Abstract—We report here the development and initial test of a novel system for the virtual support of in-home family caregivers of Alzheimer's disease patients. Based upon information and communications technology, the system includes 1) a pocket computer for reminders, monitoring of events and behaviors, and information support; and 2) an integrated web page which updates automatically with information from the pocket computer. Local and remote family and friends can track the in-home activities through the weblog and provide virtual support to the caregiver. Through a series of interviews and laboratory tests we have developed and refined the proprietary interface which maximizes the usability of the pocket computer by older adults. The considerations that shaped the interface are presented, and the appearance and operation are described. When implemented, this system will facilitate aging in place for both caregiver and patient while also enhancing direct and virtual interactions with family and friends.

Index Terms—Aging in Place, Assistive Technology, Coordinated Healthcare Systems, Gerotechnology, PocketPC, Usability.

I. INTRODUCTION

In recent decades, extraordinary societal changes in the U.S. have taken place from both human and technological perspectives. Life expectancy continues to increase due to both improvements in medical care and technology. The baby boomer generation, now turning middle age, is expanding significantly whereby one turns 50 years old every seven seconds [1]. Older adults, 65 years plus, comprise about 12.4% of the U.S. population with about one in every eight Americans being in this age group [2]. By 2030, the percentage will have increased to 20% of the total population representing twice the number as in 2000. Those 85 years and older represent the fastest growing group [3].

Older adults in the United States not only are living longer but many are staying in their homes without institutionalized care. The U.S. Bureau of the Census [4] has reported that more than 55% of older adults live at home with their spouse. The number of adults living without a spouse increases with age with about 50% of women aged 75 years and older living alone at home. Many older adults prefer to age in place rather than in an assisted living facility [5] citing independence and social interaction as being critical to well-being [6]. Many older adults require long-term care due to diseases associated with aging. About 7 million older adults over 65 years have mobility or self-care limitations [2].

A side-effect of the rapidly expanding older adult population is a significant increase in caregiving responsibilities typically performed by family and friends. Fifty-seven percent of the adult population in the U.S. is currently providing or has provided unpaid caregiving services to family or friends. In addition, 80% of all long-term care services are performed by family caregivers [7]. Other societal trends compound the burden placed on these unpaid caregivers. By 2030, the average number of children per family will be about 2 compared to 3 in 1990 [4]. Smaller family sizes along with geographically dispersed family members make it difficult to provide long-term care without some type of external support system. These demographic trends highlight the need for innovative support systems for family members and their caregivers.

The U.S. Administration on Aging [8] defines assistive technology as being any service or tool that helps the elderly or disabled do the activities they have always done but must now do differently. This includes communication equipment, computer access, tools for independent living, education, and mobility aids, among others. These technologies often determine whether an older adult is able to live independently or must move to an institutionalized environment. The National Council on Disability [9] found that 80% of older adults who used assistive technology were able to reduce their dependence on others. Assistive technologies not only support the aging adult, but also the family and friend caregivers. Most often, devices that increase the independence of an older adult will decrease the time required for caregiving assistance [10]. Assistive technology and home modifications have been found to provide caregivers immediate relief, reduce their stress and help them provide care more easily and safely [11].

The use of assistive technology to support the elderly and his or her caregiver network has recently been expanded to include information and communication technologies (ICT). Emerging technologies, sensors and other information gathering devices, used in the home provide an opportunity to improve independence and safety thus promoting aging in place initiatives [12]. The Internet along with online information sources offer a means for older adults to engage in lifelong learning and healthcare management thus promoting quality of life while aging in place. Advances in wireless and wired communication provide the technology for home monitoring systems, social interaction, and the potential for...
virtual support systems linking an older adult to geographically dispersed family and friends.

This paper provides an overview of our research on the use of ICT in providing an older adult, sixty years plus, assistive technology within the context of a virtual network of support. A proposed framework builds upon past research in computer coordinated care systems, for which an overview is provided in Section 2. Section 3 provides a brief description of each component in the proposed framework. A user profile is presented in Section 4 as a basis for designing the PocketPC component of the framework to be used by an aging caregiver. The proprietary interface to the PocketPC is described in Section 5 followed by a summary of initial feedback. The paper concludes with an overview of future research.

