Sensible Organization

Inspired by Social Sensor Technologies

1. INTRODUCTION

1-I. Background

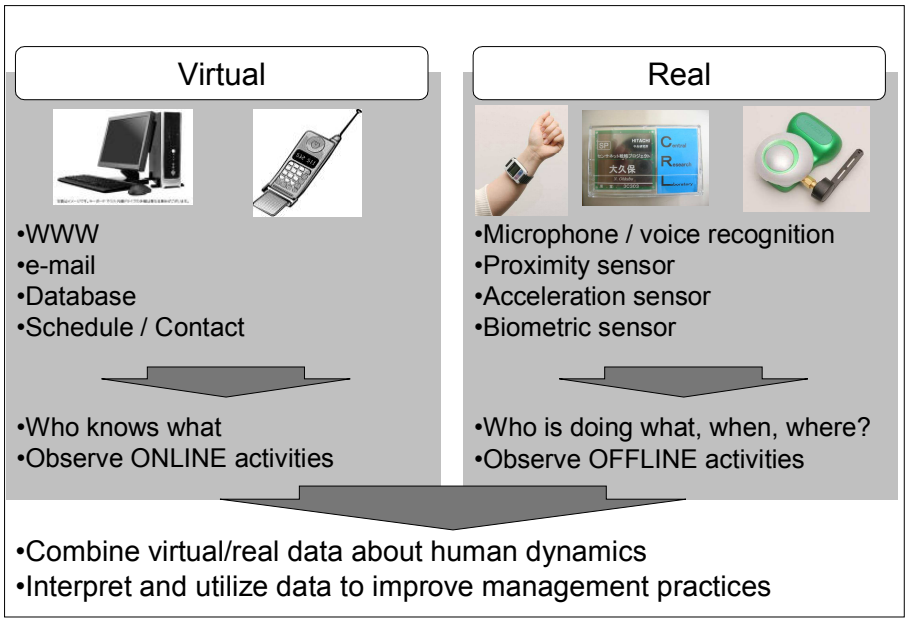
This paper is the final report by *Hitachi Innovation-Lab project* jointly conducted by Hitachi, the MIT Media Laboratory Human Dynamics Group, and the Innovation Club at the MIT Sloan School of Management during the spring semester of 2006.

Hitachi identified future opportunities for "social sensors," sensor network technologies applied to improve organizational practices, and started a joint research project with the MIT Media Laboratory's Human Dynamics Group to investigate these opportunities. The MIT Sloan School was invited to join this research effort to provide perspectives on management problems in organizations and to identify potential markets for social sensors. The Innovation Club, a student organization at the MIT Sloan School, took the lead in organizing this project, by creating a diverse team and identifying and involving faculty advisors.

Goal and project approach

The goal of the project is to explore future market opportunities of social sensor technologies in an organizational setting. The primary question to answer is "How can we combine data pertaining to social, physical or *real* information, with *virtual* information to improve organizational effectiveness?" (See Exhibit 1)

Exhibit 1: COMBINING VIRTUAL AND REAL



After the project started in February 2006, the team focused on developing viable applications and usage scenarios of social sensors in the middle to long-term perspectives. Rather than developing prototypes or defining specifications of applications that can be commercialized in the near future, the strategy adopted by the team was to think beyond the boundaries of technologies available today.

In response to the interim report delivered in April that described potential usage scenarios and potential applications, Hitachi requested that the team further investigate opportunities in the following aspects:

1. Develop a conceptual *model*, framing value-creation drivers enabled by social sensors.
2. Outline the *migration process* to transform an organization from as-is to should-be status to fully leverage the potential of social sensors. This should include a concrete analysis of methods of data acquisition with the sensors that are currently available, and how they can be used after the field experiments planned by Hitachi.
3. Narrow down the near-term applications to those that are feasible with technologies available in the short term.

Following these requests, the priority of the team has been to conceptualize the benefits derived from the use of social sensors from an organizational perspective, rather than to develop go-to-market strategies or business plans. At the end of the project, the team intends to hand over the results of the team's analysis in order for Hitachi to further develop, experiment and implement the ideas.

Structure of the team

Professor Sandy Pentland from the MIT Media Laboratory and Professor Mark Mortensen from the MIT Sloan School of Management have been advisors on the project. Six Students from MIT Sloan led by Koji Ara from Hitachi, joined the project as team members.

Methodology

The team followed a market-driven approach, rather than a technology-driven approach, to identify major trends driving today's organizations in order to propose social sensor enabled technologies as potential solutions to problems faced by organizations.

The process to identify problems and to come up with potential solutions involved the following:

- Studying academic papers and business articles on organizational issues
- Reflecting on past working experiences of the various team members
- Interviewing other business school students with relevant working experiences
- Brainstorming among team members and Media Lab students
- Discussing with faculty advisors and researchers from other fields

As the team's discussion progressed, members came to realize that the salient challenge in developing new product ideas was to identify very *specific and concrete* customer problems or needs, but at the same time, to come up with solutions that are *broadly applicable*. Looking for the right balance between generic and customer-specific, the team divided the set of explored problems and potential solutions into six different functions within the organization (Corporate, Sales, Research and Development, Customer Service, Marketing, and Human Resources). Following this process, the team worked on conceptualizing common features of these solutions into a broadly applicable *model*.

1-II. Executive Summary

As the business world is becoming increasingly complex and competitive, organizations are opting more and more for less hierarchical and top-down structures and more for flat, dynamic structures in order to function. With an increasing emphasis on both technology and human resources development, a huge demand has developed for methods that optimize the working relationships and structures of the firm. The IDC estimate of a $48 billion global market for consulting services[1] is one testament to this focus on processes and resources related to the human component of the organization.

Hitachi and the Media Lab started the social sensors project in order to develop a revolutionary electronic device to measure and analyze the social networks and interactions among people in an organizational setting. By understanding the social dynamics of intra-company networks more clearly, companies will gain a better understanding of how they work and how they can improve their daily routines in order to increase productivity, innovation, and job satisfaction.

The Hitachi Innovation Lab, a joint collaboration between Hitachi, the MIT Media Lab, the Sloan School of Management, and the MIT Innovation Club has prepared this report to provide Hitachi with the most promising applications for these devices in solving problems related to social networks and collaboration in the workplace. In particular, the social sensors will be best used to investigate and understand the social networks of companies and allow both management and individual employees to better understand the workplace and increase their productivity. We have identified three dimensions of analyzing the social sensor data:

- Visualizing – Focusing on viewing the data results of the organization
- Organizing – Focusing on interpreting the results into coherent knowledge of the organization
- Synthesizing – Developing new models and practices to improve the organization

These three dimensions can be used by both management and individual employees to understand the social networks of the workplace (such as hubs or information brokers) and to transform the workplace into a more productive and better place to work in. Finally, we will provide the next steps for testing the social sensor devices and creating a better workplace.

[1] Worldwide Consulting Services 2005-2009 Forecast: Redefining the Business Model and Setting a New Course (IDC #33445)

2. SENSIBLE ORGANIZATION

2-I. Basic Concept

As the model of organizations further shifts from labor-centric to knowledge-centric, organizational structure will be redesigned from hierarchical and rigid to flat and flexible. This change accelerates delegation, foster distributed leadership and accommodate autonomous initiative taken irrespective of both internal and external organizational boundaries. Successful companies will emphasize motivating and empowering, rather than monitoring and controlling, individual employees.

Such changes in organizations call for new communication technologies, as well as new technologies to further drive organizational changes. Social sensors, embedded in the environment and worn by people, will alter both the quality and quantity of interaction. Future organizations fully equipped with social sensor technologies will be characterized with *3 Value-Creation Drivers* that enable *3 dimensions of interactions*. We named this concept the *Sensible Organization* that describes how sensor-enabled organizations can release their potential capabilities to innovate.

Value-Creation Drivers

Social sensors can help knowledge workers connect to each other and take full advantage of the organizations' hidden knowledge to innovate. This process involves three value-creation drivers in sequence: Visualize, Organize and Synthesize.

1. *Visualize.* Social sensors can sense how people behave and uncover issues or reveal opportunities for improvement otherwise difficult to identify. For example, who are the socially connected members of an organization and does this connectedness correspond to official titles? This enables managers to quantify subjective variables and introduce new performance metrics, or KPI (key performance indicators), to manage organizations. In addition to end results (e.g. sales performance, operational cost, etc), interim process (e.g. customers satisfaction, likelihood of purchase, etc) can be used to plan actions ahead. Individual workers also benefit from understanding their own social and intellectual activities as well as the social and intellectual capabilities of organizations to find opportunities to be more effective.

2. *Organize.* Knowledge workers can take full advantage of their delegated leadership when they can involve, influence and inspire others, whether inside or outside their organization, who can share common aspirations. Social sensors can help by enhancing one's capacity and capability to know, connect to and bond with other people with common or related interests and expertise, both in professional and personal manners. Once the *Visualizing* capability is established, findings from social network analysis via online communications (e.g. e-mail, phone) and offline communications (e.g. data from social sensors) can promote formulation of effective networks and encourage effective teamwork. Managers can assign roles and responsibilities to his/her staff in accordance with their unofficial roles in the social network.

3. *Synthesize*. For every knowledge worker it will be increasingly important to identify and leverage internal and external intellectual resources – knowledge of customers, technologies or colleagues - together indicating opportunities to collaborate and innovate. Once the *Organizing* capability is established, social sensors can help this challenge by interpreting

the work context in the social network, shedding light on complex social situations, uncovering hidden tacit knowledge and stimulating knowledge sharing.

Dimension of Interactions

In establishing each of the three value-creation drivers, social sensors will open communication channels and encourage collaborative relationships across organizations. The range of interactions through social sensors includes 3 dimensions: Bottom-up, Top-down and Autonomous.

