The Information Technology & Innovation Foundation

ITIF

Digital Quality of Life

Understanding the Personal & Social Benefits of the Information Technology Revolution

EXECUTIVE SUMMARY

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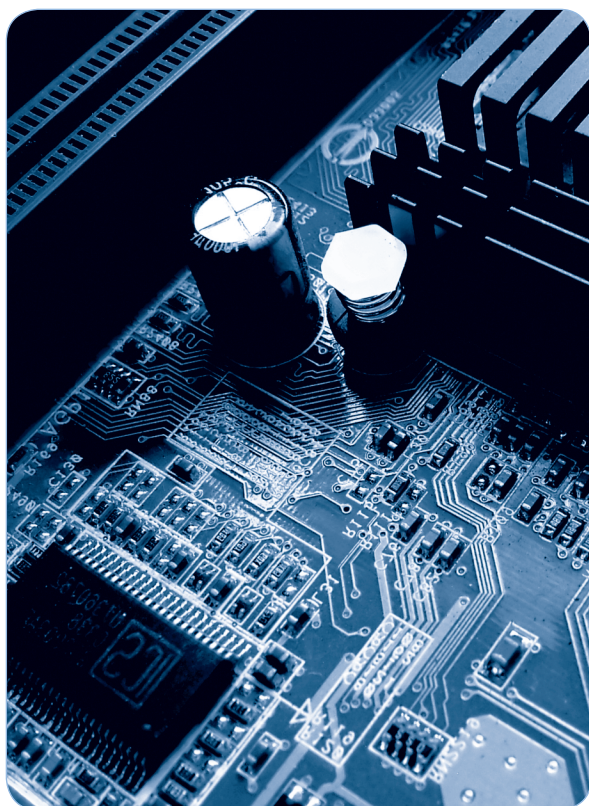
The Digital Information Revolution

In the new global economy information technology (IT) is the major driver of both economic growth and improved quality of life. The Information Technology and Innovation Foundation (ITIF) in its 2007 report *Digital Prosperity: Understanding the Economic Benefits of the Information Technology Revolution* documented how IT, since the mid-1990s, has been the principal driver of increased economic growth not only in the United States but also in many other nations. However, IT is also at the core of dramatic improvements in the quality of life for individuals around the world. In our new report, we show how IT is the key enabler of many, if not most, of today's key innovations and improvements in our lives and society—from better education and health care, to a cleaner and more energy-efficient environment, to safer and more secure communities and nations.

This is happening because after 5,000 years of human progress, the digital information revolution is finally allowing us to move from a relatively inert and obtuse world to one that is intelligent and "alive with information." It is opening up an amazing array of information for people to get access to, par-

ticularly through the Internet, an incredible innovation. But the information revolution is not only or principally about the ability to more easily access text or video information on the Internet. Information in digital form—from real-time traffic updates for in-car navigation systems, to pollution alerts from wireless sensors in a bay, to information on disease outbreaks—can now be far more easily generated, transmitted, and analyzed than ever before in history. Thus, the digital information revolution is extending to virtually all aspects of our lives, all parts of society, all organizations and all nations, potentially enabling billions of people around the world to live better lives.

Indeed, in a world saturated with information and with the tools to effectively get it and process it, we are entering a new era where IT is the major driver of progress and change in many areas of our lives and society, among them the following:

- **Improving our access to information.** IT is putting a variety of information at people's finger tips, whether they be students in Ghana accessing MIT course materials online without ever leaving their homes or people in Holland getting information online to help them better understand a medical condition. Moreover, real-time language translation software is now letting people access information in languages other than their own.

- **Helping us sort out "the needles from the haystacks."** The digital revolution has led to an explosion of information and data, and powerful tools allow researchers to analyze data to find patterns and connections to make sense of all that information. For example, in health care, IT systems can be built to create rapid learning networks to discover which medical treatments work best and which do not work at all.

- **Letting us substitute information for travel**. IT, which allows distances to be bridged without physical travel, is letting a growing share of activities that previously required face-to-face presence be conducted without travel. Substi-

tuting information for travel saves people time and money and saves society energy and space in offices, roads, and airports.

- **Harnessing the power of markets.** Markets can bring improved efficiency and quality, but require information and transparency to work and IT can provide both. As an example, smart electricity meters that charge for electricity usage based on the time-of-day provide an incentive for consumers to consume less at peak periods.

- **Giving us a vast array of choices.** IT is giving us a previously unimaginable range of choices in products and services, allowing us to find what best meets our needs. Internet radio, for example, gives listeners the chance to move beyond the limited formats presented on local over-the-air radio and to hear hundreds, if not thousands, of formats from around the world.

- **Letting us know more things in real time.** IT is enabling information to be collected, organized, and presented in near real time so that users can make the right decisions at the right time. For example, air quality monitoring systems are letting residents know in real time the quality of the air in their neighborhoods.

- **Letting us monitor our homes and loved ones.** IT is providing us with much greater security for our homes and loved ones. As an example, real-time detection systems can send information to our computers at work or our cell phones to let us know if an intruder is in our home. Global positioning system (GPS)-enabled cell phones can let parents know where their children are.

- **Letting us enjoy higher-quality goods and services.** IT is dramatically increasing the quality of many goods and services with technologies such as more precise medical imaging technology, more energy efficient vehicles, and even high-definition TV.

