# Computing and Convergence: Bigger, Faster, Better?

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The use of tools to address personal needs, one of the identifying characteristics of our humanness, underlies the development of most technological invention throughout the history of industrial societies. Whether fabricating tools for agriculture, creating weapons for hunting, or developing more complex mechanisms to address the aggregate needs of social groups, mankind has tended to consider new technologies as tools to address identifiable needs. Many of today's technology consumables, however, have come to be marketed on the basis of "creating needs" in the perceptions of consumers. Nowhere is this more evident than in the marketing of computer products in industrial nations in an endless cycle of "bigger and faster" continuously disposable machinery upgrades, along with the associated software upgrades that fuel further hardware cycles.

In the late 1900s, following rapid advances in electronics on the heels of multiple wars and man's first efforts in space, great strides were made in digital information processing that have allowed us to look at large-scale needs in new ways. In the early 1970s, for example, I waited in long lines at Saint Louis University's West Pine Gym to register for undergraduate classes. Of course, the freshmen registered last, so I vividly recall feverishly filling out forms, all the while dreading the collective moan that would arise from the registration floor when a coveted class was closed on the huge "tally board." But what gave me hope was reaching the front of a departmental line to get a precious "computer punch card" for each class I needed, assuring that I had the keys to the kingdom in my hands! Needless to say, from those humble beginnings SLU has moved through online advising to fully Web-based registration for students, and I don't think anyone misses the "old way" we did things.

Computers have undeniably and in many ways changed the way we process information, but our society has almost lost its sense of perspective about computing as another technological tool. TECHNOLOGY = COMPUTERS is an unspoken but accepted equation today in much of our institutional technology-planning consciousness, as if the challenge of supplying and supporting the machines we use every day has become self-evident and somehow unrelated to our actual needs as humans. I contend that it is critically important to reject such narrow and limiting definitions, for computers are simply a visible manifestation of our *current* technological state as a response to human needs. It would be foolhardy to presume that other needs might not be better addressed by other technologies (I don't expect to drive to work in a PC, for example) or that new technologies would never emerge to replace the computer as we now know it. Further, the importance of digital information processing is more far-reaching than just the computer itself. Be careful of limiting definitions for technologies, for changes will continue as surely as new human needs will emerge.

Alvin Toffler framed the issue of technological change in human terms that help us gain a sense of perspective on the challenge:

> It has been observed ... that if the last 50,000 years of man's existence were divided into lifetimes of approximately sixty-two years each, there have been about 800 such lifetimes. Of these 800, fully 650 were spent in the caves.
>
> Only during the last seventy lifetimes has it been possible to communicate effectively from one lifetime to another as writing made it possible to do. Only during the last six lifetimes did masses of men ever see a printed word. Only in the last two has anyone anywhere used an electric motor. And the overwhelming majority of all the material goods we use in daily life today have been developed within the present, the 800th, lifetime."[1]

Toffler's insights regarding the effect of technological change on human social systems led him to a number of incredibly accurate observations about the world we live in today -- but he described these in 1970! *Information overload* is a problem for everyone today as junk mailers, telemarketers, advertisers, and others push unsolicited messages at people every day. *Overchoice* is the inevitable result of feature diversification as comparable competing products vie for our dollars. *Oversimplification* results from excessive complexity in increasingly specialized technological systems, creating an environment where technology management decisions are made on the basis of "executive summaries." Ironically, at the same time that *information sorting* has become our most critical human skill in a technological society, we have developed an appetite and expectation of *instant* *information access* via fax, email, web, cell phone, and beeper. Yet in the midst of this stressful option-rich society, we struggle to adapt our slow human business models from an industrial age to the scale of demands in the information age.

