Accessible Telehealth - Leveraging Consumer-level Technologies and Social Networking Functionalities for Senior Care

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Abstract— **The increasing cost of healthcare represents a serious challenge to most developed countries. Telehealth has been widely promoted as a technology to make healthcare more effective and affordable. However, current telehealth systems suffer from vendor lock-in and high cost, and are designed for managing chronic diseases, rather than preventing them. In this paper we evaluate technologies for supporting senior health consumers. Based on this we propose a framework for a novel telehealth system overcoming many of the shortcomings of existing technologies. The new system is web-based, has a Facebook-like plug-in architecture for adding new health applications, and incorporates social networking functionalities. We discuss the challenges in implementing the system, and summarize a user study evaluating the system. Our results demonstrate that health consumers have a positive view of this new telehealth technology, and that it can positively change the attitude of users towards their health.**

I. INTRODUCTION

The healthcare systems in many developed countries are struggling with an increasing number of elderly people, more chronic diseases affecting them, a shortage of healthcare professionals, and healthcare spending rising faster than GDP [49], [30]. A recent study revealed that the three main emerging issues concerning public health are: providing access to affordable healthcare, solving chronic health problems and preventing diseases [16]. One promising approach to achieve these goals is to empower health consumers to better manage and monitor their health. Home-based healthcare applications can enable users to track their health status and to actively participate in treatment regimes and preventive strategies. In order to impact overall healthcare spending such systems must be widely available and affordable.

In this paper we will review consumer-level health informatics applications and demonstrate their advantages and shortcomings. Based on this we will propose a novel framework for web-based, patient-centric, affordable and extendable telehealth systems and explain in detail the development of a prototype based on this framework. Our implementation uses OpenSocial and Drupal to achieve social networking functionalities and a Facebook-like plug-in architecture for user generated healthcare content. Our user study shows that elderly users welcome the opportunity to become more proactive in managing their health, and that such tools can empower users and give them more control over managing and improving their health.

Section II analyzes current consumer-level health informatics applications. Section III derives requirements for a more patient-centric telehealth system. Section IV presents our framework for a novel telehealth system and Section V and VI explain its design and implementation, respectively. We evaluate our prototype in Section VII and conclude the paper in Section VIII with a summary of our contributions and future work.

II. CONSUMER-LEVEL HEALTH INFORMATICS APPLICATIONS

The most common consumer-level health informatics applications are telehealth systems, health record management systems, health information websites, and exergames.

Telehealth systems consist of vital signs measurement devices and a patient station, which allows interaction between patients and care providers [45]. The patient station can be a mobile phone, a specialized PDA-like device [15], or a sophisticated computing device with a large display allowing video conferencing [2]. The system's clinical interface allows care providers to check individual patient data or to monitor an entire cohort by displaying patient alerts sorted by priority.

Telehealth systems are most commonly employed for patients with chronic diseases where regular vital signs monitoring, such as heart rate, blood pressure, or weight, is necessary. The regular recording of patient data allows early intervention, reduces hospital admissions, and improves patients' quality of life [10]. Further advantages are the ability to reach underserved sections of the population, especially those in remote locations [26], and facilitating "aging in place" rather than in an institution [24]. The main drawback of telehealth systems is their high price. While it is widely accepted that the systems are useful to patients, there is conflicting evidence of their cost effectiveness [48] and there is a reluctance of many funding agencies, e.g. health insurance companies, to cover the costs. Since telehealth systems are part of the formal healthcare system, clinicians owe the same duty of care as with conventional forms of delivery and hence their commitment is crucial [14] and suitable incentives might be necessary. Additional disadvantages are the need for technical support [5], the inability to touch the patient [41], missing patient data such as posture, speech and mental state [18], reduced social contact, and vendor lock-in, which makes it difficult and costly to add new functionalities and content.

Health record management systems allow patients to manage and share their healthcare data (personal health record) [17], [27]. An increasing interest in these systems can be observed by employers, professional health groups, and government agencies. Major software organizations such as Google and Microsoft initially invested heavily in this field because of the promise of attracting a large audience for health-related advertising and services [27]. However, "Google Health" has been permanently discontinued and Microsoft's "HealthVault" [34] is available only at a limited number of jurisdictions. The usual funders of healthcare, e.g., governments and insurance companies, seem reluctant to invest in such systems.

