The Aware Community

Howard Wactlar
Carnegie Mellon University
wactlar@cmu.edu

Robert Walters
Pennsylvania State University
raw2@psu.edu

John Bertoty
Blueroof Technologies
jbertoty @comcast.net

Alexander Hauptmann
Carnegie Mellon University
alex@cs.cmu.edu

Abstract

The McKIZ Aware Community will enable us to move the paradigm of an aware and assistive home to the development of an aware and assistive community infrastructure by incorporating devices and methods into a small urban community of homes, recreation facilities, retail and service providers, on city streets with vehicular traffic and public transportation. This broadens our research, data collection and evaluation of persons with disabilities and aging residents to include instrumental activities of daily living and quality of life that extend beyond the confines of their home.

1. Introduction

The Aware Community is an ensemble of projects that moves the paradigm of an aware and responsive home to the development of an aware and responsive community by incorporating devices and methods into the infrastructure of a small urban community of homes, recreation facilities, retail and service providers, on city streets with vehicular traffic and public transportation. We will help aging residents with physical and cognitive deficits with the activities of daily independent living that extend beyond the confines of their home. We will automatically quantify differences observed in their mobility, activity and social interactions, and measure perceived change in senses of safety and security and quality of life overall with standardized self-reporting instruments The McKeesport Independent Zone (McKIZ) is an urban 10-acre, 12-block area community development project of new and existing structures which will be used as an integrated test-bed and evaluation environment for projects and technologies that are developed by academic researchers and industrial developers. Blueroof Technologies, a non-profit corporation, has already developed, built, and tested a prototype Smart Cottage for seniors that includes a vast collection of at-home sensors, monitoring devices, internet accessibility, and advanced technology systems for accessibility, energy conservation, safety, convenience and health maintenance. The Aware Community project at McKIZ builds from this initial technology system to integrate sensors and technology systems into the community infrastructure on streets, in buses, in stores, and the community center recreation facilities. We will utilize devices and systems that may be borne by the individual, incorporated as appliances that they use, or inconspicuously embedded in the environments in which they reside, travel and possibly work.

2. Community Description

We seek in our effort here to establish an actual, continuously active community

environment in which the occupants are permanent residents. We depart from the prototypes of our academic colleagues [3] by replacing short term observable subjects in contrived settings and circumstances with varied individuals conducting their normal lives. Our subjects engage in personal and social activities both inside and outside of their homes. Our infrastructure is one that facilitates installation, integration, and evaluation of new and emerging devices and systems to measure their outcomes. We extend the range for activity and behavior monitoring and communication from a home's interior to an urban neighborhood of new and existing structures, streets, and municipal services.

McKeesport is a city of 24,000 inhabitants located 15 miles South East of Pittsburgh. It is an old steel town on the Monongahela River and the city was devastated by the steel industry decline in the 1980's. In McKeesport there are 6000 (25%) seniors over 60 years of age. The single-family home sale price in McKeesport is 38% of the national average and there are over 300 vacant lots in McKeesport. The average senior is a 75 year old woman living alone with under $12,000 annual income. Most homes are 80-100 years old, energy inefficient, three stories with a single bathroom on an upper level, very inaccessible and in need of repairs.

The McKIZ Aware Community is located on a ten acre site in the Third Ward of McKeesport as shown in the Figure 1 site plan. At present, the Blueroof Smart Cottage/R&D Center, YWCA Community Center, Salvation Army and two active churches are located in the McKIZ and will remain. Blueroof will build a number of new structures to include 15-20 single family houses, a small grocery store and a new building for the Blueroof Tech Center. There are 22 existing HUD houses (five of which are accessible) that have infrastructure in place to accommodate sensors and other technology. In addition to single-family homes, Figure 1 shows the location of the four other new homes included in the first phase: 1) Energy Efficient Demonstration Home; 2) Group Home (3 Bedroom); 3) Disabled Veteran Home; and 4) Senior "Congregate Living" Home (6 adults). This will enable the study of health and wellness

