Special Section: Cloud Computing NYT NOW

The Era of Cloud Computing

By QUENTIN HARDY

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SynapDx searches hundreds of thousands of genetic markers, looking for clues about autism in 880 children across 20 states. A few years ago, this would be the task of a major company or research institution. Thanks to cloud computing, the start-up in Lexington, Mass., does it with 22 people, a few laptops and an Internet connection.

"Without the cloud I'd need $1 million, plus staff, just for the computer," said Mark DePristo, a vice president for SynapDx. Instead, his company spends $25,000 a month on computing and steadily gets more computer power as it needs it.

You already work in the cloud, too, if you use a smartphone, tablet or web browser. And you're using the cloud if you're tapping online services like Dropbox or Apple's iCloud or watching "House of Cards" on Netflix.

Cloud computing, an airy term for real systems of cleverly networked computers, powers thousands of mobile games, workplace software programs and advanced research projects. These services harness global networks of millions of computers, renting and using huge amounts of computing power.

Special Section: Cloud Computing

An inside look at how technology is remaking an industry, lowering costs for some and handing even more influence to a handful of powerful companies.

For the half-century that computers have been part of the workplace, companies have bought their own machines for corporate data centers. But that

may be about to change. Industry analysts at IDC figure that if largely cloud-based things like mobile apps, big data, and social media are counted, over the next six years almost 90 percent of new spending on Internet and communications technologies, a $5 trillion global business, will be on cloud-based technology.

Technically, cloud computing refers to an efficient method of managing lots of computer servers, data storage and networking. More than a decade ago, engineers figured out ways that data and software could be distributed efficiently across several machines and their power pooled for collective use.

It no longer mattered which servers were running a job; it was just inside this "cloud" of machines. There were immediate performance gains, since stand-alone servers typically used only a fraction of their capacity in case there was a surge in demand. By linking the machines together into a larger "virtual" system, the surge problem eased and a lot of computation was freed.

And it became available to anyone able to pay the rent.

"The biggest events in the world, the World Cup, the Super Bowl, the big reality shows, all use the cloud" for various online services, said Andy Jassy, the head of Amazon Web Services, or AWS, the largest cloud computing company. The National Aeronautics and Space Administration broadcast the Mars Lander using AWS, and the Obama campaign used it to place a million calls on Election Day 2012. Even part of the Central Intelligence Agency is inside AWS.

A handful of big companies dominate this new sort of technology. Customers like Netflix and Shell run on AWS. In Shell's case, it's for seismic research. For Netflix, it's for all those movies and television shows streaming to your television and computers.

Google has a big cloud, too. You're on it if you use any sort of Google service like email and photo editing. Seventy million Nigerians recently registered for local elections on Google's cloud and millions more people study on Google's cloud through the online educational service Khan Academy. The young messaging app Snapchat grew to millions of users overnight, without spending millions to support them, by running on Google's cloud.

Microsoft tapped cloud technology for running email accounts and Xbox games. Now it sells its cloud resources. For example, the Chinese automaker Qoros uses Microsoft's cloud, called Azure, to connect its cars to social media and provide entertainment. Google and Yahoo developed cloud techniques for their search businesses, along the way pioneering big data analysis inside their clouds. IBM even made it possible to use its Watson supercomputing technology through a cloud service.

And Apple, of course, supports millions of customers through its cloud services.

A great deal of this power in the so-called public cloud where other companies rent usage will be controlled by just a handful of companies. That means two things: First, individuals and small teams are uniquely empowered by this trend. Without the cloud, it would be almost inconceivable to fund a start-up like Pinterest, which now loads 60 million photos a day onto AWS but employs 300 people.

But it's likely that fewer than a dozen companies will really understand and control much of how the technology world will work.

"There will always be national boundaries, geopolitical distortions," said Yousef Khalidi, who holds the title of distinguished engineer at Microsoft. "There are maybe 200 telephone companies in the world, but only a few global ones that are dominant." Within five years, he said, "the actual design of these things will be understood by just a few hundred people."

That ability to pool tremendous processing power is also leading to innovations thought impossible just a few years ago, like a real-time translation of any human language, self-driving cars and thermostats that learn our behavior and adjust themselves accordingly.

"The fact that it's been said a million times doesn't make it any less true: We're still at the very beginning of this," said Greg DeMichillie, the director of product management for Google's public cloud. "Doing something that reaches 100,000 people is no longer in the realm of corporate data centers. Two or three people can build something on a global basis."

There Is a Private Cloud

Here's where describing what the cloud is gets tricky. Many corporate data centers have adopted cloud-based computing architecture — that method of making many computers in far-flung places efficiently work together — but they have no intention of offering that technology to other companies. Others, like Apple, don't rent capacity to other companies, but offer a variety of cloud services to consumers.

Interestingly, Facebook, which operates large data centers around the globe, does not use cloud computing technology, its executives say, but rather uses aspects of it for the specialized use of a social network.

