

Prepared (also subject responsible if other) Ericsson AB		No. EWU-04:000203 UEN		
Approved Ericsson AB	Checked	Date 2004-02-20	Rev A	Reference

Migration to CDMA2000 1xEV-DV

An overview and checklist for Application Developers

1.1	Purpose	2
1.2	Introduction	3
1.3	Key features and characteristic of CDMA2000 1X EV-DV	4
1.3.1	Backward compatibility	8
1.4	Quality of service in the packet domain	9
1.5	Reverse link performance	9
1.6	Summary of key benefits for end-user applications	10
1.7	BREW	11
1.8	Upgrading to 1xEV-DV with Ericsson	11
2	Checklist – CDMA2000 1xEV-DV	12
3	Conclusions	14
4	Acronyms	14

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Approved Ericsson AB	Checked	Date 2004-02-20	Rev A	Reference

1.1 Purpose

The purpose of this document is to provide Ericsson Mobility World Application Partners with;

1. An understanding of the CDMA2000 1X evolution path.
2. An outline of the key features of CDMA2000 1xEV-DV and how they apply to end-user applications.
3. A checklist for migrating and/or delivering applications supported with CDMA2000 1xEV-DV.

Further, the intent of this document is to provide Ericsson Mobility World partners with additional information about CDMA2000 so as to encourage application developers to be more involved with providing/supporting applications for Ericsson's CDMA customers.

Reference sites:

www.ericsson.com/cdmasystems

www.3gtoday.com

www.phonescoop.com

http://www.ericsson.com/mobilityworld/sub/open/infrastructure/mobile_network_technology/index.html

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Approved Ericsson AB	Checked	Date 2004-02-20	Rev A	Reference

1.2 Introduction

CDMA2000 1X Evolution, (1xEV) is defined in a phased approach first with 1xEV Data Only (DO) followed by 1xEV Data Voice (DV) for integrated high-speed data and voice. This continued standardization effort leads to higher capacity, higher data speeds, and improved quality of service, providing end-users better and better experiences using the emerging mobile data services. Ericsson strongly supports the implementation of the third generation (3G) standards proposed by the Third Generation Partnership Project 2 (**3GPP2**), as they lead to more efficient solutions for our customers. Due to the strong support, CDMA2000 1x EV has always been part of the design plans for Ericsson's CDMA2000 products. However, an evolution of the standard does not necessarily mean that other 1X products on the market can easily evolve into 1xEV-DV. However, Ericsson supports solutions for each of the evolution scenarios mentioned and offers a CDMA2000 1X product that today can easily be upgraded to 1xEV-DO with a channel card addition and is additionally prepared to support 1xEV-DV as a channel card upgrade. This ease of migrations is due to much thanks to Ericsson's vision of offering a true 3G product.

In most scenarios, the end-users will continue to use voice services together with the mobile data services. The use of voice together with efficient packet data is addressed in 1xEV, but in two significantly different ways; 1xEV-DO requires a 1X carrier for voice and dual mode mobile devices whereas 1xEV-DV allows for a mix of voice services and data on the same carrier. The main 1X evolution options are:

1. **Integrated voice and data path - 1xEV-DV.** Go directly to 1xEV-DV that is backward compatible with 1X allowing for a gradual upgrade of mobile devices and carriers and a flexible mix of voice and high-speed data on the same carrier.
2. **Separated voice and data path - 1xEV-DO.** Introduce 1xEV-DO as a high capacity data complement to 1X as an overlay on a separate carrier. Dual mode mobile devices enable 1X voice together with 1xEV-DO high-speed data.

Both 1xEV-DO and 1xEV-DV are deployed in areas where there is a need for additional data capacity beyond the capacity of 1X. The existing 1X network can provide wide area coverage for both scenarios. The main difference is that the 1X network may be completely upgraded to 1xEV-DV in the first scenario whereas the second scenario requires a 1X network, or even 1X-EV-DV in the future, in parallel with the 1xEV-DO overlay to provide voice services to the 1xEV-DO users.

