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Interaction Patterns in Collaborative Product Development (CPD)

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Abstract

Purpose – This article endeavors to provide a potential framework for analysing knowledge transfer in CPD through social network analysis (SNA).

Design/methodology/approach – The survey is used to describe how the supplier and buyer worked together to transfer knowledge for developing product in practice.

Findings – The results show that to enable collaboration, the effective synergy and communication and transfer of knowledge are important. In the context of CPD, this refers to the capability of individual project members to broker and the intermediate relationship between supplier and buyer by assuring the effective information and knowledge transfer and collaboration between team members. A further important issue is that the communication and knowledge transfer is different between different roles.

Research limitation/implication – This study is conducted in high-tech companies. However, it could serve as the basic for conducting similar further studies in a large amount of companies and more research into a board spectrum of companies than just the high-tech.

Originality/value – This research contributes to a better understanding of collaborative relationships and knowledge flow within CPD. Based on findings it is suggested that the roles of the different positions [and the clarification between them] should be considered as collaborative planning.
Keywords – Interaction, synergy, collaborative product development, social network analysis, knowledge transfer, research
Paper type – Research paper

1. Introduction

The importance of new product development has grown dramatically over the last few decades, and is probably the most important factor of competition in many businesses (Griffin and Page, 1996). Due to ever increasing complexity, product development is not an easy task; it takes time and money and also often involves many different areas of skill and expertise. Therefore companies need to find a way to manage and reduce any barriers that emerge from product development. One of the effective means to overcome various difficulties of product development is to collaborate with partners. Firms need to establish relationships with other companies in order to get access to resources, particularly knowledge, which is necessary for the development of new product. Furthermore, due to the high degree of change and specialization, it is not possible for a single firm to master all information and knowledge and achieve by their own. Companies have tended to focus on their own core competence and have forced to outsource certain parts of product development to partners (Simons, 1994). Collaboration, therefore, has become an important strategy for developing the new product.

Usually accessing or acquiring, for example, the know-how, skill and knowledge during collaborative product development (CPD) means that the company must interact with partners. The relationships between partners are created for developing the new product (Pikka, 2007). In itself CPD needs probably a different kind of network than traditional order-delivery supply chains or business network descriptions; the social network or personal contacts plays an essential role in product development collaboration. Addressing collaboration issues among product development teams is critical to the success of each product development initiative. The success of product development often hinges on ensuring that people are collaborating effectively in knowledge transfer. However, knowing which knowledge and through which channels of transfer is not enough to improve collaboration within the process. Understanding in depth the pattern of individual interaction during collaborative product development can help gain insights as to how to improve the whole process. Furthermore, the company can see the way to improve the product development team's ability and the findings can also provide insight into who is critical within collaborative relationships during new product development in terms of knowledge transfer.

The goal of this paper is to clarify the individual interactions between buyers and suppliers during CPD for analysis on the performance of CPD and to provide insight into ways of improving the collaborative strategy, so that CPD work can be facilitated and improved. In order to meet the objectives of this study, the following research questions need to be answered:

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RQ1. How to analyze interaction in collaborative product development collaboration through SNA?

RQ2. How buyer and supplier are collaborated in case development projects?

This research attempts to answer these questions by developing the analysis framework for analyzing interaction in CDP for knowledge transfer through SNA, and examining the knowledge transfer in collaborative relationships within the case company. Using this framework as an analytic tool for visualizing the collaborative relationships and analyzing patterns of interaction among people in collaborative product development, in order to: understand knowledge transfer and collaborative relationships within collaborative new product development, to foster product development process and knowledge flow, to strengthen relationships within collaborative new product development, to develop strategies for the creation of knowledge environments, to sustain knowledge transfer, and finally, leads to improve the collaborative strategy.

2. Research Process

This research examined the pattern of interaction in collaborative product development (CPD). The research process had two phases. The first phase is the literature review which has been built up in order to understand collaborative new product development, knowledge transfer, and social network analysis in previous studies, in order to create a theoretical analysis framework to analyze the interaction pattern in collaborative product development. Then empirical data was collected using a questionnaire that was developed using information from the first phase. In order to conduct this investigation, the case company located in Finland and their supplier in UK, was studied. This case company is in a high tech industry where it outsources some parts in R&D to the other company.
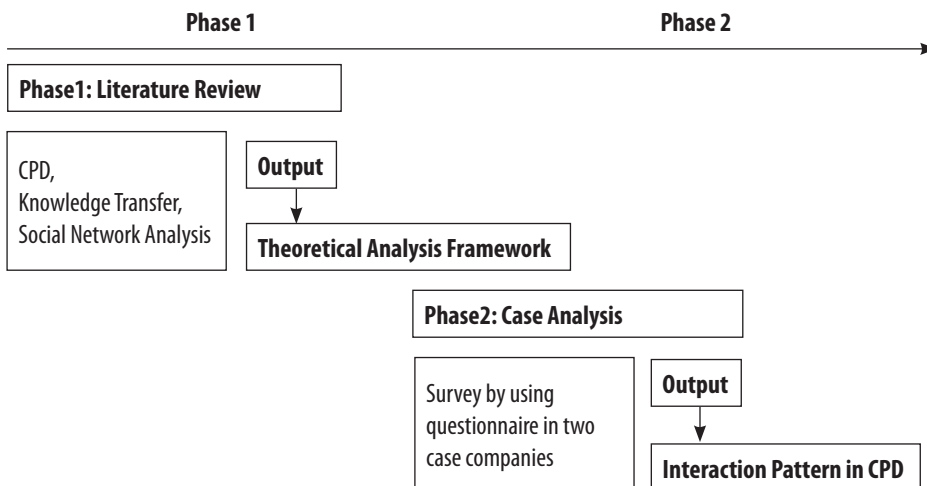
Figure 1: Research Process

There were altogether sixteen personnel nominated to be an informant in this research; seven from the buyer company and nine from the supplier company. The criterion for selecting those persons is that they must be collaborating in the CPD project. Selected informants are in the same project and hold responsibility in defining and transferring requirements which is the early phase in product development. Most positions of informants are specialist and project manager-related but there are a few informants who are in other positions, namely, CTO, technical manager, director, program manager and operations. The experience and the current interests ensured high motivation among the participants and up-to-date knowledge with respect to the discussed topics.

