# Chameleon – Reconfigurability in Hand-Held Multimedia Computers

Gerard J.M. Smit, Ties Bos, Paul J.M. Havinga, Sape J. Mullender, Jaap Smit
University of Twente, Dept. Computer Science, Enschede, The Netherlands,
e-mail: smit@cs.utwente.nl

**Abstract.** In this paper a *reconfigurable systems-architecture* in combination with a QoS driven operating system is introduced that can deal with the inherent dynamics of future mobile systems. We claim that a radical new approach has to be taken in order to fulfill the requirements - in terms of processing power and energy consumption - of future mobile applications.

## 1 Introduction

In the next decade two trends will definitively play a significant role in driving technology: the development and deployment of personal mobile computing devices and the continuing advances in integrated circuit technology. The development of personal hand-held devices is quite challenging, because these devices have a very small energy budget, are small in size, but require a performance which exceeds the levels of current desktop computers. On the other hand they should have the *flexibility* to handle a variety of multimedia services and standards (like different video decompression schemes and security mechanisms) and the *adaptability* to accommodate to the nomadic environment, required level of security, and available resources. We believe that state-of-the-art system-architectures cannot provide the wealth of services required by a fully operational mobile computer given the increasing levels of energy consumption. Without significant energy reduction techniques and energy saving architectures, battery life constraints limit the capabilities of these devices. This paper discusses reconfigurability issues in low-power hand-held multimedia systems, with particular emphasis on energy reduction.

## 2 Energy Efficiency

In the area of mobile computing it will be an enormous challenge to work with a minimal power budget. Yet, the architecture must provide the performance for functions like speech recognition, audio/video compression/decompression and data encryption. Power budgets close to current high-performance microprocessors, are unacceptable for portable, battery operated devices. We think progress has to be made in two areas in particular:

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- *Reconfigurable system architectures*
  Reconfigurable architectures are flexible and adaptive, use the chip area effectively and are relatively easy to design.
- *Energy-aware operating systems*
  Mobile systems should be flexible and adaptive to the inherent unpredictability of the mobile environment, and should be able to control the multimedia streams through the reconfigurable architecture. The operating system has to be Quality of Service driven to be able to adhere to these requirements efficiently. Here QoS not only involves network performance parameters, but also energy cost and infrastructure cost. These parameters are 'vertical' controls: they have impact on all layers of the protocol stack, from applications down to the physical layer. Therefore our approach is based on an extensive use of power reduction techniques at all levels of system design.

## 3 Reconfigurable Systems Architecture

The strength of a *reconfigurable systems architecture* is its flexibility. Reconfiguration can be applied at several layers in the system and in various levels of granularity, for example: a) reconfigurable processing modules b) reconfigurable media streams, and c) system decomposition. In addition to that, a generalized QoS model that encompasses different levels of granularity of the system is essential to select an efficient configuration.

**Small grain reconfigurability: Reconfigurable processing modules**
Multimedia applications have a high computational complexity with a regular and spatially local computation. Communication between modules is significant. State-of-the-art application-specific coprocessors have the potential to perform multimedia tasks efficiently: both in terms of performance as well as in energy consumption. Such coprocessors are not attractive though, due to their inflexibility [1].
For a wide range of functions that use digital filtering algorithms on parallel data state-of-the-art reconfigurable devices (such as FPGAs), do not posses the required processing power. We defined a novel architecture called FP*F*As (*Field-Programmable* ***Function*** *Array)*. These devices have a matrix of ALUs and lookup tables [3]. A broad class of compute-intensive algorithms can be implemented on an FPFA efficiently. The instruction set of an FPFA-ALU can be thought of as the set of ordinary ALU instructions, with the exception that there are no load and store operations which operate on memories. Instead, they operate on the programmable interconnect; that is, the ALU loads its operands from neighboring ALU outputs, or from (input) values stored in lookup tables or local registers. A novel aspect in this concept is that chip design is replaced by dynamic reconfiguration and reprogramming for future applications using a highly efficient platform. In our opinion, this sheds a new light on the fundamental issues of low-power embedded systems.

**Medium grain reconfigurability: Reconfigurable media streams**

Much energy can be saved in multimedia systems by improving the component interaction [2]. Autonomous, reconfigurable modules such as network, video and audio devices, interconnected by a switch, offload as much work as possible from the CPU to programmable modules that are placed in the data streams. Thus, communication between components is not broadcast over a bus to main memory, but delivered exactly to where it is needed, work is carried out where the data passes through and, if memory is required at all, it is placed on the data path where it is needed. Modules are autonomously entering an energy-conservation mode and adapt themselves to the current state of resources, the environment and the requirements of the user. To support this, the operating system must become a small, distributed system.

**Coarse grain reconfigurability: System decomposition**

In a system many tradeoffs can be made. A careful analysis of the data flow in the system and decomposition of the system functions can reduce energy consumption considerably. For example, when we consider the transmission of an image over a wireless network, there is a trade-off between image compression, error control, communication requirements, and energy consumption. In an architecture with reconfigurable modules and data streams, functions can be dynamically migrated between functional modules such that an efficient configuration can be obtained.

## 4 Conclusion

Without significant energy reduction techniques and energy saving architectures, battery life constraints limit the capabilities of future mobile systems. In this paper we claim that a *flexible* and *reconfigurable* systems-architecture in combination with a QoS driven operating system is needed to deal with the inherent dynamics of future mobile systems. This reconfigurability can be found in the interaction of multimedia devices, in the media processing and in migration of functionality.

**References**

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