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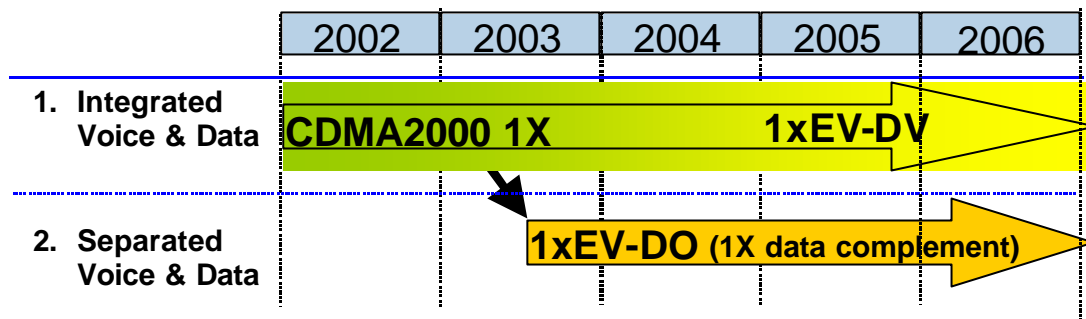


Figure 1: CDMA200 1X Evolution options

It is anticipated that due to the key characteristics and flexibility of CDMA, we expect to see a number of operators support a variety of air interfaces within their networks e.g. cdmaOne, CDMA2000 1X, CDMA2000 1x EV-DO and CDMA2000 1x EV-DV.

1.3 Key features and characteristic of CDMA2000 1X EV-DV

The first phase of 1xEV-DV has already been standardized by 3GPP2 and the final phase will be ready by end of 2003 for commercial products in 2005. Table 1 captures some main characteristics of the CDMA2000 air interface standards.

	CDMA2000		
	1X	1xEV-DO	1xEV-DV
Standard	IS-2000 0, A	IS-856	IS-2000 D
Published	Q4 1999	Q4 2000	Expected Q3 2003
Peak data rate	153.6 kbps FL/RL ¹ (0) 307.2 kbps FL (A)	2457.6 Mbps FL 153.6 kbps RL	3.0912 Mbps FL 1.2 –1.8 Mbps RL
Voice and data support	Voice + Data	Data only	Voice + Data

Table 1: CDMA2000 air interface standards overview

¹ FL – Forward Link; RL – Reverse Link

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Approved Ericsson AB	Checked	Date 2004-02-20	Rev A	Reference

1xEV-DO and 1xEV-DV are both high-speed data boosters with similar best effort data performance. 1xEV-DO is available today and currently supports over 1 million users worldwide. 1x EV-DO is a high-speed data complement to 1X on a dedicated data carrier. 1xEV-DV, based on IS-2000 rev. D provides both voice and data integrated on the same carrier as well as supporting backward compatibility with 1X. To many, 1x EV-DV is considered a more natural evolution of 1X.

Their main characteristics of 1x EV-DO and 1x EV-DV are summarized in Table 2.

	1xEV-DO	1xEV-DV
Packet data and QoS	Optimized for high-speed best effort packet data services	Optimized high-speed best effort data and real-time data services
Voice & data support	Dedicated data carrier, 1X carrier required for voice	<u>Integrated</u> voice and data on the same carrier
Backward compatibility	No backward compatibility	Backward compatible with 1X
Simultaneous voice & data	Either voice or high speed data, handoff between 1X an 1xEV-DO	Simultaneous voice and high speed data to the same user

Table 2: 1xEV main characteristics

Some of the key factors driving the evolution of the 1X standard are presented in Table 3. 1xEV-DO and 1xEV-DV addresses both the two major key factors that are increased data throughput and improved peak data rates in a similar way. The key difference is that 1xEV-DO does not address the evolution of 1X services and mobile devices and does not efficiently support packet based real time services such as voice and voice over IP. 1xEV-DO and 1xEV-DV therefore address slightly different needs.

1xEV-DO	1xEV-DV	Key factor
ö	ö	Increased data throughput per spectrum unit is a key factor since it directly translates to cost
ö	ö	Improved data peak rates are key for improving the average data throughput and potentially marketing data
	ö	Concurrent voice and high speed data per user allowing for increased data usage
	ö	Flexible mix of voice and data services on the same carrier allowing for better utilization of the spectrum
	ö	Backward compatibility with 1X protects investments already made in 1X infrastructure and 1X mobile devices

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Approved Ericsson AB	Checked	Date 2004-02-20	Rev A	Reference

	ö	Real time Quality of Service to provide real-time packet based services such as Voice over IP
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Table 3: Key factors for packet data success driving 1x-EV.