3. Outlining Social network analysis for CPD
3.1 Collaborative product development (CPD)

Companies may collaborate with partners at various stages of the value chain, such as its customers or suppliers during a new product development. The companies need to collaborate with the partner because they want the highest efficiency in developing and producing the new products (Blonder and Pritzl, 1992; Hamel et al., 1989; Littler et al., 1995; Millson et al., 1992). To develop any products by one single company is difficult to achieve because it is very difficult for a company alone to be an expert in every area. Therefore, companies needs to rely on the skills, knowledge, and resources of which they are lacking from the other companies, in order to develop the new product. To access the skills, knowledge, and resources as much as possible, it is crucial to drive the collaboration among companies so that the resources can consequently be shared and led to the firm's innovation capability. The important sources of those resources are from the partners. One of the purposes of inter-firm cooperation is to get knowledge from partner firms (Glazer, 1991). Thus the collaboration is a form of knowledge transfer for developing new knowledge (Simonin, 1997; Poppo and Zenger, 1998) and it is considered very important for driving the product development capability (Hoopes and Postrel, 1999).

The researchers, furthermore, claimed that the knowledge transfer is the main activity for running the business of the organization. It needs the collaboration between partners. Kanchana et al. (2010) claimed that the transfer of information and knowledge was ranked the first key important business activity required by the supplier and customer to collaborate with. The company with the higher level of such collaboration tends to be more successful in developing the new product (Simatupang and Sridharan, 2005). Thus, it can be concluded that collaboration is the pattern of knowledge transfer that is more efficient than the self-development method. In addition, the successful collaborative relationships can smooth the activities of the company as well. In other words, the company can develop itself at the higher level with the more effective aspects that leads to many benefits. For example, the customers are more satisfied with such development and the cost and time for developing can be reduced (Daugherty et al., 2006). Moreover, the employees' knowledge and capability can be improved and the knowledge base can be expanded. Therefore, according to literature review, the researchers can conclude that the knowledge transfer, which is considered the crucial element of the collaborations

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among organizations, can strengthen the capability of the organization in developing and creating the innovations because of the resources accessibility of the partners which are the important sources of invaluable knowledge.

3.2 Knowledge transfer

Knowledge transfer is the process in transferring the information, knowledge, skills, and experiences from one position to another. Szulanski (1996) described knowledge transfer as being the exchange of knowledge between the sender and the receiver. In other words, it is the learning action from the other's knowledge. The success of such a process depends on many factors, such as the characteristics of the sender and the receiver, transfer method, organizational culture (i.e., Argote and Ingram, 2000; Szulanski, 2000). The knowledge transfer between organizations can be defined as the learning process between companies and the partners through the direct interaction (Osborn and Baughn, 1990). Currently, the importance of the knowledge transfer is increasing because it is impossible for an organization to survive by itself. In fact, the organization needs to rely on the expertise and skills from the sources outside and integrate them with the existing sources for the advantage above the competitors (Argote and Ingram, 2000). Therefore, many organizations realize on the importance and benefits of knowledge transfer. Albino et al., (1999) claimed that the knowledge transfer can be compared as the strategic of the organization for competitive advantage. It is also the crucial factor of the organization in handling changes and uncertainties that happen all the time. In addition, many companies are now paying more collaboration with the other companies and such collaborations can be in various forms, such as joint ventures, strategic alliance, acquisition, therefore the trend of the business nowadays focuses on the knowledge transfer. In the supply chain, the buyer and supplier can be connected by the relationship they build. The collaborations occurred lead to a close relationship between firms which is necessary for knowledge transfer (Teece, 1981).

According to the literature reviews, there are many researchers who confirmed that social interaction is not only related to the knowledge transfer but it is also a very important element. Tsai and Ghoshal (1998) found that social interaction ties have positive affects for resource exchanges between organizations. The closeness between the companies makes it possible for the employees of the companies to communicate to each other for various purposes; for example, sharing experiences, emotions, and feelings – through meeting and face-to-fact contacts etc. No matter what kinds and purposes of communication the employees of the companies make, it develops the relationship between people and consequently leads to the knowledge and experience transfer (Kraatz, 1998). The contact and interactions between partners drive the learning process of each other which is considered important for the success of the knowledge transfer process. For example, during the process of a new product development with the manufacturer, the supplier may obtain the knowledge or the new method of work that is different from it. Therefore, the network and social interaction development with the other companies are very important for the success, possibility, and efficiency of the knowledge transfer for developing the new product.

As explained above, the knowledge transfer is very important for the success of the organization and it is one important part of inter-firm cooperation. Thus, the current research focuses on the study of the social aspects of interactions between partners in CPD. The knowledge transfer is meant that the receiver has learned many things from the sender through the interaction of each other. The knowledge transfer between partners is the way in which people in CPD interact for transferring information, knowledge, skills, and other things. Therefore, to clearly understand about the knowledge transfer, it is crucial to understand the pattern of interactions between partners and the instrument employed for exploring such understanding is social network analysis, a tool which the current research employs to analyse knowledge transfer between partners in CPD.

3.3 Inside Social Network Analysis

Social network analysis (SNA), which is becoming increasing popular as a method for understanding complex pattern of interaction, is a useful tool to analyse patterns of relationships among people in groups and also to analyse the structure of these patterns and discover what their effects are on people and organizations (Wasserman and Faust, 1997; Scott, 1999; Anklam, 2005). The concept of social network analysis has been examined under two properties: relational properties and structure properties (Streeter and Gillespie, 1992). Relational properties focus on the content of the relationship between network, member and on the form of these relationships. The aspects of relational properties have been studied going by what flows or what is exchanged in networks by focusing on the four basic types of exchange content: resources, information, influence, and social support. Another aspect of relational properties is the nature of the relationship which refers to the qualities of the relationship between members in the network. Structure properties, on the other hand, describe the structure characteristics which can be divided into three levels of analysis: individual members, subgroups, and total networks. The main goals of SNA are to understand and visualize relationships among people in groups, to study the factors which influence relationships and to uncover the correlations between relationships, and to improve, for example communication, workflow, collaboration, and knowledge flow in an organization (Allard, 1996). Borgatti and Molina (2003) described that SNA is a systematic approach to make the invisible flows seems more visible and to make the intangible become tangible. SNA uncovers the patterns of people's interconnectedness and interactions. The analysis can produce understanding as well as action. The success or failure of organizations, societies or any type of collaborations may depend on these patterns. Therefore SNA is a very powerful approach for measuring relationships and flows between people, group, organization, or other entities.

