PeerAssist: A P2P platform supporting virtual communities to assist independent living of senior citizens

Nikos Passas*, Michael Fried^, and Elias Manolakos*

*Dept. of Informatics & Telecommunications
University of Athens, Greece
{passas, eliasm}@di.uoa.gr

^Semantic Technology Institute
Innsbruck, Austria
michael.fried@sti2.at

Abstract

This paper describes the system architecture and status of PeerAssist, an Ambient Assisted Living (AAL) project that aims at designing, implementing, and demonstrating a flexible Peer-to Peer (P2P) platform, which will allow elderly people (not necessarily familiar with information technology) to build virtual communities dynamically based on interests and needs they share. The PeerAssist technology platform will facilitate establishing on demand ad-hoc communities with friends, family, neighbors, caregivers, etc. The community building and the P2P interaction is achieved using information extracted from peer roles and profiles, context that describes the overall user environment, and the specific request initiated or service provided by a peer, all of which are represented semantically in a machine understandable form. An end-user request (query) is first represented semantically and then routed through the network in order to find semantically matching peers. PeerAssist will find many applications including (but not limited to): i) peer-driven organization of social activities (such as going out, going to the movies, etc.), ii) soliciting peer help with housekeeping and other daily activities, iii) allowing caregivers and family members to receive alerts if certain periodic home activities of the elderly are interrupted. The selected peer-to-peer platform exploits the system's intelligence to provide connectivity at the network level optimized to efficiently serve the objectives of the system.

Keywords: elderly, social networking, peer-to-peer

1 Introduction

The shift in the distribution of earth's population towards older ages makes research for improving the quality of life for the elderly people an urgent priority. Support mechanisms need to be in put in place to allow the elderly people to continue living normal lives and make it easier for them to remain fully integrated in their local societies. It is well known that retirement from a profession and age-related health problems or disabilities force the elderly to spend longer periods at home, away from social activities. As their involvement with social activities diminishes, they start feeling lonely and disconnected despite their interests and desires. Properly designed information and communication technologies can help them overcome this isolation and prolong the period of their active engagement with the rest of the society. As a

result, the whole society can reap the social and financial benefits associated with improving the quality of life for the elderly, as well as alleviating the financial burden of prolonged elderly people care which may severely stress family budgets.

Towards this direction, this paper presents PeerAssist, a flexible Peer-to-Peer (P2P) platform, which allows elderly people to build virtual communities dynamically based on interests and needs they share. PeerAssist can form the basis for developing a wide number of applications including (but not limited to): (i) peer-driven organization of social activities (such as going out, going to the movies, exchanging books, organizing a social gathering, etc.); (ii) soliciting peer help with housekeeping and other daily activities; (iii) allowing support organizations to "push" relevant content to interested elderly users; (iii) allowing caregivers, facilitators and family members to receive alerts if certain expected home activities of the elderly people are interrupted; (iv) responding to emergency situations that may ask for immediate action.

The paper is organized as follows: Section 2 presents the related state-of-the-art to set up the framework for the system description. Section 3 includes the main part of our contribution, i.e., the system architecture. It starts with the conceptual basis, and moves to the description of the PeerAssist node. Section 4 and 5 describe two of the most critical parts of the platform, the community networks, and the query processing system, respectively. Section 6 contains details on the platform implementation, while Section 7 contains information about the system evaluation and user trials. Section 8 concludes the paper.

2 State of the art

One of the PeerAssist project's main goals, to connect elderly people via virtual ad-hoc communities, can be viewed as an extension to general purpose social networks which helps users to feel socially connected and active. A multitude of publications and research projects for building AAL centric online communities have emerged in recent history.

One notable example is the interLiving project [1] which dealt with exploring and developing technologies for inter-generational communication between remotely located family members. Within this project the PeerCare initiative studied habits and social behavior of elderly people. Current AAL projects researching in similar directions include GO-myLife [2] a mobile social networking platform and Co-Living [3] a virtual collaborative community for elderly people.

However, the roots of research in the direction of supporting elderly people through online networks can be found earlier in literature. Already in 2001Camarinha-Matos et al. [4] wrote about the concept of "Virtual Communities and Elderly Support". As part of the European IST project TeleCARE, aimed at developing a configurable framework for virtual communities supporting elderly people, the authors already took into account many emerging topics like mobile agents as well as rising privacy issues.

