The R380s—The first smartphone from the Ericsson–Symbian partnership

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The Ericsson R380s is the first GSM mobile phone to use the Symbian EPOC32 operating system, which gives the phone the functions that make it a smartphone. The original concept for the R380s was to provide mobile phone and personal organizer functionality in a single phone-sized device. The device was characterized as a business tool rather than a lifestyle accessory. As development progressed, the specification was modified to include a WAP browser, unified messaging (e-mail and SMS), and secure access to restricted-access systems, such as a corporate intranet.

The author explains why EPOC was chosen, and describes the work required to develop the R380s software from EPOC32.

What is a smartphone?

The term *smartphone* has been coined to describe devices which, while being primarily a mobile phone, incorporate elements of functions found in paper-based personal organizer systems or in modern electronic personal digital assistants (PDA). Typically, a smartphone contains a calendar, an address book, e-mail and messaging functions, and a browser for the wireless application protocol (WAP), together with a range of ancillary functions. It is also expected to work simply as a mobile telephone. A smartphone is roughly the same size as a standard business mobile phone—for example, the Ericsson R320—and like a standard phone, it allows users to operate its basic functions in a one-handed fashion. Extra functionality is accessed via the large touchscreen, which differentiates it from standard phones.

What is the R380s?

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Why EPOC?

EPOC32 is an ideal operating system for smartphone devices. This real-time, multitasking, multithreaded operating system was created specifically for use in handheld devices, and has been optimized for the constraints of such an environment, the chief of which are

- low power consumption;
- small display;
- limited input and output methods;
- slow processor speed; and
- stand-alone operation.

The creation of Symbian—a joint venture between Ericsson, Matsushita, Motorola, Nokia and Psion—meant that a suitable in-house operating system became available as the R380s project was starting up. However, the fit between EPOC32 and the R380s was not a perfect one. This article describes the work required to develop the R380s software from EPOC32.

The R380s concept

The original concept for the R380s was to provide mobile phone and personal organizer functionality in a single phone-sized device. The device was characterized as a business tool rather than a lifestyle accessory and was specified accordingly. As development progressed and the concept of the mobile Internet took shape, the specification was modified to include features that would take advantage of this mobile business environment:

- a WAP browser would take advantage of the mobile services expected to be offered for this new wireless standard;
- a unified messaging feature would allow standardized control of all available text-transmission services, such as e-mail and short message service (SMS); and
- secure access with built-in security algorithms would allow users to dial up a secure link with restricted-access systems—for example, a corporate intranet.

To provide good functionality both as a smartphone and as a basic phone, two modes of operation were specified. This design affected the hardware of the phone and the user interface (UI).

The solution to the product requirements

The product would include features and functions not previously found in mobile devices. In hardware, the device would have to operate in two significantly different modes: normal phone mode, and smartphone mode. The device must also control two different basic functions with maximum efficiency:

- GSM functionality and the air interface; and
- PDA-type operations.

The requirement to support two different modes of operation while having the largest screen possible for the size of device resulted in the design of a hinged, passive flip. The flip holds the normal phone keypad and covers 60% of the touchscreen. In flip-closed (FC) mode, the R380s looks and operates

BOX A, TERMS AND ABBREVIATIONS

API	Application program interface
ARM	Advanced Research Machines (the manufacturers of the processor used in EPOC devices
ECK	Ericsson component kit
ETSI	European Telecommunications Standards Institute
FC	Flip closed
FO	Flip open
GSM	Global system for mobile communication
OS	Operating system
PC	Personal computer
PDA	Personal digital assistant
QWERTY	Standard typewriter keyboard: first six letters, top-row, left
ROM	Read-only memory
UI	User interface
VGA	Video graphics array
WAP	Wireless application protocol

like an ordinary GSM mobile phone. Key presses are physically transmitted through the flip via plungers attached to the keys. The resultant contact with the underlying touchscreen is interpreted by the operating software. In this mode, the exposed part of the screen does not respond to touch, and the phone looks and feels like an ordinary mobile device, with some added display functionality to help users. The flip is a purely mechanical device that contains no trouble-prone electronic parts or flexible electrical connections. In the event of damage, it can easily be replaced by an approved Ericsson service center.

