

Information Technology and Sustainability: Enabling the Future

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The information technology (IT) industry (hardware, software and services) has provided many tools to help generate and process data, communicate globally, and improve productivity. However, all the rapid advances in this sector have not made society more sustainable, in terms of financial, ecological and social measures. Yet, since the IT industry has provided many tools to track, measure, and broadcast the financial performance of companies, IT companies are in a strong position to provide tools to understand, track, and address the social and ecological performance of business.

The core argument of this article is that there is potential for IT to transform modern business into a more efficient, cyclical, networked, and sustainability-oriented system that pays returns through economic, ecological, and social prosperity. The article presents strategies and opportunities for the IT industry to become a leader in enabling both business and society to move towards sustainability. It also offers a new vision for the IT sector—as the source of innovation and tools for advancing society towards sustainability and building strong, prosperous sustainability-oriented businesses.

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“Foresight is the key to survival. Managers able to perceive trends and weak signals where others see only noise or chaos can capitalize on the changing nature of the market to reposition their firms before new entrants become a serious threat.... Today’s corporations can seize the opportunity for sustainable development.”

- Stuart Hart and Mark Milstein. MIT Sloan Management Review (1999)¹

When the excitement of the internet’s “information superhighway” abated and the downturn began, companies with vision began to focus on perceiving and investing in new trends. One of these new trends is sustainability-oriented business, which considers, addresses, and devises solutions to prevailing ecological, social, and economic problems. Businesses that integrate sustainability into strategy and operations seek to ensure economic, environmental, and social returns for both *shareholders* and *stakeholders*.

The information technology (IT) sector is uniquely positioned to realize new opportunities from this shift to sustainability-oriented business. The need is growing for IT systems that can capture, manage, and integrate a complex range of economic, ecological, and social information for use in core business strategy and operations decision-making.

Leading companies such as Hewlett Packard, Ford Motor Company, and DuPont are all exploring how to apply sustainability factors to supply chain logistics and product design. These firms are part of the first stages of a larger transition from environmental management to sustainability-oriented strategy and operations. An increasing number of analysts assert that this shift is becoming integral to

¹ Hart, Stuart and Milstein, Mark. “Global Sustainability and the Creative Destruction of Industries.” Sloan Management Review. (Fall 1999): 24.

corporate success in the changing context of the 21st century.²

As both multi-national companies and governments further explore realizing sustainability returns—measured by financial, environmental and social parameters—there will be a growing need for managing complex data sets. The challenge will be tracking and integrating different types of information related to dynamics within ecological, social, and economic systems that affect businesses.

Technology Sector:

High Tech and IT Definitions

High Technology and Information Technology (IT) are generally defined as the technology for using, creating, storing, and exchanging information in a digital format. The industry is typically broken into three sectors: hardware, software and services. There exists a growing list of various sub-sectors as well.

What is the value of the market?

In 1999, the Information and Communication Technology (ICT) market was valued at over \$2 trillion worldwide, and growing rapidly.

(Source: World Information Technology and Services Alliance. 2000. “Digital Planet 2000.”

Whereas many of today’s companies track linear flows, of inputs and outputs, tomorrow’s sustainability-oriented businesses will incorporate cyclical flows in the development, delivery and “reverse logistics” related to returning and re-using products at the end of their use by consumers. IT will become essential to this shift by providing the information

² Hart, Stuart. 1997. “Beyond Greening: Strategies for a Sustainable World.” Harvard Business Review. 75(1): 66-76; Hawken, Paul, Amory Lovins, and L. Hunter Lovins. 1999. Natural Capitalism: Creating the Next Industrial Revolution. Boston: Little and Brown Company; Senge, Peter and Goran Carstedt. 2001. “Next Industrial Revolution.” Sloan Management Review. (Winter): 24-38.

architecture to enable the cyclical flow of data through businesses.

Similar to the period of integrating internet technology into business operations, the expansion of IT and sustainability tools will have early adopters and latecomers. The early adopters will embrace the possibilities and innovate new trends. The latecomers will be either companies without resources or wedded to old ways.

This article describes some of the sustainability issues that present IT firms with both opportunities and risks. It is intended to begin a discussion about a new vision for the role of information technology in 21st century business.

21st Century Business, Sustainability and the Pivotal Role of IT

“...[W]e have become increasingly aware of an inescapable and disturbing fact: We will not be able to sustain our businesses over the long haul because they are based on two assumptions that no longer hold. One is that cheap, unlimited supplies of hydrocarbons and other non-renewable resources will always be available. The other is that the earth’s ecosystems will indefinitely absorb the waste and emissions of our production and consumption”

- Chad Holliday, CEO, DuPont. Harvard Business Review (2001)³

A growing number of companies are looking to sustainability as a way to increase overall value and gain competitive advantage.⁴ Brit-

ish Petroleum, DuPont, IKEA, McDonalds, Nike, Royal Dutch Shell, and Starbucks are a few of the companies exploring applications of sustainability to their businesses. Why? Sustainability practices increasingly make business sense.