SNA is widely used as an analytical tool in a number of disciplines such as business organizations, collaboration, health care, psychology and it is widely applied to study in various cases, for example analysing political power networks (Mendieta et al., 1997), analysing terrorist networks (Van Meter, 2002), analysis disaster, analysing the transmission of infectious diseases outbreaks, analysing the online network (Haythornthwaite, 1998), analysing the information exchange (Haythornthwaite, 1996), analysing social relationship among people (Hawe and Ghali, 2008), analyzing communication patterns (Scott et al.,

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2005), analysing the nature of the informal problem-solving network in R&D (Allen et al., 2007), and analysing knowledge transfer and knowledge sharing in organizations (i.e., Cohen and Prusak, 2001; Mueller-Prothmann and Finke, 2004; Cheuk, 2007; Marouf, 2007). In this research, social network analysis is used to analyse knowledge transfer in the collaborative product development process.
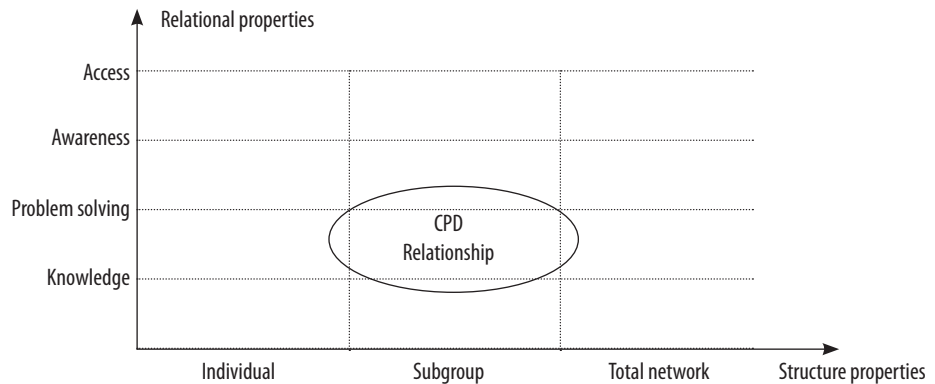
3.4 The theoretical analysis framework

Efficient collaboration between buyers and suppliers involved in the development process is a key factor to efficient collaborative product development. To ensure efficient collaboration between the numerous persons involved, both transfer of relevant knowledge and coordination of the people involved have to be ensured. Communication, however, can be understood as a means of coordinating common efforts. Transfer of knowledge is therefore crucial. Commonly, the question of what knowledge has to be transferred from whom to whom at what point of time and through which channels of transfer, are asked. However, knowing which knowledge and through which channels of transfer is not enough to improve collaboration within the process.

The Social Network theory suggests the importance of a particular pattern of individual interaction to identify the effectiveness and efficiency of collaboration. In this research, the theoretical analysis framework (see figure 2) has been created based on the theoretical study to analyse collaboration patterns and relational ties among development teams in CPD for knowledge transfer purposes, in order to develop and ensure the efficient and effectiveness of the collaboration structure by using SNA as a tool.

According to the framework, the CPD relationship will be analysed into two perspectives: the relational properties and the structural properties. On one hand, the relational properties have been studied going by what flows or what is transferred in networks by focusing on four key dimensions: knowledge, problem solving, awareness, and access. Regarding the knowledge to be transferred issue, the current research would look at the one that is transferred in accordance to a general knowledge and specific kind of knowledge; problem solving knowledge. We defined a general knowledge as explicit knowledge and a problem solving knowledge as a tacit knowledge. We go beyond the general knowledge flow to look at deeper relationships; problem solving flow. The problem-solving dimension can identify experts and a capacity for innovation in ways that knowledge flow dimension does not. However, collaborative network effectiveness hinges on more than just information or knowledge flow. When we assess knowledge networks, we typically get a snapshot of collaboration, a sense of who is connected to whom based on the current set of projects in an organization but this network cannot tell us in the sense of opportunities or problems and rapidly tap into the right expertise for an effective response. It is necessary to know who has relevant expertise, who has knowledge in the collaborative product development work and the ability to get access to those people. Therefore, the other two dimensions; awareness and access dimension are necessary in the sense of relationship that reveals knowledge transfer potential of a network. Awareness dimension reflects actors recognizing the knowing and valuing of what they know and what another person knows. However, knowing where the knowledge is does not necessarily imply the ability to communicate. Thus, access

dimension seeks to identify whether the person who owns the knowledge is accessible and how easy it is to retrieve. The structure properties, on the other hand, described the structure characteristics. In this study, the networks have been studied in three different kinds of structures including the interaction between buyer-buyer, supplier-supplier, and supplier-buyer. We considered the interaction within buyer and supplier side because the efficient transfer over the organizational interface resulted from the goods transfer within the firm. Therefore to ensure efficient collaboration and transfer knowledge between the numerous persons involved over the organizational interface, focusing on only the interaction between the supplier-buyer, is not enough.

Figure 2:
Theoretical Analysis
Framework

4. Results and discussions

According to the survey, the members in the network of buyers total seven people and those of the supplier are nine. The positions among each of them are specialist, project manager and others such as technical manager, director or operations. Regarding the part of knowledge network, there are two parts consisted in which are transferring knowledge and retrieving knowledge. Transfer knowledge is the pattern of sending knowledge from one person to another. The arrow that points from one person to another represents that the first person has sent the knowledge to another person. The arrow with two directions means both people have sent the message to each other. While, retrieving knowledge means the pattern of knowledge taken from others to own self. The arrow that points from one person to another indicates that the person has taken the information from the second person and the arrow with two directions means both of people share knowledge to each other. Both patterns present the knowledge and information transfer patterns as well as the new ideas for developing the new products. In the part of problem solving network, it shows the pattern of work collaboration for solving the problems occurred. The person to whom the arrow points is the problem solver. He or she is the person to whom everyone can go and consults about the solutions in the problems. Next, the analysis of interaction in each network has been presented and discussed.