II. RELATED RESEARCH

Recently, technology solutions have been proposed that would promote a support network for an older adult living at home. The Digital Family Portrait [13] and the CareNet Display [14]-[15], in particular, focus on the use of ICT to share information about an older adult with family and friends in the support network. Both of these projects utilize ambient displays as a means of information monitoring of an older adult by members of his or her support network. Ambient technology requires minimal perceptual bandwidth such that the family or friend can view changes that occurred through a quick glance at the device [16].

Both projects propose to use sensor devices strategically placed in the older adult’s home. The devices gather data that are made electronically accessible via the ambient displays. Sensor technology is becoming popular because it is considered unobtrusive. There is little or no technological intervention by the older adult in the data gathering process [17]. Those older adults with few or no technology skills could still be observed by members of the support network.

However, sensor technology is considered invasive in that the older adult has no control over the data being gathered. There is the risk of data manipulation when the older adult selectively avoids the sensors. In addition, the older adult cannot spontaneously record information about an event or behavior that occurred. He or she is unable to use the technology for social interaction or any type of interactive caregiving support.

The Digital Family Portrait project, part of Georgia Tech’s Aware Home Research Initiative (www.awarehome.gatech.edu/), connects geographically distant family members to older adults living at home. The technology, when fully developed, would utilize sensors to gather data about the older adult’s health, relationships, and activities. This information would be shared electronically via the ambient display placed in the distant relative’s home. The ambient display, presented as a digital picture frame, has a border of icons that provides user access to detailed information. The information presented to the user is similar to information typically observed by a neighbor or another member living in the older adult’s household [13].

The CareNet Display project, developed by Intel Research Seattle, is similar to the Digital Family Portrait in that it uses the concepts of ambient display and home sensors to build a support network [14]. The ambient display, an interactive digital picture frame, provides information to a support network regarding the status of meals, medications, outings, activities, mood, falls, and schedules. The ambient display allows the user to view an older adult’s daily activities and interactively access data through touch screen capability providing detailed information associated with an icon.

There are several distinctions between the two research projects. The CareNet Display, unlike the Digital Family Portrait, allows for the sharing of sensitive data regarding medication and activities performed. The older adult would control who has shared access to this type of personal information. The CareNet Display allows for the sharing of data about other members in the support network through the use of the proposed technology. It also places more emphasis on building a local support network, though distant members can be part of it.

These projects hold great promise in developing a support network for an aging family member; however, there are several areas that require further research. To date, neither of these projects has been fully implemented in a support network to assess their viability from both the perspectives of the older adult participant and members of his or her support network. Data are manually gathered through phone calls in order to update the ambient displays, though the actual system is intended to electronically transmit data from sensors. The use of sensors in the home may be viewed as invasive by an older adult given the lack of control over data gathered by the devices. Further study would be needed to uncover potential resistance from the older adult being monitored.

A third project proposes the use of ICT by an older adult as a means of building a support network. As an outgrowth of the Archimedes Project at the University of Hawaii, the Ho’alauna (“Good Neighbor”) Tablet project utilizes ICT to assist with nutrition, healthcare, financial management, and leisure activities, among others [18]. It is proposed that a TabletPC along with specialized software supported by Internet access assist older adults living at home to interact socially with family and friends, search the web, control home technology, receive emergency information and assistance, track health-related information, and participate in community events, social activities, and educational programs.

Several unique aspects of this proposed network of support emerge when comparing it to the previous projects. Unlike the Digital Family Portrait and the CareNet Display network support systems, the Ho’alauna utilizes obtrusive technology in that the older adult uses the TabletPC to provide data to the support network. The user interface of the Ho’alauna Tablet has large on-screen buttons to account for normal aging factors, separate emergency buttons for fast response times, and a rotary knob to make selections taking into account interface designs commonly used by older generations. The network support components focus on the needs of the older adult to minimize the isolation often experienced when living at home. Similar to the other projects, this technology is in the
development phase with little information provided about its actual use by an older adult and his or her support network.