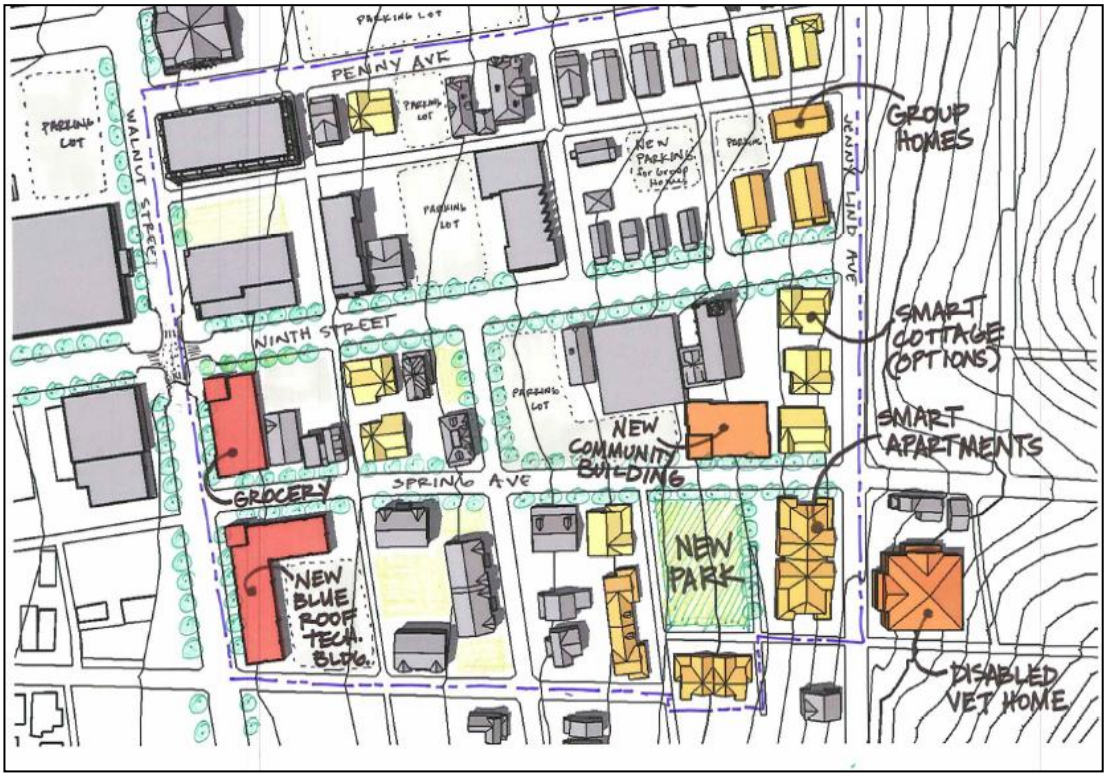

Figure 1. McKIZ Aware Community site plan.

maintenance technology and support systems in varying social settings. Ultimately we anticipate the steady-state McKIZ Aware Community to be a mixed population of over 100 residents occupying 40 dwellings, including some families with children, of whom 60% are seniors, and of whom 50% are of racial or ethnic minorities.

All of the Blueroof homes to be built in the Zone for seniors, mentally and physically challenged individuals and disabled veterans, will be accessible, smart, energy efficient, and affordable. They are constructed with infrastructure enabling integration of a large number and variety of wired and wireless sensors and cameras with robust communication and control of them. The homes will include a number of the features that Blueroof has tested in its Model Smart Cottage. The features include, but are not limited to, Sun Clean windows (PPG), tankless hot water system (Nortiz), ZigBee and Wi-Max wireless network coverage of the neighborhood (Wellspring) and a home automation controller (HAI).

3. Research plan

This McKIZ Aware Community testbed supports multiple research goals and methodologies. With respect to technology development and assessment, it broadly enables us to:

- Conduct longitudinal studies to determine accuracy and efficacy of developed devices and systems in situ, e.g., rigorous user home and outdoor environments
- Address user involvement, acceptance and abandonment
- Evaluate trade off among fixed, mobile & wearable sensors
- Test inter-operation among multiple systems
- Involve industry partners for evaluation & standards setting.

