Bridging Social and Awareness Networks in Distributed Research Collaboration

Jeremy Birnholtz, Y. Connie Yuan, Geri Gay
Department of Communication & Faculty of Computing & Information Science
Cornell University, Ithaca, NY
{jpb277, yy239, gkg1} @cornell.edu

ABSTRACT
Awareness plays multiple, critical roles in the initiation and sustenance of research collaborations. Potential collaborators must first be aware of each other and their respective skills so that they can meet to discuss potential projects and begin collaborating. This type of awareness is the traditional domain of transactive memory and other theories of knowledge in organizations. Once people begin working together, however, they require awareness at a finer level of detail – who is around and available for interaction and how their shared project is progressing, for example. This has traditionally been the focus of CSCW theories and systems. We argue that these two approaches should be combined for smoother transitions from collaborative project initiation to collaborative work. We present preliminary evidence and discuss our current project exploring these issues.

INTRODUCTION & BACKGROUND
As collaboration becomes more dominant in knowledge production [11], virtual organizations (VOs) of researchers become more crucial to addressing key science and engineering challenges [7]. Despite their importance, however, VOs have been shown in many cases to be difficult to initiate (e.g., [8]) and sustain [3].

These problems in VOs have two critical consequences from an awareness standpoint. First, collaborating researchers must be aware of and find each other prior to collaborating. This seems obvious, but it is a nontrivial point in that it renders social ties with other researchers and knowledge of their expertise extremely important. Without access to these ties and knowledge, important VOs may not form at all.

Second, VO participants have allegiances to multiple organizational entities – some traditional and some virtual. This means that, simply by virtue of spatial propinquity and the improved interpersonal awareness thus enabled, their local colleagues and affiliations may get more attention and be easier to coordinate with than other members of their VOs (e.g., [5]). Thus, VO members often have trouble coordinating and communicating effectively [3].

These two issues have historically been addressed by separate literatures. Knowledge management researchers have focused on the problem of knowing who knows what, and have developed the concept of transactive memory to describe this [10]. And CSCW researchers have focused on the development of network-based tools to support interpersonal awareness and coordination in geographically distributed groups. These parallel streams of work have resulted in an artificial separation of awareness on these two dimensions.

We believe there is substantial utility in unifying these disparate approaches to multiple instances of what is fundamentally the same problem: how do prospective and current members of VOs keep track of and coordinate with each other?

We use the term "awareness network" to refer to a set of individuals who, at some level of granularity, keep track of each other's knowledge and activities. At a very coarse level, people may merely be aware of another person's existence and perhaps have some knowledge of their expertise. At a much finer level, people may be aware of each other's day-to-day activities and availability for spontaneous/informal conversations. Where prior approaches have treated these two types of awareness as distinct, our network-based approach allows us to explore the role of awareness at multiple levels of analysis; as well as to understand individual trajectories within these networks. This will allow us to better understand the formation and sustenance of VOs, and to develop better tools for supporting VOs.

Awareness Networks in Initiating ROVOs
Much research on the initiation of research collaborations presumes that potential collaborators already know each other – that is, they are already a part of each other's awareness networks. Decisions about collaboration at the individual level have been shown to depend on a range of factors, including the availability of "attractive" collaborators in terms of influence or unique skills , entrepreneurial aspirations , attributes of the work to be performed and the need for access to special data or research equipment [1].

As collaborations become larger and more heterogeneous, however, it is not always reasonable to assume that potential collaborators will already know or be able to find each other. In a preliminary study of interdisciplinary collaborations within our university, for example, we found

that institutionally sponsored events such as retreats played a significant role in helping researchers previously unknown to each other meet and explore collaboration possibilities, and to learn about each other's interests and areas of expertise [6]. We argue that it is therefore important to focus on how researchers' individual awareness networks form and grow, and how ties within these networks lead to the formation and evolution of VOs.

Transactive Memory: Knowing Who Knows What.