Advantages of personal health records include the empowerment of patients, increased patient safety, improved quality of care, and cost savings by reducing duplicate examinations and improving diagnosis and treatment. Disadvantages are the costs of assembling personal health records from different sources [47], interoperability with existing systems, user concern about privacy [31], and dealing with different legal requirements (privacy, security, etc.) in different jurisdictions [17]. A recent comparative study of Google Health and Microsoft's HealthVault suggested that both systems had flaws in the user experience and entry of health data must be made simpler, quicker and more enjoyable [40].

Health promotion websites include general healthcare information [32], healthcare support tools [1], education resources [36], monitoring and self-diagnosis tools [29], health and fitness evaluation tools [37], online care providers [19], and patient discussion groups [7].

The websites enable users to take a more active role in their health by raising awareness of symptoms, risk factors, treatments, and prevention of diseases. This can result in improved communication with healthcare professionals and increased compliance. Online doctor consultations can reduce costs and increase availability of healthcare [33], [22]. However, the large volume of online health information makes it increasingly difficult for users to discern which resources are accurate and appropriate. Inaccurate information can result in patients using wrong medication or not taking prescribed medication, which can have severe medical consequences. Furthermore, a large amount of advertisement is disguised as independent medical advice, and the complexity of information requires a high level of reading ability [38]. Most health related websites merely provide information about a disease, but do not address lack of patient motivation, anxiety, low confidence, or ignorance when considering positive lifestyle changes.

The popularity of computer games is resulting in increased research and development of "serious games" for use in therapy, interventions, healthcare education and training [13]. Many professional game developers offer Exergames that support physical and mental exercises [43]. This trend has been accelerated by the integration of new sensor technologies, such as accelerometers and RGBD cameras, into consumer-level devices (smartphones, Wiimote, Kinect, etc.).

Various studies report that exergames can give players regular exercise, reduce the risk of falling [8], improve self-esteem [21], reduce depression [20], and improve participants' feelings about their general health. Despite these advantages there is still a debate about the long-term benefits of exergames. A common problem is the limited content of most exergames and that gameplay might replace other physical activities. A study using the Wii Fit showed no noticeable long-term increase in exercise activity and fitness [46]. Memory games can reduce stress and improve cognitive skills [9], [6], but there is no evidence that this improves general cognitive abilities [6]. Smart phones can be used to record patient data such as heart rate [3], physical activity and falls [23], but results can be unreliable since there is no independent assessment (e.g., FDA or TÜV review) or quality standard (e.g., an ISO standard).

III. Requirements

A. Literature Review

The above review of consumer health informatics applications demonstrates a series of shortcomings constraining widespread use and health outcomes. Commercial telehealth applications and many health record management systems are centered around the clinical user, the health service provider and the vendor's interest of generating a reoccurring revenue stream. The applications perform well in collecting, analyzing and monitoring health data, but there is little support for patients to positively change their lifestyle. Furthermore, most of these applications are expensive, suffer from vendor lock-in, which makes it difficult to add new content, and their use does not fit into the regular activities of the user, i.e., the applications are disruptive.

Health information websites offer an impressive range of information, but it can be difficult to assess the reliability, meaning, and implications of the information. Web-based discussion and support groups can provide a more personal experience and add a social factor which can help patients with coping and commencing positive lifestyle changes.

Serious games and exertainment applications are arguably the most patient-centered consumer health informatics applications. However, evaluations of their effectiveness report mixed results, especially for long-term use. One of the main problems is the limited content, which means applications can become repetitive and boring and hence lifestyle changes are only temporary [42]. In most cases content is controlled by the vendor, must be purchased, and monitoring data is not shared between different games, i.e., a continuous recording of health parameters and activities is not possible.

