

Opening a New Road to 3G Evolution

GSM in 800 MHz for TDMA and
CDMA Migration

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Executive Summary

With the decline in voice airtime revenues and the explosive growth in data, 2G network operators must seek innovative evolutionary pathways to the IP-driven marketplace of tomorrow.

This Nokia white paper examines the impact of GSM 800 MHz on the 3G migratory routes of TDMA and CDMA operators. The paper examines the underlying forces that are driving the move from 2G to 3G and evaluates the relative standing of current GSM, TDMA and CDMA wireless technologies. Advances in technology, as well as crucial marketplace and regulatory developments, have opened an interesting new 3G pathway for TDMA and CDMA networks.

This new route employs GSM/GPRS with an evolutionary pathway to EDGE and WCDMA. When analyzing the comparative advantages of 3G alternatives, operators and others must consider the strengths and limitations of all participating technologies. They must understand the details of each potential evolutionary path and dispel various misconceptions associated with this evolution. Finally, this white paper examines the benefits available from this GSM/GPRS with migration to EDGE/WCDMA route and offers insights into those operators throughout the Americas who have chosen the GSM pathway.

Reevaluating the 3G Possibilities

Evolutionary Trends

Voice revenues have begun to decline dramatically, while analysts industry-wide are adjusting upward their already expansive estimates of revenues from fast packet-switched data services. Voice services currently account for more than 90 percent of income, but by the year 2005 it has been forecasted that data and other non-voice services will generate 50 percent of operator income.

Meanwhile, the mobile telecommunications revolution continues. Nokia recently increased its estimate of mobile phone ownership to at least one billion customers by 2002, and Nokia expects mobile Internet terminals to more than triple in number to 200 million this year. The coming boom in mobile communications is driving significant advances in the race to third-generation service capabilities.

The International Telecommunications Union's (ITU) 3G recommendations confirm the growing importance of mobile multimedia services. As noted on the ITU website:

"International Mobile Telecommunications – 2000 (IMT-2000) represents the global standard for meeting the emerging needs of mobile telecommunications in the 21st century whereby mobile telecommunications subscribers will be able to access voice, data, Internet, and multimedia services at any time and at any place."

The ITU has approved five distinct air interfaces for IMT-2000, and of those five WCDMA, EDGE and to some extent cdma2000 have gained measurable backing from equipment vendors and wireless operators. Global 3G consortiums and partnerships are now being formed to leverage the more than 80 3G licenses already granted and the hundreds more now under review.

These dynamics are forcing operators to examine more closely than ever their underlying technology and business strategies.

Industry analysts estimate that vendors are currently allocating from \$200 billion in research and development resources to specify, design and manufacturing infrastructure for evolving 3G networks. Of the 3G licenses currently awarded, more than 90 percent of those operators have specified WCDMA as their core 3G technology. Observers point out that, given this expected dominance of WCDMA as the 3G standard, this technology will undoubtedly receive the majority of R&D funding and will yield the earliest, most extensive and most reliable product availability.

It is also estimated that from 2003 through 2005, TDMA/GSM/WCDMA terminals will combine to account for more than 60 percent of the global terminal marketplace. The GSM total in this estimate includes GPRS- and EDGE-capable terminals.

Informed industry observers recognize that third-generation wireless communications will be

driven by subscriber-oriented services and not by provider-driven technologies. In the mobile telecom landscape of tomorrow, subscribers will expect and demand seamless anytime/anywhere access to voice, data, Internet and a growing universe of exciting new multimedia services.

Current applications will evolve to 3G, and the success of those new applications will depend heavily on a network to deliver capacity, bit rates and services. This growing reliance on data for revenue will drive the migration of current infrastructures to the faster, high-capacity packet-switched networks of the future. To meet those requirements, operators are searching for the clearest possible pathways to the third-generation.

GSM and TDMA adopted known and accepted data routes for 3G some time ago, while the CDMA evolutionary pathway remained less certain. But now shifts in technology and the wireless marketplace have opened an exciting new evolutionary possibility.

A New Pathway

Now wireless operators in the Americas and elsewhere have a promising new pathway to the 3G future. Nokia believes that a solution employing GSM and GPRS with evolution to EDGE and WCDMA will allow operators to maximize both market share and 3G margins.

