A Service-oriented Infrastructure for Mutual Assistance Community

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Abstract

Elder people are becoming a predominant aspect of our societies and solutions both efficacious and cost-effective need to be sought. This paper proposes a service-oriented infrastructure approach to this problem. We propose an open and integrated service infrastructure to orchestrate the available resources (smart devices, professional carers, informal carers) to help elder or disabled people. Main characteristic of our design is the explicitly support of dynamically available service providers such as informal carers. By modeling the service description as Semantic Web Services, the service request can automatically be discovered, reasoned about and mapped onto the pool of heterogeneous service providers. We expect our approach to be able to efficiently utilize the available service resources, enrich the service options, and best match the requirements of the requesters.

1. Introduction

As well known, the proportion of elderly people keeps increasing since the end of last century. The European overview report of Ambient Assisted Living (AAL) investigated this trend [1]. The studies of EUROSTAT [2] indicated that the share of the total European population (EU 15) older than 65 is set to increase from 16.3% in 2000 to 22% by 2025 and 27.5% by 2050, while that over 80 (3.6% in 2000) is expected to reach 6% by 2025 and 10% by 2050.

Studies of Counsel and Care in UK found out that elderly people would prefer to live in their own house rather than in hospitals[3]. Old people living at home could save the caring expense[4]. Assistive devices are developed to facilitate the daily lives of these elderly and disabled people [5]. But they cannot constitute the sole ingredient for an effective solution to the AAL challenges.

The AAL country report of Finland [6] pointed out that those “devices are not useful if not combined with services and formal or informal support and help”. We share this view and deem informal carers as indispensable when constructing timely and cost-effectively services to assist the elderly people. In [7], Sun developed a design tool to evaluate the performance of informal carers in so-called mutual assistance communities. His research shows that informal carers can contribute effectively to the community welfare.

We proposed the service-oriented Infrastructure for Mutual Assistance Communities (iMACom) which we are willing to mediate the available resources with the goal of providing timely and cost-effective service to the elderly people. This approach raises two main research challenges. Firstly, the assumption that the service in a mutual assistance community is dynamic means that a service may join, update or leave in the community at any time especially when integrate the informal care. Secondly, the service provider is heterogeneous in nature (computer, human, and hybrid) and capabilities; a service may be deployed in various forms. The lack of formal and semantic way to post semantically match and share service information hinders the effort in building the AAL community.

In iMACom system, we use the semantic web service model to leverage these challenges. Each AAL service provider is mapped to the web-service and described with semantic service descriptions profile. Service are matched by employing semantic match algorithm described in [8] with certain non-functional requirement extensions scheme which will be described in section 4.3.

The remainder of the paper is organized as follows: In Section 2, related work will be reviewed. In Section 3, we present the overview of the mutual assistance community. The service architecture of the iMACom system is stated in Section 4. Section 5 gives scenarios of the operation of our iMACom system. Conclusions and future work are given in Section 6.
2. Related work

In this section, we summarize related work focusing on two aspects—research on assistive systems design through Ambient Intelligence, and research on conceptual tools for semantic service description and mapping.

2.1. AAL design

Numerous researches are being carried out on building intelligent environments around people, such as Aware Home [5]. Devices such as RFID, motion detectors, etc. are used to accomplish tasks such as activity reminding, health monitoring, personal belonging localization, emergency detection, and so on. These researches on “smart house” improved the independency of the elderly people, and reduced the manpower usage. However, the “smart house” approach is mainly focused inside the house where the elderly people reside. This lack of the community support inherently limits the service exploration, and may isolate the user from the outside world.

Other projects focus on the communication with the outside community. COPLINTHO[9] builds an eHomeCare system combing forces from the patient’s family, friends and overall care team. This application is restricted to the recovery progress of a patient. The communications between different players are mainly focused on exchanging the medical data of the patient.

