A CMC-Based Design Communication for Collaborative Design Projects

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ABSTRACT

Design processes in a traditional design project mainly rely on the designer's personal skills such as drawing, presentation and prototyping capability. However, in a collaborative design project the focus is transferred from personal skills to design communication and knowledge management. Current advanced information and communication technology (ICT) dramatically changes the design process in terms of communication, information sharing and knowledge accumulation. This kind of design process deals with a huge amount of information and involves much more complicated interpersonal communication. Conceptual divergence among design team members usually starts from the initial design vision and mission. This paper presents a framework for managing communication-based collaborative design projects that rely on close coordination. Through an interactive communication mechanism, designers perform creative thinking dependent on a variety of abilities and disciplines. A software interface design project is used as a case study to describe the proposed framework. In this case study the design team informs the customer of the design requirements and concepts via face-to-face communication (FTF) and computer-mediated communication (CMC). The management of information flow and creative generation flow are integrated and design knowledge is accumulated during the design project. A communication-based collaborative design process is performed in the case study.

Key words: design communication, Computer-mediated communication (CMC), design project, collaborative design.

1. INTRODUCTION

Advanced information and communication technology (ICT) provides designers with powerful tools in terms of communication, information sharing and knowledge accumulation. The more ICT equipment the designers use the more adaptations they have to make during the design process. Furthermore, current development of ICT, such as ubiquitous computing and cloud computing, shows great potential to influence the design process in the near future. Rapid development of the internet makes information flow free from the limitations of time and location. The accuracy of information communication becomes a more important topic. Design communication means disposing and interpreting a huge amount of information in the design development process. Conceptual divergence among design team members usually starts from the initial design vision and mission. Design as a creative activity, which comprises the application of a set of learnable and developable skills (Cooper & Press, 1997). This creative action

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combines the discipline of engineering with human factors, the environment, culture and aesthetics, and includes a series of developmental processes rather than just imagination. During the creative process designers moves toward "perfection" through internal and external coordination to overcome communication barriers and other limitations. In a collaborative design project team members with multidiscipline experience work together to coordinate design efforts. Therefore design communication is very important under the collaborative design environment via mutual interaction that integrates different skills, thinking modes and values to inspire more creative solutions. Nevertheless, the failure report of communication among multi-disciplines can be found in many historical design projects. This paper discusses the operation cycle of design communication for a design team in the collaborative product-development environment and proposes a framework for managing communication-based design processes. Members of the collaborative design team are closely connected to share experiences and integrate various concepts for the project success. Therefore members of the design team gain experience via the design knowledge-base during the creative process, and a more effective design performance can be anticipated.

2. LITERATURE REVIEW

The trend of globalization and cross-discipline integration increasingly promotes the broad application of collaborative product design and development for enterprises. Collaborative design projects have the features of team cooperation and cycle time reduction. To take the advantage of collaborative design projects, communication between project members becomes more and more important because everyone needs to understand how their team connects to the overall goal of what they are trying to accomplish. In order to discuss communication for a collaborative design project, several issues need to be addressed: collaboration, new communication technology and design communication.

Collaboration means all members establish a goal altogether and solve problems in a cooperative manner to reach common objectives (Kvan, 2000). Collaboration usually divides into two types: data-based collaboration and reciprocation-based collaboration. The former, such as product data transmission and product design technique exchange, narrates mainly the sharing of data and knowledge through the integration of artificial intelligence and database technology. While the latter discusses the situation in real-time and synchronous operations between the participants in a collaborative process, such as real-time virtual 3D drawing and design (Cera, Kim, Han & Regli, 2004). Collaboration utilizes computer supported cooperative work (CSCW) and computer-based groupware to assist the communication, cooperation and coordination between groups or users in order to finish the work (Anupam & Bajaj, 1994; Ellis, Gibbs & Rein, 1991). Applications in which collaboration is used can be found in access control, information notice, user management, group interface, information distribution, data storage, general surveys of data, working meetings, information cognition and user transmission (Eiderback & Jiarong, 1997). The collaborative product design assembles many personnel who simultaneously participate in the product development process, including designers, manufacturers, suppliers, and marketers. Members from different locations can communicate and discuss together to concurrently carry out the product design and modifications via the network, so making design results be more in accordance with the consumer requirements (Tang, 2004).

