

## ENHANCING CONSTRUCTION INTERFACE MANAGEMENT USING MULTILEVEL INTERFACE MATRIX APPROACH

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**Abstract.** Many interfaces typically exist in the construction phase of a project. Since project participants usually fail to share interface information, most interfaces are difficult to solve effectively during that phase. Furthermore, future activities might not be implemented based on changes made by predecessors. In practice, failure to manage interfaces may result in additional work or in low project performance. In order to manage construction interfaces effectively, this study proposes the novel Multilevel Interface (MI) Matrix approach to enhance interface management during the construction phase of construction projects. By using the MI matrix approach, construction interface issues will be tracked and managed easily and effectively. Furthermore, this study develops a construction web matrix-based interface management (WMIM) system integrated with the proposed MI Matrix approach. The MI matrix approach and WMIM system are applied to a pilot test to illustrate how to support interface management during the construction project. As results of the pilot test indicate, the MI matrix approach and WMIM system provide an effective interface management tool for the construction phase.

**Keywords:** interface management, project management, web-based system, information management, interface matrix.

### 1. Introduction

Many organizations coordinate and collaborate with others in order to achieve the objectives of a construction project. Construction projects have become extremely complex with many organizations working together. Thus, project managers must deal with more complex interfaces than ever before, such as managing both internal and external interfaces. Internal interface is the interaction of implementing a job within a single organization, while external interface is the interaction of different organizations doing a job (Healy 1998). For the project management, project participants often complete their individual activities based on their viewpoint (Shen *et al.* 2007). Communication and interaction among the organizations is very important for the success of a project. Under best conditions, it is a match between interfacial parts, such as physical and operational compatibility, which is difficult to achieve (Chua, Godinot 2006). During the construction phase, interface problems often occur due to informational gaps among participants which lead to errors. Therefore, effective and efficient approaches should be applied and integrated in project management to manage and track the status of interface problems. The management of interface problems involving people, components, systems, and concepts is called Interface Management (IM) (Nooteboom 2004). The failure of IM may result in low productivity, low quality construction, problems, and increased cost (Chen *et al.* 2008). Addi-

tionally, if interfaces are not managed well during the construction phase, it may result in rework, wasted time, increased costs (Sundgren 1999), and poor project performance.

Construction management should see benefits in construction projects when interfaces are well managed and the IM is applied and well implemented. Although the interface matrix was applied in the construction interface management, it was difficult and complex for users to retrieve the information of interfaces and to track the recent status of interfaces in procedure. In order to solve this problem, the Multilevel Interface (MI) Matrix approach and the construction interface management system were proposed for this study in order to enable participants to manage interfaces efficiently. With the combined MI matrix approach and the construction interface management system, interface issues can be easily tracked and controlled (see Fig. 1). The MI matrix mainly facilitates and easily and efficiently acquires the interface information related to people, events, and time interfaces. The main advantage of the MI matrix is its ability to provide interface relationships between participants for each issue, present activity sequence in the matrix, and enable users to directly identify the clear status information of interface issues. Finally, this study develops a construction web matrix-based interface management (WMIM) system based on a proposed MI Matrix approach for project participants. The MI Matrix approach and WMIM system are applied on a pilot test to illustrate how to

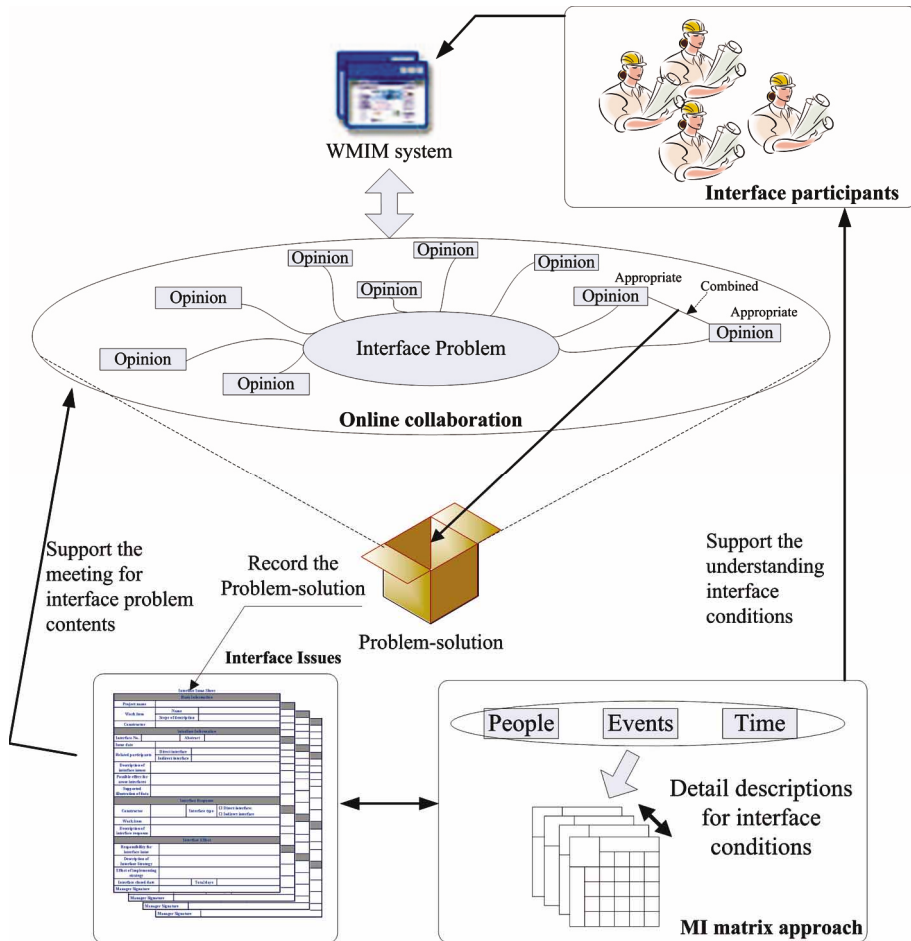


Fig. 1. The application of interface management in construction projects

support IM during the construction project. The results of the pilot test indicate the MI matrix approach and WMIM system provide an effective interface management tool in the construction phase of the project.

