LETTERS TO THE EDITOR

What defines a 32-bit microprocessor?

I am concerned about the criteria used by Hubert Kirramm to distinguish 32-bit processors from 16-bit processors in "Data Format and Bus Compatibility in Multiprocessors" (August 1983). The bus does not seem to be the most critical place for determining the 32-bit characteristics of a processor. For example, DEC's recently unveiled Micro VAX and its existing 730 product line both utilize 16-bit buses, but also meet almost every expectation that can be reasonably set for 32-bit processors (except perhaps performance). Although the new VLSI chips have a 16-bit data path, it does not mean they are 16-bit machines. There are systems such as the MC68000-based Charles River Data Systems' Universe that do take full advantage of 32-bit bus transfer operations by utilizing a cache as part of the architecture.

The critical characteristic that distinguishes a 32-bit processor is a direct linear address space of 32 bits. To achieve this a processor must be able to generate large addresses, a capability which affects the size of the program counter and address registers and the kinds of operands that can be manipulated by the processor. A simple test is to determine if a large data area (something in excess of a couple of megabytes) can be randomly accessed without requiring modification of the base address, the segment registers, or the memory management hardware on each address operation.

The Motorola MC68000, National 16032, and Zilog Z80000 all have this basic characteristic. These processors utilize 32-bit registers and offer 24 to 32 bits of address pinout and program counter size. There is enough confusion...
in the marketplace about the distinctions between 8-bit, 16-bit, and 32-bit processors that it makes imperative for professional organizations to establish well-defined criteria. The importance of 32 bits is most clear with products like the VAX and Apple Lisa. The VAX provides low-cost engineering computation because of its 32-bit structure. The Lisa’s ease-of-use features involve a degree of program complexity that cannot be accomplished with a 16-bit processor. Over the next few years, such characteristics will prove more important than strict performance considerations.

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Author’s reply:

In my article I classified the processors according to the width of their data path. I defined a 16-bit processor as a processor having a 16-bit data path and a 32-bit processor as one having a 32-bit data path. So, under this scheme the 8088 is an 8-bit processor while the 68000 is a 16-bit machine. The motivation behind this classification is performance, as Mr. Isaak correctly notes. Performance is also the key motivation behind Mr. Isaak’s company using a cache to give 32-bit capability to a 16-bit system.

I agree that address size is an important characteristic, but where do we draw the line?

- Is the size of the program counter relevant? Then the IAPX 432 would be a 40-bit machine (although its physical address space is only 24 bits long).
- Is the size of the externally accessible address relevant? Then the 68000, which manipulates 32-bit addresses internally, would be a 24-bit machine, and the VAX would be a 30-bit machine.
- Or is the physical address relevant? Then the Z80 with a management unit would be a 24-bit machine.

The size of the internal PC does not seem relevant to me, since anybody can build a 60-bit PC without any advantage to the user.

The virtual address size has no direct impact on performance—performance depends on the partition of the software. If the registers of the memory management unit are seldom changed, then a 16-bit address processor can be as fast as a 24-bit processor. Although everybody

complains about the small address size of the PDP-11, it has not prevented the widespread use of that machine in industry. A linear address space of 32 bits (four gigabytes!) is today more a sales argument than a practical necessity.

There are, of course, applications (such as those in computer graphics) in which it matters to be able to randomly access 16 megabytes of memory, but then the processor must be able to generate 24-bit addresses, and not just have internal 32-bit ones. In this case, the maximum size of a memory segment that can be linearly addressed (possibly by using contiguous segments) is a more convenient measure of the addressing capabilities of a processor than the size of the address registers. From this point of view, the 8086 has a linear address space of 16 bits, although its physical address size is 20 bits.

Nevertheless, the most important factor is which part of the PC is accessible to the outside world, that is, which part of it comes out of the processor chip—it tells exactly how much one can address without external hardware. And it is a good measure of the processor’s addressing capabilities.

So, to make everybody happy, I propose that processors be classified according to both the size of their accessible address path and the size of their data path. Also, since multiplexing affects performance by about 25 percent, I propose that when we write about processors we use a slash (/) to indicate that the address and data paths are multiplexed and a plus sign (+) to show that the address and data paths are separate. The 68000 would be a 24 + 16 processor, for example, and the 8086 would be a 20/16 processor. This tells much more about a processor than “16/32-bit architecture” or “complete 32-bit virtual memory performance.”

Some examples:

- Z80: 16 + 8
- 8088: 20/8
- MC68008: 20 + 8
- Z8002: 16/16
- 8086: 20/16
- LSI-11/23 +: 22/16
- Z8001: 23/16
- IAPX 432: 24/16
- NS16032: 24/16
- MC68000: 24 + 16
- 80286: 24 + 16
- NS32032: 24/32
- Z80000: 32/32
- MC68020: 32 + 32

The double slash for the IAPX 432 means that the address is transmitted in 2 parts.

I wholeheartedly agree with Mr. Isaak that support of high-level languages and operating systems can significantly improve the benchmarks of a processor. Since this has been recognized by all manufacturers, in a few years raw speed will again be the dominant factor for evaluating microprocessors.

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Copyrighting of IEEE standards challenged

Each year I receive a membership renewal form from the IEEE, and I dutifully fill it in and return it with a check. This year I seriously considered not doing so, because for the first time I found myself in strong disagreement with IEEE policy.