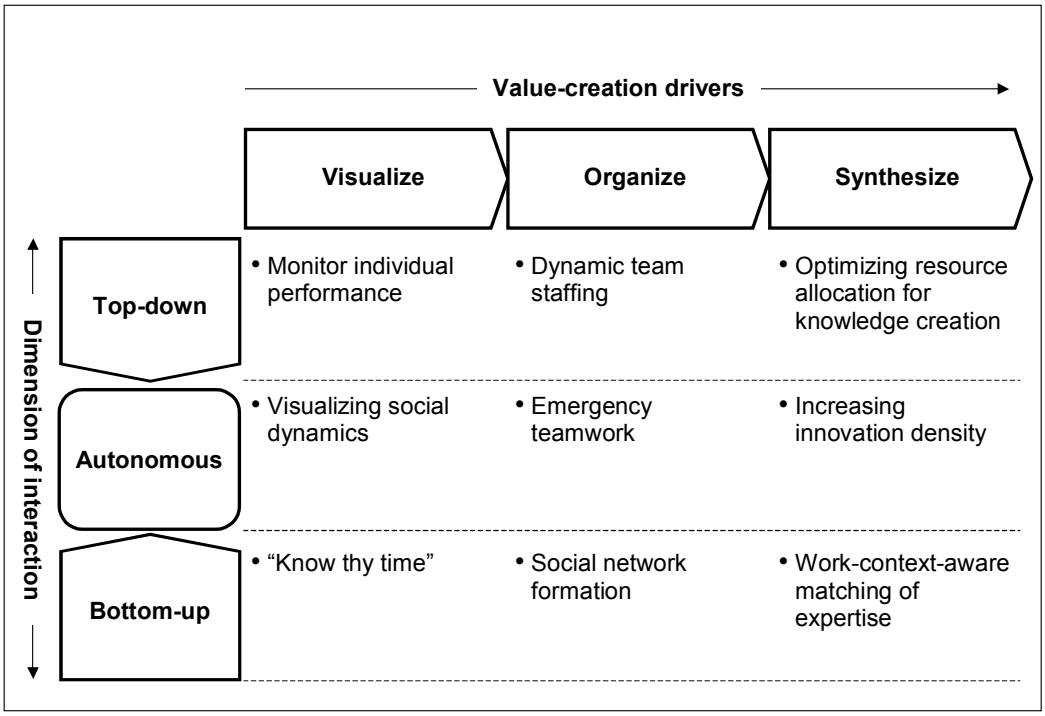
1. *Bottom-up*. Each individual employee in the organization can benefit from capturing data of his/her own interactions or the organization overall, analyzing it or receiving guidance and recommendations to enrich the social network and improve his/her effectiveness. Establishing this kind of direct benefits for individuals is critical to wide acceptance of sensor devices prior to further development of other functions.

2. *Top-down*. Managers can utilize the data captured through social sensors widespread across his/her organization to observe its social dynamics and plan and implement measures to improve its performance, such as staffing or work assignment. Following this approach, managers should be particularly careful not to link sensor data to individual evaluation, paying special attention to ethical considerations (further details discussed in chapter 4-II).

3. *Autonomous*. Once both the *Bottom-up* and *Top-down* interaction channels are open, the organization will be ready to ignite autonomous initiatives and foster distributed leadership. The goal of autonomous interaction channels is to build the organizational capability to form dynamic teams responding to rapidly-changing and sometimes emergent environments.

The representative benefits of social sensors for *Sensible Organization* is summarized in exhibit 2 below.

Exhibit 2: SENSIBLE ORGANIZATION



In the following section, we will describe each of value-creation drivers and its underlying theories in greater details.

2-II. Value Creation Drivers and Underlying Theories

Visualize

There is a pletheora of management literature that emphasizes accomplishing productivity goals through a range of structural/organizational solutions. The impact of such solutions in the past was often realized over a period of time ranging from weeks to years. However, technology is now available to empower organizations to measure subtle, less tangible impacts of organizational behavior and thus measure the efficacy of management solutions. The advent of tools such as social sensors now allows real time measurement of the effects of organizational structures on behavior and bring to light serious issues that could earlier go unrecognized for long periods of time.

INCREASE PRODUCTIVITY

"KNOWING THY TIME"

Peter Drucker's aphormism "Know Thy Time" though originally cited in the context of making executives more productive, holds equal value when it comes to monitoring an organization's productivity. Drucker originally recognized that before planning should come an awareness of where one's time is being spent. Only then one can cut down on unproductive demands and dedicate more effort to tasks that best utilize the executive resource. The aforementioned is equally applicable to organizations. Particularly today when technology has enabled tools to track the productivity of knowledge workers it is more important than ever that organizations delve in an exercise of exploration and use their time wisely. A sensor network like a one enabled by the uBERbadge can provide just the information that we need to accomplish this goal.

STRENGTH OF "WEAK TIES"

Stanford sociologist Mark Granovetter discovered that we most often communicate with those with whom we have the strongest ties[2,3]. ("Strong ties" in this context are defined by the social structure that sorrounds individuals in an organization and not necessarily defined by the intensity of the relationship.) These individuals tend to be our friends, neighboring co-workers and other allies in the workplace. He also postulates that since we communicate with these individuals often on short intervals, the information we share on a regular basis is often not as relevant to the workplace. Therefore the real goldmine of information that we do not get access to resides with those that we choose not to interact with; ie those with whom we have "weak ties." There are two underlying issues that visualization in the context of this paper can help resolve: 1) A social structure is a necessary but not a sufficient condition to promote rapid transmission of information. But if organizational changes are made with the above observation in mind, a visualization mechanism is needed to ensure that the objectives of the structure are being met. 2) Additionally, a visualization mechanism can also help identify unintended organizational structures that are not lending themselves to efficient dissemination of information. Such structures can then be modified to promote a more frequent and efficient information exchange.

LEVERAGING INFORMATION BROKERS AS TOOLS FOR ENHANCED PRODUCTIVITY

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[2] Granovetter, Mark "The Strength of Weak Ties" American Journal of Sociology 78, 1360 (1973)

[3] Hargadon, Andrew: "How Breakthroughs Happen, The Surprising Truth About How Companies Innovate"

Certain individuals within organizations assume the role of informations brokers, either through formal or informal means (a structural role could potentially create an information broker by design, but there are often individuals who become brokers of information by virtue of their idiosyncratic talents, length of employment, etc.) These individuals often serve as crucial links between separate silos, acting as brokers for the exchange of information between different part of the organization. These individuals often veil considerable power due to the vital role they play in fostering innovation through collaboration within an organization. Often enough, there aren't enough of them. A visualization scheme that can identify these candidates, or lack thereof, can significantly enhance the abilities of an organization to put in place other brokers by design to: 1) either alleviate disproprotionate burden on one or a few, 2) create new brokers between groups where information gets exchanged at a slower rate, or not at all. [4]Bulkley and Alstyne note that organizations often do not know themselves what they know. Information is often spread across large groups or divisions who often do not realize the extent of knowledge accumulated within different groups. Messrs Bulkley and Alstyne refer to this as achieving below economies of scope. In such cases, strategically creating information brokers could lead to a free exchange of information that could allow an organization to better leverage its own information resources.

Therefore, the ability to identify areas where information exchange is crucial, the ability to monitor the rate of exchange and the ability to identify the agents of exchange could play a crucial role in improving the overall productivity of an organization. The social sensors technology could easily accomplish the tasks listed above.

SOCIAL SENSORS AND THEIR APPLICATIONS

Social sensors can sense how people behave and uncover issues otherwise difficult to identify. This enables managers to quantify subjective variables and introduce new performance metrics, or KPI, to manage organizations – in addition to end results (e.g. sales performance, operational cost, etc), interim process (e.g. customers satisfaction, likelihood of purchase, etc) can be used to plan early actions. The principles underlying the analysis above have perhaps been around for years, but now with the advancement of technology we finally have tools that allow us to measure organizational variables in objective terms. A network of sensors connecting members of a group, or groups to other groups within an organization, can now reveal the crucial elements of data that can be applied in ways discussed above. Such a network can create a visual map of interactions along dimensions of time (when such interactions took place), distance (how far apart were the participants), and frequency (how often did they occur). Most of these variables previously only existed in the subjective interpretations of a manager. Today, thanks to the technological leap allowed by sensor projects like the uBERbadge, they can exist as numbers and images that provide clear, tangible evaluations of organizational structures and the productivity of the employees they are supposed to influence. Such visualization can now facilitate prudent decision making by at times exposing certain organizational weaknesses and at other times by highlighting opportunities that could not be justified with concrete data until now.

Organize

Social networks are an increasingly important aspect to study and improve organizational behavior[5]. In this section we will discuss which aspects of social networking would be most important to measure and how the Social Sensors can enable this.

[4] Alstyne, Marshall Van; Bulkley, Nathaniel: "Why information should influence productivity"
[5] See Appendix II

In their book The Hidden Power of Social Networks[6] Rob Cross and Andrew Parker observe "using e-mail logs to assess connectivity is quick and easy. However, the conduits that are easiest to analyze may not be the ones that carry critical information…executives are much more likely to be engaged with a network of face-to-face interactions where the bulk of the work happens." They then go on to suggest that using electronic nametags which measure face-to-face meetings may be more effective at resolving the underlying network.

Social Sensors will enable an accuracy and resolution of organizational behavior rarely possible before. However, many organizations are already drowning in too much data. Social Sensors will only be effective if they not only produce data but Hitachi uses this data to accurately gauge the organizational network and interpret it for the client.

SOCIAL NETWORK ANALYSIS

In a review of the social network analysis, we have found that there are two main types of data that can be collected: individual data and collective data.

Individual Data

Individual data allows the company to see how different individuals place in the network in terms of social contacts. It can allow the company to realize who crucial individuals are who help the company work, despite any formal hierarchical designations. There are several ways to assess individuals' impact on the organization[7,8,9]:

1. Centrality Measures – Who is central in the organizational social network? Who seems to be peripheral? Why does it matter? These are some of the questions centrality measures try to ask in analyzing social networks. There are many centrality measures, and it will take careful evaluation to determine which is best so here we will summarize two:
    a. Hubs – Hubs are people very well connected to many other people in the organization. In Exhibit 2 in the appendix, you can notice that Clemence and Wilson are two of the hubs in the initial organization. Hubs are comparatively easy to spot in a network analysis though they are often not necessarily the highest and most senior people in the organization.
    b. Betweeness – Betweeness is an alternate measure of centrality in social networks. In every social network, there is a shortest path between any two people. If they know each other, the shortest path is 1. If they have a mutual friend, the shortest path is 2, etc. What betweeness measures is how many times each person is located on a shortest path in the network. If a person is located on many shortest paths, they are considered more central and have a higher betweeness score.
2. Clustering – A measure known as the clustering coefficient can give one measure of how intimate the associates of any given person are. This measure is different from centrality because it doesn't tell us about the size or quality of social contacts, but rather how many of their social contacts also know each other. Clustering coefficient measures range from

[6] Cross, Rob and Parker, Andrew The Hidden Power of Social Networks, Boston: Harvard University Press, 2004.
[7] Watts, D.J. Six Degrees: The Science of a Connected Age, New York: Norton, 2003.
[8] Newman, M.E.J. "Who is the Best Connected Scientist: A Study of Science Co-Authorship Networks" Phys Rev E 64 016131 (2001)
[9] Newman, M.E.J. "The Structure and Function of Complex Networks", SIAM Review 45, 167-256 (2005)

0 to 1. At 0, a person's friends all do not know each other. They may have many friends or a few but they are all separate social relationships. At 1, all of the social contacts for a person know each other. This may be a large group or a small one but it is relatively well-connected, and perhaps (but not necessarily) insular. Of course you can give an individual other values between 0 and 1.