## 2. Literature review

A construction project includes many interfaces, such as the technical, contractual, organizational, physical, and time interface (Pavitt, Gibb 2003; Stuckenbruck 1983; Healy 1998). Interface issues arise when the boundary between systems cannot be controlled due to interfacial mismatch (Chua, Godinot 2006). Interfaces should be identified along with how they may affect a project as the interface issue appears (Pavitt, Gibb 2003). Interface issues, such as mismatched parts, coordination difficulties, or systems performance failure negatively impact the performance of construction projects (Chen *et al.* 2008). There are researchers who have proposed approaches to support IM, such as the application of a WBS matrix to manage interfaces between systems and activities (Chua, Godnot 2006), using a cause and effect diagram to analyze affected interface factors of a project (Chen *et al.* 2008), and decreasing the number of interfaces by integrating the dependent structure matrix into the design phase (Chua *et al.* 2003). These events stem from a lack

of communication among participants and poorly defined and coordinated responsibilities. Communication problems among participants can deteriorate on-site work (Park *et al.* 2010). Effective sharing of interface information can decrease interface events or issues that may arise during the construction phase or between the design and construction phases (Lin 2009; Siao, Lin 2010). Senthilkumar *et al.* (2010) can also help in the communication for the design to enhance design IM by the developed web-based system. Overall, insufficient information prevents the implementation of interface-related work (Chen *et al.* 2010). Currently, 3D/4D modeling for the building is used to represent spatial discussions, such as activity sequencing, constructability, and conflict. (Emerging Construction Technologies 2009). Also, new building information modeling is applied to present the integral building information for various phases of a project within the unified data repository (Gu, London 2010). Consequently, effective communication can improve interfaces while IM manages the common boundary of organizations or phases via communication and coordination processes (Wideman 2002).

Despite many articles and system developments in academic and practice literature, there is a lack of easy and friendly platforms to track and manage interface events and problems during the construction phase.

### 3. Methodology

To assist the IM implementation, the construction interface management procedure and a MI matrix are used in this study. By using the MI matrix and following the proposed IM procedure for dealing with interface issues, interface issues can be managed and tracked effectively.

#### 3.1. Procedure of construction interface management

This study proposes a procedure for construction interface management in implementing IM. The proposed construction interface management procedure consists of five phases (see Fig. 2), as follows: interface collection, interface identification, interface review and submission, interface communication, and interface closing. After an interface issue arises during the construction phase, data related to the problem is collected, problem statements are proposed, and attributes (such as the interface type) are identified. Related participants meet to exchange opinions and offer solutions to address the interface issue. During the solution implementation, the interface issue

must be tracked to ensure that the solution is appropriate. All interface information must be stored to be used as reference in future projects.

#### Interface collection

Interface collection is the first step in dealing with any interface problems. When an interface problem is encountered, the problem must be identified and the issue described by the interface proposer, including interface issue subjects, date, and problem statements. The interface proposer can also collect related information/data to support the proposed problem statements.

#### Interface identification

In order to understand interface problems in detail, the interface proposer also illustrates possible impacts of the project interface, the type of interface, and identifies the interface-related participants. These illustrations are a reference to support project participants in determining how to address interface problems. Finally, the interface proposer must submit the interface issue.

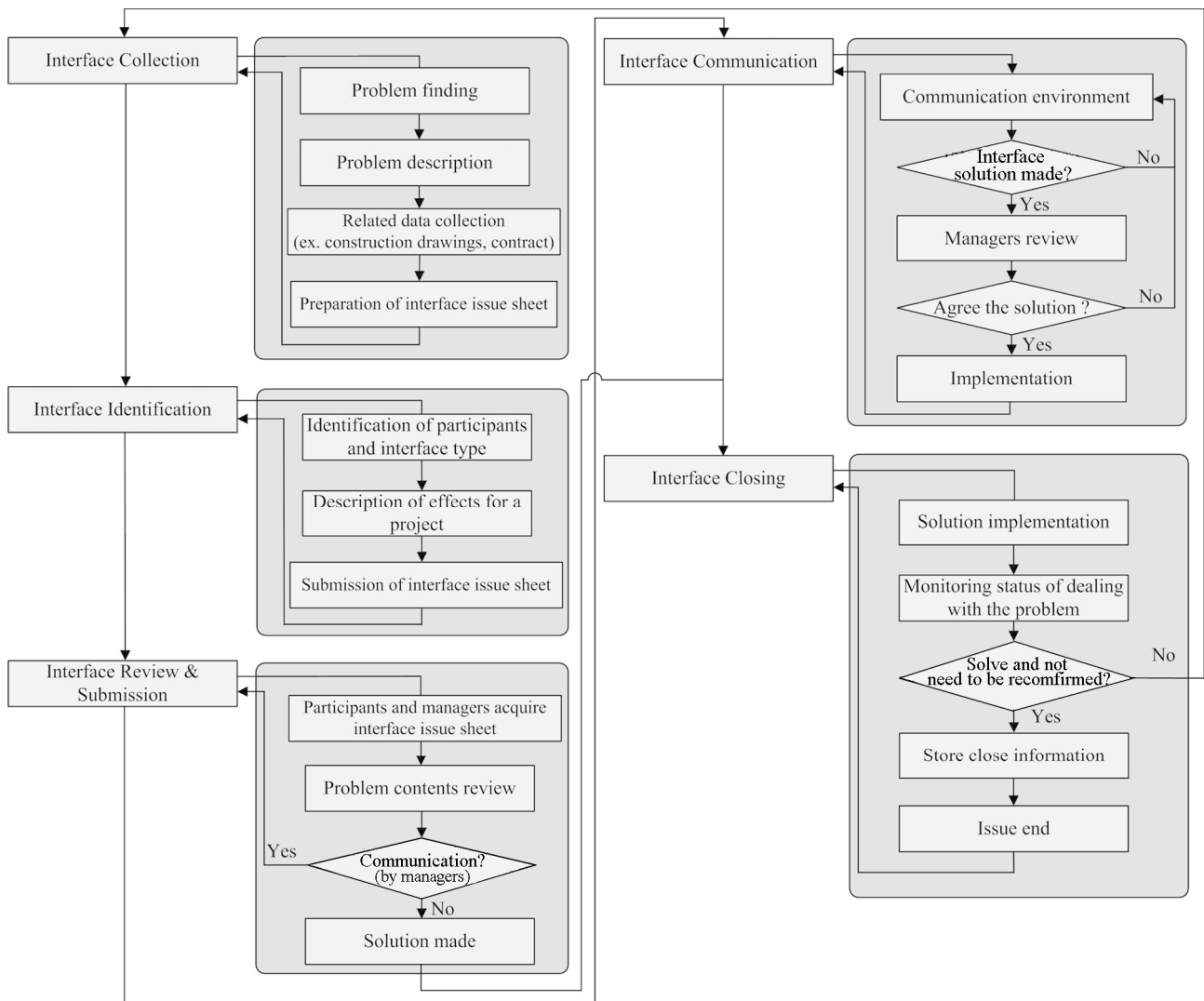


Fig. 2. Construction interface management procedure

### *Interface review and submission*

This phase mainly provides project participants the opportunity to handle the interface problems of a project. All interface issues that occur must be reviewed by project participants and managers to proceed with the following steps. When managers receive the interface issue, they are able to understand the problem from the detailed description of the proposed interface issue and know which participants are joined in this interface issue. Project participants and managers can check the assignments for each interface-related participant using the previously completed MI matrix. Identifying assignments effectively is important in determining assignment responsibility for interface issues during the communication. After managers understand and handle the latest condition of the interface problem, the issue is submitted and the follow-up communication phase is opened to solve the problem.

