Mobile Processors: Future Trends

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Abstract. Mobile devices, such as handhelds, PDA's and mobile phones, have been developing together with the need of mobility. Capabilities that go from GPS to wireless communications are making a stand in the market, and microprocessors have been adapted to each platform requirements. The aim of this communication is to present an overview of the current mobile architectures and its future trends.

1 Introduction

Mobility is now starting to grow as an important need in people's life. The possibility of having a mobile device capable of being used as a phone, personal computer or personal information manager is now real. This demand, accompanied by the last 5 years of severe electronics development, is being satisfied with the improvement of several types of mobile platforms.

There is actually no doubt about that convergence between computing and communication will be a matter of a short period of time.

Devices capable of handling digital audio, digital video, multimedia applications, personal information managing applications and wireless communications are requiring a new generation of wireless platforms combining all does elements.
Mobile processors are the cores of those platforms. The market provides a set of different solutions that are following different paths but with the same purpose.

The goal of this communication is to provide the reader with some background on mobile computing today, and tries to identify some technology trends. In order to provide this a technological review was made, but also some market behaviors were explored.

At start a survey on mobile platforms identifies the major groups of these devices. Then an approach to mobile microprocessors challenges is made. The last chapter presents some vendor approaches of some architectural and technological solutions available today.

2 Mobile Platforms

In this section I will try to approach the different groups of embedded platforms according to their target use. In other words, it can be said that mobile platforms can be grouped based on its aim.

2.1 Mobile Computers

In the year 2000, the term mobile computer was associated with notebooks, that is, computers that provide the end user with no more than 25% of performance reduction [2].

During the last two years the technology has been aiming for smaller and powerful devices. The term powerful not only means processing power, but also an improvement in battery and storage capabilities.

Laptops. Usually, these devices use a low power version of desktop microprocessors. To reduce power consumption, most of the current mobile processors operate at low power voltage and frequencies than the corresponding desktop versions. As of today, the highest clock rate for laptops is 2 GHz compared to 3 GHz of desktop processing power. [1]

Handhelds and PDA's. In 2000 a PDA was considered to be as a device that could function as a cellular phone, fax and personal organizer. It was also a pen-based device, using a stylus for rather then a keyboard for input, while a Handheld PC's was considered to deliver PC functionality in super portable form, while offering more computing power than a palm-sized PC. [1]

It is curious how it is difficult to separate these two concepts… This way, PDA's and handhelds, during the course of this communication will be considered to be the same.

The four major handheld platforms are: the Pocket PC, Palm and Symbian. The Pocket PC platforms run Microsoft Windows CE witch is a 32-bit operating system. The aim of the Pocket PC platform is to provide personal information management (PIM) capabilities.

Palm platform, runs PalmOS operating system, and has the biggest share on the PDA market. This platform was designed to work with PIM applications. Palm devices are known to be highly efficient concerning battery life.

Symbian platform was born out of a consortium formed by Ericsson, Nokia, and Motorola. Symbian distinguishes three major platforms: tablet PC, smart phone, and a PDA device. They also run PIM applications and have a keyboard. Currently this operating system is running on a large number of "mobile phones".

2.2 Mobile phones

Long gone are the times when mobile phones were devices used only for phone calls. It is clear that technologies like WAP and GPRS made the mobile phone market to be targeting its aim to a wither range... Nowadays mobile phones like Nokia 9210 are equipped with storage and multimedia capabilities.

Two good examples of the convergence between handheld devices and mobile phones are, for example Ericsson P800, witch is a stylus-based device, running Symbian operating system, and Qtek, witch is a device that has mobile phone capabilities, together with PIM capabilities, running Microsoft PPC2002.

2.3 Other devices

It might be also necessary to mention some other types of embedded systems like MP3 players, digital cameras and smart cards. Due to the lack of space I will not focus on those devices.

3 Challenges of Mobile Processors

The design of mobile processors has to comply with mobile platforms needs. Mainly users look for a device that can fit in a pocket, with a long battery life and also inexpensive. This leads manufacturers to be mainly concerned with:

- Power consumption
- Digital Signal Processing
- Peripherals Integration
- Multimedia Acceleration
- Code Density

3.1 Power Consumption

This is one of the most important challenges of mobile processors. In order to accomplish this objective several strategies can be used: [2]

Advanced Silicon Process. One of the possibilities to lower power usage is to use a leading-edge silicon process to manufacture the chips. Chips like Intel's XScale or the SmartMIPS family rely on cutting-edge silicon like that used for Athlon or Pentium 4.

