

Smart Outfit

Computers worn like clothes may alter the fabric of everyday life

By PETER WEISS

When asked the date of a certain pivotal event in his life, Bradley Rhodes develops a faraway look. His left hand twitches.

Has the question stirred anguished memories of that fateful day?

No—in fact, Rhodes feels fine. His seemingly vacant gaze is actually fixed upon a tiny computer display inside a purple plastic box glued to the rim of his black beret. Strapped to his hand is a miniature, one-

Rhodes is a computer scientist at the Massachusetts Institute of Technology's Media Laboratory. Attired in his borg gear, he can pull up his borg birthday or reams of other information in seconds. Across the MIT campus, abundant wireless transceivers enable him and other borks to extend their reach around the globe via the Internet.

Soon, everyone could be a borg, say Rhodes and his colleagues. They are some of the more zealous members of a small but growing sector of academia and industry that's developing personal computers to be worn as clothing.

To borks such as Rhodes, wearing computers means adopting an entirely different lifestyle—a better lifestyle, borks argue—in which the computer's always on and participating unobtrusively, often automatically, in nearly every facet of one's life. The enhanced self is continuously receiving information from anywhere in the world.

"One of the things people don't realize is how slick you can get with this," says Thad Starner, one of the Media Lab's first borks, who now leads research on wearable computers at the Georgia Institute of Technology in Atlanta. His computer, for example, employs an agent, a software program written by Rhodes, which continuously searches for reports, E-mails, and any other data pertinent to Starner's activity.

"I've been [wearing this computer] every hour for the past 7 years," he says. "It's a wonderful existence."

To others developing wearable computers, the borg lifestyle seems a bit premature. Given the current limits of the technology, they see the wearable computer as an advanced tool for carrying out particular missions in industry or on the battlefield.

From either viewpoint, proponents of the technology agree that the "wearable" is far more advanced than just a computer that's portable in a new way.

"Twenty years from now, the world is go-

ing to look back on this time and what this community is doing as a changing point in the history of computing," predicts Dick C. Urban of the Defense Advanced Research Projects Agency in Arlington, Va.

Laptop computers—and more recently, smaller keyboardfree computers called personal digital assistants—are already portable. By contrast, wearable computers will eventually adorn the user with an array of sleek, lightweight electronic devices, all linked together by a so-called personal network, wearable developers predict. This equipment leaves the wearer's hands free.

"The vision is that eventually your garment will have all the electronics that you need, and it will all be soft," says David Eves of Philips Research Laboratories in Redhill, England.

"I think you will see wearable computers replace every portable electronic device out there," Starner says.

Tiny cameras and displays, microphones, cell phones, and other sensing and wireless-communications gear may all be part of the wearable computer. Video cameras, Global Positioning System receivers, and detectors of motion and other cues may enable the computer to continuously monitor the environment and the wearer. From the readings, the device will get hints of what the person is doing and what might be interesting or important to the wearer in his or her environment.

Developers say wearables will enhance even the most common of daily activities.

- Want to make a phone call? Just raise a hand to an ear to indicate "phone call" and speak the name of the person to be contacted into a headset with a microphone. Or silently spell the name in sign language. The computer will make the connection.

- Talking with a friend about gardening? Eavesdropping, an agent in the computer will scan databases for related topics and then display for the wearer a menu of notes on past discussions, E-mails, gardening catalogs, and other material that might be useful in the dialogue.



Shrinkage of computers, displays, and other gear has made "rigs" worn today by wearable computer pioneers smaller and more comfortable than earlier versions. The electronics that weighed down Steve Mann in the early 1990s (left) now fits into devices tucked discreetly into sunglasses, a one-hand keyboard in left hand, and hidden flaps in Mann's clothes (right).

handed keyboard called a Twiddler. The twitching of his fingers is simply the motion of typing commands to a computer in the bag dangling from his right shoulder.

"It was May 30," Rhodes reads from the screen. That was the day in 1996 that he officially became a borg. That's *borg* as in *cyborg*. He and a dozen or so other computer enthusiasts have adopted the name, common in science fiction, that describes a curious amalgam of human and machine.