Table 4 outlines the CDMA2000 standards main characteristics with typically published numbers for average throughput per sector. The large range of data throughput numbers is due to its dependency on several factors such as the traffic model (applications being used, number of end-users using each application), channel conditions (pedestrian/vehicle, urban/rural), and scheduler (grade of fairness). The upper bound numbers are based on relatively idealistic simulations whereas the lower numbers can be experienced in less idealistic radio environment and usage patterns.

	CDMA2000		
	1X	1xEV-DO	1xEV-DV
Standard	IS-2000 0,A	IS-856	IS-2000 D
Multiplexing of users	Code multiplexed	Time multiplexed	Code multiplexed +Time multiplexed
Peak data rate	153.6 kbps FL/RL (0) 307.2 kbps FL (A)	2.4576 Mbps FL 153.6 kbps RL	3.0912 Mbps FL 1.2–1.8 Mbps RL
FL Throughput per sector	150 - 350 kbps	600 - 1200 kbps (4 times 1X)	600 - 1200 kbps (4 times 1X)
RL Throughput per sector	150 - 350 kbps	150 - 350 kbps (1x) (same as 1X)	300 - 700 kbps (2 times 1X)

Table 4: CDMA2000 characteristics.

More important than the specific data throughput is that 1xEV-DV and 1xEV-DO provides three to five times higher data throughput in the forward link than 1X for similar assumptions and the same radio environment. A typical data capacity increase of four times over 1X can therefore be assumed. 1xEV-DV has a penalty in terms of larger overhead for backward compatibility with 1X but has improved features such as higher peak rate and improved hybrid ARQ (retransmission) compared to 1xEV-DO resulting in similar forward link (base station to handset for downloading data) performance. It is generally more important to improve the forward link capacity and the 1xEV-DV reverse link (handset to base station for uploading data) capacity improvement of two times the 1X data capacity is seen to be more than sufficient. 1xEV-DO has a reverse link similar to 1X and therefore similar performance whereas the 1xEV-DV reverse link is improved and use many of the forward link improvements.

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Approved Ericsson AB	Checked	Date 2004-02-20	Rev A	Reference

Simultaneous voice and data (and concurrent per user)

Voice services will continue to be important when the mobile data services take off. The combination of more efficient packet data and voice services can actually help to increase the revenue per subscriber; the increased usage of mobile data will lead to increased use of the mobile device, which may also increase voice usage. Most data applications will complement voice services and used in the same device, which means that the end user must be able to concurrently use voice and data and be able to switch between voice and data. Equally important is a flexible allocation of voice and data applications on the same carrier, which allows for an unknown and changing mix of voice and data applications on the same carrier.

To provide simultaneous real time services and high-speed packet data, 1xEV-DV combines the best of two worlds; the code multiplexed 1X channels and the time multiplexed channels similar to 1xEV-DO on the same carrier. Both 1X and 1xEVDO are proven and demonstrated technologies ensuring commercially available 1xEV-DV products based on experiences from 1X and 1xEV-DO products.

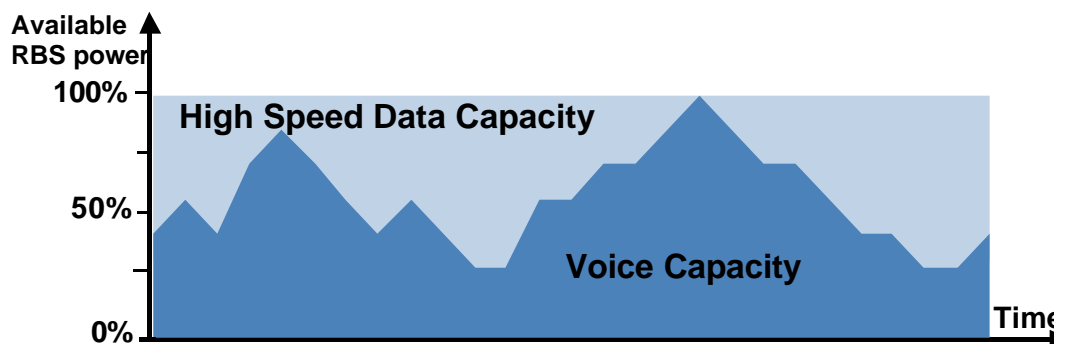


Figure 2: Flexible allocation of voice and data on the same carrier

The flexible allocation of voice and data services on the same carrier in 1xEV-DV, see Figure 2, allows for an unknown and changing mix of voice and data services, a mix that will change during the day, week days, and over the years (also refer to section 1.6 of this document). Voice and data on the same carrier allows also for prioritization of voice users over data the opportunity to prevent blocking by reducing data rate for high-speed packet data users.

