Cloud Computing:
The Economic Imperative

What is cloud computing? There is an amusing video on YouTube.com that tries to answer that very question.

The video's author, an employee of a cloud-computing company called Joyent Inc., asked that question to several top tech editors and CEOs at the Web 2.0 Expo last May and pieced together their responses in a short, comical video.

One interviewee quipped that cloud computing is when you're using your laptop in an airplane at 40,000 feet. The amusing, and rather telling, aspect of the video is that all the interview subjects said something different.

It seems cloud computing is still an abstraction. But the term itself isn't new. Anyone who has ever seen a network diagram has probably seen a cloud with arrows pointing to and from it. The cloud represents the network—either a local intranet, or the internet at large—and all the resources available on it. Instead of having software that is stored and run on an individual PC, the user taps into this "cloud" for his or her computing needs.

These days, cloud computing relates to the way IT professionals design, build, deploy, and run applications that operate in a virtualized environment.

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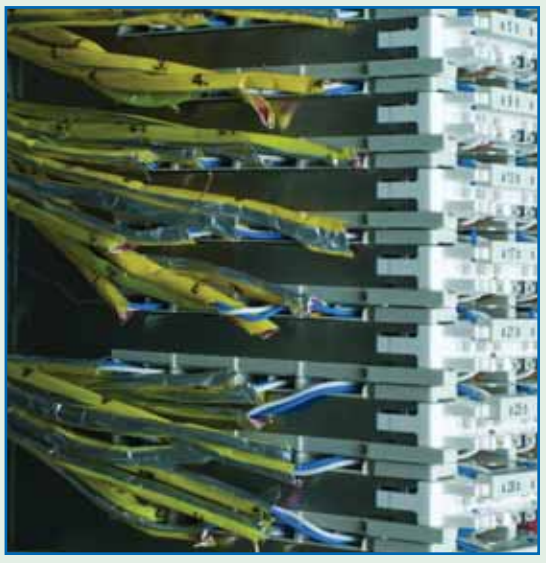
630 servers, one machine: Cloud computing on a mainframe

An upstate New York college sees great economic advantage by running cloud computing on a mainframe.

On one mainframe, Marist College in Poughkeepsie, N.Y., runs 630 virtual servers. Some of them are dedicated to computer sciences, some for web sites, and some for client and/or partner organizations. The end users don't know they are on a mainframe; they think they have their own server.

"The advantage of using a mainframe is tremendous," said Bill Thirsk, chief information officer at Marist College. "One of the applications that we use for managing the school … requires 10 large servers to run the entire suite of programs. We didn't buy 10 machines; we simply put it on our mainframe, which pre-existed."

A mainframe is highly efficient as far as the power, cooling, and floor space needed.



"My data center is only 2,000 square feet," Thirsk said, "yet I have in total probably 630 servers running in there. It takes your computing room, your heating and cooling, your power requirement, and your processing requirement and puts them into what I call an extremely high-density services model."

A mainframe that is virtualized into many smaller servers does not need network switches, cables, additional electrical outlets, more UPS capacity, racks, or any other additional equipment, Thirsk said. It's infinitely scalable, too.

"The price tag is expensive. However, it's much less than buying server, server, server, server," Thirsk said. "The return on that asset is considerably higher than doing one server at a time, one switch at a time."

iLearn

Marist College developed its own version of the open-source education platform Sakai, which it calls iLearn. Through its cloud, Marist runs iLearn internally and distributes it to partner organizations.

"We started to see that, very much so, we were offering Software as a Service through our instructional technology," Thirsk said. "We developed it so not only could a student sign up and take courses online, but we could also host [the software] for other [organizations], where we simply create them an instance and provide them access to our mainframe."

Marist College often helps other schools and colleges teach courses online, do online collaboration, and set up virtualization. "We are very much a hub," Thirsk said.

Transparency

Like all clouds, the technology behind Marist's interface is transparent. Students at Marist College don't think to themselves, "I'm logging into a cloud" when they use their secure login.