### *Interface communication*

Fig. 1 presents the communication and coordination framework for dealing with any interface issue. Project participants and managers may communicate to exchange information and combine appropriate opinions, and then find solutions for the interface problems. However, if the problem-solution is rejected by project managers, it may be that it is a complicated problem and the related participants must meet again to resolve it.

### *Interface closing*

When a problem-solution has been made and implemented, project participants and managers can monitor conditions to ensure that the problem-solutions are appropriate, and their descriptions recorded. If interface problems still exist, the interface management procedure must be re-implemented as a new submission to collect the related data, identify the new status of the interface issue and assignments, communicate and coordinate, and make new problem-solutions to address them. If interface issues are solved and do not need to be reconfirmed, the interface management process and results, including efforts in implementing problem-solutions and resolution date, must be stored.

## **3.2. Multilevel interface matrix approach**

A project usually includes dependent and interdependent activities. A dependent activity relationship means the succeeding activity requires acquiring information to begin a job, while activities that require information from each other to start the job and progress is an interdependent relationship. There are fewer interdependent activity relationships than dependent activity relationships in practice. Thus, the bulk of activities in a project are dependent. If the information exchange between activities is insufficient to provide valuable information for the follow-up construction, problems may arise due to incomplete information. In practice, some problems exist in using these meeting minutes related to handling the rela-

tionships between participants for each problem and the status of interface problems. In order to solve the problems, the interface relationships are categorized into direct interface and indirect interface. The relationship is the connection between activities. The predecessor must provide information to support the successor's implementation, and the relationship between the predecessor and successor is called Direct Interface. In practice, other participants may be involved in interface issues. Therefore, the relationship between the interface proposer and other project participants (who are not the predecessor or successor to the interface proposer) is called Indirect Interface. Both direct and indirect interfaces are applied in the proposed MI approach.

While the interface matrix is proposed and applied in construction interface management, it is too hard and complex for users to retrieve the information of interfaces and track their status in procedure. In order to solve the problem, this study proposes using the Multilevel Interface Matrix approach to enhance the interface management during the construction phase. The primary characteristics of the MI matrix approach are as follows: (1) the MI matrix shows interface information and status directly integrated with automatic updates and notices function in the matrix environment; (2) the MI matrix provides clear and dynamic interface-related information based on related interface events and participants; (3) the MI matrix is formed by crossing vertical factors for project participants, event, and time with a horizontal factor for the interface participants; and (4) successors can trace easily and effectively changed and updated situations and information of predecessors.

This proposed MI matrix approach includes a construction events matrix, an interface presentation matrix, and a construction interface network. The cells of the matrix can be marked to determine the assignments for project participants and to record information about interface issues. Participants can also obtain information related to the relationships of activities applying the sequencing function in the MI matrix. In the construction events matrix, the sequencing function proposed sequence sub-activities based on start-time for activities to present the dependence of sub-activities. By utilizing the sequencing function, users can identify the interface type, which indicates the direct interface, and can also acquire the information related to construction sequence. The construction events matrix displays the activities of a project according to the sequence of activities, allowing the identification of the construction sequence and direct interface relationship for participants. The assignments and construction schedule of each project participant for activities also are recorded in this matrix. The interface presentation matrix shows interface issues and interface relationships between project participants for each interface issue and such relationships include both direct and indirect interfaces. Finally, the construction interface network shows all interface conditions which include the presentation of direct and indirect interface relationships between project participants, and the number of interface issues and closed interface issues. In this network, inter-



face relationships for participants are shown by two types of lines, the entity line and the dotted line. The entity line indicates the direct interface relationship and the dotted line indicates the indirect interface relationship. The entity lines can be drawn between project participants according to the construction events matrix. Moreover, based on indirect interface issues recorded in the interface presentation matrix, dotted lines can also be drawn to connect the related project participants to clearly present the indirect interface relationships.

If any interface arose or if a situation changed during the construction process, they would be updated in the MI matrix to ensure that the interface information is current. The two interface sheets have been applied in this study, including the notice sheet and interface issue sheet. The notice sheet will be used before the activity is completed. The notice sheet records the preceding activity's scope, duration, and interface issues so the successor can know the condition of the predecessor's work and propose an interface problem he may find and request a response from the predecessor. Each interface problem is proposed by using the interface issue sheet. In the interface issue sheet, descriptions of work scope, the interface problem, the interface response, and the problem-solution are included. When managers have identified interface problems solved, efforts of the problem-solution implementation and the interface resolution date have to be recorded in the interface issue sheet. By utilizing the notice sheet and the interface issue sheet, interfaces will be tracked effectively during the construction phase of a project.

Fig. 3 describes the procedure for developing the MI matrix approach. In the first step, the construction events

matrix allows managers to directly mark assignments in related matrix cells to class work ranges of project participants for activities of a project. In the second step, the direct interface relationships between participants must be presented in the construction interface network according to defined dependence of activities in a construction events matrix. For example, in Fig. 3, contractors' works have been identified by the manager who marks what activities are done by whom in the construction events matrix. Because the set out activity (worked by Sub-contractor F, labeled S.C. F) and assembly of RF~PF of pillar of re-bars activity (constructed by Sub-contractor E, labeled S.C. E) are dependent and the S.C. F is a predecessor for S.C. E in these two activities, the direct interface relationship between S.C. E and S.C. F is identified in the construction events matrix. Then, the entity line can be drawn to connect S.C. E and S.C. F. All direct interface relationships can be drawn following similar reasoning.