Technology has always played a role in the management of information in the industrial age, even before the advent of computing. Information *inputs* (phone calls, customer feedback, sales receipts, consulting reports) always drove business processes that required information *management* (file cabinets, planning meetings, memos). Decisions from management processes generate *outputs* (products, reports to investors, advertising) which may in turn create *feedback* to the input stream (lagging sales may indicate a need to reduce production). While the prior example appears business-oriented, it in fact describes a simple linear human communication model as well. But such nice, neat models in communication must also consider the effect of *noise* at each stage of the process, making it difficult to assure that the information remains intelligible and unaltered from sender to receiver. It is easy to envision the problems created by construction noise, phone static, or illegible handwriting as obstacles to communication/information flow. In our business example, a lost file folder, stock market price fluctuations, supply variations, and similar information management challenges create an absolute imperative to have accurate, timely, understandable, and accessible information.

Digital information management technologies emerged as a way to deal with the *noise* factor in information flow. Analog technologies used for information transmission and storage (recordings, phones, video) have historically mimicked the human experiential environment of continuously variable inputs and outputs. Voice and hearing, for example, work on the basis of the creation and perception of air pressure waves that vary continuously in pitch, intensity, and envelope. While air transmits such sounds naturally for limited distances, the analog telephone enabled man to communicate over long distance by *transducing* these waves into comparable variations in electron flow over an electrical wire. But just as noise disrupts information flow in the air, electrical noise can reduce the integrity of analog telephone signals (hum, lightning, static). With digital transmission, by comparison, a signal is either received or not, but it is not received in degraded form!

The mechanism by which digital information integrity is maintained is quite simple: only two possible signals are sent/stored/received, and if noise interferes they can be re-transmitted. Digital signals are characterized in various ways -- as *1 or 0*, as *on or off*, as *high or low* voltages, as *present or absent* signals -- but always as a pure binary condition with no "shades of gray." Thus the information received is exactly the information that is sent or stored; it's possible that transmission could be blocked but what comes through is accurate. By the same token, in order to receive a perceived higher quality signal at the destination, more information must be "digitized" at the point of origination. The human interface to digital information systems still remains consistent with our analog perceptual systems, but the ambiguity and degradation inherent in analog processing, storage, and transmission is eliminated. *Convergence* is the inevitable result of the human need to *input* and *output* information by analog means, but to be assured of accuracy in intermediate information processing. I offer this as a definition of convergence: *the migration of traditionally analog information technologies to digital processing, manipulation, storage, and transport*. In some cases this convergence is strikingly evident to us, as in the replacement of records with CDs some years ago. Many convergent trends go unnoticed, however, as has been the case as telephone companies upgrade many central office "voice processing" components to digital.

Several ideas from communication theorist Marshall McLuhan are worth considering in trying to grasp the impact of convergent technologies as they emerge from the "computing soup" that generates them. First and most important, media are "extensions of man"; they help us to reach farther across boundaries of space and time to communicate more effectively, but do not themselves replace people. Second, new media do not necessarily replace old media, but rather they change them; so even as television changed radio and cable news changed television news, the Internet is changing the role of television in our information consumption mix. Third, *the medium is the message*; that is to say, the physical characteristics of a medium can be as important as the messages they carry, influencing our social patterns and values in ways that can be pervasive but difficult to articulate consciously.

## *The Computing Technology Environment*

Rapid developments in digital technologies can be generally categorized in four major areas: processing, memory, storage, and transport. All of these areas are certainly well represented by comparing a typical microcomputer of 1980 with a similar contemporary one.

The same development categories that have improved the computer itself also extend to the devices that are used as inputs and outputs to the machine. For example, the TRS-80 offered keyboard input period! Other devices such as light pens and joysticks were offered in later models. Today's PC will also have a mouse, microphone and speakers, audio in/out, CD playback, and may have a scanner or digital video camera as an accessory as well as dozens of options.

