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14th August 2015

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Yours sincerely

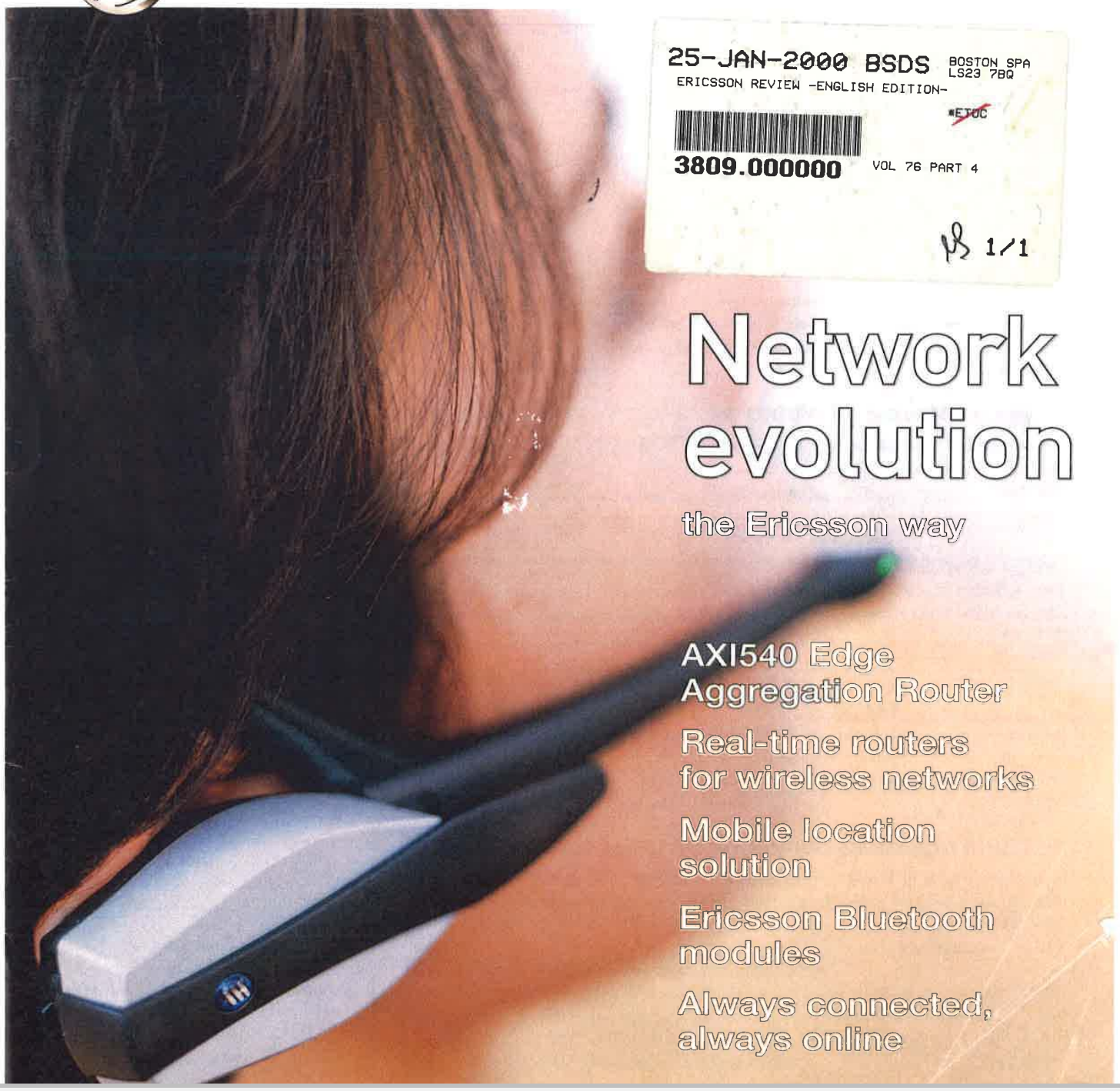
Maria Lampert

4/1999

ERICSSON REVIEW

THE TELECOMMUNICATIONS TECHNOLOGY JOURNAL

1924 1999 75 YEARS IN PUBLICATION



Network evolution

the Ericsson way

AXI540 Edge Aggregation Router

Real-time routers for wireless networks

Mobile location solution

Ericsson Bluetooth modules

Always connected, always online

Ericsson's Bluetooth modules

Henrik Arfwedson and Rob Sneddon

In just over a year, more than 1,600 companies have adopted Bluetooth, making it one of the fastest growing technologies ever. By 2002, it is estimated that more than 100 million mobile phones, computers and other types of electronic equipment will incorporate this technology. Bluetooth, which is a short-range radio communication link developed and introduced by Ericsson, is currently in the process of becoming an accepted world standard.

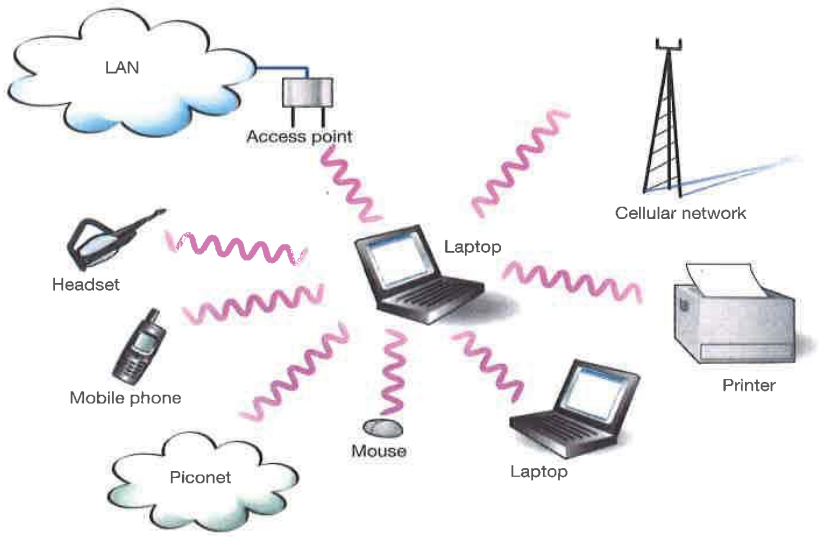
The authors describe various technical constraints and considerations associated with the development of Ericsson's Bluetooth modules. When these modules are used together with the accompanying OS-independent software stack, customers can focus their R&D resources on developing specific hardware and software for their Bluetooth applications. The authors also discuss the main issues that developers need to consider when designing Bluetooth-enabled equipment.

Background

In 1994, Ericsson Mobile Communications launched an initiative to study low-power, low-cost radio interfaces between mobile phones and their accessories. A radio-access solution was sought because it would eliminate the need for cables and overcome line-of-sight restrictions. It was also recognized that a low-cost solution would usher in wireless connectivity for a multitude of new applications and give rise to a host of associated components and devices.

For more than ten years, Ericsson Microelectronic has been involved in the research and development of semiconductor and packaging technologies for wireless applications. Capitalizing on this experience, Ericsson's engineers have realized a truly low-cost, high-density solution—Bluetooth.

Figure 1
User model with local wireless connectivity. Applications envisioned for the near future.



Industry-wide commitment

Bluetooth was envisioned to be an open, global standard. To achieve a critical mass and to promote a joint worldwide standard, Ericsson approached IBM, Intel, Nokia and Toshiba with its concept. In May 1998, the Bluetooth Special Interest Group (SIG) was announced, and within 18 months more than 1,600 companies had signed the Bluetooth Adopters Agreement. Today, based on massive global interest and support for the technology, analysts are predicting that by 2002 over 100 million mobile phones, computers and other electronic devices will incorporate Bluetooth technology. Bluetooth specifications are issued under the authority of the Bluetooth SIG.

