



## SMART HOMES & SOCIABLE DEVICES: RFID TAKES OFF

Assuming RFID does not stumble because of security- or privacy-related problems, people will begin to use RFID in their homes within the next two years. Many may first notice RFID tags in security and health applications. For example, they might see tags on prescription-medicine bottles, library books, or luggage tags.

These are useful but incidental applications of RFID. People will also begin to experiment with personalized applications. RFID will become a component in home-management systems, which will help to schedule shopping, laundry, and other tasks. RFID will also help track essential everyday items like car keys, wallets, and book-bags. Finally, this technology will become part of systems that help patients complete prescription-drug courses.

Ultimately, RFID will be one of the technologies that bring pervasive computing from the computer laboratory into the home. From 2008, the emergence of pervasive computing; the appearance of cheap, ubiquitous RFID tags; and the ability of users to make their own tags and readers will create two new dynamics.

First, RFID systems will become instruments for delivering content, entertainment, and education. Flexible displays on appliances and packaging will offer basic instructions on product use; interact with experienced users who want to do more with their products; and layer entertainment or group activities atop intended product use.

Second, people will reinvent RFID. Users will create and share applications and services using the technology; providing an example of creative destruction and technological evolution at its messiest—and its best.



THE FUTURES OF RFID: A MEMO SERIES

Technology Horizons Program

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[www.iftf.org](http://www.iftf.org)

### The Futures Of RFID: A Series of Memos

To help **Technology Horizons**

**Program** members understand the long-term potential

RFID, the Institute for the Future (IFFT) has undertaken a project to map the future of RFID beyond the supply chain.

Even though companies are struggling with the Wal-Mart and Tesco mandates to add RFID tags to pallets and cases of goods, it's not too early to begin thinking about how the technology could be used outside the supply chain. Our findings are presented in a series of five memos. In the first memo, **Thinking About**

**RFID** (SR-926A), explains what RFID is and how it has evolved.

The second, **Public Concerns and the Near Future of RFID** (SR-926B), analyzes consumer concerns about RFID, and discusses recent and coming controversial uses of the technology. The third, **Flashpoints and Controversies** (SR-926C),

focuses on controversial potential uses of RFID. This memo, **the fourth in the series, Smart Homes and Sociable Devices:**

**RFID Takes Off** (SR-926D), looks at RFID's role in smart homes and a world of pervasive computing. And in the fifth and final memo, **RFID: Implications and Recommendations** (SR-

926E), we discuss what the future of RFID means and how to avoid potential pitfalls posed by controversial uses and navigate to a world where businesses and consumers alike find great value in RFID.

### FIRST USES OF RFID WILL BE INCIDENTAL

As RFID becomes commonly used in the packaging of prescription drugs and is embedded in expensive consumer goods, library books, and government IDs, people will become more aware of their everyday interactions with this technology. In many cases, however, users will not be able to actively use RFID for their own purposes. Rather, RFID will be used to identify lost or stolen property, retrieve purchase and warranty information on consumer products, speed checkout of library books, or simplify traveler passage through immigration control.

For consumers to actively use RFID to serve their personal needs—to complete household tasks, for example—it will be necessary to bring several components of the RFID system into the home: readers, middleware, databases, and networks. Within the next two years, these components will begin to appear in the form of intelligent appliances.

### MOVING TO PERSONALIZED USE

Two key trends will shape personalized use of RFID technology.

First, intelligent appliances and home-network technology will reach the mass market. These devices will bring computing and connectivity to everyday appliances and utilities, allow devices to coordinate tasks with one another, and work with software agents, online retailers, and health care providers.

Second, aging baby boomers in North America, Asia, and Europe will begin to use intelligent appliance technologies and RFID to remain independent, combat age and frailty, and stay connected to family, friends, and health providers. This is an example of a so-called “aging-in-place” system. Such systems will demonstrate the value of RFID in assisting with everyday tasks. And because each use exposes adult children, grandchildren, and caregivers to home-use of RFID, this type of application will have a viral marketing effect.



## COMING SOON: INTELLIGENT APPLIANCES

Two major trends will characterize the growth of the smart home and intelligent appliances.

### 1. There Will Be No Single Smart Home; Instead, There Will Be Many Intelligent Appliances

There will be a wide variety of smart homes, each configured to meet the needs and interests of its residents. People who are interested in shrinking their energy budgets may never be in the market for a virtual butler, and *vice versa*.

