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Business Reputation of Social Networks of Web Services

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Abstract

This paper introduces a set of criteria that are used to establish the reputation of a social network from a business perspective. This network is populated with social Web services. Compared to regular Web services, social Web services establish and maintain networks of contacts, count on their (privileged) contacts when needed, etc. These criteria are membershipCost, demandLevel, satisfactionLevel, and retentionLevel, and assist a social Web service in selecting the best social network in which it will sign up. Similar criteria have been defined in the past with emphasis on the security perspective of a social network. A set of simulations conducted over an in-house built JAVA testbed, are also presented in the paper with focus on analyzing three aspects: profit of network, quality of network, and profit *versus* quality of network.

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1. Introduction

In [1] and [2] we introduce the concept of Social Web Services (SWSs) and discuss how it addresses certain limitations (e.g., discovery and high-availability) that refrain IT practitioners from adopting Web Services (WSs) technology in their system development. Compared to (regular) WSs, SWSs establish and maintain networks of contacts; count on their (privileged) contacts when needed; form with other peers strong and long lasting collaborative social groups; and know with whom to partner so that ontology and policy reconciliation is minimized [2]. To support a SWS perform these operations we established specialized Social Networks (SNs) known as collaboration, substitution, and competition in which the SWS signs up and thus, becomes a member (upon signing up in a social network a Web service is referred to as social Web service).

Like persons who sign up in Web 2.0 applications like Facebook, Instangram after analyzing their pros and cons using criteria such as types of offered services, protection level, and popularity among users, we argue that WSs (in fact their providers) should be given the same opportunity of assessing the appropriateness of the collaboration, substitution, and competition networks with respect to their needs, requirements, and characteristics. A WS that

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signs up in a network becomes exposed to both the authority of this network and the existing members in this network as well. They (i.e., authority and members) can screen the WS's credentials with the risk of altering them and hence, putting its reputation and correctness levels at risk, for example. To assist WSs make the right decision when selecting the SNs we established in a previous work the reputation of SNs from a *security* perspective[3]. Four security criteria known as robustness, trust, fairness, and traceability are used to establish this reputation and permit for instance, to tell which SN deploys the necessary means that guarantee (*i*) the safety of its members' sensitive details from unauthorized accesses and (*ii*) the fair treatment of all its members.

In this paper we continue the efforts put into the reputation of SNs with emphasis, this time, on the *business* perspective. Similar SNs (of same type) are in competition and hence, reputation can be a decisive factor for the WSs at selection time. Like with the four security criteria, we put forward additional business criteria such as membership cost, demand level, and retention level that permit for instance, to indicate which SN has the best market share. Section 2 is an overview of SWSs and security-based reputation of of SNs. Section 3 presents the experiments that were carried out to establish the business reputation of SNs. Finally Section 4 concludes the paper.

2. Background

2.1. Social Web services in brief

Three communities discuss the blend of social computing (exemplified by social networks) with service-oriented computing (exemplified by Web services). A first community deploys SNs of persons using Web services as an implementation technology. A second community deploys SNs of SWSs to address issues like discovery. Finally, a third community combines both SNs of users and SNs of SWSs together to develop composite Web services.

In the first community, Al-Sharawneh and Williams mix semantic Web, SNs, and recommender systems to assist users select Web services with respect to their functional and non-functional requirements[4]. In[5], Bansal et al. examine trust for Web services discovery. Trust of users in Web services' providers is the social element that affects this discovery. In[6], Maaradji et al. propose a social composer (*aka SoCo*) that advises users on the next actions to take in response to specific events like selecting a certain Web service. Last but not least, Wu et al. rank Web services based on their popularity among users[7]

In the second community, Chen and Paik build a global social service network to improve service discovery. They connect services together using specific data correlations[8]. In[9], Maamar et al. develop a method to engineer SWSs. Questions that the method addresses include what relationships between Web services exist, what SNs can be built upon these relationships, how to build SNs of SWSs, and what social behaviors SWSs can exhibit. Last but not least, Maamar et al. use SNs of SWSs to tackle the "thorny" problem of Web services discovery[10]. At run time Web services run into various situations like competing against similar peers during selection, collaborating with different peers during composition, and replacing similar Web services during failure despite the competition. These situations help build the privileged contacts of a SWS.

