an operator's final decision. They are: 1) revenue generation capability, 2) cost efficiency, 3) fastest time-to-market, 4) technical performance and upgrade path, and 5) the promise of addressing new business domains.

Considering these five criteria in total, and with operator's needs in mind, one wireless technology clearly stands above and apart from all others: 3G WCDMA/HSPA.

Key benefits of 3G WCDMA/HSPA evolution for mobile operators

- Superior revenue generation capability
- Cost advantage in the evolution to high performance data services
- Fastest time to data mass market
- Comparable performance against any wireless technology – with a further upgrade path
- Competitive position in new business domains, like mobile broadband

For revenue generation, 3G WCDMA/HSPA clearly enjoys the largest addressable market. Unlike any other alternative, it supports practically all services with the added benefit of full mobility and global roaming capability. There are a number of factors making the consumers stay with the 3G services, such as 3G WCDMA/HSPA's interoperability with 2G networks, service portability, familiar user routines and high dependability. Further, untapped revenue opportunities presented by 3G WCDMA and 3G HSPA provide a solid business case for existing 2G operators and clearly justify the incremental cost necessary for operators to rollout the technology on top of their 2G networks.



When considering the cost aspects, 3G WCDMA/HSPA is clearly the most attractive option for the mobile operators. First, the majority of existing network assets in 2G networks – base station sites, support systems, core network, customer care and billing systems, etc. – are reusable in 3G. Second, the broadband capabilities through HSPA can be added to the 3G WCDMA network incrementally with low investment levels. Third, to enable cost-efficiently very high broadband data volumes, the operators have an easy evolution to simple and flat Internet architecture, with solutions such as Nokia Internet-HSPA. Additionally to the broadband cost-efficiency, the cost of voice is of importance. 3G WCDMA's radio efficiency and scalability allows the mobile operators to multiply the voice capacity in highly cost-efficient manner – and by fully re-using all of the current network assets.

Crucial to the success of any wireless broadband technology is time-to-market. 3G WCDMA deployments are well underway. There were over 30 million subscribers, over 80 operators having deployments, and hundreds of thousands of base stations in operation as of August 2005. The operator base will grow to hundreds, the user base

will grow into hundreds of millions, and the number of base stations in operation will grow to millions within the next few years. These factors enable a significant time to market and scale advantage for 3G operators. The 3G WCDMA has globally standardized evolution path to higher performance: HSDPA is commercial in 2006, and HSUPA in 2007. The above factors mean that the 3G WCDMA operators enjoy a time-to-market advantage for wireless broadband capability, considering that just the deployment to potential target markets would be expected to take around 1–2 years with any technology.

Turning to performance comparisons, the goal of most operators is to be able to deliver as many service categories as possible, thus raising the level of potential revenue. 3G WCDMA/HSPA, has a unique capability to support virtually any known mobile or Internet service with broadband speed, full mobility, service continuity and roaming. The HSPA phase provides typical average speeds of around 1 Mbps downlink and 0.5–1 Mbps uplink, the peak speeds being multiple times higher, up to 14.4 Mbps. Further, the 3GPP roadmap includes long-term evolution to UTRAN LTE (UTRAN Long

Term Evolution). The requirements have already been agreed in 3GPP and targets have been set to increase data rates to reach up to 100 Mbps, as well as to achieve further increased spectral efficiency and reduced latency.

Finally, new business development targeting additional revenue streams must be supported by any mass-market wireless broadband technology. 3G WCDMA/HSPA offers compelling advantages in such potential new areas as mobile broadband access, fixed voice replacement, wireless Internet access in residential and small office environments.

To conclude, as mobile operators expand their networks to offer ever richer services and content to their customers, among the most important business decisions that they will make is the selection of their mass-market wireless broadband technology. While certain wireless broadband technologies offer situational use scenarios and can complement operators' overall service delivery portfolios, none provide the overall advantages in revenue generation, cost efficiency, time-to-market, performance and future business creation potential as 3G WCDMA/HSPA.

Superior revenue generation capability

The evolution to 3G is clearly welcomed news for the mobile industry and the customers it serves. Business users appreciate the productivity enhancements brought by higher data rates as well as the same high levels of security, quality, coverage and international roaming as with today's GSM networks. Consumers appreciate faster response times, download speeds and especially new classes of content that are available due to dramatic performance advances in 3G WCDMA/HSPA networks.

An important starting point in evaluating which wireless broadband technology offers the most benefit to operators is to examine its revenue generation capabilities. Factors that impact this include the range of services and depth of user terminals the technology supports, ubiquity of network coverage, service portability, the level of continuity and familiarity offered to users, and very importantly, the ability of the technology to support current and future voice-based services.

The consumers are seeing an increased value from 3G: new applications, better quality service, lower cost are the most commonly seen benefits. As a result of the higher value for money, people tend to use the services in a higher volume, generating higher revenue streams. Supporting the higher usage levels is feasible for operators because of the low cost structure of advanced technology. Win-win proposition for consumers and operators is available, which is demonstrated by the result from a 3G-user study. (Figure 1)

The increased value for both consumers and operators is also visible from the ARPU (Average Revenue Per User) analysis. The Figure 2 illustrates the increase in ARPU that the operators with a substantial 3G WCDMA user base by August 2005 have been able to reach compared to the national average ARPU.

