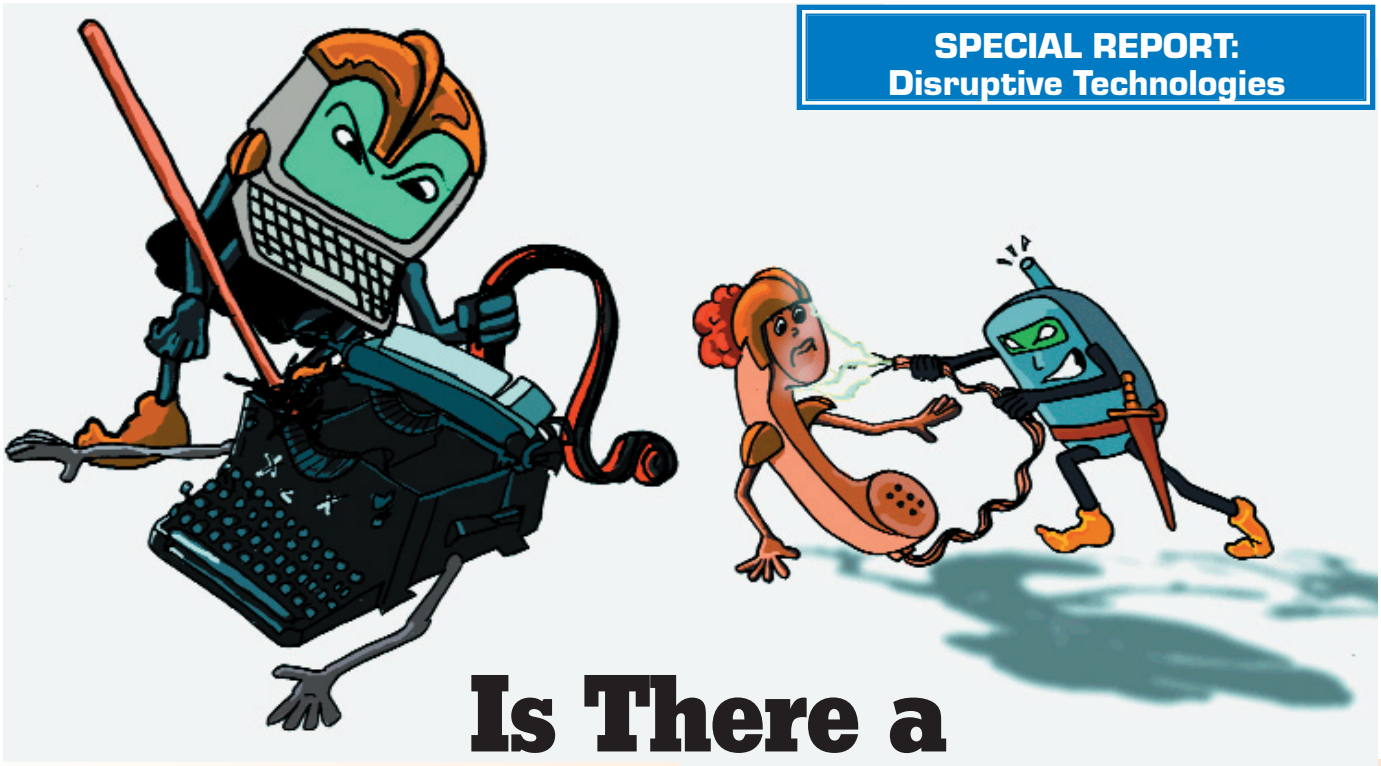


Is There a Disruptive Technology In Your Future?

Count on it. Although the problem is nobody really knows what a disruptive technology might be until it, well, begins to disrupt. National laboratories, research institutions and corporations are nevertheless in the throes of innovation. BY JOAB JACKSON

In 1894, when Italian Guglielmo Marconi invented a way to send messages through the air, the Italian government turned down his offer of first rights because it saw no use for the technology. After all, Marconi's crude prototype could only send signals a hundred yards—hardly a match for the increasingly popular telephone.

Who would have known such a weak transmission method would pave the way for everything from television to cellular phones? Even now, 100 years later, wireless is still opening up new markets and changing the way governments and businesses communicate and operate. Marconi's wireless invention represents what's called "disruptive technologies." These are technologies—the internal combustion engine, transistors and the personal computer, for example—that not only create new industries, but eventually change the world.

Disruptive technologies often come from outside the mainstream. The light bulb was not invented by the candle industry looking to improve output. Owners of established technologies tend to focus on making incremental improvements

to their own products, avoiding the potential threat to their own businesses.

