Prototyping mobile technology

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In the world of mobile telecommunications, early availability of terminals has often been an important factor for the success of new technology. To manifest its leadership role in radio access technology and advanced wireless multimedia concepts, Ericsson demonstrates complete end-to-end (E2E) solutions from network system to terminals. Accordingly, it invests in specific mobile phone prototype projects that are based around mobile phone technology from Ericsson Mobile Platforms (EMP).

The goals of the projects are to strengthen Ericsson's innovative capabilities, accelerate testing of new technology, and enable the company to prove and demonstrate its end-to-end solutions.

Representatives from Ericsson's radio and core networks, multimedia services, and mobile phone platforms actively participate in end-to-end technology prototype programs. In this respect, Ericsson is probably one of few companies worldwide with sufficient in-house technical capability to facilitate end-to-end demonstrations and to push technology in a rapid and efficient way.

Figure 1
Accurate prototype form factor for demonstrating MBMS, VoIP and HSPA.

Prototyping, early functionality, products

Prototypes are used to demonstrate, test, and verify concept technology at an early stage. This calls for overdimensioned but not fully optimized hardware. Prototyping facilitates the testing and analysis of different implementations at an early stage. Flexible designs make it possible to add and modify hardware according to needs. Obviously, this is not possible in commercial product development cycles.

Although ideal for proof-of-concept applications, prototype terminals are typically too expensive for high-volume production and cannot be optimized for other features, such as low power consumption and small size. For this reason, they cannot be turned into a commercial market solution even when they excel at demonstrating functionality.

Ericsson's prototype projects typically lie 12 to 18 months ahead of commercial rollout of handset platforms and infrastructure products.

EMP product technology

After having used a prototype to prove a concept, the next step is to transfer functionality to real products via EMP's mobile phone platform offerings.

The use of prototypes also helps developers to identify and resolve potential problems, which significantly shortens the development time of commercial platforms. The idea is to elaborate the solution with a prototype, make tests, and integrate the proven concept into an Ericsson infrastructure implementation. After the basic solution has been predeveloped in a prototype environment, the new functionality is designed into an ASIC. One can thus bring a compact, cost-effective platform solution to market by moving the functionality from a software solution on overdimensioned hardware to a slim ASIC implementation.

Overview of prototype projects

Ericsson developed the following prototypes in 2006, among other things, to demonstrate functionality at 3GSM World Congress 2007:

- Multiband terminal based on EMP's U360 platform. The terminal covered every spec-

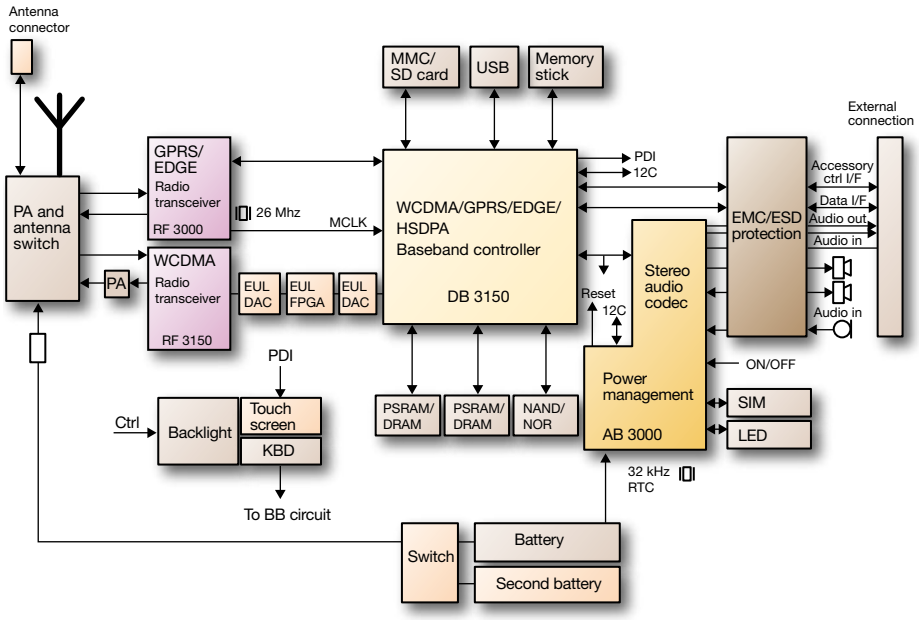


Figure 2
Prototype hardware design.