Previous collaboration models were normally defined by time, location and operation of collaboration, such as close coupled and loosely coupled (Kvan, 2000); face to face collaboration, synchronous distributed collaboration, asynchronous collaboration, asynchronous distributed collaboration (Anumba, Ugwu, Newnham & Thorpe, 2002); mutual collaboration, exclusive collaboration and dictator collaboration (Maher, Cicognani & Simoff, 1998). The advantage of face to face collaboration, synchronous distributed collaboration, close coupled collaboration and mutual collaboration is to provide on-line interpreting and real-time operating functions for participants to reduce process duration. Its weakness, however, is the difficulty in reviewing and auditing personal performance in an effective way. On the other hand, the strength of loosely coupled collaboration, asynchronous collaboration, asynchronous distributed collaboration and exclusive collaboration is that there is no need to gather all participants to accomplish the work in a specific location at one time. The weakness of this kind of collaboration is that the project work breakdown structure may cause potential problems of task completion due to individual delay (Kvan, 2000; Anumba *et al.*, 2002; Maher *et al.*, 1998).

The five elements of communication are source, transmitter, channel, receiver and destination (Shannon, 1948). The source of information is encoded by the transmitter, transmitted through specific channels, and decoded by the receiver after its arrival at the designated destination. There are two types of communication application: face to face communication (FTF) and computer-mediated communication (CMC) (Gabrie & Maher, 2002; Caplan & Turner 2007; Johnsen, 2007; Stone & Posey, 2008; Kerr & Murthy, 2009). Thanks to internet development and greater technological flexibility, traditional FTF communication is now mediated by technology. "These changes put the responsibility for supporting trust and trustworthy action on the designers of the technical systems involved (Riegelsberger, Sasse & McCarthy, 2005)." CMC can be used either in synchronous or asynchronous mode (Blasio & Milani, 2008; Derks, Fischer & Bos, 2008; Lewis & George, 2008; George & Labas, 2008). Teams using CMC show greater task-oriented communication, given implicit information (Nam, Lyons, Hwang & Kim, 2009). CMC may create dynamic feedback loops via some bias-prone communication processes (Walther, 2007). The electronic system of CMC has known as Computer-Mediated Communication System (CMCS). The CMCS could store documents, data and information collected from computer nets then transmit to every location via communication networks. The user could choose the time and location for transmission of the data, and then utilize the system to create and edit documents that interchange with other locations (Steinfield, 1986).

Design communication differs from general commercial communication in the process of communication which focuses more on "looking over" drawings than "seeing" the meeting participator (Gabrie & Maher, 2002). Design communication pays more attention to the following issues: communication of images, communication of abstract concepts, clarity of communication, detailed descriptions and the tempo of communication. The design innovation establishes a bridge from question space to answer space via the affirmation of the key concept, rather than merely jumping to creation (Dors & Cross, 2001). Thus design communication is a necessary path for the accomplishment of the design goal. It is therefore essential to keep communication channels open and smooth during the design process to ensure design project success (Teng, 1995).

3. MANAGING COMMUNICATION-BASED COLLABORATIVE DESIGN PROCESS

The framework for managing a communication-based collaborative design process emphasizes mutual and inseparable coordination. The design team performs work group coordination, relation connection, knowledge sharing, and cognition integration to create new products under the foundation of design communication in the collaborative environment throughout product design and development. During the creative process, the design team gains experience through the storage, classification and combination of the design knowledge-base which provides the design team with the skills of product design and development. As shown in Fig. 1, its mechanism is described below.

(1) Work Group Coordination: It is necessary to coordinate every team member to harmonize and encourage each other. The degree of participation should be adjusted based on the project requirements to reach maximum project benefit.
(2) Relation Connection: Members of the collaborative design team create interrelationships via direct, indirect, formal, and informal approaches to enhance understanding of the current status.
(3) Knowledge Sharing: Members of the collaborative design team share their professional knowledge and transfer tacit knowledge of design to explicit knowledge.
(4) Cognition Integration: The whole team recognizes that an identical vision is important to establish a value network.

