Papers About Fast Chips and Computers

This is a rather small selection of papers about this subject.

♦ By year 2005, IBM hopes to have a super computer that is 15 times faster than today, but which uses only 2% of the energy.

♦ In Jan 2002, the peak speed of chips is about 2.1 GHz (2100 MHz). Intel thinks they will be able to achieve chip speed up to 30 GHz.


♦ There are 8 items and 24 pages here.

Roy Jenne
12 Feb 2002
Papers About Fast Chips and Computers

Roy Jenne
12 Feb 2002

There are 8 items and 22 pages here plus 2 pages in front.

1. IBM develops new range of supercomputers (Nov 9, 2001, 1 p)


3. A Compaq at NCAR (1999, 1 p)


5. PC hard disks, very fast chips (Jenne, Feb 2002, 9 p)

6. Power use by chips (Forbes, Apr 2, 2001, 3 p)

7. Spending on information technology (Economist, Nov 14, 1998, 1 p)

8. Engineer pay (Aviation Week, Oct 8, 2001, 1 p)
IBM develops new range of supercomputers

By Clive Cookson, Science Editor

IBM, the world’s largest information technology company, is to develop a new generation of commercial supercomputers which it says will run 15 times faster than today’s most powerful machines – while consuming only one-fifteenth the energy.

The programme is based on Blue Gene, the $100m experimental supercomputer that IBM is building to tackle large-scale biomolecular calculations, particularly predictions of how proteins fold up into threedimensional shapes. Blue Gene is unlikely to be finished before 2005.

Today the company announces a new partnership with Lawrence Livermore National Laboratory in California to build a machine called Blue Gene/L – the L can stand for Livermore or Low-power or Lite, IBM researchers say.

Although slightly slower than the original Blue Gene design, Blue Gene/L will have more computing power than the 500 top supercomputers in the world combined, IBM says.

After the scheduled completion of Blue Gene/L in 2004, Lawrence Livermore will use it to simulate physical phenomena of national interest, such as fires and explosions.

But IBM sees it as the prototype of a new generation of supercomputers that is more adaptable to commercial applications than current scientific supercomputers.

IBM is looking for a partner to develop a commercial version of the machine.

Bill Pulleyblank, project leader, says a suitable partner could, for example, be a financial services company that has to manage and search through vast amounts of data.

While today’s supercomputers are amazingly fast number-crunchers, many data-intensive applications are slowed down by the time taken to obtain information from the memory chips.

The Blue Gene/L design will run such jobs much faster because the machine will be populated with data-chip cells optimised for data access. Each chip includes two processors, one for computing and one for communicating, and its own on-board memory.

The Lawrence Livermore machine will have 65,000 cells, each working on a small part of a large problem.

This increase in data access speed will make a huge difference in the kinds of results these machines can produce and the kinds of problems they can solve.

The cellular architecture pioneered through Blue Gene is likely to eventually find its way down to commercial workstations and then to home computers.

One advantage for users, besides faster operation, is that cellular computers are more fault-tolerant than today’s machines.

by year 2005:

• 15 x faster than today
• Use only 2% of the energy

Ray Penne
Intel to unveil more efficient transistor

P-I NEWS SERVICES

SAN FRANCISCO — Intel Corp. plans to introduce technologies to help microprocessors run cooler and use less power, key issues in the semiconductor industry’s struggle to increase the computing speed of chips while reducing their size.

Today, the Santa Clara, Calif., chipmaker will reveal its Terahertz transistor, which has key improvements important in manufacturing computer chips that could run as fast as 30 gigahertz or more in clock speed. The challenge stems from the company’s efforts to keep Moore’s Law alive. Intel co-founder Gordon Moore made an observation 25 years ago that the number of transistors crammed into a given area of silicon doubles every two years.

That would mean by the end of this decade, Intel has to squeeze each transistor to the point where each microprocessor could have more than 1 billion on a thumbnail-size chip.

As transistors are made smaller, electrical current leaks from their microscopic components. More heat-generating power is then needed for them to function. Intel’s new design stems that energy flow by using a new insulation structure.

• Chips that could run as fast as 30 gigahertz
• Help to reduce heat and power consumption

Intel Creates New Structure, Material for Transistors

BY MOLLY WILLIAMS
Staff Reporter of THE WALL STREET JOURNAL

Intel Corp. said it has developed a new structure and material for making transistors, which will help reduce heat and power consumption and allow a greater number of faster circuits to be packed onto silicon chips.

The advances, along with other recent announcements, will help develop chips with capabilities such as real-time voice and face recognition, and smaller computing devices with higher performance and better battery life, Intel said.

Some elements of the new technology will start appearing in Intel chips as early as 2006.

Intel, Santa Clara, Calif., said the advances will help further shrink transistors, the building block of computer chips, and could lead to tenfold speed increases without additional power consumption.

The company expects to produce transistors as small as 15 nanometers across, compared with 70 nanometers today. (A nanometer is one-billionth of a meter.)

The new structure is called the “tera-hertz transistor” because it can turn on and off more than one trillion times each second. It features a slight change to the positioning of “gates,” the connection points between transistors on a chip.

The new material prevents leakage of current across the gate, helping to reduce the amount of power consumed, the company said.

Shares of Intel rose 25 cents to $31.06 in 1 p.m. trading on the Nasdaq Stock Market on Friday.

The shares are trading well below their 52-week high.
long-term vision, but... where an optical interface component might cost $10,000 today, over the next decade, I want to make it cost a penny. I don't see [Intel building] optical transistors and things like that... in the near future, if ever.

Will applications need to change to leverage hyperthreading? Maybe. If Microsoft builds in the ability to have an operating system and a networking stack and the printing daemon running in parallel, and it's all part of the operating system, then the application could benefit from hyper-

Pat Gelsinger, vice president and chief technology officer at Intel Corp., leads Intel's Corporate Technology Group in Hillsboro, Ore., which includes the Intel Architecture Lab and Intel Research group. He also contributed to the design of Intel's original i286 and i386 CPUs. Computerworld's Linda Rosencrance asked Gelsinger to comment on emerging technologies that will affect corporate computing.

Of the interconnect technologies Intel is working on, which ones are likely to have the biggest impact on corporate computing? The five that I'm really excited about are optical, high-speed Ethernet, 3GIO (third-generation I/O), Serial ATA (Advanced Technology Attachment) and Infiniband. Those to me are the ones that redefine connectivity in the enterprise and in the data center in a fundamental and dramatic way.

What other technologies are likely to have a significant impact? Our goal with the Itanium processor family is to rearchitect the data center of the future. Today, that's filled with proprietary RISC-based machines, and our job is to move those to standard building blocks.

Will the IA-64 processor commoditize the 64-bit server market as the Pentium has done in the IA-32 space? With IA-64, we're trying to deliver a building block for big-iron machines. It's not that those other ones are bad; they're all different, they're all incompatible, they're all forcing investment in areas that no longer are the things that IT cares about.

Intel has announced the 2-GHz Pentium 4 processor. How fast can you go? We're on path to deliver multibillion transistor chips in the next decade, operating in excess of 25 GHz. We're going to keep pushing away at clock speed. However, clock speed alone will become less and less a determinant of performance as we look forward to things like hyperthreading.

How will that work? Hyperthreading is the idea of doing more than one thing at once. In today's applications, when you finish one set of instructions, you go on to the next set of instructions and so on. In the future, we [will] have the transistor budgets and the technologies to have one microprocessor doing more than one thing at a time. This is reasonably well established in servers or high-end computing. We want to... bring this into the mainstream of computing. You'll see the first implementations start to emerge next year.

What optical technologies are you developing that will affect IT? Optical redefined long-haul networking over the last decade. Over the next decade, [it] will have dramatic implications for metropolitan and campus data centers. We want to... get to the point where we're building direct optical interfaces onto our silicon component. That's a
INTEL'S ITANIUM FINALLY ARRIVES

But hardware won't be mature for a year

BY JAIKUMAR VIJAYAN

The announcement last week that systems based on Intel Corp.'s long-delayed Itanium processor should start shipping this month was welcome news to users hoping to run large enterprise applications on commodity hardware, users and analysts said.

But it will be at least another year before the operating systems, commercial applications and servers based on the processor are mature enough for this to happen, they said.

"For those who have been champing at the bit for 64-bit Intel hardware, here it is," said Tony Massimini, an analyst at Semico Research Corp., a Phoenix-based chip consultancy. "Those who want better performance, just wait a bit."

Intel last week said that up to 25 vendors are expected to start shipping servers and workstations based on the 64-bit processor later this month.

Itanium, page 89

Continued from page 1

Itanium

They include Dell Computer Corp., IBM, Hewlett-Packard Co. and Compaq Computer Corp., which are all slated to start shipping Itanium boxes in mid-June.