III. VIRTUAL NETWORK OF SUPPORT

A significant difference between the Buddy Coordinated Healthcare System (BCHS) and the previously described projects is technological support for an older adult taking care of a chronically-ill loved one. Specifically, we focus on older adult caregivers of Alzheimer’s disease (AD) sufferers. There are more than 4 million older adults in the U.S. suffering from cognitive impairments due to Alzheimer’s disease [19], and most live at home with an aging caregiver. Caregivers endure increasing emotional and physical stress, as they assume responsibilities that include managing daily routines and making important medical decisions [20]. Due to these responsibilities, caregivers become increasingly homebound and isolated as the disease progresses.

The primary objective of our research is to provide lifelong engagement for the aging caregiver through the use of a virtual support network. Lifelong engagement can be viewed as instrumental in allaying the onset of isolation, depression, and cognitive disabilities for older adults [12]. To accomplish this objective, it is proposed that handheld technology be used by the aging adult to assist in caregiving activities and monitor the well-being of both the caregiver and his or her loved one. A handheld device, in the form of a PocketPC, would provide the capability to unobtrusively link to the Internet thus sharing information via a family and friend web site.

A secondary objective of our research is to link electronically family and friends to the aging family members in order to foster sharing of the responsibilities associated with caregiving. Too often, family and friends are not as actively involved as they would like to be due to geographic distance, work, children, and other commitments. Through the use of our proposed BCHS framework, members of a support network can be distant or local. Regardless of geographic location, they can be involved actively in the daily life of the caregiver and his or her chronically-ill loved one.

In addition to PocketPC technology, our virtual network of support utilizes database, communication, and web technologies in the BCHS framework shown in Figure 1. Each component in the framework is briefly described.

**PocketPC Technology** – The PocketPC technology, called PocketBuddy, is used by an older adult caregiver. Though the current version of PocketBuddy targets the caregiver of an AD loved one, it could also be adapted for use by an older adult living alone or caregiving for a loved one with other chronic illnesses or aging impairments. PocketBuddy is used to record patient behaviors and the emotional well-being of the caregiver, document daily activities and events, schedule appointments and personal events, manage medication, and provide for social interaction, among other features.

**Database Technology** – BCHS has two database components to support the caregiver and members of the family and friends network. PocketBuddy contains a localized version of the central database and it is used to store data entered by the caregiver. The central database stores the most recent data as well as historical data that have been gathered on the PocketBuddy. Today’s data can be shared in detail with the support network through the family and friend Web site (referred to as the “BuddyBlog”). Historical data can be mined for health and safety trends associated with both the caregiver and the loved one for whom care is provided. The BuddyBlog would provide controlled access to data such that members collectively can make decisions related to the well-being of both the caregiver and the loved one.

Both databases require transparent synchronization such that data are merged correctly to maintain integrity. This must be accomplished with no intervention by the aging caregiver or members of the support network. For example, the shared calendar feature would require the merging of data from PocketBuddy and the BuddyBlog such that neither the caregiver nor a member of the support network overwrites a previously scheduled event with a new one.

**Communication Technology** – A unique aspect of the proposed framework is the use of the Internet to retrieve PocketBuddy data. The older adult caregiver does not have to be familiar with Internet use nor have any type of web experience. What is needed, however, is network access through a traditional telephone line or cable service. A server connects to the PocketPC device through a wireless modem placed in the home. As a result, data is transmitted to the server unobtrusively in order to share it with members of the support network. Email and text messaging capabilities, optional components of PocketBuddy, are simplified.

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1 The term “loved one” is used generically in this paper to represent the person for which care is being provided. The chronically ill individual could be a spouse, significant other, relative or friend.
messages are transmitted along with other PocketBuddy data when an Internet connection is made by the server. Though messaging is not real-time, there is still the capability of sending and receiving email through the PocketBuddy interface.

**Web Technology** - There are two web interfaces associated with BCHS both of which are made available to the caregiver’s support network. One interface allows for the customization of PocketBuddy (e.g., entering new or revised prescriptions and instructions for taking them). The other is the BuddyBlog providing daily information about the caregiver and loved one retrieved from the PocketBuddy database. The customized blog provides summary data about the day’s events (e.g., Dad went to day care. Mom had a doctor’s appointment at 3 pm.), the caregiver’s well-being (e.g., Mom rated the day as “Fair” and felt “Tired”) and the patient’s behaviors (e.g., Dad experienced “sundowning” and was “hiding objects”), among other data.

