Identifying Collaboration Strategies in Scientific Collaboration Networks

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Abstract. A number of virtual networks, called Scientific Collaboration Networks (SCNs) have been increasingly adopted as means to connect researchers around the world. In this article we have analyzed how the SCNs ResearchGate and Academia.edu support collaboration between researchers, through an analysis of their interface and contrast with the general purpose online social network (OSN) Facebook. The analysis of these systems allowed us to identify four categories through which network members collaborate: information sharing, interaction levels, communities and artifacts. Although the categories are the same for SCNs and OSNs, the strategies adopted in each context are different. We discussed how these strategies, which can be used to support design and evaluation of SCNs, are used to foster collaboration among researchers in these systems.

Keywords: Scientific Collaboration Networks · Social networks · Semiotic engineering · Semiotic Inspection Method · Communicability evaluation

1 Introduction

Applications and services that facilitate collective action and social interaction online between people with rich exchange of information, motivated by different interests, have come to dominate the Web [11]. Thus, a large number of online social networks (OSNs) have emerged, allowing for greater interaction between their users, based on exchanging and sharing of information. In the academic context, specifically, considering that scientific research is usually developed through collaboration between researchers and research groups, networks similar to OSNs can be used by researchers to share knowledge and find potential research partners, enabling collaboration on a global scale [9].

In this context, a number of virtual networks, called Scientific Collaboration Networks (SCNs) have been proposed. These systems support individual researchers' efforts to form and maintain collaborative relationships for conducting research within a specific context as well as expanding the scientific collaboration scope [13]. Thus, understanding collaboration strategies that are used in SCNs becomes important in order to ensure that they effectively meet scientific communities' needs.

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This article contributes to this line of research by identifying the collaboration strategies that are currently provided in SCNs. To do so, we analyzed the SCNs ResearchGate[1] and academia.edu[2], using the Semiotic Inspection Method (SIM) [5, 6]. In order to discuss the differences between these collaboration strategies and those adopted in OSNs, the results from the SCNs analysis were contrasted with the results from analysis of the OSN Facebook[3].

The results of this study contribute to researchers and developers of collaborative systems, specifically SCNs. To researchers, the identification of the types of collaboration provided in SCNs is a relevant step in understanding the context of collaboration and the proposed solutions in current SCNs. The results can also be useful in allowing for more effective design and evaluation of SCNs, and thus improving the quality of their interaction.

In the next section, we present the related works that investigate SCNs. We then present the underlying theoretical framework of our study and the method used in the analysis of the systems. Next we describe how SIM was applied in our study, followed by the results of the analysis. Finally we discuss our results and present the next steps in our research.

2 Related Work

SCNs are noteworthy for presenting a number of features designed specifically to meet the scientific community's needs [14]. Considering the importance these systems have acquired recently, due to their ability to enable collaboration and sharing of scientific knowledge, some studies have been conducted in order to encourage the SCNs projects to effectively reach their proposed goals [1, 2, 8, 13, 15].

Schleyer et al. [13] suggested a research agenda for SCNs that covers four areas that contribute to their success: foundations, presentation, architecture, and evaluation. "Foundations" addresses core principles and general factors that underlie the design of effective SCNs; "presentation" deals with issues concerning user interfaces, interaction design and system functionality; "architecture" is concerned with internal design of SCNs and how they interact with external information sources; and "evaluation" is concerned with how SCNs outcomes can be framed and measured.

Lackes et al. [8] presented a conceptual design model of an SCN that helps bridge the gap between researchers at universities and enterprises, improving collaboration within systems. Also regarding the conceptual modeling of SCNs, given that the turnover rate of users remains a great challenge for the viability of these systems, Cao et al. [2] explored the determinants that impact members' continued participation behavior in SCNs by attempting to address what factors would cultivate different forms of commitment of members to a virtual group. Besides, the authors explored how would these different forms of commitment impact members' continuance intention in

[1] www.researchgate.net.

[2] www.academia.edu.

[3] www.facebook.com.

SCNs and proposed a preliminary model for understanding continued knowledge sharing in SCNs.