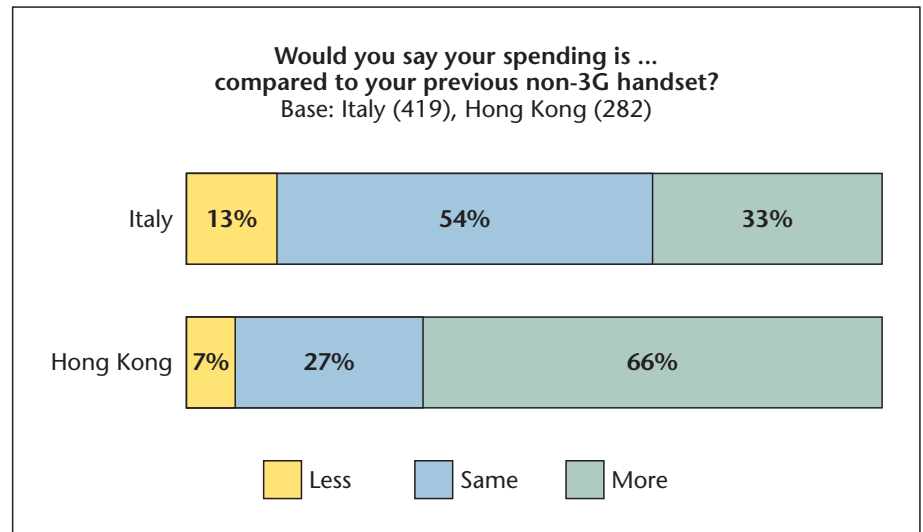


Figure 1. Results of 3G user study. Source: Synovate

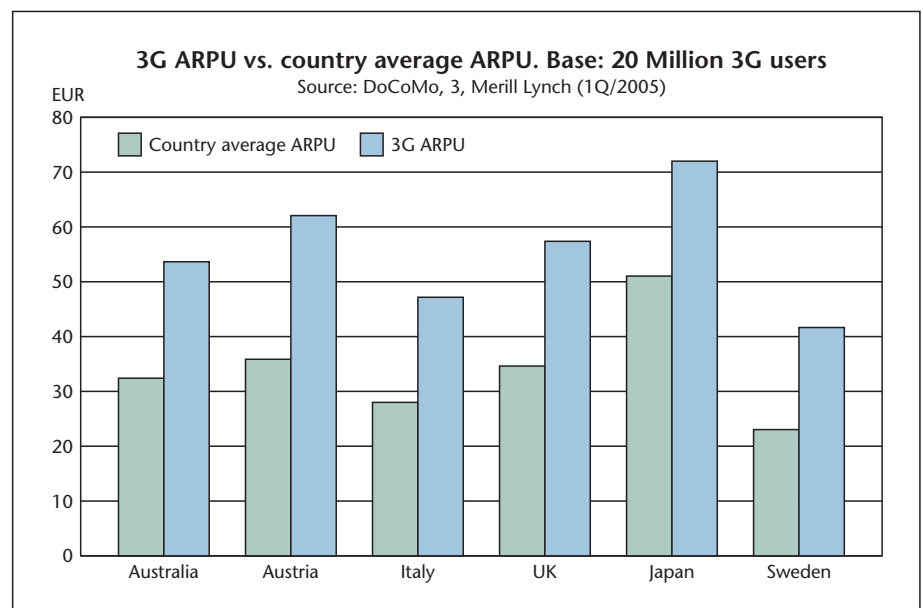


Figure 2. Average revenue per user in different 3G markets.

Full range of service propositions – larger accessible market

The 3G WCDMA/HSPA platform provides support for virtually any known service; voice, messaging, content, combinations of voice and multimedia, broadband and enterprise services – all with full mobility and global roaming capability. This is relevant for operators so that direct application revenue can be maximized, but even greater is the positive impact on subscriber acquisition and retention.

Companies often want to minimize the number of service providers they must deal with in order to make their own operations more efficient. Operators who are able to deliver the broadest range of services naturally stand a better chance of becoming the customer's preferred provider.

The following examples from Vodafone's 3G services illustrate how consumers and enterprises may find 3G services entertaining or useful.



Figure 3. Examples of Vodafone 3G services.

Examples of 3G services:

- **Entertainment** on the move: High-speed access to video clips, sporting moments, games and music
- **News:** Keep up to date with breaking news throughout the day by either streaming or downloading the news headlines directly to the handset.
- **Music:** Enjoy music on the move with quick and easy downloads of full music tracks, ringtones and even music videos, and turn your mobile into an online music player.
- **Games:** Battle zombies, race cars and fly planes with your 3G handset. 3G means that it's both cheaper and faster to download the hundreds of games available to play on your mobile phone.
- **Communicate** in new ways: In addition to being a high-quality, and higher-capacity means for voice calls, 3G opens the door to a whole new way of communicating with family, friends and colleagues using your mobile. Video Calling and Video Sharing are both totally new services made possible by 3G. See loved ones in person or hold face-to-face conference calls with business colleagues using Video Calling. It's the closest thing to being there yourself!
- Let people **see what you see** with Video Sharing. Need a second opinion on an apartment you are looking to buy or want to show friends what a great holiday you are having? With video sharing you can send live or prerecorded video clips during a phone call so both speakers can see the same video and discuss it.
- **Access the Internet:** Thanks to 3G you can browse the Internet on your mobile phone or laptop at speeds 5 to 10 times faster than on existing mobile services, and in the very near future data speeds will match and exceed those of broadband DSL services today.
- **Mobile E-mail & Productivity:** 3G also brings a variety of benefits for business users. Make sure you keep in touch with developments in the office and the latest customer inquiries with fast downloading of e-mails and access to e-mail attachments while on the move.
- **Mobile TV** – watch your favorite programs on your mobile device

Widest possible terminal range to meet the different user preferences

The single largest factor attributable to GSM becoming the dominant mobile voice platform in the world is that it offers the widest terminal range of any other cellular standard. Today, GSM has over 700 actively selling models from over 50 vendors, featuring all terminal styles, sizes, form factors and price categories, and catering to all user segments (Source: GSA). It is this very same factor that will make 3G WCDMA/HSPA the dominant mobile voice and data platform.

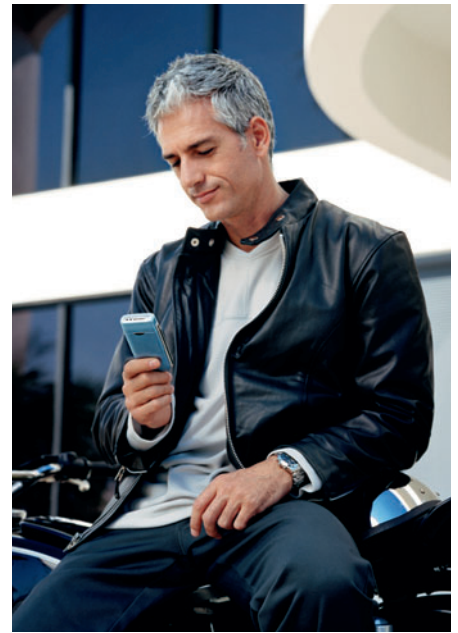
By August 2005, there were 186 different 3G WCDMA terminals from 26 different suppliers either commercially available or launched, according to terminal manufacturers' public announcements. These terminals include both handsets and data cards. This figure is rapidly rising as 70 of the models were launched in the past six months. (Source: GSA)

As 3G WCDMA terminals reach commercial maturity, their scale will

start to build from late 2005 onwards. Terminal segmentation is beginning to develop for the mass-market and the level of promotion of 3G WCDMA-compliant terminals in global retail channels is expected to increase their visibility.

Figure 4 shows Nokia's latest 3G handset models (launches until August 2005). There is an accelerating technology evolution trend: In 2003, Nokia launched one new 3G handset; in 2004 two; and in the first half of 2005 there have been five new handset launches.

3G terminals have been offered initially to high-end, early adopter flagship segments, however, this is expected to quickly encompass mass-markets as the technology matures.

