
Preface

In December, 1995, the Association of Safe and Accessible Products (ASAP) held a Special Interest Forum on “Intelligent Housing Controls.” Funding was provided by the Center for Inclusive Design and Environmental Access (IDEA Center), State University of New York at Buffalo, as part of a grant from the U. S. Department of Housing and Urban Development entitled “Fair Housing Means Universal Design.”

This report is based on the presentations made during the SIF. It also includes additional information obtained since the event. The report presents an overview of home automation and how it relates to the evolution of universal design in housing.

Introduction

The Fair Housing Act Amendments of 1988 mandated elimination of discrimination in housing based on disability. The Fair Housing Accessibility Guidelines, which apply to all new construction of multi-family housing, recognize that environmental controls are an important aspect of non-discriminatory design. Developing case law on to accommodations to existing structures under the Act has reinforced the importance of environmental controls as an essential element in accessible housing. Rapidly evolving technology is creating a quiet revolution in controls. Understanding this technology can help professionals and consumer advocates utilize its potential for expanding the horizons of independent living. The automation of many environmental control tasks will affect every housing consumer. It is a unique area of product development that both enables and demands the application of universal design principles.

Since the first science fiction stories, home automation has captured imaginations of literary and scientific circles alike. Home automation can be seen as a natural direction in the evolution of greater convenience in

daily living. As the pace of life increases and the benefits of advanced technology are tapped, automation of the home environment has materialized in many ways. In fact, even conventional homes today, when viewed from the past, demonstrate significant advances in this area. Perhaps the best example is automated heating controls. The conventional thermostat is manually set to a comfort range. The operation of the system from then on is fully automatic. In a hot water system, for example, automated controls monitor the temperature of the water in the boiler and they open and close valves to insure a steady supply of heat. The thermostat provides feedback to insure that the temperature of the space being heated stays within the comfort range. More sophisticated systems also obtain data about the outside air temperature and adjust the temperature in the boiler accordingly to reduce energy waste. These heating systems with their anticipatory controls, feedback and automated decision making characterizes the broader concept of home automation.

With the technology available today, of course, far higher levels of automation are possible. Home automation systems can produce fully automated living environments that reduce the occupants' direct intervention to the establishment of routines and preferences. Control over the home environment can be implemented from a distance using telephone or computer communication. The availability of micro-processor control allows highly sophisticated personalization to occur. For example, most conventional thermostats are set for a standard range of comfort spanning from a few degrees above to a few degrees below the set temperature. With micro processor control however, home climate control systems can be programmed to meet precise preferences related to the time of day or the day of the week. Through feedback loops that include the use of sensors that collect data on the functioning of the home and its relationship to its environment, home automation systems can be employed to save energy and money. Simplified and flexible user interfaces with centralized monitoring systems reduce the need to understand the technology. Finally, although early demonstrations and applications were relegated to new

construction, current systems are designed for easy installation in existing buildings as well. Thus, state of the art home automation is not only reserved for the new home buyer; it is available to everyone.

There are clearly many benefits to home automation. The first is greater comfort and convenience. A second is improved safety and security. A third is a high level of control over operating costs (e.g., energy conservation). In the past, the complexity of the technology and its uniqueness presented barriers to widespread application. Today, lower cost, friendly user interfaces and adaptability to existing equipment has reduced these barriers. Furthermore, the advent of personal computers in the 80s and the rapid dissemination of this technology in industrialized countries will spur the employment of home automation systems in the years to come. As we shall see, a centralized control system is the “brain” of comprehensive home automation. Now that millions of homes have the basic technology to create this control system we are likely to see it being applied to the common problems of daily living in technologically advanced societies. That is not to say that barriers no longer exist to the dissemination and implementation of home automation. The rest of this paper will explore many of the opportunities and identify some of the barriers to widespread use. We will demonstrate, in particular, how application of home automation to simplifying the activities of daily living for people with disabilities and the elderly can serve as a major opportunity for the industry and a “proving ground” for technology that will appeal to the broader population. At the same time, we wish to demonstrate how technology and products that have been developed for the broad consumer market can provide great benefits for people who have functional limitations by improving convenience, safety, security, quality of life and independence.

Home Automation Defined

Home automation can range in complexity from the simple *gadgets and gizmos* that provide control over individual components to *individual home sub-systems*



Figure 1. Security system keypad
(photo by Honeywell)

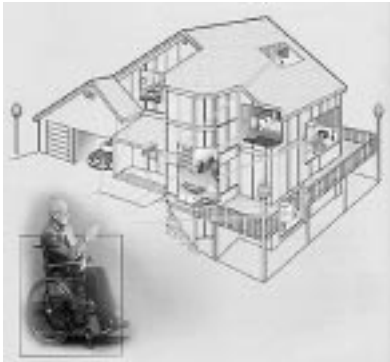


Figure 2. Total control from a
single location
(photo by Leviton)

and *integrated whole house systems*. An example of a gadget or gizmo would be an “X-10” device that controls an appliance or fixture plugged into it. An example of an individual home sub-system would be a security system. An integrated whole house system would unify all such devices and sub-systems within the home with a central control system. Home automation can encompass lighting, security, telecommunications, access and safety, information and entertainment systems, and thermal comfort systems.

The metaphor of a tree with branches reaching into different locations is a good image for an integrated full home automation system. Each branch of the tree performs a different function. One branch of the tree might include home entertainment, such as television and audio. A second branch could include security, including video surveillance. A third branch could include telecommunications, like telephone and intercoms and a fourth branch could include energy and environmental management including air and water quality, lighting and thermal-comfort. An essential ingredient of home automation is system feedback. Feedback brings intelligence to automation. It is important to note that home automation systems are quite diverse and many configurations are possible. The four branches described above could, in fact, be replaced with eight branches or two branches. Often the branches have interconnections. For example, a home entertainment system and the security system might utilize the same video monitor.

