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Social capital in distributed system development: A case of grid development in particle physics

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WEB-ENABLED BOUNDARY SPANNERS AND THEIR ROLE IN THE KNOWLEDGE FLOW NETWORK

Abstract

No organisation, no matter how large, can remain totally reliant on the stocks of new knowledge it generates itself. In order to keep abreast of the latest scientific and technological developments, R&D organisations must continuously import knowledge from beyond the organisations boundaries. How does this external knowledge which is critical to success then become absorbed and integrated into the firm? Our paper addresses this question through the lens of the influential technological gatekeeper theory. Drawing on social network analysis (SNA) and interview evidence from a medical devices R&D group, we find that the gatekeeper role is still vital, but no longer needs to be performed by a single individual. Instead, the modern R&D group can keep abreast of the latest technological advances through a combination of Web-enabled internal and external communication specialists. A unique contribution this paper makes to the IT-enable social network literature is the development of an updated conceptual framework of how the gatekeeper role is performed in the modern R&D group.

Keywords: Web Technologies, Socio-Technical, Technological Gatekeeper, Boundary Spanners, R&D.

1. INTRODUCTION

Research and development (R&D) intensive firms must keep abreast of and adapt to the latest scientific and technological developments in order to remain competitive. Increasingly, however knowledge vital to the firm's competitive advantage is located outside the firm's boundaries (Chesbrough 2003). How does this external knowledge which is critical to success then become absorbed and integrated into the firm? A large body of literature exists which highlights the importance that both formal and informal social networks play in transferring knowledge within and between organisations (Allen and Cohen 1969; Allen 1977; Hansen 1999; Wenger, McDermott et al. 2002; Assimakopoulos and Macdonald 2003; Wasko and Faraj 2005; Su, Mark et al. 2007). However, the rapid adoption of Web technologies in recent years is challenging our extant understanding of what constitutes a social network. Today, not only can a person be a member of close, face-to-face social networks, but he or she may also participate in numerous Web-based collaborations comprising thousands of globally dispersed unknown and anonymous individuals. Research is needed to inform organisations of how business value can be generated from the interplay between the social and technical aspects of these socio-technical systems (Parameswaran and Whinston 2007). Thus, the purpose of this exploratory paper is to address this research gap by examining how external knowledge is accessed through Web-based channels and personal contacts and then disseminated throughout the R&D group.

To fulfil our purpose, we turn to the concept of the technological gatekeeper (Allen and Cohen 1969; Allen 1971; Allen 1977; Tushman and Katz 1980; Katz and Tushman 1981; Tushman and Scanlan 1981). Through decades of innovation research, the role of the gatekeeper has proven to be a critical factor in understanding the performance of R&D organisations as gatekeepers have served as key nodes in the innovation process – acquiring, translating, and disseminating external knowledge throughout the R&D organisation. The question arises, however, as to how the role and tasks of the gatekeeper are changing due to the ability of every professional in an R&D organisation to quickly and easily access external knowledge through Web-based channels. Thus, after a review of the seminal literature on gatekeepers as well as of the relevant IS literature, we develop the research question: *how have Webt technologies impacted the technological gatekeeper's tasks of acquiring, translating, and disseminating external knowledge?* We then present our results from a case study of a medical device company in Ireland in which we collected social network and semi-structured interview data. Finally, the paper presents an updated gatekeeping conceptual framework and concludes with the implications of our findings on research and practice relating to organisational knowledge and learning.

2. THE TECHNOLOGICAL GATEKEEPER

R&D groups are the drivers of innovation in high-technology firms. In order for the group to sustain itself, the literature on R&D innovation emphasises the importance of acquiring a diverse and novel body of knowledge from beyond the organisation's boundaries (Allen 1977; Tushman 1977; Aldrich and Herker 1997). The acquisition of external R&D knowledge helps the firm to build its 'absorptive capacity' (Cohen and Levinthal 1990) and will serve as the seeds for future technological developments (March and Simon 1958; Leonard-Barton 1992). A rich stream of research throughout the 1970s and early 1980s examined the processes through which scientific and technological knowledge enters the R&D group. This particular stream was headed by MIT's Thomas Allen and his seminal book *Managing the Flow of Technology* (Allen 1977) documents over a decade's worth of studies with some of the largest American R&D corporations. Using social network analysis techniques, Allen discovered that knowledge of the latest scientific and technological developments entered the R&D group through a two-step process. Not every R&D professional was directly connected with external sources of knowledge. Instead, a small minority had rather extensive contacts and served as sources of knowledge for their colleagues. These individuals were termed 'technological gatekeepers' (Allen and Cohen 1969; Allen 1971; Allen 1977; Tushman 1977; Allen, Tushman et al. 1979; Katz and Tushman 1981; Tushman and Scanlan 1981) as they act as the conduit through which knowledge of external technology flows into the R&D group. A more formal definition explains that technological gatekeepers are those key individual technologists who are strongly connected to both internal colleagues *and* external sources of information (Allen and Cohen 1969; Allen 1977; Tushman and Scanlan 1981).