There are many other measures of individual interaction in a social network can also be used depending on the situation such as alternative measures for centrality.

In their book, Cross and Parker class people in social networks under four categories:

1. Central Connectors: These are people who are "hubs" in the network. Central connectors may seem like the "holy grail" of network analysis but you must be careful in assessing their impact. The impact of central connectors on social networks can be heroic or limiting. In a heroic aspect, these may be the people who get things done, bridging social distances and providing valuable insight that pushes the group forward to its goal. On the other hand, they can be the equivalent of an operational bottleneck. If too many connections and attention are focused on one individual, his or her speed in dealing with these multiple issues can be the bottleneck for work processes in the organization. This can be exacerbated if they are not a senior person and need high level permission to act. You have to be very careful about assessing the value of central connectors to the group.
2. Boundary Spanners – These key people are the connections between separate groups or divisions. The different groups may be geographical, company division, or even political. They are important in providing a vital link between the two (or many) sides of the organization. They may not have as many contacts of hubs, but usually have betweeness scores that are very high for their comparatively fewer contacts. Like central connectors they can play a great facilitating role or become a bottleneck in cross-group collaboration.
3. Information brokers – Information brokers usually also have high betweeness scores and are vital sources of information for getting work done in a network. Instead of bridging two different groups though, they are usually nested in a standard group of the organization.
4. Peripheral people – These people usually are not hubs and have relatively low betweeness scores. They are relatively socially unconnected. However, do not jump to conclusions. Though some people end up peripheral because they are isolated from the group, this can be by choice. They mentioned in some hi-tech organizations, technical experts can choose to be peripheral because it helps them get work done.

Individual information in the network analysis should be used very carefully (see ethics section). It can be very dangerous and divisive if used improperly. However, there are also collective measures that can be used to analyze the organization.

Collective Data

Collective data tells us about the whole network, or part of it, by certain collective properties. This can give us an idea of the organization's makeup and a rough idea of how it interacts. Like individual data, there are many ways to look at it. Below, several are highlighted.

1. Average shortest path and network diameter - These both measure the "width" , in terms of relationships, in the organization. The diameter is the length of the longest shortest path in the network between two people and can give you a rough idea of how separate the network can be. The average shortest path is the average of all shortest paths between

any two people in the organization ($n^2 - n$). It can tell you roughly how connected the organization is by seeing on average the distance that separates any two people.
2. Average Clustering Coefficient – This is the average of the clustering coefficients for all people in the network. It can tell you, in some ways, how connected the group is. Confined to the group being analyzed, a high average clustering coefficient can indicate how well-connected the group is. One must be careful how to interpret the results though using real knowledge of the network
3. Department data – Department data is also used to see the interaction between people with different designation from geographies, departments, or other distinctions. It can give a clear idea how the two departments interact and which people are central to each.
4. Location data – You can possibly use location based data to correlate the social connectivity of network participants. Distance, even relatively short distance, has been shown to be a huge factor in social relationships in an organizational setting.

How to collect this data

The analysis recommended above can be collected using the social sensors by measuring proximity contact between individuals and locations in the organization. Thresholds will likely need to be set, as well as an idea about how level of contact is enough to form a connection. Many personal contacts may be frivolous and in order to raise the "signal to noise ratio" of meaningful connections against background superficial relationships, more research will likely need to be done so algorithms can be created to find the optimum measure of real social connections in the organization.

BENEFITS

The organization can obviously benefit many ways from the social sensors analysis. In particular, it can give a clearer idea how work is done in an organization. Improved work processes and better organizational cohesion can result. Cross and Parker recognize several organizational aspects that can be improved from identifying and reducing tensions, limiting redundant relationships, and improving the speed and efficiency of the organization by giving the right sorts of responsibilities to hubs or spreading out their responsibility to keep them from being a bottleneck.

Many metrics should improve as a result. One of the key metrics to be measured is some form or workforce productivity. This can be the completion of routine tasks, the shortened cycle time for R&D or other processes, as well as a more smooth functioning in the more bureaucratic aspects of the organization.

However, they also mention certain aspects which cause for pause. Parker and Cross as well as Borgatti in an article on the ethics of such analysis warns that network analysis is often used by management to "redesign" or do layoffs in organizations and such an exercise can be fraught with peril. Network analysis does not supply much information such as skill sets among others and should not be blindly used to make personnel decisions. In addition, in highly political environments network analysis can be an explosive issue and may cause tensions to increase or elicit uncooperative behavior from participants (see chapter 4-II). Hitachi should restrain from trying to "mold" organizations but rather give them information that would allow them to better act towards a common goal in everyone's interest.

Synthesize

Synthesis is commonly understood to be an integration of two or more pre-existing elements which results in a new creation[10]. With tremendous success stories such as open source software projects including Wikipedia, Linux and Biotech firms, the importance of such collaboration is now widely understood not only by businesses but also academia. In his book "The Future of Work", Thomas Malone outlines the shift from "command-and-control" management to "coordinate-and-cultivate".

"We are in the early stages of an increase in human freedom in business that may in the long run be as important a change for business as the change to democracy was for governments. New technologies are making it possible for the first time in human history to have the economic benefits of very large organizations and, at the same time, to have the human benefits of very small organizations, things like freedom, flexibility, motivation and creativity. Information technology is reducing the costs of communication to such a low level that it's now possible for huge numbers of people even in very large organizations to have all the information they need about the big picture to make their own decisions for themselves about what they do rather than waiting for people above them in some hierarchy to tell them what to do." [11]

In such democratic shift in workplace, coordination effort is important for businesses. Knowledge is also widely distributed and needs coordination today, because a ton of business data is stored in brains, rather than databases. Estimates are that anywhere from the 70 to 90 percent of the business knowledge is still in employees' brains[12]. Today, workers in large companies have a tough time figuring out who of their colleagues knows what, who is doing what, and who is interested in what. Social sensor will ease this difficult coordination task, and even further help employees synthesize new knowledge.

SOCIAL SENSORS AND THEIR APPLICATIONS

Work-context-aware matching of expertise

Social sensor technology will help employees to find who knows what, who can provide support, who will give you a hint to a breakthrough idea. As Dey, Salver, and Abowd have emphasized, the first step is to observe discoverable elements of the environment. These elements include the location and identity of people and objects, their activity status (tired, hot, noisy), the general activity they are involved in, such as reading, attending a meeting, and the time period they are in a location, and engaged in an activity[13]. Social sensor technology automatically generates such work contexts, by looking through workers' behavioral patterns (such as who one speaks with, where one visits), biometric clue, e-mail, search keywords and conversations. It will create profiles for employees, their areas of expertise and interests, and creates "work context and knowledge map" that are updated real-time.

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[10] Wikipedia (http://en.wikipedia.org/)

[11] Thomas Malone "The future of Work", 2004

[12] Charles Savage, "Fifth Generation Management, Dynamic Teaming, Virtual Enterprising and Knowledge Networking", 1996

[13] Daniel Salber, Anind K. Dey and Gregory D. Abowd, "The Context Toolkit:Aiding the Development of Context-Enabled Applications" 1999

Employees can take advantage of this map to contact experts in and out of the organization. Information seeker will be able to reach the right resources in right time by looking at map in a computer, or by receiving notification sent to his sensor-badges when one gets close to information providers. In a situation like party or a meeting, one can get to know the presence of the expertise, know it's the right time to ask for advice. The sensor data also provides information on what is the best way to connect with that expert, such as preference for direct or indirect contacts, friends and hobbies in common to facilitate better communication.

Social sensors can actively suggest the information or expertise one may need in order to get things done. This suggestion can help breakthrough idea to emerge, as it may accelerate integration of different area of expertise and knowledge to synthesize solutions to common problems, just like technology from other areas such as nanotechnology and chemical processes helped hard disk capacity to increase beyond the limit of magnetic processes.

Increasing Innovation density

Inspiration often occurs when people interact with each other or when people encounter something new. Social Sensors can be used as a tool to help people know when an innovative idea emerges and help cultivate the idea as follows:

1. Notification when inspiration occurs: Biometric information such as voice properties, facial expression and body movement can identify when people get excited.[14] The sensor will track changes in such biometric properties and matches them with contents and context of the conversation.
2. Help remember the inspirations: Social sensors add the information to personal profiles, and help employee to remember what inspiration was born during conversation and in what context.
3. Assist follow-up process: The inspirations are connected with the aforementioned knowledge map, and connect employee with adequate experts or information seeker/provider. The context data will help to reproduce the environment when the most innovative idea was born, such as member structure of the conversation and environmental settings of the meeting.

Social Sensor will help companies to create a marketplace for such inspirations and ideas, increase innovation density and help employees exercise their creativity.

Optimize resource allocation for knowledge creation

As an organization becomes more democratized, management's role will be transformed from "command-and-control" to "coordinate-and-cultivate". That is, as the leadership and decisions are delegated to lower level managers, senior management needs to foster employees' collaborative activities and give enough time and shared resources to them. Takeuchi and Nonaka emphasize that bringing together people with different knowledge and experience is the necessary condition for knowledge creation.[15] It creates a larger, more complex pool of ideas and helps a group to create new ideas combining their old knowledge in new way.

