Evolving from cdmaOne to third-generation systems

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The evolution to third-generation services is a hot topic in the CDMA industry. The convergence of voice and data services and packet-switched networks is transforming the entire playing field for most cdmaOne providers. Additionally, the division between wireline, wireless, and Internet service providers (ISP) is beginning to blur. The wireless networks of the future must be able to handle certain traffic loads and provide telecommunications reliability to all customers—even those who use Internet services.

Although Ericsson CDMA Systems is a relatively new player in the wireless market, thanks to the cooperation of numerous contributing product units, it can provide a total system offering of CDMA and third-generation services.

The author describes Ericsson's comprehensive, but flexible and varied five-step path for migrating present-day IS-95 systems to a fully layered, third-generation solution.

Introduction

As cdmaOne (IS-95 CDMA) operators begin delivering a wide range of voice and data services over diverse media, their networks must evolve to support a complex mix of user demands. Ericsson's cdmaOne products and services are positioned to guarantee an effective and cost-conscious delivery of all telecom services—today and tomorrow.

Figure 1 illustrates the layered network architecture of the future, which will enable the efficient delivery of voice and data services. A layered network architecture, coupled with standardized open interfaces for wireless networks, will allow operators to introduce and roll out new applications and services more rapidly than they ever imagined. Ericsson is aggressively developing products that allow for the delivery of traditional telecom services and newly formed packet-based (Internet) services over the same backbone. We are committed to helping cdmaOne operators to make the transition from present-day IS-95 networks to the third-generation networks of tomorrow. Our comprehensive and varied migration path allows operators to choose to what extent as well as how fast they want to evolve their networks. These migration options can most easily be understood in terms of five steps, as described below. Any or all of these steps can be adopted on the road to a profitable third-generation business.

In addition to migrating their networks toward a layered network architecture, some operators want to implement all-IP delivery of services. That is, they want to eliminate circuit-switched services from their networks. The standards for third-generation all-IP networks are being defined for IS-95-based systems in the Third Generation Partnership Project (3GPP2).

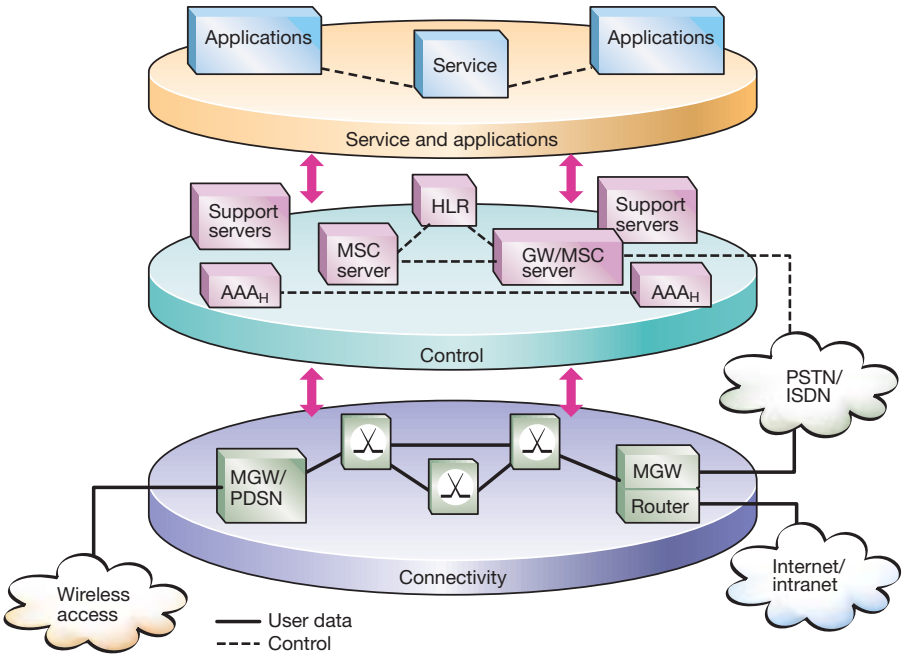


Figure 1
Future layered network architecture.

Evolution of the IS-95 air interface

IS-95-A

Before we discuss the evolution of specific products, we need to review the evolution of the IS-95 air interface, which was standardized by the Telecommunications Industry Association (TIA) in July 1993. Networks that utilize the IS-95 CDMA air interface and the ANSI-41 network protocol are branded as cdmaOne networks. Ericsson IS-95 networks utilize one or more 1.25 MHz carriers and operate within the 800 and 1900 MHz frequency bands.

The first commercial launch of a cdmaOne network was in Hong Kong, in September 1995. Today, there are more than 50 million cdmaOne subscribers worldwide. Some key benefits of the IS-95 air interface are soft handoffs (a *make-before-break* concept that reduces dropped calls) and increased capacity compared to AMPS networks.

Ericsson's current cdmaOne product portfolio was designed from the ground up

- to maximize the advantages of CDMA digital wireless technology; and
- to incorporate the efficiencies of IP—for example, the Ericsson cdmaOne network, known as CMS 11, supports packet data at rates of up to 14.4 kbit/s (as supported in the IS-95-A standard) and packet-based transport on the backhaul.