Itanium is the name for Intel's next-generation 64-bit processor family as well as for the first chip in that new generation. Work on the technology began in June 1994, when Intel and HP announced a joint development agreement to design a generation of processors that would be capable of running high-end x86-based applications and Unix applications equally well.

Itanium processors at one point were expected to ship as early as 1999. Intel claimed that it underestimated the time it would take to develop a processor architecture of this scope, though there have been previous reports of design glitches and problems in the manufacturing process.

The chips are based on a new design called Explicitly Parallel Instruction Computing. The design implements features called predication, speculation and explicit parallelism that significantly boost performance over existing CISC- and RISC-based processor architectures, said Intel.

Such features, combined with full 64-bit addressing, large memory support, increased floating-point performance and high-memory bandwidth, make Itanium a good platform for large server and workstation applications, according to the company.

The National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign plans to install a cluster of 160 IBM Itanium-based IntelliStation workstations because of the enhanced performance, said Dan Reed, director of the NCSA. "It's early in the path, but so far, the performance we have seen has been spectacular," Reed said.

The NCSA has been testing Itanium systems for a year.

"It has been really excellent performance on even early hardware," agreed David Lifka, chief technical officer at the Cornell Theory Center, which plans to install a 128-processor Dell Itanium cluster to power research applications at Cornell University in Ithaca, N.Y.

"We have seen it outperforming even late-generation RISC architectures on certain applications, he said.

But most corporate users will have to wait until Itanium's successor, known as McKinley, starts shipping sometime next year before they can begin to tap such performance. That's at least how long it is going to take for all of the pieces to become available.

Note: The Itanium was once called Merced

June 4, 2001

Computer World
SCIENCE AND TECHNOLOGY

guages, to stop them making silly mistakes.

The first set of grammatical rules is used by
the parser to analyze an input sentence
(“I read The Economist every week”). The
sentence is resolved into a tree that de-
scribes the structural relationship between
the sentence’s components (“I” [subject],
“read” [verb], “The Economist” [object] and
“every week” [phrase modifying the verb]).
Thus far, the process is like that of a Weaver-
style transformer engine. But then things
get more complex. Instead of working to a
pre-arranged formula, a generator (i.e., a
parser in reverse) is brought into play to cre-
ate a sentence structure in the target lan-
guage. It does so using a dictionary and a
comparative grammar—a set of rules that
describes the difference between each sen-
tence component in the source language
and its counterpart in the target language.
Thus a bridge to the second language is
built on deep structural foundations.

Apart from being much more accurate,
such linguistic-knowledge engines should,
in theory, be reversible—you should be able
to work backwards from the target lan-
guage to the source language. In practice,
there are a few catches which prevent this
from happening as well as it might—but the
architecture does at least make life easier
for software designers trying to produce
matching pairs of programs. Tsunami (Eng-
lish to Japanese) and Typhoon (Japanese to
English), for instance, share much of their
underlying programming code.

Having been designed from the start for
use on a personal computer rather than a
powerful workstation or even a main-
frame, Tsunami and Typhoon use memory
extremely efficiently. As a result, they are
blindly fast on the latest PCs—translating
either way at speeds of more than
300,000 words an hour. Do they produce
perfect translations at the click of a mouse?
Not by a long shot. But they do come up
with surprisingly good first drafts for expert
translators to get their teeth into. One mis-
take that the early researchers made was to
imagine that nothing less than flawless,
fully automated machine translation
would suffice. With more realistic expecta-
tions, machine translation is, at last, begin-
ing to thrive.

Animal behaviour
Terning sociale

THERE is safety in numbers—and not
just for people. The adage also explains
why many fish swim around in shoals and
why mammals often live in herds. It is, too,
the reason why some birds breed in large
colonies, cheek by jowl with a vast array of
their neighbours.

Numbers help in several ways. They
provide hydra-headed vigilance, making it
difficult for predators to creep up unan-
nounced. They also allow for collective de-
ference—as anyone who has attempted to
walk amid the shrieking calls and dive
bombing of a colony of ground-nesting
birds can attest. But they should, in addi-
tion, give a more subtle means of protec-
tion. If an individual is surrounded by
many others, its chance of being the target
of a particular predator ought to be cor-
respondingly reduced.

This theory—that being a member of a
group dilutes the risk of becoming a vic-

An epic future?

As THIS newspaper recently observed,
breakthroughs in the computer-chip
industry are actually two a penny. But
when Intel, the world’s largest manufac-
turer of microprocessors (the chips that
do the number-crunching that is central
to the whole process of computing), an-
nounces its technological plans for the
future, it is at least worth sitting up and
taking notice. And, on October 14th, the
company did just that.

Inevitably, Intel’s announcement came with acronyms attached. The most
important one was EPIC—Explicitly Par-
allel Instruction Computing. This is sup-
posed to be replacing CISC (Complex In-
struction Set Computing), which Intel
uses for its current chips—the x86 series
that includes the Pentium. It is also sup-
posed to leapfrog RISC (Reduced Instruc-
tion Set Computing), which other manu-
facturers have adopted, but which Intel
has largely eschewed. The second new ac-
ronym is IA-64—the IA being short for
Intel Architecture and 64 being the num-
ber of digital “bits” of data that the new-
style processors will be able to handle in
one chunk.

Actually, calling the new EPIC-based
chip architecture “IA” is a bit of a cheek,
for most of the hard work was done by
Intel’s one-time rival, and now collabora-
tor, Hewlett-Packard. H-P began work on
EPIC in the early 1990s. But, after analys-
ing how programs behave in existing
chips, finding the most glaring hinders-
ances to higher performance, and then
designing ways to get around them, the
company realised that it did not actually
have the money to do anything about it.
Instead, in 1994, it took its ideas to Intel.

The intervening period has been oc-
cupied with making the IA-64 architec-
ture “backward-compatible” with soft-
ware designed to run on CISC-based x86
chips (IA-32, for real geeks). The result, a
chip code-named Merced, should be av-
ailable in 1999.

Merced is designed to be better than
existing chips in several ways. One of
these is its handling of branches in the
programs it is running. Another is the
workings of its compilers—the programs
that translate “high-level” computer lan-
guages used by human programmers into
binary instructions that a processor can
understand.

Branches are the basic building blocks
of programming: if a specific condition is
met, the program executes one group of
instructions; if the condition is not met,
different code is run. Such branches can
cause a processor to waste valuable time
dealing with the ancillary book-keeping
that comes with every branch. EPIC in-
cludes several schemes that keep the
wasted time to a minimum by anticipat-
ing future instructions and using capacity
that would otherwise be lying idle to carry
them out. If the results are needed, they
are then available instantly. If they are not
needed, nothing has been lost.

EPIC also promises to make processor
designs more efficient by putting a great
deal more responsibility on to the com-
piler to group instructions together in
such a way that the processor can execute
them as quickly as possible. Compilers
are complex pieces of software to begin
with, but making ones that can take ad-
vantage of these new features is a daunting

Initially, IA-64 processors will be
found only in machines such as work-
stations and servers. Microsoft and sev-
eral other software houses are purported-
edly eager to offer IA-64 programs for
such applications. But if the new architec-
ture works as well as Intel hopes, it should
eventually make its way to the desktop
and that stodgy old workhorse the x86
may, at last, become a thing of the past.
Will Sun’s 600-MHz Chip Put It In Digital’s League?

By Russ Brit
Investor’s Business Daily

S

un Microsystems Inc. Monday will make a processor announcement intended to shake off its image as a "me too" kind of chipmaker.

It’s unveiling plans for a 600-megahertz UltraSparc III processor for workstations and servers running Unix. That would double the clock speed of today’s fastest UltraSparc II processor and put Sun in a class with such companies as Digital Equipment Corp.

Digital currently is tops in chip speed, with a 600-megahertz Alpha processor it has been shipping since June. Sun’s chips are expected to roll off production lines next summer. Full production is scheduled for early 99.

Analysts and Sun competitors agree that although the company is behind Digital, its chip plan is a surprising leap. The move could help Sun get an edge on Digital, Hewlett-Packard Co., Silicon Graphics Inc. and International Business Machines Corp. in the Unix workstation and server businesses.

"(Sparc) is usually never connected with being the fastest chip in the world," said Chris Willard, an analyst with International Data Corp. in Framingham, Mass. "It may be that they’ve decided they’re going out for the performance sales."

"I wouldn’t have expected it," said Tim Counihan, marketing manager for Digital’s Alpha processors. "Certainly for Sun this would be a significant move forward."

Sun’s move into high-speed processing comes as a number of companies experiment with new manufacturing technology to boost clock speeds. Intel Corp. is working with the Department of Energy to develop a new process that will make microscopic transistors even smaller.

International Business Machines Corp. is using copper to create a process that will make it easier to send electronic signals in and out of chips.

Meanwhile, Sun has quietly been building up its processor workforce in preparation for this.

