Organization Diagnosis Tools Based on Social Network Analysis

Takanori Ugai and Kouji Aoyama

Fujitsu Laboratories Limited
4-1-1 Kamikodanaka Nakaharaku Kawasaki Kanagawa 211-8588, Japan
ugai@jp.fujitsu.com, aoyama.kouji@jp.fujitsu.com

Abstract. Many organizations have challenges such as inter-organizational barriers and motivation of employees. However, these kinds of problems are not easy to visualize, and it is even more difficult to derive, implement and assess appropriate measures to deal with them. We developed a tool to visualize the dynamic structure of cooperative relationships between employees in organizations based on questionnaires given to employees of those organizations. This tool is used for visualizing barriers between teams and the effects of measures. In this paper we explain some features of this tool and verify its capabilities and effectiveness with a case study. The case study is some field research based on interviews that we conducted in which we applied measures to improve the employees' communication. We collected a set of data about relationships in an organization with questionnaires before and after implementing the measures. And we compared the observed result produced by the visualization tool with the result from the field research.

1 Introduction

It is very important to have a company that is growing and whose entire workforce is activated. To have such a company, one of most important disciplines is to collect a lot of useful information and effectively use the knowledge of individuals within that organization [1]. We have proposed a mathematical model for transferring knowledge with the purpose of making a KM mechanism or system take root in an organization and obtaining guidelines to make that system functional [2]. We have applied this model to some cases and produced guidelines for appropriate systems to manage knowledge [3].

We have found that many organizations have communication problems such as inter-organizational barriers. Mistakes occurred because of a lack of communication. The efficiency of work does not improve because information and knowledge do not spread in the organization owing to this lack of communication.

However, this kind of problem is not easy to visualize, and it is even more difficult to derive, implement and assess appropriate measures for it.

In many cases, people in the organization realize there is a lack of communication after an accident has occurred, but it is often too late to take measures. Generally, measures to eliminate a lack of communication cannot be expected to produce short-term

results. Because organizations change and improve gradually, using indicators such as the decreased number of mistakes or ROI is inappropriate.

We developed a tool to visualize the dynamic structure of cooperative relationships between employees of an organization based on questionnaires given to employees. This tool visualizes not only the organization's static structure but also its dynamic structure. It can clearly visualize barriers in an organization and the effect of measures which the organization has taken.

In this paper, we propose tools which show a layout of employees as nodes and the cooperative relationships between them as edges and a layout of employees' position among organizational vision. Vision gap visualizing tools show relationships between organization's vision and personals'. Relationship tool visualizes the static structure of cooperative relationships and the dynamic structure of relationships as a sequence of static structures and shows any difference between those static structures. We also describe how these tools work with a case study. The case study is based on our field research on an organization that develops software. We compare the field research with findings from the tools' visualization based on a questionnaire given to the employees.

There are such visualization and analysis methods and tools in existence today [4,5,6]. However, they are general analysis tools, and it is difficult to understand problems which happen in the field from the diagrams which those tools draw. The users have to analyze and interpret the meaning of the diagrams and numbers by making investigations in the field. Our tools target the managers of an organization. It should show what kinds of communication problems their organization has in an intuitive way.

In chapter 2, we describe the functions of the visualization tool of employees' relationship. In chapter 3, we describe how the gap-visualizing-tool layouts employees and their personal vision among organizational vision. Chapter 5 describes a case study to show the tool works in practical manner.

2   Visualizing the Cooperative Relationship

This tool graphically represents answers to a questionnaire given by employees of an organization regarding their cooperative relationships. We developed the questionnaire by combining an Interpersonal Solidarity Scale [7] and Bales' Interaction Process Analysis [8], and simplified it as much as possible. The questionnaire asks the employees to classify the other employees into any of the following five categories.

1. I don't know him or her.
2. I know his or her by sight.
3. I know his or her work and responsibilities.
4. I have talked about business with him or her.
5. I have worked with him or her.