Anything students or faculty would do on a traditional computer, they can do online through the cloud, and usually with much greater convenience, at any time of the day, Thirsk said.

They can register, take a course, look up grades, pay bills, search the library catalog, collaborate online for team projects, go back and forth in asynchronous conversation, post documents and presentations, and access social-networking sites like Facebook.

"They are not [aware] that they are on a cloud, or a cloud configuration," Thirsk said. "They are [aware] that they log in with their login, and there, through our portal, is everything they are allowed to access."

Marist College has some low-cost, thin-client devices from DevonIT Inc. installed in its student services office and some research labs. These next-generation thin-client devices don't have a hard drive; the processing power and software is delivered from the mainframe.

"The user doesn't know [he's] not using the desktop. It looks like Windows, it behaves like Windows, but there are no data stored there," Thirsk said. "It [requires] very, very low power usage, but you get all the functionality, network connectivity, bandwidth, and everything you get from a very large computer. And, they are cheap."

Extra security

Cloud computing offers an extra layer of security, Thirsk said, because data are not stored on local machines. If someone steals a laptop or computer, the thief will not get any data.

"Where we worry is if someone sticks a thumb drive in it and tries to download data—[but] we have routines to protect that," Thirsk said.

Marist College has up to 7,000 people within the college using the network. Overall, Marist manages 130,000 eMail accounts; however, not everyone logs in at once.

"The worst thing that could happen is the internet connection could go down through some provider. And that does happen from time to time," Thirsk said. "If you are a cloud provider or cloud user, and someone's network goes down or their internet connection gets cut, you are out of business for a while until it comes back up."

Marist College has two internet connections, one primary and one backup, and it's also a member of Internet2. During outages, the college implements speed restrictions for traffic going over the different secondary routes. For security purposes, Marist College also monitors its network traffic.

"We worry about natural disasters, of course," Thirsk said. "What would we do if there is a flood, or an earthquake or tornado, or things like that—and that's just a [function] of good data-center management and organizational readiness."

Marist College shares a data center in Syracuse, N.Y., called NYSERNet, with a number of other colleges and nonprofit organizations. It also has one main data center at the college and is building a secondary data center in a new technology building, Thirsk said. The college has three electrical grids on campus, so if one goes down, users can come up on another grid.—C.E.

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"IT as a service … is what cloud computing is all about," said Hagen Wenzek, a senior strategist at IBM.

In the same way a utility company delivers electricity, natural gas, or water—you sign up, then don't have to think about it any more—cloud computing delivers IT services to the end user. Advocates of this service model say it's simpler, faster, and cheaper for organizations—and the experience for the end user is also superior.

Concepts such as on-demand resources, utility computing, virtualization, Software as a Service (SaaS), and Desktop as a Service are integral parts of cloud computing.

"All of these bits and pieces are now finding their way into a more comprehensive story that explains how IT is being delivered and consumed as a service," Wenzek said.

Characteristically, cloud computing is efficient, automated, and delivers standardized resources—all of which can result in significant cost savings. Several U.S. colleges, universities, and K-12 school districts are already reaping the benefits of switching to a cloud-computing model.

The current economic crisis in the United States and worldwide is pushing businesses and institutions to adopt this new way of running technology. In the private sector, spending on IT cloud services will grow almost threefold, reaching $42 billion by 2012, according to research firm IDC.

'The cloud model offers a much cheaper way for businesses to acquire and use IT,' said IDC analyst and senior VP Frank Gens. 'In an economic downturn, the appeal of that cost advantage will be greatly magnified.'

"The cloud model offers a much cheaper way for businesses to acquire and use IT," said Frank Gens, senior vice president and chief analyst at IDC, in a statement. "In an economic downturn, the appeal of that cost advantage will be greatly magnified."

The investment in technology infrastructure since the turn of the century is also driving the trend toward cloud computing: As school and business networks have become faster and more robust, the capacity to deliver software and IT services through these networks to users on demand has increased.

