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Honey, I Programmed the Blanket

By KATIE HAFNER

THE average middle-class American household has about 40 microprocessors in it. If you own a PC, with all the paraphernalia that goes with it, that number increases to about 50.

There's a microprocessor, or chip, in a bathroom scale with a digital readout, and there's one in an iron that turns itself off automatically. An average electronic toothbrush has 3,000 lines of computer code. On the more sophisticated end of the spectrum, there's a smoke detector that places a call to the fire department, a dishwasher with sensors that gauge the soil level of the water and adjusts its cycle accordingly and an identification tag placed under a pet's skin.

Known as embedded microprocessors (or, in a simpler form, microcontrollers), these invisible chips are far more numerous than those that drive desktop or portable computers. Tom Starnes, an analyst at Dataquest, a market research company, said that the number of embedded processors sold in 1998 was 4.8 billion and that only about 120 million of them, about 2.5 percent, had been intended for personal computers.

PC's, video games and smart phones get all the attention as symbols of the electronic age. But the chips that really make this age electronic are almost completely hidden. It may seem like the era of the personal computer. It is just as much, if not more, the era of the hidden chip.

And chips will be found in even more places in the future. Mr. Starnes estimated that in five years, the average number of chips in the home could grow to 280 and the number sold to 9.4 billion. The tough question in predicting the future is figuring out what won't have computing power in it.

An embedded chip is any processor that is not inside a computer. Its job is to make its presence barely known. It can lie at the heart of something as trivial as a musical greeting card or as vital to life as a pacemaker, which uses a processor to analyze signals from the heart and determine if the heart needs some help.

"Almost anything with a power switch now has a microprocessor in it," said Peter N. Glaskowsky, a senior analyst at Micro Design Resources, which publishes Microprocessor Report, a newsletter.

In accord with Moore's Law, which states that the density of chips doubles every 18 months, the semiconductor industry has steadily found ways to shrink the size of chips and increase their performance. "The same thing that would have filled a room in the 50's is now on a chip that costs $1.95 and sits in a microwave," said Jim Turley, vice president of marketing for ARC, a microprocessor design company based in London. "It's really a pretty spectacular thing to watch."

The result has been a profusion of chips in everyday objects: toothbrushes, cars, kitchen appliances, office buiildings, toys and sports gear. "If the engineers can dream it, they'll do it," said Guy Thomsen, an applications and support manager at Hitachi Semiconductor in San Jose, Calif.

One inventor even dreamed up an idea, patented in 1992, for a condom with a chip in it. The chip was set up to produce sound -- music or voice. It's not clear whether the condom ever went into production.

The upper-middle-class house of Scott Smyers, a vice president at the U.S. Research Laboratories of Sony Electronics in San Jose, Calif., who focuses heavily on embedded microprocessors for consumer electronics, is a good example of a house that has chips the way cats have fleas.

The laundry room in Mr. Smyers' house has a $1,000 Maytag washing machine called the Neptune, which eliminates the exorcist effect that takes hold of most washers when they go out of balance. Before the machine has a chance to spin out of control, its processor senses the abnormal vibration and slows the drum down enough to rearrange the laundry.

In Mr. Smyers' kitchen, the Thermidor range produces a perfect simmer by turning the flame on and off. If a gust from an open window extinguishes the flame, the stove relights itself. Mr. Smyers' $100 Accu-Sense toaster, or "toasting technology" as it is advertised by Kitchen Aid, senses the temperature of the surface of the food inserted. If it is frozen, the toaster stays on low heat slightly longer. For Mother's Day, Mr. Smyers gave his wife a double thermal convection oven with as many buttons to push as a VCR.

A typical family car may have 20 embedded chips, which control things like the fuel in the engine, air bags, remote keyless entry, radio, CD changer and dashboard displays.

As chips grow more powerful, engineers are finding ways to connect them. Particularly clever examples of this are showing up in some luxury cars, which can have more than 60 processors.

