Antonio Scotto DiCarlo, MSW
Glen Cove, NY

SMART HOMES
(Home Automation)

Smart houses (or homes) are known by a variety of names, including intelligent homes, home networking, home automation, sensor-embedded houses, and adaptive homes.

Smart home technology refers to houses installed with monitoring systems (sensors, actuators, and biomedical monitors) and special wiring to enable residents to program, control, and operate an assortment of appliances and other household features throughout the house. Smart homes have been defined as the integration of technology and services through home networking for a better quality of life.[1] Monitoring devices, such as sensors, are small and can be installed anywhere—inside or outside the home, or worn by an individual.

Depending on the user's needs, a smart house can include a basic network of wires operated by a central control panel in the home, while others might utilize wiring that allows the user to operate the appliances and features remotely from any area of the house—or even from outside the home—using a remote-control device similar to a television remote control "clicker." Through either method, home automation provides relative ease of use. Much of the work is carried out by the system itself, where it detects activity and discerns information based on homeowner input. The key goal for home automation is to give the occupant total control over the house from anywhere in the house or from a distant location.

Home automation can range from (1) simple, fixed applications with pre-defined and pre-established operations, to (2) applications and devices that are programmable by the user, to (3) fully flexible and automated applications and networks of devices that provide information to the home consumer or that can be programmed to share the information with others.

Historical Evolution—
A major focus of this technology, which has existed since the 1980s, has been to provide convenience, personal comfort, security, and energy-conservation; for example:

- All windows and doors can be locked from a central location in the home.

- A telephone call to the house can turn on the coffee, oven, or other elements.

- Lights can be programmed to turn on and off when someone enters and leaves a room.

- Exterior sensors can turn lights on and off in response to the amount of daylight entering the home.

- Home comfort systems (heating, air-conditioning, ventilation) can be set to automatically change in response to the time of day or to external temperatures.

- Exterior video or movement detectors can alert a homeowner to unusual activity, through sensors that evaluate foot-pressure changes, breaking glass, movement, and contact with windows and doors—and, if a resident is away from home, through a cell phone.

- Stove controls can detect high temperatures and automatically shut off burners and ovens.

- Room-to-room video and audio communication systems allow viewing and talking among people in different rooms and floors of the home.

- Audio/video controls allow music to be heard in one or more rooms of the house, multiple televisions to be controlled from a central location, and multiple media sources to be interconnected and manipulated.

More advanced systems are continually being developed—for example, a smart house can electronically maintain a cat's litter box and water the household plants. Recent developments have involved the internet, whereby a home can send messages to its owner who is away from the house via e-mail and text messages— for example, door sensors can inform the owner when children have come home or if an older member of the family has stepped out of bed in the morning.

Recent Focus—
While smart house technology has primarily focused on convenience and energy-efficiency, this technology is increasingly targeted for use by people with disabilities and for the care of frail older adults—providing safety, security, and ease of self-management, as well as providing both on-site and remote monitoring and health care. Over 34 million people in the United States are aged 65 years and older and nearly 15 percent of people aged five and older have one or more disabilities.[2] This recent increase in interest is related to (1) its practicality in supporting the ability of older adults and people with disabilities to remain living independently and self-managing in their own homes for longer periods of time, supporting a major preference of all people to "age in place" in the living environment of their choice; (2) its ability to support the significant efforts of family caregivers; and (3) its cost savings through reducing the need for expensive personal aide assistance, reducing the need for in-person medical care, and through delaying or avoiding costly institutional care.

Early applications of smart home technology included devices such as LifeAlert, introduced in the 1990s, which is a pendant worn around the neck that allows a wearer to alert a central response center when he or she experiences an emergency or needs help. Today's devices expand upon such efforts—sensors can be placed

on virtually any household object, even on the floor, where it detects movement and determines issues in mobility. Sensors can now detect if an individual has fallen and is unconscious, setting off an alarm and automatically signaling for help to an agency or family member. Other recent advancements can detect when a person gets up to use the bathroom during the night, automatically switching on a light.