Moore's Law has borne out for so long that we've moved into an age of digital abundance, where the cost of technology devices for end users is fairly low, said Michael King, IBM's vice president of global education industry.

That fact has shifted IT managers' focus from the initial cost of purchasing technology to the total cost of ownership (TCO) for operating and maintaining the technology, King said. What's important now to schools is, how much electricity will it consume? How many maintenance technicians will be needed?

"It's not the technology itself any longer, it's the stuff that goes around the technology [that is most important]—and I think that's an economic driver toward cloud computing," King said. "Cloud computing is ultimately going to enable a significant transformation of education to increase quality, increase access to educational resources, and at the same time lower costs. It's a very

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fundamental shift, on the order of the shift toward the PC computing model a couple of decades ago."

How it works

Cloud computing takes the complexity off the desktop—the software, operating system, and processing power—and moves it into the cloud, which is a central location.

The experience is transparent to the end user, who is not aware that the computing power is not coming from his or her desktop computer. The servers at the cloud center dole out whatever the user requests, whether it's the internet, software applications, his or her personal files, or even supercomputing capabilities.

There are multiple ways to implement cloud computing.

A school or institution can build and run its own data center to power the cloud on campus. Or, if the school can't afford a mainframe computer or large server farm, it can outsource that function to a hosting company and sign up for services delivered over the internet—eliminating the need to invest in robust hardware or install software.

Kentucky's Pike County Schools subscribes to an outside company for server capacity, software, and IT services. North Carolina State University (NCSU) runs its own computing cloud on a server farm consisting of 2,000 blade computers from IBM. Marist College in Poughkeepsie, N.Y., runs cloud computing on a mainframe.

"Marist decided to go for the very optimized, big mainframe that can slice and dice highly efficient computing resources," Wenzek said, "while N.C. State has massive amounts of simple, cheap servers."

"For a college that is not high-tech or invested in technology, SaaS … is very, very attractive," said Bill Thirsk, chief information officer at Marist College. "Instead of having to buy hardware and software licenses and pay for maintenance, [the school] can pay some company or some organization a usage fee and get the functionality of a system [without having] to own it."

Schools can host cloud services themselves—or outsource these functions to an IT provider.

For institutions that choose to construct their own data center, this requires a big investment in staffing, building space, and equipment—but the return on their investment is significant, Thirsk said.

"The interesting thing about cloud computing is it's not hard to develop a cloud. You take all your pieces and parts, you interconnect them, and you make them work together as an information system. Then you have to decide how you are going to scale that," he said.

Cloud computing can be highly energy-efficient, Wenzek said. Because software runs in the "cloud," end users don't need powerful machines with lots of processing power or memory. And scaled-down machines use less energy than operating the equivalent number of desktop computers.

Efficiency also comes because a data center centralizes resources in just a few locations; the resources are standardized, meaning they consist of "like" components with the lowest possible number of variations, and the processes are automated.

"Every manual step leads to increased complexity,

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Virtual Computing Laboratory delivers IT resources on demand

At North Carolina State University (NCSU), requesting IT services couldn't be simpler, thanks to cloud computing.

If, every Monday at 10 a.m., a professor needs 20 computers that have Windows, Microsoft Office, and SolidWorks on them, for instance, the professor simply goes to a web page and chooses from a menu to make group reservations that repeat throughout the semester.

Using the same web page, a faculty researcher could ask for a combination of an Apache server, a database server, and an application server. Or, he or she could ask for a computational cluster or even a low-end supercomputer.

"That can all be done in a very smooth way by essentially going to the web," said Mladen Vouk, head of computer science and associate vice president for information technology at NCSU. "For the end users, it's very easy to use."

Faculty can pick applications, a platform or groups of platforms, or whatever they need for IT resources, and request them either right now or for some time in the future. The options presented in the menu vary based on a user's privileges.

The cloud-computing software, or platform, that allows this functionality is NSCU's Virtual Computing Laboratory (VCL). Software as a Service (SaaS) is only a fraction of what VCL is capable of.

