GSM and WCDMA—Common network approach

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Many of today's GSM operators view WCDMA as a technology enhancement that enables them to offer new data services and as a cost-effective extension in capacity for voice service.

Operators who are rolling out WCDMA and EDGE are advised to pay extra attention to the end-user experience, because end-users expect the quality of the new bearers to exceed that of GSM. Operators who introduce WCDMA coverage are thus advised to build a WCDMA layer that provides continuous coverage and offers sufficient capacity. They should also build out WCDMA indoor coverage.

Initially, those GSM operators who deploy WCDMA will experience significant gains in capacity. But eventually they will want to use all available radio spectrum as a common resource. Doing so, however, will require traffic-steering mechanisms. Ericsson has already begun introducing mechanisms for steering traffic between WCDMA and GSM. Parameters that trigger redirection are load, coverage, a specific service, or QoS requirement.

Giving ample consideration for end-user perception and the optimization of network resources, Ericsson has identified and addressed an enhanced approach to idle-mode distribution. This, in turn, has resulted in four main assertions: (a) the mobile station should camp in the network that can most efficiently provide the requested subscriber service; (b) lack of coverage is the prime justification for employing mechanisms that steer traffic between different radio access technologies; (c) traffic-steering mechanisms for balancing load should be designed for the dominant application; and (d) end-users need not be aware of which underlying radio access technology is currently serving them. To steer the traffic of ongoing sessions, the performance of the underlying service-continuity mechanism must match the QoS class, and relevant services must be available both in WCDMA and GSM.

BOX A, TERMS AND ABBREVIATIONS

3GPP	Third-generation Partnership Project
CAPEX	Capital expenditure
CS	Circuit-switched
EDGE	Enhanced data rates for global evolution
GGSN	Gateway GSN
GPRS	General packet radio service
GSM	Global system for mobile communication
GSN	GPRS service node
GUI	Graphical user interface
HLR	Home location register
IPMM	IP multimedia
MGW	Media gateway
MMS	Multimedia messaging service
MSC	Mobile switching center
OPEX	Operating expense
PS	Packet-switched
QoS	Quality of service
RAT	Radio access technology
SGSN	Serving GSN
SMS	Short message service
SMSC	SMS center
WCDMA	Wideband code-division multiple access

Introduction

The introduction of GPRS established the veracity of data services in mobile environments and pointed the way toward rich-multimedia services. However, much of the vision that spawned from GPRS could not be realized until greater bandwidth and higher bit transfer rates became available, for example, via WCDMA and upgrades of GSM with EDGE.

To bring multimedia services to market without jeopardizing their business (in terms of revenue and capital expenditure, CAPEX) operators need a smooth network upgrade. GSM has already been widely deployed and many operators are currently in the process of deploying WCDMA. Their objective, of course, is to derive increased streams of revenue from past and present investments. An important factor in this context—given that the systems will run in parallel for many years—is efficient co-existence. Ericsson has had this in mind while developing its products.

Many of today's GSM operators view WCDMA as

- a technology enhancement that enables them to offer a plethora of new data services; and
- a cost-effective extension in capacity for voice service.

Initially, GSM operators who deploy WCDMA will experience significant gains in capacity. Eventually, however, as they reach the limits of that capacity they will want to use all available radio spectrum as a common resource. This will require mechanisms for steering traffic between WCDMA and GSM. One objective of doing so will be to balance load between the two systems. One other objective will be to steer traffic by service—for example, operators might want to steer voice traffic to GSM to free up WCDMA resources for high-bit-rate services and video telephony.

Because enhanced services are expected to increase operator revenues, it stands to reason that operators are anxious to offer as many services as possible across a broad area of coverage. The service offerings in WCDMA and GSM must thus be aligned so that new service roll-outs are not entirely dependent on WCDMA coverage. Instead, new services can be rolled out to take advantage of WCDMA and GSM. Continuity mechanisms, which facilitate smooth handover between GSM and WCDMA during ongoing sessions, will guarantee that

end-users experience a seamless transition of service.

Roll-out

The end-user experience is very important when operators introduce new mobile access technologies, because end-users expect the quality of the new bearer to exceed (or at least match) existing GSM bearers. Therefore, when introducing WCDMA coverage, operators should build a WCDMA layer that provides continuous coverage and sufficient capacity to optimize service and satisfy end-user perception (minimum number of handovers, dropped calls, and so on).