In contrast to existing approaches PeerAssist's emphasis on P2P services will have high impact within the field because they: (1) constitute social communication that

goes beyond a regular service provider/client interaction, (2) foster exchange between more than two parties additionally stimulating the processes of community building; (3) can be integrated into a network of added-value components of caregiver and technical service providers. This functionality is further extended by context aware, preference based suggestions and user interface adaptations.

3 The PeerAssist system architecture

3.1 Conceptual basis of PeerAssist

Before presenting the PeerAssist architecture let us establish a clear view of the PeerAssist concepts summarized by the UML diagram shown in Figure 1.

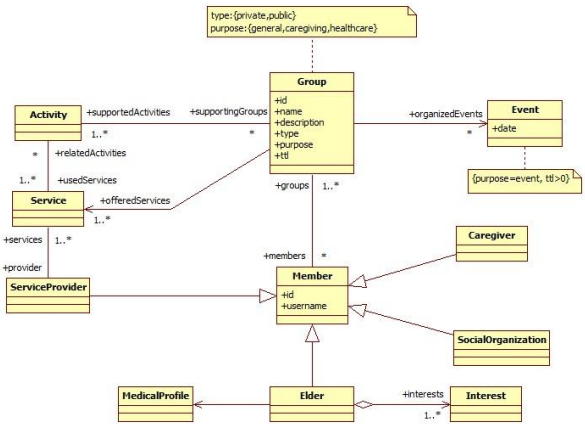


Fig. 1. PeerAssist concepts and their relation (UML diagram).

According to this conceptual model, a *Group* is a community of people driven by common interests and has a unique identifier, and is characterized by a name, a description, a type (i.e. either private or public), a purpose (i.e. general, event, caregiving, or healthcare related), and a time-to-live. A group may participate or organize *Events* (e.g. a social gathering) or support an *Activity* (e.g. an online discussion activity).

A Group is populated by at least one *Member* and, reversely, a Member may participate in one or more groups. There are many specializations of the core Member concept, namely the Caregiver, the Social Organization, the Service Provider, and the Elder. The latter specifies one or more Interests and has a specific Medical Profile.

Each Group supports one or more Activities (e.g. a discussion about a specific topic, playing an online game, etc.), which are realized through a set of *Services*. It should be noted that, a particular Activity may be supported by more than one group. Also, a particular service may be used in the context of more than one activity. For example, the chat service can be used both in the discussion and online game activities. Finally, services are provided by service providers, which are seen as a speciali-

zation of the Member concept. Each group may organize one or more Events and with a date associated.

3.2 The PeerAssist node

The PeerAssist node (PAnode) is the main software entity of the PeerAssist platform. A *PAnode* is a software components architecture running in each user's PC and interacting with the rest of the entities of the PeerAssist platform (i.e. the portable user interface device, available sensors etc.) in order to orchestrate the execution of use cases that provide the PeerAssist functionality.

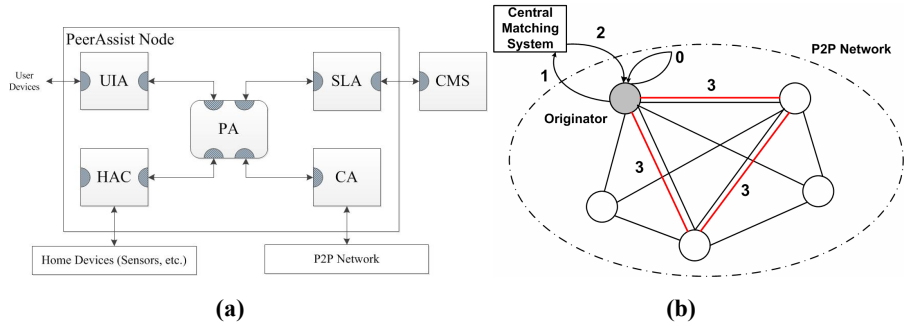


Fig. 2.(a) The PeerAssist node software components architecture. (b) Formation of a peer group in response to a user query.

In Figure 2(a) the main software components of the PAnode and their interfaces are shown. A brief description of their responsibilities is provided below:

User Interface Agent(UIA). It is responsible for:(i) Capturing user intent by interacting with the portable end-user device, (ii) gathering and communicating data that are used to form user queries.