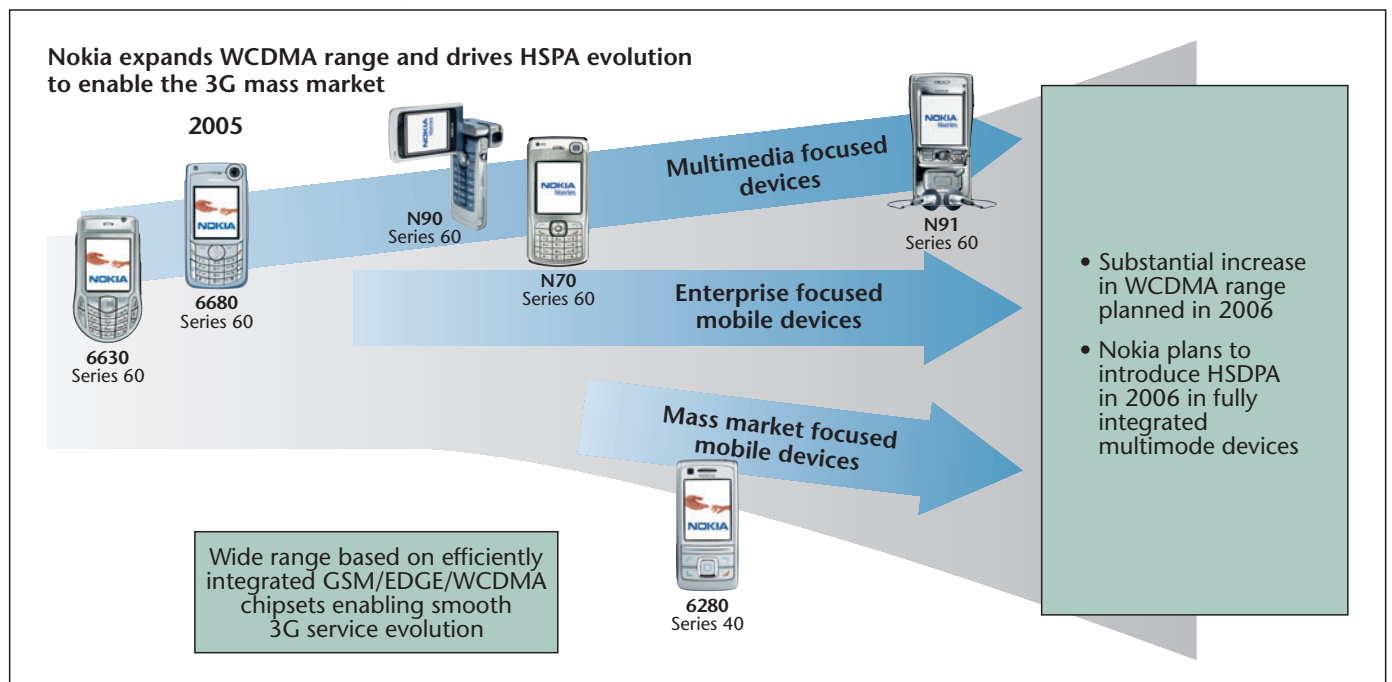


Nationwide service continuity

Nationwide coverage has proven to have a significant impact on an operator's ability to acquire and retain subscribers. 3G WCDMA's attraction is that even with a limited network deployment the user retains nationwide service continuity for

most services through seamless voice and data handovers in the underlying GSM network. This is enabled by the fact that the 3G WCDMA terminals support also GSM and its data features. In many cases, the 3G WCDMA-licensed operator owns a GSM network, but even in the case of 3G WCDMA greenfield operators, service continuity is provided through national roaming arrangements with other operators.

Figure 4. Latest Nokia 3G handsets (by August 2005).



International roaming to virtually all countries globally

Typically, users who travel internationally tend to also be among the highest communications services spenders. Given this, the roaming facility also supported in 3G WCDMA has a significant direct and indirect revenue impact for any mobile operator.

Continuation of a widely adopted, familiar user experience

3G WCDMA builds on the success of GSM with a complete range of attractive, multimode GSM/WCDMA handsets and a familiar, user-friendly experience. Due to the service continuity provided by GSM, 3G WCDMA does not detract from the current service nor network availability, but does enable enhanced service quality and new services to be introduced on top of the currently available ones. This is a critical factor for most subscribers since only few people would be willing to give up the dependability and familiarity of their mobile service in order to try a something new.

Voice business expansion

On average around 30% of voice minutes from all forms of telephony went via mobile networks in end-2004. Estimates show that this share will grow to 60% by 2009 (source: CSFB). At the same time the overall voice traffic levels are still on the rise, meaning that most mobile networks will have to manage multiple times higher voice traffic levels in the coming years in comparison to the current level.

Capturing this business opportunity would be more costly and difficult without employing 3G WCDMA,



since the 2G networks with their current frequency allocations are less economical and scalable in comparison. Also, using any alternative radio technology to provide reliable mass-market voice expansion is not realistic, as they in general do not have the required end-to-end capability or suitable terminal portfolio to achieve this.

In addition to the expansion of today's traditional mobile voice services, there are emerging voice service opportunities that are opened by 3G WCDMA technology. For example, new business opportunities are possible including parallel use of voice, data and video services when videoconferencing, playing interactive games and surfing on the web. Person-to-person voice communication can also be enhanced with parallel video streaming.

The voice quality of current 3G WCDMA networks, using AMR codec, is on par with landline networks. To further improve voice quality level, an enhanced voice codec – Wideband-AMR (Adaptive Multi-rate) – will be taken into use in 3G WCDMA networks. The new codec offers superior speech quality and voice naturalness compared to existing codecs, and is even superior to landline voice quality. Such a boost in quality will provide opportunity for the operators to better differentiate and retain or increase the value of voice services. (Figure 5)



- 3GPP Release 5 introduces WB-AMR wideband speech codec, which brings substantial voice quality enhancement for GSM and 3G WCDMA networks.
- The AMR-WB codec operates on nine speech coding bit-rates and the typical rates are 6.6, 8.85 and 12.65 kbps
- The term wideband comes from the sampling rate, which has been increased from 8 kHz to 16 kHz. This allows covering twice the audio bandwidth compared to the classical telephone voice bandwidth.
- While all the previous codecs in mobile and landline communication operate on narrow audio bandwidth limited to 300–3400 Hz, AMR-WB extends the audio bandwidth to 50–7000 Hz bringing substantial quality improvement over other landline and mobile services.

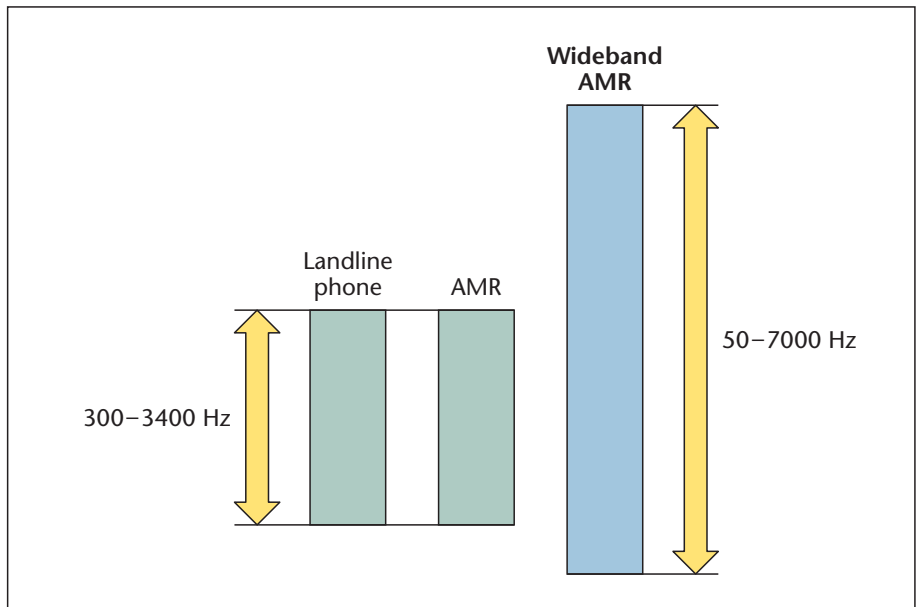


Figure 5. Audio bandwidth of different codecs.

Cost advantage in the evolution to high performance data services

3G WCDMA and 3G HSPA are incremental investments for GSM operators

The evolution path from GSM to 3G WCDMA is simple and clear, as the majority of the network assets can also be reused in 3G WCDMA including base station sites and support systems, core networks, network management, application platforms and applications, customer care and billing systems. (Figure 6)

The benefits in this evolutionary approach include the following:

- **Build-as-you-grow.** Thanks to the interworking with 2G, the 3G WCDMA new capacity and capability can be introduced within a small footprint initially, and expanded later as needed.
- **Low investment requirement to add Broadband capability.** Through the addition of 3G HSPA, full broadband uplink and downlink speeds can be added. A software upgrade is all that is basically required in the 3G WCDMA base stations.
- **Future upgrade roadmap.** Additional broadband capacity and simplified IP architecture (e.g. Nokia Internet-HSPA) can be introduced easily with plug-in units and software.
- **Operational efficiency** via integration with existing business processes and operations.