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4.1. Buyer-Buyer

4.1.1. Knowledge Network

1) Transferring knowledge

Figure 3 presents the pattern of knowledge and information transfer in buyer team. From the figure, we can see that BSP3 BOT7 and BPM6 are the main actors within the network since the majority of knowledge within the network is sent to these persons. However, this kind of network is considered loosely connected because of the centralization of knowledge with a few main actors. In case that there is a loss of these three people within the same time, the organization could be affected because of the loss of knowledge and information as well. Therefore, this is the weak point of this network. In addition, we found that BOT7 sent the knowledge to other people including those outside the team; B8 B9 and B10. While, BSP3, the specialist, and BPM6, the project manager, sent the information and knowledge back to the team at very low level. BSP3 chose to send the information back to BPM2 and BPM6. And, BPM6 sent the information back to BSP3, BOT7, and people outside the team who are B16, B17 and B18. The people outside the team mentioned involvement in working with hardware and software. This is also considered the weak point of the network. In other words, BSP3 and BPM6 are the experts and possess a high level of knowledge and experiences. They should convey more of this information to the other members of the teams. However, the hidden benefit found from the network is that BSP3 BOT7 and BPM6 send information to each other all the time. Therefore, in case that there is the loss of either of them, the information is not lost.
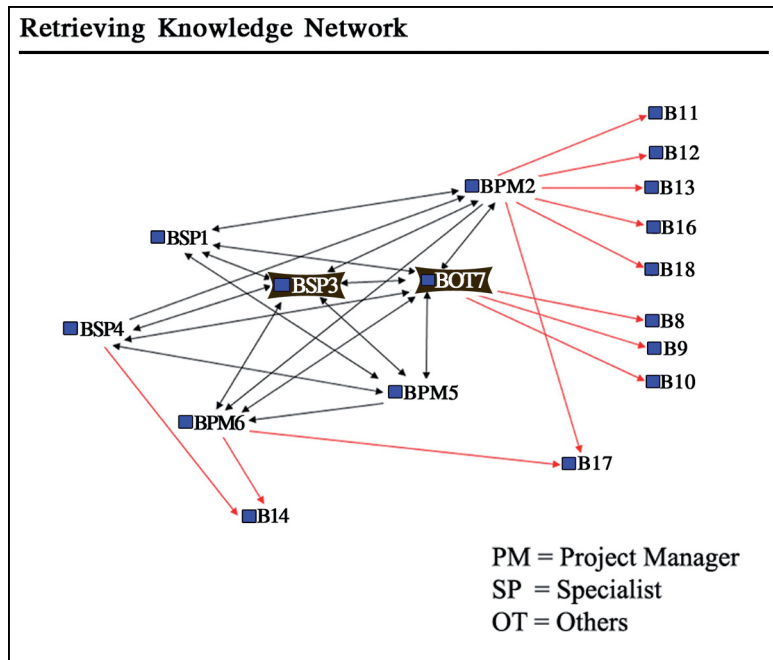
2) Retrieving knowledge

Figure 4 presents the pattern of knowledge and information received among members in the buyer team. From the figure, we can see that most of knowledge and information of the team comes from only two main members, BSP3 and BOT7. Moreover, BOT7 also received the information from people outside the team, who are B8, B9 and B10, too. This kind of network is, nevertheless, considered loosely connected as the information and knowledge is chunked at two people only. It can affect the speed of the production, team work performance, and loss of knowledge because of the loss of any of them such as the case of resign, deployment, or any unavailability for work. In addition, we also found that another weak point of this network is that BMP6 declined receipt of any knowledge from any members of the team except BSP3 and BOT7, but admittedly prefers to obtain data from team members, B14 and B17.

If we consider further at Figure 3 and Figure 4 which present the pattern of general knowledge transfer in CPD, we will see that BSP3 and BOT7 are the main members, transferring knowledge and information in the team. BSP3 is the expert networker to whom everyone comes to exchange and transfer knowledge at the highest level. This implies that BSP3 is considered to be the member with high knowledge, expertise, importance, and usefulness for the development in CDP. While, BOT7 can be considered as the expert and cut-point. Therefore, BOT7 is the member with high knowledge
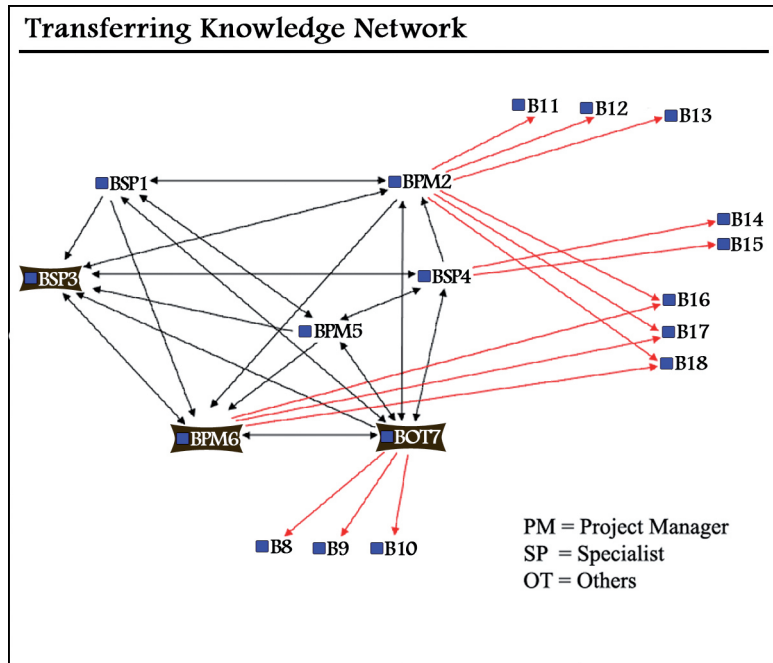
Figure 3:
Transferring knowledge
network within buyer
team

Figure 4:
Retrieving knowledge
network within buyer
team

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expertise, importance, and usefulness for the development in CDP. In addition, BOT7 is the facilitator between the expert networker for members inside and outside the team. If BOT7 is lost, the knowledge and information will be lost too. In addition, it can be found that BPM2 is considered as the silent expert and boundary spanner, even though BPM2 is not the centre of information. He or she is important and an expert team member because the position in question connects the information and knowledge between expert networker, expert and cut-point and people outside the team.

4.1.2 Problem Solving Network

Figure 5 shows the pattern of problem solving knowledge transfer in CDP. From the figure, we can see that BSP3 and BOT7 are the main problem solvers to whom every member of the team comes during the product development process. This pattern may make BSP3 and BOT7 as the bottleneck, if they do not have enough time for providing help in the problem solving process. In addition, we can see that BPM2 has been considered as the main person in general knowledge transfer. However, when it comes to being considered for problem solving knowledge, he or she is found to have a very less frequent rate of members asking for the suggestions. This point indicates that, although possessing a very high level of knowledge but failing to apply it to problem solving, BPM2 is not trusted by the members of the team to solve the problems occurred.

When we look at the whole picture of knowledge network and problem solving network, we can provide the summary as follows.

