SOAF - Design and Implementation of a Service enriched Social Network

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Abstract. In this paper, we propose the integration of services into social networks (SOAF - Service of a Friend) to leverage the creation of the Internet of Services vision. We show how to integrate services and humans into a common network structure and discuss design and implementation issues. In particular, we discuss the required extensions to existing social network vocabulary with regard to services. We illustrate a scenario where this network structures can be applied in the context of service discovery and highlight the benefit of a service-enriched social network structure.

1 Introduction

The Internet of services [1] vision focuses on the extension of the existing Internet with regard to services. In a future Internet of services, information is not static any more, but dynamically provided by all kind of data intense services. This vision involves a set of challenges such as the integration of social aspects, since Web 2.0 phenomena such for instance like social networking (e.g., facebook [1], xing [2], twitter[3]) or the end user driven creation of applications on the Internet (mashups [2], situational applications [3], [4]) are playing an important part on the Internet now. Indeed, as Kleinberg observed in his work [5], social and technical networks converge. In these networks, user generated content, like for instance folksonomies [6], provides a vast source of information that is able to classify arbitrary content (e.g., del.icio.us [4]. Network structures described with FOAF [7] provide the technical foundation to link persons in social networks in a machine readable form.

Viewed from a business perspective, these developments have a profound impact on the way businesses are conducted. In his Wired article, Howe shows how the idea of crowdsourcing [8] can be applied to businesses. With regard to (Web) services that already provided by companies and the integration of humans into common networks, companies can benefit of these emerging network structures. However, with the existing infrastructure, this endeavor proves to be difficult to achieve. One of the main reasons is

[1] `http://www.facebook.com`
[2] `http://www.xing.com`
[3] `http://www.twitter.com`
[4] `http://delicious.com`

that, there is little support to integrate humans and services into networks to benefit from social connections within such network structures. There are approaches that support the integration of human activities [9] [10] into business processes. These approaches assume that there is already a workflow and that there is repository that can be used to select the required services for a given workflow. This discovery process is well studied in literature [11]. However, with the failure of centralized registries [12] and no Web service standard for the discovery of Web services, the discovery process is fragmented and cumbersome. In the context of centralized registries, governance of data is an issue, when the data is published in a central authority. This leads to a situation, where Web service related information is distributed among several isolated company registries, if this is the case at all. Especially smaller companies hesitate to use registries, because of the overhead involved in maintaining dedicated registries. In such cases, Web services are often published simply by mailing customers the necessary information about the endpoint of a Web service.

This practice hinders the creation of Web service marketplaces [13] where one can discover Web services and learn from the experience of others by using a particular Web service. When investigating the process of Web service discovery, one finds that the human factor is dominant in (semi-) automated approaches [14]. Furthermore, structured meta information in form of ontologies [15] suffers from the same limitations concerning availability as centralized registries. Even with available semantic information, the process of discovering Web services requires human activities, since different semantic service descriptions can be provided by different ontologies. These ontologies require mappings which cannot fully automated due to ambiguities or even contradictions within their content [16].

In context of Web service discovery, we can learn lessons from humans and how they look for solutions of problems. Humans exploit local information and use links to other persons to ask for pointers or for information when needed. In short, humans asks their friends whether they had a similar problem and how the problem was solved. This way, humans build networks of knowledge around each other.In our work, we link services and humans in a common network structure. We refer to this approach as *Service of a Friend* (SOAF) and follow the spirit of FOAF. We believe, that the integration of humans and services into networks fosters the creation of Web service ecosystems [17]. Our approach bears several challenges that we are going to address in this paper. First of all, we need a representation of the links between services and humans. Secondly, dynamic changes must be represented in our network, since there are relations that exist only over a certain time (e.g., projects may require collaboration for several months). And finally, we need to consider that past relations provide useful information for potential future use (e.g., a service that was useful for certain tasks in the past may be again useful for new tasks of different users).

The rest of the paper is organized as follows. We discuss our approach in Section 2. We provide an analysis and discussion of our findings in Section 3. Afterwards, we introduce our prototype architecture in Section 4. We conclude our paper with related work in Section 5 and an outlook for future research directions in Section 6.