Sustainability-oriented companies focus not only on economic performance, but also social and environmental performance. Investments in all three areas—as an integrated approach to business decision-making—are paying off in the form of:

- *Innovation*
Sustainability-oriented companies continually position themselves to perceive of, and adapt to, competitive pressures and changing contexts.⁵
- *Operational efficiency*
Sustainability-oriented re-design and re-engineering of products can significantly cut operational costs, including material and energy use.⁶
- *Brand equity*
The enhanced brand equity and reputation that comes with more sustainable business practice attracts customers and talented

“Integrating Environmental And Social Issues Into Corporate Practice.” Environment. 42 (5); Halme, M. and J. Niskanen. 2001. “Does Corporate Environmental Protection Increase or Decrease Shareholder Value? The Case of Environmental Investments.” Business Strategy and the Environment. 10: 200-214; Holliday, C. 2001. “Best Practice Sustainable Growth, the DuPont Way.” Harvard Business Review. (September): 129-134.

⁵ A UK study by Innovation through Partnerships showed that the core of innovation is a dynamic and resilient relationship between a company and its stakeholders (www.innovation-partnership.org).

⁶ Numerous organizations have cut operational costs through sustainability-oriented practices. For example, 3M saved more than \$810 million since 1975 through its “Pollution Prevention Pays” program (www.3m.com/profile/evt/3t.html) and Interface saved more than \$165 million between 1994 and 2000 by reengineering production and redesigning processes to reduce waste (www.interfaceinc.com).

³ Holliday, Chad. 2001. “Sustainable Growth, the DuPont Way.” Harvard Business Review. (September): 129-134.

⁴ For examples, see: Altomare, Mary and Brian Natrass. 1999. The Natural Step for Business. British Columbia, Canada: New Society Publishers; Haverman, Mark and Dorfman, Mark. 1999. “Breaking Down the ‘Green Wall: Early Efforts at Integrating Business and Environment at SC Johnson.” Corporate Environmental Strategy. 6 (1): 4-13 Hoffman, Andrew J. 2000.

employees while increasing shareholder value.⁷

- *Lower risk*
The stakeholder engagement and environmental process focus of sustainability-oriented companies decreases risks of public relations disasters, fines, boycotts, and clean-up costs.⁸
- *Talent*
Sustainability-focused firms find it easier to attract and to retain talent.⁹

⁷ A study by Cone-Roper found that 86% of consumers have a more positive image of a company if they see it doing something to make the world a better place (E. Creyer and W. Ross, "The Influence of Firm Behavior on Purchase Intention: Do Consumers Really Care About Business Ethics?" *The Journal of Consumer Marketing* 14(6) 1997). A DePaul University study found that the average reputation score for a company with a strong commitment to business ethics was between 4.7% and 6.7% higher than for companies without this commitment (C. Verschoor, "A Study of the Link between a Corporation's Financial Performance and Its Ethics," *Business and Society* 1998).

⁸ According to an IFC Kaiser study, "both an improved environmental management system and improved environmental performance result in significant reductions in a firm's Beta," reducing systematic risk about 13% and, along with it, reducing cost of capital from 13% to 12.34% (see S. Schaltegger and R. Burritt, *Contemporary Environmental Accounting: Issues, Concepts, & Practice* (Greenleaf 2000)). A study on the effects of the Superfund in the United States found that 62.5% of banks analyzed had rejected loan applications because of the possibility of environmental liability (Schaltegger and Burritt). Following allegations that Talisman Oil was helping to finance human rights abuses in Sudan, a large number of pension funds publicly divested their stock of the company ("Halting Sudan's Slavery and Slaughter," *Boston Globe*, November 8, 1999).

⁹ A Rutgers University study found that firms applying "high performance work practices" have a 7.05% decrease in employee turnover with a \$3,814 increase in profits per employee (see M. Huselid, "The impact of human resource management practices on turnover, productivity, and corporate financial performance," *Academy of Management Journal* 38(3), 1995). A Students for Responsible Business study found that 82.7% of MBA respondents would choose an offer for a more socially responsible company if the salaries offered were equal and more than 50% were

- *Shareholder value*
Research shows that companies pursuing sustainability-oriented business strategy have greater shareholder value than their peers.¹⁰

It is not surprising that sustainability-focused business practice increasingly makes economic sense. All businesses and economic systems operate within—and are fundamentally reliant upon—social and ecological systems. Corporate value creation has always been affected by three dimensions—of environmental, social, economic—rather than one. Social unrest and environmental problems have effects on business. The challenges faced by builders and contractors in contaminated neighborhoods reveals the direct links between the environment and the economy. The workers' rights issues that Nike and Gap have faced clearly show that social performance matters in how firms are perceived. In sum, environmental and social issues affect the bottom line, whether or not they are captured on balance sheets. Forward-looking business people are recognizing these additional dimensions as essential to business.

willing to take a lower salary to work for a company with a good SD reputation (M. Albion, *The Future of Socially Responsible Business: MBA Students Speak Out* 1996).

