

1. Reception

It's a Friday afternoon in the year 2009. Today, Annika is the last to arrive home. As she opens the front door, the house computer recognizes her from the RFID chip on her key ring. "Great that you're here," says the android voice. "Volker and Melanie are here too." "What a pity the voice sounds a bit tinny," Annika thinks to herself. Because the other two have already eaten, she quickly makes herself a sandwich.

2. Refrigerator

Ready for the weekend, the fridge has ordered new supplies via the Internet. Thanks to small microchips in the packaging, the sensor knows what the family needs. It also knows when a product's shelf life has expired.

3. World Cup tickets

Instead of football from the living room TV, soon there will be seats in the stadium. The whole family has ordered tickets for the 2010 World Cup. Names and identity card numbers will be stored in RFID chips in the tickets. This should make sure that Volker, supporting Germany, doesn't end up among the England fans.

4. Going to school

Daughter Melanie does her homework on the floor. It's a long way to her school, but now it's safer. Thanks to microchips woven into her clothing and the new satellite-based positioning system Galileo, her parents always know where Melanie is. There's sometimes confusion when she takes off her RFID-equipped wardrobe on weekends though.

5. Weekends

Friday evening means bop 'til you drop. Thanks to a small chip in his arm, Volker is recognized as a regular at his favorite nightclub. Meanwhile, Annika goes to the cinema. While they're out, motion detectors and the home computer will tell them whether Melanie is really asleep or not.

6. Dog

The family's German shepherd, Osso, is back home. He was missing for two days. A small chip under his fur meant the police who picked him up could at least identify him immediately.

7. Books and DVDs

There is an explosion in the number of lending libraries and DVD rental shops. The costs of tracking leased media have dropped dramatically with the advent of RFID.



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Tiny transmitters will soon be everywhere. RFID chips, which can be read from a distance, are changing our lives and transforming retail.

{Text} Hilmar Poganatz {Photos} Dejan Patric



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Visions



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1. Welcome

A supermarket in 2009. Magda and her son Felix have no time for pleasantries, but a speaker at the door greets them by name. Magda's been a customer here for years, and is identified by the RFID chip on her customer card.

2. Security

Thanks to the introduction of RFID, shoplifting in supermarkets has dropped to almost nothing. More expensive items can be displayed openly, instead of in locked cabinets. Retailers save billions, offsetting part of the costs of implementing RFID.

3. Shelves

Out of three types of pasta, Magda always chooses the one with the red label. When she takes a packet, a small display on the shelf shows how much it costs. RFID chips also make shelf inventories superfluous for store managers.

4. Promotion

"Enjoy your spaghetti", says a voice through a speaker on the monitor. "With these fine noodles, I would recommend Bonino sauce." RFID technology opens up a range of extraordinary new opportunities for the marketing business.

5. Customer profiles

RFID product data combined with the personal data on a customer's payment card means that customer profiles can be more accurate than ever before. Should your preference for ready-made spaghetti sauces be part of your profile, those items – when on sale – will automatically be called to your attention whenever you pass by a display with your customer card.

6. Checkout

Another two or three purchases, then quickly to the checkout. All products are automatically recorded via their transmitter chips. And as Magda lifts Felix out of the shopping trolley, her account is automatically debited when details are transmitted by the RFID chip on her card.

