Future Directions in Mobile Communications

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Abstract

This paper will outline the technological challenges faced in mobile telephones as wireless networks evolve further, to offer a multitude of services, including broadband services.

Introduction:

The evolution of telecommunication technologies has been very fast. Great advances have already taken place in such areas as video and speech compression, digital transmission, data storage and network capacity. The evolution and expansion of corporate and public networks is giving rise to visions of access to a plethora of information on the so called “Information Superhighway”.

Digital wireless technology today offers the transport media for these new services, including multi-media. The new information services present a challenge to mobile wireless phones. The phone is evolving into a end-user terminal which must be able to support the services and present them in a user friendly way. User friendliness means low-cost terminals, small enough to fit into a pocket, with usage time between battery charging exceeding the performance of todays phones.

All these challenges drive the underlying technology. The major technical challenges in a mobile phone can be attributed to four key parameters: volume, weight, power consumption and component count. The performance of integrtaed circuit technology has a major effect on all four parameters.

1. Mobile wireless markets

Mobile communications has been enormously successful during the 1990's. Average growth rates exceed that of PC's and the market volume of mobile terminals is expected to overtake PC's within the next years. The success goes hand-in-hand with the introduction of digital services.

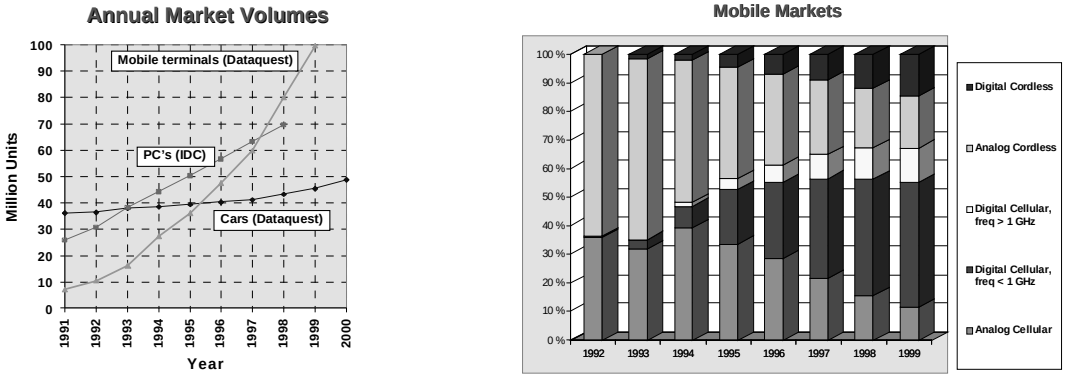

Figure 1. Annual market volumes of mobile terminals could exceed that of PC's.

2. Evolution of services and applications

The introduction of digital technology has enabled the introduction of new services and, thanks to development in technology, improved the performance of networks and terminals. Advances have already taken place in such areas as video and speech compression, digital transmission, data storage and network capacity. A step in upgrading the quality of service is the adoption of a high-quality speech codec for several systems, including GSM, US TDMA and CDMA. The Enhanced Full Rate (EFR) voice codec, according to user tests, even outperforms ADPCM. Half-rate codecs, which are important because they increase network capacity, have also been standardized. Half-rate codec technology is crucial for Japan's PDC system, where there are fears that the networks will run out of capacity by 2000.

Currently efforts are going on to standardize various enhanced data services. Data compression algorithms are entering the market and High Speed Circuit Switched Data (HSCSD) is being standardized for GSM. GSM phase 2 and 2+ services are gradually evolving towards the next generation of broadband wireless systems, UMTS.

