Ericsson's *e-box* system—An electronic services enabler

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The emergence of the "connected home" is creating opportunities for incumbent and new players to provide a range of advanced value-added services for residential users. New technology, changing industry and consumer maturity are accelerating the development of the electronic services—or e-services—market.

Ericsson has developed a new system for delivering complete e-services all the way to the home. The design is based on a few major principles, expressing what has been considered the most important properties of the system: security, robustness and remote-management capability. The use of standard technologies will allow third-party markets for hardware and services to evolve.

The authors present an overview of the e-services market and describe the design and architecture of the *e-box* system, the central part of which is a remote-controlled edge server to be installed in the home.

BOX A, ABBREVIATIONS

AMR	Automatic meter reading
API	Application program interface
DNS	Domain name server
GSM	Global system for mobile communication
GWSW	Gateway software
IP	Internet protocol
ISDN	Integrated services digital network
ISP	Internet service provider
JDK	Java development kit
JVM	Java virtual machine
LMDS	Local multipoint distribution system
MTBF	Mean time between failures
O&M	Operation and maintenance
PCMCIA	Personal Computer Memory Card International Association
PDA	Personal digital assistant
PSTN	Public switched telephone network
WAP	Wireless application protocol

Overview of the e-services market

Technology and industry deregulation are rapidly changing the way companies who address the residential market define and conduct their business. The primary competitive determinant is shifting from owning and maintaining an infrastructure to managing customer relationships. At the same time, incumbent and new players in the telecom and utility industries are seeking new ways of differentiating themselves from the competition, and of providing additional value-added services.

There are also strong indications that the networked home is emerging. As consumers become increasingly sophisticated and mature in the use of information technology, they are also growing accustomed to having their informational needs satisfied instantaneously. New technology, changing industry and consumer maturity are combining to accelerate the development of this nascent market of e-services to the home.

BOX B, CONSUMER REQUIREMENTS OF E-SERVICES

Reliability
While most people tolerate their PC crashing, this will be unacceptable for mission-critical services such as security and energy management.

Security
Consumers do not tolerate invasion of privacy or hacking into mission-critical services by strangers or neighbors.

Simplicity
Home services must be simple to install and easy to use. Services should be intuitive to learn and use.

Utility
Home services must provide an obvious consumer value: Does it save money, help consumers to stay in touch, or make life more enjoyable?

Typical consumer requirements are listed in Box B, whereas Box C lists the fundamental requirements put on an e-service infrastructure, as seen from the service provider's perspective.

The market seems to favor an open e-service platform that allows several independent service providers to share the same infrastructure in order to reduce cost. In a likely market scenario, a third-party network operator will assume responsibility for operating and maintaining a complete industry network (Figure 1). In this e-service network, potential operators will include telephone operators, Internet service providers (ISP), cable TV operators, and utilities. Service brokers and third-party application developers will be other players in the scenario.

The network operator is likely to play a leading role in creating the e-service industry network and putting an open e-service infrastructure in place. This is because

- individual service providers have little incentive to invest in and maintain a large service network—their primary focus is on the provision of services;
- the strength of the network operator depends on the number of service providers using the network, and an operator will therefore try to keep the platform as open as possible;
- a strong operator business case facilitates consumer subsidies and accelerates the adoption of the new technology.

An industry value system based on an open, e-service infrastructure for the home stands a strong chance of creating a scenario in which consumers, service providers and network operators can share in the creation of value. This is where Ericsson's new *e-box* system enters into the picture. As will be seen from the technical overview later in this article, Ericsson's system has been developed to provide an efficient means of delivering complete e-services all the way to the home.

Requirements of an e-service infrastructure

Close collaboration between many players—wherein it is beneficial to use an open and widely accepted platform—is needed to create the e-service market. Ericsson's view is that some basic guiding principles should be followed for such an infrastructure to be successful:

- Any new e-service infrastructure must use existing technologies and standards.

It should also complement and build upon current solutions.

