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China's Microprocessor Dilemma

China Needs Affordable Computers, but Which CPU Architecture?

By Tom R. Halfhill {6/26/06-02}

Masterminding a centralized economy for a nation of 1.3 billion people is an awesome task. Former leaders of the Soviet Union tried to manage a nation one-fourth as large and ultimately failed. That's almost certainly why China's communist leaders are increasingly outsourcing the job to the Chinese people. Private enterprise and market forces, though still confined, are transforming China in ways that centralized management could not.

However, as *Microprocessor Report* learned during a recent visit to China, the country's leaders still face difficult decisions. One is the seemingly minor question of which microprocessor architecture to support in a coming wave of low-cost personal computers designed for the Chinese domestic market. The most obvious answer—the x86 architecture, already the world standard and the only platform running Microsoft Windows—isn't necessarily the best answer for China.

MPR learned that the question of which CPU architecture to promote could significantly affect the direction of China's future economic growth. It's related to seemingly unrelated things, such as China's ambition for technology independence, a widening gap between rich and poor that threatens social stability, and mounting problems with urban sprawl and environmental pollution. Indeed, so much is riding on this question that the Chinese government doesn't want to delegate the decision to the unruly chaos of the free market, as has happened elsewhere in the world.

Are we overstating China's dilemma? Read our analysis and judge for yourself.

Heavy Industrialization Is a Dead End

Throughout the world, there's a common perception that China is building a highly successful industrial economy by exploiting cheap labor and other resources to take manufacturing jobs away from more-developed nations. That's true, to an extent. However, there are signs that the Chinese government perceives a limit to that strategy—a frustrating limit that will prevent China from achieving the affluence it desires.

As a result, the nation's leaders are looking further ahead. They want to build a modern post-industrial economy on a foundation of high technology, instead of an old-tech economy relying on heavy manufacturing. Their great leap forward to a post-industrial age will require universal computer education and affordable computers. Hence their quest for cheap, relatively powerful PCs.

The proximate limits on China's industrial growth are energy and pollution. Already, some Chinese factories must idle their machinery and workers for hours a day because they can't get enough electricity. The international competition for oil and the rise of oil prices worldwide are everyday news in the mainstream media and need no further mention here. And after two decades of aggressive growth, China is becoming uneasy about environmental pollution. It's not that the Reds are suddenly turning green. Their concern is more practical. Pollutants in the air, water, and workplace are having a measurable effect on health-care costs and worker productivity. As anyone who has visited China's big cities knows, the smog can be overpowering, and even the locals fear to drink the tap water.

So here's the problem. Despite China's incredibly rapid economic growth and apparent success, only about 5% of the

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Worsening pollution in cities like Shanghai is making the Chinese question whether an economy based on heavy industry can support the kind of progress the country needs to make.

population has reached a level of affluence approximating the middle class in developed nations. Lifting a significant portion of the other 95% to that lifestyle looks almost impossible, after extrapolating the additional energy it will require and pollution it will create. Sure, energy conservation and environmental controls will help, as they did in the U.S. and Europe. But the U.S. and Europe had already built their affluent industrial societies before cracking down on waste and pollution, and now they are moving away from heavy manufacturing. China faces the challenge of controlling the rise of those problems while simultaneously expanding its industrial economy at an unprecedented pace. Some very knowledgeable Chinese people we met in Beijing and Shanghai think China can't get there from here.

Of course, China could simply forget about improving the lives of its poor people and be satisfied with a tiny middle/upper class. It certainly wouldn't be the first nation in history to do so. But nobody we met in China considers such abandonment a realistic possibility. China is a proud country on the move, and it won't settle for Third World status. In addition to genuine concern for the poor, there is awareness that a nation forged by a violent peasant revolution will not long tolerate such an unfair disparity of wealth. (Chairman Mao warns about that in his *Little Red Book*.) Already there is unrest in rural areas, especially among people who have seen the remarkable progress in the big cities.