2 Linking Web Services

We consider information to be highly distributed in a future internet of services. Therefore, emphasis on the linking between services must be placed. In the existing Internet, linking structures are very simple, a link contains very limited information in addition to an URI to identify a location. Due to distributed nature of services, the lack of centralized repositories to search for registries, we require rich links between services to be able to discover services by exploiting network structures. These network structures originate for instance from organizational structures of companies or social networks that model social connections between humans.Thus, links and their associated information are very critical for the traversal of networks efficiently and to facilitate the discovery of distributed services. Therefore, we include meta information into links to make the traversal more efficient. Furthermore, as the linkage between elements of networks is constantly changing, we consider dynamic aspects of the relations between services, organizations and humans as well. These are not static and may change over time. For instance, a person might move from one organization to another or the service provision might depend on the duration of a project (e.g., event notification services).

2.1 Extending FOAF

The integration of services and humans in a common information network requires the integration of existing social network structures and service related information. Our idea is to augment FOAF network structures with service related information and to link services and humans in the same network. The data structure requires new concepts to be added to the main FOAF data model with regard to the needs of services. In particular, we extend the relation mechanisms of FOAF to model relations between services and persons. FOAF defines a class *Person* that inherits from the class *Agent*. Likewise, in SOAF [5], we include a (i) *Service* class to represent services that inherits from Agent, a (ii) *uses* relation which is similar to the *knows* relation, but provides additional information, (iii) a *provides* relation that defines the connection between service providers (which may be organizations, persons, teams, virtual teams) and services, and (iv) a dedicated *Connection* class (also inherits from Agent) that encapsulates the connection between services, persons and organizations (see Figure 1).

The introduction of the connection class addresses the major shortcoming of FOAF with regard to connections between persons and services. Similar to connector oriented architectures, connectors offer a rich set of meta information to classify the type of connection. In our approach, we provide time and state information that defines the lifecycle of a connection. In combination with lifecycle information we are able to model dynamic aspects of the network structure (for a detailed discussion see Section 2.2). Listing 1.1 shows how we represent service related information with connection classes.

With these extensions, we can establish relations between persons, services and organizations/groups. We summarize the relations in Table 1.

[5] `http://www.infosys.tuwien.ac.at/staff/treiber/soaf/index.rdf`

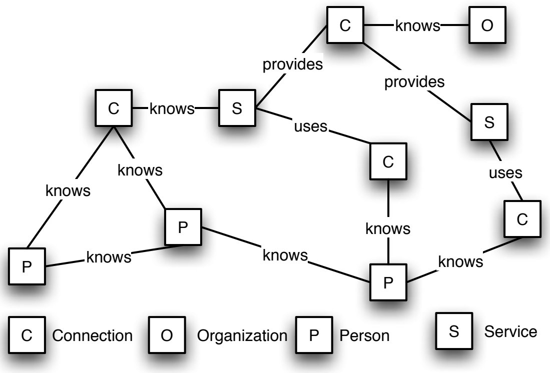

Fig. 1. Overview of SOAF network structure

```
<rdf:RDF
    xmlns:foaf="http://xmlns.com/foaf/0.1/"
    xmlns:soaf="http://infosys.tuwien.ac.at/soaf/">
    ...
    <foaf:Person rdf:ID="me">
        <foaf:name>Martin Treiber</foaf:name>
        <foaf:mbox_sha1sum>eca5c5a5cd830b11af3726ec1ff58b3b89767f6d</
        foaf:mbox_sha1sum>
        <foaf:knows>
            <soaf:Connection>
                <soaf:established>January 23rd 2009</soaf:established>
                <soaf:active>true</soaf:active>
                <soaf:connectiontype>continuous</soaf:connectiontype>
                <soaf:uses>
                    <soaf:Service>
                        <foaf:name>SOAFer</foaf:name>
                        <soaf:endpoint></soaf:endpoint>
                        <soaf:description>SOAP Web Service that creates SOAF
                        Service Profiles</soaf:description>
                        <soaf:interface rdf:resource=""/>
                        ...
                    </soaf:Service>
                </soaf:uses>
            </soaf:Connection>
            <soaf:Connection>
                <soaf:established>October 2nd 2005</soaf:established>
                <soaf:removed>September 30th 2008</soaf:removed>
                <soaf:active>false</soaf:active>
                <soaf:connectiontype>continuous</soaf:connectiontype>
                <soaf:provides>
                    <soaf:Service>
                        <foaf:name>WISIRIS Task List Service</foaf:name>
                        <soaf:endpoint></soaf:endpoint>
                        <soaf:description>SOAP Web Service for adding tasks to a
                        personal project task list</soaf:description>
                        <soaf:interface rdf:resource=""/>
                    </soaf:Service>
                </soaf:provides>
            </soaf:Connection>
        </foaf:knows>
    </foaf:Person>
</rdf:RDF>
```

