Smart House:
Home Automation and Housing for the Future

By
Ping Zhang, B.Eng.

A thesis submitted to the
Faculty of Graduate Studies and Research
In partial fulfillment of the requirements
For the degree of
Master of Architecture

School of Architecture, Carleton University
Ottawa, Ontario, Canada
August, 2003

@2003, Ping Zhang

National Library
of Canada

Bibliothèque nationale
du Canada

Acquisitions and
Bibliographic Services

Acquisitions et
services bibliographiques

395 Wellington Street
Ottawa ON K1A 0N4
Canada

395, rue Wellington
Ottawa ON K1A 0N4
Canada

Your file Votre référence

ISBN: 0-612-89024-4

Our file Notre référence

ISBN: 0-612-89024-4

The author has granted a non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of this thesis in microform, paper or electronic formats.

L'auteur a accordé une licence non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de cette thèse sous la forme de microfiche/film, de reproduction sur papier ou sur format électronique.

The author retains ownership of the copyright in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author's permission.

L'auteur conserve la propriété du droit d'auteur qui protège cette thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

In compliance with the Canadian Privacy Act some supporting forms may have been removed from this dissertation.

Conformément à la loi canadienne sur la protection de la vie privée, quelques formulaires secondaires ont été enlevés de ce manuscrit.

While these forms may be included in the document page count, their removal does not represent any loss of content from the dissertation.

Bien que ces formulaires aient inclus dans la pagination, il n'y aura aucun contenu manquant.

Canada

The undersigned hereby recommends to
the Faculty of Graduate Studies and Research
acceptance of the thesis

Smart House Design and Technology

Submitted by

Ping Zhang, B. Eng.
Chongqing Jianzhu University

In partial fulfillment of the requirements
for the degree of Master of Architecture

Director, School of Architecture

Thesis Supervisor

Carleton University

2003

Abstract

The future home is a popular topic when discussing the possibilities of technical inventions related to our ordinary needs. The advent of microelectronics combined with the integration of the basic techniques of telecommunications, sensors, optoelectronics and computers are effecting residents' daily life. Each separate use for a household appliance can now be integrated using developed home automation technologies.

This thesis contains a literature study and case studies on the current Smart House technology and market, analyzes the housing demand in the 21st century, and displays some solutions to security, energy saving, convenience and comfort of residential lifestyle in a prototype design. The purpose is to form a picture regarding the state of the art and current trends of the Smart House market, and what may happen in the future.

Acknowledgments

I would like to express my sincerest gratitude towards Prof. Greg Andonian, my thesis supervisor, for his constant encouragement, support and precious advice during the course of my paper-writing. I would also like to thank my classmates, Yi Xiong, Yonghai Guo, Zenxing Qu, Xiaoyong Wang, Bing Ma, for their help and support. Finally I would like to thank Mr. Nils Larsson and Mr. Phillip Sharp for their help and suggestions.

Ping Zhang

Contents

Abstract.....	iii
Acknowledgments.....	iv
Contents.....	v
List of Figures.....	ix
List of Tables	xi
Chapter 1. Introduction.....	1
1.1 Background.....	1
1.2 Housing Demand in the 21st Century.....	2
1.2.1 The Aging Population.....	4
1.2.2 Healthy Home.....	6
1.2.3 Changing Work Patterns.....	8
1.2.4 Attitudes Towards the Home	9
1.3 Rationale.....	10
1.4 Objective.....	11
1.5 Methodology.....	11

Chapter 2. Home Automation	13
2.1 Definition of Home Automation.....	14
2.2 Benefits of Smart House.....	16
2.3 A Brief History of Smart House.....	19
2.4 Smart House Technology.....	23
 Chapter 3. Case Studies.....	 30
3.1 House R128, Germany.....	30
3.2 e-House2000, US.....	34
3.3 The inHaus Complex, Duisburg, Germany.....	39
3.4 The INTEGER Hong Kong Pavilion.....	47
3.5 The Warden Home, Newbury, Berkshire, UK.....	51
3.6 Alpine Close, Greenfields, Maidenhead, UK.....	53
3.7 Westlea's INTEGER Home, Cherhill, UK.....	55
3.8 CMHC's Healthy House in Toronto, Canada.....	59
3.9 Ecology House, San Rafael, California.....	66
3.10 Research House, Queensland, Australia.....	73
3.11 Brisbane Smart House, Queensland, Australia.....	77
 Chapter 4. Analysis and Discussion on the “Smart House”.....	 88
4.1 “Smart House” and Aging Population.....	88

4.1.1 Home Technology and the Networked Home.....	91
4.1.2 Telecare, Telehealth Technology and Residential Gateways....	93
4.1.3 Dependability.....	94
4.2 “Smart House” and Healthy Home.....	97
4.2.1 Energy Savings from Home Automation Systems.....	99
4.2.2 Photo sensor, Occupancy, and Remote Control of Lighting and Appliances.....	99
4.2.3 Load Shifting and Load Management.....	100
4.2.4 Staged Power Return.....	100
4.2.5 Thermal Storage.....	101
4.2.6 Zoned and Programmable HVAC.....	101
4.2.7 Air Quality.....	101
4.3 Three Perspectives of the “Smart House”.....	102
4.3.1 The Technological Side of the Smart House.....	102
4.3.2 The Architectural Side of the Smart House.....	106
4.3.3 The Sociological Side of the Smart House.....	108
4.3.4 Connecting the Three Corners.....	112
4.4 Future Trends in “Smart House”.....	112
4.4.1 Computerized And Integrated Home.....	113
4.4.2 Environmental Healthy and Self-Sufficient Energy Supply.....	114

4.4.3 Information Technology and Tele-Communication.....	115
4.4.4 Space Flexibility and Multi-Functionality.....	115
Chapter 5. Concluding Remarks	117
Postscript.....	120
Glossary.....	124
Bibliography.....	127
Appendix A. Products in Smart House Market.....	135
CD of Presentation	

List of Figures

Figure 2.1: The First Smart House.....	21
Figure 3.1: House R128.....	30
Figure 3.2: Plans for the R128 house.....	32
Figure 3.3: e-House2000.....	34
Figure 3.4: Plans for e-House2000.....	36
Figure 3.5: inHaus.....	40
Figure 3.6: Network within Smart House.....	41
Figure 3.7: Bathroom of inHaus.....	44
Figure 3.8: Kitchen of inHaus.....	44
Figure 3.9: Home office of inHaus	45
Figure 3.10: Family room of inHaus	45
Figure 3.11: Controlling InHaus from the Car.....	46
Figure 3.12: The INTEGER Hong Kong Pavilion.....	48
Figure 3.13: The Warden Home.....	51
Figure 3.14: Alpine Close Home.....	53
Figure 3.15: Westlea's INTEGER Home.....	56

Figure 3.16: CMHC's Healthy House in Toronto.....	59
Figure 3.17: Heating, cooling, ventilation and electrical systems.....	62
Figure 3.18: Water and waste water management.....	65
Figure 3.19: Ecology House.....	67
Figure 3.20: The Research House.....	73
Figure 3.21: The Plan of the Research House.....	74
Figure 3.22: Brisbane Smart House.....	77
Figure 4.1: Five Main Attributes of Traditional Dependability.....	95

List of Tables

Table 2.1 Comparison of Major Home Automation Systems.....	29
Table 3.1 Design Features of the Research House	75
Table A.1 Products for HVAC System.....	135
Table A.2 Products for Lighting System.....	136
Table A.3 Products for Communication System.....	137
Table A.4 Products for Entertainment System.....	139
Table A.5 Products for Security System	141
Table A.6 Other Home Automation Products.....	143

Chapter 1. Introduction

1.1 Background

These days it is hard to imagine a kitchen without a microwave or a family room without a VCR. Whatever the age or size of a home, technology has become an integral part of a comfortable, enjoyable and convenient household. But houses can be smarter still. Smart House technologies, also called home automation, intelligent home, automated home, computerized home, home networks etc., can enhance a home's IQ, making it possible for its owner to control lighting, temperature, entertainment and security automatically - even from remote locations.

Smart House and other home automation technologies require widespread changes to the way buildings are made. As with other major technological developments of the electronic age, the coming of the Smart House has had many impacts on human life. Besides making homes more comfortable, convenient and safer, the rapidly-developing information infrastructure offers people the possibility of broader participation in civic and community activities. The increase in home networking is having great effects on the lives of people, and allows the home to become fully connected, controlled externally as well as internally.

In this information age, the "Smart House" is a term that includes both

the automation processes as well as the informational processes.

The future home is a popular topic when discussing the possibilities of technical inventions related to our ordinary needs. The demographic, economic and attitudinal trends are shaping housing needs. Today, a home is becoming a location not only for living, but also for work, education, medical care and entertainment. The evolution towards the multi-functional home requests advanced technology, while the development of household technology is reshaping our needs and home design.

It has often been thought that the newest, best and most suitable technology is spread to the consumers in a top-down manner without any counterforce. This technologically deterministic view neglects the social construction of technological systems. History has shown that in all occasions the technically best solutions have not succeeded. This is why markets nowadays also look at things from the consumers' perspective including mental images and ideals. There is a thin red line between technology adapting after people's needs and people adapting their life after new technological products. A certain pattern can be distinguished in the lifecycle for a successful technological invention.

1.2 Housing Demand in the 21st Century

More than thirty years ago, Nicholas Johnson argued that the home will ultimately become:

"...a home communication center where a person works, learns, and is entertained, and contributes to society by way of communications techniques we have not yet imagined -

incidentally solving commuter traffic jams and much of their air pollution problems in the process.”

In many of the visions speculated by writers and film makers, future homes are seen as a physical access node for “electronic spaces” within advanced communications networks. Typical is Alvin Toffler’s notion of the “electronic cottage” as a locus for employment, production, leisure and consumption. (Toffler, 1981) Common to many perspectives is a redefinition of the home to allow the household to reassume roles – such as work, education, medical care and entertainment - which amount to a revolutionary change in lifestyles. (Forester, 1989) Nevertheless, change is occurring as new communications and information technologies become “domesticated”. (Silverstone, 1994)

The evolution towards the multi-functional home is also a result of changes in advanced capitalist society. Lorente (1996) suggests that “global houses” are needed in “global villages” and fully inter-connected housing can act as an interface between Castells’ (1989) “flow space” - the increasingly important network of information flows - and physical space, where the experience and daily life of most people takes place. In this way the home can become part of a world of dialogue between people, between people and machines and between machines themselves. (Barlow, J. and Gann, D., 1998)

Presently, the housing market is seeing pressure both in the demands placed on the dwelling stock by demographic change and in the way services to the home are provided. This is partly a function of demography, partly shaped by trends within the labour market

and partly the result of attitudinal shifts. Additionally, developments in information and communication technologies clearly have the capacity to fulfill and create demands from households for new services. New “system builders” are seeking to deliver shopping, entertainment, banking and medical services direct to consumers. Furthermore, a set of smart homes technologies is evolving to control domestic functions within the home. These developments raise questions about the control of new technologies and extent of user participation in their introduction.

Many of the newly forming households will comprise elderly people, but an even larger number will comprise middle-aged single person households. While the latter may well generate a growing demand for new tele-mediated consumer services, as well as having the economic capacity to invest in new smart homes technologies, it is the rise in the elderly population that is generating particular interest amongst suppliers of smart homes technology and government.

1.2.1 The Aging Population

The trend towards a predominantly older population is both a national and global one. Major strides in healthcare, housing and economic and social structure over the last century see people now leading longer, healthier and more active lives. In a study prepared for the Second World Assembly on Aging, Madrid, Spain, April 2002, the UN Population Division of the Department of Economic and Social Affairs showed that by the year 2050,

20% of the world's population will be over 60 as compared to 10% today. This is a doubling of older persons over the next 50 years. An aging population impacts on the housing market if the current housing stock is unable to cope with changing social and medical needs, because enabling and supportive housing and living environments are becoming more and more important issues for aging population.

The increasing prevalence of health impairments and chronic illnesses which go along with old age can cause drastic changes for those affected. This process can make independent living, mobility, and the maintenance of social relationships considerably more difficult. (Mollenkopf, 1993) "Research usually confirms that most seniors, including seniors with disabilities, intend to remain in their own homes for as long as they can." (Canada Mortgage and Housing Corporation (CMHC), 1999) Together, these suggest there will be a growing demand for appropriate servicing and adaptation of the existing housing stock to allow "barrier-free" living - maintaining independence within one's own home.

While barrier-free housing can be created by relatively minor design adaptations and the introduction of physical aids, evolving technologies in telecare - the provision of health and support services over the new high-speed digital telecommunications infrastructure - also offer possibilities for enabling greater independence in the home and overcoming isolation in the community. The types of activities which could be supported include

routine diagnostics, monitoring, screening, basic counseling and advice. Telecare offers a variety of benefits to users who can receive routine treatment almost immediately without traveling to, and waiting in surgeries; they can participate in monitoring and diagnostics which is less intrusive than traditional forms; or they can be assisted in routine treatments, including reminders about taking medication. These benefits can all help people to lead more active and independent lives in an environment of their own choice.

At all levels of dependency the option of elderly people staying at home is considerably cheaper than moving them to specialized accommodations. This increases the likelihood that government and health authorities will seek to introduce telecare services, reinforcing any effective demand for suitable smart homes applications from individuals and households seeking to remain in their own homes.

1.2.2 Healthy Home

For most of us, ideal indoor conditions are similar to outdoor conditions during pleasant weather, with gentle breezes blowing, limitless fresh air, subtle fragrances, pleasant diffuse light, and so on. However, many of us live and work in buildings filled with desiccated and stagnant air, surrounded by chemical vapors and hazardous dust, under monotonous lights, assaulted by a chaotic symphony of buzzing, clanking, growling, and squeaking equipment. These conditions are largely the result of poorly conceived, financially expedient building design. There is growing evidence that today's artificial

environments are a major cause of irritation, stress and ultimately disease.

Therefore, the healthy home should provide the best possible setting for people, with light and air, thermal comfort and freedom from excess noise, as well as appropriate and interesting spaces, lighting, colour and textures. But the healthy home is not just for people; it can also be better for the environment outside.

Healthy buildings aren't just for old or sick people. In this age of health consciousness a great deal of attention has been focused on diet, exercise and personal habits such as smoking, alcohol and drug use, but there is another, less apparent realm that may be affecting our health: home and work environments. About one quarter of all people are considered "allergic" to environmental conditions in the usual sense, that is, they suffer from hay fever, asthma or other disorders triggered by plant materials, molds or animal dander, there are also people who are sensitive to chemical exposure. It is hard to say how many are affected, but it is likely that about one in three of us is sensitive to something in the environment, and will experience symptoms, often without knowing the source. (David Rousseau and James Wasley, 1999)

Our home environment is vital to our health, especially in hot and cold weather. The very young and the very old spend up to 90% of their time inside. People working outside the home still spend about 50% of their time at home, indoors. Some well-known indoor hazards such as lead, asbestos and carbon monoxide are toxic, while others such as pollen,

fungi and animal dander are allergenic. But there are thousands of toxic and allergenic substances, plus a wide range of irritants which are not as well understood: pesticides, solvents, vapors from plastics, and glass and mineral fibers. All of these are capable of causing chronic or acute illness, some in the short term, and others which may not appear for 20 years. (David Rousseau and James Wasley, 1999) That is the reason people need to live in a healthy environment. A healthy home may play a key role in preventing health problems.

1.2.3 Changing Work Patterns

Another area of social change which may impact on the demand for smart homes systems deals with changing patterns of work, driven by rapid technological development and globalization of economic activity. Currently, working at home is quite common. There are many different categories of homemaker, ranging from the factory outworker, the home-based salesman and self-employed person to telecommuting employee and executives who occasionally take work home. These have led to shifts in division of labour between the workplace and home, although progress towards mass teleworking has been slower than commentators predicted in the 1970s. Using the home for work activities has certainly grown, but a more realistic view of teleworking involves individuals spending some of their time working at home, some in the office and some while traveling. As Hillman (1993) puts it, teleworking involves a flexible combination of physical and electronic movements and spaces, rather than a total substitution of the physical by the

electronic.

Teleworking is attractive to employers because it offers them the chance to shift some of the costs of employing workers onto the home as well as potentially increasing productivity by overcoming the problems of lengthy journeys to work. This is likely to promote the continued rise in teleworking for routine activities where there is only a limited need for physical interactions with the office. (Graham and Marvin, 1996)

1.2.4 Attitudes Towards the Home

Changes in attitudes towards the way the home is used are more ambiguous. The purchase of a home may increasingly be seen as a lifetime investment, with first-time buyers delaying the decision to buy for longer and existing owners remaining in their homes for longer. Most immediately, this stems from a disillusionment over the financial benefits brought by owner-occupation and concern over insecurity in the labour market. More fundamentally, there may be a trend towards the adoption of “post-materialist” values, emphasizing freedom to choose lifestyles, the aesthetic improvement of one’s surroundings and desire to enhance intellectual ability. Whether this translates into more home-centered lifestyles - and, consequently, a demand for on-line services - is impossible to predict. However, over the next two decades the large growth in single person households, who have a high propensity to consume new products and services, suggests there may be a growing demand for information and entertainment services and smart

homes equipment from this group.

1.3 The Rationale

Tomorrow's homes should be Smart Houses if owners care about health, convenience, energy saving, and security. The demographical, economic and attitudinal trends which are shaping housing needs may form the foundation for a future housing market. Smart homes technologies give us beneficial options to meet these new housing demands, and make our homes successfully multi-functional. These are seen as a way of enabling people to achieve greater independence within their own homes, as well as helping health and social service authorities to save cost.