GSM and TDMA offer a path of 3G migration employing Enhanced Data-rates for Global Evolution (EDGE). By deploying GPRS and EDGE technology, wireless competitors can lay down a clear, logical evolutionary pathway to WCDMA, which is rapidly gaining acceptance as the de facto 3G standard.

Given the changing dynamics of the wireless marketplace, we now expect that GSM and TDMA operators will implement EDGE to meet the growing demand for network capacity and data and multimedia services.

Real World GSM

The GSM pathway is rapidly becoming the world's most popular 3G evolutionary route. In what may have been the seminal event of this shift, AT&T Wireless Services has announced plans to deploy a GPRS-ready GSM network incorporating 3G capabilities with triple-mode (GSM/EDGE/UMTS) base station functionality. AT&T Wireless Services is one of the world's premier voice, data and fixed wireless communications companies, serving more than 15 million customers.

Under an agreement signed in November 2000, Nokia Networks will deliver a GSM/GPRS/EDGE/UMTS-ready base station radio solution as well as network planning and

implementation services. The deployment will enable AT&T Wireless to implement 3G, or Universal Mobile Telephone System (UMTS), service in the United States. With this move, AT&T Wireless will become one of the first U.S. carriers to offer advanced mobile multimedia and data services.

That decision, and the maturation of key evolutionary technologies, demonstrates the validity of the GSM/GPRS with an evolution to EDGE/WCDMA strategy.

Understanding the Technologies

To fully appreciate the potential of this GSM/GPRS and migration to EDGE/WCDMA pathway, it may be worthwhile to examine in more detail the nature and performance of these technologies.

WCDMA

Wideband Code Division Multiplex Access (WCDMA) is the radio frequency technology indicated for all UMTS networks, and WCDMA is widely expected to be the dominant technology for 3G networks worldwide. The current multi-billion dollar R&D investment in WCDMA ensures this technology will produce an extensive terminal portfolio. Informed observers now expect WCDMA to be the de facto standard for data-centric terminals. WCDMA supports high capacity,

multiple simultaneous services and bit-rate performance of up to 2Mbit/s. But as a wideband (5 MHz channels) technology, WCDMA presents deployment challenges when implemented on narrow frequency allocations.

When evaluating WCDMA infrastructure, operators should consider system solutions that provide well-established Third Generation Partnership Project (3GPP)-compatibility. WCDMA radio access systems that incorporate open, supplier-independent interfaces allow for faster, more cost-effective rollouts. WCDMA-enabled base transceiver stations will boost capacity by up to 75 percent, while supporting up to six sectors and as many as four carriers per sector. Using intelligent

resource management techniques, these new BTS solutions will move capacity to less-loaded adjacent cells to handle sudden traffic spikes in growing networks. These resource allocation capabilities follow UMTS traffic class guidelines and Quality of Service attributes, allowing operators to optimize service differentiation. Modular designs allow these solutions to scale quickly to meet escalating network traffic demands. These same design advantages will allow these WCDMA solutions to be adapted to meet the demand for location-based services, personalized messaging and packet data traffic volumes that will define the coming wireless IP networks. These advanced WCDMA systems will also support seamless integration with GSM networks.

GPRS

For many wireless operators, General Packet Radio Service (GPRS) can be a crucial transitional phase on the evolutionary pathway to 3G and the all-IP future. GPRS brings IP-based services to the mobile marketplace and supports the convergence of data networking and mobile telecommunications. As non-voice services begin to predominate the wireless environment, the GPRS core represents a secure carrier investment, a basis for 3G services, and an optimized transition step to 3G.

A fully featured GPRS solution should also comply with ETSI and ANSI standards and provides full roaming support and vendor interoperability. GPRS functions as an ideal bearer platform for Wireless Application Protocol (WAP) services. Well-integrated GPRS billing solutions provide optimized control of revenues generated by the

introduction of WAP services. These systems support access- and content-based billing, prepaid billing, and the smooth migration to transactional-based micro-payment models. Carriers should consider any GPRS solution's ability to integrate into their current service and billing architecture.

EDGE

Enhanced Data-rates for Global Evolution (EDGE) is a narrowband (200 kHz channels) radio technology that allows operators to offer 3G services without the necessity of purchasing a 3G license. EDGE is suitable for narrower frequency allocations, and can be deployed in just 2.4 MHz of spectrum with 4/12 reuse. EDGE can support 800/900/1800/1900 MHz frequency bands. By enhancing the capabilities of an existing TDMA or GSM network, EDGE creates a smooth, cost-efficient migration pathway

towards an all-IP network. EDGE allows operators to leverage the considerable advantages of GPRS, including fast-connect set-ups, data rates to 473 kbps, and measurably higher bandwidth.