Eight years ago, Amazon got the idea of turning some of its internal cloud over to the public, starting with the most basic kind of computing and storage. Amazon was also fierce about cutting prices and finding more efficient ways to run systems. Since then, AWS has added hundreds of capabilities and features, like data analysis tools.

Amazon and Google won't say how many servers they run in linked data centers around the world, but estimates are as high as 10 million computer servers, for each. Microsoft's Azure service runs close to one million servers.

Renting other companies' machines for their computing, the public cloud, is what most people now think about as cloud computing. And the scale at which the big companies operate creates all sorts of advantages.

"We see folks at traditional computing companies, and we can't even have the same conversation anymore," said David Campbell, who oversees technology at Azure. "They're just not learning what we do about power and software when we get past one million servers."

Google has developed its own semiconductors optimized for the cloud, executives say, while Amazon has in at least one case re-engineered how a 50-megawatt power substation feeds one of its computing centers.

As these companies learn how to cut costs and increase performance, they pass along at least part of that gain and costs go down for everyone.

Take data storage, now as low as a penny a gigabyte on AWS. That is about one-hundredth of its cost when AWS began. That kind of price collapse is about six times faster than posited by Moore's Law, a rule in computing (named for its creator, Gordon Moore, one of the co-founders of the chip maker Intel) that says the same amount of money buys twice as much capability every 18 to 24 months.

Economists say Moore's Law is the reason our world has been transformed by technology. People inside the public cloud companies, flush with the scale and cost savings they have already seen, think they can keep crushing costs indefinitely, increasing the impact of Moore's Law.

Besides making it much cheaper to experiment, do research and even fail at starting a new company, the cloud is what is enabling the so-called Internet of things, with billions of sensors measuring huge amounts of data and shaping the performance of connected objects.

"Now you can get microprocessors for 25 cents that have a network connection to the cloud, where computing systems can understand context, and how to optimize behavior," Mr. Campbell said. "We'll create an amazing amount of economic value."

Mr. Jassy of Amazon, who was once technical assistant to the company's chief executive, Jeffrey P. Bezos, thinks that AWS will eventually be as big as Amazon's book and reselling businesses. Microsoft's new chief executive, Satya Nadella, was formerly the head of Azure, and has reorganized Microsoft to move faster to the cloud.

"Microsoft has good relations with companies; good for them. We're growing in that," Mr. DeMichillie of Google said. "Amazon has a head start. We're in the position of building on the capabilities of Google."

While Amazon, Google and Microsoft enjoy a lead in offering public cloud services, others are looking to close the gap.

IBM, long a leading light of tech, has spent over $2 billion on cloud technologies and services in the last year. CenturyLink, a provider of telecommunications and Internet services to business, is rushing to add public

cloud services to its 520,000 miles of fiber around the world. Hewlett-Packard, until recently the largest technology company by revenue, has a deal with a Chinese manufacturer to supply other people's clouds under its brand and hopes to develop new kinds of clouds that push even more cheap computing everywhere.

Upending Old Businesses

By now, many consumers know they no longer have to buy that expensive desktop software from Microsoft, Adobe or any number of software companies. Instead, they can find free, nearly as good alternatives that work over the Internet. Yes, that's probably a cloud app. Even Microsoft and Adobe are offering lower-cost cloud alternatives to their traditional software.

But more dollars could be involved in the cloud's impact on software for businesses. Selling software via the cloud, called Software as a Service, has upended one of the biggest businesses in tech. Software companies like Oracle (and much of Microsoft) were used to selling software in packages, frequently loaded onto computers, along with costly service contracts.

New business software companies, like Salesforce, Workday or Concur, instead rent data storage and software via the cloud. It is a lower-margin business that can grow quickly, challenging the incumbents, and it is gradually winning share.

Salesforce, one of the pioneers of software as a service, has increased in value 1,200 percent since going public in 2004, to a market capitalization of $33 billion, though it has generated scant profits over the years. Most of these "software in the cloud companies" still work on their own private clouds, since many of their customers aren't yet comfortable with putting everything on Amazon or Google, but it's likely that they will follow the consumer companies to the public cloud.

In the last few years, Oracle has spent over $4 billion acquiring cloud software companies and billions more building out its own cloud. SAP of Germany, the world's second-largest maker of software to run companies, has spent even more. Venture capitalists in Silicon Valley are frequently torn about

whether to sell their cloud start-ups to these giants or fund new cloud-based companies that will bury them.

Among the cloud giants, it is all more demand, abetted as wireless networks put more people in places like India and Africa into the cloud. "Our companies come into it for cost savings," Mr. DeMichillie said. "We didn't build this to enable Nigerian voter registration, but that is very gratifying."

He added: "Historically, we've been in a world where computing was a scarce resource. Now it is moving to being an abundant resource. Anybody who claims to have a crystal ball about where this is heading is kidding themselves."

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