It can be said that our homes reflect our lifestyles whether it features a healthy environment, a home office, advanced lighting controls, or an enhanced security system. A house that centrally manages these subsystems and others is not a technological dream. A house whose subsystems -- security, lighting, entertainment, heating and cooling, and more -- work together in harmony, enhancing each others capabilities, is necessary for today's lifestyles.

Therefore, it is important to analyze the future trends for Smart House, to learn how to use latest technologies to make our homes even smarter, to discuss how housing demand and smart house technologies shape each other. All these factors form the foundation for a future housing market. The research on this topic benefits homeowners, designers, and

builders.

1.4 The Objective

The purpose of this thesis is to form a picture regarding the state of the art and current trends pertaining to the Smart House market and what may happen in the future. Specifically, this thesis explores Smart House concept from its technological, architectural, and sociological perspectives, analyzes the relationship and interaction between Smart House technology and current housing needs and design, and attempts to draw together ideas from Home Automation, Assistive Design, Healthy Housing, Computer Supported Cooperative Work (CSCW), Human Computer Interaction (HCI), Sociology, Engineering, and Psychology. It examines the relevance of these notions in the area of smart home and future housing.

1.5 The Methodology

- Investigating the Smart House market and collecting information from web and journals.
- Literature searches of previous theses, books and reports.
- Reviewing articles about Smart House issues.
- Using case studies to compare and analyze the advantages and disadvantages of different technologies and designs.
- Analyzing the relationship and interaction between smart house technology and

new housing demands.

- Attempting to understand how our future homes will look like and predicting how buildings will be technologically equipped.

Chapter 2. Home Automation

Home automation makes it possible for house owners to control lighting, temperature, entertainment and security automatically - even from remote locations. For example, home security networks can detect smoke, frozen pipes, carbon monoxide leaks, pool accidents and intruders, then notify owners and the proper authorities. Audio systems allow users to listen to music from a central source in any room in the house. Even better, they allow different people to listen to different things. Video networks enable homeowners to connect every television in the house to a central DVD or satellite source, which can be controlled from any location. There are even systems that control outdoor functions like watering the lawn.

It does not take a scientist to incorporate these appointments into a house. Most of us have had automation in our homes for some time now. The thermostat turns on the fireplace or air conditioner when the temperature reaches a certain point. Telephone answering machines record a call while we are away. VCR players are programmed to record a television show while we're gone. And the alarm clock wakes us up in the morning. These are all forms of home automation. What else can we do?

The following description, by senior feature writer Taylor Moore, is “one of many possible scenarios that may be commonplace to new homeowners”:

“Half an hour before you rise, the water heater turns on to reach just the right temperature in time for your shower. Bedroom and bathroom lights turn on as the radio wakeup alarm sounds. The rooms you use at that hour have been preheated. The coffee maker comes on while you're in the shower; when you finish, you're greeted by a full pot, and the television is on with your favorite news show.

“During the day, as it warms up outside, the air conditioner keeps the indoor air comfortable if anyone is home but avoids running during a two-hour afternoon peak period when electricity rates are the highest; the dishwasher that was loaded the night before runs itself early in the morning. A security system keeps watch while you're away but decides not to call the police when a neighborhood kid tosses the evening paper against the front door.

“When you return, recorded telephone messages are played back over the bedroom speakers while you change, but soothing music fills the den where you relax. A flashing light on a video screen announces that dinner in the microwave is ready. As dusk falls, outdoor lights turn on, the garden sprinkler gives the begonias a drink, and during commercials on the evening news you watch a display on the screen of the day's energy consumption and costs.

“Before you retire, the screen provides a status check of all outside doors and locks. The house turns off all nonessential appliances that were on, save for the reading lamp over the bed. Room occupancy sensors automatically light the hall and kitchen if you venture out of bed for a nocturnal glass of milk.”

2.1 Definition of Home Automation

From the scenarios mentioned above, we are able to figure out what functions a smart house can perform for its owner; in other words, how a Smart House is different from ordinary homes.

Automation refers to a system or method in which events are sequentially performed,

controlled, or produced by self-operating equipment and electronic devices without direct human control. Commercial industries have used this technique to produce superior products faster and more efficiently. Home automation is designed to provide those benefits to the home.

Home automation is the integration of electrical, mechanical devices and systems in the home to function automatically as one unit. This includes lighting, security, HVAC (Heating, Ventilation, and Air Conditioning), audio, video, sprinkler systems, garage door openers, driveway gates, motorized drapes, and so on. Integration of the home systems allows them to communicate with one another through the home controller, thereby enabling single button and voice control of the various home systems simultaneously, in preprogrammed scenarios or operating modes. This affords owners the ability to run these systems together, more conveniently, more efficiently, and more easily: smart.

Some people may think home automation is still science fiction. In fact, after more than two decades of development in market, home automation has grown increasingly accessible. Prices of systems designed to manage the lighting, audio and security needs of homes are declining and household applications are increasing. Systems are becoming more convenient to install and use. An automation system can control as little or as much as necessary, and it can be set to suit the schedules and habits of any family. No matter how comprehensive its control, though, the system remains an unimposing member of the

household. Most components are hidden in closets or basements, controlled by a keypad on the wall, remote controls or desktop units.

Smart House is the term commonly used to define a residence that uses the latest home automation technology in designing home systems to provide the family with home security, energy efficiency, entertainment and communication. Smart Houses can be used for older people and those with disabilities, providing safe and secure environments. With the development of fast-paced modern life, a Smart House is also good choice for anyone who cares about security, his/her health and saving energy; who appreciates convenience and new lifestyle.

2.2 Benefits of Smart House

Security

With current technology, electric power is provided to all appliances that are plugged into a wall outlet. Cutting a wire, inserting a screwdriver into a wall outlet, or a fault inside the appliance can result in a severe electric shock. The Smart House, in contrast, provides power only to outlets that have appliances plugged in and turned on, and the Smart House controllers monitor the circuit, disconnecting power at the first indication of a short circuit or other failure. In addition, when sensors detect gas or water leaks, smoke, or other abnormal conditions the electronic controllers can shut down the appropriate devices and trigger the alarm.

Closed-circuit television (CCTV) systems with small, inexpensive cameras discreetly placed and aimed at the doors allows visitors to be viewed from any television set in the home. Using the same idea, entry doors and some specific rooms such as an infant's bedroom can be monitored. Security mode can be used to manipulate lights; heating, ventilation, and air conditioning (HVAC); sprinkler systems; televisions; and radios to make an unoccupied home look and sound as if someone is home.

Convenience

Most of today's consumer electronic appliances such as radios, personal computers, and even power tools step the line voltage from 110 down to 6, 9, 12, or 24 volts. Smart House technology includes provision for power at several voltage levels, eliminating the need for numerous small power adapters at each appliance. The Smart House cabling provides a single outlet for power and communications; gas is provided through flexible tubing and its own, quick-connect outlets. In addition, Smart House technology can automatically control the temperature, humidity, and lighting in the dwelling on a room by room basis. Lights, sound, temperatures inside the residence, all the doors and gates can be monitored and controlled in any area of the home or office from a remote location.

Economy

In the traditional scheme, each appliance is provided with sufficient power to provide for its peak use. The Smart House technology adjusts the power supplied to each appliance

according to where and when energy is needed. Remote and timed control of heating, air conditioning, lighting, and appliances eliminates wasted energy. In addition, the Smart House controllers could schedule the operation of heavy power consuming appliances (such as dishwashers, electric water heaters, and air conditioners) to take maximum advantage of off-peak electric rates. These adjustments could result in lower utility costs.

Time and effort savings

Control the lights (inside and outside) from the bed at night. Program the stereo or television to automatically lower the volume when the telephone or door is answered. Preprogram lighting for various functions such as parties, the daytime, housework, sleep, or home theater viewing.

Comfort

Smart House systems can adjust pools, hot tubs, hot water heaters, air filters humidifiers, heating and/or air conditioning, electric blankets, and bathroom heaters till according to users needs.

Accessibility

Customized systems with unique voice- and/or touch pad switches designed specifically to assist physically challenged people. These necessary tools help users to perform daily tasks, therefore return some of an individual's independence. These systems control electric appliances such as lights, televisions, and interior and exterior doors. Plumbing

fixtures such as toilets and tubs can be operated with water adjustments. These systems can be used to operate normal computer functions such as word processing, faxing, and surfing the Internet. These systems can even answer and dial telephones.

2.3 A Brief History of Smart House

Manufacturers of laborsaving appliances have been promising homeowners an automated “home of the future” since the World's Fair days of the 1930s. The intelligent home has been a popular vision for a few decades. In the 60's, experts considered that by the end of the century people would live in smart homes, that contained independent household machines. Although many of the machines in these visions are today technically possible to manufacture, of course, the present situation is not exactly the same as what experts expected decades ago. The current major initiatives in Japan, the US and Europe to develop more comprehensive systems originated in the 1980s.

In Japan

The term “home automation” was first coined among the Japanese companies who showed the earliest interest in the concept of a complete home control system. The earliest home control systems were proposed by Hitachi and Matsushita in 1978. In 1980, Yoneji Masuda (one of the early pioneers of computerization in Japan) wrote the book *The Information Society As Post-Industrial Society* in which he discussed changes in society, information and knowledge industries, analyzed the technology that would free people to

live more creative and happy lives: computer-controlled vehicle systems, automated supermarkets, etc.

From the early 1980s, many Japanese firms published their own home automation blueprints, developed demonstration houses and launched proprietary systems. These included major electrical appliance manufacturers such as Matsushita, Toshiba, Mitsubishi, Sanyo, Sony, and Sharp. Some interphone companies first added security functions to their systems. Secom, a security services firm, expanded upon its original security system to develop a central control station for remote control of home security. The TRON project, which started in 1984, encompassed more than the other home automation packages currently under development, being especially concerned with architecture and the experience of space inside the house. In September 1988, the “Home Bus System” industry standard was issued.

In US

In 1982, AT&T established the concept of “Intelligent Building”. The Informart Building, an office building and conference center in Dallas which promoted a good sense of community among tenants and customers, was erected to demonstrate how advanced IT from different suppliers could be used in the intelligent building.

The Smart House Project was established in 1984 as a project of the National Research Center of the National Association of Home Builders (NAHB), USA, with the cooperation

of a number of major industrial partners. NAHB formed the SMART HOUSE Limited Partnership (L.P.). It sought the participation of several manufacturers for every major type of hardware that would be needed for a Smart House system. By 1987 more than forty leading manufacturers had joined the project. Some of them signed formal contracts, called “Research and Licensing Agreements”, to develop products. Another 25 companies have formed business affiliations with SMART HOUSE to develop applications.

Figure 2.1: The First Smart House

In April 1987, a laboratory Smart House (Figure 2.1), which is considered as the world's first Smart House, was constructed at NAHB's Research Home Park in Bowie, Maryland. This lab house was used for research on the design of the network.

As the project moved out of its initial stages, The NAHB National Research Center spun it off as a separately incorporated profit-oriented entity called the Smart House Development Venture (SHDV). SHDV began to bring Smart House to market quickly.

About a year after completion of the Laboratory House, construction began on a number of prototype houses at locals in the United States. In 1992, two manufacturers of electrical connectors, AMP, Inc. and Molex, teamed to buy all the rights to the SMART HOUSE technology and to provide additional funds for the SMART HOUSE L.P. to continue system development. In August 1997 SMART HOUSE L.P. was dissolved and the assets transferred to a new company, SMART HOUSE, Inc. The focus of the new company is franchising home automation through independent dealers.

In Europe

The European Union is the third place where efforts towards the intelligent house have been made. The larger European firms first examined the idea of home automation at the same time as their counterparts in Japan and the US.

In 1978, Philips' Eindhoven R&D staff developed a prototype of a "Dobus" system, which, although concerned mainly with audio-visual products, was extendable to cover control of security. Zanussi's Zeltron Institute started work on an "Integrated Kitchen System" in 1980. In the UK, the National Economic Development Office (NEDO) first discussed home automation in a 1980 Report and in 1984 it set up a Task Force on "Interactive Home Systems". In 1979, Thorn started to explore home systems with the interest in domestic appliances. Thorn's Central Research Labs subsequently built a demonstration house and by 1985 were organizing a business plan for developing marketable systems

products.

Here are some of the various projects that dedicated efforts on this topic: ESPRIT Home Systems Project, initiated in 1989; FAST (future studies); TWE (Technology, Work, Employment); SERV (Activities and Services being offered by technology); RACE (with its 1006 project) and EUREKA, which created a two-year subprogram called “Integrated Home Systems.” Several important reports have been issued that have a direct implication with this subject: “TV without borders” (related to entertainment); the Green Book on Telecommunications; Europe 2000; and Domotique 88 (a huge qualitative survey among 300 experts carried out by Bis Mckintosh).

A great deal of groundwork has been done to coordinate the building industry in bringing Smart House technology to market. Whether home automation technologies succeed at changing standard residential construction, it is clear that at least some of the innovations are already entering the marketplace, although some in fragmentary forms.

2.4 Smart House Technology

Within the home automation industry, several groups have formed, which support specific systems and standards. The standards, like communication languages interpreting and conveying commands among devices and subsystems, are used to carry out all the functions of various home automation systems. There are two ways that standards are developed. Planned standards are developed by the joint agreement of participating

entities. De facto standards are developed because consumers determine which one they prefer, and they vote on those standards by buying the products that they prefer.

Some systems and standards do not provide compatibility with others, because of the proprietary nature of these standards. However, the development of nonproprietary standards, combined with participation by giants such as AMP and Lucent, has recently resulted in standardized components and architectures that allow easier planning, development, and installation of systems. Several control architectures have been adapted into nonproprietary standards and are prevalent in most products.

Here are four major control standards: X10, LonWorks, CEBus, and Smart House.

X-10

The term “X-10” refers to a home automation technology that uses existing power lines to convey information and commands between a control unit and various sensors or apparatus. The controller is able to receive signals from input devices and interpret this data to then send the appropriate commands to the proper devices. The individual components that the controller manages have several different ways in which they can be connected to the system and to the appliance. One common way is to use a appliance module that plugs into the outlet, and then the appliance to be controlled plugs into the receiver. Another, less obtrusive, way is to use an appliance module that mounts behind the outlet. There are also a wide variety of products for the user to communicate with the

controller. Some input devices include a software driven voice interface, remote controls (such as a TV remote), and simple switches that mount on a wall.

X-10, at its simplest, consists of the following parts: transceivers such as control boxes or wall module that send a control signal to lamps or appliances, lamp or appliance modules that receive control signals and process them, remote input devices that let the user communicate with transceivers, and the AC power lines that transmit the data. The controllers can be as simple as a switch, or as complicated as a PC-programmable controller. The transceiver could also be a photo-sensitive device, or a motion detector. X-10 systems provide flexibility (due to the wide range of products available), low cost (because they use existing wiring), and are readily available since there are many merchants who carry X-10 products.

LonWorks

LonWorks is a home control system made by the Echelon Corporation. It is based on the communication protocol LonTalk, which has been ratified as an open industry standard by the American National Standards Institute (ANSI/EIA 709 1-A-1999). Instead of having a master/slave setup in which a controller manages the actions of the nodes, Echelon made a system in which nodes communicate with one another using the LonTalk protocol. With LonWorks, a complex control application is orchestrated by a network of nodes without a master controller, although controllers for LonWorks are made which can monitor and

control nodes on a network. There are four types of devices for LonWorks systems: local control nodes, supervisory nodes, network services tools, and routers. Supervisory nodes are not to be confused with the controllers of a master/slave architecture, although they can coordinate the operation of one or more local control nodes. They can also collect and log data from one or more control nodes. Network services tools are used to install, configure, diagnose, monitor, repair, and control the devices in a control network. Routers provide a transparent connection between two LonWorks network channels.

The nodes made by Echelon use their Neuron Chip, which has LonTalk imbedded in it. Their chip is not necessary to use LonTalk however, since LonTalk can be implemented on other processors under the EIA 709.1 control networking standard. LonWorks also includes the ability to transmit over several different wires including twisted pair (supporting a variety of topologies) and existing AC or DC power lines. In fact, their routers can be used to provide a connection between networks wired in different ways. LonWorks has flexibility similar to that of X-10, although more so since it can support different transmission mediums. It is limited however in that the individual controllers are more expensive than X-10 and the components of a LonWorks system are more complicated than those of a X-10 system.

CEBus

CEBus is a standard under the ACSI (ANSI/EIA 600 series). CEBus uses the Common

Application Language (CAL) defined in EIA 600.81. This document presents the language and an object-oriented model of diverse products (that constitute the home environment) operating together. CEBus uses existing home power lines as its transmission medium. CEBus also is said to use spread spectrum, in which a signal is transmitted over a range of frequencies, rather than using a single frequency signaling (this claim is controversial, as the Metricom claims that CEBus does not actually use true spread spectrum signaling). This allows CEBus to overcome any problems that might arise from the communication impediments found in homes power lines. One caveat of the CEBus standard is that every node must transmit and receive. This makes sense with respect to knowing what is going on in the system, but it also drives up the cost for simple devices such as switches. Since CEBus is only a standard around which a system could be built, it would be uninformative to compare it to either X-10 or LonWorks because it would depend on how the system that follows CEBus's standard was built.