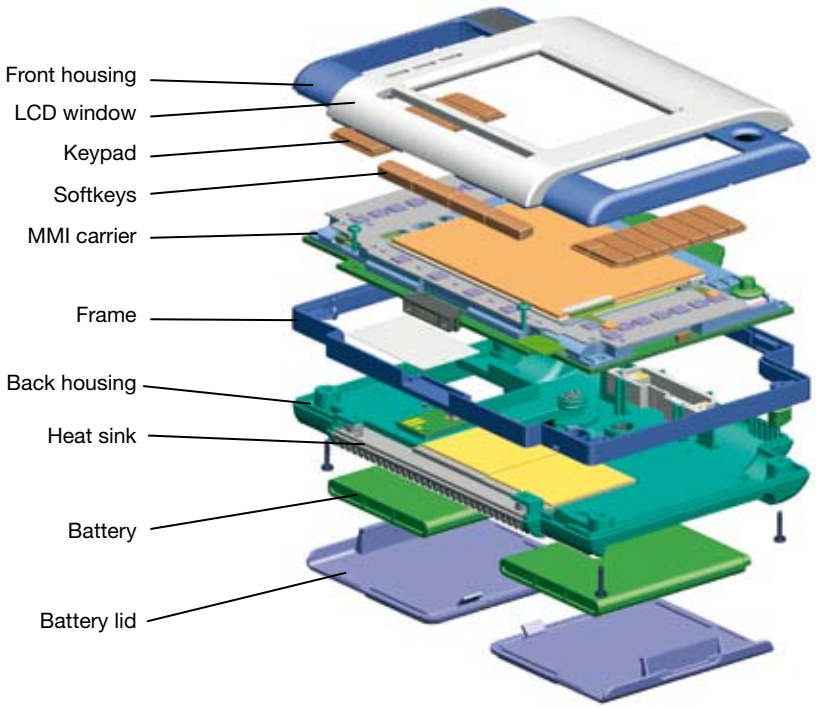
ified 3GPP band (1 to 9) from 850MHz up to 2.5GHz.

- Small-form-factor HSPA (E-UL cat-3 and HSDPA cat-5) prototype based on the EMP U350 platform.
- MBMS demonstrator. The prototype demonstrated hybrid MBMS broadcast and unicast technology.
- Multimedia voice-over-IP (VoIP). The prototype, based on the HSPA solution, demonstrated a VoIP application that featured short roundtrip delay and eliminated the most crucial echoes associated with today's internet telephony solutions.

Prototyping technology

Organizational flexibility is a criterion for prototype design, in part because new requirements and changing assumptions arise on short notice, and because standards are often in a state of flux at this early stage. To guarantee the requisite organizational flexibility, Ericsson has set up separate, specific processes and engineering teams that operate outside ordinary company processes.

Figure 3
Accurate prototype form factor, showing special cooling and dual-battery solutions.



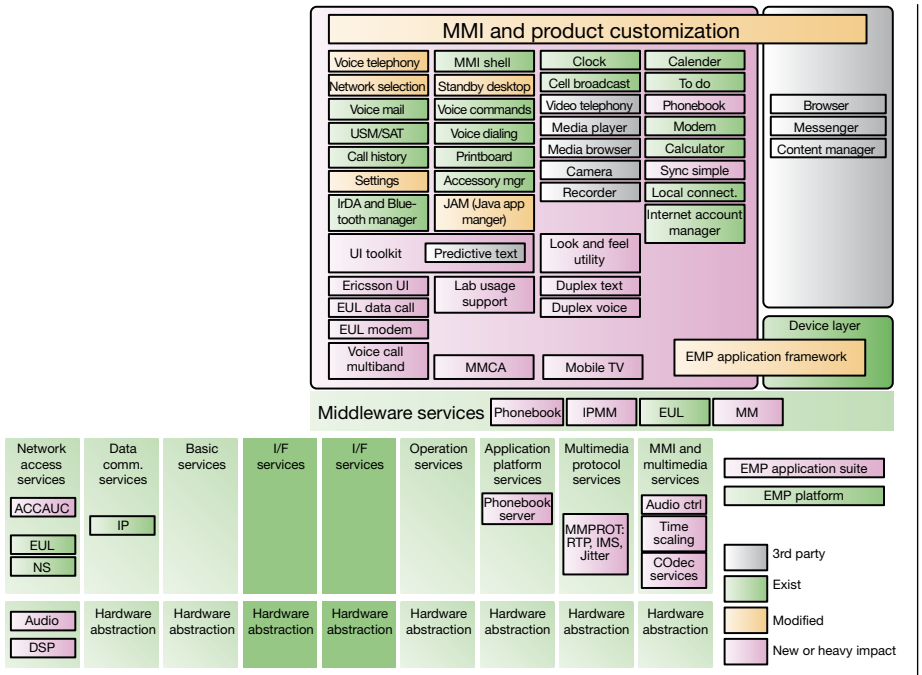


Figure 4
Multimedia VoIP deployment view showing basic architecture of EMP U360/U350 with modifications and additional components needed for real VoIP.

Prototype form factor, accurate mechanical designs

To attract maximum attention beyond the technology itself, the prototypes should be encased in an appealing industrial design (Figure 1). To do this well while keeping costs and development time at a minimum, Ericsson has borrowed innovation technology from other fields. For instance, Ericsson makes its prototype housings using machinery more commonly associated with the design of plastic parts for functional clothing, such as the soles of sports shoes. The fashion industry developed these machines to shorten development cycles and accommodate quarterly fashion collections. The machines produce excellent prototype housings by "printing" layers of liquid ink (each layer is hardened with ultraviolet light before a new layer is added). With these methods, one can produce and modify housings in a matter of hours, whereas traditional tooling might take up to 14 days or more.

