An Assessment of Independent Living Deployment Readiness from Social, Political, Economic, and Technological Perspectives

Steve Huseth, John Hajdukiewicz
ACS Advanced Technology Laboratories, Honeywell

Brian Isle
Adventium Labs

Today, nearly one out of four households contain a family caregiver for someone over 50 years of age (MetLife, 2001). Nearly two-thirds of family caregivers work full or part-time, and over half of these caregivers report that they have had to make some sort of workplace accommodation, such as coming in late to work or leaving early, dropping back to part-time, turning down a promotion, choosing early retirement, or giving up work entirely to provide care. A key element in handling this explosion of the need for care is providing new products and services that allow individuals to cost effectively remain self-sufficient and continue to live in their own homes. Technology advances in sensors and communications has long promised to provide some of these capabilities. However, to date many of these needs remain unmet. We explore several dimensions of this issue looking at obstacles to technology insertion as well as the multiple motivators advocating solutions. We review a taxonomy of several systems that have been deployed into the market space and assess new trends. We conclude with recommendations for research that will drive the development of these enabling technologies.

Introduction

The cost of assisted living and nursing home care for the elderly combined with the shortage of professional caregivers is forcing the healthcare industry to explore alternative approaches to eldercare. This search for lower cost alternatives will become increasingly urgent in the near future as the baby boom generation in the US joins the population of elderly people. An attractive alternative is the application of technology to assist and aid elderly persons *in their homes,* making it possible for them to live independently for a longer period of time.

A number of studies have sought to examine this question (e.g., Mynatt & Rogers, 2002). We have been involved in one such study using the Independent Life-Style Assistant (ILSA) prototype which monitors the daily activities of elders through a variety of sensors to identify functional decline as an indicator of imminent health concerns. Caregivers use the Internet, telephone, and email technologies to check the status of the elders under their care at any time, while the system can self-generate alerts via telephone and email with important elder status updates. By alerting caregivers to potential health concerns, ILSA hopes to prolong elder independence at home and improve caregiver effectiveness and experience. From our research, we have discovered numerous obstacles to creating such a system where technology is only one of the challenges. The ILSA prototype system is more completely described in (Haigh, Phelps, & Geib, 2002; Haigh & Yanco, 2002; Miller, 2001).

In this paper, we explore a number of dimensions of providing technology to improve the efficiency of caregivers and enable elders to remain longer in their own homes. The need is very great but the obstacles are also significant. As with any new market, the solutions are varied and disjoint. We discuss our perspectives developed from our research and examine a number of promising solutions that we hope will point the way into this emerging marketplace. Finally, we provide views on the next steps needed to enable independent living.

Obstacles to Technology in Caring for the Elderly

Technology has long promised to enable elders to postpone moving into institutional settings by providing more convenience, safety, mobility, and communication. But in many ways, technical solutions are often at odds with a number of other important needs.

Need for privacy: Providing a system such as the one we have developed offers a great deal of information on the health, well-being, and personal habits of the patient. The accuracy and timeliness of the information is directly proportional to the amount and frequency of information collected. Having such a wealth of information on a particular individual is clearly a significant privacy concern. Although the use of the information is ostensibly to allow the patient to remain longer in their own home, our experience has shown there is concern about the intrusiveness of the system, particularly by family members of the elder.

Need for socialization: Elders that need additional care to live in their own homes often live alone and are not able to get out to meet other people. Visits by a caregiver can be important as much from a socialization perspective as from a care-giving perspective. Care for the elderly is a "high touch" environment and technology cannot result in reducing contact with other people. Although the system is able to monitor the health, well-being, and safety of the elder, the need for adequate human contact and socialization must also be met.

Need to augment deteriorating capabilities: As a person ages, several capabilities a person uses to live on their own must be augmented or replaced. The most significant of these can be loosely collected into 4 categories: *loss of hearing*, *loss of eyesight, loss of mobility*, and *deterioration of cognitive abilities*. Successful technology offerings must address one or more of these areas and be usable, useful, and rewarding, for a reasonable cost and benefit. Many obstacles encountered by an elder as a result of deteriorating capabilities can be addressed by specific point solutions. However, the cost of addressing all the obstacles the elder faces to enable them to remain longer in their own home can be cost prohibitive.

Framework for Motivating a Solution

As with many emerging markets, the list of solutions and approaches that are available is significant. However, unique to this market is the broad set of interested parties pursuing solutions motivated by social and political needs, economic market opportunities, and emerging technology changes.