¹⁰ An IFC Kaiser study of 330 companies within the S&P 500 found that a 50% improvement in environmental management systems and environmental performance resulted in a 13.2% decrease in Beta, a measure of sensitivity of stock used by analysts (P. Ameer, S. Feldman, and P. Soyka, *Does Improving a Firm's Environmental Management System and Environmental Performance Result in a Higher Stock Price?* For IFC Kaiser, November 1996).

The Role of IT in Enabling the Shift to Sustainability

Information technology is positioned to play a key role in facilitating the shift toward sustainability-oriented business. As the use of IT in business grows—and both public and private demand for environmental and social responsibility increases—the need for effective sustainability-oriented IT systems will similarly expand. Figure 1 outlines a few of the present and future uses for IT in enabling sustainability.

Through R&D innovation and entrepreneurship, the IT industry has the opportunity to provide leadership and create solutions that will revolutionize the industrial system and address core 21st century environmental and social concerns. IT can enable the shift from a “take-make-waste” economy to a closed loop system, by providing the necessary information flows that will enable cyclic industrial systems that use waste from some processes as inputs for other processes. In addition, IT can enable further information sharing and innovation related to eliminating the use of toxic,

Figure 1
A View of Future Information Technology’s Sustainability Tools

IT applications that are...	Tools that will help to...
Presently available	<ul style="list-style-type: none"> • Track and enable compliance with regulations; • Reduce risks; • Increase eco-efficiency by assessing and decreasing life-cycle costs.
Currently in development and/or early models in existence	<ul style="list-style-type: none"> • Track the full life cycle of product and service inputs, flows, and impacts; • Enable sustainability-oriented product design by engineers and product designers; • Create “green chemistry” and sustainable materials quality databases and services; • Increase innovation and creativity, through other easily accessible sustainability information sources, improved searching functions of internet, and more on-demand software capabilities; • Develop waste e-trading marketplaces in which companies can sell their “waste” products as raw material (“inputs”) for other companies manufacturing process; • Establish, and widely use, more sustainable circuits/chip manufacturing processes.
Future areas of innovation	<ul style="list-style-type: none"> • Engage stakeholders on sustainability issues and concerns; • Facilitate sustainability-oriented supply chain system decision-making; • Create waste trading industrial clusters of closed loop manufacturing.

persistent, and bioaccumulative materials and inputs. Within such systems, and re-considered design and business propositions, both waste and hazardous pollution can become non-existent. Simply stated, IT could link sustainable processes to sustainability-oriented products, the local to the global, and the present to the future.

Business Opportunities for IT Related to Sustainability

Strategies for Moving Forward

Think of “e-sustainability” as using information technology tools—from sensors to databases and websites—to integrate sustainability factors into business operations. Just as using the internet dramatically altered business strategy and operations, using IT tools for “e-sustainability” will require re-thinking traditional business models. In place of the current market role, a more integrated, systems-based economy will develop over time. To achieve this transformation, the capabilities of the IT sector will be expanded significantly.

For example, researchers at the Massachusetts Institute for Technology (MIT) are creating new identification tags to track products throughout their lifecycle. These tags could assess interactions between products and the environment while sending this data to various systems. Other opportunities exist in the role of IT in enabling a switch from products to services, such as through computer leasing programs, which create long-term service-based customer relationships. Already, many applications are available, but the real integration of sustainability concepts in IT and business is still to come.

Four strategies can be used to further develop this field and create economic, social, and environmental value through the use of information technology:

- **Strategy 1: Build a *Real* e-Company: Dematerialize and Digitize**
Technologies available today are ripe for

application throughout any company or office, such as through dematerializing products, digitizing documents, and teleconferencing or netcasting meetings.

- **Strategy 2: Maximize Efficiency**
Efficiency—through sensors and computerized control of energy and material use—can provide a range of environmental benefits. For example, a new generation of computerized controls with sensors and information flow could enable variable speed motors and continual adjustments to minimize energy use.¹¹ The gains could be significant as motor systems account for 50% of total energy use in the U.S.¹²
- **Strategy 3: Create Tools for Sustainability**
Combining software, networks, and sustainability-oriented thinking has the potential to create powerful tools for more sustainable businesses. Designers and engineers could use sustainability-focused databases and software to improve product design and/or dematerialize products into services. Companies could easily apply new IT tools for managing the supply chain in terms of minimization of ecological and social impacts.
- **Strategy 4: Network with Nature and Re-Design Products into Services**
IT systems can capture information about how the ecological systems work, which can then be used to build better businesses. That is, natural systems can show, and inspire, smarter, more connected systems. Nature also offers examples of smarter materials and production methods, which businesses can apply through biomimicry techniques, which seek to mimic natural processes.¹³

¹¹ Green Business Letter (November 2000).

¹² <http://www.oit.doe.gov/bestpractices/motors/>

¹³ Benyus, Janine. 1997. *Biomimicry*. New York, New York: William Morrow and Company.

These four strategies present enormous opportunities for visionary leaders to reap market advantage by integrating sustainability into IT business models, products and services.