The tool produces a matrix between employees which expresses their relationships. **Static Structure:** The tool renders employee's names as nodes and shows the cooperative relationships between employees as edges using a spring layout algorithm [9]. The spring strength is proportional to the value of the cooperative relationship. The

edge is Omni directional and the strength of an edge between the nodes is the average value of the relationships. A diagram shows that the cooperative employees are collocated and unknown employees are located far from each other. This tool can decorate nodes and edges in the following ways.

− The thickness of the edges can be proportional to the length. Users can easily see which relationships are strong in the diagram.
− Details of members of the group including their names and affiliation to the group are shown by color in each node.
− The nodes can be cauterized based on edge betweenness[10] and the nodes in a cluster are painted with a color. Users can identify isolated members.

Dynamic Structure: The tool computes differences within the organization and draws a comparison using two matrixes.

− It is possible to place two diagrams of cooperative relationships side by side, or switch over two drawings with a click.
− For each diagram, branches that show differences between cooperative relation-ships can be shown in red if their value is larger than the other branches or in blue
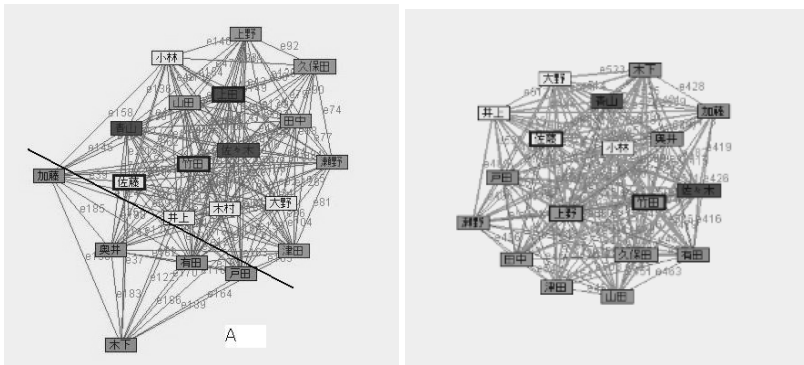

Fig. 1. Pre-poll cooperative relation and Post poll cooperative relation
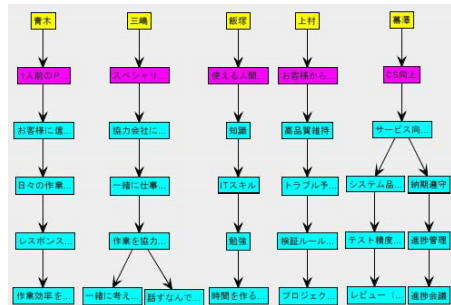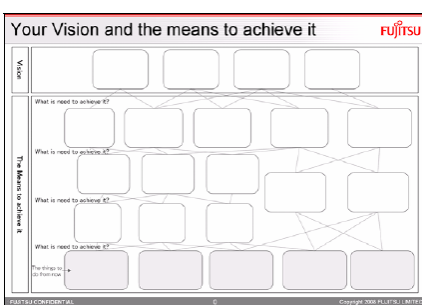

Fig. 2. Vision-Mean Analysis Worksheet and Examples

- if their value is smaller than the other branches.
- A diagram showing only the difference between cooperative relationships can be displayed.

If nodes are divided between each group as shown in figure 1, it is expected that the distance between groups is large and there are no cooperative relationships between those groups. On the other hand, if employees of each group are uniformly spread as shown in figure 2, it is expected that there are cooperative relationships between the groups.

3   Visualizing the Gap between Organizational Policy and Personal Vision

We use a work-sheet form, as shown in Fig. 3, to have the members fill in their personal visions and the means to achieve them. The work-sheet is derived from a motivation theory described in the section 4.3.1.