- The infrastructure must be flexible, open and modular, to accommodate a range of communication standards and protocols and to allow individual components rather than entire systems to be replaced as new technology is introduced.
- Consumers should not have to administer any part of the infrastructure. Instead, a professional operator should do this for them, using a management system for operation and maintenance (O&M).
- Edge servers should bridge the public and local networks. These servers run local applications, store information, and control and protect devices.
- Services should be implemented as distributed applications. By executing over several infrastructure nodes, more complex services can be developed without the need for extremely powerful and complex edge servers. Distributed applications will considerably increase the technical life and reduce the cost of the edge servers.
- Consumers should be able to access services and information through different kinds of client. Clients fall into two broad categories: "fat" clients, such as workstations and PCs, and "thin" clients, such as mobile phones, personal digital assistants (PDA) and pagers. The edge server should adapt the presentation of information to the type of client terminal in use.

Interoperability and standards

Different markets put different requirements on access and local network technologies. This implies that an architecture is needed that allows smooth adaptation to new network technologies and protocols.

The access network can be any IP network, and although a permanent connection is preferred, the system must accept other low-speed, wired or wireless connections.

Local network technologies will have to adhere to the "no-new-wires" motto, which limits options to power-line communication, radio, or existing wiring. For these areas, several protocols already exist and new ones are being developed. Which of these will survive is a matter for the market to decide.

Scalability and network management

Functional scalability is vital, because operators must be capable of gradually deploying and maintaining a large network of edge servers. This is particularly true for the management system, which will grow at least linearly with the size of the edge server network.

The network management structure will also affect reliability and security, which are implemented at different levels throughout the system. At the architecture level, the network operator has a key role, by assuming the responsibility for maintenance and upgrades from the end-user.

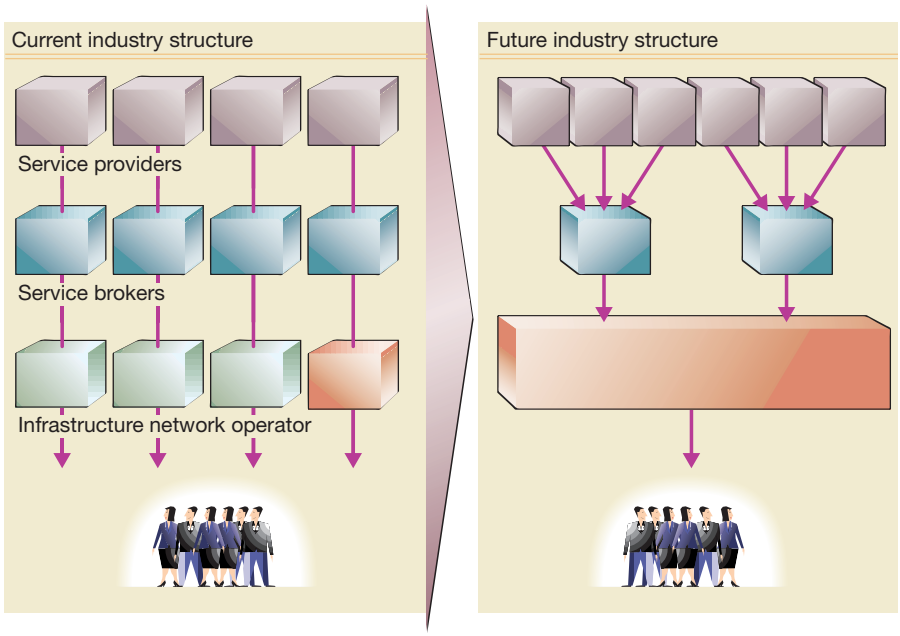


Figure 1
Industry network.

Development environment for application software

The development environment must follow the "write-once, run-everywhere" maxim and should be based on Java standards. New applications will interact with the e-service infrastructure through Java application program interfaces (API) that comply with mainstream Java development. By leveraging the Java development, the application software environment can be taken to a higher level of abstraction, allowing non-specialists to develop service applications more easily.