Already, a small number of early adopters exist. The following sections illustrate how companies are beginning to apply elements of each strategy and finding real, financial, and bottom-line benefits.

Build a Real e-Company: Dematerialize and Digitize

What may seem like very standard applications of IT—telecommuting, electronic documentation, file storage, and intranet sites—are only recently being used by companies for their full potential benefits.

For example, electronic documentation is resulting in considerable paper savings. By storing files on laser disks or other electronic media, sending manuals in electronic format, and offering customers online records, businesses can save large quantities of paper, staff time, and money. In addition, through a shift to electronic record storage, companies have the potential to also save money in reduced warehouse space. Figure 2 highlights a few other efforts in which IT tools are being used to save money and move in a more sustainable direction.

These measures represent sound first steps. However, to truly build a company that takes advantage of information technology for sustainability purposes, businesses should consider turning products into services.

Maximize Efficiency

A Fall 2001 *Business Week* special issue described the current period as the “era of efficiency.” According to the journal, the most successful companies are the ones that, “either achieved the efficiency long promised by the technology revolution or that sell products and services that help others improve their

bottom line.”¹⁴ The number one company on that issue’s “Top 100 Info Tech” list was Celestica, which uses IT to stay extremely lean, fast, and efficient. As *Business Week* points out, “Having all the plants wired proved critical. Celestica keeps one huge database of parts it buys...” Celestica is using IT to do more work, but IT systems can also be an effective tool in becoming more energy efficient or reducing waste.

Figure 2
Profits for People, Planet and Company:
IT innovators

- XEROX remanufactures or recycles 95% of their **electronics equipment**. This effort saves several hundred million dollars annually and keeps millions of tons of waste from the landfill.¹⁵
- Weirton Steel Corporation installed **computerized controls and sensors**, which saves \$12 million annually on fuel and is polluting less.¹⁶
- Estee Lauder used a **reverse logistics software application** and saved over \$30 million in one year from reduced volume of destroyed products, while also preventing the materials from going into a landfill.¹⁷
- AT&T initiated a **telework program**, saving the company \$125 million per year in reduced real estate costs and increased productivity. Plus, there is the added environmental benefit from keeping cars off the road.¹⁸

¹⁴ Burrows, Peter. 2001. “The Era of Efficiency.” *Business Week*. (June 18): 92

¹⁵ Cramer, Jacqueline and Ab Stevels. 2001. “The Unpredictable Process of Implementing Eco-efficiency Strategies,” in Charter, Martin and Ursulat Tischner. (editors.) *Sustainable Solutions*. London, England: Greenleaf Publishing: 327.

¹⁶ U.S. Department of Energy, Best Practices Case Study. <http://www.oit.doe.gov/bestpractices/pdfs/weirtonm.pdf>

Another example of growing use of IT for efficiency is evident in use of computers in automobiles. Systems like those that control the energy flows of Rocky Mountain Institute's "HyperCar" provide a crucial element in the new generation of hybrid vehicles.¹⁹ The Toyota Prius, a hybrid vehicle, uses an on-board computer that factors in inputs from the battery, accelerator pedal, engine, and other parts prior to selecting the energy source that will maximize efficiency. Toyota's website claims the Prius' computer system is, "like having an efficiency expert onboard at all time."²⁰

The market in new "clean" transportation is predicted to grow from \$2 billion today to \$10 billion in 2005 and \$48 billion by 2010.²¹ IT systems will play an important role in guiding both the development and deployment of clean transportation technologies.

Since motors account for over 50% of total U.S. energy use, one of the most powerful uses for computerized efficiency-oriented controls is clear. Motors traditionally have just two settings, off and on. However, sensors and computer-based controls can create variable speed motors that can cut the energy use—and accompanying emissions—in half.²² Pairing new variable speed motors with a networked system of sensors and computer controls allows for much higher energy efficiency. Sensors throughout the supply chain and manufacturing process can provide real time information flow.

¹⁷ Caldwell, Bruce. 1999. "Reverse Logistics." Information Week. (April 12)

<http://www.informationweek.com/729/logistics.htm>

¹⁸ <http://www.att.com/telework/>

¹⁹ <http://www.rmi.org/sitepages/pid386.php>

²⁰ <http://prius.toyota.com/technology/control.html>

²¹ Clean Edge. 2001. "Clean Tech: Profits and Potential." <http://www.cleantech.org/>

²² Kelly, Henry. 1999. "Information Technology and the Environment: Choices and Opportunities." Information Impacts Magazine (October). http://www.cisp.org/imp/october_99/10_99kelly.htm

All of these factors are increasingly critical, as Vinod Khosla asserts:

"Corporations will not be competitive five years from now unless they have near-real-time information systems."²³

One company that has implemented exactly such a system is Weirton Steel Corporation, the 8th largest U.S. steel producer. Within two years of replacing antiquated control equipment with computerized controls, the plant has been able to achieve a 30% reduction in blast furnace gas and waste steam releases and a 50% reduction in the amount of fuel it purchases. In fuel savings alone, Weirton has reached \$12 million in annual savings. Weirton has gone one step farther and created a networked system that will allow real-time communication between 22 different operating units. In so doing, Weirton will be able to continuously evaluate and optimize flows, thus continuing to save on energy, emissions, and fuel costs.²⁴

As corporate transparency is increasingly demanded in a post-Enron era, and as the parallel trend of corporate social responsibility reporting also grows, information flow in the coming years will include many aspects of operations. Another layer of information flow within businesses will relate to complete understanding of, and accounting for, a firm's environmental and social impacts. Sustainability-oriented IT systems are an essential way to enable this task, particularly within large multinational firms.