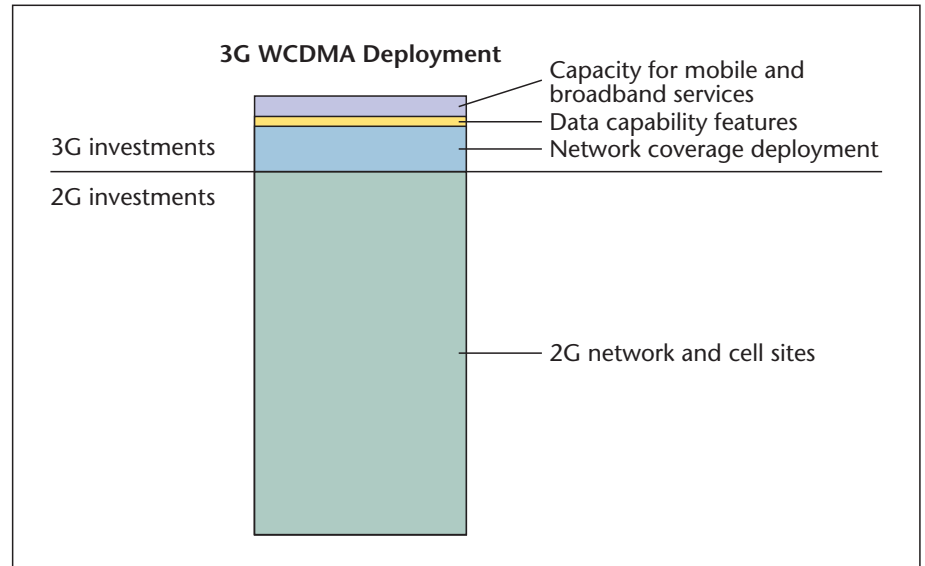


Figure 6. Approximate comparison of 2G and 3G network expenditure.



The most cost-efficient way of delivering services, including voice calls

Today, 3G WCDMA is able to deliver over 2,000 minutes per month per user in a typical network deployment of around 2,000 subscribers per site and 10 MHz of spectrum. Considering that the global average monthly usage levels per subscriber was 267 minutes (source: CSFB), the 3G WCDMA voice capacity means that operators can deliver extremely cost-efficiently the required voice capacity expansions. (Figure 7)

The data capacity of the air interface should also be sufficient enough to support much higher data usage per subscriber than is typical in the current mobile networks. HSDPA, which can easily be added on top of 3G WCDMA networks, can meet this data capacity demand. This means that HSDPA is as competitive as fixed line DSL and other wireless broadband technologies in offering up to 1GB per subscriber per month and a few hundred users per site. For reference, the household density per square kilometer in suburban centers is typically around 500 households, and in urban centers around 2000

households (Source: Analysys report about the UK, 2004). Based on this data, the 3G HSPA air interface capacity allows broadband service operation at a high usage level and with a reasonably high household penetration – even with a single data carrier. (Figure 8)

Key assumptions:

- 2-carriers per sector allocated for voice
- These capacities assume typical macro cell deployment with AMR voice codec
- Traffic model where busy hour carries 10% of the daily traffic and cell loading is 80% during the busy hour – in line with typical mobile networks
- Single 3G WCDMA base station cabinet per site, single diversity antenna per sector, making the site solution simple to deploy and operate.
- Source: Nokia

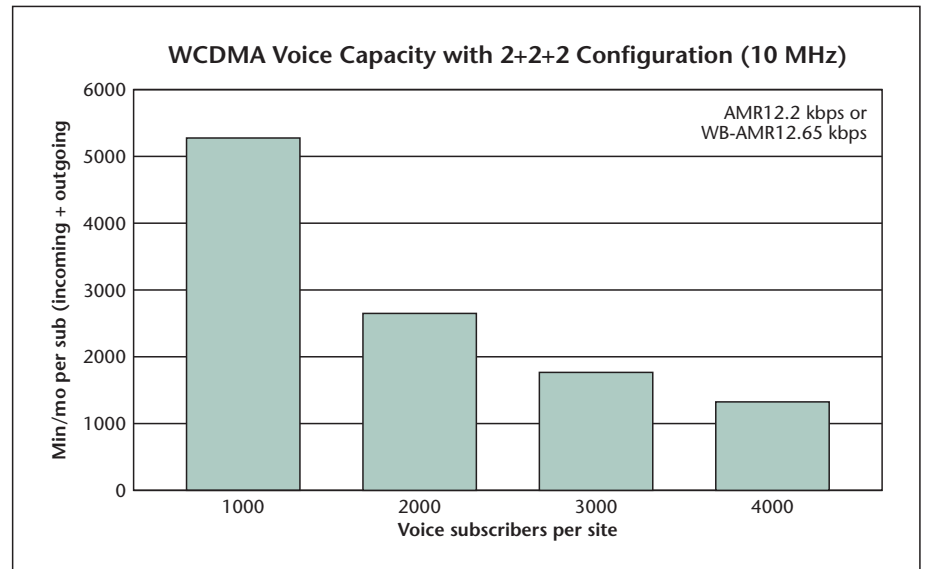


Figure 7. WCDMA voice capacity with 10 MHz frequency allocation.

Key assumptions:

- Single carrier
- Traffic model where busy hour carries 20% of the daily traffic – in line with experiences in DSL services.
- Single 3G WCDMA base station cabinet per site, single diversity antenna per sector, making the site solution simple to deploy and operate.
- Source: Nokia

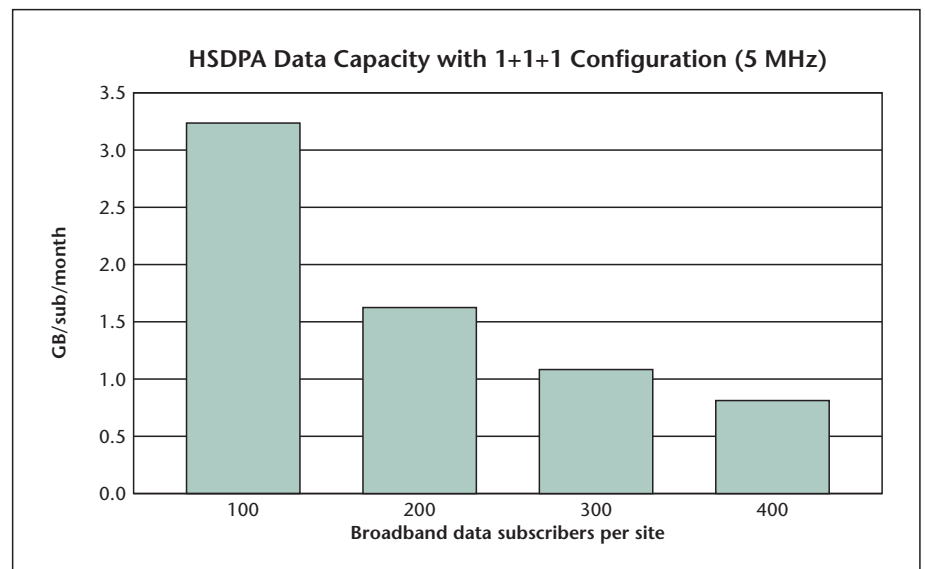


Figure 8. HSDPA data capacity with 5 MHz frequency allocation.

Evolution to IP-based architecture

As and when operator's goal is to provide wireless broadband services at very high volumes, becomes beneficial to utilise simplified Internet architecture, to bypass certain network elements. Such flat architecture can be deployed through a simple upgrade to an existing HSPA system, as is illustrated in the picture of Nokia's Internet-HSPA. (Figure 9)

The benefits with this simplified architecture are network cost savings and simplified network operation, as the architecture connects the base station directly to the Internet via a home agent, bypassing the Radio Network Controller and Packet Core. This innovation uses the packet data functionalities of standard 3GPP Rel-5 or Rel-6 terminals, and integrates the network functionalities into the existing base station cabinet and Home Agent.