Emerging e-services

Ericsson's view is that the e-services market will take off where high consumer value and low impact on the access network intersect. The first services likely to emerge will cater for the homeowner segment, which is both large and significant in most developed mar-

BOX C, SERVICE PROVIDER REQUIREMENTS OF AN E-SERVICE INFRASTRUCTURE

Flexibility
Service providers must be able to define their own business model, while at the same time deriving cost synergies from sharing the infrastructure.

Integrity
Different service providers must be allowed to share the infrastructure without adversely affecting each other's services.

Reliability
Consumers will expect the same levels of reliability for critical services as they receive from the telephone system.

Upgradability
It must be easy to modify and upgrade services on the existing infrastructure, with a minimum of consumer involvement.

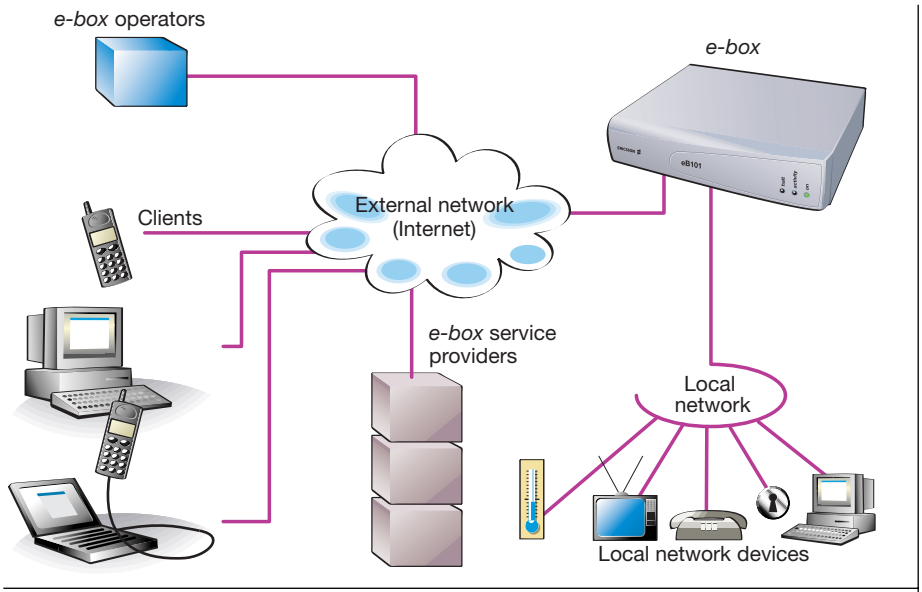


Figure 2
The Ericsson e-service infrastructure.

kets. By definition, homeowners have often met a certain economic criterion, namely the ability to afford or secure financing for a home. In the homeowner segment, the primary sets of homogeneous consumer needs that can be met by the e-service infrastructure are those of communication and entertainment, security, energy management, home automation and home care.

Communication and entertainment

Communication and entertainment services are likely to be the fastest developing of the five homeowner e-service applications. The primary consumer applications will probably be

- shared Internet access for PC, TV, Web phones and gaming consoles;
- the ability to network multiple devices in the home;
- new telephony services, such as IP telephony.

Key consumer needs to be addressed are ease of use, simplicity, affordability and personalized services.

Security services

The security services market is relatively mature, although we are seeing a shift toward bundled integrated systems, and new players from the telecom and energy industries are entering the arena. E-service security systems will provide a flexible platform and facilitate new and more advanced services; for instance, remote monitoring and control through a standard Internet browser or a mobile phone.

Energy services

The market for residential energy services is likely to grow dramatically over the next few years. The strongest driver for change is deregulation in the energy industry. Utilities are looking for new ways of creating revenue as prices and margins fall, but they are also seeking ways of securing customer loyalty. At the same time, new entrants from highly competitive industries, such as the retail and banking industries, see an opportunity to develop their consumer relations on a huge new market.