Create Tools for Sustainability

After the foundations of hardware and operating systems were firmly established in the late 20th century, software applications

²³ Quote of Vinod Khosla, partner with Kleiner Perkins Caufield & Byers, in Luc Hatlestad. 2001. "On the Shoulders of Giants." Red Herring. (May 1-15): 170-174.

²⁴ U.S. DOE, Office of Industrial Technologies. 2000. Best Practices Management Case Study. (December)

emerged to enable customer relationship management, supply chain management, e-commerce, and many other business functions. Every new category brings a host of competing designs.

There are a growing number examples of early forays into the field of software for sustainability-oriented business, including:

Logistics Tracking

One study by AT Kearney, estimates that inefficiencies in supply chain can waste up to 25% of a company's operating costs. Therefore, even a 5% reduction in waste throughout the supply chain can double a typical company's profit margins.²⁵

Examples of sound investments in logistics systems abound. Estée Lauder spent \$1.3 million on a reverse-logistics IT system of scanners, business-intelligence tools, and a data warehouse. In the project's first year, it recovered more than it invested in the effort through reduced staffing and decreased costs. In addition, destroyed products—that end up in landfills—plummeted from approximately \$60 to \$30 million a year.²⁶

Home Depot also found a creative application for IT in the supply chain. By having sales associates walk through the aisles and electronically record what needs to be restocked, the company has virtually eliminated their need for warehouse space. Eighty-five percent of their merchandise moves directly from manufacturer to retail store, saving energy-using storage space and transportation costs.²⁷

Increasing efficiencies in these ways is the first step to integrating sustainability factors into the business. IT is enabling this shift.

²⁵ <http://www.bsr.org>

²⁶ Caldwell, Bruce. 1999. "Reverse Logistics." Information Week. (April 12)
<http://www.informationweek.com>

²⁷ Cohen, Nevin. 1999. "Greening the Internet: Ten Ways E-Commerce could Affect the Environment and What We Can Do." Information Impacts Magazine. (October).

Data and Knowledge Management

The companies that create systems to capture sustainability information flow will become invaluable in the future. The field is already growing.

For example, Ecos Technologies, created a "Knowledge Management System" to track environmental information flows. Their software system is helping large businesses, such as Timberland and Unisys, in supply chain management, decision-making, and product design. Natural Logic is creating a software system for assessing flows, as are other entrants into this expanding field.

Product (Re)Design

A product design tool that could integrate environmental and social considerations into engineering plans could offer an invaluable resource to companies. However, one of the current obstacles to creating sustainability-oriented products is the time and expense required to gather information and conduct analyses, such as life cycle assessments. This issue offers a number of business opportunities for software and computing power for assessing products.

For example, researchers at Carnegie Mellon's Green Design Initiative²⁸ have developed a software program to measure the environmental impact per dollar of product. In addition, the Alliance for Environmental Innovation has created an IT-enabled tool to guide designers in selecting the least environmentally damaging material, process, and products to use.²⁹

In the future, sustainability software programs will include additional components, such as assessing working conditions in the country where materials and products originate and considering various measures of sustainability on an array of materials and products.

²⁸ <http://www.cc.cmu.edu/GreenDesign/>

²⁹ <http://www.aci.org>

Network with Nature and Re-Design Products into Services

One of the most exciting new strategies in business today—used in companies from Interface carpets to engineering firm CH2M HILL—is to learn from nature how to build better products and improved business models. Janine Benyus details the concept of designing with nature in mind in her 1997 book *Biomimicry*.³⁰ Mimicking nature’s approaches to solving problems can be readily applied to IT systems to create new business opportunities.

Learning from Nature: Potential Biomimicry Applications

- **Cell Membranes:** A design for a filter desalination devices
- **Mussel Adhesive:** An underwater adhesive that works without catalysts or primers
- **Teeth and Bones:** Layering technique for 3-D structures
- **Mother of Pearl:** Super strong coatings for airplane wings and cars

(Source:
http://www.biomimicry.org/case_studies_materials.html)

For example, a business can start by asking completely new questions, such as: What can a computer chip learn from the cooling systems used by a leaf? What can computer networks learn from ant communication systems? These questions are not as far out as they may seem, and scientists and business leaders are already considering possible answers.