Universally recognized technology

Each Bluetooth unit has a unique identity. Equipment enabled with Bluetooth technology automatically searches the vicinity for other Bluetooth-compliant equipment. On contact, information is exchanged allowing the systems to determine whether or not to establish a connection. At this first encounter, the Bluetooth devices transmit a personal identification number (PIN). After that, no further identification process is necessary. Up to eight devices can operate at the same time in a Bluetooth cell. Moreover, each Bluetooth device can be active in several cells at the same time.

Basic operation

To minimize the risk of disturbance from other radio devices, such as microwave ovens, garage door openers, and so on, a frequency-hop scheme causes the system to switch 1,600 times per second through 80 channels. This means that if one frequency channel is blocked, the disturbance to Bluetooth communications will be limited. It also means that several Bluetooth networks can run concurrently without disturbing one another. First-generation Bluetooth-enabled equipment can exchange information at a rate of 1 Mbit/s at a range of up to

10 meters. Also, because Bluetooth operates in the global industrial-scientific-medical (ISM) band at frequencies between 2.4 and 2.5 GHz, it has the potential to become a universally recognized standard.[1]

Market confidence

Having convinced both the telecommunications industry and the wider electronics industry of the viability of the Bluetooth concept, it has been recognized that products based on Bluetooth technology must be developed, demonstrated and delivered quickly in order to maintain the interest and confidence of these market sectors.

The first goal—to produce actual product demonstrators—has already been achieved. Through enormous efforts of many diverse groups of design and development engineers, Ericsson has been first to successfully demonstrate Bluetooth compliance in real telecommunication products at recent trade shows. With market confidence in the technology established, efforts are now being focused on Bluetooth products and product support for the two major markets—that is, for

- applications within telecommunications; and
- applications within PCs and other electronic equipment.

Bluetooth-enabled products from Ericsson

Within Ericsson, more than twenty separate projects for "Bluetooth-enabled" products are currently under way. These projects, which cover a wide spectrum of applications, are being coordinated through the Ericsson Bluetooth technology council—to ensure that common Bluetooth features and key support activities are properly controlled, and that effective use of resources is maintained. Within these Ericsson products, the Bluetooth function can be integrated into the application to achieve maximum system optimization.

At Mobile Focus and COMDEX/Fall'99, in Las Vegas, USA, Ericsson unveiled the Bluetooth Headset, a practical headset that connects to a mobile phone by a radio link instead of a cable. This is the first hands-free accessory to incorporate Bluetooth technology. The Bluetooth Headset will be available on the market in mid-2000.

The Bluetooth Headset is a lightweight, wireless mobile phone headset with a built-in Bluetooth radio chip that functions as a connector between the headset and a Bluetooth plug on the Ericsson phone. To answer or initiate a call (using a voice-recognition-capable phone, such as the T28, T28 World or R320), the user presses a key on the headset. Because the Bluetooth radio link covers distances of up to 10 meters, the phone can be left in the user's briefcase, a coat pocket, or even in another room. Weighing a mere 20 grams, the Bluetooth Headset sits comfortably on either ear.

BOX A, ABBREVIATIONS

ANSI	American National Standards Institute
API	Application program interface
ASIC	Application specific integrated circuit
BGA	Ball grid array
CMOS	Complementary metal-oxide semiconductor
EMC	Electromagnetic compatibility
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
HCI	Host Controller Interface
IC	Integrated circuit
IrDA	Infrared Data Association
LTCC	Low-temperature, co-fired, ceramic
OS	Operating system
PCM	Pulse code modulation
PIN	Personal identification number
PSTN	Public switched telephone network
RF	Radio frequency
RFCOMM	Serial Port Emulation based on ETSI TS07.10
RX	Receiver
SDP	Service discovery protocol
SIG	Special interest group
TX	Transmitter
UART	Universal asynchronous receiver and transmitter
USB	Universal serial bus
VCO	Voltage-controlled oscillator

Figure 2
Ericsson's Bluetooth Headset is the first hands-free accessory to incorporate Bluetooth technology.