Investors and entrepreneurs must keep track of movements outside established markets. Something such as the personal computer or the Internet is always just around the corner.

Two potentially disruptive technologies today are open-source software and nanotechnology. Each holds the promise of radically changing the landscape of information technology.

The concept of open-source software, for example, challenges many notions about how software should be created and sold. Linux, developed under the open-source license, is already provoking turmoil in the market for operating systems.

"If you are an entrenched proprietary software vendor, this paradigm shift can be alarming," said John Weathersby, chairman of the Oxford, Miss.-based Open Source Software Institute. However, companies that exploit the growing open-source software movement in government can crack new markets, especially in the Department of Defense, where numerous offices are using open-source solutions as low-cost alternatives to commercial software.

The same holds true for nanotechnology. Although still a few years out, nanotechnology can be exceptionally destructive as small, cheap computational devices are placed in everything from shoes to unmanned aerial vehicles.

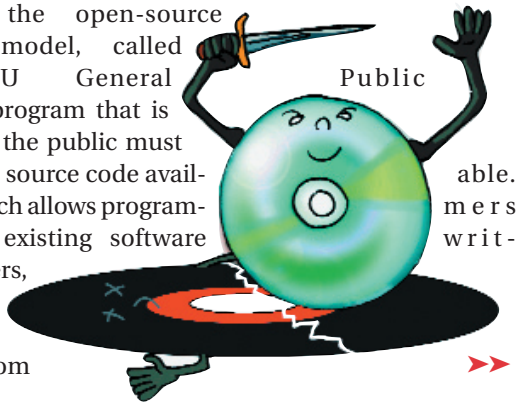
"It will cause people to rethink the potential of IT," said James Ellenbogen, senior principal scientist of the nanosystems group at the Bedford, Mass.-based Mitre Corp. "When you make something a thousand times smaller, you cross a transition line where things that formerly were impossible suddenly become obvious."

OPEN-SOURCE SOFTWARE: GROWING IN GOVERNMENT

When Weathersby founded the nonprofit Open Source Software Institute in 2001 to promote the idea of open source to government agencies, one of his first tasks was to determine how much this software actually was used in the public sector.

Use of open-source software in the government sector is difficult to quantify, because the software is usually not obtained through regular procurement channels.

Under the open-source licensing model, called the GNU General Public License, a program that is available to the public must also have its source code available. This approach allows programmers to modify existing software written by others, rather than having to write it from



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THE 'FATHER' OF DISRUPTIVE TECHNOLOGIES

Clayton Christensen

Clayton Christensen, a professor of business administration at the Harvard Business School, introduced the principles of disruptive innovation in his book, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (1997). The book helped managers understand how an organization that does everything right—listens to customers, keeps a close eye on the competitors, and invests heavily in technological advancements—may lead itself down a road to failure. When understood and applied, the principles can guide organizations to tremendous growth. The lessons he learned from his extensive research provide a framework for detecting and countering disruptive technologies.

Dr. Christensen has his own consulting firm, Innosight, LLC. The following review is taken from the company's web site, <www.innosight.com>.

WHAT YOU SHOULD KNOW ABOUT DISRUPTIVE TECHNOLOGIES

• **Technology just keeps getting better.** In every market, technology advances and improves—driven by a set of behavioral, economic, regulatory and institutional factors. Companies take advantage of this by offering better products at higher prices, and by listening to and targeting mainstream and high-end users.

• **Customers will use a technology, up to a point.** Technological progress inevitably reaches a point where it is far above what customers actually need and use. For example, Microsoft's Excel is a very useful piece of software, but how many of us use all of the bells and whistles that are packaged in it today? Many of us probably only need the basic functionality that enables us to create simple spreadsheets and perform non-complex calculations.