1) Pattern of loosely connected and bottleneck: Both of these patterns are considered not well connected in terms of communication. The knowledge and information have not flowed in the team as appropriate but consolidate at a few main members (bottleneck).
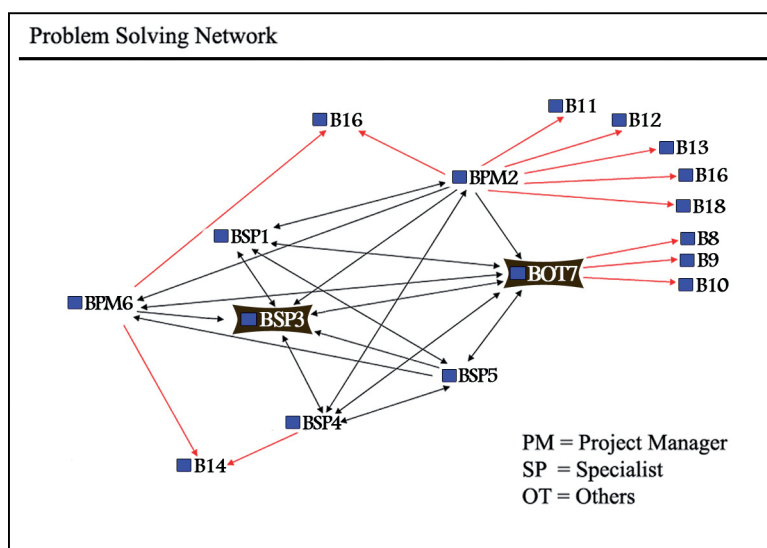
This will lead to more workload to any one member and consequently drive a delay in the development and production process. Some problems can be solved immediately without necessary postponement. The key members will possess less time to process in their personal jobs which reduces the efficiency of the work as well.

2) The network mentioned an indication that there are the differences between the transfer pattern of general knowledge and problem solving knowledge. The possession of high level skills or expertise does not necessarily mean also acquiring a strong problem solving skill. This issue should be considered seriously by the organization so that the expertise and ability in such staff members can be brought out efficiently.

3) Information accessibility: According to the findings, we found that some members in the team may possess enhanced skills and experience but other people in the team cannot access such knowledge because there is a lack of willingness to share.

4) Knowledge gap: The findings show that the level of knowledge among members in the team is varied, which leads to the untrustworthiness for sharing the knowledge. The obvious example can be seen in the case of knowledge network. BPM5 sent and received the knowledge from BSP3 but BSP3 did not realize that BPM5 had already sent any knowledge. That means BSP3 thought that what had been sent was neither useful nor informative for the product development. BSP3 believes that him or her possess a higher level of experience than BPM5. Such examples are the reason why the flow of information is not thorough. In addition, previous research also shows that knowledge gap and trust are the main challenge of joint development between buyer and supplier (Distanont, et al., 2011).
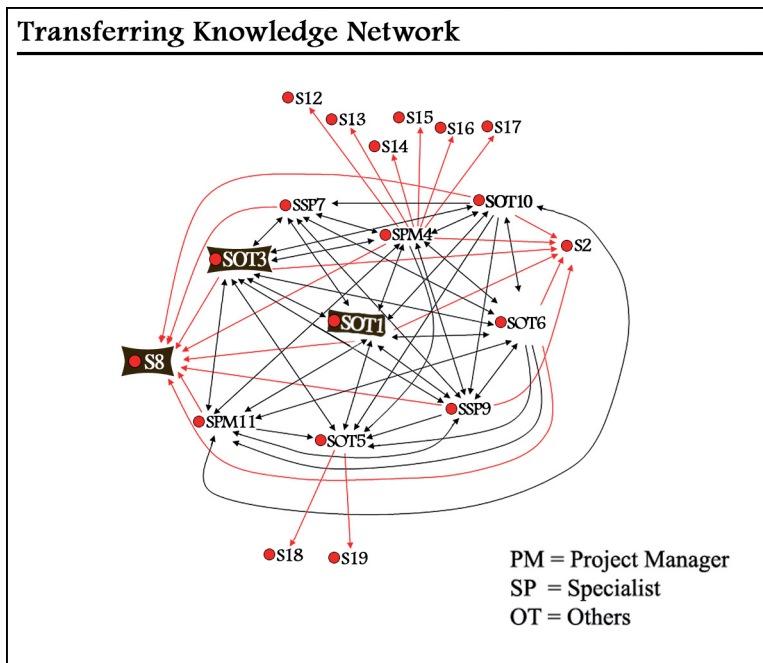
4.2 Supplier-Supplier

4.2.1 Knowledge Network

1) Transferring knowledge
Figure 6 shows the pattern of general information and knowledge transfer in supplier team. From the figure, we can see that knowledge and information has mostly been sent to SOT1, SOT3 and S8. While, there are only SPM4 and SOT5 sending the information outside from the team. In addition, we can find that with most of the knowledge and information of the team, instead of being sent to the team members, the knowledge has been sent to S8 and S2 who are the team outsiders. This implies that both S8 and S2 have the crucial roles for the team. When considering the communication occurred, we can see that the internal communication of the team is considerably good; there is the wide contact among the team members.

2) Retrieving knowledge
Figure 7 shows the general information and knowledge received in the team. From the figure, we can see that SOT1, as the executive of the team, is considered the most key element of the network. The team members have received the information from SOT1 the most. On the contrary, SOT1 has not received any information from the other

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Figure 6:
Transferring knowledge
network within supplier
team

team members at all. That may be because of the differences in the level of knowledge (knowledge gap) and information possessed among them. In other words, SOT1 does not realize the importance of the information or knowledge sent by the other members or sees it as the basic information without any fruitful implication. However, such situation may affect the development in CDP because there are some parts of knowledge that have been ignored. In addition, in the transferring knowledge network, SPM4 is the person who sends the information to the outsider but, in the retrieving knowledge network, SPM4 does not gain any information back from those outsiders at all. This is not considered a well connected network because it is only one-way communication.

Furthermore, when looking at the overview of the knowledge network of the supplier, we can see that SOT1 is considered as the expert networker to whom most people come and transfer knowledge. While, BOT5 can be considered as a silent expert and boundary spanner. That is, although not being the knowledge center, he or she is considered important because of the role as the connector or facilitator among expert networker team member and outsiders. When looking at the flow and the distribution of the information and knowledge, we can see that the members in the team have transferred the information and knowledge more appropriately than the buyer element.