Operators should also build out WCDMA indoor coverage to guarantee good user perception of new services.[1] Likewise, to minimize inter-system handover and boost perceived service quality, operators should provide coverage along main thoroughfares that run between individual islands of WCDMA coverage.

Some operators have chosen to deploy WCDMA; others are upgrading their GSM/GPRS networks to include EDGE functionality; and some are doing both. These activities are being carried out in parallel, initially in densely populated areas. Operators are thus providing new data services to virtually every customer segment, which will further stimulate data usage. After they have covered densely populated areas, deployment will continue in other areas in response to market demand.

Implementing EDGE has only a minor impact on existing GSM/GPRS networks—that is, operators can upgrade their networks rapidly and easily with only minor hardware and software upgrades. Herein lies the

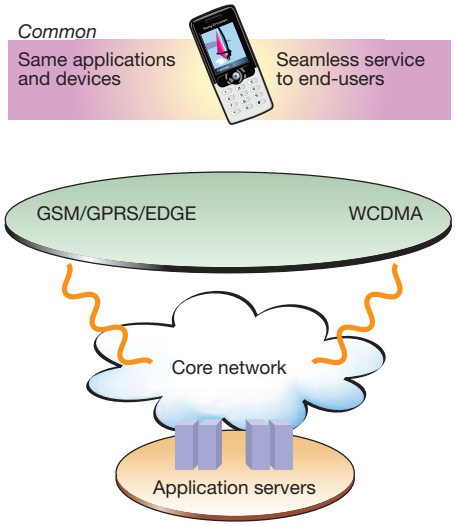


Figure 1
Complementary technologies enable end-users to use the same applications and devices seamlessly in GSM and WCDMA networks.

BOX B, NODE ASPECTS OF A COMMON NETWORK APPROACH

Ericsson knows that operators want to run their GSM and WCDMA networks as a single, common network. Therefore, each of Ericsson's nodes has been developed to handle GSM and WCDMA access.[2] Having a common core network enables operators to connect different kinds of radio access to the same core network nodes. Ericsson's home location register (HLR), serving GSN (SGSN), gateway GSN (GGSN), mobile switching center (MSC), IP multimedia (IPMM) and media gateway (MGW) are thus each fully compatible with GSM and WCDMA. Similarly, to guarantee seamless service, all of Ericsson's service layer and application nodes, such as multimedia messaging service (MMS) servers and the SMS centers (SMSC), are fully compliant with GSM and WCDMA.

The operator's network management system must also view and enable GSM and WCDMA networks to serve as a common network, giving each application a uniform graphical user interface (GUI, same look and feel) and greatly facilitating fault management and performance management in the core network, GSM radio network and WCDMA radio network.

Ericsson provides solutions for operators who share sites for GSM and WCDMA radio networks to greatly reduce their CAPEX and operating expenses (OPEX).[3] The same is true for operators who use a common transmission solution for GSM and WCDMA accesses.

