Expander—Cost-effective expansion into new geographical areas

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Ericsson has developed a set of solutions that help operators address opportunities in high-growth markets by reducing their total cost of ownership. The solutions encompass everything from the core network and radio access network, to transmission, charging systems and services. Ericsson Expander consists of cost-effective solutions that provide coverage-optimized technology for GSM/EDGE and CDMA2000 networks. The article *GSM network solutions for new-growth markets*, published in Ericsson Review no. 1, 2004, explained Ericsson's Expander solutions for GSM.

In this article, the authors present a case study that illustrates the potential of Ericsson's Expander solutions in the GSM radio access network. They also describe how operators may obtain cost-effective coverage by utilizing different parts of the Expander offering throughout the network.

Using TCO to highlight Expander solutions for the GSM radio access network

Total cost of ownership

The article *GSM network solutions for new-growth markets* laid the groundwork for understanding how Ericsson's Expander radio solutions can help network operators to lower their operating and capital expenditures.[1] This article applies the concepts introduced in that article to a specific case—in a recent study completed for a large African mobile operator, Ericsson demonstrated that it makes economic sense to invest in advanced radio solutions to lower the cost of expanding coverage. Using a progression of five scenarios, Ericsson calculated the total cost of ownership (TCO, a benchmark of the cost of expanding coverage in a defined area) for the radio access network. The study showed that the operator could significantly reduce its cost of operating the network.

The TCO of a GSM radio access network is the sum of costs associated with dimensioning the access network, including operating expenses (OPEX) and depreciation. The TCO model is not a business case because it does not include revenues or the costs of business operations. Instead, it concentrates on annual network expenses calculated for specific coverage and capacity.

Ericsson developed the TCO model to evaluate the impact that decisions to deploy base stations (including all site equipment and costs, transmission, BSCs, and related software) have on network OPEX and depreciation (Figure 1). The model includes the following costs:

- GSM radio access equipment (BTS hardware, BSC hardware and BSS software);
- additional BTS site equipment (shelters, towers, antenna systems, air conditioning, sets of power generators);
- civil works;
- network roll-out;
- operations and maintenance (O&M);
- power;
- site rental;
- transmission (terrestrial microwave between BTS and BSC); and
- vendor expenses (spares, support, training).

TCO model for the GSM RAN

The TCO model makes general assumptions about the area to be covered. These include population, penetration, expected traffic intensity, percentage half-rate traffic, dedicated resources for data traffic, and so on. This data is input into a cell-planning tool (TEMS) to dimension suitable cell layout and BTS configurations. Next, costs are estimated. All capital expenditures (CAPEX) are then converted to depreciation and added to OPEX to yield total cost of ownership—TCO.

Highlights of the study

In the study for the African GSM operator, Ericsson estimated the annual TCO for a prospective expansion in a region where the operator is currently building out its network. Using a progression of five scenarios

BOX A, TERMS AND ABBREVIATIONS

3G	Third-generation mobile communication	MCPA	Multi-carrier power amplifier
AMR	Adaptive multirate	MGW	Media gateway
ARPU	Average revenue per user	M-MGW	Mobile MGW
ATM	Asynchronous transfer mode	MSC	Mobile switching center
BSC	Base station controller	MSC-S	MSC server
BSS	Base station subsystem	NMT	Nordic mobile telephone
BTS	Base transceiver station	O&M	Operation and maintenance
CAPEX	Capital expenditure	OPEX	Operating expense
CDMA	Code-division multiple access	PLMN	Public land mobile network
CGSN	Combined GGSN and SGSN	PSTN	Public switched telephone network
CS	Circuit-switched	RAN	Radio access network
EDGE	Enhanced data rates for global evolution	RBS	Radio base station
EFR	Enhanced full rate	SGSN	Serving GSN
GGSN	Gateway GSN	TCO	Total cost of ownership
GPRS	General packet radio service	TDM	Time-division multiplexing
GSM	Global system for mobile communication	TMA	Tower-mounted amplifier
GSN	GPRS service node	TrFO/TFO	Transcoder-free operation/tandem-free operation
IP	Internet protocol	TRU	Transceiver unit
IVR	Interactive voice response system	USSD	Unstructured supplementary services data