Smart House

In 1984 the U.S. Congress passed the Cooperative Research and Development Act, allowing collaboration between companies for purposes of research and development (R&D), in a private consortium without violating antitrust laws. The National Association of Home Builders (NAHB) in Washington, D.C., formed the Smart House Limited Partnership (L.P.). The NABB then invited companies to consider membership in Smart House. The intent of Smart House was to allow three competing manufacturers per Smart

House component or product to join the consortium.

Smart House is very proprietary and dealer-oriented. Installation and service to the systems require training, certification, and specialized tools and hardware. Many larger companies, such as AT&T, Sears, Honeywell, and Square D, were once involved with Smart House and have since left. Originally proposed as a standard which included centralized intelligence and new wiring and hardware for new homes, Smart House has recently begun to work with both CEBus and LonWorks in an effort to develop hardware and components intended for existing homes. It is expected that someday soon Smart House will change from the centralized-intelligence concept to a CEBus- and/or LonWorks-based network concept. When this occurs, Smart House will have changed status from a proposed standard to a brand name.

Table 2.1 Comparison of Major Home Automation Systems

	X-10	CEBus (EIA IS-60)	LonWorks	Smart House
Developer	X-10 (USA) Inc.	Electronics Industry Association (EIA). Further developed by CEBus Industry Council	Echelon Corp. testing and certification programs Led by LonMark Interoperability Association	Smart House Limited Partnership (Smart House L.P.) for the, National Association of Home Builders
Media supported	Power Line. X-10 manufactures devices for other media, but there are no standards for them	Power Line Twisted pair Coaxial cable RF IR Eventually fiber optic	Power Line Twisted pair RF Third-party transceivers support others	Custom-made wiring available from three sources
Maximum data rate	60 bits/s	10 kbits/s, additional support for video, audio, and data	610 bits/s to 1.25 Mbits/s	50 kbits/s, additional support for coaxial distribution
License requirements	Proprietary, company does not License others to use it.	Public domain, does not require a License. Certification required to use CEBus Logo.	License required. Certification required to use the LonMark Logo.	License required
Relative cost	Low	Low to moderate	Low to moderate	Moderate to high
Target applications	Existing and new homes	Existing and new homes	Existing and new homes, commercial and industrial buildings, automation	Mostly new homes, some Light commercial buildings

Chapter 3. Case Studies

3.1 House R128, Germany

SEAOI (Structural Engineers Association of Illinois) announced the 2002 Excellence in Structural Engineering Awards during its Annual Awards Banquet. The 2002 Best Small Structure Award was won by *Werner Sobek Ingenieure* for **House R128** constructed in Stuttgart, Germany.

Figure 3.1: House R128

The building is a 4 level futuristic concept residence built on the steep slope of a small

hill. Access is via a bridge leading to the top floor. This level accommodates the kitchen and dining area and the next two levels contain living and sleeping areas respectively. The bottom level has a nursery and houses mechanical components. Each of the four floors is defined by a few pieces of carefully selected furniture, reflecting the minimalist, transparent quality of the exterior of the building.

The house is a modular design and it is constructed entirely of glass with no internal partitions. The load-bearing structure of the building consists of a steel frame stiffened by diagonal members and erected on a reinforced concrete slab. The floors are heavy-sectioned timber modules. All load-bearing and non-load-bearing elements including the façade are modular. The R128 house is assembled by means of mortise-and-tenon joints and bolted joints. As a result, it is both easy to erect and dismantle, making it completely recyclable. There are no cables or pipes embedded in the walls. All supply and disposal systems as well as the wiring are housed in metal ducts which run along the façades and are built into the floor and ceiling structures.

The R128 house is entirely self-sufficient in its energy requirements. The electrical energy needed to operate the mechanical ventilation system and heat pump is supplied by solar cell panels installed on the roof. This system uses the public electricity grid as a zero-loss energy store by feeding into it surplus energy and tapping it when there is an energy shortfall.

1st Floor Plan 2nd Floor Plan 3rd Floor Plan 4th Floor Plan

Figure 3.2: Plans for the R128 house

Using advanced smart technology, the house is devoid of switches, door handles, and other such fittings normally associated with comfortable residential living. Various functions in the house are controlled using non-tough sensors, voice control, or tough screens. Operations such as controlling lights, opening and closing windows, watering

garden and setting room temperatures uses especially developed house control software.

Activation is by means of touch screens provided on each floor and in the guest annex.

Bathrooms and toilets feature reflecting photocell units permitting a swipe of the hand to control the doors and the flushing of toilets. Showers and washbasins also have non-touch controls. The refrigerator has a concealed microwave sensor that responds to closeup hand movements to open and close the door.

The completely glazed building has triple glass panels. The heat energy radiated into the building by the sun is absorbed by water-filled ceiling panels and transferred to a heat store which provides warmth for the building in the winter by reversing the heat exchanging process. In this mode, the ceiling panels become radiators and no additional heating is needed. Another important ingredient of the climate management of house R128 is the mechanical ventilation system which controls the air flow and allows heat to be recovered from the exhaust air. Fresh air is injected at a single point on each floor and exhausted via the sanitary modules. To utilize the almost constant temperature of the subsoil as a heat source and heat store for preheating or precooling the fresh air supply, the exhausted air is blown through a heat exchanger located in the ground below the foundation of the house. The temperature inside the house can be selected separately for each floor.

All pipes and cables for electricity, water, communication systems, and waste water are

run in folded aluminum ducts along the inside of the façades. This allows each function to be connected at any point simply by opening the appropriate duct. The freestanding bathtub, for example, can be connected anywhere thanks to this flexible installation system. The four-story staircase as well as some areas not covered with ceiling panels create continuous vertical spaces. The absence of internal partitions coupled with the all-glass façade provide a visual continuity between the horizontal, internal, and external spaces.

3.2 e-House2000, US

Figure 3.3: e-House2000

The e-House is an experimental house of the future - a laboratory for living built in the rural woods of Stone Ridge, NY. US. It is designed by award-winning architect Michael McDonough. McDonough used the name "e-House" because he signed on sponsors and specified products electronically over the Internet. This high-performance Internet-based

building was developed with a team of engineers, building scientists, computer scientists, environmentalists and over 100 manufacturers.

Michael McDonough, AIA, advocates using smart-building technology at home—but one of a different way. While most smart-home systems emphasize entertainment and convenience, he suggests investing in technology to gain efficiency rather than only convenience. McDonough designed e-House 2000 to demonstrate how wireless computing and monitoring technology enable energy-saving features and systems like radiant cooling and passive solar heating. Sensors will be used to track temperature, humidity, heat gain, and even ground freezing near critical underground systems that could be damaged by frost. The sensors will monitor the parts of the house most prone to failure or poor performance, like drains and flashings. Information from the sensors flows to Supervisory Control And Data Acquisition (SCADA) software that will alert house owners to potential problems and either automatically adjust systems to work optimally in sync or let the user manually turn on dehumidifiers, lower window shades, and make other adjustments from a home computer.

Cantilevered sections of the house with north-facing windows are built of steel rather than wood. The insulation around the steel will be monitored to add heat as needed, to avoid the problems that often hamper steel's performance in cold climates. This also gives the house a light, clean, modern look.

Figure 3.4: Plans for e-House2000

When we study e-house2000, we have to go beyond thinking in term of sticks and bricks, beyond specific products and systems. We have to rethink the whole house innovation, not only for this particular house, but also for the future of all housing. Here are some highlights that e-house2000 has shown to us:

Quick assembly/long-life-span building systems: The changing labour market and improved production automation demand that builders consider components that erected fast and last for long. Structural insulated panels are made off site, computer-cut, and crane assembled.

Energy-efficient assemblies: Lower utility operating costs aside, floors, walls, ceilings, and roofs are now part of heating, cooling, and snowmelt systems operating on multi-fuels-liquid petroleum gas, solar hot water, site-sourced firewood, and fuel cell - or photovoltaic-generated electricity. Floors, stairs, and ceilings deliver radiant heating and cooling made of AdvanTech OSB (oriented strand board) and recycled slag content concrete.

Smart house networking: Satellite Internet access provides two-way communications for Web-based home controls and automation (and TV programming). This, in conjunction with home automation products, will make e-House as efficient as a dual-fuel automobile and as personalized as owner's home page and e-mail address.

Design for disassembly: In this throwaway culture, recycling is a mandate. It is time for builders to take note of recycled content and recyclable materials and include them in their building plans. In this project, the radiant snowmelt system has 100 percent post-consumer recycled newspaper panels.

Computer-aided design/computer-controlled buildings. High-tech equipment needs to be designed and managed at evermore complex and demanding levels. Computers can do the job, and when mixed with high-bandwidth Internet access, they can do it any time and report the information to anyone anywhere on the earth. The SCADA system lets users turn the dishwasher on, or monitor power outages and energy efficiency from Paris via cell phone, for example.

Health and wellness. Clean indoor air, water filtration, energy recovery, natural materials, low-VOC (volatile organic compounds) paints, organic fabrics, building performance monitoring, dehumidification, cleaning and maintenance regimes are now designed into the building. With built-in vacuums, energy recovery ventilators, super dehumidifiers, balanced air intake and outflow, and demountable baseboard wire management, partitions will never be the same.

Biotech and natural. Sustainable and fast growing, bamboo removes massive amounts of greenhouse gases from the air. Indoors, it adds oxygen to the air. Hydroponic bamboo

plantings in the “light catcher” stair clean the air. Bamboo is used for flooring, door veneers, treads and risers. Bamboo is field tested and readily available.

Earth as project component. Footings, foundations, and slabs are still about structural support, but now they also support geothermal heating, computer network cabling, and future-proofed conduits for wiring, plumbing, and other upgrades. The earth itself can be reengineered using flowable fill concrete for thermal conductivity and moisture retention.

3.3 The inHaus Complex, Duisburg, Germany

Built in Duisburg, Germany, the smart wired house “inHaus” is a thematically and organizationally unique and integral concept in the field of product-oriented innovations for a networked life. The basis of the project is the inHaus facility in Duisburg which includes a residential home, a workshop, a networked car and a networked garden. This so-called “Innovation Center for the intelligent House” is used by researchers and industrial firms as a workshop and testing ground for future forms of living and working.

The inHaus complex is housed in a pair of connected buildings. One is an authentic home, with the laboratory for living and a home office, supplemented by a car (the connect-Passat) and an intelligent garden. The other is a research and development workshop, containing a bathroom laboratory, a kitchen laboratory, the future craftsman's workshop, a central building utilities room and a planning and advice office, which also handles tele-services.

Figure 3.5: inHaus

Two features make inHaus stand out from other similar projects. It is both an experimental laboratory for living and a workshop for innovation and will therefore continue to change in light of new developments. It is an open system ready to accommodate all suppliers and concepts. This innovation center for future forms of living and working in a “smart environment” is being supported by a broadly based consortium of firms headed by the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in Duisburg who have all chosen to coordinate their components so that they work together.

The systematic tests carried out at inHaus are intended not only to solve technical problems but also to investigate user requirements such as interior design, ergonomics, hygiene, comfort and lifestyle. The residential unit of the complex has been deliberately

furnished as a perfectly normal modern-style home. The idea is that the technology should remain invisible in the background, hidden under plaster or inside the appliances. For instance, in the bedroom, the matt glass doors of the wardrobe serve as a TV projection screen.

Figure 3.6: Network within Smart House

Klaus Scherer of the IMS, initiator of the project and now project manager for strategy and marketing, defines the objectives as follows:

“On the one hand we want to find out how various appliances, components and infrastructures, which often operate on the basis of extremely different standards applicable in different professional fields, can be made to work together in a single system, in a useful and efficient way. In other words: find ways for technologies to understand each other better. And on the other hand, we want to find ways for technology and people

to understand each other better. The aim is to provide people with genuine support in their living environment, in their world of work, in communications and in mobility. This means, for instance, that the technology must as simple as possible to operate.”

The operators of inHaus are testing several networks simultaneously, both cabled and wireless. The system integration solutions are largely based on Internet technology. The IMS has embedded this technology in the appliances and system components (“embedded Internet”). The multimedia home cabling system HomeWay links TVs, telephones and personal computers and provides any required service in any room of the house. Hometronic and EIB networks use wireless and cable connections to control all electrical elements including heating - fully automatically or by manual keypads via remote control or telephone and Internet. To allow the Internet messages to leave the house, the IMS and its partners developed a Residential Gateway, as the central element linking the external and internal data networks. Therefore, inHaus residents can connect with appliances in their home while they are at work - to check their status or issue mote-control commands. Another major element providing links with services in the outside world is “Smart Home”, a novel Internet service platform that is connected to the Hometronic wireless network in the inHaus complex. Special emphasis has been placed on new functions for saving energy. Sensors in the rooms measure the temperature, humidity and air quality, and automatically open and close the motor-driven windows. If a thunderstorm approaches, the house automatically makes sure that everything is weatherproof. When the occupants leave the house, the heating switches itself down to economy level.

Electricity is reduced by active load regulation, for instance, the washing machine is on during off-peak hours at night. The occupants of the house have constant feedback on their energy consumption enabling them to change their usage habits. Even the inHaus garden - its water sprinklers and lighting system - is integrated in the resource management program.

A particularly important aspect is the testing of new operating controls and the investigation of the acceptance of their design and function. For example, glass touch switches made by the company Merten respond to a mere touch or to infrared signals. A central control unit permits the user to activate predefined scenarios such as “after dark” or “breakfast time”. The lighting and window blinds immediately set themselves to the appropriate levels. The stereo system plays suitable preprogrammed background music.

The intelligent bathtub can be filled by remote control to personalized parameters. It displays the temperature of the bath water, has a child security device, overflow protection, anti-scalding protection, and gives off a signal when it is filled to the desired level. A further potential feature is voice-controlled faucets which raise or lower the temperature in response to a spoken command or pour the exact measure of water into a saucepan.

The Cool-Logic refrigerator makes housekeeping quicker, simpler and better organized. An electronic label is attached to every package of food. A reading device inside the fridge records such data as quantity, date of purchase and use-by date. The content of the fridge

can thus be checked at any time. A signal is emitted shortly before the use-by date expires. The user can define the minimum required quantity of specific items which will then be noted on electronic shopping lists. It is even possible to place orders automatically over the Internet.

Figure 3.7: Bathroom of inHaus

Figure 3.8: Kitchen of inHaus

Figure 3.9: Home office of inHaus

Figure 3.10: Family room of inHaus

In collaboration with appliance manufacturers, suppliers and service companies such as power utilities, security firms and building services companies, a wide range of services relating to the house and home management are offered, including security systems, remote control capabilities, remote maintenance, telemetering of electricity, gas and water supplies. Other new services are also emerging such as heating and energy management. If an appliance or system develops a fault, it is reported directly online to the appropriate manufacturer's repair service or authorized tradesman.

Figure 3.11: Controlling InHaus from the Car

The “comings” and “goings” of people at the front door are monitored by an entry-phone system with camera. The electronic security locking system allows the door to be opened by means of digital codes, transponders and a world first - with the ignition key of the inHaus car. Because every German household owns a car, inHaus has been joined by its mobile equivalent. The system is capable of communicating with the entire building services by using a cell phone when residents are not at home. The user can also download music from the home stereo system to the car stereo, or turn up the heating while driving home. The intelligent car recognizes “its” driver through wireless communication even before he or she has opened the door, and automatically sets the driving seat and mirror to the chosen position.

Serious attention has been paid to the risks posed by hackers who might reprogram the garage door or switch on the coffee machine in the middle of the night. “As well as testing new security systems for protection against burglaries, fire and water damage, we are also

looking into ways in which the private environment can be protected against incursions by ‘net pirates’ ”, reassures Dr Viktor Grinewitschus, inHaus project manager for technology and innovation, and co-initiator of the inHaus project. In addition, the inHaus participants also intend to develop special applications for the elderly, the handicapped and the sick, and conduct trials of new lifestyle practices such as home-working, home-shopping, home-eating, home-learning. Over the next five years, they hope to systematically evaluate what is useful, desirable, manageable and ultimately also affordable. “In ten years or so,” predicts Klaus Scherer, “the intelligent house will have become a normal part of everybody’s life.” Already today, it is possible to catch a glimpse of the way of life and working to come.

3.4 The INTEGER Hong Kong Pavilion

The INTEGER Hong Kong Pavilion, situated on the Tamar site in the heart of Hong Kong Island, is an exhibition demonstrating how intelligent and green technologies can deliver better value and performance in housing. Its main themes are innovation in construction, technology and environmental performance.

A range of intelligent technology features has been used throughout the INTEGER Hong Kong Pavilion. The aim is to create a realistic and flexible network of intelligent technologies which could be integrated into new residential developments today to improve building and energy efficiency.

Figure 3.12: The INTEGER Hong Kong Pavilion

Smart features showcased in the INTEGER Hong Kong Pavilion include:

Intelligent Central Services

The entire pavilion will be networked with an intelligent central system. The system will demonstrate how temperature and air quality can be monitored and controlled in a residential development to provide a more pleasant living space while generating substantial energy savings.

- Technology used to regulate air conditioning according to the number of people in a given area
- Central dehumidifying, which improves air quality by minimizing the growth of fungus in the ducting
- An energy efficient and silent cooled air displacement system

- A building management system, accessible from anywhere in the world, which notifies building operators and maintenance professionals should a problem arise
- The utilization of a standard open protocol for building control meaning the building operator is not restricted to using one supplier for the lifetime of their equipment

Home Automation System

A home automation system allows the home user to monitor and operate the apartment from any location which has an internet connection.