Semantic Layer Agent (SLA). It is responsible for: (i) Maintaining the user profile and local context information in the Local Semantic Information (LSI) knowledge base, and (ii) interacting with the Central Matching System (CMS) (that is in a central server) whenever needed to process user queries.

Personal Assistant (PA). It is used to: (i) Dispatch information between the rest of the agents acting as an intelligent intermediary, (ii) mediate whenever needed on behalf of the user to facilitate interaction and support limited autonomy in certain use cases, (ii) maintain relevant information to improve interaction with the user through machine learning.

Communication Agent (CA). It is responsible to handle P2P communication with the other PAnodes in the PeerAssist community network, thus abstracting the communication aspect of the design for the rest of the agents. It also handles security and distributed trust related issues.

Home Automation Controller (HAC). It handles the control of and communication with local user devices and sensors.

4 The PeerAssist community networks

A typical use case in PeerAssist consists of a workflow with the following sequence of steps (not all steps are necessarily present in every use case):

1. Capturing end-user intent: This is accomplished using the UIA and is facilitated by taking into account the elderly user's profile and context. Potentially it may also involve the PA in an assistive/suggestive role.
2. Building a user community (group) to participate in an event/activity: The Semantic layer of PeerAssist (SLA-CMS) suggests which users may join the group based on intent, constraints, user context, profile, etc. Existing groups are presented to the user (through the UIA) and allowed to join the associated peer group (an ad-hoc user community maintained by the SLA). Users can join and leave a group dynamically on demand.
3. Execution and progress monitoring of the use case (application task): A task may involve calling several services. Some services may be offered by local devices interacting with the PAnode, and some others may be global services with implementations obtained from a remote service repository.

Following this generic use case paradigm, a PeerAssist task execution may necessitate the creation and maintenance of a logically fully connected graph of PAnodes. As shown in Figure 2(b) a specific end-user (called the “originator”) uses its PAnode (shaded node) to create a group (peer community). Through interaction with the user interface a query is formed (step 0). The query may need to be sent all the way to the remote Central Matching System (CMS) in order to find matching users (step 1). The CMS returns a list of matching users rank ordered based on relevance (step 2). The originator’s PAnode filters the matches and sends invitations to a selected subset. Once these users accept the invitation a logical communication channel (pipe) is opened among pairs of peers participating in the formed peer community (step 3). These pipes (shown as red edges) are maintained by the CA for as long as they are needed to support the interaction of members of the formed group.

5 The PeerAssist query processing system

With the exception of actually communicating with a peer, every other action that the user wants to perform using the PeerAssist platform is interpreted as a query that either retrieves information (for example Search Item scenario), or triggers changes of the stored information (for example Join Group or Leave Group scenarios).
The Matching and Query System's functionalities are as follows:

1. Formulate queries based on user inputs and query templates: The users provide inputs through the user interface, which is forwarded to the Semantic Layer Agent. A sub-component of the SLA translates the captured user intent into a machine interpretable formalism, namely SPAQL queries.

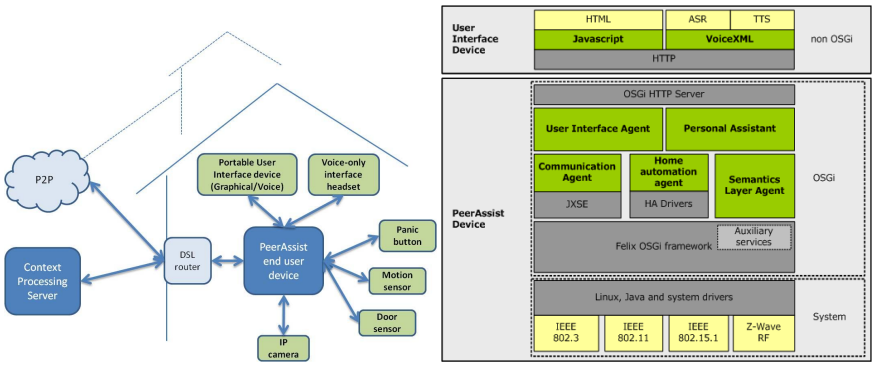
2. Execute a query against internal (local) semantic data: Every PAnode stores information about the end-user locally. A local matching system is available in every node for executing queries referring to locally stored data. It is optimal, for minimizing processing time and reducing network traffic, to execute queries locally, whenever possible.