Listing 1.1. SOAF example snippet

Table 1. Relations between SOAF entities

Relation	Description
Service uses service	Denotes direct service invocation by other services. For instance, in service compositions, a service might call another service directly
Person uses service	Denotes the service use of a person
Person knows service	Denotes mutual knowledge of a service and a person without usage
Service knows service	Denotes that two services are related within a certain context (e.g., workflows, compositions or mashups) without any direct invocation of each other
Organization/Group provides service	Defines the relation between organizations and their provided services
Person provides service	Denotes the service provision by a person, e.g., a human provided service

2.2 Dynamic SOAF

As discussed before, we model three basic relations between entities in a SOAF network, i.e., (i) knows, (ii) uses and (iii) provides. The latter two imply automatically knows, since it is required to know a service before it can be offered or consumed. Knows, uses and provides are pairwise related through a simple subset relation: uses is a subset of knows, since it is required to know a service before a service can be used. Besides, persons/organizations might know more services than they actually use. The provides relation is also a subset of the knows relation, since a provider knows obviously the services that are provided and knows/uses additional services.

Viewed from a time based perspective, elements of the knows/uses/provides sets are subject to changes. For instance, a service might move from the knows set to the uses set and vice versa. Consequently, we allow to have multiple links to a single service from a person at any point in time. For instance, as soon as a service is used by a person, a uses relation is created. If the service is not used anymore (e.g., the service was used for registration purposes or the access has been revoked due to company changes, etc.) the uses relation is not valid any more and its internal state and timestamp are set accordingly. Thus the service moves to the knows set.

Notice that the knows relation is static: once a person knows another person/service, the relation remains - it is not removed anymore and the connection class remains. However, with services we have to pay attention to the fact that a service does simply not exist any more. In these cases, the knows relation points to an inactive services that have been used in the past.

An aspect that needs explicitly to be considered is the type of service usage. We've identified several types of service usage that we include in our model. We use this kind of information to be able to generate accurate historical information. In particular we consider the usage frequency of a service and classify the usage as summarized in Table 2.

Table 2. Service usage in SOAF

Usage	Description
Once	The service is only used once and then never again during the lifetime of the service (e.g.,a registration/unregistration service is used to subscribe to a mailinglist, a polling service might exist only before a certain event takes place, etc.).
Continuously with pre defined time to live	The service is used for a certain activity during a pre defined time and is removed afterwards (e.g., a service that provides state information about persons in a project).
Continuously	The service is used continuously without limitations concerning the time of use and frequency.

Complementary to the use of services is their provision. Service provision changes also over the time, but is generally less dynamic than the uses relation. In particular we consider three distinct service provision scenarios that are supported by our model (see Table 3). Of central importance for the representation of the network dynamics is the connection class. We include additional meta information that provides management hooks. Due to the nature of connections, connections cannot exist on their own, and depend always on the endpoints of the connection. In SOAF networks, we require that a connection connects exactly two entities, we do not foresee connections with more than two entities of the SOAF network at the same time. The reason is that we include additional meta information in the connection class that is important for management purposes (e.g., creation, deprecation, etc.) (see Table 4).