- **Making our lives safer.** Safety is often a matter of getting the right information at the right time, and IT is enabling a host of products to become safer, including power table saws, guns, and pill bottles. And it is giving first responders and law enforcement better tools, such as gun shot locator systems, robots for bomb disposal, and integrated communication networks.

- **Improving convenience and saving time.** From self check-in kiosks at airports, to ordering products online, to interacting with government over the Internet, IT is saving people time and giving them new, more convenient, channels by which they can conduct their daily lives.

- **Improving accessibility for people with disabilities.** IT is enabling millions of people with disabilities to live better lives with technologies including text-to-speech software, GPS navigation systems with voice prompts, artificial retinas, and IT-enabled artificial limbs. These advances are creating a more accessible world and enabling people to interact with their physical environment in ways never before thought possible.

- **Facilitating communication.** IT has led to an explosion in modes of communicating from e-mail to video conferencing, as well as machine-to-person communication such as airline computers that can call a customer's cell phone to let them know that their flight is delayed.

- **Giving people greater control over their own lives.** IT is liberating and empowering people to more effectively take control of their own lives—from farmers in India who get real-time information on crop prices on their cell phones to patients who get the latest medical information to enable them to take more responsibility for their own health care.

- **Holding organizations accountable.** Low-cost digital video cameras and cell phone cameras combined with sites like YouTube, are providing a check on government and corporate abuses—from exposing police brutality to documenting abuse of animals in meat packing plants.

Public Policy Principles

IT is the most important factor driving improvement in a wide array of areas critical for the quality of life for individuals and healthy societies. But by and large, policymakers have not fully appreciated the extent to which IT is driving change and enabling improvements, nor the impact—pro or con—that public policy can have on this development. Though it is beyond the scope of this report to lay out a detailed policy blueprint for IT-enabled change, it is imperative that policymakers around the globe follow at least ten key principles if their citizens and societies are to fully benefit from the digital revolution. To ignore these principles risks slowing down digital transformation and minimizing the benefits of a digital society. These principles are outlined below.

1. Look to Digital Progress as the Key Driver of Improved Quality of Life

Spurring widespread use of IT must become a key component of public policy, supplementing government's three traditional tools: tax policy, government programs, and regulation. Progress in a host of policy areas—including health care, transportation, energy, environment, public safety, and the economy—will be determined in part by how well nations develop and deploy IT. As an example, solving surface transportation challenges will be difficult without the widespread use of IT, whether it is to implement congestion pricing or to provide real-time information on traffic conditions. Indeed, IT transformation must become a key component not just of government agencies dealing with commerce or telecommunications but of every government agency or ministry.

2. Invest in Digital Progress

Many of the technologies and applications driving digital progress will be developed by the private sector and purchased by individuals, with little or no role needed for government. But many IT applications are inherently related to core public functions including transportation, education, health care, public safety, the provision of government services, community development, and the environment. These IT applications must be considered critical areas for increased public investment because they form core components of the new "intangible" public infrastructure that is driving improvements in quality of life. In addition, governments should be investing in research and development (R&D) and supporting private sector R&D to help develop new technologies and applications, including areas such as robotics and large-scale sensor networks.

3. Ensure Affordable and Widespread Digital Infrastructure

For the digital revolution to continue, policymakers must invest in renewing and revitalizing the underlying digital infrastructure. This entails not only spurring investment in physical IT infrastructure, but also ensuring that the appropriate and necessary regulations and standards exist to spur, and not hinder, adoption. Thus, for example, policymakers should make adequate spectrum available for wireless innovation by taking measures to open up unused "white spaces." In addition, policymakers must remain vigilant in ensuring that the components of our digital infrastructure, from global positioning system (GPS) signals to high-speed broadband Internet access, continue to be upgraded and improved.

4. Encourage Widespread Digital Literacy and Digital Technology Adoption

The benefits and promise of the digital information revolution are immense. As IT becomes more central to improvements in our lives, it is important to ensure that people are digitally literate and have access to digital tools so that they can realize the full benefits of the digital revolution. To succeed in today's global, knowledge-based economy, people at least need basic computer and Internet skills. In 2008, about 75 per-

cent of American adults reported using the Internet; the comparable percentage in many developing nations was far lower. Governments in the United States and elsewhere need to do more in partnership with the for-profit, nonprofit, and subnational government sectors to spur widespread digital literacy and technology adoption.

5. Do Not Let Concerns about Potential or Hypothetical Harms Derail or Slow Digital Progress

By definition, all technological innovation involves change and risk, and driving digital progress is no different. As we go forward in an array of areas, policymakers must give adequate concern to issues of privacy, security, civil liberties, and other issues. But the focus should be on addressing these concerns where appropriate in ways that enable digital progress to rapidly proceed—not on stopping or slowing digital progress as so many advocacy groups and special interests try to do today. In part because of the claims made by some of these groups, and notwithstanding the progress that IT enables, all too often, well-intentioned policymakers are willing to consider laws and regulations that would slow digital transformation and reduce, not improve, quality of life.