3. Execute the query on the central data repository: There are two scenarios under which queries need to be executed against the central matching system (CMS). Firstly, if the user performs some updates on its own node, these updates need to be propagated to the global repository (e.g. updating a user's list of friends is performed both locally and on the global repository). Secondly, if the user searches for data not available locally (e.g. searching for a group with certain interests).

4. Filter data based on additional criteria: It refers to filtering query results based on user preferences expressed via the User Interface (e.g. according to location, gender etc.).

6 The PeerAssist platform implementation

The central element of the home network is the PeerAssist end user device, running the PAnode software components, providing home services, interacting with the user and managing the home infrastructure. This local server is a simple PC (desktop or laptop). The Portable User Interface Device is used to interact with the user and can be either a tablet, or a laptop, and it will connect to the PeerAssist end user device (in case they are two separate devices) through a graphical user interface, or a voice user interface using a headset or a microphone and a set of speakers. This device may also be part of the PeerAssist end user device.



(a) (b)

Fig. 3. (a) The elements of the PeerAssist home network. (b) The PeerAssist platform software implementation.

Added value services are enabled by supporting several home peripherals: panic button, motion/door sensor, camera, microphone etc. The Panic button is connected to the local server and when pushed it triggers an alarm to notify the elderly user's caregivers. The Camera is connected to the local server and it is employed in monitoring activities. Sensors, e.g. Motion and Door sensors are used to provide context monitoring during specific activities. The home devices (camera, speakers, microphone, panic button etc.) may be connected to the local server directly via cable, or through Bluetooth or some other wireless networking protocol.

The PeerAssist end user device acts as an edge peer to the P2P network. It runs an instance of the Apache Felix OSGi framework [6]implementation (see Figure 4(b)) and it hosts all the main components that need to be accessed as OSGi bundles. It also runs a web server (as an OSGi bundle or as a standalone server), that hosts the web applications that must run locally in order to use the equipment (microphone, speakers) that connect locally to the end user device. The web server sits behind the firewall and it can be accessed only from within the home network, for security reasons and because there is no application that needs to be accessed from outside. The applications that run on the web server, can access the internet and the P2P network only through the OSGi interface and the JXTA [7]network, by communicating with the rendezvous and relay peers that have the ability to communicate through firewalls.

The end user device also runs a VoiceXML browser, which hosts the voice XML scenarios for the voice user interface. The end user device finally hosts the automatic speech recognition (ASR) and Text to Speech (TTS) modules that are used by the voice user interface, for the voice recognition of the user voice commands and the response to the user. The VoiceXML browser is hosted on the same machine as the application server, but they communicate through http calls so they could be hosted on different machines, or even different platforms. The ASR and TTS modules are not part of the VoiceXML browser, but third party components serving the need for supporting different languages, other than the default English language that is integrated in the browser. The scenarios supported by the VoiceXML browser, include the same actions that the user can perform with the graphical user interface, so that the user can either learn one of the two different options and use the other the same way, or during an action s/he can switch back and forth from one option (graphical, voice) to the other.

7 Evaluation and user trials

As integral part of the project, the partners agreed on testing the software in two different countries, namely Greece and Spain. In a first step we conducted a user survey regarding the usability of the interface with existing mockups. Targeted were elderly people with mild computer experience i.e. using the PC multiple times a week, ability to check emails. The following findings were discovered as part of the assessment: So far the user interface was accepted well and participants were able to perform the given tasks (search users, join groups, etc.) mostly without problems. However in some points regarding for example the font size and spacing the user interface still

needs improvement. These outcomes will influence the final version of the system used for the trials which we decided to split into two parts: A first test run will take place with users from Spain by the end of this year with 10-20 elderly participants and 1-2 doctors. After the system has been changed and extended according to the collected feedback the Greek trials will take place in 2013.

8 Conclusions

With the use of peer-to-peer technology and advanced semantic representation and matching techniques, PeerAssist aims at providing an efficient yet simplified way for communication and social networking for the elderly. Entering its last project year, preliminary system evaluation results have been extracted from focus groups that show increased user interest for the kind of applications the platform targets. With the introduction of sophisticated user interfaces, such as graphical touch screens, television and voice input, average user impairments can be handled, reducing the need for prior computer knowledge. What remains critical is the construction of a convincing and realistic business plan, to make the service work in large scales after the end of the project.

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