When the flip is opened, a sensor signals the operating software, which alters the display. In flip-open (FO) mode, the entire touchscreen is exposed, the touch input is enabled, and the screen orientation is rotated through 90 degrees to give a landscape-style display. This mode maximizes the potential for data display and input with a look and feel that more closely resembles established PDA design than that of a mobile phone. Many PDA-type functions are solely available in the flip-open mode, since they are best served by static, two-handed user operation.

Given the requirements for data-input methods, and that in software the device had no proven user interface for the size and form-factor of its screen, the user interface had to be designed from the ground up. A two-processor design was implemented to provide efficient execution of the two main groups of functions in the smartphone, maximizing the possible reuse of software and hardware from earlier successful development work.

The GSM (phone-side) functionality is controlled by a processor similar to that used in standard Ericsson GSM phones. This processor, which runs the OSE real-time operating system from Enea Data, handles all operations related to the air interface and controls audio operation.

The organizer (PDA-side) functionality is controlled by an ARM-based processor design, which manages PDA-side functions and controls the phone-side processor at a high level, initiating and terminating calls on user command. The ARM processor runs the EPOC32 operating system, which has been optimized for this processor family.

The need to close-couple the two different sets of functionality without causing loss of performance on either side led to the design of a specialized communications channel. The two processors communicate via a high-speed software backplane, which provides an efficient interchange of data and commands. Because standard GSM voice calls are handled entirely by the phone-side processor, the PDA-side processor is free to manage other activities during a call.

Figure 1
Image of the R380s.

EPOC32—the starting point

Before Symbian was formed, EPOC32 was associated with the popular Psion 5 organizer (Figure 2), a PDA with a half-VGA-sized touchscreen, a full QWERTY key-

Figure 2
Image of the Psion 5 personal digital assistant.

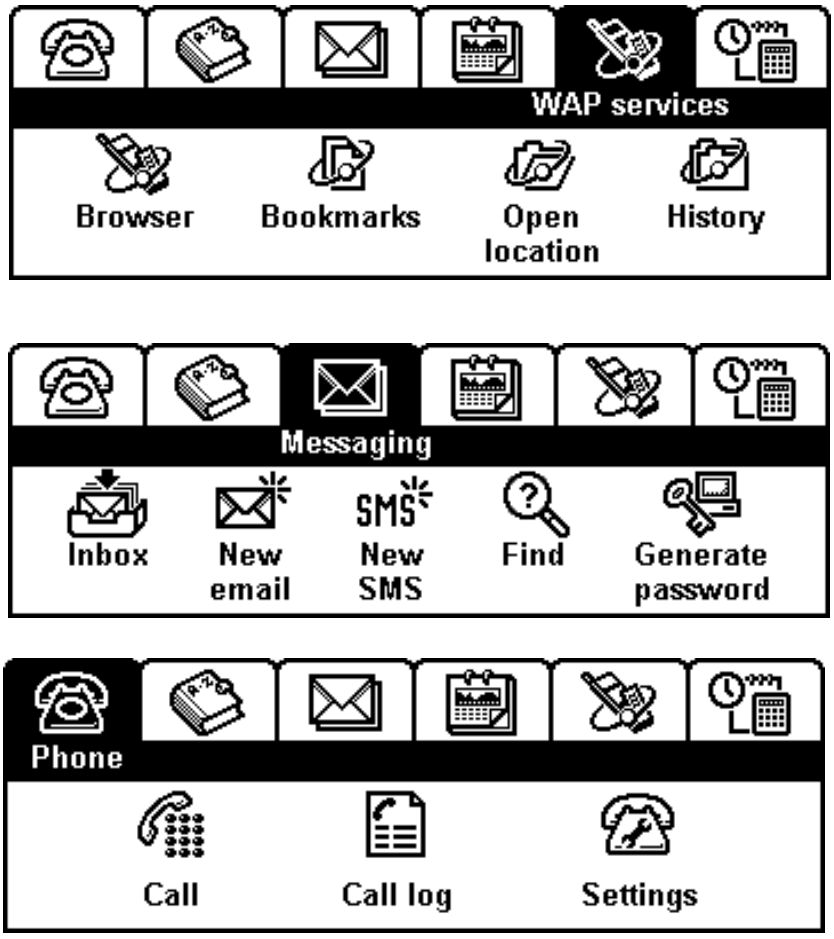

Figure 3
Screen shots of the R380s user interface.

board, and the ability to add extra software packages via PC download or plug-in cards.