**RISC Leaders**

<table>
<thead>
<tr>
<th>Processor</th>
<th>Market Share 1996</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEC Alpha</td>
<td>8.3%</td>
</tr>
<tr>
<td>Other</td>
<td>1.1%</td>
</tr>
<tr>
<td>HP PA/RISC</td>
<td>29.6%</td>
</tr>
<tr>
<td>Sun Sparc</td>
<td>17%</td>
</tr>
<tr>
<td>SGI MIPS</td>
<td>15.9%</td>
</tr>
<tr>
<td>PowerPC</td>
<td>27.5%</td>
</tr>
<tr>
<td>Microprocessor</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>51.7 bil</td>
</tr>
</tbody>
</table>

Source: Inside the New Computer Industry (newsletter)

Sun is using conventional aluminum-based processes to create the microprocessor, says Gary Lauterbach, chief architect for Sun’s UltraSparc chips. Lauterbach says the company isn’t just interested in fast clock speeds.

He says Sun is working to ensure the new chip will work well in multiprocessor machines. In fact, Sun officials claim that more than 1,000 of the new processors could work together in a system, as long as the company’s Solaris is the operating system used.

Sun intends for the chip to be used with its own line of servers and workstations, but says it will be available on the open market. It also may be used with Windows NT, says Marge Breya, marketing director for Sun Microelectronics.

Breya says, however, that Sun is not looking to compete with Digital and is not keeping in mind Alpha clock speeds. Digital’s Alpha is moving more toward Windows NT users, she adds.

Nathan Brookwood, an analyst with Dataquest Inc. in San Jose, Calif., says that closing the clock-speed gap with Digital will give Sun’s processors and workstations a boost in the Unix market.

"To compete with the fastest Alphas, Sun had to use two (chips)," Brookwood said. "This definitely puts (Sun) in a different class."

He also says the new chip will help Sun grab more share in the Unix workstation market, especially since Digital has been putting more marketing muscle behind its NT server and workstation business.

Digital’s Counihan, however, says Digital plans stay ahead in clock speeds. He claims Sun will be far behind by the time this new chip reaches the streets.

"That puts us a good year ahead of them," Counihan said. "Our expectations are that we’ll have higher-performance processors by that time."

Counihan also questioned whether Sun will be able to double the clock speed on its processors in such a short time. He says Digital has moved up in speed more gradually — say, from 500 megahertz to 533 megahertz.

In the Unix-only market, it appears Sun will be well ahead of its other competitors, though it

Investor’s Business Daily

Oct 6, 1997

move. Company officials say its Sun Microelectronics division has tripled in size over the past two years, although they wouldn’t give specific numbers.

Also, Sun is partnering with Texas Instruments Inc. to make the new chips. Sun’s Sparc processors have been made by Fujitsu Ltd. and Toshiba Corp. in the past.

Sun is building the new chip with an eye toward increasing power for its rapidly growing server business. Workstations have been Sun’s mainstay, but network servers are taking on increasing importance, particularly with expansion of Internet usage.

The UltraSparc III will be offered with 16 million transistors that should handle 6 billion instructions per second. Current UltraSparc chips have 5 million transistors. Each transistor will be 0.25 micron wide, or 1/400th the width of a human hair. The industry is moving toward 0.25 micron transistors in its chips. Eventually, Sun wants to get transistor

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Go to A

Go to B

Go to C

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is uncertain how long that will last.

Hewlett-Packard and IBM also produce reduced instruction-set computing (RISC) chips, used in machines running Unix. Hewlett-Packard is working on a new high-speed chip dubbed Merced, with Intel. However, HP, like Digital, has been de-emphasizing Unix in its marketing in favor of pushing its NT systems.

It is unknown how fast Merced will be. IBM hasn’t revealed its chip plans for workstations and servers.

The other major competitor — Silicon Graphics’ MIPS division in Mountain View, Calif. — has announced plans for future chips that lag far behind Sun.

Silicon Graphics’ R10000 chip currently runs at 200 megahertz. It’s expected to move up into 300-megahertz territory with next year’s introduction of the R12000 chip. It’s next generation of chips isn’t expected to reach the market until 2000 or 2001.
### Table 3: Solution Overview

<table>
<thead>
<tr>
<th></th>
<th>Proof of Concept</th>
<th>Expansion Option 1</th>
<th>Expansion Option 2</th>
<th>Expansion Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td>$1,000,000</td>
<td>$3,000,000</td>
<td>$7,000,000</td>
<td>$11,000,000</td>
</tr>
<tr>
<td><strong># Systems</strong></td>
<td>8</td>
<td>6</td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total # CPUs</strong></td>
<td>32 @500MHz</td>
<td>96 @729MHz</td>
<td>240 @729MHz</td>
<td>352 @729-850MHz</td>
</tr>
<tr>
<td><strong>Aggregate Memory</strong></td>
<td>32 GB</td>
<td>96 GB</td>
<td>240 GB</td>
<td>352 GB</td>
</tr>
<tr>
<td><strong>Theoretical Peak FLOPS</strong></td>
<td>32 Gflops</td>
<td>140 Gflops</td>
<td>350 Gflops</td>
<td>513.2 - 598.4 Gflops</td>
</tr>
<tr>
<td><strong>Estimated Sustained Performance</strong></td>
<td>6.4 Gflops</td>
<td>28 Gflops (guaranteed)</td>
<td>85 Gflops (guaranteed)</td>
<td>150 Gflops (guaranteed)</td>
</tr>
<tr>
<td><strong>Disk</strong></td>
<td>1 TB</td>
<td>1.2 TB</td>
<td>4.06 TB</td>
<td>6.24 TB</td>
</tr>
<tr>
<td><strong>Support FTEs</strong></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Maint</strong></td>
<td>8 hr</td>
<td>on-site, 4-hour</td>
<td>on-site, 4-hour</td>
<td>on-site, 4-hour</td>
</tr>
</tbody>
</table>

* This arrived at NCAR at the end of Nov 1999.*
The capability of personal computers has changed enormously over the past ten years. The speed and storage performance of the lower-end PC’s have increased by large amounts, while the actual price in current US dollars has decreased. From 1989 to 1998 there has also been ____% of inflation. This makes the PC changes even more impressive. PC computers have increased markedly in speed, memory, hard disk capacity, etc. A low-end (Table 1) and a high-end (Table 2) configuration is given for each of the dates listed. We have used information and prices from ads by Gateway Computer Company in Computer Shopper. All of these computer chips are made by Intel.

**TABLE 1: TIME CHANGES OF LOWER-END PERSONAL COMPUTERS**

<table>
<thead>
<tr>
<th>Date</th>
<th>Chip (-MHz)</th>
<th>Memory</th>
<th>Disk</th>
<th>CD-ROM</th>
<th>Monitor</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar 01</td>
<td>P III, 933 MHz</td>
<td>64 MB</td>
<td>10 GB</td>
<td>48X</td>
<td>17”</td>
<td>$999</td>
</tr>
<tr>
<td>Sep 99*</td>
<td>Celeron 466 MHz</td>
<td>64 MB</td>
<td>13.6 GB</td>
<td>40X, vrbl</td>
<td>17”</td>
<td>$1300</td>
</tr>
<tr>
<td>Feb 98</td>
<td>G5-233 MMX</td>
<td>16 MB</td>
<td>2.0 GB</td>
<td>13X</td>
<td>15”</td>
<td>$1500</td>
</tr>
<tr>
<td>Mar 97</td>
<td>P5-133 MHz</td>
<td>16 MB</td>
<td>1.2 GB</td>
<td>12X</td>
<td>15”</td>
<td>1600</td>
</tr>
<tr>
<td>May 96</td>
<td>P5-100</td>
<td>8 MB</td>
<td>850 MB</td>
<td>6X</td>
<td>15”</td>
<td>1900</td>
</tr>
<tr>
<td>Feb 95</td>
<td>(486) DX2-66</td>
<td>8 MB</td>
<td>730 MB</td>
<td>2X</td>
<td>14”</td>
<td>1900</td>
</tr>
<tr>
<td>Nov 93</td>
<td>(486) SX-25</td>
<td>4 MB</td>
<td>212 MB</td>
<td>None</td>
<td>14”</td>
<td>1275</td>
</tr>
<tr>
<td>Mar 92</td>
<td>(286) –16 MHz</td>
<td>2 MB</td>
<td>40 MB</td>
<td>None</td>
<td>14”</td>
<td>1345</td>
</tr>
<tr>
<td>Feb 90</td>
<td>(286) –12 MHz</td>
<td>2 MB</td>
<td>65 MB</td>
<td>None</td>
<td>14”</td>
<td>1995</td>
</tr>
<tr>
<td>Mar 89</td>
<td>(286) –16 MHz</td>
<td>1 MB</td>
<td>40 MB</td>
<td>None</td>
<td>14”</td>
<td>2395</td>
</tr>
</tbody>
</table>

*Note: In Sep 99, Gateway also sells a $999 computer (400 MHz, 32 MB, 6.8 GB, CD-ROM, 15”)