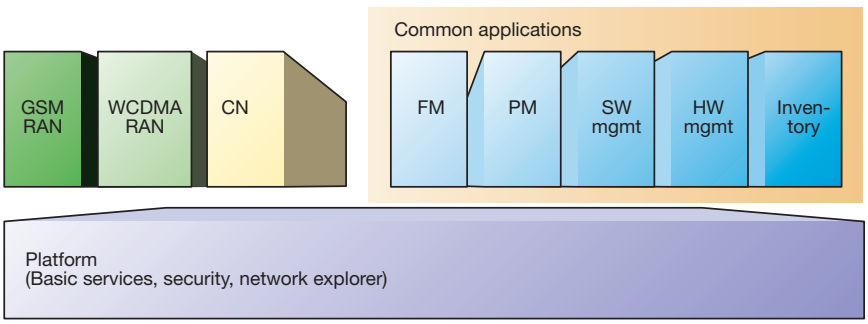
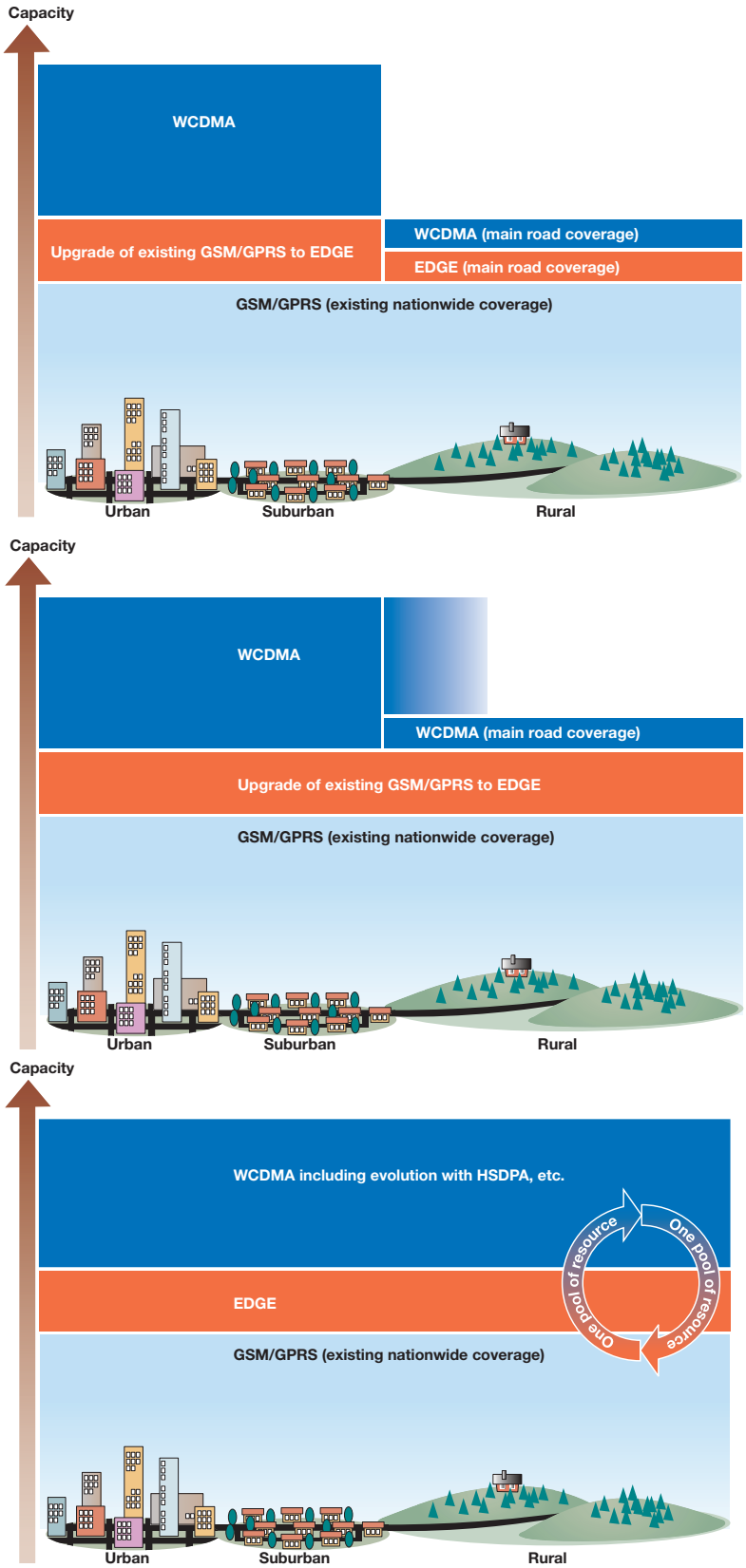


Figure 2
Network optimization.

Figure 3
Roll-out evolution.



strength of EDGE: it gives operators the ability to win larger market share by launching initial third-generation services early and with broader national coverage. Operators can thus offer new nationwide services to every user segment.

Likewise, the introduction of HSDPA—an additional booster of WCDMA network capacity and performance comparable to the introduction of EDGE in GSM/GPRS networks—constitutes only a minor network upgrade of the installed base. The new functionality further enhances the user experience and facilitates the introduction of a broad array of custom-made end-user service packages.