Some home automation systems are packaged as fully integrated systems whereas others provide only a limited set of functions. Standard integrated packages usually include security systems, HVAC control, lighting and appliance control. Interface panels and remote access capabilities are essential components of integrated systems and some individual subsystems as well. Both wireless and hard-wired systems are available.

Some common devices used in home automation systems are:

- burglar alarms
- video entry systems
- programmed thermostats with zoned heating and cooling
- intercoms
- entertainment systems with many speaker and video connections
- central vacuums
- hazardous gas detectors
- electronic air cleaners
- water filtration systems
- flood alarms.

As implied above, there are different levels of home automation. While the more advanced systems are comprehensive, many households elect not to have a complicated system because they only desire control over one or two functions. The standard security alarm system, in fact, can be viewed as an example of home automation at a low level. The difference between low level and high level systems are based on the extent of control provided, the degree of feedback, the level of “intelligence” and the sophistication of the user interface. For example, although a standard security system with central station monitoring has a fairly high level of technology, most such systems have to be set manually as occupants leave and de-activated manually as occupants enter the home. More sophisticated systems include a remote transmitter, similar to those used for remote control of automobile alarm systems, that can be activated as an individual arrives home or as one leaves. Higher level systems could also include several pre-programmed modes, based on the day of the week and the time. The user would not have to key in the appropriate modes when leaving or entering; the system would automatically set itself based on pre-established criteria. As another example, sensors to detect heating system or sump pump failures can activate alarms, but a more sophisticated system could notify the occupant at work, if they’re not at home. The more intelligent system might also automatically activate a back-up sump pump if the main pump failed. While



Figures 3, 4, 5, & 6. Common devices in a home automation system (photos by Honeywell)

many “occupancy sensors” exist to turn on and off lights and appliances as individuals move through a house, higher level controls can adjust to individual preferences. For example, Bill Gates’ widely publicized new home has a system that adjusts the lighting, multi-media displays and other features automatically to individual user preferences. Prospective guests to the home will be given a questionnaire and data will be entered into the home computer about their preferences. Guests and residents will wear “badges” that transmit coded signals notifying the home computer of their whereabouts. The computer program will adjust the environment to the individuals preferences as they use specific parts of the home.

Home Automation and Universal Design

Jerome (SIF Presentation) identified several features of home automation systems that contribute to universal design in housing.

1. Home automation improves control over the functions in a home; in effect, from a universal design point of view, this increases user effectiveness and extends a user’s capabilities.
2. Home automation improves access to systems in the home. Remote control, computer interfaces and other methods of access substitute for mobility, strength and agility in providing access.
3. Home automation allows systems in the home to communicate automatically and share information. The individual does not have to be continuously involved in the control of system operations; moreover, he or she does not have to make decisions about the operation of individual systems nor about the relationships between them.

From a universal design perspective, all this means that house operation in general requires *less effort*; the activities related to it are *simplified*; and individuals have

more *choices* to determine their relationship with the environment.

Universal design has focused primarily on accommodating physical abilities. For example, large button key pads and lever handles on doors make it easier for people with limited dexterity to operate devices in the home. Optional input devices such as “sip and puff” switches, provide alternative methods of control, essentially more flexibility and choice. Home automation builds on these characteristics of universal design but adds another level of function through sophisticated sensors and computers. Home automation systems can “anticipate” a user’s needs or intentions and respond in an “intelligent” way. For example, universal design for building entry might include wide doors, low thresholds or power assisted operators. Home automation adds to these features devices such as movement sensors that detect someone approaching the entry, a coding device to determine if the person should be admitted, automated unlocking and opening of the door and simultaneous activation of lights, heat and other household systems as desired by the occupant. Jerome proposes that the key selling points of home automation are its ability to minimize action, anticipate needs and integrate functions. These functions extend universal design beyond the physical realm of immediate action to other important aspects of function.

One of the key features of home automation is the user interface. The provision of a powerful adaptable and flexible user interface is an important universal design attribute. It creates “ability” by empowering the user and it increases adaptability to individual needs. The user interface, in effect, is a way to reduce the number of actions necessary to operate the home. The integration of intelligence reduces the amount of thinking necessary and therefore simplifies the work involved in maintaining a household.

Another important universal design feature in home automation systems is the wide-ranging benefits to all users. Home automation benefits the older adult be-



Figure 7. High color contrast keypad
(photo by Honeywell)

cause it reduces the mental load and the level of physical activity needed to maintain a home. It benefits people with limited time schedules by reducing the number of things to which they have to attend during the course of a typical day. It is beneficial to people with home offices because it can help to integrate the communication functions of a work place with the systems of the home. It benefits people with large homes because it allows communications and control to take place without physical movement. And, it benefits families, particularly single parent families, because many of the home automation features protect and support the needs of children and extend the parent's influence, even when parents are not present.

While home automation clearly has universal design characteristics, it is important to acknowledge that a home automation system itself may not be fully accessible and usable to everyone unless it is designed with universal design in mind. For example, an older person is not likely to use a system that is too complicated and has interfaces that are not meaningful to them, based on their own generational experience. To be a true universal design, a home automation system must appeal to many user groups. To do this, it must be flexible so that it can adapt to individual needs. For example there should be interfaces for people who cannot use a keypad or who have sensory impairments. It must be easy to understand so that the functions can be programmed effectively and feedback can be easily understood. It must be forgiving; that is, when someone makes a mistake, it should not have serious consequences for the operation of the system nor be difficult to correct. The system should require a low level of effort to use, for example remote control and phone access should be available. And, it should be easily adaptable, that is, it should be possible to connect a wide variety of devices and interfaces with a variety of different networking tools.



Figure 8. Temperature setting dial
(photo by Honeywell)

In summary, home automation has the potential for increasing universal design of homes and the systems used in homes. And, following universal design prin-

principles can make home automation user friendly and effective. Another way of putting this is that automation *leads to* universal design in housing but automation *needs* universal design to give people control over the system.

