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When Worlds Collide...Again.

Jeffrey R. Harrow
Principal Technologist, The Harrow Group

This isn't about asteroid threats to Earth, or about H. G. Wells' destructive machines invading from Mars (although it is poetic that his vision, in reverse, is now taking place as our robotic Rovers poke, prod, drill, and otherwise defile the Martian plains.) Instead, this is about two *technological* worlds that, like the Earth and Mars, have remained largely separate in their individual journeys--until now.

Here we explore how *this* "collision" is about to change all the rules--again.

Let's begin with a brief history of each world:

World Number One

'The House That Moore Built' (Intel's Gordon Moore's early observation and still-accurate trend line that the number of transistors on a chip would double about every 18 months while the price remained stable) has increasingly, utterly, redefined how we live, work, and play for more than three decades.

The semiconductor industry has become incredibly skilled at herding electrons ever-faster, through ever-smaller circuitry that remembers or executes the seemingly simple choice of "one or zero" -- but at the rate of billions of times each second. Taken en mass, these simple operations drive almost every aspect of modern business and entertainment. In the case of pacemakers and related assistive medical devices, these patterns of ones and zeros even drive our very lives!

And this is good (mostly). Despite the consistent naysayers and critics who have foretold the end of the era of Moore, innovative scientists and engineers have continued to find ways past, around, or through every technological roadblock that has appeared.

We have tamed and trained our electrons well, even though they do suffer from problems such as generating heat as they work, or that their circuits have the potential for information loss due to noise, or that some electrons, in some circuits, have the poor manners of "tunneling" where they should not go.

Nevertheless, our machines are now very "smart" (note that I didn't say "intelligent"), in that they carry out very complex tasks under our control, and in some cases autonomously.

Yet left to themselves (literally), these incredibly useful computers might never have changed so many aspects of our world--computers might have remained in the province of corporate "glass houses" and hobbyists' garages. It took a very different kind of innovation, a "hijacking" if you will of a very different field, to help computers truly "change all the rules."

World Number Two

This second industry is the well-established world of telecommunications, embodied by The Phone Company of thirty years ago. Initially, computers began connecting to each other using electrons over wires within a computer room. Shortly thereafter, they broke the computer room constraints by using modems to convert their bits of information into audible sounds -- the only thing that the telephone network could carry--to communicate point-to-point with other computers. As crude, as cumbersome, and as slow as those first 110 bits (*NOT **kilo**bits or **mega**bits)* per second modems were, they brought these infant computers together and taught them to "share" their "information toys."

This too proved to be a good thing, especially as the Internet taught computers to speak a common, no longer "point-to-point" tongue for sharing. Computer users recognized the incredibly-growing value of the Internet as each new computer joined-in (Metcalfe's Law). Even end-users realized the benefits of bypassing the harshly-regulated and technologically limited "audio-only" constraints of the traditional telephone network; hence the growing adoption of "cable," DSL, and other "broadband" connections. Each computer began sharing more, and sharing it faster.

"Bandwidth" became the watchword, and "fiber" the deliverer. These hair-thin, miles-long strands of glass could carry the same "ones and zeros" of information as our trusty electrons did over wires, but in the form of photons (tiny "particles" or "wavelets" of pure light) that didn't suffer from the effects of electrons passing through miles of wire. Especially with developments like Dense Wavelength Division Multiplexing (DWDM) which allowed many "colors" of light within a single fiber to each carry their own ultra-fast information stream, bandwidth became free (relatively), and innovation blossomed into the World Wide Web that rapidly became an integral part of business and society.

The thing is, we ended up with two complementary but completely separate technologies: the ultra flexible and controllable world of electrons (computing), and the ultra fast, secure, ever more capable, yet very "dumb," world of photons through fiber.

Computers' electron-driven information had to be turned into photons for their long and speedy trips through fibers. But the photons had to then be re-converted back into electrons at each way-station or "junction point" along the fiber network mesh, because only in their electron form could the individual packets of information be read and switched onto the correct path for the next stage of their journey! Then at each subsequent junction point the photons were again turned into electrons, routing decisions were made, and the electrons yet again turned into photons to enter the next fiber leg. Finally, at the receiving end, the photons had to once more be converted back into electrons so that the information packets could be acted upon by the receiving "electrons-only-please" computers. If this seems cumbersome and expensive, it is.