Traffic-steering mechanisms

To help operators to realize a common network approach for WCDMA and GSM, Ericsson has begun introducing mechanisms for steering traffic between WCDMA and GSM. These mechanisms are needed to support the roll-out of WCDMA and to facilitate subsequent optimizations. A common belief in the industry is that traffic-steering mechanisms—triggered either by service or network load—will be used from the outset to shift every kind of traffic between WCDMA and GSM. This tactic is not viable, however. According to the present 3GPP standard, packet-switched services are subject to long interruptions during changeovers between radio access technologies (RAT). What is more, the 3GPP standard does not sufficiently support RAT changeover for some services. Finally, RAT changeovers degrade end-user perception of quality of service (QoS), and if frequent, give rise to excessive network load.

With traffic-steering and service-continuity mechanisms, WCDMA and EDGE networks can be used as a common pool of resources. The ultimate aim, of course, is to optimize the use of these resources. A flexible portfolio of traffic-steering mechanisms can give different operator-specific optimizations. Traffic-steering mechanisms are employed in three main stages:

- to distribute mobile stations in idle mode between GSM and WCDMA (idle-mode distribution);
- to redirect calls to accommodate a service request during call or session setup; and
- to redirect ongoing calls or sessions.

Parameters that trigger redirection are load,

coverage, a specific service, or required quality of service.

Giving ample consideration for two essential drivers—end-user perception and optimization of network resources—Ericsson has identified and addressed an enhanced approach to idle-mode distribution. This, in turn, has resulted in a number of assertions as follows:

- The mobile station should camp in the network that can most efficiently provide the requested subscriber service.
- Lack of coverage is the prime justification for traffic-steering mechanisms for inter-RAT changeover.
- Traffic-steering mechanisms for balancing load should be designed for the dominant application.
- End-users need not be aware of which underlying radio access technology is currently serving them.

Idle-mode camping

In areas where WCDMA and GSM coverage overlap, the cell re-selection procedure directs mobile stations in idle mode to camp on either a GSM or WCDMA cell. A random distribution of mobile stations in such an area might require the system to change radio access technologies when establishing calls or sessions. But without adequate traffic-steering mechanisms in place, the system might be unable to establish service. For example, a subscriber who is camping on GSM and requests a 384kbps packet-switched service (which can only be provided via WCDMA) cannot be served unless the system supports a redirection mechanism to WCDMA.

Consequently, given that mechanisms do not currently exist for steering GSM subscriber traffic to every WCDMA service or for steering WCDMA subscriber traffic to every GSM service, operators should not use a random idle-mode distribution. Instead, they can configure broadcasted radio parameters to direct mobile stations to camp either on WCDMA or GSM—that is, by penalizing surrounding cells, they can control the outcome of cell re-selection procedures.

Given the limitations of the current standard, and consequently, implementation, Ericsson recommends that operators set the radio parameters to direct all dual-mode mobile stations to camp on WCDMA. When a mobile station requests service, the system can, if necessary, move voice connections to GSM. This solution gives direct access to WCDMA services. At present, no

