Control software relates the input from electronic sensors to the output from robotic effectors. In its simplest and most familiar form it specifies a fixed sequence of operations–the cycle of a dishwasher or microwave oven, for example. More advanced control software applies decision rules in order to determine appropriate responses to current conditions. Thus an air-conditioning system may respond to temperature variations by varying its cooling output, a houseplant irrigation system may respond to soil moisture content by increasing or decreasing water supply, a clothes washer may respond to the particular fabric and cleaning problem by adjusting its chemical mix and cycle, and so on.

The most sophisticated control software has the capacity to observe and learn. For example, an advanced climate-control system might observe patterns of variation in external climatic conditions and internal user behavior, develop predictive models based on these observations, and thus anticipate needs. Instead of merely *reacting* to a drop in temperature, as a simple thermostat-controlled system would, it might *anticipate* the drop and prepare for it efficiently by adjusting heat production. Even more ambitiously, advanced control software might coordinate the actions of multiple devices and systems; on a snowy winter morning it might wake up a household by turning up the heat at the usual time, making wake-up calls at appropriate moments, switching on the lights, setting appliances to work to prepare breakfast, piping in personalized versions of the day's news, and starting the car.

Control software need not be fixed for the life of a device. Software-controlled devices may be reprogrammed as necessary–thus providing far greater flexibility than was possible with the hard-wired devices common in the past. And, where a device is networked, reprogramming may be accomplished by downloading the new software from the Internet.

These new capabilities fundamentally change the way in which buildings respond to the requirements of their inhabitants. Preindustrial buildings, as we have seen, relied mostly on passive strategies for responding to environmental variation and meeting user needs. Buildings of the industrial era made much more use of active, electrical and mechanical devices to perform these tasks, but depended on manual and simple automatic control systems. The intelligent interiors of the twenty-first century will increasingly integrate diverse electronic sensors, robotic effectors, embedded intelligence, networking, and control software to create distributed systems that respond in far more sophisticated and efficient fashion (Figure 3-3).

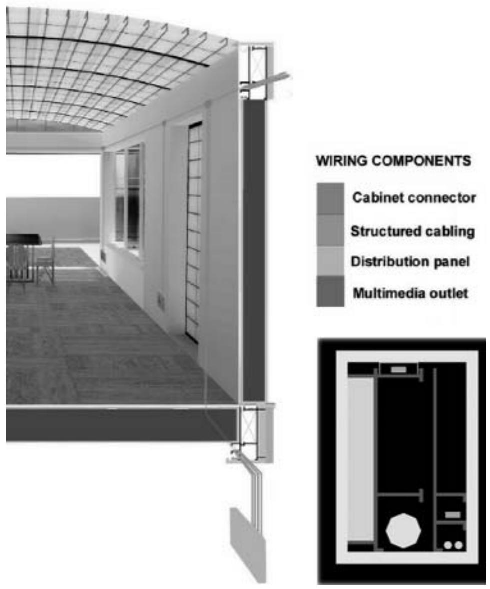

FIGURE 3-3
Buildings of the 21st century are acquiring electronic nervous systems. (House_n project, MIT, 2001. (Courtesy of Kent Larson)

CONNECTION TO GLOBAL NETWORKS

Just as a building's

Just as a building's internal plumbing is connected to the external water-supply network, and its electrical wiring to the electrical grid, so its internal network (the nervous system of its smart interior) is normally connected to an external information utility–the Internet.

The Internet had its origins in the 1960s, with the invention of packet-switching for digital telecommunications and implementation of the Arpanet –a network that initially connected a few large computers at universities and research centers. Later, development of the TCP/IP protocol allowed packet-switching networks to be readily interconnected, the proliferation of personal computers and engineering workstations increased the demand for interconnection, and the Internet emerged. Growth accelerated with the superimposition of the World Wide Web, the development of graphic browsers to facilitate surfing the Web, and the dot.com investment boom of the late