

A REMOTE CONTROL FOR YOUR LIFE

BY CHARLES C. MANN ILLUSTRATIONS BY MARCOS CHIN

A CELL PHONE
THAT PAYS YOUR
SUBWAY FARE, GETS YOU
THROUGH AIRPORT
SECURITY FASTER, AND
RUNS YOUR HOUSE
REMOTELY? JAPAN'S
NTT DOCOMO IS
BUILDING IT—AND
BRINGING “UBIQUITOUS
COMPUTING” TO LIFE
FAR AHEAD
OF SCHEDULE.



TAKESHI NATSUNO WANTS YOUR WALLET. MONEY, CREDIT CARDS, DRIVER'S LICENSE, PICTURES OF JUNIOR AND SIS—THE WORKS. AND WHILE HE'S AT IT, HE'LL TAKE YOUR KEYS, YOUR BANK PASSBOOK, AND A BUNCH OF YOUR OTHER VALUABLE STUFF.

But Natsuno is no thief. He's the managing director for i-mode strategy at NTT DoCoMo, the biggest cell-phone company in Japan—and one of the most innovative telecommunications firms anywhere in the world. His title bears some explanation: "NTT" stands for Nippon Telegraph and Telephone, the former state telephone firm that owns two-thirds of his company. "DoCoMo" is a labored English acronym for "Do Communications over the Mobile Network," as well as a play on the Japanese word *dokomo*, which means "anywhere." And "i-mode" is DoCoMo's wireless Internet service—by far the world's most successful, with some 41 million subscribers in Japan alone (compared to four million for Sprint's PCS Vision, the first popular wireless data service in the United States), not to mention licensed versions in seven European nations and Taiwan. Natsuno wants your wallet because DoCoMo plans to build on i-mode to transform the cell phone into a kind of remote control for your entire life—and a preview of tomorrow's universal computing.

The plan will go into gear this summer, when DoCoMo introduces a new and radically more versatile type of phone. Like a regular cell phone, it will make and receive telephone calls. Like a regular i-mode device, it will let you send and receive e-mail, play online games, and access any one of the 78,000 i-mode-compatible websites around the world. And like other DoCoMo phones, it will take photographs, read bar codes, and play downloaded music over headphones or tiny but surprisingly good speakers. But it will also contain a special chip made by Sony that lets it pay for groceries, serve as personal identification, unlock doors, operate appliances, buy movie and subway tickets, and perform dozens of other tasks.

"All the credit cards, loyalty cards, keys, money—all that stuff in a woman's purse or a man's wallet—should go into the phone," Natsuno says. "By having the phone with you, you shouldn't need anything else but your clothes."

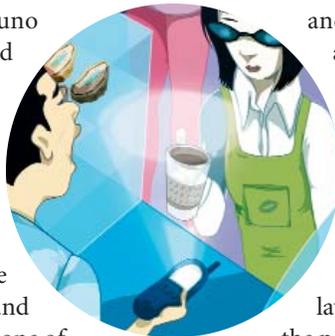
More than just a major advance in cell-phone technology, DoCoMo's new system is a first step toward a low-rent version of one of computer science's biggest dreams: ubiquitous computing. Coined by the late Mark Weiser of Xerox's Palo Alto Research Center in the 1980s, the term refers to the promised "third wave" in computing, in which networked computers merge seamlessly into the human environment. In the archetypal scenario for such networks, office workers' refrigerators scan themselves every afternoon to see whether they have any milk; when workers get into their cars, their phones automatically call their houses, which

respond with "buy milk" reminders. Most visions of ubiquitous computing have involved either a flotilla of exotic new devices like smart refrigerators and coffee cups or an extensive retrofitting of our surroundings with sophisticated sensors and actuators.

DoCoMo, though, is taking an entirely different approach. It is cobbling together a kind of quick-and-dirty version of ubiquitous computing by adapting existing hardware and software and funneling control of the system through the cell phones its customers are already carrying in their pockets.

"'Ubiquitous computing' is one of those engineer's terms that customers don't want to know about," Natsuno says. "The words never cross my lips. But yes, that's where we are heading."