**TABLE 2: TIME CHANGES OF HIGH-END PERSONAL COMPUTERS**

<table>
<thead>
<tr>
<th>Date</th>
<th>Chip (-MHz)</th>
<th>Memory</th>
<th>Disk</th>
<th>CD-ROM</th>
<th>Monitor</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar 01</td>
<td>P 4, 1.3 GHz PP</td>
<td>128 MB</td>
<td>20 GB</td>
<td>48X</td>
<td>17”</td>
<td>$1600</td>
</tr>
<tr>
<td>Sep 99</td>
<td>P III 600 MHz</td>
<td>128 MB</td>
<td>27.3 GB</td>
<td>6X, DVD</td>
<td>19”</td>
<td>$3000</td>
</tr>
<tr>
<td>Feb 98</td>
<td>P II-300 MHz</td>
<td>64 MB</td>
<td>6.4 GB</td>
<td>13X</td>
<td>19”</td>
<td>$3000</td>
</tr>
<tr>
<td>Mar 97</td>
<td>P-Pro-200</td>
<td>64 MB</td>
<td>3.8 GB</td>
<td>12X</td>
<td>17”</td>
<td>2900</td>
</tr>
<tr>
<td>May 96</td>
<td>P5 –166</td>
<td>16 MB</td>
<td>2.5 GB</td>
<td>8X</td>
<td>17”</td>
<td>3600</td>
</tr>
<tr>
<td>Feb 95</td>
<td>P5 –90</td>
<td>8 MB</td>
<td>1.0 GB</td>
<td>4X</td>
<td>15”</td>
<td>2900</td>
</tr>
<tr>
<td>Nov 93</td>
<td>P5 –60</td>
<td>8 MB</td>
<td>424 MB</td>
<td>None</td>
<td>14”</td>
<td>2995</td>
</tr>
<tr>
<td>Mar 92</td>
<td>(486) –33</td>
<td>8 MB</td>
<td>340 MB</td>
<td>None</td>
<td>14”</td>
<td>3895</td>
</tr>
<tr>
<td>Feb 90</td>
<td>(386) –33</td>
<td>4 MB</td>
<td>160 MB</td>
<td>None</td>
<td>14”</td>
<td>4395</td>
</tr>
<tr>
<td>Mar 89</td>
<td>(386) –20</td>
<td>4 MB</td>
<td>80 MB</td>
<td>None</td>
<td>14”</td>
<td>3995</td>
</tr>
</tbody>
</table>

PP: There are also more costly ones (but Computer Shopper does not show them).

**TABLE 3: WHEN DID MAIN INTEL CHIPS START SHIPPING?**

<table>
<thead>
<tr>
<th>CPU Chip</th>
<th>Date started</th>
<th>Start MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>486</td>
<td>~Feb 1990</td>
<td>~25 MHz</td>
</tr>
<tr>
<td>Pentium (P5)</td>
<td>Oct 1993</td>
<td>60 MHz</td>
</tr>
<tr>
<td>Pentium II</td>
<td>May 1997</td>
<td>233 &amp; 266 MHz</td>
</tr>
<tr>
<td>- new speed</td>
<td>Feb 1998</td>
<td>300 MHz</td>
</tr>
<tr>
<td>Pentium II</td>
<td>Sep 1998</td>
<td>400 MHz</td>
</tr>
<tr>
<td>Pentium II</td>
<td>Oct 1998</td>
<td>430 MHz</td>
</tr>
</tbody>
</table>

**NOTE 1:** In Mar 99, the Pentium II chips, 400 and 450 MHz, were still the high-end. In May 99, the Intel Pentium III at 500 and 550 MHz was selling.

**NOTE 2:** In Aug 1999, another company (AMD) started selling their 600 and 650 MHz Athlon chips. On speed tests (at the same MHz), they are faster than any Intel chips. News: AMD started shipping a 700 MHz Athlon (Wall Street Journal, Oct 4, 1999). It will sell for $849, wholesale.
1) A PC hard drive (3.5 inch) now holds
   - 120 GB if 3 platters
   - 160 GB if 4 platters
   - These use 30 qbits per square inch
   - IBM hopes to hit 100 qbits/in² by 2003

2) Note: 180 GB hard drives are here now
   - We will have small 400 GB hard drives in about 2 years.

---

CPU chips - fast speed gain

1) Shows when the fast chips are coming

2) A few PC chips will be very fast 64-bit chips
   - Intel released the 64-bit Itanium May 2001 (now)
   - The 64-bit McKinley (Intel) will come mid 2002 (2X as fast as Itanium
   - The 64-bit Hammer chip from AMD comes later in 2002. Probably starts at 2 GHz, very fast chip.
Hard Drives
Reach the Next Plateau

BY JOHN R. DELANEY

ver time, most PC users realize that they can never have enough storage space. This is equally true for IT administrators who manage huge stores of data across networks, as well as for desktop users who work with digital imaging, large databases, and content-creation applications. As more users integrate their PCs into home entertainment centers, storing MP3 and streaming video files will eat up valuable hard drive space at an alarming rate.

Up to now, integrated drive electronics (IDE) drives topped out at 137 GB of storage because of limitations inherent in the 28-bit addressing scheme developed for the current Advanced Technology Attachment (ATA) specification. But Maxtor's Big Drive technology tears down this 137 GB barrier by incorporating a newly developed 48-bit addressing scheme, resulting in the industry's first 160 GB IDE/ATA drive and opening the door for higher capacities in the not-too-distant future.

Led by Maxtor and other industry leaders such as Compaq, IBM, Microsoft, and Via Technologies, the Big Drive initiative solves the 28-bit hard drive addressing dilemma, which, in mathematical terms, allows for a maximum 268,435,456 sectors that hold 512 bytes of data. Simply put, 28-bit technology recognizes only 137 GB of storage space. The new 48-bit addressing system changes the equation drastically, allowing drive capacities of up to 144 PB (petabytes, or 144 million GB).

While petabyte drives are still years away, we can expect to see IDE hard drive capacities double in size within the next year. Having Microsoft on-board is significant, since its operating systems will have to support 48-bit addressing to work correctly. Storage capacity is only half the story, though. As hard drives become bigger, they need to be able to move data more quickly through the interface to avoid becoming a bottleneck to system performance. Even though the newer "fast" IDE hard drives have speeds of 7,200 rpm (as opposed to 5,400 rpm), they are limited to peak transfer rates of 100 MBps through the ATA/100 interface.

At this point, the ATA/100 interface is still ahead of the pack as far as meeting the required Big/Fast drive data rates, but eventually, the interface will become a bottleneck. As a result, new interface technologies are emerging that will increase the interface speeds by as much as 50 percent in the coming year and by as much as 500 percent in the next four years.

One such technology, known as ATA/133, was recently introduced by Maxtor and is currently implemented in the company's two newest drives, the Maxtor Diamond Max Plus 7400X and the Maxtor Diamond Max Plus 540X.

Unlike ATA/100, which is supported by most motherboard chip sets and integrated onto the system board, ATA/133 (which offers transfer rates of up to 133 MBps) requires the use of an add-in PCI card for Intel-based motherboards. (Via Technologies has announced support for the ATA/133 interface with the VIA VT8223A South Bridge chip set.)

ATA/133 has not gained wide acceptance as the next new standard for a number of reasons, most notably because Intel and many leading hard drive and chip set vendors are already focusing on the successor to ATA/100—the recently announced Serial ATA (SATA) interface, which will initially support 150-Mbps transfer rates. Original plans called for SATA devices to be available in the first half of 2002. We'll probably have to wait, however, until the first half of 2003 before SATA becomes the standard. Eventually, SATA will replace the ATA/100 interface, which uses bulky ribbon cables to transfer data in parallel mode. SATA will use thinner, longer cables, thus improving airflow though the PC chassis and enabling systems to run cooler. More important, future SATA revisions will enable transfer rates of up to 600 MBps in the coming years. Even so, Maxtor believes the ATA/133 interface will provide an interim solution should drive speeds breach the 100-Mbps barrier before SATA is ready.

Maxtor has implemented Big Drive technology for the first time in its Maxtor DiamondMax 0540X ($399.95 direct, www.maxtor.com) a mammoth 160 GB IDE, 5,400-rpm drive that targets the network-attached storage...
FIRST LOOKS

and enterprise server market. The DS40X, the first IDE drive to break the 137GB barrier, is designed using four 40GB platters and features a 2MB cache buffer. It is also one of the first drives to incorporate the ATA/133 interface. (We tested it with the Ultra331TX2 add-in card from Promise Technology.)

Setting up the drive/controller combination on our 2.0GHz P4-based Dell Dimension 8200 test system was straightforward. We installed the ATA/133 card, connected the DS40X drive, booted the system with the included Maxtor MaxBlast II utility disc (which contains a wizard for easily partitioning and formatting the drive), and installed Microsoft Windows 2000. Since our Dell test-bed unit is a fairly new system, the BIOS recognized the drive without a problem, although older machines may need a BIOS update or may not be able to support the drive at all.