Given that one common motive for collaboration is a desire to work with others who have complementary expertise and skills, one important factor is the knowledge of "who knows what" within the set of potential collaborators. Wegner [10] proposed the concept of "transactive memory" to describe the pooling of expertise that occurs in workgroups. If group members are aware of the capabilities and information possessed by other group members, they can pass information among each other in ways that harness their distributed expertise without requiring one person to know everything. Memory in this context is transactive in that the group's cognitive activities (i.e., generating knowledge, sharing and retaining information) are distributed among the individual group members, but connected via communication ties among members.

While the initiation phase of a VO clearly has different shared knowledge requirements than the already-formed workgroups described by Wegner, we believe this is a useful theory for understanding how VOs are formed. Transactive memory accounts for how groups develop and assess individual members' expertise in relevant knowledge domains; and there is a useful sense in which we can consider all members of a focused research community to be members of a single transactive memory system.

Network Ties for Gaining Actual Access to Expertise.

A second challenge in the initiation of VOs is the establishment of social ties with others in one's awareness network. While developing a collective transactive memory of "who knows what" as described in transactive memory theory is important for locating needed experts, it is only a necessary, but not a sufficient condition for successful collaboration. Yuan et al. [13] found that the strength of communication ties mediated the relationship between the development of individual expertise directories and access to expert information, meaning that even when team members were aware of who had the needed expertise, without the support of social ties, simply knowing "who knows what" may not result in access to needed expertise.

Research on information seeking in organizations has also found repeatedly that accessibility was deemed a more important factor than competence in a person's decision regarding to whom s/he would turn for advice. Casciaro and Lobo [2] found that people preferred to work with friendly peers than those deemed "competent jerks" even when the friendly people were less competent. These findings highlight the importance of having friendship ties in gaining actual access to expertise, as well as the potential role of awareness technologies in facilitating accessibility. In a recent field research on a sales team within a multinational corporation, Yuan et al. [12] have also found that social accessibility and awareness of expertise distribution are equally important in seeking information and expertise. In the context of the current research, we believe that social ties will play a major role influencing who will actually self-organize into collaboration groups. We anticipate that among those interested potential collaborators, those who have existing ties or who can develop social ties among themselves quickly will be more likely to form a project group because these pre-established social ties provide confidence of actual access to expertise in different expertise domains. We will investigate what properties of social ties have played a role in the initiation of the VOs we study through multiple case studies of just-starting projects.

Awareness Networks in Sustaining VOs

So far we have seen that awareness and social networks are likely to play key roles in VO initiation because they facilitate the location of prospective members and the formation of connections with these individuals, both of which together lead to collaboration. As a VO takes shape and members begin to work together, the awareness ties between them should grow stronger and this should be reflected in their behavior. This is not always the case, however. Rather, there is substantial evidence that interaction within VOs is often largely between those who already know each other well [4], or that there are communication and coordination troubles. This is a significant disconnect and a major obstacle for VOs.

We argue that one key reason for this disconnect is that existing approaches to VOs focus too heavily on the initiation of collaboration and not enough on sustaining it. Our focus on awareness and social networks allows us to study how to better support VOs as these networks evolve.

Members of VOs, once they have started working together, face many challenges when compared to their colleagues in traditional organizations. In particular, it has been suggested that it is more difficult to maintain a sense of interpersonal awareness [9], more difficult to coordinate work [3], and more difficult to maintain the social ties that are crucial to all of these activities. In other words, it is difficult for VO members to make the critical transition from awareness of others' expertise only to a finer-grained level of awareness of activities and presence that allows for the communication and coordination that are crucial to research success. We aim to better understand how successful VOs are able to make this transition. We focus on two aspects of this transition.

TM: Beyond Awareness of Expertise Distribution

Existing studies of VOs point to many difficulties and challenges that impact members' ability to coordinate and

maintain adequate awareness. In our preliminary study of surgeons collaborating with engineers, for example, we found that one key source of trouble was that surgeons could be summoned to the operating room at any moment; and their remote engineering colleagues were frustrated by the schedule changes that ensued, of which they were sometimes not informed at all [6]. This example is particularly interesting because it is an extreme case of a commonly observed phenomenon in VOs of many types – that local colleagues and priorities often take precedence over the remote. In the surgery case, however, the local priority is literally a matter of life and death.