Finally, some efforts aim to assist the aging people by building a community. Beer[10] developed an Integrated Community Care) system with Agent-oriented Unified Modeling Language, intending to develop care plans for the elderly people by coordination. Informal carers are making contributions by providing non-medical carer. Beer’s system is the one more similar to the one described herein but lacking the mechanism of services description and semantic reasoning.

None of these methods represented above is a true combination of technical and social forces, like we envisage in our infrastructure. They lack a systematic approach to describe, query, and orchestrate different AAL service. In iMACom, the human assets and computer resources are both considered and exploited. Our system is constructed to coordinate optimally the demand and the offer for services. Semantic reasoning is adopted for request analysis and service mapping.

2.2. Service discovery and mapping mechanisms

As already mentioned, in mutual assistance communities, service requesters and providers, even from the same ontology domain, are heterogeneous in nature and capabilities. This heterogeneity may jeopardize the effectiveness of any infrastructural approach to AAL, as it hampers the effectiveness of service discovery and mapping between the request and service.

Industry efforts to standardize web service description, discovery and invocation have come to standards such as WSDL [11] and UDDI[12]. However, these standards, in their current form, suffer from the lack of semantic representation. The notion of Semantic Web services [13;14] takes us one step closer to interoperability of autonomously developed and deployed Web services, where a software agent or application can dynamically find and bind services without having a priori hard-wired knowledge about how to discover and invoke them.

OWL-S [15] is a specific OWL[16] ontology designed to provide a framework for semantically describing such services from several perspectives, for instance, service inquiry, invocation, composition. However, this approach suffers from several limitations in dealing with the problems exists in the AAL system. In the AAL, different users and service providers describe their requirements or services by using their own ontologies. Consequently, the translation capability to specify inter-ontology correspondences must to be provided to facilitate matchmaking between the service requests and service advertisements. Also, the introduction of the non-professional service provider brings the complexity of QoS. The service provider may vary greatly in such parameter as service quality, availability and price etc. The existing state-of-art technologies [11] for publishing and finding services use static descriptions for service functional aspects of IOPE (input, output, precondition, effect). Such approaches do not take into consideration dynamic service selection based on the assessment of non-functional attributes. Finally, with the enlargement of service provider, it is inevitable that there will be services offered by multiple providers with the same functionality. In such case, user should be able to order the discovered services based on certain criteria. For instance cost, service quality etc. However, existing approaches for service selection [13;17] make no provision for user-specified ranking criteria as part of the service request.

In our approach, the services are described as Semantic Web Services. Automatic discovery and accessing are enabled by employing semantic web technology. The non-functional characteristic such as QoS and Service expenditure are taken into account in the service mapping algorithm. The matched Services are ordered based on the service requester’s profile according to different users’ prudent.

3. Key ingredients in iMACom

Much work has been done in Ambient Assisted Living either in the technology domain or in the societal domain,
but few of them, to the best of our knowledge, have focused on a design combining both fields. By providing uniform abstractions and reliable service representation model, IMACom could make it easier to develop and incorporate a diverse and constantly changing set of service providers, human or devices. It would help people and devices to share their requests and service data, placing the burden of acquisition, processing and interoperability on the infrastructure instead of on individual devices and service.

This infrastructure aims at fostering a mutual assistance community. By integrating the current research on technology and people in community, it allows disparate technologies and people working together to helping people who suffer from aging or disabilities. Some key ingredients of iMACom are analyzed in the following sections.

3.1. Service Requester

In the mutual assistance community, a requester entity is a person or smart device that wishes to make use of a provider entity's service. The service requester (SR) can be people who either explicitly required one type of service or an intelligent device which raises a service request by reasoning on the context-data provided by, e.g., sensors.

Normally, the service requester raises their service request by specifying requirements such as service type, scheduling time, requester estimated duration, priority, location, etc. In our proof of concept prototype, we express such requirement by OWL-S service profile.

3.2. Service Provider

As mentioned already, our approach involves both professional and non-professional people as possible service providers (SP). A service provider can also be a smart device providing information or actuating actions. In the rest of this section we describe these main classes of service providers.