Sensors have been developed to detect, record, and analyze movement patterns, footfalls, and the pace at which someone has climbed the stairs or moved between rooms, alerting family members living elsewhere if there are significant deviations from the pattern or if a sudden weakness in the foot, a collapse, faint, or black-out is detected. Other sensors can detect irregular heart rhythms or blood pressure.

Smart home technology can also aid in disease prevention—for example, providing inconspicuous memory aids, such as medication reminders; or refrigerators can evaluate an inventory of contents and provide suggestions for menus, healthy choices, and a list of groceries that need to be purchased. Vibrating bracelets or audible prompters can remind people when to eat or when to go to the bathroom, and other wrist devices monitor pulse rates and skin temperature. Sensors and wireless devices are being used in homes to monitor individuals' vital signs and whether medication has been taken, with this information sent wirelessly, through a sensor in the home or on the individual, to the doctor or to family members—which is an added benefit for people who are home-bound, living in more remote rural areas, or are without immediate access to healthcare.

Much of the current smart home technology for tracking occupants uses small portable tags or badges that send and receive radio waves or infrared light—inexpensive alternatives to camera systems. Tags can be attached to a variety of items, such as lapels, bracelets, pins, key chains, or medicine bottles. Such technology is extremely useful for monitoring individuals with Alzheimer's, allowing them to remain living in their own homes safely for longer periods of time and, when relocated to a housing or health care facility, allowing them more flexibility in moving around a building or yard and staying integrated with other residents.

Telemedicine: Services that provide health and social care directly to users in their own homes is an area of care defined as telecare, which uses interactive video and audio contact between a user and care provider. Peripheral devices can also be attached to computers to aid in an interactive examination, and video-conferencing can be used when face-to-face consultation is necessary. The "real-time" consultation, diagnosis, treatment, and delivery of medical care is carried out with the user in the home, eliminating the need for frail or homebound individuals to travel to health care offices or facilities. "Store-and forward" electronic information-processing technologies transmit medical and health information, X-rays, and data between health care providers and patients and among a patient's multiple health care providers, for more efficient and accurate record-keeping on diagnoses and treatments.

Looking at the evolution of telecare, Celler, et al.,[3] find that home telecare technologies fall broadly into three generations:

(1) First-generation systems, which are designed to reduce anxiety among elderly and high-risk patients and reduce their use of primary healthcare services (for example, personal alarm systems and emergency response telephones that make a voice connection between the patient and the response center);

(2) Second-generation systems, which can continuously monitor a large number of variables that are sensitive to changes in functional health status, generating alarms *without* the intervention of the patient, on the suspicion that something may be wrong; these systems can be integrated with evolving "smart home" technology for home automation, security, and environmental control; and

(3) A third generation of telecare, which attempts to deal with issues of loneliness and patients' quality of life by creating a virtual community of clients, caregivers, healthcare providers, and other community services—connected via the telephone, interactive television, and the Internet.

The past decade has also seen renewed attention in smart house technology as academic institutions, such as the University of Florida and the Massachusetts Institute of Technology, develop their own research centers—many of them resembling actual homes—to test sophisticated home automation technologies. Despite the convenience and comfort characteristics of smart house and home automation technologies, younger generations and families have been slow to respond to their use over the past two decades. However, sophistication in infrastructure, advancements in ease of use, and an increased knowledge and familiarity with computers among the public has generated more attention; and older individuals and younger-aged individuals with disabilities have especially benefitted from such technologies, helping them live safely and independently in their own homes.

Some manufacturers and experts note that privacy issues are an important consideration in building smart homes. Nevertheless, multiple surveys have indicated that people are willing to trade-off some of these concerns for practicality, comfort, and independence.[4] As the 78 million baby boomers continue entering their elder years, and people of all ages with disabilities continue to live much longer lives, experts believe that the demand for such technology will increase significantly in years to come.

References:

[1] Tiresias.org: http://www.tiresias.org/research/guidelines/smart_home.htm, quoting Smart Homes Association, i.bierhoff@smart-homes.nl, P.O. Box 8825, 5605 LV Eindhoven, The Netherlands.

[2] United States Census Bureau (2009), "People QuickFacts," *USA QuickFacts*: http://quickfacts.census.gov/qfd/states/00000.html.