There are several features that promote collective interaction among members of the support network. There is a input box that allows for posting shared comments about data displayed on the BuddyBlog (e.g., “Sue, will you be able to help Dad tomorrow evening? I have a deadline at work.”) There is also a shared calendar feature that reflects the caregiver’s scheduled events via the PocketBuddy. It also displays those events scheduled by members of the support network.

IV. **OLDER ADULT PROFILE**

Perhaps the most innovative component of BCHS is the use of a PocketPC in providing a link to a “day in the life” of the caregiver to family and friends in the support network. Because of the obtrusive nature of the technology, it would be important to design the PocketPC interface to meet the usability needs of an older adult. Other researchers have recognized normal aging factors as posing potential barriers to the use of technology [21]-[23]. It is important, therefore, to account for normal aging and the impact on user interface designs including handheld devices.

The authors [24] composed an older adult profile as a basis for assessing the usability needs of older adults in the use of handheld technology. Normal aging factors play a significant role in the usability of technology given the degradation in vision and hearing, physical impairments in the hands and fingers, and cognitive decline. Each of these aging factors is briefly described to gain an understanding of the potential impact on technology use.

1) **Vision** - The aging eye has a reduced ability to focus on close objects due to a reduction in the elasticity in the lens. There is a decline in visual acuity affecting the ability to see objects clearly. The lens of the eye yellows and thickens thus impacting color perception. There is decreased light sensitivity affecting adaptation to changes in light levels, and increased sensitivity to glare from light reflecting into the eye. Depth perception is reduced making it more difficult to judge the distance of an object [25].

2) **Hearing** - There are several changes in both the outer and inner ear that are age-related thus impacting the ability to hear sounds. Age-related loss of sensitivity is especially pronounced for high-frequency sounds ([26]; as cited in [27]). The aging process is responsible for a lessening discrimination of similar sounds that may differ in intensity or frequency. In addition, Olsho et al. [28] found that older adults may have problems with object localization with low frequency sounds.

3) **Cognition** - There are several cognitive factors to take into account when designing technology for older adult users. These include problem solving, working memory, attention, and concept formation. An aging adult’s performance on working memory tasks declines with age, with a reduced ability to discern details in the presence of distracting information [29].

4) **Other Psychological Factors** - In addition to the cognitive changes that occur as a function of normal aging, there are many psychological aspects of aging that may impact usability assessments. For example, the style of coping with stressors change with age, from the problem solving approaches common in early and middle adulthood, to a more emotional-focused style. Such a style tends to be more passive, and with many older adults can result in simple acceptance of what seems to be a final reality as opposed to manipulation of the environment [30].

With the older family caregivers involved in the present project, the stresses attendant upon the caregiving role result in severe strain on already changing coping resources. Thus, any added behaviors of a technical or mechanical nature are likely to exacerbate the cognitive demand, and may require other interface characteristics to be enhanced. For example, a man caring for his wife (who is beset with AD) may be attending to basic needs of the individual and the home for much of the day. Adding a new task, such as interacting with the PocketPC, increases burden and stress.

5) **Motor Skills** - Older adults have decreased motor coordination such that it becomes difficult moving and clicking on a screen. For those who have a chronic disease such as arthritis, using a mouse or stylus may be difficult in manipulating interface objects. An older adult typically takes longer to complete a movement than younger adults [31], and movements tend to be less smooth and less coordinated [32].

7) **Technology Skills** – Eisma et al. [33] point out that for many seniors computer-related technology isn’t a regular part of the everyday life. Though computer use is growing in popularity for this user group, there are still many who have had limited exposure to newer technologies including handheld devices. Technology to older adults may have meaning in terms of fax and copiers, answering machines, and VCRs but lack understanding when mentioning the web, personal computer, or a PocketPC.

V. **USER INTERFACE DESIGN OF A POCKETPC**

The PocketPC is used in this project because it is relatively inexpensive, lightweight, and portable with the potential for both wireless and wired communication capability. It offers multimodal capabilities such that audio can be used to support textual display of information. It has a landscape mode for horizontal presentation of screen objects and information.
It is important to note that the impetus of our work can be promoting usability of the PocketBuddy component of BCHS. The electronic Pocket Assistant (SePA2) is proposed as a means of research, a unique user interface design called the Senior account normal aging factors. As an outgrowth of our above. To address this need, we have initiated a study of specifically designed for seniors.