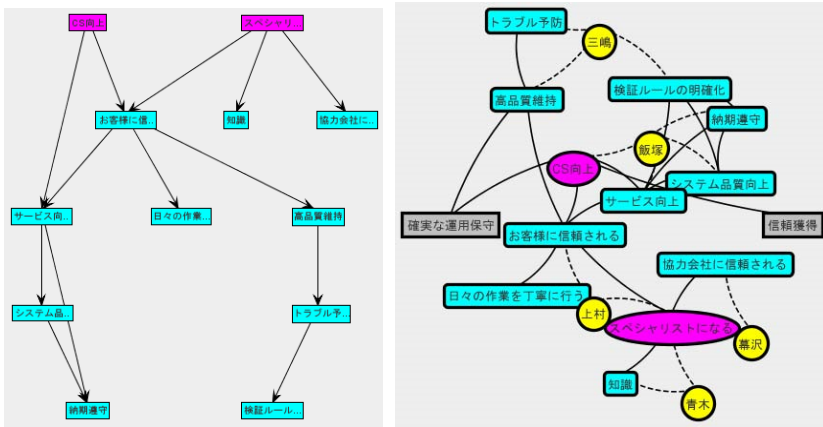In the right-hand figure in Fig.4 is made by unifying the same or similar description as a single box.

Fig. 3. Eliminated Tree Graph and Anchored Map of Vision-Mean Analysis

The left-hand figure in Fig.3 is drawn by Anchor Map [13]. Anchor Map has two kinds of node: "anchors" and "free nodes." The anchors are arranged on the circumference at equal intervals and in the figure two squire boxes are anchors. The free nodes are arranged at suitable positions in relation to the adjacent anchor nodes using a spring layout algorithm [9]. The edge is directional and the default length of an edge is the half length between two boxes. In the left-hand figure of Fig.3 all node but the two organizational policies which are squire boxes are free nodes. The five small circles stand persons and the locations stand for the position among the organizational vision. The figure says that all five members are located almost middle of two visions but none of them are connected to the visions.

4   A Case Study by Field Research and Questionnaires

4.1   Research Field and Research Methods

The organization we surveyed implements software development projects based on various pieces of package software. It has about 200 employees in 7 groups, and we studied 4 of those groups. Of the employees, 23 people from 4 groups were interested in our research and we decided to do this research with them. The four groups deal with different work packages for their customers. Two or three people from one group worked together on a system development project, though usually they don't work together on projects and they don't talk or chat with employees of a different group in general.

We conducted two-hour interviews with 5 people from the 23. And we analyzed them, derived measures to improve their communication, and helped them to implement those measures. We have continued to observe them. Independently from the interviews and observations, we gave questionnaires to all 23 employees and got answers from 21.We decided to use those 21 employees and their answers for our analysis and to make diagrams.

4.2   Cooperative Relations

Cooperative Relations Based on Prior Surveys. Figure 1 shows result of the questionnaire was taken in prior surveys. Three teams B, C and D have a relatively uniform spread, but team-A is located too far from the other three teams. We found a barrier between the team-A and the others. The average value was 2.7, and the average value with different team employees was 2.3. This means they know other team employees by sight but don't know what other team employees are doing in their work.

We found that the organization doesn't place much value on knowledge exchange and employees don't get much profit from providing knowledge. A lot of background knowledge is required to share knowledge of their work. And they don't know each other by sight. So we can say the barrier between employees is very large. We can suppose that there is insufficient communication for knowledge transfer and knowledge sharing.

Casual Information Exchange Meeting. From the aforementioned situations, we suggested that the employees should have meetings for casual information exchange to develop relationships between employees in which they can help each other. In order to reduce barriers we tried the following variety of strategies to implement.

- **System:** Following the instructions of managers, employees participate as part of the work. By positioning this work as work done during work hours, it becomes authorized work and the employees are not working as volunteers, and we thought this would reduce barriers in the system.
- **Trust:** the purpose of this meeting is anxiety awareness where employees create relationships in which they can consult with each other, and we combined this meeting with self-introductions and icebreakers to build a relationship of trust.
- **Sense of camaraderie:** We selected topics for the meeting very carefully, such as facilitation and reflection. These topics related to all employees because the topics

are not related to their work and are what all employees require in general. All employees can empathize with each other and feel a sense of camaraderie. We took what was bothering them as the theme, and had them share their problems and also share a sense of camaraderie.