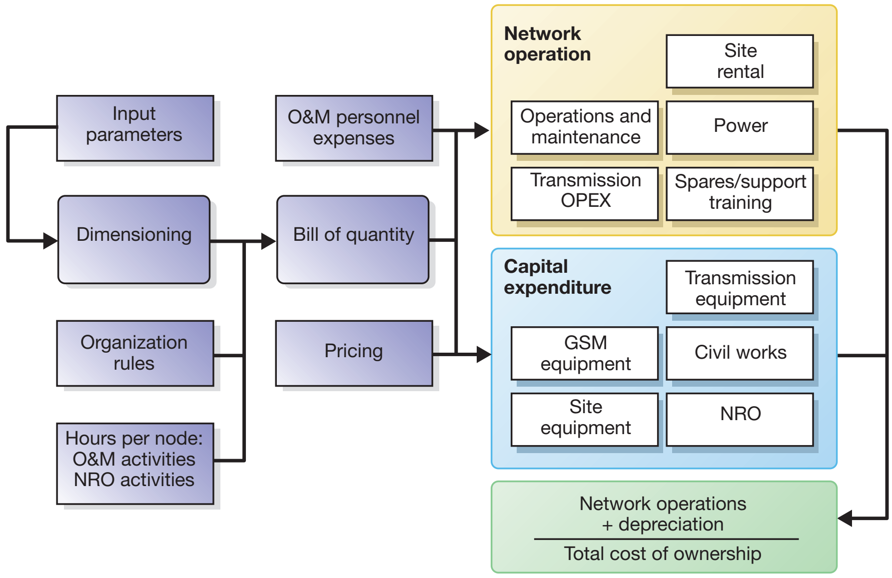


Figure 1
Logical diagram of the TCO model.

(Figure 2), Ericsson first demonstrated the positive impact of reducing the number of sites using its Expander radio solutions. The focus of each subsequent scenario was on reducing cost per site.

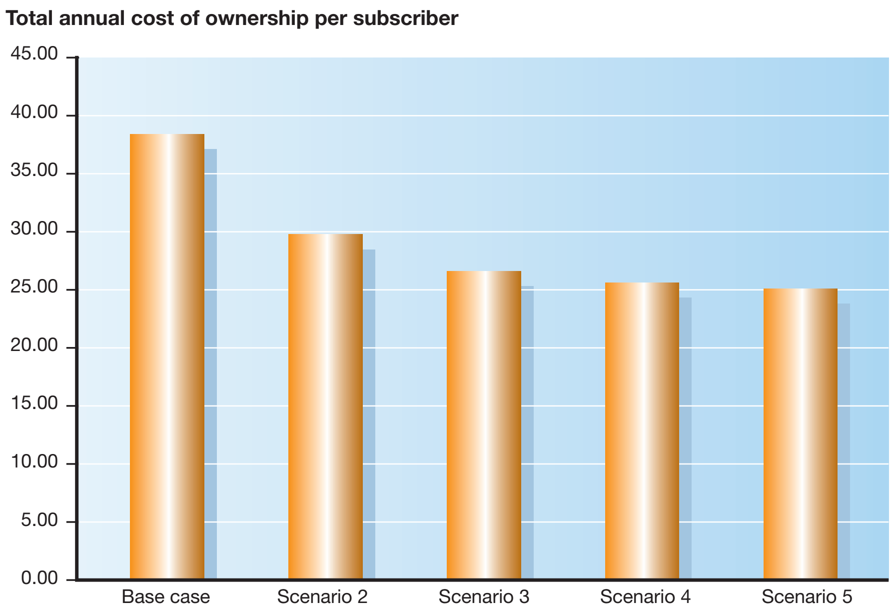
Scenario 1, "Base case"

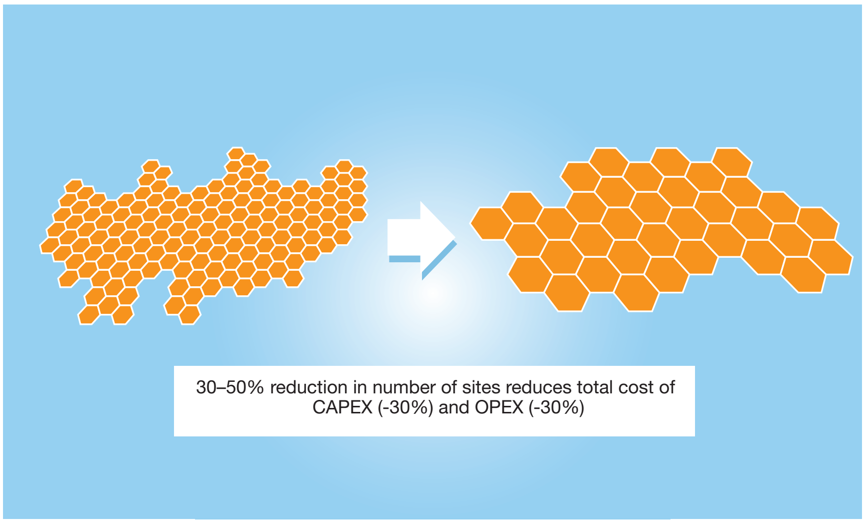
Ericsson collected the operator's costs for O&M personnel, power, RBS site rental, transmission, support agreements, site security, civil works, and so on. From the outset, it was known that power would be a major issue: in fact, the operator estimated that half the BTS sites in the new coverage area would not have access to regular electrical power. This meant that the operator would have to invest in twin sets of diesel generators and arrange for the delivery of vast amounts of diesel oil.