- A network connecting domestic appliances, utility meters, lighting and temperature, computer products and entertainment systems
- A standardized home gateway bringing together all of the features above into one data stream over the internet
- A home interface - or visual representation of all the networked features in the apartment - which allows the user to monitor or change apartment systems from within the apartment or externally via the Internet

Biometric System

Biometrics covers any personal unique distinguishing feature. The most common example is the fingerprint, but more recent technologies have looked at the advantages of face and

iris recognition. The biometric system demonstrated in the pavilion shows the technology can be used to allow “key-free” secure access to the apartment. Simply look into the special camera and the biometric system will recognize the unique features of the face, even if hairstyle or make-up is changed.

Environmental features showcased in the INTEGER Hong Kong Pavilion include:

- Computer-controlled energy efficient central air conditioning
- Use of photovoltaic and solar panels providing renewable electricity and hot water
- Natural ventilation
- Infra red filtering glass and special sun shading louvers to reduce the need for air conditioning and improve air quality
- Targeting a 40% water saving per year through the use of pre-set temperature taps, gray water recycling, dual flush toilets and a waterless urinal system
- Use of natural light and low-energy light fittings reducing over dependence on artificial lighting
- Use of green household appliances such as condensing clothes dryers, energy efficient fridges and washing machines help reduce environmental impact
- Sky garden timber decking is from sustainable, managed forests
- Internal and external tiling from recycled materials
- Waste separation systems allow for hygienic disposal and easy recycling

3.5 The Warden Home, Newbury, Berkshire, UK

The Warden Home, a four-bedroom house, was completed in Spring 2001 and is being rented out to a family at market rates for two years after which it will be offered commercially for sale. The family is monitoring energy consumption and “live-ability” in the house in order to get real-time data on the performance of INTEGER homes.

Figure 3.13: The Warden Home

Environmental Technologies

- The highly insulated building loses less than half of the amount of heat than the maximum acceptable in the Building Regulations
- Passive stack ventilation maintains excellent air circulation through a combination

of trickle vents, humidity sensitive extractors and a low-energy fan

- Solar water heating provides free hot water for domestic consumption, meeting 60% of the total annual demand
- A grey water recycling system cleans water which has been used for washing and bathing and then re-uses it for toilet flushing, providing annual savings on water consumption of up to 40%
- Energy-efficient white goods have been provided to the home to reduce energy and water consumption, while increasing convenience
- Lighting uses low-energy light fittings resulting in low carbon dioxide emission

Intelligent Technologies

- The house is pre-wired with high-quality cabling for data and voice and with satellite specification CT100 cabling for television. Pre-wiring provides the performance and is future-proof for residents' future requires in the most cost-effective way
- The cabling is an integrated structure originating from a single main connection centre on the ground floor, giving connectivity, communication and control wherever it is required
- The data network enables computers in every room to be connected to each other and to the internet. Capacity exists for the provision of extra ISDN or telephone

services

- Entertainment within the home is comprehensive. Both analog and digital satellite TV can be provided in every room in the house

3.6 Alpine Close, Greenfields, Maidenhead, UK

This project was built in Maidenhead UK. The site was a car park for 166 cars including 131 within pre-cast concrete garages and was bounded by a mixture of four-story maisonettes and two-story terraced houses of mixed tenure, a grove of mature poplar trees, and a large open recreation ground and children's play area. The client's request was that the development should incorporate all of the "Intelligent and Green" elements best suited to give maximum benefit to the future occupants of the scheme.

Figure 3.14: Alpine Close Home

Environmental Technologies

- Water from baths and hand basins is treated and recycled through a grey water recycling system to be used for flushing toilets
- Surface water from the roofs is collected, treated with UV light to kill bacteria and is then stored for plant irrigation
- Low-flush toilets and water efficient taps are installed to minimise water usage
- Use of efficient recycled cellulose insulation means that the energy loss from these buildings is less than half of the maximum permitted in the Building Regulations
- Solar water heating is provided to augment the domestic hot water production which is otherwise from conventional gas boilers
- Photovoltaic panels are used to generate electricity which is used to supplement the supply from the Grid. The system is remotely monitored by the manufacturer for performance

Intelligent Technologies

- Pre-wired structured cabling system for voice, data, and entertainment services, allowing easy upgrade and modification
- Communal receivers for conventional analogue, digital terrestrial and digital satellite television reception and Digital Audio Broadcasting (DAB) provide tenants with maximum choice for the reception of entertainment services

- Door entry is integrated with existing telephone and television systems providing functionality and security without the need for expensive stand-alone systems
- Heat from a centralised boiler system is distributed to each unit where intelligent controls manage the heating load in relation to room temperature, meaning that if the room is already warm enough the heating will not come on even though it may be timed to do so
- Heat metering and a Building Management System allow professionals in authorized organizations such as MDHA (Maidenhead & District Housing Association) to diagnose and manage the systems in the buildings from their own offices
- Surplus electricity from the photovoltaic panels is sold back to the electricity supplier and monitoring of incoming and outgoing flows means that tenants gain credit on their bill for any electricity which has been fed back
- Remote utility metering has been installed where possible allowing greater control and transparency of costing to both supplier and tenant

3.7 Westlea's INTEGER Home, Cherhill, UK

This project started in December, 1998, and was completed in early August 1999 in Wiltshire. The three/four bedroom semi-detached homes are designed to have very low running costs for heating, lighting, water and general maintenance.

Figure 3.15: Westlea's INTEGER Home

These homes are real homes for real people, relatively traditional in appearance but with innovative award-winning features. The design aims to integrate elements to accommodate not only “Lifetime Homes” features (in-built flexibility so that the home can easily be adapted to cater for the elderly or the disabled, such as wider doorways, reinforced walls for fixing grab rails, power and switches at a height accessible from a wheelchair, etc) but changes in the tenant's lifestyle as well, such as the need for an extra bedroom (via a removable wall) or working from home. This adaptability leads to increased space standards, partly achieved through the use of attic as living area.

INTEGER is promoting intelligent technology for managing the systems within the home

and for communications to and from the home. Benefits are better control, comfort, safety and security for the occupants. “Intelligent” aspects will include accessible cabling for telephones, computers, CCTV security and energy management. This will facilitate future modifications and updating, and include features such as lighting control for all rooms from one point (e.g. the bedside at night) and simple, precise heating controls, reducing energy used. In INTEGER homes a number of systems function automatically with varying degrees of intervention from the occupants. Space and water heating, security, ventilation and, to some degree, lighting are all operated automatically.

The lighting system includes low level lighting to stairs and landings operated by movement detectors so that at night residents can either find their way to the bathroom, or to the front door in the event of a fire, for example. Emergency lights at the top of each flight of stairs and in the dining area automatically operate in the event of a power failure (apparently fairly common in Cherhill according to the tenants) and the lights can be removed to light your way to the fuse box in case of a blown fuse. The ceiling lights at the top of the stairs are turned on and off in response to temperature sensors to maintain comfort conditions, but also in response to rain sensors. Manual over-rides are also provided if these are required. The lighting system includes an 'all off' feature so that it is no longer necessary to switch off each light before going to bed - one switch does it all (apart from the stair lights).

The INTEGER homes are “future-proofed”. Removable timber skirtings and panels at ceiling level allow for access to the main cable routes in the house should these need to be upgraded in the future. A service void behind the plasterboard internal wall surfaces allows for additional switches and sockets to be added in the future without damage to the building fabric. The heating system comprises off-peak electric storage heaters linked to movement sensors that operate the heaters when rooms are occupied, with electric panel heaters and movement sensors to the bedrooms, and heated wall mirrors to the ground floor shower/WC and upstairs bathroom.

The ConnectHome system is a communications network to which television, stereo, telephone, fax, ISDN (Integrated Services Digital Network), baby monitor, CCTV and computers can all be connected. ConnectHome comprises computer-type cabling, sockets dispersed around the home and a control cabinet. This allows the various modules described to be connected to the system. Thus any socket can be used as a telephone point, or connected to a stereo system and speakers plugged into any socket in any room. Control and monitoring facilities are also available for elderly care, as well as internal CCTV to allow users to monitor the baby up in bed while they watch TV downstairs. The homes have CCTV on the front and rear doors to monitor visitors, with pictures available via the TV and movement detector operated lights that switch on automatically.

3.8 CMHC's Healthy House in Toronto

In June 1991, Canada Mortgage and Housing Corporation (CMHC) announced its Healthy Housing Design Competition. The objective was to demonstrate to the public and the housing industry that it is now possible to design houses for the Canadian climate that are in keeping with the principles of sustainable development and are healthy for the occupants. The competition challenged the industry to develop innovative ways to design homes with the right balance of occupant health, energy efficiency, resource efficiency, environmental responsibility and affordability.

Figure 3.16: CMHC's Healthy House in Toronto

In February 1992, an independent jury selected two winners. One was in Vancouver. The Toronto winning entry is a 1,700 square foot semi-detached house on a vacant (infill) lot in Riverdale. The design clearly meets all the criteria of the competition. This house is healthy for the people who live in it and the community. It incorporates ingeniously efficient systems in a comfortable and attractive environment.

What is truly amazing is that CMHC's Healthy House in Toronto provides all the comforts of home without using municipal services. It has been designed to rely on the sun and precipitation as the basis of its heating, electrical, water and waste water management systems. And it is affordable, with total annual operating costs expected to be under \$300. Right from the start, the way it is built and the materials used in construction mean more comfort, less maintenance and lower operating costs. That goes for the landscaping, too.

CMHC's Healthy House in Toronto is located near public transportation, and is designed to provide maximum usable space on a minimum amount of land, to limit air and water pollution, and to use locally available materials and durable renewable resources wherever possible. It is an affordable solution to housing now that will keep on working for many years to come.

Features:

- Solar panels generate electric energy which can be stored for later use. A co-generator provides back-up power and heat.

- Energy efficiency is achieved through airtight wall and roof construction, thermally efficient windows and doors and high levels of insulation and weather resistance in the building envelope.
- The house depends on rainfall for its water supply and recycles much of the water used.
- Its water purification system mimics the natural path that rain follows when it passes through the ground to a spring.
- In addition to recycling much of the water used, the house uses low-volume toilets, low-flow shower heads and aerator faucets to conserve water.
- Materials used to furnish and decorate the house emit few chemicals and vapors, improving indoor air quality.

Heating, cooling, ventilation and electrical systems:

CMHC's Healthy House in Toronto takes advantage of outside conditions to provide comfortable interior temperatures year round; ensures users to breathe clean, fresh air in an energy-efficient environment.. Conventional energy use is considered a last resort. House design, landscaping and technology are all used to help heat and cool the house and reduce dependence on the earth's resources. Large energy-efficient south-facing windows and solar panels capture sunlight, while the thermal mass of the house - concrete floors and walls - make efficient use of solar energy. The house uses about one-tenth of the amount of energy needed to heat a conventional house. This means that sunlight can

provide most of the energy for space heating needs. Trees and ivy trellises provide shade in summer, and do not block sunlight during winter.

Energy storage and conversion technology ensures that the solar energy is available in whatever form is needed year-round. When additional energy is needed, a co-generation unit supplies additional electricity and heat. The ventilation system is designed to ensure that the air entering the house is as clean as possible and is evenly distributed.

Figure 3.17: Heating, cooling, ventilation and electrical systems

In winter:

- Triple-glazed, thermally efficient windows are strategically located to make maximum use of solar gain and minimize heat loss in winter.
- Solar radiant floors have been specifically designed to retain solar heat during the day and radiate it to the interior at night.
- Heat radiates not only from floors, but also from ceilings.
- Sunlight is collected through solar panels and heat is retained.
- If required, warm water is circulated through pipes in the floors to supplement solar heat.
- The heating bill is estimated at \$80 per year.

In summer:

- Heat gain is controlled by window shading and moderated air flow.
- Efficient electrical appliances and grey water heat exchangers provide less internal heat gain and less need for air conditioning.
- Excess heat is radiated to the ground surrounding the house.
- Waste water system provides evaporative cooling through a heat exchanger.

Water and waste water management

CMHC's Healthy House in Toronto provides clean water for all household and

landscaping needs - without using municipal services. Rain and snow collected from the roof provides all of the water supply. The water is filtered, purified and stored for drinking and washing. It is then recycled for use in the showers, washing machine or toilets. Water, stored in an underground cistern, is purified without the use of chemicals.

All waste water, which would ordinarily drain into the municipal sewage system, is treated in the home in a system that duplicates the soil's natural filtration process. It is then recycled for use in toilets, showers, and the washing machine. Water is typically recycled up to five times, with a small amount being safely released into the soil each day. Microorganisms, oxygen, ultraviolet light and charcoal are used to treat waste water flowing into the soil so that it is not harmful to the environment.

In addition, the house features appliances, fixtures and devices that use less water. Water consumption will be approximately 120 liters per day for a family of three. Normal consumption for a family of three is 1,050 liters, or 350 liters per person per day.

Drinking water:

- Rainwater is collected and stored in a cistern, which contains limestone. The limestone gives the water a fresh taste and lowers acidity.
- Water then passes through a "slow sand" filter, just as rain water passes through the soil along to a river or stream.
- It then contacts activated charcoal to absorb any inorganic compounds.

- As a final precaution, ultraviolet light shines through the pure water to disinfect it without chemicals.
- No chlorine, aluminum or other additives are used in order to make the water safe to drink.

Figure 3.18: Water and waste water management.

Waste Water regeneration:

- All of the waste water in the house is treated and purified. There are several steps in the treatment process:
 - First, anaerobic organisms break down complex molecules into simpler compounds.
 - A biofilter, using aerobic organisms, then devours and digests the waste, leaving nearly pure water.
 - Following digestion, water passes through a slow sand filter and a carbon filter. Ultraviolet light shines through it for safety precautions.
- The result is clean, pure water suitable for uses in the house, such as flushing toilets and washing clothes.
- Surplus clean water that is generated filters into the ground under the front lawn, where it waters fruit trees and flowers.

3.9 Ecology House, San Rafael, California

The Ecology House is a low-income apartment building designed, constructed and maintained for people with extreme environmental hypersensitivities. A groundbreaking project, Ecology House has attracted a great deal of controversy since opening, but is proving to be a successful step toward healthy, low-income housing. The 11 apartment units are occupied, and although three of the original tenants found the air quality

unacceptable and moved out, other tenants report that their health has substantially improved since moving in.

Figure 3.19: Ecology House

The board and the architects searched for two years before settling on the location for the Ecology House. They wanted a rural site away from potential sources of air pollution. This was difficult to find given local zoning laws and economic constraints. The final site represents a compromise. The site is on a parcel of land that had been set aside for low-income housing within a larger residential development. The entire development is built on reclaimed marshland adjacent to San Francisco Bay, which provides the cleanest possible air within an otherwise urban area.

The Ecology House presented a formidable design challenge--creating an acceptable environment for future clients, each with unknown specific health requirements. To meet

this challenge, the board of Ecology House Inc. assembled a group of chemically sensitive advisors who volunteered to provide input on design and to screen potential construction materials. The architects were selected based on their long and successful track record of designing nonprofit and special needs housing in the San Francisco area. The general contractors were brought on board early in the process and selected without a bidding process in order to have them participate in the development of the design. Their early involvement was crucial to the success of the project which depended on the general contractors working with the architect to solve the project's unique problems, and educating the subcontractors about the special health-related requirements of the job.

The Ecology House is a two-story building housing 11 apartments grouped around a central courtyard and connected by exterior walks. The courtyard scheme was chosen to facilitate passive ventilation, and each unit has operable windows on two sides as well as in each kitchen and bath. An alternative approach would have been to seal the building to allow filtering of the supply air. But the site has a steady breeze, and there was concern over the maintenance of filters in a closed system so an open building was chosen. The open plan was ultimately less expensive.

The project is integrated into the neighborhood yet maintains the separation necessary for the environmentally sensitive to control their surroundings. The courtyard provides individual outside entrances for each unit and a sheltered and semipublic space. An

elevator makes each unit accessible to the disabled. The elevator, and the building's trash and recycling room are housed in a building separate from the apartments, guaranteeing isolation of equipment odors and noise. The separate structure also houses an open-air community storage room which allows residents to air out personal belongings before bringing them into their units.

The units are designed for accessibility and have generous passage dimensions. At the same time, they make the most of their limited size. For example, the coat closets at each front door are metal units which can be moved to make room for a wheelchair-bound occupant. A great deal of attention was devoted to minimizing the electromagnetic fields. In the kitchen the refrigerators and electric stoves are set against the outside wall rather than the wall between units to ensure that their fields aren't directed toward habitable space.

Design Criteria

- Use wiring techniques which minimize electromagnetic fields. Locate refrigerators, stoves, electric panels and electric motors to minimize the impact of electromagnetic fields and noise.
- Install mechanical ventilation through the roof, with fans at roof level, not in the apartments.
- Mechanically vent the attic with fans vented up through the roof and not at eaves or rakes.

- Design for cross-ventilation in all occupied spaces, rather than air conditioning.
- Beware of remanufactured materials. Most are less tolerable for persons with Multiple Chemical Sensitivity (MCS) because of added chemicals.
- Use design features to discourage termites and other pests, since pesticides cannot be used.
- Select landscape plantings which need no mowing, and never require fertilizers, herbicides, or pesticides.