Each round of design communication goes through the following four steps: interpret design, comprehend design, temper mind and generate consensus. Details are listed as follows.

(1) Interpret design: The transmitter interprets the design value and transmits it to the receiver. This stage may result in an interpretative gap which shows the different values between the anticipation of the receiver and the interpretation of the transmitter, as shown in the left square of Fig. 2.
(2) Comprehend design: The receiver understands the design value transmitted from the transmitter. A comprehension gap derives from the difference between the original anticipation value and the transmitter's recognition of this value collected from the receiver via the design method. This gap is shown in the right square of Fig. 2.
(3) Temper mind: When the above interpretation and comprehension have

proceeded mutually with the design process, a cognitive gap is unavoidable. Both sides of the communication should temper their minds together as said in “Iron makes iron sharp; so a man makes sharp his friend.” In this stage, various kinds of communication skills can be utilized, such as spoken and written language, graphic language and body language as depicted in Fig. 2.

(4) Generate consensus: Coordiation between the transmitter and the receiver is required for the subsequent design activity.

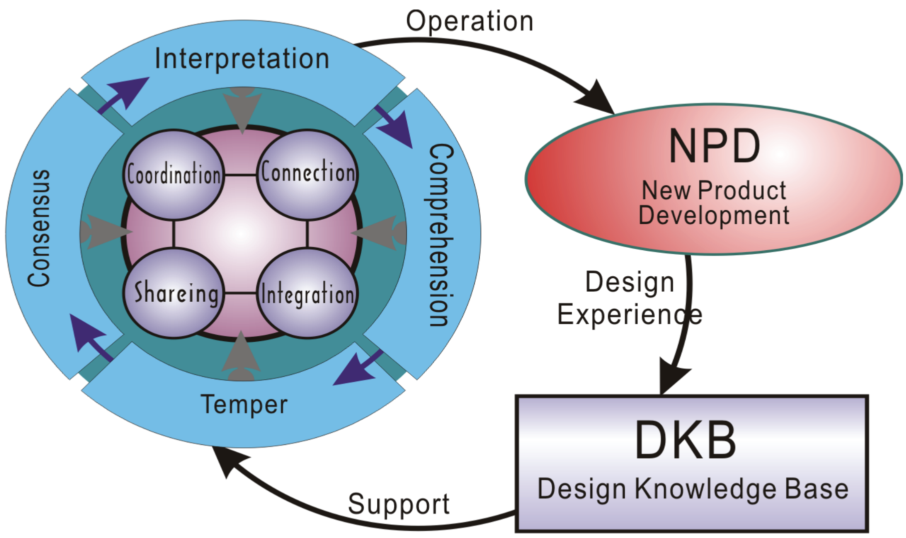

Figure 1. The framework for managing a Communication-Based Collaborative Design Process.

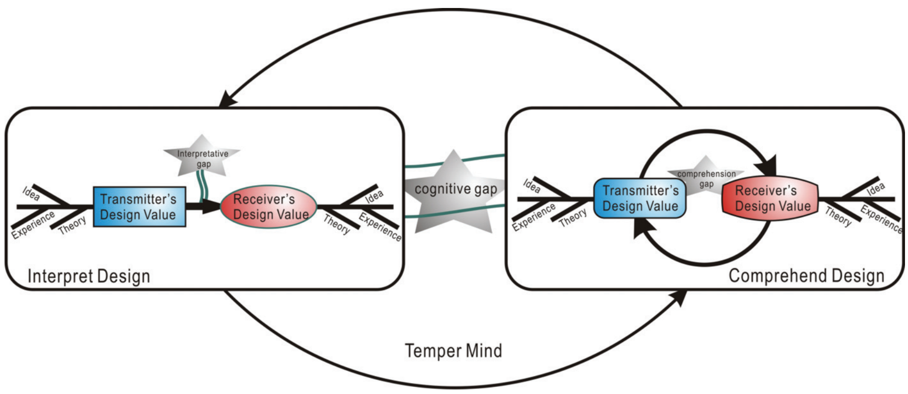

Figure 2. The Cycle of Design Communication.