Given the general assumptions listed above and the link budget data for the radio configurations, Ericsson planned the cell layout for the region. Note that Ericsson did not use its Expander solutions for this initial layout. In this particular case, it was determined that a "traditional" layout to meet coverage and capacity demands at the specified requirements for signal strength would require 53 sites.

Next, using output from the TEMS cell-planning tool, Ericsson put the site configurations into the TCO model to calculate annual TCO per subscriber (depreciation plus network OPEX): the outcome was slightly more than USD 38.

Figure 2
Five scenarios for reducing TCO (depreciation + network operations expense).





Figur 3
The network view—fewer sites means lower total cost of ownership (TCO).

Scenario 2

Keeping capacity constant, Ericsson re-planned the cells using its Expander solutions, which make use of transmitter coherent combining, four-way receiver diversity, SmartRange, tower-mounted antennas (TMA) and so on. As can be expected, this significantly affected the grid for the radio access network by

- decreasing the number of sites from 53 to 41;
- increasing coverage; and
- improving quality.

The reduction in sites translates into a 22% reduction in annual TCO of the radio access network per subscriber (Figure 3).

Scenario 3

The next step entailed taking a close look at on-site costs. As mentioned above, the operator would have to generate power for half its sites. Consequently, power accounted for 28% of TCO. Moreover, it was learned that the operator's standard site configuration, including container, air conditioning, and diesel generators, was dimensioned to accommodate up to three RBS cabinets. This configuration put an unduly heavy burden on operating costs—in particular, for an operator expanding into new, untested areas with thin coverage. By re-dimensioning site cooling and power-generation equipment, Ericsson was able to lower the annual TCO per subscriber by an additional 8% (or 30% off the base case). Changing the configuration, however, would leave the operator with less flexibility (fewer options for subsequent expansion).

Scenario 4

By deploying RBS 2106 outdoor cabinets with heat exchangers instead of RBS 2206s with shelters and air conditioning, Ericsson could further reduce the annual TCO per subscriber by an additional 3% (33% cumulative reduction from the base case) and restore the operator's ability to expand the site beyond a single cabinet. In many instances, the higher price of outdoor cabinets has served as a barrier to sales, but TCO shows that this a false economy. That is, operators who opt for outdoor cabinets gain both in terms of

- CAPEX—the higher price of the cabinets is offset by savings in air conditioning equipment and shelters; and
- OPEX—eco-cooling solutions consume less power and require less maintenance than traditional solutions.

Scenario 5

Finally, Ericsson explored the use of an alternative source of energy—bio-diesel. Calculations showed that this option would lower fuel and operating costs further, resulting in an additional 2% savings, or 35% cumulative reduction from the base case in annual TCO per subscriber. Bio-diesel, which is refined from locally produced vegetable oils, offers substantial economic and ecological advantages:

- at least 20% lower price per delivered liter;

- lower maintenance requirements for the diesel generators; and
- less pollution.

Summary and conclusions

TCO is the sum of network OPEX and network-related depreciation. Using the concept as a benchmark for the cost of expanding the radio access network, Ericsson showed that it has a method for evaluating the economic impact of different solutions. Ericsson then introduced the concept on a step-by-step basis beginning with advanced radio solutions to reduce the number of BTS sites needed for a defined coverage and capacity, and then by reducing CAPEX and OPEX per site.

By applying these methods to the African operator's prospective expansion, Ericsson demonstrated a 35% reduction in the projected annual TCO for the RAN per subscriber as follows:

- 22% reduction using Expander radio solutions; and
- 13% reduction through more efficient site dimensioning, the introduction of the 2106 outdoor BTS cabinet, and the use of bio-diesel.