However, we could not find studies that focus specifically on the analysis of types of collaboration provided by SCNs. In this article we analyze SCNs identifying and discussing the collaboration strategies used to support interaction among researchers through these systems.

3 Theoretical Framework

Semiotic Engineering [4] is an explanatory theory of HCI that perceives human–computer interaction as a special case of computer-mediated human communication. A system's interface is a message sent from designers to users about the designers' vision on who the users are and how their product meets the users' needs, and what benefits and value it can ultimately bring to the users' lives. Designers are not present at interaction time, so the message is conveyed to users as they interact with the system's interface. Thus the designer to user message is in fact a meta-message being conveyed by the interface.

In collaborative systems, such as SCNs, the message sent from designer, through the interface, is not to a single user, but to a group of people who will interact with each other through the system. In this case, the designers' message to users also conveys their decisions with respect to the roles that each group member can take, the activities and tasks through which they can or should interact, and the protocols and languages that should be used by users to communicate [4].

The designer-to-user message is comprised of signs arranged at the interface. A sign, as defined by Peirce [12], is "anything that stands for something else, to somebody in some respect or capacity". Semiotic engineering classifies the signs in three classes [3, 5, 6]: static, dynamic and metalinguistic. Static signs are signs whose meaning is interpreted independently of temporal and causal relations and express the system's state. Dynamic signs represent the system's behavior. They are bounded to temporal and causal aspects of the interface and communicate the processing that leads to transitions between system states. Metalinguistic signs are explanations from designer to users about the system or other interface signs.

One of the methods that have been proposed to evaluate the quality of the system as a designer to user communication is the Semiotic Inspection Method (SIM) [3, 5, 6]. SIM is an inspection method that evaluates the intended message being sent by designers to users and identifies potential breakdowns users may have when interacting with the system. SIM is an interpretive and qualitative method and that can be used technically (to identify problems in a system's interface) or scientifically (to identify or explore research issues represented in the interface) [3, 6].

SIM is composed of one preparation step and five application steps. The preparation step is carried out in four sub-steps: (i) definition of the purpose of the inspection; (ii) informal inspection of the system in order to define the intended focus of the evaluation; (iii) identification of the intended users, main objectives and activities that the system supports; and (iv) preparation of inspection scenarios that provide the contextual structure necessary for the communication analysis.

The application steps of SIM are: (1) inspection of metalinguistic signs; (2) inspection of static signs; (3) inspection of dynamics signs; (4) compare and contrast the meta-message identified in steps (1), (2) and (3); and (5) carry out the appreciation of the meta-communication quality. Steps (1), (2) and (3) are done iteratively. In these steps the evaluator makes a segmented analysis of the system, one for each of the three classes of signs: metalinguistic, static and dynamic. As a result of each step the evaluator reconstructs the meta-message being conveyed by the designer through each type of sign and identifies the potential breakdowns (in the technical application) or evidences regarding the research issue of interest (in the scientific application). In step (4) the evaluator should contrast and compare the results generated in the first three steps. The evaluator should explore the possibility of the user assigning different meanings to the signs or even identify cases where the meta-message is incomplete due to the lack of signs that clarify the designer's intent. Finally, in step (5) the evaluator must reconstruct a complete/unified meta-communication message by comparing, integrating and interpreting the data collected in previous steps of the method. The evaluator is also expected to articulate his/her findings about the communication quality of the system based on the communicative strategies identified in previous steps.

When applied scientifically, the purpose of the evaluation is defined through the research question to be investigated. The system to be evaluated is only then chosen as an application instance that serves the purpose of research [3, 6]. Moreover, in this case, SIM requires a final triangulation step, in order to ensure the scientific validity of results, taking into account interpretations generated from other sources [3]. Figure 1 illustrates Semiotic Inspection Method steps for a scientific application.