Professional Service providers: these are those who have specialized intellectual or creative expertise based on personal skills. This type of service providers consists of professionals, private firms, professional organizations or municipalities. Normally, the type of service may have better quality and higher availability but the cost is comparatively higher.

Non-professional service providers: This type of service providers normally is made of ordinary people, volunteers or specifically employed people. Specialized expertise is not necessary for providing this type of service. They could do some non-professional work such as gardening, housing or transportation either volunteer or for income. They could do some non-professional work such as gardening, housing or transportation either volunteer or for income. In some cases, service providers with proper training can provide some professional work such as first-time aid when the professional people are unavailable.

Smart Device: smart device technologies can provide some sort of service for the assisted people (AP). Normally, these services are located in the smart house domain. These devices can provide services such as health monitoring, alerting, personal belonging localization etc.
3.3. Coordination center

The coordination center is designed to coordinate the services and requests inside the community and establish connections with other communities. In a community, the coordination center (CC) deals with: providing service registration for the service provider, parsing the user request and match it against the available services. Due to technology and social restrictions, each community has a certain boundary. However, the coordination center of each community could be linked together, share their services and exchange information, thus breaking through the boundaries. In Fig. 1, a “smart house” could be considered as a small community under the control of a local coordinator center. Connecting the local coordinators together we come up to the overall community in Fig 2. Moreover, the coordination center in Fig. 2 could also connect with other CCs to set up a community in larger scale.

4. The iMACom Architectures

Based on our previous analysis, we design the iMACom architecture which aims to provide an efficient infrastructure support for building AAL community. It consists of the following infrastructure service which acts as basic service components.

4.1. Format Service

This service helps to collect request and service descriptions from heterogeneous sources – people or devices –, and convert them to semantic representations so that request information can be shared and reasoned upon by other service components.

In SOA, individual users or communities are expected to query for services of interest by using term in their own ontologies. The format service should be able to specify the inter-ontology correspondences between service requests and service advertisements [8]. In the mean time, user’s preference should be expressed as part of service request.

For the smart device, due to the resource limitation of pervasive devices such as CPU speed and memory, it may not be able to implement the format service by itself. A smart device with plenty of resources may act as a proxy to perform formatting task.

4.2. Service Registry

Service provider registers their services in directories along with profiles that describe their various relevant capabilities and characteristics. Most service registries are asked on the UDDI standard, which focuses on registration of service descriptions. UDDI provides information about the entity that owns it and provides mechanisms to classify the service in terms of standard taxonomies such as North American Industry Classification System [18] or refers to an entry in certain ontology.

Here, we tacitly assumed a registry model in which service capabilities are advertised and then matched against requests of service. This is the model adopted by registries like UDDI while other forms of registry are also possible such as P2P architecture. Due to the consideration of the low computing power of smart device, we propose to use the registry model to reduce the complexity of service retrieval.

4.3. Semantic Match Service

The Semantic Match Service (SMS) is responsible for semantic processing, reasoning and matching the request to service by employing logic reasoning.

In order to perform semantics based match, an ontology-based approach should be used to describe service semantically. This model should enable formal analysis of domain knowledge in a way which is independent of programming language, underlying operating system or middleware. A good candidate for this model is the Web Ontology Language (OWL). The SMS matches functional and non-functional requirements between service request and service provider.

Two properties are considered a match if they either match exactly, or as defined by some relationship that can be inferred from the ontology using an inferring engine which employs the ontology relationship and the rules in the Knowledge Base. By specifying this type of matching criteria, this allows for matches that are close though not exactly equivalent. For example, the match results from the “House Cleaning” service holding an ‘Is-a’ relationship with “Housework” in the AAL domain ontology.

Normally, this service consists of a semantic service reasoner and an ontology-based Knowledge Base (KB).

4.3.1. Semantic Service Reasoner

The semantic service reasoner has the functionality of providing deduced ontology information from the ontology service descriptions and the KB. Multiple logic reasoners can be incorporated into the semantic service reasoner to support various kinds of reasoning tasks. Different inference rules can be specified and preload into various reasoners. Developers can easily create their own rules based on predefined format.