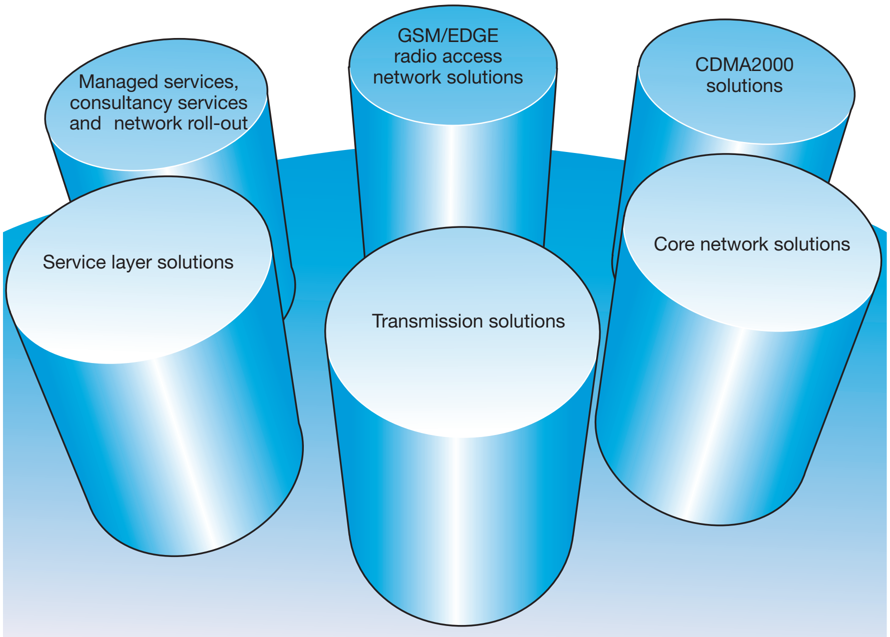


Figure 4
Ericsson Expander solutions.

Expander characteristics

Expander is both a concept and a set of mobile solutions for the core network, radio access network, service layer, and transmission and telecommunications services (Figure 4). It includes tailored-to-fit business and technology consultancy services to help operators develop business cases and design networks with optimum quality and performance.

Serving new users profitably should not mean compromising on quality. But to obtain the lowest TCO, operators must take advantage of advanced features. Ericsson's Expander solutions and functionality are taken from the company's high-tech portfolio (Figure 5), which was designed to reduce operator TCO by

- optimizing entry-level investments;
- ensuring flexible growth in capacity, as needed;
- reducing maintenance requirements; and
- protecting investments through proven, future-proof technology platforms.

GSM/EDGE Expander RAN

New capabilities included in Ericsson's GSM/EDGE Expander RAN solution use Ericsson's most recent technology platform (the double TRU) to extend cell coverage and reduce the number of radio sites. For a more detailed description of the solutions for GSM/EDGE RAN, please read *GSM network solutions for new-growth markets.*

CDMA2000 Expander

Ericsson's CDMA2000 Expander solution addresses changing market needs, giving operators in high-growth markets a cost-effective way of scaling from low capacity to heavy network traffic. Several new products have been developed specifically for operators in these markets.

All of Ericsson's CDMA2000 products are based on the company's third-generation mobile communication (3G) platforms—that is, the hardware and software have been designed specifically to meet 3G requirements and to accommodate future technology migration. What is more, Ericsson's CDMA2000 products are easy to scale and have the best footprint-to-performance ratio in the industry.

The use of common platforms, which span across different technologies and network nodes within each technology, greatly increases product reliability. It also means that

Figure 5
Expander, a part of Ericsson's complete portfolio.

operators can reduce their inventories of spares and cut training costs.

Base stations fit for CDMA2000 Expander

Ericsson's CDMA2000 Expander product portfolio is extremely versatile and offers the ideal solution for operators with requirements for low capacity and wide coverage.

The RBS 1143, a single-carrier, omni-cell RBS that is highly suitable for remote rural coverage with low capacity, gives operators the option to deploy RBSs in rural hot-spots at a fraction of the cost of a fully sectorized RBS. And being the smallest of Ericsson's RBS products, it is very easy to deploy—it has been designed for outdoor deployment and can be mounted on walls, rooftops, or poles. When used together with a 20W single-carrier power amplifier, the RBS 1143 can transmit over great distances in flat-area coverage scenarios.

The RBS 1140, which offers a two-carrier, omni-cell configuration, provides adequate scalability for operators who require small to medium capacity. Like its little brother, the RBS 1140 is ideal for rural hot-spot coverage. And by having two carriers instead of one, it gives operators slightly more capacity. Operators who pair it with a 60W multi-carrier power amplifier (MCPA) have considerable flexibility in building out

- extremely high-coverage, low-capacity networks; or
- medium-capacity, medium-coverage networks.