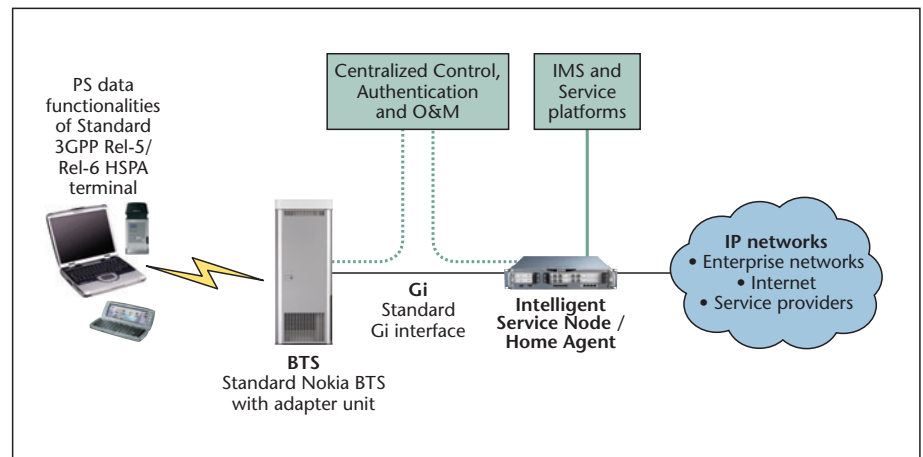


Figure 9. HSPA with flat architecture, Nokia Internet-HSPA.

Globally adopted standard – economies of scale advantage

The prospects for speedy adoption of 3G WCDMA are better than perhaps any other wireless broadband technology. The same economies of scale that are today enjoyed in GSM will be available in 3G WCDMA/HSPA over the coming years as can be concluded.



Key take-up figures related to the 3G WCDMA platform:

- As of August 2005, there were over 30 million 3G subscribers, of which over 20 million have joined in the last year. The pace of growth is significantly faster than any mobile technology has.
- As of August 2005, there were altogether 146 WCDMA license holders, of which 82 had commercial 3G WCDMA networks in operation.
- Operators who had a license for 3G WCDMA deployments have a combined 2G/3G user base of close to 700 million as of mid-2005.
- There has been high interest in 3G WCDMA in countries such as China, India, Russia, Brazil, Mexico, Thailand, Philippines and many others. In a scenario where the mentioned countries proceed with licensing by 2006, the combined 2G/3G user base of the 3G licensed operators will double to around 1.3–1.5 billion. Including other potential countries for 3G licensing, the figure will grow yet higher.
- CSFB has estimated that there will be 819 million unique WCDMA terminals sold between 2006 and 2009. The number of WCDMA subscribers in 2009 is expected to correspond closely with that figure as the most of these terminals are expected to remain in operation 2009.

Projected take-up of 3G WCDMA and 3G HSPA is very likely to be rapid in comparison to other wireless broadband technologies, which is illustrated in the Figure 10.

Secure evolution path

3G WCDMA systems are well standardized by 3GPP and carefully tested for interoperability, enabling mobile operators to select among multiple radio and core vendors for their 3G WCDMA network. As a result, the global network vendor market is highly competitive with several full-scale providers of 3G infrastructure.

The 3G WCDMA standard includes several different frequency variants. These variants use the same standard; only the RF requirements are modified to operate on the different frequencies. This evolution into new spectrum bands utilizing the same technology means that the coverage and capacity potential of 3G services can be further enhanced as required by the market. (Figure 11)

Comparing cost of 3G HSPA evolution to alternative options

3G WCDMA's evolutionary roadmap continues to give established operators a clear cost advantage in the mobile broadband services market.

The Figure 12 (see next page) illustrates the relative capital expenditure with alternative network deployment scenarios, as a function of added subscribers per site. In each scenario the subscriber is assumed to use 1 GByte of broadband traffic per month. To make the scenarios easily comparable, it is assumed that the cell coverage range and cell capacity are similar in each scenario. As the technology assumptions are harmonized across the different scenarios, this calculation provides an

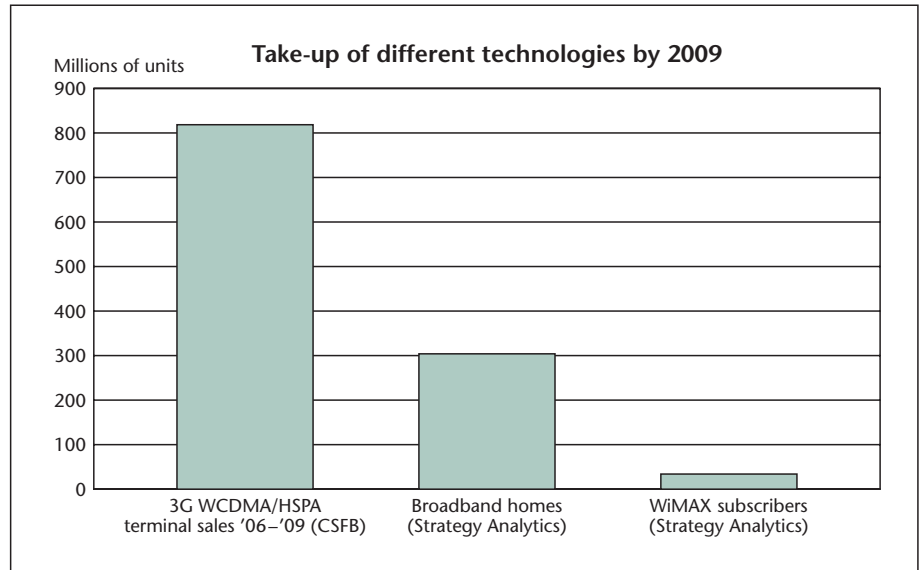


Figure 10. Take-up of different technologies.

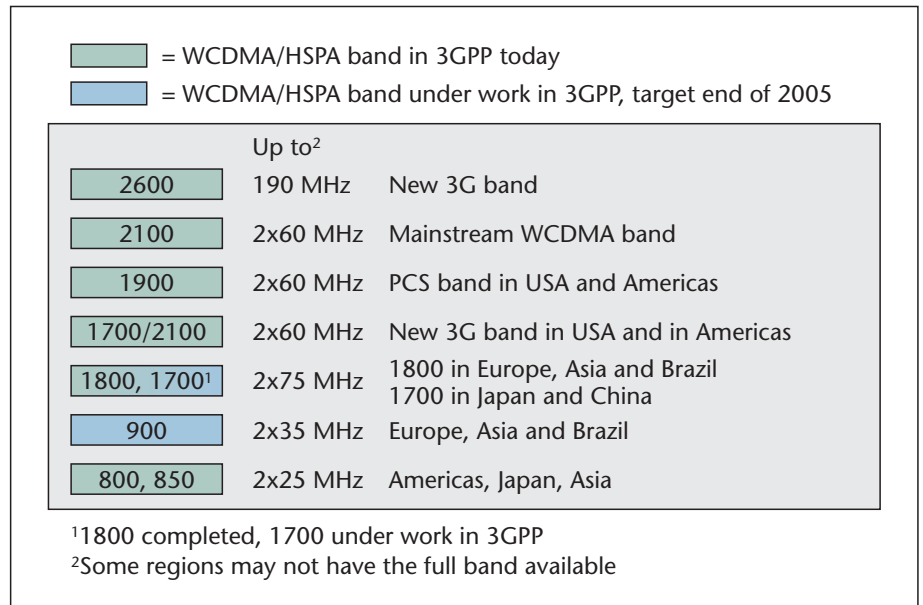


Figure 11. Standardization of WCDMA frequency variants.