The book Working Knowledge describes five managerial principles that can help organization to achieve an optimum knowledge creation process[16]as follows:

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[14] Emotion recognition - IEEE Signal Processing Magazine, 2001

[15] Tokujiro Nonaka, Hirotaka Takeuchi "The Knowledge-Creating Company", 1996

[16] Thomas H. Davenport, Laurence Prusak "Working Knowledge", 1998

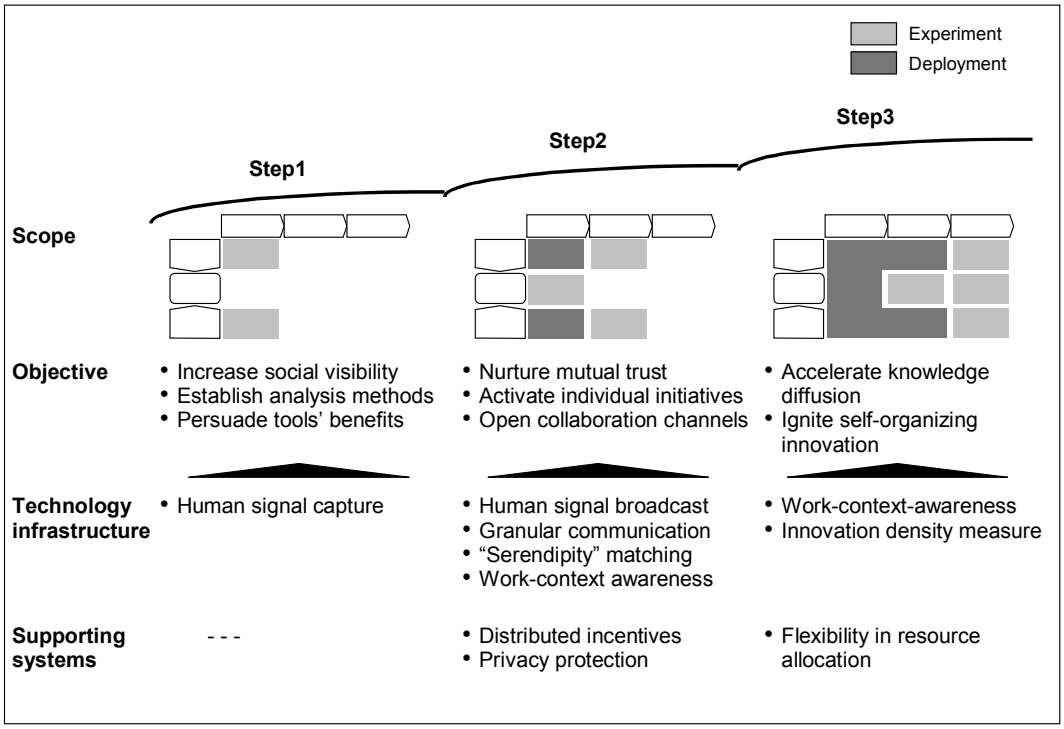
1. Foster awareness of the value of the knowledge thought and a willingness to invest in the process of generating it.
2. Identify key knowledge workers who can effectively be brought together in a fusion effort.
3. Emphasize the creative potential inherent in the complexity and diversity of ideas, seeing differences as positive, rather than sources of conflict, and avoiding simple answers to complex questions.
4. Make the need for knowledge generation clear so as to encourage, reward, and direct it toward a common goal.
5. Introduce measures and milestones of success that reflect the true value of knowledge more completely than simple balance-sheet accounting.

Social sensors can help management to make sure those five principles are shared and implemented throughout organization. Management can implement those five principles by encouraging knowledge creation by observing the diversity of teams and time/resources allocation to cultivation and coordination, and take necessary measure to improve it if the behavior of employees is not aligned to the organization goals.

2-III. Migration Process

Sensible Organization may seem to be just a conceptual and theoretical model. In practice, organizations should build such capabilities through several steps over time. While actions to be taken vary depending on the current status and the nature of business of each organization, such actions should be summarized into 3 phases in general. (Exhibit 3)

Exhibit 3: STEPS TOWARD SENSOR-ENABLED ORGANIZATION



Phase 1 : Disseminating Devices

In this phase, an organization starts trial and error approach with simplest applications of visualization in either the top-down or bottom-up dimension, distributing social sensor devices to one or multiple parts of the organization. Collecting raw data and experimenting with various analysis, the organization should find out which meaningful analysis method fits well with the organization's business objectives and is in line with expected performance metrics.

To move on to the next phase, it is critical to demonstrate social sensors' direct *benefit to individual employees* by introducing bottom-up applications such as "know thy time" and showing their effects.

Phase 2 : Stretching the Net

In this phase, the use of technologies shifts from just capturing data to *broadcasting* data, enhancing the visibility of the entire organization and stimulating individuals' reaction. An immediate effect will be *granular* communication through existing channel – frequent, quick and informal reporting and feedback. Beyond that, more intelligent applications such as *serendipity matching* would encourage social networking, helping individuals get to know someone he/she did not know. Data recurring from these interactions would accumulate, enabling the organization to interpret work-context and implement further intelligent applications.

At this point, informal collaboration channels, stretched across organizational boundaries, would provide the basis for the organization to move on to the next phase. Now managers have to break out of the *command and control* mentality and shift to the *cultivate and coordinate* model so that individual workers start to take bottom-up initiatives. Mutual *trust* between managers and employees would be another requirement, with managers delegating broader responsibilities and employees expecting managers' sound judgement based not only on measurable data.

However, we should note that technologies alone cannot achieve this change. Collaboration happens only if the *right incentives* are in place; in addition to those who contributed to the end result, those who supported them in the process should be rewarded as well, not necessarily financially, but through broader range of measures according to the organization's culture (e.g. recognition, assinment of new roles, etc)

Phase 3 : Harvesting Knowledge

In this phase, knowledge is diffused and dynamic teams are formed through official and unofficial collaboration networks.

Data about social behaviors captured by sensors, such as attendance of meetings, frequent topics or key counterparts of interactions, will be used to interpret *work context.* This can be used to identify potential needs for new knowledge at one place as well as accumulation of new knowledge at another place, helping to match the demand and supply of knowledge. Interactions stimulating high level of creativity, or high *innovation density*, can be identified so that the topics or the counterparts of such interactions are recorded to assure future continuity. In addition to individual employees willing to fully utilize these opportunities identified, it is important for managers to be flexible in assigning resources required for new opportunities.

3. ANALYSIS AND IMPROVEMENT METHODOLOGIES

3-I. Implimentating Migration Processes

Here are some of near term applications in phase 1, 2, and 3 which we believe to be quite promising in showing the effectiveness of sensors, and in changing workers' minds and actions in the self-organized, innovative organization.
In these applications, we are considering R&D organizations, but these are applicable to any white collar, creative, knowledge work type organization in which people have a lot of flexibility with respect to both their time and human network.

The following paragraphs describe in details the near term applications according to the three phases, namely *Visualizing*,

Phase 1.

At this first stage, we believe that the use of sensors by individuals for visualization purposes has the following applications:

- To create awareness for individuals regarding their own capabilities, their time allocation across various activities, their social network within the organization, with the aim of providing objective data that can be confronted with their own personal and subjective thoughts
- To facilitate the adoption of social sensors by emphasizing their usefulness for individuals, especially if private information is not published.
- Since privacy could raise some concerns initially, personal information should not be made public within the organization. However, even if private information is not available, team dynamics could be examined and provide a wealth of information on potential ways to raise productivity, increase efficiency and improve time management within the organization .

Individual time analysis

In this part, the objective is to provide individuals with information that enables them to analyze their activities, their time management and their allocation of time and/or resources among different activities. The end goal is to (1) minimize unknown time (time that cannot be classified into a clear use) and to (2) minimize and/or consolidate long and "unproductive" time segments. The process to achieve this objective includes 3 steps.

Step1 is to measure individual use of time. We believe it to be very useful for individuals to visualize the information - which, to some extent, is available with current technologies - pertaining to the following:
(raw data)
- Degree of interaction: alone, one-to-one, group work
- Mode of interaction: face-to-face, phone, e-mail
- Direction of interaction: active, passive, broadcast, broadcasted
- Use of PCs: viewing,editing email, web browsing, editing document
- Location: meeting room, individual desk, coffee room, smoking room
(interpreted data)
- Purpose of the tasks: particular project, particular customer

- Nature of the tasks: reporting, processing, socializing, commanding, managing

Observing the data above, individuals can identify how often they "encounter unknown time", or how often is their work considered too short or too long.

Step2 is to confront the perception with the real data and identify the room for improvement. Once objective personal data has been collected, individuals need to confront these data with their own perception of their time allocation. According to Drucker[17], individuals should maximize their "discretionary" time into the largest possible continuum of units. In other words, they need to identify the long or short "unproductive"lapses of time and figure out how to minimize them.

More specifically, it might be useful for individuals to compare their own activities with the following benchmarks.
- Average amont of time spent by colleagues in the same team/division/company
- Their position in the distribution in the organization

Step 3 is to evalute the change in the following perspectives.
- Has this change been overall been accompanied by any general improvement?
- Has the change led to an increase in the continuous "discretionary" time?
- Has it led to a decrease in "unproductive" and too long lapses of time?
- Has the change been followed by a consolidation or decrease of too short "unproductive" lapses of time?

The evaluation process can be done on a daily, weekly or monthly basis. According to Drucker, everyone should take the time to analyze his or her own time more than once every six months.

Throuout these steps (step 1 to step 3) in *phase 1*, it is important to identify the potential issues and develop appropriate plans to move forward to *phase 2.* Specifically, following aspects might be considered.
- Level of acceptance of devices, and reasons for reluctance if any
- Appropriate degree of automation, active/passive balance (notifying when to reduce/increase amount of time spent on particular activities, scheduling meetings)
- Appropriate channels and timing to active/automated notice (e-mail, IM, etc)

Individual network analysis

The objective of this application is enabling indivisuals to understand their social network and identify how they can change the way they interact with others to utilize their network more effectively. The following measures might be useful to this objective.
- Identify the individuals that are part of the network
- Evaluate the connection according to its nature (tight vs. not tight), its frequency and the extent to which it is highly active (high motion, high voice energy, etc.)
- Identify the context and the purpose of the connection
- Determine the means of communication

Individuals can undertake the process similar to *individual time analysis* (step 1 to step 3).

Time and network analysis by managers

[17] Drucker, Peter The Effective Executive, New York: Harper, 1967.

The objective of this application is to enable managers to visualize the time allocation and social network of his/her teams and identify room for improvement.

The simplest approach to this objective would be just consolidating data from *individual time analysis* and *individual network analysis* into a larger unit of team or division, and conducting a similar analysis (e.g. communication channels, location, type of tasks, etc) and following a similar process (steps 1 to step 3). Managers can get insights into his/her teams by comparing these data among different teams and tracking changes in chronological order.

A more sophisticated approach would be comparing the actual time allocation and strategic priorities of the team. Examples of such situation might includes the following.

- A research group focusing on developing new applications for sensor technologies is prioritizing interaction with marketing division and potential customers
- A product development team focusing on cost reduction is prioritizing improvement in manufacturing processes and allignment with purchasing and design team

Phase 2.