Supporting a medication-reminder program that was conducted by Siek et. al. [34], it was found that there was little great promise in their use by older adults. In a study Personal Digital Assistants (PDAs) and PocketPCs, shows accommodation older adult usability. Alternative user interface designs for the PocketPC in order to accommodate older adult usability.

Because of these limitations, researchers have been cautioned about older adult usability and the PocketPC [34]. Many of the built-in features of the PocketPC may be considered difficult if not impossible to use when taking into account normal aging factors. It would be essential to create alternative user interface designs for the PocketPC in order to accommodate older adult usability.

Initial research in the use of handheld devices, including Personal Digital Assistants (PDAs) and PocketPCs, shows great promise in their use by older adults. In a study conducted by Siek et. al. [34], it was found that there was little difference in performance between older and younger users of PDAs. This was the case when physically interacting with the devices and in completing both conventional (press button, view icon) and nonconventional (scan bar code) tasks. Sterns [35] studied the use of PDAs by older adults as a memory aid, organizational tool, and communication device. It was found that the technology could be used readily by older adults in supporting a medication-reminder program that was specifically designed for seniors.

Clearly more research is needed than the initial studies cited above. To address this need, we have initiated a study of innovative user interface designs for the PocketPC taking into account normal aging factors. As an outgrowth of our research, a unique user interface design called the Senior electronic Pocket Assistant (SePA2) is proposed as a means of promoting usability of the PocketBuddy component of BCHS. It is important to note that the impetus of our work can be attributed to the design recommendations for senior-friendly web sites put forth by the U.S. National Institute on Aging [36]. The basis for these guidelines is significant research on the use of web technology by older adults. (A summary of this research is found in [37].) These guidelines propose that the good use of color and appropriate font sizes and styles improve web usability by older adult citizens. These and other guidelines have been incorporated into SePA when it made sense to do so.

Software applications that are part of the PocketPC operating system (e.g. Microsoft Word or Excel) are not available on PocketBuddy. SePA applications are the only ones accessible on PocketBuddy in order to directly support caregiving activities. (Figure 2 shows the Main Menu screen used to access PocketBuddy applications.) There are two major reasons for this design approach. First, the older adult does not have to be familiar with a Windows-based operating system in order to use PocketBuddy. Thus, the complexity associated with using the desktop features and navigational structure of the Windows operating system are eliminated. The second reason concerns the input mechanism associated with using PocketPC applications. The existing software applications, as part of the Windows Mobile™ 5.0 interface, most often require the use of the stylus pen for navigation, object selection, and data entry. The stylus pen, provided with the PocketPC, is very small in both diameter and length. As such, it is difficult to use when accounting for degradation of vision and motor skills associated with normal aging. By eliminating the need to use a stylus pen, there is less opportunity for losing the input device. In addition, potential usability barriers (e.g., shaky hands prevent the point and click requirement in using the stylus or impaired vision making it difficult to accurately click on objects) are eliminated.

Several of the SePA design features are described with an emphasis on older adult usability.

Landscape Mode – All SePA applications are displayed in landscape mode in order more effectively to use the screen space. To accommodate aging vision and degrading motor skills, the landscape mode allows for larger button sizes with information content displayed using 12, 14, or 16 point font size based upon the user’s selection. In addition, the use of

Figure 2: Main Menu in 12 Point Font

2 Provisional patent pending for SePA and virtual network support system.
landscape mode allows for the device to be held with both hands while using thumb taps to navigate and scroll between SePA screens. (Figure 3 shows the use of landscape mode to display event buttons as part of the Journal feature.)

**Button Lists** – In order to eliminate the need for a tiny scroll bar used to manipulate objects in a list, the SePA interface utilizes an innovative design. A button object is used on the screen to represent each item in the list. The user simply taps on a button to select it. The side navigation bars are used to scroll forward and backward through the list. In the Behaviors list presented in Figure 4, each button represents a behavior that would be used to describe the AD loved one for that particular day. The buttons selections are saved in the local database and will later be shared with members of the support network via the Buddy Blog. More than one button can be selected by tapping on multiple selections. (Figure 4 shows part of a list whereby a left and right nav bar would be used to scroll through it.)