In order to promote a more widespread use of health informatics applications and achieve better health outcomes, the applications must offer a wide range of content and functionalities, there needs to be a quality control of content, and different applications must be integrated to deliver a complete picture of health status and changes over time. Furthermore the application must be low-cost (preferably free), easy-to-use, concentrate more on the prevention of diseases, and provide patient motivation and support. The latter requirement suggests the incorporation of social networking features. This can also help to reduce loneliness, which has been shown to result in serious health problems [35].

B. Interview Study

In order to get a clearer picture of the requirements for a more accessible patient-centric telehealth system we performed an interview study with eight elderly potential users [11]. The study was designed as a qualitative inquiry focusing on elderly people's perceptions and requirements. The first part of the study consisted of semi-structured interviews conducted with each participant. For the second part paper prototypes based on different existing heath informatics applications were presented to the users and evaluated.

The results demonstrated that the Internet is a suitable platform to deliver telehealth applications. Elderly users suggested several applications such as exercises for different health problems, diet control, and simple network games. They generally favored a user interface layout which is clean, iconic and colorful, and uses a single horizontal menu at the top, which makes it easy to identify and choose key functionalities. Buttons or icons are preferred over hyperlinks and ideally should contain suitable images and text. Interview results indicate that social support through Facebook-like features is useful, as long as an online community of like-minded users exists. Social interactions can be used to reduce loneliness, motivate each other, and share experiences.

IV. Conceptual Framework

A. Key Design Principles

The above analysis and user study resulted in the following key design principles (ordered by importance):

- **Open and extensible:** The system should offer a wide variety of health-related applications that are tailored towards the needs and preference of patients. Otherwise, the content can become repetitive and uninteresting to users and results only in short-term lifestyle changes. The system should be "open", so that third-party developers can contribute content via a plug-in mechanism (eliminate vendor lock-in).
- **Ubiquitous and affordable:** The system must be accessible online for free via a common web browser, ideally such that it can be viewed on PCs, tablets and smartphones.
- **Social and emotional support:** The system should create a caring community, enabling users to provide and obtain social support to and from other users. Social features should be incorporated to reduce loneliness, e.g., enable users to become friends of other patients (that have similar health conditions and interests), to perform health-related activities together (e.g., playing a memory game), and to motivate each other.
- **Feedback and motivation:** The system should provide users with feedback on their health progress and motivate them to become more proactive, e.g., make positive lifestyle changes. Visual feedback via easy-to-understand graphs and charts is particular important to users with limited health literacy.
- **Privacy control:** User privacy must be maintained and users must be able to fully control their health data, e.g., what is shared with other users.
- **Personalized user interface:** Users should be able to easily customize the system and select applications tailored towards their needs.
- **Linear structure and clear instructions:** The system should follow a linear structure wherever possible in order to avoid confusion and frustration.

The key differences between our proposed design (`Healthcare4Life`) and traditional telehealth systems are summarized in Figure 1.

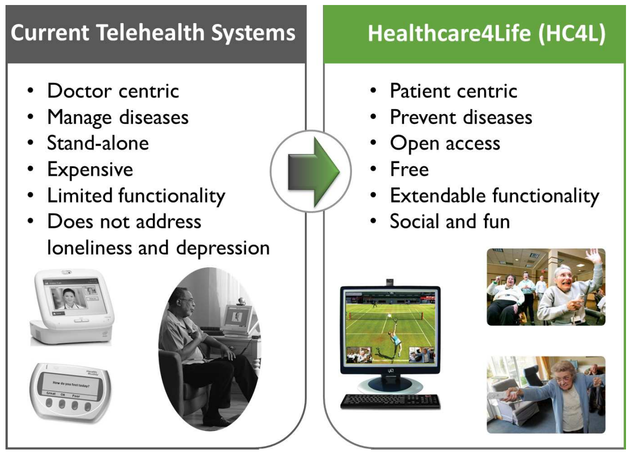

Fig. 1. Key design changes to make telehealth more accessible and more effective in addressing key challenges of public health.