IS-95-B

The original IS-95-A air-interface standard was supplemented with the IS-95-B standard, which includes several improvements for hard-handoff algorithms in multicarrier environments and in parameters that affect the control of soft handoffs. Nonetheless, the primary change in the standard had to do with higher data rates for packet- and circuit-switched CDMA data: data rates of up to 115 kbit/s can now be supported by bundling up to eight 14.4 or 9.6 kbit/s data channels (14.4 kbit/s · 8 = 115.2 kbit/s). Today, some operators in Asia are implementing IS-95-B data with service rates of up to 64 kbit/s.

3G IS-95/cdma2000

The third-generation evolution of IS-95-based systems is referred to as cdma2000. This wireless standard was developed to support third-generation services (IMT-2000) as defined by the International Telecommunication Union (ITU). The standard is divided into two phases, commonly known as 1X and 3X.

IS-2000/cdma2000 1X

The cdma2000 1X standard (IS-2000) has been completed and published by TIA. The term 1X, derived from 1XRTT (radio transmission technology), is used to signify that the standard carrier on the air interface is 1.25 MHz—the same as for IS-95-A and IS-95-B (that is, 1 · 1.25 MHz). This standard can be implemented in existing spectrum or in new spectrum allocations. The standard also paves the way for the next phase of third-generation networks—cdma2000 3X (IS-2000-A). In brief, cdma2000 1X, which is implemented in existing spectrum allocations,

- delivers approximately twice the voice capacity of cdmaOne;
- provides average data rates of 144 kbit/s;
- is backward-compatible with cdmaOne networks and terminals; and
- enhances performance.

BOX A, ABBREVIATIONS

1X	From cdma2000 1X (IS-2000), derived from 1XRTT), which signifies 1 · 1.25 MHz carrier
3GPP2	Third-generation Partnership Project
3X	From cdma2000 3X (IS-2000-A), derived from 3XRTT, which signifies 3 · 1.25 MHz
AAA	Authentication, authorization and accounting
AC	Authentication center
AMPS	Advanced mobile phone service
ANSI	American National Standards Institute
ATM	Asynchronous transfer mode
BSC	Base station controller
BSS	Base station subsystem
CDMA	Code-division multiple access
CORBA	Common object request broker architecture
DS-41	Direct-sequence air interface on an ANSI-41 core network
GCP	Gateway control protocol
GPRS	General packet radio service
GSM	Global system for mobile communication
HA	Home agent
HDML	Handheld device markup language
HLR	Home location register
IMT-2000	International mobile telecommunication 2000
IOS	Interoperability standard
IP	Internet protocol
IS-2000	cdma2000 1X
IS-2000-A	cdma2000 3X
IS-95	Specification of the air interface used for CDMA
ISP	Internet service provider
ITU	International Telecommunication Union
IWF	Interworking function
LMDS	Local multipoint distribution system
MAP	Mobile application part
MGW	Media gateway
OHA	Operators Harmonization Agreement
PCN	Packet core network
PCS	Personal communication services
PDSN	Packet data service node
PSTN	Public switched telephone network
QoS	Quality of service
RBS	Radio base station
RTT	Radio transmission technology
SBS	Selector bank subsystem
SCE	Service creation environment
SCP	Service control point
SMS	Short message service
SMSC	SMS center
TIA	Telecommunications Industry Association
VoIP	Voice over IP
WAP	Wireless application protocol
WCDMA	Wideband CDMA
WIN	Wireless intelligent network

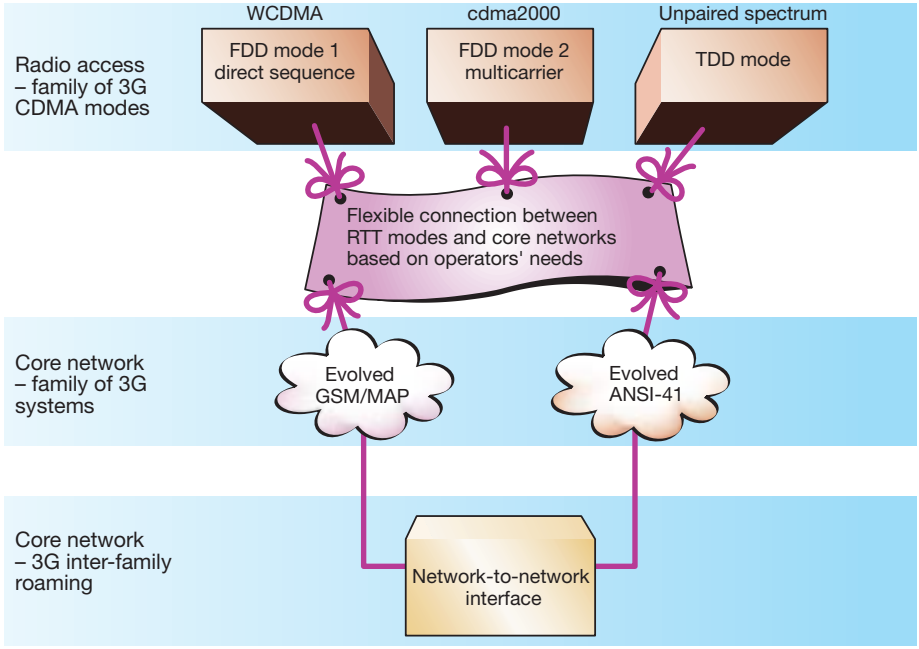


Figure 2
Operators Harmonization Agreement.