4.2.2 Problem Solving Network
Figure 8 presents the pattern of communication between the suppliers in the problems solving situation in the development of the product. From the figure, we can see that
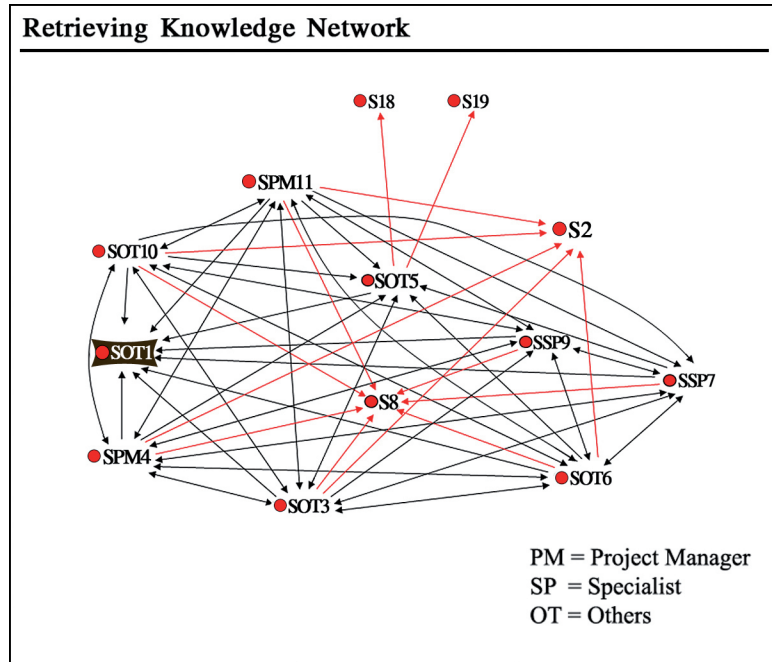
Figure 7:
Retrieving knowledge
network within supplier
team
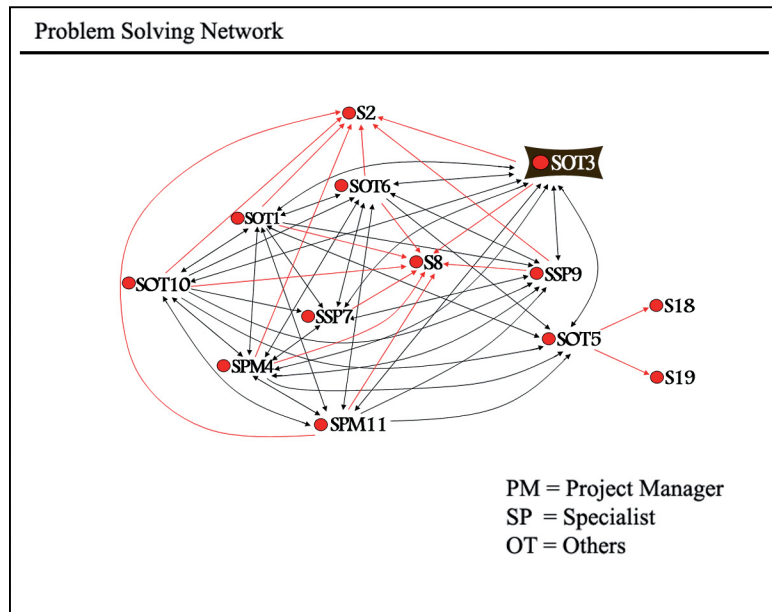
Figure 8:
Problem solving
network within supplier
team

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SOT3 is the centre of the network because when problems arise, everyone will approach him or her for the consultants; rather than to SOT1 who is, in fact, considered as the main member in sending and receiving general knowledge.

According to the findings obtained, we found that the pattern of general knowledge and problem solving knowledge transfer are somehow different. More elaborately, the person who is the main actor for accessing and transferring information and knowledge is not the one who possesses crucial skills and knowledge for problem solving that everyone requires. In addition, we found that S2 and S8 who are the team outsiders play a crucial role in the problem solving process. This may be because that they are the specialists with a certain field of expertise that the team members need. Moreover, such expertise may be particularly required for fixing the obstacles laid in CPD. When we look at STO5, we can see that when the problems occurred, he or she decides to ask for help from the outsiders rather than the team members. This kind of collaboration is not considered appropriate because the information and knowledge applied to solve the problems are hardly shared to the team members.

When looking at the overview of Knowledge Network and Problem Solving Network, we can conclude the issue as follows.

1) The communication and knowledge transfer are considered good and there is more rate of knowledge distribution than that of the buyer.

2) The differences in general knowledge and problem solving knowledge transfer: According to the results obtained, we found that the transfer of general knowledge is more distributed than that of the problem solving knowledge. The reason is that in solving any problems in CDP, it is necessary to rely on the person with sufficient special technical knowledge as well as experiences. Hence, the knowledge transfer is chunked.

3) Information accessibility: The findings gained show that the information and knowledge accessibility is good because the team members can access the main people in knowledge network and problem solving network who are SOT1 and SOT3, properly. In addition, the knowledge has been transferred through each member. However, the connection of those two main members can turn out to be the bottleneck in the case that they do not have enough time to exchange knowledge or help solving the problems occurred.