B. Framework

Based on the above requirements we developed the framework illustrated in Figure 2. The framework has an open Facebook-like architecture enabling third-party developers to contribute new content and functionalities. Examples are applications for monitoring, health information, mental fitness and education. Physical fitness and rehabilitation can be achieved by adding applications using consumer sensing devices [12]. Accessibility is further improved by making the system web-based, so that it can be assessed on a PC, PDA, and mobile phone. In order to assess the quality of content we propose to employ a ranking system displaying user satisfaction and popularity of each service. The ranking system should contain separate scores from patients and registered clinical/academic users.

In order to share data among multiple applications unifying data elements must be introduced which relate different types of data. This can be achieved by using a triplestore database: data entities are composed of subject-predicate-object triples, where the predicate represents the unifying element. For example, different exercise games might use different measures to record users' physical activities, which can be unified using a "calories burned" and "perceived-level-of exertion" [4] scale similar to those used in gym equipment. The unified data can then be used by monitoring applications to enable users to design activity plans and track progress.

While commercial telehealth systems put an emphasis on clinical networks, we utilize social networks to help users get in touch with their family, make new friends, and discuss medical complaints with peers and support groups. The aim is to improve emotional health, which is essential for the overall well-being. Social networks can also help with motivating the patient, e.g., by achieving family support, and competing/exercising together via a video link or in a virtual environment.

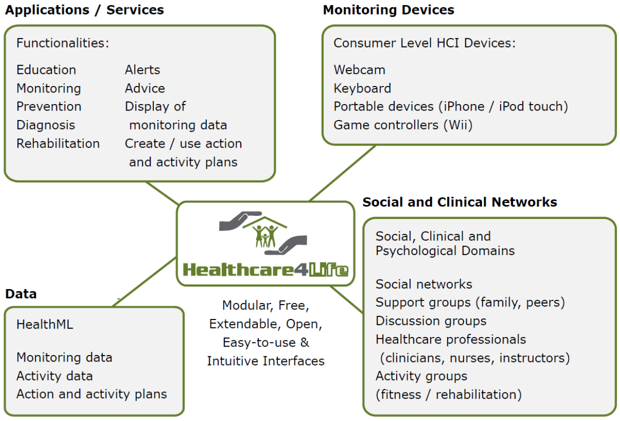

Fig. 2. Conceptual framework for `Healthcare4Life`.

V. Design

Based on the framework in Figure 2 we designed a prototype in order to demonstrate the key design principles and test user reactions towards them.

A. *Key Functionalities*

The primary focus was on the plug-in feature enabling third-party developers to contribute new content and functionalities. Therefore, a user interface for health consumers is provided and a separate interface enabling developers to add applications to the system. The user interface employs large-sized fonts and an icon-based horizontal menu (top of Figure 3). The navigation structure is predominantly linear (bottom of Figure 3). Users can customize functionalities by creating a personalized application directory by searching through all available applications (Figure 5).

In order to give the user immediate summative feedback, the current *Healthcare4Life score* is displayed on the main page as illustrated in Figure 4. The score combines the current health status and exercise and memory performance. The health status is computed from vital signs measures such as weight (body mass index), heart rate, and blood pressure. The current prototype scores vital signs measurements using scales obtained from the literature. For example, a body mass index between 18.5 and 25 (normal weight) gives a high score, whereas a body mass index of above 40 (morbidly obese) gives a very low score. The current calculation does not take into account patient-specific parameters such as

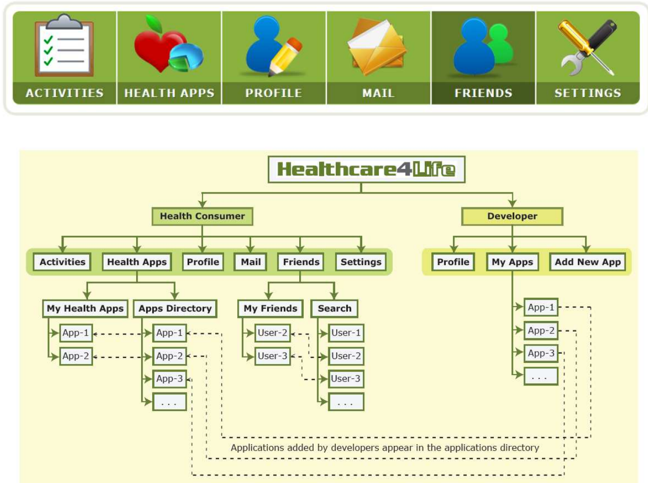

Fig. 3. Main menu depicting key functionalities (top) and content and navigation structure (bottom) of `Healthcare4Life`.