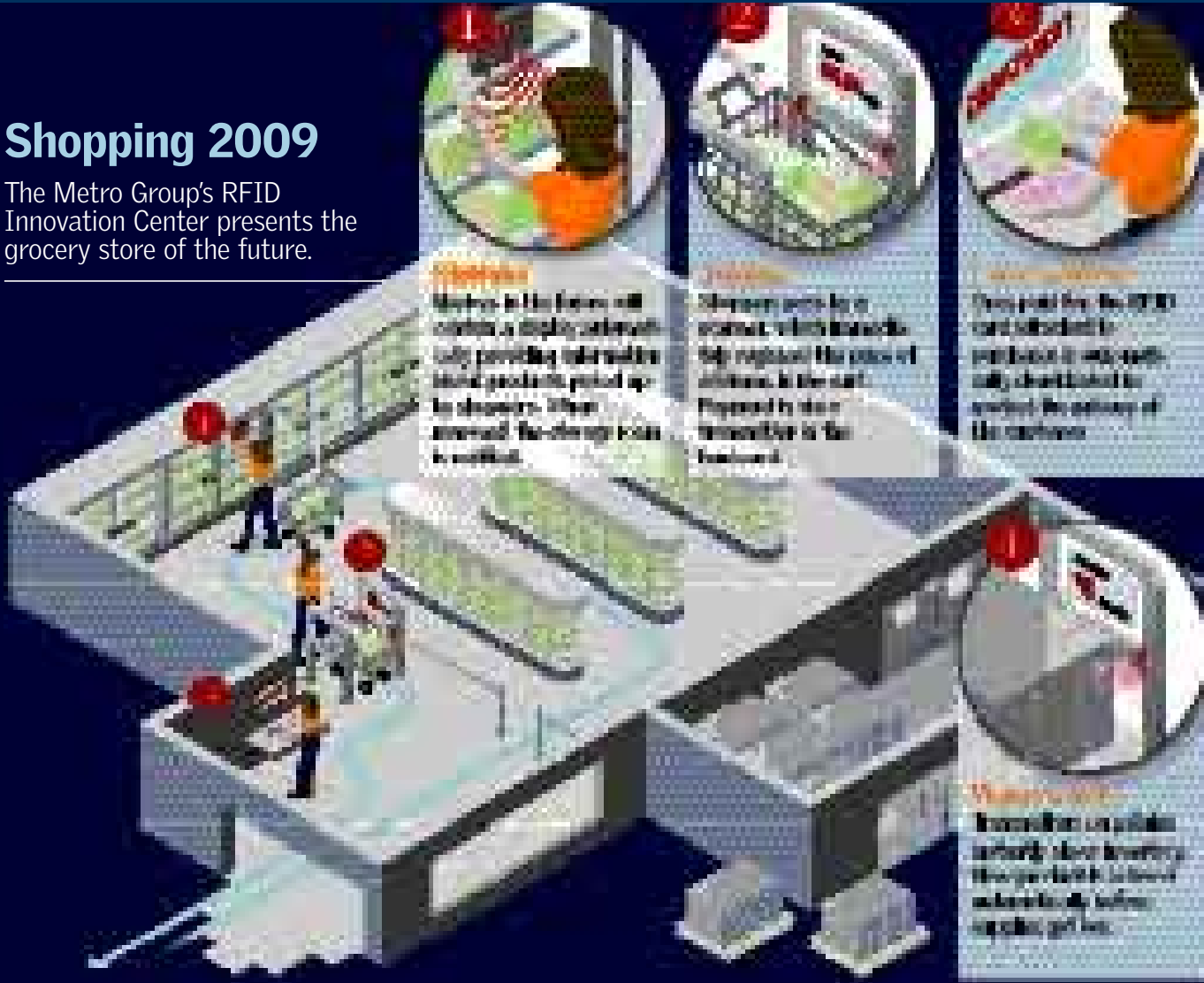
7. Closing time

Magda and Felix are last to leave, and their customer card notifies receivers at the store that they have left the property. The store's computer dims the lights in the empty aisles.

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Shopping 2009

The Metro Group's RFID Innovation Center presents the grocery store of the future.



Shopping
Members of the future will control a single cart with only providing information about products picked up by shoppers. When returned, the shopping cart is recharged.

Shopping
Shoppers come by a scanner, which tracks the help represent the price of products in the cart. Powered by their smartphone in the background.

Shopping
They pay for the RFID card collected by the scanner is automatically identified to control the payment of the customer.

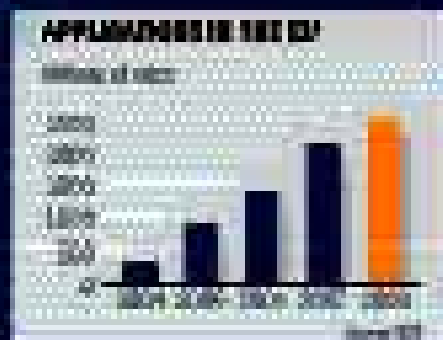
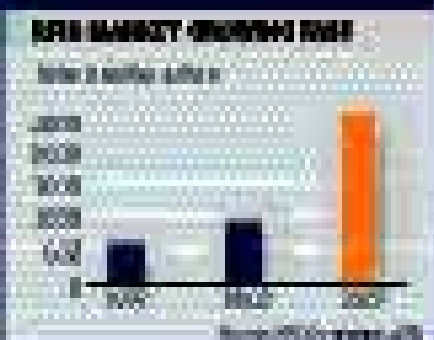
Shopping
Innovation can make it easier to shop. However, they can think about what they do before they get to the store.