Social and Political Motivations

Over the last two decades, great advances in technology and medical care have created enormous opportunities for enabling better health and assisting care delivery. Driving these advances is America's demand for higher quality, efficient, and effective care that will enable people to be *mobile*, *independent*, and *healthy* throughout their lives.

As a result of these efforts, people are living longer. While this is clearly a national, political, and social objective, this will increasingly put pressure on the health care systems of developed countries. There are three reasons for this:

1) First, health care costs for the elderly are proportionately higher per individual compared with younger people because they typically require more medical treatment and health management. This will be a significant contributor to rising overall health care costs, currently at 14% of GDP and projected to increase by 0.3% annually (Smith, 1998; Levitt, 2002).

2) Second, a significant demographic trend points to an aging population. Baby boomers are just starting to reach the retirement age. In the next few decades the number and relative proportion of this demographic group compared with the entire population will be rising (Foot & Stoffman, 2000).

3) Third, because of the shift in demographics, key resources that are needed to satisfy an increasing demand for health and assisted care will be decreasing relative to the population, because many of these professionals are part of the group that is set to retire. This will place significant strain on households to keep the elderly at home. It is projected that by 2030, 50% of households will have someone who will require a caregiver (Robert Wood Johnson Foundation, 1996).

These facts point to significant challenges for sustaining effective health and assisted care with limited financial and caregiver resources. Federal, State, and local government agencies are motivated to find solutions through public policy and publicly funded programs.

Economic Motivations

One of the more distinguishing questions that define new products and services to assist the elderly is "who pays?" There are at least four groups that would be interested in paying for solutions. First, elders desire to postpone moving to an institutional setting and have a significant amount of economic motivation to invest in assistive devices. Second, family members have historically spent large amounts of time and resources taking care of their aging parents (MetLife, 2001) and have significant interest in simplifying care and making it more accessible. Third, healthcare and insurance companies are following developments in this area for its potential to offset the high costs of institutionalized care. Fourth, the government is interested in developments in the area as a way to maintain or enhance elderly care and safety, while managing the escalation of health care costs through Medicare and Medicaid.

Each of these groups has shown significant interest in trying and evaluating new solutions. This has lead to a diverse marketplace without any clear winners.

It has been our experience that many of these new technology-oriented products in the market can be placed into one of two categories: low-cost/low-value systems that are typically point solutions addressing a single issue, and high cost/high value systems that

provide a number of features but at significant installed cost. Our research has shown very few systems in the middle.

Low-cost/low value systems are often single purpose and customer installed. Many of these kinds of devices can be complicated and difficult to install. Consequently, they often rely on the "brother-in-law installation" approach where some limited level of technical capability is required and is assumed to come from a family member or close friend. These kinds of devices offer simplicity at the expense of completeness of the solution. The failure rate for these systems can be relatively high for multiple reasons including power failures, accidental disconnections, and battery failures. Without continuous monitoring of the system, the reliability is difficult to determine, particularly years after it has been first installed.

High-cost/high value systems typically consist of expanded home security monitoring systems and physically assistive devices such as elevators and lifters that require professional installation and configuration. Security systems can be configured with a number of sensors and information collection devices that range from motion and location sensors to more sophisticated video cameras, medical monitoring sensors, and accident alarming devices. The extent to which the necessary devices and sensors are built into the home during home construction has a major impact on the capability and cost of the overall system. Institutions and planned communities that can standardize the design and construction of a system can have a significant advantage in offering these types of systems over retrofitting existing homes.

Professionally installed security systems already provide a great deal of information about the activities in the home. By introducing additional information sensing and processing, the ability to passively capture certain activity patterns such as eating, toileting, medicine schedule compliance, health monitoring, and gait speed becomes possible. This approach has been used with our ILSA prototype system which has proven to be quite successful. Our experiments have shown that while a system can be highly robust at sensing critical alarms, the required fidelity of the information for assessing other factors of well-being such as medication compliance and activity levels is more difficult.

Technical Motivations

With the dramatic reduction in the cost of consumer electronics and sensor technology, the development of intelligent devices capable of sensing emergency situations, medical conditions, and deteriorating or missed behaviors becomes feasible. The availability of low-cost display devices and radio-frequency (RF) connected handheld devices are then able to provide textual, video, audio, and tactile feedback to the elder. However, the real value of these systems is in their ability to communicate outside the home to a caregiver or emergency service.