Active enhancement of time and network

As opposed to the *phase 1* in which the emphasis was on passively visualizing time and network, *phase 2* would be more focused on improving time and network by sending messages and actively influencing individuals. Appropriate channels and timing of messages should be determined based on the feedback from *phase 1*. Possible channels of *influencing messages* might include the following.

- Sending a reminder (by IM to Badge/PC, by email)
    - If someone you want to talk to is nearby
    - If you spend too much time, with unwilling people, an unwilling place, or with an unwilling job
- Automatically a schedule a meeting time with someone you want to see
- Automatically schedule a discretionary time

Incorporating managers' intentions

These applications can be modifed so that the managers' intentions are reflected in the *influencing messages*. The managers' intentions can be targeted to either individuals or whole the group. Examples of such managers' intention include the following.

- Set managers' hope in group level (ex. group 1 should meet group 2 more often)
- Everyone should have at least 5 minutes per a day to communicate face-to-face with someone new
- Set managers' intentions by task level (ex. Each meeting should be finished within 2 hour)
- Set managers' intentions by work context (ex. Everyone should meet someone who knows certain topic well)

Below are some potential problems that should be investigated through experiment or further academic research:

- In case of a mismatch between managers' and individuals' intentions, can conflict be reconciled or prevented?

- In case managers cannot access an individual's level of information (for privacy concerns) and can set the intention only at a group level, how would the intention be adjusted according to individuals?

Phase 3.

Increasing innovation density

Organizations can try to promote innovations by first identifying the environmental conditions conducive to innovations and then by trying to replicate these conditions.

Sometimes, innovation is created through a combination of existing elements. For instance, in the R&D department, innovation might arise when two people from different expertise talk for the first time, or on a new topic, or based on new information. However, even though individuals recognize the potential interest, its realization might sometimes be hampered. Indeed, individuals may find it difficult to have additional opportunities to meet and discuss together. It might also be difficult for them to know precisely who is related to the dicussion. Yet, if organizations can keep track of these innovative discussions, they can enable individuals to further investigate these potential innovations.

To this end, organizations have to be able to identify these "special encounters" by evaluating them according to whether:

- The discussion was more lively compared to usual ones with a high tone of voice and a high motion
- The talk lasted a very long time..
- The discussion was based on a new topic found on the individuals' PC

In addition, organizations need to recreate these similar conditions and situations in order to maximize the potential of innovation by:

- Initiating a conversation, between a specific or related person
- Recommending a related information source
- Sending a reminder (by IM to Badge/PC, by email)
    - If someone you have to talk is nearby
    - If something special happens among your colleagues, related your work context

Work-context-aware expertise matching

Expertise recommenders are well known applications in knowledge management, allowing individuals to identify experts in a specific topic. The critical issue for such a knowledge management tool is how to create a database of experts that can easily updated. Sensors can be used to update the knowledge database automatically, taking into consideration human relations aspects and work context data.

Practically, databases would:

- Store key information on who knows what and who knows who.
- Take into account and match experts' work context with the inquirer's work context according to location, current work (meeting, face-to-face conversation) and health/mental condition.

3-II. Timeframe

In the near future (1-2 years) the team believes that social network analysis and organizational analysis will be the primary fields in which the social sensors can be successsful. Given the data collected by the social sensors and the large volume of literature supporting social network research, it will likely have a much smoother acceptance by all parties if it is used for this clear purpose. In terms of the cocept of *Sensible Organization*, the social sensors will be best used in the Visualizing the network by both bottom-up and top-down participants. The Organizing and Synthesizing will be conducted using information from the sensors but will mostly be in the hands of people, not an automatic system.

Beside organizational analysis, sensors can also be used in specified tasks. For example, in the marketing section of Appendix I, trade shows and conventions are mentioned as a possible application. The social sensors can allow the conference organizers to analyze who communicate during the trade show, which booths are popular and perform well, as well as identify other metrics that can be used to improve the event.

Of course, the future applications should allow social sensors to extend their usefulness into the Organizing and possibly even Synthesizing areas. In addition, the autonomous aspect of the social sensors will become more important as will be discussed in our conclusion.

4. MARKET ANALYSIS

4-I. Competitive Dynamics

The Social Sensors would obviously be a new device and possibly even a new market play for electronic devices meant primarily to understand an organization's social structure. Since this market is so new, it can be difficult to accurately gauge its size or future rate of growth without an extensive study. However, by placing the market in its proper context one can clearly understand the current market environment which it will operate in.

As a tool, the Social Sensor can be thought of more as a consulting device than an IT device. The market in which it will be sold will more likely be the market for companies looking for innovative solutions to analyze and improve their organizations. In general, the consulting industry engages in such work. This is a huge and diverse market however that market research firm IDC[18] estimates at $48 billion USD worldwide. In particular, however, the Social Sensors seem best suited for the relatively new niche of management consulting where social network analysis is becoming popular.

Major Players

Several major players in the consulting industry have already begun to take social network analysis seriously and are offering services targeted at some aspect of it. The global consulting giant the Boston Consulting Group last November launched a system to track research papers and patents by clients and their clients' competitors to analyze the internal social networks of those firms. In addition, for the past year consulting firms Accenture and Katzenbach Partners, LLC have begun offering their clients analysis of their social networks[19]. The Boston Consulting Group and Accenture are both huge organizations and social network analysis is likely still an extremely small part of their revenues (BCG revenue is unknown but Accenture had $17B USD in revenue in 2005). Katzenbach Partners has emphasized social network analysis more but only has estimated revenues of $6.6M USD[20].

In addition, there are the small consulting firms run by many experts or academics in the field. Stephen Borgatti, Rob Cross, among others all offer consulting services to firms who want to manage and understand their social networks.

Niche Players

Probably the most active space where sensor based technology has been combined with social networks is the conference and meeting management market. Several research groups have created devices to assist with social networks and interaction. Most prominently, two main firms have entered this market with devices that allow participants in meetings and conferences to better connect with each other using sensor technology.

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[18] Worldwide Consulting Services 2005-2009 Forecast: Redefining the Business Model and Setting a New Course (IDC #33445)

[19]McGregor, Jena "The Office Chart That ReallyCounts; Mapping informal relationships at a company is revealing -- and useful", BusinessWeek Feb 27, 2006

[20]Dun & Bradstreet Million Dollar Database

nTag

nTag, founded in 2002, by Rick Borovoy (an ex-MIT Media Lab PhD) and George Eberstadt, is a wireless badge worn by conference attendees that allows them to communicate with each other as well as the conference organizer. The nTag, like uBERBadge, uses an infrared sensor to detect other badges when two people communicate with each other. It also has other functions including:

- Networking features – Using attendee interests to help them meet similar people
- Radar – that allows the user to see the profiles of all people nearby
- Audience participation – Such as polling and disseminating messages
- Exchanging electronic business cards
- Sending electronic text messages
- Advertising by sponsors
- Methods to help calculate ROI in meetings and conferences

nTag does not report revenue, however, the badges rent between $40-$100 USD per tag[21] per day. nTag has claimed to have had about 31,000 users for its devices which given an average revenue of $70 USD per tag would give them revenues to date of $2.1M USD. nTag is still venture capital backed having raised more than $12M USD in venture capital funding since 2002.

SpotMe

SpotMe is a device similar to nTag developed by ShockFish SA based in Switzerland. Shockfish's SpotMe is not a badge but a handheld device used in conferences and meetings for similar functions such as exchanging electronic business cards, meeting people of similar interests, polls, text messaging, and using an RFID "radar" to locate people nearby.

SpotMe also does not report revenues but rents for about €100 EUR per person for a three day conference[22]. Using the number of people having used the SpotMe from each conference that was on their webpage, we estimate their total revenue to date at about $1.1M USD.

Related Research

Many other groups are currently doing research on similar devices which have not yet been developed commercially. The Intellibadge developed at National Center for Supercomputing Applications at the University of Illinois Urbana-Champagne is a device for conferences that works similar to nTag and SpotMe using RFID. In addition at the 2003 International Conference on Ubiquitous Computing, several companies such as Microsoft and Intel presented research papers on using RFID to detect the proximity of people or measure interactions.

[21] Appell, David "Hello, will you be my friend?" New Scientist Nov 15, 2003
[22] "Product - Toolkit Spotme." Conference and Incentive Travel, June 4, 2003

4-II. Ethical Considerations

The use of the Social Sensors to analyze an organization's social networks and behavior can be a powerful tool. Powerful tools, however, always require responsible users and it is absolutely necessary to take privacy and ethical considerations into account before and during and after the use of the Social Sensors in a project. Put simply, though much of the data collected is partially public, the way which users will be tracked and analyzed using the device could be felt by many as deeply invasive. Therefore, here we will conduct a review, though not exhaustive, of several issues connected with the social sensors.

Consent: Management and Personal

An excellent review of the ethical issues in social networking experiments is given by Borgatti and Molina[23]. In the paper, they relate that in normal social science experiments, only one type of consent is needed: that of the individual participants. This is a relatively straightforward process. However, in the social network analysis, you have two layers of consent: one from the management of the organization and one from the individual participants.

The consent of the management obviously is essential to the success of the project. When obtaining consent of the management, the management will likely negotiate a use of or access to all of the data or results of the research. This is the time to clarify any issues over use of the data, anonymity, and how or if the raw data will be shared with the management. Consent from individuals is the consent by all individuals to participate in studies. In the case of companies, these individuals are employees. In normal stand-alone research, individual consent is independent and the decision of each individual. However, in the company setting, there can be pressure, direct or not, to participate in the study. Even if there is not outright refusal to participate there can be subtle altering of behavior in order to obfuscate the true behavior of the participant.

It would make the project much more feasible if there is a near complete buy-in by employees on the project. Management dictates and threats of punishment for those who do not participate on privacy grounds should not be an allowable source of coercion. If employees are reluctant about their personal information being viewed, they can work with Hitachi and the company on a suitable anonymization as shown below.

Anonymity

In many cases it will be desirable or necessary to anonymize participants. Many proxies can be used such as department and demographic data instead of direct names. However, there is a problem that many individuals can still be recognized by demographic or other data. If, however, you wish to use names in analysis, the participants should be fully informed of what information is being collected and exactly how it is being used.

Uses of Data

[23] Borgatti, Stephen and Molina, José-Luis "Toward ethical guidelines for network research in an organization" Social Networks 27, 107-117 (2005).