IS-2000-A/cdma2000 3X

The cdma2000 3X standard is scheduled for completion in early 2000. The term 3X, derived from 3XRTT, is used to signify three times 1.25 MHz or approximately 3.75 MHz. The cdma2000 3X multicarrier approach, or wideband cdmaOne, is an important part of the evolution of IS-95-based standards. In all likelihood, IS-2000-A will be followed by supplemental standards that offer additional functionality as the industry evolves. In short, cdma2000 3X

- offers greater capacity than 1X;
- offers data rates of up to 2 Mbit/s;
- is backward-compatible with 1X and cdmaOne deployments; and
- further enhances performance.

DS-41

Another migration path for cdmaOne operators is to evolve from cdma2000 1X to DS-41, or to introduce DS-41 into new IMT-2000 spectrum. As part of the Operators Harmonization Agreement (OHA) for third-generation systems, cdma2000 systems that are based on the multicarrier air interface and WCDMA systems based on the direct-sequence (DS) air interface (3.84 MHz) will be compatible with ANSI-41/mobile IP and GSM-MAP/general packet radio services (GPRS) core networks (Figure 2). Accordingly, cdmaOne operators can implement a solution that uses the direct-sequence air interface on an ANSI-41 core network (DS-41).

Most cdmaOne operators plan to implement cdma2000 1X for increased voice capacity and faster data rates. But instead of migrating to cdma2000 3X, many are eyeing other technologies, such as 1X with enhanced data, DS-41, or even local multipoint distribution system (LMDS), for high-speed data access. Ericsson understands the market's need for different paths of evolution and is fully prepared to support them.

Step 1: Upgrading cdmaOne systems with Ericsson infrastructure

Figure 3 shows the typical components of the cdmaOne system infrastructure. Ericsson provides the items depicted in blue, for expanding coverage and capacity through an open interface from the mobile switching center (MSC) to the CDMA access network. In cdmaOne systems, the open interface between the MSC and the base station controller (BSC) is generally referred to as the interoperability standard (IOS).

The original standard for the MSC-BSC interface in CDMA systems was defined in

the IS-634 specification from TIA. The IOS, which is a refinement of the IS-634 specification, has been broadly embraced by cdmaOne operators worldwide. Ericsson has deployed several IS-634 and IOS networks, and supplied equipment to the base station subsystem (BSS) of the world's first commercial implementation of the IOS (Figure 3).

The primary nodes in most present-day CDMA systems are the MSC, the radio-access network, a home location register (HLR), an interworking function (IWF), and a handheld device markup language (HDML) server. Other key elements include operations and network management systems, voice-mail servers and short message service centers (SMSC).

In most cdmaOne systems, the interworking function is an external piece of equipment that provides subscribers with data services and Internet connections. However, for more efficient and cost-effective delivery of data services, Ericsson's CDMA network offers the choice of embedding the interworking function and packet-data routers in the BSC.

The HDML server is used for delivering Internet content to cdmaOne phones that are equipped with HDML microbrowsers. In the near future, wireless application protocol (WAP) microbrowsers will also be introduced.

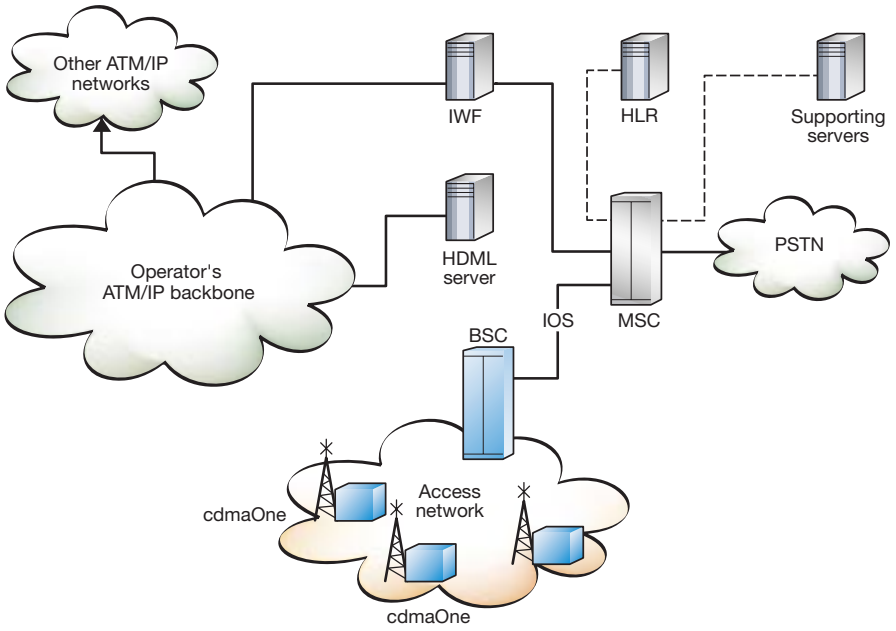


Figure 3
Step 1: The Ericsson BSS, which can interoperate with any present-day cdmaOne network.