The design team reaches the design goal together and shares knowledge in a collaborative manner during each design cycle. It forms a spiral type of design communication process and advances to the next cycle. The participants are designers, engineers, suppliers, customers, design development consultants and marketers. Individual values based on versatile discipline, opinion, market experience, product experience, know-how and culture are connected, then interact to develop a common value throughout the cycle of design communication.

4. CMC-BASED DESIGN COMMUNICATION

CMC (Computer-mediated communication) indicates that people use computers as the media or channel to transmit messages and achieve their purpose of communication (Herring, 1996; Culnan & Marcus, 1987). The modes include Email, Bulletin Board System (BBS), Discussion Board, Instant Messaging (IM), video conference, Internet Relay Chat (IRC), and Blog. The design team usually uses Email and IM to access information and discuss design together through a design knowledge base. The design information includes documents and graphs: such as schedules, specifications, test reports, trial balances, flow charts, renderings, drawings, design references, research reports, and so on. Furthermore, the internet is used to connect other design departments, suppliers, customers and research institutes. Members of the design team utilize networks which provide related project information to help their jobs. For example, designers can discuss assembly topics for modularity design with manufacturing departments, exchange new ideas about customers with marketing departments and learn new methods or technologies from research institutes. Design managers can also communicate with the project team members through CMCS, such as Email, to exchanging design messages, web phone and IM for monitoring project schedules, and video meetings for online communication. He or she knows the status of the design project execution based on data analysis of the design knowledge base (DKB). Members of the design project team transfer their design knowledge stored in documents, drawings and annotations into a design knowledge base (DKB) around the design process. The DKB then supports other members to execute designs and provides the team's novices with professional training. The collaborative design process with CMCS is shown in Fig. 3 and has the features of efficient communication between departments, accurate implementation of design projects, and close relationships for organization.

The main advantages of this process are described as follows:

(1) Resource sharing: members of the design team can concurrently retrieve related information or knowledge to reduce the time of design. Design resources including data, information, and knowledge are stored in DKB and used to support the design project.

(2) Cross-domain communication: the design team use CMCS tools such as e-mail, IM and video phone to communicate content and progress of the design. Design communication is open and effective without the restrictions of time

and location.

(3) Visual platform: design project members use a visual platform to review design status, such as shape features, interior assembly and interface configurations. This common platform can speed up design project execution and reduce the time of coding and decoding to advance design communication quality and efficiency.

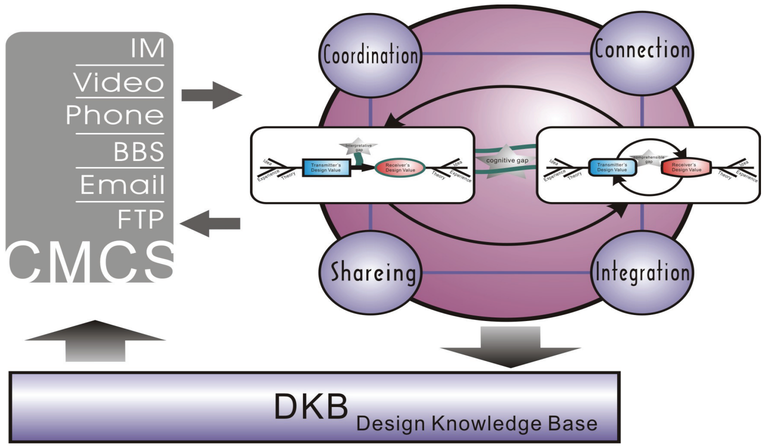

Figure 3. The Collaborative Design Process with CMCS.

