The Network is the Computer:
The Changing Direction of Classroom Computing

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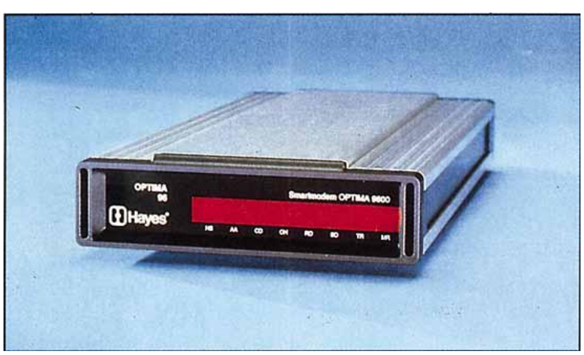
In 1984, John Gage, from Sun Microsystems, coined the phrase "The Network is the Computer" to describe the then-emerging world of distributed computing.

Think about this for a minute.

1984 was the year the Apple Macintosh was first introduced into the marketplace with a processor speed of eight MHz. While the commercial Ethernet had been in existence for a few years, the Internet was in its early stages. William Gibson wrote Neuromancer[1], a science fiction novel that coined the word "cyberspace." Furthermore, he wrote this book on a typewriter. There were only a thousand Internet hosts – in the world[2] and the Web did not exist.



Ordinary people wishing to access a computer network had to do so through an external modem,typically operating at a speed of only 1200 bits/s, although modems operating at up to 9600 bits/s were soon coming to market. This connection took place over a standard telephone line.

Computers were connected to the network only when network access was required, since the telephone company typically charged on a per minute basis.

While DSL existed, it was not a service being sold into homes. In 1984 virtually no schools had access to networked computers. The World-Wide Web was still almost 9 years away from capturing the attention of the public.

And here was John Gage, a brilliant Sun Microsystems scientist proclaiming that the network *was* the computer.

It is hard, from today's perspective, to see how strange his pronouncement must have sounded. And yet, like other brilliant visionaries, he was right – if just a bit ahead of the curve.

During the intervening years, computer power continued its exponential growth driven by the inexorable force of Moore's Law, in which raw processor power doubles annually. In 1984, the Intel 286 processor reigned supreme with a speed of up to 20 MHz, but this was not commonplace for the computers being sold into homes and schools. The following year saw the introduction of the 386 processor operating at up to 33 MHz [3].

Today's processors run at more than 100 times that speed. And they are far cheaper as well.

As for bandwidth, that has grown even faster. Using the service at www.speedtest.net, my DSL network is running today at a download speed of 1.53 Mb/s, and an upload speed of 324 kb/sec. Using an average of these two numbers, I have increased my bandwidth by about one thousand in the years since 1984.

The message here is clear – bandwidth is growing even faster than processor speed and, thanks to the growth of powerful networked services, connection speed is becoming more powerful than processor power. This, as we shall see, has profound consequences.

First, consider how you use your computer at home, or for your personal work. According to a recent Pew study, you are more than 50% likely to have broadband in your home[4]. The desire to access remote data wherever and whenever we want was revealed in a related study showing that 62% of all Americans have used their cell phones to access digital data services away from home or work[5].

This represents a huge shift from earlier computer use styles in which the computer was a self-contained repository of information and software. In the days of dial-up modems, network access was "intentional" – you had to specifically log on to the network to check your mail, or gather information, and then remember to disconnect yourself from the network when you were done. Today, in contrast, we expect our computers to access the network on their own to check for software upgrades, etc.

While I missed the "revolution" by a decade, in 1994 I wrote a book, *Education in the Communication Age*, that proclaimed that there was a shift coming in the educational use of computers[6]. Looking at that book today, I almost laugh. The Web receives almost no mention (Mosaic had been just introduced, but dial-up service to Web servers was hard to find). Instead I wrote about ftp and gopher and other tools that have largely faded into historical oblivion. Even so, I was bold enough to suggest that the coming communications revolution was changing the face of computing. This fit in with Vice-President Gore's call for an informational superhighway. As he said in 1994 [7]:

> I've often spoken about my vision of a schoolchild in my home town of Carthage, Tennessee being able to come home, turn on her computer and plug into the Library of Congress. Carthage is a small town. Its population is only about 2,000. So let me emphasize the point: We must work to ensure that no geographic region of the United States, rural or urban, is left without access to broadband, interactive service.

While we still have a way to go, large parts of his vision have come true.

By the time Netscape went public, I was suggesting that the browser might become the next operating system. At the time, this was seen as too bold a statement. My reason for making it was based on a few things. First, if applications were going to be browser-based, then it mattered little if you were running a computer using Windows, the Mac OS, or Linux. Second, the rise of software written in Java or Javascript virtually guaranteed platform independence for developers, if they chose to work in those environments.

Fast-forward to today, and we are seeing some interesting (and largely unanticipated) consequences of the full-scale rush toward network-based computing. First, many consumers have realized that network access speed is more important to them than processor speed. The annual upgrade cycle to ever faster and more powerful computers is hitting a stall point for many users. Instead of investing in more powerful computers, we are seeing the rapid growth of compact "netbooks" – full-featured laptops with slower processors, and greatly reduced prices. As this is being written in 2009, you can purchase one of these computers for under $300 just about anywhere.