Nevertheless, if the activities sequencing is not considered in the construction events matrix, errors in identifying direct interface relationships and the construction sequence may occur. For instance, one project has four activities: activity A, activity B, activity C, and activity D. Activity C is implemented first, followed by activity B, then activity D, and lastly, activity A. If these four activities are put in the construction events matrix and the activities sequencing is not considered, the direct interface relationship between activity A and B will be identified in the matrix. However, it is not a direct interface relationship because activity A is not the preceding work for activity B. Furthermore, it is easy to understand the relationships among activities using sequence function in the matrix.

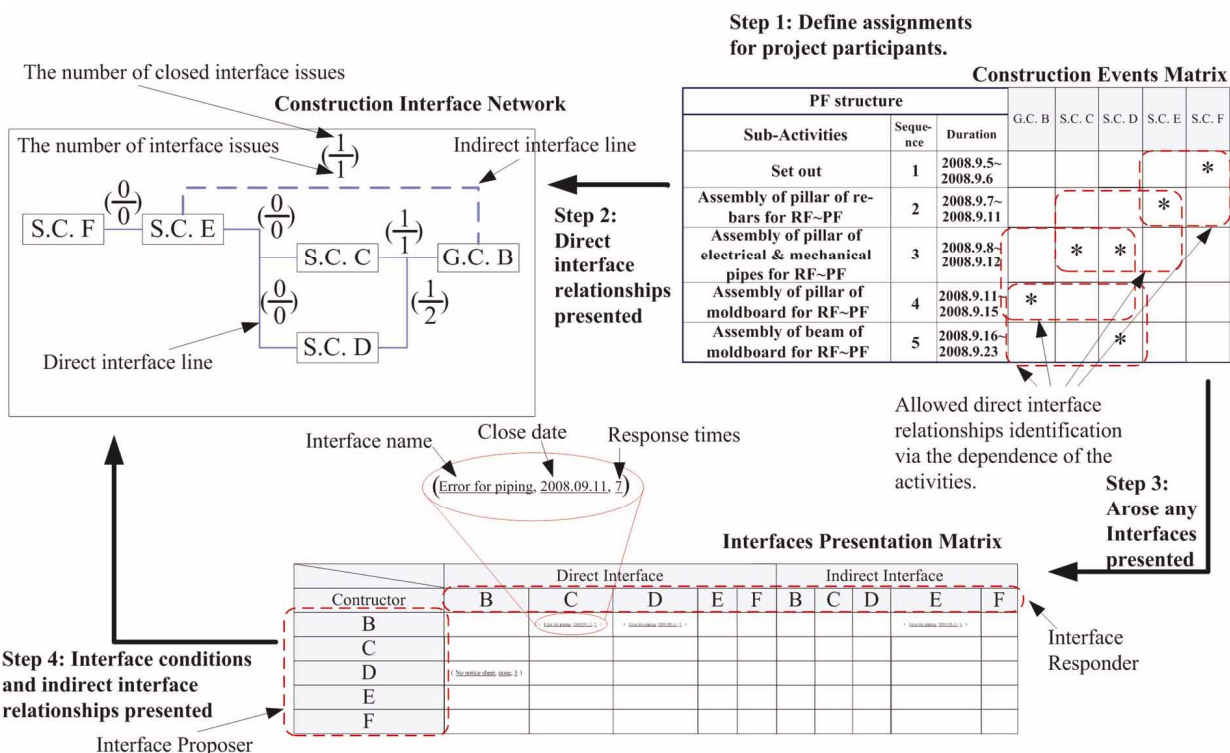


Fig. 3. The structure of Multilevel Interface Matrix

The third step is to present interface issues in an interface presentation matrix. Any occurred interface issue should be recorded, to include an assigned interface name, close time and the response times. For example, if General-contractor B (G.C. B) finds problems related to the work Sub-contractor C (S.C. C) constructed, G.C. B proposes the interface issue and then S.C. C must respond to G.C. B. At this time, the subject of this problem (same as interface name), close time, and response times will be recorded in the interface presentation matrix. Project participants and managers can use such information to handle problems existing between participants and to solve problems without reviewing other data. Furthermore, an interface issue may have both direct and indirect interfaces which must all be recorded in the interface presentation matrix.

The final step is mainly to present whole interface conditions between participants when any interface issue occurs, and that any indirect interface that occurs is recorded in the interface presentation matrix. Indirect interface relationships between project participants must be updated in the construction interface network using the dotted line. For instance, an indirect interface issue has occurred between general-contractor B (G.C. B) and S.C. E and recorded in the interface presentation matrix. Therefore, a dotted line must be drawn to connect G.C. B and S.C. E in the construction interface network (see Fig. 3). Interface conditions, which include the number of interface issues and close interface issues, are also recorded on the lines. For example, G.C. B and S.C. E have one indirect interface issue in the interface presentation matrix which has been closed (this information can be obtained from the interface issue), and recorded on the dotted line connecting them. Following this reasoning, whole interface conditions, including direct and indirect interfaces, can be presented. Managers can obtain information related to the status of interface issues in the construction interface network, such as knowing the number of problems presented and solved between participants.

#### 4. System implementation

The WMIM system is designed and developed based on the MI matrix approach. The WMIM system is applied on Microsoft Windows XP with Internet Information Services (IIS), such a system environment as a web server. The WMIM system is built by Active Server Pages with dot NET framework (ASP.NET). ASP.NET provides an approach to create dynamic web application and it can be used to design and develop the friendly-user interface of the WMIM system. There are three distinct layers in the WMIM system *which are* the presentation layer, the business layer, and the data access layer. Each layer does its own work to support the system. The presentation layer defines the level of browsing information with administrators and normal users, administrative and normal-user interfaces respectively. Users can obtain and propose any interface information via a browser such as Internet Explorer (IE) to connect in this system. Administrators not only are able to obtain requirements from this system

but can also control and manage interface data via the browser. Moreover, the proposed MI matrix approach can also be applied by administrators and normal users. The business layer consists of several application functions to support the system. These applications include indexing, interface matrixes, interface network, and communication functions. Finally, the data access layer provides a stored function for managed interface data within the Microsoft Access Server 2003 database. Administrators must back-up data to avoid losing and missing any interface information related to construction (see Fig. 4). Also, the WMIM system provides five services for interface management, including the interface events matrix, the interface presentation matrix, the construction interface network, online communication, and the interface sharing.