ethnicity, gender, age, or being a professional athlete. In future versions the computation of the vital signs score can either be refined by using more complex formulas, or patients can be enabled to adjust scales for the vital signs measures in consultation with a health professional. The exercise score is obtained from exercise games and other applications measuring physical activity such as pedometers [12]. The memory performance is currently computed from a single memory game, but more games will be added in the future. A large number of commercial applications are already available in this field [39], [28].

It is interesting to note that the commercial tool LifetimeHealthDiary [25] also uses a single index called "total health score". The score is computed using imported clinical data, device-derived data, and community-entered data, but no details are given on the underlying formulas. Since the company offers modules based on patient condition, data types to be imported, and the professional services that are to be offered, we assume that their computation uses more patient-specific parameters than our application.

Fig. 4. The *Healthcare4Life score* is a summative weekly health score providing easy-to-understand feedback.

B. *Health Applications*

In order to be successful `Healthcare4Life` requires a large number of health applications catering for different needs of users. The user can select applications from the application directory (top of Figure 5). A basic overview of each application and average user ratings are provided to help users choose the most suitable applications. After selection the applications are shown in the *Health Applications* directory of the user (bottom of Figure 5).

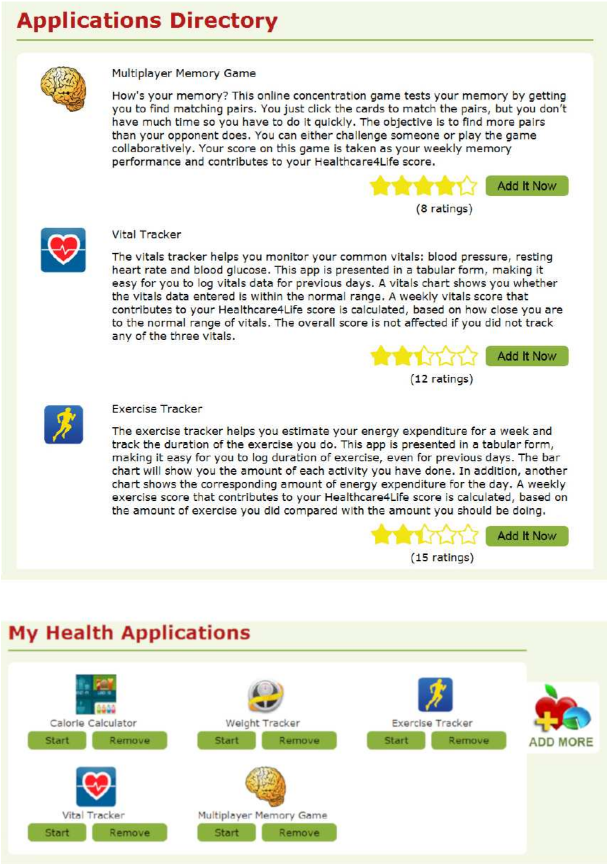

Fig. 5. The application directory listing all available applications (top) and a set of applications selected by a user and displayed in the user's *Health Applications* directory (bottom).