**Finger Taps** – The SePA interface has been designed such that the user taps a button with a finger or thumb in order to activate it. As a cue that a button has successfully been tapped, it turns black in color. When navigating through a list by tapping a side nav bar, the buttons appearing in the list flash once. Thus, an older adult user is provided a cue regarding the display of a new section in the list. The user also has the option of turning on a sound feature associated with each tap of an object. For an older adult who has less than normal sensitivity in his or her fingertips, sound activation provides a cue that the button was successfully tapped.

**Help** - Each screen has a built-in help feature to assist the older adult in using a SePA application. Tapping the question mark button at the top left corner of the PocketBuddy screen provides user access to help information.

**Customized Keyboard** - The SePA interface does not utilize the PocketPC built-in keyboard. Instead, a customized keyboard is used to replicate typewriter technology. The keyboard is displayed in landscape mode in order to enlarge the keys and space bar. Using his or her finger, the user taps on a number, letter, or special key on the keyboard in order to enter a text string. When completed, the user taps once on the enter key and the keyboard disappears. (Figure 5 shows the customized keyboard as part of the SePA interface design.) An optional audio feature simulates the sound of a typewriter as each key is tapped. This SePA application along with a similarly designed calendar feature (not shown in this paper) requires further usability testing to determine the impact of button size when typing information content.

**Font Resizing** – To improve readability, the SePA user interface supports the dynamic resizing of text on each screen with the exception of the keyboard. The user has three choices: 12, 14, and 16 point font sizes. Figure 4 shows the resizing button, “A”, at the top left corner of the screen. The previous illustrations show the use of 12 and 14 point font sizes in the use of PocketBuddy features.

**Multimodal Support** - Figure 6 shows the Options Menu for multimodal settings. For those who have difficulty reading the screen even with a larger font size, there is a text-to-speech component that reads aloud button labels and information content. The Read Menus button on the Options screen allows the user to turn on or off the text-to-speech feature. This feature is still under development in order to offer the user a set of voice options. It would be important for an older adult user to select a voice that is audible and understandable, similar to what is provided in other assistive technologies (e.g., screen reader devices).

As mentioned previously, the user can supplement button
selections with sound as a cue that a button has been tapped successfully. The Audio button on the Options screen allows the user to not only turn sound on or off, but to select tones that would be readily audible to the user. There are various frequencies and sound patterns available to take into account normal hearing loss associated with aging. The Notify button on the Options screen allows for the selection of a tone associated with the firing of an event. A medication reminder, for example, would utilize the Notify tone that has been selected by the user.

![Figure 6: Options Menu in 14 Point Font Size](image)

Other optional settings include a screensaver feature for displaying personal images or pictures when the device is not used for a specified time period. The Color Scheme feature is used to display color options some of which take into account color deficient vision. (The examples presented in this paper use one color scheme set that can readily be changed to another.) The user would select the color scheme that best supports his or her ability to read button labels and information content. The Font Size feature is used to select a default font size for all SePA applications. Button labels and information content can temporarily be resized on a particular screen using the “A” button on the upper left corner.

![Figure 7: A Morning Checklist in 16 Point Font Size](image)

**Generic and Personal Checklists** – The user has the option of using a generic checklist or creating a personal checklist. Figure 7 shows part of a generic morning checklist. This checklist, for example, would be used by the caregiver to ensure the loved one is prepared for attending adult day care. A specific version of a checklist can be saved or discarded, but the checklist can be used over again.

A personal checklist can be created and reused. For example, a caregiver may create a shopping list of items that support caregiving activities. Once created, the list can be edited and used repeatedly on shopping trips.

**VI. USER REQUIREMENTS**

In the early phase of SePA prototyping, informal interviews were held with two caregiver volunteers who will use the BCHS in their homes in an upcoming research activity. The interviewers included a social worker and psychologist who specialize in assisting older adult caregivers, as well as the computer scientists. The objective of the interviews was to identify user requirements specific to meeting the needs of an aging caregiver of an AD loved one. Both caregivers involved in the interview process were male adults over the age of sixty-five. Each is the primary caregiver and lives at home with his spouse. Caregiving activities consume most of the day when the spouse is at home. The user requirements focused on PocketBuddy features to support daily activities and lessen the burden of caregiving responsibilities.