Today's self-proclaimed borks have volunteered to be merged with a computer for many—in some cases, all—of their waking hours.



Carnegie Mellon University

Wearables-at-work: Employees with head-mounted displays scroll through on-screen checklists and repair manuals while testing electrical equipment (left) and inspecting an aircraft (right). They move cursors and click on selections using belt-mounted controls.

- Looking for a hot date? An infrared transmitter-receiver on a button broadcasts that information into space and reads information broadcast from nearby buttons on other people's wearables. If a compatible match comes up, the computer gives an alert and prompts with a few opening lines geared to the interests that the person broadcast in his or her profile.

The technology required by such scenarios is just beginning to emerge from research labs. Some researchers predict it will be widely adopted within a few years; others say decades. Ultimately, "people will wear computers all the time," says Cliff Randall at the University of Bristol in England. These machines "will know where you are, how you're feeling, and they'll be continuously feeding you information," he says.

While the potential of wearables may dazzle, the current reality lies largely in relatively mundane, special-purpose gear. In the past decade, researchers have produced a variety of prototype wearables for testing in military operations, vehicle and aircraft inspection, equipment maintenance, and other tasks.

"We want to make the blue-collar worker in the field more efficient," says Daniel P. Siewiorek of Carnegie Mellon University in Pittsburgh. He's a leader of a research group that has carried out more than 20 wearables-at-work projects.

Some U.S. soldiers in Bosnia, for instance, use a prototype wearable computer that translates between English and Serbo-Croatian. Basically a high-tech phrase book, the device, which is worn in a harness, listens to a spoken English phrase, repeats those words back through a headset to check that it got them right, and then states the translated message aloud.

Another wearable system that has been tested by the U.S. Marine Corps serves as a paperfree checklist for vehicle inspections. Screens with lists of conditions to seek appear in a head-mounted display, and the inspector scrolls through, clicking responses by means of a dial on his or her belt. Because it frees up inspectors' hands and feeds reports directly into databases, it cuts the time required for the task by 70 percent, Siewiorek says.

Researchers at a number of labs are developing and testing more sophisticated wearables that include wireless video, audio, and data communications. Such systems would allow two-way communication with a remote expert or leader who could ship blueprints, manuals, and other helpful information to the wearer's screen and virtually peer over the wearer's shoulder by means of video feedback.

Meanwhile, new technologies are appearing that bring the grander goals of wearable computers closer.

At the Third International Symposium on Wearable Computers last month in San Francisco, researchers from the University of California, Berkeley unveiled a technology that will sense the position and motion of a person's hands through minuscule sensors glued to the fingernails.

So far, the Berkeley group has created a prototype glove with sample sensors fastened to the tip of each finger. In the prototype, the sensors are wired to a computer, but in the final version they will be wireless.

Because the sensors detect acceleration from gravity and motion, the glove converts gestures into patterns of electrical signals that the computer can recognize as letters of the alphabet or other codes. No keyboard is required. "It offers a brand-new way of thinking about how you interact with a computer on a daily basis," says the team's Seth Hollar.

So far, the system can only deal with gestures in which the hand stays still. With additional programming, however, it can learn to recognize hand signals involving motion as well, the developers say. Eventually people may paint the sensors onto their nails, like nail polish, replacing the tiny detectors when they wear off.

Eves and fellow researchers at Philips have created another wearable sensor. It's a brilliant orange-red jacket that gives clues about the body to a computer system. Devised with the help of a fashion designer, the experimental garment incorporates 11 strips of electrically conductive fabric—"technical textiles," the researchers call them—at the shoulders, elbows, chest, and back. "The resistance [of the strips] changes as you stretch," says codeveloper Jonny Farringdon.

He puts on the jacket to demonstrate it, causing a three-dimensional stick figure to appear on a computer screen. The stick figure positions and bends its arms

in sync with the researcher. By tracking the arm positions and motions of the wearer, a computer might interpret the wearer's situation, recognizing clues that the person, for instance, is on the phone or driving.