### 5. Pilot test

#### 5.1. Description of pilot test

The following pilot test involves a contractor with twenty years of specific experience in the Taiwanese high-tech building project. The high-tech building project involves the 1 general contractor and 3 subcontractors during the construction phase. Furthermore, the general contractor hopes to utilize interface management to manage interfaces effectively and enhance construction management. Therefore, the general contractor encourages all participants to use the WMIM system and manage interfaces effectively among participants for better interface management. During the construction phase, project participants can trace and manage interfaces, and changes regarding the construction phase of clear room in the high-tech plant. All project participants fully utilize the WMIM system for interface management. The general contractor applies the MI matrix to manage installation of building components. The mechanical, electrical and plumbing (MEP) engineers utilize the WMIM system to handle and trace interfaces when working on building heating, cooling, and plumbing subprojects. The subcontractors utilize the WMIM system to manage all interface problems. Fig. 5 presents the interface-sharing management in the WMIM system.

During the interface collection and identification phase, all interfaces were continually identified by responsible project participants or managers during the construction phase. In the beginning, the interface proposer entered the system and edited interface problems regarding to clean room construction in the WMIM system and waited the project manager approved. The interfaces included the "installation and test interfaces between MEP and construction Section" problem description, detailed situation description, and explanation of suggested solutions. After the project manager approved the issue, the interface proposer initially generated an MI matrix based on the interface requirement in the system. Also, the interface proposer checked and confirmed the interface information in the MI matrix. During the interface review and submission phase, responsible participants were invited to edit their comments related to the "installation and test interfaces between MEP and const-

reduction Section” problem in the WMIM system after the MI matrix was generated. When the identified interface began to be traced, the system showed the latest status and result for each interface. Participants could access related interfaces directly by clicking on cells in the MI matrix. During the phase, the notice sheets and the interface issue sheets were utilized in the implementation of IM. Furthermore, all interfaces were centralized and sto-

red in the central database to avoid adding redundant data.

During the interface communication phase, project participants communicated with each other regarding selected interface issues in the WMIM system and shared latest interface information. All participants had to edit their responses relative to the interface issues for which they were responsible. Each participant presents their