Traditionally, these systems use the most common denominator, the telephone, to direct dial into a central communications center. The cost of the call center and the long distance telephone charges makes this a costly option particularly for smaller startup companies; this can also be a significant solution bottleneck (i.e., the call center is the gatekeeper of the system).

A second option is to dial a local Internet Service Provider and send the data through the Internet. This reduces the communication costs but adds complexities of providing adequate data security and privacy of the information transmitted.

A third option, which was used in our ILSA prototype, was to use a broadband connection. In addition to eliminating the costs and complexity of the call center, this also allowed near real-time information transfer. Dial-up connections, whether direct dial or when using a local Internet Service Provider, must respect the use of the telephone line by the elder. This requires minimizing the frequency and duration of the calls that can be made. The use of a broadband always-on connection removes this limitation. We have found that the availability and reliability of broadband varies widely across the country; however, its advantages are clear. Immediate access by the caregiver and family member to up-to-date information significantly enhances the value of the system. We also found the complexity of the in-home device could be significantly simplified by not having to manage the telephone connection resulting in a lower cost system.

Analysis of Current Industry Offerings

Sensing and Alarming

The most successfully implemented products that assist elderly patients to live independently are those that allow the person to quickly and easily obtain assistance in emergency situations. These typically take the form of a panic alerting device worn as a pendant or on a wristband. Such devices are typically standard options with most professionally installed security systems or are available as standalone systems. These products successfully alert emergency personnel in the event of a fall or other emergency situation with a high degree of reliability. A critical element of these devices in an emergency situation is being able to quickly establish

contact with a monitoring service agent through a speakerphone.

An example of these kinds of systems is ResponseLink, (www.responselink.com). ResponseLink provides a wall or desk mounted security panel connected to a telephone line. An RF panic-button pendant and smoke alarm provide immediate access to a monitoring station that is able to summon additional help. This product also supports a medication reminder alerting feature and a speakerphone for communicating with operators.

An extension of the sensing and alarming capability is location tracking that is performed by a number of systems using badges and wristbands. GPS receiver technology enables the device to provide precise location information in addition to alarming. For example, Digital Angel (www.digitalangel.net) can be effective in tracking elders prone to wandering and becoming unable to find their way home.

A final area for sensing and alerting is in monitoring medication compliance. E-PILL (www.epill.com) offers products and solutions to monitor medication taking and help patients remember to take medications.

Point to Point Solutions

Point-to-point solutions are where the physician or caregiver provides additional services to monitor or enhance communication with the patient. These solutions can be categorized as low-fidelity and high-fidelity medical monitoring systems that have different infrastructure requirements.

The Health Buddy (www.healthhero.com) is an example of such a low fidelity device which provides a simple display appliance in the patient's home and is used by the patient to answer simple health related questions. The system connects to the caregiver's office through the telephone line to upload a set of answers and download a new set of questions. Such a system allows the caregiver to obtain additional information on the patient's health and catch problems before they become serious health issues. The system requires the caregiver to have a reasonably high level of comfort with technology and the staff to support patients in becoming comfortable with the devices.

Other systems capture and transmit clinical information about the person. For example, the MedStar System from Cybernet Medical (www.cybernetmedical.com) is a low cost home monitoring system for blood pressure, pulse oximetry, and spirometry. Data is transmitted over a phone line to a central server; this data is available to patients and physicians over the Internet. Also, HomMed (www.hommed.com) offers a monitoring system that monitors critical variables of people with chronic illnesses in their homes. HomMed Sentry™ collects and transmits data from the patient using wireless digital pager technology or the phone through an internal modem. HomMed Observer™ receives the data and presents patient information to the care provider. Finally, AvidCare (www.avidcare.com) provides equipment and software for home care of the chronically ill. Their home health monitors provide measurements of weight, blood pressure, blood oxygen, blood glucose, and spirometry. Data is transmitted automatically over phone lines to a central monitoring station or via the Internet to a data center.

Higher-fidelity systems are available that capture more sophisticated clinical information. For example, Andromed (www.andromed.com) offers a home telemedicine system designed to provide a continuous collection of patient data such as pulmonary artery pressure, pulmonary ventilation, breathing regularity, graphical presentation of cardiac sounds, and electrocardiographs. Data are collected from noninvasive sensors that patients wear while conducting day-to-day activities. A wireless system transfers the data to a base unit that transfers the information through high-speed DSL lines to a telemonitoring center. Physicians can access this data from the Internet Also, FireLogic (www.firelogic.com) is building an infrastructure for internet-enabled health data, providing a suite of web and wireless enabled applications to manage, gather, store, track, and chart vital health data. One of their current offerings, HealthEngage Asthma, provides asthma sufferers and providers the ability to collect, store, and chart peak flow readings, medications, personal diaries, and other health information.