RFID LABEL

The label used in the process of the RFID system is a small, thin, and flexible label that can be attached to a variety of products and materials.

RFID TAGS

Most of the RFID tags are used according to the RFID system. The RFID tags are used to track the location of the products in the store.



Information overload? Data amounting to as much as 30 typewritten pages can fit on one chip.

Something was scratching Elmar Bongartz's right hand. A couple of days ago, he had bought a new pair of gloves – they were on sale for ten euros at a clothing store in Cologne. "There's probably still a price tag or something inside," Bongartz thought. He peered into the glove and, yes, there was a sticker with a barcode there. About half the size of a credit card, it had a number too – 80025 75540 – but otherwise, there was nothing special about it. Bongartz carefully peeled the sticker off. On the reverse side, he found concentric silver lines that looked like an electronic circuit. "That's more than just a price label," he thought, "But what is it?" Shrugging his shoulders, Bongartz chucked the thing in the bin.

What he threw away with barely a thought was a precursor of what is currently the biggest thing in retailing and logistics: a tiny transmitter or, more accurately, an integrated circuit. In the trade this is known as an RFID chip, for "radio frequency identification." This chip is a tiny technical marvel. It not only can store large amounts of information – as much text as would fit on 30 typewritten pages – but can also send it independently and unobtrusively to an inconspicuous receiver hundreds of meters away. A transmitter? Does this mean the customer is being tracked without him knowing it?

"No," says Knut Brüggemann, a spokesman for German fashion retailer C&A, where Bongartz bought his gloves. Brüggemann points out that, although the clothing company is watching the development of RFID "with great interest," it is not yet actually using the radio technology – the flat chip in the glove was nothing but a security device to prevent shoplifting. And it would be deactivated at the cashier. So far, C&A is not taking full advantage of the potential which the chip offers. But how can customers be sure of that? "They can't," says Brüggemann.

This example shows how common RFID chips already are today. Companies in all areas, not just in the industrial and logistics sectors, are already taking advantage of the fact that remote receivers can detect the chips. The American market research company In-Stat predicts that the market for RFID technology will grow tenfold by the end of this decade. This could make RFID even more of a revolution than cellular telephone technology, although lots of people don't yet realize that this technology even exists.

In the near future, the use of RFID will rise dramatically. In particular, plans to use transmitter chips on tickets for the 2006 Soccer World Cup in Germany are currently the subject of a lot of discussion. Ostensibly the chips are to prevent counterfeiting. But because the football association FIFA will also have access to the ticket holders' identity details, it will – at least in theory – be possible to locate individual fans inside the stadiums provided they have the ticket on their person. German



Fast food: RFID technology smoothes the supermarket check-out process.

Son of radar

RFID technology was used for the first time during World War II. Now it is indispensable in many fields.

■ For more than half a century, engineers, programmers and inventors have been toiling away on the technology that could completely revolutionize the future of logistics. RFID builds on insights into electromagnetic waves which scientists gained in the 19th century. After the invention of radar, the Allies first used RFID transmitters during World War II to identify their own aircraft.

■ In 1948 an American called Harry Stockmann laid the theoretical groundwork for RFID technology, although it wasn't until the 1960s that it was first used to combat theft: a simple sticker – a tag – made possible electronic monitoring of articles (EAS) in stores. Ten years later, the tag was

adopted in livestock breeding: it was used to identify animals and transmit their characteristic features to wired-up farmers in real time.

■ In 1987 Norway pioneered the commercial use of RFID technology to levy road tolls. Just a few years later, toll stations all over the world were fitted with readers that could book toll charges without slowing down the traffic. The number of companies using RFID technology exploded.

■ Today, enormous advances in electronics have made available state-of-the-art chips that can send active data over great distances and be reprogrammed thousands of times.

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Visions

Interior Minister Otto Schily's plans to include both biometric data and a special RFID chip in the next generation of passports due out this fall are fueling the public debate in Germany as well. But there's more. RFID technology is also scheduled to arrive on banknotes. The Federation of German Engineers says it has been informed that the European Central Bank will also start putting RFID chips into euro banknotes this year to combat counterfeiters and monitor circulation.