IBM hopes to hit 100 gigabits per square inch by 2003, which means that meagacapacity drives of 400GB or more are a real possibility.

Both Promise and Maxtor boast a 33 percent increase in data rates because of the ATA/133 interface, but our benchmark test results provided no proof to support this claim. Although the ATA/133 interface was slightly faster. We tested the DS40X while it was connected to the Promise controller and received scores of 8,120 on our Business Disk WinMark 99 and 54.1 on our Business Winstone 2001 tests. We then tested the drive using the primary IDE port (ATA/100) on our system’s motherboard and received scores of 7,810 on Disk WinMark and 53.5 on Business Winstone, indicating that the ATA/100 interface still has the overhead to handle the transfer rate of high-capacity hard drives running typical business applications, at least for now.

The Maxtor DiamondMax Plus D740X ($299 direct) features 80GB of storage capacity and also uses the ATA/133 interface, but it is a 7,200-rpm drive designed with two 40GB platters and 2MB of SDRAM for cache buffering. Geared towards the business and enthusiast market, the D740X is a performance drive.

The D740X features a ball-bearing motor or Maxtor’s Quiet Drive technology to reduce the noise associated with ball-bearing drives. Quiet Drive uses a fluid dynamic bearing (FDB) motor to achieve a low-noise, high-speed storage solution for desktops, as well as gaming console systems.

Like the DS40X, the D740X was easy enough to install using Maxtor’s Max guilt Plus II utility. Once again, we noticed only a slight performance increase when testing the drive with the ATA/133 card compared with the integrated IDE controller, with Disk WinMark scores of 9,400 and 8,900, respectively.

Western Digital is one of more than 70 companies that are throwing their weight behind the SATA standard and forging the implementation of ATA/133 technology in their product line. Our family of 7,200-rpm Caviar hard drives, which targets the high-performance desktop market, has a high-capacity boost with the Western Digital Caviar 120 GB ATA/100 drive, the first 120GB 7,200-rpm drive to hit the market ($599 direct, www.westerndigital.com). Based on a three-platter (40GB each) architecture, the Caviar 120 includes a 2MB cache, but Western Digital plans to release an 8MB buffer version in the near future. Though the increased buffer size may be advantageous when used in server configurations, whether desktop users running normal business applications will see a notable performance boost compared with the 2MB version is not clear.

The Caviar 120 is bundled with Western Digital’s Data Lifeguard utility, which includes tools for installation and diagnostics, as well as a set of reliability and data-protection tools for monitoring and repairing drive errors. We connected the drive to our system’s integrated IDE port, ran the EZ Installation program, and installed Microsoft Windows 2000 without a hitch. The Caviar 120 produced a score of 54.4 on our Business Winstone and 8,740 on our Business Disk WinMark tests. When we connected the drive to the Promise ATA/133 card, we received an identical Winstone result and a WinMark score of 8,900, which is a bit higher than that with the ATA/100.

The IBM Deskstar 120GXP ($369 direct, www.ibm.com) may not have been the first 120GB 7,200-rpm drive available, but our benchmark test results show it to be the best performer we’ve seen so far, if only by a small margin. For now, IBM is sticking with the ATA/100 interface while waiting for SATA to make its presence known. The Deskstar 120GXP, which uses three 40GB platters and includes a 2MB buffer, is IBM’s highest-capacity IDE drive. It is well suited to desktop systems that require the speed and capacity needed for digital content creation and storage, as well as for storing large video and audio files.

The drive also implements IBM’s AFC (antiferromagnetically coupled) media coating, better known as pixie dust, which the company claims improves data stability and increases areal density (the amount of data, in bits, that can fit onto a platter). Greater areal density enables higher-capacity drives. To put it in perspective, the areal density of the Deskstar 120GXP is just under 30 gigabits per square inch. But IBM hopes to hit 100 gigabits per square inch by 2003, which means that meagacapacity drives of 400GB or more are a real possibility.

Using the included Disk Manager utility, we installed the Deskstar 120GXP on our test-bed system and loaded Windows 2000. Connected to the system’s IDE controller, the 120GXP produced a Disk WinMark score of 8,840 and a Business Winstone score of 54.8. After we installed the Promise ATA/133 card and connected the drive, we received scores of 9,410 and 56.

All things considered, any of these drives would be a fine complement to a high-end system. Their capacities might seem like overnight success stories, but if multimedia is on your roadmap, you might just save yourself an upgrade headache farther down the line.

HARD DRIVES

<table>
<thead>
<tr>
<th>Drive Type</th>
<th>ATA/133</th>
<th>ATA/100</th>
<th>Business Disk (WinMark 99)</th>
<th>Business Disk (WinMark 99)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM Deskstar 120GXP</td>
<td>ATA/133</td>
<td>54.1</td>
<td>36.1</td>
<td>8,120</td>
</tr>
<tr>
<td></td>
<td>ATA/100</td>
<td>53.9</td>
<td>35.8</td>
<td>8,120</td>
</tr>
<tr>
<td>Maxtor DiamondMax D540X</td>
<td>ATA/133</td>
<td>54.1</td>
<td>36.1</td>
<td>8,120</td>
</tr>
<tr>
<td></td>
<td>ATA/100</td>
<td>53.9</td>
<td>35.8</td>
<td>8,120</td>
</tr>
<tr>
<td>Western Digital Caviar 120</td>
<td>ATA/133</td>
<td>54.4</td>
<td>36.1</td>
<td>8,120</td>
</tr>
<tr>
<td></td>
<td>ATA/100</td>
<td>54.4</td>
<td>36.1</td>
<td>8,120</td>
</tr>
</tbody>
</table>

We ran all tests on a 2.0GHz P4-based Dell Dimension 8200 with 512MB of RAM, running Windows 2000 (Service Pack 1). All drives were formatted for NTFS.
WHAT'S INSIDE?

- Fast CPU Chips

The CPU is the heart of your system, and choosing the right one is key. Our guide will help you navigate this fast-changing technological landscape and avoid any hidden pitfalls.

BY CADE METZ

Today's biggest breakthroughs in the world of computing are occurring, ironically, at the atomic level, shattering the prediction that Moore's Law will soon hit a wall. That's good news for an industry that thrives on packing more smaller, faster transistors onto chips and producing them inexpensively, but it's difficult for consumers to keep pace with such rapidly changing technology. While you're shopping for today's latest processor, engineers at AMD, IBM, Intel, Motorola, and other technology firms are deep

REVIEWED IN THIS STORY

Thank goodness, we've finally gotten over "How much speed do you need?" We'll show you which processor is perfect for today and what to look forward to in 2003.

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110 64-Bit Mania: AMD vs. Intel
111 And the Winner Is...

112 Performance Tests
114 Overlooked No More
114 Summary of Features
### Processor Time Line

<table>
<thead>
<tr>
<th>AMD</th>
<th>Intel</th>
<th>Transmeta</th>
<th>Motorola</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Athlon MP</strong>: The first dual processor capable Athlon, based on the Palomino core.</td>
<td><strong>Ritanium (Merced)</strong>: The first in the Itanium line of microprocessors.</td>
<td><strong>Xeon</strong>: Based on the Pentium III core, faster clock speeds and the Intel 805 processor.</td>
<td><strong>McKinley</strong>: The first version of the Itanium processor to use new technologies.</td>
</tr>
<tr>
<td><strong>Athlon XP</strong>: Single microprocessor capable Athlon, based on the Palomino core.</td>
<td><strong>Duron</strong>: Based processor, based on the Merom core, with improved core and SSE instructions.</td>
<td><strong>Thoroughbred</strong>: Faster bus and clock speeds, with the addition of a clock distribution network.</td>
<td><strong>Appaloosa</strong>: Budget-oriented processor with the same bus and clock speeds.</td>
</tr>
<tr>
<td><strong>Pentium 4</strong>: Higher performance.</td>
<td><strong>Pentium III</strong>: Higher clock speeds, but the same bus and clock speeds.</td>
<td><strong>Pentium 4</strong>: Faster clock speeds, with the addition of new technologies.</td>
<td><strong>Mobile Pentium 4</strong>: Supports SSE2 and enhanced power management.</td>
</tr>
</tbody>
</table>

### Desktops

| Athlon MP: The first dual processor capable Athlon, based on the Palomino core. | **G3**: 400 MHz with integrated CD-ROM. | **G4**: 667 MHz with 2.53 MB cache. |
| Duron: Based processor, based on the Merom core, with improved core and SSE instructions. | **Thoroughbred**: Faster bus and clock speeds, with the addition of a clock distribution network. | **Appaloosa**: Budget-oriented processor with the same bus and clock speeds. |
| **Pentium 4**: Higher performance. | **G3**: 400 MHz. | **G4**: 533 MHz. |

### Mobile

| Athlon 4: Based on the Palomino core. | **Mobile Pentium III**: Higher clock speeds. | **Cruzer TM5100 and TM6000**: Faster clock speeds and improved performance. |
| **Cruzer TM5100 and TM6000**: Faster clock speeds and improved performance. | **Celeron**: Budget-oriented processor with the Pentium III core, with faster clock speeds. | **Cruzer TM6000**: Faster clock speeds and improved performance. |
| **G3**: Faster clock speeds. | **G4**: Faster clock speeds. | **G4**: Faster clock speeds. |

### Cell phones

| **PowerPC G3** and **G4** architectures. | The latest G4 chip, the Motorola MPC7450, which is now available at 867 MHz, offers an on-chip Level-2 cache and operates at much higher speeds than an external (off-chip) cache used by previous versions; it also offers the new Altivec instruction set, which improves the chip's ability to handle streaming audio and video. Unlike past G4 models, the MPC7450 can also be used with a Level-3 cache, which further improves performance. |

### DESKTOPS<<

As has been the case for many years, the desktop CPU market—at least here in the U.S.—is controlled by three manufacturers. AMD and Intel build the processors used in Windows PCs, and Motorola builds those used in Apple machines.