Assistive Devices

Physically assistive devices range from elevators and battery-powered wheel chairs to lifting devices and electric door openers. These devices provide a focused capability and can offer significant value for addressing specific disabilities. The principal disadvantage of these devices is their high cost and limited ability to address a spectrum of home care issues. A number of companies provide these devices. For example, Redman Power Chair (www.redmanpowerchair.com) builds battery-powered wheel chairs for mobility, and also brings a person from a sitting to standing position. Whitaker builds stair lifts (www.stairlift.com) that move people from one floor of their house to another.

Information Systems and Care Coordination

A category of technology that has yet to emerge is the information systems approach to care coordination. With the increased health care needs of the elder, the number of physicians and caregivers the patient interacts with

can be significant. Coordination of the treatments, diagnoses, and prescribed needs should be shared among all the individuals participating in the patients care, including the patient. There are three examples of companies that are starting to fulfill this need. First, CyberCare (www.cyber-care.net) offers products and network-based telehealth solutions, including remote monitoring and real-time interactive communications between the chronically ill and their providers. Second, Homecom (www.carelink1.com) provides products and solutions for 24 hour a day Health and Wellness Centers where nurses handle information and advise local providers on intervention requirements. Third, Beyond Speech Therapy (www.beyondspeechtherapy.com) offers a customized on-line Internet application for speech. Hospitals, home care companies, and other providers can implement speech therapy programs in a cost effective manner.

Internet Medical Information Sites

A category of independent living technology that is gaining in interest is information-based services, including web sites. These sites provide a range of services from finding a physician to providing basic health related information. These kinds of web sites can be invaluable to people with limited mobility and access to outside information. A certain comfort level with browsing the Internet and using a computer is required. However, as Internet access becomes more common place, these kinds of services can be expected to grow as well. WebMD (www.webmd.com) is one of the most popular health and medical information web sites, providing medical information on a wide range of topics. Eldernet (www.eldernet.com) provides seniors with health, housing, financial, retirement, and lifestyles information.

Proposed Next Steps for Independent Living Deployment

There are four major areas that need to be addressed to enable the current fragmented solutions to evolve and mature. We describe the needs from the perspective of the care recipient, the companies developing product and services, the care provider, and the Government.

Needs of Care Recipient

Until the next generation of elders arrive that are comfortable with computers and complex devices, the elder community as a group is technology averse. Consequently, the technology supporting the device or service must be unobtrusive and easy to use. This requires an adaptable user interface that can meet the changing needs for the elderly.

In the ILSA experiment, we made use of a WebPad, an untethered web interface with a touch sensitive screen to display key information to the elder and allow the elder to control certain aspects of the ILSA prototype system. This graphical web-based interface provided a high degree of flexibility for the research team to experiment with how best to design interfaces for the elderly. Key elements included the use oversized selection buttons which allowed the use of fingers rather than a stylus, and the careful use of color to make the screen easy to read. The amount of information contained on any one screen was reduced several times to provide only the most relevant information and create a non-technical, uncomplicated look. A key element in the design was to ensure that the user was able to easily recover from any mistakes. Fear of pushing the wrong button and not being able to reverse the selection has been highlighted as one of the principal concerns in using the system. We found that the WebPad interface was quite well received and provides promise of a successful approach to remotely interact with the elderly. The flexibility of the interface allows it to be customized to the individual person with respect to eye sight, comprehension, and manual dexterity. It also provides an ideal platform to connect a variety of other subsystems we were not able to evaluate such as video conferencing and various entertainment applications that could increase the perception of “high touch”.

Other more familiar devices were also used including the telephone for alerts and reminders and a panic button for emergencies; the panic button was not integrated with the ILSA prototype but was available to the elder from another provider. The television was assessed as an excellent alternative interface that would be familiar and comfortable to most elders and could be used to display reminders and alerts. It was not included in our experiments due to the complexity of providing this kind of capability with existing televisions.