4.3.2. Ontology-based Knowledge Base

Knowledge base (KB) consists of a set of sub-domain ontologies in the different domains (housing, transportation, nursing, etc.) and a set of correspond rules in these sub-domains. These ontologies describe the concepts and relationships
from the application domain. The rules are the problem solving procedures expressed with the terms from the ontology. The ontology information can be manually predefined or can be updated by dynamically parsing the ontology-based profiles of service descriptions. The KB also should provide a set of API’s for other service components to query, add, delete or modify the KB.

In our prototype, the AAL service ontology and service provider ontology are designed with the help of protégé[19]. The service and service request are described by the OWL-S service description. Non-functional requirements are expressed as the preconditions of OWL-S service profile and expressed by using the SWRL logic language[20] in the service and service request’s profile. While matching, the service type and precondition are firstly checked. If successful the fitting service candidate are matched by the functional part. The compatibility between the request and service are computed by using the algorithm that described in [21]. This algorithm typically uses subsumption reasoning to find similarity between service advertisements with the requests based on the match between inputs and outputs. After the functional part match, the selected candidate services are ordered by the service request preference. We extended the OWL-S service profile to include the order description. The SMS parse this information and return correspondent results.

4.4. Service Binding

The binding service will provide a scheme to sign a “contract” between the service requester and service provider. This contract can ensure the requester gets required service and the service provider gets the correspondent return the “contract” can be exploited in late accounting & auditing usage. This service also provides the participants additional information about this transaction such as correspond methods and etc.

5. Scenario Analysis

We envisage there are several devices and companies registering their services in local service registry either in the house domain or in the community service registry. In house domain, each of the smart devices should register their capability to local service register. We envisage there is smart TV and smart phone exist. The smart TV registers for “Text display” service and “Video display” service. The smart phone registers for the “Phone service”, “Context display” and “Network connection” service via GPRS or 3G. In the community domain, we envisage the telephone company to register in the community service registry for a “reminder” service.

Reminds Service Scenario Remind service is a service that helps the AP to follow his/her cyclical routines, such as taking medicine or taking vital signs. We
demonstrate the reminder service in two different situations.

With smart device: the request is sent directly to the local CC with service restrictions. The local CC will perform semantic service discovery in the local service registry first. When it perform service match, it will not find the match service by only employ syntactic matching. By semantic inference, the “Text display” service can be matched to the “Reminder” service request because the reminder service can be produced by displaying a reminder sound. The smart TV and the smart phone will be the good candidate for the remainder service request after semantic match. The local CC will select one of the two by user preference or by context-awareness.

Without smart devices at home: When the house is not equipped with smart TV or smart phones, the local CC could not find a match service provider. In this case it will raise its request to the community service discovery service. The latter will perform semantic service discovery in the community domain. Now, the telephone company will be matched because it registers the “Remind service”. So it will help the service request to set a contract with the telephone company and the telephone will provide the reminder service. Of course, some volunteers or professional service providers would also provide “reminder” services. If available, the community may also select one from this candidate through user’s preference or other factors

6. Conclusion

The need for the assisted living supportive environment is compelling, due to the increasing economic and social problems posed by aging. In this paper, we provided an overview of iMACom, a service-oriented infrastructure for mutual assisted community. In this infrastructure, the Semantic web service technology is employed to provide ubiquity service. Within iMACom, services are described with ontology description and represented as Semantic Web Service. By employing semantic web technology, system is able to determine if a service is suitable for a particular request by semantically matching both the functional and non-functional capabilities. The SMS connects with external SMS which enables them to forward internal service request and discovered outer services which match the requirements.

We are designing and implementing a prototypic iMACom based on OWL-S and with QoS extension. We are working on a simple proof of concept prototype to grounding the Service to a concrete smart device based on OSGi.

An area of future research is to support the composition of the AAL service. Other interesting topic is how to prevent the malfeasant service provider from biasing the service data. Solutions may include those based on reputation and social network.

Reference

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