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CLOUD COMPUTING

First Hand:
An Interview With Economist W. Brian Arthur
on *The Nature of Technology*

NOVEMBER 2009

ECONOMIST W. BRIAN ARTHUR ON THE NATURE OF TECHNOLOGY

W. Brian Arthur is a leading economist who brings his background in engineering into play when writing about the symbiotic relationship between technology and the economy. Currently a visiting researcher at Palo Alto Research Center (PARC) and external professor at the Santa Fe Institute think tank in New Mexico, Arthur is the author of *The Nature of Technology: What It Is and How It Evolves*, (Free Press, 2009). The book is featured in the 2009 LEF Report, "Cloud rEvolution" (see page 10). *CSC World* recently spoke with Arthur about his book and his thoughts on technology, innovation and cloud computing.

Why did you write *The Nature of Technology*?

Arthur: I've been looking at technology for decades, and it became clear to me that there isn't any framework for thinking about technology. We don't have any clear idea of what innovation is and how radically new technologies — call them inventions — come about. And the more I read, the more nebulous the thinking seemed to be. In the first chapter of my book I say that technology is not just something we use in our lives, it's something that completely determines our lives; from our houses to jobs, to our cars, to medical technology, to staying alive, to making sure our children are alive, to the whole economy. Our entire well-being depends on technologies. My conception of technology is much wider than iPhones or iPods. Take away all the technologies we've developed in the last 500 years, and we'd literally be in the Middle Ages. And yet, nobody appeared to be deeply investigating this incredibly important facet of human life.

In the LEF Report "Cloud rEvolution," you state that technology innovation is about combining and recombining technologies in new ways. Can you explain?

Arthur: What really fascinates me is innovation and where it comes from, especially new technologies, like GPS [global positioning system], MRI [magnetic resonance imaging] machines and laser printers. Nobody seemed to have a clear idea of how an invention arises. People tend to say new technologies come out of some creative process, some sort of "thinking outside the box." We vaguely think of very bright people, maybe even geniuses, cooking up these things.

I began to realize that new technologies come into being, by and large, when engineers or technologists ask how they can fulfill some purpose. And they have to work with the vocabulary they have available to fulfill that purpose; they put new technologies together from components — technologies that already exist.

An example is GPS, which is put together from existing technologies: computer processors, radio transmitters, receivers, atomic clocks, satellites. Looking at other technologies like jet engines or the computer, it's the same story.

So then, how do you define innovation?

Arthur: Innovation happens when somebody cooks up a new means of achieving a purpose. And people do that by finding some new combination of things that already exist.

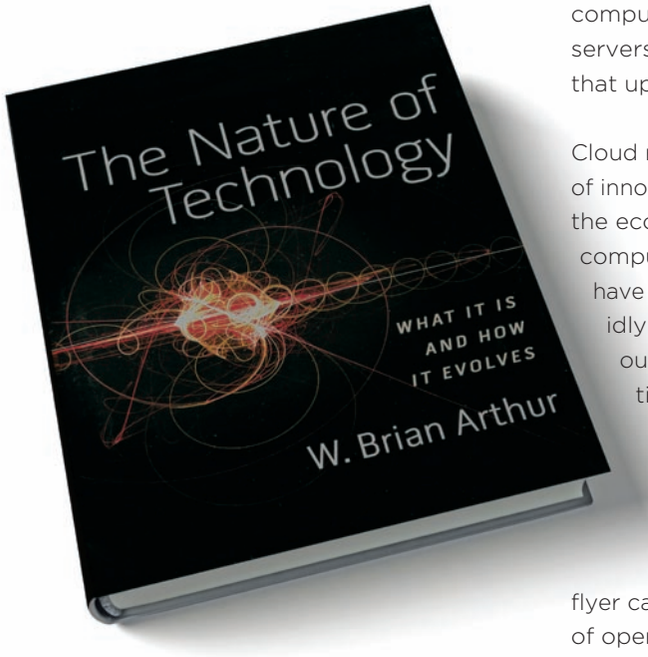
Are there any new discoveries to be made, then?