Radio base stations

Ericsson's cdmaOne radio base stations (RBS) and BSCs support the current IOS interface. The RBS 1106 and 1107—which is Ericsson's most recent RBS product for CDMA—were designed using direct operator input for requirements such as:

- rapid network build-out;
- support of high-capacity and long-range coverage;
- low operating costs;
- high reliability;
- simple operation;
- low deployment costs; and
- support of future generations of technology (upgradeable to third-generation systems).

Available for operation in the 800 and 1900 MHz frequency bands, the RBS 1106 is a modular product that consists of a main unit and up to three isolated remote units (Figure 4). It is a true macro-cellular product (15 watts of output power at the antenna) in a micro-cellular package. The RBS 1107, which is a multicarrier version, was

Figure 4
The Ericsson RBS 1106—typical installation configuration.

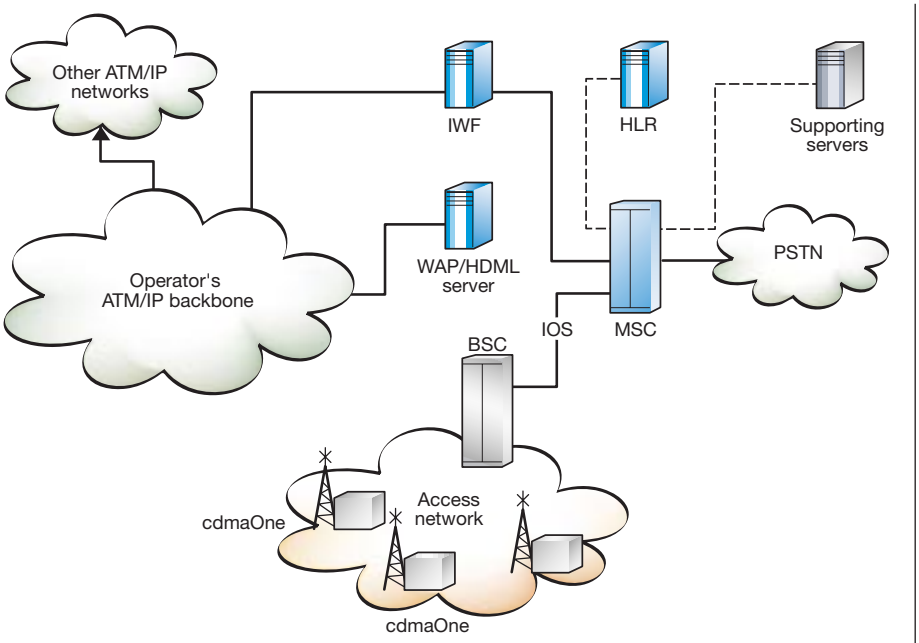


Figure 5
Step 2: Enhancing service offerings. New additions to the network are shown highlighted in blue.

announced in February and will be commercially available during the second half of this year.

BSC

Ericsson's CMS 11 BSC is a flexible and scalable packet-based product. When designing this product, engineers put special emphasis on

- the efficient handling of backhaul to and from base stations;
- advanced power control—to improve CDMA air-link capacity; and
- best-in-class processing of soft handoffs.

The CMS 11 BSC is currently the only product in the industry that can support cdmaOne packet-data services. It also has an integrated interworking function that allows operators to offer voice and data services via the same selector cards from the selector bank subsystem (SBS.)

Step 2: Increasing service offerings

Service differentiation and reduced costs of delivering existing services are operators' primary requirements. Step 2 of Ericsson's migration path introduces enhanced data, more features, and greater reliability. The Ericsson CMS 11 products that can be integrated for this step include the IWF, HLR, WAP gateway, and AXE 10 CDMA switching platform, each of which will be commercially available before the end of 2000. Because these products make use of open interfaces, they can be integrated into any CDMA network (Figure 5).

MSC

AXE 10, which is one of the most acclaimed, highly reliable switches in the industry for wireless applications, is well configured for delivering the services and features of tomorrow's layered network architecture. Ericsson's feature-rich switching platform can be installed by new customers or by existing cdmaOne operators who are interested in replacing their current switching solution. The AXE will be IOS-compliant and capable of supporting over 400,000 wireless subscribers. The CDMA version of the AXE 10 MSC will be available in mid-2000.

IWF

In response to operator demands for greater capacity, Ericsson will soon begin offering an external interworking function for processing cdmaOne data calls through the MSC. The interworking function, which will be based on the Tigris platform[1], can easily be migrated to new standards for third-generation systems. Ericsson's interworking function will offer more than three times the capacity of the nearest competitor's product.

HLR

To maintain a strong and loyal subscriber base, operators need new, high-value services that target an increasingly segmented end-user market. The open-interface Jambala platform[2], which is Ericsson's next-generation application platform, facilitates the delivery of industry-leading user features and introduces wireless intelligent networking (WIN) capabilities into CDMA systems.

Ericsson's CDMA HLR provides reliable operations with zero downtime. Furthermore, in addition to (or instead of) serving as an HLR, this multi-application platform can function as a service control point (SCP) or authentication center (AC). And because it supports Java and CORBA technology, the CDMA HLR also provides operators with an ideal service creation environment (SCE).