It is logical to assume that direct communication between R&D professionals and external sources of knowledge would be a more efficient knowledge integration mechanism than a two-step process. However, studies have found that widespread direct contact by all project members is not an effective method for transferring technical knowledge into a project from external sources (Katz and Kahn 1966; Allen 1977; Tushman 1977). The reason for this phenomenon relates to task specialisation and the evolution of local norms, values and languages that emerge as a result (Tushman 1977). Not every individual has the ability to understand contrasting coding schemes and misinterpretations are likely to occur if one communicator is without knowledge of the others local coding scheme (Cherry 1965). Thus, scholars have argued that specialised boundary spanners are required to facilitate the transfer of knowledge across intra and extra-organisational boundaries (Tushman 1977; Tushman and Scanlan 1981; Bouty 2000; Teigland and Wasko 2003; Cross and Parker 2004). The technological gatekeeper is one such boundary-spanner who mediates between the local R&D Group and the world beyond the firm's boundaries. Allen and Cohen (1969) noted when studying gatekeepers in the R&D division of a large aerospace firm that *"…if one were to sit down and attempt to design an optimal system for bringing in new technological information and disseminating it within the organisation, it would be difficult to produce a better one than that which exists"*. The inference is that there is an association between gatekeepers and higher performance, however, no empirical data existed until the early 1980s when a number of studies advanced Allen's original gatekeeper concept by examining the relationships between the existence of gatekeepers and project performance for different types of tasks (i.e. research work vs. development work). Tushman and Katz (1980) and Katz and Tushman (1981) found that development projects with gatekeepers were significantly higher performing than those without gatekeepers. Thus, development projects are higher performing when external communications are monopolised by a small number of individuals.

Given the vital role which gatekeepers perform in development projects, it would be useful for R&D managers to be able to identify these individuals. While there is no pre-requisite checklist that an individual has to conform to, the literature does provide some clues to recognising those performing the gatekeeping role. The original studies of Allen and Cohen (1969) and Allen (1971;1977) suggest that the gatekeeper is a highly competent technical performer who is likely to be a first line supervisor. Seldom were gatekeepers found with fewer than five years organisational experience as it takes time to develop one's communication network. They are genuinely interested in keeping abreast of developments in their technology domain and knowledge of their specialty is deep as opposed to wide-ranging. They tend to read the harder-literature (e.g. scientific journals), present more papers at technical conferences, and maintain long-term relationships with colleagues outside their own organisation. The gatekeeper's principle contribution comes by way of the translation that they can perform (Allen 1977). The gatekeeper can convert knowledge gained from journal papers and personal contacts into terms that are understandable by members of the local R&D group. It is because of this ability and their technical competence that they are frequently sought out by their colleagues.

The gatekeeper concept has received modest attention since the early 1980s, presumably because the likes of Allen, Katz, and Tushman ploughed the field so thoroughly and left little for other scholars to explore. In recent years however, interest in the concept has been reignited, particularly in the IS field. The gatekeeper existed in a time when it was a difficult and time consuming process for the average R&D professional to acquire knowledge from beyond the company's boundaries. The past decade has borne witness to major advances in ICT and particularly Web technologies. What these advances have changed is the ease and speed with which employees at all organisational levels can access and disseminate knowledge (Teigland and Wasko 2003; Whelan 2007). With a PC and an internet connection, a knowledge worker can join computer-supported social networks to seek solutions, share expertise, and discuss ideas with like-minded individuals far beyond the reach of their local social network of friends, contacts, and colleagues (Wasko, Faraj et al. 2004). Recent ethnographic research by Su, Mark et al. (2007) has found that throughout the working day knowledge workers constantly switch between multiple social networks, all of which are a complex mixture of formal and informal, face-to-face and computer-mediated, intra-organisational and extra-organisational, and work-related and private interactions. Yet, we have a limited understanding of how the interaction between the social and technical aspects of practice-based networks impact the knowledge flow network. We address this gap by examining how Web technologies have impacted the gatekeeper processes in development focused R&D:

> RQ: *How have Web technologies impacted the gatekeeper's tasks of acquiring, translating, and disseminating external knowledge?*

We have specifically chosen to examine the impact of Web technologies as an earlier pilot study by some of the authors (Whelan and Donnellan, 2008) found that the key communication technologies used by R&D engineers to acquire and distribute technological information were websites, search engines, and email. Hence, our definition of Web technologies centres on these applications. For the purposes of this study, we define Web technologies as "Web-based communication technologies, such as websites, search engines, and email that enable the easy exchange and retrieval of digitized content."

3. METHODS

For the purpose of our research, case study methods are appropriate as the objective of the study is theory building (Eisenhardt and Graebner 2007), there is a need to focus on contemporary events (Benbasat, Goldstein et al. 1987; Yin 1994), and the phenomenon of interest cannot be studied outside its natural setting (Yin 1994). In order to compare with the original high-technology engineering gatekeeper studies, we have collected data from MediA, a medical device firm who have requested to remain anonymous. The case study setting is further described below.

3.1 Case Setting - MediA

MediA is an American multinational that has been in the medical device business for over 25 years with an annual turnover of $8.3 billion. MediA employs approximately 4,200 people in Ireland. The company has advanced the practice of minimal-invasive medicine by providing a broad and deep portfolio of innovative products, technologies and services across a wide range of medical specialties. The company employs approximately 3,000 R&D engineers, scientists, and technicians worldwide. While the majority of these are based in the US, an R&D group comprising 76 professionals are co-located in MediA's Irish subsidiary (referred to as Group A in the rest of this paper). While a high level of collaboration exists between the Irish and US R&D bases, Group A is largely a stand alone entity. Both the Irish and US groups are design owners of certain products, and it is the responsibility of each group to advance those designs. Group A is organised on a functional basis into four specialist subgroups – Drug Eluting Stents, Test Method Development, Vascular, and Stent Delivery Systems. Each of the four subgroups has a technology brief which relates to a specific part of the product design.

3.2 Data Collection and Analysis

Data were gathered from Group A between the months of February and March 2008. The data collection methods are summarised in table 1.

Methods	***Details***
Phase 1 – Social network analysis	Online survey issued to group members, n=76, 92% response rate
Phase 2 – Semi-structured interviews	n = 11, recorded and transcribed Interviewees = 3 gatekeepers, 2 external stars, 4 internal stars, 2 non-stars

Table 1 Data Collection Methods

Phase 1 involved analysing the flows of knowledge into and around Group A using social network analysis (SNA) techniques. SNA or sociometry is an established social science approach of studying human relations and social structures by "disclosing the affinities, attractions and repulsions between people and objects" (Moreno 1937). SNA views social relationships as nodes and ties which can be illustrated visually and mathematically. As such, it can provide an x-ray into the inner workings of a particular network. With this tool, important patterns become visible, the relationships between people can be better understood, the health of a group can be assessed and, the people playing key roles within the group can be identified (Cross and Parker 2004). In recent years, SNA has found increasing use as a structured way to analyze the extent of informal relationships that exist within various formally defined groups (Cross, Nohria et al. 2002). However, despite the knowledge intensive nature of R&D, SNA of the R&D function remain relatively rare (Allen, James et al. 2007).

The purpose of phase 1 was to identify the 'stars' of the knowledge flow network. To collect these data, all group members were asked to complete a short online questionnaire on their internal and external communications. To measure internal communications, we used the question asked by the original gatekeeper scholars – *'Please identify which work colleagues you discuss technical issues with at least once a week?'* The choice of once-a-week frequency is purely arbitrary although it does represent a fairly heavy degree of consistent communication (Allen 1977). To measure external communications, respondents were asked to indicate how often they used three sources of external knowledge: personal contacts, internet, and academic publications. An earlier pilot study by one of the authors at MediA indicated that these three knowledge sources were the most frequently used by R&D professionals when acquiring knowledge from outside the company. We used the SNA software package UCINET (Borgatti, Everett et al. 2002) to illustrate the knowledge flow network in Group A. To increase validity, only reciprocated interactions between group members were included in the analysis. This ensured that group members who reported higher than actual interactions did not distort the analysis.