Hardware design for prototypes

Ericsson does not use field programmable gate array (FPGA) technology for the entire baseband subsystem. Instead, it combines specific FPGA elements with existing handset platforms and off-the-shelf components. These "patchwork" designs yield more stable prototypes than multiple arrays of FPGAs (Figure 2). The HSPA prototype utilizes the baseband processor from the EMP U350, the BD3100, one Altera Stratix 3 FPGA, and one Ti 64xx series DSP.

Cooling solutions

As mentioned above, prototypes are not optimized solutions, but rather flexible vehicles for proof-of-concept designs. The prototype design for HSPA, for example, must handle up to 10W of heat dissipated by FPGAs and DSPs (Figure 3). In small devices, this much heat is problematic. Ericsson's solution has been to incorporate silent microfans and special heat sinks from the machinery and medicine industries.

Software design example

To achieve rapid turnaround and maintain clear focus on new areas of implementation, one should try to reuse existing technol-

ogy wherever possible. For software design, Ericsson integrates EMP's commercial platform releases. To illustrate this concept, let us consider the modifications that were needed for multimedia VoIP over HSPA (Figure 4).

1. The multimedia VoIP demonstrator was based on a data modem that can send data over HSPA (uplink and downlink) to give low latency (reduced delay in voice transmission). An FPGA and DSP were added to speed up data processing in the modem. In addition, new software was developed to control the receiver and transmitter chains.
2. The data modem core was based on the commercial U360 HSDPA handset platform. The standard U360 DSP software was modified to accommodate improved scaling of data flows and jitter buffers for VoIP voice processing.
3. Additional audio control elements were added and linked to the existing stacks.
4. Multimedia protocols were added on top of the modem functionality enabling users to combine media, for example, by browsing data or transferring a file while engaged in a VoIP call.
5. Modified codec services were designed to make use of existing codecs for new protocols, such as H.264 for VoIP multimedia services.
6. The EMP A200 applications suite was integrated and extended to meet prototype requirements (for instance, the need to manage VoIP phone book entries).
7. A special suite of VoIP multimedia control applications (MMCA) was developed to enable users to add and drop media while engaged in a VoIP call.

Integration and verification

Prototyping requires tight collaboration between system design, mechanics, hardware, ASIC and FPGA design, and every software discipline, including modem software, platform drivers, codecs, and application development. Finally, the prototype must connect to Ericsson's infrastructure and be compliant with its implementation. The challenge is thus an integration that spans across an entire telecommunications system.

Managing this scale of integration and verification complexity calls for the use of standard Ericsson tools and methods, including anatomy planning, graphical integration plans, and intensive system analysis.

Early verification is often a challenging task due to a lack of available commercial test tools and functionality. As a consequence, the test teams frequently have to create their own tools on standard equipment, such as logic analyzers and signal generators.

Wherever possible, the R&D organization collaborates with test equipment manufacturers to develop prototypes and test equipment in parallel. The resultant test suites provide important input for subsequent product development.

Demonstration of results

A great benefit of prototypes is that they embody tangible, working technology – tomorrow's technology and products in your hands today. Using prototypes to demonstrate technology enables people to touch, feel, experience, and thereby grasp the value and benefits of the final product. It is one thing to describe the advantages of, say, MBMS and VoIP, and something altogether different to actually watch TV on a mobile phone or hear the astounding audio quality of VoIP telephony over HSPA.

Prototypes may contain bugs, but people who understand the complexity involved are apt to forgive these imperfections during demonstrations and trials.

Conclusion

Prototyping is used to demonstrate, test, and verify concept technology at an early stage of design. It eliminates risks by validating design ideas, building blocks and hardware designs at the earliest possible phase of any given development cycle. Notwithstanding, although prototype terminals, for example, are ideal for proof-of-concept applications, they are typically too expensive for high-volume production and cannot be optimized for other features, such as low power consumption and small size. Therefore, they cannot be turned into a commercial market solution even when they excel at demonstrating functionality.

Ericsson successfully uses prototyping to more rapidly develop access technology and end-to-end multimedia solutions that are closely aligned with operator and end-user requirements. In 2006, for example, Ericsson developed prototypes to demonstrate multiband terminals, HSPA, MBMS, and multimedia VoIP. Ericsson's prototype projects typically lie 12 to 18 months ahead of commercial rollout of handset platforms and infrastructure products.

TERMS AND ABBREVIATIONS

3GPP	Third Generation Partnership Project
ASIC	Application-specific integrated circuit
DSP	Digital signal processor
E2E	End-to-end
EMP	Ericsson Mobile Platforms
E-UL	Enhanced uplink
FPGA	Field programmable gate array
HSDPA	High-speed downlink packet access
HSPA	Combined HSDPA and E-UL
MBMS	Multimedia broadcast/multicast service
RX	Receiver
VoIP	Voice over IP