Many luxury cars, for instance, have a chip that compensates for road noise by adjusting the volume of the radio as the speed of the car varies. And many have sensors on the back bumper that tell you if you're getting too close to someone or something while backing up. You can also find cars with side-view mirrors that communicate with the transmission so that if the car is put in reverse, the mirror automatically tilts to provide the best view for backing up, as well as cars with driver's seats that remember each driver's preferred seat and wheel adjustments and switch configurations depending on who unlocks the car.

"The future of the embedded processor is not a stand-alone embedded processor but with an eye toward communications between devices," Mr. Smyers said.

Mr. Smyers' new Mercedes ML320 sport utility vehicle has a braking function that communicates with the transmission during both deceleration and acceleration. "If you're accelerating and one of the wheels loses traction and starts to slip, it senses that and automatically applies the brake to the slipping wheel," Mr. Smyers said. The car also has two spark plugs per cylinder, and an embedded computer optimizes fuel conservation.

Airplanes are also now filled with embedded chips. The Boeing Corporation's newest jet, the 777, has some 1,300 microprocessors, 10 times the number of chips in the first Boeing planes with digital components. The 777's chips control among other things, the flushing of the toilets, the entertainment system at each seat, the fuel tanks, the thrust of the engine, the landing gear and the navigation system.

Embedded processors have received more attention than usual in recent months because of fears of Year 2000 computer problems. Companies and government agencies are rooting out these chips to determine whether they will fail on Jan. 1, 2000. Some people worry that Year 2000 problems could send traffic lights into chaos

or elevators plummeting to the ground.

But experts say that only a small percentage of embedded processors will malfunction. The ones that may be vulnerable are those that have timing mechanisms that are programmed to pay attention to the date, not the time of day or day of the week.

Traffic lights, for instance, are controlled by processors that change lighting patterns according to the time of day or day of the week. Even those that might use a calendar to determine the day of the week will hardly go haywire, Mr. Turley said. "The worst thing that could happen is they think it's Wednesday instead of Saturday and they follow the Wednesday pattern instead of the Saturday pattern," he said. "Where's the disaster?"

The same holds for the chips in buildings. Many elevators in high-rise office buildings are programmed to hover around certain floors at the lunch hour, for example, but are oblivious to the calendar. And heating and air-conditioning systems in the building are tuned to the time of day and day of the week to maximize their efficiency.

Embedded processors are using sensors in increasingly inventive ways. State-of-the-art printers have sensors in the paper tray that detect when the paper is low. In some new office buildings, infrared devices that detect crowd densities in lobbies are used to dispatch elevators. Many elevator lobbies also have heat sensors so elevators will not go to a floor where there is a fire.

And the $30 toy pet called Furby, a complex bundle of circuitry and mechanics, has captured the imagination not just of children but of engineers around the world.

Dave Hampton, the inventor and engineer who designed Furby, said his creation contained a chip with more processing power than the electronics inside the original lunar lander. The 21,600 lines of programming code on Furby's main two processors are devoted mainly to communicating with the many sensors in the toy. Furby's forehead has a light sensor as well as an infrared transmitter and receiver, for Furby-to-Furby communication. Furby also has a sound sensor, a tilt sensor and touch sensors on its front and back and in its tongue.

Still, the race to load objects with chips has also given rise to skepticism. Just because a chip can be installed in pretty much anything, does that mean it should be?

Upon reflection, Mr. Smyers recalled with some fondness the toaster his parents, Delbert and Eleanor, received as a wedding gift 50 years ago. The bit-free, sensor-free Toastmaster was a fixture in the Smyers household for 40 years, faithfully browning all manner of breadstuff, frozen and otherwise. "We put toast in and pushed the lever down, and turned the knob to dark, medium or light," Eleanor Smyers said. It wasn't until the Smyerses prepared for a move to a retirement community that the toaster, still in fine working condition, was given away.

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