WAP gateway

WAP-capable phones will become available on the market in mid-2000. CDMA operators who want to offer WAP functionality can integrate Ericsson's CDMA WAP gateway. The WAP gateway system thus satisfies operator requirements for a server that provides standardized delivery of microbrowser Internet applications. Like the CDMA HLR, Ericsson's WAP gateway for CDMA is based on the Jambala platform.

Step 3: Improved packet-handling, Phase I 3G

To offer third-generation services, operators will have to invest in the access and core networks of their systems. Obviously, operators will be looking for solutions that are easy to adopt and provide a wide range of services. Initially, emphasis will be put on the introduction of high-speed mobile data services, multimedia services, and services that require a guaranteed quality of service (QoS). End-users will expect to have access to services anywhere and at any time. Moreover, they will expect reliable, secure connections during transmissions. Step 3 in Ericsson's solution for migrating cdmaOne systems to future third-generation systems begins with the addition of a cdma2000 1X access network and the introduction of new packet-data services, mainly in the form of mobile IP (Figure 6).

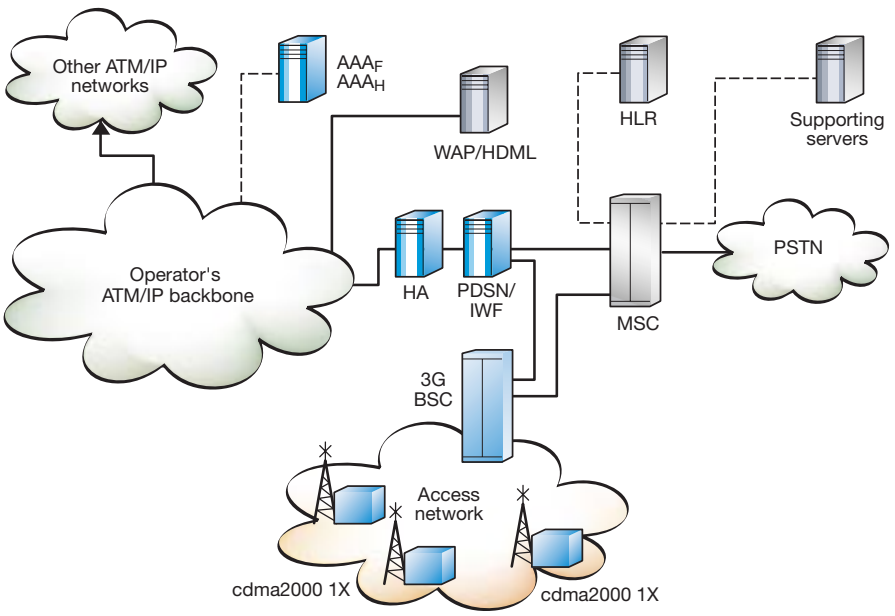


Figure 6
Step 3: Phase I 3G wireless capabilities.

cdma2000 packet core network

During the first quarter of 2001, operators will be able to enhance interworking functions from Ericsson with software and hardware that support the packet-handling capabilities defined for third-generation systems. The interworking function will thus also become a packet data service node (PDSN). Similarly, a new server can be added for authentication, authorization and accounting (AAA). Ericsson will also introduce home-agent infrastructure and home/foreign-agent software to support mobile IP functionality.

Mobile IP, which gives data users seamless mobility in and between CDMA networks, is the basis of the cdma2000 packet core network (PCN). Based on the Internet standard for mobility, mobile IP incorporates home agents (HA) and foreign agents (FA) into the CDMA packet data equation. The cdma2000 packet core network also offers mechanisms for more secure data delivery. The PCN standards for cdma2000 are being defined by the TR45.6 working group within TIA.

Because Ericsson's PCN solution is based on open interfaces, it can easily be integrated into any IOS-compliant cdma2000 infrastructure. The design of the cdma2000 PCN draws on the know-how Ericsson gained while developing its GPRS nodes for GSM and WCDMA systems. The Ericsson PCN makes efficient use of available spectrum and alleviates the need to use MSC channel resources when setting up data calls.

cdma2000 1X-capable BSS

Operators are demanding greater capacity for voice and faster data solutions. Having anticipated this development, Ericsson has designed a BSS for cdma2000 1X. The BSS (BSC and multi-carrier macro-RBS) for third-generation wireless network systems is based on an ATM/IP platform—the same platform on which Ericsson bases its WCDMA products. The RBS 1106 and

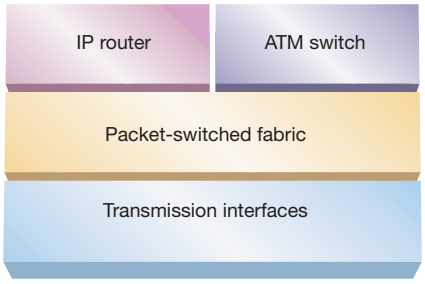


Figure 7
Ericsson's third-generation BSC.

RBS 1107 compact radio base stations (introduced in Step 1) can also be upgraded to support cdma2000 1X.