Obviously, management will want to use the data collected to improve the organization. However, there can be constructive and destructive ways to use the data collected. Use of the data only for simple personnel decisions such as layoffs or restructurings is very risky. Hitachi should work with the management at the beginning of every project to scope out the exact use of the data and allow management to understand both the power and limitations of the data collected.

Also, the management and Hitachi should weigh carefully the costs of keeping personal information of this nature in permanent storage. Some clients may desire the work be erased except for a few reports at the end of the project. It would b best to broach this topic earlier rather than deal with possible later issues.

Privacy

The privacy of the participants should be considered a right and that they are granting Hitachi and the management a privilege to collect and use data about their personal interactions. A respectful and open rather than an authoritative and secret approach will most likely elicit the respect and cooperation from participants in these studies.

Professional Advice

The above constitute general guidelines from the group and do not constitute professional advice. Of course professional researchers should be consulted when designing and implementing any large scale study on human participants.

5. CONCLUSION AND NEXT STEPS

The Social Sensors will provide organizations with a powerful and insightful way to measure organizational behavior and connections. By implementing the Social Sensors in a structured manner following the concept of *Sensible Organization*, an organization will be able to find many ways to make itself more efficient and effective for all of its participants.

Next Steps
The first step Hitachi must make to allow the Social Sensors to be respected sources of data is to build a series of studies that quantitatively demonstrate their accuracy and impact. Hitachi has already taken the first steps to work with organizations in the Boston area such as Boston Hospital, Cisco, and Fidelity. Hitachi should leverage these projects in order to understand the powers and limitations of the Social Sensor devices. It can also use these as an opportunity to realize the comfort levels for individuals' privacy and create ethical guidelines for the use of the devices.

First metrics collected from such studies can include the individual and collective metrics mentioned in the Visualizing and Organizing section of this paper. Hitachi should make sure to use interviews and other methods to verify the accuracy of its data and understand where its methods should be improved. Next, Hitachi can work with the organization and other outside experts to understand how to best advise the organization to improve given the results of the study.

Further Steps
Hitachi should further look into research on how to improve the Social Sensors to answer parts of the *Sensible Organization* currently not accessible. For example, the Autonomous dimension of Visualizing-Organizing-Synthesizing is an intermediate between the Bottom-Up and Top-Down approach. In particular, it imagines a situation where the Social Sensors can provide active feedback into the organization to allow certain improvements in predetermined metrics. For example, if a group of researchers in Hitachi R&D want to form a team and would like the Social Sensors to help their team perform a certain task or maximize a certain behavior, they could specify rules to the system that the system would give them active feedback on. Therefore, groups of people would on their own initiative use the system to help themselves rather than management using rules to force feedback into the organization.

In addition, certain aspects of the Social Sensors such as the accelerometer were not included in this paper since a larger burden of research proof will likely be needed for them to be accepted. Also, it would be interesting if the nature of interactions between people gleamed by tools like the accelerometer would provide a more rich view of the entire network instead of being used to scrutinize the activities of many individuals' interactions.

The social sensors, as a new technology, have a unique and interesting capability to provide a greater insight into organizations than ever before. By allowing organizations to understand how they really work, they can help the organizations become more efficient, tolerable for employees, and focused on company goals. The Social Sensors must be used responsibly, however, taking into full account any concerns of privacy rights and freedoms. We, however, believe that a balance can be met that would allow all parties to benefit from a better work community.

APPENDIX

List of Ideas Investigated

Corporate

I – Observing organization culture for efficient meetings
Room for improvement
The efficiency of inter-department meetings can be greatly improved if the organization structure lends itself to a flexible exchange and flow of information across departments. These informal channels of communication within the firm allow individuals to share information, knowledge and interests, and consequently to boost individual and firm productivity. In the absence of such informal communication channels, how easily and how efficiently does leadership from the management team translate into actions across departments? In addition, does such an absence lead to a lack of trust between departments that could undermine the efficiency of inter-departmental meetings? This could translate into tougher negotiations and lengthy meetings in order for an inter-departmental consensus to be reached.

Solution
By observing individual behaviors prior to and during meetings through social sensors, it is possible to have an indication of the extent to which individuals from different departments communicate and share information. This information could also provide some indication regarding the degree of acceptance/rejection of proposals from other departments, the extent to which consensus is easily reached (top-down strategy vs. bottom-up strategy) and its effect on the decision-making process of the management team.

II– Promoting inter-group communication
Room for improvement
Promoting inter-group and inter-department communication can potentially improve the quality of both social and professional networks within the company, resulting in more trust, more information sharing, higher motivation and more buy-in during meetings. In addition, improved inter-department communication is likely to reduce harmful inter-department competition that can arise because of conflicting interests, misalignment of incentives or simply because the culture is such that each department maintains and retains its own information. This kind of competition is certainly not conducive to overall maximization of firm performance and may lead to a loss of critical information.

Solution
By creating inter-departmental social events, one can observe through the use of social sensors the degree of interaction among departments, the formation of "clusters", and the sharing of knowledge and information. The aim is to provide individuals within a company with a flexible structure that induces trust, collaboration and sharing of information/expertise.

III – Solving miscommunication between headquarter and regional branches
Room for improvement
Many multi-national companies often struggle with aligning regional branches with the goals and strategies of the corporate headquarters. On the other hand, many regional branches often feel a lack of information and support from the main branch. This miscommunication can result in conflicts of interest, poor incentive mechanisms, lack of trust and information retention, and asymmetry of information.

Solution
The social sensors can be used to observe how leadership structures and patterns differ between the central and regional offices. In addition, sensor can serve to analyze the flow of information and allow the company to better understand how its remote operations are structured and how they communicate with the central headquarters.

IV-Recognizing large-scale collective behavior
Room for Improvement
Oftentimes corporations have winning or losing operations the cause of which is often not completely known. With large numbers of people performing many tasks subject to many variables, it can be difficult to cheaply or easily and in a cost-effective way identify trends and large-scale behavior that may be helping or hurting the corporation. Oftentimes, the large-scale behavior is based on tacit information and informal processes that are difficult to detect.

Many of the current advances in social network theory indicate that social and economic networks behave as complex systems which can often develop a spontaneous self-organization at large scales that only require simple activities or reactions by their participants.

Solution
Use a large-scale sensor network rollout, we can investigate the connections and behaviors among many members of the organization in aggregate. Such a scheme would not require tagging individuals or identifying individual patterns but rather would search the aggregated data for self-organized patterns and properties that may hugely impact operations within the firm.

Sales

I – Promoting sales force's productivity
Room for Improvement
Hiring a sales force is one of the most important decisions a firm makes. A firm's sales force is the main and most impactful face of the company with its customers and clients. However, for such an important task and position, it is often difficult to measure sales force productivity and quality. In addition, salespersons often do not know how to take steps to improve their own performance and why their strategies are not resulting in increased sales and better results. Because salespersons often work in remote areas, complete tracking of their efforts is both costly and time consuming.

Solution
Use social sensors to observe salesperson behaviors in key situations to help improve performances. Sensors, however, will not be used to measure or to punish salespeople for their behavior. Using a cooperative approach, buttressed by feedback from the salesperson, would allow both to identify key winning behaviors for reinforcement and other behaviors to be improved on.

Research and development

I – Incorporating customer needs with R&D

Room for improvement

Goal of a research can be more aligned to customers' needs by improving external communication. When making a decision on the research or development target, R&D managers sometimes don't know customers' expectations or recent interaction between sales and customers. Reports from sales does not convey "nuance" in customers' request, so R&D has to guess customers' priority or sense of urgency.

Solution

Observing interaction between sales and customers can enable R&D to understand their needs better. By identifying who in the sales team is the key in conversation/negotiation with the customer, R&D can collect down-to-the-earth information talking with the key person in the sales team. For example, voice analysis (tone of voice, voice recognition) using sensors can help R&D better understand context of customer's requirement.

Daily socialization between R&D and sales/marketing can also improve internal communication beyond sales reports, teaching R&D customers' potential concerns and enabling sales understand potential technical difficulties. "Serendipity[24]" application – supporting unofficial networking by suggesting to talk with each other when 2 persons with similar problems/interests come across – can accommodate such internal socialization, giving foundations to dramatically improve external communication with customers.

II – Boosting team performance

Room for improvement

A team's performance can be kept constantly high by avoiding natural stagnation of team dynamics over time. 5 key roles are critical for successful innovation process – idea generator, entrepreneur/champion, project leader, gatekeeper and sponsor/coach[25]. Staffing should be reconsidered when any of these key roles are missing. A team can also become complacent and less willing to look for outside knowledge, a phenomenon often referred to as Not Invented Here (NIH) Syndrome.[26]

Solution

Observing team dynamics can detect lack of leadership and identify missing critical roles. Analyzing communication among team members can identify reasons for such decline in team dynamics – maybe too much stress, mismatch in opinions among members, etc. Based on the observation of team activities (e.g. physical interaction, bio-metric and voice analysis during team meeting), manager may want to consider giving feedback, facilitating discussions involving different members, modifying the development target, or even re-assigning members.

III – Context aware expertise search

Room for improvement

Breakthroughs can be accelerated if researchers can find a right person to ask for expertise and advice at a right timing. Due to large size of research organizations, it is often hard to locate

[24] Nathan Eagle, *Can Serendipity Be Planned?* MIT Sloan Management Review, 2004

[25] , Edward B. Roberts, "*Staffing the Innovative Technology-Based Organization"* MIT Sloan Management Review, 1981

[26] Tushman & Moore, "*Investigating the Not Invented Here (NIH) Syndrome"*, Readings in the Management of Innovation, 1988

internal experts. Existing knowledge management does not work - obsolete document repository, inadequately classified expertise database, etc.[27]

Solution
Companies can construct a database using not only static data (expertise description, past papers, etc) but also dynamic "context" data (peers often interacting with, frequent topics, recent visit to customers/factories, attendance to meetings, etc). When searching for experts from such a database, a user can use not only searches, but also searcher's context data as a search key – when, why and in which specific context help is needed.
The system can also "sense" the needs for expertise, from a user's context, and proactively suggest "Talk to Him" on screensaver or wallpaper, even if the user does not search for experts proactively.

IV – Connecting "inventions" with product launch
Room for improvement
How can we effectively take inventions to successful product launch?
An R&D manager has an invention that he believes to be important to the organization. However, even though he knows the high level people he should contact, he is unaware of other key managers (i.e. business unit managers, marketing managers and sales managers) in the organization who may be interested in collaborate or help moving the invention through the product launch pipeline. He inputs certain keywords or interests into the sensor-network system. The system then lets him know if someone interested in collaboration or championing his idea in the general vicinity.