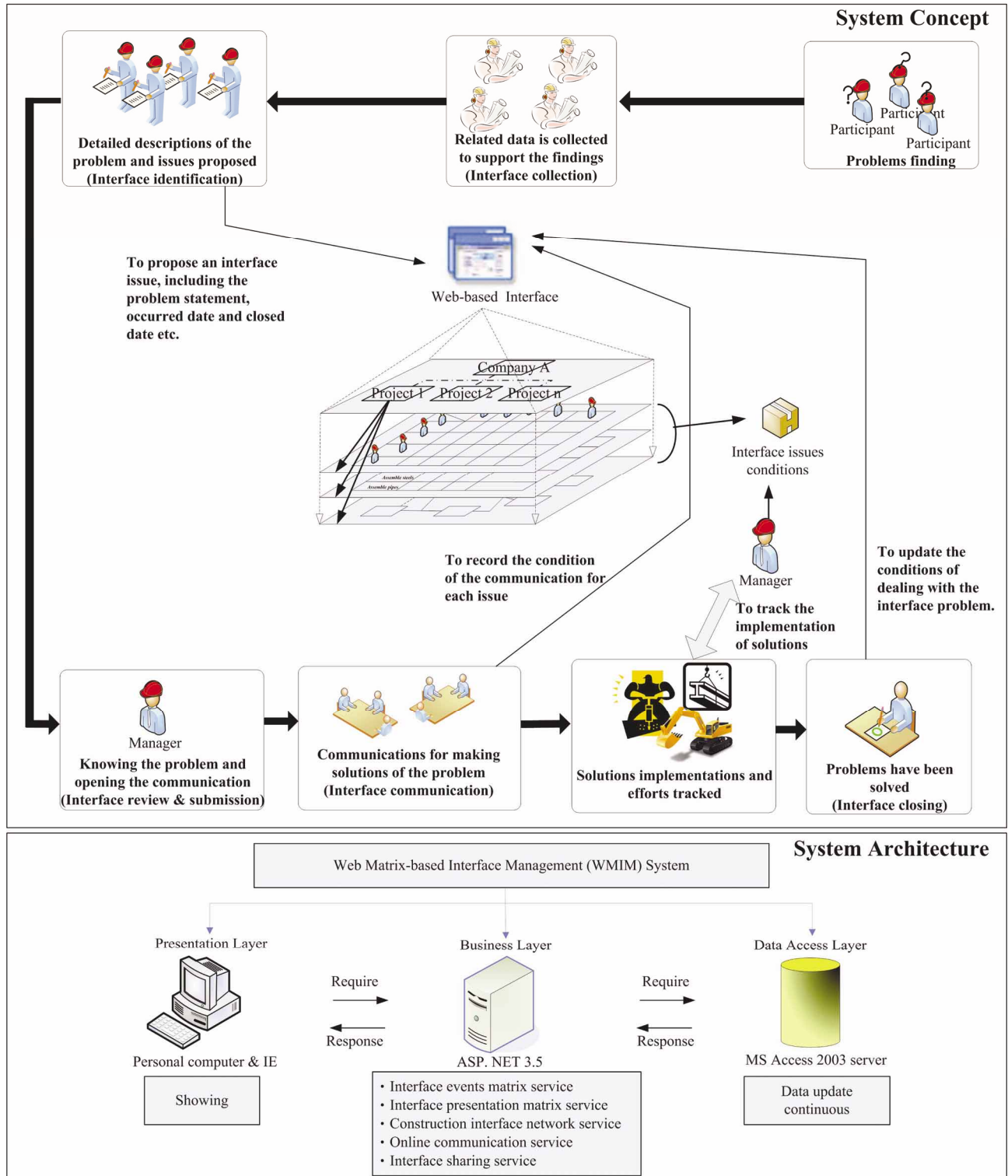


Fig. 4. The structure of the WMIM system



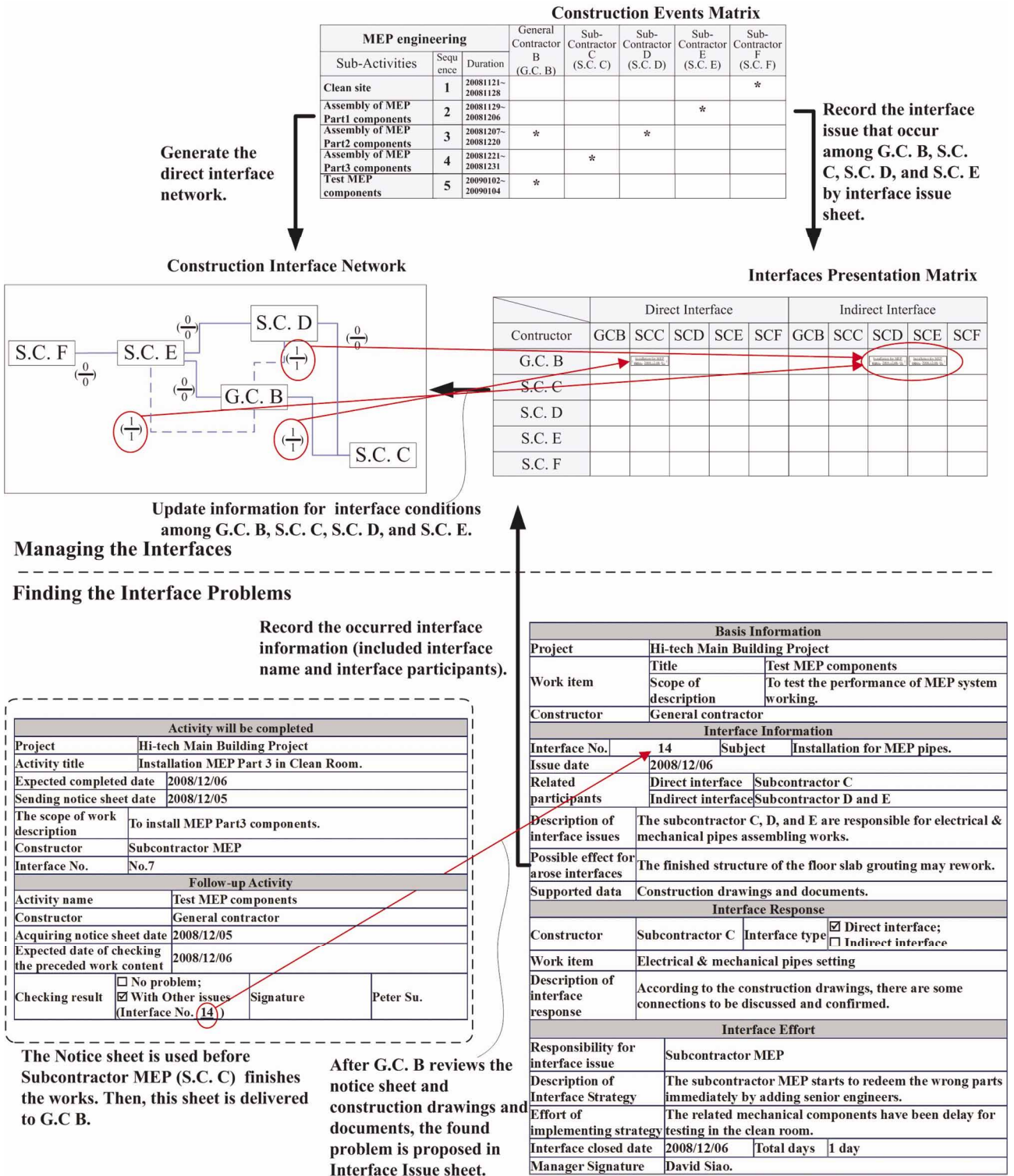


Fig. 5. The interface-sharing management in the WMIM system

explanations and comments in the WMIM system in order to share interfaces issues with others. In the test, one construction engineer utilized the WMIM system to discuss the two mechanical engineers regarding to the interfaces. Furthermore, the project manager utilized the WMIM system to request the responses and related two electrical participants who were involved in the interface. The electrical participants also noted the descriptions for

interfaces with digital video. Finally, all records of interface processes would be saved and traced all the time. Some of interfaces didn't be responded or processed in the assigned time would be traced and pushed again by the WMIM system. Furthermore, project managers and related participants could trace and manage effectively all well-done interfaces or processed interfaces during the construction phase. The two electrical participants began



to respond to the requests. Furthermore, the mechanical engineer provided solutions and feedback, and offered suggestions regarding the interface. Numerous requests and comments regarding the interface were communicated among all related participants during the phase. Furthermore, the interface proposer encountered numerous problems that could not be solved by other participants. The interface proposer requested assistance from other senior engineers involved in other related projects to handle problems directly using communication services in the WMIM system. After receiving comments and assistance from all related participants, the interface proposer solved the problem and shared the interface results and solution with others.

During the interface closing phase, the interface proposer identified the whole process of the interface which had been finished without any further confirmation and assistance from related participants. The interface proposer submitted the interface closing action and waited for the project manager's confirmation. The project manager finally confirmed the action. The status of the interface was updated in the WMIM system after completing the process, and a notice and report were transmitted by e-mail to the project manager and authorized participants.

## 5.2. Pilot test results and discussions

Overall, the pilot test results demonstrated that the WMIM system is an effective and simple platform for construction interface management, especially for the general contractor and subcontractors. The WMIM system was installed on the general contractor's main server during the test. During the pilot test, verification and validation tests were performed to evaluate system functions. The verification test determined whether the system operated correctly according to the system design, while the validation test evaluated the system's usefulness. The verification test was performed by assessing whether the WMIM system performed tasks as specified by the system design. In the validation test, selected case participants were asked to use the system; project teams then provided feedback by answering a questionnaire. The pilot test participants consisted of two subcontractor engineers with 5 years of experience, two senior engineers and one project manager with 10 years of experience as general contractors. To evaluate system functions and user satisfaction with system capabilities, questionnaires were distributed by using a five-point Likert scale, ranging from 1 for "not useful" to 5 for "very useful". Questionnaire results indicated that the performance of interface management implementation was significantly improved (see Table 1). Comments regarding improvements to the WMIM system were also obtained from project participants (general contractor and subcontractors). Fig. 6 presented the screen of the WMIM system used in the Pilot Test.