To reconcile the need for rapid growth with the practical limits on industrial expansion, the Chinese have a plan. They will use industrialization as a springboard to leap more quickly into a post-industrial economy based on high technology. Telecommuters don't burn gasoline traveling back and forth to work, and they don't need factories that gulp energy and spew pollution. The new model is today's Silicon Valley, not yesterday's Pittsburgh.

Naturally, this ambition requires creating millions of jobs suitable for telecommuters. But first, it requires computer education on a scale never seen before. And that, in turn, requires hundreds of millions of inexpensive but capable computers. As *MPR* saw firsthand, China's quest to design an affordable PC occupies some of the best minds in the country.

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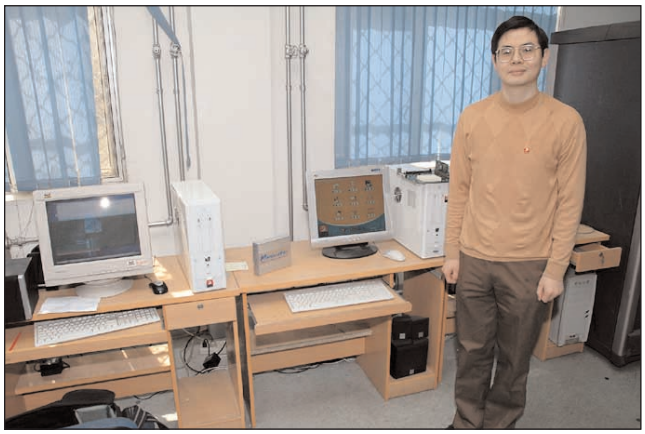
In the former rural district of Pudong, across the river from central Shanghai, China has constructed a clone of Silicon Valley—complete with office parks, tree-lined boulevards, freeways, and exhibition halls.

Striving for Technology Independence

At the Chinese Academy of Sciences in Beijing, the Institute for Computing Technology (ICT) has a small lab supervised by Weiwu Hu. Hu is a professor at the institute and is arguably the top CPU architect in China. He has designed two of China's most advanced processors, known in the West as Godson-1 and Godson-2. (For our detailed analysis, see *MPR 7/25/05-01*, "China's Emerging Microprocessors.") During our visit, Hu gave us a tour of his lab and talked about his next design, Godson-3.

MPR promised to keep Hu's plans for Godson-3 confidential for now. But he proudly showed us a project whose requirements are driving the designs of his processors: an inexpensive PC called the Municator. The Chinese government hopes Municators will be so cheap to manufacture



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Weiwu Hu in his lab at the Institute for Computing Technology, part of the Chinese Academy of Sciences in Beijing.

that domestic factories can replicate them by the tens of millions. Spread throughout China's vast school system, Municators will help train youngsters for future careers in everything from data entry to engineering. Millions more Municators will bring affordable personal computing to the homes of ordinary people. They are the key to a government initiative called the Computerization Movement.

The Municator isn't the only cheap PC intended for the masses. The most famous project of this type is the One Laptop Per Child (OLPC) initiative sponsored by the faculty of the Massachusetts Institute of Technology Media Lab in the U.S. Its champion is Nicholas Negroponte, a longtime faculty member at the MIT Media Lab and now chairman of OLPC, a nonprofit organization. OLPC's vision is a $100 laptop computer sturdy enough to withstand rough handling in harsh climates. The laptop even has a hand-operated crank for recharging its built-in battery. OLPC recently unveiled brightly colored prototypes of the simple machine.

Winning China as a customer would be huge for OLPC, because the Chinese market would guarantee mass production on a scale large enough to hit the aggressive $100 price target. But when Negroponte approached the Chinese, the government preferred to encourage a homegrown solution. It was a disappointing setback for Negroponte, who is trying to sell the OLPC concept elsewhere.

