Computation: A Byproduct of Home Water Heaters

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In the future, home water heaters will provide for the bulk of the computational needs in a modern home. The modern home has many needs of hot water including such exciting uses as bathing, laundering clothes, and washing dishes. Likewise a modern home has many uses for computation such as gaming, desktop computing (word processing and spread-sheets), home automation control, video archiving, and personal search indexing. Traditionally electric water heaters take in electricity and by utilizing resistive heating elements produce heat which is captured to heat water. Traditional computer chips take in electricity and produce computation and waste heat which needs to be removed. Clearly in the future, these two technologies will be married in a symbiotic relationship. In this work we investigate how the marriage of computation and home water heaters is desirable and how it impacts multicore computer chip design.

The Design of a Merged Water Heater-Computer

The energy used to heat water typically takes the form of fossil fuels or electricity. In many places in the world, electrical water heaters are favored to fossil fuel water heaters due to such reasons as inexpensive electricity (hydro or nuclear power), lack of a fossil fuel delivery mechanism, and a relatively little need for heat to justify fossil fuel delivery (warmer climates). A typical home water heater utilizes 1-3kW of electrical power. This is easily supplied by a host of multicore computer chips. For example just ten 100W x86 chips could be utilized to heat all of the water in a typical house. We propose removing the resistive heating elements from a home water heater and replacing them with a host of multicore computer chips. Utilizing computer chips for heating is just as efficient as the incumbent toaster-wire technology with the added bonus of a computational byproduct.

The power directly consumed by a computer system in a data center is only a third of the energy needed to run the system. Another two thirds is needed to remove the waste heat. Thus we foresee a future in harnessing the multicore computing revolution for such noble goals as dish washing. In fact, we believe that in the next ten years, we will see Intel and AMD enter the water heater market as a means to sell more power hungry multicore processors.

Alternatively a cottage industry of plug-in computation cards may spring up to allow the latest and greatest computers to be plugged into a water heater and allow an easy upgrade path.

The basic design of a merged water heater-computer consists of a large water tank with an internal computer heating element. Power is provided as in a typical home water heating application. Conveniently no flu is needed as computation does not produce harmful carbon monoxide. The home water heater-computer has gigabit Ethernet included to interface with the house's display devices and the Internet.

Architectural Implications

The merging of water heaters and computers has some interesting multicore-chip design implications. The multicore computer designed to heat water efficiently does not need to be the most power efficient design. In fact, it may explicitly be less power efficient. Multicore heater chips will be throughput oriented and capable of trading extra computation throughput with an Internet based computation pool. The water heating multicore chip will need extensive support for enabling and disabling cores, and dynamic voltage scaling over a large range. When a large amount of heat is needed and large amount of computation is needed, the processor can execute in a relatively efficient manner at a low voltage. When large amounts of computation is needed and low hot water demands occur, the voltage can be reduced to operate in the most power efficient means. When large amounts of hot water is needed, all of the cores can be enabled and the voltage increased to produce more heat.

Challenges

One of the primary challenges of heating water with computation is determining what to do with all of the extra computation generated across the planet. We foresee the usage of this spare computation being applied to such noble causes as computing pi to great precision and computational protein folding to explore a cure for cancer. In a market based system, the added computation can be sold back the computational grid. Another challenge is the costs associated with silicon computing chips being more expensive than toaster wire resistive heating elements. We believe the added benefit of a computational byproduct and economies of scale will in time mitigate these cost differences. Also, older fabrication technologies can be used which has two benefits; they produce more heat and cost less.

Typical home water heaters produce water around 140F (60C). In order to create this temperature of hot water, the heating element needs to be significantly hotter. Silicon can undergo relatively high temperature extremes. Silicon computing chips can be designed to operate up to 400C which is plenty hot enough to efficiently transfer heat to water. At this temperature, the chips in fact are more efficient for producing heat. Care must be taken such that they do not have thermal runaway and so that the service lifetimes of the chip are not significantly reduced. Older process generations are a good way to increase their reliability.

Future

In future work, we would like to explore how multicore designs can be applied to toasting bread and house heating.

So remember that the next time that you jump in the shower, be sure to kick off that prime factorization job.