6. Do Not Just Digitize Existing Problems; Use IT to Find New Solutions to Old Problems

IT offers powerful new methods for collecting, manipulating, and distributing data; however, IT is a means and not an end. Simply using technology to continue existing practices will not necessarily lead to better results. It is important to recognize the potential benefits of IT and promote the use of new solutions that harness IT to address existing problems in new ways. Organizations may find that investing in IT solutions to solve targeted problems gives them the tools they need to solve additional problems. City governments like Baltimore that collect citywide data, for example, can analyze this information in real-time not only to improve deficient city services but also to discover new opportunities for government savings.

7. Create Reusable Digital Content and Applications

Rather than focusing on creating flashy websites and graphics, government agencies and ministries should concentrate on creating reusable digital content using interoperable standards such as XML. Providing digital data that can be shared and reused multiplies its value many times—and is far more valuable than just building a website that may only solve a small set of problems. Government alone cannot do it all nor will it always come up with the best solutions. Instead, policymakers should promote efforts that encourage collaboration between stakeholders in the public and private sectors.

8. Collaborate and Partner with the Private and Nonprofit Sectors

Policymakers should recognize that government alone cannot provide its own digital solutions to every problem and will not always come up with the best solutions. For that reason, the government should embrace opportunities to partner with the private and nonprofit sectors. Currently, in the United States, a number of public-private partnerships are working to spur demand for broadband services. One such partnership is ConnectKentucky, which is helping to foster demand by providing a variety of services, including the No Child Left Offline project that provides computers and training to disadvantaged populations.

9. Lead by Example

When practical, government should be an early adopter of new technology rather than solely relying on industry to lead the way. Through technological leadership, government can play an important role in spurring markets and proving concepts. By establishing telework policies and creating telework best practices, for example, government agencies can pursue green IT initiatives.

10. Nudge Digital

By using "choice architecture," institutions can encourage or discourage certain group behaviors—when appropriate, policymakers should nudge citizens to adopt digital technologies that deliver proven value. As shown repeatedly throughout this report, digital solutions often provide substantial cost-savings while improving quality and outcomes. For example, imagine all of the savings in energy and paper if by default all personal banking and credit card statements were electronic. If citizens had to opt-out of programs, such as receiving electronic statements, instead of opting in, more individuals would participate. Governments should make or allow the default choice to be digital.

Improving the Lives of Individuals

IT is improving the lives of individuals in a host of areas including education, health care, personal safety, and accessibility for people with disabilities.

a. Education and Training

From the abacus to the slide rule to the computer, technology has always played an integral role in education. But it is only recently that technology has advanced to a point that enables fundamentally new and exciting improvements in the learning process. Educational software, for example, gives students instant feedback and individually tailors instruction in ways that a classroom teacher never could. Flexible online classes give people access to education that would never have been possible before the Internet. Parents now use the Internet to follow their child's school assignments and academic progress through Web portals. Organizations use technology to save on workforce development costs. IT has made all of these innovative applications possible, and promises to continue to rewrite the rules of what is possible in education and training. IT is transforming education in three important ways: improving learning outcomes, providing options that serve multiple learning styles, and expanding access to education.

Educational software helps improve learning outcomes and can be customized to fit each student's learning style and pace. Virtual tutors such as Carnegie Mellon University's "Cognitive Tutor" software help students master difficult subjects—from foreign languages to physics—by applying the latest teaching methods. Educational games like "Immune Attack" engage students by, for example, battling virtual viruses inside a body, while exploring concepts in immunology. And the Internet is opening up new worlds of information and communication, for example, allowing students to explore thousands of websites on every topic imaginable and to interact with experts in every profession. A key contribution of IT is that it can allow a student's interests, needs, strengths and weaknesses to drive the learning process, with the instructor facilitating rather than dictating the learning experience. Ultimately, the effectiveness of using IT in the classroom depends on the implementation, curriculum, and the pedagogical approach used.

IT is helping to expand access to education. One way is by making distance learning possible. Courses offered on the Web give a student at a small school in rural Idaho, for example, access to Chinese language or Advanced Placement courses her school does not offer. In fact, as the online course catalog continues to grow, in the near future most high schools will be able to offer students a course in every conceivable subject. Governments and other organizations have found e-learning tools to be efficient and cost-effective for teaching, as well. For example, IBM found that it saved over $500 million in two years with its online learning program. E-learning programs have been especially successful in health care. Medical students can now use high-fidelity simulators—lifelike robots that breathe, talk, and respond to treatments—to learn clinical and technical skills without the risk inherent in real-life patient encounters. And Kenya implemented an e-learning program to rapidly train over 22,000 nurses that greatly improved the basic medical skills of the health care workers treating critical diseases such as HIV/AIDS, malaria, and tuberculosis.
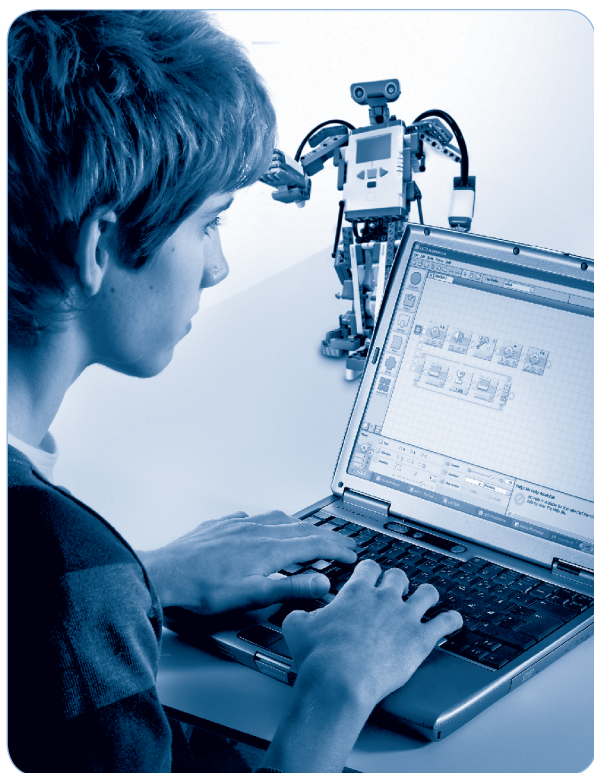
b. Health Care