- The 3G WCDMA deployments in Europe and Asia have started at 2.1 GHz mainstream band with total 2 x 60 MHz. More spectrum for higher capacity can be obtained using 1.8 GHz and 2.6 GHz bands for 3G WCDMA extension.
- Best coverage can be obtained by using lower frequencies, like 850 MHz or 900 MHz.
- 3GPP WCDMA standard has been defined or is under work for all major current cellular bands.
- The standard is exactly the same for the different bands except for the RF channel numbers and detailed RF requirements.

opportunity to evaluate the cost benefit of an evolutionary network build vs. building a new system. It is important to note that the comparison results here are indicative and do not refer specifically to any particular technology.

With the evolutionary approach the initial entry cost per subscriber is 3–6 times lower for the established mobile operators in comparison to a stand-alone network and 2–3 times less even in high traffic levels.

- The scenario ‘HSPA’ includes the cost related to an upgrade of WCDMA network to HSPA capability. This scenario assumes 3GPP Rel-99 or Rel-4 based network architecture. This scenario is used as the reference point for the comparison.
- The scenario ‘HSPA with simplified IP architecture’ shows the cost related to evolution from WCDMA to HSPA with flat IP architecture (e.g. Nokia Internet-HSPA). This is the most relevant scenario for mobile operators who aim to develop high-volume broadband business.
- The ‘New Wireless Broadband, leverage existing sites’ scenario shows the cost of a new wireless broadband network in a new frequency band, if the operator is able to leverage the existing cell sites and other physical infrastructure. The network element expenditure is assumed the same as in the previous scenario, however there is an incremental cost due to the requirement for new radio cabinets and related units for basic functionality, power systems, antenna and cabling solution, implementation work, network planning, and network optimization.
- The topmost scenario, ‘New Wireless Broadband, Greenfield sites’ shows the cost of a completely new wireless broadband network including new sites and the related civil works.

The impact of frequency bands is also of importance. The Figure 13 shows the relative site number that is required with different frequency bands in order to achieve a similar coverage quality, all other factors being the same.

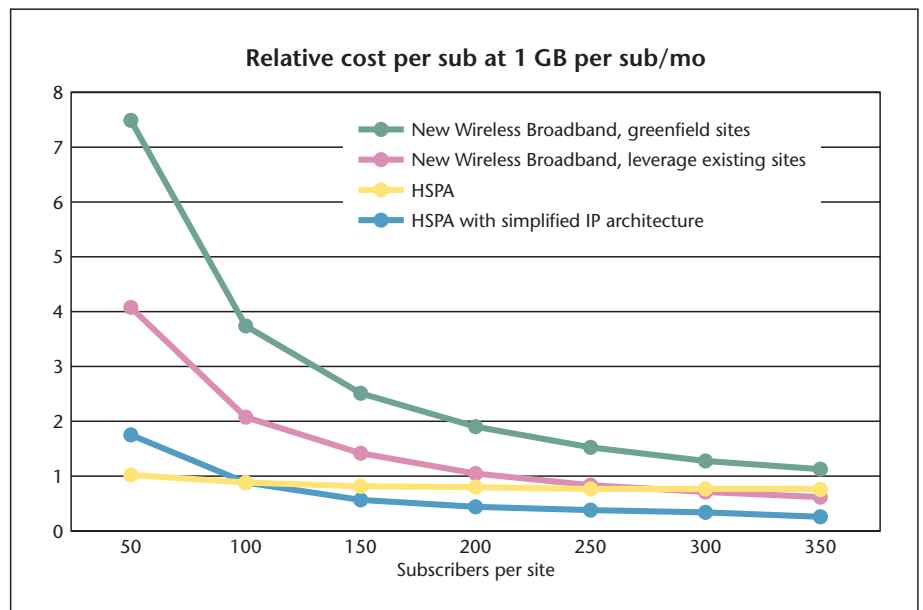


Figure 12. Relative cost of different Wireless Broadband options for 3G operators.

- Each scenario assumes the same cell range. However, it is to be noted that cell ranges may differ based on the utilised frequency band and technology.
- HSPA terminals can be either handheld or Mobile Connect cards, single antenna and equalizer receiver are assumed.
- Dual antenna terminals can improve HSPA cell throughput by more than 50%. Dual antennas are more likely to appear in the Mobile Connect cards.
- Source: Nokia

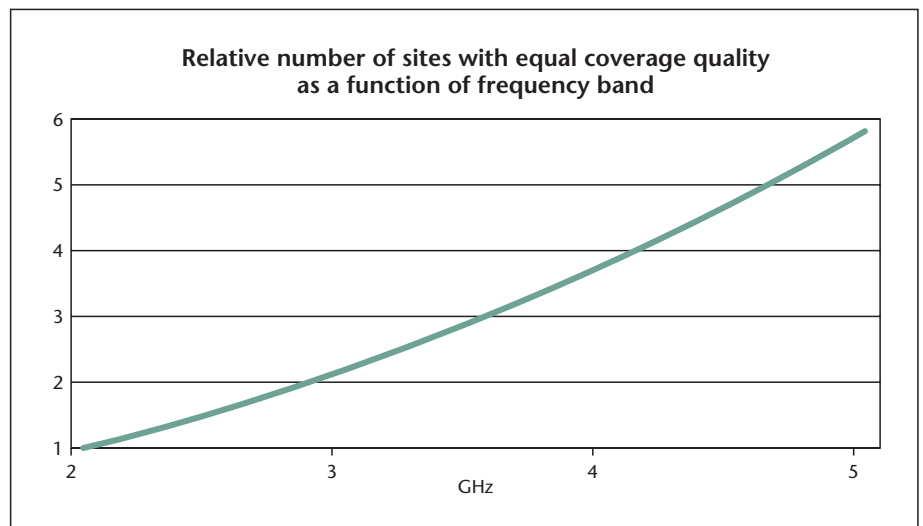


Figure 13. Frequency band impact on the relative site number. Propagation model: Cost 231 Okumura-Hata.

In practise, however, when the higher frequency bands are utilised operators commonly design the network for a lower quality requirement (especially indoor coverage) to avoid excessive

site numbers. The coverage issue can be improved through the use of outdoor antennas at customer premises, however the deployment would have a cost impact.

Fastest time to data mass market

Mobile operators deploying 3G WCDMA/HSPA enjoy a time-to-market advantage as higher bandwidth services start to go mass-market. Among them are the following:

- **General availability of technology platform** – over 80 operators have already commenced 3G WCDMA deployments, with hundreds of thousands of base stations deployed by August 2005. Millions of 3G base stations are being rolled out in the next few years.
- **Security of supply** – many global suppliers of standards-compatible and interoperable infrastructure and terminals.
- **Deployment capability and capacity** – an existing and experienced industry segment takes care of the network delivery and implementation projects globally.
- **Fast speed of coverage roll out** – mobile operators can leverage existing network, service creation, and physical infrastructure. It would typically take a minimum of 1–2 years for a new operator to deploy coverage in the most important zones from a greenfield situation.
- **Fast service launch** – Operators can leverage existing business processes – e.g. marketing, sales, customer care, and billing. Also, a smaller initial coverage is sufficient, due to service continuity with GSM.