The primary application in the energy area is automatic meter reading (AMR). When customers in the same local distribution network start buying from different suppliers, a need arises to measure hourly consumption by consumer, so that the suppliers can work out how much they owe each other. In terms of network optimization, load balancing, and outage detection, distribution companies have much to gain from AMR.

Home automation

Key drivers for a home-automation application will be ease of use and the penetration of network-enabled devices. The primary business opportunity for service providers will be to bundle home automation services with the services mentioned above.

Home care

Home care represents a large, growing and relatively untapped market for service providers. The initial home-care applications will probably provide the elderly and physically challenged persons with security and monitoring services. Communication services, such as user-friendly home shopping and video telephony, will also be of interest. Key drivers of this market are the aging population in developed countries around the world and the desire to bridge increasing geographical distances.

Technical overview of the *e-box* system

Guiding principles

Ericsson's design of the *e-box* system has been guided by a few major principles that ex-

press what has been judged its most important properties. Although technical in nature, they are based on expected business models and markets.

Security

The nature of many of the services that can be expected to be based on the *e-box* system, and the fact that the system will be shared by multiple service providers, make security a major issue. Mechanisms for authentication and authorization must be well integrated into the *e-box* system design.

Robustness

An *e-box* is expected to have a life of at least ten years; therefore, its hardware must be guaranteed to be robust and reliable throughout this period. The *e-box* must also be robust with respect to errors in software developed by different service providers; that is, two applications must not interfere with one another. This latter property is referred to as *application integrity*.

Remote management

A network of *e-box*es is potentially very large; it might include several hundred thousand units installed in places that are difficult to access. For this reason, it must be possible to manage an *e-box* remotely. This includes system software upgrades as well as supervision and error detection.

Standard technologies

To the greatest possible extent, the *e-box* system is based on standard technologies, so as to allow third-party markets for hardware and services to evolve. Nonetheless, some parts of the design have been developed specifically for the *e-box*.

System architecture

The *e-box* system consists of several components, one of which is an edge server (the *e-box*) for installation in the home (Figure 2).

The *e-box* is positioned between an external Internet protocol (IP) network and local networks that connect a number of devices to the *e-box*. These devices may consist of practically any form of equipment with embedded processors, ranging from simple sensors and actuators to more complex terminal equipment.

In the external network, there are three different types of *e-box*-related entity:

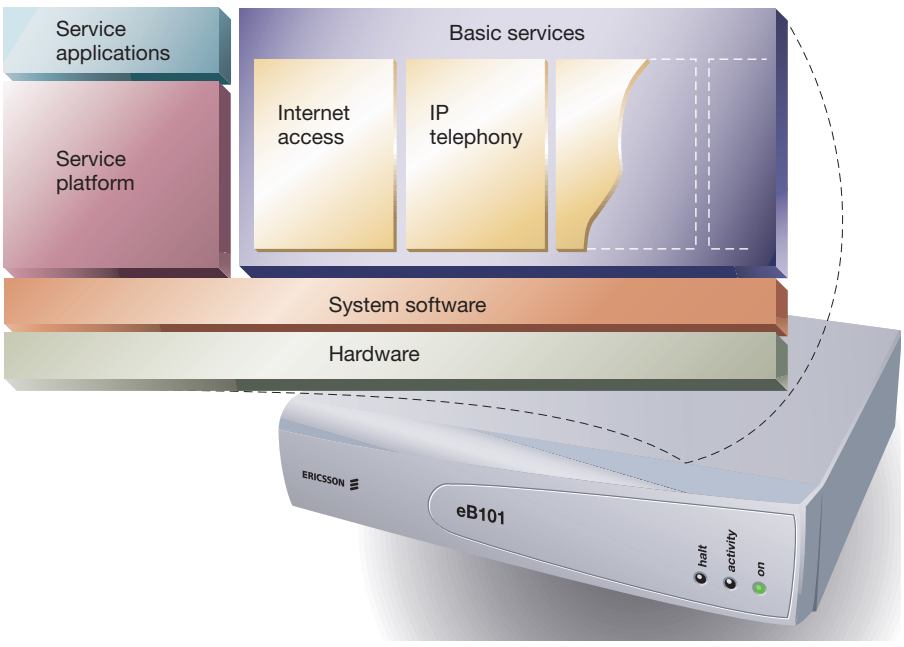
- *e-box* operator—the *e-box* operator is the owner of the *e-box* network and, as such, is responsible for managing the individual units. From a technical viewpoint, this network is an operation and maintenance system.
- Service provider—various service providers furnish services to *e-box* end-users. Technically, what they furnish is an *e-box* application or a piece of software that implements a service.
- Client—a client is any form of terminal equipment that, when connected to the external network, provides a user interface for interacting with a service application on an *e-box*. Examples include ordinary PC equipment, TV sets, mobile phones and Web phones.