We see the most difficult barriers to clinical assessment of devices and systems requiring human participation for application and evaluation to be:

i. Collecting data on use or application over a range of natural and unpredicted conditions
ii.Longitudinal observation or evaluation of continuous use
iii.Institutional Review Board (IRB) proposal process of lengthy, iterative review cycles
iv. Recruitment of subjects

The McKIZ Aware Community addresses (i) and (ii) by providing a range of natural living environments constructed and outfitted for continuous monitoring, data collection, possible data aggregation and anonymization, and transmission. The IRB issues (iii) are partially addressed by establishing a blanket IRB for means of informed consent and data collection, amended for the particular device or system to be evaluated. The difficulty of recruiting subjects (iv) is ameliorated by Blueroof's aggressive resident recruitment program. They work with individuals and local, state and federal social service agencies or programs to seek individuals for each of the categories of living, and provide them mortgage or rent subsidies. Residents are then provided incentives, such as a computer with internet access and personal training for its use in exchange for participating in research projects.

4. McKiz Technology

All of the homes in the McKIZ will contain the technology features and systems described in Table 1. High speed Internet access and ZigBee monitoring will be delivered by wireless transceivers in each Blueroof Cottage. The transceivers will be integrated into a neighborhood mesh that will deliver internet access and energy control/medical/security monitoring to each of residents in the McKIZ at no cost to the residents. All homes will not only share in the internet access but will also connect with all of the homes in the McKIZ through one private multifunctional network. Data from all

homes will be collected and stored in a central server to allow Blueroof and all of its research partners access to the data generated by each home.

Each home in the McKIZ will have an integrated security system that includes fire, carbon monoxide, heat, and window and door sensors. Additionally, cameras will be used to monitor the doors of the homes. Wireless network cameras will be situated throughout the McKIZ to monitor and record the activity of the community. In addition, Blueroof will install unique and innovative PERS (personal emergency response systems) receivers within all of the homes as well as in the community to allow the residents to walk outside the homes and be able to signal for help. Each home will include an outdoor mounted ZigBee transceiver that will work together in the mesh network to allow neighborhood coverage, inside and out. Any transceiver will pick up any alarm, regardless of location. Figure 2 illustrates the outdoor mesh.

5. Research projects

We build considerably on the significant body of work evolved over the last decade in ubiquitous computing, context-aware homes and automated behavior recognition. The 2003 Meyer and Rakotonirainy survey [4] of the research on context-aware homes lays out its various dimensions. Most research efforts on technology and aging focus on the home – more specifically on the home's interior – but surprisingly little attention has been given to the outdoors. One reason is that many people, especially older adults, spend the majority of their time indoors. Yet, participating in activities outside the house is clearly helpful in maintaining physical fitness and countering the often self-imposed reduction of seniors to an increasingly shrinking and impoverished world of social interactions.

By comparison and extension, this effort focuses on the application of technology to promote independence in community participation by the subject citizens. Many accessibility accommodations have been ubiquitously incorporated in US urban infrastructures for those with physical disabilities, particularly the removal of barriers to wheelchair access to streets, public transportation and retail enterprises as a result of the US Americans with

Energy Management	**Wireless remote adjustment of thermostat. Improve efficiency. Automatic cutback on peak, at night and when unoccupied.**
Appliance and lighting control	**Turn on lights remotely. Stoves "on too long alert". Water "on too long alert".**
Video monitoring	**Front door camera modulated onto a TV channel.**
Video conferencing	**Family, Medical, Shopping**
Security	**Fire, smoke, and carbon monoxide alarms. Intrusion-all windows and doors. Motion/temperature sensors in every room (wireless).**
Health	**Blood pressure, weight, medication management recording. Gross resident activity measurement.**
Safety	**Activity monitors, alert buttons and fall detectors**
Wellness	**Diet, exercise and preventive medicine**
Cyber Nurse	**Visits a number of patients each day via the Internet. Video conferencing to see and talk with patients. Database of patient records and activity.**
Media Center	**A user friendly center to interface with the cottage's technology. Includes an LCD TV/computer monitor**

Table 1. Blueroof Cottage "smart" functions

Disabilities Act (ADA). A novel goal of the Aware Community development is to explore the concept of *cognitive accessibility*, i.e., enabling individuals with cognitive deficits to be able to participate in various outside-of-home activities with increased capability, security and self-assurance, thereby achieving improved instrumental activities of daily living ratings and perceived quality-of-life overall. The initial projects described below all contribute toward that vision.