"The platform we use … allows you to construct any type of cloud you wish," Vouk said. "You can construct what we call a high-end terabyte cloud, which is different, for instance, from an application cloud or something else."

VCL is a general solution that asks: What would you like to use? Would you like a physical environment, would you like a virtual environment that has particular characteristics, or would you like application software? Or, would you just like to do calculations?

"It really depends on how the end user wishes to use it," Vouk said.

The software also keeps track of who has asked for what resources, how long the reservations are for, whether there is enough capacity to fulfill requests, and whether there are any conflicts—in which case, one party gets a message to make the reservation in the future.

NCSU has 30,000 students and faculty. "Half of our customers might be doing high-performance computing jobs for our researchers or some other researchers in the States, and the other half might be doing what we call single-seat or multi-seat," Vouk said.

NCSU's data center is made up of 2,000 IBM blade servers, plus some other components to VCL that use HP or Sun machines. The data center is distributed across four places in Research Triangle Park, N.C.

"It's not limited to blades, but we have found blades to be very, very efficient and cost-effective," Vouk said. He estimates that one blade server can serve 25 students at a time.

Compared to a traditional computer lab, the school's virtual computing resources and software get more use, because they can be used 24-7.

"You can use it anytime; you can use it from home, you can use it much later, you don't have to physically show up in the lab," Vouk said, "so you increase the efficiency and usage."

IT staff can buy software licenses based on actual usage, not the number of computers sitting in a lab. "In our case, if we know there are no more than five people using a particular piece of software at a time, then we only need to buy five licenses," Vouk said.

Managing a cloud system requires fewer staff, too, which also results in a huge cost savings.

"With cloud computing, because of the way it's organized and centralized in roughly a few places, you can actually manage, with one person, thousands and thousands of machines without any problem at all," Vouk said.

NCSU has two to three full-time equivalents managing 2,000 blade servers and 30,000 student and faculty accounts, which is considerably less than the school would need to manage software on desktop machines and in computer labs. Vouk estimates NCSU would need at least 10 to 15 full-time equivalents in that case.

"We don't get rid of people, we simply have the same IT staff do the next advanced things that we want to do," Vouk said.

Having a strong network is crucial to the success of cloud computing. NCSU has strong security and authorization and monitors its network regularly.

"We have not had a single security incident," Vouk said. "Someone may have accidentally infected [their machine]—but they next time they reload the image, they are clean."

NCSU offers pilot accounts to others who might be interested in looking into VCL, Vouk said. Interested parties can go to http://vcl.ncsu.edu to read more about VCL and to send a request for a test account.

At NCSU, cloud computing has increased access to computing resources for all students. It's easier and more flexible, Vouk said.

"It really increases the productivity of both the students and the information technology personnel considerably. We have seen … both educational benefits and technological benefits, in terms of savings," he said.—C.E.

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increased cost, and slower response time—all working against the notion of simpler, faster, cheaper," Wenzek said.

On top of the servers in a cloud center, you install cloud management software, which does everything from configuring and rationing resources to authenticating users and cleaning up "dumb" terminals so the computers in a lab are ready for the next user.

NCSU developed its own cloud-computing management software, called the Virtual Computing Lab. (See side story, page 16.) IBM's cloud-computing solution consists of Blue Cloud software running on iDataPlex servers.

"iDataPlex is basically a super-simple, very, very dense rack with a lot of blade servers in there," Wenzek said. "That is one of the most efficient ways to build infrastructure for a cloud."

Public and private clouds

Public computing clouds are open to anyone who wants to sign up and use them. Private clouds typically sit behind the firewall of an enterprise or university, and only people within that organization have permission to access the cloud and its resources.

"There's also something in the middle," Wenzek said. IBM, for example, operates a cloud data center for its customers. Multiple customers share the same infrastructure, but each customer's cloud is secure and separated as though behind its own firewall.

"It brings you the value of more efficiency," Wenzek said, "because we are able to share the same infrastructure with many other customers, and therefore it's more efficient. If you had your own small little cloud, [it] can never be as efficient as a huge pool of IT resources."