Instead, people will be likely to create “hotspots” of intelligent appliances in specific rooms, to serve particular purposes. One family may focus on home-entertainment-system networking; their neighbors may prefer appliances to manage household tasks; while their elderly parents may want technologies to help them stay healthy. Few homeowners will invest in systems that make their entire home “smart.”

Recent research suggests that there will be no single configuration defining the smart home of the future. There will be many different designs, which mix and match a variety of technologies to perform a multitude of tasks.

### 2. Elders Will Be Early and Important Adopters

Elders will have good reason to adopt intelligent appliances. A remote control for your house is an expensive, cool toy. A system that enables an 80-year old woman to continue to live safely in her own home, while advising her children whether she’s okay or has become ill or depressed, offers life-changing benefits.

Technologies that allow elders to “age-in-place” look even more appealing once you consider the high cost—both financial and psychological—of nursing homes, let alone weighing the projected shortage of nurses throughout the rapidly-aging, advanced world.

Elders won’t just be early adopters, they will become influencers. Aging-in-place technologies will have powerful multiplier effects. Unlike smart kitchens or house remote controls, assisted-living technologies deliver benefits to entire families. Some systems, like the Digital Family Portrait, will help keep elders and their families connected. Others will provide regular updates about an elder’s condition to physicians and/or family members. Finally, all aging-in-place technologies will allow families to avoid—or at least delay—the upheaval of moving elders out of their homes.

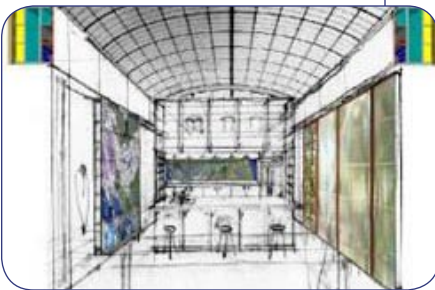


Imagine searching an RFID-equipped home or office with something like “Google@Home.” Item-level RFID tagging will automate many household tasks, including both the mundane, like finding lost items, as well as the more complex, such as cooking dinner using only ingredients in the fridge.

### VARIETY OF INTELLIGENT APPLIANCES

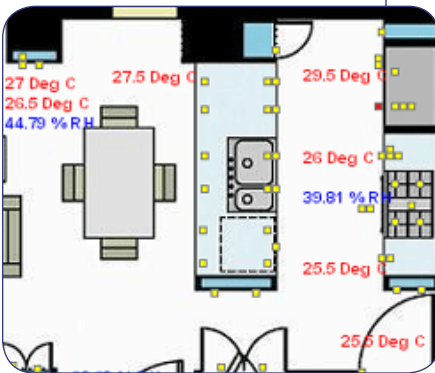
There are a variety of intelligent-appliance technologies; each designed to serve different markets and functions.

Smart Home



### Convenience Systems

Today, you can buy systems that are essentially remote controls for your whole house. These provide centralized displays that allow you to program the dishwasher from your bathroom or turn on the home theater system from your kitchen. Marketing of these devices has been aimed at wealthy, tech-savvy homeowners. While they will continue to have a place in high-end homes, such devices are not likely to reach the mass market. It is more likely that some other common home electronic equipment—TV cable box or personal computer, for example—will take on some of the functionality provided by these centralized systems.



### Infrastructure Control

Infrastructure systems—which are largely still under development—manage heating and cooling, turn lights off and on depending upon room occupancy, and schedule household tasks for off-peak hours. These systems are designed to reduce energy and water consumption.

Other systems aim to be more like software agents for the kitchen; helping you prepare a meal from the seemingly-random contents of your refrigerator, sending a shopping list to the online grocer, and suggesting menu options for a weekend dinner party.

Source: [http://architecture.mit.edu/house\\_n/publications.html](http://architecture.mit.edu/house_n/publications.html); <http://www.research.phlips.com/newscenter/pictures>

Each system will continue to have its advocates. But the coming global wave of elders will demand other kinds of intelligent appliances: technologies that help them stay connected to family, friends, and caregivers; and technologies that help them manage everyday tasks and remain in control of their homes and their lives.

### Daily Maintenance and Complexity Management

Many “smart appliances” are designed to simplify household management. Prototype smart refrigerators that “know” their contents, suggest dinner menus, and can order groceries online, offer the prospect of reducing the complexity of routine tasks. As do prototype smart washing machines that read RFID tags on garments and warn users of mismatched items or tailor wash cycles.