The *e-box* architecture is subdivided into the following blocks (Figure 3):

- Hardware
- System software
- Basic services
- Service platform
- Service applications

End-user services are implemented either as a service application or as a basic service. A service application executes on the service platform and can only access system resources via this platform. Basic services are inherent in the *e-box* and normally require special hardware or low-level software with which the service interacts directly via the system software. Greater restrictions are put

Figure 3
Architecture of the *e-box*.



on the actions of a service application than on those of a basic service, which utilizes operating system interfaces directly.

The service platform, the basic services and the system software make up the *e-box* gateway software (GWSW).

e-box hardware

The hardware was designed with very high availability in mind. All components have high mean time between failures (MTBF) and there are no moving parts, such as fans and rotating storage devices. The *e-box* is meant to be a remotely controlled and maintained device that is always on.

The *e-box* hardware has a standard PC architecture. The first-generation *e-box* has the following characteristics:

- 32-bit CPU.
- DRAM: 8, 16 or 32 MB.
- FLASH: 4, 8 or 16 MB.
- SRAM: 128 kB battery-backed.
- LonWorks interface.
- RS232C port.
- Two I/O card slots for support of 10BaseT Ethernet, a 56 k modem, or a PCMCIA connector: the slots are typically used
  - for external network access (via a modem, ISDN or a cellular device);
  - for local network access.
- Small size: 183 · 157 · 42 mm (width · depth · height).

System software

The system software consists of

- an operating system;
- drivers for external and local network access;
- server components—for example, Web servers, wireless application protocol (WAP) servers and domain name servers (DNS);
- a Java runtime in the form of a Java virtual machine (JVM).

Any UNIX-like standard system, including Open Source, can be chosen as an operating system. The system must have fairly strong resource-control and protection mechanisms to ensure application integrity.

Basic services

The basic services currently being implemented are Internet access and IP telephony. The reasons for treating these as basic services rather than service applications are twofold: they are basic in the business model, and this approach offers technical advantages both in terms of performance and hardware complexity.

Service platform

On the *e-box* service platform, applications that implement services can be downloaded, installed or removed. The platform also permits the remote life-cycle management of service applications.

A service application typically fulfills the role of a gateway between servers in the external network (from which the service is accessed and controlled) and devices in the local network. The service application is the