Table 3. Service provision in SOAF

Usage	Description
Continuously with pre defined time to live	The service is provided for a certain activity during a pre defined time and is removed afterwards (e.g., a service that provides state information about persons in a project).
Continuously	The service is provided continuously without limitations concerning the time of use and frequency. This includes the case when a service is used only once for registration purposes, but nevertheless is required by different customers to register and thus must be available continuously.
Deprecated	The service is still available but not actively maintained,

Table 4. SOAF Connection attributes

Attribute	Description
Creation	Date, on which the connection between the entities was established
Removal	Date on which the connection was removed
Active	Flag that indicates if a connection is currently active
Type	Defines the type of connection, either uses, provides or knows

2.3 Managing SOAF service networks

The management of dynamic aspects of distributed networks is complex task. The first challenge is to identify a resource in a network in a unique manner. In our approach, we follow the concept of ”inverse functional properties” from OWL [18]. We use a functional property that defines the URL of a person, an organization or a service. Services include a functional property that points to the endpoint of the service as well. Since we do not intend to define a centralized authority that manages available information, we have to rely on all network members to manage their links and to keep the links updated. However, there is no guarantee that this process works without disruption, since this process relies partially on the intervention of humans. However, since links between entities in the SOAF network imply a certain degree reciprocal agreement (knows relation, uses relation) we support this by including Atom feed based [19] notification mechanisms. SOAF generates a set of basic events that can be subscribed to and that can be accessed as Atom feeds (see Table 5).

Table 5. SOAF events

Event	Description
Registration	This event describes the creation of a new SOAF entity in the SOAF network. This event is generated upon the creation of a service, a person or an organization
Change	This event describes changes of SOAF entities
Removal	This event is generated upon the removal of a SOAF entity
Connection	This events is generated if a new connection between two SOAF entities is established

Service Publication, Service Removal Service publication in SOAF is done locally. A service provider updates its SOAF description with new services that are offered. Since we do not have a central entity that is used for service registration, we do not require service providers to actively contact a registry and provide information. Other SOAF network members that are registered for service publication events receive corresponding notifications, i.e., a registration event that contains service related information. If a network member is interested in this newly registered service, the network member contacts the service after having received the registration event and asks for the service

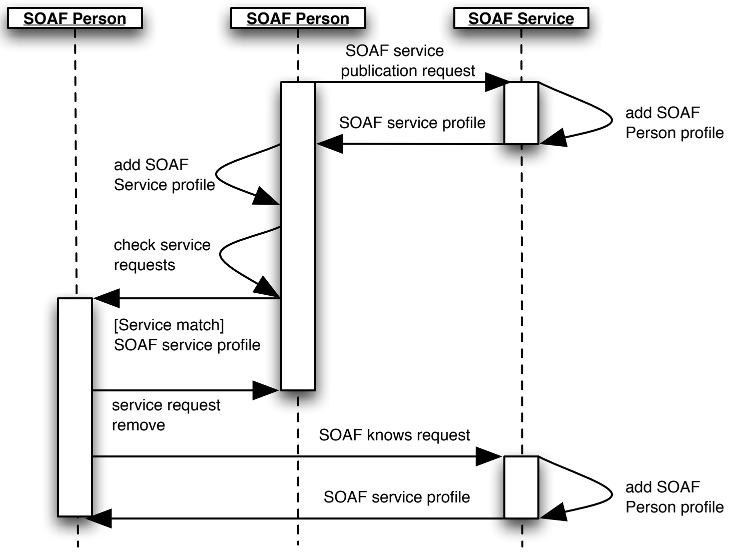

Fig. 2. SOAF publication information protocol

profile. The protocol is shown in Figure 2. The removal of existing service is closely related to the publication process. A service provider that decides to remove a service, removes it locally from its SOAF description. The propagation of the update follows the same pattern as the publication with regard to the propagation of changes. Upon service removal, the provider obtains a list of all service users. Then, the provider checks its subscribed SOAF network members and informs all service users and the subscribed network members about the service removal with a removal event (see Figure 3).