Many intelligent appliances will be variations of current prototypes, with one key difference. They will be smart through connectivity to other devices or software and will use common data interchange standards (like XML) to share and act on information. The smart refrigerator of the future is more likely to create menu recommendations by gathering information from both the household schedule database and a medical software agent that tracks food allergies and nutraceutical prescriptions, than to contain all that information, itself. Smart washing machines will consult schedules and weather forecasts to see what clothes will be needed and when they need to be cleaned.

Another important category of RFID-enabled intelligent appliances will be “gateway devices,” which monitor the passage of RFID tags. For example, a system that helps families keep track of everything they needed to take with them would consist of a database and an RFID reader installed in a doorway. The reader might be programmed to always check for particular items, like car keys, backpacks, or lunch boxes. If the middleware could talk to a family scheduling program (say, Mom’s PDA), it could perform more detailed, time-specific checks.

Such a system would not require cheap tags to be useful, for two reasons. First, items like purses and backpacks are large enough to carry larger, more expensive tags; other items, like a child’s house key or a parent’s cell phone, may be less expensive, but still worth tracking because of the inconvenience caused by not having them.

## THE COMING GLOBAL WAVE OF ELDERS

Today’s intelligent appliances are aimed at wealthy early-adopters. But the future of these appliances lies with the rapidly growing number of elderly in North America, Europe, and Asia. As many companies now realize, retiring baby boomers are going to constitute an important new market in the coming years. Indeed, the aging of the boomers is a symptom of a broader aging of advanced societies. In the United States, the share of the population over age 65 will increase from 13% in 2000 to 20% by 2050.

Table 1  
The World's Population  
Is Aging  
(Percent of total regional  
population that is ...)

	2000	2015
<b>Europe</b>		
65 years	14.0	16.3
80 years	2.8	4.3
<b>North America</b>		
65 years	12.6	14.8
80 years	3.3	3.8
<b>Asia</b>		
65 years	5.9	7.7
80 years	0.8	1.3
<b>Latin America</b>		
65 years	5.5	7.4
80 years	0.9	1.5

Source: U.S. Census Bureau,  
*Preparing for an Aging World*,  
National Academies Press, 2001.

### Aging Is a Global Phenomenon

While the aging of baby boomers has received plenty of attention in the American press, it is a global phenomenon. As Table 1 shows, the share of elderly in Europe and Asia (and to a lesser degree, in Latin America) will also rise.

Some of the world's most advanced national markets are also its fastest-aging. Japan, for example, has one of the highest proportions of elderly in the world. Nearly 20% of the population is over 60 years old. At the same time, birth rates in Japan are falling—meaning that there are fewer young workers to care for the old. Forty percent of Japan's elderly are over the age of 75, and that share will reach 48% by the year 2020. A growing number of elders are living alone: about 15% live independently now, a figure that will grow to about 25% by the year 2020. As Japanese economist Naohira Ogawa noted, "Compared to the United States, it is nothing." But given that multigenerational households have been the norm, the fact that more elders are living alone represents "a major revolution as far as Japan is concerned." Korea faces a similar situation; by 2020 the elderly will make up 15% of the population (some 7 million in all) and life expectancy will also rise.

### This Generation of Elders Will Redefine Old Age

This generation will redefine old age, work hard to remain active and independent, and possess the financial means to support such efforts.

The boomer generation has been a global cultural force and center of market attention since the 1960s. Its members are used to having their tastes reflected in the market and will not accept the public marginalization and personal frailty that has defined age in the past. As Harvard public health professor Jay Winsten put it, "boomers won't stand for being put out to pasture."

Aging boomers will be too attractive of a market to ignore. In developed countries, people over age 50 own three-quarters of all financial assets and half of all discretionary spending power. They have more time to spend their money. A few decades ago, most people lived only a few years beyond retirement. In contrast, workers retiring today can look forward to 15–30 years of leisure. Thanks to medical advances and healthier living, they can also expect to remain active longer.

Free time, health, and relative financial comfort are creating a mature market of immense potential. Over the last two decades, consumption by the over-50s in Europe has increased three times as fast as that by the rest of the population. In industrialized countries, people over 50 buy about half of all new cars (a fact of which auto makers are just starting to respond).



