Computer Architecture Brings Together:

Device physics
Device circuits
Digital design
Mask layout
Processing

Programming languages
Assembly (machine) language
Instruction set architecture
Automata theory

How to do tradeoffs
How to handle complex problems
How to use interfaces

Business and economics
e.g. of consumer price:
1/3 is parts and labor
1/3 advertizing, marketing, ship
1/3 overhead and profit

***Requirements* – everyone contributes:**

Customer

Computer Architect

Digital Logic Designer

IC Circuit Designer – circuits – cell family

IC Mask - layout and route

IC Process and Fabrication

Packaging Designer – IC – PWB – connectors

Operating System Designer

Compiler Designer

It takes a large team to create a new CPU

Units, dimensions, size and scale

10^{-12}	pico-	picosecond ps
10^{-9}	nano-	nanosecond ns, nanometer nm
10^{-6}	micro-	microsecond us, micrometer=micron
10^{-3}	milli-	millisecond ms

10^{3}	2^{10}	kilo-	kilobit Kb, kilobyte KB
10^{6}	2^{20}	mega-	megabyte MB, megahertz MHz
10^{9}	2^{30}	giga-	gigabyte GB, gigahertz GHz
10^{12}	2^{40}	tera-	terabyte TB
10^{15}	2^{50}	peta-	petabyte PB

speed of light

300,000,000	meters per second
300,000	meters per millisecond
300	meters per microsecond
0.3	meters per nanosecond (about 1 foot)

1 Ghz clock has a 1 ns period: 0.5 ns ‘1' 0.5 ns ‘0'
electrons can travel about 4 inches in an integrated circuit in 0.5 ns with 130 nm features

DVD’s use a laser with a wavelength 650 nm
a bit length of 133nm with a track pitch of 740 nm

Some Steps a CPU May Perform:

- increment/set Program Counter, PC
- send (PC) to Memory Controller, as address
- send read request to MC
- wait for MC to return instruction
- decode instruction
- compute operand memory address, EAR
- send (EAR) to MC with read request
- wait for MC to return operand
- perform instruction operation
- update register(s) and condition status
- send result and (EAR) to MC, write request

Some or all steps may be used by a single instruction.
Some or all steps may be performed in parallel.

THE I.S.A. DEFINES THE REGISTERS, INSTRUCTIONS, etc.

CHEMICAL LAB ON A CHIP
MICRO PUFFS OF AIR
MICRO MIXING
ANALYSIS

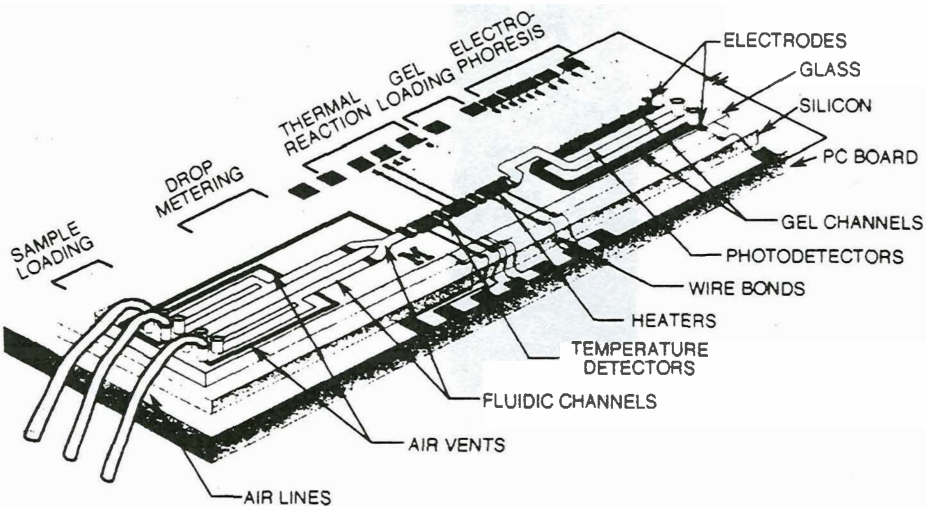
"The goal of designing a nanoliter DNA analysis device was to replace conventional hardware and trained technicians," said Burns. "DNA analysis methods have improved over the last decade. However, the cost for reagents and labor remain high. And if high throughput is needed, the cost of supporting equipment becomes prohibitive."

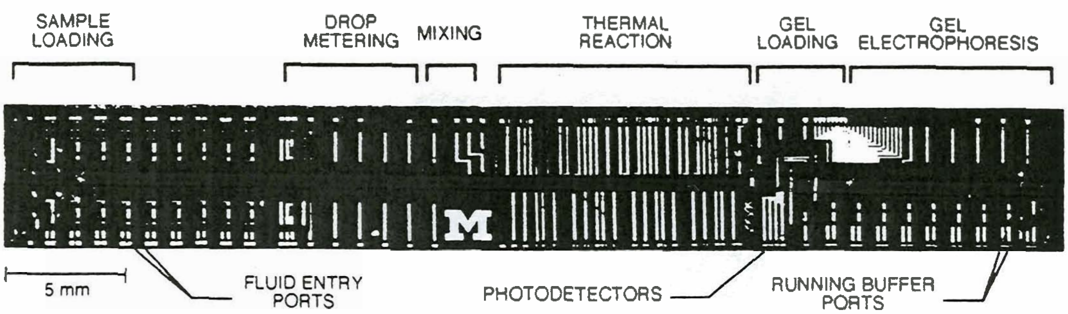
Preliminary estimates by Burns suggest that the cost of producing the DNA-testing chip in research-sized quantities may be approximately $6 per device. Mass production would lower that amount considerably.