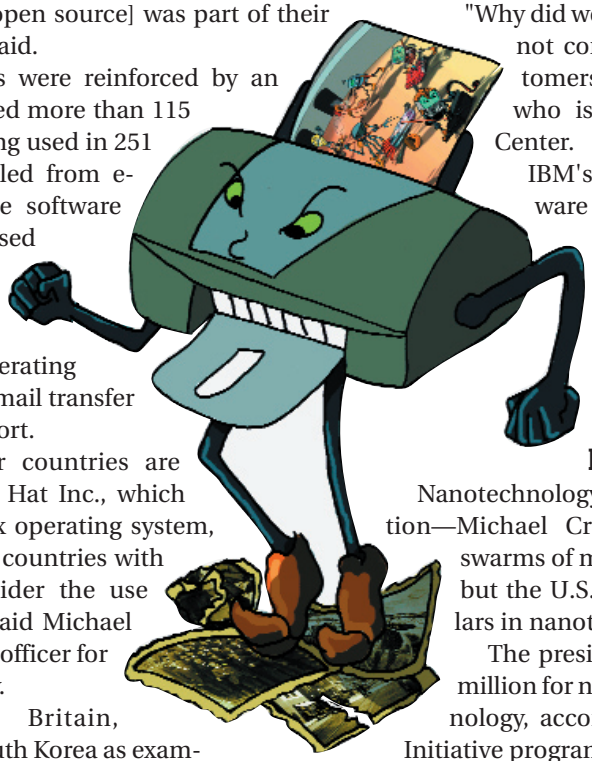
• **Overshooting customer needs enables disruption.** When the level of technological progress is far above what customers actually need and can use, the phenomena of overshooting creates the opportunity for an upstart to come in with something that's cheaper, simpler, and good enough for a set of customers who don't need the advanced technology. Once the entrant carves out a piece of the market on the low end, they

scratch. It also allows programs to be easily customized for end users. Most importantly, this approach has a powerful cumulative effect that has resulted in a large pool of high-quality, freely available software that can take the place of sometimes expensive commercial software.

Weathersby's organization worked with the Naval Oceanographic Office under a Navy Cooperative Research Development Agreement to find where open source was used within the service. Preliminary findings found that use of open-source software was extensive.

"IT departments were using free and open-source software ... but for the most part, the purchasing or policy-makers had no idea that [open source] was part of their IT structure," Weathersby said.

The institute's findings were reinforced by an Oct. 28 report that identified more than 115 open-source programs being used in 251 tasks. Results were compiled from e-mail surveys. Open-source software programs that are heavily used within Pentagon organizations include the Apache Web server, the Perl scripting language, the Linux operating systems and the Sendmail mail transfer agent, according to the report.



Governments in other countries are taking notice as well. Red Hat Inc., which sells a version of the Linux operating system, has counted more than 50 countries with policies in place to consider the use of open-source software, said Michael Tiemann, chief technology officer for the Raleigh, N.C., company.

Tiemann named Britain, Venezuela, Sweden and South Korea as examples. Some governments, such as China, deliberately use open source as an alternative to becoming dependent on U.S. commercial software companies. Having the source code on hand, officials can be more assured the software has no back-door entrances to allow spying or disablement. "If a country is building an information technology infrastructure from scratch, and it has an alternative of being completely independent, why would it become dependent?" Tiemann said.

Not that such enthusiasm hasn't met with resistance but commercial software vendors may find it difficult to compete with an identical product available for free, or one that allows for more customization.

With the growing popularity of Linux, for instance, companies are getting the message that "operating systems aren't tremendous value-adds," said Chris Willard, research vice president of International Data Corp., Bedford, Mass.

Not surprisingly, software giant Microsoft Corp. has mounted a campaign to discourage use of open-source software in the federal government.

"We consider Linux a competitive threat, but we are happy to compete," said Keith Hodson, a spokesman for Microsoft Federal. Because free software still needs to be supported with services, Microsoft's commercial products may have a lower overall cost of ownership, he said.

Many companies have been looking for other ways to work with the open-source model. For example, the bulk of Red Hat's revenue does not come from software sales, but from services it offers to support the software.

In December 2000, IBM Corp. announced that it would spend $1 billion in developing and marketing Linux-based servers, middleware and new technologies, such as grid computing.

"Why did we devote $1 billion to something we cannot control? It wasn't philanthropy. Our customers were demanding it," said Daniel Frye, who is director of IBM's Linux Technology Center.

IBM's strategy with Linux is to "sell the hardware under it, the software over it and the services around it," Frye said. Linux was a key component in the company's 2001 win of the National Science Foundation's three-year, $53 million grid computing project to tie together laboratories around the country.

NANOTECHNOLOGY: MAKING IT REAL

Nanotechnology may be best known in works of fiction—Michael Crichton's latest novel, *Prey,* features swarms of microscopic machines running amuck—but the U.S. government is investing very real dollars in nanotechnology research and development.

The president's fiscal 2003 budget calls for $710 million for nanoscale science, engineering and technology, according to the National Nanotechnology Initiative program office. [The bill that was passed in the Senate and House in the current session puts the National Nanotechnology Initiative into law and authorizes $3.7 billion over the next four years for the creation of the National Nanotechnology Coordination Office and the funding of federal government nanotechnology programs.]

First envisioned in the 1960s by physics academicians, nanotechnology is the technique of building devices on nanometer scale, or a billionth of a meter.