State of the Art

This section will discuss the state of the art in system technology and various devices that can be included in a home automation system. We will start with security systems because of their widespread use.

There are many devices used in security applications. An in-depth look at this field provides insight into the diversity of needs and sophistication of available home automation technology. Home security systems include the devices used to keep intruders away and trigger alarms when intrusion takes place and the communication systems that are needed to program the system, sound alarms and communicate with central stations. The most basic security system simply rings an alarm. The next level up also notifies a designated party by telephone that there has been a security breach. Obviously when security is compromised, notification significantly improves the level of protection. The highest level is provided by a continuously manned central station that receives coded messages from the micro-processor in the home. Staff at the central station can interpret the signals to identify what kind of alarm has been sounded and contact either police or others to take action. Phone dialing systems that play recorded messages are much less effective because they depend on the presence of someone at the number being dialed. There is no guarantee there will be anyone present. But they can be useful for people who live alone. Some systems will keep dialing from a priority list until someone answers. These systems can also detect and ignore answering machines.

Security systems can vary significantly in complexity and sophistication. Some can handle both wireless and hard wired devices; others can only handle one or the other. Most systems are organized by zones. The fewer the zones the less information that can be transmitted to a central monitoring station. For example, if all windows are on one zone,

a central station cannot tell which window has been opened. While this may seem to be unnecessary, it is useful when systems malfunction because it is easier to diagnose the problem area. Moreover, the greater the number of zones, the higher the degree of control over system function. For example, it is often desirable to leave a window open on a hot night when the air conditioning is not working. If each operable window is on a separate zone, the perimeter system can be activated and that zone bypassed. If all the doors and windows are on one zone and one window is left open, the whole perimeter security system must be shut down. When sensors are used to identify other problems in the home, for example, flooding in the basement or a malfunctioning furnace, each special sensor should be on its own zone so it is possible to identify the source of the problem easily.

From a universal design perspective, the more intelligence a home security system has the better. Intelligence provides a higher level of control. However, simplicity of operation must be maintained as intelligence is added. Complicated systems that are hard to use will result in added life stress and probably will be underutilized, thereby creating a false sense of security.

In multi-family housing applications, controlling unauthorized entry to the building is a major security concern. The familiar intercom with automated door latching activated from apartments has several limitations from a universal design point of view. First and most obvious is that only people who can hear well can make use of this system. Second, they require manual activation and manipulation. Often such systems are mounted out of reach by people who are non-ambulant and have reaching limitations. Newer systems utilize close circuit TV and a video monitor. The cost of video systems has come down rapidly. They are currently available for less than a thousand dollars. Such systems are being manufactured for use in single family homes as well as multi-family applications. Some of these systems include their own small monitor on the intercom itself and others utilize the tenant's television to

provide a close circuit view of the individual requesting entry. Another advance is the use of the telephone wiring in the building to provide both control over the main door and intercom communications. Such systems have a telephone dialer at the entry. When an individual enters the apartment number, it dials the telephone in the apartment. The inhabitant then enters a code through their telephone that opens the door for the visitor. The advantage of these systems is that an individual with limited mobility can communicate with anyone at the front door from any place in the apartment. Remote cordless phones can facilitate communications at all times. Clearly such systems have significant universal design advantages, even though they do not provide video capabilities.

Perhaps one of the most interesting developments in security systems has been the development of integrated approaches that include energy management and communications. Because security wiring runs throughout the home and is designed to control many devices, the systems provide an infrastructure for a much more comprehensive home automation system. The same technology that can be used to call a central security station can also be used to call a home care service or relative in case of emergency or accident. The same systems that are used to communicate with the security system can also be used to control the heating, ventilating, lighting and air conditioning systems. Intercoms used to communicate between the front door and a station inside the house can also be used to communicate from one room to another.

Control devices are an essential element of all home automation systems. Light sensors can be used to link timing of devices to the diurnal rhythm of day and night. Occupancy sensors can be used to control devices that only need to be on when an occupant is present, either in the house itself or in a particular location. Sonic devices, such as “The Clapper,” can also be used to activate any electronic device. Hand held remotes reduce the need to move around the space to operate the equipment. These are particularly useful for



Figures 9 & 10. Intercom and video entry system (photos by Honeywell)

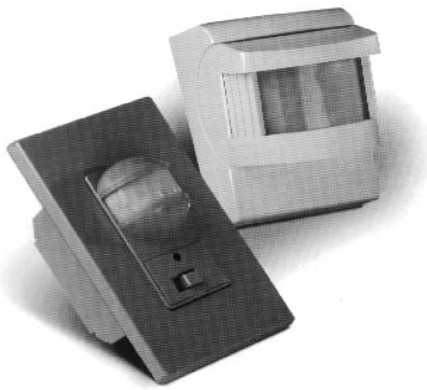


Figure 11. Motion activated occupancy sensors (photo by Leviton)



Figure 12. Keypad with large graphics and raised lettering (photo by Honeywell)

electronic and mechanical devices. There are interfaces for remotes that can control valves for water or gas. A primary control is the keypad. By entering in pre-established codes, occupants can initiate programs with a great deal of complexity using only a few key strokes. A good example is the programmable thermostat.

Light, occupancy and sonic sensors clearly have an advantage from a universal design point of view, in that they require very little cognitive skill to operate, if any, and require no hands to use. While hand held remotes are fairly simple at the lowest level, they can become quite complicated and very difficult to understand when many features are added. In television, there has been a trend toward use of remotes with on-screen programming. Similar systems for other devices may make these products much easier to use because the display provides more flexibility in the programming, greater visibility and better feedback. In addition, on screen programming makes it possible to have fewer buttons on the remote and therefore they can be larger without making the remote itself awkward and unwieldy.