In our study, SIM was applied to investigate whether SCNs offer collaboration strategies which are specific to the scientific collaboration context. To do so, firstly we applied SIM to ResearchGate and identified the collaboration strategies offered to users. Next, we applied SIM to academia.edu with the same focus and compared the results with the ones found through the inspection of ResearchGate. Finally, SIM was applied to Facebook to identify how the previously identified scientific collaboration

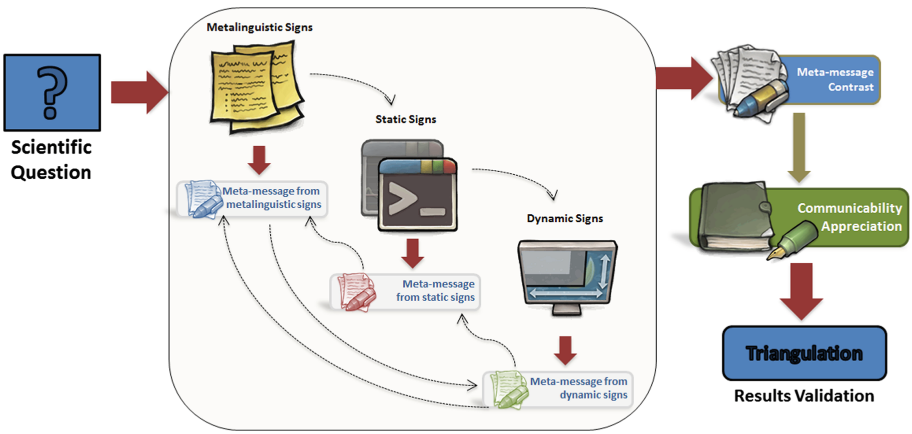

Fig. 1. Semiotic Inspection Method steps for a scientific application

strategies differed from social collaboration strategies. In the next section we briefly describe how SIM was applied in each case.

4 Methodology

In order to investigate whether there were collaboration strategies that were specific to Scientific Collaboration Networks, the first step in our study methodology was to identify which collaboration strategies were being used in SCNs. The next step was to contrast the strategies identified for SCNs with collaboration strategies being used in general OSNs. Figure 2 shows an overview of the methodology.

To perform the first step, two instances of SCN applications – namely, Research Gate and academia.edu were chosen. The two systems were chosen due to their high popularity[4]. Research Gate was initially inspected using SIM in November 2011 and the inspection was reviewed in July 2012, by two evaluators independently and their findings consolidated. As a result an initial set of the adopted collaboration strategies being used were identified.

Next, we proceeded with the application of SIM to academia.edu. The same inspection scenario used in Research Gate was used in academia.edu and the analysis was conducted by one evaluator in May 2012 and reviewed in September of the same year. The set of collaboration strategies identified for academia.edu were used to confirm and refine the initial findings for Research Gate. As a result, we identified what types of collaboration were being offered to researchers in SCNs and what was their focus.

The next aspect to be investigated was whether these collaboration types or their focus were specific to the scientific domain, as opposed to support needed in any online social network. Thus, we chose a general-purpose OSN – Facebook[5], in order to compare the results with those obtained for the SCNs. Facebook's inspection was conducted from September to October 2012 by two evaluators. The results[6] described in the next section show that although the categories of collaboration support are the same, the interaction strategies available are different in SCNs and OSNs.

It is worth noting that although the interface of all three systems have been modified since they were analyzed in our study, the results are still of interest to the community, since they do not focus on interface elements, but rather on the identification of scientific collaboration strategies in SCNs, as will be presented in the next section.

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[4] At the time of the analysis Research Gate and academia.edu claimed to be used by over 1.5 and 2 million users, respectively. Currently (Feb. 2015) the number of users have increased to over 6 million users for Research Gate and over 18 million for academia.edu according to their websites - http://www.researchgate.net/ and http://www.academia.edu, respectively.

[5] At the time of the study (2012) Facebook had already reached over 1 billion users. In Feb. 2015 Facebook reports (http://newsroom.fb.com/company-info/) having over 1.39 billion active users.

[6] Due to the limited space available, we only present the final results of the analysis and not the individual analysis of each system.