The result, he believes, will be both a glimpse of the future and a step toward spreading DoCoMo technology across the world.



LOVE AT FIRST BYTE

The scene never fails to startle visitors from the United States. A subway train stops in the station, and the public-address system announces a pause to clear some bit of detritus from the tracks. Delayed for several minutes in hyperpunctual Japan, all the passengers silently and simultaneously extract their cell phones and thumb-tap messages to whomever they are on their way to meet: *Sorry, I'm going to be a little late...*

Japan isn't the most wirelessly connected society in the world; that honor goes to Taiwan and Luxembourg, which both have 106 cell phones for every 100 inhabitants, compared to a mere 64 per 100 in Japan, according to the most recent data from the International Telecommunication Union. But the Japanese use mobile communications for more purposes than any other people. Text messaging, for example, is a strongly encouraged alternative to phones ringing and people chatting in public places, which are (rightly) considered irritations. A common sight in grocery markets or takeout stands is a man photographing a food display with his phone, cell-mailing the image to his spouse, and asking whether the food should be purchased. Meanwhile, bored children riding in the shopping cart play fortunetelling games on the family's second phone.

According to Mizuko Ito, an anthropologist at the University of Southern California's Annenberg Center for Communication, the reason for this rapid adoption of cellular technology lies less in the peculiarities of Japanese etiquette than in the nation's dense, urban population and relatively low rate of computer own-



"All that stuff in a woman's purse or a man's wallet should go into the phone," says Takeshi Natsuno.

ership. “The Japanese spend tremendous amounts of time on mass transit and as pedestrians in cities,” she says. “So where U.S. teenagers might sit in their suburban bedrooms and instant-message each other from their computers, Japanese kids, who don’t have their own computers and their own bedrooms, are out on the train or in city streets texting each other on the keitai [cell phone].” As the U.S. grows denser, more urban, and more dependent on mass transit, it may well become more like Japan. “In that sense,” Ito says, “Americans can look to Japan as the future.”

DoCoMo has long fueled the Japanese love affair with cell phones. The firm officially began life in 1992, when the government eliminated NTT’s previous monopoly on mobile communications. At that time cell phones were “an executive tool supplied by the corporation to a select few,” according to Kenji Kohiyama, a longtime NTT executive and director of DoCoMo House, a company-sponsored communications think tank at Keio University near Tokyo. In Kohiyama’s view, cell phones did not become a mass-market item until 1994, when DoCoMo stopped leasing them to customers and began selling them outright at reduced cost, making up losses on their sales through the increased volume of telephone calls. Within two years, the number of DoCoMo subscribers doubled, from fewer than 1.5 million to almost three million. In five years, the number was almost 20 million.

That year—1999—the company introduced i-mode. “We thought the market for voice was saturated, so we had to do something,” Natsumo

says, half-joking. “So we brought the phone into the Internet—the virtual world.”

Users at first could do little more than access a few score corporate websites. But because i-mode used a special, compact version of ordinary Web software rather than the wholly new software demanded by European and U.S. cell-phone companies, individuals and companies were quickly able to put up tens of thousands of i-mode sites, DoCoMo-endorsed or not. Meanwhile, DoCoMo kept expanding the capacities of the handsets; the newest models, introduced in March, can take two-megapixel photographs, read Word and Excel files, record up to two hours of audio, and run Flash animations and PlayStation-like games on screens that by U.S. standards are startlingly crisp and bright.

Today, says Natsumo, “We’re starting to saturate on multi-media. So now we bring the phone to the real world.”

MAKING SMART CARDS WISE

At first, that mainly means equipping new phones with what is known as a “contactless IC” chip. Smaller and thinner than a dime, and attached to an antenna made from a thin film and embedded in the phone, the chip is like a small, fast, rather stupid computer, one that is exuberantly cheap to manufacture. The chip chosen by DoCoMo is Sony’s FeliCa (the name comes from “felicity” and “card”), which has nine kilobytes of random-access memory and just enough smarts in its onboard programming to respond to the short-range radio signal beamed out by a chip reader/writer.