[3] Branko Celler, Nigel Lovell, and Daniel Chan (1999), "Clinical Practice: The potential impact of home telecare on clinical practice," *Medical Journal of Australia*, Vol. 171, pp. 518-521.

[4] Anne Eisenberg (April 5, 2001), "A 'Smart' Home, to Avoid the Nursing Home," *The New York Times*: http://www.nytimes.com/2001/04/05/technology/a-smart-home-to-avoid-the-nursing-home.html?pagewanted=1.

Benefits:
- *Security*
  - Advanced technology in the area of home security has provided a convenient and safe way to keep homes and family members out of danger, with improved methods of detecting a variety of unusual activities and potentially dangerous situations—both inside and outside the house.

- *Healthcare*
  - *Costs:* It is more cost-effective for older adults and persons with disabilities to remain living at home for as long as possible, with assistive, supportive, and health-monitoring devices, than to be placed in healthcare institutions. One study (Chan, et al., 2008)[5] revealed that 46 per cent of "on-site nursing activities" could be replaced by technology that can supervise health status from afar. The study also found that average hospital inpatient care in the United States costs $820 per day, average nursing home care costs $100 per day, and an average house call costs $74—while a telemedicine evaluation costs $30.
  - *Staffing decline:* A study by Kevin, et al. (2003)[6] finds that the number of caregiver and direct care clinicians has declined. Appropriate and judicious use of smart house, home automation, and telecare technology can be successfully used as one strategy to address this decline.
  - *Older adults and people with disabilities*:
    - Smart-based technology, integrated into the home environment, supports the ability of older adults and people with disabilities to continue living safely in their own homes for longer periods of time.
    - Such technology increases a user's ability to be self-managing for longer periods of time—promoting feelings of competency and reducing vulnerability to depression.
  - *Caregivers-emotional and physical support*:
    The availability of smart house technology supports the substantial caregiving efforts of the nation's millions of family caregivers:
    - Caregivers' emotional and physical stress is reduced by (1) reducing the number of hours of hands-on physical assistance needed by a frail or impaired family member, and (2) allowing caregivers to monitor family members and perform tasks from a remote location.
    - A caregiver's ongoing emotional worry about the well-being of a frail or impaired family member is reduced by (1) increasing the safety and security of the family member's home environment, and (2) delaying or

eliminating the traumatic decision of relocating a family member out of his own home and into another environment.

- *Ease of use*
  - Advancements in technology, together with increasing knowledge of and experience with computers and computerized devices by the general public of all ages, has made smart home technology much easier to use and to adapt to daily routines.

- *Rural areas*
  - Smart house technology is especially attractive for use in rural areas, where lack of proximity to health care could compromise medical conditions.

References:
[5] M. Chan, D. Esteve, C. Escriba, and E. Campo (2008), "A review of smart homes—Present state and future challenges." *Computer Methods and Programs in Biomediscine,* Vol. 91, pp. 55-81.

[6] C. Kevin, et al. (2003), "Caregiver and Clinician Shortages in an Aging Nation," *Mayo Clinic Proceedings*, Vol. 78, pp. 1026-1040.

Impediments or barriers to development or implementation:
- *Practicality*
  - The practical design of smart home technology is extremely important for older adults and individuals with disabilities. If devices are prone to system failures (similar to those encountered on a personal computer—such as unresponsive networks or software malfunction), complex actions to fix the situation (i.e., resetting the entire system) may prove too inconvenient or even dangerous for the user.
  - Devices that assume prior computer skills or devices that are not tailored to individual needs could also prove problematic. For example, for people who are vision- or hearing-impaired, certain technologies are ineffective, such those that require video monitoring or being attentive to auditory signals.
  - These technologies also present issues for cognitively impaired individuals who might find a control panel or remote control device difficult to use.

- *Privacy*
  - Issues of privacy often surface as a major concern in smart house development. Much of the technology being devised for older adults and people with disabilities involves an element of monitoring by others that some people find obtrusive. Cameras and surveillance devices are a concern for many who value privacy. Therefore, it is important that informed consent be obtained before installing technology that could create discomfort. Developing a code of conduct for healthcare providers who monitor individuals could further prevent a compromise of privacy.

