

AC 2007-1219: TECHNOLOGICAL ASPECTS OF A SMART COTTAGE FOR SENIORS

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Development of a Smart Cottage for Seniors

Abstract

This paper presents the design, development and construction of a new kind of housing for senior citizens. A Smart Cottage for Seniors has been developed that is accessible, affordable and contains technology to keep the seniors at home longer, safer and healthier. The cottage uses Universal design techniques that ensure that the cottage will change with the needs of the occupants. A technology system integrates the security, home automation, energy management and medical monitoring functions into one web page that can be viewed and controlled from any web browser (with proper identification). A prototype of the home has been built and tested.

Introduction

This paper describes the design, development and implementation of a “smart” cottage for senior citizens. The Smart cottage is a single-level, two-bedroom home that has been designed using Universal Design concepts. Technology has been integrated into the cottage from the design phase. This technology will keep seniors at home longer and help them stay healthier and more productive and allow caregivers and/or family members to monitor, adjust and control the cottage from the internet. An additional requirement of the Smart Cottage was that it must be affordable. These requirements are summarized below:

- Easily manufactured
- Energy efficient
- Wired for smart technology
- Web access of all smart functions
- Affordable
- Low maintenance
- Qualify for HUD or other support agency

The fundamental goal of the Cottage is to use information and computer technology to keep seniors at home longer, safer and healthier. Each year a senior remains at home instead of living at an assisted facility will result in significant savings for the family.

Western Pennsylvania has become a NORC. This is a **naturally occurring retirement community**. A great many of the senior citizens do not have the resources or the desire to move to retirement communities in the Sun Belt. This presents many unique challenges to the area, but also provides a great many opportunities for service learning and social entrepreneurship. The number of older Americans is growing—faster than other segments of the population. Today’s elderly population is expected to double by 2030, expanding at a rate of almost 3 percent each year to almost 70 million people.

Bluroof Technologies is a non-profit corporation that is working with Penn State University, University of Pittsburgh, and Carnegie Mellon University to design, develop and construct a prototype of a Smart Cottage for Seniors. Engineering and Information Science interns from Penn State are wiring, testing and debugging the Smart Cottage. In addition to the interns, Bluroof has provided space and expertise to the Information Sciences and Technology program at Penn State University for students to use the Smart Cottage as a lab and a living classroom.

Design and Development

The design and development of the Smart Cottage for Seniors was started by Blueroof Technologies in early 2003. The design consisted of five main components:

- House design
- Technology design
- Senior Computer Interface
- Energy efficiency
- Medical Monitoring

Affordability and manufacturability were two key concepts that guided the design process. The first phase of this project was to build a prototype Smart Cottage, but the ultimate objective was to build many of these cottages at an affordable cost. The reference cost was the HUD two-bedroom price limit of \$104,000 for the Western Pennsylvania area.

Universal Design

The Smart Cottage for Seniors has been developed using Universal Design techniques that will insure a long lasting and comfortable home for seniors. The Universal Design features of the cottage are:

- 1040 sq. ft. single-level floor plan
- Technology channels embedded in walls during manufacture
- Large bathroom with 5-feet turning radius
- Walk-in shower
- Pocket doors
- Washer and dryer on first floor
- Self-cleaning windows

The accessibility of each cottage is also very important. These are:

- 36" wide pocket doors
- On grade, no step, low threshold entryways to the concrete walk
- Lowered tilt plate light switches and raised electrical outlets throughout home
- Grab bars in bath
- Walk-in shower
- Five-feet turning radius in bathroom
- Washer and dryer mounted on one-foot high pedestal
- Slip resistant flooring in bathroom
- Switch for walk-in closet lights

Shown in Figure 1 - a floor plan for the Smart Cottage:

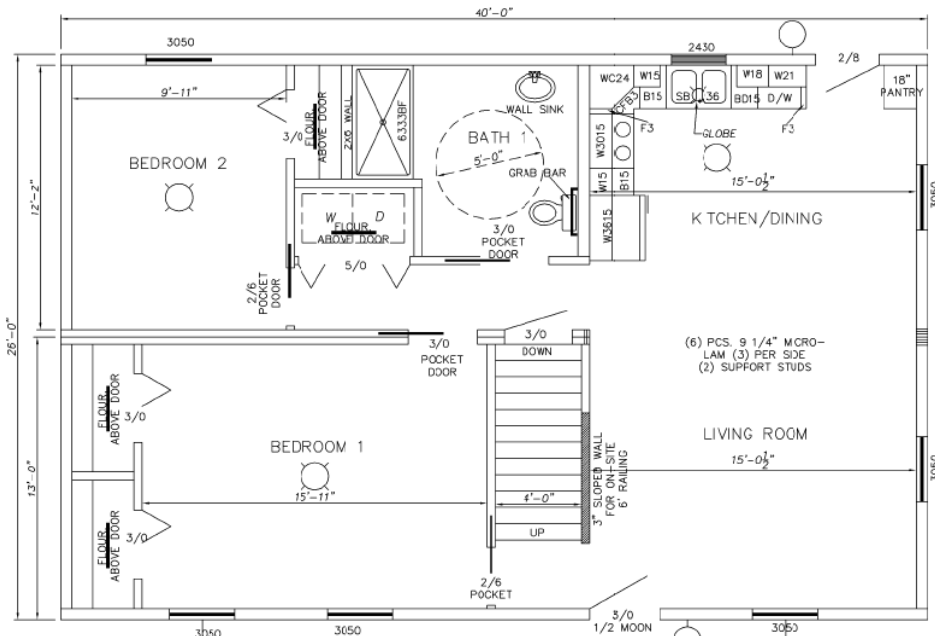


Figure 1. Smart Cottage Floor Plan

Technology and Infrastructure

The *Smart Cottage* has a small computer/logic center with the modems, firewalls, routers and switches that are required to connect the home to the Internet. Data/network security is an integral part of the house. The cottage has “technology” channels embedded in each wall during construction. After the house is constructed, CAT 5E cable, RG-6 coaxial cable and telephone cable (Tri-modal) is dropped through the technology channels from the computer center to all rooms, all appliances and sensors. Cables of any type can easily be inserted into the channels for future applications. Therefore, the Senior Smart Cottage is future-proofed.

The main components of the technology system include:

- Dedicated security and home automation controller
- Low cost server
- IP cameras
- Network modem and switch

While the majority of this equipment is off the self components, the main task has been to integrate all of this equipment into a system that is easily accessible from the Internet. The controller communicates via a serial port, the cameras all use IP protocols, and the security system uses the telephone to communicate events.

A block diagram of the Smart Cottage Technology system is shown in Figure 3 below:

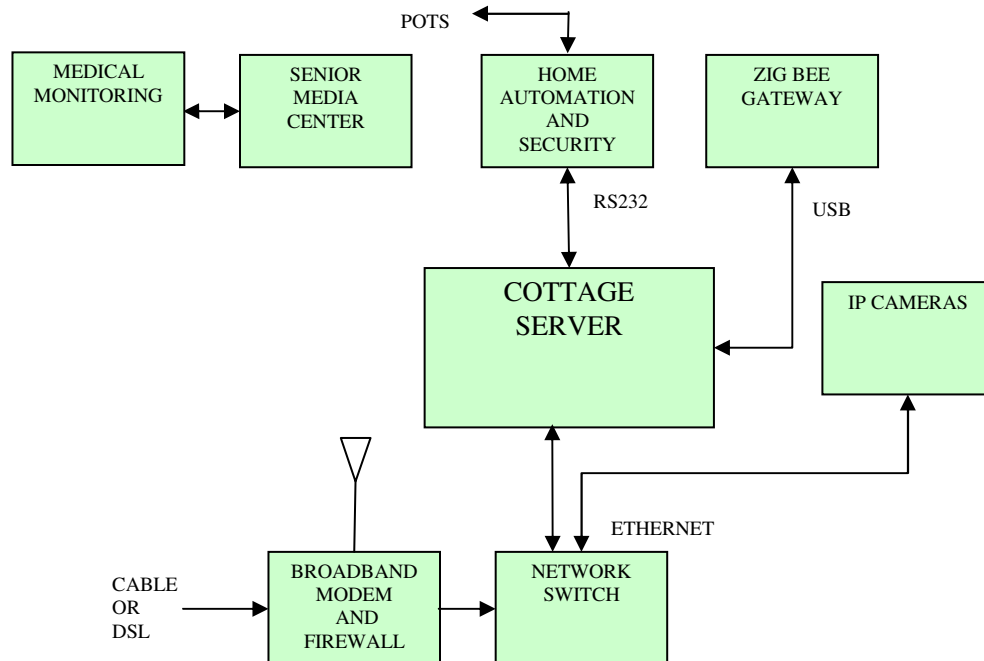


Figure 3. Technology block diagram

In addition to the normal security functions such as entry, window and fire alarms, the Smart Cottage has a number of unique and custom sensors, which include an alarm to monitor how long the water in the shower has been on. After a preset time, the system will sound an alarm for the senior to check the shower. A similar alarm has been developed to detect the length of time the oven has been on.

A small dedicated server has been developed for the Smart Cottage. This server interfaces with the home automation equipment and contains software for each cottage; such as a unique web page for the home, storage of events, and senior records. This server can be reset via a telephone activated control system.

Lighting and appliance control is obtained by using a technique called Universal Powerline Bus (UPB). This is a state-of-the-art home automation control system that uses the existing AC power lines to carry control signals. The UPB power line communication method consists of transmitting digitally encoded information over the electrical power line as a series of precisely timed electrical pulses (called UPB Pulses) that are superimposed on top of the normal AC power waveform. This method includes two-way communication from the switch or outlet back to the main transmitter. This greatly improved the reliability of this system over the previous X10 technique.