Motorola offers the PowerPC G3 and G4 architectures. The latest G4 chip, the Motorola MPC7450, which is now available at 867 MHz, offers an on-chip Level-2 cache and operates at much higher speeds than an external (off-chip) cache used by previous versions; it also offers the new Altivec instruction set, which improves the chip's ability to handle streaming audio and video. Unlike past G4 models, the MPC7450 can also be used with a Level-3 cache, which further improves performance.

If you're set on buying an iMac or an iBook, you need only choose from among the G3's various clock speeds. Unlike the G4 geared at power users—those running high-end games, graphic-design packages, and extravagant multimedia applications—the G3 runs at slower clock speeds and lacks Altivec technology, but it's still good for home users.

If you're in the market for a Windows machine, however, you have choices galore. Intel offers three types of desktop CPUs. The Pentium 4 is the fastest and most expensive chip and well suited to high-end multimedia work. The Pentium III is an older, slightly slower but cheaper chip that many corporations are still buying. And the Celeron is the slowest and...
least expensive chip, good for those who want to save money and run basic applications like e-mail or word processing.

In early 2002, Intel introduced a new Pentium 4, code-named Northwood. It is the first Pentium 4 manufactured using a 0.13µm technology, which means that its smallest part is no wider than 0.13 microns. Using this new process, Intel can fit more—and more effective—transistors onto each chip and run each at higher clock speeds, resulting in better performance. That means your high-end multimedia and gaming apps will run slightly faster.

Manufactured on a 0.13µm process, the existing Willamette Pentium 4 is 217 mm² in size, contains 256K of L2 cache, and tops out at 2 GHz. Despite having a much smaller die (146 mm²), the Northwood has 512K of L2 cache and is currently available at 2.0 GHz and 2.2 GHz. The more L2 cache a processor has, the more efficiently it can perform sequential tasks, such as encoding streaming media. In the future, the Northwood should be capable of attaining even higher speeds. Intel demoed a 3.5-GHz processor this fall and plans to bring a 3-GHz version to market by the end of 2002.

As it unveiled the Northwood, Intel made another important change to the Pentium 4 landscape with its new 845DDR chip set, which supports the use of DDR memory, a technology that has given an edge to AMD's chips over the past year. Previously, Intel's only Pentium 4 chip sets were the 845HV, which supports SDRAM, and the 850, which supports RDRAM.

DDR is only marginally more expensive than SDRAM, and it's significantly faster. Paired with the 845DDR chip set, the 2.2-GHz Northwood scored 5 percent higher on our Business Winstone 2001 tests than when paired with the 845HV. And though Rambus provides a significant performance boost if you’re performing certain high-end tasks, such as editing video or audio, DDR provides comparable performance under most other apps and is significantly cheaper. (For a more in-depth look at the role of memory in PC performance, see

“Overlooked No More.”)

Given this combination of new technologies, most analysts see the Pentium 4 as the mainstream solution for everyday users in 2002. When it first arrived on the scene a year ago, the Pentium 4 wasn't necessarily a better option than the Pentium III. Its NetBurst architecture—offering a 400-MHz bus, new pipeline and cache technologies, and SSE2, an update to Intel's SSE multimedia instruction set—could improve the performance of certain multimedia and Internet applications, such as audio and video editing, but the architectural enhancements that led to this boost could provide a similar boost under common business applications, such as word processors and e-mail clients.

Over the past year, however, the Pentium 4 has matured. It's now nearly a gigahertz faster than the Pentium III, so it's leading the business app department, and the introduction of the 845HV and 845DDR chip sets has made it much more affordable.

Considering Intel's long-standing rivalry with AMD, the company that pioneered the use of DDR memory, the arrival of the 845DDR is particularly important. Via Systems, a Taiwanese manufacturer, has sold DDR chip sets for the Pentium 4, but most of the major American PC manufacturers choose Intel chip sets. This year marks the first time many manufacturers will offer the better-performing DDR memory at a reasonable price, and the Pentium 4 can better compete with AMD's processors in both performance and price.

Celeron machines are still cheaper than Pentium 4 models, but not much. Entry-level Pentium 4s are now selling for around $700, only about $200 more expensive than basic Celeron machines. In most cases, it's best to go with the Pentium 4, which offers so much more speed under business software and—even more crucial—high-end multimedia software. During testing at PC Magazine Labs, the 2.2-GHz Northwood machine, equipped with 845DDR for our Business Winstone 2001 tests, scored 20 percent higher than the 1.2-GHz Celeron and 1 minute 12 seconds faster on our Windows Media Encoder 7 test. That said, the Celeron is a good option if pinching pennies is your primary criterion. The chip, which uses the

www.pcmag.com FEBRUARY 12, 2002 PC MAGAZINE 109
64-Bit Mania: AMD vs. Intel

The race to grab the 64-bit computing ring is under way. With heavyweights like AMD and Intel building the chips and Microsoft crafting the OS to run on them, the industry is ready to push 64-bit computing into the mainstream.

Intel was first out of the gate last year with its Itanium processor, but it was by no means the first company to develop a 64-bit chip. In 1991, MIPS Technologies introduced its 100-MHz R4000 64-bit RISC processor, followed by Digital Equipment's 150-MHz DECchip 21064 Alpha AXP 64-bit architecture in 1992. 64-bit computing has been used in RISC and Unix servers and workstation ever since. So what's the big deal about now?

The large amount of memory that 64-bit computing can handle makes it very desirable for large, high-end data applications, such as data mining on servers, and for dealing with terabyte databases. A large part of Intel's Itanium architecture relies on software compilers, so a new technology known as EPIC (Explicitly Parallel Instruction Computing) comes into play. Much of the performance gain you get with Itanium comes from these optimized compilers.

Current 32-bit code will not take full advantage of Itanium's architecture, which requires developers to compile programs and needs an operating system specifically designed for Itanium's 64-bit EPIC architecture.

Lagging behind Intel is AMD, which will not release its 64-bit Hammer chip until the second half of 2002 (but just in time to compete with Intel's next generation IA-64 chip, the McKinley). Currently, there are two versions: Clawhammer for desktops and workstations, and Sledgehammer for servers. Hammer chips are based on a more straightforward extension of the 32-bit architecture rather than a completely new technology. AMD says its chips will provide top-of-the-line performance for 32-bit applications, as well as great performance for 64-bit applications. Although applications will still need to be recompiled for the 64-bit extension, it won't be necessary to rely so heavily on the compiler for high levels of parallelism as you would for the IA-64. If all goes according to plan, Hammer could be the chips to bring 64-bit computing to the mainstream instead of IA-64.

Clearly, 64-bit power is not necessary for running office applications and Web browsing. It is much more useful for memory- and compute-intensive applications with large databases, business intelligence or data mining, security transactions, and mechanical computer-aided engineering. Though Intel's 64-bit architecture is not aimed specifically at office workers, AMD claims it is just fine for them.

Since its release in May 2001, the Itanium chip has been used more as an assessment system than a real product. Intel all but assured this by delaying the ship date: The Itanium was originally set to ship a year earlier. By shipping it in 2001 and concurrently stating that its next-generation IA-64 McKinley chip was still scheduled for mid-2002, people chose to use the Itanium chip to evaluate IA-64 processing solutions while waiting to buy the McKinley architecture. McKinley is rumored to start at over 1 GHz and will roughly double the Itanium's performance. Hammer is said to be starting at 2 GHz.

Rumors aside, by 2002 all bets are on: the CPUs, operating systems, and compilers will all be in place. AMD and Intel will strive for highest market share, hoping that their 64-bit entries will be strong, with good performance and a low price. And although first out of the gate sometimes means winning the brass ring, it doesn't necessarily guarantee anything.—Rich Fisco

same core as the Pentium III but contains less cache, competently runs everyday applications.