In the last community that combines SNs of users and SNs of SWSs together, Maamar et al. intertwine these networks to compose, execute, and monitor composite Web services[11]. To achieve this intertwine three components are developed: composer, executor, and monitor. The composer considers both relations between users and relations between Web services to develop composite Web services. The executor assesses the impact of both relations on the execution progress of composite Web services. Finally, the monitor replaces failing Web services so that the execution continuity of composite Web services is guaranteed.

2.2. Security-based reputation of social networks

To keep the paper self-contained we discuss the security criteria of a competition social network, only. For collaboration and substitution networks readers are referred to[3]. We recall that a competition social network consists of SWSs that offer similar functionality.

When a SWS (SWS_i) signs up in a competition social network, it becomes exposed to its competitors and *vice-versa*, which makes them aware of each other. The four security criteria are privacy, trust, fairness, and traceability. Because of lack of space only privacy is presented. Indeed a SWS needs to be "sure" that appropriate means in the competition social network guarantee the protection of its sensitive details (e.g., non-functional properties (QoS)) from unauthorized accesses of competing members in the network. If some competing members access these details they could use them for instance, to beef up their capabilities and hence, become better competitors. We measure the privacy level of a competition social network ($Privacy_{Comp}$) by: $Privacy_{Comp} = \min_{i\in[1,n]}(\frac{|failedAttacks_{SWS_i}|}{|Attacks_{SWS_i}|})$ where $|failedAttacks|$ represents the total number of attacks that SWS_i was subject to but failed, $|Attacks|$ is the total number of attacks on SWS_i, and n is the number of SWSs in the network.

3. Business-driven reputation of social networks

3.1. Business criteria

To identify the necessary business criteria that will help establish the reputation of SNs of SWSs we studied a questionnaire that evaluates social networks from a marketing perspective [12]. The objective of studying this questionnaire is to help identify criteria for evaluating a SN reputation. Eight questions are included in the questionnaire: Who are the current users, Who is likely to use the network over time, Are these people potential customers or do they have the ability to influence your potential customers, What types of content are those people passionate about and likely to share, How does content get exposed to other people on the network, Can you create new types of content for your business to leverage a popular new social network, How much time and resources are required to participate in this social network, and finally, Can you foresee a promising ROI? In addition to this questionnaire we considered our previous work on the reputation of communities of Web services [13].

Our proposed business criteria are listed below and will be monitored over a certain observation window (w that was set to every 30 days during simulation):

1. membershipCost criterion: represents a fee for a SWS that would like to sign up in a SN. The fee needs to be attractive to SWSs due to the competition that exists between similar SNs.
2. demandLevel criterion: represents the popularity of a SN among SWSs. This criterion considers the membership demands that a SN receives from WSs and accepts over the total membership demands accepted by the M competing SNs (Equation 1); by competing we mean similar SNs.

$$\text{demandLevel}^{w}_{SN_i} = \frac{\text{acceptedDemands}_{SN_i}}{\sum_{k=1}^{M} \text{acceptedDemands}_{SN_k}} \tag{1}$$

3. satisfactionLevel criterion: represents the aggregation of the SWSs' subjective opinions on the "services" that a SN offers to these SWSs, e.g., how efficient the SN is when directing user requests to a SWS.

$$\text{satisfactionLevel}^{w}_{SN_i} = \frac{\sum_{j=1}^{N} \text{acceptedServices}_{SWS_j}}{\sum_{i=1}^{M}\sum_{j=1}^{N} \text{acceptedServices}_{SWS_j}} \tag{2}$$

   where M is the total number of competing SNs and N is the total number of SWSs in a certain $SN_{1..M}$.
4. retentionLevel criterion: represents how good a SN is in keeping its member SWSs. A higher satisfaction level (Equation 2) indicates a good retention level[1] and *vice-versa*. retentionLevel refers to the exit demands that a SN receives over the membership demands that this SN accepts (Equation 3). retentionLevel criterion also helps establish the growth level of a SN with respect to the current number of SWSs in the network.

$$\text{retentionLevel}^{w}_{SN_i} = \frac{\text{exitDemands}_{SN_i}}{\text{acceptedDemands}_{SN_i}} \tag{3}$$

3.2. Experiments

We discuss the scenarios that are simulated and then the testbed supporting the analysis of these scenarios.