Early adoption of EDGE technology allows carriers to offer multimedia services in 2001, and to position themselves to serve the estimated 60 percent of global mobile subscribers who will be EDGE/WCDMA customers by the year 2006. EDGE provides enhancements to GSM and supports the use of existing sites and frequency bands for 3G services. EDGE capabilities improve coverage and capacity and streamline to migration to a full-service 3G network. EDGE also compliments WCDMA, which industry analysts agree is emerging as the de facto 3G technology standard for new or re-farmed spectrum.

Tracking the Pathways

The important first steps towards 3G have already been taken. Here are potential deployment scenarios for the major wireless communications technologies.

GSM. Considering the market and evolutionary advances made by this technology, GSM is now a viable alternative for operators throughout the Americas in both 800MHz and 1900MHz. GRPS provides the core network backbone for EDGE, which will be the 3G network standard for deployments in existing spectrum, and for WCDMA, which is recognized as the 3G standard for new or re-farmed spectrum.

Current-generation base stations can be converted to EDGE and WCDMA with the quick and easy replacement of a radio card, and Nokia's GSM800 incorporates native EDGE capabilities. GSM coverage and roaming capabilities will be incorporated into WCDMA handsets. In the 2003 to 2004 timeframe, IP-based multimedia services will be available to operators throughout the Americas.

TDMA. TDMA operators have two clear options available in the GSM environment: GSM/GPRS at 800 MHz and GSM/GPRS at 1900 MHz. These options give TDMA operators a

springboard to packet-data technologies and will allow them to deploy data services to their networks more quickly. These pathways allow TDMA operators to open a clear evolutionary pathway to 3G and to use their new GSM core as the basis for delivering 3G services.

If an operator has built out all 800 MHz properties and has under-employed 1900 MHz licenses, they can deploy GSM/GPRS 1900 this year to gain immediate access to the faster data speeds of this packet-data infrastructure, and then add EDGE 1900 MHz capabilities as

they become available near the later part of 2001. GSM/GPRS 1900 terminals, which will be available later this year, will be data-capable for 1900 MHz markets and will deliver GSM data/voice roaming on 1900 MHz networks. In the 800 MHz properties the deployment of GSM/GPRS/EDGE can start at the end of 2001.

TDMA operators can elect to begin to implement GSM/GPRS/EDGE 800 MHz solutions in selected regions towards the end of 2001. GSM/GPRS/EDGE 800 and 1900 MHz terminals are expected to be available in 2002, as well as TDMA and GSM interoperable terminals. In either case, these operators may

add WCDMA as a complimentary 3G technology in new or re-farmed spectrum.

CDMA. The CDMA marketplace reflects the previous dominance of IS-95A at 14.4 kbps, and the advent of cdma2000 1x that will provide acceptable current-generation packet data services. The 1Xev-DO (data only) CDMA standard is available now, and deployments may begin in 2002. The 1Xev-DV (data and voice) CDMA standard is expected to be available by the end of 2001, with a number of technology options still under consideration. A growing number of industry observers, however, point out that as EDGE and WCDMA bring

higher data speeds to the TDMA/GSM world, fewer 3G service licensees will take the cdma2000 route.

CDMA also does not offer the global roaming or economies of scale available from the GSM pathway. CDMA's advertised 2Mb/s data rates apply only to short range and indoor modes that may or may not be supported by vendor solutions. In reality, there may actually be only minor performance differences between EDGE, WCDMA and cdma2000, because user experience depends heavily on cell engineering, location, power usage, sector load and other variables.

Market Misconceptions

In the fast-moving landscape of wireless communications, a number of misconceptions have arisen regarding these various 3G evolutionary options. To better understand the pathway based on GSM/GPRS with evolution to EDGE/WCDMA, these misconceptions must be addressed and corrected.

It has also been said that EDGE is a data solution only and does not offer significant voice capacity. The truth is that any timeslot on a current Nokia EDGE TRX can be used in GSM voice mode Full Rate, Enhanced Full Rate or Half Rate codecs with Nokia EDGE TRX can support the dynamic allocation of GSM/GPRS/EDGE on a per time slot basis. This gives operators the ability to flexibly deliver voice and data services in accordance with subscriber demand.