In places from rural India to state-of-the-art hospitals in the United States, IT is transforming and revolutionizing health care. It is doing this by reducing health care costs, increasing access to health information, improving the quality of care, and increasing access to care.

In the United States, rising health care costs are a prominent concern. IT can help restrain the growth in these costs. Two studies have estimated that societal cost savings from implementing and using health IT in the United States could be at least $80 billion per year. Much of the savings in these estimates comes from increases in efficiency such as shorter hospital

ing and simulations are contributing to better treatments and diagnoses.

Finally, IT is helping to break down geographical barriers to health care. Advances in IT have allowed engineers to produce portable and inexpensive medical devices, such as a 3 pound electrocardiograph that doctors in India can carry with them from village to village. Telemedicine systems can also be used to provide access to health care for individuals in remote or other locations who would otherwise not receive care. As an example, the Australian Broadband for Health Program connects indigenous and rural communities with health care providers in urban areas. And applications such as Cisco HealthPresence, which allows

IT is improving the quality of health care through technologies like rapid learning networks that help medical researchers identify the most effective treatments and spot harmful side effects from drugs.

stays because of better coordination, better productivity for nurses, and more efficient drug utilization.

In terms of increasing access to health information, IT is empowering patients by giving them access to the latest medical research, their own health records, and information on the quality of care they receive. Online applications such as Microsoft HealthVault have emerged to allow individuals to track and analyze their personal health information. Patients can use tools such as the Leapfrog Group's hospital ratings to review objective performance metrics and compare hospitals in their community. Thus, for example, patients can learn which hospitals in their community have the most experience and success with a particular high-risk treatment.

IT is improving the quality of health care through technologies like rapid learning networks that help medical researchers identify the most effective treatments and spot harmful side effects from drugs. Replacing paper records with electronic records will also help reduce medical errors by ensuring that the right patient receives the right treatment at the right time. In addition, countless examples of IT-enabled medical solutions such as electronic prostheses and orthoses, high-definition medical imaging, computer-assisted surgery and advanced computer model-

patients and doctors to interact over a secure connection through high-definition video and audio, can give patients access to medical experts even when they are geographically separated from them.

c. Personal Safety

Individuals have always turned to the latest technology to ensure their personal safety. The digital information revolution has introduced new opportunities for improving personal safety—from high-speed broadband networks that allow high-definition video monitoring to wireless networks that allow individuals to receive security alerts no matter where they are. Today, IT-enabled burglar alarms secure homes, electronic devices secure personal vehicles, and home medical alert systems ensure the safety of adults living alone. Low-cost sensors allow homeowners to more thoroughly monitor their homes, and biometric technology allows drivers to more securely control access to their vehicles.

IT also helps individual avoid loss—from mundane items (like a TV remote control) to essential items (like a set of keys) to vitally important items (like a handheld glucose meter). Individuals can even avoid getting lost with GPS devices that provide directions from one location to another.

IT is also preventing accidents. In personal ve-

hicles, IT is being used to improve driving safety and avoid collisions. For example, rear-mounted cameras provide drivers with a better view when driving in reverse. In other devices, such as table saws, IT is being used to make dangerous equipment safer. Devices such as the SawStop have an electronic detection system that senses if the blade touches flesh and instantly stops—preventing injury. As electronics get smaller, more powerful, and less expensive, more devices will come equipped with sensors to detect dangerous situations. Smart pill bottles, for example, could remind patients to take their pills and notify doctors of missed dosages.

Despite all of the innovations that help keep people safe, there will always be emergencies. IT helps individuals cope with these situations. For example, in-vehicle communication systems, such as BMW Assist or GM OnStar, help individuals involved in accidents on the road or in other emergencies get assistance quickly. Next-generation versions of these systems promise to deliver additional information automatically, like informing first responders about the nature of the crash, the point of impact, which seats were occupied, and which airbags deployed. This information can then be passed on to emergency rooms so that they can begin preparations to accept injured passengers, ultimately helping improve the medical care received following an accident.
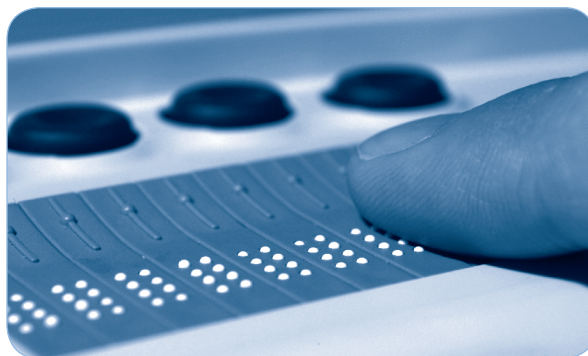
d. Accessibility for People with Disabilities

For much of history, many people with disabilities have had to rely on technologies that were designed for the non-disabled community. However, the shift from analog technology to digital technology has made it easier to convert digital information into voice, text, or even physical patterns (e.g., Braille) making IT better able to meet the specific needs of people with disabilities.