5. CASE STUDY

Since the communication-based collaborative design process involves intensive use of various CMC tools, projects whose team members have different specialty areas are worth further investigation . In this paper, a case study regarding a collaborative design development project carried out by two teams with different disciplines is investigated. The first team is a public sector client with a specialty in meteorology. The five participants are from the forth division (Telecommunications and Radar) of the Central Weather Bureau (CWB) and are a project manager (male), two weather forecasters (1 male and 1 female), a meteorological analyst (female) and a programmer (male). All these five members have postgraduate degrees and their ages range from 26 to 45. They aim to promote modernized meteorological observation, to develop refined meteorological forecasting, and to provide multiple channels of information dissemination by which to improve the quality of their meteorological services and to achieve the goals of disaster prevention (Central Weather Bureau, 2009a). The second team is the contractor who is a design studio skilled in multimedia design and information visualization. The target project is to build a new typhoon warning briefing system. The four participants in the second team are a design manager, a programmer, an interface designer and a graphic designer. All are male with postgraduate degrees and the ages range from 26 to 35. The objective of this design project was to change the existing presentation type of typhoon warning briefing. Users of this briefing system are professional weather forecasters and meteorological analysts in the CWB. The project began with real-time touch control handled by the weather forecaster to explain the typhoon warning briefing. The second feature was to integrate typhoon information and provide the weather forecaster with a flexible operation through an interface design in the typhoon warning briefing system. A professional image and service quality were expected to be the achievement through the public release of typhoon warning briefing from the proposed system. The design development process of the typhoon warning briefing system (TWBS) project is shown in Fig. 4. The design communication process is divided into the following two stages:

(1) Design specification and design proposal stage:
This stage allowed initial contact for the purpose of reaching mutual understanding and trust through intensive meteorological data, information and knowledge transfer. There were also many presentation meetings held to communicate the design philosophy with each other and recognize the design values in common. Face to face communication was performed mainly in this stage.

(2) Interface design and information visualization stage:
In this stage, briefing meetings were initially used to discuss the design progress using FTF communication. The results of these meetings guided data and information collection from the meteorological team for further design purposes. The procedure consisted of providing data, making requests, proceeding designs, demanding revisions and modifying designs. Due to the various demands requested by the meteorological team causing frequent design modification, the design team identified severe problems of redundant design and inconsistent versions. The confused situation is shown in Figure. 5.

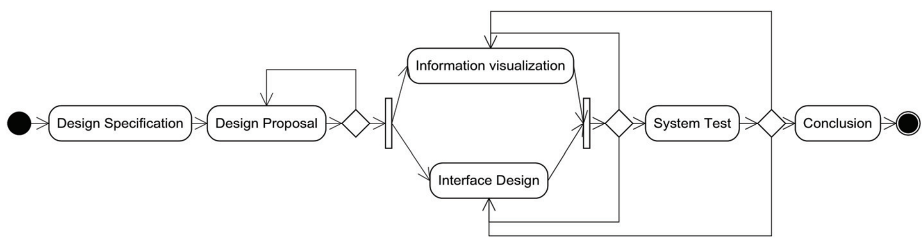

Figure 4. TWBS Design Project Process

After examining the design communication process, deviation caused by different professional perspectives and languages were labeled and discussed as follows.

(1) Briefing Meeting:

The progress report was carried out by FTF communication. FTF has important advantages in the sense of close communication through spoken language, written language, graphic language and body language. However, it is very time consuming for use in design discussions due to preparing briefing materials.

(2) Interactive discussion during design process:
This kind of discussion in design communication is the most complicated, especially in the step of "temper mind" mentioned above. The meteorological team brought up design demands and offered four kinds of data: original drawings, sketches, content descriptions, and fuzzy concepts. Original drawings included blueprints, meteorological maps, and different kinds of statistical graphs and data. Sketches were hand drawings depicting ideas and partial manuscripts. Content descriptions explained the demands either in oral or written form; and fuzzy concepts were just a very vague concept, such as feeling of a non-artistic idea. Among them, original drawings and sketches had the highest degree of accurate communication, and the other two kinds provided respectively low accuracy. Unfortunately, content descriptions and fuzzy concepts were very often used in this design project and resulted in inconsistency between design outcome and original demand.