RFID is just now breaking into public awareness. Surveys in the US show that the number of people who have some idea what the term RFID means grew from 28 to 41 percent in the last six months. The results of US surveys by the market researcher Big Research also indicate the number of people – about two thirds of those surveyed – who have reservations about the new technology is unchanged. In particular, respondents saw the remote tracking of privately purchased goods as negative.

Indeed, the brave new RFID world promises “real-time supply chain management.” In the future, orders for goods will no longer seen in terms of days or weeks, but in terms of now. When an item is taken off a particular shelf, the network immediately registers that fact. That means the system can place an order for more goods with the producer while at the same time checking the progress of fresh supplies already coming in by road or rail. “With RFID, a company no longer has to rely on assumptions,” says Mark Roberti, founder of the authoritative US trade magazine *RFID Journal*.

Now that the world's largest retail chains have started to support the new technology, RFID has been getting closer and closer to the end customer. US retailer Wal-Mart, for instance, has required its 100 main suppliers to use RFID chips on their goods. Here in Europe, Metro has announced it will be working with RFID along the entire chain from ordering products to putting them on supermarket shelves. It has launched a project with 100 suppliers, ten central warehouses and 250 shops.

The logistics industry is also making huge investments, ensuring that RFID technology will soon penetrate into nearly every aspect of modern life. The ultimate scenario foresees massively scaled-down operations to supply retailers. They will provide the product and collect proceeds from the sale, but at the same time, they will reimburse the wholesaler and order replacements. Steve Muliak from the Progress consulting company, which specializes in logistics, says RFID is like a moving locomotive. “And it is going to arrive very soon.”

Back in Europe, the Metro Group's RFID Innovation Center in Neuss, Germany shows how a complete RFID-controlled supply chain could look. In the first hall of the vast test operation, commissioning – preparing consignments for dispatch in the warehouse – is simulated. This is where RFID, working together with SAP software, should minimize the amount of downtime needed by warehouse workers to locate products in



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With RFID, a company no longer has to rely on assumptions about where its products are.



1. Biometrics

2009 in the office. Ludger had an important meeting in the United States. Because his iris and fingerprints are recorded as biometric data in the RFID chip in his passport, he went through US Customs without a hitch.

2. Personal greeting

In the building, the elevator greets him by his first name. "At least someone is talking to me," thinks Ludger. In his jacket pocket, he's carrying a company chip that allows him round-the-clock access to his office and computer.

3. Washing machine

Ludger's clothes are always clean because washing them takes less time. Washing machines automatically follow wash and care instructions from broadcasts by tiny chips sewn in the label of wardrobe articles.

4. Security

Security is a big concern at Ludger's company. The security staff use handheld receivers to keep an eye on who is in which part of the building, and when. They can also keep track of employees' time on the job.

In the warehouse of the future, things don't go where they belong, but anywhere there's room.

storage and update inventory. A carton glides over the silver rollers of a distribution warehouse and stops at a photoelectric barrier, where a receiver records the RFID label and promptly calls for Triumph-brand underwear. Julia Bellemann, a student trainee at the plant, packs the box, which then clatters off with its load. "If I'd packed the wrong underwear, this is the point where the box would have been sorted out," she explains. "We're already in the future here as far as our thinking is concerned," she adds: until now, transponders were too expensive to put into low-priced articles such as underwear. The receiver functions at 13.56 MHz high frequencies. The relatively low wavelength makes this frequency suitable for short distances and therefore ideal for use with individual articles.

Next, Metro spokesman Albrecht von Truchseß, who is conducting the tour of the Innovation Center, strides over to a suspended sorter. Hangers carrying blue and white dresses and blouses from Esprit clatter along its elevated rails. Over



{ Peter Schaar }

"They don't have to inform customers if they integrate chips into products."

his head, the commissioning system reads the RFID labels and assigns each item of clothing to its destination: Berlin, Düsseldorf, Munich. "This sorting can reduce the amount of empty shelves by up to 15 percent," says von Truchseß. A printer on the commissioning test run produces RFID labels on the spot, underlining the simplicity of the procedure.

To test warehouse management, Metro uses another hall, which is dominated by a three-meter high portal. It looks like a science fiction "stargate" that can beam the beholder into far-off galaxies, and it stands white and majestic in the middle of the chamber. In fact it's an entrance and exit for goods deliveries. The trainee pushes a pallet with 18 cartons of Pampers disposable diapers through the portal and a green light blinks. "The portal knows exactly what it's looking for," says Julia Bellemann. Together with handheld receivers, receivers on the forklift trucks and the receivers on the high-rise racks, the system is a warehouse manager's dream come true: items no longer have to be put where they belong, only where there's room, because Big Brother knows where everything is anyway. That saves both space and time.

