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Big Switch: Rewiring the World, from Edison to Google

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The historic evolution of the electric grid has striking similarities to the current evolution of the compute grid. Nicholas Carr, in his book Big Switch: Rewiring the World, from Edison to Google,[1] traces the parallel evolution of these two great technologies that have transformed and are transforming the world in which we live.

The Electrical Grid

Before the introduction of electricity, factories were powered by several means. Water was initially a major source of power. Factories were built near rivers or water falls that drove gigantic water wheels. Complex, inefficient, and dangerous shafts, gears, and belts transmitted the power throughout the factory. Water wheels gave way to steam engines, but the intrafactory distribution of power remained the same.

Edison's Invention of Electric Power

Carr, in his book, traces the maturing of the electrical industry from isolated and independent power-generating stations to today's massive electric utilities. In the late 1800s, Thomas Edison developed the first electric generator, the dynamo, along with the light bulb. His plan was to light entire cities with electricity. To do this, he set up companies that operated large (by the measures of the day) multi-kilowatt generating plants to distribute electricity for this purpose.

His dynamos generated direct current at relatively low voltages (equivalent to today's common 120 volts). This meant that large amounts of current had to be distributed (10 kilowatts at 100 volts required the transmission of 100 amperes). This required large copper cables and therefore limited the range that a power plant could service to about a square mile. Consequently, small independent power plants sprung up all around the country to provide local power.

The ready availability of electricity led to many other inventions, primarily the electric motor and a range of household appliances – washing machines, irons, vacuum cleaners, refrigerators, stoves and ovens, and the like. This led to an increased demand for electricity, but the distribution of electrical power was still limited to small distances by the direct current generators.

Introduction of Alternating Current

It was not until the Serbian engineer Nikola Tesla invented the alternating-current motor that the transmission problem was solved. Electrical use was no longer constrained to direct current devices. Alternating current could be converted to very high voltages with step-up transformers and consequently transmitted with much lower currents and correspondingly smaller copper lines. It could then be

[1] Big Switch: Rewiring the World, From Edison to Google, *W. W. Norton & Company, Inc.*; 2009.

transformed back to the low voltages required for end-user use via step-down transformers. Electrical power could now be transmitted over hundreds or even thousands of miles by high-voltage transmission lines using alternating current.

Seeing this as a significant threat to his business, Edison launched a grizzly public relations campaign against alternating current. He made great arguments as to the danger of high voltages, and even got Westinghouse to build an electric chair for the State of New York to carry out executions of death-row prisoners.

The Electric Grid

However, the advantages of alternating current prevailed. In 1896, power was transmitted from Niagara Falls to Buffalo, New York, 22 miles away. This success started a worldwide revolution that doomed the use of small local power plants. Major utilities could now be formed to generate electric power delivered thousands of miles away.

Furthermore, with standardization, these utilities now drive the common electric power grid that shares the consumer demand load among utilities as needed.

The Evolution of Computing

Punched-Card Tabulators

The author entwines the story of the emergence of electrical power with the emergence of computing. About the time that electricity became common place, the age of information processing began to take shape. It started with the punch-card tabulator invented by Herman Hollerith in the early 1880s. His invention was put to use by the United States Census Bureau with great success for the 1890 census.

Major industries were attracted to the savings in time and cost provided by this amazing machine, and the information age was born. Through a series of acquisitions, Hollerith's Tabulating Machine Company grew into the International Business Machines Corporation – IBM. Other competitors rapidly sprang up such as Burroughs, Remington Rand, and Bull. Punched-card processing had become entrenched in business practices by the 1950s.

Mainframes

In the first half of the 20th century, companies dismantled their power generator departments as cheap commodity electricity became available. In the second half of the century, they established new departments dedicated to the technology of automated data processing. Leading the way again was the U.S. Census Bureau. It purchased the first true commercial electronic computer – the UNIVAC 1 – in 1951.

