Power

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1 Introduction

Power dissipation is one of the fundamental physical issues which must be taken into consideration in the design of a computer architecture. The basic problem is that while heat in a processor is created proportional to the volume of the processor, it can be dissipated only by the surface area of the processor. Additionally, as more components are packed into a smaller volume, the amount of heat that can be generated by a processor increases.

Current directions in architecture design are stressing the power issue in two directions. On one end are high performance computers, which are indifferent to the amount of power dissipated by the computer in order to run the processors as fast as possible, so long as the computer can be run without turning into a pile of molten parts. At the other end are systems such as PDAs and other types of handheld and wearable computers, which are explicitly designed to require as little power as possible. A handheld computer which required a 20 pound battery and cooling system to run for a few minutes would be of little practical use or interest.

2 Issues in High Performance Designs

The first area of architecture where power issues are an integral part of the design are high performance processors. This space includes any system where performance is considered to be significantly more important as a design goal than minimizing the amount of power consumed by the processor. Because of this, it becomes necessary to have a cooling system which meets the demands of the processor, and to ensure that the processor doesn't require a cooling system which is more complex than the processor itself. Such designs then depend on a number of techniques to dissipate power as efficiently as possible in order to run the processors fast. As performance becomes a more important goal and power consumption less important, the power dissipation systems become more complex.

At the high end are high performance supercomputers, such as the Cray series. Such large scale systems typically use a liquid-based cooling system to dissipate heat, by continuously cycling coolant into the system to dissipate heat from the processors, and then removing the coolant from the system to dissipate with the outside environment.

At the low end of this space are processors used in modern workstations and servers, such as the Intel Pentium III, AMD's Athlon, or Compaq's Alpha. The processors themselves are fairly inexpensive and do not warrant as elaborate a system as the liquid coolants used in high performance computers. However, they do generate enough heat to require some type of cooling system. THis requirement is usually satisfied through the use of a heat sink and fan.

Some new developments in this area include recent work involving the use of microchannels to flow water within the packaging. The goal of such microchannels is to significantly increase the surface area of the processor, increasing the efficiency of power dissipation without requiring the large, elaborate, and potentially very messy cooling systems such as that used by the Cray 3.

3 Design for Low Power

The other architecture space where power dissipation is an important issue is in devices which are specifically designed to use as little power as possible. The basic technique in these designs is to create architectures which generate an amount of heat that is in proportion with their performance. Parts of the design which increase the amount of power dissipated more than they increase the performance of the processori are suspect. Also it is possible to reduce power dissipation through some clever tricks or improved materials and fabrication processes. Overall, in low power designs, the basic rule is to keep it simple.

One example of such a design is in the Digital StrongARM processor. The basic design of this processor is the same as that used in the Digital Alpha 20264. By removing the FPU, branch history table, and complicated control circuitry for things like out of order execution, while reducing the output voltage, slowing the clock down, and using some clever tricks to reduce the power necessary to drive the clocks, an Alpha is turned into a StrongARM which uses 1/50th the power.