Solution
Often times invention is measured according to "cycle time" which is the time from proposal to implementation. If an inventor has an idea, he/she can set certain parameters so his sensor device "broadcasts" when he is in the vicinity of someone else who may be helpful for collaborating or implementing his/her invention through product launch. Often times they may know who these persons are but the sensor network can help them link with other inventors or implementers who they had no prior knowledge about.

Customer service

I- Generating quality of service metrics
Room for improvement
There is a critical gap in generating real time, quantifiable QoS metrics. For instance, today the only way to determine customer satisfaction is through satisfaction surveys administered after a support call. There is little data to support whether there is a self selection bias in the data that a company receives on how the quality of its customer support; do we know what percentage of the customers who take a follow-up support survey are taking the survey because they are dissatisfied or satisfied? There is also no way to generate a benchmark quality of support that different customer's experiences can be objectively compared against. Potential application areas include, but are not limited to: Retail - Cashiers, help desks and Customer Support Centers.

Solution

[27] Michael Idiopulos, "*Do you know who your experts are?"*, McKinsey Quarterly, 2003

An ideal solution will "observe" customer service interactions and provide real time data on the quality of service being provided. The data could be further consolidated and published as metrics against which performance is measured.

Marketing

I- Improve effectiveness of trade show presence

Rooms for improvement

Companies will spend almost $10 billion in 2006 in representing their products at large conferences.[28] Business cards are exchanged, verbal clues are dropped expressing interest, but there is no reliable methodology in place to predict the success or failure of setting up a booth, no effective way to know which visitors are interested in the product, nor ways to get clues of how to improve displays for better results.

Solution

Our solution could provide a measurable way to predict the success or failure of attending a conference by deriving intelligence through customer interactions. Sensor-network could be placed within the booth environment and conversations between interested parties could be evaluated on qualitative parameters and we can attempt to gauge the real enthusiasm about the product being advertised. By getting bio-metric clues of visitor reaction, company can 1) predict the products' success or failure in early stage and give feedback to R&D team, 2) identify the visitors' interest level and effectively prioritize and communicate with potential customers, 3) get real-time feedback of visitor feedback for each display/product and quickly improve displays.

II- Use customer biometric feedback to successful product launch

Room for improvement

Despite enormous amounts of time and money dedicated to customer surveys and marketing, approximately 80% of all new products fail within six months or fall significantly short of their profit forecast[29].

A focus group is one of the most common way to measure consumers' reactions to the products. However there are some questions about its effectiveness because 1) consumers behave differently in focus group than in shopping mall, 2) Participant does not always express every feeling they have and 3) Some participant maliciously lie.

This costs company millions of dollars for directing development towards wrong direction that leads to market failure, plus the cost of focus group more than $15,000 in average (for 10 people group).

Solution

Observe focus group using wireless sensor-network devices. Observe the groups' biometric reaction, eve ball movement, motion and voice pitch will give companies the way to understand participants' reaction more deeply includes even unconscious reactions. Also, analysis of social setting of participants gives company a new view in designing consumer touch point (i.e. trade shows, shop front). Using a Sensor-network, company can observe how the customer group

[28] Marketing News, Feb. 15, 2006

[29] Gerald Zaltman *"How Customers Think: Essential Insights into the Mind of the Market"* February 2003

configuration (ie.friends or family, group of early adaptors or combination of innovators, late majorities and laggards[30]) affects purchasing decision. This approach is effective not only for product impression, but also for promotion effectiveness.

Human Resources

I – Team allocations based on preference indicators

Room for improvement

Efficient utilization of human resources often depends on the personal likes/dislikes. While people can express their rational preferences for working in particular team/project, it is very difficult to extract subjective ***real*** interest from employees. Yet, according to McKinsey research "global executives say that talent management is one of their foremost concerns"[31]. How can we improve the resource allocation to encompass the subjective factors?

Solution

Our device will be able to capture employee's actual interest towards particular department, project or team. This information, together, with individual's expressed formal interest will improve team formation process.

Device can be used in the beginning of employee's engagement in the firm (introducing new consultants) or in the process of team formation within the existing set of employees (forming R&D projects). New hire, for example, can be given an opportunity to mingle with various departments in the beginning of his/her career. The device, worn by such hire, will then measure a genuine interest of an employee, captured by accelerometers and proximity scanners based on interaction patterns, current role in the team, time spent face-to-face, individual styles. In this case, device can be used for periods of time. Thus, we can collect the subjective information and use it to enhance our understanding of the hire's real preference and ability to work in a particular team.

[30] Geoffrey A. Moore *"Crossing the Chasm"* July 1999
[31] The McKinsey Quarterly, March 14, 2006

Academic Referrence

Social Sensors and related academic work

Unofficial networks has drawn more and more attention in the academic and business press. For example, sociologists publish significantly more work today on social networks than ever before:

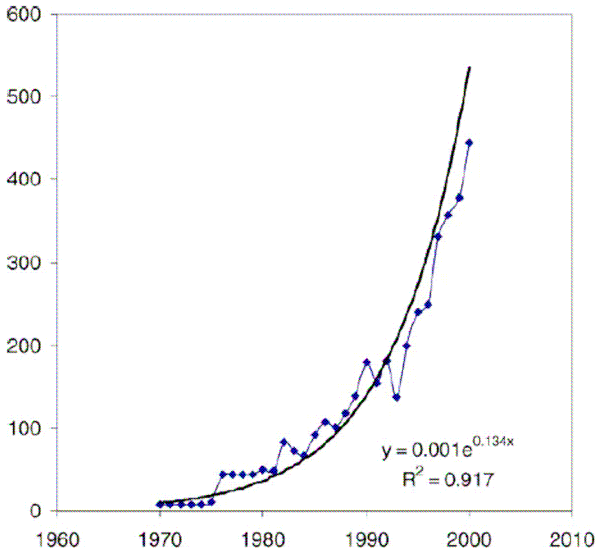


Figure 1. Exponential growth of publications indexed by Sociological Abstracts containing "social network" in the abstract or title.

Unofficial networks range from organizations themselves to the cross-company levels. On the level of organizations, last twenty years were marked with a rise in implementation of various management tools such as manufacturing resources planning (MRPII), just-in-time (JIT), total quality control (TQC) or computer-integrated manufacturing (CIM).(32) Most of these techniques are aimed at improving the teamwork at workplace. As a result, more companies now appreciate the importance of teams and spend considerable time/effort to fine-tune their organizational practices.

However, team collaboration has already crossed the organizational level. For example, according to McKinsey, there are certain networking patterns which "reveal intriguingly promising "networks of creation" (or "creation nets"), where hundreds and even thousands of participants from diverse institutional settings collaborate to create new knowledge, to learn from one another, and to appropriate and build on one another's work - all under the guidance of a network organizer." The idea of such large commercial networks is similar to the open-source community collaboration such as Linux. This type of collaboration (between vendors, suppliers, contractors, researchers, consumers) can play a crucial role in the new stage of creativity and innovation.

[32] Neslon, Mel and Nelson, Susan "Building the dream team: Don't make it a nightmare", Hospital Materiel Management Quarerly. 19, 2 p.4 (Nov 1997)

Hence, the importance of networks is well-established. Our purpose here is to highlight three themes which run through the research on networks and indicate the potential applicability of social sensors to them.

Lateral capability

Social networks arise almost naturally. Yet, according to organizational design experts, these networks can be promoted. In the 1970s, Jay Galbraith coined a term "lateral relations" to reflect the unofficial, hidden layer of any organization. According to Galbraith, organizations are usually good with constructing the rigid structures (rules, programs, hierarchies) in the environment where there is a task certainty. However, as the task uncertainty factor increases, the information must be processed during the task performance and, therefore, demands greater flexibility. "The greater the task uncertainty, the greater the amount of information that must be processed among decision makers during task execution in order to achieve a given level of performance."[33] Creation of such lateral processes may be one of the organizational design strategies employed by executives to promote flexibility. Among particular processes which promote an organization's ability to deal with uncertainty are direct contact (two unit may perform better if have chance of direct exposure to each other), liaison roles (some people may play slightly more official role of connecting the units together), teams (temporary teams, formed between units for the achievement of common goal), integrating roles, etc.

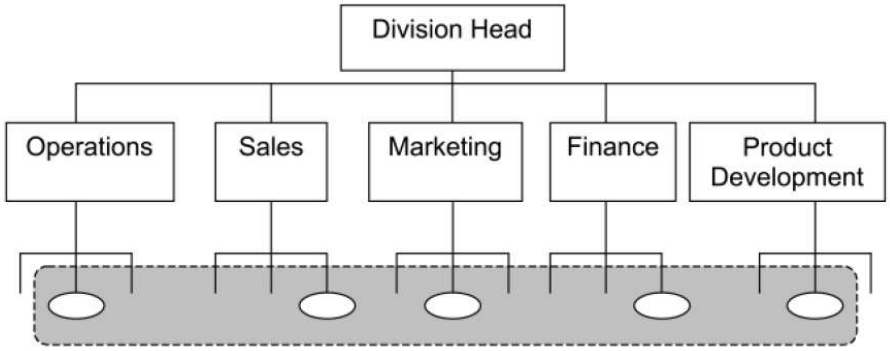


Exhibit 1. Cross-functional Lateral Team

Unfortunately, according to the researchers, organizations can also diminish their own "integrating" abilities. Here are several of examples how:

- People don't know who has knowledge or experience outside of their own department that they might be able to draw upon.
- People have never met their counterparts in other areas of the organization in order to establish relationships with them
- Policies inhibit the internal mobility that would give employees opportunities to work in other areas of the company and broaden their perspective.
- Processes cause conflict because no one is sure who has the authority to make a decision,
- Team members lack group process skills, causing more time to be spent on navigating the group dynamics than creating results
- Matrix relationships are created, but the "two bosses" have neither the common ground nor the skills to negotiate collaborative solutions".[34]

[32]Design: an Information Processing View, by Jay R. Galbraith, Interfaces, May 1974
[33]Downey and Amy Kates; .Journal of Organizational Excellence, Spring, 2002.