Continued standardization of Adaptive Multi Rate (AMR) is expected to produce additional enhancements to the EDGE voice capacity. Nokia's EDGE TRX provides dynamic GSM/GPRS/EDGE support on a per-time-slot basis to give operators economic, customer-driven voice and data service capabilities.

Narrowband CDMA performance depends on multi-path channels. CDMA typically provides better capacity in long delay spread channels. Downlink fast power control improves CDMA capacity performance in short delay channels, but reduces capacity in long delay spread channels.

While some believe it requires 8 MHz to deploy an initial EDGE solution, EDGE can be deployed in an existing GSM network with no additional frequency or infrastructure

requirements. Even in a GSM greenfield situation, EDGE can be deployed in 2.4 MHz of spectrum. In some circles, it has been said that CDMA 1xRTT delivers higher spectral efficiency than GSM/EDGE and that this difference translates into higher capacity and faster data rates. The most recent implementation of GSM features such as Adaptive Multi Rate (AMR) codec, Frequency Hopping and Automated Planning that serve to make GSM competitive with CDMA on these issues. GSM systems now in development will also introduce Dynamic Frequency Channel Assignment for even greater spectral efficiency.

Contrary to one popular industry misconception, EDGE does not require high-dollar network investments or the acquisition of new spectrum. One key advantage of EDGE is that it can be deployed to

enhance the strengths of an existing GSM network. A world-class EDGE system can be implemented through rapid and affordable software upgrades and the addition of EDGE-capable TRXs to existing base stations. EDGE also uses the existing GPRS core infrastructure and does not require the deployment of new core network elements.

Because EDGE/WCDMA are based on a common GPRS core network, operators can plan a smooth and cost-efficient evolution from GSM/GPRS to 3G capabilities. In most implementations, the spectrum required to deploy an EDGE TRX is the same as adding an ordinary GSM TRX. Leading EDGE solutions offer broad backward compatibility with existing network hardware and software systems.

GPRS or EDGE solutions do not require the addition of a proprietary network core. The GPRS core is built on interfaces that are open and fully standardized. This approach allows

carriers to seek competitive, multi-vendor solutions and to migrate seamlessly from GSM to EDGE with no change to the GPRS core or interfaces. This openness and interoperability has led to the success of GSM as the global wireless standard.

Another misconception is that GPRS and EDGE offer identical data rates. In fact, EDGE offers data rates of ~20 kbps per timeslot, compared to ~10 kbps for GPRS even in poor C/I conditions. In more favorable conditions, and when supported by intelligent radio enhancements, EDGE can deliver data rates of ~50-60 kbps per timeslot, or up to three times the ~20 kbps rate of GPRS under the same conditions. When deployed with eight full-speed 59.9 kbps timeslots, EDGE can achieve maximum data user rates of 473 kbps.

Some have implied that EDGE is at best an interim 2.5G solution, and that WCDMA will eventually

supplant EDGE deployments. In reality, EDGE can provide data rates of up to 384 kbps as defined by the ITU for 3G services. EDGE can deliver an average of 40 kbps per timeslot. With typical EDGE mobile devices using three timeslots for downlink, that adds up to 120 kbps, which is sufficient for the most popular data services such as streaming. The EDGE solution is a proven, viable radio access technology that can and will play a pivotal role in future all-IP networks.

Finally, contrary to some assumptions, EDGE is the ideal choice for 3G in existing bands, because it uses the same 200KHz channel as GSM. Operators who choose EDGE for 3G will not depend on new spectrum auctions, and can evolve with confidence from a proven GSM foundation. WCDMA is the ideal choice for new or re-farmed spectrum, and because EDGE and WCDMA are complimentary, they create a seamless pathway for greenfield opportunities.

Benefits of GSM

Product Availability. Thanks in large part to the fact that GSM is the largest 2G protocol, serving more than 450 million subscribers, and that WCDMA/EDGE is emerging as the accepted 3G protocol, this evolutionary pathway offers clear advantages in the depth and quality of its terminal, infrastructure and application portfolios. The economies of scale associated with this global standard ensure good selections and competitive prices for these 3G products.

Standardization. ETSI has established comprehensive standards for GSM technology, ensuring the interoperability of terminals and infrastructure. Similarly, the Third Generation Partnership Project (3GPP) has served in this same role during standardization activities aimed at UMTS, working to ensure that global roaming and interoperability can be provided through a highly standardized 3G framework. These standards allow operators to select base stations and

other equipment offered by a number of competing vendors. An open, standardized technology also ensures more reliable roaming performance and the smooth compatibility of elements across networks and geographic regions.