## AGING IN PLACE AND INTELLIGENT APPLIANCES

How will elders cope with the challenges of aging? Many will turn to connective and assistive technologies to remain independent and continue living in their homes. The former will help elders remain active, and the latter will help them with daily tasks that they can no longer complete themselves.

The ideal smart house used to be thought of as one that would take care of everything for you. It would be a “machine for living in,” to borrow modern architect Le Corbusier’s phrase. In contrast, some of today’s best scientists aim to create systems that help residents do things, instead of systems that do things for them. As professor Stephen Intille has described the MIT House\_n project:

Our primary vision is not one where computer technology ubiquitously and proactively manages the details of the home. Technology should require human effort in ways that keep life as mentally and physically challenging as possible as people age.

Work on communications and monitoring systems has taken off thanks, in part, to the discovery of a clear relationship between isolation and depression. Elders are much more likely to stay active when their social lives are active and they’re in touch with family and friends. Active elders are healthier elders. Sedentary elders are at greater risk of heart disease, diabetes, and obesity. (Elders often need encouragement to remain active. In Japan and the United States, the elderly watch 5–6 hours of television per day.) Likewise, there is evidence that, by remaining mentally and physically active, elders can fight the onset of Alzheimer’s. Having a house that does too much to take care of you, can be bad for you.

These insights have driven work on intelligent appliances in two directions: toward the development of connective systems and assistive systems.

### Connective Systems

Connective systems keep active, independent elders in touch with family and friends. These systems might, for example, remind a user that they haven’t talked with a relative in a few days (or, for more distant relatives, in weeks). This system might link with calendaring systems to schedule get-togethers with neighbors. They might analyze a resident’s sleep and activity patterns, alerting a child or doctor if an elderly parent’s routine shifts dramatically—an indication that something could be wrong.

For example, the Digital Family Portrait, developed by Georgia Tech engineers, “reconnects family members by providing a qualitative sense of a distant relative’s well-being, while striking a reasonable balance between privacy and the need for information.” The

### Smart Home Entertainment Center



Source: <http://www.research.phillips.com/newscenter/pictures>

portrait's "digital frame changes daily, reflecting a portion of the person's life," and providing a sense of that person's condition.

### Assistive Systems

Assistive systems are designed to help users with everyday tasks. One early example is the smart medicine chest: cabinets with RFID readers, connected to medical databases and other services. A smart medicine chest would be a delivery platform for a variety of health services. A smart medicine chest could remind users to take their medicine and verify that they've completed a prescription-drug course. It could warn patients against taking drug combinations that produce adverse effects. If connected to a physician's office, the chest could order automatic refills when a prescription runs low.

None of these sounds like a major problem, but they are. Forty percent of prescription-drug courses aren't finished, which keeps people from getting well, helps create new drug-resistant illnesses, and increases overall health care costs. Thousands of people in the United States die each year from adverse drug events caused by unsafe combinations of drugs.

More complex assistive systems are designed to help elders who have problems with household tasks or memory. These consist of monitoring devices in rooms or furniture that closely follow vital signs, provide guidance in preparing meals and other daily tasks, and warn against potential dangers—an unattended pot boiling, bath water that's too hot, or clutter on the floor that creates a hazard.

For example, Georgia Tech's Memory Mirror uses RFID tags to sense when an object has been moved, and places a photograph of the object on a digital "mirror" showing the last 24 hours. The mirror helps users remember whether they've done daily tasks like feeding pets or taking medicine.

More ambitious is Intel's effort to use wireless sensor networks and embedded computing to assist elderly users compensate for memory impairment. Its CareNet "detects, monitors, and records the daily living activities of an elder by collecting data through postage-stamp-sized wireless RFID tags affixed to household objects. Ultimately the system could help manage everyday activities so that the elders' independence is maintained, while relieving some of the burden of around-the-clock care by caregivers."





## RFID SYSTEMS AS ENTERTAINMENT CHANNELS

As RFID tags are joined by interactive displays on packages, and as flexible displays become ubiquitous in the home, it will be possible to construct experiences and entertainment that layer atop products. RFID tags will become triggers for content and interaction designed to make products more entertaining and useful.