The third-generation BSS (BSC and RBS) for cdma2000 1X combines the advantages of IP with the QoS capabilities of ATM (Figure 7). Because the platform has been optimized for mobile technology, it can deliver IP services with the same kind of reliability as is associated with traditional telecommunications. Ericsson's BSS architecture also facilitates migration to voice-over-IP (VoIP) services and serves as the basis for media gateways (MGW, see Step 5).

Step 4: Phase II 3G

While many of today's cdmaOne operators are certain to migrate to cdma2000 1X, many are still defining their needs for migrating to even higher capacity, higher speed data networks. By supporting cdma2000 3X, DS-41, or other 1X enhancements, Ericsson's products are designed to give operators a number of options in the future.

Phase II 3G RBS

Ericsson's RBS products for Phase I 3G can be upgraded to support either cdma2000 3X or DS-41 wideband technology (Phase II 3G). After they have been upgraded, the radio base stations will support IMT-2000 data speeds of up to 2 Mbit/s over the air. The upgrade to Phase II 3G also includes improved capacity for voice (Figure 8). Moreover, the technology facilitates international roaming between cdma2000 and WCDMA systems (Figure 9).

Step 5: Fully layered architecture

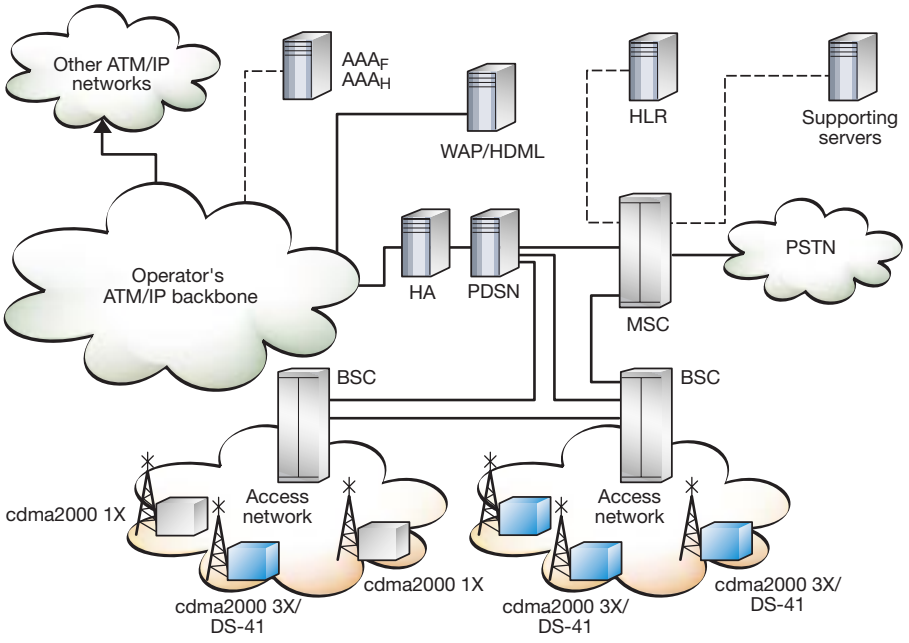
Step 5 of Ericsson's migration solution results in a fully layered network architecture (Figure 10). Wireless operators will structure their networks in layers for packet- and circuit-switched services, or migrate to all-IP systems. The finished network is composed of three layers:

- the user application layer;
- the control layer; and
- the connectivity layer.

User application layer

The user application layer will contain the services for which end-users are willing to pay. These services include e-commerce, global positioning services, and other differentiating services—each of which resides on off-network servers. In addition, some applications will be implemented in mobile terminals. Open application programming will be used between the off-network servers

Figure 8
Phase II 3G, Step 4: the addition of cdma2000 3X- or DS-41-capable radio base stations.



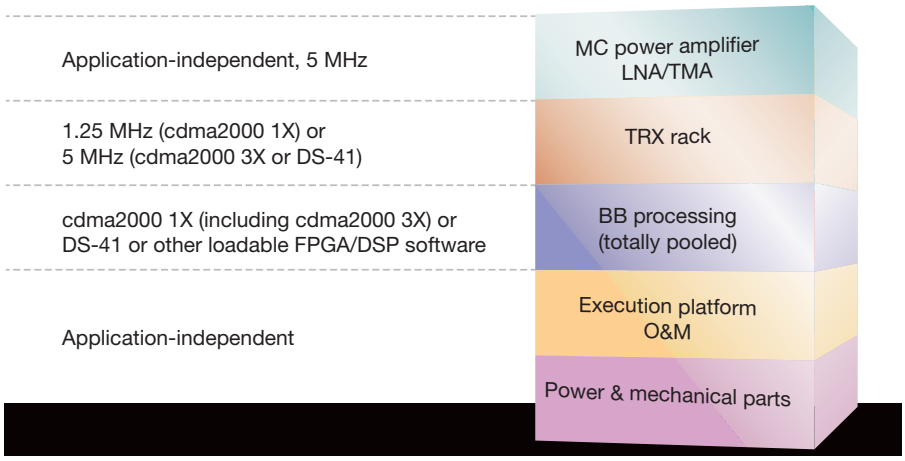


Figure 9
Design of Ericsson's third-generation RBS.

and the on-network control plane, to define the interfaces and to promote development compatibility with CDMA.