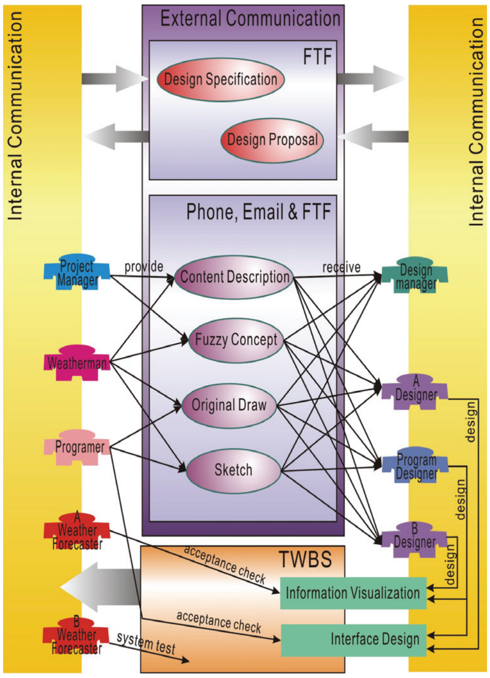

Figure 5. TWBS project without CMCS.

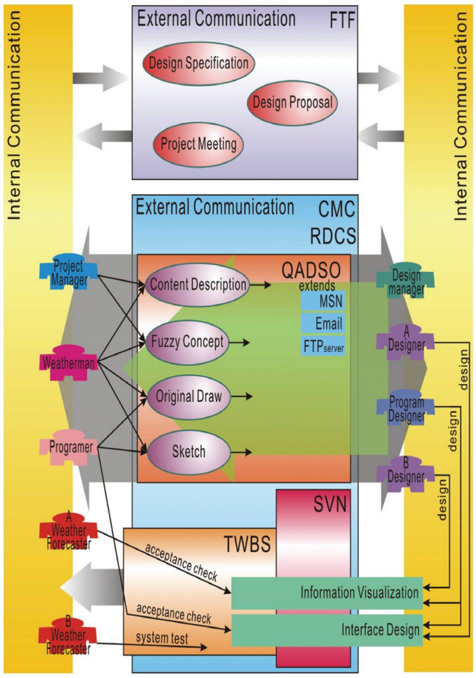

Figure 6. TWBS project using CMCS.

(3) Contact channel:

As shown in Fig. 5, requests from every meteorological team member forced immediate design changes. The redundant contact channels had caused out of control situations. The design team was unable to judge the exactness of the information due to misunderstanding or information omitted in the process. The design project eventually revealed severe schedule delay caused by poor design communication. For this reason the design team decided to introduce CMCS to assist the design communication and speed up the remaining project progress.As a result, both time for the interactive discussion during design process and file transfer were substantially reduced. The CMCS tool used in this design project was River Design Communication System (RDCS) and divided into SVN program and Q&A Database System Online program as shown in Fig. 6, and discussed as follows:

(1) SVN (Sub-version) program:
TWBS project applied the SVN program to integrate version management and avoid communication error resulting from version inconsistency. SVN can reveal the revised content among versions and upgrade the content conveniently and immediately. It improved the efficiency of design communication and accuracy of design changes.

(2) Q&A Database System Online (QADSO) program:
The telephone is the most easily used communication tool but lacks a recording function during the design project. Email is sometimes hard to integrate communication content due to repetitive sending. In real cases, papers and electronic files are frequently used for recording functions in briefing meetings. In order to completely record the historical data of the design project, the TWBS project also used a mode of instant online communication - Q&A Database System Online (QADSO). Both sides of the communication used QADSO synchronously to record various design information, solve problems and revise designs online in real time, as shown in Fig. 7. The design team used QADSO to enable fast reaction to design communications and rapid data and information transfer. This program utilizes spoken language, written language and graphic language to reduce misunderstandings of the design, as shown in Fig. 8.

(3) Combining other CMC tools with RDCS:
Other CMC tools such as Email, MSN, and FTP can also be combined with RDCS. The TWBS project connected team members by using three CMC tools: Email to send and receive formal meeting records and data, MSN to offer instant communication, and an FTP server to deal with large-scale file transfer.