AMD is an even better choice for the budget-conscious, offering three desktop chips: the Athlon, Athlon XP, and Duron. All are typically cheaper than their Intel counterparts, and at times, they even perform better.

Though the Athlon XP's clock speeds aren't as high as the Pentium 4's, its performance isn't slower. The 1.6-GHz Athlon XP machine—equipped with an AMD chip set and DDR memory—outperformed the 2.2-GHz 845DDR Northwood by 7 percent on our Business Winstone 2001 tests. Because of the discrepancy between clock speed and performance, AMD uses numbers that ostensibly show how well its Athlon XP performs relative to the Pentium 4 to market its chip. For example, the 1.2-GHz Athlon XP is sold as the 1900+, and the 1.5-GHz Athlon as the 1800+.

You'll have to sacrifice a little speed if you choose AMD's Duron, but it's an undeniable bargain. Intel's latest Celeron uses the 0.13-m process, which helps it attain higher clock speeds. Intel is holding back the Celeron's bus and clock speeds to make a noticeable difference among Intel chips. AMD, meanwhile, has raised the Duron to the same clock speed using the older 0.18-m process. Although the 0.13-m process should be cheaper than the 0.18-m, AMD keeps the average Duron chip at $50 or less. Thus, the average machines are no-
The MP indicates that it's intended for multiprocessor machines, which in this case means two processors. Intel's first 64-bit processor, the Itanium, arrived this past year and is now being sold in servers and workstations meant to compete with high-end RISC platforms. The chip can use 4,000 times as much memory space as existing Intel chips because of its new technology known as EPI (Explicitly Parallel Instruction Computing), a means of processing multiple instructions in parallel. But because most applications must be recompiled before they run on the Itanium, dual-processor and multiprocessor servers with new ones built around the Pentium 4 architecture and a new technology called hyperthreading. When running a multithreaded application (an app that can benefit from multiple processors), a hyperthreading chip can act like multiple chips. "It makes a single processor look like two logical processors," says Shannon Poulin, Intel's enterprise marketing manager. "The chip's performance isn't quite as good as two physical processors, but it's still an improvement." "In the end, few are going to say Intel's market after 2002? They'll be faster current chips—that's certain. Power consumption management will also play a role in defining the market and pushing RISC envelope in research and development. Intel's Willamette concur, "Our processor power consumption is going to double exponentially, and at this rate, we'll be reaching the power comparable to that of a nuclear reactor in a microcomputer. "Well, maybe that advanced technologies like the terahertz transistors show that we have another few decent years before we hit a brick wall.
without opening their lines to outside competitors. The principle behind it is that ILECs will be more willing to invest in new infrastructure if they think they have a better chance to recoup the costs. For now, what effect the Tauzin-Dingell legislation would have on how quickly new DSL services are deployed is not completely clear. Regardless of the fate of the bill, the government seems likely to address the situation, according to experts. But whatever the outcome, don't hold your breath for quick results; it will be as much as two years before any effects become apparent.

NOW THE GOOD NEWS
Despite the pandemonium of the past year, the process of getting broadband has actually been simplified. In particular, it's now easier to provision a DSL connection. The average installation time for DSL has dropped from a range of 30 to 45 days to 5 to 15 days. More than 90 percent of the DSL connections are now self-installed by customers, according to industry analysts.

Part of the time savings results from the ironing out of kinks in the provisioning process as the interfaces between providers become increasingly automated. Telcordia Technologies, a telecommunications research and development firm, estimates that just the provisioning for the network elements to support a DSL installation once took as long as 50 person-hours to complete from start to finish. The automated process used by almost all telcos today takes just under an hour.

That is not to say, however, that all DSL installations are easy and painless, just that the behind-the-scenes work has gotten easier. There are still often several parties involved in provisioning a line, including the incumbent phone company (Verizon, for example), a DSL provider (such as Covad), and an ISP (EarthLink, perhaps), all of which have to hit deadlines, dispatch people, or roll trucks on time to make it all work. And no matter how much the process is refined, DSL installations can still end badly. The quality and condition of the copper wiring that has gone into the telephone system for the past 100 years varies widely from neighborhood to neighborhood and even from building to building. Tests may need to be run on the lines, adding further time to the installation. For instance, Pacific Bell estimates that only 65 percent of the customers within 14,000 to 18,000 feet of the central office will actually qualify for the service. In some cases customers can pay to have new lines run, but often they are simply disqualified.

Improvements to the standard PC platform have helped speed up the broadband installation process, allowing just about anyone to install the in-home equipment without a technician on hand. Many PCs today have built-in Ethernet adapters and USB ports, so connecting a DSL or cable modem can be a matter of plugging in a single connector. Broadband providers previously had to get inside the PCs to install a network card—a step that added significant time and cost to each installation. In addition, the automatic network configuration feature in Microsoft Windows XP eliminates much of the tweaking required with older versions of Windows.

CABLE AHEAD
While the order-to-install gap is closing between DSL and cable, you're still likely to get cable modem service faster. The industry average to turn on a cable modem connection currently ranges from two to five days. Furthermore, chances are better that you live in an area where cable is available. The Yankee Group estimates that, at the end of 2001, cable was available to 66 percent of U.S. households, versus 45 percent for DSL. Finally, the newer cable infrastructure—hybrid fiber coaxial—is a much more predictable, known quantity than the phone lines.

Victor Chi, of The Bronx, New York, unsuccessfully tried to get DSL—first from Verizon Online, then from EarthLink Network—for three months before finally learning his phone line wouldn't support it. He threw in the towel last fall, subscribed to Cablevision's Optimum Online service for $30 per month, and was online in two days. "I didn't even have to talk to anybody," he marveled. "They just sent me the modem, and I hooked it up. Now I'm wondering why I didn't go with cable to begin with."

DSL providers like to think they have at least one clear advantage over cable, disparaging the shared coaxial system—

DSL PROVISIONING IS NOT YET painless, but the behind-the-scenes work has gotten easier.
TECHNOLOGY

Power use by chips

Too Hot to Handle

As microprocessors simultaneously shrink and speed up, they turn into little furnaces. One more reason to fret about the end of Moore's Law?

BY ELIZABETH CORCORAN

WILLIAM POHLMAN'S 1999 retirement party, capping a 20-year tenure at Intel, had barely started when two former colleagues pulled him aside. They wanted him to help them start a new chip company, Primarion, which wound up focusing on regulating the energy demands of microprocessors. The back nine could wait. "I knew the technology megatrends that were creating problems for building future chips," says Pohlman, a former vice president of engineering in Intel's microprocessor group.

Two years later Intel is pulling off breathtaking feats, squeezing 42 million transistors onto a sliver of silicon 217 square millimeters. Its new Pentium 4 churns through data at rates of 1.5 gigahertz; one gigahertz is a billion clock cycles a second.

But as chips get this dense and quick, they get hot—hot enough to boil water. The heat makes them so electrically "noisy" that they can fail. And the materials that enabled such chip density are reaching physical limits. Says

GETTING THE HEAT OUT

To make more powerful microprocessors, engineers try to squeeze more transistors onto a single silicon chip. That means transistors have become vanishingly small. If Intel's top-of-the-line Pentium 4 processor measured 500 miles on a side, then each of its 42 million transistors would be only 19 feet across the top. But the tinier the transistors, the hotter the whole chip becomes. Here are a few of the techniques designers are trying to get the heat out. Just about all of these, however, add some cost and difficulty to chipmaking.

FIND A BETTER WAY TO FLUSH OUT HEAT

1. Heat sinks. These are chunks of material that pull heat away from the microprocessor. Metal is a good conductor of heat; water is better. (Air is the best.) Some designers are building novel heat sinks with tiny water chambers. The water draws out the heat, vaporizes and, as it cools, condenses again.

2. "Encapsulate" a microprocessor. Startup Incelp hopes to package a chip, heat sink and the ability to modulate voltage. By sliding the chip into this tidy package, it could expose more of it to air.
Pohlman, now chairman of Primarion in Tempe, Ariz.: “We’ve hit an inflection point.”

And it’s a biggie. If nothing is done to rethink chip design, the most powerful microprocessors could be consuming more than 1,000 watts by 2004. “If it’s business as usual, we wind up frying eggs” with microprocessors, says Dennis Monticelli, a Fellow with National Semiconductor in Santa Clara, Calif.

Many of these problems could occur within two chip generations, about four years from now. Since it takes about two years and more than $1.5 billion to build a new semiconductor factory, chipmakers are rolling some expensive dice betting researchers will find solutions in time. “Our goal is to make Moore’s Law work for the next decade,” says Patrick Gelsinger, chief technology officer at Intel, referring to the tenet that the number of transistors on a chip doubles every 24 months.