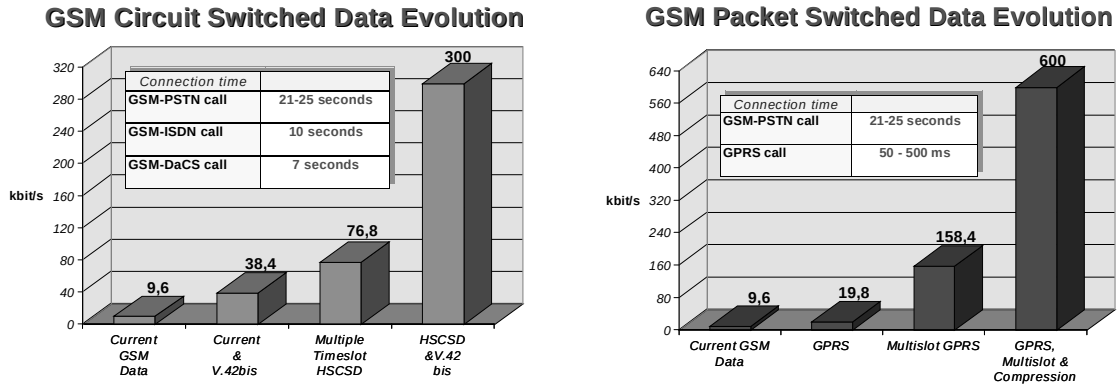

Figure 2. Increase in data speeds and improved connection times will be achieved with the standardization of new data services.

Even analog systems are being enhanced with digital technology. The NAMPS system in the US is a digitally enhanced cellular network with higher capacity than the analog AMPS system and enabling operators to offer digital messaging services.

The diversity of network technology drives the need for dual- and multimode terminals as well as dual frequency band operation. In time the ultimate user friendliness will be seamless global roaming between the networks, using the same handset, or as an intermediate solution a personal subscriber identification module, which will be accepted globally.

3. Product evolution

The mobile terminal has evolved from the early 1980's bulky car-phone to an ergonomically designed terminal with extended usage time or at the high-end of the product spectrum a communicator with email, fax and Internet services available, in addition to plain old cellular service.

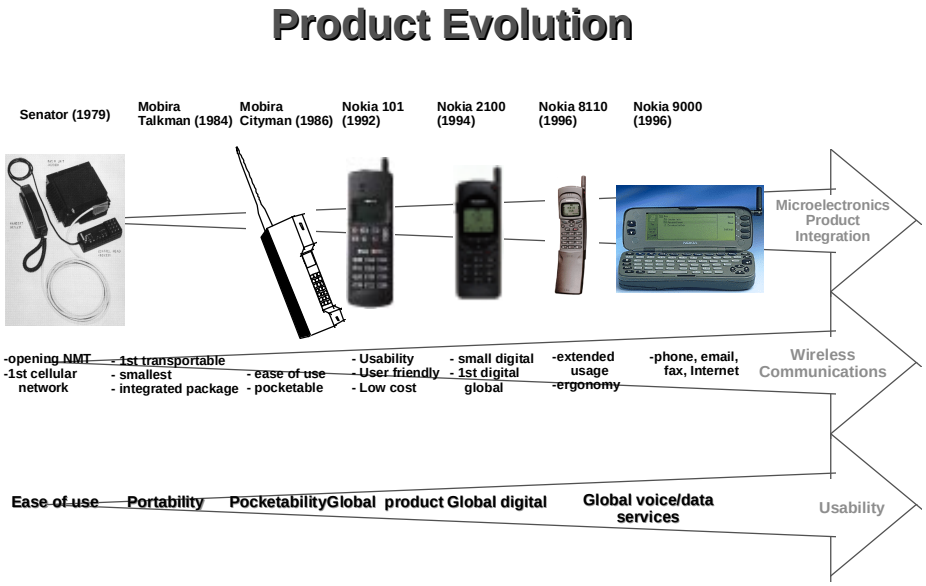

Figure 3. The evolution of the mobile phone.

The phone is evolving into a end-user terminal which must be able to support the services and present them in a user friendly way. User friendliness includes smaller and lighter terminals, small enough to fit into a pocket, with usage time between battery charging exceeding the performance of today, by far. To make the equation more complicated all of these requirements must be achieved with the lowest possible cost.

The requirements for user friendliness and increasing flexibility of services to be accomodated in low-cost terminals presents a major challenge to the underlying technology.

4. Major challenges

The major technical challenges in a mobile phone can be attributed to four key parameters: volume, weight, power consumption and component count. Component count affects the other key parameters, but is considered separately since it influences reliability and quality issues. Volume and

weight has been decreasing steadily and is reaching a level of comfortable use. Power consumption has yet to achieve a major breakthrough, primarily due to slow development of battery technology. Moderate improvement is expected in talk time but standby time will improve quickly.