Currently implemented applications include:

- **Weight Tracker:** The application allows users to input their current weight at arbitrary points of time, which can then be displayed over user-defined time intervals. In addition the user can input a target weight, which should be discussed with a health professional. We decided against automatically computing a target weight from the body mass index, since setting too ambitious targets can be demotivating and dangerous (loss of muscle mass instead of fat).
- **Multiplayer Memory Game:** We implemented the popular "Matching Pair" game with a multiplayer modus. The purpose of the game is to find a pair of matching cards by turning over two cards at a time, and turning them back if they do not match. Different levels of difficulty can be selected and users can collaborate or play against each other.
- **Exercise Tracker:** The exercise tracker allows users to track their physical activity over time. Examples include walking, housework, gardening, and swimming. Exercise goals can be set and users are advised to discuss them with their health professional. The total physical activity is measured in the form of energy expenditure, i.e., the amount of calories burned. The default value for healthy individuals is 14 kcal/kg per week and corresponds to low/moderate intensity exercises in STRRIDE studies [44].
- **Vitals Tracker:** The *Vitals Tracker* allows users to input vital signs measurements using a simple tabular interface, and displays them as a graph over user-defined time periods. Values within the normal range are indicated in green. Currently tracked vital signs are blood pressure (systolic/diastolic), resting heart/pulse rate, and blood glucose.

C. Social Networking Functionalities

Users can create social support groups using a Facebook-like interface. Friends can be searched for using various criteria such as name, hobbies and health conditions. The actual health conditions of other users are not displayed and users are encouraged not to use their real name as profile name for privacy protection. Users can send friend requests and accept or decline other users' requests.

VI. Implementation

We implemented our web-based telehealth platform using OpenSocial and Drupal. In order to simplify the addition of social networking functionalities an existing API or specification can be used. We prefer OpenSocial over Facebook and other single platform APIs because the developer is not constrained by vendor restrictions and usage policies. Developers have full control over their system and the freedom to integrate it with other OpenSocial containers. The ability to run applications on various containers may encourage potential developers to contribute health applications.

The implementation of our application is further simplified by using a content management system supporting the development of dynamic websites. We use Drupal because it includes the OpenSocial Shindig-Integrator, which can be used to integrate the Apache Shindig container (an open source reference implementation of an OpenSocial container) with any Drupal-based system. Hence, Drupal can be used to construct a fully-featured and extensible web-based telehealth system that can host OpenSocial health applications. Other advantages are the large developer community and the fact that Drupal includes more than 11,000 contributed modules.

A. Container

One of the key challenges is the development of the plug-in feature that enables developers to contribute health applications. We started the implementation process by designing a customized theme for `Healthcare4Life` using HTML and CSS, which was imported into Drupal. Although Drupal comes with many design templates, we opted for a new theme based on the derived interface design requirements. We then installed and activated existing Drupal modules where appropriate. For instance, we employed the Flag module for storing data (e.g., friends and activities) and the Webforms module for developer and user registration.

After implementing the basic functionalities, we integrated OpenSocial with Drupal to transform `Healthcare4Life` into an open platform. Apache Shindig was installed and integrated with Drupal via the Shindig-Integrator module. Figure 6 depicts the architecture of our system. We also connected `Healthcare4Life` with Apache Shindig's OpenSocial SPI (Service Provider Interface) to allow gadget applications to access shared data. The SPI implements: (1) retrieving profile information, (2) storing and retrieving activities, (3) storing and retrieving application-specific persistent data, and (4) sending messages.

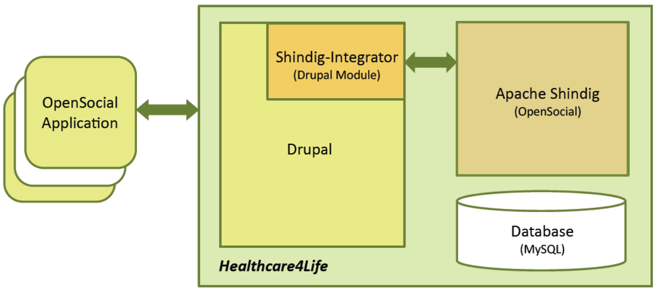

Fig. 6. Plug-in architecture of `Healthcare4Life`.