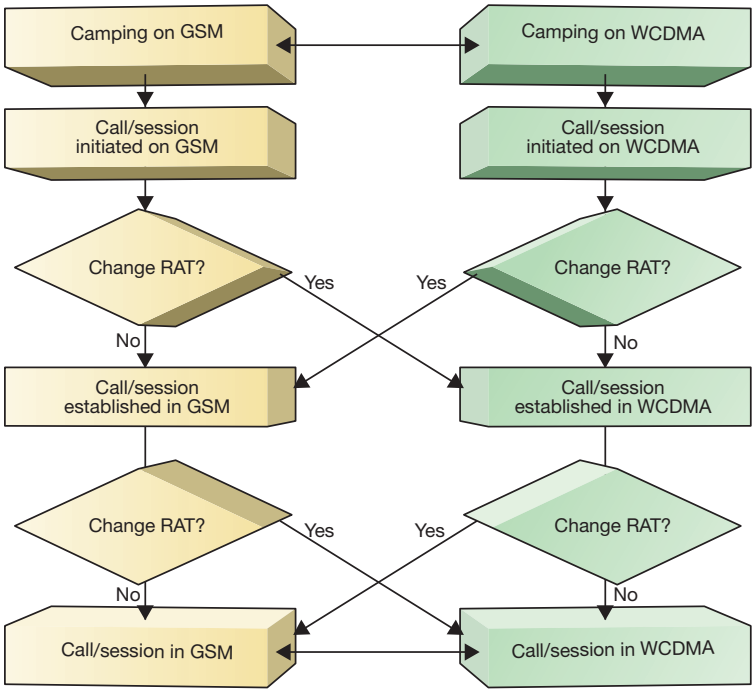
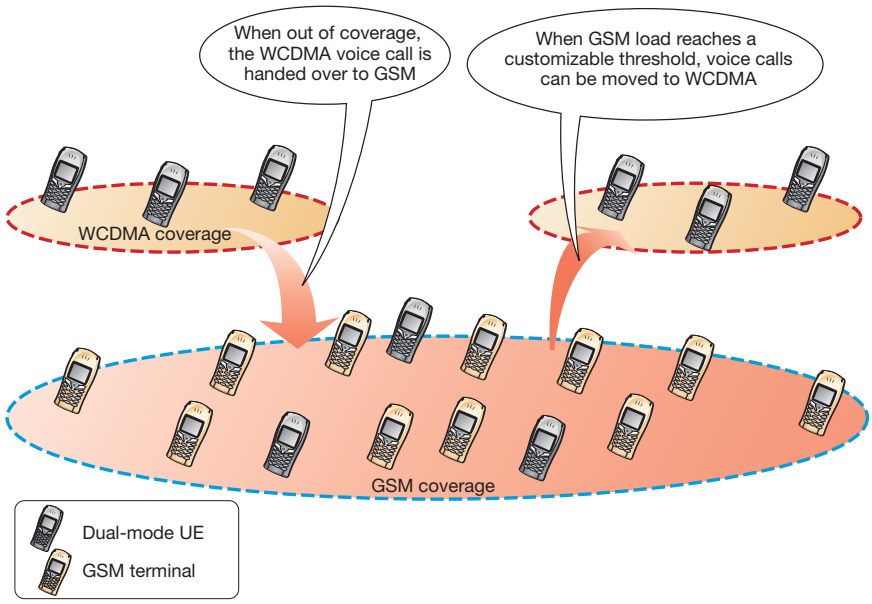


Figure 4
Traffic control between GSM and WCDMA. The illustration describes the complete set of possibilities for transferring traffic between WCDMA and GSM. Each arrow represents a different technical solution. Note in particular that there are major differences between inter-system solutions for circuit-switched calls and packet-switched sessions.

Figure 5
WCDMA camping and voice handover.



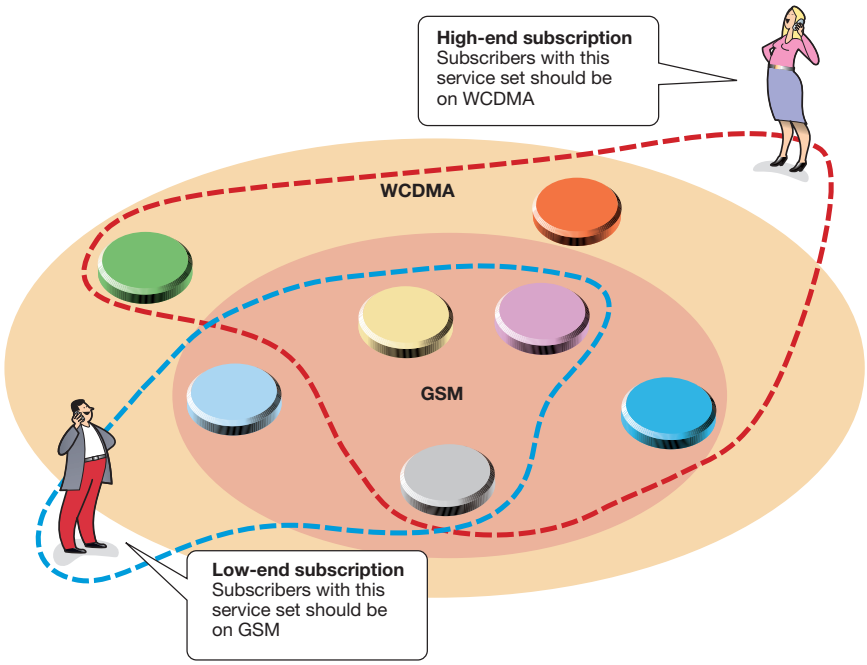


Figure 6
Subscriber differentiation.

mechanisms exist for reaching WCDMA services—such as video telephony and high-bit-rate packet-switched data—from GSM during call or session setup.