Superior Features. GSM was the incubating technology for many of today's most popular value-added wireless services. In fact, features such as location-based services, over-the-air provisioning and others

were originally specified for GSM, which is by far the largest deployed wireless technology in the world. Because GSM is a truly global technology, value added services such as SMS and voice mail can roam with the subscriber, greatly increasing operator revenue opportunities.

Notable features available via GSM include:

- SMS chat, picture messaging, ring tones, logos/icons
- Circuit switched data (9.6 kbps to 14.4 kbps to HSCSD x times 14.4 kbps)
- WAP
- Packet data (GPRS and EGPRS)
- Location based services (E-OTD, Cell ID and TA and GPS)
- Accessories (handspring visor GSM module, telematics and more)
- SIM card (security, M-commerce, SIM ATK, Class 2-SMS handset configuration control, and distribution)
- GSM Supplementary Services
- Integration with SyncML, MMS, Java, EPOC terminals

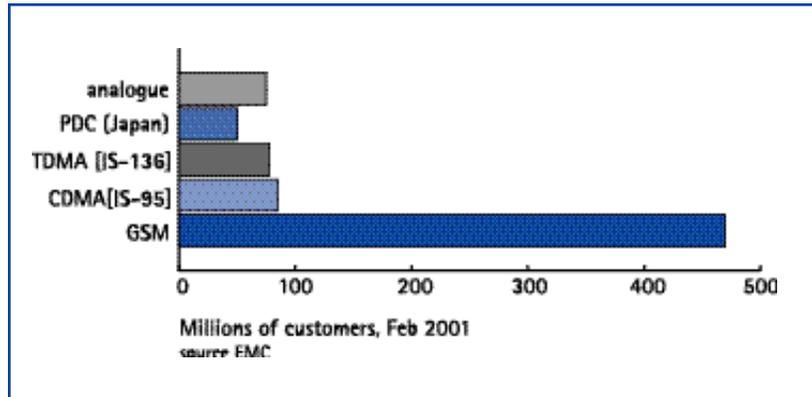


Figure 1. Global reach of GSM

Global Reach. GSM is the most extensively used digital cellular network technology in the world, serving more than 450 million subscribers worldwide and with successful deployments in over 100 countries. This extensive deployed infrastructure ensures the broadest possible roaming coverage for GSM-based 3G services.

Summary

3G Evolutionary Imperatives

Nokia offers a clear, logical vision of 3G evolution for GSM, TDMA and CDMA networks. The operators who succeed in 3G will be those who can readily adapt to the shifting value chain brought by mobile Internet. Because airtime profits are declining, creative thinking about how to generate new revenue streams is needed. Nokia's objective is to increase operator ARPU (average revenue per user) by up to 100% through the incubation and delivery of innovative 3G applications. We believe our success - and the success of our partners - will be based on three factors:

Speed. Speed in building a cost-optimized 3G network, speed in developing applications, and speed in anticipating and reacting to consumer needs.

Recognizing Value. Pinpointing the relevant applications among the host that will be launched. Creating a brilliant service portfolio and then promoting it to prompt greater usage.

Cooperation. Sharing competencies across industry boundaries. Creating solid yet flexible partnerships that help all parties to profit while navigating the intricacies of 3G, end-to-end mobile applications, and rapid changes in the consumer market.

In short, success in 3G will come from the hundreds of leading Internet content providers, application developers, and systems integrators working with Nokia to guarantee the richness of 3G services.

The GSM-based evolutionary strategy described in this white paper study supports this strategic, profit-driven approach to 3G evolution. By rethinking the migratory path, and by considering the GSM/GPRS with a migratory path to EDGE and WCDMA, operators throughout the Americas can maximize both their immediate performance and their long-term 3G opportunities.

Acronyms

3G	Third Generation Mobile Telecommunications
3GPP	Third Generation Partnership Project
AMR	Adaptive Multi Rate
ANSI	American National Standards Institute
CDMA	Code Division Multiple Access
EDGE	Enhanced Data rates for Global Evolution
ETSI	European Telecommunications Standards Institute
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
TDMA	Time Division Multiple Access
UMTS	Universal Mobile Telephone System
WCDMA	Wideband Code Division Multiple Access

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