Processors are the devices that contain transistorized "instructions" that govern data manipulation in a computer. Processor speeds have doubled approximately every 18 months from the earliest IBM PC at 4.77MHz to Intel's recently announced Pentium III offering at 1GHz (1,000MHz). With support from newer operating systems today's computers can also share the load among

| A TYPICAL MICROCOMPUTER 1980 vs. 2000 | |
|---|---|
| **TRS-80 Model 1 (TRS-DOS)** | **PC/Windows** |
| Zilog Z-80 <4MHz | Intel Pentium III 700Mhz |
| Block B&W graphics | Photographic resolution |
| 16KB memory | 64MB memory |
| 90KB single-sided floppy drive | 15GB hard drive |
| 300 baud modem | 56K-100Mbps Internet connection |
| Line printer, one font | Laser printer, photos, fonts |

multiple processors, scaling up to 8-way SMP (symmetrical multiprocessing) and beyond. Yet the external speeds by which these chips communicate with the motherboard has not kept pace, increasing to only 100MHz in that same time period.

Processors have also gotten "bigger" in more than just physical size. Today's Pentium processors exceed 7.5 million transistors, as compared to the 29,000 offered in the original 8088 chip of the IBM PC. And they can read or write up to 64 parallel bits of information (1s and 0s) at one time with their expanded bus width, as compared to the 8-bit bus of the 1980 Intel offering.

Memory chips actually store the volatile data that processors will work with while the machine is operating. Memory speeds have not kept pace with the processor, which is one of the primary reasons for the 100MHz limit on external processor speeds. Yet with the introduction of 64-bit widths, interleaving, cache memory, new memory types, and techniques that eliminate processor "wait states," improvements in memory speed have continued.

Memory size has, of course, continued its astonishing growth. Not only is it common to find 128MB of memory in a new Windows 2000 PC, but the maximum addressable memory for the PC architecture has grown from 1MB in 1980 to 64GB in a modern Pentium III machine.

Storage devices include hard drives, floppies, and other media that contain data in nonvolatile forms whether the computer is operating or not. Removable media have evolved from the first 90KB 5-1/4" mini-floppies to 250MB Zip drives and beyond. Early hard drives with their l0MB (on the original IBM XT) have evolved to today's standard drives of 15GB and higher. And CD, DVD, tape drives, and numerous other options offer solutions that target distribution, near-line storage, and backup.

Storage devices have also seen great gains in speed. Even removable floppies, currently a 3-1/2” format, have seen increased magnetic density and two-sided recording result in performance increases. Hard drive transfer rates have made dramatic gains, with the early 1MB per second peak speeds now eclipsed by 80MBps high-performance SCSI units. And new interface standards such as ATA/66 and Ultra SCS13 LVD have brought additional performance to computer users as newer machines make extensive use of hard drives as “virtual memory.”

The transport of data between machines once meant primarily the exchange of data by asynchronous means such as tapes or diskette exchange (“sneakernet”). But the synchronous transport of data has progressed quickly in many forms. Modems, which in 1980 connected to the CompuServe Information Service at 300 baud, are now common for Internet connections at 56Kbps and beyond with DSL, cable, and satellite modem options. And most businesses and institutions of higher education today use Ethernet as a standard method of sharing files, data, and printing devices. Ethernet was originally a l0Mbps cable transport, but today 100Mbps is common and Gigabit Ethernet is becoming available.

The “pipes” that carry data between campuses, cities, and other places are also becoming bigger and faster, due largely to the popularity of the Internet. While the telephone companies were the original suppliers of bandwidth for wide-area communication, today’s computing environment includes a variety of data transport media via fiber, satellite, and dedicated high-speed backbones that compete for data service markets.

## *The Convergent Environment*

Assuming that computers and the Internet had earlier reached the “critical mass” that has generated the rapid adoption of new computing technologies across our society, the maturation of a market at this stage quite naturally will evolve toward diversification of applications and features as competition for a large, but more fixed-size, customer base becomes intense. This diversification, which caters to individual tastes and to more specialized market segments at the expense of core innovation, marks the maturation of any major technology trend.