Materials Selection

The choice of materials for the Ecology House sets it apart from a conventional project. Like many healthy housing projects, it avoids asphalt, formaldehyde-emitting materials, pressure-treated wood, finishes that require on-site painting or gluing, carpeting and finishes which could trap odours and dust. Long-term durability was another important issue, because even routine maintenance was likely to expose the residents to unacceptable irritants. The desire for both irritant--and maintenance--free materials conflicted with the financial constraints of the project, and the need for manufacturer's warranties. These often disallow substitute materials that would eliminate offensive components, and warranties may require specific materials such as sealers which may not be acceptable to the sensitive.

The following design criteria were developed by the Ecology House Design Committee. The criteria consist mostly of a list of materials, commonly used in California affordable housing construction, which should be avoided:

- Onsite application of paint or sealers. Avoid materials which will need to be maintained by painting.
- Particle board and formaldehyde-bearing materials.
- Pressure-treated wood
- Glues and laminates
- Asphalt.
- Carpeting.
- Natural gas in living spaces.
- Fluorescent lighting.
- Exposed wood -- minimize use of exterior plywood or use alternate method to establish lateral/seismic shear strength.

Mechanical Systems

Although individual gas-fired forced air furnaces are typical for low-cost housing in California, the Ecology House uses a central gas-fired boiler to supply hot water to baseboard convectors. This eliminates natural gas odours and the potential for contaminated ductwork in individual units.

The kitchens and baths are mechanically vented to the roof with the fans mounted far enough away to allow acoustical and electrical field isolation. Fans also vent all attic spaces to cool the building and prevent odours from sun-baked roofing and insulation from entering the units. The project conforms to California energy codes, except for the substitution of incandescent for fluorescent lighting.

Assessment and Critique

While 3 of the original 11 tenants were unable to tolerate the newly completed units and the resulting publicity was extremely negative, the Ecology House is now fully occupied and the board feels increasingly justified in calling it a success. As noted, several current residents report that their health has substantially improved due to the safe haven that the building provides. The Ecology House cost approximately 11% more than conventional housing for this site. Most of this money was for material substitutions.

The natural ventilation has worked well as have most of the material choices, although the use of additive-free concrete has resulted in minor cracking. The use of the veneer plaster system has had mixed results with half of the residents in favor of it and half not tolerating it well. The walls and ceiling of one unit have subsequently been sealed with four coats of nontoxic acrylic sealer on a trial basis. The tile floors are appreciated by all residents but the grout was left unsealed and now tends to rub loose creating a minor annoyance. The baked-enamel kitchen cabinets have proven to be the most contentious item, peeling and

producing complaints about odours. No one is certain about the source of odours or why the cabinets are deteriorating. Ecology House Inc. would now recommend stainless-steel cabinets. The whole house water filtration system is a success though the carbon filter is somewhat expensive to keep charged.

3.10 Research House, Queensland, Australia

The Queensland Department of Housing's Towards Healthy and Sustainable Housing Research Project is an essential part of the Queensland Government's response to encourage greater interest in valuing our environment and promoting development that improves the total quality of life, both now and in the future.

Figure 3.20: The Research House

The project - known as the Research House - involves the design and construction of a family home in Campbell Street Rockhampton, which is developed as a research centre to trial, validate and apply sustainable design, contemporary technologies, and building products and practices. The project brings together new and innovative design, technology,

products and concepts and tests them in a single, living environment. The Research House was completed and officially opened in December 2001. It was then open for public display for a period of three months until the end of April 2002. Tenants moved into the house in May 2002.

Figure 3.21: The Plan of the Research House

This research gives people choices for making their home safe, comfortable and affordable over its lifespan ensuring cost savings and value for their investment over the longer-term. Importantly, the research will demonstrate that this can be achieved while protecting our natural environment.

Changing the way to build and subsequently live in the homes can significantly reduce the detrimental effects that lifestyle has on the environment and residents' health. Many home owners overlook simple design features that could make their homes comfortable and economical to live in during all seasons. Orientating a building to capture prevailing

breezes and insulating walls and ceilings are just two methods of reducing household energy consumption. Insulating the ceiling and walls of a building reduces the heat flow between the outside to the inside and vice-versa. In summer, up to 35% of heat enters a house through an uninsulated ceiling, while approximately 15% to 25% enters through uninsulated walls. (Environmental Protection Agency)

The Research House takes a holistic approach to housing design and construction that recognises and embraces the concepts of sustainability, affordability and climatic appropriateness in a responsible and responsive manner. This is based on the Department of Housing's concept of Smart Housing, which encourages the design and construction of affordable, energy efficient, universally designed, safe and secure homes in Queensland. "Energy efficient home design" is the design of homes that generally maintain an internal living environment for human comfort throughout the year, using very little or no energy for cooling or heating. Similarly, there is only a need for minimum energy for lighting, water heating and other services necessary for comfort and amenity.

Table 3.1 Design Features of the Research House

Item	Advantage
Four good-sized bedrooms with built-in wardrobes	All rooms designed for home office use
Two bathrooms	En-suite is wheelchair accessible
Bedrooms pre-wired for the Internet	More flexible use of space
High impact plasterboard in high traffic areas	Reduces wear and noise
Doorways with sliding doors are 1020 mm wide	Access for wheelchairs and for other mobility issues

Doorways with swing doors are 920 mm wide	Access for wheelchairs and for other mobility issues
Sliding doors fitted inside walls	More flexible living space
Security screens/doors	Well-ventilated, safe, secure home
Insulation to roof/ceiling and wall spaces	Maximizes thermal comfort
High-level space ventilation to walls/ceiling	Maximizes thermal comfort
Cross flow ventilation to living/bedrooms	Maximizes ventilation/thermal comfort
Wide eaves to 900 mm	Shading/weather protection/thermal comfort
Energy smart glazing	Reduces solar heat gain/glare
Effective day-lighting technology	Minimizes need for artificial lights
Smart lighting technology	Minimizes energy consumption
Low-energy electric fans throughout	Maximizes ventilation and thermal comfort
Ceramic tiles in wet and high traffic areas	Low maintenance to enhance indoor air quality
Low allergy carpets in bedrooms	Minimizes sensitivity potentials
Low allergy jute carpet in living area	Renewable, recyclable product
Water saving devices/measures throughout	Enhances water conservation
Appropriate tropical landscape design	Improved amenity, safety and security
Secured children's play area	Improved safety and security
"Kidsafe" design principles throughout	Improved occupant safety/security
Low emission products throughout	Facilitates improved indoor air quality
Adaptable Kitchen design AS4299-C	Better access for mobility-impaired people
Pantry with pull-out sliding shelves and pocket retractable slide-away doors	Better access for storage
Soffit mounted retractable clothesline	Enhances amenity and flexible use of space
Two rainwater tanks	Water catchment /conservation for irrigation
Energy-efficient hot water heaters (Monitoring: heat pump, solar/gas, continuous flow, high efficient gas units)	Minimize energy consumption
Double car garage with automatic door	Ease of safe secure access and unloading
Affordable and energy-efficient appliances	Minimize energy consumption

3.11 Brisbane Smart House, Queensland, Australia

Figure 3.22: Brisbane Smart House

The home was developed from the winning design by Fred Iezzi of Iezzi Design Enterprises & Architects in the 1999 Smart Housing Design Awards. It incorporates features that make it affordable, safe and secure, energy efficient and universally designed - the elements of Smart Housing.

General Features:

- 4 bedrooms with built-in wardrobes
- 2 bathrooms
- low maintenance brick construction
- open plan living areas with patio off living area
- secure carport
- insulation
- louvre ventilation
- security screens

- breezeways
- lockage storage areas
- solar pergolas

Affordable and cost-efficient over time: extra initial costs can be quite minor compared to the savings that will be generated over time.

- Durable, low maintenance materials have been used throughout the home.
- It is easy and cost effective to modify the home as needs change.
- Insulation and ventilation reduces heating and cooling costs.
- A termite management system is in place.
- Garden beds are kept away from the house.

Energy efficient: reducing energy costs and improving living comfort.

- The house is orientated to protect the main living areas from the western sun.
- Roof and wall insulation keeps the interior cool.
- Light colour roof tiling deflects heat in the summer.
- Opportunities for ventilation have been maximised.
- Eaves protect the house from direct sunlight.
- Solar hot water and rainwater tanks reduce water and energy use.

Universally designed: which makes the home comfortable for people through different

stages in their lives.

- All doorways are at least 850 mm wide and have low thresholds.
- Space around furniture and wide hallways (1200 mm) allows for easy manoeuvrability.
- Bathroom has a hobless shower and reinforced walls.
- Lever door handles and large rocker switches are easily for everyone to use.

Safe and secure: incorporating features to improve security against crime and reduce the occurrence of common household accidents.

- Childproof locks are installed on the pantry and low storage doors.
- Hot and cold water taps are clearly marked.
- The floors have reduced-slip tiles.
- Children's play areas can be supervised from the kitchen and main living areas.

Front Yard and Entrance

- A well-placed, easily read house number assists visitors and emergency services to locate the home.
- People of all abilities can use on the gently-sloped footpaths and driveways.
- The car parking area is level and the distance from the home has been kept to a minimum.

- The front entrance is clearly visible from the driveway and footpath, making it easy for visitors to find the entrance.
- The home's covered entrance provides people waiting to enter with protection from the elements.
- A level landing provides easy access to the home for someone pushing a pram or a person in a wheelchair.
- A well-lit entrance welcomes visitors and exposes intruders.
- Walkways and landings lead visitors to entrances and away from private spaces.
- Windows are placed to allow a seated person to see the view of the garden and street outside whilst maintaining privacy.
- Door viewers at child and adult heights allow people of all heights to see who is at the door.

Throughout the House

- Lever door handles can be easily operated by everyone using one hand or an elbow.
- Reduced-slip floor surfaces can prevent accidents in high traffic and wet areas.
- Wide doorways (850 mm) allow people with strollers or in wheelchairs to access the home easily. Large objects can be more easily carried through the

door without causing damage to doorjambs.

- Contrasting colors assist people with a vision impairment to identify the room boundaries, doorways and switches.
- The use of durable and low maintenance building materials will reduce ongoing costs over the long term.
- A hard-wired smoke alarm will provide constant detection and batteries are only necessary as a backup.
- The raked ceiling in the central living area allows the hot air to rise above the living space.
- Electronic ceiling ventilation can be opened during warmer months to create a breeze through the home and closed during colder months to help to heat the home.

Windows and Doors

- Windows allow for maximum exposure to summer breezes that cool the home.
- Eaves over doors and windows provide sun protection to furnishings.
Windows can be opened when it is raining without water getting in.
- Interior doors that connect a garage to the home have a security lock. This makes it difficult for intruders that manage to access the garage to then enter the home.

- A security door allows breeze into the home while keeping the doorway secure.
- Security locks help to deter thieves by making it difficult to gain entry to the home.
- Exterior doors are hinged securely from the inside.
- All doorways that open to the outside are well lit so occupants do not have to walk into darkness outside.
- Wide hallways (1200 mm) allow occupants to easily move furniture and provide easy access.
- Entrances without steps provide easy access in and around the home for people in a wheelchair or with a stroller and for a person with a mobility or vision impairment.
- Glass doors are clearly marked so that people can see if they are open or closed.
- The strategic location of windows and doors provides good cross-ventilation throughout the house that helps to catch the breezes and cool the home.
- Heat absorbing tinted glass is used to all windows and glass doors.
- Catches on doors will hold them open during a breeze, helping ventilation and making it less likely that they will slam shut.

- Louvers on interior walls help cross-ventilation, keeping the house cooler.
- Insect and security screens allow open windows to catch prevailing breezes while keeping the home secure and free of insects.

Kitchen

- A clear, uncluttered floor space reduces the likelihood of trips or falls in the kitchen.
- Windows and fittings are positioned so that parents can easily supervise inside and outside play areas while working in the kitchen.
- Drawers are located away from the stove, making it less likely for children to climb the drawers and burn themselves.
- A childproof cupboard allows secure storage of household cleaning agents and poisons.
- The side-opening wall over is easy to access, especially for a person in a wheelchair.
- A kitchen door stops children from entering the kitchen unsupervised.
- The kitchen does not double as a passageway to other parts of the home, reducing the likelihood of accidents involving people carrying hot food or boiling water.
- Non-combustible, round-edged kitchen bench tops reduces the both the chance of fire and injury.

Bathrooms and Laundry

- The bathroom is designed to provide occupants with adequate space to maneuver.
- People of all abilities can easily use hobless showers.
- Powerpoints are positioned so that appliance cords do not extend across basins or vanity units. This reduces the likelihood of electrocution.
- Low water-volume toilets and taps are installed to reduce the amount of water used.
- Taps are located away from the shower rose to reduce the chance of scalding.
- Laminated safety glass to the shower screen will reduce the chance of it breaking.
- Toilet cistern supplied by water collected in the roof water tanks.

Bedrooms

- Bedrooms are located close to a bathroom for convenience.
- A telephone cable jack is installed in the main bedroom in case a phone is required in the future.
- A light switch is within easy reach of the bed, reducing the need for a person to walk through the room in the dark at night.

Garden and Outdoor Living Areas

- Appropriate outdoor lights deter intruders and allow people in the home to see outside clearly.
- The driveway is separated from the play areas in the yard to reduce the chance of accidents involving children and cars on the driveway.
- Reduced-slip surfaces are designed to allow surface water to drain away easily, helping paving to dry quickly.
- Water tanks allow for water run off from the roof to be captured and used to flush the toilets.
- Carefully selected plants that are not toxic or poisonous will not harm children.
- Raised garden beds mean that everyone can reach the garden without having to bend down. These gardens are accessible to older people and people in wheelchairs.
- Keeping garden beds away from the house makes it harder for termites to hide and less likely that continual watering will affect the foundations of the home.
- The solar pergola provides shade to block out the harsh summer sun while allowing the winter sun through.
- Secure shaded play areas allow children to play out of the direct sunlight.

- A lockable storage area in the yard can be used to store tools, equipment and poisons that children will not be able to access.
- Effective drainage reduces the likelihood on slipping on wet grass and the impact of water on the home's foundations.

Powerpoints and Switches

- Easily-accessible powerpoints, switches and controls can be reached from sitting and standing positions.
- At least three separate circuits, each with 'safety switches', are fitted in the home so that some power remains when a fault occurs.
- Large rocker-type light switches are easy to operate for people of varying abilities.
- Having sufficient powerpoints located throughout the home avoids occupants using trailing flexes and double adaptors for their appliances. This reduces likelihood of accidents involving electricity.

General Considerations

- The light-coloured external walls reflect sunlight off the home, helping to cool the home.
- Light-coloured roof sheeting helps to reflect the heat of the sun, helping to keep the home cooler.

- Ventilated eaves allow cooler air to displace hot air in the roof-space.
- Insulation keeps the home cool in summer, reducing the need for expensive cooling appliances such as air-conditioning. It also helps to trap heat in winter reducing heating costs.
- Physical barriers and concrete paths make it easier to monitor termite activity.
- Wide overhangs provide shade to external walls helping to keep the home cool and protecting it from the elements.
- The home's simple, logical layout has no obstructions or hazards so that evacuation is easy in the event of an emergency.
- The orientation of the home considers the climate and weather conditions. Living areas have been located for optimum exposure to cooling breezes and the main living areas are protected from the hot western sun.
- The home has been designed to provide adequate space to accommodate normal furnishings while still allowing allow easy circulation.
- Solar hot water helps to reduce energy costs.
- Building materials, such as external brick, have been selected that are relatively inexpensive to maintain over the long-term.

Chapter 4. Analysis and Discussion

on the “Smart House”

4.1 “Smart House” and Aging Population

As society becomes increasingly reliant on computer-based systems, and as assistive technology (AT) in housing market becomes increasingly hi-tech (Dewsbury 2001), the systems themselves have become more complex and the need for dependable systems correspondingly important. Achieving sufficient dependability in these systems and demonstrating this achievement in a rigorous and convincing manner appear crucial in moving towards an inclusive information society.

“Dwelling with computers, they become part of the informing environment, like weather, like street sounds...computers will help turn our houses into homes” (Weiser 1996). The notable rise in the usage and general acceptance of domestic technology in the last four decades has had considerable implications for the home occupant. There has been also been a blurring of the boundaries of technology within recent years, such that devices that were previously only seen in cars, offices, or hospitals are now finding their way into the average home. The home itself has undergone considerable alteration, not necessarily in

outward appearance or architectural detail but in the way it is used by its occupants (Crabtree et al, 2001). The original design and layout of rooms for specific and static purposes has been modified such that there has been a blurring between designated spaces while activities are no longer confined to pre-designated spaces (Junestrand & Tollmar, 1998). Similarly, as domestic spaces are created to meet needs of the individual occupiers, these needs are themselves often related to technological developments. The home computer, for example, along with video games machines, televisions, VCRs, etc. now act as a determinant and identifier of these spaces.

Technology has become part of everyone's life. We have clearly become a technologised culture relying and accepting the benefits and disadvantages of technology. Although we may embrace it, technology can and often does work against us. Cars tend not to start in cold or wet weather when they are needed most. Computer users will all recognize the blue screen as the computer has crashed. Technology systems are excellent when they work properly but can cause severe misery when they fail to respond in the appropriate or expected manner.

As computer-based systems penetrate more and more into people's everyday lives and homes, the "design problem" is not so much concerned with the creation of new technical devices as it is with their effective and dependable configuration and integration. It is evident that satisfactory resolution of such concerns demands major interdisciplinary

breakthroughs in understanding the development of complex socio-technical systems in domestic environments since inadequate understanding of the context of the reality of use and user needs is often a significant cause of lack of dependability.