A whole host of technologies for people with disabilities radically increases their functional capa-

bilities. Among them are cochlear implants for improved hearing for individuals with hearing disabilities and artificial silicon retinas for improved vision for people with visual disabilities. IT devices also enable many individuals to live independently. For example, individuals can use a personal emergency response system so that with the push of a button they can call for medical assistance.

IT also helps individuals with disabilities access information. For users with visual disabilities, text-to-speech computer screen readers and screen magnifiers help make digital information more accessible; devices such as tactile graphic displays can even raise and lower a series of small pins to create tactile patterns based on a digital image. Individuals with visual disabilities can use GPS devices to navigate and orient themselves, even in unfamiliar settings, by relying on voice prompts that tell users where they are and how to get to their destination (e.g., "turn right").

Using IT, individuals with mobility impairments can better interact with their environment. For example, speech recognition software allows individuals to control computers and IT-enabled devices such as motorized wheelchairs. Researchers have even designed systems that allow individuals with mobility impairments to control a computer cursor using their brain waves.

Finally, IT enables individuals with disabilities to choose the form of communication that works best for them. For example, people with hearing disabilities can use the texting, instant messaging and e-mail features on cell phones. Similarly, users with hearing disabilities can bypass traditional voice communication mediums and use video conferencing services to communicate through sign language or lip reading. With speech recognition software, broadcasters can offer closed captioning for all of their programs, even live programs, at a lower cost than using a human stenographer. In addition, IT-based communication has given rise to telehealth and telework applications that benefit many people, including those with mobility impairments.

Improving Our World

IT is improving our world by helping to build stronger communities and addressing challenges related to the environment, energy, transportation, public safety, and government.

a. Environment

With populations exploding and economies expanding, humanity faces a number of pressing environmental challenges in the 21st century—among them pollution, environmental degradation, dwindling biodiversity, and global warming. The good news is that with growing awareness of the myriad environmental problems come efforts to find innovative ways to assess and combat them, many of which rely on IT.

IT enables sophisticated technologies to track air and water pollution and to gain a better understanding of the processes contributing to a warming Earth. The Global Earth Observation System of Systems, for example, is integrating global data from satellite observations, ground-based and mobile sensors, and other sources. This enables scientists to develop computer simulations that model atmospheric conditions—including weather, pollution from forest fires, and future warming—more accurately than ever before. Residents of coastal areas can go online and see virtual maps showing how rising sea levels may affect their local communities, and researchers are using soil erosion models based on geographic information systems (GIS) to predict the effects of global warming on crop yields worldwide.

In addition, IT is being used to detect and help prevent water pollution in lakes, rivers, oceans, and groundwater. As an example, IBM has partnered with a local nonprofit organization to install sensors along the entire Hudson River in New York. The sensors will transmit the collected data wirelessly to shore and allow scientists to construct a virtual river, including information about pollution levels and the state of marine life.

Scottish researchers have developed a Web-based GIS decision management tool to model data about soil conditions and better understand the different management options. By using a Web-based tool, the researchers hope to increase transparency into the decision-making process for soil management. IT can even help reduce pollution from unnecessary use of chemicals for weed control. Danish scientists have developed the "Hortibot," a robot that uses visual sensing to navigate crop rows and then uses either manual weed removal tools or precision herbicide spraying to kill weeds.

Another area where IT is making a contribution to the environment is in facilitating the recycling of paper, plastics, glass, and other materials. IT underpins the identification, sorting, and reprocessing of recycled materials. In some cases, it even helps increase recycling. The city of Philadelphia, for example, uses RFID tags in recycle bins to track the amount of recycled material that households leave out for collection in order to reward participants. The city's recycling participation rates have skyrocketed, reaching 90 percent.

Finally, IT is being used to understand and preserve delicate ecosystems, for example, by using satellite imagery to enforce preservation agreements and fight deforestation. Conservationists use IT to organize and rally others to their cause. For example, a Web video showing a seal covered in oil in the wake of a spill is far more compelling than a simple written description of the tragedy. Researchers also use RFID tags to track and monitor migratory patterns of endangered wildlife to advocate for the protection of their habitat and fight animal trafficking.

b. Energy

By enabling a transformation to a more digital and information-driven economy—from e-commerce and just-in-time manufacturing to telecommuting and clean alternative energy technologies—IT is improving energy-efficiency and reducing carbon

emissions around the world. Although IT itself consumes energy, improvements in efficiency from more energy-efficient processors and data centers to better power management, has kept the overall energy usage of IT in check, even as societies become more digital. And, in fact, the net impact of IT is overwhelmingly positive—for every unit of energy consumed by IT, there is a corresponding savings of between 6 and 14 units of energy.