The policy that disturbs me concerns standards. I hope that the IEEE will continue to produce standards for the microcomputer industry and for other areas of electrical engineering. I also hope that these standards will be distributed as widely as possible and not copyrighted and used as a source of income for the institute. I don’t object to paying $6.75 for the S-100/IEEE-696 bus standard, for example, but I do object to the fact that the document is copyrighted and cannot be reproduced in a journal, magazine, or book.

The IEEE, having produced a standard, should make every effort to distribute it as widely as possible. An author who wants to include a standard in a book or an editor who wants to publish it should be encouraged to do so. There is no point in having standards that no one reads.

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We forwarded Mr. Grogono’s letter to Herbert Hecht, chairman of the IEEE Computer Society’s Computer Standards Committee, for a reply. Dr. Hecht’s comments appear below.

—Ed.

I find myself in agreement with much of what Mr. Grogono says, and we are taking steps to publish more standards-

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IEEE MICRO
internal funds will no longer be available for the development of future generations of semiconductor products. Moreover, a disincentive effect can occur when other firms see the misfortunes of the pirate's victim.

To risk the loss of new chip development in the US is to risk the loss of the entire US semiconductor industry. US semiconductor products compete successfully on international markets precisely because they are, on the whole, the best and most innovative products available. US semiconductor manufacturers have achieved that position because they have long stressed the development of innovative products and have utilized pricing structures enabling that development to take place.

HR 1028, the Semiconductor Chip Protection Act of 1983, which Congressman Norman Mineta and I introduced and which is cosponsored in the House by over 25 other representatives, will ensure that US semiconductor producers are protected from the threat of unfair competition from pirated chips. The act will accomplish this by amending the present Copyright Act to provide for the registration of new semiconductor designs with the Copyright Office. Once registered, a semiconductor design cannot be legally copied by another firm. The term of the copyright protection will be 10 years, as compared to 75 years for other copyrighted items.

The bill is designed specifically to encourage innovation. Hence, it will not prevent legitimate reverse engineering—the practice by which engineers of one firm photograph, analyze, and study the semiconductors produced by other firms in order to understand and improve upon the technology embodied in the other firms' chips. Nor will legal action under the terms of the proposed legislation result in the termination of semiconductor utilization innocently entered into by an American user. If a supplier's semiconductors are determined to be illegal copies, an innocent customer whose end product is based on those semiconductors will be able to continue to produce and sell his product, but will do so under a license agreement by which reasonable compensation will be given the copyright owner. In such a situation, the purchasing firm will pay reasonable royalty fees to the innovative firm. This will offset most, if not all, of the pirate firm's unfair initial cost advantage. Furthermore, innocent purchasers of copied semiconductor devices will face no penalties as a result of their use of the pirated product.

The piracy of chip designs can be readily prevented through the enactment of the Semiconductor Chip Protection Act. Currently such piracy, though viewed as morally wrong or at least unfair by most members of the semiconductor industry, is not specifically forbidden by US law. The change in the legal environment itself can be expected to reduce dramatically the incidents of chip piracy, since most people prefer to obey the law once it has been set down. In addition, enforcement of the act should be relatively simple and straightforward. Should a firm believe that its chip has been copied, it need merely take the alleged pirate firm to court and compare its copyrighted original with the alleged copy. Enforcement of the bill's provisions will require no new government expenditures; it will result in the creation of no new federal bureaucracy; and it will cause no loss of tax revenues. In fact, if pirated chips are removed from the US market, the US semiconductor industry can anticipate an improved financial position, and, as a result, tax revenues can be expected to rise.

Piracy in the second half of the twentieth century takes forms which were previously unimaginable. The technology which has given us the semiconductor industry has begotten also the means to copy semiconductor chips. Though this modern form of piracy may appear more ethereal than the piracy carried out on the seas of yore, it is no less a threat to the victimized industry. The two types of piracy are tied by the common greed of the perpetrators, but they differ in the ease with which they may be stopped by government action. The fight against the pirates of semiconductor chips requires no guns, no ships, no millions for defense, no new government resources. All it requires is the passage of the Semiconductor Chip Protection Act. Once this is done, the private sector will provide the necessary police action. The fight against piracy was a major role of nineteenth-century governments. Twentieth-century governments cannot afford to abandon that role.

Don Edwards has been a congressman from California since 1963. He is chairman of the House Judiciary Subcommittee on Civil and Constitutional Rights and is the senior member of the House Veterans' Affairs Committee. He also serves as chairman of the California Democratic Delegation.

To obtain additional information about the Semiconductor Chip Protection Act, contact either of Congressman Edwards' offices: 2307 Rayburn House Office Building, Washington, DC 20515, (202) 225-3072; or 1625 The Alameda, Room 709, San Jose, CA 95126, (408) 292-0143.

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related material in the periodicals of the Computer Society.

Standards are copyrighted by all standards-developing organizations that I am aware of; one reason for this is to prevent the publication of falsified or obsolete material under the cover of a current standard. The IEEE does not consider the publication of standards to be a revenue-generating operation. The price charged is intended to cover the cost of publication, handling, and mailing. The copyright is held by the IEEE, and use within the copyright is therefore open to all constituent bodies. The IEEE, through its standards office, routinely grants permission to authors and publishers to include excerpts of standards in their publications. I have been told that permission to include an entire standard will be granted if the standard is accompanied by a substantive discussion of its provisions. This condition is required so that such material will not constitute a direct duplication of the IEEE role in the publication of the standards developed by its constituents.

Precisely because we don't want to develop "standards that no one reads," we are encouraging the authorship of articles that discuss draft or approved standards. We invite any interested party to participate in this activity.

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