"We can do things so cheaply by relying on the principles that currently make computers so cheap,"

The invention is the product of five years of work by Professors Burns, Mastrangelo, and Burke and their colleagues. In a short time, these three professors were able to construct a trial microfabricated system, perform preliminary experiments, and write several successful National Institutes of Health (NIH) proposals. Their work was funded by NIH grants totaling nearly $3 million. Also, the team received the inaugural Team Excellence Award in 1998 from the College of Engineering.

Their method of microfabricating a fluid and electronic chip capable of complex chemical analysis was detailed in the October 16, 1998, issue of the journal *Science*, in an article by Dr. Burns et.al. titled "An Integrated Nanoliter DNA Analysis Device" (pages 484-487).





$DNA Testing

Dual-Core Duel: AMD Beats Intel

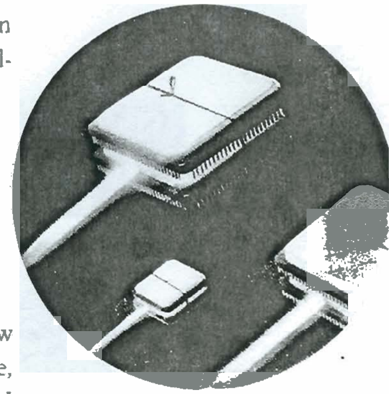
FIRST LOOK: TWO PROCESSORS IN ONE ATHLON CHIP GIVE PERFORMANCE EXTRA OOMPH.

READY FOR THE era of dual-core? You now have a choice of dual-core processors; and based on *PC World* tests, the winner is clearly AMD's new Athlon 64 X2, which handily outdistanced a dual-core Intel system we tested last month (see find.pcworld.com/48040).

Our tests indicate that with both AMD's and Intel's dual-core chips you'll obtain the biggest performance benefit when you work with multiple applications at once or when you use multithreaded software, designed to recognize more than one processor.

Dual-core chips build in two processing cores, in effect giving you two CPUs in a single piece of silicon. You also get two L2 memory caches, one for each core; the 2.4-GHz Athlon 64 X2 4800+ chip that we tested, for example, had 1MB of L2 cache per core. The 64-bit Athlon 64 X2 chips ship in June, joining currently available dual-core Opteron server and workstation CPUs.

PCs with the new chips, which will come in several variations, should be available now. Also, you should be able to upgrade your existing Athlon 64 PC to the new chips with just a BIOS change, whereas to convert an Intel unit to dual-core you'll need to purchase a new motherboard.



SPEED BOOST

WE TESTED A reference system provided by AMD that ran Windows XP Pro. It came configured with 1GB of 400-MHz DDR memory; a 10,000-rpm, 74GB hard disk; and an NVidia GeForce 6800 Ultra graphics card with 256MB of DDR3 RAM. (The Intel system we previously tested came with comparable hardware.)

The AMD machine was the second-fastest we've ever tested, with a 116 mark on WorldBench 5, easily surpassing the 95 posted by the 3.2-GHz dual-core Pentium Extreme Edition 840 reference system that we looked at earlier (see the chart below; and go to find.pcworld.com/48046 for more results).

The unit showed its prowess on the multitasking portion of WorldBench 5. Its time of 6 minutes, 44 seconds was an impressive 3 minutes, 42 seconds faster than the average of two Athlon 64 FX-55 systems, and about 3 minutes faster than the dual-core Pentium EE 840 reference PC's time.

If you want one of these powerful beasts, you'll have to pay dearly for it: AMD's 4800+ chips alone are priced at $1001 each in quantities of 1000, while Intel's 3.2-GHz Pentium EE 840 chips currently sell for $995. Entry-level Athlon X2 chips will cost only about half that much, however, so you can still get the benefits of 64-bit technology and dual-core processing without breaking the bank.

Intel devotees should also observe dual-core Pentium D–based systems arriving about the time you read this, and such PCs should be considerably less expensive than those with the Pentium EE 840.

—Anush Yegyazarian

TEST REPORT

PC WITH AMD'S DUAL-CORE CHIP BESTS INTEL'S SYSTEM

COMPARED WITH THE PENTIUM dual-core PC, the Athlon unit scored very well in the multitasking and Windows Media Encoder tests.

PROCESSOR	WorldBench 5 score (Faster →)	TIME (IN SECONDS) TO RUN: Windows Media Encoder 9	Roxio VideoWave 1.5	Multitasking test[1]	Ahead Nero Express 6.0	Adobe Photoshop 7.0.1	Adobe Premiere 6.5
2.4-GHz Athlon 64 X2 4800+	**116**	**256**	**246**	**404**	**437**	301	**344**
3.2-GHz Pentium EE 840 (dual-core)	95	340	274	590	457	357	479
3.73-GHz Pentium 4 EE	[illegible]	338	269	581	477	331	441
Average of two 2.6-GHz Athlon 64 FX-55[2]	107	355	297	626	494	**299**	367

TEST Center

FOOTNOTES: [1]In the multitasking test, systems load various Web pages while encoding video with Windows Media Encoder. [2]Average of previously tested systems. **HOW WE TEST:** All systems were tested with WorldBench 5 and ran Windows XP; for test details see www.worldbench.com. Application tests are part of WorldBench 5. All rights reserved. We used reference systems from AMD and Intel for the dual-core tests and for the 3.73-GHz Pentium 4 EE test. Intel-based PCs were tested with Hyper-Threading on. **CHART NOTES:** For WorldBench 5, higher is better; elsewhere, lower is better. Bold denotes best score. Systems in italics are comparison units.