- *Intimacy*
  - Most people are accustomed to communicating with an actual person when receiving care. A replacement of human contact by technological devices can present a level of fear, discomfort, isolation, or loneliness for people receiving this type of impersonal care, which can have a major effect on both physical and emotional health.
  - Some individuals may also experience fewer visits from family members who rely too heavily on the technology to assist and respond to daily needs.

Resource—examples:
- Duke University Smart House; website includes an extensive list of links for smart homes throughout the world: http://smarthome.duke.edu/.

- Drexel Smart House, Drexel University: http://www.drexelsmarthouse.com/.

- Gator-Tech Smart House, University of Florida: http://www.icta.ufl.edu/gt.htm.

- MIT Smart House, Massachusetts Institute of Technology: http://architecture.mit.edu/house_n/.

- Royal National Institute for the Blind (RNIB) Digital Accessibility Team, "Smart Home: What is a Smart Home," *Tiresias.org.* United Kingdom: RNIB. Extensive information and numerous links to additional resources, research, and examples of homes with smart home technology around the world: http://www.tiresias.org/research/guidelines/smart_home.htm.

Resources—written and web:
- M. Chan, D. Esteve, C. Escriba, and E. Campo (2008), "A review of smart homes—Present state and future challenges," *Computer Methods and Programs in Biomedicine,* Vol. 91. This journal article presents an overview of smart homes, a brief history, and a look into future technology. It also discusses smart homes in regards to assistance for older adults and smart home technology advancements in the United States, Europe, and Asia.

- Daniel H. Wilson (October 1, 2009), "Smart House: Your So-Called Sci-Fi Life," *Popular Mechanics.* An overview of the current state of smart homes, its direction and practicality: http://www.popularmechanics.com/technology/gadgets/4216434.

- Ed Mayberry (November 23, 2009), "Smart House Demonstrates Energy-Saving Technology," *Houston Public Radio.* This affiliate of National Public Radio highlights new technology for the home that can save homeowners money on energy bills while protecting the environment: http://app1.kuhf.org/articles/1258749225-Smart-House-Demonstrates-Energy-Saving-Technology.html.

- H. Jia, H. Chuang, S. Wu, X. Wang, and N. Chumbler, (2009), "Long-term effect of home telehealth services on preventable hospitalization use," *Journal of Rehabilitation Research & Development*, Vol. 46, No. 5, pp. 557-566. http://www.rehab.research.va.gov/jour/09/46/5/pdf/jia.pdf.

- Nancy Brown (September 28, 1996; updated January, 2005), "Telemedicine Coming of Age," *Telemedicine Information Exchange*. This article discusses past, recent, and future technologies that can be installed in smart homes, helping older adults age in place: http://www.telemedicineprograms.com/.

- Diane Chun (January 29, 2005), "UF's 'Smart Home' helps seniors live independently," *The Gainesville Sun*: http://www.gainesville.com/article/20050129/LOCAL/201290318?Title=UF-s-Smart-Home-helps-seniors-live-independently&tc=ar.

- Anne Eisenberg (April 5, 2001). "A 'Smart' Home, to Avoid the Nursing Home," *The New York Times.* A look at the existing state of smart homes and designs that are being put to use in order to help older adults live at home independently, with an emphasis on the impact of the baby boomers on healthcare in upcoming years: http://www.nytimes.com/2001/04/05/technology/a-smart-home-to-avoid-the-nursing-home.html?pagewanted=1.

- *ScienceDaily* (November 20, 2003), "University Of Florida 'Smart Home' Demonstrates Concept Of Automated Elderly Help And Care": http://www.sciencedaily.com/releases/2003/11/031120075923.htm.

- Japanese Ministry of International Trade and Industry: built 13 "Welfare Techno-Houses," with the objective of improving the quality of life of both elderly people and their caregivers: Tamura Toshiyo et al. (2007), "E-healthcare at an experimental welfare techno house in Japan," *The Open Medical Informatics Journal*, Vol. 1, pp. 1-7: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2666468/.