Keypad systems have evolved from simple touch pads without feedback to touch pads with LED or LCD readouts that provide much better information on the status of the system and the accuracy of the entries. The top-of-the-line systems include illuminated displays with audible feedback that make it easier for people with poor vision to use. They, of course, help everyone, especially in the dark. Voice feedback would be a further improvement toward universal design.

Communication systems for the home encompass a wide variety of different devices. They could include telecommunications using standard telephones, video phones or TTY's; they can include intercom systems that facilitate communications with household members throughout the home or speaker phones that allow hands off use and conference calls. They can also include personal emergency response devices that can notify family members, friends or paid care givers of an

emergency. For the person with a severe disability, perhaps the most exciting technology is the development of voice recognition systems that allow an individual to control any device that can be hooked up to a computer.

Changes in telecommunications policy have opened up the market for diversified information services to home users. It is likely the demand for entertainment and information will provide a similar impetus for home automation as we are currently seeing in the security business. The infrastructure provided by sophisticated information processing equipment and high bandwidth connections to the home will open up opportunities for many other services in addition to the provision of movies on demand and world wide web access. A particular important development will be the evolution of the television into a multi-purpose two-way information interface. We are likely to see another surge in interest as new information and entertainment systems come on line

Computer information systems are becoming more comprehensive. They are developing into a “made to order” product with the capability to personalize the information services for each customer. The focus is on choice and what is needed to make a person’s environment the most comfortable, efficient, secure place to be. Services are evolving that match the capabilities of machine intelligence with individual needs. When machines have the ability to talk to each other, or inter-communicate, they are able to serve the needs of people better. This “handshaking” is evident in the meshing of cable television and telephone communications. Originally, cable television wiring was designed to run as a loop which provided service to a large number of households concurrently. Information transmitted through these lines has a direct bearing on the others receiving service. The telephone, on the other hand, is designed to be a star network, which has lines radiating out from a point. The star pattern can increase “bandwidth” significantly. Cable technology is rapidly improving. The use of fiber optic cable can create a true

information superhighway. It is capable of delivering 1,000 million bits of information per second. At this speed, a fiber can deliver a million television channels at the same time. People will no longer have to receive the same television programming as their neighbors. Television, like telephone service, will be personalized.

Computer and consumer electronics catalogs now feature a variety of messaging systems, including sophisticated answering machines and voice mail that allow messages to be sorted into various mailboxes to different members of the household. TTY's have evolved to become multi-function telephones that provide both voice and printed display. They come equipped with memory and printer options so that one can even keep a record of the conversation in text form. Further advances are likely to make the TTY's an all-purpose device that can benefit anyone, not just someone with a hearing impairment. One can envision a day when someone can leave either a voice or text message at any phone, have it recorded either in a text file in a computer, printed out as a fax message or translated into synthesized speech for audio retrieval, depending on the wishes of the users at each end.



Figure 13. Chronotherm programmable thermostat (photo by Honeywell)

Energy and environmental management systems have been a developing area for home automation although they are not as popular as security and communication systems. Remote systems for energy management are available that allow occupants to call from work or some other location and activate specific programs for control of devices in the home. For example, a family returning from a long trip could call from the airport and, through an activation code, start the heating/air conditioning system in anticipation of their arrival. The most common applications of automation for this function are programmable thermal comfort systems and lighting controls. As described earlier, programmable thermostats have become very common and inexpensive. From a universal design perspective, however, they leave a lot to be desired. In most devices, the controls are small and feedback is only visual. Since the programming unit is integrated with a wall

mounted thermostat, using the systems is awkward for most people and very difficult for those who have limited reaching ability

Automated lighting controls are becoming more common, particularly those used for security such as motion sensitive switches for exterior lighting. In many new office buildings, occupancy sensors are now in widespread use to turn lights out automatically when no one is in a room. Lighting control manufacturers are making similar equipment for home use (see Corporate Strategy: Leviton section). Perhaps the most important development, however, is the systems approach that allows a wide variety of devices to be interchanged at each box. As with security systems, this builds an infrastructure to support many future applications.

Current trends in the home automation industry suggest that the market is growing rapidly. Although not always defined as such, many activities in the home are being automated. Devices originally conceived for people with severe disabilities, like voice recognition systems, will clearly have applications for the broader public, leading to real universal design in housing. Other, general applications, such as those used in security and lighting systems, for the broader population provide clear advantages for improving usability in housing and independent living for people with disabilities.

The demand for improved security and personal safety in the home is one of the most powerful forces driving home automation. As Irma Dobkin, a SIF participant, observed, “People are ‘fortressing,’” Installation of more sophisticated security systems in the home provides an infrastructure to which many other features can be added. It also is supporting the development of a network of technicians and installers that will seek to expand their markets by offering new services and products.

As the home automation industry evolves, three important issues will need to be addressed. The first is over-

coming the fragmentation currently evident. This will insure the development of comprehensive systems that provide seamless operation for different functions and that reduce complexity by integrating control systems. It will be necessary to find ways to encourage the development of standard practices that will allow service providers and manufacturers of different kinds of devices to work together in serving the consumer. The second issue is the development of a means to improve upgrade compatibility. The installation of infrastructures such as security wiring, electrical device boxes and central processing units should enable expansion and upgrading to improve the scope of a system's functions and performance. The best systems will be those that allow continuous improvement and upgrading without the loss of investment in the initial stages of automation. The third issue is insuring quality service by providers. Questions exist as to whether companies that are primarily in the information and entertainment services business can provide adequate security services or vice versa. The use of whole home integrated systems can overcome many of these problems because the companies and service providers that install them are equipped to respond to multi-purpose needs. But currently, home automation is evolving more rapidly through the security and information services functions. The producers and service providers in these areas do not have the same training or knowledge as the comprehensive system providers.