Provided the penetration of dual-mode mobile stations is relatively low, having them camp on WCDMA will not cause inefficiencies in the network.

One solution to the problems associated with idle-mode distribution is to restrict location registration. The system can use subscription information to determine whether a subscriber should be restricted to GSM or WCDMA access—for example, by defining subscriptions that nearly always use services offered in GSM and subscriptions that nearly always use services in WCDMA. This information could then be used to control where mobile stations camp.

In the long term, a more advanced method of distributing mobile stations in idle mode might predict service from a history of usage. Operators can thus maximize network capacity by basing the distribution of mobile stations on actual radio quality. What is more, these two methods may be combined so that the distribution of mobile stations in idle mode

- minimizes the need for system change during call setup; and
- maximizes network capacity.

Redirection at call setup

There are two main reasons for using traffic-steering mechanisms during call setup:

- to reach services that are solely available in the other network; and
- to balance load.

The directed retry from GSM to WCDMA for video telephony is one example of a service-reachability mechanism being standardized in 3GPP. One other example is traffic redirection (GSM to WCDMA) for high-bit-rate packet-switched services.

The steering of packet-switched services

is currently an issue because system change is regulated by the 3GPP cell-re-selection procedure, which interrupts data transfer for intervals of up to 10-15 seconds. Obviously, this is unacceptable for some applications. Standardization efforts are underway to introduce handover for packet-switched services that will minimize these interruptions. Notwithstanding, the 3GPP must still address mechanisms for actively steering packet-switched services (by load or content) between WCDMA and GSM.

Ericsson is introducing traffic redirection for voice at call set-up, a so-called Directed retry WCDMA to GSM. This mechanism, which helps operators to manage load during call setup, is triggered by service or a configurable load threshold.

Redirection during ongoing calls or sessions

Ericsson already supports a basic redirection mechanism for handing over voice calls. In the initial releases, handover from WCDMA to GSM is triggered by lack of coverage; handover from GSM to WCDMA is triggered by load (overload).

When packet-data traffic begins to dominate, operators will also need to redirect traffic from ongoing sessions of packet-based services.

Load balancing

Initial parallel deployments of GSM and WCDMA will have WCDMA offloading GSM. Eventually, however, unless operators introduce load-balancing mechanisms, a shortage of radio resources will give rise to a bottleneck. Two prerequisites for balancing load follow:

- the service can be offered in WCDMA and GSM with similar quality; and
- mechanisms are in place for steering the service to the other radio access technology.

In particular, given that voice service is expected to continue generating considerable traffic, load-balancing mechanisms will be needed to address this service. Ericsson currently supports efficient load balancing for voice during call setup and during ongoing voice calls. Directed retry is used during call setup to offload WCDMA to GSM; likewise, handover is used during ongoing calls to offload GSM to WCDMA. However, to obtain the most efficient balance of load between WCDMA and GSM radio resources, one should tackle the problem while the mobile stations are still in idle mode. This is because the most efficient way of serving a mobile station is to provide it with the requested service via the system on which it is camping. Doing so reduces the time it takes to establish service and makes optimum use of network resources. System changeover, by contrast, increases time for call setup, which has a negative effect on perceived quality of service. Also, the increase in network signaling increases the load on network resources.

As packet-data volumes grow and account for more traffic, operators might also need to redirect packet-data traffic to balance network loads.

Subscriber differentiation

To maximize revenues, some operators may need to differentiate between GSM and WCDMA subscriptions—for example, by adapting the service offering to different subscriber groups. This way, operators can offer distinct charging packages to users who predominately use a given application or who require a specific quality of service. Operators can establish basic differentiation by offering the subscribed services in either GSM or WCDMA. Doing so might also give them greater control over quality of service. Eventually, operators and end-users might also be able to dynamically update subscription data according to their current needs.

Besides being employed as a traffic-steering mechanism for controlling the distribution of load, restricted subscription-based location registration can also be used for differentiating subscribers.

BOX C, EXAMPLE OF POSSIBLE THREE-LEVEL LOAD DISTRIBUTION

Level 1: Load distribution for dual-mode WCDMA/GSM mobile stations in idle mode can restrict registration by location (location registration restriction)—for example, if operators need to restrict certain subscriptions. Operators can base restrictions on subscribed service or history of service usage. The former criterion can be used where traffic-steering mechanisms do not exist for subscribed services or in cases where the specific quality of service is available in only one of the networks. The latter criterion reduces system changes but requires traffic-steering mechanisms when the requested service is not available in the current network.