Ericsson has designed its Macro RBSs—RBS 1130 and RBS 1131—for operators who need to scale to high-capacity networks. However, when configured as one- or two-carrier base stations, these products can also serve as the main building blocks in a very cost-effective, small-footprint solution for low-capacity CDMA2000 networks. Like the RBS 1140, the indoor RBS 1130 and outdoor RBS 1131 feature MCPAs that enable them to blast a signal with up to 60W per carrier, resulting in low-capacity cells with a large area of coverage. In addition, the RBS 1130 has been designed to support operators with spectrum in the 450MHz frequency band. In this spectrum, the RBS 1130 supports three-carrier, three-sector configurations with MCPA technology.

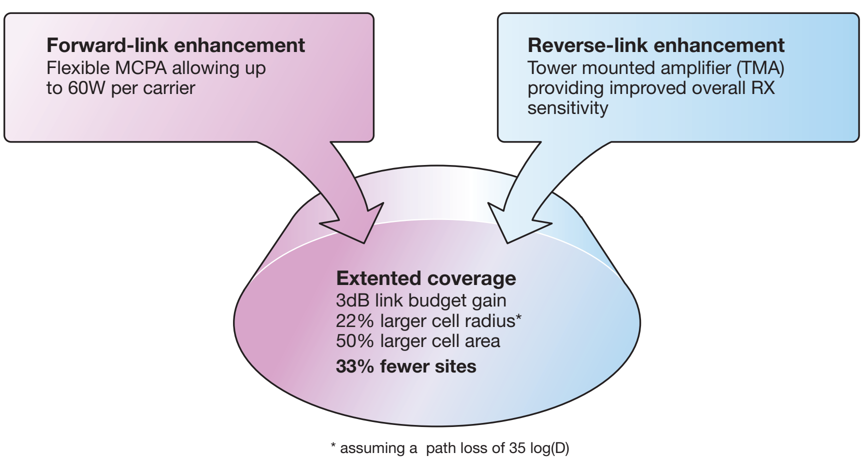
Fewer base stations

MCPAs and TMAs make up a cornerstone of Ericsson's CDMA2000 Expander offering. MCPAs enable operators to adjust the power output of any given RBS to up to 55W per channel; TMAs enhance the ability of RBSs to receive weak signals. When used in combination, MCPA and TMA technology can increase the cell radius by up to 22% (Figure 6). This increase has the potential to reduce the number of RBSs needed for a network by up to 33%. For operators of low-capacity networks this translates directly into reduced CAPEX.

Ericsson offers 60W MCPAs for deployment with the RBS 1130, RBS 1131 and RBS 1140. Operators may choose

- to use full output power (55W) on one carrier;
- to increase the reach of the cell;
- to distribute the cell across several carriers, at a minimum of 20W power output per carrier; or
- to increase capacity by decreasing the reach of the cell.

Figure 6
The combined benefits of MCPA and TMA technology.



CDMA450 Expander technology

Government agencies in many countries see CDMA2000 in the 450MHz frequency band as a cost-effective alternative to higher frequency build-outs and are opening up this spectrum for use in remote areas and rural networks.

Thanks to better propagation, products operating in the 450MHz frequency band can cover rural areas at a fraction of the cost of networks operating at higher frequencies. For example, a base station operating in the 450MHz frequency band effectively covers

- 100% more area than the same base station operating at 800MHz; and
- 500% more area than the same base station operating at 2.1GHz.

Rural operators can thus significantly reduce their capital and operating expenditures. The solution is of particular interest to NMT450 operators who want to continue using the 450MHz spectrum, and to operators in countries where CDMA450 technology is being considered for either rural or fixed wireless access (FWA) coverage.

Core network

Ericsson's mobile core network includes several solutions that specifically address TCO (Figure 7). Special focus is put on layered architecture—a network design that physically and logically separates sub-networks that are responsible for

- service management and control (control layer); and
- transport of service data (connectivity layer).

This design is essential for optimizing costs and achieving excellent service quality. The primary building blocks of the layered architecture are the MSC server (MSC-S) in the control layer and the mobile media gateway (M-MGW) in the connectivity layer. The MSC-S handles all network signaling and intelligence for setting up, releasing and monitoring circuit-switched (CS) calls. The M-MGW processes and manages the transport of circuit-switched voice traffic and interconnections to external networks, such as the PSTN, other PLMNs, and international telecommunications networks. The MSC-S (signaling traffic) and the M-MGW (payload traffic) each flexibly handle TDM, ATM and IP transport technologies.