Simple upgrade – timing advantage in broadband service coverage

Once the basic technology platform is implemented, operators can deploy the best available features to maximize their commercial potential. In the case of the 3G WCDMA/HSPA platform, the following data rates will be enabled:

- **HSDPA**: practical downlink bit rate of around 1 Mbps, theoretical maximum according to the standard 14.4 Mbps



- **HSUPA**: practical uplink bit rate of around 0.5–1 Mbps, theoretical maximum according to the standard 5.8 Mbps.

The process of upgrading a 3G WCDMA network to support 3G HSPA is a simple one. For the vast majority of the network elements, only a software upgrade is required. Due to the simple evolution path, the expectation in the industry is that all 3G WCDMA operators will adopt HSDPA and HSUPA because of the high value it provides for end-users at a marginal incremental cost.

Advantage in scaling to mass market

Once the technology is deployed for wide area coverage, and relevant feature sets are in commercial use, the capability to ramp up volumes becomes the critical next step in technology adoption. This is the first phase where the operators with different technologies actively compete with each other.

It is at this stage where the industry scale largely defines who the winner is. In industries that enjoy broad adoption of a common platform, there are more providers of services, technology and above all terminals. In a larger industry the cost of developing new solutions and terminals can be amortized across the entire global customer base meaning that suppliers and operators are able to develop more and more segmented services and terminal offerings spurring yet higher demand. Higher volumes lead to a lower cost structure across the logistical chain, again enabling the technology to penetrate to new user segments.

In the mobile industry there is only one family of standards that has gained a global acceptance – GSM. The scale benefits seen in the GSM industry are available in 3G WCDMA, with HSDPA and HSUPA to follow.

Comparable performance against any wireless technology – with a further upgrade path

Broadest service delivery capability

The 3G WCDMA/HSPA platform is designed to provide a full cellular coverage, and deployments tend to be continuous in a given area also indoors, and due to the requirement for mobility services. In contrast, many Wireless Broadband radio technologies are typically employed for a more specific purpose in certain geographic area – on the basis of the expected location of the targeted customers. Because of the smaller range of services and terminals in comparison to fully mobile services, the potential user base is lower and thus justification for large coverage investments is less obvious. As a result, the Wireless Broadband services, typically complement the fully mobile or fixed services. (Figure 14)

The following table illustrates some of the key differences between 3G WCDMA and HSPA, other Broadband Wireless technologies and WLAN. (Table 1)

3G WCDMA/HSPA operator can support virtually any mobile-optimized or Internet service – with service seamless continuity and global roaming.

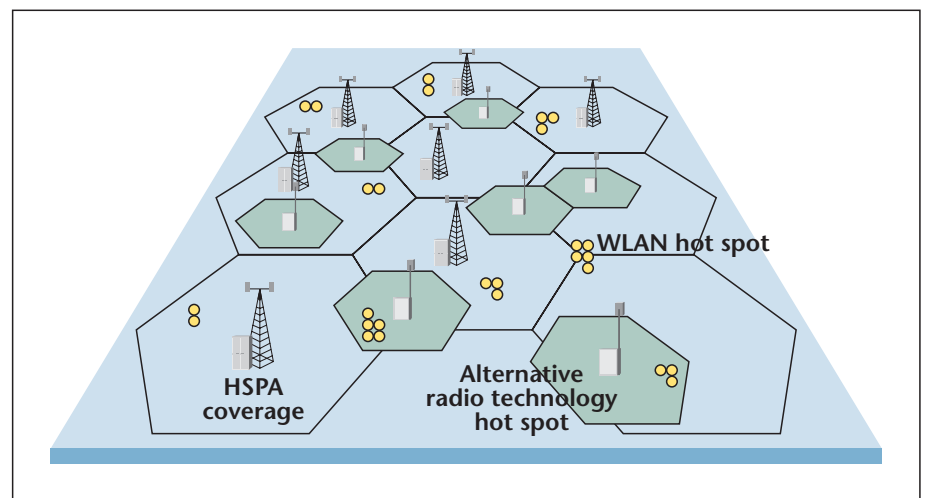


Figure 14. Illustration of wide-area, metropolitan-area and local-area wireless networks.

Table 1. Comparison of different technology alternatives. Source: Nokia

	Typical coverage deployment	Voice	Mobile data	Broadband access typical speed range
3G WCDMA and HSPA	Wide area coverage in urban, suburban, key roads Indoor coverage in most locations Global 2G/3G roaming; automatic handovers with GSM/EDGE	Full mobility and handover support Circuit switched and VoIP	Mobile use-case optimised applications & terminals Interoperability Internet applications	Practical 0.6–2 Mbps
Other Broadband Wireless technologies	Metropolitan area coverage in urban and key suburban areas Indoor coverage typically with external antennas or dedicated deployment	Partial mobility and handover support VoIP	Internet applications	Practical 0.2–2 Mbps
WLAN	Offices, homes, specific public premises and hot-zones 50...100 nodes per typical office/hotel	Limited mobility and handover support VoIP	Internet applications	Practical 1–10 Mbps

Evolution to 10–100 Mbps speeds

The 3G WCDMA platform has a clear and long term evolutionary roadmap for further increased data speeds and reduced latency. The next step after HSDPA and HSUPA is UTRAN LTE (UTRAN Long Term Evolution). The requirements have already been agreed in 3GPP and targets have been set to increase data rates to reach up to 100 Mbps, increase spectral efficiency and reduced latency. Other areas being addressed are spectrum flexibility, broadcast performance and inter-working with 3G WCDMA/HSPA. The completed specification for this evolution step is expected in 2007. (Figure 15)

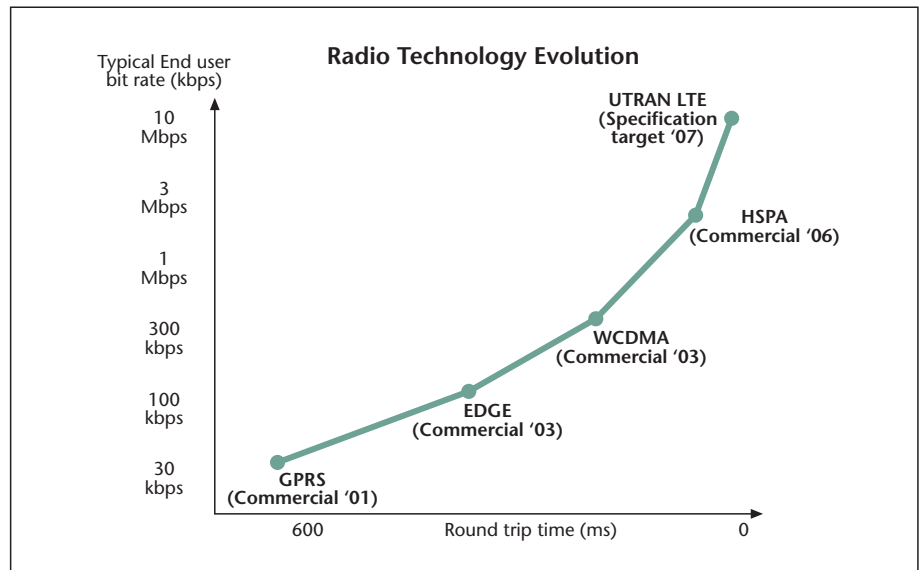


Figure 15. Typical bit rates and latency values in 3GSM evolution path. Source: Nokia



Competitive position in new business domains, like mobile broadband

The 3G WCDMA/HSPA platform is suited for mobile operators who seek to strengthen their current business portfolio while enabling new revenue streams. The Figure 16 summarizes the most important new business opportunities and their key enablers from both voice and data perspectives. Mobile voice and basic mobile messaging/content services have delivered the bulk of mobile operators' revenues. With 3G WCDMA, operators can find new areas of growth from their current services portfolios made possible through the increased, scaleable capacity and higher level of quality.