Level 2: Load distribution (also executed in idle mode) can be regulated via the parameters broadcasted for the cell-selection procedure. By adjusting these parameters, operators can distribute mobile stations between networks, provided the mobile stations can be served equally well by either network. To avoid local overload while still in idle mode, Ericsson recommends that operators set the parameters at cell level.

Level 3: Load distribution consists of redirecting traffic during call setup and during ongoing calls. At this level, Ericsson believes that load will suffice as a trigger for redirecting voice services, because once load has been distributed as described in levels 1 and 2, the remaining need for distributing load will be minimal thanks to optimized network performance.

Continuity of service between WCDMA and GSM

Two prerequisites for steering the traffic of ongoing sessions follow:

- the performance of the underlying service-continuity mechanism must match the QoS class; and
- relevant services must be available in WCDMA and GSM.

One major mechanism for guaranteeing service continuity is seamless voice handover in each direction (GSM-to-WCDMA, WCDMA-to-GSM). Ericsson's implementations already provide this mechanism.

At present, the services that distinguish WCDMA from GSM are video telephony and high-bit-rate (384kbps) packet-data service. The introduction of EDGE reduces the gap between the packet data services of GSM and WCDMA by increasing available data rates in GSM (yielding 160kbps on downlink packet-data channels over four time slots).

Long interruptions (10-15s) are a serious drawback to steering packet-switched services between WCDMA and GSM. Due to limitations in the service-continuity mechanism, packet-data traffic is temporarily suspended while the procedures for inter-RAT changeover are executed.

Service fallback

For the majority of applications, it might be acceptable to lower data rates for packet-data applications when changing RAT, for example, when changing from WCDMA to GSM. However, for video telephony, a better solution might be to fall back to voice when changing from WCDMA to GSM. End-users might accept this solution, because it is similar to voice/video toggling, which is currently being specified in 3GPP.

Conclusion

GSM operators with a WCDMA license are not forced to choose between EDGE and WCDMA. Instead, the question is how can they best take advantage of each technology? GSM networks will continue to run for many years. Therefore, Ericsson recommends that operators upgrade their GSM networks to EDGE, to increase data rates throughout the entire network. WCDMA and EDGE can be rolled out in parallel, initially with coverage in densely populated areas.

Traffic-steering and service-continuity

mechanisms are needed to guarantee a smooth introduction of WCDMA. At the same time, to maximize performance, inter-system changes should be kept to a minimum. Notwithstanding, system changeover is inevitable where coverage is lacking—for example, when users leave a given area of coverage. WCDMA coverage must thus be as contiguous as possible in the planned coverage area. Furthermore, indoor coverage solutions play an important role, even if deployed on a small scale.

In the short run, the preferred strategy for giving users complete access to third-generation services is to have them camp on WCDMA. By providing efficient traffic-steering mechanisms (including handover) for voice service in the initial WCDMA and corresponding GSM releases, Ericsson gives operators a tool for balancing load and guaranteeing service continuity. Because voice is expected to be a dominant application for the foreseeable future, it will suffice to have a load-balancing solution based on voice.

Looking further down the line, as the penetration of WCDMA increases, Ericsson believes that administrative roaming restrictions can be used to distribute load from subscribers in idle mode. The most efficient method of distributing load seeks to minimize system changeover while subscribers are still in idle mode.

In the long run, as the role of packet data increases, operators may address traffic-steering and service-continuity mechanisms for packet-data services. A significant enabler will be a mechanism for shortening the interruptions to packet-data services during network changeover. The introduction of packet-handover techniques, which are in the process of being standardized in 3GPP, is expected to resolve this issue. Given that adequate traffic-steering mechanisms are in place, operators can use broadcasted radio parameters to randomly distribute load from subscribers in idle mode. As an alternative, the system might analyze end-user histories to predict service requests and to steer mobile stations in idle mode to the network that is most apt to serve them.

Ericsson understands the complexity and implications of adopting a common network approach, which is why it actively drives the standardization of inter-system steering mechanisms in coming 3GPP releases. Ericsson's aim is to optimize the end-user experience and to help operators maximize their revenue through the timely introduction of needed mechanisms.

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