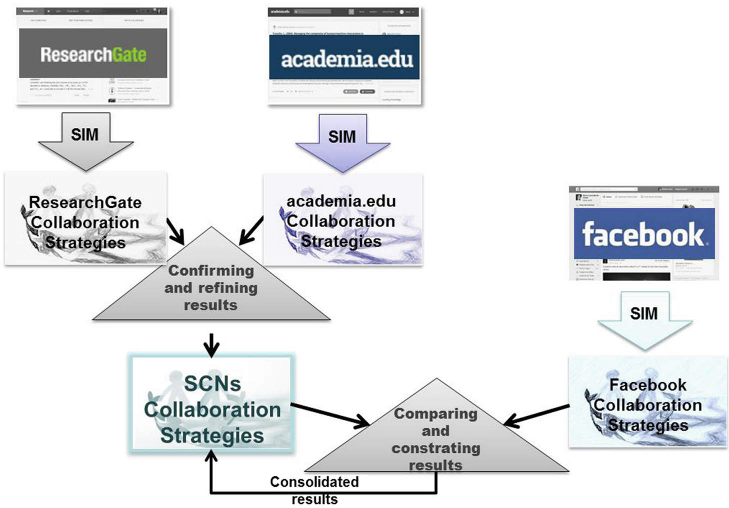

Fig. 2. Study methodology

5 Collaboration Strategies

The analysis of ResearchGate, academia.edu and Facebook allowed us to identify four categories through which members collaborate: information sharing, interaction levels, communities and artifacts. Although the categories are the same for SCNs and OSNs, the strategies adopted in each context are different.

5.1 Information Sharing

Users share information about themselves in ResearchGate, academia.edu and Facebook. However, the nature of the information of interest is different depending on the focus of the network system. In SCNs the focus is on aspects related to the person's research and expertise. Thus, these systems' information fields focus on users' background and research, such as their affiliation, their advisors, disciplines, skills and experience in research.

The **nature of the information shared** differs in SCNs and OSNs, since in the latter the information is more of a social focus. Thus, it usually includes general information about the person, such as birthday, civil status or sexual preferences. OSNs may also include some pieces of information related to professional aspects, such as workplace and professional skills, but these are superficial when compared to the researcher profile information in SCNs.

SCNs and OSNs also differ in relation to the **visibility of users' informabion**. In SCNs all information about a user is visible by all other users in the system, and there are no privacy settings available. This is suitable to the scientific context given that one of its main goals is to facilitate scientific knowledge dissemination and to provide visibility to one's work. Thus, it is interesting for researchers to know other researchers' background, as well as having access to their publications. OSNs, on their turn, consider that users may have different relationships with different people, and thus users may not want to share the same information with all other members of the network system. For instance, Facebook offers complex privacy settings to users, allowing them to define with whom they share the different pieces of information about themselves.

Another relevant aspect in SCNs is the researcher's scientific **reputation**, which refers to the reliability and significance of the information generated by each one. Therefore, SCNs present indicators regarding the relevance of each researcher's work. Some indicators are already associated to research (e.g. impact factor), whereas others are generated by the system itself and take into consideration data collected through the interaction of users, such as how many followers a researcher has, or how many of his/her publications were requested or downloaded. In this direction ResearchGate offers among other stats the RG Score for each researcher and academia.edu offers an analytical overview on the number of times that a researcher's profile, as well as his/her documents were visualized in the previous thirty days. OSNs do not always offer indicators associated to reputation, for instance in Facebook there is no such indicator. Nonetheless, when they do, indicators tend to point to users' popularity in the system. For instance, Orkut showed how many of a users' friends declared being their fan.

5.2 Interaction Levels

The analysis performed showed that SCNs offer researchers different levels of interaction with other researchers. The first interaction level identified is a weak tie relationship, which we have denominated **coexistence relationship**, and is available by default to all users of the system. This relationship allows any researcher to interact with any other researcher through asynchronous messages. These messages can either be of free content – user defines content of message; or of predefined content – the message is predefined by the system, and is sent by the system from one user to the other by request of the sender, for instance, requesting a copy of a publication. This type of relationship is also present in OSNs. However, the predefined messages are of a social nature, e.g. request to be a friend.