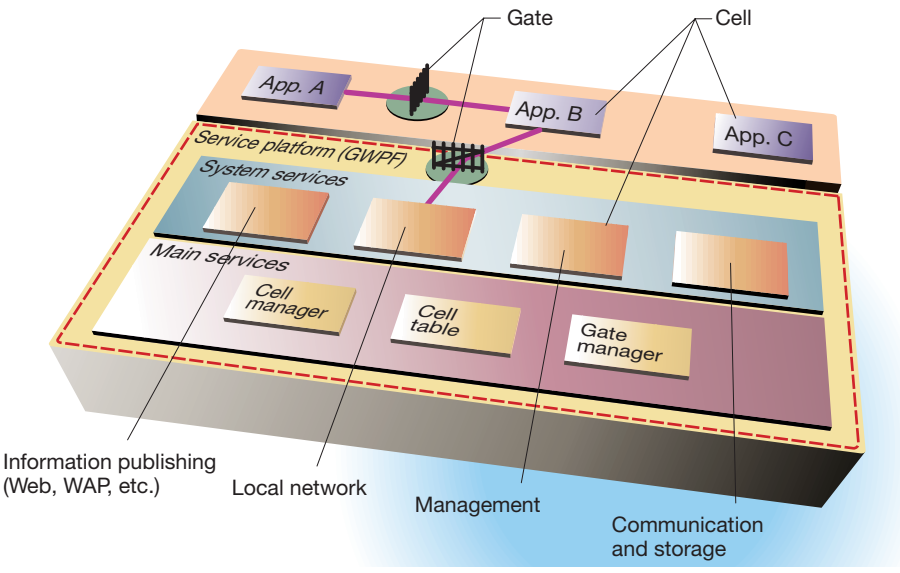


Figure 4
Organization of the service platform.

central entity, and its authorities are defined by the service platform.

The platform consists of two layers (Figure 4):

- Main services, which control applications.
- System services, which offer utilities to the service applications.

Service applications

A service application consists of three components:

- A boxlet
- A cell
- One or more gates

The service platform is a Java environment; that is, a service is basically a Java application, albeit a somewhat restricted one. The type of Java application allowed by the service platform is called a *boxlet*, which consequently, is a piece of Java code that implements a service.

When executed as a service application, the boxlet code is executed within a cell, which represents the resources made available to the application. A cell is analogous to a process in an operating system. Unlike operating-system processes, a cell is implemented using class loaders to provide the encapsulation and protection required for a service application.

Cells are created and controlled by the cell manager, which is part of the main services layer (Figure 4). All cells are registered in a cell table, which describes the collection of cells that should be present on the service platform.

Communication between applications

There is a strict requirement for integrity between applications, meaning that two applications should not be able to inadvertently interact in such a way as to cause one or both of them to fail. However, this does not imply that they may not interact. On the contrary, it must be possible for certain applications to furnish a service to other applications.

The mechanism used for communication between applications is called a gate. A gate provides a controlled interface that a client can use to interact with another application. The interface is defined by the application that offers it, but the actual gate is created and issued by the gate manager in the main services layer.

A gate is created upon request from an application, but only after checking that the requesting application is authorized to receive the specified type of gate.

A service application is not required to export gate interfaces. However, at least one gate—called main gate—is always associated with each application. The purpose of this gate is to provide the interfaces that are needed for communicating with the cell and gate managers.

System services

The system services layer (Figure 4) in the service platform provides several general services that a service application can make use of. System services include local network services, which allow an application to communicate with a local network device.

A system service is implemented exactly like any other service application; that is, in the form of a boxlet executing in a cell. The interface offered by a system service is exported as a gate.

Development environment

Boxlets are created using a standard Java development environment. For instance, the Java development kit (JDK) from Sun Microsystems can be used as well as other development environments. The only parts that are specific to boxlet development are the libraries that contain APIs for the main services and system services layers.

Service application management

The management of service applications—downloading, installation, execution, control, and removal—is performed via a specific O&M interface implemented as a system service boxlet. This system service is primarily used by the management system.

External network access

The *e-box* implementation does not stipulate the type of external network to be used in an *e-box* system, nor does it specify what access technology is to be used. In practice, the external network is an IP network and in most cases this network forms part of the Internet.

A typical access network uses dedicated connections in the public switched telephone network (PSTN), integrated services digital network (ISDN) access, or wireless technologies, such as GSM or local multipoint distribution systems (LMDS).