4.3 Supplier-Buyer

4.3.1 Knowledge Network

Transferring and retrieving knowledge
Figure 9 presents the pattern of general knowledge transfer between the supplier and buyer. From the figure, we can see that SOT6, BPM2 and BSP4 have the vital roles in sending the general knowledge between two organizations. In addition, SPM4 BPM2 and BSP4 are the main people sending information to the outsiders. Whereas, figure 10 shows the pattern of general knowledge received between supplier and buyer. From the figure, we can see that the general knowledge flowing between supplier and buyer is mainly from SPM4 and BPM2.
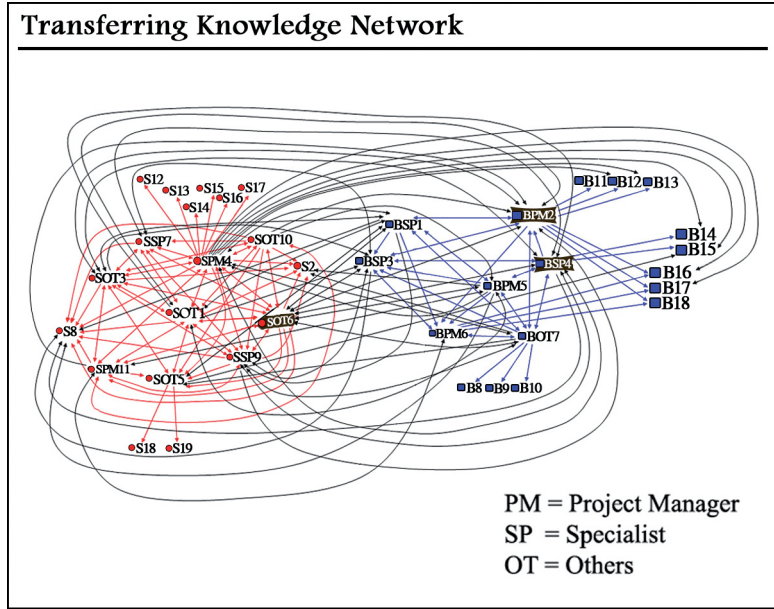
Figure 9:
Transferring knowledge
network
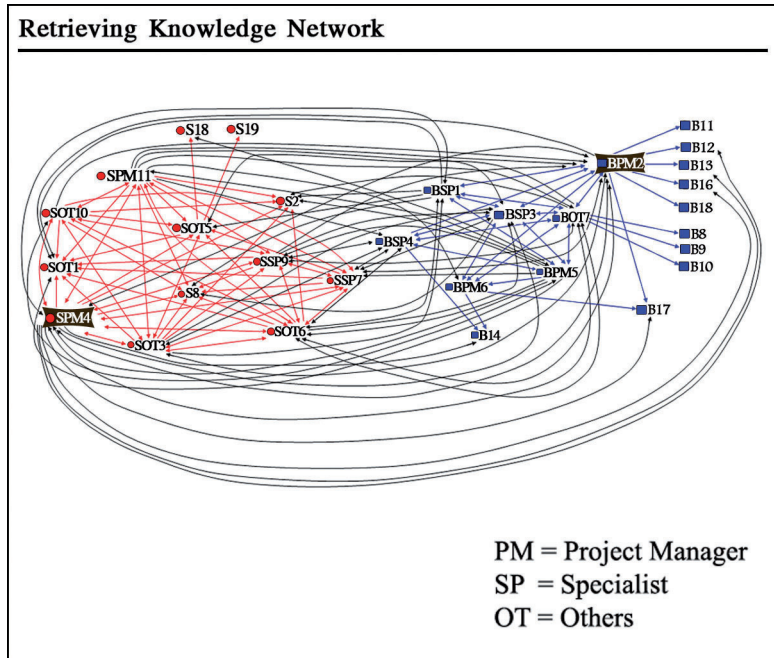
Figure 10:
Retrieving knowledge
network

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The pattern of this network is interesting because, as for the transferring knowledge network, SOT6 is the central connector sending the information to the buyer the most, but with regards to retrieving knowledge network, SOT6 is not the main point that buyer can obtain the information. This indicates that what SOT6 realizes as new and interesting knowledge and worthy of sending to the buyer is not what the buyer needs or pays attention to. In addition, another interesting point is that, in retrieving knowledge network, most general knowledge for the supplier are from BPM2 but in transferring knowledge network, the main people sending the information to supplier are BPM2 and BSP4. The results obtained imply that there is the similar situation as previously mentioned. That is, BSP4 sends the information to the supplier but the supplier does not see it as the knowledge or the informative data at all. Such situations need urgent resolution and investigation of the cause. Relevant people may need to look at what is being sent by BSP4 and SOT6, such as whether or not it is the effective information and knowledge for CPD, and whether or not it is the knowledge gap leading to the ignorance of the information and knowledge. The problems found through the use of SNA Analysis are needed to be detected for the causes and resolved by the organization, so that the information and knowledge transfer can be run effectively.

4.3.2 Problems Solving Network

Figure 11 shows the pattern of problem solving knowledge transfer between supplier and buyer. The figure presents that the main people as the problem solvers between supplier and buyer are SOT6 and BSP3. The analysis presents that in the problem solving network, SOT6 becomes the problem solver who everyone needs advice from when problems occur in CPD. But, in knowledge network, it is found that most general knowledge does not come from SOT6. That indicates the reluctance to share the information which drives to the lack of general knowledge transfer, which is important and useful for CPD development. When there are problems occurring, the solutions are just simply thrown down to the floor without appropriate ways of suggestions to the members. However, it may because there is the knowledge gap that makes others difficult to absorb or understand the knowledge of SOT6. For BPM2, he or she is the main person in the general knowledge network but not in the problem solving network. It can be seen that the most kind of information and knowledge which BMP2 transfers to others is explicit knowledge. When there are any problems occurring, any knowledge, skill or experience from BPM2 cannot be transferred to help the others. No matter what the root of the situation is, CPD team needs the urgent fix of such a situation so that the transfer of general knowledge and problem solving knowledge can be run more effectively that everyone can access the information and knowledge in time through the network and leads to the true collaboration for development of the product as expected.

However, the study of the collaboration between supplier and buyer in CPD can be concluded as follows.

1) From the overview of the knowledge network and problem solving network, the connection and knowledge transfer between supplier and buyer are considerably good. The knowledge has flowed thoroughly and not centralized at any specific point too much.
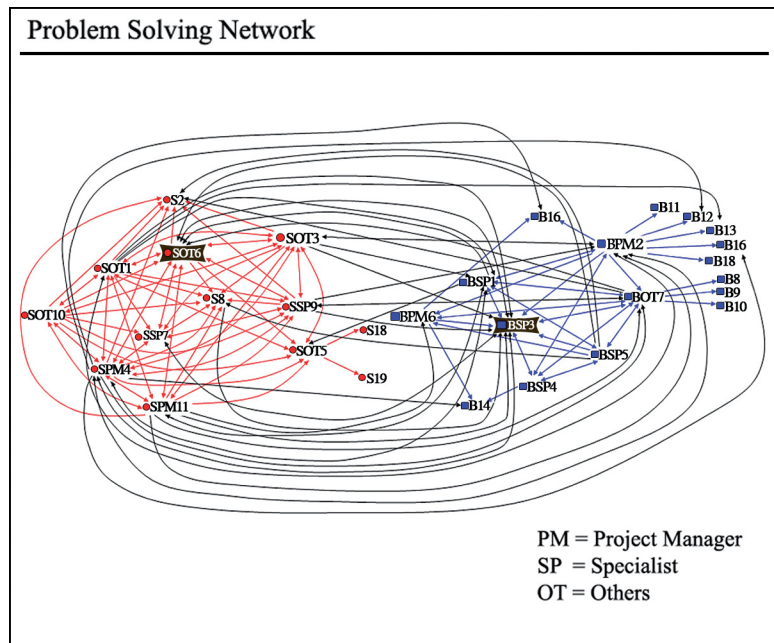
Figure 11:
Problem solving
network

2) Differences in the transfer of general knowledge and problem solving knowledge: General knowledge transfer between the supplier and buyer in CPD is higher than that of problem solving knowledge. The reason may be that most of problem solving knowledge is the tacit knowledge and can be obtained only through experience, skills, or the expertise of an individual which is difficult for the transfer. However, most of general knowledge is the explicit knowledge, which can be in the form of documents, manuals, general ideas. They are presumably easier to be transferred.