Older people are a heterogeneous group; their needs are different and dependent on the issues that they face in their everyday life. Traditional designs of AT systems have tended to be undertaken by social care workers who initially define the problem and then pass the needs list to the AT “expert” who is skilled in the design of the AT system. The latter designer tends to understand the hardware and software of systems from an engineering perspective, which is usually a result of their training, but they are not trained to understand the people for whom they are designing. Hence the designs tend to be static, unresponsive and inappropriate to meet the real needs of the client.

There are two forms of requirements that must be considered namely, requirements on the AT to be installed and requirements on the AT to be designed. Evidently, for designs to meet the needs of the user(s), the user(s) must be considered as the essential point from which the design is derived. Social care workers use a range of tools and tests to assist them in their assessments, yet people who actually know and understand the user have undertaken the best designs.

Overall, appropriateness is based on and built around developing interactions between users and the technology. These interactions are subject to various general kinds of

reconfiguration and change such as evolving social demands and uses of domestic space. Changes in technology usage and development as well as specific aspects of appropriateness are related to the particular application or function and issues such as privacy or security.

4.1.1 Home Technology and the Networked Home

Home automation systems for residential housing add some intrinsic value through incorporation of increased security, safety, convenience and comfort within the home. The increase in home networking is having great effects on the lives of older and disabled people. This socio-technical system allows a residence to be connected to the outside world through a residential gateway. Home networking allows the home to become a fully connected entity that can be controlled externally as well as internally. The increase in telemedicine and telecare as initiatives that extend beyond the conceptual into the real world are only possible through the home network. The smart home, in which devices are interconnected (networked) and programmed to act in predetermined patterns, has been extended through the home network to allow external monitoring and control. For a disabled or older person, home networking offers the potential for their home to be programmed to monitor and respond to cues while allowing the occupant the safety and reassurance that should a fault develop or a problem occur within their home then the correct people will be informed by the technology within the home network. The home network has negative as well as positive aspects to it. One difficulty is caused by the

ISDN/DSL connection which remains in the state of “always-on”. This denotes that the permanently connected home could potentially face threats from external hackers. Moreover, this “always-on” connection means that the system is constantly open to potential viruses and other attacks by malevolent programmers. Thus, the home network should have a suitable virus checker and a firewall to deter hackers.

Today the role of technology is integrated into other living spaces, such as the physical and social to make up the whole notion of the home. As the 21st century commences, technology can be used to enable people to derive an improved quality of life through the appropriate use of advanced technology. The home network can allow isolated individuals to retain contact with the world around them as well as allow for external monitoring of people who require this service.

A clear and practical use of technology is the introduction of home networks, involving smart homes, telecare, telehealth and telemedicine, to allow people with possible illnesses or disabilities to retain a quality of life within their own home. Home networks and smart homes can assist in undertaking operational tasks. Telecare enables a person to remotely assessed and monitored by medical staff and telemedicine allows a full virtual medical service to be brought into the home of the person requiring the specialist service. The role of technology within the home is extensive and the application of this technology extends into a number of areas which are enhanced by home networks. The home network appears

to be a manifestation of the 21st century as computer-operated systems are adopting protocols that should easily interface with home networking products, and manufacturers are redesigning their products to allow for greater standardization and interoperability.

4.1.2 Telecare, Telehealth Technology and Residential Gateways

“The current offerings in Home Automation are both exciting and frightening. The means to automatically manage almost anything that uses electricity is available today. Until security is taken seriously in these systems, though, there is great risk in doing so. The favorable trend of making high tech devices easy to use is resulting in a diminished focus on reliability and safety.” (Brodeur, M J. ,2001)

Assistive technology in housing design for an aging population requires the designer to make choices concerning the most appropriate and available technology that is cost effective. Telecare systems are still in their infancy and there are few proprietary systems available on the market at this time. Both telehealth and telecare systems rely on the use of the Internet or telephone lines as a means of transferring information from the source (the house) to the receiver (the doctor/nurse etc). This relies on a Residential Gateway (RG) (also known as routers) and a number of security issues surround the use of this form of data transference. Within the e-service “Monitor and Control” the residential gateway on the home net is accessible by e-service clients via the Internet only after authorization by the system service provider. The RGs are configured to reject all other service traffic than that from the system service provider, yet they allow ftp. (File Transfer Protocol) download and web browsing from the home net without system service provider interference. There is little control over the data that leaves the home; there is little control

over who has access to this data and what is done with the transferred data. The Data Protection Act does not cover this form of data transference as it is still in its infancy.

Davies and Raverdy (2000) contend that future home networks will consist of multiple networking and platform technologies integrated through a series of gateways and shared devices. They go on to suggest that it is for developers to build heterogeneous middleware platforms that are irrespective of the operating system used. Experts suggest that the home networking environment is more heterogeneous and dynamic than traditional network environments as consumer devices are likely to be connected to different networks, running different protocols and madder by different manufacturers. Technology might be based on self-organizing networks in which devices would automatically recognize what they are and what they should do with the information.

4.1.3 Dependability

A system is dependable to the extent at which its operation is free of failures. Dependability issues often include safety, security, reliability and usability. The issue of system dependability is critical to the development of appropriate technology solutions. The design of systems should be dependable and the users' needs are truly reflected in the design.

Figure 4.1 demonstrates the five main attributes of traditional dependability:

Figure 4.1: Five Main Attributes of Traditional Dependability

Baxter et al (2002) observe that dependability can be broken down into other attributes that effect system design, namely:

Safety - What are the key safety issues for households? How can we make safety arguments for ubiquitous computing in the home?

Integrity - Security is a major concern for home owners. What are the threats for the networked home particularly where automatic doors and windows have been fitted ?

Privacy - Privacy is a very different issue at work. In the home there is no central authority and privacy from other family members may be a major issue.

Usability - Work oriented views of usability will have to be widened to accommodate leisure tasks and entertainment.

In order for a home system of networked devices to meet the needs of older or disabled people effectively, system failures need to be minimized and controlled. Hence, the designer is required to consider how the technology is to be used in the home, who is using it, in what ways will it be misused, the cost, the benefits, etc., based on the needs of the occupants. There are 11 main non-linear elements that are required to be considered (Dewsbury G. et al, 2002):

- Affordability
- Configurationality
- Functionality
- Interactivity
- Interoperability
- Repairability
- Personalization
- Reliability and susceptibility to breakdown
- Technological
- Usability
- Utility

The eleven elements are intertwined with one another. This elemental network provides the infrastructure for system failures and system security. Two elements stand out as cross elemental, namely safety and sensitivity. Systems are required to be safe, to provide a safe environment, and devices themselves are sensitive and need to be set to the appropriate levels to avoid unwanted results or system failures.

Overall, from dependence to independence, from institutional care to community care, from control to empowerment, Smart House technologies make residences more dependable for the users.

4.2 “Smart House” and Healthy Home

Our lives today are more complex, stressful and difficult than ever before. Physical and emotional trauma and anxiety are daily conditions for many. Another layer of stress from toxic or allergenic environmental exposures and poor living and working conditions can overload the immune system, leading to environmental sensitivity which can, in the long term, have serious consequences for sufferers and everyone close to them. For example, the air in many homes is filled with things that can affect the occupants. Mould and fungus that thrive on moisture in basements, bathrooms and kitchens. Chemicals given off by synthetic materials. Dust and pollen that seep into the air through cracks and leaks. Odors produced through cooking and other household activities. In most homes, the amount of fresh air the occupants get is largely accidental.

On its website, Canada Mortgage and Housing Corporation (CMHC) lists *The Five Essentials of Healthy Housing*:

- Occupants health
- Energy efficiency
- Resource efficiency
- Environmental responsibility
- Affordability

There are many considerations and solutions for building a healthy home, such as using energy-efficient appliances, selecting non-toxic materials and furnishings. Home automation technologies offer more choices for builders and occupants to make the homes meet “healthy home” criteria.

Since the mid-1980s, several major participants in the housing, large appliance, and electrical control industries have pursued the idea of an integrated home automation system. Ideally, such a system monitors and operates many different functions within the home. Lighting, heating, cooling, ventilation, appliances, entertainment, and security can all be operated automatically. The “Smart House” with advanced home automation technologies helps the occupants to build and run a quality home for healthy, comfortable living.

4.2.1 Energy Savings from Home Automation Systems

Much of home automation system marketing is based upon its “space-age” technology. (Security, fire safety, and home entertainment systems figure prominently in brochures and advertisements in magazines that describe this technology.) Vendors believe that the technology of home automation systems will also save significant amounts of energy. Direct savings come from automatic shut-off features and occupancy sensors. The potential for indirect savings through participation in utility load-shifting programs or time-of-use rates is even greater.

4.2.2 Photo Sensors, Occupancy, and Remote Control of Lighting and Appliances

When used as individual device controllers, these technologies have a proven track record of energy savings. They are also the first energy-saving applications in home automation systems. Occupancy sensor technologies save the automated house owner energy and money by limiting lighting, appliance, and space conditioning use when rooms or zones are unoccupied for a certain length of time. Photosensors adjust the lighting in a room to take advantage of daylight. When tied to a home automation system, heating, cooling, and ventilation systems (HVAC) can be adjusted to account for passive solar heat gains. Systems connected to a home automation system can also be turned on by telephone, so the home is comfortable when the owner arrives.

4.2.3 Load Shifting and Load Management

One energy-saving option is peak-load shifting. Many “smart” appliances are programmable, so that homeowners can take advantage of lower utility rates at times when the demand on the utility is low (some utilities already offer off-peak rates to certain customers). Further developments are expected. In the future, houses with home automation will “communicate” with utilities so that certain appliances (washers, water heaters, HVAC) are automatically deactivated during the peak demand periods. Many utilities are experimenting with real-time pricing methods. This concept involves directly tying the marginal price of electricity to the marginal cost of producing it. The home automation computer would receive the real time price of electricity (or gas) from the utility. It would then operate the house in the most cost-effective way (according to pre-programmed instructions).

4.2.4 Staged Power Return

Another utility interactive feature that home automation supporters expect to be popular with utilities is an option for “staged power return” after blackouts. It requires a great deal of energy for utilities to restart a power plant after a power failure, particularly in the summer when many air conditioners run continuously. With a staged return of power, utilities can control the rate at which power returns after a blackout, first issuing electricity to essential home appliances, such as heating or refrigeration, then to the remaining appliances.

4.2.5 Thermal Storage

Heat, generated by conventional or renewable means during off-peak hours, can be stored in ceramic bricks, water, or other storage media. Chilled water tanks or ice storage provide a similar function in summer cooling seasons. Optimization of storage and release of thermal energy by computers is a common strategy for large commercial and industrial facilities. Home automation systems would make it more feasible to operate such systems on a residential scale.

4.2.6 Zoned and Programmable HVAC

Home automation systems also control temperature within different zones of a home. They operate as programmable thermostats and regulate household temperatures on a room-by-room basis, instead of the whole house. For example, rooms in which the family spends a great deal of time can be allotted heat on a more regular basis than seldom-used rooms. When hooked up to occupancy sensors, the zones are only activated when occupied. In one high-tech application, people carry sensors that are programmed to their personal preferences. The system reads these when people enter a room and adjust the environment accordingly. The possibilities are limited only by the imagination.

4.2.7 Air Quality

In many tightly constructed, energy-efficient homes, air quality and ventilation are a concern. While heat recovery ventilators recover most of the heat from exhausted air, a

home automation system could control the ventilation system to operate only when the house is occupied. Additional sensors could control the humidity as well.

4.3 Three Perspectives of Smart House

In this information age, the “Smart House” is a term that includes both the automation processes as well as the informational processes. Smart House is an interactive and automatic home. “Interactive” means that the home is communicated both within the house (internal wiring, home bus, etc.) and between the house and the outer world by means not only of radio and TV waves and cables (copper, coaxial, fiber optic), but also through the various channels of energy (gas, electricity), water, heating and disposal sewers. “Automatic” indicates there is or there may be a substantial degree of electronic intelligence in it. This is what is called “cybernetics” in the true sense. Smart House must be approached from three different perspectives simultaneously: *technological*, *architectural*, and *sociological*.

4.3.1 The Technological Side of the Smart House

The technological supply is also varied. First of all, technology is being offered to the residential market in terms of **telecommunication networks**, ranging from the traditional ones up to the coming broad-band ISDN, if this is ever to come to the home. The services include from the plain old telephone service up to the value added services, Internet and the Information Superhighways and mass media (radio and TV). Secondly, the

technological supply reaches the house in terms of **domestic informatics** (PC, work stations and various other gadgets charged of automatic processes). Obviously, the informatics' supply comes both in terms of hardware and software. Finally, the weakest technological supply comes in terms of the **traditional electric** devices such as washing machines, microwave ovens, refrigerators, and so on. This latter supply is the one that still contains the least amount of electronic intelligence.

From the technological point of view, several processes are taking place. First of all, there is the well known process of convergence and integration between microelectronics, informatics, telecommunications, automation and contents. The boundaries among each of these are increasingly blurred. Secondly, there is a growing flexibility. There is an increasing ability to fit the hardware's varied characteristics to the environment. Thirdly, there is an ever-growing interconnectivity among the various devices. The case of the PC is paradigmatic insofar as it will become a unified device including a TV, telephone, answering machine and HiFi equipment. This is just the beginning, and the potential interconnectivity is very great indeed. Interconnectivity means complementarity and alternativity, that is, that the so called "dedicated" devices are being abandoned and those of general purpose are being adopted.

All this can be summarized by saying that the technological possibilities for the home aim at and can be labeled as "synergy," in the sense that the production outcome is becoming

greater than the sum of the isolated technological devices. Yet, technological advances do not flow easily, and there are very strong obstacles to standardization as far as networks, buses and compatibility.

When we discuss the relationship between technologies and our daily lives, the most important consideration may be the speed with which technologies are being introduced in the everyday life, which blocks the possibility to study and analyze, measure and explain their effects upon society. There is a “seduction” for the modernity that is behind the use of technology in the people’s minds. Present-day societal tendencies are caused by structural causes and not so much by technological causes. We can also see a generational gap in the assimilation of technologies. We are seeing a tendency towards individualization and privatization of work, culture, entertainment and leisure. It is necessary to develop a “technological culture” in order to create a greater acceptance and use of technologies.

From some quantitative surveys, we can find, in the households that have PCs, that the devices considered most interesting and useful are the external surveillance cameras, and the fire and burglary alarms. This shows the peculiar values of high society: security and fear of the outside world. The Personal Computers’ usefulness mainly comes from its capacity to store information and its role as a device for communicating with the outside world, for example, when people browse websites. The difficulty in the use of

technologies does not prevent people buying advanced devices. Access to technology comes from the mass media, families, and friends; specialized advertising has very little to do with this. The attitudes towards technologies were dichotomous: comforting, time saving, increasing productivity were among the positive attitudes, whereas isolation and dehumanization were among the negative. Age emerged as the main independent variable best explaining differences of opinions and behaviour patterns (acceptance/rejection, use/non-use, etc.).

There exists a technological supply that amply exceeds the social demand for technology. Furthermore, the social demand lacks the basic knowledge as to what the technologies “are,” but also what they “are for” in the house.

The Smart House is a bordered and dynamic human-physical space (individual and societal) implying a patterned set of “human” and “machine” activities (both inside and outside human space) which can be created, modified and carried out by the joint influence of technology (of information and automation) and of architecture.

Such a concept of the Smart House encompasses the two traditional and classical technological approaches about the house: (a) the “automation” approach, which is about the technical management of the house material environment, domestic tasks and security/surveillance operations, and (b) the “informational” approach, that is, the one derived from the operational activities of Information Technologies (informatics and

telecommunications) which provide the basis for the management of the family and of the professional life (health, food, finances, reservations, shopping and stocking, work, disabilities and elders, leisure and entertainment, and learning).

4.3.2 The Architectural Side of the Smart House

Le Corbusier defined architecture by stipulating that “the house is a living machine.”

Domestic architecture is the art of the space for humankind’s well being (Rafael de la Hoz). It deals with the home as a peculiar man-made “landscape” where the person is and exists, either individually or in a small group. The permanent challenge for domestic architecture is finding a true balance between function and form, between usual practice and new life styles. Two main issues come up around the architectural aspect of the Smart House: space and furniture.

For more than two centuries, ever since the real growth of cities has been a sub product of the industrial revolution, the space structure of the home has varied very little: kitchen, dining room, living room, bathrooms and bedrooms. The kitchen has very often played the role of the dining room. The household could very easily be divided up into public (kitchen, dining room, bath rooms and living room) and private (bedrooms).

Time has passed by, and new functions (including needs) develop whereas the form remains still, thus creating a very remarkable unbalance and real gap between the two. New family structures, new activities, new interpersonal relations, new roles of hierarchy

and new roles of status have emerged.

This unbalance is especially worth noting in the case of the emerging Smart House, especially in the space configuration of two areas of the house: the living room and the bedrooms. The TV has rather smoothly settled down in the living room, besides other places (where there are more than one TV set) like the kitchen and the bedrooms. The PC has found a tougher time to find a decent place in the house, since there is usually one per home and several members of the family may use it. For aesthetic reasons, it seems that the PC is rather incompatible with the living room. But the more difficult situation comes in the case of teleworking and free-lance working, that require not only a place for the PC, but a wider space for the “office” furniture: table, fax, answering machine, photocopier, folder cabinets, book shelves and the like.

The automation area of the household will demand new space requirements. Where should the central working station be placed? Where will the future robots find a place to operate and to rest?