The lessons learned from the pilot test are as follows: (1) each project participant should be responsible and high support for IM works; (2) project managers should join IM team since the MI matrix requires them to

**Table 1.** System evaluation results

Functionality of system	Mean Score
Ease of Interface Tracking	4.2
Ease of Interface Sharing	3.8
Applicability to Construction IM	4.3
Use of system	Mean Score
Ease of Use	3.7
User Interface	3.7
Over System Usefulness	4.0
Capability of system	Mean Score
Reduces Unnecessary Costs	4.1
Reduces Rework	4.2
Ease of Accessing Interface Records	4.2
Improves Interface Communication	4.3
Enhances Interface Sharing	4.5
Improves Interface Management	4.6

Note: the mean score is calculated from respondents' feedback on  
Five-scale questionnaire: 1(Strongly Disagree), 2, 3, 4 and 5 (Strongly Agree)

assign and manage interface-related assignments; (3) e-mail notice service is very important for IM to notice all responsible participants to respond the interfaces in the WMIM system; (4) the MI matrix is the friendly and simple tool for identifying, managing and tracking interfaces; and (5) the on-site engineers may use mobile devices or smart phones in the jobsite to utilize the WMIM system directly for IM works.

Questionnaire results indicate that the primary advantages of the MI matrix are (1) the MI matrix shows easier and clearly interface information and status than previous interface matrixes; (2) the MI matrix provides clear and dynamic representations, thus identifying the relationship of interface-related participants relevant to interface events; (3) the MI matrix clearly identifies available interface information in the matrix-based environment; (4) the MI matrix approach easily provides automatic corrections and notices when interfaces and changes are made to a current project; and (5) users can trace changed situations and information of predecessors easily and update the changed situations for the successors effectively.

The following recommendations are based on received feedback: (1) policy and strategy must be considered to encourage the use of the WMIM system because its effective use requires that changes be made to almost every aspect of a firm's business; (2) further effort is required to update interface information related to various interfaces in the WMIM system; (3) most project participants require substantial time and assistance to edit interface information; (4) training and workshops for the WMIM system are necessary and beneficial for all users; and (5) the WMIM system may be integrated with web-based project management in the future.

The feedback results indicated that the primary barriers to using the WMIM system were as follows: (1) it was inconvenient for on-site engineers to edit or respond

interfaces directly using the notebooks; (2) substantial time and assistance was needed for engineers and managers to edit and update the interface information; (3) some of the project participants and top management did not pay attention to the IM work; and (4) low willingness of project participants to share related interface information.

6. Conclusions

The application of interface management is to allow project participants to efficiently understand and manage the whole status of interfaces. The MI matrix proposed in the study allows project participants to easily present the

identified interface problems and handle them effectively. Overall, the MI matrix approach enables project participants to track the condition of managing interface problems that occur without reviewing other data. By using the MI matrix, interface relationships, including both direct and indirect interfaces, and interface conditions can be presented for project participants in a construction interface network. The results based on pilot test indicate that the MI matrix is an effective approach for construction interface management. The MI matrix significantly enhances the performance in tracing and managing construction interfaces. Also, the application of the notice sheet and the interface issue sheet are used in the IM

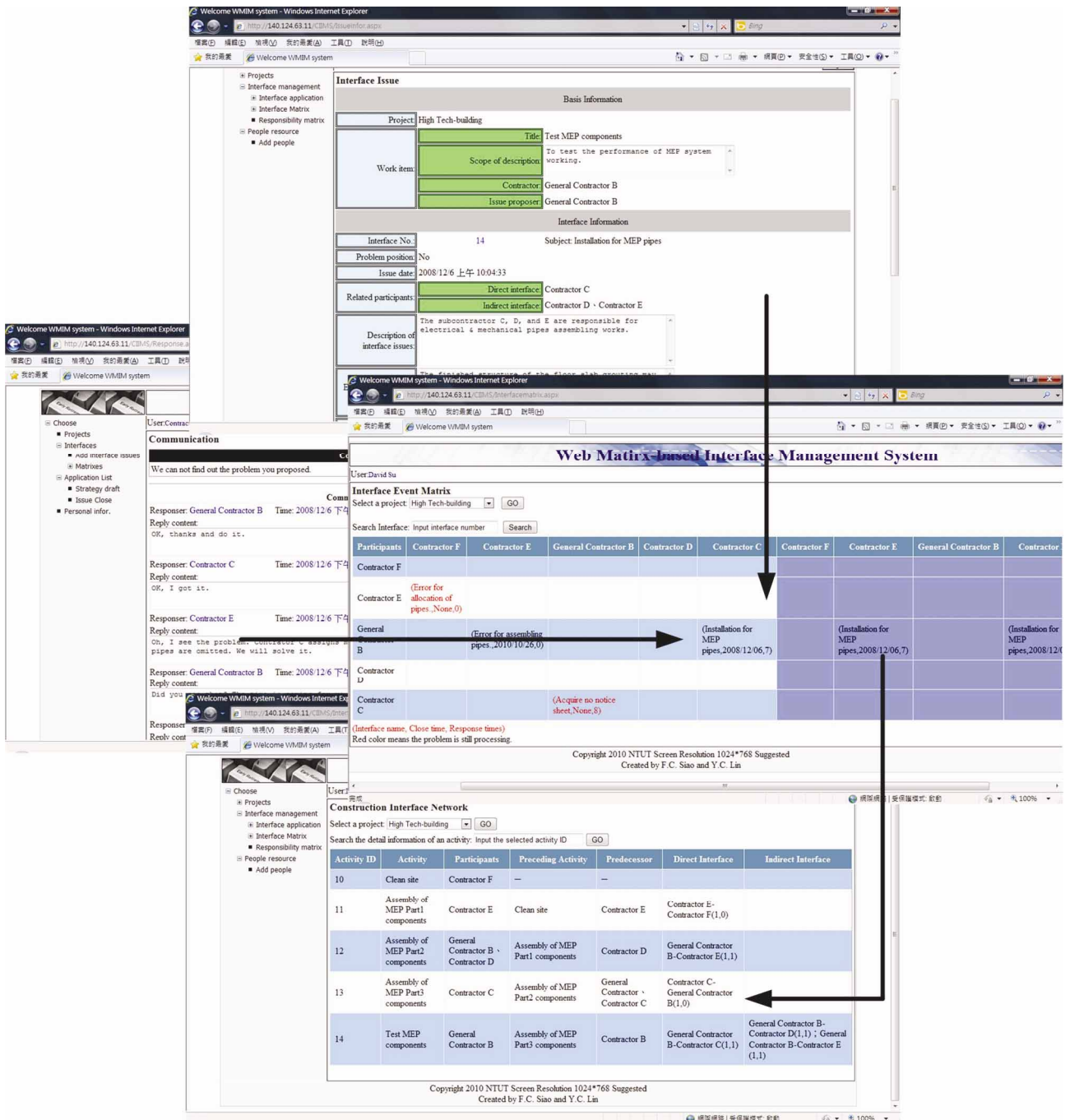


Fig. 6. The screen of the WMIM system using in the Pilot Test

procedure to implement an effective IM system. The application of the interface issue sheet presents problem statements, interface types, problem-solutions, and implemented efforts. Furthermore, the successor can review the construction conditions of the predecessor's work after acquiring the notice sheet provided by the predecessor. And interface problems can be detected early via the notice sheet and interface issue sheet to decrease negative impacts for a project. Finally, this study develops a construction web matrix-based interface management (WMIM) system integrated with the proposed MI matrix approach for project participants. By utilizing the WMIM system, whole interface-related information sharing can be tracked and managed effectively for project participants. Furthermore, the MI matrix approach and the WMIM system are applied to a pilot test to illustrate how to support interface management during the construction project. The results of the pilot test indicate the WMIM system integrated with the MI matrix approach provides an effective interface management tool in the construction phase of the project.