All of this back and forth conversion between electrons and photons stemmed from the fact that common and inexpensive silicon chips could only deal with electrons and not with photons. This is also the limitation that has generally prevented computers from making use of photons' desirable characteristics within their own logic circuitry, even as some people believe that our ever-smaller chips are approaching certain physical limits where electrons fear to tread.

This remained the (general) status quo until Feb. 12, 2004.

The New Order

A recent announcement and demonstration from Intel, however, may presage another "merging" that may prove even *more* powerful, and *more* far-reaching, than the previous merger of computing and telecommunications -- because this "merger" breaks the barrier that has been keeping electrons and photons from coexisting and working together in the same relatively inexpensive silicon chips. (http://www.intel.com/pressroom/archive/releases/20040212tech.htm and http://www.intel.com/labs/sp/)

Essentially, Intel has come up with a way to create "photon switches" on standard silicon chips (rather than on esoteric and very expensive chips required previously) to work with photon ones and zeros. And that switching of ones and zeros is essentially what's at the heart of the millions of "electron switches," better known as transistors, that have enabled the computer age!

Intel's new chips can process these photons at speeds faster than a billion bits per second (one gigahertz), which is 50-times faster than was previously possible on standard silicon chips.

According to Intel's senior VP and Chief Technology Officer, Patrick Gelsinger,

"This is a significant step toward building optical devices that move data around inside a computer at the speed of light... It is the kind of breakthrough that ripples across an industry over time enabling other new devices and applications. It could help make the Internet run faster, build much faster high-performance computers and enable high bandwidth applications like ultra-high-definition displays or vision recognition systems."

Being able to rapidly encode and decode ones and zeros into photons within commodity chips; to be able to carry vast amounts of information on single optical paths within a chip; and to be able to control and "switch" those photons in the same manner as we have been doing with electrons, portend a vast new playground for circuit designers. As well as for many future generations of electro-optical, and perhaps eventually purely optical, computers.

Unsurprisingly, this is just the beginning. Researchers believe they may eventually be able to scale-up the speed of on-chip photonic switching by another ten times (to 10 gigahertz per second). And that's only *today's* expectations.

How might this affect your future computer? For just one example, imagine computer busses that shuttle data around, not at today's speeds of a "mere" few hundreds of megabits/second, but at gigabits/second! And that suggests enormous increases of commodity computing power that will be able to take on previously impossible challenges.

The Bottom Line

This may sound like an interesting, although primarily technical breakthrough, but to consider it provincially as "technical" would be similar to those folks who felt the same way about semiconductors, computers, and the global Internet. As we've seen historically in these fields and others, any time that technological advances occur on a rapid and continuing basis, which seems likely to also be the case for silicon photonics, the results can and do reshape almost every element of our lives and our businesses and our countries.

Compare how you did business only twenty-three years ago as the IBM PC was delivered, whirring and beeping, into our world -- to how you do business today. And consider how our computers, plus the Internet, have globalized commerce, entertainment, communications, and far more: fortunes have been made (and lost); entire entrenched industries at the pinnacle of their decades-long successes have been marginalized; jobs and paychecks now move at the speed of light across national and geographic boundaries, and GNPs have danced to these technological tunes.

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It's happened before, and major technological watersheds like silicon photonics may prove to make it happen again.

The greatest danger to each of us lies in ignoring what's happening; in believing that these changes won't be important to *our* business (or to *us*); and in staying our historic courses. *That* course leads to opening the doors of opportunity to nimble young competitors who may not yet even exist.

To repurpose a couple of currently popular phrases, we should each "be technologically vigilant" in a world of exponential technological growth, because that keeps the current technological/business/societal "status quo" at "Condition Orange."

In other words, "Don't Blink!"

This essay is original and was specifically prepared for publication at Future Brief. A brief biography of Jeff Harrow can be found at our main Commentary page. Other essays written by Jeff Harrow can be found at his web site. Jeff receives e-mail at jeff@theharrowgroup.com.

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