

A birthday even a curmudgeon could love

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Mr. Processor, the wunderkind of the electronics world, is having his twenty-fifth birthday. [See *IEEE Micro*, Feb. 1996, p. 3.—Ed.]

Technical curmudgeons will have a field day griping that birthdays for inventions commemorate insignificant events.

Give the curmudgeons their due. Most inventions are not very inventive. Often, an invention just marks when someone familiar with the state of the art figured out how to put two and two together. Some inventions are just incremental improvements on a long-run technical trajectory. Another inventor probably would have done the same thing for some other reason at some other date sometime soon.

We should remember the magnificent inventions, historians say. History commemorates Bell, Pasteur, and Watt for a reason—they were way ahead of everyone else; they invented solutions to the interesting problems of their day and nobody got close to them for years.

So, the curmudgeons ask, Was the microprocessor a magnificent invention? And they answer, no. Despite being a difficult engineering achievement, it was not far ahead of its time.

Although I hate to agree with curmudgeons, they are partly right.

Why they're (almost) right

Mr. Processor's birthday celebrates the genius of a few Intel managers and employees 25 years ago. Whether you assign credit to Noyce, Hoff, Faggin, Moore, or any other employee is not really the issue. We all agree they were clever. They showed initiative and imagination. They appreciated the importance of improving their design. All this is true, but beside the point.

If Intel had not invented the microprocessor, technical history would not have changed greatly. By the late 1960s the idea behind the microprocessor already existed at Bell Labs, IBM,

Texas Instruments, Motorola, and many other firms. Not all these firms possessed the ability or desire to produce the architectural drawings or manufacture the final product in 1970. Eventually, however, somebody would have developed the microprocessor.

Why? Because the microprocessor does (with hindsight) appear to be just one small step on a long technical trajectory. Observers often label this trajectory "the battle between digital and analog." Engineers developed the transistor without much foresight, partly to satisfy scientific curiosity, partly to satisfy military and NASA requirements, and only secondarily to do anything commercially useful. Once the commercial feud with analog gained momentum, however, there was no contest: Analog was Neanderthal. Digital was smaller, lighter, more reliable, and eventually cheaper. Scientific instruments, broadcasting equipment, telecommunications equipment, and finally just about everything had to become digital.

Digital technology spread for one simple reason: The firm that manufactured and sold the best digital designs made money. Once this profit-making strategy became obvious—it has been obvious to private industry for a few decades now—many firms would pursue the battle to its logical conclusion.

In other words, it was not any specific invention that mattered, but the root idea behind generations of inventions: The transistor represented a new idea and started the shift from analog to digital. Thus, the invention of the transistor was magnificent, but the microprocessor, incremental.

Why they miss the mark

That said, it is here that I usually part company with the curmudgeons. I do not think their analysis is wrong, just incomplete.

The invention of the microprocessor may have been inevitable and possibly incremental; that fact does not render the actual inventive act insignificant. Inventions matter for more than the mere satisfaction of a technological trajectory.

Economic impact. To put it another way, if an invention does not have much economic impact, it deserves and receives historical obscurity. In contrast, if an invention defines the contour of economic activity—usually because it initiates dramatic industrial change—then the defining moment may be the inventive act itself. The appropriate historical question concerns which economic contours were inevitable and which were not.

Reasonable people may disagree on this question; by its nature it is speculative. It is an argument about events that never happened and could not have happened unless an actual and particular historical event had never occurred.

For example, here is an inevitable event: Today, Mr. Processor can reliably operate almost any simple mechanical device—the toaster, lawnmower, automobile engine, telephone equipment, a large boiler in a factory—that has electrical components. As he grows bigger and stronger, Mr. Processor flies planes in good weather, steers ships in calm seas, and guides vehicles through light-rail tracks.

These developments are fun to watch, but are not the main point. All the same gee-whiz stuff would have happened if a company other than Intel had invented the microprocessor. Thus, it would seem that this invention's birthday simply serves as a focal point to remind us of the technical accomplishments that came later, sometimes much later.

Coinvention. Focusing on gee-whiz stuff is also wrong for a related and more subtle reason: All significant technologies only become economically useful after significant coinvention of complementary technologies. So, what is more important, the initial invention or the coinvention that must follow?

Consider the personal computer, Intel's cash cow and one of the biggest

users of microprocessors today. Future historians will remember the PC as the first primitive attempt to develop decentralized computing applications for workers who did not have the time, skills, or inclination to learn complex operating-system commands. Among other things, the PC allows nonarchitects to design their own kitchens, nonaccountants to track financial transactions, secretaries to send e-mail, and nontypesetters to format and publish their own writing.

Most of what the PC accomplishes comes from being easy to use. Insiders know that this simplicity is deceptive, however. Such functionality was hard to achieve and is difficult to improve. It took lots of time, energy, imagination, and inventiveness—at least as much and probably much more than it took to invent the microprocessor itself.

Admittedly, it is rather silly to compare the effort put into generations of microprocessor technology with that of generations of PC technology. Yet, the comparison illustrates an important idea: Much coinvention, quite apart from Intel's initial invention, lies behind the microprocessor's economic value. Thus the effort associated with the microprocessor's invention seems insignificant in comparison.

So, what's to remember?

At the end of the day, then, where are we? The microprocessor was close to inevitable. It might have been only a small improvement in a longer trajectory. It required much coinvention to be useful. All this is true, but still beside the point.

This particular invention's birthday is worth remembering because first, it put Intel in the driver's seat, giving that company the power to shape many industry decisions. Other firms could have assumed leadership in Intel's absence or if Intel has failed to build on its initial lead. It matters, however, that IBM, DEC, Motorola, or AMD cannot assume such a position today. It matters to chip buyers, chip builders, venture capitalists, and stockholders.

Second, the invention helped anchor the electronics industry in Silicon Valley. To be sure, many fac-

tors contributed to this outcome. Yet, many other regions of the country (particularly the greater Boston area) might have assumed that status if Intel had dropped the ball. Face it, no area comes close to the Valley now, nor could any area hope to. Many people find it relevant that so much happened there and not somewhere else. The electronics industry influences every business in the region, the labor market for engineers, and the spread of economic activity across the country. It also influences the distribution of wealth in the US. (Have you recently looked at Stanford University's endowment?)

Third, and probably most significantly, this invention occurred at what was then a small, independent firm. The door opened—ever so slightly at first and then massively later—to vertical disintegration in the electronics industry. Yes, many events contributed to that dramatic structural change. But it might not have happened at all if IBM or DEC or some other large, vertically integrated firm had technical control over the microprocessor's development. I shudder to imagine what would have happened to this industry if a large, clumsy corporate giant with many intellectual property lawyers—such as, say, AT&T in the 1970s—had first invented and patented the microprocessor.

So cheer up curmudgeons! Most inventions' birthdays are worth ignoring, but not this one's! The inventions worth remembering are those that shape our daily lives as employees, consumers, and market observers for years and years.

So that leaves me with one question: Will we still commemorate the invention of the microprocessor when it turns 50?

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