Both caregivers have a break during part of the day when the spouse is in adult day care. During this time, the caregiver can run errands, shop, attend a support group or counseling session, pursue hobbies, rest, socialize online or in person, perform household chores, or pursue other activities. The user requirements associated with daily routines assisted in identifying features that would offer support during the caregiver’s free time.

Using requirements gathered during the interview process and informal discussions with the social worker, PocketBuddy features were enhanced to meet the caregivers needs. The journal component, for example, now includes the recording of daily behaviors associated with Alzheimer’s disease as illustrated in Figure 4. As such, members of the caregiver’s support network can monitor the progression of the disease in the loved one and its impact on the well-being of the caregiver.

The subjects were asked to provide feedback on PocketBuddy features that would support them in performing caregiving activities. The following features were identified as a result of these discussions. Each has been incorporated into the current version of SePA in order for PocketBuddy to provide enhanced support. Some require further research in identifying interface designs and applications that would meet the needs of older adult caregivers.

**Quick Timers** – One of the caregivers pointed out that a useful feature would be a quick timer for checking the completion of laundry and to support other household chores. He found that doing certain chores, such as laundry, is a daily task for which he would like some type of support. Of a more sobering nature, the caregiver plans to use the quick timer to remind him to take his wife to the toilet and change her undergarments. Figure 8 shows the quick timer that was developed to support his request. The interface provides for
three timers that may be set simultaneously.

Generic Caregiving Checklists – Our original prototype had an option for making a personal checklist (e.g., grocery list). In addition to personal ones, the caregivers requested generic checklists that could be used regularly to assist with daily caregiving activities. Before leaving the house for day care, for example, the generic Day Care checklist would be used to ensure that items such as hearing aids, dentures, adult pads, extra pants, and other items were packed. The checklist, illustrated in Figure 7, is another example of a generic list whereby items are checked as part of a morning routine.

Games – One caregiver discussed an ever-increasing stress level as the day progresses. It was requested that electronic games be programmed into the device in order to provide some stress relief when a few minutes became available. These games could be played in short time increments to accommodate the erratic nature of caregiving activities. It was requested that the games be designed to support one or two players in a virtual environment.

Several games are currently under development. To accommodate a subject’s request for Poker, a simple Black Jack game has been designed to be played by one person. PocketBuddy’s lack of real-time Internet capability requires innovative gaming features to support more than one player. Further study is needed to formalize user requirements for this type of gaming environment.

Virtual Support Group – One caregiver requested an electronic support system that would include other caregivers of AD loved ones. These caregivers would also be using PocketBuddy to support daily activities. The electronic support system would be modeled after existing support group structures (e.g., Alcoholics Anonymous) whereby a virtual sponsor is made available for each caregiver. In addition, caregivers would look after one another through electronic interaction. Though a messaging component has been added to PocketBuddy, it doesn’t support these user requirements. The support group feature requires further study in designing an innovative user interface and applications that would provide for virtual intervention.

Future interviews will allow for the gathering of additional user requirements and enhancements to those that have been formalized in SePA applications.

VII. Potential Barriers to Overcome

Several technological and usability issues have been identified during the user-requirements gathering and development phases of the project. Each of these will be addressed in order to minimize or eliminate their impact on older adult usability of PocketPC devices. These are described briefly.

Hardware Button Location – When using the PocketPC in landscape mode, the hardware buttons located on the device can interfere with the SePA applications. During prototype demonstrations and unstructured walkthroughs with older adult volunteers, the inadvertent pushing of these buttons has become a usability issue. One button, for example, activates a voice recording as a built-in feature of the PocketPC. Though there is no direct impact on the usability of PocketBuddy and its SePA applications, data storage is filled with unusable recordings.

The initial design of PocketBuddy utilized hardware buttons to support audio and text-to-speech components. Because of the usability issue associated with the location of hardware buttons, they have been temporarily disabled. Further studies are needed on the good use of hardware buttons as part of the PocketBuddy design.

Screen Smudges – The utilization of finger tapping on the PocketPC is innovative from a usability perspective. An older adult no longer relies on a tiny stylus to manipulate objects and enter data. However, tapping on the PocketPC screen leaves a residue (smudge marks) that would have to be removed on a regular basis. Further study is needed to determine whether this is simply an annoyance or a potential readability barrier during long-term use of PocketBuddy. An alternative design to be studied will incorporate the use of a larger stylus that also serves as a writing device.