Simpler, faster, cheaper

"The overall experience of being able to stop fussing around with IT is one of the biggest shifts that is happening out there," Wenzek said.

Most students and faculty just want to use technology tools and resources; they don't care where these resources are located or who is delivering them. Cloud computing makes it easy for them to do so. Faculty members simply go to the web to request the IT services they need for themselves or their students. From a menu, they can choose the operating system, the software applications, and the server capacity they need, and then they can schedule this request to repeat for the entire semester, or as needed.

"You look at that catalog, and you select what you want, and you press a button—and whoop, it's there. It's up and running," Wenzek said. "I have my distance learning course. I have my administration system. I can run my payroll. All of that without even fussing with the IT department—that's a fundamental shift for how you are using IT."

Often, when someone needs additional server capacity, it can take weeks or months to fulfill the request. You have to fill out procurement forms, place an order, wait for shipping, and then set up and configure the machine.

Cloud computing can fulfill that same request within minutes. It provides a highly scalable, near-instantaneous way to deliver computing power or resources on demand. You just go to the web, choose what you want from a menu of available services, and then that server is allocated as a virtual machine almost immediately.

"That's just a huge, huge difference from what we had before," Wenzek said. "It's a very different way of buying servers. You don't ship the server anymore. Someone just automatically allocates capacity to you that is equivalent to what you were ordering as a server, out of a huge data center that provides IT like a utility provides electricity."

"Any time you streamline and standardize within your organization, whether it be in computers or processes, you are going to save money," Thirsk said.

Cost savings come from centralizing and standardizing computer resources and drawing less power. The simplicity of the system also results in less maintenance, especially if cloud computing is outsourced. That means fewer IT staff members are needed.

Another advantage to cloud computing is being able to buy software licenses based on actual usage, not on the number of computers you have.

Typically, cloud computing supports all types of devices. It is operating system agnostic and supports open-source applications. In the case of Pike County Schools in Kentucky, the district used cloud computing to transform 1,400 old computers that were ready for surplus into fully functioning virtual machines. (See side story, page XX.)

Instant supercomputing power, on demand

Most students and faculty are already familiar with public clouds, or consumer-based cloud services such as those offered by Amazon, Google, Adobe, Expedia, or Facebook. These clouds give users a login and access to specific software.

"Someone is giving you software, they are running all their own servers, you get an account, and those services are delivered to you. It's a very low-cost way for companies to deliver very high-valued services for you," Thirsk said.

Amazon resells its idle computing capacity, outside of the holiday rush, to computer users. Individuals can go onto Amazon's web service, called the Amazon Elastic Compute Cloud (Amazon EC2), sign up for server space, and pay by credit card. Amazon charges 10 cents per gigabyte, per month, plus transmission fees. Users can terminate the service at any time.

"You can get it very fast, and you can get rid of it very fast," Wenzek said. A service like this would be useful for meeting temporary, high-capacity computing needs—such as executing research algorithms or testing software—but it might be too costly or generic for most educational uses, he said.

The advantage of this kind of service is that you can

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Advocates of cloud computing say it's a secure, easily scalable way to deliver IT resources to students and teachers on demand.

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sign up for a thousand servers for just a few hours to run an algorithm, without having to buy them and scrap them afterward. "Here, [the servers are] automatically allocated to somebody else, and you just buy them for the time you are using them," Wenzek said.

Regulatory issues ... and other concerns

Some state laws say it's necessary to keep certain data, such as health or employment records, inside a single jurisdiction. With a subscription-based cloud computing model, the user doesn't always know where the data center is located. Many data centers are being built in locations that offer the best return on investment.

"Iceland or Greenland is a fantastic location for a data center, because it's cold and you have great internet access, you have geothermal power," Wenzek said, explaining that data centers generate a lot of heat and use a great deal of energy to cool. "You need to make sure that whatever you do is actually complying with those laws."