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### References

- Chen, Q.; Reichard, G.; Beliveau, Y. 2008. Multiperspective approach to exploring comprehensive cause factors for interface issues, *Journal of Construction Engineering and Management* ASCE 134(6): 432–441. doi:10.1061/(ASCE)0733-9364(2008)134:6(432)
- Chen, Q.; Reichard, G.; Beliveau, Y. 2010. Object model framework for interface modeling and IT-oriented interface management, *Journal of Construction Engineering and Management* ASCE 136(2): 187–198. doi:10.1061/(ASCE)CO.1943-7862.0000120
- Chua, D. K. H.; Godinot, M. 2006. Use of a WBS matrix to improve interface management in projects, *Journal of Construction Engineering and Management* ASCE 132(1): 67–79. doi:10.1061/(ASCE)0733-9364(2006)132:1(67)
- Chua, D. K. H.; Tyagi, A.; Ling, S.; Bok, S. H. 2003. Process-parameter-interface model for design management, *Journal of Construction Engineering and Management* ASCE 129(6): 653–663. doi:10.1061/(ASCE)0733-9364(2003)129:6(653)
- Emerging Construction Technologies. 2009. 4D modeling. [cited Jan. 19, 2011]. Available from Internet: <http://rebar.ecn.purdue.edu/ECT/links/technologies/other/4d.aspx>.
- Gu, N.; London, K. 2010. Understanding and facilitating BIM adoption in the AEC industry, *Automation in Construction* 19(8): 988–999. doi:10.1016/j.autcon.2010.09.002
- Healy, P. 1998. *Project management: Getting the job done on time and in budget*. UK: Butterworth-Heinemann. 300 p.
- Lin, Y.-C. 2009. Developing construction network-based interface management system, in *Proc. of the 2009 Construction Research Congress*, 4–7 April, 2009, Seattle Marriott Waterfront. USA: Seattle, 477–486.
- Nooteboom, U. 2004. Interface management improves on-time, on-budget delivery of megaprojects, *JPT Online*, The Society of Petroleum Engineers, August, 32–34.
- Park, M.; Lee, H.-S.; Kwon, S. 2010. Construction knowledge evaluation using expert index, *Journal of Civil Engineering and Management* 16(3): 401–411. doi:10.3846/jcem.2010.46
- Pavitt, T. C.; Gibb, A. G. F. 2003. Interface management within construction: in particular, building facade, *Journal of Construction Engineering and Management* ASCE 129(1): 8–15. doi:10.1061/(ASCE)0733-9364(2003)129:1(8)
- Senthilkumar, V.; Varghese, K.; Chandran, A. 2010. A web-based system for design interface management of construction projects, *Automation in Construction* 19(2): 197–212. doi:10.1016/j.autcon.2009.10.007
- Shen, L.-Y.; Hao, J. L.; Tam, V. W.-Y.; Yao, H. 2007. A checklist for assessing sustainability performance of construction projects, *Journal of Civil Engineering and Management* 13(4): 273–281.
- Siao, F. C.; Lin, Y. C. 2010. The Development of the Assistant Interface Management and Collaboration System in Construction, in *Proc. of the 2010 International Conference on Environmental Science and Development (CESD 2010)*, 26–28 February, 2010, Singapore, 454–458. doi:10.1080/13923730.2007.9636447
- Stuckenbruck, L. C. 1983. Integration: The essential function of project management, in D. I. Cleland, W. R. King (Eds). *Project Management Handbook*. New York: Van Nostrand Reinhold, 56–82.
- Sundgren, N. 1999. Introducing interface management in new product family development, *Journal of Product Innovation Management* 16(1): 40–51. doi:10.1016/S0737-6782(98)00035-6
- Wideman, R. M. 2002. *Wideman comparative glossary of project management terms v3.1*. [cited Jul. 19, 2010]. Available from Internet: <http://www.maxwideman.com/pmglossary/PMG\_I03.htm>.

## RYŠIŲ VADYBOS STATYBOJE GERINIMAS TAIKANT ĮVAIRIALYGIŲ RYŠIŲ MATRICOS METODĄ

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### Santrauka

Statybos projekto statybos darbų etapui būdinga tai, kad su įvairiais subjektais palaikoma gausybė ryšių. Daugumą jų šiame etape veiksmingai palaikyti dažniausiai ne itin lengva, nes projekto dalyviai paprastai informacija apie juos nesidalija. Be to, perimantys darbą gali ir nesiremti savo pirmtakų padarytais pakeitimais. Praktinė prasme nesugebant valdyti ryšių, gali tekti darbus perdaryti arba projekto efektyvumas gali sumažėti. Efektyviam su statyba susijusių ryšių valdymui šiame darbe siūlomas novatoriškas įvairialygių ryšių (ĮR) matricos metodas, leidžiantis pagerinti ryšių valdymą statybos projekto statybos darbų etape. Taikant ĮR matricos metodą lengva veiksmingai sekti ir valdyti statybų ryšių klausimus. Be to, atliekant tyrimą sukuriama projekto dalyviams skirta internetinė matricinė statybų ryšių valdymo (WMIM) sistema, į kurią įtrauktas siūlomas ĮR matricos metodas. Taip pat, taikant ĮR matricos metodą ir WMIM sistemą, atliekamas bandymas, rodantis, kaip jie padeda valdyti statybos projekto ryšius. Bandymo rezultatai rodo, kad ĮR matricos metodas ir WMIM sistema – tai efektyvi ryšių valdymo priemonė statybos darbų etape.

**Reikšminiai žodžiai:** ryšių valdymas, projekto valdymas, internetinė sistema, informacijos valdymas, ryšių matrica.

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