"The laws of physics are completely different at that level," said Philip Kuekes, chief architect at the research labs of Hewlett-Packard Co., Palo Alto, Calif.

Building devices from individual atoms promises no end of inventions. In his book, *The Investor's Guide to Nanotechnology and Micromachines,* Glenn Fishbine envisions a postage-stamp-size chemical analysis machine with protein, DNA and chemical sensors that can take a sample of blood and return a complete genetic analysis.

Paul Schneck, chief technical officer of Veridian Corp., Arlington, Va., foresees nanotechnology used to create microsized sensors that can be attached to unmanned

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aerial vehicles to gather environmental information in a theater of combat.

Although much nanotechnology research aims at enhancing the properties of clothing and other materials through molecular-level design, some researchers are developing tiny electronic devices that ultimately will extend the reach of information technology.

The Defense Advanced Research Projects Agency, or DARPA, is one of the prime movers in bringing nanotechnology-based computational devices to fruition. Its nanometer-scale molecular electronics program, which relies on universities and the private sector, has set an ambitious timetable to bring some basic components online.

Mitre Corp. is performing design, simulation and integration tasks for the program. It is part of a team that plans to deliver a nanocomputer memory in 2004. This working 16 kilobit nanomemory will be 10 microns by 10 microns, or about 30 to 100 times the density planned by the computer industry for its memories in 2004, according to Ellenbogen.

"This is not simply literature research and writing about nanocomputers. We're collaborating directly with groups that are fabricating nanomemory systems," Ellenbogen said. "From that experience, we can see that this program is going to succeed."

At the same time, the company also has begun developing a prototype of a millimeter-scale robot, about the size of a housefly, which will be driven by seven nanoscale computers, Ellenbogen said. "The goal is to see if you can have a nanocomputer network on a very small platform, This network has to work together to make the robot walk."

Raytheon was part of a team that also included MIT and DuPont that won a $50 million contract from the Army to establish the Institute for Soldier Nanotechnologies, an organization that will take basic nanoscale research and apply it to developing smart uniforms.

These uniforms, applied with nano-scaled sensors and coatings with uniquely customized properties, will be able to heal wounded soldiers, said Ned Thomas, director of the institute.

"YOU WANT TO KNOW where the guys are, what's wrong with them. You can even imagine the suit being activated to do something," Thomas said. "A soldier has a wound but is unconscious, so you send a signal to the arm of the suit to close down and make a tourniquet. "We're looking at the soldier as a system, even a system of systems," Thomas said.

"If you go look at MIT's vision of the suit, it really is the integration of a large set of different technologies," said Bruce Snider, director of science and technology initiatives for Raytheon's Tactical Systems Business Unit and program manager for the institute's work.

Other companies are jumping into the game with research into the manufacturing processes that will be needed to mass produce nanotechnology devices. Many companies see nanotechnology as a natural solution for the rising cost of a chip fabrication.

Today, according to industry experts, it costs a chip manufacturer an average of $3 billion to build a factory for a new line of computer microchips—a cost that is expected to exceed more than $10 billion in the coming years.

Plants now coming online can carve out features in silicon with a resolution of less than 100 nanometers, but, thanks to the industry's competitive drive, feature sets on the chips soon will be scaled down to the level of individual molecules (approximately 3 nanometers).

As the level of required precision increases, so will costs. Nanotechnology would provide an alternative to this increasingly expensive proposition.

IBM's research in nanoscaled technologies, if successful, would disrupt the entire semiconductor fabrication business with a cheaper way of building microchips, said Philip Wong, a senior manager of nanoscale materials, processes and devices at IBM's Research division.

"We're interested in developing new ways of building devices using molecular self-assembly. There are a lot of techniques that the chemistry world has been using that allow materials to assemble themselves," Wong said. By relying on natural chemical forces to forge components, the cost of production can be cut radically. TC

JOAB JACKSON IS A STAFF WRITER FOR *WASHINGTON TECHNOLOGY* MAGAZINE, FROM WHICH THIS ARTICLE WAS EXTRACTED.