"It's very handy for the rest of your wearable system to know what you're doing," Farringdon says.

Others agree that technical textiles are the stuff of the future. "There's a real potential now for making fabric do a lot more things than it has done in the past," Siewiorek says. "You're just seeing the tip of the iceberg."

Other presentations at the San Francisco meeting concentrated on innovative uses of wearable display screens. Several groups described using transparent screens to superimpose information onto a person's view of the world. The information could be anything, such as historical information for tourists or a map of a battlefield for soldiers. Says Richard W. DeVaul, another MIT computer scientist and borg, "This is a way to annotate reality."

The exciting new technologies of wearables currently face a discouragingly mundane obstacle: the lack of lightweight, long-lasting batteries.

"Batteries seem to be the bane of wearable-computing existence," says Thomas L. Martin of the University of Alabama in Huntsville.



A transparent cube of complex optics (wedge in left lens) serves as the screen for a prototype display built into prescription eyeglasses. The left temple-piece projects a color image. The ordinarily invisible cube was darkened for this photograph.

In the absence of better batteries, wearables makers are focusing increasingly on schemes to minimize the power used by their designs. At the symposium, Martin described experiments in which he determined that the peak power, rather than the average power, consumed by a device has the greatest impact on battery life. He encouraged wearables developers to devise ways to lower the peak demands of their equipment.

Besides inadequate batteries, wearables developers face the challenge of incorporating wiring and electronics into garments in such a way that they are lightweight, washable, and safe. Wires carrying a sizeable current must run from the wearable's batteries to devices

distributed around the body.

Offering one power-fashion statement, Michael M. Gorlick of the Aerospace Corporation in El Segundo, Calif., showed up at the meeting in suspenders made of webbing with embedded power wires and metal snaps as outlets. Gorlick hung gadgets with blinking lights to the suspenders during the conference to show that they worked. He cautioned that moisture, such as sweat, could short out his crude prototype. "I'm willing to give my life to the cause," joked Gorlick.

Seriously though, safety considerations could be a hurdle for wearables, should they ever develop mass-market appeal, says social scientist Jane Siegel of Carnegie Mellon. She studies how well wearables field-tested by the military and industry actually suit the needs and preferences of potential users. "Whereas most of the people around here are zealots about the technology," she says, referring to attendees of the San Francisco symposium, "I'm an agnostic."

Siegel speculates that borgs may be risking their health by carrying electrical devices so close to their bodies for long periods and peering all day at tiny computer displays.

Rhodes counters that he and other borgs investigated such risks early on. Physicians reassured them, he says, that low-power devices such as theirs pose no risk. The computer wearers also received assurances from optometrists that their vision wouldn't suffer as long as they

avoided staring at the screen, he says.

Siegel questions whether there have been sufficient studies to back up such claims about vision safety.

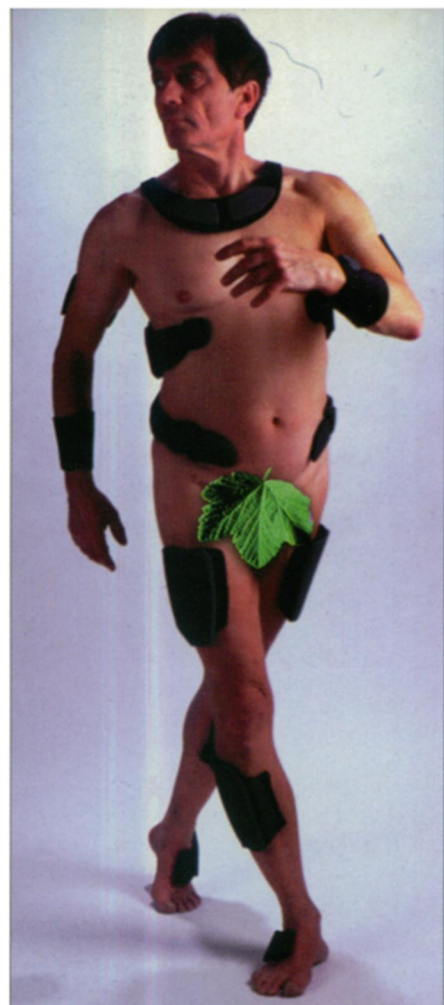
Even if wearables prove to be safe—and live up to their hype—developers still face a potentially serious snag. Will people be willing to wear them?