From these experiences, it was clear that any device brought into the home must be extremely easy to use and easy to install. The need for professional installation significantly increases the cost of the system and may make the system unaffordable to many elders limiting the size of the market that can be reached.

Needs of Companies Developing Products and Services

A plethora of sensing and monitoring devices that are available to assist with the care of elderly are emerging rapidly. One of the most significant obstacles in the development of these devices is how to transfer the information collected to a doctor, caregiver, or monitoring station outside the home. As these devices proliferate, the conflicts arising from multiple devices in the home using the same telephone line are significant. In addition, communication occurring over the Internet

raises significant privacy issues that also must be addressed individually by each product supplier.

The solution we suggest is a common medical communication infrastructure providing a high degree of availability and integrity that can be shared by multiple device suppliers and significantly simplify the process of bringing new products to market. The communication architecture used must be cost effective and provide a spectrum of interfaces for both high and low bandwidth applications.

Many of the home devices for the elderly, particularly medical monitoring equipment, are required to be small, often battery operated, and mobile. Communication though a telephone connection or a wired broadband connection is often not possible. The solution typically implemented is to use RF to connect to a gateway that can be connected to the telephone line or broadband. However, the proliferation of gateways in the home is also not an acceptable solution. A common gateway that can be used by a variety of device manufacturers is required and must be part of the common communication solution.

Needs of Caregivers

Caregivers require tools and applications that will allow them to assess the specific needs of the care recipient, plan and schedule effective care, document progress and activity, and coordinate care across different providers. Once the information from the elder has been captured and transmitted to a central site for analysis, the organization and presentation of the information to the caregiver can be accomplished easily. However, a consistent and appropriate user interface is needed that can be tailored to a variety of physical platforms from standard PCs to portable cell phones and handheld computers. Caregivers are in many work settings and are typically not able to easily obtain client information from a standard PC. The use of a variety of mobile platforms will significantly increase the value of the system. Finally, communication to these devices must be always available, reliable, and secure.

Needs of Government

The government will play an increasing role to ensure the elderly are properly cared for, and that privacy and safety are maintained. Regulatory agencies, such as the FDA (Food & Drug Administration), will increasingly mandate that mechanisms be in place to ensure any solution and infrastructure minimize risks to public health. In addition, any infrastructure must support information privacy and HIPAA (Health Insurance Portability and Accountability Act) compliance.

Acknowledgements

This work was performed under the support of the U.S. Department of Commerce, National Institute of Standards and Technology, Advanced Technology Program Cooperative Agreement #70NANBOH3020.

Conclusions

Demographics point to a significant growth of the elder population over the next three decades. As these changes occur, both elders and their caregivers stand to benefit from the technologies we have described. This will allow the elder to live more independently in their own home. It will also allow the caregiver to remain a productive member of the work force which is desperately needed to mitigate the increasing costs of an expanding elder population.

It is our conclusion that research into flexible, easy to use user interfaces for the elderly, effective presentation and organization applications for the caregiver accessible from a variety of mobile platforms, and a robust, reliable, HIPAA-compliant communication infrastructure will be lynchpins in the development of breakthroughs for new products and services.

References

D. K. Foot & D. Stoffman. (1998). *Boom, Bust, & Echo 2000*. Macfarlane, Water & Ross: Toronto.

K. Z. Haigh, John Phelps and Christopher W. Geib. An Open Agent Architecture for Assisting Elder Independence. *The First International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS)*. July 2002.

K. Z. Haigh & H. Yanco. Automation as Caregiver: A Survey of Issues and Technologies, in *AAAI-02 Workshop on Automation as Caregiver: The Role of Intelligent Technology in Elder Care*, July 2002.

K. Levitt et al. (2002). *Inflation spurs health spending in 2000*. Health Affairs, Jan/Feb 2002 (on-line).

MetLife. *The MetLife Study of Employed Caregivers: Does Long Term Care Insurance Make A difference?*, National Alliance for Caregiving and LifePlans, Inc., March 2001

C. A. Miller. (2001) Automation as Caregiver; The Role of Advanced Technologies in ElderCare. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, Minneapolis, MN October 8-12, 2001.

E. D. Mynatt & W. A. Rogers (2002). Developing technology to support the functional independence of older adults. *Ageing International*, 2002.

S. Smith et al. (1998). *The Next Ten Years of Health Spending*. Health Affairs 17, 1281-40.

Robert Wood Johnson Foundation (1996). *Chronic Care in America: A 21st Century Challenge.* Eatontown, NJ.