In Tokyo, the most familiar example of a reader is at the turnstile used in Japan Rail train and subway stations. From station vending machines, passengers buy “smart cards”—plastic rectangles the size and shape of a credit card with chips inside. Each card is “charged” with a predetermined sum: approximately \$10, \$30, or \$50. People stick the cards inside their wallets and purses and slap them on the turnstile as they pass through. In the brief interval when the card brushes by the turnstile, the chip inside the card and the reader inside the turnstile perform a “cryptographic handshake”—that is, they exchange a set of encrypted messages. The turnstile tells the card its location; the card tells the turnstile how much money it contains; the turnstile deducts the base cost of a ticket. On the way out, the exit turnstile performs an analogous transaction, calculating the actual cost of the journey and deducting it from the card.

The entire transaction takes less than a tenth of a second. Not only does that help shuttle people quickly through the turnstiles, a key consideration for Japan Rail, but it also means the exchange of data takes place before users can pull away their cards. That reduces the risk of incomplete transactions—a major technical challenge in systems where cards do not physically pass through readers. According to Tadashi Morita, FeliCa’s chief engineer at Sony (no relation to Sony’s late founder, Akio Morita), slower systems run the risk that users will send payment information but walk past the readers before they have received their tickets in return. “They don’t know if they’ve been charged or not,” he says. “You don’t want [people] to pay twice, or not at all.”

Wireless payment systems are spreading fast. Hong Kong and Singapore have FeliCa systems in their subways so similar to those

A PHONE FOR ALL REASONS

With help from companies such as Coca-Cola, All Nippon Airways, and MasterCard, NTT DoCoMo is developing a bevy of practical uses for its i-mode FeliCa phones.

AT A VENDING MACHINE

Want a soft drink? Tap the phone against the special pad on the face of the vending machine. In the split second before the can drops down, the reader authenticates your phone, checks the amount in your account, and deducts the cost of a soda. The phone displays the purchase price and your remaining e-cash.

AT THE AIRPORT

Purchased an airline ticket online? After the transaction is complete, the airline e-mails an identifying code to your cell phone. At the airport, an automatic check-in machine verifies the code and uploads an electronic boarding pass to the phone. At the gate, another reader checks the boarding pass—confirming that, yes, you’re going to Osaka—and you’re allowed to board.

AT HOME

Want to unlock your front door? The phone’s FeliCa chip stores an encrypted numerical key unique to your residence. Tap the phone on a card reader next to the door. The reader verifies the code and unlocks the door.

“WE HAVE TO INNOVATE”

Takeshi Natsuno, NTT DoCoMo's director of i-mode strategy, is the main proponent of the company's effort to roll out all-in-one phones that take the place of cash, keys, credit cards, and other modern accoutrements. *Technology Review* contributing writer Charles C. Mann interviewed Natsuno at his Tokyo office.

TECHNOLOGY REVIEW: Introducing this new technology, which requires an expensive handset, just a few years after you asked consumers to adopt i-mode—which also required a costly new phone—is a gamble. Are you worried your customers won't want to adopt another format?

Takeshi Natsuno: Maybe, but we have to innovate. The history of the Japanese mobile-phone industry is that every five years it changes completely. Our company was founded in '92. For the first two years after it was set up, service was expensive and limited. We decided to sell handsets to the end user rather than leasing them. This changed the whole system. There was an explosion of demand....Our subscriptions increased from one or two million to 25 million. [In 1999] we realized the only new customers to get would be the lower-usage ones. We had to bring in something new to grow. So we added data use on top; we started i-mode. Now, already, more than 90 percent of the 45 million voice subscribers are i-mode users....But that market has matured.

TR: So how do you create new demand?

Natsuno: The next five years will link the phone to the real world. The first part is the contactless IC card. You'll use it on the post office register, as a building pass, a corporate ID, any kind of membership card, a credit card—the phone will replace the wallet in five years. Our goal is to have millions of people walking around without wallets in 2009.

TR: Isn't there a chicken-and-egg problem? People can't beam money from their phones until stores have payment mechanisms; but until a lot of people have the new phones, stores won't want to install new equipment.