Corporate Strategy: Honeywell

Honeywell Corporation has marketed the "total home" concept. Their marketing campaign focuses on "helping you to control your world," providing a comfortable, secure, energy efficient and simplified living environment. They stress the environmental benefits of the Total Home concept: a healthier home with clean fresh air and water, without effort. This is consistent with Honeywell's roots as an environmental control company. At one time there was a small market for comprehensive housing automation but they have found that the market is now growing because it is no longer cost

prohibitive. They see the Total Home concept fitting in with the quest for the “good life” of convenience, comfort, safety and ease of use.

The Total Home system integrates security with environmental controls, including lighting and other electronics. It is a programmable system that allows full customization using a “lifestyle” approach. The system is accessible through a telephone for remote control. Honeywell was one of the first major companies to embrace the universal design concept. Their first product with universal design features was a thermostat with large raised numbers. The attention this product received spurred them to integrate universal design into their home automation products.

The target market for the first Total Home system were households with homes valued at least \$200,000 and incomes of over \$100,000. The target group are professionals who are busy and often away. They want a quality company with a good reputation and the latest features in their systems.

Experience with the first Total Home system demonstrated:

- as a security based system, it couldn't work without those features
- it had cryptic descriptions, modes and interfaces that made it difficult for consumers to use
- it was based on the utilization of other Honeywell products which limited the range of devices that could be connected
- it only really appealed to Honeywell branch offices and home automation dealers

Total Home II, the second version, is fully modular. Any device the consumer wants can be attached to it. It “pulls through” a greater range of Honeywell products as well. In other words, it helps Honeywell to market more of its own products and so it therefore appeals to its dealerships. Because of these features, it has greater value and flexibility. The Total Home II system is also



Figure 14. Easy-to-See thermostat (photo by Honeywell)



Figure 15. TotalHome system panel (photo by Honeywell)

appealing to dealers that are utility companies. For example, it includes the feature of automated meter reading to monitor utility usage. It can also be sold by cable companies. These advantages expand the original dealer base.

In the development of the Total Home II system, Honeywell has created many alliances with other companies. This allows them to serve as an original equipment manufacturer (OEM). Other companies that provide products that are used in Total Home include:

- AIPHONE (Video entry)
- Channel Plus and Video Distributors (Monitoring)
- AT&T (Multi-line telephone)
- JBL (Sound system)
- Hoover (Central Vacuum)

Corporate Strategy: Leviton

Leviton, like Honeywell, has had considerable experience with universal design. Research on improved accessibility in Leviton products started in the late 1980s. This research has involved the development of child safety products and a focus on the older consumer. They are working with Future Home and the Center on Universal Design. Leviton sees the home automation market growing rapidly. They feel that an important feature of home automation products should be upgrade compatibility that allows people to continually expand and improve the effectiveness of their system.



Figure 16. Decora Home Controls (photo by Leviton)

Leviton makes electrical devices. Their first experience with universal design was with the Decora line of products (switches and outlets). These products incorporated a large rocker plate to replace the conventional toggle switch. Since that time, the Decora home controls line has evolved into a multi-faceted product line, with many different devices. Some of these devices work independently while others can work as complete systems within the home. Still others are used as a part

of more extensive home automation systems. Independent devices include products such as occupancy sensors that can switch on lighting or other devices, “anywhere” devices, that replace existing switches with units that can be activated by remote control and the “911” switch that is a panic device that flashes exterior lighting in the home. Using a variety of individual Leviton devices, combined with controllers that they also manufacture, comprehensive home systems can be developed. For example, one product within the Decora line is a telephone transponder. The occupant of the home can call up and activate a variety of devices controlled by the transponder. This system utilizes existing electrical wiring in the home and devices are plugged into existing switches and outlet boxes. The transponder send signals over the home wiring to control them. This device has a “set and forget” interface that makes it easy to use by consumers. Other products provide interfaces between Leviton devices and more comprehensive systems. Leviton makes an interface to security systems. It allows the security system to control any Leviton device that might be included in the home. They also make many devices for application in energy management and convenience systems, including photo cells, program cycle switches and remote and local controllers.

For the past two years, individuals within the company have been advocating for more emphasis on universal design. They used the success of individual products to persuade the marketing division to promote universal design features. They had to educate people in this division. They also had to educate members of their product management groups and provide sensitivity training for the engineering staff so they would be sensitive to the needs of people with disabilities.

The company continues to improve existing products along universal design lines. For example they have added illuminated buttons for emergency use to a table top controller. They developed a hand held remote for the Decora line. Initially, an adjustment screw was provided on the Decora remote. They recently switched



Figure 17. Lighting controls
(photo by Leviton)

to a knob that makes it easier to use. They changed the color of lenses on the illuminated switches to amber so they are easier to see and they provided feedback on the level setting for the switch.

Leviton is developing more products with universal design features. In their “Anywhere” lines, they have added indoor and outdoor occupancy sensors that transmit information to lights along a path. As a person walks along the path, the sensing devices activate lights well ahead of them. They have developed a screw-in dimmer for adapting existing fixtures and they have expand the codes that can be used to control devices.

Two new technologies are being used to improve the utilization of Leviton products in the dark. One technology, called electro-luminescence is a less costly approach to illuminated switches. Less energy is needed to produce the same amount of light. Electro-luminescence is being used for guide lights to help people find their way from one spot to another in the dark, to illuminate switches so they can be more easily seen and to illuminate receptacles and wall plates. A second technology, photo-luminescence, is a light sensitive material. This material stores energy during light periods and emits it during dark periods. Leviton is using photo-luminescence in wall plates, switches, frames and receptacles. The focus in applying these two technologies is to improve way-finding, make it easier to find devices quickly and make emergency use more effective.

Leviton has searched for common themes for the benefits of universal design. These are characteristics of products that are attractive to anyone. They include safety, comfort, energy savings, security and convenience. The company produced a universal design brochure that showcases the universal design characteristics of their products. In this brochure, they included both new and existing products and examples of how these products can be applied. The company has decided that universal design can be used to enhance general marketing efforts and that a special emphasis

on universal design features in their promotional materials will attract buyers who are interested in a high level of convenience. They have made efforts to be involved in demonstrations of automated housing, including Future Home and the Fairland project, described elsewhere in this report.