Local network

The *e-box* can accommodate a large number of network technologies, including fixed and radio-based networks. As far as software

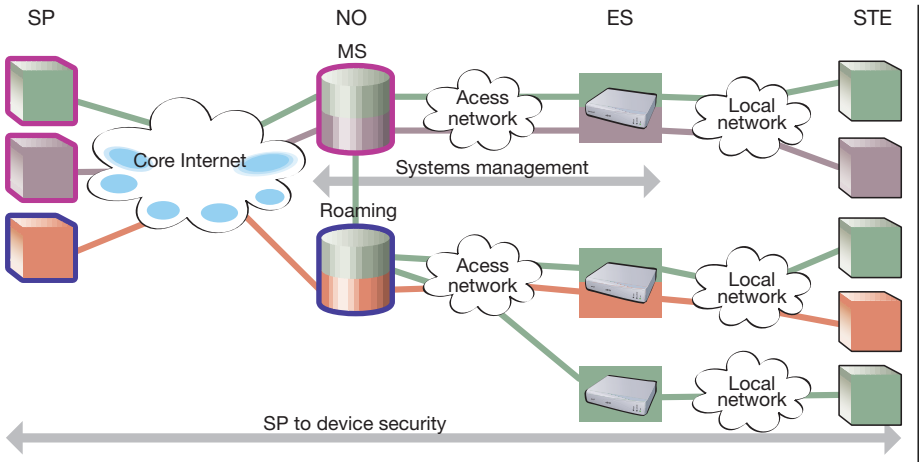


Figure 5
Distributed services system architecture (see also Box D, below).

is concerned, adapting the *e-box* to a new form of local network is a matter of integrating the necessary drivers into a local network system service. On the hardware side, it may entail the development of a suitable network interface card.

Management system

For the *e-box* operator, the major task is to manage a potentially large network of *e-box*es, and a good management system thus becomes important. Management of an *e-box* system can be logically divided into three layers, each of which represents a different view of the *e-box* system.

- *Network*—each *e-box* is viewed as a network element in an IP network; the important aspects of the *e-box* include its address. The management task typically involves management and supervision of the *e-box* as an IP node.
- *Platform*—the *e-box* is seen as a node that executes certain software, and the management task involves operation and maintenance of that software. Note: In this context, software means the *e-box* service platform, basic services and system software, not the *e-box* service applications.
- *Service*—the *e-box* is seen as executing service applications, and the management task involves installation, configuration, and removal of these applications.

A fourth layer involves the management of individual service applications in an application-specific fashion. However, because this management task is handled by the service provider and not by the *e-box* operator, it is not considered part of the *e-box* management system.

Conclusion

As consumers become increasingly sophisticated and mature in the use of information technology, they are also becoming accustomed to having their informational needs satisfied instantaneously. To cater for these needs, a new e-service infrastructure is required—an open platform that can be used by several independent service providers. This new infrastructure might well create a situation in which consumers, service providers and network operators can share in the creation of value. Anticipating these changes and demands, Ericsson has developed the *e-box* system for the delivery of complete e-services all the way to the home.

In the design, much effort has gone into ensuring system security, robustness and remote-management capability. The use of standard technologies allows third-party markets for hardware and services to evolve.

The *e-box*—which will serve as a remotely controlled device that is always on—can accommodate a vast number of network technologies, including fixed and radio-based networks.

BOX D, DISTRIBUTED SERVICES SYSTEM ARCHITECTURE

Edge server (ES)
The edge server provides the basic Internet access and application environment that allows the SP agent to control devices on the local network and to communicate with the SP. Distributed computing and control makes the SP agent executing in the gateway resilient to network failure and reduces the requirements for access network bandwidth and availability.

Management system (MS)
The management system is a key tool for the NO. It allows the NO to control edge servers and the service applications that run on them.

Network operator (NO)
The entity that operates and maintains the system service registry and network of service access points and edge servers. The NO sells network access to service providers and can have roaming agreements with other NOs to provide a global service network. Examples of potential system service providers include network operators and Internet service providers.

Service provider (SP)
The entity that furnishes services to end-users. The local component of the service is implemented using Java applications that run on the edge server (and optionally, in the management system and at the site of the SP). Potential service providers include electric utilities, security companies, electronic media and banks.

Service terminating equipment (STE)
STEs are service end-point devices located in the local network. A broad range of devices must be supported, ranging from simple sensors for temperature and moisture to actuators or power switches and more sophisticated devices for user interaction, such as keyboards and screens. All devices are connected to the edge server through one or more local networks.