Natsuno: This is a credit-card-like device. Credit card machines need to be replaced every three to five years. The new ones will be properly equipped. When I launched i-mode, it was our dream to have the Web inside a phone, so you could check your bank account and play games on your phone. Now that is all true, so I'm confident about the next five years. The phone will extend its reach.

TR: Into a kind of remote control for your life?

Natsuno: Literally! One application we are thinking about is for TV. If you have a DVR [digital video recorder], you can spend boring meetings in the office registering what TV program you want to record and call them in to your television. When you get home late, there they are. It's technologically easy to go beyond that, to send data to your air conditioner or appliances. All the technology is there. You just need a way to control it.

in Japan that the three governments are discussing the creation of pan-Asian transit cards. And in the United States, Washington, DC, subway riders can buy similar cards manufactured by Cubic Transportation Systems, of San Diego, which also set up the computing infrastructure behind the Chicago Transportation Authority's new contactless fare system.

But the cards do have disadvantages. Because users can't see how much money remains on their cards, they often discover that they have run out, or don't have enough to pay their fares, only when the doors slam shut on them as they try to walk through the turnstile. Exacerbating the humiliation, FeliCa cards are inconvenient to recharge: a card owner must back out of the turnstile through the rush-hour crowd, find the nearest FeliCa machine, and put the card and money into it. If a card is stolen, its owner may be out of luck: unlike credit cards, many FeliCa cards can't be canceled. Except, that is, when they cancel themselves; some Tokyo commuters report that the FeliCa chips go bad after a year or so in sweaty wallets, and that they have to whack them against the turnstile repeatedly to register transactions. When the cards die, their owners lose whatever money is still on them.

Connecting the smart card to a cell phone with a sophisticated display eliminates these problems at a stroke. Rather than having to feed bills into a special vending machine to recharge cards, users can check their balances by calling up bank websites and add funds to their accounts by direct deposit, then read their balances on the phone's screen. Protected by the carapace of the phone handset, the chips are less likely to go bad; even if they do break down, the bank records all transactions, preventing monetary losses. And if thieves snatch the phone, says Natsuno, "one call to DoCoMo cancels the thief's access to your phone—and your money."

More important to both Sony and DoCoMo, connecting the cell phone and the smart card opens up both to new uses, such as allowing phone owners to make small purchases at train- or subway-station vending machines and convenience stores. Later, as users gain experience with the system, DoCoMo will enable larger purchases. Items purchased with the FeliCa card could simply be added to monthly phone bills. (Having DoCoMo serve as a de facto collection agent should ease business fears about non-payment, because the phone company wields the power to cut off phone access—a powerful disincentive in a country where phonelessness is tantamount to banishment.) According to company representative Nobuo Hori, the new phones are also being tested as corporate ID badges and apartment-door keys. "Post office registers, airport gates, building passes, any kind of membership card or loyalty card, business cards—all should be in your phone, so you don't have to carry around so many pieces of paper," Hori says.

Ultimately, says Sony's Morita, the phone should become the main interface between the networked devices in homes and offices and the people who own them. "You will walk into a room and tap your phone on the wall," he says, "and the room will know who you are." An office worker might go into an empty office to borrow a computer, for instance, and his phone would identify him to the computer, which would then let him access his own files. "Everything would be set up just by touching a couple of pads." Particularly interesting to Sony is the prospect of using the new phones for digital rights management. "The TV would know what programs you had paid for," Morita says. "The PlayStation would know what games you can play. You would touch the screen with the phone, and it would be ready with your content."

To Natsuno, such an environment is a practical, here-and-now version of ubiquitous computing. “You get so many engineers saying this is not true ubiquitous computing because it does not follow some technical rule they have invented.” In his view, “the computers are everywhere, they are talking to each other, you are controlling them with the phone. This is ubiquitous as far as I am concerned.... We are just doing it without using the term.” If it takes building a ubiquitous system to allow DoCoMo customers to “turn on their air conditioners when they are 15 minutes away from home on their commutes,” he says, then “I’ll build it.”