A conveyor system suspended on the wall opposite shows how RFID sorts individual articles: dresses and suits are identified by radio transmission and automatically hung there in

the right order. According to a study carried out by full-service RFID system providers R4 and Intelligent Systems, these RFID labels can make warehouse management eight times more efficient. Another example is baggage handling at airports: the American carrier Delta Air Lines is planning to use RFID transponders on suitcases. That should make it possible to capture data on at least 95 percent of luggage automatically: with hand scanners and bar codes, only 80 percent of data is collected automatically. It could save around \$100 million a year – that's how much the airline industry shells out to return luggage that has been sent to the wrong destination. So it's no surprise that the operator of Frankfurt's international airport Fraport is testing RFID at this very moment.

The warehouse at Metro's test center was fitted out by German fashion label Gerry Weber. This is where the contact with the end customer is simulated. "Well, here we've taken a real step into the future," says Metro's von Truchseß. At first, the hall looks like any normal fashion department at a Kaufhof or Karstadt department store. But then you start to notice the details: if you take the striped satin blazer "Stromboli" off the hook, you'll see in a small display next to it that it is 40, costs 139 euros and, most important, perfectly matches a certain blouse which costs 74.95 euros. "The aim of the exercise, of course, is that you don't only buy the item which you came to get in the first place," says Bellemann with a smile.

The private household is the most futuristic part of Metro's Innovation Center. Behind the wine rack, there's an ultramodern kitchenette. It's supposed to hint at developments that can be seen in their full glory in various "Houses of the Future" such as the new Deutsche Telekom high-tech dwelling that's currently on display in Berlin. The futuristic refrigerator doesn't only have an RFID receiver that will check how much milk is left and the date of expiry of the mayonnaise, it's also permanently connected to the Internet. The state of the pantry can be checked remotely, and if you don't have time to do any old-fashioned shopping, you can order online, too – maybe from a website also set up by Metro.

Further back in the supply chain, which cannot be illustrated at the Metro Innovation Center, the application of RFID can take various forms. BMW and Volkswagen, for example, both use Siemens' Moby-R system to pinpoint the exact location of any given car among the thousands of automobiles on their vast factory sites. Unlike the RFID labels in the retail sector, the transponders here are larger, battery-operated and transmit on a frequency of 2.54 gigahertz (GHz). Such a high frequency allows signals to travel bigger distances – up to 300 meters – on the huge vehicle parks.

Another example: at clothing manufacturer Gardeur's plant near Oldenburg, Germany, a recyclable RFID chip is attached to each item in the postproduction phase. After an almost fault-free test run, Gardeur decided to invest nearly a quarter

Snooper chip or super technology?

So far, there has been no law anywhere specifically to govern the use of RFID tags.

■ **Invasion of privacy, industrial espionage or sabotage:** aside from its advantages, RFID technology can also be misused. But while the authorities and businesses can guard against remote decryption or alteration of mobile data storage devices, private individuals have been left out in the rain as far as data protection is concerned. Linking product data from RFID chips with information about existing or potential customers provides detailed information about the behavior of private individuals. Anyone who allows themselves to be identified by RFID devices could, in theory, be registered elsewhere as well. That means their movements could be tracked. In addition, the issuer of a customer card could find out, for instance, whether the customer is wearing clothing bought from a competitor. Consumer protection groups are calling for a complete halt to all RFID applications until there is more clarity in what kinds of data can be collected, how it will be used, and what recourse consumers have to inspect their data.

■ **Companies have not exhausted all the technical possibilities of these miniature transmitters.** That is why Germany's Federal Office for Security in Information Technology (BSI) thinks there is no great potential for danger as long as RFID isn't pervasive. The German government also sees "no need to legislate at present." Because RFID chips used in the retail sector can only be read from relatively close at hand, the government thinks that "the current level of technology" excludes any possibility that product and customer data can be combined, and believes existing regulations to be sufficient.

