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| **Overly smart buildings** |  | **April 20/27, 2005** |
| **By Ted Smalley Bowen, Technology Research News**  The notion of buildings as "machines for living in," as pioneering modernist architect Le Corbusier put it in the 1920s, morphs to fit the technologies and issues of the day. In the '70s, it was energy efficiency. In the '80s, computer technology spawned "smart" buildings sporting automated controls and pre-configured information systems.   The latest crop of technologies [[1](http://en.wikipedia.org/wiki/Intelligent_building),[2](http://www.ibuilding.gr/definitions.html)] include microelectromechanical systems that combine sensors and actuators, wireless sensor networks, and fuzzy logic control schemes, and has the makings of a sophisticated nervous system.   This allows for close monitoring and adaptive control of building equipment, materials performance and environmental conditions, including temperature, air flow, and air chemistry.   The long list of potential benefits from intelligent buildings includes energy savings, better indoor air quality and more comfortable environments, [seismic and structural monitoring](http://trnmag.com/Stories/2003/061803/Wires_make_wireless_strain_gauge_061803.html), "predictive" maintenance, and tighter security.   Intelligent buildings have the potential to more easily adopt new, alternative and clean energy systems -- individually or in combination. The enlightened self-interest of energy efficiency has major significance, as the heating, ventilation and air-conditioning (HVAC), and lighting of US buildings accounts for [40 percent](http://www.pewclimate.org/document.cfm?documentID=391) of the nation's total energy consumption . [Worldwide figures](http://www.sustainable.doe.gov/pdf/sbt.pdf) are similar.   Among the efforts to make buildings more manageable, [research](http://www.isr.us/pdfs/publishedpapers/BAPParchitecture.PDF) led by Carnegie Mellon University scientists has mapped out a monitoring and control scheme that includes HVAC, power production, lighting, elevators, safety, and security.   Such schemes can be complex, however. They involve computer simulations tied into building control systems and updated by sensor feedback and performance data. Sensors keep tabs on virtually anything that can be monitored, whether mechanically, magnetically, electromagnetically, thermally, optically, chemically, biologically, or acoustically. And the conglomeration of sensors packed into intelligent buildings is increasingly accessed via wireless networks.   Architects and engineers extol elegant simplicity -- at least as a goal. But many of the problems that undermined earlier attempts at smartening up buildings, including complexity, incompatible and failure-prone components, difficult operation and troubleshooting, flawed or outmoded operating parameters, threaten to compromise the next generation.   There's also a heavy reliance on commercial information technology systems, including complex wireless networks, and communications, database and operational software. Much of the standard computer technology that has fueled economic productivity in recent years -- while introducing its own incompatibilities, inconsistencies, and vulnerabilities -- figures in intelligent building scenarios.   Buildings are especially unforgiving when it comes to new, complex and interdependent technologies, said Michelle Addington, a professor of architecture at Harvard University's Graduate School of Design. "There's a troubling sense that a well-networked building is simply going to be able to sense, track and analyze everything," she said. "The behavior of building environments is not as predictable as everyone would like to think."   The variety of equipment and software running intelligent buildings is nominally made coherent and manageable by industry standards [[1](http://ieee1451.nist.gov/intro.htm),[2](http://www.bacnet.org)] for smart sensor networks and building automation and control networks.   But equipping an intelligent building with sensors and information technology systems is not simply a matter of plugging in a few off-the-shelf products. Intelligent buildings introduce their own limitations and special cases.   While distributed sensors might run a scaled-down version of an industry standard operating system, they make less than ideal nerve endings. One effect of their spotty communications, restricted power supply, low capacity for computation and susceptibility to error is the need for a specialized method of [polling sensor nodes](http://www.cs.cornell.edu/johannes/papers/2003/cidr2003-sensor.pdf).   This approach involves modifications of network interfaces, routing protocols and other information technology building blocks that were not foolproof in the first place. This doesn't guarantee failure, but the more specialization and tweaking of standard components that goes into intelligent buildings the harder they're likely to be to operate, modify and troubleshoot.   Experience with intelligent buildings is limited, but researchers are beginning to put distributed sensors and automated controls through their paces. One recent [experiment](http://abi.ini.unizh.ch/public_pages/publications/%20pdfs/RutishauserJollerDouglas04_revised.pdf) measured the effectiveness of a decentralized control scheme in regulating the indoor environment of a Swiss office building.   The researchers focused on a single performance metric -- user comfort -- putting aside energy use and security. The complexity of meeting multiple, sometimes conflicting criteria is one of the main challenges of designing intelligent buildings.   The researchers' fuzzy logic software for controlling the building's heat and lighting is self-tuning, using feedback from sensors and switches. Measuring comfort in terms of how often users changed the settings themselves, the researchers found that the building system gradually took over the controls and made the majority of adjustments.   In general, artificial intelligence and fuzzy logic systems are only as good as the assumptions underlying their rules, Addington noted. "The computational structure might be there. The problem is the physics is not," she said. "There's all this talk about designing for performance, but performance [criteria are] based on a fairly out of date technology."   "The baseline comes from trying to make an archaic technology perform acceptably. HVAC science came 30 years after the systems became codified," said Addington. "This doesn't take anyone anywhere and it might freeze people into place."   Another hurdle is the expense of adding all that intelligence. Upfront costs are likely to be higher, maintenance could be a wash (upkeep of the sensor networks and control systems may offset savings from preventive and predictive maintenance), and obsolescence looms over all high-tech components. They will also require more extensive testing and commissioning than the norm.   Intelligence also imposes design constraints, including the need to anticipate the systems' failure. "Should something be open or closed?" said Addington. "It's... important to understand what these failure modes are."   And because intelligent building schemes apply only to new or recent buildings their global impact will be limited. "We're looking at it in a perfect world," Addington said. "The question for existing buildings will be very much in coupling intelligent systems with existing systems, dealing with aspects that you cannot design."   Many schemes amount to overkill, deploying too many sensors and gathering too much data, rather than narrowing in on key performance measures, atmospheric conditions, and other variables, and channeling the flow of air or people to a few monitoring areas, she added. "I honestly think the idea of having everything networked together misses the point," she said. "You can do a hell of a lot with a few discrete things."   While its building blocks include many promising technologies, the intelligent building addresses some uniquely complex issues, according to Addington, who noted that building environments represent some of the most difficult problems in fluid dynamics. "There's a concern that the technology is coming in before we have the sophistication to know how best to deploy it," she said.   At a time when support for basic research is being [cut back](http://www.aaas.org/spp/rd/guihist.htm) and applied research dollars are flooding to the latest security threat or most profitable product prospects, the challenge will be focusing enough resources on the kind of systematic, less glamorous projects that can make intelligent buildings more than the sum of their parts. |  |
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