This is not to say that mature technologies do not change. However, maturation brings with it a desire for “compatibility,” “interoperability,” “standardization,” or a “migration path” that reassures users of the value of their purchase as a precondition of sale. Sometimes such standards are created by regulation for the “public good” as in radio, television, and telephony. Yet at other times standards result from a mixture of competition and negotiation, as in recent standards that have emerged for Internet browser software (file formats, applets, plug-ins). The road to standardization is not always smooth (remember Betamax?), but proprietary deviations from established standards are often resisted by consumers in favor of the “sure thing.” Thus mature technologies are marked by pressure from current users to avoid any changes that risk the integrity of existing standards.

Computers themselves, especially desktop microcomputers, exhibit the characteristics of mature technology levels, but the broader digital convergence market is still approaching critical mass. As new input devices, output devices, and service-level applications for traditional computing functions emerge, they often take on a life of their own that goes beyond the computing infrastructure from which they emerged. Convergence technologies suggest new paradigms that at first will compete with, and then change the media that spawned them. Video games did this to computers, the Internet did this to mail-order catalogs, and fax did this to printed product literature. Can the U.S. Postal Service avoid changing in response to email?

The convergence of digital technologies on traditional media applications has already created a number of new equipment applications. Photography now requires no darkroom, with digital cameras and ink printers moving as quickly as the PCs that make the digital darkroom viable. Digital/High-Definition Television is now being broadcast in most major cities in the U.S., with full conversion and the end of today’s analog television by 2006 mandated by the FCC. DVD (Digital Video Disc) and the “Tivo” hard-disk video recorder provide such high quality and versatility to video playback that VHS is really showing its age. Digital flat-panel Plasma televisions and LCD projection displays offer picture quality that today's television systems can't match. And new wireless technologies, "smart" appliances, and web-connected phones are all searching for the buyers who will define "the next big trend."

Convergence addition is the "new math" of businesses who are speculating on how content can be leveraged with technological delivery systems. Recently America Online merged with Time Warner, mixing cable television and Internet services in what both hope will be a profitable new synergy. Similarly, AT&T bought out TCI Cablevision, Microsoft and NBC have marketed strategic products as MSNBC, and Sony has become a market force in the movie industry, video gaming, and consumer video equipment.

They and others envision a significant expansion of "services on demand" made possible by convergent delivery systems such as "video-on-demand." Already the potential of such services has become evident, with explosive sales from Internet shopping, archived technical specs and drivers on demand from most hardware vendors, online financial services emerging from most major banks, online applications and forms for anything from student financial aid to taxes, and endless variations on "name your own price" and electronic auctioneering.

Convergent technologies are also creating opportunities to overcome differences in "time and space." Asynchronous (out of real time) applications such as email allow not only messaging but the transport of formatted data files as attachments for collaborative projects. Web-based collaborative tools such as WebCT or Hotoffice similarly reduce the need for physical meetings. And new synchronous tools such as AOL Instant Messenger have created a "virtual community" of young people around the country who chat with each other before their parents even know what "instant messaging" is! Videoconferencing tools such as NetMeeting have also grown in popularity since the adoption of the H.323 communication standard two years ago. Internet phones could one day threaten even Ma Bell.

It is difficult to project the breadth of new media that could emerge from the "digital soup" of possibilities, or even which ones will ultimately be successful. But applying principles of long-term thinking to our institutional planning efforts will help in gaining good value from convergent products and services in a period of rapid diversification and change. Here are some suggestions:

- Centralize those technology functions that offer economies of scale and foundation support services, while encouraging diversity in end-user applications of technology services.
- Establish and fund minimum core institutional standards in core technical areas to foster interoperability.
- Reduce structural "reinvention of knowledge" by clear communication of standards and processes.
- Develop and leverage information sharing with and among users, our intellectual assets.
- Don't think "computers"... think "information."

***References***

1. Alvin Toffler. *Future Shock* (New York: Random House, 1970), p. 13.