In phase 2, we conducted semi-structured interviews with selected members of Group A. Interviewees were selected based on the SNA results from phase 1. The objective of the interviews was to explore how the use of Web technologies impacts the acquisition, translation, and dissemination functions of the technological gatekeeper. Group A members were categorised as being a gatekeeper, an internal communication star, an external communication star, or a non-star. Following the approach of (Allen 1977; Tushman and Katz 1980; Katz and Tushman 1981), this study operationalised gatekeepers as those individuals who were in the top fifth of *both* the internal and external communication distributions. Internal stars were operationalised as those individuals in the top fifth of the internal communication distribution but outside the top fifth of the external communication distribution. The reverse applies for external stars. To get a non-biased view of how knowledge flows around the R&D group, we interviewed a sample of gatekeepers, external stars, internal stars, and non-stars. Care was also taken to ensure that all levels of the formal group hierarchy were represented in the interviewee sample. All interviews were conducted face-to-face and ranged in length from 30 minutes to 75 minutes. In addition, all interviewees gave permission for the interview to be recorded. The procedures outlined in the dramaturgical model (Myers and Newman 2007)were adopted in order to ensure that high-quality interviews were conducted. Interview data analysis was performed using the NVivo software package and followed established inductive qualitative methods: coding, data categorization, and pattern identification (Miles and Huberman 1984; Eisenhardt 1989; Yin 1994).

4 FINDINGS

4.1 Social Network Analysis

Figure 1 illustrates the flow of technical knowledge into and around Group A. The nodes in the diagram are the individual members of the R&D group and the lines represent the flow of technical knowledge between them. The external stars are represented as triangles. The size of the triangle is reflective of how well connected that individual is to external knowledge sources. For example, Node 52 is the biggest triangle as this individual is the most frequent user of external knowledge sources.

Nodes 23, 33, 42, 46, 60 and 75 did not complete the questionnaire hence the reason they are isolated on the left. Nodes 2, 18, 21, 41, 56 and 69 completed the questionnaire but are also isolates because they have no reciprocated interactions with another group member. The overall reciprocation rate in Group A was 64%.