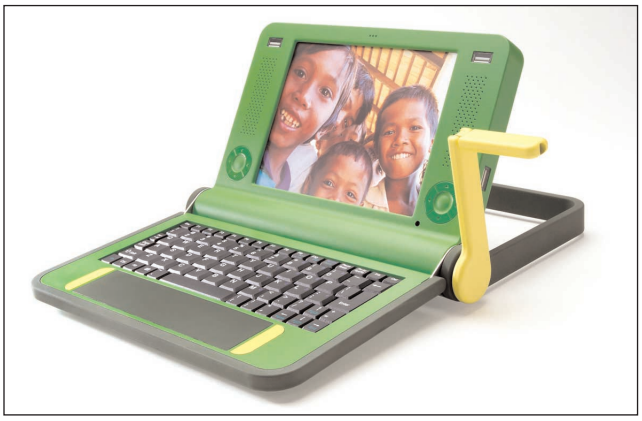
China's decision isn't surprising. In all fields of technology, the Chinese government wants to achieve as much independence from the rest of the world as possible. That is the long-term goal of China's National 863 Program, a government-funded research and development project to create native technology for Chinese industries. (The 863 Program derives its name from the month and year of its inception: March 1986.)

Hu's Godson processors are one outgrowth of the 863 Program. As is common in China, Godson is the result of a public/private partnership. In his government-funded role at ICT, Hu designs Godson processors. But he's also the chief technology officer of BLX IC Design Corp. Ltd., a Beijing-based startup that sells Godson chips to the domestic market. BLX IC Design is jointly owned by private investors and the government.

Technology independence is partly a matter of national pride. Centuries ago, China was the world leader in technology. Internal strife and foreign interference stalled the country's progress. Today, China is the world's most populous nation and seeks status on the world stage commensurate with its size. However, a more practical reason for pursuing technology independence is that China doesn't want to be forever beholden to foreign interests, whether those interests are nations or corporations. That includes corporations owning patent rights to the world's most popular CPU architectures.

Inside the Municator

In March, when *MPR* visited the ICT lab in Beijing, we saw early Municator software running on Hu's Godson-2 processor. Godson-2 is a 64-bit four-way superscalar processor patterned after the MIPS64 instruction-set architecture (ISA). Lacking a bona fide MIPS license—a sore point with MIPS Technologies—Hu designed an ISA that's largely MIPS compatible, omitting a few special instructions patented in the U.S. and other countries (but not yet in China). The Municator software we saw running on Godson-2 was an alpha version, not yet fully operational, as we discovered when we sat down at the machine and used it for a few minutes.



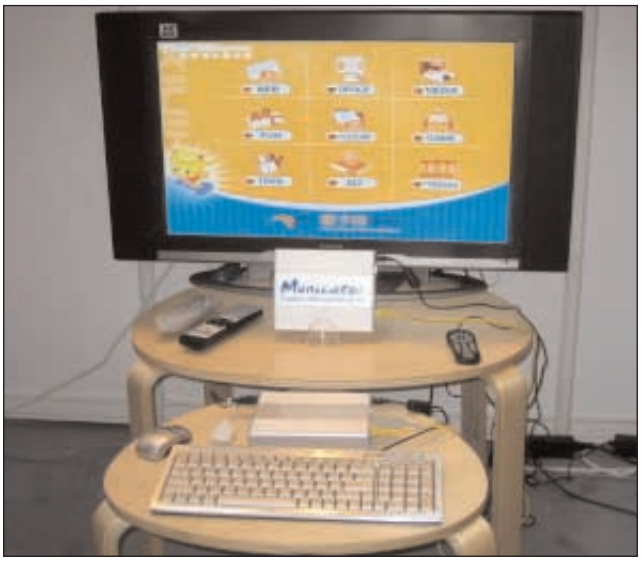
OLPC

This is one prototype design of the $150 computer designed by the nonprofit One Laptop Per Child organization.

The Municator doesn't run Microsoft Windows. To cut costs and avoid intellectual-property (IP) entanglements that could balloon into international trade disputes, the Municator runs a Linux-based operating system called Thinix 3.0. Originally known as the Miss Dragon operating system, Thinix was developed by Wisdom Ltd., a Hong Kong company. Early versions of Thinix ran on the x86, but Wisdom has ported it to the Godson ISA.