The dynamic allocation of resources on a 1xEV-DV carrier takes places instantly by sharing the common resource, the power, in the following way:

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Approved Ericsson AB	Checked	Date 2004-02-20	Rev A	Reference

1. Determine the power required for supporting voice and packet services with a fixed bit rate and low delay on the code-multiplexed 1X radio channels.
2. Determine the remaining power that can be used for the time-multiplexed data channel for each timeslot and serve one user at a time with highest possible rate.

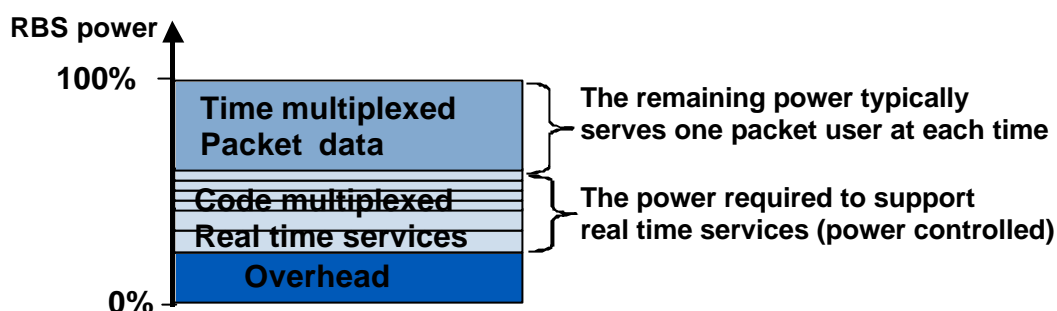


Figure 3: Sharing of power for code and time multiplexed channels.

1.3.1 Backward compatibility

Making 1xEV-DV backward compatible with 1X protects previous investments in 1X infrastructure and mobile devices, and allows for a gradual 1xEV-DV introduction. 1xEV-DV maintains all the voice and packet data capabilities of CDMA2000 1X and incorporates all existing CDMA2000 1X features, services, and applications by maintaining the 1X physical radio channels and upper layer protocols. The new physical time multiplexed channel enhancements described in the previous section provide the improved data performance. In other words, 1xEV-DV combines the best of two worlds; code multiplexed 1X radio channels for backward compatibility with 1X and new time-multiplexed radio channels for highly optimized packet data.

The 1xEV-DV carrier supports both CDMA2000 1X and cdmaOne mobile devices and services² as well as the new 1xEV-DV mobile devices and services. The 1xEV-DV mobile device is backward compatible with 1X and supports all 1X services due to the fundamental structure of 1xEV-DV incorporating the 1X channels. Therefore, the introduction of 1xEV-DV could initially be limited to capacity constrained sites. The 1X carriers provides the wide area coverage for 1xEV-DV users and can later be upgraded to 1xEV-DV when there is sufficient high-speed data demand in these sites.

² 1X is backward compatible with cdmaOne, therefore 1xEV-DV is backward compatibility with cdmaOne

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1.4 Quality of service in the packet domain

The variety of mobile data applications will have different Quality of Service (QoS) attributes, for example, different prioritization, delay and guaranteed bit rate. Real time applications such as Voice-over-IP require short delays and guaranteed bit rates whereas best effort services such as web browsing applications tolerate longer and varying delay and bit rates. It is therefore important to be able to offer proper QoS for different types of applications and to be able to charge accordingly to increase the revenue, it is generally more expensive from an air interface perspective to guarantee QoS compared to offer plain best effort

The 1xEV forward link improvements primarily target optimization of the best effort data throughput. The scheduling algorithm in 1xEV can introduce basic QoS in terms of relative prioritization between users but cannot efficiently guarantee delay or data rates without significantly reducing the data throughput. The code multiplexing approach in 1X is much better suited for guaranteeing short delays and constant data rates and is therefore used in 1xEV-DV to support real time services such as Voice over IP.