Service Discovery Social based service discovery is the translation of every day activities into service discovery. Consider the following example where Company A needs a service that is able to provide information of public holidays in european countries, for a project meeting planning purposes. Traditionally, an employee of company A would search a public registry or search engine [6] for a service that is able to fulfill this requirements. Currently, if no corresponding service can be found, the search is repeated after a while in order to find a service and eventually a service may be found (we assume, that such a service exists in reality and is published during the time the employee searches for it). This discovery process is not very well supported [20] and lacks of dynamics: the service requester must query the registry regularly to look for the service. Approaches like [21] support event notifications and thus can support the discovery process. However, social network structures and the inherent knowledge are not included in the discovery process. In particular, since organization can be regarded as networks

[6] seekda.com, strikeiron.com, xmethods.net

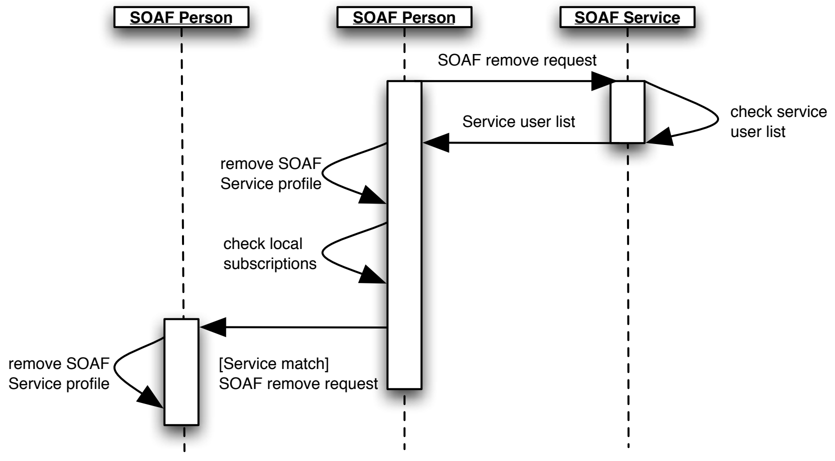
SOAF Person
SOAF Person
SOAF Service
SOAF remove request
check service user list
Service user list
remove SOAF Service profile
check local subscriptions
remove SOAF Service profile
[Service match] SOAF remove request

Fig. 3. SOAF removal protocol

(hierarchical, star, full, etc.), we propose to utilize social network structures to support the discovery process.

When we transform the discovery example from above to a social network oriented approach, person A would ask another person B (colleague from work or friend and part of the network) if s/he knows a holiday information service. If this is not the case, then person A could ask person B if person B either knows another person that in turn could be asked or if s/he hears from such a service to inform person A about the service.

This approach is also known as epidemic protocol [22]. The discovery process we envision in SOAF mimics the process the we described above. First of all, we assume that SOAF provides a link between person A and person B. Furthermore, Person B has connections to services and persons s/he knows and/or uses. By following our example, person A browses all services that person B knows and learns that none of the services that are known by B is able to provide the required functionality. In this case, person A registers to a feed person B provides in order to get a notification if person B finds a service or if person B is linked with a service of the required functionality. Simultaneously, person A can do the same with other persons that are part of the network and thus distribute the discovery among other network participants by following links. In the case of success, person A would be notified (by checking the subscriptions).

It it worth noticing that from a conceptual point of view, SOAF does not limit this approach to humans. Since we envision services as part of the network and thus providing well formed information, we can extend the notification to services as well. When applying the aforementioned search approach to services, a service might notify another service when a required service is linked to the service, since we consider the knows relation as bidirectional.

3 Discussion

One of the major benefits of the SOAF network is that we are able to create a dynamic ecosystem of services from a bottom up approach. In particular, since we integrate humans and services alike, we can track relations between different stakeholders of Web services [23]. For instance, a service developer might integrate different services into a new service by wiring the respective service invocations in the code of the service. By storing such information into SOAF networks, we provide information about service dependencies and input for creating dependency graphs of services.

Another important aspect considers historical information in SOAF. Related to the developer example from above, consider service mashups. These are created for a certain purpose, and this kind of information is reflected by connections of different services and persons that used this particular service mashup. Depending on the amount of meta information provided, we provide the ability to search in SOAF networks for examples of mashups that solved particular problems. These examples can be viewed as best practices and thus serve as blueprint for the creation of other mashups.

