DECWRL Celebrates 10 Years of Influence

1-GHz, 130-W, 6M-Transistor Alpha Implementation in Development

By Brian Case

If asked to name a prominent computer-science research lab, most computer-industry insiders would respond with Xerox PARC, IBM Yorktown Heights, or a favorite university. These institutions have been around for decades and have established their reputations for excellence with a sustained string of important results that have shaped our industry.

Digital Equipment Corp.'s Western Research Lab (DECWRL or just WRL) is a relatively new addition to the league of corporate-sponsored research labs. Yet, as its staff celebrates the 10-year anniversary of the founding of the lab, it has already produced an enviable string of important computer architecture results. While WRL may not yet have the same visibility as a lab like PARC, it has something PARC and other labs have lacked: a good match between the goals of the lab and the goals of the parent corporation. WRL was founded to find ways of building the fastest possible computers, and DEC is in business to sell computers. This is in contrast to the parent companies of other labs, which have a very diversified product mix. The close fit with the overall goals of DEC make it easier for WRL to influence DEC's products than, say, for PARC to influence Xerox's products. WRL may be getting set for its biggest influence yet as it pursues the BIPS project.

Star-Studded Anniversary Celebration

The celebration began with a few remarks from current WRL director Richard Swan. Next, we saw a slick, Hollywood-quality—but excellent—video that detailed some of the achievements of WRL. Finally, a distinguished group of computer scientists made some remarks on the computer industry over the past decade or so and their involvement with DEC and WRL. These informal speakers included Forest Baskett—original director of the lab, John Hennessy, John Ousterhout, Dave Patterson, Smokey Wallace—founder of the DEC Western Software Lab but currently a bartender at a popular Palo Alto watering hole, and Brian Reid—who gave an entertaining and graphical account of worldwide network activity.

WRL History

WRL was established ten years ago as DEC's first research laboratory in California. At that time, RISC was causing a stir not only in the academic circle of the computer architecture community but within DEC as well.

Professor David Patterson of U.C. Berkeley had spent some time at DEC developing microcoding tools in conjunction with VAX development. When Patterson began to write papers about the advantages of RISC techniques, he naturally chose the VAX as a contrast and called it a CISC (a term that, even before you know what it means, sounds negative). The VAX was a natural choice because he had firsthand knowledge of VAX implementations and even insight from its designers and implementors about the difficulties in implementation caused by the architecture.

More than a few engineers in DEC were upset that the integrity of their computer architecture was being attacked. They published a scathing rebuttal to the early RISC paper, thereby establishing a visible anti-RISC position at DEC.

Still, Sam Fuller believed RISC had some merit, and championed WRL to investigate this new idea under the DEC umbrella. DEC engineers would be convinced of RISC's advantages only if they could witness a valid, controlled RISC vs. CISC experiment; the Titan was directly comparable to some ECL VAXs. Since there was significant, if knee-jerk, opposition to the idea on the East Coast, it made good sense to locate WRL somewhere else. The Palo Alto area was chosen as the home of WRL because it was near both epicenters of RISC sentiment—U.C. Berkeley and Stanford—and because it gave access to the large and growing talent pool of Silicon Valley. Forest Baskett decided WRL "should be a sweaty bike ride from Stanford."

WRL Achievements

WRL has a distinguished, if partially unknown, list of original contributions to the computer industry. Some, such as the development of the Titan ECL RISC computer, are fairly well known. Others, such as the development of the earliest versions of the X-window system (WRL called it "W" at the time), come as a surprise to many people. While MIT certainly deserves credit for evolving and dispersing the X-window system, WRL deserves the credit for the initial development.

At the open house, a technical report order form was distributed. It contains a list of 51 technical reports and 15 technical notes. These papers—many published in prestigious journals—cover topics including computer architecture (Titan and MultiTitan), compiler technology (the Mahler intermediate language and

global register allocation), networking, program trace analysis (superscalar vs. superpipelined strategies), test pattern generation, microarchitecture (ALU design, analysis of processor implementations), and nuts-and-bolts hardware (heat-sink design, chip packaging, and boiling small pools of water as a heat-dissipation technique).