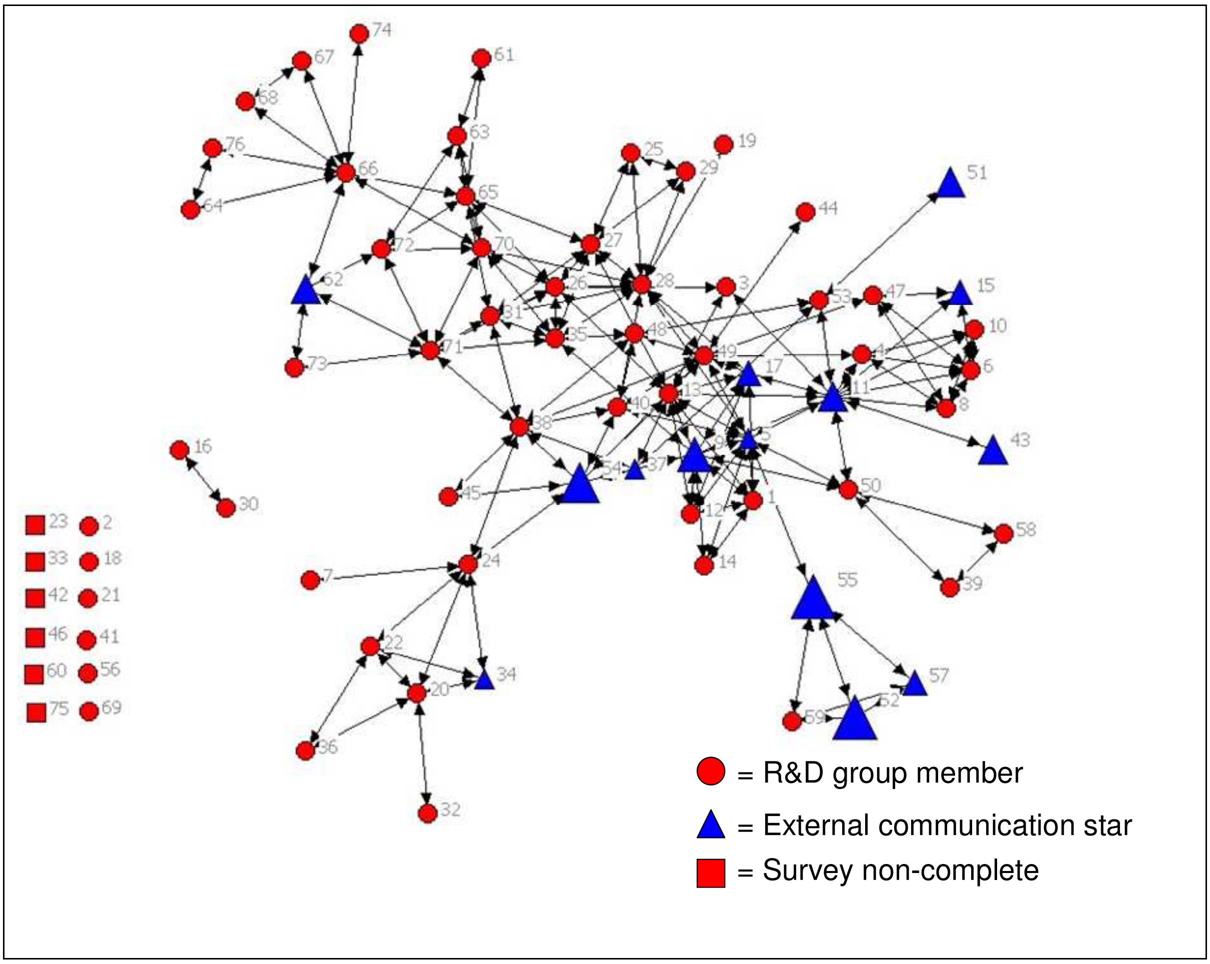

Figure 1 Group A's Knowledge Flow Network

The SNA data reveals that only 4 members (or 6%) of the group can be classified as technological gatekeepers. The gatekeepers of the group are nodes 5, 9, 11, and 54. Rather than relying on single individuals to both acquire and disseminate external knowledge, the SNA evidence shows that one set of boundary spanning individuals acquire external knowledge, and a largely different set of individuals disseminate this knowledge around the group. The relationship between node 62 and node 66 can be used to demonstrate this process. Node 62 is an external communication star. This individual is well connected to external knowledge sources but is not very well connected internally. Node 62 acquires external knowledge and communicates this to node 66. Node 66, on the other hand, is well connected internally and can distribute this knowledge around the group through his or her many connections. In fact, many of Group A's external communication stars have low levels of internal communication, hence the reason why they are located on the periphery of figure 2. The average number of reciprocated internal interactions per week in Group A is 4.343. Nine of the 14 external communication stars fall below this level.

Where do the external stars acquire their knowledge from? The Web was by far the most widely used source with 79% of external stars using this knowledge source at least once a day. 29% reported consulting academic publication while only 21% would consult an external colleague on a daily basis. Thus, knowledge from beyond the company's boundaries is acquired by the external communication stars who predominately use the Web to acquire this knowledge. This knowledge is then passed to the internal communication stars who distribute that knowledge around the R&D group.

4.2 Semi-structured Interviews

External Knowledge Acquisition

The SNA of Group A reveals that external knowledge flows into the group via external communication stars who predominately use the Web to acquire this knowledge. There are a number of specific medical technology websites which these external stars access in order to keep up-to-date with developments in the field. For example, cvpipeline.com is one website that many of the external stars identified as being a good source of external knowledge. Cvpipeline.com is a subscription based service that promotes itself as *"a new online database solution that keeps you up to date with emerging companies, products, technologies, people, and clinical studies in the fast-changing cardiovascular market"* (www.cvpipeline.com). One theme in the interviews with Group A's external stars focused on the benefits that websites such as cvpipeline.com offered over traditional sources of external information e.g. conferences and journal articles. As is reflected in the following quotation, the prime advantage of the Web relates to the ease with which technical professionals can keep abreast of the latest developments in the industry:

> *I would use the internet quite a bit. For my own development I use it to keep up-to-date with new technologies, new medical device developments. Recently I subscribed to a [trade] magazine…which I think is very good for providing information on new technologies and new medical devices outside. I think another good source of information would be attending conferences…but I think that can be got through the internet. You'd get current information, very up-to-date. I think the internet is a great source of information in that way…it's there at your fingertips and it's just a matter of using Google. But subscriptions to magazines, attending conferences, attending procedures over in the hospital and watching the 'docs' do their stuff…they can all be good sources of information too.*