The Market for Home Automation

Honeywell Corporation completed a marketing study that provides a good overview of the market for home automation. In 1992, there were 4,000 integrated home automation systems sold in the United States. They estimate that home automation is a fifty million dollar market. Eight percent of that market was captured by Honeywell. Some of their major competitors are Custom Command, Home Automation Inc., and Smart House. By 1994, there were 20,200 installed integrated systems. Honeywell's share of the market had dropped to 6%. By 1994, the market was experiencing new competition from security system companies and media companies, as both began to provide more comprehensive services.

Research by Parks Associates on the home automation market identified the following key factors leading to the growth of this industry:

- The baby boomer generation has a home orientation
- The growth of the 'grey' market
- Increase in the number of women working
- the number of people living independently who have special needs
- the increased complexity of lifestyles, leading to a demand for products that simplify
- the quest for the 'good life'—convenience, comfort, ease of use and safety

Parks Associates found that the three most desirable functions in an integrated home automation systems are security, energy management and communications, in that order. Two other functions that are desirable are

entertainment and information services. In new construction, the type of home buyers who want home automation include retirees, empty nesters and single people. Demand for home automation systems in terms of specific functions include security (98%), lighting (84%), audio visual capabilities (80%) and energy management (76%).

Attitudes toward home automation have been explored as part of market research. Many consumers don't know what home automation really is. They believe they cannot afford a home automation system because they are too expensive for them and they would be expensive to fix. Another conception is that they are too complicated to operate. Consumers believe that such systems may not really make life more convenient; they feel that many things could go wrong with them and that the systems on the market now really don't do what they advertise. They believe that in time, the cost will come down to make them more attractive. Parks Associates believe that a communications standard is a necessary first step to making it more understandable. Home automation companies will "come out of the woodwork" once standards are set.

Case Study: Future Home

Future Home is a demonstration of how state-of-the-art home automation can be used to achieve universal design. A unique feature of the project was the re-use of a historic house. Future Home is located on the Old Post Road from Baltimore to Washington DC. The house was originally a post house. The mission of Future home is to change the way people think about how people with disabilities and older people should live. The philosophy of the project was based on the Swedish concept that disability is caused by the environment. Future Home seeks to go beyond improving function to improving quality of life and "quality in life." David Ward spearheaded the development of the project, in conjunction with Jerry Jerome, who provided the expertise on automated home technology. Ward now acts as resident curator.

Future Home has a fully integrated home automation system. All doors and windows are powered and can be controlled from a central system or by remote for any place in the house. Roaming control is provided through “gateways,” which control anything in Future Home with the use of six buttons. There is a heating, ventilating and air conditioning that can be customized for each individual. Communication provides supervision of children from a distance. There is automated lighting control and even push button programmable plumbing. Accessible shower includes a built-in bench and two handheld shower heads. Personal care assistance is one of the most important needs of seriously disabled people. Ward needs such assistance and his household includes both his family and his personal care assistant. Ward has found that living in the home has provided a sophisticated lifestyle without complications or intimidation. He obtains more privacy because the automated systems relieve much of the need for his assistant.

The Future Home demonstration has been publicized widely in this country as well as internationally. Articles have appeared in many diverse publications and the AARP has done a public service announcement to bring attention to the project. It has become a demonstration project to showcase ideas on independent living for physically challenged individuals and senior citizens. It is estimated that 100 people per month tour the building.

The project has demonstrated that it is possible to achieve different levels of automation for different costs. Thus cost is not a serious constraint to installing a system. The automated features are received positively and add value to the house. Another finding has been that products must be appropriate for the individual’s needs. If they are not, these products will be, essentially, worthless to the individual and will be terminated (technology abandonment). Finally, the Future Home experience has demonstrated that electronics are more reliable than typical home equipment. They rarely

breakdown. The key problem with electronics is that the response time for service is longer than what would be necessary for simple mechanical breakdowns. Thus, quality of service is a critical factor rather than reliability of the products per se.



Case Study: Fairland Manor

Fairland Manor is a commercial apartment development, consisting of ten townhouses in Silver Spring, Maryland. Unlike Future Home, the intention was to develop the project and sell the units for a profit. Thus Fairland Manor is a test of how home automation will be received in the conventional housing market. The town houses each have three levels and 2,000 to 3,600 square feet. Fairland Manor is designed to be fully accessible and includes Decora home controls. The units are designed so that elevators or chairlifts can be installed. These controls include general switches, specialty switches, receptacles, dimmers, motion activated occupancy sensors, night lights and programmable lighting controls. Lights can be controlled from two or more locations. The interior/ exterior lights can either be switched on or off or dimmed by remote control. “Anywhere” switches are used for control of entertainment and appliances. These include both surface mounted switches or remote controls.



The Fairland Manor project demonstrated that home automation can appeal to an older population. They are not intimidated by well designed automated features. It also demonstrated how home automation is appropriate for a population with disabilities and that universal design through home automation is not cost prohibitive for this market.



Figures 18, 19 & 20. Fairland Manor
(photos by Leviton)

Like Future Home, Fairland Manor implemented an extensive public relations campaign. They had a grand opening. Three thousand invitations were sent out. Sixty people attended and there were at least five hundred inquiries. This is a “response rate” of over 15% and is considered good in this type of marketing. A series of spin-offs from this PR campaign have continued.

The units retailed for \$150,000-175,000, including all hardware such as televisions. The most expensive items are the motorized devices such as power-operated doors. To date, no units have been sold. It is believed to be the result of expensive land prices in Montgomery County, Maryland. To make the project more marketable, there is now a joint venture between builder and owner to rent out the units, hoping to attract those otherwise unable to afford the price of home ownership.