The information exchange meeting was held once a month for seven months. Figure 2 was made using the results of the questionnaire which we collected after this period. And also we got the following feedback from the employees.

− There were relationships in which people can consult with each other.
− It was good to know that employees in other groups had the same problems a slight angle and to the right of you.
− We want to continue with implementation but we cannot do that yet by ourselves.

Validation of Findings from the Visualized Cooperative Relationships. In the interviews, some employees said they know other employees only by sight. In figure 1, there is a gap between the upper right group and lower left group. This gap is backed by results from the interview. Also, the edges in Fig. 4 have values of more than 3.0. The gaps between the groups are shown in the diagram. The value of 3.0 means that they know what they are doing as their work. The diagram shows that they don't know about the other groups' work. The findings from this diagram are consistent with the fact that the employees said they required lots of background information to understand each other.
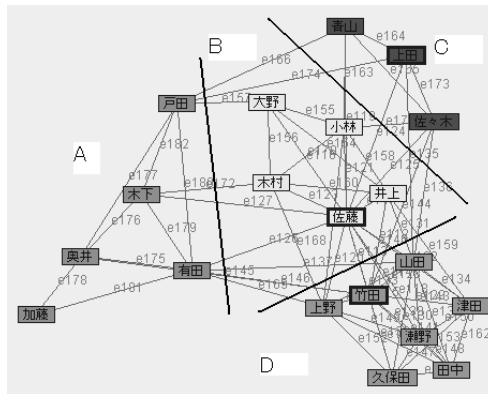

Fig. 4. The edges have values of more then 3.0

The number of samples was 21 and the average points rose from 2.7 (they knew each other by sight) to 3.1 (they know what each other are doing in terms of work). In the t-test, the value of p was $0.000012 < 0.0001(0.01\%)$, which means the rise of the average value was statistically significant.

Each employee increased the value of his or her relationship with 6.8 employees on average. This means each employee built a deeper relationship with about 7 employees compared with before. The size of the circumcircle of employees in figure 2 is 17% smaller than the size of that in figure 1. This also backed the feedback from employees in section 4.4.

The purpose of the meeting was to develop relationships in which employees could consult with each other and we believe that purpose was achieved. This was also backed by the feedback from employees mentioned.

4.3   Gap between Organizational Policy and Personal vision

Theory of Motivation. In this section, we describe the method to increase members' intrinsic motivation. We discovered a theory of motivating members for knowledge sharing and built it up as a method.

In the interviews, we asked members about their own visions and the means to achieve them. Then, we discovered the means to achieve their own visions were in close agreement with the knowledge sharing of organizational policies. The purposes of knowledge sharing were improvement of profit and loss or improvement of efficiency. The members recognized these purposes as the organization's issues. On the other hand, the personal visions of the members were concerned with working more easily or developing a relationship built on trust with customers. When they analyzed their own visions, the means to achieve their visions were reusing someone else's documents or standardizing development processes. These means were organizational policies themselves. We discovered that when members analyzed the means to achieve their personal visions, they discover that means are connected to their organizational policies. We considered this theory was useful to promote the members' motivation for knowledge sharing. And we built it up as a method to increase intrinsic motivation. We called it Vision-Mean Analysis.

Experiment. We did an experiment to verify the Vision-Mean Analysis and whether it motivates the members' for knowledge sharing. We applied the method to fifteen system engineers of two different organizations and showed them the diagrams like Fig. 4.

As a result, it was affirmed by all fifteen members that the means to achieve their own visions were connected to the organizational policies. For example, one member held up increasing customer satisfaction as his own vision. And that member thought that providing a high-quality system was a means to achieving his vision. Furthermore, the member thought that knowledge sharing and explicating his own tacit knowledge was a means to achieving his vision. So, these means were the organizational policies in themselves. And we interviewed the members of one organization after the experiment, and got the following positive comments.