3) The potential and expertise of team members are not utilized appropriately for the development of CPD, because of reasons concerning the reluctance to share the knowledge and lack of trustworthiness. In addition, the knowledge gap is also considered the obstacle in supplier-buyer's knowledge transfer or even within the team of buyer or supplier.

4) The findings reveal that members in CPD possess huge differences in knowledge so there are many difficulties occurred in the knowledge transfer. The previous research also shows that individual's experience has a strong affect to the absorptive ability of the person. The mentioned absorptive ability; hence, plays the crucial role in knowledge transfer (Cohen and Levinthal, 1990). As such, whenever there is the knowledge gap found, it means the level of absorptive ability will be reduced, respectively. Consequently, the collaboration between the supplier and buyer in CPD will be reduced as well.

Furthermore, in Table 1 presents the measure to identify key actors who have a key role in communication and transfer knowledge in each network by summing the number of interactions.

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Actor	Position	Number of Interactions								
		Buyer-Buyer			Supplier-Supplier			Supplier-Buyer		
		Explicit		Tacit	Explicit		Tacit	Explicit		Tacit
		Transferring network	Retrieving network	Problem Solving network	Transferring network	Retrieving network	Problem Solving network	Transferring network	Retrieving network	Problem Solving network
BSP1	Specialist	3	4	4				5	3	4
BPM2	Project manager	4	4	2				**6**	**8**	5
BSP3	Specialist	**6**	**6**	**6**				5	6	**8**
BSP4	Specialist	3	3	4				**6**	5	0
BSP5	Specialist	3	4	3				4	2	0
BPM6	Project manager	**5**	4	3				1	1	1
BOT7	Technical Manager	**5**	**6**	**6**				3	4	3
SOT1	CTO				**8**	**8**	6	3	3	1
SOT3	Director				**8**	6	**8**	3	2	1
SPM4	Project manager				7	6	7	4	**5**	3
SOT5	Program manager				7	6	6	2	2	1
SOT6	Director of engineering				7	6	7	**5**	5	**4**
SSP7	Specialist				6	6	6	2	4	1
S8	Outsider (Software)				**8**	7	7	4	2	1
SSP9	Specialist				7	6	7	4	3	1
SOT10	Operations				5	5	4	0	1	0
SPM11	Project manager				7	5	5	2	1	1

Table 1:
Key person in the network

According to the Table 1, the overall interaction within the buyer side is considered low-frequency than that in the supplier side. Furthermore, if we consider the frequency of interaction between explicit and tacit knowledge network, we find that the interaction in the tacit knowledge network is somewhat low-frequency than in the explicit network, both within company and between companies. These findings could be explained that the transferring of the tacit knowledge is very challenging. The company should pay much attention on this kind of knowledge and find some practices to support tacit knowledge transfer during collaborative product development work.

5. Conclusions and Recommendations

The current research is attempted to build the framework for the study and analysis of collaboration pattern between supplier and buyer in the collaborative product development (CPD) through the use of social network analysis (SNA). SNA can lead to the better understanding of relationships among human resources in CPD and help indicate a problem or impediment to the improvement of knowledge transfer. This study is intended to analyse the pattern of interaction between supplier and buyer according to the theoretical analysis framework we have been created. The framework is consisted of two aspects: relational and structure properties. Two aspects of relational properties have been studied: transfer content and potential of a network. Transfer contents refer to the transfer of general knowledge which is close to explicit knowledge and problem solving knowledge which is close to tacit knowledge, whereas the potential of a network refers to awareness and access dimension. The structure properties can be divided into three levels of analysis. First, analysis of an individual level describes the interaction among people within buyer and supplier side and this analysis can be used to identify who is the key person in the network. Second level is subgroups; it can be identified whether to have more linkages or interactions between members than others. The last level is the total network, it represent the analysis of the interaction between supplier and buyer.

The results obtained show that, in overall, the communication and knowledge transfer in the case network are considerably good. However, certain problems found to be solved for the better efficiency of the transfer are: 1) The reduction of knowledge gap (technical knowledge) among team members in CPD. Management could help the staff bridge the knowledge gap by, for example, providing training, facilitating open experience-sharing/story-telling sessions or providing mentoring and coaching programs whereby experienced people advise and guide those employees with less experience. 2) Build more rapport and trustworthiness value. Communication can assist in the development of a good relationship and trust between people. Management should facilitate more face-to-face communications or informal conversations between staff. Managers may build informal relationships between team members by creating social interactions and events (e.g., sport activities and dinner parties), supporting an open communication flow between all organisational levels, encouraging people to be open, proactive, and forthcoming with ideas and opinions, and recognise and reward such behaviour. 3) Build motivation for the highly expert people to transfer more knowledge and information obtained. 4) Support the higher level of transfer of the knowledge concerning problem solving knowledge, which can be seen as tacit knowledge. The organization is able to build the motivation and support the higher level of knowledge transfer by creating a collaborative environment and setting an indicator to grade or evaluate working performance on joint problem-solving efforts and/or transfer knowledge work, ensuring a non-bureaucratic communication flow between all levels, and minimise or eliminate mentalities that people who have obtained a certain level of expertise have nothing to gain from people with lower experience levels, for instance. All purposed solutions are just a quick list of some of the potential ways a company could solve the problem, to make collaboration between organizations more efficient and productive. However, these solutions are an alternative to solve the difficulties, there are also other ways. The company just learns what the solution is and how to make use of it.

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Moreover, beside the results obtained, which can be used to study and analyse the collaboration and knowledge transfer between supplier and buyer in CPD; especially the tacit knowledge, the current research can also be applied to analyse the possible problems or obstacles which can be occurred in the future of CPD or in the collaboration among organizations. Therefore, the relevant parts can plan and set priorities as well as solve the social connections and knowledge flows, in the level of individual, subgroup, or the entire CPD network as appropriate. Additionally, the further important issue found is that the communication and knowledge transfer is different between different roles. The central people in each kind of network really are the central beings, no matter whether they are specialists, project managers or others. They are important in the network because there is more communication there than elsewhere. Therefore the role of different positions of persons should be considered collaborative planning.

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