OutPost on the Endless Frontier©

EPRI e-News on Recent Key Developments in Energy Science and Technology
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Faster, F a r t h e r…Smaller: Toward "Street Smart" Electricity

In the mid-1950s, still in my teens, I was lucky enough to become part of IBM's SAGE computer project, the heart of what was to become NORAD, the North American Air Defense System, and really the world's first supercomputer. This was indeed a watershed machine which presaged much of what we take for granted today in computers and data processing…random access memory, visual displays, parallel computing, multiple processors and packet networking…only now we have all this on our desktop. In 1955 it required 45,000 vacuum tubes, a three story building with a small substation for a power supply, and SAGE ran a lot slower with minuscule memory by present standards.

On February 4th, 1998, IBM announced that its research laboratory in Austin, Texas, in conjunction with its semiconductor fabrication facility in East Fishkill, New York, had fabricated and demonstrated a microprocessor with a speed in excess of 1000 MHz.[1] Today's PCs typically run at speeds around 150 MHz with the highest performance units topping out at 400, and contain a memory capacity averaging 32 megabytes. In contrast, SAGE's original clock rate was about 1 MHz accessing 32 *kilo*bytes of storage!

OutPost has learned that the 1000 MHz processing rate was actually achieved only within that portion of the chip containing a limited instruction set performing integer arithmetic. Nonetheless, it remains remarkable that it was accomplished with IBM's current 0.25 micron lithography and aluminum interconnect technology. IBM told *Outpost* this fact alone would make it possible to begin mass production in 12-24 months. Coupled with the impending delivery of 4 gigabit DRAM memory chips from several vendors over the next two years, the new millennium will open with an enormous increase in computational power attractively priced for wide application.

The implications for the energy enterprise could be staggering. Geological modeling and data analysis in aid of oil and gas exploration will accelerate. Weather prediction will improve with consequent benefit to utilities as an early warning system for storm, hurricane and tornado preparation. Global climate models will become more inclusive in scope allowing (hopefully!) more comprehensive and consistent analysis of meteorological, astronomical and geological measurements. Automated power plant management and operation with increased safety and confidence in its application will arrive.

But perhaps the greatest impact of the availability of powerful, cheap and distributed computation will be on the delivery and marketing of electric power as deregulation proceeds. Call it the coming emergence of "street smart" electricity.

Imagine the following scenario. It is late summer, 2010. There have been heavy rains for four months in the Canadian northeast. The James Bay hydro reserve is overflowing. A computer at Corporate Headquarters of the managing utility posts an offer to the commodity server at the Chicago Board of Trade for block power at 0.01 cents/kWh lower than the North American spot. A multiple-service provider company in Southern California running the latest Netscape Watt-Finder browser, offers at market for 10 GWh which it will store in the Hermosillo SMES (Superconducting Magmetic Energy Storage) plantation in Mexico for delivery that winter as electric heating for customers in the Sierra Nevada.

How do system operators move all these watts and dollars reliably in a milieu of hundreds, perhaps thousands, of other transactions in progress simultaneously on a continental grid whose behavior is highly nonlinear and at times unpredictable? How do energy providers and their customers select the optimum financial transaction and transfer path from a set of almost countless possibilities? The problem is mind-boggling. In its inaugural issue, *OutPost* described the continuing expansion and application of complexity theory as a new exciting branch of science and mathematics. A sub-field of complexity theory, known as "complex adaptive systems" (CAS) has particular relevance to the previous question.[2] Brokering and controlling the flow of electric power on the scale posed will most likely not be centrally controlled, but rather determined by a network of distributed computers, somewhat like today's Internet, with access to market supply and demand information, but additionally able to tailor Kirchoff's Law via a massive FACTS continental grid control system to meet generation and delivery schedules as required. A major difference from today's network concept, however, is that these individual computers will act as, to use the jargon of CAS, "intelligent agents," interacting at times cooperatively (e.g., sharing grid resource when appropriate) and at others competitively (denying peer access to competitive strategies), and sometimes operating completely alone (isolated by unexpected power outages and/or insufficient knowledge of the state of the grid). In other words, these agents, both collectively and individually, will learn by experiencing what past strategies worked and adapting them accordingly to whatever a new financial/power-transfer scenario may require.

This news from IBM, using just today's technology, is only part of the next round of microprocessor performance improvements. Several months back, in September, 1997, IBM had announced the successful substitution of copper for aluminum for chip wiring, thus promising even faster and more dense circuits per chip to come.[3] On February 25 of this year, a team[4] from the University of Texas and DuPont Photomasks, Inc., released the news that they had achieved, using a technique called "phase-shift masking," 0.08 micron interconnect widths, approximately three times smaller than that in the IBM 1000 MHz chip, using presently available photolithography materials and tools.

These, and other pending developments, will continue to advance us much closer to the practical application of complex adaptive system concepts for the realization of our imagined 2010 electricity scenario above. Stay online, and look for an announcement of EPRI's new strategic program in Complex Interactive Networks!

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[1]http://www.ibm.com/News/1998/02/ls980204.html
[2]A. Martin Wildberger, IEEE Control Systems Magazine, Dec. 97-Jan. 98, p. 77.
[3] http://www2.ibmlink.ibm.com/cgi-bin/master?xh=2aKLORnp2ES$eL0USenGnN??&request=pressreleases&parms=P%5f97092204&xhi=pressreleases%5e
Copper is more conducting than aluminum; however, until these developments, its chemistry…adhesion, corrosion…was more difficult to integrate with current silicon CMOS technology.