Quality of service for packet services can be introduced independently of 1xEV-DV already in 1X and to some extent in 1xEV-DO. The main difference between 1xEV-DO and 1xEV-DV is the support of real time packet based services such as voice over IP. The code multiplexed channels of 1xEV-DV and the shorter slots are needed to guarantee short delays efficiently.

1.5 Reverse link performance

The 1xEV-DV Reverse Link (RL) improvements are part of IS-2000 revision D and are anticipated to provide approximately twice the capacity of 1X packet data. Some of the key features that improve the reverse link similar to the forward link are:

- New modulation schemes in the RL allowing for up to 1.2 to 1.8 Mbps peak rates.
- Adaptive modulation and coding similar to the forward link
- Efficient retransmission schemes with ARQ retransmission on the physical layer

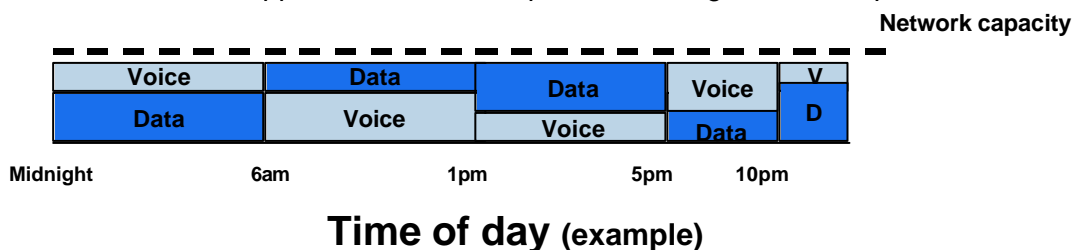
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Approved Ericsson AB	Checked	Date 2004-02-20	Rev A	Reference

1.6 Summary of key benefits for end-user applications

- Supports **simultaneous voice and data** – so that new or existing applications can be enhanced with the inclusion of voice. For example; play an interactive game with a friend and talk to them at the same time – to broaden the experience (simultaneous voice and data available with CDMA2000 1X and CDMA2000 1xEV-DV). Or, integrate voice in with the interactive game – say “shoot” instead of hitting a key.
- **Forward and backward compatibility** – to support and enhance existing applications available on CDMA2000 1X with higher speed data. Existing applications can be used on either network.
- Increased data speeds:
 - Forward link (i.e to receive larger data packets more quickly)
 - Reverse link (i.e to send larger data packets more quickly)



- Ericsson analyzed the **data throughput** on the reverse link using an algorithm proposed by Ericsson to 3GPP2
 - CDMA2000 1X, throughput to send a data file more then doubled with EV-DV. 292 kbps for 1X and 623 kbps for EV-DV
 - Therefore, we could assume that even at peak hours on the network, EV-DV users could expect over twice the throughput in half the time compared to their 1X service (half the time).
- Operators can support **flexible network scheduling** between voice and data services. This will allow application developers support applications that have peak-time usage. For example:



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Approved Ericsson AB	Checked	Date 2004-02-20	Rev A	Reference

- CDMA2000 1x EV-DV will be more efficient for web surfing and other bursty services. For example; MP3, due to the **multiplexing gains**.
- The **delay sensitivity traffic** can be scheduled with higher priority, as there is no set-up delay with EV-DV compared to CDMA2000 1X.

- Four key attributes in which to compare/contrast wireless data services

Attribute	Description	Improvements with EV-DV	End-user services enriched
Jitter	The (near) constant rate	More flexible rates	Streaming media, video conf, VoIP (quality)
Throughput	The speed of data delivery	Better statistical multiplexing gains, higher data capacity	Web services – bursty demands (e.g. MP3 downloads)
Delay sensitivity	Response times	No set-up delay, fast transmission	Interactive games
Frame/ packet error rates	Error tolerance	Flexibility to select packet error rate	All services

1.7 BREW

Many commercial applications available today are supported by BREW (<http://www.qualcomm.com/brew/>). Ericsson's CDMA2000 equipment supports BREW applications.

1.8 Upgrading to 1xEV-DV with Ericsson

The Ericsson CDMA2000 1X and 1xEV-DV architectures are the same with the same interfaces to the core network and between the BSCs, see Figure 4. 1xEV-DV uses IOS-standardized interfaces enhanced to support 1xEV-DV. The existing Packet Core Network (PCN) and the existing circuit-switched core network and Mobile Switching Center (MSC) are used for 1xEV-DV.

