Introducing homophily to improve semantic service search in a self-adaptive system

(Extended Abstract)

E. del Val, M. Rebollo, V. Botti
Universitat Politècnica de València
{edelval, mrebollo, vbotti}@dsic.upv.es

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ABSTRACT

Humans create efficient social structures in a self-organized way. People tend to join groups with other people with similar characteristics. This is call homophily. This paper proposes how homophily can be introduced in Service-Oriented Multiagent Systems (SOMAS) to create efficient self-organized structures.

1. MOTIVATION

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 others in a few steps taking only local information into account. One of most salient properties present in these social networks is homophily[3][4]. The idea behind this concept is that individuals tend to interact and establish links with similar individuals along a set of social dimensions (attributes such as religion, age, or education). Therefore, in a structure that is based on homophily, an individual has a higher probability of being connected to a more similar individual than to a dissimilar one. This criterion creates structures that facilitate the location task. For this reason, homophily could be considered as a self-organizing principle to generate searchable structures.

2. SYSTEM MODEL

A system for decentralized service management in dynamic and open SOMAS is presented in this work. The agents in the system offer their capabilities through semantic services. In the system there is no a central agent who controls the services offered by the agents. The system structure is based on *homophily* between agents. The homophily is calculated based on attribute similarity. This means that agents have preferences about who are going to be their neighbors. This preferential attachment structure, allows the organization of the system in an autonomous and decentralized way and also it facilitates the search of agents functionality using only local information. Besides that, the system is self-adaptive. Agents decide to continue or leave it considering the service demand in the system.

The MAS is modeled as a undirected graph (A, L), where agents knows their direct neighbors only and this knowledge relationship is symmetric. An agent $a_i \in A$ is defined as $a = (R_i, N_i)$ a set of roles that defines its behavior and its neighborhood $N_i \subset L$. The role an agent plays $R_i = (\phi, S_i)$ is defined by a semantic concept ϕ defined in some common ontology and the set of semantic services the agent provides, defined by their inputs and outputs $s_i =$ (I,O).

The system is fully decentralized. For that reason, the system needs some kind of structure to facilitate the search of provider agents. The system is structured based on agent

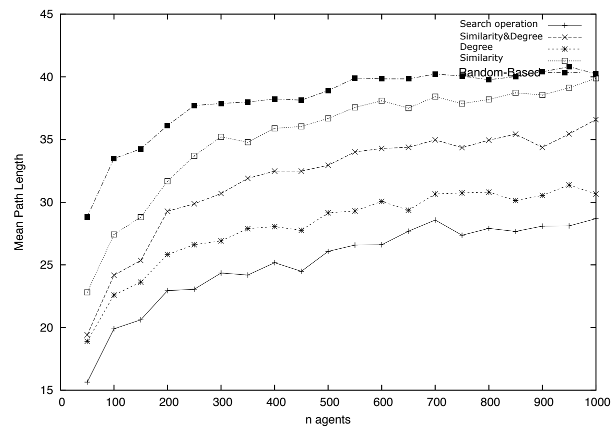

Figure 1: Search strategies (search operation based on Choice Homophily, service similarity and degree, degree and random) when the number of agents increases in the system.

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preferences: *Choice* and *Structural* homophily[4].

3. COMMUNITY CREATION BY HOMOPHILY

Choice homophily is used to create the structure of the system. This kind of homophily presents two forms: *status* homophily ($\mathcal{H}_s(\mathcal{R}_i,\mathcal{R}_j)$) that is defined over the agent's role (it is considered as the semantic similarity between the organizational roles played by the agents), and *value homophily* ($\mathcal{H}_v(\mathcal{S}_i,\mathcal{S}_j)$) that is defined over the agent's services (it is considered as the semantic similarity between the services offered by the agents). Therefore, the *choice* homophily between two agents is defined as the linear combination of *status* and *value* homophily [2]:

$$\mathcal{CH}(a_i, a_j) = \alpha * \mathcal{H}_s(\mathcal{R}_i, \mathcal{R}_j) + (1 - \alpha) * \mathcal{H}_v(\mathcal{S}_i, \mathcal{S}_j) \quad (1)$$

When a new agent, a_i, arrives to the system, it establishes at least one link with another agent, a_j, that is already present in the network. The link between two agents is established taking into account the probability for the agent a_i to establish a connection with agent a_j, that is proportional to the *choice homophily* between the agents. Once the agent is connected in the system, it starts to receive queries asking for services. These queries are generated by other agents that try to locate an agent that provides a required service. The system structure guides this search process. The search strategy is an extension based on EVN algorithm[1][2] (see Figure 1).

4. HOMOPHILY FOR SELF-ADAPTION

Structural homophily refers to how the structure, where the individuals are situated in, adapts itself to be similar to external conditions. In the system, this homophily reflects in which proportion the services offered by an agent are similar to the system service demand. Each agent controls the category of the queries which pass through it and it keeps this information in a local registry (see Figure 2). Periodically, each agent checks the demand of its services ($SH(a_i) = ae^{bc_i}$ where $c_i = \text{argmax}_x\, ae^{bx}$). If the value of its *structural homophily* is greater than a threshold, the agent decides to continue in the system ($P(cont) = SH(a_i)$). Otherwise, the agent leaves the system ($P(leave) = 1 - SH(a_i)$).

Before leaving, the agent queries its neighborhood. If it is the last agent that offers services of certain category in the neighborhood, it continues in the system with a certain probability, even though its services are not demanded in that moment. This guarantees that the system is going to maintain a minimum service offer. In the case that the agent continues in the system, it has a certain probability to create a set of clones in order to fulfill the demand of the system (see Figure 3). As the experiments demonstrate, the structure generated allows agents to reach other agents that offer a required service in a few steps. Of the set of typical strategies used in decentralized environments, the strategy that takes into consideration choice homophily between agents to lead the search obtains better results. Also, the system is able to adapt itself to the service demand, in a completely decentralized way based on structural homophily. The experiments demonstrate (i) that homophily is a good criterion to structure agent communities based on similar services, increasing the performance of service discovery in decentralized environments, and (ii) that structural homophily is a good strategy for adapting the system

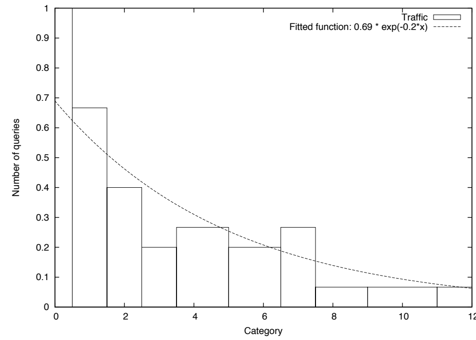

Figure 2: Demand analysis in agent a_i. For each query received, a_i classifies it in a category. The x-axis shows the identified categories and the y-axis shows the number of queries of that category that a_i has received.

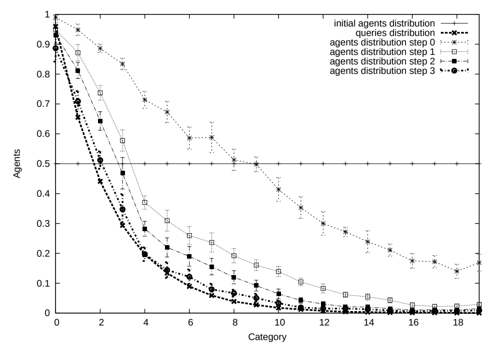

Figure 3: Adaptation process for uniform initial agent distribution. The query distribution follows an exponential function.

agent distribution to the service demand.

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