April 1, 2000

A High Performance Coffee Maker

J.P. Grossman

Abstract

Today's programming environments are poorly suited to maintaining high programmer efficiency as they do not address the issue of fatigue. In this paper we present a novel system architecture which supplies the programmer with an amount of caffeine proportional to the amount of work being done. Experimental results confirm that this enables a higher level of productivity than would be possible in a conventional system.

1 Introduction

Programmer efficiency is a crucial consideration in system design; in many cases it is more important than the raw speed of the computer. In an ideal system, a programmer's productivity should scale linearly with the amount of effort that she expends. However, in current programming environments both the programmer and the architecture are limited in their ability to support such scaling.

Human beings are inherently inefficient due to fatigue and the eventual need to sleep. Experienced programmers, on the other hand, overcome these shortcomings by drinking a variety of beverages containing caffeine. Experimental studies have verified that caffeine improves performance ([Jarvis93], [Smith93], [Warburton95], [Smith99]). The problem is that the harder a programmer works, the more caffeine they need to maintain their efficiency. They therefore need to break more frequently to make coffee or buy coke. This is disruptive and reduces the amount of time available to work. The alternative of continuing to work when caffeine is required is unappealing as even a brief deprivation of caffeine can have a noticeable impact on performance ([Phillips97], [Lane98]).

High performance computers are becoming increasing limited by issues of power consumption and cooling. Typical cooling systems are not effective at removing large amounts of heat. Furthermore, they do not respond to changes in cooling needs. The amount of heat produced by a processor can vary dramatically with the workload. The harder a programmer works the hotter the computer gets, yet there is no corresponding increase in cooling resources.

2 High Performance Coffee Maker

We have constructed a prototype system which solves these problems. An AMD Athlon overclocked to 3GHz is cooled using microscopic channels [Tuckerman81]. We use ordinary tap water as coolant. Rather than construct an expensive heat exchange system to remove thermal energy from the water, we use the resulting hot water to make coffee and replace its volume with fresh cold water. The coffee maker is directly integrated. We call this system a **High Performance Coffee Maker** (HPCM).

This system naturally addresses the problems of programmer efficiency outlined in section 1. The cooling system is responsive to the needs of the hardware; hot water is removed and cold water is added at a rate needed to maintain a constant processor temperature. The harder a programmer works, the more heat the processor produces. As the processor produces more heat, more water is exchanged through the system, and more coffee is produced. Thus, the programmer's need for increased caffeine with increased work is directly met by the system. No breaks are required to obtain coffee or coke, and the programmer can maintain maximum efficiency for an extended period of time.

3 Experimental Results

We conducted a series of experiments to determine whether or not HPCM provides the expected linear relationship between programmer effort and productivity. Sixty undergraduates were randomly assigned to a test group and a control group. Each subject was given a sequence of programming tasks which increased in difficulty from writing a program in LISP that displays a simple output string in a LISP interpreter, to writing a program in assembly that displays a simple output string in Windows 2000. The control subjects carried out their work in a standard work environment with nearby coffee makers and coke machines; the test subjects carried out their work in the prototype HPCM environment.

Project Aries Technical Memo ARIES-TM-09
Artificial Intelligence Laboratory
Department of Electrical Engineering and Computer Science
Massachusetts Institute of Technology
Cambridge, MA

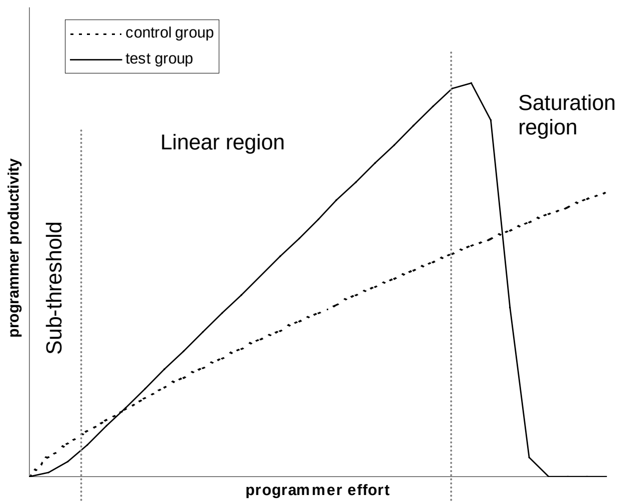

Figure 1: Productivity vs. effort

Figure 1 shows the results of the experiments. Control subjects in the standard programming environment were efficient for simple tasks, but efficiency drops off rapidly with programmer effort due to the need for frequent coffee/coke breaks. The graph of productivity vs. effort for the HPCM environment can be broken down into three distinct regions. In the *sub-threshold* region, the processor is not yet hot enough to make coffee, and as a result programmer performance suffers. In the *linear* region the amount of coffee (and hence programmer productivity) increases linearly with programmer effort. In the *saturation* region the programmer becomes saturated with caffeine, resulting in a sudden and large decrease in performance. This region is also referred to as the *cardiac arrest* region [Mrvos89].

4 Conclusion

The HPCM system provides a highly efficient programming environment in which productivity scales linearly with programmer effort over a wide range of tasks. The experimental results show that while HPCM outperforms standard programming environments, there is still room for improvement. The sub-threshold region can be improved fairly easily by running a few Quake3 servers, raising the temperature of the processor enough to make coffee. Methods of improving performance in the saturation region are currently under investigation. We are confident that further research will produce a system featuring both the high programmer efficiency of HPCM and the low mortality rates of more conventional programming environments.

References

[Jarvis93] Martin J. Jarvis, “Does caffeine intake enhance absolute levels of cognitive performance?”, Psychopharmacology, Vol. 110, No 1-2, Jan. 1993, pp. 45-52.

[Lane98] James D. Lane, Barbara G. Phillips-Bute, “Caffeine deprivation affects vigilance, performance and mood”, Physiology and Behavior, Vol. 65, No. 2, Aug. 1998, pp. 171-175.

[Mrvos89] R.M. Mrvos, P.E. Reilly, B.S. Dean, E.P. Krenzelok, “Massive caffeine ingestion resulting in death”, Veterinary and Human Toxicology, Vol. 31, No. 6, Dec. 1989, pp. 571-572.

[Smith93] Andrew P. Smith, P. Brockman, R. Flynn, Andrea Maben, et. al, “Investigation of the effects of coffee on alertness and performance during the day and night”, Neuropsychobiology, Vol. 24, Nol 4, 1993, pp. 217-223.

[Smith99] Andrew Smith, Wendy Sturgess, John Gallagher, “Effects of a low dose of caffeine given in different drinks on mood and performance”, Human Psychopharmacology: Clinical and Experimental, Vol. 14, No. 7, Oct. 1999, pp. 473-482.

[Phillips97] Barbara G. Phillips-Bute, James D. Lane, “Caffeine withdrawal symptoms following brief caffeine deprivation”, Physiology and Behavior, Vol. 63, No. 1, Dec. 1997, pp. 35-39.

[Tuckerman81] D. B. Tuckerman, R. F. W. Pease, “High-Performance Heat Sinking for VLSI”, IEEE Electron Device Letters, Vol. EDL-2, No. 5, May 1981, pp. 126-129.

[Warburton95] David M. Warburton, “Effects of caffeine on cognition and mood without caffeine abstinence”, Psychopharmacology, Vol. 199, No. 1, May 1995, pp. 66-70.