Some content will be primarily instructional. Cosmetics, for example, are difficult to apply. It requires skill to use cosmetics to enhance appearance but not call undue attention to the makeup, itself. This skill is difficult to communicate in print, but much easier to convey via video. Not only could such systems provide basic instruction about how to use a product, they could teach more experienced users the underlying rules for their smart use. Different cosmetics are designed to serve different purposes and to create different effects. Users who understand the “why” behind instructions, and who also understand what other products could be useful, are happier, savvier consumers.

Another place RFID systems can teach users and improve their experiences is in the kitchen. Smaller numbers of Americans learn the basics of cooking today. Interactive packaging could walk the culinary novice through a recipe or instruct them on basic cooking tasks—sifting flour or separating eggs, for example. In a kitchen where countertops (or cutting boards) have RFID readers, the tags could trigger software agents or videos to help with preparation; communicate with appliances to set temperature, timers; offer entertainment (e.g., classic *Julia Child*, *Iron Chef*); and provide information about the origins and cultural background of the dishes being prepared.

A third area in which consumers would benefit from real-time, contextual help of RFID technology is in the nursery. New parents constantly need help with tasks. Baby care is unpredictable enough to make real-time help especially valuable. Imagine, for example, an RFID reader-enabled changing table that could detect the presence of a new diaper. The device could trigger an audio feed featuring instruction about how to change diapers; analyze diaper-changing patterns over the last several weeks; and warn parents of problems (or more likely, assure them that nothing is wrong); or trigger an overhead display to play a snippet of *Baby Mozart* to calm an upset child.

There are other opportunities for turning such instruction into a group activity. Most young girls learn how to use cosmetics from their friends; interactive instructions that let girls “pair up” to learn new techniques and practice on each other, would take advantage of the social dimension of learning about beauty. Likewise, cooking can be solitary and functional, or a group activity. A virtual master chef that assigns tasks to an entire dinner party, and delivers background information about dishes and cuisine, could turn a strenuous, one-person job into a pleasant social experience.

Talking Trivet



Source: <http://context.media.mit.edu>

### WHAT IS USER INNOVATION?

User innovation is a major source of progress in personal high-tech. The personal computer, PDA, IM, e-mail, and blogs (among other technologies) have been extended beyond their inventors' markets by tech-savvy users, who moved them into new use contexts, extended their technical abilities, and created new software and services around them. The first generation of personal computer entrepreneurs in the 1970s (most notably Bill Gates and Steve Jobs) included a number of hobbyists trying to extend the bounds of an infant technology.

User innovation is powerful because it's a "bottom-up" process, wherein the producers and consumers of technologies are one in the same. Innovation is also a deeply social, collective process. Innovations can't survive unless they're popularized. Because they're often openly distributed, user innovations can be refined and improved by fellow users. Such user networks are a low-cost way to distribute and test new products.

A few industries have already recognized the value of user innovation. The auto industry closely tracks which cars are popular among customizers. Some car designers even work with makers of custom accessories to ensure their vehicles can be easily modified. The cell phone industry has spawned a vigorous aftermarket in everything from colored covers to downloadable ring tones.

User innovation has not been a significant factor in most consumer goods. Today, it's harder to hack a box of Tide than an iPod. As ordinary products acquire computing, sensing, and networking functionality, however, they'll become more like high-tech products—interactive and reprogrammable.

### FROM EFFICIENCY TO SOCIABILITY

Communications technologies often start out being used to increase efficiency, but users reinvent them as media for sociability—for connecting to other people. This pattern is visible at the dawn of civilization. The earliest written records in the West—the clay tablets left by the Babylonian and Sumerians—are not poems or myths or laws. They're inventories. In fact, writing in the Near East is thought to have evolved from a system of tokens that merchants used to account for goods carried on caravans.

This pattern continues throughout history. The telegraph and telephone were first targeted at businesses, and only after a couple decades did companies realize the potential in letting ordinary people use these systems. Likewise, Thomas Edison imagined that the phonograph would be a tool for businessmen, a device for



dictating memos to clerks or secretaries. It enjoyed modest success as an office technology. But when music companies discovered that phonographs could record and play music, the technology took off.

## USERS INNOVATE AROUND SOCIABILITY

What do high-tech user innovations look like? In the early days of personal computing, they were focused around applications. Personal computers didn't do much, so users wrote everything from spreadsheet to publishing programs. They also extended the PC's capabilities by creating hardware—networking systems, printers, and more.