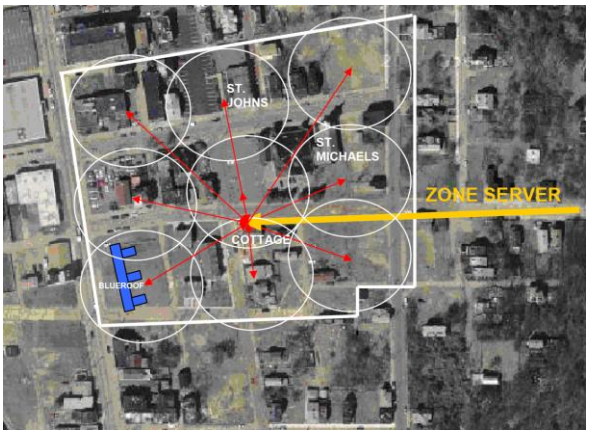

Figure 2. McKIZ outdoor communication

In the research and development projects underway and planned, we start with a development effort that provides some enabling infrastructure for outdoor aware environments, the Smart Street Pole Information and Communication Node. A second development effort produces a Retail Store Shopping Assistant that also lends itself to application as a cognitive orthotic for shopping and errands in the community. A third development, the Caregiver Home Interlock, serves as sort of a partial lock-down - when the caregiver leaves, the occupant can't do certain things, for instance, the stove might be disabled. The fourth implements a Community Person Locator and Tracker to follow participant travel between points and detect if there are unanticipated delays or wandering, and automatically detect and report aberrant motion such as falls, aimless wandering, or other undesirable movement. For example, we might automatically detect when a participant is moving slowly in a crosswalk, and adjust the stoplight timing accordingly, or proactively query the subject on their cell phone if their path has wandered from their originally intended destination.

The "Smart Street Pole Information and Communication Node" integrates solid state lighting, Zig Bee transceivers, WiFi repeaters, sensors, and network cameras, speakers and microphones into the lamp posts. The poles will be instrumented to support the research project described later as the Community Person Locator and Tracker. They will jointly identify the individuals living in the Zone, will monitor their activities and movements, will assist them in freely visiting the different resources in the Zone and will activate alarms if they ask for (or are automatically interpreted as in need of) assistance.

The "Retail Store Shopping Assistant" aids the many older adults who are intimidated by even small convenience stores because of perceptual and/or cognitive impairments. They may be perplexed by the variety and array of products available, remembering what they came for, reading labels and locating what they want. We hypothesize that their desire to go shopping would increase, and the correlated mental and physical advantages of maintaining shopping as a regular out-of-the-home activity would be realized, if commonplace technology is applied to help them overcome those deficits and make the task of shopping simple once again.

This effort prototypes and evaluates an information appliance, the "Retail Store Shopping Assistant," that provides its user with a variety of useful capabilities while shopping. It provides shop-specific assistance, enabling the customer to inquire as to the location of (and direction to) a specific item or category of items sold in the store. When pointed at a particular product, the device indicates salient information such as item and unit price (e.g., $/ounce), ingredients, and nutritional facts. It is designed to allow seamless communication directly with the partner at home or the caregiver, so s/he can confirm that the product selection is correct, that the amounts are reasonable and that extraordinary circumstances (product not available or

special bargains) can be handled with mutual satisfaction.

The shopping assistant device may also provide user-specific assistance by remembering the user's favorite brands and products, potentially keeping track of what's in the shopping cart relative to what's on the shopping list.