[1] i.e., the SWSs are satisfied with the SN's offered "services".

3.2.1. Scenarios

In addition to membershipCost, demandLevel, satisfactionLevel, and retentionLevel criteria we deemed necessary having an additional criterion, that is assignedBudgetSWS, so that we carry out the necessary experiments. assignedBudgetSWS allows a SWS to cover the social networks' membership fees. For the sake of simplicity, we set assignedBudgetSWS every month. A SWS could secure extra income by processing users' requests and/or acting as substitute or collaborator but this is outside this paper's scope. membershipCost is an income for a SN and thus, the SN would like to maximize it. This could happen by accepting a maximum number of SWSs' membership demands to the network while considering the computing capacities (e.g., performance and storage) of the infrastructure upon which this network is deployed. The three scenarios that we simulate are:

1. Scenario A(profit-driven): a SN would like to accept a maximum number of membership demands that SWSs submit. This might impact the SN's satisfactionLevel[2], which could force the SWSs to leave the network and thus, have an impact on retentionLevel.
2. Scenario B(quality-driven): a SN would like to maintain a high satisfactionLevel and retentionLevel according to a certain threshold. Is it safe to assume that the higher these two criteria are, the higher membershipCost is? A SN needs to be aware of assignedBudgetSWS constraint. A higher or continuous increase of membershipCost might force the SWSs to look for other networks.
3. Scenario C(profit-driven *versus* quality-driven): a SN would like to establish a tradeoff between profit and quality. How does membershipCost impact both satisfactionLevel and retentionLevel and *vice-versa*?

3.2.2. Testbed configuration

Scenarios A, B, and C have been analyzed using an in house built JAVA testbed. The testbed consists of three distinct SNs and ten SWSs per network. SWSs pay different membership fees depending on the SN that they belong to. The cheapest and most expensive are SN_0 and SN_2, respectively. SN_1 is in between. By being members of SN_2 compared to $SN_{0,1}$ the SWSs are guaranteed a certain level/percentage of user requests to process, which should help improve SN_2's satisfactionLevel.

Simulations last for a sufficient time-interval in which we are able to analyze the dynamic of all the networks. During this time-interval, which we measure as one year of simulation, the SWSs could be **disappointed** in the "services" that they receive from a SN and may quit. This happens when their satisfactionLevel drops below a certain threshold, which is common for all SWSs in the same network. The SWSs that leave a network end-up residing in a temporary "world" that we call *Limbo*, until they have the opportunity of signing up in another network again. *Limbo* allows to generate a movement of SWSs so they can identify the most suitable network. Moreover, the introduction of new SWSs, not coming from *Limbo*, happens during the year-time simulation. New SWSs join random networks so that the same networks are not targeted at startup time. Afterwards the SWSs could move to other SNs during their lifetime. This way of inserting SWSs into SNs makes the testbed dynamic.

Other considerations in the simulation are: (*i*) 30% increase in membershipCost each trimester (could be fine tuned if need be), (*ii*) presence of *users* who assign requests to SWSs based on the quality of networks (20% of requests are assigned to SN_0, 30% of requests are assigned to SN_1, and 50% of requests are assigned to SN_2)[3], and (*iii*) each scenario runs for 100 times and each plotted line is represented by the mean value with a confidence interval of 95%[4].

Analysis of satisfaction level. A SN's satisfactionLevel measures the "happiness" of SWSs in the network. To this end we consider the number of user requests assigned to a SWS when it joins a SN. Fig. 1, 2, and 3 illustrate the trend of a SN's satisfactionLevel when simulating Scenarios A, B, and C. In particular, Fig. 1 shows that the more crowd a network has, e.g., Fig. 7, the lower the satisfaction level is. In fact, each SWS in SN_0 receives a low number of user requests to process since competition among the SWSs is high. On the contrary SN_2 obtains the highest satisfactionLevel among the networks due to the highest membershipCost. As a result of the highest cost SN_2 attracts few SWSs.