The second interaction level, called **unidirectional interest relationship**, represents relationships in which it is sufficient for one of the parties involved to be interested for a relationship to be established with another user. In SCNs they represent the possibility for a researcher to unilaterally state their interest in obtaining information on another network users' work. In the analyzed SCNs, instances of such a relationship were represented by the possibility of a researcher to "follow" other researchers within the system, being informed automatically about their updates or new content shared by them.

In OSNs unidirectional interest relationships may be available, but are not the main type of interaction between users. For instance, in Facebook, users may follow other users in order to receive information about them. However, this relationship is turned off by default and, if users wish to allow others to establish a unidirectional interest relationship to themselves, they must explicitly activate that possibility. Thus, we may conclude that it is expected that most users will not have an interest in such relationship.

The third interaction level identified is **bidirectional interest relationship**. This level consists of a situation in which two researchers establish a unidirectional interest to each other. For instance, researcher A decides to follow researcher B and researcher B also decides to follow researcher A. In this case, the system may treat them as two unidirectional interest relationships, or it may identify that the relationship is bidirectional and augment the relationship between the two by increasing the possibilities of interaction between them. For instance, in ResearchGate when two researchers follow each other they are allowed to suggest a publication to each other through the system. In academia.edu, on the other hand, this situation is treated as two independent unidirectional interest relationships.

Besides the previous levels of interaction, we have identified a stronger type of relationship, which we have denominated **trust relationship**. This relationship requires two users to agree upon establishing a relationship between themselves. For instance, in ResarchGate it is characterized by two researchers defining themselves as each other's "contact". To do so, a user adds another user as a contact and the latter has to accept the relationship. In ResearchGate[7] this level of interaction offered users a broader range of collaboration and communication between themselves, such as one being able to introduce another researcher to a trusted relation. In OSNs the friendship relationship is an instance of a trust relationship.

5.3 Communities

Communities in SCNs can be seen as a space for a group of people with common interests to communicate with each other and share content related to those interests. Specifically in this type of system, we can describe two types of communities: **communities of interest** and **working groups**. In the first one, the goal is to group content provided in these systems in specific areas of research, allowing for discussion on specific topics within these areas, besides involving a variable and unlimited number of people. These communities are open and users can join them without the need for approval, encouraging them to share their knowledge within such communities. In addition, users can create a community of interest at any moment, simply entering a name for it. However, a novel community name may require approval by system administrators to ensure that it is a research topic. The working group, on its turn, is a closed group, with a limited number of people. This community can be created by a user in order to allow for collaboration (not just discussion) between a specific group of researchers.

In ResearchGate, communities of interest are named "Topics" and their functioning is similar to forums devoted to discussing the scientific issues and sharing knowledge, in the form of questions, links, publications and archives. In academia.edu, these communities are named "Research Interests", which aim at bringing together people, questions, documents, journals and jobs within a specific area of research/knowledge.

[7] In the evaluated version of the ResearchGate all four interaction levels were available to users. However, an informal inspection of the current version indicates that these levels seem to have been simplified and reduced to only the first two levels.

Concerning the working groups, ResearchGate offered the resource known as "Workgroup"[8], which gave access to tools to facilitate collaborative work at a distance, such as collaborative document editing.

OSNs may offer users the possibility to create groups for (a subset of) their contacts on whatever topic they decide. For instance, Facebook works with the idea of groups, which can be open, closed or secret, and, within these, users can send messages, create events, share ideas, add photos, videos or files, or ask a question. It is interesting to notice that people have appropriated these groups and often use them for a virtual place for a workgroup. For instance, studies show that Facebook groups have been used in educational settings to support online or face-to-face courses [7, 10].

Once again both SCNs and OSNs may present the same categories of communities, however, the strategies of use of these communities are different. In SCNs communities of interest are public by definition and their topic must be recognized as a research topic. Working groups, on their turn, focus on offering more resources to researchers. In OSNs users can create their own groups or communities which are highly configurable and can be used for a wide range of purposes – from social purposes (sharing recipes with friends) or to work related purposes (supporting a course).