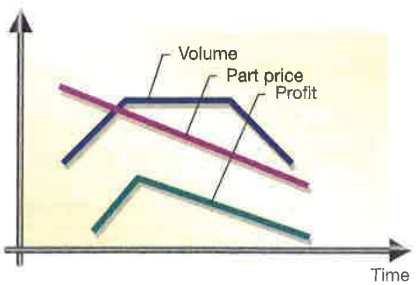


Figure 3
A typical product cycle.

Bluetooth products and product support for developers

As already stated, in order for Bluetooth to become accepted, many telecommunications, PC, and other electronic system developers must adopt the technology within their products. In terms of Bluetooth integration, these developers range from the very sophisticated to the complete novice. Accordingly, Ericsson has developed a multi-track strategy that addresses the needs of diverse customers. Ericsson offers a Bluetooth Starter Kit and a complete Bluetooth Developer Kit for Bluetooth evaluation. Finally, to support the software stack, Ericsson has partnered with Symbionics.

Bluetooth partitioning

The simplest solution for most developers is to buy a complete Bluetooth module from Ericsson. The module includes radio frequency (RF) and baseband circuits, FLASH memory, and the associated software stack. However, if developers want to integrate the Bluetooth baseband (EBC) themselves, they need only buy a Bluetooth RF module, which is designed to be compliant to the Bluetooth RF interface specification. Before undertaking their own integration, developers should carefully consider time to market, product cycles, and profitability.

Microelectronics for Bluetooth

The Bluetooth module development roadmap is closely associated with the ASIC development roadmap. On first-generation Bluetooth modules, the RF ASIC has been designed on biCMOS technology; the baseband ASIC has been designed on complementary metal-oxide semiconductor (CMOS) technology. The general trend followed by ASIC silicon technologies is toward processes with smaller geometries and lower supply voltages. Apart from reducing cost per function, this approach also permits greater levels of integration. However, although many future-generation products will benefit from the implementation of single-chip modules, there will continue to be applications in which the optimum level of integration employs a two-chip solution.

Optimum levels of ASIC and module integration

Several factors that could influence decisions concerning the optimum level of integration are:

- circuit compatibility—digital and RF circuits do not mix well;
- functional stability—future products may require baseband ASIC migration to accommodate additional functionality or to take advantage of a less expensive process while the RF interface remains stable; and
- cost—depending on the choice of technology, a multi-chip solution might cost less than a single-chip solution.

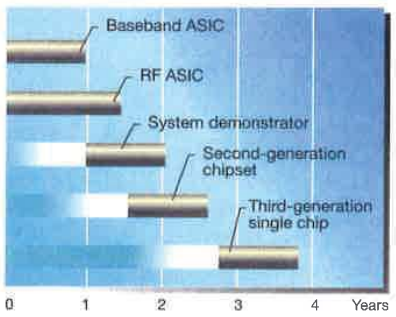
Product cycle and profitability

Sales volumes grow for a short period after a new product has been introduced. This introductory period is followed by a long period during which sales volumes remain stable. Finally, sales volumes decline as market demand decays, or the product is superseded or becomes obsolete (Figure 3).

Initial production volumes do not begin to generate profits until development costs have been recovered. Once this milestone has been passed, profit per unit increases, due to improvements in production and yield. In time, however, profit per unit declines, due to price erosion and increased competition.

The key point to be made is that the end of the product cycle should be thought of as being fixed in time. Consequently, any delay in delivering volumes to the market will result in loss of profit during the most profitable phase of the product cycle. Figure 4 shows typical time scales for the development from scratch of a family of ASIC chipsets. The first-generation product takes approximately two years to develop. Each subsequent generation takes about one year to develop. The ASIC development cycles are on the critical path for product development.

Figure 4
Typical time scale for developing a family of ASIC chipsets from scratch. The first-generation end product takes approximately two years to develop. Each subsequent generation takes about one year to develop.



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