The layered architecture supports a distributed switching system that concentrates call control and processing to a limited number of central locations. M-MGWs can be distributed to remote sites (that is, they can be co-located with each BSC) to enable local traffic switching. Because at least 60% of all calls typically originate and are terminated within a given local area, this approach yields maximum transmission efficiency.

For non-locally switched traffic, the layered architecture supports efficient packet

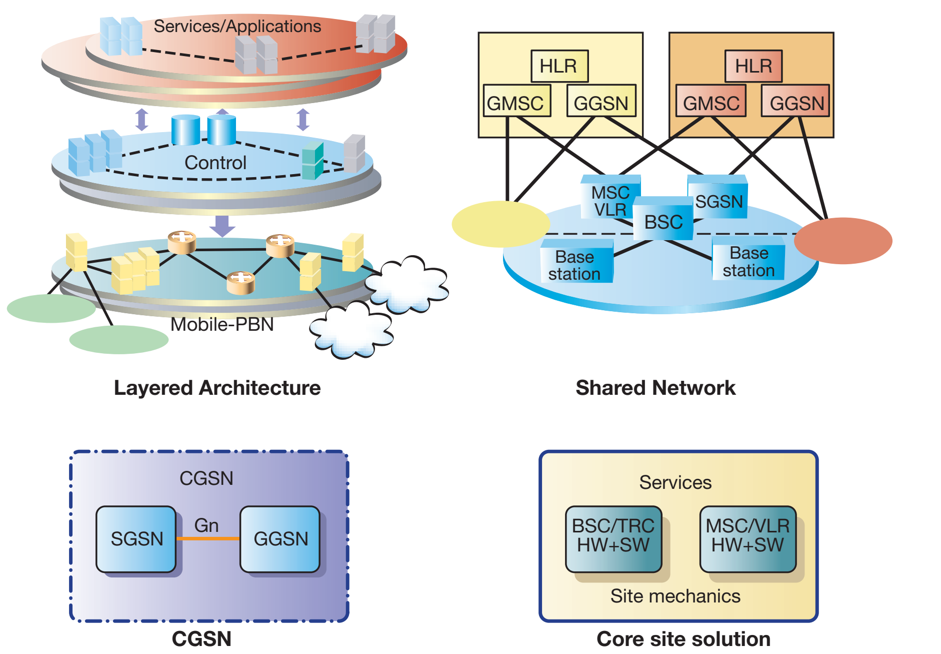


Figure 7
Expander solution—building blocks of the mobile core network.

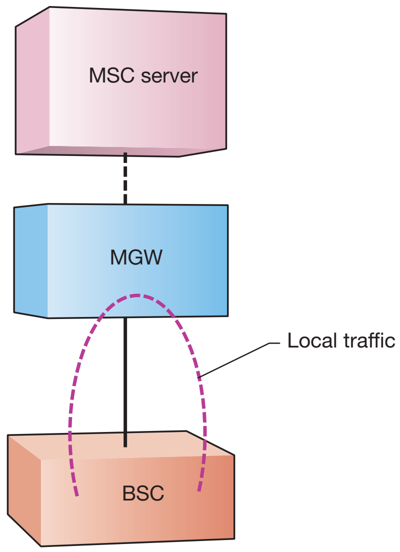


Figure 8
Thanks to the layered architecture, operators can expand into new areas with a cost-effective core network. Benefits include
- huge reductions in transmission costs—the case study showed that nearly 60% of all traffic can be handled with local switching; coded voice in the backbone network can reduce bandwidth requirements by nearly 80%;
- centralized sites and specialist resources; and
- independent evolution of each network layer.

backbone technology (ATM or IP) and features that reduce the amount of bandwidth needed to transport voice traffic across the network. Features in the core network, such as transcoder-free operation/tandem-free operation (TrFO/TFO) interworking, preserve the voice coding (EFR, AMR) used in the radio network, which improves bandwidth efficiency 300-600% and reduces the cost of the transport infrastructure.

The layered architecture also facilitates the establishment of highly centralized control facilities at key network operations centers. Operators may thus benefit from a rationalization of switching sites, more efficient network operations with fewer centers and heads, more efficient use of network infrastructure, and massive reductions in floor space and power requirements.

The layered architecture gives operators with core network operations the most cost-effective means of expanding the core network into new geographic areas (Figure 8). By separating the execution and control functions from payload transport, they can expand into the new service area using only compact and cost-effective M-MGWs. The M-MGWs can transport payload in the new area. The core network can manage the service and control parts using existing MSCs both as traditional MSCs and as MSC-Ss.

