Social Capital in Network Organizations

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Abstract

In a dynamic network organization, member agents usually interact to coordinate their actions and to cooperate towards a common goal with which they have no previous experience. These relations allow them to produce a cohesive group to build and maintain their network. This paper will outline the effect of social capital on a network structure inside a network organization.

There is increasing interest in cross-organization, service-oriented computing that aims to dynamically amalgamate computational resources across organizational boundaries. The most common examples of these are the semantic web, cloud computing, crowdsourcing, and peer-to-peer networking technologies. A feature of all of these systems is that the organization's services from data and software will be remotely invoked with other organizations' services to be used together toward some common goal. In a cloud computing scenario, for instance, an agent may invoke data hosted by one organization with a remote application server for data mining run by another, and then store the result on a public cloud data service. This may often allow a number of competing service providers to achieve their respective service goal. Nevertheless, the multi-organizational nature of these systems means that they will invariably create uncertainty surrounding the capabilities and incentives of the organizations offering these services.

Social Capital (SC) transcends issues surrounding heterogeneity of agent affiliations since it captures benefits resulting from the preferential treatment and collaboration among agents. Quantities of SC can be used to replace quantification of interpersonal trust among agents. When a network organization generates positive SC, constituent agents gain benevolence and behave in a cohesive manner (Smith, Giraud-Carrier, and Purser 2009). A main concern of multi-agent systems is the coordination of autonomous agents that interact dynamically to achieve their goals. There is a need to develop SC assessment models or mechanisms that can measure qualities among autonomous agents operating in large-scale and open service-oriented organizations. Such mechanisms are required to estimate the future behavior of agents and agents' peers in order to simplify the interaction process with those peers. We are striving to overcome these problems with a novel perspective by utilizing a *network organization* (NO). This wide coverage collaboratively generated organization maintains by a disparate group of agents to decide and act locally. These agents share affinities and possess similar objectives or ideologies that are socially connected via social online mediums, such as Twitter and Facebook.

Social Capital Measurements

Social capital in the network can be defined as the cooperative nature of agents who belong to myriad networked organizations. These agents operate independently yet in unison from their organizational origins when they perform actions together. In other words, it can be characterized as the collocated or virtual collaboration to produce successful outcomes and connections (Alqithami and Hexmoor 2012). There are two major perspectives on SC in networks. In the macroscopic perspective, SC for the entire network is considered. In this view, individuals do not incrementally add to the system or withdraw units of SC. Instead the foci are on the system principles like norms and conventions that provide resources for overall social welfare. In contrast, the microscopic perspective adopted here explores how individuals can gain access to resources by their positions and connections in the network.

There are a few main elements of the SC, which have a proportional relationship to one another. Topologically speaking, high bonding rates provide more opportunities for interaction and growth of social capital. However, network structure by itself is inadequate for determination of SC. We must examine the contents of interaction and dispositions that create social forces that attract or repel individuals (Hsu and Hung 2013). At the level of a single link, the nature of social flow leads to accumulation of SC. Social flows can be either benevolent and positive or negative and without benevolence. Whereas positive flow leads to net positive gain in SC, negative flow leads to loss of SC. Apart from social flow, dyadic ties may harbor trust or promote distrust. Trust supports SC, whereas distrust erodes SC. If the topic of interaction between the pair is centered on the main problem for the NO, that link positively contributes to SC. In sum, flow, trust, and topic are linked attributes that are proportional determinants for SC.

Definition 1 *Social capital in a link is measured from ac-*

cumulation of positive values of social flow and trust plus abundance of communication over the common topic of NO. At this point, we treat all three attributes equally.

Since considering a topic of interaction is included in the definition, we note that this formulation of social capital is relativized for links only in an NO. Next, we focus on determination of social capital in a given network as stated in Lemma 1.

Lemma 1 *The total amount of social capital in the network is proportional to the sum of social capital in network links.*

Social capital is generated in the links through dynamics of interaction inside the links. Therefore, SC for a network linearly scales by summing SC for all links in the network. Increased links are proportional to increased social capital stated in Lemma 2. The effects of topology are overlooked in this network perspective but will be considered in the egocentric in the next definition. All bridged communities contribute to accumulation of the overall SC, which is the instrumental purpose of SC. In general networks and from an egocentric perspective, bridging is said to contribute to social capital (Smith, Giraud-Carrier, and Purser 2009). This is discussed later in the egocentric view of SC.

Lemma 2 *Social capital in the network is proportional to network bonding measure.*

Network bonding leads to increased density and closure in the network, which is believed to increase resource access. Lemma 2 is obvious since bonding rate is proportional to the number of links. According to Lemma 1, the number of links in the network, i.e., the more interconnections a network has, the more opportunities it will have for accumulation of SC. If a network has the most links possible (i.e., a clique) it would support the highest SC.

Theorem 1 *A network topology that is a clique produces the highest social capital.*

To this end, we define an egocentric perspective for social capital.

Definition 2 *Social capital for a node (i.e., egocentric for an individual) is the sum of social capital derived from its links with direct neighbors plus sum of SC of all its neighbors.*

This egocentric definition of SC deliberately mirrors the Bonacich Power Index (Bonacich 1987). This coincidence helps us to exploit the topological position of nodes. A node that is well positioned by having a high power index (i.e., high Bonacich centrality value) will similarly possess high social capital.

Lemma 3 *Nodes in a network with higher power or roles possess higher social capital.*

We consider SC to be a scalar value that can be accumulated as well as consumed either verbatim or used as credit. In a network, SC might be used to trade for help or exchanges with others in the form of delegation of tasks. Bartering with SC can be limited to a pair of nodes through an immediate link between them. Alternatively, a node might enter bartering anonymously with another node with whom there may not be a direct link. Next, we turn to a description of a mechanism for trading. First, we define an independent value we call commitment level.

Definition 3 Commitment Level *(CL) is the degree to which agents in an NO are willing to work hard to achieve the network objectives. This level is an independent value from the social capital. For simplicity, we assume a value range of* $[0.0 - 1.0]$.

Definition 4 *Contribution of an Agent A toward a task i with performance $P(A, i)$ is $P \times CL$. This means that $C(i, A) = performance\ P(A, i) \times CL$.*

Definition 5 *Retention rate of the task i by Agent A is measured by the complement of A's contribution to task i (i.e.,$R(A, i) = 1.0 - C(i, A)$).*

When an Agent A's retention rate for a task i is low, A may wish to trade a task i with another agent provided the agent has sufficient social capital. The value of each trade will depend on the private value assigned by the trading partner. In order to secure a trade, the agent offering to trade must determine the strategic equilibrium value for agent profiles over tasks, i.e., the trader agent must compute the maximum contribution (MC) any agent can make over any task. If the social capital value offered is equal or greater than this MC value, the trade is rational and can be guaranteed.

Conclusions and Future work

In open environments, such as the environments envisioned for NO, agents are integrated dynamically across their organizational and geographical boundaries to justify each other's needs. Such systems should be modeled as multi-agent systems, in which autonomous agents can interact in an open environment, despite potentially conflicting interests. NOs are commonly subservient to electronic institutions (EI) that make and monitor policies. Water quality and health quality exchanges are two examples of electronic institutions guiding large subordinate network organizations. EIs must routinely monitor and improve SC by updating the organization's policies. A SC assessment model has been described to measure relations among autonomous agents operating in large-scale open service-oriented organizations. Such mechanisms are required to estimate the future behavior of agents and agents' peers in order to simplify the interaction process with those peers. The aim in the future is to further validate and develop SC models and to produce a method to quantify network organization's responsiveness.

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