A powerful, secure, and reliable data center and network are essential to the success of cloud computing. "There is a very important role for companies, IT departments, and the like to guarantee that experience, or else people will become disappointed," Wenzek said.

Cloud computing might not be the right solution for all schools. Some IT directors might have concerns about data security, while others might worry what will happen if they lose their network connection.

IBM's King says this latter concern is becoming less of an issue, however, as schools build redundancies into their network infrastructure.

Moving forward

King said the education community should consider leveraging public service clouds and build their own private cloud services to keep students and faculty engaged, to keep their institutions relevant, and to keep costs down.

"There are things people should do today that can be done. Things like moving the desktop into the cloud. It is something that is very green. It immediately generates cost savings, and it is something that the technology—and, for the most part, the people—can do today," he said.

"I think the next two to three years will really be about developing shared services, exploiting cloud-computing models, and really driving fundamental transformation in how we organize education and deliver value to students and the education community."

LINKS:

Joyent Inc.'s "What is Cloud Computing"
http://www.youtube.com/watch?v=6PNuQHUiV3Q

Amazon Elastic Compute Cloud (Amazon EC2)
http://aws.amazon.com/ec2

North Carolina State University
http://www.ncsu.edu

Pike County Schools
http://www.pike.k12.ky.us

Marist College
http://www.marist.edu

Subscription-based cloud helps Pike County extend computers to more students

Through a subscription-based cloud-computing model, Kentucky's Pike County Schools brought its student-to-computer ratio down to 2 to 1 without spending millions of dollars.

"We were running into a case of [having a] limited budget, and still not wanting to cut back on our goals for our students as far as technology is concerned," said Maritta Horne, the district's chief information officer and director of technology.

"Purchasing machines was a problem," Horne said. "If I were to purchase 1,400 machines, it would be well in excess of $1 million for my district. It's just not feasible at this time."

With cloud-computing software from Desktone Inc., the district transformed its relic computers that were ready for the scrap heap into fast, fully functioning virtual machines.

The district could revive these old machines because cloud computing eliminates the need for a hard drive on the local computer. In a cloud environment, the processing happens at the server level, not locally at the desktop. The desktop machine is simply a conduit, or dumb terminal, that receives processing power and software delivered from the server, or the "cloud."

Students have access to Microsoft Office, portals for education software, and storage space for their work. Teachers have attendance, grade reporting, and lesson planning software as well. Everyone has a secure login.

"With this process, it doesn't even matter if they don't have a hard drive," Horne said of the machines. "As long as the CD-ROM works or the USB works, we can get them on the network."

Pike County's technology staff carry a boot image, on either a CD or a USB key, which tells the machine how to access the district's cloud. If a computer is too old or too costly to fix, they simply pop in the CD and make it work.

Not only has the district saved money by reusing its old computers, but maintenance costs have gone down tremendously, too.

"Typically, we would have between 150 and 200 work orders a month with a regular system," Horne said, "and now we are down to a fraction of that, a quarter of that."

Because Pike County uses a subscription-based model for its cloud computing, its IT staff members don't have to worry about server maintenance or configuration. "That's a major savings for me. Not only do I not have to have the expertise on site for my staff, but I don't have to maintain [the servers], either," Horne said.

Electricity consumption has decreased as well. The computers no longer draw as much power, because the hard drives are not running.

In this model of cloud computing, also known as Desktop as a Service (DaaS), everything needed on a traditional desktop computer resides on the server: the processing power, the operating system, the software, and the user's files and data. All the user needs is a screen, a keyboard, and a communication device—such as a laptop, PC, mobile telephone, or some type of handheld device—to access the virtualized desktop.

Pike County has 10,200 students and is the largest county geographically in Kentucky, covering 700 square miles. The district has 27 K-12 schools, including two "day" treatment facilities and three vocational and technical facilities. Sixty percent of classrooms have "smart" classroom tools, including interactive whiteboards, projection devices, and document cameras.

With its cloud, Pike County serves up about 5,000 desktop images. Every student who logs onto the server gets a separate image, consisting of whatever they are working on or requesting from the server.