This collaborative design system removed the restrictions of location both in briefing meetings and design discussion meetings, and greatly reduced the time for communications after introducing RDCS. Both meetings could handle real-time design discussions and revisions and reduce the cognitive difference through online meeting mechanisms. A single contact channel is applied to avoid chaos, confusion, and omission of information during design communications. Take the “Main Navigation Menu” design as an example, the frequency of design change became less. Each period lasted for approximately two weeks. In the first three periods, the ide gap between interpretation and comprehension induced frequent design changes. Starting from the fourth design period, this project applied the RDCS system, which improved the quality of design communication. It showed that design change had minimized to an acceptable level in the subsequent periods due to better understanding of design requirements. Since the TWBS project was a totally new project executed by both sides, the issue of the efficiency of the proposed framework was conducted by a satisfaction survey and in depth interviews with all project members (five from CWB and four from the design studio) at the end of the project. twelve open interview questions were asked to gather opinions on design communication, RDCS introduction and future suggestions. A satisfaction survey with 10 questions and measured by a 5-point Likert scale (degree of agreement) was conducted regarding RDCS. Both designers and programmers agreed that RDCS could efficiently support design communication in the TWBS project. Overall, all nine members from both teams averaged a score of 4.11 (1 being low and 5 being high) to show the recognition of help from CMC-based communication mechanism embedded in RDCS. However, an interesting response from the CWB team showed that administrative staff preferred FTF communication and mostly by phone call. The main reason was that online system communication needs written, spoken and graphic languages which are expertise usually not owned by the administrative staff. This raises an important question about how we can construct a visual environment to assist team members in this kind in design communication in the future.

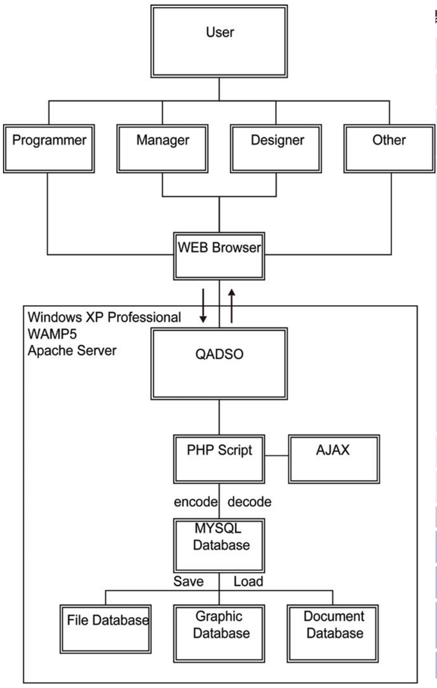

Figure 7. The framework of QADSO.

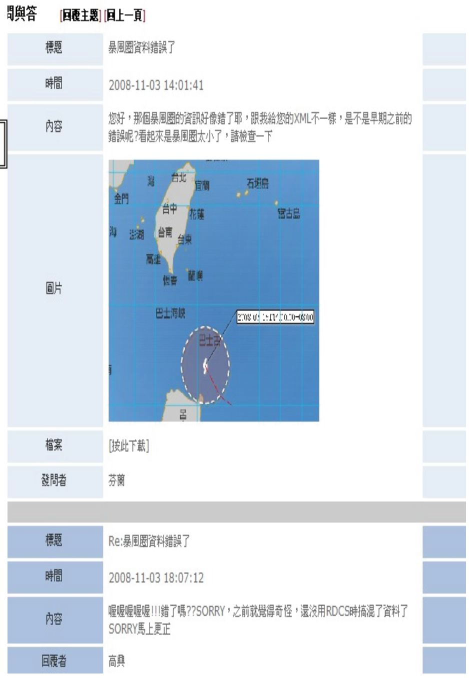

Figure 8. Detail contents of QADSO.

