CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY

Name(s)
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Project Number
S0917

Project Title
An Analysis of Clock Rate and Thermal Scaling in Modern Mutli-Core Microprocessors

Abstract

Objectives/Goals
The drift speed of electrons traveling through a circuit is directly related the current traveling through the circuit. Based on the idea that the current through a transistor can be manipulated by adjusting its input voltage, the drift speed of electrons can be increased to lower the delay time of the processor's logic gates and increase clock rate. This project investigated the relationship between core voltage and the clock rate of a microprocessor, along with the effects core voltage has on temperature and power consumption.

Methods/Materials
1) Modern multi-core microprocessor (G0 Revision Intel Core 2 Quad)
2)Aftermarket cooling solution (Xigmatek S1283) Heatsink/Fan
3)Motherboard with configurable BIOS (ASUS P5Q-E P45 Chipset)
4)Memory/RAM 4GB Samsung DDR2 800 6-6-6-18
5)Other hardware components -Graphics Chipset (Nvidia G92), Power Supply (700W OCZ Modular Power Supply)Optical Drive, Hard Drive, Display
6)Peripherals -Keyboard, Mouse

Results
As predicted, the temperature of the processor as well as its power consumption increased linearly with core voltage. The maximum operable clock rate increased initially with core voltage, but this increase quickly diminished while power consumption and temperature climbed steadily. Eventually, there was a point where the maximum clock rate ceased to increase at all. Testing ended when the processor's maximum temperature exceeded 100°C the maximum safe temperature given by the manufacturer.

Conclusions/Discussion
The results of this experiment point directly to inherent barriers in increasing microprocessor clock rate directly via voltage. Not only did the gains yielded in clock rate diminish rapidly as the voltage increased -the relationship was essentially logarithmic, but the rate at which temperature and power consumption increased relative to the obtained clock rates were quadratic. As the operating temperatures of silicon are limited, the trend of increasing temperature suggests that even if clock rate were to steadily increase with increasing voltage, the problems associated with operating temperatures would prevent such an option from being viable. The results indicate that alternative methods must be used to increase processor clock rate and speed, especially in environmentally friendly applications of computers where efficiency (low power consumption) are paramount.

Summary Statement
What is the relationship between increased core voltage and the maximum clock rate, temperature, and power consumption of modern multi-core microprocessors?

Help Received