We envision that the Retail Store Shopping Assistant is available to customers in the store and has been pre-loaded with the current store information, layout and product details. The device itself is based on a multimedia-capable personal digital assistant (PDA) customized to interact with the user in appropriate and tailored ways. The PDA is updated with information about the specific store, where products are located in the store, what they cost, and other associated product content details, including a picture of the packaging, nutritional information, etc. The need for assistance when shopping depends on the nature and degree of the user's impairments. For the visually impaired, it informs either verbally or in suitably large letters on the device's screen; users with mild cognitive impairments receive more in-store coaching and reminding than other users. In an earlier project [5] called Trinetra, a shopping assistant for blind people was demonstrated that helped the user find his favorite brands of snack foods. After being led to the cookie shelves by a store clerk, he was able to find and scan bar codes on packages, and hear the name of the product he was handling. In all cases, a variety of shopping assistant functions are possible, and we are interested in understanding which ones are most useful and how to make them easy to use.

The "Community Person Locator and Tracker" expands on home monitoring by extending the capability to the community-wide outdoors within the community. Like indoor monitoring, it is a realized as a distributed system of sensors and processors that provides information both in real time and as summary reports on the subject's activity levels, behaviors and trends in those data. In contrast to its indoor counterparts, the "Community Person Locator and Tracker" is a resource shared by multiple caregivers and residents.

Such a capability can be used to support and assist older adults as they move about. For example, by detecting that a person with a rollator (a rolling walker with a seat) is at an intersection, the normal sequencing of the traffic light could be temporarily modified to give her more time to cross the street. Accompanied by a device that inquires about her intended destination and anticipated time away, the system could determine if she is off-route and provide her with navigational advice, potentially through the smart street pole network. Alerts could be sent to companions and caregivers (and emergency responders if warranted) when she leaves the boundaries of the neighborhood, has fallen, or seems to be wandering aimlessly.

We are particularly interested in understanding the technical viability of such a system, having developed related capabilities through earlier research. In the Caremedia project [1], we developed video-based techniques to locate people, track their movements, and classify and catalog several activities and a few behaviors. The Caremedia system used 44 cameras and was implemented and tested inside a nursing home facility. Many algorithms developed for Caremedia can be directly applied to the Community Person Locator and Tracker. A significant challenge is recognition of activity robust to time of day, weather and seasonable outdoor light and environmental conditions. In the Visual Surveillance and Monitoring project [2], we prototyped a distributed outdoor system to track the movements of multiple people around a facility (in our implementation, a section of the Carnegie Mellon campus). An important re-usable capability from that project is "handing off" subjects between adjacent cameras.

The "Caregiver Home Interlock" aims to prevent mishaps and injuries that occur in the home that could be prevented. For example, burns and kitchen fires might be avoided by disabling the stove and microwave of dementia adult who lives alone and is prone to forgetting they've been turned on. Such an interlock would simultaneously increase safety for the older subject and

provide reassurance to her caregiver when the caregiver was away. Other examples include disabling hot water valves, clothes irons and toasters or securing cabinets that contain sharp implements. It requires a long term study with large test and control populations to prove with statistical significance that accidents are reduced when such interlocks are employed. We can, however, make a significant contribution to the body of knowledge on caregiver well-being and can elucidate technical and social issues associated with this type of technology.

The amount of relief provided to the caregiver by the interlock is a critical factor in determining their value. Many studies show that caregivers experience high rates of anxiety and depression, and frequently resort to excessive use of psychoactive medications in response to the constant strain of having to provide for an elderly patient. A key goal is to lighten the burden of the caregiver.

This development project will develop and deploy a variety of home interlocks together with a control interface where a caregiver can selectively enable and disable specific functions. It also explores a variety of operational modes, triggers, overrides, interfaces and system designs and evaluates them for cost, utility and ease-of-use and -installation.

6. Current status

New residents are currently being sought and will be offered incentives to participate as subjects in ongoing research projects. A number of new homes are scheduled to come on-line in the coming year: 1) Blueroof Research Cottage (BRC) for a senior family with disabilities; 2) BRC exclusively for an industrial partner for their research activities; 3) disabled veteran home; 4) group home for seniors (6 adults), and 5) a demonstration home with very high energy efficiency for seniors occupancy.

A sensor package of 87 sensors of many types, combining commercial and academic research inventions, has been developed and deployed in the model experimental cottage for integration and testing by senior (as in elderly) associates on a visiting basis.