In addition to the wired network, the smart cottage contains a wireless sensor system based on Zig Bee technology (802.15.4). This system includes a personal pendant that is worn by the senior. The senior can activate the alarm by pushing a button and it can also be automatically activated when the senior falls. A number of other sensors are placed through the house and these components establish a wireless mesh network that communicate among themselves and also transmit data back to the zig bee hub. The Zig Bee hub is connected to the cottage server so that all information is available over the Internet. Zig Bee is a relatively new wireless network that offers great advantages in cost and power consumption, and is simply implemented.

Senior-Computer Interface

The senior/computer interface is an extremely important part of the Smart Cottage. A great many seniors have never used a computer and are somewhat intimidated by them. After a great deal of senior discussion groups and computer training sessions, a senior computer-entertainment center has been developed. This system uses a Media PC with a XP-Media operating system. The normal interface to this system is not the keyboard or the mouse but it uses a remote control to control just about all functions. During the senior discussion groups, it was quickly determined that all seniors can use a remote control. The “Senior Media Center” includes a 21” LCD monitor that also functions as a TV and a DVD player that is seamlessly integrated into the operation of the system. Seniors can switch from TV to DVD to video conferencing to medical monitoring with a simple click of the remote. Also connected to the Media Center is a video camera that will be used for video conferencing with family and friends and also for visual medical evaluations.

The Senior Media Center shown in Figure 4 has a wireless network connection to the server and router in the tech cabinet.



Figure 4. Senior Media Center

Energy Efficiency

An important component of the development of the Smart Cottage is the overall energy efficiency of the cottage. This includes heat, air conditioning, insulation and hot water. Most of the homes in the service area of our program are 70-80 years old with very little insulation, old windows and outdated HVAC systems. In the winter months, energy bills can exceed \$500 per month. [5] This is an area where the Smart Cottage can have an immediate impact and the savings obtained in energy costs can be applied to the purchase price of the home. The following is a list of the energy efficiency components of the Smart Cottage:

- High efficiency HVAC components
- Tankless hot water tank (Natural gas)
- Energy Star rated insulation

- Energy Star appliances
- Energy efficient windows
- Computer controlled energy management
 - Programmability
 - Night set back
 - Control of HVAC to optimize heat pump and gas furnace operation
- Appliance monitoring and control
 - Load Shedding
- Databases to record and store information on the SCS
 - Energy usage
 - Indoor and outdoor temperature
 - Appliance usage.

For the first 18 months of operation, the average heating bill was less than \$40 per month.

Medical Monitoring

The technology system in the Smart Cottage has been developed in layers from simple functions to complex functions. As the needs of the senior change, additional technology can be added to perform more complex functions. Medical monitoring is a dedicated layer that can be seamlessly implemented into the Senior Media Center. This system consists of: blood pressure, body weight, medication management and video conferencing with the care giver. Off the shelf blood pressure cuffs and scales that have a serial communication capability have been interfaced to the Media PC. Software has been developed that accepts this data, stores and puts it into a format for the caregiver to review and analyze. The video capabilities of the Senior Media Center are used to help the senior use this medical equipment. Medication management is also integrated into the SMC with the following actions. The senior is reminded that it is time to take their medication. This reminder can take the form of the playing of one of their favorite songs. A sensor on the medication cabinet is monitored to determine if the senior has attempted to remove the medication from the cabinet, the senior must then inform the SMC that the medication has been taken. There is no foolproof method to determine if the senior has really taken the medicine, but this approach does give some degree of confidence that the senior has done something.

Construction

The construction of a prototype Smart Cottage was undertaken for a number of important reasons. The first was to build a cottage to prove the concept and to be able to test all of the technology systems. The second reason was to provide data on the actual construction costs and to also provide information on delivery and coordination of subcontractors.

The prototype was designed and ordered from New Era Homes of Clarion, PA. This home used the floor plan shown in Figure 1 and also included a second floor that would not normally be included in the Senior Smart Cottage. Blueroof will use the second floor for office space and meeting rooms. The cottage was installed on a pre-manufactured foundation shown in Figure 5 below. The basement will be used for a Research & Development lab for the cottage technology system and also for the development of future systems.



Figure 5. Smart Cottage Foundation



Figure 6. Smart Cottage

Conclusions

This program has demonstrated the feasibility of constructing a Smart Cottage for Seniors. The overall cost of this prototype was under \$150,000, and the technology system has proven to operate with very little problems. The research and development aspects of the Smart Cottage have attracted numerous institutions and companies to develop and test products for their senior markets. These include Carnegie Mellon University, University of Pittsburgh, Seagate, Bosch, Sonicare and Philips.

The prototype has proven to be an asset to the city of McKeesport - the activity associated with the construction of the model, and also with the interest and traffic generated, has helped rejuvenate a depressed section of the city. Blueroof is developing the ten acres surrounding the Smart Cottage into an independence zone. Plans are underway to construction approximately sixteen Smart Cottages on the thirty five tax delinquent lots. These homes will be built for many different residents, including: senior citizens, mentally and physically disabled individuals, and disabled veterans. The first house to be built is a 2 bedroom senior cottage that will incorporate all of the accessibility and technology features and has been designed to demonstrate the energy efficiency aspects of these cottages.