Decentralized Semantic Service Discovery based on Homophily for Self-Adaptive Service-Oriented MAS (Extended Abstract)

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ABSTRACT

The aim of my PhD thesis is to propose a decentralized system for service management based on the social concept of homophily. The system provides self-organizing features, and it is established and maintained without supervision. Each agent manages autonomously events such as searching services, joining or leaving the system, which reduces the service management and the structure maintenance cost. Agents, considering only local information, carry out all these tasks.

Categories and Subject Descriptors

C.2 [**Comp. Comm. Networks**]: Network Topology

General Terms

Algorithms, Management, Performance, Experimentation

Keywords

Decentralized service management, self-adaptive systems, homophily and social networks

1. MOTIVATION

Paradigms for computing, such as P2P technologies or grid computing, can be considered in terms of service provider and consumer entities. SOMAS can be described as one of these systems where agents provide their functionality through services. The available services change dynamically and service management is not an easy task.

Centralized mechanisms, such as registries or middle-agents, partially address this task. These approaches are suitable for well-defined organizations where all the roles inside the organization are clearly defined[4]. However, they have several weaknesses that make them not suitable for highly dynamic systems. These weak points are bottlenecks, coordination effort, or outdated data. Besides that, the most important drawback is that these mechanisms rely on global knowledge. Hence, decentralized service management mechanisms are required in this type of systems. P2P approaches try to deal with the resource management in a decentralized way. Most of the proposals make use of pre-defined structures where the resource management rely on a set of peers. These structures are efficient but are not adaptive and are sensible to deliberated attacks. There are other proposals where there is not a central entity or entities which control and coordinate the resources and the peers. This fact makes more complicated the resource location task and it is carried out by flooding algorithms that increase the traffic [6].

Observing current society, human beings are able to create efficient social structures, in a self-organized way, without the supervision of a central authority. These structures allow individuals to locate other individuals in a few steps considering only local information. Scenarios where this property appears are labor markets, buyer-sellers networks, e-mail, or scientific citation networks[1]. Milgram also observed this fact in the experiment of 'six degrees of separation'[7]. The results of this experiment arose two questions: how is the structure of these social networks? And how is an effective search of individuals carried on only using local information? Several works began to pay attention on the analysis of the underlying structures in human societies and the properties of these structures. One of these properties is homophily.

Homophily is one of the most salient properties present in social networks. Lazarsfeld and Merton introduced the term in 1954. The idea behind this concept is that individuals tend to interact and establish links with similar individuals. Therefore, homophily establishes the proportion in which two individuals are similar along a set of social dimensions. This criterion to establish links between individuals creates structures that facilitate the location task [9]. For that reason, homophily could be considered as a self-organizing principle to generate searchable structures[5].

2. PHD THESIS

The aim of my PhD work is to propose a completely decentralized and self-adaptive system based on the social concept of homophily for service management in open SOMAS.

System Description. Each agent of the system plays an organizational role and offers a set of semantic services. Agents are situated in a Preferential Attachment network. In this type of networks links among the nodes are based on preferences, so some nodes are more likely to be connected than others depending on different factors. This structure ensures that the diameter of the network is $ln(n)$, where $n = |A|$ is

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the number of agents in the system [2]. The preferences in our system are based on *homophily*. Besides that, the agents that form part of the SOMAS have a reduced view of the global community. Just a handful of direct neighbors are known and the rest of the network remains invisible.

How Homophily is Included in the System. The preferences used in the proposed system are based on *homophily* and the number of neighbors of the agent. Homophily is a social feature which emerges from two mechanisms[5][8]:

- individual preferences about attributes such as religion, education, or geography among others. This homophily is called *choice homophily* and can be divided in two types: *status*, based on the formal or informal status similarity of the individuals, and *value*, based on the similarity of shared attributes.
- social structures and dynamics, which make individuals more similar over time. This is called *structural homophily*.

Matching these concepts with the agency-related concepts, *status* homophily can be identified with the role an agent plays within an organization, whereas *value* homophily represents the individual characteristics of the agent. In the case of a SOMAS, the semantic services are what characterizes an agent to the rest of the system. *Structural* homophily refers to how the structure, where the agents are situated in, adapts itself to be similar to the service demand.

Network Creation. The system grows according to a simple self-organized process. The probability to create a link between two agents is directly proportional to the *choice* homophily. If the *choice* homophily between agents is high, which means that they have similar semantic service descriptions and also play a similar role, the agents have a higher probability to be connected. Furthermore, the importance of the agent in the system is considered throughout the degree of the agent. Therefore, agents with a higher degree are more likely to receive new connections that loosely connected agents. Because the link creation is based on a probability function, it allows new agents not only to establish 'direct connections' between agents with similar attributes (services), but also between agents that are not similar. These connections are responsible of the small-world characteristics of the system that will allow navigating and locating desired agents efficiently by using only local information.

Semantic Distributed Search of Services. Agents should rely on local information for service discovery. The main reasons are: to avoid a dependence on a unique point of failure, to avoid the effects of changes in the system structure and because global information may not be available. The selected algorithm for service discovery in the system is the Expected-Value Navigation (EVN) algorithm [3], which uses degree and similarity. Basically, the algorithm selects the most promising neighbor to redirect a query about a service that it cannot provide. This selection is based on *choice* homophily and the connectivity of the direct neighbors.

Structural Homophily as Local Self-Adaptive Method. The concept of *structural* homophily is closed to self-adaptive structures. This homophily means in which proportion the services an agent supplies are similar to the system demand. In our system, each agent controls the queries that pass through it. The agent stores this information in a local registry. This registry consists on a set of entries. Each entry has two fields: one for the category and the other for the frequency of the queries of that category that have been received by the agent. The query contains the semantic description of the required service and the role that the provider agent should play. When an agent receives a query, it classifies the query in a category. With this information, periodically, each agent analyzes its *structural* homophily in the system, in other words, how similar are the services it offers to the services demanded in the system and estimates if it is worthwhile to continue in the system, because its services are demanded, or to leave it.

3. FUTURE WORK

The work presented here is a proposal in which we are going to continue improving several aspects. Currently, the agents in the system are homogeneous. We want to use the concept of 'agent personality' to introduce heterogeneity among agents. In the part of self-adaptation, we are going to include more actions such as the effect of the innovation in the system. The innovation for agents would be a service composition. Moreover, now the topology of the system remains static. Links that are not frequently used by the agent should disappear and the most frequently used should be reinforced. Besides that, the system could create new links as a result of the searches. These links would reduce the system diameter and therefore the path length, improving the performance of the system. Another idea to consider is that agents activate and deactivate the provided services considering the system demand. Instead of leaving the system, when the demand of a certain type of services is low, agents would deactivate that services and activate the most demanded services.

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