Additional open-source software has been ported to Godson, including the Mozilla web browser and an office application suite compatible with Microsoft Word, Excel, and PowerPoint files. Layered atop Thinix is a simplified desktop GUI reminiscent of one that Apple created for the Macintosh Performa in the 1990s. The GUI's most prominent feature is large on-screen buttons for launching application programs with a single mouse click. The idea is to save beginners the trouble of navigating menus and folders. (Although, like nearly all simplified GUIs, its oversize features seem to assume that newbies have poor eyesight, too.)

We couldn't help noticing that the software needed further development, but that's to be expected for a project at the alpha stage. The hardware was strictly lab grade, but it's not Hu's job to design the finished product. That task has been undertaken by a Chinese company called YellowSheepRiver Municator Inc., headquartered in Macao. During the second week of June, YellowSheepRiver ventured across the Taiwan Strait and demonstrated the Municator at the annual Computex trade show in Taipei. (The company also exhibited at the recent CeBIT show in Germany.)



YELLOWSHEEPRIVER MUNICATOR INC.

This photo shows the silver Municator computer directly in front of a large video monitor, which displays the simplified GUI for launching application programs. On the lower table is a keyboard, mouse, and external optical drive.

According to YellowSheepRiver's latest specifications, production models of the Municator will have a Godson-2 processor running at 400–800MHz, an ATI Radeon 7000M video processor, up to 512MB of DDR-266 DRAM, up to 512KB of flash memory, a 40GB ATA-100 hard drive, Fast Ethernet, four USB 2.0 ports, an RS-232 serial port, VGA out, S-Video, and audio out. Options include an external CD-ROM or CD/DVD combo drive, 802.11 wireless networking, and a lithium-ion rechargeable battery.

The Municator is even smaller than a Mac Mini (because there's no internal optical drive) and costs about $150. Although that price might appear to be a step backward from OLPC's $100 laptop, the Municator is probably a more powerful machine, and the cost will fall if production reaches the huge volumes its creators anticipate.

Not Quite MIPS, Not Quite Mainstream

The larger question is whether the Chinese will make a long-term commitment to Godson's almost-but-not-quite MIPS ISA. As we noted in our Godson-2 article last year, MIPS is an efficient, well-understood architecture used as a teaching tool at colleges worldwide. It has proven itself in virtually every application, from powerful servers and workstations to low-cost embedded systems. Many software-development tools and operating systems support it. However, the MIPS architecture has a flaw that matters little to the rest of the world but is potentially fatal for the Chinese: dwindling software support outside the embedded market.

Despite a long-ago MIPS version of Windows NT, the MIPS architecture never caught on as a desktop operating system. In addition, the decline of Silicon Graphics (SGI) has caused MIPS to fall out of favor as a CPU for servers and workstations. Today, the MIPS architecture is used almost exclusively for embedded systems. But the Chinese want their homegrown PCs to run the world's vast library of open-source software, development tools, and (especially) electronic-design automation (EDA) tools. Without that software, they can't turn industrial-age assembly-line workers into post-industrial telecommuters.

For that reason, the MIPS-like ISA of the Godson processors may not be the wisest long-term solution. The rest of the world is using MIPS for embedded systems only and is writing system software, application software, and development tools for other architectures. If China standardizes on the Godson ISA for desktops and workstations, the latest EDA tools won't run on it. Although China seeks a degree of technology independence, it doesn't want to become an isolated technology island.

An alternative view is that almost any CPU architecture widely adopted by the Chinese will attract whatever software support it needs. If the Municator or something like it becomes as ubiquitous as the Chinese want it to be, the Godson ISA would probably establish itself as the dominant CPU architecture in the world's most populous nation. That possibility would be difficult for anyone to ignore. In addition to millions of Chinese programmers writing software for Godson, foreigners would also have an incentive to support it—if they could sell their software in China at prices justifying their effort. (That's a big if.)

So the Chinese face a dilemma: Which CPU architecture can they implement without legal entanglements, but which also guarantees broad software support?