The external communication stars interviewed not only scan their own industry for the latest developments, but also monitor advances in related industries like electronics and pharmaceuticals. Some of the best innovations in the medical devices field have actually come from other industries. This is explained by one of the gatekeepers. He highlights in the following quotation that the Web provides him with access to a broader range of external information and this is used to stimulate more and better ideas:

> *There would be a lot of overlap between what we do, and say, the electronics industry. The physicists and electronic engineers in companies like Intel have been coming up with ideas and solving problems for years and the medical device industry has said "Oh, hold on a second now, that could be very useful in this application". Inkjet technology for example…Hewlett Packard has developed that technology down to such precise detail…inkjet technology is actually being used now for injections in low dosages onto the tiniest medical devices that you can think about. The internet keeps you in touch with those industries. You might see some new drug delivery system treating some obscure disease that had nothing to do with our industry. You find out that they took X and Y and sorted the problem out. Now we can try a similar approach with our problem. [The internet] stimulates a thought process rather than sorts something out for you there and then.*

External Knowledge Translation

A number of interviewees commented that it took a number of months working at the company for them to become familiar with the technical jargon and abbreviations unique to Group A. In order to be usable by Group A, knowledge acquired from the external environment needs to be translated into a form consistent with these local norms. However, as is evidenced in the following quotation from an internal star, these contrasting coding schemes create a problem when communicating with external contacts:

> *It's mind blowing how much jargon we have – not jargon – more abbreviations. We have abbreviations for everything. I'd say within the [this] R&D group, there is probably no real misinterpretation of abbreviations. People usually understand what you mean when you say something like that. However, when you go outside R&D – if I was talking to customers, which I do sporadically, probably about once or twice or three times a year…it's like I'm talking a completely different language. The jargon and abbreviations are needed but they can be a barrier.*

The analysis of the interview data reveals the existence of a small number of individuals who perform the knowledge translating function for Group A. These individuals are frequently sought out by their colleagues, hence the reason they are also likely to be internal communication stars. One interviewee, Chris[1], acknowledged that many of his colleagues often consult with him when they have discovered novel external information. The analysis of the SNA questionnaire reveals that while Chris is one of the most connected people internally, he has very low exposure to external sources of knowledge. Chris is a senior person in the Group A and has 13 years experience in the medical device field, eight of those with MediA. The knowledge translation discussions he has with his colleagues are almost always conducted face-to-face and focus on figuring out if and how outside knowledge can be used by Group A. While he believes that his colleagues consult with him because of the formal reporting structure, he also suggests that he has certain skills which are useful for translating external information. In the following quote, Chris explains these skills. As he is well connected internally, he has the ability to see the bigger picture within the wider R&D group, and he understands how external knowledge needs to be modified in order to fit into that bigger picture:

> *So anything mechanical related…people would probably run it by me just to make sure it makes sense. The reason for that is probably – I wouldn't say it's my technical expertise – there are a lot of people in the group that would burn me in terms of pure technical expertise. My skill sets would lie in that I know a little about a lot of different things, and I probably have a good appreciation for how they all fit together into the overall picture. We do have people who are bond experts, who are crimping experts, who are balloon experts, [but] they probably wouldn't have as good an appreciation for the impact that something new would have on other people…whereas I probably would have that visibility. The skill set I have – other people probably don't have that.*

While the Web is the most widely used source of external information, there is a realisation within the group of the need to be selective when gathering web-based information. There are no guarantees that information sourced from the Web is truly accurate. The medical device industry is highly regulated and the information used to produce these products has to be documented for FDA and EU inspection. Popular websites like wikipedia are extremely convenient for explaining a particular topic however, anyone in the world has the potential to edit a wikipedia article. Thus, the reliability of this information is always open to question. One internal communication star acknowledges that while wikipedia is frequently used as an information source, the validation of this source information is an important process. Group members cross-reference web-based information against other data sources to check its validity:

> *I've heard comments where people talk about something like wikipedia [but] you have to be careful with it. I suppose I'm guilty of it myself – it's just convenient, you just pull the information. If it's just for illustration purposes it's not a problem. But if it's something where you're probably going to rely on this as a source to make a decision or to go and use it in support of a submission to a Regulator, then yes – clearly you have to go and check the source of the information. And we do enough cross referencing, reviewing or peer reviewing*

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[1] Fictitious name

of our internal documents, and that in itself is the catch for it. We go look for a source document.