■ **But there is some dissent among the ranks.** Ulla Burchardt, the technology expert for Germany's Social Democrat Party, has warned the Interior Ministry against integrating RFID in passports as planned. She says the new passports are open to unauthorized reading and copying. Peter Schaar, the government's data protection commissioner, is also skeptical. He wants to see not only obligatory



Under the skin: The chip implanted in this man's arm contains medical records and data about his health which could one day save his life.

warnings on products that contain RFID chips but also right of access to the information stored on those chips, as well as their permanent deactivation after a purchase has been made. "In theory, they don't have to inform customers if they integrate chips into products, only when they link personal data to them."

■ **Californians have been quicker off the mark.** A year ago, the state Senate proposed the world's first law to lay

down data-protection standards for the use of RFID. "Senate Bill 1834" includes provisions banning the collection of personal data from RFID labels on products. But the law disappeared into the bottom drawer as fast as it was put forward. Lobbies applied huge pressure against the legislation at the committee stage, and it never reached the state parliament for a vote. A coalition of industry groups argued the technology was too new to be restricted at the regulatory level.

A chip for all seasons

We've been surrounded by RFID technology for a while now – usually without realizing it.

■ **The next year alone** will see three times more RFID tags sold than in the entire 60 years since their invention. Even now, the number of potential applications is dizzying. E-Z Pay RFID toll chips have been a feature of American highways for years, and now a new variation of the technology has arrived in Germany. Initially used only to identify vehicles, the miniature transmitters are now indispensable to entire traffic management systems.

■ **The possibilities for tagging animals** with RFID chips have increased exponentially since the development of new chips the size of rice grains. Since February, every dog in Austria has had to carry one of these digital fleas in its fur. In Florida, Applied Digital Solutions wants to plant



VIP treatment: A chip under the skin smoothes entry to the most fashionable nightclubs.

its new VeriChip under the human skin. The chip will record a patient's data.

■ **The Baja Beach Club** in Rotterdam has taken things to the next level. Not only has it declared itself the "most fun place in Europe" but it's also the very first disco to put VeriChips under the skin of its regular guests. The chips are used as VIP tickets and for electronic cash. But will they become a fashion accessory?

■ **In southern Europe**, the late Pope John Paul II approved RFID systems for the Vatican. The chips help to control two mil-

lion books and documents in the Vatican library as well as monitoring who goes in and out of the parking lots in the Roman Catholic city-state.

■ **And finally, even the hacker community** is beginning to have fun with the RFID chips they have hitherto eyed with such skepticism: a German hacker called Dividuum has succeeded in writing music files over RFID chips holding a kilobyte of information. As soon as the chip goes anywhere near a reading device, music rings out in the old Commodore-64 format SID.

of a million euros in a complete package from Infineon Ident Solutions. "At the moment, we are only using RFID for the receipt and issue of goods," says logistics manager Heiner Gangfuss. Gardeur removes the chips before the goods leave the factory. "But sooner or later, the transport companies will buy the chips from us in order to save counting goods manually four times," says Gangfuss. Gardeur is also working on ways of marking each individual item of clothing coming from its production facilities in Tunisia. "There's no way of reversing the trend," says Gangfuss.

However, there's still some way to go before real-time supply chains become a reality: companies that want to take advantage of these innovations are still faced with problems at just about every level. For example, not all materials or surfaces are equally suitable for RFID applications. Physical impediments such as metals, fluids or reflective surroundings all require different frequencies. In America, RFID pioneer WalMart failed to pay enough attention to these aspects and immediately started getting a 60 percent failure rate on chip transmissions in its stores. "13 MHz applications don't have a problem there," explains Bodo Ischebeck from European chipmaker Infineon. However, they aren't suitable for use in the delivery bays nor for large-scale industrial logistics, where longer ranges call for higher frequencies of around 900 MHz or 2.5 GHz. "If I want to cover the entire supply chain, then I'll need three different technologies," Ischebeck says.

Another problem is the lack of any global standards. As Germany's Federal Office for Security in Information Technology notes in its survey *Risks and Opportunities in the Application of RFID Systems*, "The only solutions on the market

at present are individual ones particular to each manufacturer; in many cases, the necessary soft- and hardware is not compatible with other solutions." So now the race to develop a universal RFID standard is underway. The EPC Global standard is making headway, especially in North America. In time, it is supposed to supplant the large number of existing ISO sub-standards and become the only application covering the entire supply chain. However, EPC Global is itself a compromise solution with a very broad frequency range. Although it avoids the various established mobile communications frequencies, it does so at the cost of efficiency. A switch to second-generation chips is now underway: these will function with different regional frequencies, which means they can be used anywhere in the world.