Findings like this show further opportunities to extend transactive memory theory in providing comprehensive guidelines to improve work coordination. Coordination underlies effective group work in that it allows for mutual understanding and adaptation of work assignments and progress. Coordination in geographically distributed VOs has been shown to be difficult, and this is particularly true in research projects where there is often uncertainty about exactly what will happen or need to be done.

Under such situations, developing awareness of mere expertise distribution appears insufficient to improve work coordination. We argue that the sustenance of VOs requires the development of awareness from multiple dimensions, such as awareness of who is around and available for interaction. Maintaining such awareness has been shown to be useful in addressing questions as they arise, troubleshooting, and maintaining an informal sense of how work is progressing.

OUR WORK AND APPROACH

We are in the early stages of a 2-year project seeking to explore the role of awareness, in multiple forms as described above, in the initiation and sustenance of multi-campus research collaborations within our university. In particular, we are interested in the following questions:

- How are research-oriented VOs initiated and what is the role of awareness in that process? How do members locate each other and maintain awareness of prospective collaborators?
- How do effective VOs sustain themselves? What role does awareness play in this process? What role does social network play in this process? How do VOs sustain a sense of awareness and how do members coordinate with each other? How do they maintain both social and expertise awareness?
- What roles does network tie play in fostering awareness of others' expertise and in turning expertise awareness into actual access to expertise? What properties of social networks are beneficial for the initiation and sustenance of VOs?
- What mechanisms are needed to create open sharing and easy bridging between multiple groups? How can participants author, visualize, manipulate, and share information?

To address these issues, we are using a combination of archival analysis of past and current collaborative projects, interviews and observations with project participants, and periodic questionnaires regarding participant social networks and perceptions of transactive memory.

Through these methods, we aim to bridge gaps in the literature between the high-level "who knows what" awareness that fosters the initiation of collaborations, and the day to day "who is around and what are they up to" awarenesss that fosters strong network ties and effective coordination and collaboration.

Understanding awareness in VOs

To better understand how VOs are started and the role of different types of awareness information in this process, we will conduct a field study using both interview and observation methods.

We are currently identifying participants in WCMC – Ithaca VOs to participate in 30-60 minute detailed interviews about how their collaborations started. We will discuss the initiation of VOs, problems and challenges experienced along the way, how they coordinate within the VO, their competing priorities, and the extent to which they feel their projects are successful so far. These in-depth interviews can help us gain a better understanding of how participants really feel about the collaboration.

We will also conduct detailed observations of retreats and other institutionally sponsored events identified in our interviews as being important to the formation of new VOs. We will observe social interactions between participants from multiple campus sites and from different research communities, with the objective of evaluating the extent to which these events can successfully support increased awareness of each other's presence and expertise. In addition, we are also interested in observing how people interact in their initiation meetings. Data collected from interviews and observations will be combined and contrasted to explore possible causes of misunderstanding and miscommunication in collaboration, which will help us provide practical management guidelines or intervention tools to improve work coordination in these VOs.

Awareness Profile Development.

In addition to observing the role of different events in fostering awareness network development, we will also employ a multiple-methods approach to track and document the spontaneous use of everyday, ubiquitous communication technologies, such as landline and mobile phones, email, instant messaging, search engines, etc., that distributed groups of researchers use to support their collaborations in newly funded research projects. The primary objectives during this phase of the project will be to develop "profiles of use," which describe a given

technology's typical pattern of use, including by whom, when, where, for what, and with whom. These observational methods will be critical to understanding how, where, and why researchers actually use technologies to collaborate and share information, within and across their awareness networks. The data derived from these profiles will be combined and contrasted with data derived from survey and social network data, which are discussed below.

Networking Ties and Transactive Memory in VOs

We will administer questionnaires to all members of the past and present VOs that we are studying**.** Questionnaires will be used for both longitudinal and cross-sectional analysis. Questionnaire data will be analyzed in conjunction with the archival data on the VO program between the two Cornell campuses.