Then there is the second architectural issue, that of the furniture, where the function-form unbalance is also patent. In the case of entertainment and leisure (i.e. TV), several consequences come up for furniture. TV sets will soon be “wall” TV sets, and more than one TV set will be placed not only in the living room but in the bedrooms which will become entertainment and leisure rooms as well. This will force to readapt present-day

furniture (especially sitting furniture) to the coming new developments in this area. Yet, the furniture issue is all the more important when speaking about teleworking and free-lance working activities.

So, there is much at stake around architectural issues to adapt to the new technological realities and to the new family patterns.

4.3.3 The Sociological Side of the Smart House

Architecture and technology are for people, and not vice versa.

Sociology and Social Psychology have studied rather well the new and emerging family realities as well as its future trends, but they have not taken into consideration the architectural requirements and the extremely rapid changes that are taken place in the Information Technologies world. Present-day sociology, as a whole, has a rather weak interest in these issues. One basic proof of this is the amount of publications that can be found in sociological data bases and in technological data bases: articles and books about the intersecting areas of technology-society and of architecture-society are by far most common in technological data bases than in the sociological ones.

The sociology of the family must, in the first place, study the family from a dynamic perspective, that is, from the family life-cycle perspective. The Global House, in order to be viable, must be a renewable house as far as space, furniture and

information/communication/automation activities. According to Salustiano del Campo (Spanish sociologist), the family life-cycle has four stages: creation, expansion, contraction, and extinction. Each one of the four stages has quite different technological and architectural requirements.

New demographics are part of the new family. Sociology has traditionally called it the age variable. There is longer life expectancy due to the fall of the death rates. Nowadays, universal design and service offer customers equal opportunities of access to information technologies at affordable prices, regardless of class and geographical condition.

Another element of the present-day family is its size. Now, many families have no children, and the average family size is 3~4. Also the “one person families” (mono-personal or single-person households) are becoming increasingly prevalent, as well as older couples. All this has very much to do with space and with technological supply for the elderly and handicapped.

Besides the dynamic perspective, the sociology must tackle the family from a cultural point of view. Culture is understood as a rather stable set of patterns laid on three layers: knowledge patterns, thought patterns, and behavior patterns. Patterns are socially created and defined and are passed on from individual to individual thanks to the process of socialization. Present-day families show new patterns on each of the three levels.

As far as knowledge patterns go, new requirements, especially around occupation and work, come up, which make permanent training and education a reality that has reached a universal consensus. Updating knowledge has become a crucial requirement for having a job. Consequently, new information needs are part of modern family life. Knowing, learning and studying are important activities of family members as well as other traditional ones (resting, enjoying, communicating, eating, sleeping, etc.).

Cultural thought patterns are also changing, especially the technology-oriented patterns. Images, attitudes and the acceptance of information technologies have been studied. Modern information technologies mean more comfort, progress, and efficiency, but also fear, de-humanization, unemployment, power, inequality and threat.

The ability to use technologies is playing an important role to keep the balance between technological supply and societal demand. Not only the school, but the home is a necessary socializing agency to create “technological literacy” .

Values form a the key cultural thought pattern. The value of privacy competes with the value of interpersonal communication and with the value of information. Comfort, progress and efficiency are also values very much connected to present-day societies. Consequently, the whole question of space and use of Information Technologies are at stake.

Finally, there are the cultural behaviour patterns. Family life is full of activities like child care, catering, working, cleaning, health care, eating, resting, enjoying, communicating, etc. The house is a place where more and more there is the need for a technical management and family life management. Activities are increasingly supported by technological devices and take place in concrete spaces, so that information technologies and architecture have much to do with the behavior patterns of the family. It has been argued that the activities of entertainment and leisure (TV, video games, etc.) are the most technologically consuming, but if one thinks of the automation needs, new technological developments will be welcome. One of the newest behaviour patterns is the fact that a growing number of people stay at home because of unemployment problems. Consequently, permanent education and training by means of tele-education become of utmost importance.

From a sociological perspective, we can find that the Smart House, as an “automation machine”, is divesting people from routine tasks. This is nothing new since machines were invented to facilitate actions especially the ones most hard and difficult to carry on. As an “informational receiver and creator”, the Smart House is precisely reinventing old family roles which the family was forced to give up recently. With the tele-education, telework, telemedicine, telebanking, and telecommunications technologies, the Smart House makes a home more multifunctional than ever before.

4.3.4 Connecting the Three Corners

The richest insight into the conceptualization of the Smart House comes from connecting the technological, architectural and sociological models. Briefly, these can be summarized as follows:

- The main intersection between the sociological and technological sets have to do with entertainment, leisure, and work of the members of the family, as well as the utmost important activities related to the technical and informational management of the household according to the life cycle, and the adaptation of the various information and entertainment services and applications to the pertinent needs of the people living in the house
- Intersections between sociology and architecture have to do with the home space and furniture in relation to the life cycle of people and the societal construction of space. The question of privacy and community have very much to do with space and furniture, too.
- There is finally the technology and architecture intersection which implies the home bus requirements for installation (wiring conducts) during construction. Ergonomic and aesthetic considerations belong to this connecting issue as well.

4.4 Future Trends in the “Smart House”

To realize how quickly things change, it is important to look at how far we have come in a

short time. Just take a quick look at how things have changed in the past few decades:

- Just 35 years ago, no one owned a personal computer. Today, nearly 60% of homes in the U. S. have a PC.
- Twenty years ago, cell phones had just emerged and were owned only by the wealthy. Today, it seems practically everyone is walking around with one of those things on their hip.
- In the early 1980s, a 1200 baud modem was considered a pretty fast communication tool. Today's DSL lines and cable modem lines communicate at thousands of times this speed.
- In 1990, Internet usage was restricted to mostly educational and research institutions. Today, more than half of U.S. households have Internet access, and usage continues to grow at breathtaking speed.

The advances in the electronic microchips technology that are at the center of all these devices continue to accelerate, and the intelligence that ordinary products in our homes will have in the future is mind-boggling. Things are changing quickly, and in the near future we may see major changes in the following aspects in our domestic lifestyles due to new networking and communications technologies coming into our homes.

4.4.1 Computerized and Integrated Home

All or most devices in a household will be networked. Every major manufacturer of

consumer electronics, appliances, and any other electronic home system, is looking at how to “network-enable” their product. Robert Metcalfe, the inventor of Ethernet and founder of 3Com, once said that the value of a network grows with the square of the number of its users. This means things are much more valuable if they can talk to each other. Home automation improves control over the functions in a home; this increases user effectiveness and extends a user’s capabilities. Home automation also 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.

4.4.2 Environmental Healthy and Self-Sufficient Energy Supply

Environmental concerns drive much of housing change. Smart House technologies will be one of the main solutions to control the quality of air and water, conserve and save energy, manage waste, and so on.

The Smart House can be entirely self-sufficient in its energy requirements by benefiting from solar or geothermal energy. High-efficiency instant hot water heaters are tied into multi-fuel geothermal loops that fit into floors, ceilings, and roofs. These radiant heating/cooling systems eliminate the need for large ducts, ensure good indoor air quality, and can be computer-controlled to keep rooms at a specific temperature and balance the

heat according to energy surplus and shortfall. Materials for building walls and roofs are fireproof and provide thermal and acoustical insulation. Properly manufactured high performance doors and windows are greatly helpful for heating, air conditioning, and fuel costs.

4.4.3 Information Technology and Tele-Communication

Everybody will be, or can be “online”. Communication, such as telecare, tele-education, home office, security, and e-commerce, will be channeled through a high-speed Internet link. Much of the entertainment, such as audio, video, and gaming links will be accessed at any time over the Web, and home network will be the platform for this content to be distributed through the home. With the advances in communications and compression technologies, it is not inconceivable to think that the convergence of different communications technologies will come into and out of future homes. Web connection will be the all-in-one communication and entertainment link.

4.4.4 Space Flexibility and Multi-Functionality

With the rapid development of Internet and other communication technologies, people can complete various activities without going out like before. Therefore, more and more homeowners will spend much more time at home. The tragedy of 9/11 reinforced this trend. The home is not just a “home”, but also can be an office, a classroom, a theater, a gym, a health maintenance center, and so on. This multidimensional role is changing what

a house looks inside. The compartmentalized space with separate rooms for preparing food, eating and entertaining has been giving the way to a large, flexible living area.

Open area not only integrates indoor space, but also links outdoors through large French windows. Using outside scenery as an extension of inside space gives the feeling of living closer to the nature. Now, improvements to glass coatings allow windows to do a better job of protecting furnishings from ultraviolet light, and reducing the conduction of thermal energy. Therefore, shades, blinds and drapes are sometimes not necessary for modern windows. This also gives houses a simple and clean appearance.

Chapter 5. Concluding Remarks

Instead of using separate household appliances, the integration of appliances and systems within the network, combined with new services, will provide the user with an added value. From “Single Function System” to “Data Integrated Buildings” (Delegation for Sustainable Technology, 1999), Smart House technologies have been introduced to consumers for more than twenty years. 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. Home automation market is still in its primary stage. 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. As homeowners become more familiar and comfortable with the concept, many aspects of life around the home would be automated at some degree.

Nevertheless, what are the reasons that prevent the Smart House market being as mature as “experts” predicted years ago? Why are some service providers such as telecom, security, contractors, installation, and real estate companies waiting for the breakthrough on the market?

One of the reasons is that there is a weak link between the technical supply and the demand. Nobody really knows what the customers want. Usually, new solutions focus too much on technology instead of user-friendliness. Another cause is the price levels for the products, services and installations; some of them are expensive. Customers want to see the savings potential before buying anything.

Therefore, to make home automation system more user-friendly and affordable is the right direction to meet customer needs. Implementation may start in new buildings and gradually move on to the existing ones. Different designs and perhaps simpler solutions may have to be used to reduce installation costs. Technology makes us reachable everywhere, and can help plan our lives efficiently. Hence, technology should be for people, not vice versa. Practicing universal design principles can help home automation companies expand their traditional markets from gadgets to improved home functionality. It is not enough to promote convenience functions. Rather, 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.

To sum up, the role of technology is integrated into other living spaces, such as the physical and social to make up the whole notion of the home. The home network can allow isolated individuals to retain contact with the world around them as well as allow for external monitoring of people who require this service. Home automation technologies are offering us great opportunities to fulfill new housing demands. Eventually, Smart House services and functions will gradually and systematically enter into our homes, and residents will enjoy the benefits brought from new technologies. As the 21st century commences, technology can be used to enable people to derive an improved quality of life through the appropriate use of advanced technology.

Postscript

There are clearly many benefits to home automation from comfort, convenience, safety and security to a higher level of control over operating costs. Smart House technologies not only establish efficient connections between the house, the users and the outer world, but also support the operating independence of the house itself and enhance its systems logic and functionality. As homes become more multi-functional, people will be able to carry out many daily life tasks without going out, thanks to the advanced telecommuting technologies. This makes people spend more time at home, therefore increasing the utilization efficiency of the houses, saving time from travel, reducing car pollution and making homeowners feel safer about their properties. The four most desirable functions of a Smart House which integrates automation systems are safety, energy control, tele-commuting and professional networking; they broaden the scope of home buyers to include retirees, professionals and single people.

Research by Parks Associates, a Dallas, Texas, US based market research and consulting firm, on the Smart House market identifies the following key factors leading to the growth of the home automation industry:

- The baby boomer generation

- The growth of the aging population
- 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

Smart House technologies can definitely enhance the quality of life. However, hi-tech alone cannot replace poor architectural design features. From the perspective of universal design, it is clear that home automation will not, in itself, provide usability and accessibility for people with disabilities and the aged, without proper physical access. The architecture of the building should be responsive to human anthropometric and ergonomic needs. Technology could only be a good augmentation for an elegant architectural design if people use it properly.

Hi-tech devices may be useless when power blackouts occur, or the system is crushed, or attacked by hackers, or the users operate inappropriately. When hi-tech products fail, it is particularly critical for people with disabilities or anyone who is vulnerable to safety or security threats. Therefore, it is always a good idea to integrate the electronic smart systems with mechanical devices as much as possible. To have a comprehensive system, there should be a back-up mechanism or a generators set in place, to insure safety and security for the dwellers.

The life cycle of hi-tech products is different from that of traditional products. The research takes longer for the “Cutting Edge” hi-tech innovation and introduction phase which is followed by the “State of the Art” accelerated take-off period as the technology becomes accepted in the market. A shorter plateau “Maturity Phase” of the market follows as technology becomes embedded into working practices and common acceptance. However, the “Maturity Phase” can often be followed by a very abrupt and dramatic “Decline Phase” as the technology is replaced. As the home automation market grows rapidly, an important feature of home automation products will be its upgrade compatibility that allows people to continually expand and improve the effectiveness of the system.

The market for Smart House products is increasing especially with the introduction of broadband and the Internet in homes. All new buildings will soon be equipped with energy metering and climate control systems. Basic infrastructure for smart services and installation costs can be built-in into the new building costs. As for the existing buildings, hi-tech costly augmentations will be required. Elderly and handicapped people can be much helped by “smart” devices. Most older people live in older homes and they have a strong desire to remain where they are. Therefore, 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.

Now technology has the capability to make devices be “smart”. For example, a smart refrigerator can order milk through the Internet when it detects the milk box is empty. However, does any store offer corresponding service to the delivery of milk? Another serious barrier to expand home automation technology is the lack of a single distribution and installation network. Currently the providers of home automation systems are diverse. Hence, consumers do not have a clear image of how their needs can best be served. As the market matures, service providers will play an important role to respond to the consumer demands. The cooperative partnership between manufacturers of different systems and service departments would be the appropriate response to issues pertaining to the Smart House design, maintenance, and functionality.

Glossary

AIA: The American Institute of Architects

AT: Assistive Technology

Bluetooth SIG: The Bluetooth Special Interest Group (SIG), is composed of leaders in the telecommunications, computing, and network industries. Its purpose is to define a specification for a small-form factor, low-cost radio solution providing links between mobile computers, mobile phones and other portable handheld devices, and connectivity to the Internet.

BUS: Primary internal communications channel of a computer. Examples include ISA, PCI, SCSI.

CCTV: Closed-Circuit Television

CMHC: Canada Mortgage and Housing Corporation

CSCW: Computer Supported Cooperative Work

DAB: Digital Audio Broadcasting

DSL: Digital Subscriber Line, a service that offers a faster Internet connection than a standard dial-up connection

DVD: Digital Versatile Disc

FTP: File Transfer Protocol, a commonly used protocol on the Internet that defined how to transfer files between computers

HCI: Human Computer Interaction

HVAC: Heating, Ventilation, and Air Conditioning

ICT: Information and Communication Technologies

IR: Infrared

ISDN: Integrated Services Digital Network

IT: Information Technology

LAN: Local-Area Network, a group of computers and associated devices that share a common communications line and typically share the resources of a single processor or server within a small geographic area.

LED: Light Emitting Diodes

Low-VOC paints: paints with low level of volatile organic compounds (VOC), used for reducing air pollution

MDHA: Maidenhead & District Housing Association, established in 1995 as a registered housing association providing affordable rented housing in east Berkshire, UK

NAHB: National Association of Home Builders, US

OSB: Oriented Strand Board

RF: Radio Frequency

RG: Residential Gateway, also known as routers

Sensor: A device used to measure and/or detect change in a device or system.

Smart House: the term commonly used to define a residence that uses the latest home automation technology in designing home systems to provide the family with home security, energy efficiency, entertainment and communication.

VCR: Video Cassette Recorder

WAN: Wide Area Network: A computer network that spans a relatively large geographical area.

Bibliography

Baggs, Sydney and Baggs, Joan. (1996). *The Healthy House*. Sydney, Australia: HarperCollinsPublishers Pty Ltd.

Baker-Laporte P., Elliott E. and Banta J. (2001). *Prescriptions for a Healthy House : A Practical Guide for Architects, Builders, & Homeowners*. Gabriola Island, BC, Canada: New Society Publishers

Barlow, J. and Gann, D. (1998). *A Changing Sense of Place: Are Integrated IT Systems Reshaping the Home?* Electronic Working Paper Series, Science Policy Research Unit (SPRU): University of Sussex

Berlo Ad van (Ed.) (1999). *Design Guidelines on Smart Homes: A COST 219bis Guidebook*, Inclusion of Disabled and Elderly people in Telematics
<http://www.stakes.fi/cost219/smarthousing.htm#Distributed%20intelligence>

Berman, Allan. (2001). *Your Naturally Healthy Home : Stylish, Safe, Simple*. Rodale

Blake, Jill. (1998). *Healthy Home*. Toronto, ON: Key Porter Books Ltd.

Bower, Lynn Marie. (1995). *The Healthy Household : A Complete Guide for Creating a Healthy Indoor Environment*. Bloomington, IN: The Healthy House Institute

Brayer, Marie-Ange and Simonot, Beatrice (Ed.) (2002). *Archilab's FutureHouse: Radical Experiments in Living Space*. New York, NY: Thames & Hudson Inc.

Briere, Danny and Hurley, Pat. (2003). *Smart Homes for Dummies*. New York, NY: Wiley Publishing, Inc.