Arthur: Yes. Every so often we rope in some natural effect or phenomenon and find a way to capture that, which then becomes a building block for further technologies. For example, in 1895, Wilhelm Röntgen noticed that X-rays illuminated the bones in his hand and realized that was a good way of seeing whether or not bones were fractured. That phenomenon was captured and gave us the technology of radiology. Similarly, in the 1870s, physicists figured out that radio waves exist, and from that phenomenon we got radio and radar. In the late nineteenth and early twentieth century, we figured out how to control electrons, which were captured in vacuum tubes and transistors. Knowing how to move electrons around, we developed ways to do computing. Bottom line: Innovation consists of putting together building blocks — think of them as LEGO blocks — of technologies that already exist.

Every so often, we get even more new basic building blocks, because some phenomenon in nature gets captured. And those become building blocks for yet more technologies.

In the "Cloud rEvolution" you describe the cloud as a domain. Can you explain?

Arthur: The steam engine, the transistor and the laser were major inventions, or building blocks. They were applied to areas such as computation, and as a result, the economy moved forward. Every so often, whole bunches of technologies form completely new clusters, which I call "domains." For instance, capacitors and transistors and resistors form a body of technology we call "electronics."



Innovation moves forward in two slightly different but overlapping ways. Sometimes we find something radically new, like the laser or the transistor, and it results in gizmos and gadgets, hence moving everything forward. Other times, whole groups of related technologies, or domains, emerge. Computing is a domain that emerged in the 1940s and has been morphing and building out ever since. Computing has deeply transformed all kinds of things across the economy, from transportation to shipping, to banking, accounting and printing, to running business processes.

Are you saying that cloud computing is affecting the global economy?

Arthur: Absolutely. The domain of computation is a whole cluster of technologies — servers, routers, the Internet, individual transistors, devices, methods, IT protocols — not just the computer. All of what's possible in that domain keeps changing every 10 or 15 years, and the newest morphing of computation is cloud computing. It's a whole collection of methods and technologies. It basically involves using a bunch of centralized servers and doing things remotely; being able to carry out operations very fast, and automatically, and in quasi-intelligent fashion. You don't have to sit at your computer and decide how all these processes are going to get done. The computation itself figures out what servers are going to operate and sets that up automatically.

Cloud represents a very important set of innovations because it's transforming the economy of computing and how computing is done. We don't have to have all that processing capacity sitting idly on our desktops or stored in our computers. It's a bit like airline ticketing. Ten years ago you would have to produce a paper ticket or e-ticket at the airport, and somebody behind a desk would look at it and process you. Now you flash a frequent flyer card under a machine, and all sorts of operations are remotely triggered that you don't see — and the machine spits out a boarding pass. Cloud computing means that a lot of computing — much of the economy — is occurring unseen and in places that are unlikely. Companies like Amazon and Google are providing much of this remote capacity. This is a huge transformation.

On the flip side, how is the economy affecting innovation?

Arthur: Economies may go through ups and downs, but innovation keeps going on. We always will have problems, as human beings with purposes and needs, and we always find new ways to fulfill those needs. So, even as everybody cuts back, cloud computing isn't going to be stopped because that's the next natural way of computing expressing itself.

Why did we develop cloud computing? The big driver of computation in the last two or three decades is not the computer, it's telecommunications. It's now costing us close to nothing to send messages anywhere, all over the world. It's as if the world economy is developing a nervous system where everything is becoming connected. And that means where business processes were independently carried out in the 1970s and 1980s, now they are interconnected and for almost no cost, and reliably. Suddenly it makes sense, for instance, for operations in Brazil to be using servers in Seattle.

This has led to cloud computing. In the 1970s, we had mainframes, but they didn't talk to each other. Then in the 1980s and 1990s we got workstations and PCs on our desks. They were everywhere yet still didn't talk to each other much until the 1990s when the Internet came into play. Today, everything is talking to everything. Some business processes, like moving packages along a conveyer belt, have to happen physically and locally. But everything else pertaining to computation — tracking, keeping track of records, directing machines — can be done remotely, very cheaply, in the cloud. And that's profoundly changing business.

What message would you like a C-level IT executive to take away from your book?

Arthur: Innovation isn't the invention of individual technologies, it isn't anything particularly mysterious. It's not a matter of thinking outside boxes, it's not some weird creative process. It's simply problem solving using options, actions and functionalities that already exist. ■

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