We will measure the development of TM systems using a network approach. Specially, when measuring the (a) development and (b) usage of transactive memory to retain and retrieve expertise, we will first ask team members to report what they believe are the key expertise areas for the successful completion each aspect of the team project, based on the master list of expertise areas provided by interviews with key team leaders. Participants of the research will then be asked to report (a) who they perceive as experts on each special expertise area in their team, (b) how frequently they have retrieved expert knowledge from each team member, a relationship measure for the resource exchange networks among team members, and (c) how they feel in general about their expertise retrieval experiences, connecting to the affective aspect of expertise exchange.

We will also collect information about whether VO collaborators use any electronic expertise directories and communal information systems to store and exchange expertise. Content analysis will be used to code the quality and quantity of information on different expertise areas in the communal information system. When measuring the usage of these information systems for expertise retention and exchange, the subjects will be asked to report (a) their frequency of allocating and retrieving expertise from the communal database, and (b) their general evaluation of the quality (in terms of timeliness, accuracy, credibility, etc.) and quantity of the expert knowledge they can obtain from the communal information system, using an adapted scale tested in our earlier research.

Network Ties. Network ties can be measured at multiple times during both the initiation and sustenance stages of the project. Both socio and ego-centered network data will be collected. At the initiation stage, we will provide retreat participants a complete roster of engineers and surgeons from both departments, and then ask them to report whom in the other department (a) they know and (b) are interested in exploring possible future collaborations. Data collected from this survey will be cross-examined with archival grant proposal submissions to evaluate what projects have been successfully initiated.

ACKNOWLEDGMENTS

We thank the National Science Foundation (OCI 0942659) for support of this research.

REFERENCES

[1] Beaver, D. d. Reflections on scientific collaboration (and its study): past, present and future. *Scientometrics*, 52, 3 (2001), 365-377.

[2] Casciaro, T. and Lobo, M. S. Competent jerks, lovable fools, and the formation of social networks. *Harvard Business Review*, 83, 6 (2005), 92-99.

[3] Cummings, J. and Kiesler, S. Coordination costs and project outcomes in multi-university collaborations. *Research Policy*, 36, 10 (2007), 138-152.

[4] Cummings, J. and Kiesler, S. Who collaborates successfully?: prior experience reduces collaboration barriers in distributed interdisciplinary research. *Proc. ACM CSCW* 2008, 437-446.

[5] Kraut, R., Egido, C. and Galegher, J. Patterns of Contact and Communication in Scientific Research Collaborations. In J. Galegher, Kraut, R.,& Egido, C., ed. *Intellectual Teamwork.* Lawrence Erlbaum Associates, Hillsdale, NJ, 1990.

[6] Nomura, S., Birnholtz, J., Leshed, G., Rieger, O., Gay, G. and Trumbull, D. Cutting into Collaboration: Understanding Coordination in Distributed and Interdisciplinary Medical Research. *Proc. ACM CSCW,* 2008, 427-436.

[7] Olson, G. M., Zimmerman, A. and Bos, N. *Scientific Collaboration on the Internet*. MIT Press, Cambridge, 2008.

[8] Shrum, W., Genuth, J. and Chompalov, I. *Structures of Scientific Collaboration*. MIT Press, Cambridge, 2007.

[9] Teasley, S., Covi, L. A., Krishnan, M. S. and Olson, J. S. Rapid software development through team collocation. *IEEE Transactions on Software Engineering*, 28, 6 (2002).

[10] Wegner, D. M. Transactive memory: a contemporary analysis of group mind. In B. Mullen and G. Goethals, ed. *Theories of group behavior.* Sprinter-Verlag, New York, 1987.

[11] Wuchty, S., Jones, B. F. and Uzzi, B. The increasing dominance of teams in production of knowledge. *Science*, 316, 5827 (2007), 1036-1039.

[12] Yuan, Y. C., Carboni, L. and Ehrlich, K. The impact of awareness, social accessibility and media multiplexity on expertise retrieval. Paper presented at the Academy of Management Conference, Chicago, IL, 2009.

[13] Yuan, Y. C., Fulk, J., Monge, P. R. and Contractor, N. Motivation to cooperate in the effective functioning of transactive memory systems: The role of communication ties and task interdependence. Paper presented at the conference of the International Communication Association, Chicago, IL, 2008.