The price difference between the first and second-generation RFID chips is so great that hi-tech market research company Gartner assumes not everyone can afford them. Why's that? Because margins on the fast-moving consumer goods which would profit most from the technology are so low that attaching expensive G2 chips to them would seriously impact their profitability. A survey by management consultants AMR has shown that a lot of WalMart's suppliers have only grudgingly taken up RFID because they are not sure what benefits it will bring. In fact, some suppliers have already pulled out.

"If we see RFID in use in end sales at any time in the near future," says Metro's von Truchseß, "then it will be for fashions." With a high-margin item like a Boss suit, he says, "It doesn't matter if a chip costs 80 cents." Even for manufacturers such as appliance-maker Philips, which has already attached RFID chips to 400 million products, economies of scale

For every computer you can see, there are 160 other processors hidden in appliances nearby.

haven't yet kicked in. For the user, RFID is still mainly of interest in closed, backroom systems where the transponders can be recycled. A final breakthrough is not expected until the unit price drops below ten cents.

Even when that happens, data protection will remain an explosive issue. Both sensitive commercial data and information about private individuals can be collected through RFID and misused. Even password-protected G2 chips cannot be totally shielded from data pirates. Because of the security concerns, the German Armed Forces' main supply depot in Kassel does not employ RFID. Although Germany's information technology watchdog BSI currently assesses the threat from outside interference as "very low," it assumes that any widespread adoption of RFID applications could prove "a temptation to attack the system."

As far as protecting privacy is concerned, however, the BSI is less concerned about targeted attacks on RFID systems than it is about threats "from normal operations" – in other words, from the collection of personal information relating to customers by the retailers themselves. In theory, they could use the information stored in a chip combined with electronic payment details from cash and credit cards to work out when a particular customer bought a particular product, how they paid for it and, if the chip keeps on transmitting, what they did with it afterwards. Peter Schaar, Germany's data protection commissioner, warns that so far regulations are insufficient: "Manufacturers don't have to inform customers if they integrate chips into products." Protests at Metro and Tesco in Britain have already forced both companies to remove the RFID chips from some items on their shelves.

Alois Ferscha from the Institute for Pervasive Computing in Linz, Austria, suggests that people have already long lost control over how they interact with technology. "It would have been nice if the developers had given us the chance to decide for ourselves," he says, "but I don't think we can stop it now." For every visible computer, there are 160 invisible processors installed in machines such as cars and microwave ovens nearby. "If all these things were to start communicating with each other by radio," Ferscha extrapolates, "then they won't be individual devices any more."

Aided by transmitters with microscopic dimensions, computer processors could form part of a global matrix that is present in everything. Hitachi has already developed digestible granular "smart chips" to put into foodstuffs. Microscopic "Smart Dust" is another new development. In the future, a country could be able to use it to guard its own frontiers and monitor the territory of its enemies. "What is coming at us is unimaginable – and very threatening," Ferscha warns. "If we're not grown up enough to deal with it, it could do us a great deal of harm." ■



Unclear future: Good for warehouses, but safeguards needed.

Limited uses at present

Schenker says high costs and a lack of standards mean RFID won't be widely implemented for a few years yet.

■ **Schenker**, as a worldwide logistics services provider, sees chances as well as risks in the advent of RFID-based logistics systems. Adhesive electronic tags within the supply chain will make it easier to design transport streams and create more efficient procedures within the company. Automated systems also make it possible to improve both the planning and the monitoring of shipments. Vehicle and warehouse capacity can be better exploited, and the productivity of employees improved. But Schenker sees some problems in the area of data protection. Depending on which RFID application is used, safeguards are required.

■ **Wolfgang Diehl**, Schenker Deutschland AG director of IT and Systems Development, says that technical standards have to be

better defined before the full potential of RFID technology can be exploited. "First we want to see that overall standards are created so that all parts of the supply chain can make proper use of the technology," says Diehl. "Then the price of components has to come down."

■ **While RFID is a better solution for monitoring inventory and warehouse access**, the high price of transponders does not make it an economical alternative to simple barcodes. Schenker only expects it to be widely used in shipping individual packages after 2010, at the earliest. At the moment, the company sees the optimal use for RFID as being in specialized transports outside of its core business, and where budgetary considerations are not the foremost priority.