EPOC32 offered several benefits to R380s developers, which simplified the task of producing the PDA-side software:

- EPOC is a real-time operating system that permits the support of time-dependent operations, such as telephony;
- the user interface is effectively decoupled from the underlying operating system and application engines—it can thus be modified to accommodate the look and feel of a new device; and
- the software is modular, which simplifies parallel development at multiple sites.

New features needed in EPOC32

Depite its obvious suitability for use in the R380s project, the version of EPOC32 used in the Psion 5 had certain drawbacks for Smartphone use:

- Psion devices adhere to an *always-on* concept, with both a main and a backup battery. The expectation is that the device is always powered and that data in RAM is persistent. However, if both batteries are allowed to run down simultaneously, all user data is lost. Mobile phones adhere to an *often-off* concept. Consequently, to be persistent, user data must be backed up to permanent storage;
- Psion PDAs have no concept of telephony. No engine or user interface was available in EPOC32 to support GSM telephony;
- EPOC32 had been designed to support half-VGA devices with real keyboards and multiple on-screen windows. The user interface and engine software had been optimized for this sort of design;
- the concept of dual-mode operation (FO, FC) was completely alien to EPOC32; and
- software internationalization had been considered a ROM-swap function, but a mobile phone must be able to change languages on the fly.

To overcome these obstacles, and numerous other minor issues, the software was modified as follows:

- A flash file system was introduced, to accommodate persistent data. The challenge was to produce a system that made regular updates—to guarantee an acceptable level of security—without noticeably affecting performance in the rest of the device.
- A telephony support module, known as ETEL, was produced to support telephony functions (from the processor on the PDA side). This module serves as an interface between the phone-side software and PDA-side applications and services that require telephony access.
- The entire user interface was deconstructed and redesigned to function appropriately for the R380 (Figure 3). Instead of being file-based, the concept for the new user interface was task-based.
- Application engines were modified where necessary, and an entire unified messaging application was constructed.
- The operating system was modified to support dual-mode (FO and FC) operation, with
  - seamless switching between defined equivalent views in both modes; and
  - persistence of viewable data.
- The operating system was modified to allow users to control language/locale without the need for external hardware or

without having to modify the hardware. Not all available language/locale packages can be contained in the memory of a single R380s, so provision has been made for downloading the language population not shipped with a particular phone.

- The Symbian software component kit, known as EIKON, was unsuitable for the new user interface. A new component kit—the Ericsson Component Kit (ECK)—was developed to give the correct functionality of components, such as on-screen buttons, icons, dialog boxes, and so on.

Each of these modifications was required to make a truly effective smartphone. The omission of any of them would have resulted in a significantly less attractive, less useful device. However, the primary motivation for this work was usability.

The EPOC32 architecture on the R380s

A detailed description of the R380s software architecture is beyond the scope of this article, but a glance at Figure 4 gives some idea of its complexity.