Communication between Apache Shindig and `Healthcare4Life` takes place via standardized AJAX requests, defined in the OpenSocial JavaScript API. Apache Shindig provides a variety of security options to secure requests and responses. It uses Shindig user security tokens, two- and three-way handshakes, OAuth, and various encryption technologies. The hosting process of `Healthcare4Life` via Apache Shindig is made possible through the following components:

- **OpenSocial Data Server**: Provides a mapping implementation of the server interface to the container, including a RESTful API, for the developers to connect it to a backend application.
- **OpenSocial Container JavaScript**: JavaScript environment that sits on top of the Gadget Container JavaScript and provides the OpenSocial functionalities (e.g., profiles, relationships and activities).
- **Gadget Container JavaScript**: Manages the basic gadget functionality including security, communication, and user interface.
- **Gadget Rendering Server**: Renders the gadget XML (i.e., the definition of a gadget) into JavaScript and HTML in order to expose it via the container's JavaScript, usually as an `<iframe>` element.

B. Applications

Since `Healthcare4Life` is an OpenSocial container, third-party developers can contribute content and functionalities, as long as they are OpenSocial-based applications or packaged as such. Generally, there are two broad categories of applications that can be hosted: client-side (i.e., lightweight applications that do not rely on a server) and server-oriented (i.e., applications that rely on an external server for processing and rendering data). Both types of applications execute within the `Healthcare4Life` container but differ in terms of the functionality they can provide to users. Client-side applications are created using HTML, JavaScript, CSS, OpenSocial Templates, and/or Flash. They are known to provide limited functionality and typically use the OpenSocial persistence API to store data on a container. Server-oriented applications can realize advanced functionalities, which can be developed using any technology, e.g., HTML, JavaScript, CSS, OpenSocial Templates, Flash, PHP, Python, Java, Perl, .NET, or Ruby.

Third-party applications can be deployed in `Healthcare4Life` via the application developer user interface or via Drupal's admin interface. Developers can add applications that reside on external web servers by specifying the URL of the corresponding XML file. Application developers are also requested to select a suitable application category, e.g., monitoring, diagnosis, or rehabilitation. The application will be rendered on the client side by Apache Shindig via the Shindig-Integrator module. We have tested this feature by deploying an existing application called "Calorie Calculator" from `LabPixies.com`, a web gadget developer owned by Google.

We also created and added several applications ourselves: Weight Tracker, Exercise Tracker, Vitals Tracker and Multiplayer Memory Game. These applications were implemented using AJAX. HTTP and JSON (Java Script Object Notation) was used to get back responses in object form. The Google Charts API was used for generating the graphs and charts in our applications. The memory game was originally written as standalone JavaScript application. In order to integrate it into `Healthcare4Life` it was converted into an XML document with HTML and JavaScript bodies, much like the architecture of a Google gadget. Using OpenSocial the application receives access to the social data of the `Healthcare4Life` container. This enables users to search for playing partners.

VII. Results

A. Technology Evaluation

OpenSocial and Drupal integrate well and can be used to develop extendable online telehealth systems with social networking functionalities. While in theory OpenSocial containers can be programmed in any language, it is easiest to use Apache Shindig, which supports only Java and PHP. One major problem is the lack of tutorials for developing rich and complex gadget applications, such as multiplayer games. Issues with compliance arise when rendering applications implement the 0.9.x version of the API, as the Shindig-Integrator of Drupal is only available in version 1.0. We also found that running the same application across multiple OpenSocial containers is not as simple as documented.

Our investigation so far suggests that it is possible to develop gadget applications to achieve almost anything typically seen in healthcare-related applications. For example, patient parameters (e.g., weight) can be stored in a database with the data acquisition date, and plotted using JavaScript and Google chart APIs. Complex graphics and interfaces can be integrated by using Flash ActionScript and communication through OpenSocial's external interface mechanism.

The OpenSocial specification does not deal with data sharing (e.g., patient parameters), but can be extended accordingly. Care must be taken when deciding whether functionality is provided by extending the OpenSocial API or by simply writing methods using a web development tool. For instance, sharing of patient parameters between applications can be achieved by using user profile data from the CMS instead of using OpenSocial.

It is possible to embed non-OpenSocial-based applications into containers. However, if the application depends on drivers (e.g., for sensors), libraries and plug-ins such as Silverlight, then these must all be installed on the client side. This makes it difficult to add complex applications such as webcam-based monitoring and rehabilitation tools.