One sector that accounts for a significant share of energy use in most nations—29 percent in the United States in 2007—is the transportation sector. IT can cut energy usage in the transportation sector by allowing the substitution of energy-efficient digital activities for energy-intensive physical activities. Instead of traveling to attend a meeting, to go to a medical appointment, or even to go to work, individuals can use IT to participate remotely with applications such as video-conferencing, telehealth, and telework. One study has estimated that if Europeans substituted videoconferencing for 20 percent of air travel, the European Union could reduce carbon dioxide emissions by 22 million tons annually.

Another way IT helps reduce energy use is by enabling the "dematerialization" of the economy—in which atoms (e.g., paper letters, CDs) are increasingly replaced with bits (e.g., e-mail, digital music files). The widespread production, transmission, and consumption of virtual products instead of material products leads to energy savings not just from reduced transportation but also from reduced production of material goods. For example, Apple's iTunes has sold more than 4 billion songs without shipping a single physical CD. Researchers have estimated that eliminating the production of CDs and their plastic cases in the United States alone could save 42 million gallons of oil per year while reducing greenhouse gas emissions by half a million tons.

Just as important, IT enables more energy-efficient practices and processes. IT-enabled advances in manufacturing and supply chain technologies help firms better track inventory and engage in just-in-time production, creating energy savings at every step of the production and supply chain. For example, companies engaged in transportation—from airlines that sell discounted tickets online for underbooked flights to companies like UPS that use software to optimize truck delivery routes—rely on IT to boost the efficiency of their operations. And e-commerce operations also yield significant energy savings. Amazon.com's online operations, for example, consume substantially less energy than a comparable brick-and-mortar book store—traditional superstores use 14 times more energy than an online book retailer for every $100 of books sold.

Finally, IT is revolutionizing the rules of electricity production, distribution, and consumption. Clean energy production relies heavily on IT, from the advanced computer modeling used to identify the best sites for wind farms to automated solar panels that use IT to track the sun's rays and respond to clouds. The advent of the smart grid, in which appliances are networked to manage their power consumption and consumers monitor real-time pricing and shift some consumption to off-peak periods (e.g., running their dishwasher at night), is revolutionizing the power grid. And better energy usage information, such as fuel-efficiency gauges in personal vehicles, encourages consumers to engage in energy-efficient behavior by making them aware of their energy usage.

c. Transportation

Until now most advances in transportation relied on physical materials—more cement and steel. But now, IT is playing a key role in improving surface transportation. IT has already made major inroads into personal vehicles, which have antilock braking systems, adaptive cruise control, and even in-car entertainment. One of the most important benefits of IT in personal vehicles is that it improves access to information. Navigation is easier than ever with GPS navigation systems and online access to real-time traffic information. Side-looking and rear-

looking sensors can warn drivers of objects behind them or in adjacent lanes when drivers begin to back up or change lanes, helping to prevent collisions. Sensors can warn drivers when tire pressures are below specification, or even when tires are wearing out. Concierge services such as GM OnStar can provide drivers information based on their location.

But these IT-enabled changes to personal vehicles are only the tip of the iceberg. Telematics—the combination of sensor, computational, and communication technologies—has opened up a whole range of new possibilities for improving access to transportation-related information. On the horizon, "intelligent transportation systems" that allow communication between vehicles and the world around them could provide greatly improved information about roadway weather, such as road surface temperatures and visibility. Thus, for example, vehicles operating on a roadway could act as weather "probes," sending information to a control center, which then could compile the data to provide much greater detail about real-time conditions. Such systems could even help prevent collisions.

Highway owners are already using telematics for toll collection (e.g., E-ZPass), but telematics has tremendous potential to improve transportation system monitoring and management. Smart traffic signals use IT to collect better data and provide better signal timing to improve traffic flows. Parking is made easier with telematics that can alert drivers where vacant spaces are located and high-tech parking enforcement systems that help police find parking violations. Public transit providers are incorporating IT into their control systems to offer transit patrons better information about their service. Currently, for example, bus stops in Paris and subway stations in Washington, D.C., have a digital display that shows when the next bus or train is expected to arrive for each line serving the stop. Even car-sharing services like Zipcar rely on IT, for example, to track the usage of its fleet and allow customers to locate an available vehicle. And some cities, including London and Stockholm, are experimenting with IT-enabled traffic management systems that charge drivers more during peak hours in order to reduce and manage congestion, as well as pollution.

Beyond helping transportation managers make more efficient use of the transportation infrastructure, telematics has the potential to provide them

with real-time information about the condition of the infrastructure. The Korean Bridge Management System, for example, is a network of wireless sensors that monitors 230 variables per bridge including carry capacity and environmental variables such as vibrations, temperature, and humidity to help ensure the safety of these structures.

d. Public Safety

IT has become a critically important tool for those charged with ensuring public safety. Law enforcement agencies use IT to share information and analyze data, for example, by using data mining to discover ties between known terrorists, domestic terror cells and those who finance them. At the border, IT supports the use of biometric data such as fingerprints, photographs or iris scans to identify and authenticate individuals entering a country. Using biometric data helps prevent the use of forged or stolen travel documents and facilitates legitimate travel. At airports and other public venues, backscatter X-rays and millimeter wave technology gives security screeners new tools for detecting weapons, explosives, or other contraband. IT is even a tool to combat human trafficking by allowing modern-day abolitionists to organize, raise awareness, and monitor the effectiveness of interventions.