Figure 21. Fairland Manor
(photo by Leviton)

Barriers to Implementation of Universal Design

In November, 1994, the Center for Universal Design and Future Home sponsored a two-day working conference entitled “Emerging Technologies for Independent Living.” The purpose of the conference was to identify potential applications of Home Automation and other technology to address the independent living needs of people with disabilities. The conference brought a number of “expert consumers” together with leading technology experts in the areas of robotics, home electronic controls, telecommunications, computers and voice recognition. Participants were asked to address the following objectives:

- Discuss independent living needs of people with disabilities and determine applications of technology to address these needs;
- Examine emerging technologies in relevant fields—robotics, home electronic controls, telecommunications, and voice recognition systems;
- Identify possible technology applications and discuss their broader market appeal, i.e., their Universal Design features; and
- Identify obstacles and opportunities to promote promising technology applications.

The participants at the conference identified several independent living needs amenable to technology solutions:

- front door intercom accessible via a cordless phone
- automated door and window locks
- a navigation system (e.g. using global positioning satellites for people with vision impairments)
- automated kitchen storage that brings stored items to the user
- automatic shutoff for appliances that are left on by mistake
- a lockout system to childproof dangerous areas that permits easy access to other users
- multi-sensory indicators for kitchen appliances (e.g., stove on, garbage disposal on, etc.)
- perceptible feedback for membrane switches
- feedback on status of operating systems (e.g., air conditioning, heating, etc.?)
- user interface that is accessible by people who are blind.

Although all of these applications are technically feasible, they are not currently available for a number of reasons. The following obstacles to broader availability of these applications were identified:

- Most home automation specialists are not aware of the needs of people with disabilities or how their services could be of benefit.
- Likewise, most consumers do not know where or who to contact for assistance with home automation applications.
- Product literature does not describe the possible applications of a given product to the needs of people with disabilities.
- Product and appliance manufacturers may view many of the recommended applications or product refinements as “assistive technology” with limited mass market appeal.
- There is no distribution or installation network for most home automation products and systems.
- Some manufacturers and installers may fear a negative association with applications for people with disabilities.

- Many consumers who could benefit from independent living applications may resist the technology as too “assistive.”
- Most consumers resist home automation applications as too “techie.”
- Few consumers will sacrifice aesthetics. The touch screen user interface doesn’t quite fit the Martha Stewart/Laura Ashley/Bob Timberlake look.

To address these obstacles, conference participants recommended a number of dissemination activities that could be undertaken immediately to encourage development of promising technology applications. In addition to demonstration sites, the following activities were suggested:

- Develop an illustrated “cookbook” of Home Automation solutions for people with disabilities that could be installed by any “handyperson.”
- Compile a catalog of preferred Home Automation devices and manufacturers.
- Develop a guide to Home Automation applications for specific types of functional impairments (e.g., home automation applications for people with visual impairments).
- Make presentations to Home Automation specialists on applications for the independent living needs of people with disabilities.
- Make presentations to manufacturers to encourage adoption of identified technology applications.
- Conduct a series of “how to” short courses (for architects, Home Automation installers, etc.) on Home Automation for people with disabilities.
- Establish a referral network of Home Automation specialists who can provide assistance to people with disabilities nationwide.

A number of the barriers identified through the Center on Universal Design’s conference were also addressed at the Special Interest Forum. Several additional issues were also raised and discussed.

From the perspective of universal design, it is clear that home automation will not, in itself, provide accessibility and usability for people with disabilities, the aged and others, without physical access as well. The architecture of the building must be accessible to start with. In particular, home automation demonstrations that seek to promote the idea of universal design must insure that their facilities are accessible.

An important barrier to improving the utilization of home automation is systems integration. Purchases made in the present can limit the integration of new features in the future. It is important that the industry and individual companies recognize and address this problem. Both expansion capability and “upward compatibility” for the future have to be provided to insure continued consumer interest and increased involvement.

The importance of service response when products fail is particularly critical for people with disabilities and anyone who is vulnerable to safety or security threats. For comprehensive, or critical systems, there should be a back-up system either through generators or uninterrupted power supply, to insure safety and security of the dwelling.

Marketing people believe that devices targeted for people with disabilities have limited appeal. Yet there has not really been an in-depth investigation of this belief among consumers. Home automation producers are currently not knowledgeable about disability issues and this belief may communicate stereotypical attitudes. Consumers who could benefit from such a device may be primarily concerned that the technology intrudes too much in their lives. This more general concern is really not associated with the stigma of disability and it could be overcome by appropriate design and marketing.

The consumer is not willing to sacrifice aesthetics for the sake of improved technology. High tech devices are

often incompatible with both traditional and contemporary home decoration schemes. Thus it is important that attention be given to the appearance of home automation as well as systems design. Devices can be either invisible or come in a variety of different styles or be neutral and unobtrusive in their appearance.

One of the most serious barriers to using home automation for universal design is the lack of a single distribution and installation network. Currently the providers of home automation systems are diverse. They include integrated systems manufacturers and installers, electricians that are seeking more creative work, computer hardware and software experts, audio-video custom installers, telephone system installers and the security industry. It is estimated that twenty to twenty five percent of providers are hobbyists who have started their own business. This fragmentation is restricting wider applications because the consumer does not have a clear image of how their needs can best be served. Furthermore, with respect to people with disabilities, the various providers have little experience or training in meeting the needs of people with functional limitations, be they seriously disabled individuals or simply older people who would like more convenience in their lives.

The current state of the art in service delivery is focused primarily on expert providers. Most systems are not yet mass marketed. Many products are not available directly to homeowners or non-dealers. Mass marketing outlets like Home Depot do not have the expertise to sell these systems at the current time. The consumer, or another non-expert like a general contractor, can buy certain sub-systems in retail outlets and patch them together. However, this will not result in sophisticated applications. As the market matures, providing service will clearly become more critical. It will be necessary for service providers to hire experts in order to maintain their position in the market. A good example of the value placed on service is the personal computer industry where consumer affairs often take a back seat to selling more systems, to the detriment of the industry as a whole.