Doing so, however, will demand changes in the design of chips and the materials that compose them. At a recent industry conference, Gelsinger declared that managing heat is now one of the industry’s top challenges. Switching every transistor off or on requires a touch of energy. As transistors shrink, it becomes impossible to completely turn them off, so they leak current all the time. That draws electricity—50 watts in the case of the Pentium 4—and the electricity creates heat. Without the use of cooling techniques, temperature spikes above 105 degrees centigrade have occurred. Piping out the heat is expensive. Even simple “heat sinks,” chunks of material that carry heat away from microprocessors, can add $16 to the cost of a $600 chip. More elaborate models, with tiny chambers of water that vaporize and carry away heat more quickly, can run twice the cost. Computer makers hate adding gizmos to their boxes to flush out heat, preferring to save the room for gear that makes their machines more appealing.

New cooling tricks are starting to emerge. In late February the fledgling Incep Technologies in San Diego introduced a technique for packaging together a microprocessor, a logic board for regulating power to the chip and a heat sink. Even though such “encapsulation” could cost $200 per unit, Incep President James Kaskade contends that it both cools the chips and saves space inside the box.

Isonics Corp., in Golden, Colo., a maker of specialty materials and chemicals, is proposing a new material: a “purer” version of silicon called Si-28, which channels out heat better than conventional silicon. The silicon in typical wafers is a blend of three silicon isotopes. Sifted down to just the Si-28 isotope, Isonics’ wafer conducts heat better.

Even though Si-28’s thermal properties are attractive, changing materials could be an expensive option, adding at least 25% to the cost of the wafer. Isonics Chief Executive James Alexander says he needs committed partners before manufacturing the first wafers. He claims that Advanced Micro Devices, among others, is experimenting with the materials.

Even better than getting the heat out would be generating less of it in the first place. Intel’s Gelsinger is exploiting
several tricks to make chips more efficient. Adding more local memory, or "cache," to a chip reduces the work the microprocessor must do to fetch needed data. Letting two microprocessing units share one cache cuts work even further. Designating a special section of the chip to handle common tasks also helps. So, too, does handling repetitive tasks together.

Both Intel and AMD are also trying to be smarter about how their chips use power by using software to deliver just enough juice to the chip to get a job done. "The chance that you need the highest performance at any one time is small," points out Frederick Weber, vice president of design engineering at AMD in Sunnyvale, Calif. Instead, chips might operate at clock speeds ranging from 300 megahertz to 1,500 megahertz, depending on the tasks.

Transmeta, a much-talked-about Santa Clara newcomer, is taking a different approach entirely. Instead of slowing down a fast processor, it is using software to replace transistors. Transmeta's technique, called "code morphing," translates the instructions sent to a chip into bigger chunks that can be handled more efficiently. The result: Its Crusoe chip, voltage they apply to transistors so as not to fry the electronics. But at lower voltages the signal that pulses through the chip gets so weak it could get lost in the chip's electrical cacophony. Imagine 50 million doors slamming every fraction of a second. And, when the electric potential dips below one volt, devices may not get enough juice to switch. A power-hungry transistor will steal energy from its neighbors, causing a tiny surge on the chip. "Either you have to run your processor slower, or you could get a 'blue screen'—the system fails," says Pohlman.

He thinks he has an answer to these concerns by judiciously managing the voltage. Primarion is designing small, special-purpose silicon germanium chips that sit next to a microprocessor, monitor its energy demands and supply the right amount of power at the right time. "We think it might add $20 to the cost of the microprocessor but it could run as much as 20% faster," Pohlman argues. Primarion's first chips, which operate about five times as fast as the top microprocessors, might be ready by year-end. (Silicon germanium chips run so fast because electrons travel more easily through the material than they do through silicon.)

As transistors get even smaller the materials that have been so reliable for chip designers begin to give out. One standard ingredient has been silicon dioxide, a combination of silicon and oxygen atoms that makes up beach sand and quartz crystals. Silicon dioxide has played two different roles for transistors: It insulates the tiny metal wires connecting those millions of transistors and manages the process of turning a transistor's power off and on, serving as a buffer between positive and negative charges. By thinning this "dielectric layer," designers have speeded up transistor-switching. But it will soon be stretched about as thin as it can go: The silicon dioxide layer on the daughter of the Pentium 4 will be a mere six atoms thick. Designers can't scrape away too many more atoms or else those lines will touch or interfere, garbling the digital signals.

Researchers despair of ever finding another material that can both manage the switch and insulate the wires. That leads them in different directions: adding new materials to the dielectric material governing the switch and trying to concoct new insulators for the wires. IBM and others are trying a grocery list of materials. In early March, for instance, Dow Chemical unveiled a porous organic material that it promised to make available as an insulator later this year. One radical idea for insulating the wires would be to leave nothing but air between them, says Daniel Dawson, a manager at IBM's Almaden Research Center. Such a chip might be too fragile, however.

Many solutions are under way, but if the biggest chipmakers don't settle on an approach, it will be difficult to drive down the costs of future chips. One compromise: throwing in a pair of oven mitts with every new computer.

"IF IT'S BUSINESS AS USUAL, WE'RE GOING TO WIND UP FRYING EGGS."
ECONOMIC INDICATORS

OUTPUT, DEMAND AND JOBS  Germany's jobless rate fell to 10.6% in October, its lowest in two years. Canada's unemployment rate fell to an eight-year low of 8.1% in the same month; Australia's fell to 7.7%, the lowest since October 1990. Germany's industrial production fell by 3.2% in September, but was up 2.1% on the year.

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<th>GDP</th>
<th>The Economist poll</th>
<th>Industrial production</th>
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*Not seasonally adjusted. **Average of last 3 months compared with average of previous 3 months, at annual rate. "New series. 3m-Aug:cleraint count rate 4.5% in October. **Jul-Sep: 28.3% annual inflation rate.

PRICES AND WAGES  American workers received a pay rise of 3.6% in the year to October, a real increase of 2.1%. German consumer-price inflation slowed to 0.7% in the year to October, as did Italy's, to 1.7%. France's was unchanged at 0.5%. British producer prices were up only 0.1% in the year to October, their smallest annual rise since March 1960.

% change at annual rate

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COMPUTING POWER  The United States spends far more on information technology, as a share of gdp, than other rich countries. Its spending of over 4% of national income in 1996 dwarfs the European Union's average of 2.2%. In an article in this month's International Bank Credit Analyst, Walter Ellis, an Oxford economist, says that Europeans have been slower than Americans to invest in high-tech equipment because they face higher prices. In Britain, for instance, hardware and software both cost two-thirds more than in America. Mr Ellis puts much of the blame on the Fta's trade policies. Although Europe is now scrapping tariffs on electronic components and has ditched antidumping duties on semiconductors, it is unlikely to catch up quickly with America.

Spending on information technology 1996, % of GDP

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<th>Japan</th>
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Source: International Bank Credit Analyst

THE ECONOMIST NOVEMBER 14TH 1998
The Well-Rounded Engineer

Among the most desired engineering graduates are those who can engineer, analyze financial implications, and speak and write well.

"Companies are increasingly concerned about the character of the people they hire," said David Herrello, the New Engineering Leadership professor at the University of Dayton. "We are working to produce graduates who are ready for work, but also are ready for life. Engineers normally emerge from college so focused on being the very best in a very tough discipline that they are not picking up all the life skills they need to be completely effective."

Herrello said engineers need interpersonal skills, an appreciation of the humanities, ethics and an ability to cope with difficult people—"the real business of living."

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<td>Mechanical</td>
<td>14,626</td>
<td>22.80%</td>
<td>15,293</td>
</tr>
<tr>
<td>Nuclear</td>
<td>261</td>
<td>0.40%</td>
<td>258</td>
</tr>
<tr>
<td>Petroleum</td>
<td>225</td>
<td>0.30%</td>
<td>281</td>
</tr>
<tr>
<td>Systems</td>
<td>368</td>
<td>0.50%</td>
<td>400</td>
</tr>
</tbody>
</table>

*Totals will not equal 100% because all engineering disciplines are not included

While the number of engineering students overall has remained relatively stable, the number of aerospace engineering students has declined since 1991.

Reach for it. Get it. At ACSS in Phoenix.

Avionics Systems Engineers
Requires experience with varied avionics, Analog and Digital I/O including ARINC 429. Knowledge of RF Products, TCAS, Transponder, TAWS and Windshear preferred.

Software Engineers
Requires experience in an avionics or other real time embedded system/software development environment and knowledge of DO-178B processes. Software development experience will include working with C++, UML, Modeling Tools, TCAS products, Pascal, and Clearcase/Clearquest. Use of Emulators and miscellaneous product development/release processes and knowledge of RF products are highly desired.

We offer a compensation package, including immediate medical/dental/vision, vacation, sick time, tuition reimbursement, relocation assistance, 401(k) and retirement plan.

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