Related to historical information is the aspect of network evolution. With the data that is provided by SOAF, we can observe the development of network connections (uses, knows, provides relation) and study the general dynamics of the service network. For instance, we can establish the number of services that oined the network during a certain period of time or how many services where removed, etc. Another example is the creation of metrics that define the attractiveness of services for other members of the SOAF network, based on the data SOAF provides.

As ”side-effect” in SOAF, we can observe emerging clusters of well connected services and persons. This allows us to foster communities in a bottom up manner from existing connections between services and persons. In contrast to existing Web service community approaches, we follow the social aspect more closely and do not pre-define the community functionality. We are aware that a social approach brings a certain degree of fuzziness. Furthermore, it is difficult to obtain the overall functionality of communities, since some services might overlap in their functionality. Especially when limited information is available (e.g., WSDL descriptions), a clear description in terms of overall community functionality might not be feasible. However, even with fuzzy information, we are able to define a set of core functions that are used within a community since we know by the community structure which services have the highest connection and usage rates.

A very important aspect SOAF concerns scalability in terms of bottlenecks, such as for instance centralized repositories. Since SOAF is fully distributed, SOAF is scaleable by definition. However, because processes, like the discovery of services, depends on human intervention, there is a certain limitation on the load (service requests) a human SOAF network member can process. Certainly, human network members cannot handle thousands of requests simultaneously and we need to impose certain restrictions on the load human network members can handle. However, this is subject to future investigations.

4 Prototype

We base our prototype on the distributed architecture of previous work [24] and extends it with the required functionality to model SOAF networks. Our prototype uses a XML database [7] to persist SOAF related information, which we organize internally in several different collections (see Table 6). We use XQuery expressions to generate SOAF profiles from the persisted data [8]. Our prototype provides the basic functionality

Table 6. SOAF collections in the XML Database backend

Collection	Description
Service	Stores service related information (e.g., endpoint, link to interface description, etc.)
Person	Stores all person relevant data (e.g., name, surname, etc.)
Connection	Stores connection information (e.g., knows, uses, provides, etc.)
Organization	Contains information about organizations (e.g., name, address, etc.)

(implemented as rest interfaces) to manage SOAF data. In order to provide access to events, our prototype generates Atom feeds from SOAF data. We organize the events in three separate feeds as shown in Figure 4. For analytical purposes and to co-relate events, we foresee links between different entries of the feeds.

4.1 SOAF Network Bootstrapping

For test purposes, we generated a SOAF network structure with facebook data. We extracted a friends list with the help of a simple facebook tool [9] from a single user [10]. The result is a RDF file that contains a list of persons that are known by a person. We parsed the content and transformed it into the SOAF format, resulting in persons and (knows) connections. We used a XSLT transformation to transform the content into a SOAF compatible representation [11]. The result of the transformation was persisted in the XML database in the corresponding collections. As the experiment showed, it was fairly easy to generate an initial network structure which can be enriched with additional information about services.

[7] eXist XML Database `http://www.exist-db.org/index.html`

[8] for an example see `http://www.infosys.tuwien.ac.at/staff/treiber/soaf/MartinTreiber.soaf`

[9] `http://ext.dcs.shef.ac.uk/~u0057/FoafGenerator`

[10] for the raw data see `http://www.infosys.tuwien.ac.at/staff/treiber/soaf/MartinTreiber.facebook`