5.4 Artifacts

In SCNs, artifacts are related to scientific publications or material that can be referenced or made available through the system to disseminate research and allow users to collaborate with each other. In both SCNs analyzed researchers can include references to scientific articles and, if desired, also upload the associated text. However, the categories of **publications** and their organization are different. In ResearchGate the focus is on scientific articles. Users can view publication's content, suggest it to others or share it within the system. In academia.edu besides scientific articles, users can classify their publications as books, talks, teaching documents, drafts, book reviews, presentations or thesis chapters.

In the case of OSNs, artifacts are not categorized according to their publication type as in SCNs, they are just files that can be shared. The exceptions are photos and videos, which offer some specific actions that can be performed on them, e.g. tagging someone in a photo.

6 Discussion

Based on results obtained from the analysis of ResearchGate and academia.edu, and the contrast with the results of Facebook analysis, we can verify that the collaboration categories or types available are basically the same in SCNs and OSNs. However, the strategies provided and how they are emphasized characterizes the difference between these systems.

[8] Subsequently to our analysis, the name of this resource was changed to "Project" and this resource is not available anymore, in current version of ResearchGate (Feb. 2015).

Regarding user information available in the system, SCNs and OSNs focus on different information about a person. In SCNs, the focus is on professional and research related information. In these systems, such information is always visible, in order to stimulate scientific collaboration among its members. In OSNs, in turn, user information is more general and more interesting in social or informal contexts. Also, the f focus on information visibility is completely different. In SCNs reputation is built based on the number of people who have seen or are interested in the information shared. In OSNs the concern with privacy, being able to limit access to information.

Interaction levels have been classified in four different levels ranging from unidirectional to trust relationships. When comparing SCNs and OSNs, although both of them may include all four levels, their focus is different. In OSNs the most important relationship is friendship which is a trust relationship (strong tie). In SCNs, on their turn, the focus is on following another researcher's work, which is a unidirectional interest relationship (weak tie).

In SCNs communities play an important role, since they are one of the main places where scientific collaboration can occur within these systems. From the moment they become a user of an SCN, users are encouraged to join topics or research interests. Furthermore, in these systems, users' homepages always show the latest updates and discussions conducted within their topics of interest. In OSNs, community topics and rules are freely defined by users. Users may even choose to use communities for work purposes or scientific collaboration, but in this case they may limit the range of their reach to new collaborators.

As to artifacts, SCN's organize files according to their meaning to the community – so a draft and a published paper are distinguished in the system, whereas in OSN the distinction is related to medium of the file, there are different actions available depending on the file being a text or a photo.

7 Final Remarks

In this paper we have set out to investigate whether SCNs offered collaboration strategies that were specific to the scientific collaboration context. To do so, we applied the Semiotic Inspection Method to two SCNs – Research Gate and academia.edu, and contrasted their collaboration strategies to the one identified in an OSN – Facebook. Although all three systems analyzed had their interface modified after our study, the results are still interesting, given that they focus on the identification and discussion of scientific collaboration strategies in SCNs, rather than on interface elements.

The analysis indicated that both SCNs and OSNs offer users 4 types of collaboration opportunities, information sharing, interaction levels, communities and artifacts. Nonetheless, the strategies identified for SCNs and OSNs regarding each of these types are very different..

Our findings contribute to characterizing collaboration in SCNs and to the research regarding such systems. The strategies identified are directed to supporting scientific collaboration among users. As such they can be used by designers of SCNs to reflect upon the possible collaboration an SCN could support and which ones would be more relevant to prioritize in different contexts. They can also be used to evaluate the collaboration support of an SCS or compare different systems.

The next steps in our research involve using the identified categories and strategies to analyze other SCNs, allowing us to characterize the system, as well as consolidate them even further. Furthermore, we intend to analyze virtual networks aimed at other domains (e.g. education) to investigate whether the collaboration categories identified are the same (or not), and which strategies are used. A semiotic analysis of the results may allow us to identify which classes of signs are related to collaboration in general, and which are domain dependent.

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