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DOING IT RIGHT

In fact, he’s building it already. Parts of DoCoMo’s vision, such as the payment and identification schemes, are already being tested; more will be rolled out as the FeliCa phones, which will probably cost \$200 to \$300, are introduced this summer. To Morita, the barriers to full deployment are more societal than technological. “We could do most of these things today,” he says. “And we would be doing them today, if we weren’t worried about the security implications. And the privacy issues, too.”

Because Japan has more experience with mobile communications than the United States, it has virtually eliminated some cell-phone annoyances that continue to plague Americans. With the advent of text-messaging, says Ito, the anthropologist, “people just don’t talk on their phones on the subway anymore.” To avoid the nuisance of peeling phones in public spaces, she says, more and more Japanese “turn off the ringers when they leave their homes in the morning, and the ringers stay off all day long.”

The results of this socialization process are visible on any train platform in Japan. At any given time, a large minority of the waiting commuters—perhaps even half—will be using their phones. But almost nobody will actually be speaking on them. Instead, they will be sending or reading messages, checking weather or traffic websites, playing games, or (apparently a particular favorite among women) eliciting predictions about future romance from online fortunetelling programs.

To DoCoMo, the people staring into their phones are both an opportunity and a worry. The opportunity is to find more ways for them to use their phones, up- and downloading more packets of data. (DoCoMo charges roughly two-tenths of a cent for every 128 bits that go in or out of its phones; users may pay a penny per text message or a few cents to download a Web page.) One big new opportunity is shopping. Online users will be able to find items on i-mode websites and immediately buy them with digital cash stored directly in their handsets. Offline, in the real world, DoCoMo is focusing first on train stations, which are full of restaurants, department stores, and kiosks that sell the small, beautifully wrapped gifts of food that lubricate social occasions in Japan. In both cases, DoCoMo expects to generate more revenue as it sells more bits.

The peril is that as the phones grow more powerful, they will become targets for thieves and con artists. “We don’t want someone to walk around the platform with a stolen card-reader, downloading everyone’s money,” Morita says. “If people begin to think [the new phones] are insecure or violate their privacy, they will never use them.”

Critical to the security of the new system, he says, is the short transmission range of the FeliCa cards—only 10 centimeters, which makes it difficult for thieves to scan them. But according to Bruce Schneier, chief technical officer of Counterpane Internet Security in Mountain View, CA, this isn’t much of a defense.

“People will steal and hack the card readers to make them more powerful,” he says. “You could probably get the read distance up to a couple of meters, and then you would be able to rob a roomful of people just by walking around them.”

Nonetheless, Schneier is cautiously enthusiastic about the phone-smart card combination. In 1999, he cowrote a now classic analysis of smart cards’ security weaknesses. “Most of the bad things happen because there is no good way of telling who the card belongs to—who is supposed to be responsible for it,” he says. But DoCoMo controls the FeliCa phones. “If somebody steals your money, they have to collect it through the phone company,” he says. “They have to explain what they are doing trying to get your money, and that’s hard.”

The flip side of DoCoMo’s control is that the company also controls the records of users’ behavior—not only what phone calls they make, but what e-mails they send, where they go (subway fares), what they buy (FeliCa purchases), and a host of other things. If the phones are successful, the personal information compiled by DoCoMo will grow to volumes guaranteed to alarm civil libertarians.

But Schneier downplays the privacy concerns, arguing that people have already given up control of their personal data to innumerable banks, credit agencies, and retail establishments. “Something like this is going to happen, and everyone knows it,” he says. “These Japanese companies have tremendously competent people. There’s a good chance they might do it right.”

Back at DoCoMo, Natsuno is confident that the company will not only do ubiquitous computing right but do it first, and do it profitably. U.S. companies are “years behind,” he says—but not because Japan’s technology is more advanced. Pointing to the automatic toll-collection devices in many U.S. cars, he says, “You could have put those in cell phones and built on that to introduce Web services, or almost any of the other things we have done.” The real reason for DoCoMo’s lead, Natsuno believes, “is that we have a business model. We will give the consumer ubiquitous computing and digital money and all of those other things the engineers want. But we will do it by giving people a way to get through the turnstile faster or to arrive at a house that is cooled to the right temperature and has a movie ready to play on the TV.” ■

TR contributing writer **Charles C. Mann** is spending the year in Tokyo.