[11] `http://www.infosys.tuwien.ac.at/staff/treiber/soaf/SOAFTransformation.xsl`

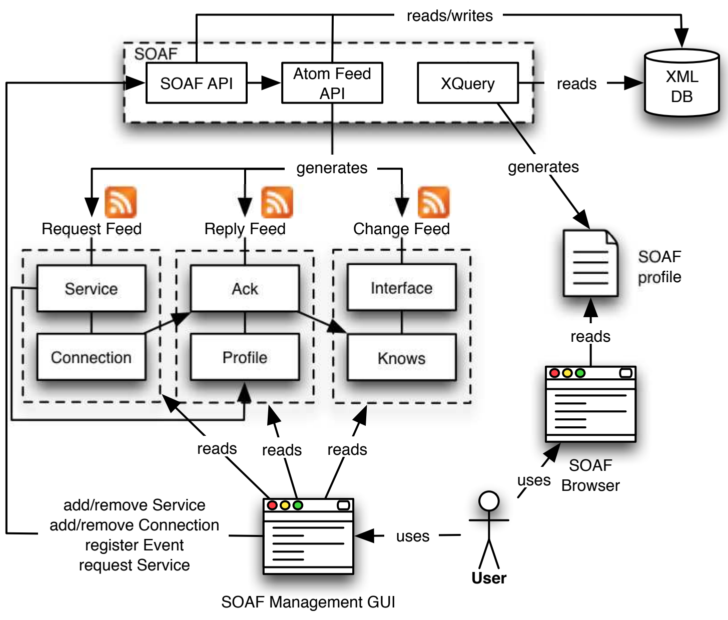

Fig. 4. Overview of SOAF architecture

5 Related Work

From a technical perspective, our approach have similarities with the Web Service Introspection Language [25]. Like WSIL, SOAF also provides a container to store Web service related data and supports the linking of services with each other. In contrast to WSIL, SOAF extends the service linkage towards social networks that is not provided by WSIL itself and integrates humans and services into a common network.

Semantic Web service communities as introduced by [26] aim at creating communities of Web services. However, the aforementioned approach focuses on issues like service replaceability and how semantic descriptions of communities can be created. We consider our approach at the other end of the spectrum, since SOAF follows a bottom up approach and doesn't require ontologies to define the available service functionality. Moreover, we explicitly consider humans and services as fundamental part of a network and integrate social structures into of service networks.

The work of Basole and Rouse [27] is related to our work in general. Value Networks [28] are of interest when business aspects are studied, i.e., the value that can be generated by such networks. In contrast, our work focuses on a different perspective, since we are preliminary concerned with the technical aspects of the integration of services and humans into a common network structure. However, for analysis purposes, value networks are relevant since they provide mechanisms

Mandelli [29] studies self-organizational aspects that are of importance for our work, since we consider SOAF as environment where we can investigate emergent structures. What distinguishes our approach is the technical focus of our work since we aim to augment existing social networks with service descriptions that we consider this as foundation for the integration of services in a future Internet of Services [30].

6 Future Work

Scalability issues are not yet fully investigated in our proposed SOAF network structure. Since we consider humans in the loop we require a simulation model to estimate the human impact in such networks (e.g., during searching).

Closely related are human provided services which we are going to investigate in the context of SOAF. In particular we are going to study dynamic aspects like quality of service of human provided services and how to address these issues in SOAF.

Furthermore, we are going to investigate how to generate larger networks from existing data. In order to obtain simulation data, we are going to crawl social networks and to address the important question how to bootstrap SOAF networks from this data. Another possibility is to analyze existing BPEL code and check for service invocations. The result of this analysis is an initial structure with knows relationships between all services that are part of the workflow.

With simulations of larger SOAF networks we are going to study evolutionary aspects of social service networks. Of particular interest is the study of concepts like fitness in simulations of SOAF networks and the impact analysis of fitness changes in such networks. Based on empirical data from existing social networks (e.g., facebook) we are aiming at the simulation the emergence of communities and how to identify such emerging communities within networks.

Within communities, we will investigate how trust is created among SOAF network members and how trust propagates within communities. We can envision scenarios, where person A trusts person B of a community and then automatically trusts all services that belong to the community of person B.

We are also going to extend the management capabilities of the prototype and introduce additional protocols to handle issues such as missed change notifications. Furthermore, we are going to investigate different update propagation schemes (e.g., flooding of direct neighbors with changes, etc.) within the network.

And finally, we consider the implementation of a SOAF network crawler that uses the available information to crawl a network efficiently. Using the collected information, we will be able to generate index pages for the SOAF network and support the discovery process.

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