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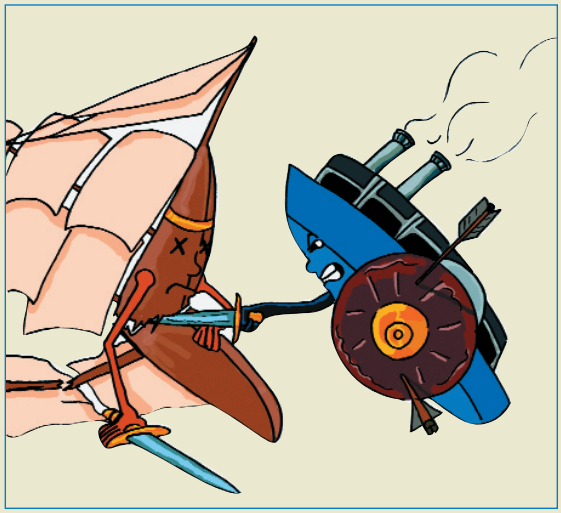
improve the "good enough" product, march upstream and can take a significant piece of market share away from incumbents. For example, think about discount brokerage companies disrupting full service firms with a simpler, cheaper, trading model.

• **But it's not really about the technology.** It's about the business model. Small, nimble, disruptive firms can succeed with business models that are unattractive to incumbents. If an incumbent requires a 40% margin on a product in order to support its operations and remain profitable, would they really encourage a product that might only have a 20% return? Whereas, for an upstart, that 20% might make them extremely profitable. But incumbents, don't give up! If you organize your operation properly, disruption will actually lead you to tremendous growth.

Some pertinent Christensen quotes:

"Identifying disruptive footholds for products means connecting with specific jobs that people—your future customers—are trying to get done in their lives. The problem is that in an attempt to build convincing business cases for new products, managers are compelled to quantify the opportunities they perceive, and the data available to do this is typically cast in terms of product attributes or the demographic and psychographic profiles of a given population of potential consumers. This mismatch between the true needs of consumers and the data that shapes most product development efforts leads most companies to aim their innovations at nonexistent targets. The importance of identifying these jobs to be done goes beyond simply finding a foothold for a new product. Only by staying connected with a given job as improvements are made, and by creating a purpose for your brand so that customers know what to hire, can a disruptive product stay on its growth trajectory."

—The Innovator's Solution: Creating and Sustaining Successful Growth, by Clayton M. Christensen and Michael E. Raynor (Harvard Business School Press, 2003).



"A dearth of good ideas is rarely the core problem for established companies. Potentially innovative new ideas seem inexorably to be recast into attempts to make existing customers still happier. We believe that many of the ideas that emerge from this packaging and shaping process as me-too innovations could just as readily be shaped into business plans that create truly disruptive growth."

—The Innovator's Solution

"The disruptive technology almost always takes root in a very undemanding application, and the established market leaders almost always try to cram the disruption into the established application. In so doing, they spend enormous amounts of money and fail.

"'Does this technology innovation constitute a threat to me or is it in fact a great growth opportunity?' If you look back in history, the disruptees always viewed new technology as a threat. In reality, they were all poised on the brink of a big growth opportunity. But because the way they reacted was first to discount this innovation as meaningful and second to frame it as a threat, they ended up getting killed. So the first thing is to look at disruptive technology as a growth opportunity and not as a threat.

"Now, there's a problem with this. There's a lot of work in cognitive psychology that suggests that if you take a phenomenon to somebody and pose it to him as a threat, it elicits a far deeper response than if you take the very same phenomenon and pose it as an opportunity. So there are deep reasons why people frame change as a threat. In fact, if a manager hopes to elicit an aggressive response, framing it as a threat is almost critical." *—Inc. Magazine, February 2002*

"A disruptive innovation is a technologically simple innovation in the form of a product, service or business model that takes root in a tier of the market that is unattractive to the established leaders in an industry. Very often this occurs at the low end of a market —that is how Toyota attacked General Motors, for example. Or it takes root by providing a simple and inexpensive product that enables a new population of customers to begin participating in a new application in the market—as was the case with personal computers.

"I don't feel that this concept of disruptive technology is the solution for everybody. But I think it's very important for innovators to understand what we've learned about established companies' motivation to target obvious profitable companies— and about their inability to find emerging ones. The evidence is just overwhelming."

—Inc. Magazine, February 2002

"There are many methods for searching for innovative new products and service ideas. While each has its strengths and weaknesses, in our experience most senior managers' assessment is that the weakness of many methods outweigh their strengths. We believe that a fundamental, underlying cause of the weakness in so many innovation efforts is that innovators' view of customers, markets and competitors is formed from the supplier's perspective. They have not worked to define the world in the ways that customers see it. In our experience, trying to understand what jobs customers hire particular products and services to do for them is a method that has a much higher probability of creating exciting, market share-changing new products and services—because when it is executed correctly, it focuses innovators on developing precisely the attributes and functionality that the precise job that the customers need to have done."

—From the research paper, Disrupting Mobile Commerce, by Carl Johnson, Michael Overdorf and Clayton Christensen ©2000 Innosight, LLC