To prevent and deter crime, law enforcement officials use IT-enabled devices such as digital video surveillance, electronic parolee monitoring, and ignition interlock devices. Using these devices can generate substantial savings: in the United States the cost of incarceration is approximately $25,000 per inmate per year, whereas the cost of remotely monitoring a low-risk offender is less than $5,000 per year. Pub-

lic safety networks allow police officers in the field to complete routine tasks online such as submitting crime reports and issuing traffic citations. At a crime scene, investigators use lasers and digital cameras to conduct high-definition surveying and rapidly construct a detailed, three-dimensional computer model of a crime scene or accident. Investigators also use IT to more quickly collect and compare biometric information, such as fingerprint and DNA evidence, to national and international databases in order to solve crimes, identify missing persons, and protect the innocent. And using robots for surveillance, handling hazardous materials, and bomb disposal helps keep law enforcement officers safe.

In addition, police departments of all sizes increasingly use IT to collect and analyze crime data, and then report on trends to gain better intelligence about crime and resource utilization—the CompStat management approach pioneered by the New York Police Department. By combining data analysis techniques such as crime mapping with effective policing strategies, the police can target specific crime hotspots. IT also makes it simple to share this information, thereby increasing transparency into police operations and improving community relations.

Finally, it should be noted that IT is at the heart of preventing, detecting, and responding to accidents and natural disasters. First responders rely on public safety networks to organize their response and NGOs use the Internet to coordinate disaster relief efforts and reunite loved ones. Scientists also use IT to monitor and model complex meteorological

come more productive, IT helps governments operate more efficiently. For example, offering government services online saves taxpayer money—renewing a driver's license online costs governments around $1, compared to about $8 for in-person renewal. In Baltimore, a program called CitiStat was launched that uses IT to track government performance indicators in real time and to help city managers improve the city government's performance. By using CitiStat to track indicators such as employee absenteeism and overtime, Baltimore was able to eliminate $13 million in unnecessary government spending in the first year of the program.

Governments also use IT to deliver better quality service to their citizens. Cities around the world use IT to collect and track the performance of basic city services such as trash removal, street repairs, and snow removal. In New York City, residents can not only submit complaints or crime reports online, but they can also submit pictures and video to help document their complaint. IT even improves in-person interactions by, for example, allowing citizens seeking a government service to check wait times at regional offices to decide when and where to go. IT is especially useful at improving government efficiency and reliability in large-scale applications such as the census or voting. Statistics Canada, for example, provides multiple online tools to allow researchers to access and manipulate national survey data. In 2006, 19 percent of Canadians responded to the census questionnaire online.

Governments use IT to empower citizens by in-

> **Governments have used e-procurement systems to increase government transparency and reduce corruption by making the procurement process more transparent, efficient, and accessible.**

and geological systems, such as hurricanes, tsunamis and wildfires, and then use emergency alert systems to warn individuals in communities that are threatened.

e. Government
The use of IT has been a catalyst for modernizing government and improving the efficiency and quality of government services. Just as IT helps businesses be-

creasing public access to information. For example, in the United Kingdom, Directgov provides a national portal for government services and the National Archives is home to multiple online databases of digitized public documents including government publications and historical documents dating as far back as the 8th century. IT also provides a platform for disseminating government information, from civics lessons to medical information to how to start

a small business.

Finally, IT promotes government transparency and accountability by enabling citizens, NGOs, journalists and others to hold governments more accountable for fraud, waste and abuse. For example, governments have used e-procurement systems to increase government transparency and reduce corruption by making the procurement process more transparent, efficient, and accessible. Electronic data can also be more easily analyzed. Websites such as OpenSecrets.org and FollowTheMoney.org provide citizens with tools to better understand U.S. government-provided data on campaign financing. And programs like the Boston Indicators Project aggregate data about local quality of life from multiple sources and publish the information on their websites, thereby making local governments more accountable to their citizens.

f. Communities

IT is helping the residents of smaller and more remote communities have more choice in products and services, giving them choices in shopping, entertainment, and education that used to be available only to the residents of large metropolitan areas. The online retailer Amazon.com, for example, carries substantially more books than the best bookstore in New York City; and the online DVD rental site Netflix stocks over 100,000 DVD titles. Even services once thought to be impossible to export beyond the immediate market—such as medical services and education—are becoming available to smaller com-

Studies have found that communities with broadband Internet access experience more rapid growth in employment and the number of businesses, and higher rates of productivity.

The worldwide reach of the Internet has created a new global community and culture that spans traditional political and geographic boundaries. IT helps strengthen social bonds with tools like social networking and online dating. Websites such as Facebook.com and Classmates.com help reconnect old friends. Online support groups for people with chronic illnesses allow individuals to connect with others and share their experiences. IT has even created new services with websites such as Prosper.com that facilitate social lending. Social lending allows individual lenders to bid on loans requested by individual borrowers; however, rather than just consider a borrower's credit score and loan terms, lenders can also consider a borrower's personal statement, endorsements from friends, and group affiliations.