Through the wide service scope and the wide-area coverage, the 3G operators are in a position to gain access to new business domains. The potential naturally varies per market, but in general such new business areas could include for example mobile broadband, fixed voice replacement, and basic Internet access in residential and small office

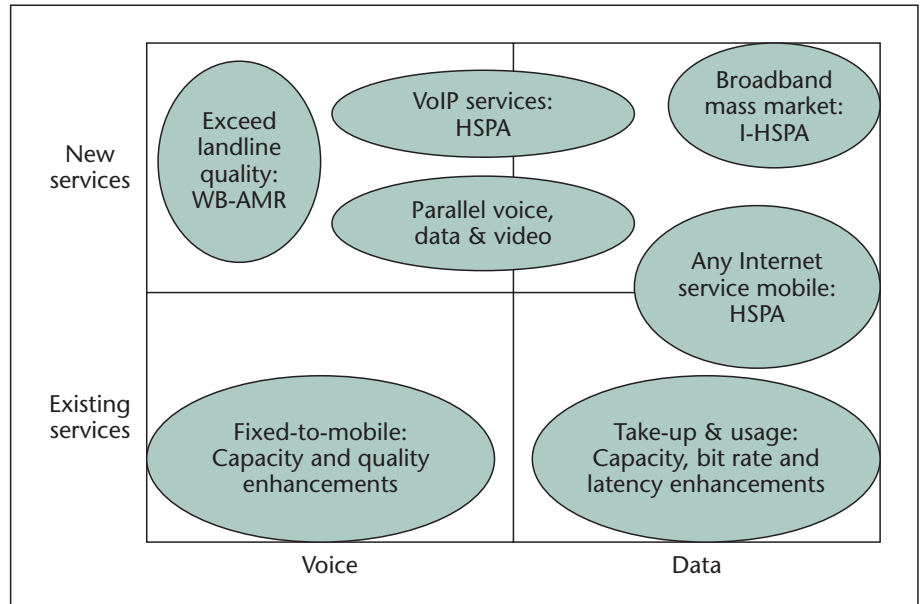
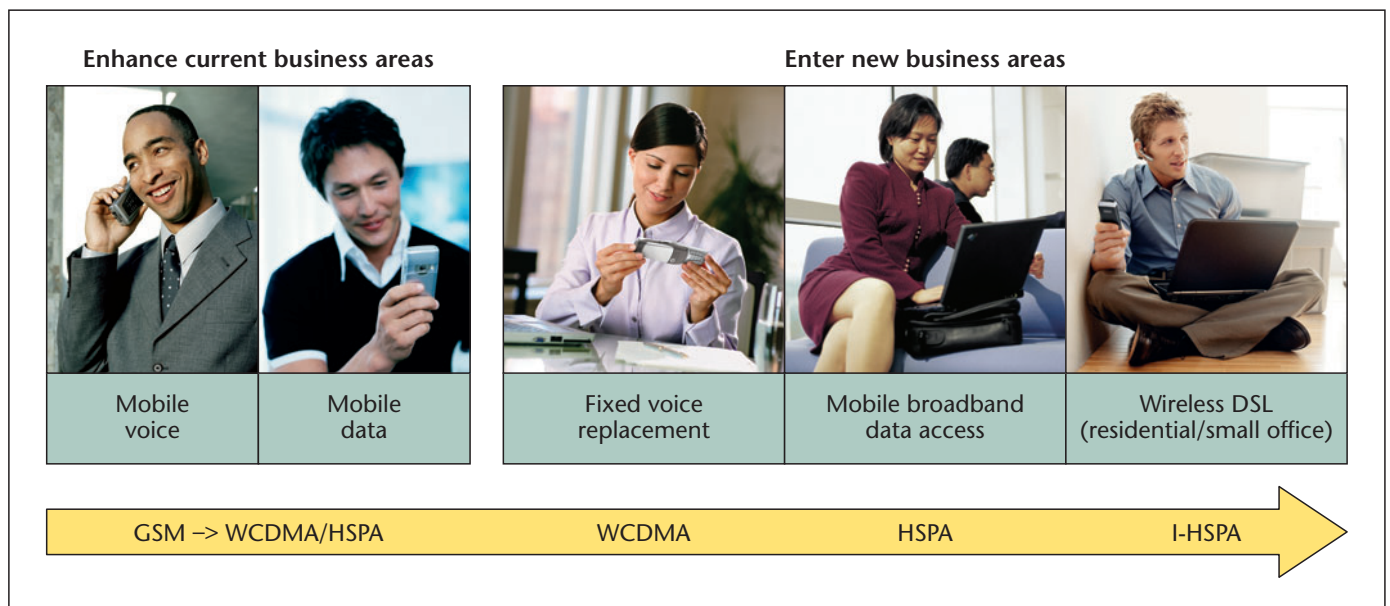


Figure 16. Improvement with 3G WCDMA/HSPA to existing and new services.

markets. The Figure 17 includes the most important existing and new business domains which are enhanced through the WCDMA/HSPA platform.

Figure 17. New business areas enabled with 3G WCDMA/HSPA evolution.



Conclusions

Wireless broadband technologies are making possible new and exciting opportunities for network operators to play a greater role in the growing mobile lifestyle phenomenon. While a host of factors will eventually decide who will emerge as winners in this endeavor, among the most crucial is the operator's selection of their mainstream, mass-market wireless broadband technology. Such a decision not only impacts significantly on their current customer base, but also has profound consequences in their ability to grow their business well into the future.

When surveying the choice of which mass market wireless broadband technology is most suitable for operators, five criteria stand out as guideposts to a final decision; the revenue generation capability of the technology, the cost efficiency of the technology, the technology's time-to-market, the technical performance and upgrade path of the technology, and the enablement of new business opportunity the technology can support.

In each of these five categories, it is this paper's conclusion that 3G WCDMA/HSPA is clearly the preferred choice for established mobile operators.

3G WCDMA/HSPA outclasses competing technologies in revenue generation capability. It supports the widest terminal range, breadth of services, ubiquitous national and international coverage area and continuity of user experience.

In cost efficiency, 3G WCDMA/HSPA allows established operators to leverage much of their 2G network's core, radio site, network management and back-office assets. Broadband 3G HSPA capabilities can be added incrementally and at reasonable cost, thus making it the most attractive wireless broadband alternative for established operators.



Already on the ground and in operation are hundreds of thousands of base stations utilizing 3G WCDMA. Because these networks and those forthcoming are able to leverage a significant portion of existing 2G infrastructures, 3G WCDMA is without doubt the fastest time-to-market alternative available to operators. To further enhance 3G WCDMA networks with broadband capabilities, HSPA can be added through remote software upgrade and tuning, again another time-to-market advantage.

Performance-wise, 3G WCDMA/HSPA offers data transfer rates comparable with DSL but with full mobility, service continuity and roaming. Moreover, 3G WCDMA/HSPA has the unique capability to support virtually any known mobile or Internet service.

Lastly, 3G WCDMA/HSPA is an excellent catalyst for new business growth; it enjoys global standardization support, is an open system attracting multiple vendors and has a secure evolution path with a technology roadmap eventually supporting data rates approaching 100 Mbps. Further, many exciting application possibilities are foreseeable in mobile broadband access, fixed voice replacement, basic Internet access in residential and small office environments and as a data cable replacement such as wireless Ethernet.

While other Wireless Broadband alternatives can play a role as complementary technologies in a multi-access environment, 3G WCDMA/HSPA is the technology of choice for established mobile operators to provide mainstream, mass-market wireless broadband services.

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