Battery Life – The battery life of the PocketPC needs to be taken into consideration in terms of the user charging the battery. This is important in supporting regularly scheduled data transmission from the PocketPC to the central data source as an integral part of network support system. It is also important in ensuring medication and other reminder events consistently fire throughout the day. We propose to train subjects in placing the PocketPC in its cradle or charging the battery when not in use. We are also studying technology solutions to address the battery life issue.

Utility and Long-term Use – Technology is typically used by an older adult when there is some known utility for doing so. Several of the features (e.g., journal entry for both caregiver and loved one) may be perceived by the caregiver as invasive with minimal utility in everyday activities. PocketBuddy is only part of the technology that composes BCHS. As such, it would be critical to the acceptance and use of PocketBuddy to have members of the caregiver support network actively involved in promoting the utility of these features. The design and implementation of the BuddyBlog component is currently underway with these types of usability barriers in mind.
VIII. CONCLUSION AND FUTURE RESEARCH

The emphasis of our research is on providing a virtual support system for aging caregivers and their family and friends. This is made possible by recent technological advances in information systems, telecommunications, and handheld devices. Handheld devices can be used as assistive technologies in aiding daily activities associated with caregiving. Linking these devices to the Internet eliminates time and space boundaries that in the past separated family and friends from older adults living in an isolated environment. As a result, older adults have an unprecedented opportunity to age in place with dignity through virtual connections with family and friends.

The Buddy Coordinated Healthcare System (BCHS), as proposed in our research, utilizes the PocketPC in providing a daily link to activities associated with the caregiving of an AD loved one. PocketBuddy promotes social interaction and medication management for both the aging caregiver and his or her loved one. It allows for the gathering of information, in the form of a journal entry, about the well-being of the caregiver as well as behavioral changes associated with Alzheimer’s disease. This information is shared with family and friends via the BuddyBlog to promote continuous involvement and periodic intervention.

The effective use of PocketBuddy by older adults requires user interface designs and supporting applications that target their needs in order to overcome potential usability barriers. In this paper, we have identified several unique aspects of the PocketBuddy interface that account for aging vision, cognition, motor skills, and hearing. The use of landscape mode, finger tapping, enlarged keyboard, and multimodal support are illustrative of interface components specifically targeting an older adult user.

The SePA applications as part of PocketBuddy are undergoing usability testing in a controlled laboratory setting. Older adult subjects, ranging in age from 65 years to 89 years of age, are actively participating in our studies. The results of this phase of work will provide valuable feedback on potential usability barriers. These changes will be incorporated into the next version of the PocketBuddy design before moving on to the next phase of our research project.

Currently, we are establishing a testing laboratory that will simulate the home use of PocketBuddy as part of the virtual support network. As such, we can identify potential barriers to its use in everyday life and technological glitches that may impact data transmission via dial-up access. Once this phase of work has been completed, we will involve caregivers in the home use of BCHS. A caregiver subject, with an established support network of family and friends, will use PocketBuddy on a daily basis. The family and friends subjects will have controlled access to caregiver data through a personalized BuddyBlog interface. We will study the daily interaction of support members to identify potential barriers to the use of the BuddyBlog. This phase of research will be closely monitored to uncover usability and technology barriers that were not discovered in the laboratory setting.

Future research is needed on improving the utility of PocketBuddy. It would be important to identify additional features that would promote its long-term use by aging caregivers. SePA applications for monitoring other age-related infirmities will be studied as adding utility to PocketBuddy and BCHS. For example, mating a glucometer to PocketBuddy would enable automated monitoring of diabetic conditions. Data would not have to be manually entered into the PocketPC thus freeing time for the caregiver to perform other activities. This data could readily be summarized to be shared with members of the support network.

We also propose to study the integration of other technologies with PocketBuddy. Sensor technology, as described earlier, RFID and GPS autolocation are three examples. Sensors strategically placed in the home of an AD loved one could provide instantaneous feedback on wandering, sundowning, and hiding behaviors. These types of behaviors are difficult to monitor manually especially at the end of the day or when the caregiver is asleep.

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