Ericsson has developed the CGSN for cost-effective introduction of packet-data (GPRS) services in new areas. This is a unique entry-level solution that combines SGSN and GGSN functionality in a single physical node. The CGSN may later be used as a stand-alone SGSN to facilitate smooth migration to a split GPRS core network.

Ericsson's Shared Network solution permits operators to share network infrastructure in order to lower their initial investments and operating expenses. There are two applications for the mobile core network: the Common Shared Network and the Geographically Split Network. In either instance, to preserve differentiation, operators keep their individual home and service networks. They may also complement the shared network with independent areas of coverage.

Ericsson's Core Site solution, which consists of highly standardized, pre-tested site-level solutions, such as pre-configured MSCs and BSCs, facilitates rapid deployment and efficient use of operator resources. Several traditionally on-site activities are now performed in a controlled environment in the factory. The solutions are delivered to the site with operator software already loaded and tested.

Transmission

Roll-out speed, flexibility and reduced cost associated with microwave backhaul networks represent an important step toward cost-effective build-out of coverage and profitable service delivery at a lower level of average revenue per user (ARPU). Today, six of ten GSM RBSs are connected through point-to-point and point-to-multipoint microwave links. Ericsson's MINI-LINK microwave systems provide excellent scalability and reliability, helping guarantee minimum transmission OPEX (Figure 9). To further reduce the cost of site infrastructure, the transmission unit can be integrated, verified and shipped as part of the RBS. This has positive impact on design, ordering, installation and operations thanks to simplification and improved network quality.

Acquiring or gaining access to land to lay copper or fibre networks—especially over long distances—can be a lengthy and costly process. Requirements for microwave backhaul networks, on the other hand, are minimal. With microwave, access is solely required at the hub and remote sites, not in between. Also, high reliability and remote configuration are especially advantageous where backhaul networks cover large, sparsely populated areas and where site access is restricted by physical barriers (mountains, valleys) or weather. Once installed, modern microwave backhaul networks are virtually maintenance-free, which translates into few repairs and site visits, and reduced need for built-in redundancy. An important consideration in this context is that the microwave infrastructure which carries mobile traffic can also be used for broadband access, thereby facilitating the build-out of rural broadband.

New, "smart" microwave aggregation nodes have gone a long way toward reducing the complexity of backhaul aggregation. Ericsson's innovative "smart" node concept combines microwave radio links with digital cross-connect capability and optional SDH multiplexers—all in one scalable platform. Compared with traditional solutions, operator experience of the integrated smart node concept shows huge savings in CAPEX and OPEX. Operators who use these smart nodes together with an effective network management system can manage all backhaul network traffic from one central loca-

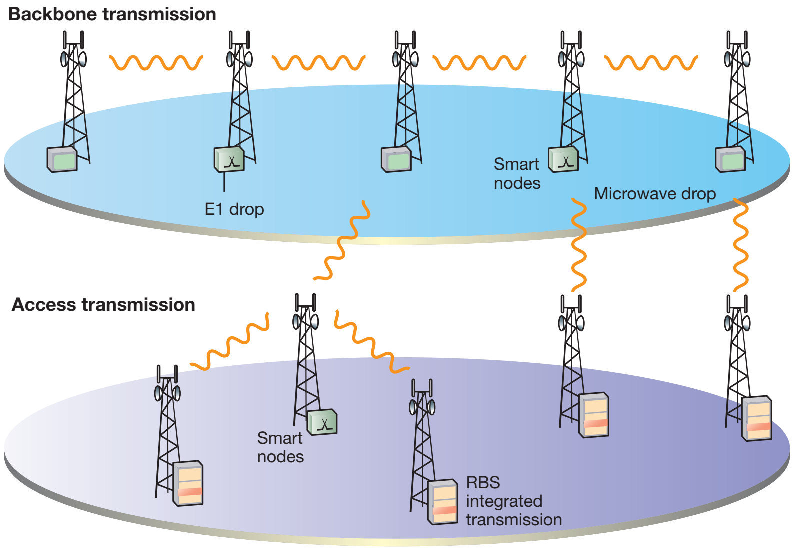


Figure 9
Cost-effective transmission solutions for backbone and access.

tion with a only few clicks of a mouse. Ericsson also offers a scalable range of digital cross-connect nodes, which when used in combination with the MINI-LINK portfolio, form a complete end-to-end solution to any transmission requirement from the smallest node to the largest optical cross-connect.

When controlled by centralized software, the backhaul network can be used to its full potential. End-to-end traffic management translates into fewer site visits for installation, capacity upgrades, and (re)configuration. The core transmission network can be built with distributed switching (local switching), lowering the capacity on inter-regional transmission links.