Most people don't even own the handheld, keyboardless computers that are getting such breathless attention in the computing market, notes Astro Teller, a computer scientist who until recently worked on wearables at Carnegie Mellon.

"Asking them to wear computers is really a stretch," he says, even though his Pittsburgh-based start-up, called Bodymedia, will be doing just that. Bodymedia is betting on a wearable shirt that will enable people to monitor their personal health. It would keep track of weight, metabolism, heart rates, and stress levels, for example.

The bulkiness of current wearables makes them a hard sell. What developers can offer today aren't really wearable but only "bearable" computers, remarks Juha Kaario of Nokia Research Center in Tampere, Finland.

Starner describes the recent connections between wearables developers and fashion designers as "geeks meet the chic." In addition to his academic role, he's an officer of InfoCharms, a new wearable-computing-devices company in Sher-



Adapted from Carnegie Mellon University

Designers have identified many sites where packaged computer equipment would not impede normal motions.

man Oaks, Calif., that sponsors wearables fashion shows around the world.

Other wearables researchers rising to the challenge of making computer clothing attractive and comfortable are Francine Gemperle and John Stivorich at Carnegie Mellon. In a yearlong study of how to discreetly place small objects on a person's body, they found they could position 41 specially designed packages that could be worn at the same time. Remarkably, this caused "no restriction, no interference," Gemperle reports. One hefty issue the researchers didn't address, however, was weight.

While developers struggle to figure out what people will want in a wearable computer, they seem unanimous about what people don't want. Even borgs admit that most people would like nothing less than to look like borgs.

The homemade computer systems that borgs carry are clunkers. "They're big. They're bulky. They short out. They get you strange looks on the subway," Rhodes confesses.

Yet someone has to be the pioneer, he argues. "We want to figure out what these are going to be useful for, and you can't do that except by building them." And then wearing them. Being a borg, Rhodes concludes, is a "living experiment." □

COMPLETELY REVISED AND UPDATED

ALLERGIES

THE COMPLETE GUIDE TO
DIAGNOSIS, TREATMENT, AND
DAILY MANAGEMENT

- Hay Fever
- Asthma
- Food Allergies
- Sinus Problems
- Drug Allergies
- Allergies in Children and more

To order by phone from
Books Now call:

1-800-266-5766
Dept. 1494

Visa, MasterCard, or American Express

Do you sneeze and sniffle with hay fever every year? Do additives in laundry detergent or perfume give you a rash? Is your asthma getting worse? Are milk products, shellfish, or peanuts forbidden foods for you?

YOU DON'T HAVE TO SUFFER ANYMORE.

This book debunks the many myths about allergies and offers long-term help to both the seasonal and chronic sufferer. *Allergies*, a comprehensive and authoritative resource, helps you make informed choices about matters such as diagnostic tests, nasal antihistamines, homeopathic remedies, desensitizing therapies, and emergency relief for severe allergic reactions, and much more. *Allergies* offers you:

- Details of the most common over-the-counter drugs
- Information on how to minimize allergens like dust mites, mold, and pollen in your house
- Advice on guarding against "sick building syndrome" and environmental toxins
- Options about when allergy shots are unnecessary
- Plus a special section on allergies in children and the elderly

—from Plume

See our Web site at
www.sciencenewsbooks.org

A SERVICE OF SCIENCE NEWS BOOKS

BooksNow The Virtual Bookstore™

400 Morris Ave., Long Branch, NJ 07740

Please send me _____ copy(ies) of *Allergies*. I include a check payable to Books Now for \$9.95 plus \$4.95 postage and handling for the first book (total \$14.90). Add \$2.50 for postage and handling for each additional book.

Name _____

Address _____

City _____ State _____ Zip _____

Daytime Phone _____
(used only for problems with order)