There are many attitudinal barriers that have retarded the development of the home automation business. People are unfamiliar with these products. They don't know what is available nor what they can achieve in terms of real benefits in their lives. Consumers think that home automation is cost prohibitive and, in particular would be expensive to fix. Although the idea of home automation is improved convenience, many view the added complications of such systems as less convenience. They recognize that many things that can fail and feel that automation could actually handicap them rather than improve their functional ability. In general, the consumer feels that home automation is not yet feasible. Although it is an interesting futuristic fantasy, they believe it is probably not functional at this point in history.

Finally although many home automation systems and devices are good examples of universal design, they are not marketed in a "universal" way. The populations that are most likely to benefit from automation need to be reached. This may require new channels for marketing and approaches that both heighten the visibility of accessibility and usability features to those who need them and also avoid the stigma of products for "the disabled" and intrusive technology.

Promising Solutions

There are a number of new trends in the industry that point toward solutions that will overcome the barriers described above. It is clear that home automation needs curb appeal. Manufacturers are starting to discover what people like and develop marketing campaigns that can reach a wide range of consumers. The involvement of companies like Leviton and demonstration programs like Fairland Manor are the beginning of a trend that links the emerging grey market and the traditional assistive technology market with mainstream consumer product manufacturers. These manufacturers see universal design as a way to reach the population of people with functional limitations who

are likely consumers of their products without turning off the broader population.

It is clear that there are many “gateway devices” that provide an entrance for consumers into the home automation field. These include remote control systems, personal computers, security systems, interactive computer games, pagers, cellular phones, the new “set-top” computer devices and even programmable VCRs. As the general population becomes experienced with such devices, it is likely their receptivity and interest in larger scale home automation systems will be enhanced. These gateway devices could be designed more effectively as examples of universal design. Manufacturers who adopt such a strategy could make inroads into the grey market and in general educate consumers on the benefits of automation. Difficult to use and hard to understand devices will only retard the development of more sophisticated home automation because it will give consumers a bad impression of how such technology can work.

One of the more interesting developments in the industry is the emergence of partnerships between manufacturers of different systems. Honeywell is perhaps the best example. They demonstrate how the cooperative development of integrated systems can benefit all participants. Partnerships allow manufacturers to take advantage of each other’s strengths and technology and also to widen their marketing networks. Such partnerships could be enhanced by the development of pre-packaged systems geared toward different kinds of markets, for example, the “young child package,” the “hearing impaired package,” etc. These consumer-specific approaches would allow individual needs to be addressed, making the benefits of products more understandable. They could also help consumers balance their needs against their budget.

The demonstration programs like Future Home and Fairland Manor illustrate how people with disabilities can be a benchmark for home automation designs. They also help to remove attitudinal barriers toward high-

tech applications. One of the best examples of how a service focusing specifically on people with disabilities has promoted general consumer response is Merrill Lynch's use of TTY's for communication with financial advisors. Advertisements promoting this service dramatically increased Merrill Lynch's clientele among the aged. Perhaps the time has come where there is no stigma attached to advertising "pitches" that target functional limitations as long as more general benefits to consumers are emphasized.

The emergence of many devices designed for retrofit to existing homes is another trend that can broaden the use of home automation. In particular, the elderly population can benefit from this development. Most older people live in older homes and they have a strong desire to remain where they are. Home automation systems can help them age in place with dignity and self-sufficiently. The development of methods to reduce the cost of retrofit and improve accommodation to existing home construction should be a major direction for the industry. An example would be improvements in wireless technology that would overcome limitations in the range of such systems and eliminate the problem of interference from other devices.

There is a need to develop systems that address the specific needs of the "grey" market. The Leviton products that improve use of the home in the dark are an excellent example of promising ideas in this area. Not only do these products meet very specific needs of older people, they are clearly of general benefit to the population at large. They go further than just making an individual device easier to use. They actually enhance way-finding in the home at a broader level. Marketing universal design could also take advantage of existing sources of information on which older people rely. For example, the Home Shopping Network and the network of senior centers across the country can be effective channels to publicize and promote home automation.

Conclusion

Marketing data on home automation clearly point to rapid development of this technology driven sector. Practicing universal design can help home automation companies expand their traditional market from gadget hungry “techie” to those who have significant needs for improved function and convenience in their homes. However, the home automation industry must fully understand the universal design concept. It is not enough to promote convenience functions; it is important that these functions be easy to use by a broad variety of people. Insuring that home automation systems have universal design characteristics will help the industry develop a more user friendly reputation.

Currently, automation of housing is developing in many directions at once. Consumers are incorporating automation to increase security, safety, convenience, access to information, energy management and other functions with great speed. The development of sophisticated integrated systems however, is not proceeding at the same pace as market penetration of key products like security systems. It is clear that consumers are interested in specific benefits rather than features. They purchase one or more “gateway” device to achieve those benefits. The challenge for the industry is to learn how to educate the consumer about system integration and to insure that all the various sub-systems being installed in homes can eventually be tied together into one system and controlled by the consumer simply and easily.

The potential complexity of home automation at the fully integrated level must be addressed. People in “decision making mode” have no difficulty satisfying their needs for specific products that will improve their life. The trick is to get them into that mode when they don’t perceive a need or benefit. Current experience of the home automation industry suggests that integrated systems need a uniform “mental model of operation,” akin to the Macintosh or Windows operating systems. A uniform interface that can unite all the branches of

the home automation “tree” would help to capitalize on incremental development of systems. If all individual systems utilize the same model, then it would be easy for consumers to add “branches” and “twigs” as they perceive their needs changing and benefits increasing.

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