Control layer

The control layer, which is the "brains" of the overall network, incorporates all the network servers that are needed to provide services to any subscriber, regardless of whether he or she accesses the network from a wireline, wireless, or IP world. Typical servers in this layer are the HLR, SMSC, AC, AAA, and the newly introduced MSC server.

Connectivity layer

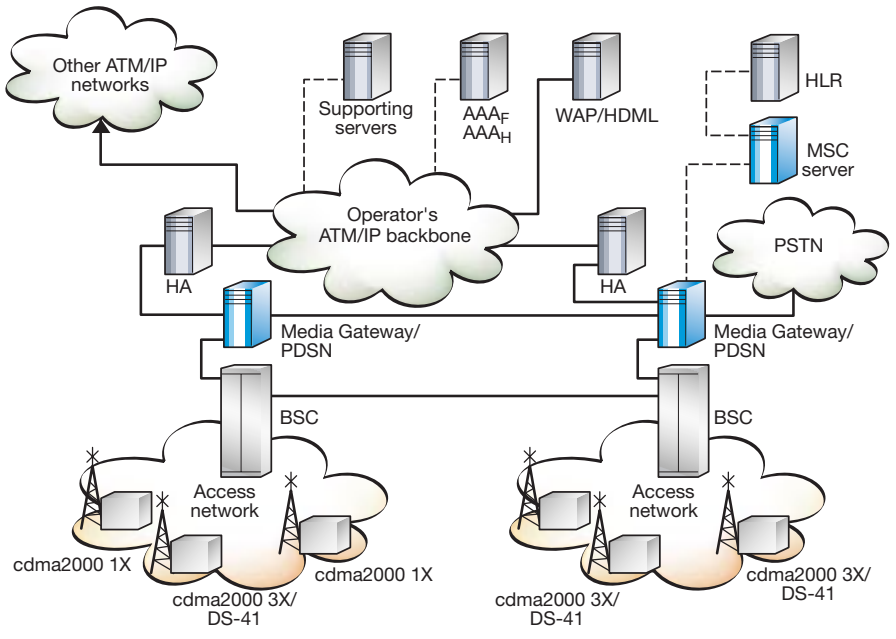
The connectivity layer handles the transport of all information, regardless of whether it is data or voice. This layer can use IP transport, ATM transport, or a combination of the two. The connectivity infrastructure can carry traffic from fixed line, cable-TV, wireless or mobile, and private networks, which means that investments made in transport gateways and transmission equipment are protected even if the traffic mix does not evolve as first expected.

The architecture of the connectivity backbone is divided into two parts: the core and the edge. Core network equipment transports all types of traffic between the service nodes in the operator's network. Typical components of the infrastructure include routers, ATM switches, and transmission media. Edge equipment, which provides the added intelligence that is needed to support the core bit stream of voice and data, is necessary for interpreting customer-specific instructions, guaranteeing QoS delivery, and forwarding information—for instance, billing information—to the control layer. Two examples of edge equipment technology in a cdma2000 network are the media gateway and the packet data service node.

Media gateway

The final step (Step 5) in migrating to a third-generation network is achieved primarily by dividing the functions of the MSC between a media gateway and an MSC server (Figure 10). This is accomplished by adding an IP/ATM interface to the current MSC and by introducing an open-interface media gateway into the network. AXE 10

Figure 10
Step 5: Introduction of media gateways.



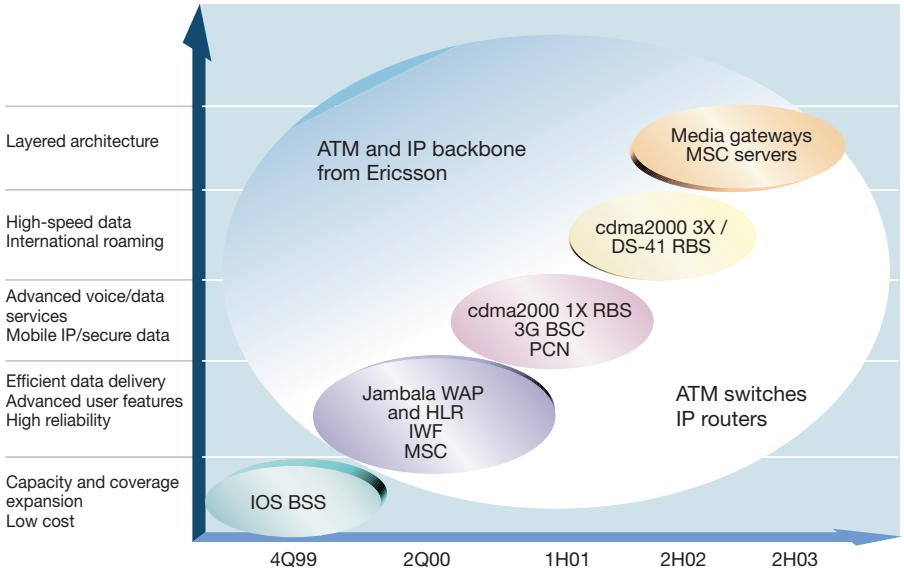


Figure 11
Ericsson's timeline for evolving CDMA to third-generation capabilities.

can be logically separated into an MSC server and a media gateway that supports ATM and IP transport.