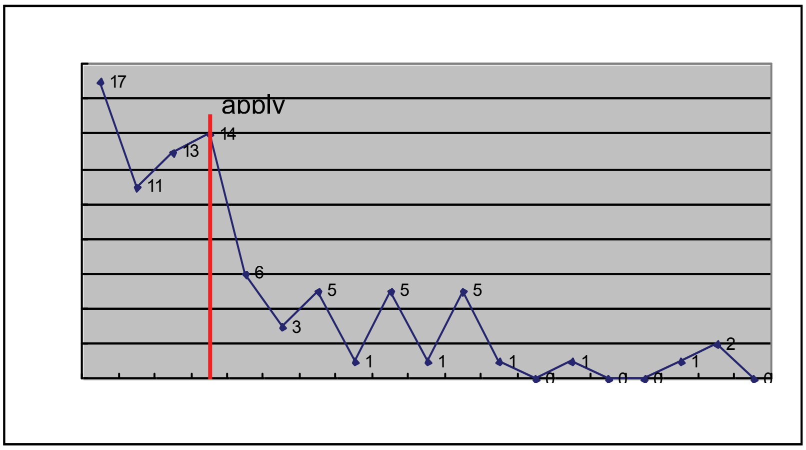

Figure 9. The situation of design change for main navigation menu.

Based on the results collected from the interview session the strengths of the proposed framework are listed as follows: 1) improve mutual trust between two teams, 2) increase communication accuracy by visualization, 3) reduce data transformation errors, and 4) reduce design changes. However, due to the project time limitation, the internalization of design knowledge was not sufficient. This issue as well as the integration with future new versions will be discussed in a future study. As a summary, the design team was glad to know that the Weather Bureau had started using TWBS before No. 6 typhoon's approach to Taiwan at 13 July, 2009 as shown in Fig. 10 (Central Weather Bureau, 2009b).

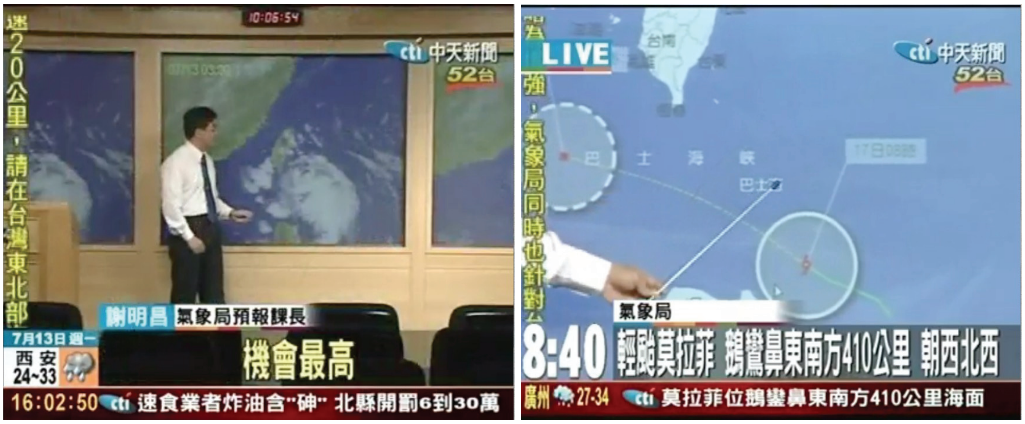

Figure 10. Using TWBS before No.6 typhoon's approach (Central Weather Bureau, Taiwan, 2009b).

6. CONCLUSIONS

Design communication is extremely important for a design team to perform a design project efficiently. It determines the chance of project success based on the degree of efficient design communication. As shown in the case study, interactive expression, single contact channel and consistent design information transfer will have a positive influence on the design project. This paper proposes a framework for managing a communication-based collaborative design process which defines the intention of design communication - work group coordination, relation connection, knowledge sharing, and cognition integration. The design communication cycle includes four steps: interpret design, comprehend design, temper minds and generate consensus. Finally, the application of computer-mediated communication in the collaborative design project addressed in this case study has shown an improvement in communication within the design team. Future studies will focus on the dynamic features of design processes and automatic design knowledge identification for collaborative NPD projects.

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