[2] Due to the high number of SWSs versus a SN's computing capabilities.
[3] Request assignment follows a probabilistic choice. The SWSs that pay higher membership fee in SNs receive more requests.
[4] http://tinyurl.com/7crgf for more details on the confidence interval.

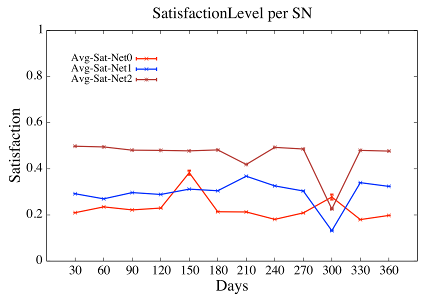

Fig. 1. SN's satisfactionLevel in scenario A:profit-driven

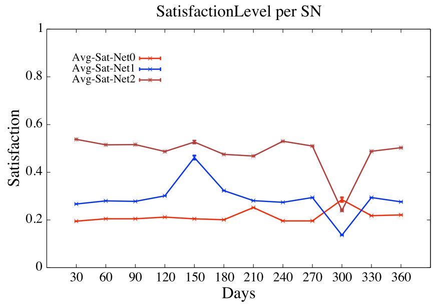

Fig. 2. SN's satisfactionLevel in scenario B:quality-driven

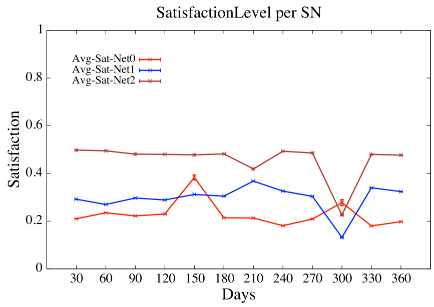

Fig. 3. SN's satisfactionLevel in scenario C:profit *versus* quality

Quite similar trend is observed when simulating a SN's satisfactionLevel with focus on quality. Here, the SNs with a higher quality, i.e. SN_2 and SN_1, still keep a high satisfactionLevel despite a high membershipCost. This, however, allows the SWSs to receive a good number of user requests in spite of an increase in the number of SWSs. When simulating a SN's satisfactionLevel with focus on profit *versus* quality, a SWS considers both membership and quality when submitting a membership demand to a SN. Fig. 3 shows better satisfaction trend for SN_0. This is because the SWSs not only avoid SN_0 but follow a quality-driven approach and prefer SN_2 over SN_1 and SN_1 over SN_0.

Analysis of demand level. Starting with Fig. 4, we notice that the highest percentage of sign-up demands fall over SN_0. The opposite occurs in Fig. 5. Finally, in Fig. 6 both SN_1 and SN_2 secure a major demand share, although the SWSs still prefer a cheaper SN.

Analysis of number of social Web services. Findings about the numbers of SWSs in the SNs are a direct consequence of these SNs' demandLevel. Results plotted in Fig. 7, 8, and 9 highlight the dynamic in the SNs. Starting with the profit-driven case, SN_0 is the most crowded since its lowest membershipCost helps attract more SWSs. Then SN_1 and SN_2 have basically similar trend.