Ericsson's media gateway for third-generation CDMA systems is based on the same third-generation ATM/IP platform that is being used for the BSC and the radio base stations. Since the emerging ITU standards for the gateway control protocols (GCP) are open, Ericsson's media gateway will interface to any MSC. The media gateway, which is controlled remotely by the MSC using GCP, contains a full set of voice and transport resources for converting protocols between different networks. It also provides signaling functionality for converting lower layer control protocols. In a third-generation system, the media gateway serves as the "edge" equipment for voice traffic; similarly, the PDSN becomes the media gateway for data traffic. This is why edge equipment in the layered architecture is labeled MGW/PDSN. Media gateways also serve as points of entry into the public switched telephone network (PSTN)—the circuit-switched world—while routers with or without home agents serve as edge equipment to the packet-switched world.

In terms of transmission, the layered architecture allows transcoders to be located at the edge of the cellular network, which yields gains in transmission efficiency. In traditional CDMA networks, the transcoders are located at the BSC and restricted by the IOS specification. Ericsson is working with standards bodies to promote optional transcoder locations, in order to exploit the full potential of the layered architecture.

Introduction timeline

Ericsson's timeline for Steps 1 through 5 is shown in Figure 11, where the X-axis indicates the introduction of commercial solutions—customer and field trials will occur prior to these dates. The Y-axis serves to remind operators of the benefits they stand to gain from each step in the evolution.

End-to-end solutions

Although the focus of this article has been on network elements that are specific to the evolution of systems based on IS-95 CDMA, it should be noted that Ericsson provides backbone solutions to complement this strategy. Indeed, Ericsson can provide operators with end-to-end network solutions—including routers, ATM switches, and edge and core network equipment—that meet current and future demands. As a leader in IP and ATM solutions, Ericsson can provide turnkey solutions for every possible element

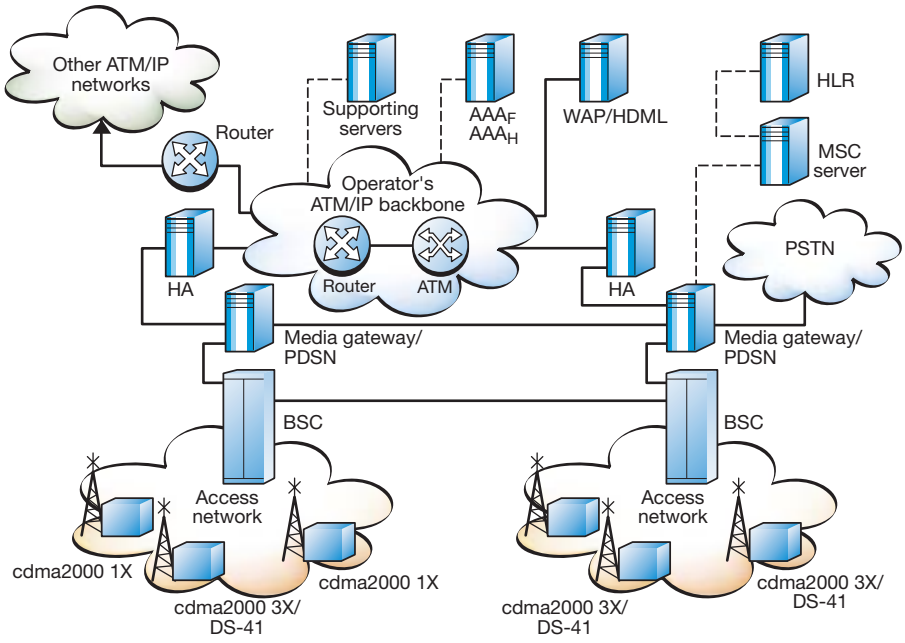


Figure 12
Ericsson's end-to-end solutions. Note: network elements are highlighted in blue. Ericsson can supply every element of a third-generation network.

of an operator's telecommunications network (Figure 12).

Conclusion

The market dynamics for cellular and PCS operators is quickly changing. Competition is increasingly being felt from wireline, ISPs, and VoIP providers. Through the acquisition and development of industry-leading CDMA expertise and resources, Ericsson has demonstrated strong commitment to the growth and evolution of IS-95-based CDMA systems. Ericsson has a strong product offering and a comprehensive five-step plan for migrating CDMA systems into third-generation systems.

A key consideration for operators is the installation of high-capacity access equipment that is small, simple to deploy, easily expandable, and can be adapted to new technologies. Ericsson's compact RBS platform was designed to fulfill these requirements.

A second consideration is the support of open interfaces and standardized system platforms. Ericsson has a full portfolio of IOS- and 3GPP2-compliant products.

A third consideration is the establishment of a packet core and switching platform that is positioned for future multimedia and data services. Here, too, Ericsson has the products operators need for early market entry.

A fourth consideration is the migration to a layered network architecture that paves the way for an all-IP network. Ericsson's end-to-end solutions enable operators to make this transition at their own pace.

As a strong participant in standards-related activities regarding the evolution of the air interface and wireless networks, Ericsson has a leading position relative to the introduction of centralized control and to the development of a single-transmission network for customer services. Operators who currently deliver wireless services with, or who are planning to install, cdmaOne technology can rest assured that Ericsson has solutions to all their current and future network needs.

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