Split Power Supplies. Building processors with different voltage inputs: a low-voltage source for the processor itself and a comparatively higher voltage to be used with the bus interface and I/O pins. This allows a very low-voltage chip to be compatible with the available memory and core logic. StrongARM was the first embedded processor to follow this strategy.

Static Logic Design. Static logic design is the ability to stop the clock dead and freeze the state of the CPU as if it was in suspended animation. Pentium, for example, does not work properly if its clock input is stopped, Motorola's DragonBall, on the other hand, does not.

Clock Gating. This is a limited version of clock stopping that partially shuts off the chip when they are not being used.

Frequency Scaling. Frequency scaling provides programmers with the ability to handle directly with power consumption (and performance). In terms of embedded systems this is not yet available because these systems are most concerned with power generally.

3.2 Digital Signal Processing

Control signalling aims at managing the establishment, maintenance, and termination of signal circuits. Control signalling is used either between the subscriber and the network or between functional entities within the network. GSM, just like ISDN, uses the signalling system number 7 (SS7), which is an open-ended common-channel signalling standard that can be used over digital circuit-switched networks.[3]

There are specialized processors for signal processing, called Digital Signal Processors (DSPs). The main difference between a general-purpose processor and a DSP processor is that a DSP has features designed to support high-performance, repetitive, numerically intensive tasks, which include:

- Single-cycle multiply-accumulate capability. Some high performance DSPs have two multipliers that do two multiply-accumulate operations per instruction cycle.
- Specialized addressing modes, for example pre- and post-modification of address pointers.
- On-chip memory and peripherals controllers. DSPs generally feature multiple-access memory architectures that enable DSPs to complete several accesses to memory in a single instruction cycle.

- Specialized execution control. DSPs often provide a loop instruction that allows a loop to be repeated without having to spend any instruction cycles for updating and testing the loop counter or for jumping to the top of the loop.
- Several operations encoded in a single instruction. DSPs have irregular instruction sets, usually allowing several operations to be encoded in the same instruction. For example, a processor that uses 32-bit instructions may encode two additions, two multiplications and four 16-bit data moves into a single instruction. In general, DSPs instruction sets allow a data move to be performed in parallel with an arithmetic operation.

DSP processors are mainly used in mobile phones. The purpose of mentioning DSP technology in this document is to show the need of DSP enabled processors when it comes to design a mobile device.

3.3 Peripherals Integration

The integration of peripherals controllers and CPU on the same chip increases chip complexity, but it will have benefits concerning power saving and system cost. [4]

There are two strategies for integrating peripheral logic such as dedicated interface controllers:

- To provide the basic core and integrate additional logic for a custom device to create an ASIC or ASP.
- To offer a standard microprocessor together with a companion chip that serves application specific needs.

3.4 Multimedia Acceleration

Capabilities like Media MIPS (MMIPS) are starting to emerge in the embedded market. In order to implement MMIPS, microprocessors designers are enhancing the conventional micro controller instruction set with instruction to accelerate the execution of multimedia code. Curiously, in some cases these instructions have a lot in common with the instruction set of DSP processor, mentioned before.[4]

3.5 Code Density

Code density is very important to reduce memory size (thus cutting overall system cost) and to enable applications deployment in ROM.[5]

CISC architectures traditionally have better code density then RISC, due to their more complex instructions. RISC fixed-length instructions simplify instruction decode, but forces more instructions to be processed. Although more adequate to enable pipelining (unified decoding process and instruction execution time), fixed 32-bit instruction length negatively affect code density. Still most of handhelds microprocessors are RISC based. To overcome code density drawback, some RISC implementations are based in a 16-bit instruction length.

Another technique to improve code density is a larger instruction set. Some of these processors architectures have specialised instructions (enabling DSP, multimedia, power management, etc). Larger instruction sets, however, imply more complex hardware inflating cost and complexity.

Code density is also of great importance for power management, more code density means less memory accesses.

Increased code density also leads to higher processor performance through more effective use of processor memory bandwidth and a lower cache miss rate.

4 Vendors Approaches

4.1 ARM11

The ARM11 micro architecture is the first implementation of the new ARMv6 instruction set architecture. It forms the basis of a new family of cores, for SoC integration, and semi-custom cores for applications that are demanding in terms of performance.

This micro architecture is targeted at high-end portable and wireless applications, consumer, networking, and automotive applications.[6]

The first ARM11 cores will be targeted, in terms of performance, in the 350-500Mhz range, but aiming for 1Ghz. By scaling both the clock frequency and the supply voltage, the Developer can control power consumption and performance. Processor implementations
based on the ARM11 micro architecture will achieve less than 0.4mW/MHz at 1.2V in a 0.13μm process technology.