Ants have emerged as a possible source of inspiration for innovating faster networks. Ant communication models are based on chemical signals, which are used to determine the most efficient pathways to gather food and supplies. The power of ants’ approach to conveying information is in “swarm intelli-

gence,” in which large numbers of local interactions can lead to global problem solving.

This observation has led to the idea that “virtual ants” can be set loose as well, gathering and sorting information from databases. With such a model, web search engines could become more useful and more organized. According to Steven Johnson, author of the 2001 book *Emergence*, ants build “a system where macro-intelligence and adaptability derive from local knowledge.”³¹

Several information technology companies are currently assessing how to merge ant models into business ideas. The BiosGroup, a Santa Fe, New Mexico-based company that develops science-based software, has studied ant behavior to develop optimization software for supply networks. Their clients include Ford Motor Company and Southwest Airlines, among other Fortune 1000 companies.³² Other companies are considering ant behavior as a model for organizing the web, peer-to-peer computing, and even, urban planning.³³

Nature can also play a role in computer hardware design through applications of biomimicry (see adjacent box).

In addition, scientists are exploring ways in which manufacturing can be more intelligent and have less impact. For instance, Xerox PARC researchers are creating “smart matter” and devices that allow microscale optical and mechanical systems to take the place of traditional manufacturing systems.³⁴ DuPont has already created a complete chemical plant on just three silicon wafers capable of synthesizing 18,000 kg/yr of chemicals.³⁵ From an en-

³¹ Johnson, Steven. 2001. *Emergence*. New York, New York: Scribner.

³² <http://www.biosgroup.com>

³³ Hafner, Katie. 2001. “Better Networks: Look to Nature” *New York Times*. (September 13): D1-D6.

³⁴ <http://www.parc.xerox.com/projects.html>

³⁵ Sheats, James. 1999. “Information Technology and Sustainable Development.” In Dorf, Richard C. 2001. *Technology, Humans, and Society: Toward a Sustainable World*. San Diego, California: Academic Press.

³⁰ Benyus (1997).

vironmental standpoint, this process has several benefits, including the reduction of storage, transportation, and excess use of chemicals. In addition, a microscale plant might be able to use ingredients available almost anywhere—such as sunlight, water, and air—to innovate substitutes for the many petroleum-derived chemicals currently in the industrial system. The potential for transitioning the chemical industry towards a more biologically-based industry—using sustainable natural resource management practices—is an area for further research.

These measures represent sound first steps. However, to truly build a company that takes advantage of information technology for sustainability purposes, businesses will have to consider turning products into services.

Traditionally, the purchase of new products—such as, computers, desks, and office carpeting—has involved a one-time cost resulting in ownership of an item and the responsibility for disposal at the end of its use. This model has created an economy where a mere 1% of the materials used in America remains in use six months after they are sold.³⁶ What will transform this “take-make-waste” economic system is a more dematerialized, service-oriented, cyclical economy.

A growing number of products are becoming dematerialized and even “servicized” as companies consider fundamentally transforming their business models from product-makers to service-providers. This service model offers a key benefit of establishing long-term relationships with clients, as products are longer-lived and companies offer on-going support and maintenance. The real engine underlying this business model is information technology. Ensuring ongoing information flows will be crucial to the provision of quality service.

³⁶ Hawken, Paul, Amory Lovins, and L. Hunter Lovins. 1999. *Natural Capitalism*. New York, New York: Little, Brown and Company: 152

One early example of a shift to a service-oriented business is the replacement of car ownership with “car sharing.” In cities around the world—including Paris, Tokyo, and San Francisco—car share programs have been established to offer inexpensive access to cars for short periods without paying for insurance or other associated expenses of ownership. At City CarShare in San Francisco, cars are reserved through an internet reservation system that can immediately locate which parking lots have cars available for use. Drivers are given an electronic key with a computer chip inside.³⁷ This type of information system—that captures data and transmits it throughout a networked system—offers an example of how IT can enable the transition from a product to a service-based business model.

However, even the most cyclical service-based company may not be sustainable without attention to addressing human needs and social issues. Indeed, meeting basic human needs may become a core business strategy of a sustainability-oriented company.

Information technology can, and already is, providing a necessary tool for the integration of social aspects of sustainability into business. For example, World Resource Institute’s Digital Dividend website maintains a clearinghouse of projects focused on bridging the digital divide, the gap between those with access to digital information and those without, through technology and business.³⁸ Hewlett Packard has begun to consider how to meet the information needs of the 4 billion humans on the planet without access to computers as a business strategy.³⁹ The company’s “e-Inclusion Solutions” project is aimed at creating profitable solutions for bridging the gap between technology-rich and technology-poor countries. Current approaches include establishing an internet center in Ghana and using

³⁷ <http://www.sfcarsshare.org>
³⁸ http://wriw1.digitaldividend.org/wri/app/navigate?_form=desktop&_action=Projects
³⁹ <http://www.hp.com/e-inclusion/en/>

handheld computers with coffee farmers in Costa Rica to help them achieve organic certification.