Over the last decade, productivity tools have been taken over by established software companies, becoming part of the foundations of modern computing. No hacker is going to write a word processor that unseats Microsoft Word. At the same time, the Internet and World Wide Web created a vast, appealing playground for user innovation. As a result, the epicenter of “bottom-up” high-tech has shifted to applications that create and exploit sociability—applications that allow people to come together, to share, and to cooperate. Instant messaging and IRC (Internet relay chat); peer-to-peer file sharing; blogging; and social software have all come from the margins of the software development world. Some have become big business, while others are still struggling to turn popularity into profit.

## RFID AND USER INNOVATION

Here are some potential, user-driven innovations involving RFID.

### Everything Will Tell a Story

The more you know about a product, and the more about how to use a product, the more likely you are to be satisfied with it. RFID will give manufacturers—and eventually individuals—the ability to mark goods with unique digital identities. It would be a simple matter to create an Amazon-like system that allows users to either review products lines or share stories about individual products—and to retrieve that information while using the product. The technical information that manufacturers provide could be supplemented by information from users about how a product works and how to make it work well.

The virtue of such a system is that it would serve as a way of capturing the highly specific, curious-but-useful knowledge that we all acquire about products and which at least a few other people would find useful.



Following a similar path as previous technologies, RFID will evolve from a tool strictly for utility to a medium for social communication and personal expression. Blank RFID tags that can be encoded with information by consumers at home could spark an entirely new way to share content, like in this imagined form of RFID graffiti.

### Google for Your Things

Kevin Ashton likes to talk about a coming “Internet of Things,” a world in which RFID and other technologies link digital data to places and things. If there’s an Internet of Things, there will be a Google for Things: specifically, a Google for *your* things.



Here’s how it might work. Once RFID tags are common features in all kinds of products—everything from clothes to children’s toys, books to batteries—and readers are cheap enough to put in doorways, it will be possible for your house to keep track of ... everything. Rather than search under the sofa for that missing left boot, a parent could ask Home Google, “Where are all the red boots?” The accuracy of the system’s response would depend on how many readers were installed in a house. Readers in doorways could record when things enter or leave a room. Readers on shelves could pinpoint the exact locations of goods on them.

This would be convenient for keeping track of things that are easily lost, like children’s clothes and toys. It would also have the added benefit of generating an inventory of your household possessions, which could be invaluable in the event of a fire or other disaster.

Easily locating a misplaced item in the home will be one of the most useful consumer applications of RFID. The smart home of the future will be made up of à la carte, off-the-shelf products that easily network with each other. One such product might be an overhead light that shines on an RFID-equipped item once it has been located.

### Safe Borrowing: Google for My Friends

The same physical infrastructure of RFID tags, readers, and search software could be married to social software, allowing groups of friends or coworkers to safely share their possessions.

College students, for example, might create inventories of their books and CDs, which they would share with friends (who likewise share their inventories). This would make it possible to create book- and music-lending circles (something that’s done in a primitive form with the online service Mediachest), while allowing owners to keep tabs on who last borrowed their property. The system would also serve as a recordkeeper, tracking who has borrowed what goods. It could also remind you (perhaps via an SMS to your cell phone) to return things after a few days, after a period set by the owner or when another member of the circle needs it.



## Products Helping People

RFID systems could also be combined with local networking and social software to make it possible for strangers to cooperate and help each other. For example, smart baby bags—bags that inventory their own contents and know what they ought to be carrying—could communicate with one another, creating local inventories of diapers, wipes, and other baby supplies. If someone in the area ran out of diapers, their baby bag could send an alert to its neighbor's, and ask if any extras are available.

This would be a significant convenience for some groups; it also becomes a way to spread information about products and to give consumers a chance to try your brand.

## THE FUTURES OF RFID

This series of memos has explored the history and current state of the technology, public concerns over its use, described potentially controversial uses, and its likely role in smart homes and for increased sociability. In the fifth and final memo, *RFID: Implications and Recommendations*, we will discuss what the futures of RFID mean and how to avoid potential pitfalls posed by controversial uses and navigate to a world where businesses and consumers alike find great value in RFID.



**New social applications will emerge in a future of cheap RFID tags and ubiquitous tagging of everyday objects. Imagine a service that facilitates connections between friends and random strangers—like the groundbreaking web service Friendster—only now done by matching users through their RFID-tagged clothes hanging in their smart closets.**

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## ABOUT THE ...

### THE TECHNOLOGY HORIZONS PROGRAM

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