The ARM11 micro architecture has been developed both for synthesizable and semi custom hard macro cell implementations. Since, primarily, the cores will be used within a system on a chip (SoC) context; enabling implementation through synthesis allows developers to integrate the design. Synthesis also allows licensees to add value to the design by exploiting the particular strengths of their semiconductor processes.

ARM11 cores have a synthesis-friendly pipeline structure, designed to work with commercially available synthesis tools and RAM compilers, that ensures timing closure is readily achieved. The resulting implementation of the synthesized ARM11 core excluding caches will typically occupy less than 2.7mm2.

It includes a set of media processing instructions to accelerate audio and video applications, it includes new memory system architecture, and it includes new instructions to accelerate real-time performance and interrupt response. In addition, since many new applications require multiprocessor configurations – for example, multiple ARM cores, or ARM plus DSP systems, it is now possible to share data with other processors, and also to port applications from non-ARM processors. ARM also provides a set of supporting IP for ARM11 processors.

4.2 Motorola DragonBall (MC68328)

Motorola DragonBall (MC68328) is an evolution to the 68000 microprocessor. This processor was developed aiming for the mobile market. It has 56 instructions and 14 addressing nodes. The core has 8 32-bit data address registers and there is no cache available.[7]

In the field of mobile computing, some interesting characteristics of this processor are:

- It includes a LCD controller;
- Implements features like Real time clock, Timers, UART;
- Has a low-power operation mode that provides features like turning off unused peripherals, reducing processor clock speed, disabling the processor altogether or a combination of these;
- Enhanced Peripheral support;

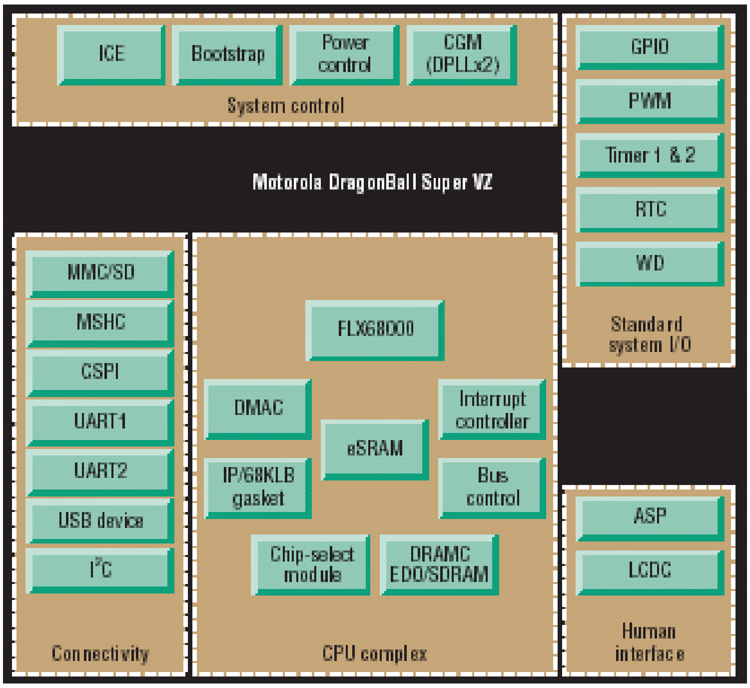

Fig. 2 Motorola's DragonBall Super VZ mobile processor, based on the company's own 68000 architecture, was the only chip that Palm PDA's used until recent decision to transition its OS to ARM-based chips. [1]

4.3 Java chips

Nowadays, specially the mobile phone market, has been invaded with the Java technology. Everyday we are being presented with marketing on mobile phones with Java games and software. Nokia and Samsung are already shipping their mobile phones with Java support.

Numerous chip manufacturers such as Jile Systems, ARM, Aurora VLSI, inSilicion, Nazomi Communications, Parthus and Zucootto Wireless, have licensed Java from Sun to implement their java processors. These companies will implement in hardware at least part of the Java 2 platform, Micro Edition's (J2ME's) virtual machine, witch translates Java instructions into commands the chip can understand [7].

5 Conclusions

The rapid change of the PDA market had immediate impact on vendor's strategies; this is obviously affecting the development of new technological solutions.

In addition to increasing functionality, the major trend in handheld devices is the convergence of wireless telephony and PDA functions.

Wearable computing is starting to grow from science fiction into reality, once the devices are in a state of some stability people will start to care about carrying the device… Why having the PDA or the mobile phone in a pocket, if it can be the pocket?

[1] Picture gently provided by David Clark, Computer

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