Innovating for Sustainability

A number of IT companies have begun to address various aspects of sustainability. Rolltronics is taking the lead in sustainable manufacture of semi-conductor devices and is making an integrated effort to define and improve its triple bottom-line by:

- Developing technology that is "cradle to cradle";
- Avoiding use of lead in their products;
- Decreasing energy used, by working with temperatures under 250 degrees F compared to industry standard of 700 degrees F;
- Using completely recyclable PET plastic film;
- Shrinking the ecological impacts and "footprint," by manufacturing in one small plant compared to industry standard of many large dispersed plants;
- Making its employees owners/partners.

The Rolltronics model clearly illustrates that Silicon Valley has visionaries who are trying to fully drive sustainability through their businesses. Figure 3 (next page) offers a list of illustrative approaches to applying sustainability within IT companies.

The field of IT and sustainability also offers numerous opportunities in governments and

communities as well as corporations. For example⁴⁰:

- **LINCOS** (**L**ittle **I**ntelligent **C**ommunities – www.lincos.net/html/eng/menu.html) is a new effort by *Fundación Costa Rica Para el Desarrollo Sostenible* that uses shipping containers that convert to a wireless communications office. The networked, portable offices are used for telemedicine, soil and water analysis, and educational resources in Costa Rica and the Dominican Republic. Hewlett Packard and MIT Media Labs have helped implement the project.
- **Greenstar** (www.greenstar.org) creates solar energy powered community centers with connections to the internet for a growing list of rural areas, including parts of India, Jamaica, and Ghana.
- **TaraHaat** (www.tarahaat.com) is designed to help rural Indians, with visuals and audio for illiterate users, as well information on farming, education, and jobs.

These strategies—of building a real e-company, maximizing efficiency, creating tools for sustainability, and networking with nature—all offer immediate pathways forward. The examples to date are just the tip of the iceberg related to opportunities for IT in enabling sustainability.

⁴⁰ Many additional examples are developing and documented at the Centre for Sustainable Communications website, a UK-based nonprofit. The website also discusses the opportunities for decreasing the environmental impacts of computer hardware. www.sustainit.org

Figure 3
Illustrative Approaches to Applying Sustainability Concepts to IT Businesses

CREATING IT SYSTEMS TO MONITOR ENVIRONMENTAL DYNAMICS

- Conservation International has partnered with Intel to create maps of biodiversity “hotspots” for use in planning conservation efforts.⁴¹
- Opportunities exist for IT-enabled precision agriculture and forestry techniques.⁴²

DEVELOPING SOFTWARE TO INTEGRATE SUSTAINABILITY INTO DECISION-MAKING

- Integrating environmental management functionality into Enterprise Resource Planning (ERP) systems, SAP has already launched their Product Lifecycle Management tool.⁴³
- Companies such as Ecos Technologies, Natural Logic, Greenware, and EcoStream are all creating new tools to manage environmental information while saving time and increasing value.
- The MERGE tool, created by the nonprofit Alliance for Environmental Innovation, enables product designers to gauge environmental impacts while developing the product, allowing for cost savings and environmental benefits.

ENABLING INFORMATION TRANSFER THROUGH ON-LINE SYSTEMS

- U.S. Department of Energy Best Practices Database (<http://www.oit.doe.gov/bestpractices/>) offers tools and case studies for improving energy efficiency in business.
- ThinkCycle, an online “collaborative design space,” is using an open-source model website to tackle clean water, health care, and other sustainable development challenges.

ADDING VALUE TO TECHNOLOGY EQUIPMENT THROUGH ENVIRONMENTAL FEATURES

- The 2000 Roadmap of the National Electronics Manufacturing Initiative says of the four leading trends in the high tech industry: “Environmental profile of products is becoming more important.”⁴⁴
- A manager at Panasonic said, “We’ve increased our sales dramatically, and were able to get contracts away from several entrenched competitors solely because we had EnergyStar qualified TVs.”⁴⁵
- Intel, Transmeta and Advanced Micro Devices are all introducing energy-saving chip lines by 2003.⁴⁶

⁴¹ For more information on: Conservation International’s GIS mapping projects see: <http://www.biodiversityscience.org/xp/CABS/research/gis/gisprojects.xml>, TaraHaat: http://www.tarahaat.com/index_english.asp, LINCOS: <http://www.lincos.net/html/eng/menu.html>, Greenstar: <http://www.greenstar.org/>, SustainIT: <http://www.sustainit.org>, Department of Energy: <http://www.oit.doe.gov/bestpractices/databases.shtml>, Ecos: <http://www.ecostech.com/pages/products.html>

⁴² For more information, please contact the Center for Precision Agricultural Systems, Washington State University.

⁴³ <http://www.sap.com/solutions/plm/keycapabilities/ehs.asp>

⁴⁴ <http://www.nemi.org/Roadmap/00highlights.html>

⁴⁵ Arensman, Ross. 2001. “The Greening of Technology.” *Electronic Business*. (May): 97-102.

⁴⁶ Gaither, Chris. 2001. “Intel and Two Smaller Rivals Plan New Energy-Saving Chip Lines.” *The New York Times*. (October 16).