<u>*External Knowledge Dissemination*</u>

Through a combination of social and technical means, the internal communication stars disseminate and integrate novel external knowledge into Group A. Email is the bedrock of the internal communication system. Many of the interviewees suggest that they easily receive over 50 emails per day. Group A has a very clear hierarchical structure and the flow of knowledge tends to follow the chain of command. The following quotation from an internal communication star provides evidence that the pattern of email traffic conforms to the formal organisational chart:

> *We have a lot of distribution lists. We all have functional managers and they have managers. So I report to my boss. He may have 5 or 6 engineers and a number of technicians in his group – he distributes to us. I'd have a couple of technicians reporting to me and I'd keep them on a little distribution list. I'd have 3 or 4 people I work with outside the area – my peers – on another list. It just goes on and on. So my manager's boss, he would have all of us in stent delivery on his distribution. Everyone has their own little tiers of it.*

Email is the primary system used to alert colleagues to new information from outside the company. However, there is an expectation that only the more senior people in the group should be sending out these emails. There is a feeling among the younger and less experienced members of the group that any external knowledge they discover would not be accepted by their colleagues if they tried to distribute it themselves. Instead, they usually ask an internal communication star to distribute that knowledge around the group on their behalf. The process of disseminating novel external knowledge usually begins with the internal star sending an email with the attached information to the group members they know would be interested in that information. The email will include one or two sentences explaining why the sender believes the attached information is relevant to the receiver. If the information is of interest to that individual, they then return to the internal communication star and have a face-to-face discussion about how that information can be used by the group. An example of this process is provided in the following quote from a non-star:

> *The information would go up the chain and then fed back down. During the week, one of the members of our group found an interesting external training course, sent an email to the functional manager who was my boss as well, and the manager sent it out to all our extended teams saying, "We've just found this, if we're interested, please come back to me". The same applies with new recruits from universities…they may have spent a lot of their last year or two in conferences. They may have exposure to new developments that people here may not have known about. They would communicate that to the functional manager, and the manager will then feed it out to everyone.*

While email is used to distribute external knowledge, face-to-face discussions are needed in order to figure out how to make use of that knowledge. The consensus among the interviewees is that it would be virtually impossible to perform the work of the R&D group without face-to-face interaction among peers. R&D work in the medical devices sector is very technical in nature. Email is useful for alerting people to external developments but a discussion about that knowledge through email is cumbersome. For this very reason, group members frequently travel to their sister site in the US. In fact, when engineers are being interviewed for positions in R&D, it is explained to them that travel is part of the job. Face-to-face time is a vital component of the group's work. This is highlighted in the following quotation from an internal communication star. He explains that integrating new knowledge into the group requires face-to-face discussion:

> *You can only truly understand something new if the other person asks questions and you reply straight away, so that you can address their needs straight away…whereas in e-mail you can't do that. You do need face-to-face time. You can do a certain amount over email and the phone but you have to build up that face-to-face rapport. What happens is once you build up*

that face-to-face rapport, people get the measure of you. They understand what your convictions are, where your strengths are, how you behave – or misbehave – and how to manage that.

5. DISCUSSION

This paper asked the question "How have Web technologies impacted the technological gatekeeper's tasks of acquiring, translating, and disseminating external knowledge?" While we find that the gatekeeping tasks are integral to the R&D operation, we also find that these tasks no longer need to be performed by a single individual. Gatekeepers do exist, but they are rare. When Allen (1977) first formulated the theory, the gatekeeping role could only be performed by a single individual because technical communications were predominately oral based. Among other skills, the traditional gatekeeper needed excellent social networking abilities in order to effectively acquire and disseminate knowledge orally. While other R&D engineers may have wanted to perform the gatekeeping role, the lack of these social networking skills possibly impeded them. Combining the results of this study with the literature, an updated conceptual framework of the gatekeeper concept is illustrated in figure 2. We acknowledge however that the framework is a simplistic representation of an extremely complex process.