Students have access to Microsoft Office, portals for education software, and storage space for their work. Teachers have attendance, grade reporting, and lesson planning software as well. Everyone has a secure login.

The district connects to its cloud, which is hosted by ICC Technology Partners, a subcontractor of IBM, via a direct fiber connection. "We don't have bottleneck issues," Horne said. In fact, she said, this is the best solution she's encountered so far. There is no degradation between systems, and the end user doesn't experience any problems.

"We've had students simultaneously sitting together," Horne said, by way of example. "One would be on a virtual machine, and one would be on a Pentium dual-core processing machine with a [gigabyte] of RAM or whatever. There is no difference in the state of connectivity," she said.

"At one point, we noticed we had 2,500 of our students online at one time … to this particular server, and we didn't have a problem," Horne said.

Before settling on its current cloud-computing solution, Pike County used a thin-client setup with Citrix Systems and the open-source Linux operating system for years, but neither met the district's needs.

With Citrix, she said, students had problems printing their files. The software also needed to use some of each computer's processing power, and some of the machines were too slow, Horne said.

Linux offered limited applications and lacked support for specific drivers. Also, some of the applications would slow down the system, Horne said. In addition, Pike County encountered problems with audio and with students saving work to their portfolios using Linux.

"This year, we are able to do all of that," Horne said. "The audio is not an issue. The directories for students to save their work to are now visible to all students."

One of the biggest advantages to cloud computing for Pike County is having enough computers on location to do computer-based formative assessment. Periodically, Pike County students are assessed online, and then they're assigned remedial or enrichment work as needed through software from American Education Corp.

"We didn't have enough machines capable of doing this, so when we would go out to test our students, and set up testing, we'd actually have to physically bring equipment in to do that," Horne said. "We got it done, but it took us two months to test all of our students."—C.E.

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Smart healthcare systems are helping to lower the cost of therapy by as much as 90%.

The list is long, and the transformation is just beginning. Its benefits will be reaped not only by large enterprises, but also by mid-sized and small companies – the engines of economic growth everywhere – and by individuals and communities around the world.

Imagine how a smarter planet will transform *all* the things we seek. The ways we pursue economic growth, societal progress, environmental sustainability and cures for disease. The way we interact with each other and with the world.

The opportunity is before us, and the moment will not last forever. Will we seize it? As we look to stimulate our economies and rebuild our infrastructure, will we simply repair what's broken? Or will we prepare for a smarter future?

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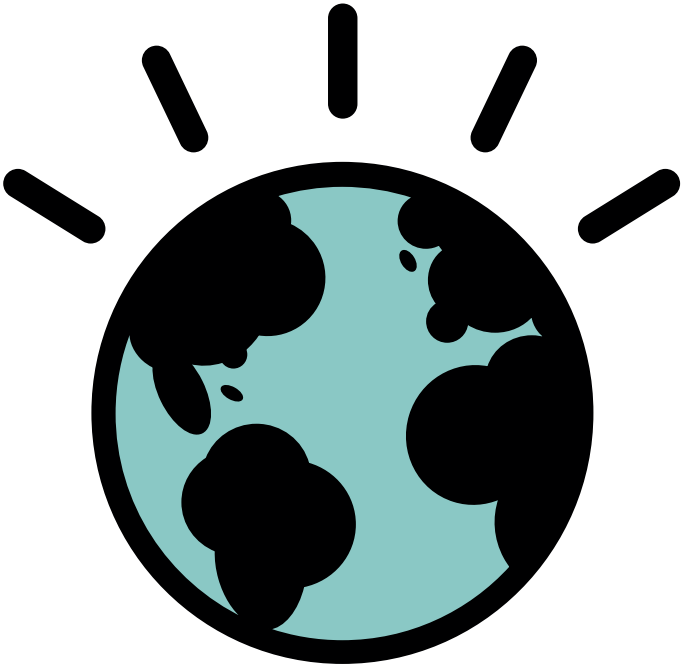

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