In addition to lower cost, netbooks are also "green" in that they consume far less power than desktop computers, and less than most traditional laptop computers as well. For those who travel a lot, the 1 kg mass of these computers is a huge plus. While not designed for running processor-intensive applications, these computers can run major office software, such as OpenOffice, the Firefox web browser, etc. As a result, the growth in sales of this class of computer is amazing[8]:

> 8% - Estimated market share of netbooks in 2009
> 12% - Estimated market share of netbooks in 2012
> (data source: Microsoft)

The critical factor that makes netbooks valuable is their connectivity. In fact, with the rise of popularity of web-based services (e.g., Google apps), it can be argued that these computers would be useful even if they only contained a browser[9]. Web-based applications reside in the Internet "cloud," not on the user's computer. While we are still at the early stages of development for cloud computing, it is clearly an emerging trend that will have implications for computer use by everyone in the future. For example, Google docs provides the tools for creating documents of many kinds – from word processing to presentations incorporating multimedia. Other applications provide calendars, wikis, etc. – all for free.

It is easy to see why netbooks have gained such a following. Consider a typical computer-intensive task: graphics editing. Powerful tools like Adobe's Photoshop can be used to create absolutely spectacular artwork. My own use of tools like this is limited to only a few of the myriad features of the software: image color balance, cropping, etc. The rest of the features, as wonderful as they are, do not get used often enough for me to even know how to use them.

So, as a result, I have a large application being used to do a limited number of things. Graphic tools that run well on netbooks meet the needs of most users. The same can be said for many other applications.

Amazingly, this is the first time in the history of personal computing when customers have said "enough!" The issue is not processor speed, RAM, or even hard drive space – it is simply the adequacy of these tools to perform the functions needed by the user that matters.

What about schools?

The beauty of netbooks (and other portable Internet devices) is that they are inexpensive enough to put in the hands of every child. When you consider the cost of school books, we can purchase a netbook for every school child and still spend less than currently spent on textbooks.

The bigger challenge for schools is bandwidth. While most schools have broadband access to the Internet, this bandwidth has to be shared among all users. When computers were restricted to the laboratory, or when they are used to run stand-alone applications, high speed Internet access is not a huge issue. But when more and more applications are moving to the cloud, bandwidth becomes a huge issue. Consider the challenge of having a class full of students streaming different videos to their computers during class. Thirty simultaneous video streams can bring many school networks to their knees. The challenge is not generally in the local area networks connecting the classrooms – modern networks operate at blindingly fast speed. The real issue is the speed of the school's connection to the cloud.

One solution to the bandwidth problem is to trade bandwidth for local storage. (I call this tradeoff "storewidth.") A device inside the school's firewall that contains web-based applications (such as Moodle,) can take pressure off the Internet, plus provide an extra level of security for student records. Libraries of videos that can be streamed to student computers can also be stored on the same device.

The Open Classroom Server from Aspen Learning (www.aspenlearning.com) is a device that brings the "cloud" indoors. This simple device can be plugged into the school's network, allowing it to be accessed by any computer in the school. For example, if the school has a wireless network, this server can be used with anything from a desktop computer to a portable Internet device such as Apple's iTouch. In addition to hosting materials that would otherwise be on the Internet, the Open Classroom Server provides collaboration through easy-to-use wikis, blogs and forums to allow students to express themselves through collaborative writing, personal and group journals, and classroom discussion boards. It facilitates learning management with calendar and organization tools to make it easy for teachers to manage a wide range of assignments, activities, and content. Communication is facilitated with simple tools that enable teachers and students to safely, privately and effectively communicate and interact among themselves in the classroom, or from home. And, as might be expected from servers in general, the Open Classroom Server provides up to 750 MB per student as a safe, convenient place to save and manage files.

From the user's perspective, the fact that part of the cloud is local, and part is remote, is not an issue. From the school's perspective, the use of this type of server can extend the life of existing broadband connections as the site moves toward meaningful computer access for every child.

It took years to come to fruition, but Gage's vision of the network *as* the computer has finally come true. The challenge is to explore how this new reality can help transform education in support of all learners everywhere.

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About the author

David is the Founder and Director of Global Operations for the Thornburg Center. He is an award-winning futurist, author and consultant whose clients range across the public and private sector throughout the planet. His razor-sharp focus on the fast-paced world of modern computing and communication media, project-based learning, 21st century skills, and open source software has placed him in constant demand as a keynote speaker and workshop leader for schools, foundations, and governments.

As a child of the October Sky, David was strongly influenced by the early work in space exploration, and was the beneficiary of changes in the US educational system that promoted and developed interest in STEM (science, technology, engineering, and math) skills. He now is engaged in helping a new generation of students and their teachers infuse these skills through the mechanism of inquiry-driven project-based learning. (For details, visit www.tcse-k12.org.)

His educational philosophy is based on the idea that students learn best when they are constructors of their own knowledge. He also believes that students who are taught in ways that honor their learning styles and dominant intelligences retain the native engagement with learning with which they entered school. A central theme of his work is that we must prepare students for their future, not for our past.

David splits his time between the United States and Brazil. His work in Brazil also is focused on education, and he is currently part of a team redesigning curricular practice for some schools in and near Recife, his home city.