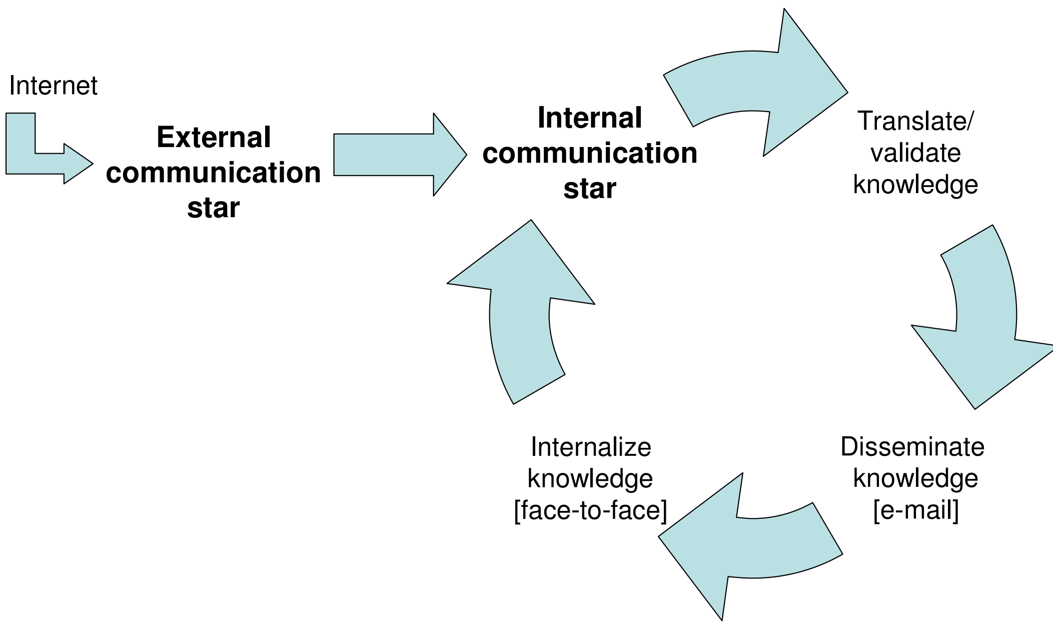

Figure 2 An Updated Gatekeeping Conceptual Framework

The framework explains that outside knowledge is largely brought into the R&D group by external communication stars. External stars primarily use the Web to scan and acquire their knowledge. External knowledge is then presented to the 'go-to' people of the R&D group – the internal communication stars. As well as translating the knowledge into a form that can be used by the group, the internal star also validates that the outside knowledge is accurate and reliable. Knowledge validation is an important step in the knowledge integration process for the modern R&D group but it is not discussed in the original gatekeeper studies. The process of disseminating novel external knowledge usually begins with the internal star sending an email with the attached information to the group members they know would be interested in that information. The email will include one or two sentences explaining why the sender believes the attached information is relevant to the receiver. If the information is of interest to the receiver, they then return to the internal communication star and have a face-to-face discussion about how that information can be used by the group. It is through this discussion that learning occurs and the knowledge becomes internalised (Nonaka 1994).

6. CONCLUSION

The findings of this paper are of benefit to both theory and practice. We contribute to the advancement of the gatekeeper theory into the 21st century. We show that the gatekeeper role has fragmented, enabling it to be performed by Web-enabled boundary spanners and internal communication specialists. This study should be of particular interest to the IS community. Practitioners are increasingly aware that innovative knowledge is located beyond the boundaries of their firm. This study finds that the Web is a vital tool for accessing this knowledge and that certain people exist who have the innate ability to find relevant knowledge on the Web. It will be increasingly important for R&D firms to find people with the right blend of social and analytical skills. We have also identified some negative aspects to the Web-enabled R&D group that managers will need to be aware of. Firstly, with so much information freely available on the Web, verifying the accuracy and reliability of this information is becoming a critical step in the knowledge integration process. Managers will need to ensure that proper verification procedures are in place. Secondly, an interesting finding was the existence of certain individuals who constantly send FYI emails to their R&D colleagues. Rather than enhancing knowledge flows, the actions of these individuals are seen as a hindrance. The FYI phenomenon could become a significant problem if group members become overloaded with irrelevant messages and end up not reading the important messages.

We see two additional areas for future research. Firstly, while our findings make a unique contribution, they are based on only a single case study. For the purposes of generalisability, future research studies should examine multiple R&D groups in differing industries. Secondly, our findings show that the gatekeeping role can be performed by a single individual or by a combination of internal and external communication specialists. Future research needs to examine which of these routes is most effective for R&D project performance.

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