Satellite transmission is an alternative over very long distances and when bandwidth requirements are small. Ericsson's transmission solutions include bandwidth

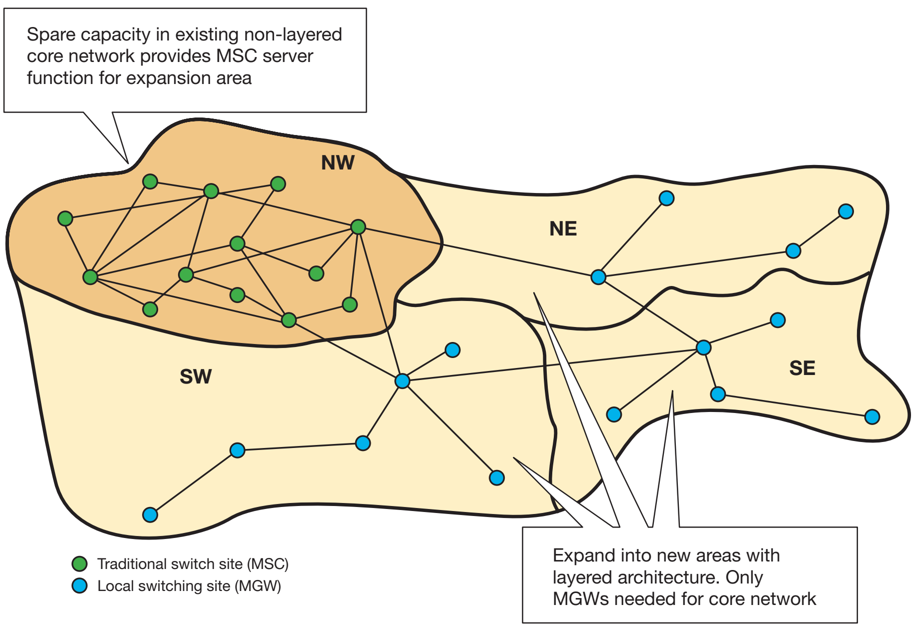


Figure 10
Ericsson Expander is a powerful concept for bringing coverage to users in rural and remote areas.

compression techniques that reduce the cost of satellite transmission.

Charging solutions

Ericsson's convergent charging solutions, which are based on the Charging System, support real-time charging of pre-paid and post-paid subscriptions. This eliminates the need for a separate billing system and improves financial risk management, which leads to significantly reduced cost of ownership.

The Charging System better enables operators to acquire customers, increase customer loyalty, and increase revenues:

- operators can, in real-time, reward users with money or free usage (depending on how much traffic an account has generated);
- operators can, in real-time, confirm prices or notify users about rewards to stimulate usage and increase loyalty;
- operators can allow subscribers to communicate with families and friends at discounted prices; and
- operators can provide international roaming for voice, data and content services.

Ericsson's Charging System allows subscribers to refill pre-paid subscriptions via alternative refill channels whose commissions are lower than those of traditional vouchers. Examples of alternative refill channels include distributor-operated over-the-air refill, web or ATM refill, and automatic bank withdrawals when the balance reaches zero. Customers can check their account balance in practically any language via the Web, interactive voice response (IVR) systems and unconstructed supplementary services data (USSD). This reduces the burden on customer care and lowers operating costs.

The Charging System also improves operator revenues by providing real-time charging and session supervision—that is, before granting a session, it checks the user account and reserves funds for the requested services. This prevents users from exceeding credit limits.

Services

In addition to technical solutions, Ericsson's Expander solution also contains a variety of services. Ericsson's business consulting services help operators to define applications that target low ARPU users. Ericsson can also assist operators with business decisions and planning.

Likewise, Ericsson can guide operators through the network design process to ensure robustness and capacity.

Ericsson can also provide operator staff with tailored-to-fit training.

Ericsson's installation and integration services draw on its base of global and local resources to ensure streamlined installation of new products, to give operators the shortest time to operation.

The Establish, Operate and Transfer service targets operators who are entering new markets, migrating between technologies, or who face a major expansion (Expander). The service is composed of Network Planning, Design and Performance Optimization, Service & Network Assurance, and Service Provisioning.

Conclusion

Ericsson Expander is a powerful concept for bringing coverage to users in rural and remote areas.

In a recent study completed for a large African mobile operator, Ericsson demonstrated that operators can profitably serve users in these new-growth markets.

Ericsson's Expander portfolio consists of several solutions developed specifically to help operators profitably address users located outside established areas of coverage. Regardless of whether operators have GSM or CDMA2000 networks, they can take advantage of Ericsson Expander.

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