Competitive mainframe computers were rapidly introduced by IBM (the 701 series), RCA, NCR, and Burroughs. This created an entirely new industry – software programming – with companies such as Computer Sciences Corporation being formed. Corporate usage of computing technology evolved rapidly, rising from 10% of capital equipment budgets in 1970 to 43% in the year 2000.

Early computers were large and expensive, and so they were institutionalized in large, dedicated computer centers. Except for highly trained IT staff, a company's employees had no direct access to the company's computers.

Because every company could not afford to build its own data center, service centers came into being. A company could now send its processing to a data processing service center via punched cards or magnetic tape and have its computing needs met, paying only for the processing capacity that it used.

Minicomputers

Then came the transistor and the inexpensive, small minicomputer. Programming became simpler with advanced programming languages using basic English words and syntax. The minicomputer business flourished with companies such as Digital Equipment Corporation, Wang, and Apollo. Data processing service centers were no longer needed, and they died out.

PCs

With the introduction of integrated circuits, minicomputers rapidly gave way to personal computers. Now everyone could have direct access to their own computer, and client-server computing was born. A new startup in the computing world, Microsoft, carried the PC into the mainstream of computing. Users sitting at their desks could not only run their own applications, but could tap into the power of major servers – the offspring of the minicomputer revolution – in their corporate data centers.

The Worldwide Web

However, expansion beyond the data center was hampered by the lack of communications standards and bandwidth. There was a great war between the X.25 advocates and the TCP/IP advocates. X.25 provided end-to-end communications. TCP/IP created a highly reliable communication fabric. TCP/IP won and the Internet, spawned by ARPA, the U.S, Advanced Research Project Agency, and the worldwide web, invented by Tim Berners-Lee, were born. High-speed fiber went a long way towards solving the bandwidth problem. Anyone could now get information from anywhere at any time.

The Cloud

The stage is now set for utility computing. No longer do companies have to maintain their own data centers. By establishing giant data centers, companies such as Amazon, Google, and Salesforce can provide data services over the Internet, creating what has become to be known as *cloud* computing. The new technology of virtualization allows a cloud provider to move data processing load and storage capacity requirements among its thousands of servers at will.

Companies can run their applications on cloud systems or use applications provided by cloud providers, paying only for the computing capacity that they use. A full circle has been made from the service centers of the 1960s to the cloud services of today.

Furthermore, as minicomputers replaced much of the mainframe market and PCs then replaced minicomputers, the cloud may replace PCs. Rather than needing a PC to run applications, users can now use stripped-down browsers to access all of their needs directly from the cloud.

The Worldwide Computer

The author looks into the future of cloud computing to what he terms the World Wide Computer. There may come a time when a user has no idea from where his computing services are coming. Standardized interfaces will allow his applications to be run on any cloud anywhere. The compute grid, akin to the electric grid, will have been achieved.

The Electric Grid and the Compute Grid

Carr points out the fascinating parallelism between the electric grid and what may become the compute grid.

In the early days of electricity, a company had to have its own generating plant. In the early days of computing, a company had to have its own data center.

The use of these two technologies was initially too expensive and technically difficult for many companies to manage. The appearance of local (direct current) power companies and the formation of data processing service centers allowed smaller companies to take advantage of these technologies.

The development of many useful electrical appliances and of small, inexpensive computers increased the demand these technologies, but they were still limited to relatively local use. The introduction of alternating current allowed generating plants to transmit their power over thousands of miles. The introduction of the Internet allowed users to access data services anywhere in the world, including those of the growing number of cloud providers.

As electrical standards became adopted, power utilities could cooperate with each other, and the electrical grid was developed. The author proposes that as computing standards become adopted, the compute cloud providers will be able to interoperate, and the compute grid – the Worldwide Computer – will evolve.

Social Implications

The introduction of wide-spread availability of electricity caused many changes in our society. Some companies such as ice manufacturers were put out of business as their services were no longer needed. Highly skilled craftsmen found their jobs being taken over by electrically operated machines that could do their better, faster and cheaper. The introduction of the mass-produced automobile made possible by electrically-powered assembly lines started a migration from the cities to suburbia.