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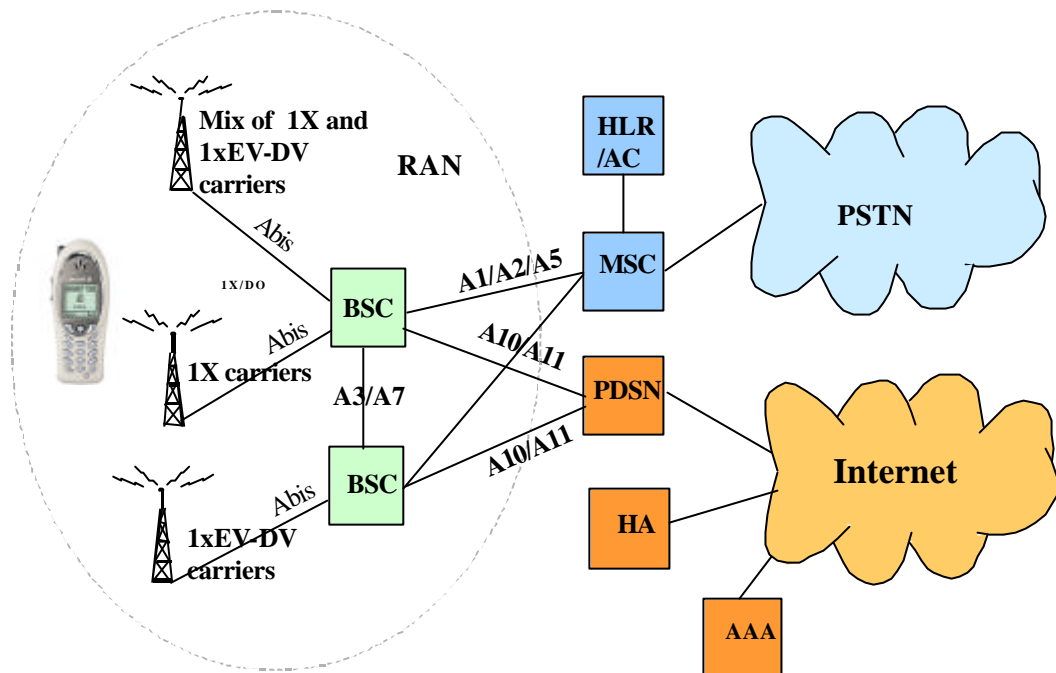


Figure 4: System Architecture of the 1xEV-DV system.

2

Checklist – CDMA2000 1xEV-DV

- **Development tool kit(s)** – Due to the inherent forward and backward compatibility of CDMA2000, by definition, applications working on CDMA2000 1X should also be able to be easily supported/ported to CDMA2000 1x EV-DV. There are a wide variety of commercial CDMA2000 1X networks in order for applications to be tested. The approach of utilizing CDMA2000 1X commercial networks to test and demonstrate new applications are proving to be very convincing forms of application acceptance with many operators.

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- **Device Emulators** – Ericsson does not have device emulators available for CDMA2000 1xEV-DV. However, device emulators will not be required when testing applications for EV-DV. Commercial CDMA2000 1X networks could be utilized to test end-user applications concept.

- **Network Simulators** – Ericsson has available simulated air interface early that can be used to test DV applications, however this is not needed to prove the commercial viability of end-user applications in a CDMA network. Due to the inherent forward and backward compatibility of CDMA2000, by definition, applications working on CDMA2000 1X should also be able to be easily supported/porting to CDMA2000 1x EV-DV.

Prior to the commercial availability of Ericsson's CDMA2000 1x EV-DV equipment, Ericsson has been demonstrating EV-DV by simulating the terminals and emulating the new features of CDMA2000 1x EV-DV.

- **How will existing applications be ported?** - Due to the inherent forward and backward compatibility of CDMA2000, by definition, applications working on CDMA2000 1X should also be able to be easily supported/porting to CDMA2000 1x EV-DV. It is as simple as if end-users are in 1X coverage using an application, they would experience 1X radio features. If the end-user moved to an EV-DV coverage zone (using the same application), they would experience the EV-DV radio features as outlined in Table 1.