IT in a Sustainable Future

“There is undoubtedly a rapid progression to greater focus and accountability on corporate sustainability or the environmental and social issues. With this comes the need to engage with stakeholders and demonstrate performance and transparency....

Failure to address the issue will result in greater cost, not least in relation to reputation, and could even lead to organizations not being allowed to operate....

To add business value, organizations need to integrate environmental and social strategies into their core business strategy in a proactive and innovative manner.”

- PricewaterhouseCoopers 2000⁴⁷

As a growing number of multinational corporations are assessing how to integrate sustainability into core strategy and operations, the IT sector has an opportunity to become a sustainability-oriented solutions provider, both for its clients and for its own operations. The question is what efforts will be first undertaken in moving IT products and practices into the realm of sustainability. As Klaus Fichter, a technology and sustainability analyst, asks:

“Will homo connecticus lovingly stroke over his computer touch screen, be beamed via the World Wide Web around the globe in a matter of seconds and get all the jobs done effortlessly, cheaply, in real time and of course using a minimum of energy resources and without any side-effects? Is that the new

⁴⁷ Price Waterhouse Coopers (PWC). 2000. *Creating Business Value Through Corporate Responsibility: Sustainability Strategies and Reporting for the Goal Industry*. London, U.K.: Price Waterhouse Coopers.

economy – clean, pollutant free and gentle on resources?”⁴⁸

This vision is far from reality. However, if the IT sector begins to strategically consider the context in which 21st century business will be conducted, a whole new set of options emerge. John Seely Brown, chief scientist at XEROX, offers one view of the future:⁴⁹

“Roughly 15 years into the 21st century, the social computing stage morphed into a period called ecological or symbiotic computing. Structural matter (atoms) and computing (bits) became inseparable. Zillions of sensors, effectors and logical elements (made of organic and inorganic materials) were interconnected via wireless, peer-to-peer technologies, producing smart, malleable stuff used to build smart appliances, buildings, roads and more.... In a way, the inorganic world took on organic properties, using computing to transparently modulate responses to the environment.”

Although realization of this vision may seem distant, companies can begin by devising the IT systems, and technology for, sustainable energy, transportation, and resource use. All of these issues represent issue areas that, if addressed, could become enormous business opportunities. The immediate business-related questions that emerge include:

- How can IT enable product designers to “grow” solutions within a design space that does not just take into account nature, but uses sustainability principles in

⁴⁸ Fichter, Klaus. 2000. “Sustainable Business Strategies in the Internet Economy.” <http://www.green-ecommerce.com/Fichter/Fichter.htm>

⁴⁹ Brown, John Seely. 2001. “Where Have All the Computers Gone?” *Technology Review*. (January). http://www.technologyreview.com/magazine/jan01/print_version/brown.html

the same way that concepts like gravity are applied?

- How can IT enable more sustainable manufacturing and delivery models?
- How can IT facilitate new, sustainability-oriented business models to be created?
- How can IT enable new materials to be developed and cycled in sustainable ways?
- What are the new ways that IT can extend the human ability to adapt, learn, ask questions, and find answers, particularly related to dynamics between industrial, ecological, and social systems?
- How can IT help us to consider factors that are farther into the future, and deeper into the past, and which fundamentally affect the dynamics between ourselves and the planet-wide system in which we live?

With these points in mind, a vision for IT in 2020 is a sector that:

- Creates new products that are characterized as being free of persistent organic pollutants, heavy metals, and toxic, persistent, and bioaccumulative ingredients;
- Operates on software models that prolong life of hardware;
- Produces machines that are designed to be upgraded and not replaced;
- Produces products that are energy efficient;
- Designs and deploys services that cycles materials through “closed loop” processes;
- Manufactures using renewable energy;
- Invests in eliminating the digital divide and providing access for all people, while respecting cultural differences and cultural needs;
- Establishes operations in developing nations that embody (and improve on) the

safety and pollution-control practices in Europe and North America; and

- Ensures the health and safety of all workers and communities.

These steps may be beyond the capacity of any single company, but all firms do have roles to play and areas in which to start. As more businesses, non-profit organizations, and government agencies take the first steps, coalitions can form and difficult, cross-cutting problems can be addressed. The ecological and social impacts of the high technology sector can be greatly reduced through a combination of product and business (re)design, closed-loop systems, and regional planning and policy. More importantly, the sustainability-based *opportunities* are wide open to hardware and software innovation and entrepreneurship.

Hardware tools, such as sensors and controls, can improve efficiency, record ecosystem information, and monitor inventories. Software has enormous potential for integrating sustainability principles into supply chain management and enterprise resource planning, product design, information capture and, information management. Finally, internet and communications technology can be used in new ways to connect people to better understand ecological and social dynamics.

Since nature is itself a large information system, the potential to change business will become unleashed when the IT sector begins to work with nature and towards sustainability. With a vision to the future, and an understanding of sustainability, the IT sector is equipped to innovate for a more sustainable world.



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