Likewise, the widespread introduction of computing power is having significant social and economic impact, both good and bad. The web is empowering individuals to be more productive and informed. New small businesses can be formed and can create an immediate worldwide presence with their own easily generated web site.

But the author points out that there are some serious consequences of the web that are concerting.

From the Many to the Few

The web lets individuals set up companies very easily, and some of them become very successful. But this attribute can be taken to the extreme.

A group of three friends came up with an idea to start a video-sharing service in 2005. YouTube was born. Just ten months after it was launched, Google acquired YouTube for a staggering $1.65 billion, bringing the two twenty-something primary founders over a third of a billion dollars each. At the time, YouTube had just sixty employees.

The web allows people to start big businesses with small payrolls. Skype was acquired by EBay two years after its founding for $2.1 billion. Skype had 200 employees, 80,000 fewer than giant British Telecom, even though Skype had twice as many subscribers.

Craigslist, one of the most popular sites on the web, is staffed by only twenty-two people (as of 2006).

PlentyOfFish is the largest dating service in Canada. By 2006, 500,000 people were logging in every day and viewing 600 million pages a month. PlentyOfFishe's total payroll? One, its founder.

The web has the potential of concentrating wealth in the hands of a few while offering little chance of employment for the masses.

Polarization

Throughout recent history, the opinions of people were shaped by the news they received from radio, television, and print. Though this represented a broad spectrum of information and opinions, it was necessarily limited and provided no effective means for feedback. People within a society tended to have a range of views based on this information, but there was reasonable overlap between their views.

The web has now changed all that. Anyone can go onto the web and find blogs, stories, and commentaries on any subject. Furthermore, they can add their own input as comments to these media and can start their own blogs.

Studies have shown that people tend to migrate to the web sources that support their own views. This makes them even more rigid in their beliefs. The result is a polarization of society where once there was reasonable overlap. The very abundance of information on the Internet may serve not to temper extremism, but rather to amplify it.

Web optimists submit that digital technology can be a natural force drawing people together. In some extreme cases such as popular uprisings against despotic regimes, this may be true. But in the general case, such optimism is called into question.

The Loss of Anonymity

A nice characteristic of the web is that one can go on and browse whatever one wants and be completely anonymous. Or so most think.

The reality is that every key stroke, every page visited, is being recorded by many companies for marketing and other purposes. Google does this openly to tailor its search results to the individual making a query.

Is this important to us? Some studies have suggested an emphatic “yes!” In 2006, AOL released a report detailing the keywords entered into its search engine by 657,000 of its subscribers. To protect privacy, the name of each individual was replaced with a number. AOL believed that the information would be useful to academic and corporate researchers studying the behavior of web surfers. But some wondered whether the data was as anonymous as it seemed.

Two *New York Times* reporters and their editor decided to find out. They looked at a set of keywords attributed to one randomly selected subscriber. It took them just two hours to deduce the name, address, and telephone number of the subscriber from information derived from their own web searches. The next morning, a sixty-two year old widow in Lilburn, Georgia, awoke to find her picture on the front page of the *Times*.

Several other similar and successful efforts have proven beyond a shadow of a doubt that the web has zero privacy.

And then, of course, there are spammers and hackers.

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The author concludes his book with a rather esoteric look into the future, based on the musings of Google founders Larry Page and Sergey Brin. They predict that someday in the not too distant future, the entire knowledge of the web will be an integral part of each person’s brain implemented by some sort of a direct connection.

Summary

The emergence of computing and especially the web have made dramatic and positive changes in our life. However, as the author Nicholas Carr concludes:

> " It's clear that two of the hopes most dear to the Internet optimists – that the Web will create a more bountiful culture and that it will promote greater harmony and understanding – should be treated with skepticism. Cultural impoverishment and social fragmentation seem equally likely outcomes."

Acknowledgement

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