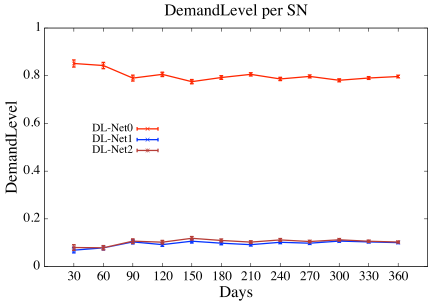

Fig. 4. SN's demandLevel in scenario A:profit-driven

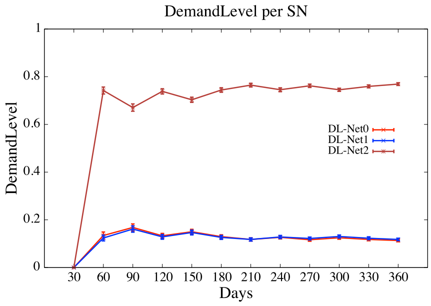

Fig. 5. SN's demandLevel in scenario B:quality-driven

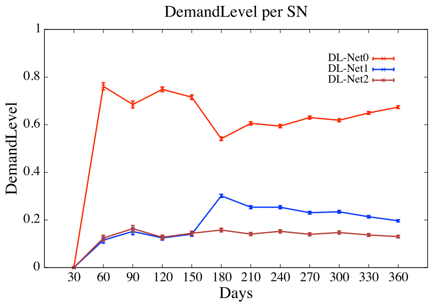

Fig. 6. SN's demandLevel in scenario C:profit *versus* quality

The quality-driven scenario provides a reverse result. In Fig. 8 SN_2 is the most attractive since SWSs consider quality first. Finally, when membership and quality are combined together, Fig. 9 shows that SWSs prefer moving towards SNs with lower membershipCost instead of high.

Analysis of retention level. We use retentionLevel to measure the ratio between exit and accepted demands of SWSs. A lower value of retentionLevel proves a good strategy for SNs to attract more SWSs. In fact, the number of SWSs is quite high and as consequence SN_0's retentionLevel is low, confirming a good network strategy. Since SN_2's choice is to be quality-driven it receives more SWSs and these latter do not leave the network so often. In the last case, again a lower membershipCost is preferred by SWSs, and they quit SN_2 to move towards SN_1 and then SN_0.

4. Conclusion

In this paper we discussed the reputation of SNs (referred to as collaboration, substitution, and competition) from a business perspective using four criteria that are membershipCost, demandLevel, satisfactionLevel, and retentionLevel. These SNs are populated with SWSs that are given the opportunity to sign-up in the appropriate SNs according to their providers' needs and requirements. Compared to regular WSs, SWSs establish and maintain networks of contacts, count on their (privileged) contacts when needed, form with other peers strong and long lasting collaborative

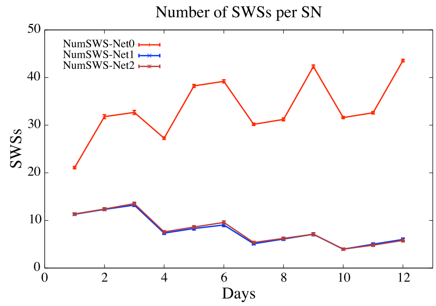

Fig. 7. SN's number of social Web services in scenario A:profit-driven

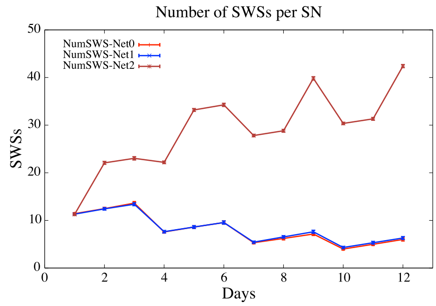

Fig. 8. SN's number of social Web services in scenario B:quality-driven

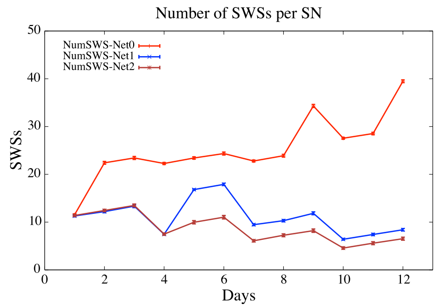

Fig. 9. SN's number of social Web services in scenario C:profit *versus* quality

social groups, and know with whom to partner. To analyze the business criteria different simulations were conducted using an in-house built JAVA testbed. The scenarios associated with these simulations are profit-driven, quality-driven, and profit-driven *versus* quality-driven. The analysis of SNs from a business perspective is built upon our previous work on the same analysis but from a security perspective[3]. Thus in term of future work we would like to mix both perspectives so that a trade-off between security reputation and business reputation is established.

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