B. User Study

We evaluated the usability and effectiveness of our application with a user study involving 43 seniors aged 60 to 85. The majority of the participants were active computer users (88%) using a computer almost every day. Less than half of them (44%) used social networking websites such as Facebook. Less than one third used self-care tools, e.g., blood pressure cuffs, glucometers or health websites. Participants were invited to use `Healthcare4Life` over a six week period and they were interviewed at the start of the study, after 3 weeks, and at the end of the 6 week period.

Figure 7 depicts the popularity of the various functionalities of `Healthcare4Life` over the trial period. The health applications were most popular among the participants (35% of all activities performed). This demonstrates the importance of having a plug-in feature for increasing the amount of available content. The Facebook-like comment page termed "Activities" was the second-most commonly used feature (22%) and was followed by the "Friends" page (17%). This indicates that users are interested in sharing experiences and making social connections. Among the applications the Vital Tracker was the most frequently used one (29%), followed by the Exercise Tracker (28%), and the Weight Tracker (22%). The Calorie Calculator was least used by the participants (8%) because of its comparably complex user interface, the time required to input data, and because many food items were not relevant to a New Zealand context. This observation emphasizes the need for customizing applications according to the users' location, culture and language.

In order to evaluate usability issues and the usefulness of different functionalities we used a survey with responses rated on a 6-level Likert scale. Participants stated that `Healthcare4Life` encourages them to be better aware of their health (80% agreement), that the charts/graphs help to better understand health progress (80% agreement), and that the health applications reduce the need to use different websites for managing health (72% agreement). 65% of participants agreed that `Healthcare4Life` has the potential to positively impact their life, and 56% found that the application simplifies cumbersome health monitoring tasks.

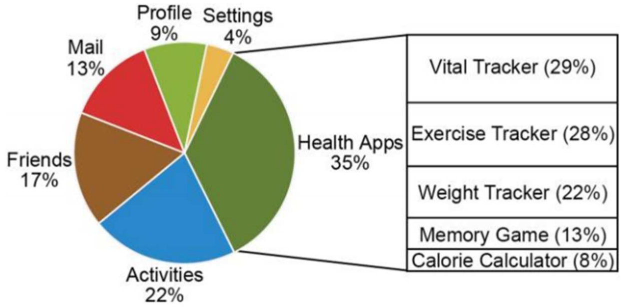

Fig. 7. Participants' activities in `Healthcare4Life`.

However, only 33% of users agreed that the social features motivated them to use the system, and only 31% agreed that the involvement of friends helped them to better manage their health. Four participants of the study expressed disappointment that their friend requests were not responded to. Most of the participants were not comfortable to accept strangers as "friends" in the system. A typical comment was: "*I would not share my medical details with someone I don't know*". One participant elaborated on this: "*I find the use of the word 'friends' for people I don't know and will never meet very inappropriate and off-putting. Also it's really important to learn more about the people in your circle so that you care enough about them and their goals to be able to offer support*".

VIII. Conclusion and Future Work

We presented a novel web-based telehealth system targeted at seniors, which is extendable by third-parties and has social aspects. Our technology evaluation and functional prototype showed that OpenSocial is a suitable platform for such a system. A user study demonstrated that there is a need for more patient-centric telehealth systems, and the overall idea was well accepted. Crucial for the success of the application is a sufficiently large user community and developer support. Participants made it clear that a wider range of health applications was required tailored towards individual needs (health conditions). Social networking functionalities are desired, but not in the form we might know from Facebook and similar social media sites. Our results suggest that web-based telehealth systems have the potential to positively change the attitude of users towards their health management, i.e., empowerment and a higher awareness of health issues.

In future work we would like to expand the range of available health applications in collaboration with health professionals. The social networking features need more investigation, i.e., how can we increase social contacts and instill a sense of mutual care while alleviating privacy concerns? One solution might be to incorporate teleconferencing facilities to allow face-to-face meetings and build up trust. The long-term health effects of `Healthcare4Life` are still unknown and we would like to investigate them once sufficient content has been incorporated.

IX. Acknowledgements

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