- **Handsets (clients)** – (At the time of writing this document) Nokia, Samsung and a few other handset manufacturers have committed to supporting and supplying CDMA2000 1x EV-DV handsets. An update on CDMA2000 1x EV-DV terminals can be found at www.3gtoday.com or www.phonescoop.com

- **New applications** - Ericsson strongly believe that future wireless data applications will continued to be based on "user needs" and that there will be more of the same applications enhanced with the following:
 - Higher data speeds
 - Easier access
 - Increased user security (protection of the user from encroachment on the private environment)
 - Improved picture and sound quality
 - More rapid response times (instantaneous)
 - Interfaces e.g. voice recognition; face expression and gesture recognition

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Approved Ericsson AB	Checked	Date 2004-02-20	Rev A	Reference

- Increased personalization – supported by agents
- Involvement of more senses: (Now: sight and hearing. Future: touch, smell, taste and thought)

3 Conclusions

For many operators, 1xEV-DV is a more optimal and natural evolution of CDMA2000 1X, especially with Ericsson's CDMA2000 solution. 1xEV-DV supports both voice and high-speed data on the same carrier and is backward compatible with 1X. 1xEV-DV flexibly supports any mix of voice and high-speed packet data on the same carrier including real time packet services such as voice over IP. 1xEV-DV combines proven and demonstrated 1X and 1xEV-DO technologies. The fact that commercially available 1xEV-DV products have utilized experiences both from 1X and 1xEV-DO deployments, further rationalizes the forecasted commercial success of CDMA2000 1x EV-DV.

Ericsson is a leading participant in 3GPP2, especially with the standardization of 1x EV-DV. Ericsson's standards participation further allows Ericsson's CDMA2000 products to be designed to easily evolve to 1xEV-DV and support end-user applications. That is, 1x EV-DV has always been part of the design plans for Ericsson's CDMA2000 products. However, an evolution of the standard does not necessarily mean that other 1X products on the market can easily evolve into 1xEV-DV. An economical and easy migration to future generation technologies such as 1xEV-DV requires a CDMA2000 1X platform that is designed for future services. Ericsson has a leading design that limits the hardware impact of 1xEV-DV to a replaceable channel card in the base station. CDMA2000 customers require a future proof BSC architecture that only requires new software to support 1xEV-DV and that can handle the four times data capacity increase.

Ericsson's CDMA2000 1X product line is prepared to support 1xEV-DV with an easy channel card upgrade that allows for any mix of 1X or 1xEV-DV carriers in the same Ericsson base station and a software upgrade in the BSC. Thus, Operators selecting Ericsson as their CDMA2000 supplier will be competitively position to evolve their network for future growth and services.

4 Acronyms

1xEV-DO	1X Evolution Data Only
1xEV- DV	1X Evolution Data and Voice
3G	Third generation
3GPP2	Third Generation Partnership Project 2
AAA	Authentication, Authorization and Accounting
AAL2	ATM Adaptation Layer 2
ACK	Acknowledged
ATM	Asynchronous Transfer Mode
ARQ	Automatic Repeat reQuest

Prepared (also subject responsible if other) Ericsson AB		No. EWU-04:000203 UEN		
Approved Ericsson AB	Checked	Date 2004-02-20	Rev A	Reference

BPSK	Binary Phase Shift Keying
BSC	Base Station Controller
CDM	Code Division Multiplexed
HA	Home Agent
ET	Exchange Terminals
FL	Forward Link
F-BCCH	Forward Broadcast Control Channel
F-CPCCH	Forward Common Power Control Channel
F-PDCH	Forward Packet Data Channel
F-PDCCH	Forward Packet Data Control Channel
IOS	Interoperability Specification
ISP	Internet Service Provider
IR	Incremental Redundancy
Kbps	Kilobytes per Second
MS	Millisecond
MSC	Mobile Switching Center
NACK	Not Acknowledged
PC	Personal Computers
PCN	Packet Core Network
PDA	Personal Digital Assistants
PDSN	Packet Data Serving Node
PSK	Phase Shift Keying
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
OTD	Orthogonal Transmit Diversity
OVSF	Orthogonal Variable Spreading Functions
RAN	Radio Access Network
RBS	Radio Base Station
RC	Radio Configuration (such as RC1, RC2 and RC3)
RL	Reverse Link
RLP	Radio Link Protocol
R-CQICH	Reverse Channel Quality Indicator Channel
R-ACKCH	Reverse Acknowledgement Channel
SO	Service Option
STM	Synchronous Transfer Mode
STS	Space-Time Spreading
TDM	Time Division Multiplexed
VoIP	Voice Over IP