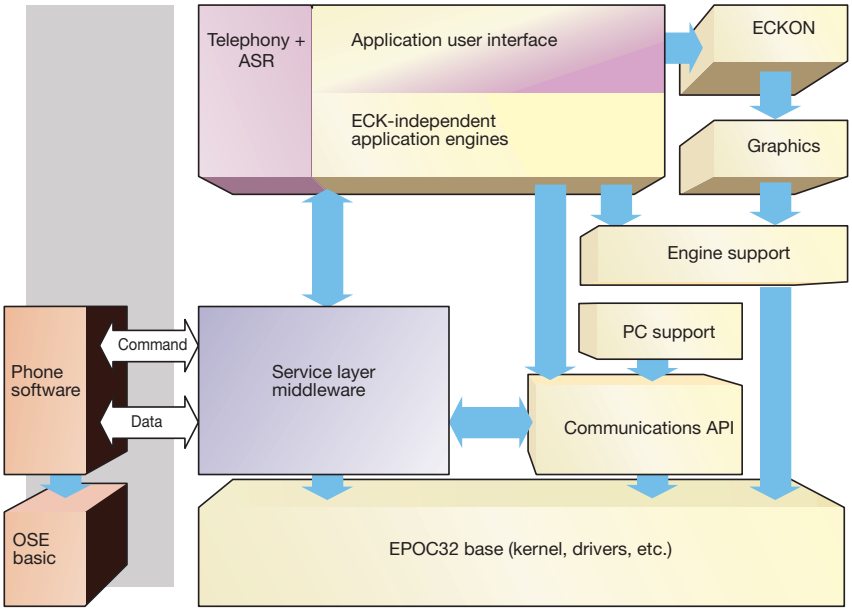

Figure 4
Software architecture diagram.

Usability and the user interface

Since no proven designs existed for this type of device, the usability team had to create a new user interface from the requirements. The team took this opportunity to incorporate continuous usability testing into the design process, to ensure that users would end up with a worthwhile and desirable product. As its guideline, the team took the European Telecommunications Standards Institute (ETSI) definition of usability—in particular, the requirement which stipulates that at least 75% of novice users should be able to perform a given task correctly on their first attempt. All major use cases on the device were tested in this manner. Reiterative testing applied to every aspect of the design, from the on-screen appearance of details, such as buttons, to the overall navigation concept of the operating system.

In this respect, the R380s software can be said to have been designed by users rather than engineers—the activities of the usability team, which acted as users by proxy, ensured that the user interface is the best fit for the size, form factor, and functionality of the R380s. The software started life as Psion 5 software, but as Figure 2 shows, the changes to the user interface were significant.

Multisite software development

The commercial requirement for rapid development dictated that the software would have to be developed at multiple sites. Obviously, this meant that the development team needed a robust system of configuration management and quality control, as well as a strong suite of common development and test tools. Three main sites were involved in software development:

- Ericsson in Stockholm produced the functional specifications and lower-layer PDA software, modified the phone software and verified the system;
- Ericsson Software Applications Laboratory in Warrington (England) produced the user interface specifications (scenario documents), the ECK, the telephony application, and the user interface code for most of the organizer applications. This team also performed the functional test on much of the software; and
- Symbian in London carried out the base port to the ARM processor, supplied software development kits, and modified some of the organizer applications.

In addition, some software development was subcontracted. For instance, the WAP

browser was developed by AU System (Sweden); the character-recognition part of the data entry component was developed by CIC (USA); the game application was acquired from EMCC (UK); authentication software was developed by Secure Computing and Security Dynamics; and the flash filing system was developed by Enea Data.

The future

The future direction of smartphone devices is heavily dependent on the uptake of mobile Internet services by consumers and on the kinds of service these consumers want. However, certain trends can be extrapolated from current data.

The R380s is Ericsson's first EPOC32-based smartphone, but it is also likely to be Ericsson's last closed smartphone platform. To provide the full range of desirable functions, future versions of the Ericsson smartphone platform will be open to third-party developers, in the same way as the Psion 5 or Palm Pilot devices are. The ability to add applications to a smartphone, either via the PC or directly over the air will be vital to the success of these devices in the next decade.

To support development, Ericsson has launched the Ericsson Developers' Zone (www.ericsson.com/developerszone)—a one-stop shop for developers looking to get information, support, training and tools related to Ericsson platforms. Test and certification services for externally developed software are also available via this site.

The modular and scalable nature of EPOC32 will make it the operating system of choice for a wide range of devices, thus ensuring a common software architecture. Future smartphones will support multimedia functions as well as traditional mobile data services.

Conclusion

The R380s, which is the first smartphone on the market to incorporate Symbian's EPOC32 operating system, opens up the future of devices by matching hardware and software to give a full range of desirable functions in a user-friendly, efficient, and portable package. The R380s points the way to a community of devices whose common architecture and open platform allow user requirements to be met by specialized developers.

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