Brodeur, M J. (2001) *Security Concerns In Home Automation Technologies*, System Administration, Networking and Security (SANS) Institute.

http://www.giac.org/practical/gsec/Matthew_Brodeur_GSEC.pdf

Browning L., Choudhary P., Davis J., Johnson D, and Miwa L. (2000). *The Future of Home Controls*. IPRO371: Home Controls Interprofessional Project, Illinois Institute of Technology

Canada Mortgage and Housing Corporation. (1999). *Healthy Housing Renovation Planner*. Canada: CMHC

Canada Mortgage and Housing Corporation. (1999). *Meeting Seniors' Housing Needs: A Guide for community Groups*. Canada: CMHC

- Carter, Barbara H. (2001). *Where Will They Live : A Guide to Help You Help Your Parents with Their Housing Decisions*. Toronto, ON: Stoddart Publishing Co. Ltd.
- Chiras, Daniel D. (2000). *The Natural House : A Complete Guide to Healthy, Energy-Efficient, Environmental Homes*. White River Junction, VT: Chelsea Green Publishing Company
- Coates J, Mahaffie J & Hines A. (1996). *2025: Scenarios of Us and Global Society Reshaped by Science and Technology*. Oakhill Press
- Cohen, Jonathan. (2000). *Communication and Design with the Internet*. New York, NY: W. W. Norton & Company Inc.
- Crabtree A., Hemmings T., Rodden T., and Schnädelbach H. (2001). *Patterns of Technology Usage in the Home: Domestic Legacy and Design*. Technical Report Equator-01-015, University of Nottingham, The School of Computer Science and IT. <http://www.equator.ac.uk/papers/Ps//2001-crabtree-3.pdf>
- Craven, Jackie. (2003). *The Healthy Home: Beautiful Interiors that Enhance the Environment and Your Well-Being*. Gloucester, MA: Rockport Publishers. Inc.
- Delegation for Sustainable Technology. (1999). *Intelligent Buildings – Good For The Environment*. Stockholm, Sweden: Swedish Delegation for Sustainable Technology

- Dewsbury G., Rouncefield M., Clarke K., and Sommerville I. (2002). *Designing Appropriate Assistive Technology for Home Users: Developing Dependable Networks*. Lancaster, England, UK: Computing Department, Lancaster University
- Forester, Tom. (1988). *High-Tech Society : The Story of the Information Technology Revolution*. Cambridge, MA: The MIT Press
- Forester, Tom. (Ed.) (1989). *Computers in the Human Context : Information Technology, Productivity, and People*. Cambridge, MA: The MIT Press
- Gaddis, David. (1991). *Understanding & Installing Home Systems*. Edmond, OK: Home Systems, Inc.
- Gerhart, James. (1999). *Home Automation & Wiring*. McGraw-Hill, Inc.
- Gershwin, M. Eric and Klingelhofer, Edwin L. (1992). *Living Allergy Free : How to Create and Maintain an Allergen- and Irritant-Free Environment*. Totowa, NJ: The Humana Press Inc.
- Graham, S. and Marvin, S. (1996). *Telecommunications and the City: Electronic Spaces, Urban Places*. London and New York: Routledge.
- Heltzel, Paul. (2003). *Complete Wireless Home Networking*. Prentice Hall

Henricks, Mark. (2000). *Mastering Home Networking*. Alameda, CA: Sybex Inc, Inc.

Johnson, Nicholas. (1972). *Test Pattern for Living*. New York, NY: Bantam Books, Inc.

Jones, Steven G., Ed. (1997). *Virtual Culture: Identity & Communication in Cybersociety*. London, UK: SAGE Publications Ltd.

Marinelli, Janet and Bierman-Lytle, Paul. (1995). *Your Natural Home : A Complete Sourcebook and Design Manual for Creating a Healthy, Beautiful, Environmentally Sensitive House*. Boston, MA: Little, Brown and Company Ltd.

Migayrou, Frederic and Brayer, Marie-Ange (Ed.) (2001). *Archilab: Radical Experiments in Global Architecture*. New York, NY: Thames & Hudson Inc.

Mollenkopf, H. (1993). *Technical Aids in Old Age – Between Acceptance and Rejection*. Berlin: Wissenschaftszentrum fuer Sozialforschung (WZB).

Mueller, John Paul. (2001). *Poor Richard's Home and Small Office Networking: Room to Room or Around the World*. Lakewood, CO: Top Floor Publishing

Murray, Charlotte C. (1988). *Supportive Housing for Seniors : The Elements and Issues For a Canadian Model*. Canada Mortgage and Housing Corporation.

National Advisory Council on Aging, Canada. (2002). *The NACA Position on Supportive Housing for Seniors*. National Advisory Council on Aging

Rousseau, David and Wasley, James. (1999). *Healthy by Design : Building and Remodeling Solutions for Creating Healthy Homes*. Point Roberts, WA: Hartley and Marks Publishers Inc.

Silverstone, Roger. (1994). *Domesticating The Revolution - Information And Communications Technologies And Everyday Life*. In R. Mansell (Ed.) (1996). *The Management of Information and Communication Technologies: Emerging Patterns of Control*. London, ASLIB.

Smith, Ralph Lee. (1988). *Smart House : the Coming Revolution in Housing*. GP Pub.

The Association for Safe and Accessible Products. (1995). *Technical Report: Home Automation*. Washington, DC.

Trulove, James Grayson. (2002). *The Smart House*. New York, NY: Watson-Guptill Publications

Warde, John. (1997). *The Healthy Home Handbook : All You Need to Know to Rid Your Home of Health and Safety Hazards*. Times Books; Random House of Canada Ltd., Toronto, Canada

Wolf, Mike. (2002). *Speed! : Understanding and Installing Home Networks*. Indianapolis, IN, USA: Sams Publishing

Websites:

<http://www.accu-lock.com/HomeWiring.htm>

<http://www.ad.siemens.de/intelligent-home/>

<http://www.allsmartsolutions.com/>

<https://www.asseenontvnetwork.com/>

<http://www.attr.com/x10/>

<http://www.automatedhome.co.uk/>

<http://www.bath.ac.uk/bime/projects/smart/>

<http://www.comfort.org.uk/index1.html>

<http://www.e-house2000.com>

<http://www.echelon.com/>

<http://www.ercim.org/>

<http://www.futurehomesystems.com/>

<http://www.gdewsbury.ukideas.com/>

<http://www.gridpoint.on.ca/>

<http://www.habitek.co.uk/>

<http://homeautomation.virtualave.net/X101.HTM>

<http://www.homeautomationzone.com/>

<http://www.home-automation.org/>

<http://www.homecontrols.com/>

<http://www.housesmart.ca/>

http://www.housing.qld.gov.au/builders/smart_housing/

<http://www.inhaus-duisburg.de/en/index.htm>

<http://www.jerrymcmullin.com/ent001/099/01.html>

<http://www.lg.ca/>

<http://www.makeitsmart.com/>

<http://www.onqtech.com/>

<http://www.openhere.com/hag/homes/home-automation/>

<http://t2000.chba.ca/>

<http://www.smarthome.com/>

<http://www.smarthomeconnection.com/>

<http://www.smarthomeusa.com/>

<http://www.smarthouse.com.my/>

<http://softwareforhomes.com/>

<http://www.toolbase.org/>

<http://www.x10.com/>

Appendix A. Products in Smart House Market

Table A.1 Products for HVAC System

<p>Omnistat Thermostats</p> <p>Get complete control of home's temperature both locally and remotely with the RC Series family of electronic communicating thermostats. Available for conventional single stage heat/cool, heat pump, two-speed heat pump, two-stage conventional, and zone control systems, the RC Series Thermostats come in a sleek, contemporary case design that blends with any home decoration.</p>
<p>Programmable Slimline Thermostat</p> <ul style="list-style-type: none"> ■ 5-2 (wk/weekend) programming with 4 events per day ■ 3 hr./continuous temperature override ■ Electronic keypad lockout prevents tampering ■ Remote indoor and outdoor temperature sensors (optional) ■ Heat, cool & auto changeover modes
<p>Electronic Duct Damper</p> <ul style="list-style-type: none"> ■ Save energy -- and money -- by shutting off heating/cooling to unoccupied areas ■ Special design ensures no air leakage for efficient air control ■ Use with multiple-zone system or control directly for ease of installation

<p>Sensaphone</p> <ul style="list-style-type: none"> ■ Automatically calls 4 or 8 numbers to report alert conditions ■ 4 or 8 inputs: Temperature or NO/NC sensors ■ -20 to 150 F temperature sensing range ■ 10-hour battery backup in event of power failure ■ Built-in microphone and power outage sensor
---	--

Table A.2 Products for Lighting System

<p>8-Button KeypadLine</p> <ul style="list-style-type: none"> ■ Now available in load-bearing versions, eliminating the need for in-line modules ■ Change the mode of home's lighting with a single button press (8 moods : All On, All Off, Away Mode, Secure Mode, Lamp, Stereo, VCR, Laser Disc) ■ See at a glance if lights in other rooms are on or off <p>(\$89.95)</p>
<p>Philips Pronto Remote</p> <p>Combining elegance, flexibility and ease of use, it features both a large touch-screen display with an intuitive user interface and direct-access buttons to conveniently provide home entertainment control. Pronto's unparalleled design combines the benefits of a dynamic, digital user interface with direct access buttons. It's easy to add, delete and label new buttons or menus. This allows maximum customization according to individual needs and tastes. (\$668.00)</p>

<p>HR10 16 channel Radio Remote Control any 16 X10 devices (433Mhz) Inc Dim/Bright (\$42.60)</p>
<p>EagleEYE Motion Sensor MS14a The EagleEYE Motion Sensor (MS14A) sends wireless Radio Frequency (RF) signals to an X10 Transceiver or any X10 security system base receiver. The Transceiver receives the signals from the Motion Sensor and passes them onto house wiring. These signals are then received by X10 lamp, appliance, or wall switch modules to control lights (or appliances) around the home.</p>

Table A.3 Products for Communication System

<p>Aiphone KC-1GRD Color Video System</p> <ul style="list-style-type: none"> ■ One video door station. ■ Up to 3 interior stations with color monitors. ■ Clear, crisp color image with 4" TFT display. ■ Tilt control for camera adjustment. ■ All Call and 2-way internal communication via handset. ■ Hands free Audio and Video monitoring.
---	--

<p>Nutone IM4406 Intercom System (Master & Sub Station)</p> <ul style="list-style-type: none"> ■ Voice Music Intercom System with AM/FM tuner and CD player ■ Up to 9 remote stations and 3 door stations ■ Control CD/radio on/off, CD track selection, and radio memory from any remote station. ■ Never miss a beat - CD pauses when intercom or chime is used. ■ One-button talk/listen: push to speak, release to hear reply ■ Monitor (listen-in) baby's room or bed confined family member.
<p>Acoustic Transmitter & Receiver (Kit)</p> <p>The ACOUSTIC Transmitter makes it possible for you to hear what is going on anywhere in your home without any installation, just by connecting transmitter and receiver to the 230Vac single phase mains power supply.</p>
<p>Doorbell Fon DP-28BF Intercom Kit</p> <ul style="list-style-type: none"> ■ Answer the door from any phone ■ Doorbell button rings phones ■ Answer & Unlock up to 2 doors ■ Simple to install ■ Answer the door from work or cell <p>(\$179.00)</p>

Table A.4 Products for Entertainment System

<p>Wristwatch Remote Control</p> <ul style="list-style-type: none"> ■ Turn up the volume on your TV without having to reach for the remote ■ Never interrupt a conversation to locate the remote ■ Make it home on time to catch all of your favorite shows <p>(\$39.99)</p>
<p>Home Theater Master MX-500 Remote</p> <ul style="list-style-type: none"> ■ Combines a touchscreen remote with tactile buttons ■ Control any of 10 audio/video devices ■ Ergonomic joystick -- easy to navigate ■ Offers easy-to-press buttons for commonly used features, so users won't have to flip through screens just to change channels ■ Pre-programmed with the latest codes for the newest generation of PVRs, digital cable and satellite receivers (\$169.95)
<p>On-Screen Programmable Timer TouchLine</p> <ul style="list-style-type: none"> ■ Entirely programmable & customizable on-screen, without a PC ■ Program & run 12 timer events without an intelligent controller ■ Program & run 12 sets of commands without an intelligent controller ■ Directly control up to 72 X10 lights and appliances on multiple housecodes <p>(\$399.95)</p>

Voice Activated Remote Control

- Totally hands-free operation — you won't have to lift a finger
 - Fully rechargeable — buy Ni-Cd batteries once and they'll last for years
 - "Learns" the voices of up to four different users — in any language
 - Recognizes up to 50 commands and macros
- (\$69.95)

In-Ceiling Motorized Projection Screen

- Available in three sizes up to 120" diagonal
 - Drop down design is completely hidden when retracted
 - Fiberglass Matt White screen surfaces
 - Low Voltage Interface for hooking up to Home Theater controller
- (\$1899.95)

Local Channel Power Antenna

- Installation can be done in minutes, without repositioning your dish
 - No new cable routing necessary; no special tools required
 - Attaches to any 18-inch satellite dish using the included mounting clips.
 - Weather-resistant antenna
- (\$59.95)

Table A.5 Products for Security System

<p>Axis 2100 Network Camera lets user view crisp, quality images and live video from any computer with Internet access or from any computer on the network. It contains a high performance web server so user can put the camera directly on the internet. No PC is required – the camera operates stand-alone and can be placed wherever there is an available modem or LAN connection. Keep a close eye on the home, family, and office by typing in an assignable IP address and password on any web browser. (\$519.00)</p>
<p>Channel Vision 6124 Day/Night Vision Camera This camera switches from color by day to black & white by night, allowing it to see much more clearly. To enhance night viewing the camera has 12 IR emitting LED lights which turn on at dusk. The IR lights are invisible to the human eye so visitors won't even know they are being illuminated. The LED's illuminate a 20 foot area in front of the camera, making it ideal for front walkway or driveway installations. (\$230.00)</p>
<p>The S132 Covert Smoke Detector camera is non-working smoke detector with a high quality B&W camera. Placed on a wall or ceiling, these covert cameras enable user to monitor an entire room - great for watching a nanny, babysitter, maid, etc.. This smoke detector is also commonly used in offices and stores to aid in theft reduction. The S132 uses a B&W camera - ideal for areas with limited light (\$121.00)</p>

<p>S126 Floodlight Covert Camera is perfect for outdoor surveillance 24 hours a day. It has a working PIR motion detector that turns on the two floodlights when there is activity. The B&W camera, hidden in the bottom of these floodlights, captures images of unsuspecting and uninvited visitors. (\$286.00)</p>
<p>The S137 miniature camera uses a cone-shaped pinhole style lens for covert monitoring. The cone-shaped tip allows the camera to be easily installed behind walls and other obstructions. Just a 1/8" is all that is need for the camera to see. The cameras are housed in metal enclosure which is approx. 1 1/4" x 1 1/4". A U-shaped bracket attaches to the back of the housing and allows the camera to be mounted quickly and easily. A 6 inch video wire and a UL listed power supply included. (\$159.00)</p>
<p>The S141 Pan-Tilt-Zoom (PTZ) camera offers the highest level of surveillance flexibility. The PTZ cameras are complete surveillance systems which include a standard resolution color camera, zoom lens, housing, pan/tilt motor, and power supply. Full control of the camera's pan, tilt, and zoom lens allow for unparalleled surveillance. The cameras can be quickly rotated 360° and the zoom feature makes it possible to monitor objects hundreds of feet away. (\$1860.00)</p>
<p>S801 14" Color Quad-Screen Video Surveillance System. Kit includes: 1 Color Quad-Screen Monitor. Quad screen allows viewing of up to 4 cameras simultaneously. 1 Color Camera with built-in microphone/speaker for two-way communication. 1 Camera mount for wall or ceiling installation. 1 White Connector Cable, 65 feet (\$849.00)</p>

<p>CT240COE SafeAir Carbon Monoxide Alarm</p> <p>The SafeAir Alarm is the only industrial-grade Carbon Monoxide (CO) alarm specifically developed for use in a monitored home security system. The unit is designed to the same standards as CO sensing systems used to protect workers in industrial plants and hospitals. (\$69.95)</p>
---	--

Table A.6 Other Home Automation Products

<p>LRSPC2661T Refrigerator</p> <ul style="list-style-type: none"> ■ FastFresh™ electronic temperature control with 6 sensors ■ Digital LCD display ■ Automatic ice maker with water dispenser & water filter ■ Stainless steel handles ■ Slide out, spill protector tempered glass shelves ■ Watch TV & Listen to Music ■ Surf the Internet ■ Photo Album ■ Message Centre ■ Recipes & Stored Food
<p>RoboSweep is a robotic sweeper.</p> <ul style="list-style-type: none"> ■ 1 motorized unit ■ 50 disposable wipes ■ 4-rechargeable batteries ■ An AC/DC adapter for charging <p>(\$29.95)</p>

A small, white, oval-shaped robotic lawn mower with a black wheel and a black sensor on top.	<p>RoboMower</p> <ul style="list-style-type: none">■ Mows your lawn independently, without human intervention■ Electric motor does not emit harmful air emissions■ No grass clippings to empty or rake■ Quieter and lighter than standard gas-powered mowers
A white, rectangular electronic device with a black sensor on top, sitting on a wooden deck.	<p>Automatic Pool Water Level Control</p> <ul style="list-style-type: none">■ Maintains consistent water level■ Use for rental or vacant homes■ Unattended operation <p>(\$89.99)</p>
A square, black electronic device with a large, circular black lens in the center.	<p>RoboDog: Computerized Barking Dog Alarm</p> <ul style="list-style-type: none">■ Scare off prowlers■ Use while residents are away■ Use for peace of mind <p>(\$59.99)</p>