A key ingredient of a healthy democracy is a vibrant civil society. IT provides tools that can help increase civic participation, improve community awareness, and organize individuals for collective action. Studies have found that access to the Internet is correlated with voter turnout. Websites such as Meetup.com encourage an active civic life by connecting individuals with others who share their common interests—over 2 million people have already used this site to find local groups ranging from political organizations to foreign language clubs. In addition, many online tools exist to help organizations

The worldwide reach of the Internet has created a new global community and culture that spans traditional political and geographic boundaries.

munities as a result of IT. Many universities have created online courses, and others, like MIT, have posted course materials online. Collections owned by organization such as the Library of Congress or the British Museum are now easily viewable online, as well. And beyond expanding choices for residents, IT has the potential to spur economic development in smaller and more remote communities by making it easier for businesses to thrive in such communities.

organize, fundraise and engage in civic action.

Finally, IT is being used as a tool to help promote corporate social responsibility and reduce harmful business practices. IT solutions can help companies track and manage the risk of a supplier breaching their corporate ethics standards by, for example, using child labor or improperly disposing of environmental waste. Companies also use IT to collect and share compliance information among their various

business units and external stakeholders. And civic groups can use IT to expand disclosure of questionable corporate or governmental practices. The availability of digitized financial information on publicly traded companies, for example, has allowed the Sudan Divestment Task Force to monitor companies with questionable ties to the Sudanese government and then lobby public pension and other funds to divest from these companies.

g. Developing Countries

IT is revolutionizing the lives of people in developing countries by increasing their access to information and services. With IT, farmers in such countries can get up-to-date weather forecasts and information about the latest fertilizers and farming techniques; patients in remote villages can see medical specialists online rather than traveling for hours to the nearest clinic; teachers can download educational materials and lesson plans for their students; and philanthropists can give a loan to someone thousands of miles away with the click of a button.

Studies have found that local economies with more access to IT are more productive than those with less access. Thus, IT can help improve economies in developing nations by increasing information on market prices, lowering transaction costs, and enabling just-in-time transactions. In the fish market in southern India, for example, an economist found that sellers' access to mobile phones not only increased profits for them by 8 percent but reduced consumers' costs by 4 percent.

Making markets more efficient is important, but developing countries also need access to capital. IT can expand access to capital in developing countries by helping people engage in transactions over long distances, such as sending or receiving money, even in the absence of local financial institutions. In addition, organizations such as the Grameen Foundation and Kiva use IT to minimize transaction costs and provide microloans directly to individuals.

IT can also be used to increase government transparency and reduce corruption in the developing world by giving leaders who want to be responsive to their citizens the tools to do so, and by increasing accountability for those leaders who do not act in their people's best interest. By automating certain tasks that would traditionally require interaction with a local bureaucrat, IT reduces the opportunities for corruption. And in the information age, repressive governments are finding it harder and harder to hide behind national boundaries—satellite imagery and video recordings can be easily shared online to expose human rights violations.

IT is also helping to bring educational opportunities to those in the developing world without access to a quality education. In Brazil, for example, satellite links enable thousands of students to attend school in areas where a lack of serviceable roads often prevents them from getting an education. Similarly, a Brazilian NGO broadcasts a radio program that delivers educational content tailored for women, who are disproportionately without access to educational opportunities, helping to empower these women economically, politically and socially.

IT is also helping to improve health care in developing nations by reducing the cost of care, improving the quality of care and increasing access to health care information. E-learning applications help countries in Africa improve the skills of their doctors and nurses. Collecting data electronically allows health care workers to better monitor public health and respond to tuberculosis, AIDS/HIV, and epidemics. And doctors have taken advantage of the widespread adoption of mobile phones with applications such as text messages to remind patients to take their medicine.

Many obstacles remain to be addressed before the full potential of IT can be realized in the developing world. These include making IT more affordable, increasing connectivity, increasing the amount of digital content available, and increasing digital literacy.

Conclusion

It has now been slightly more than a decade since the Internet became a mass phenomena and the digital economy began to take off. The United States and indeed the world have benefited greatly, with faster productivity and income growth, more innovation, higher quality products and services, and increased opportunity and convenience for hundreds of millions of IT users around the globe.

It is not clear how long IT will power growth, but it seems likely that for at least the next decade or two, IT will remain the principal engine of growth and progress. The opportunities for continued diffusion and growth of the IT system appear to be strong. Many sectors, such as health care, education, and government, have only begun to tap the benefits of IT-driven transformation. Adoption rates of e-commerce for most consumers, while rapid, are still relatively low. And new technologies (e.g., RFID, wireless broadband, speech recognition) keep emerging that will enable new applications.

In short, while the emerging digital economy has produced enormous benefits, the best is yet to come. The job of policymakers in developed and developing nations alike is to take advantage of this revolution by proactively putting in place policies and programs to spur digital transformation so that all their citizens can fully benefit.

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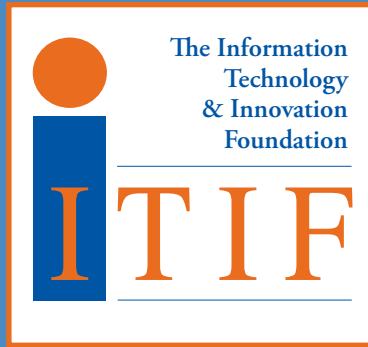
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