Evaluating CPU Architectures

Intel's x86 has the broadest software support on the desktop, and it's strong on servers and workstations, too. Even the authoritarian ruler of Apple has adopted it. But Apple doesn't manufacture its own processors, as China wants to do. *MPR* deems it highly unlikely that Intel would grant the Chinese a general license to design and produce x86-compatible processors. Intel isn't about to repeat the historic mistake it made with AMD by creating an even more formidable adversary. If anything, Intel is becoming more protective of the x86 architecture, now that it's clear Itanium will never supersede the x86.

China could try to circumvent Intel. For instance, VIA has a line of reasonably fast, power-efficient x86-compatible processors at attractive prices. More important, VIA has a license to legally manufacture them. However, VIA is a Taiwanese company with a design team in Texas. That doesn't exactly conform to China's plans for technology independence—unless the Chinese acquire VIA outright. (Don't rule it out; it's easier than reacquiring Taiwan.)

Another possibility is the Transmeta approach: x86 compatibility using hardware-assisted software emulation. Transmeta's code-morphing is flexible, power efficient, and apparently legal. Unfortunately, it has trouble competing with the performance of native x86 processors.

If China crosses the x86 off its list of viable CPU architectures, the list gets very short and may get shorter. DEC's Alpha is gone. Hewlett-Packard's PA-RISC is virtually gone. Sun Microsystems' SPARC survives, but the recent departure of Scott McNealy as CEO doesn't bode well for an expensive division of a company struggling to cut costs.

That leaves PowerPC—and a fascinating scenario. PowerPC is strong on servers and embedded systems, especially in communications. Desktops are the elusive frontier. Having failed in the 1990s to establish PowerPC as a desktop architecture, the PowerPC alliance could mount a new attack, with China as a powerful ally. Millions of Chinese programmers and engineers could breathe new life into PowerPC. It could be the last chance to dethrone the x86 on the desktop. However, *MPR* suspects that IBM and Freescale are too conservative for a gamble that could have many unforeseen consequences. We doubt the companies would license PowerPC on terms the Chinese would find acceptable. Nevertheless, it's fun to think about. A few years ago, who would have guessed that IBM would sell its PC business to Lenovo?

Of course, China could create an entirely original CPU architecture. However, that would require building a whole new software base from scratch, including world-class EDA tools—no mean feat. It would be less trouble to stick with Godson or even obtain a legitimate MIPS license and hope for programmers around the globe to write the software China needs.

Thinking outside the box, China could use a different embedded-processor architecture, such as ARM, for desktops and workstations. (ARM is becoming quite popular in China; about 30 programming books on ARM have been written or translated into Chinese.) But adapting an embedded architecture would require building a desktop/workstation software base from scratch, and China would be outside the mainstream of open-source software and professional development tools written elsewhere in the world. Furthermore, licensing a foreign-owned CPU architecture like ARM wouldn't satisfy China's desire for technology independence.

For More Information

Use the following links to English-language websites to find more information about the topics discussed in this article:

- YellowSheepRiver Municator Inc.: *www.yellowsheepriver.org*
- Streaming video demo of the Municator from the CeBIT trade show in Germany (via Google Video): *http://video.google.com/videoplay?docid=-9203462148706105599*
- Institute of Computing Technology, Chinese Academy of Sciences: *www.ict.ac.cn/en/*.

A Decision With Far-Reaching Consequences

Choosing the best CPU architecture for China is the kind of make-or-buy decision faced by project managers everywhere, except the consequences are vastly greater. The choice will affect the direction of Chinese computer technology and possibly the nation's economic progress for decades to come. Making a proprietary architecture has software drawbacks, but buying an off-the-shelf architecture would force China to become dependent on imported chips or licenses from foreign patent holders. Ignoring IP rights and illegally cloning an architecture like the x86 could ignite an international trade war and make China a pariah in world markets.

Faced with those alternatives, perhaps the Chinese will give up and delegate the decision to the chaos of the free market, after all. But we suspect the decision is important enough that China won't resort to that option unless the centrally planned approach fails. ◇