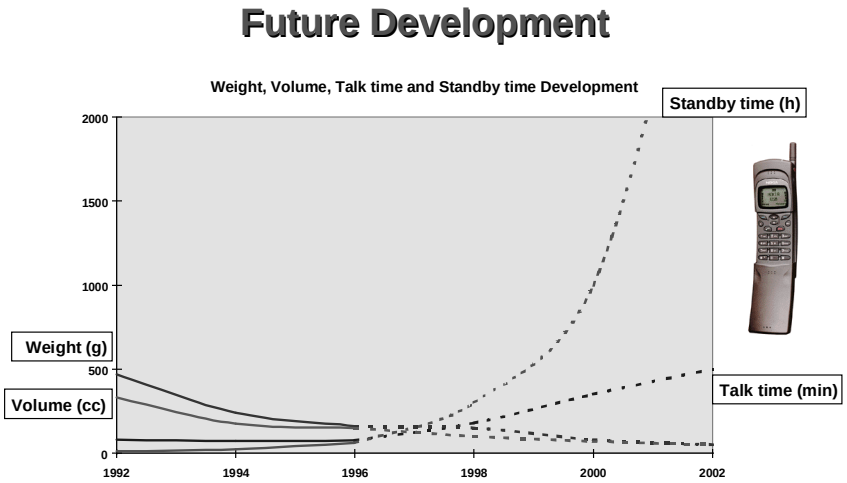

Figure 4. Future directions in mobile phones

The users almost consider the decrease in volume and weight a natural feature of mobile phones. In reality it challenges the available technology considerably. Traditional packaging technology, SMD, is approaching its end-of-life. The pressure to reduce the size is the driver for advanced packaging technology, chip scale packaging (CSP) and flip-chip, which promise great reductions in footprint area and volume. When the technology becomes commercially viable within two years, the required footprint will reduce to almost 10% and volume to less than 10%. Lack of manufacturing infrastructure and generally adopted standards present the greatest challenge.

The mobile phone still contains a large amount of discrete devices, mostly passives. Especially in the RF sections some 80% of the parts count is due to discrete passive devices. In the push towards smaller size and better reliability, also discrete passive component count needs to be decresed. This can be achieved by integration into IC's or on additional substrates, such as MCM-D or C. Because resistors and capacitors require large Si-areas the latter solution seems most viable. Using MCM-technologies discrete passive parts count can be reduced as much as 80% by the end of the decade.

The pressure on weight and volume together with demand for advanced features and services drives the integration of CPU's and DSP's, which in turn drives the IC-technology towards smaller feature sizes to accomodate the complexity and higher speed. Currently state-of-the-art 0,35 µm CMOS technology is able to accomodate the integration of DSP and MCU megacells together with logic functions on a single-chip. Power supply voltages at 2,7 V is everyday life and on-chip supply is even lower. The lower supply voltage is crucial since low-power operation is a must in mobile phones to achieve acceptable talk and standby times.

DSP's are capable of delivering up to 100 MIPS of performance, and this will double before the end of the decade. The performance will be needed to implement all new features and services on one single chip, still reducing the four key parameters over time.

The performance increase from process technology in turn allows for advanced system architectures, where the interface between the analog and digital section is being pushed closer to the antenna.

More and more system features can be implemented in software, increasing the flexibility and enabling the software configurable mobile phone.

Challenges still exist in the integration of high performance analog together with digital functions without performance degradation. Pushing the analog/digital interface towards the antenna also pushes the performance of CMOS. The integration of analog functions requires the ability to handle higher signal frequencies with higher signal-to-noise ratios than what CMOS technology is able to offer today. The future looks promising though, since the major part of process development is in CMOS, pushing it towards higher speeds.

Batteries still present the most lagging technology and are the most frequent source of user frustration. Batteries as an average represent more than 30% of the mobile phone weight and capacity increases slowly. Major breakthroughs are still to be awaited, although recent Li-based battery chemistries show improvement. Advanced Li-polymer and Li-metal batteries promise a 3-4 time capacity improvement (Wh/kg) compared to traditional NiCd-batteries. When taking into account the advancements in power management and lower power consumption achieved with advanced process technology and architectures, a considearble improvement can be expected in the near future.

5. Conclusion

The introduction of digital technology has enabled the introduction of new services in mobile wireless communications. This drives the evolution of the mobile phone into a end-user terminal which must be able to support the services and present them in a user friendly way. The requirements for user friendliness and increasing flexibility of services to be accomodated in low-cost terminals presents a major challenge to the underlying technology.

The major technical challenges in a mobile phone can be attributed to four key parameters: volume, weight, power consumption and component count. The challenges are being met by advances in packaging technology, process development, new mobile phone architectures and battery technology. Advances in all areas will benefit the end-user by allowing new services and making the mobile phone more user friendly.