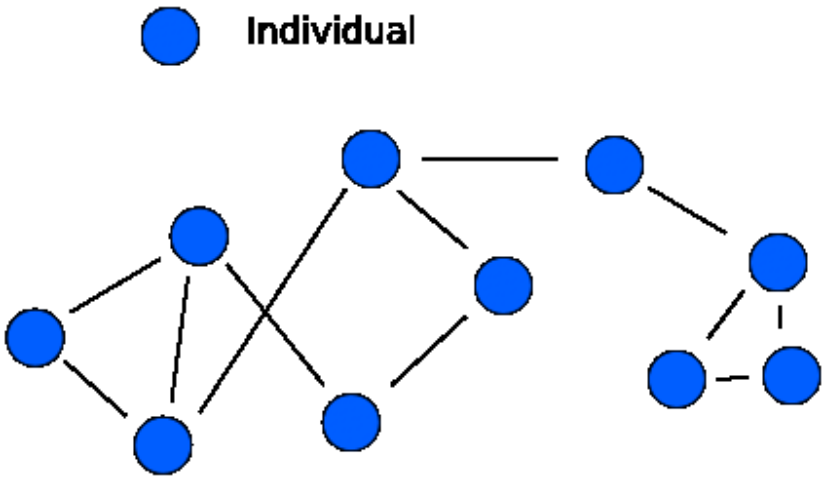
Hence, the “know-who” becomes even more important quality than “know-how”. To improve the “know-who”, Jay Galbraith and Co suggest six organizational practices:

- Co-location (including interaction hubs within co-located space)
- Communities of Practices (promoting social networks within organization)
- Annual Meetings and Retreats
- Training Programs
- Rotational Assignments
- Technology and E-coordination (instant messaging, group discussions, joint calendars, workflow management systems, CRM systems, etc)

Lateral capabilities are elements of the organizational design. As such they can be planned in advance, created and maintain. One subset of such lateral capabilities is actual social networks.

Social networking

Social network is a term coined by J. A. Barnes (in: Class and Committees in a Norwegian Island Parish, "Human Relations"). Essentially, according to social network theory, people can be seen as a collection of nodes and ties. Individuals (nodes) are tied to each other through various social relationships (professional, friendship, blood, etc). Hence, the relationship are the ties. Usually the social network is limited to 120-150 individuals. However, in today’s world, the meaning of social network is taken far beyond this number of people.

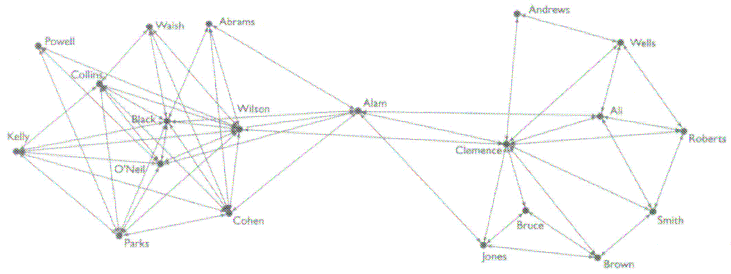


The workplace is a perfect place to look for various social networks. According to one study, for example, group performed much better when certain social network interventions were made. According to the authors, “informal networks cutting across core work processes or holding together new product development initiatives are not found on formal organizational charts. However, these networks often promote organizational flexibility, innovation, and efficiency as well as quality of products or services by virtue of effectively pooling unique expertise.”

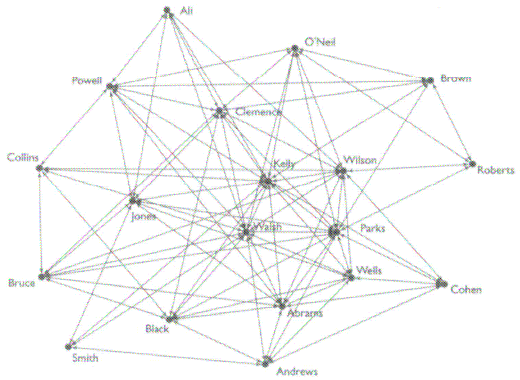
Exhibit 2

EXHIBIT 1. Information Sharing within an Expert Consulting Group*

Pre-Intervention



Post-Intervention (Nine Months Later)



Similarly to the lateral capabilities, social networks can also be supported. Indeed, the social network analysis (SNA) technique, employed by the authors, helped them to establish the barriers to communications and mend the situation. "SNA provides insight into collaborative behavior within and across boundaries that can yield a similar purchase on performance improvement opportunities as process mapping did for reengineering in the early 1990s. Reengineering generally focused on "hand-offs," decision points, and the "white space" in organizational charts to improve efficiency of work processes. Today, concern has shifted to innovation that often requires critical collaboration within and between functional units, divisions, and even entire organizations. Network analysis provides us with the means to understand where collaboration is and is not occurring."[35]

Team formation

The final element which affects the unofficial networking is actually formal teams. Teams have been popular for a couple of decades now and their formation is still a prerogative of the management. However, more often than not, individuals do not like the teams or particular individuals. To build an effective team, researchers agree that the following elements are required: common goal, ability to leverage the lack of resources, clearly stated team members

[35] Making Invisible WorkVisable: Using Social Netowrk analysis to Support Strategic Collaboration, Rob Cross, Stephen Borgatti, Andrew Parker

responsibilities and conflict resolution mechanism.[36], competent members, standards of excellence, external support and recognition, etc.[37] Others point to the understanding of the team roles and importance of equal representation of all roles within the team. Regardless of the academic underpinnings, most practitioners agree that productive team is a result of appropriate management practices: such as challenge & involvement, freedom, trust & openness, idea time, playfulness and humor, low level of conflict, idea support, debate and risk-taking behavior. All of these elements could be (and should be) created by the management in order to form successful teams.

One interesting element which is not often analyzed in the team management literature is time dimension. In the temporal teams, one of the most important elements which leads to success is trust. Contrary to some data, trust does not depend on the inter-personal relationship. "Meyerson et al., 1996 developed the concept of "swift" trust for temporary teams whose existence, like those of virtual teams, is formed around a common task with a finite life span. Such teams consist of members with diverse skills, limited history of working together, and with little prospect of working together again in the future. The tight deadlines under which these teams work leave little time for relationship building. Trust in such teams is maintained by a "highly active, proactive, enthusiastic, generative style of action" (Meyerson et al., 1996). High levels of action have also been shown to be associated with high performing teams (Iacono and Weisband, 1997)."[38] Time, therefore, is an important element which can improve the team performance. However, limited time can be a positive factor only for teams in which members share many professional and individual characteristics. Homogeneity can save teams time.

[36] Building the Dream Team: Don't Make it A Nightmare

[37] The Climate for Creativity an dChange in Teams, Scott Isaksen, Kenneth Lauer

[38] Exploring team formation processes in virtual partnerships
Violina Ratcheva, *Shailendra Vyakarnam*. Integrated Manufacturing Systems. Bradford: 2001.Vol.12, Iss. 6/7; pg. 512, 12 pgs.

TEAM STRUCTURE

Advisor

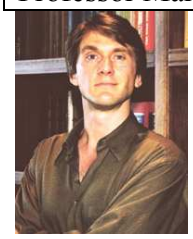
Professor Alex "Sandy" Pentland

Dr. Alex "Sandy" Pentland heads the MIT Media Lab's Human Design research group and is the founding director of Media Lab Asia. His work encompasses areas such as wearable computing, human-machine interfaces, computer graphics, artificial intelligence, and machine and human vision.

Professor Mark Mortensen

Mark Mortensen is an Assistant Professor in the MIT-Sloan School of Management's Behavioral Policy Science area. Mark Mortensen studies group dynamics in geographically distributed teams and the effects of technology on interpersonal interaction.His research interests cover the changing nature of work in an environment of increasing globalization and reliance upon technology.

Professor Marshall W. Van Alstyne



Marshall W. Van Alstyne is an associate Professor of Management Visiting Associate Professor, MIT Sloan School. In industry, he worked at Martin Marietta and at Lincoln Laboratory. His research focuses on the economics of information, its value, production, property rights, and effects on firms and social systems. He received his bachelor's in computer science from Yale, and MS and Ph.D degrees in Information Technology from MIT.

Team Member (Hitachi)

Koji Ara

Koji Ara is a researcher at the Advanced Research Laboratory, Hitachi, Ltd., and is currently a visiting scientist at MIT Media Laboratory.
His academic interests include human dynamics analysis, sensor-network systems, and design methodologies for large scale LSIs.
He holds degrees of B.Sc. and M.Sc. both in electrical engineering from Waseda University, Tokyo, Japan.

Team Members (MIT Sloan School)

Naoto Kanehira

Naoto Kanehira is a MBA/MPA student at MIT Sloan School and Harvard Kennedy School, and is a US Fulbright Scholar. His academic interests include corporate entrepreneurship, innovation management and science/technology policy. He has five years consulting experience at McKinsey & Company mainly with high-tech, telecom and automotive clients. He studied computer science at Keio University, Tokyo, Japan.

Elisabeth Megally

Elisabeth Megally is a second-year MBA student at MIT Sloan and holds a BA and an MA in economics. She is the co-founder and co-president of the Emerging Markets Club, the co-president of the Sloan Leadership Club as well as the vice-president of the Sloan Entrepreneurs for International Development. She is actively involved in projects in microfinance and technology.

Yulia Poltorak

Yulia Poltorak is currently an MBA student at Sloan School of Management. She has 6 years of strategy consulting experience with PricewaterhouseCoopers and IBM Business Consulting Services. Yulia spent 2 years in TV station group in Russia in position of VP of business development. Yulia holds BA in economics from Russian Economics Academy and Ph.D. in sociology from University of Pennsylvania.

Gagan Singh

Gagan Singh is currently a dual degree MBA/Master in Public Administration at MIT Sloan School of Management and John F. Kennedy School of Government at Harvard University. His academic interests include hi-tech strategy. Prior to graduate school Gagan worked for Mercury Interactive as a consultant and sales engineer. He holds a Bachelor of Science degree from University of California at Berkeley.

Reginald Smith

Reginald Smith is currently an MBA student in the MIT Sloan School of Management class of 2007. His academic interests include technology and product development strategy. Prior to attending MIT Sloan, Reggie worked at Bain & Company Inc. as a strategy consultant. He holds degrees of Bachelor of Science in Commerce and Bachelors of Arts in Physics from the University of Virginia

Dave Suzuki

Dave Suzuki is currently and MBA student at the MIT Sloan School of Management class of 2007. His academic interests include innovation management and high-tech strategy. Daisuke's professional experience includes product planning, product management and marketing at Sony Corporation. He holds degree of Bacholor of Art in Commerce from the Waseda University in Tokyo, Japan.