An overall master plan for the project is being finalized by Rothschild Doyno Architects. The City of McKeesport has pledged new sidewalks, curbs, sewer drops and street repairs for every house built in the zone. Meetings have been held with the local ministerium with representatives from all churches in the area, as well as agencies represented here, such as the Salvation Army, Womensplace, Ninth Street Clinic, the Consortium for Public Education, and the McKeesport/White Oak Kiwanis. A series of open group consensus meetings are being conducted to provide opportunities for additional community input.

7. Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant Nos. 0540865 and 0624236 and a grant from the Alzheimer's Association ETAC program.

8. References

[1] Chen, D., Wactlar, H., Malkin, R., Yang, J., Detecting Social Interaction of Elderly in a Nursing Home Environment. ACM Transactions on Multimedia Computing, Communication and Application,, October, 2006.
[2] Collins, R., Lipton,A., and Kanade, T., et al., "A system for videosurveillance and monitoring: VSAM final report," Tech. Rep. CMU-RI-TR-00-12, Robotics Institute, Carnegie Mellon University, Pittsburgh, Pa, USA, May 2000.
[3] Horgas, A. L., & Abowd, G.. The impact of technology on living environments for older adults. In R. Pew & S. Van Hemel (Eds.) Technology for Adaptive Aging: Report and Papers. Washington, DC: The National Academies Press, 2004
[4] Meyer, S. and Rakotonirainy, A. A survey of research on context-aware homes. Proceedings of the Australasian Information Security Workshop Conference on ACSW Frontiers 2003, 21, pp. 159-168. Darlinghurst, Australia: Australian Computer Society, Inc., 2003
[5] Narasimhan, P., "Assistive Embedded Technologies," IEEE Computer, July 2006, pp. 85-87

Authors

Howard Wactlar is Vice Provost for Research Computing; Associate Dean, and Alumni Research Professor in the School of Computer Science, Carnegie Mellon University. He earned his degrees in physics from the Massachusetts Institute of Technology and the University of Maryland. He was primary architect and remains project director of the Informedia Digital Video Library and CareMedia projects. The latter applies machine understanding of observed human behavior patterns to healthcare. He was a co-founder of the Software Engineering Institute and directs several research initiatives for defense and intelligence agencies. He holds process patents related to automated video library creation and video search and summarization. His current research centers on multimedia information systems, machine learning and intelligent systems, and their application to improving healthcare.

Robert Walters, P.E.., has been a Professor of Engineering at Penn State University since 1978. He earned his degrees at the University of Pittsburgh and Johns Hopkins. He took a sabbatical in 2001-2002 to establish the Center for Smart Aging to research and develop the concept of using Information Technology in "Smart Houses". This evolved into his present role as Director of Technology for Blueroof Technologies, Inc. He previously worked at the design and development of implantable cardiac pacemakers and communication technologies for the National Security Agency. He has been issued ten US patents and has published in a variety of technical journals.

John Bertoty was an educator for the McKeesport Area School District for 35 years, 26 as an administrator. He received his degrees in education from the California University of Pennsylvania and the University of Pittsburgh. He is a member of the Consumer Electronics Association, Organizational Advisory Board of the Center for Healthy Aging, and the University of Pittsburgh Graduate School of Public Health. John retired in 2002 to start Blueroof Technologies, Inc., a not-for-profit developer of affordable, safe, and accessible homes for the elderly, for which he currently serves as Executive Director.

Alexander Hauptmann is a Senior Systems Scientist in the CMU Computer Science Department and also a faculty member with CMU's Language Technologies Institute. He received his B.A. and M.A. in Psychology from Johns Hopkins University, studied Computer Science at Technische Universitaet Berlin from 1982-1984, and received his Ph.D. in Computer Science from CMU in 1991. His research interests have led him to pursue and combine several different areas: man-machine communication, natural language processing, speech understanding and synthesis, machine learning. He worked on speech and machine translation at CMU from 1984-94, when he joined the Informedia project where he developed the News-on-Demand application and led the evaluation efforts.