An important factor in making DEC a member of the larger computer community was WRL's connection of the internal DEC network to the outside world via Internet. At the time of WRL's founding, PDP-11s and VAXs were widespread as Internet and Usenet nodes in universities and corporations. It seems strange to think that before WRL, DEC itself was not connected.

As influential and relevant as WRL looks from outside of DEC, it may appear even more so from within. While there are signs that the DEC product-development community was not always receptive to developments at WRL—for example, no DEC products use a WRL-developed computer architecture—it is unquestioned that DEC's products have been influenced by WRL. The idea of a large, on-chip by-pass capacitor, for example—now used in the Alpha microprocessor—was tested in the MultiTitan. WRL developed CAD tools that are used within DEC.

Even graphics accelerators in DEC's workstation products were designed with WRL's help. Based on firsthand knowledge of the X-window system, it became clear that a RISC approach to graphics-accelerator hardware was valid. WRL worked directly with a DEC product group to design a graphics accelerator that has proven both cheaper and faster because some operations are implemented in software where optimization algorithms can eliminate redundant work.

WRL's Future

WRL's formal charter is not tied specifically to RISC but is, according to Sam Fuller, Vice President of Research at DEC, "...to develop the tools and understanding to build the highest performance computers in the world." To this end, WRL has started its BIPS project.

The goal of the BIPS-1 project is to design a single-chip microprocessor that will run at 1000 MHz (1 GHz). This BiCMOS chip will integrate an integer unit, a floating-point unit, and two levels of cache on a six-million-transistor die. BIPS-1 is the first reported use of two levels of cache on a single chip. The first-level cache will be about 8 KB and implemented in bipolar to meet the 1-ns cycle time requirement. The second-level cache will be 32 KB and exploit bipolar speed and CMOS density to achieve a 3-ns cycle time.

BIPS-0 was a test design that has already been retired. Although no fully working chips were produced, it proved some essential concepts. BIPS-1 will implement the Alpha architecture, and testable silicon is expected before the end of 1993.

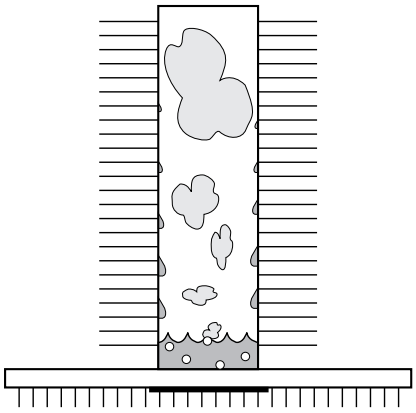

Figure 1. DEC's 175-W cooling tower package.

Packaging and power engineers are designing components able to dissipate about 175 Watts (40 Amps) at 4.5 volts, although the chip will probably dissipate only 130 Watts.

The earlier-mentioned research into boiling pools of water was undertaken specifically for this project. The coffee-warming 30 Watts of the current 21064 Alpha chip pales in comparison to the bacon-sizzling 130 Watts of BIPS-1.

To dissipate this heat from the surface of the chip, a special heat-pipe-like cooling tower has been designed, as shown in Figure 1. A small pool of water is sealed inside a low-pressure cylinder. The water boils easily, which exploits the cooling effect of an expanding gas. The steam carries the heat up and away from the chip; the fins then conduct the heat out of the cylinder, which allows the steam to condense.

Conclusions

WRL has a rich and distinguished past, and as the BIPS project proceeds, the microprocessor community can expect a string of important results. Perhaps the most interesting will come in the area of memory system design, since one of the biggest challenges will be keeping the BIPS processor occupied. WRL scientists will have to devise some innovative memory system architectures.

It seems that DEC has effectively cloned the Xerox PARC research formula: create an environment that attracts bright people and give them a charter that forces them to build their own computer systems, preferably from scratch. The string of important computer developments—including Titan, MultiTitan, BIPS-0, and the groundbreaking BIPS-1—prove that the formula works.♦

See back page for a partial listing of DECWRL's research papers.