- "I couldn't usually understand the intention of the organizational policy; however I can understand the relationship between my own work and the policy."
- "I usually make some documents for customers by myself. I will try to re-use other people's knowledge from now on."
- "I think it is important to motivate the members for knowledge sharing. So we should have an opportunity to consider knowledge sharing like this."
- "I found the means to achieve my own goal were connected to the means to achieving the organization's policy. So I can recognize that the organization's policy is my own problem."
- This result shows that the Vision-Mean Analysis and the diagrams could motivate the members for knowledge sharing.

5   Summary

In this paper, we described a tool which gives a layout of employees as nodes and shows the cooperative relationships between them as edges. It visualizes the static structure of cooperative relationships and the dynamic structure of relationships as a sequence of static structures and the difference of static structures. We also described how the tool works in a case study. The case study was based on our field research on an organization that develops software. We compared the field research results with findings from the tool's visualization based on a questionnaire given to the employees. The time needed to answer the questionnaire was between three and five minutes on average and this is much shorter than the time taken for observations and interviews. But the many findings from the diagram drawn up using the results of the questionnaire back the findings of the survey results based on interviews.

As shown in section 4.4, in an analysis of the field research, we thought it was a big issue that employees knew each other only by sight. But such employees were in the minority and they did know each other, but they didn't know each other's work well. That is an example of how field research based on interviews can be misleading. The figure showed the barriers between the groups more notably. Therefore, managers in the field can use this tool and get suggestions on how to improve communication in their organization. Looking at changes in diagrams is easier to understand than listening to opinions in the field through interviews, such as "I can now consult other team employees".

We will continue to investigate this organization to help the measures and guidelines take root. In addition we would like to apply this tool to other organizations to enhance the features of this tool and improve its accuracy.

References

1. Senge, P.M.: The Fifth Discipline: The Art & Practice of the Learning Organization. Currency (2006)
2. Ugai, T., Aoyama, K., Arima, J.: A mathematical model of knowledge transfer and case studies. The International Journal of Knowledge, Culture & Change Management 7, 9–17 (2007)
3. Aoyama, K., Ugai, T., Arima, J.: Design and evaluation a knowledge management system by using mathematical model of knowledge transfer. In: Apolloni, B., Howlett, R.J., Jain, L. (eds.) KES 2007, Part II. LNCS (LNAI), vol. 4693, pp. 1253–1260. Springer, Heidelberg (2007)
4. Wasserman, S., Stanley, K.: Social Networks Analysis: Methods and Applications. Cambridge University Press, Cambridge (1994)
5. Borgatti, S., Everett, M., Feeman, L.: UCINET IV Version 1.0 User's Guide. Analytic Technologies, Columbia, SC (1992)
6. Carley, K.M., Pattison, P., Breiger, R.L.: Dynamic Social Network Modeling and Analysis: Workshop Summary and Papers. Natl. Academy Press (2004)

 7. Rubin, R.B., Palmgreen, P., Sympher, H.E. (eds.): Communication Research Measures. Larence Erlbaum Associates, Mahwah (2004)
 8. McGrath, J.E.: GROUPS: Interaction And Performance. Prentice-Hall, Englewood Cliffs (1984)
 9. Eades, P.: A heuristic for graph drawing. Congressus Numerantium 42, 149160 (1984)
10. Girvan, M., Newman, M.E.J.: Community structure in social and biological networks. Proc. Natl. Acad. Sci. 99, 8271–8276 (2002)
11. McClelland, D.C.: Human Motivation. Cambridge University Press, Cambridge (1988)
12. Misue, K.: Anchored Maps: Visualization Techniques for Drawing Bipartite Graphs. In: Jacko, J.A. (ed.) HCI 2007. LNCS, vol. 4551, pp. 106–114. Springer, Heidelberg (2007)