A CONCEPTUAL MODEL FOR
WEB-BASED CONSTRUCTION PROJECT MANAGEMENT

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<td>3-Dimensioned</td>
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<td>AAM:</td>
<td>Application Activity Model</td>
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<td>AEC:</td>
<td>Architecture, Engineering and Construction</td>
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<td>AIC:</td>
<td>Application Interpreted Constructs</td>
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<td>AIM:</td>
<td>Application Interpreted Model</td>
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<td>AP:</td>
<td>Application Protocol</td>
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<td>ARM:</td>
<td>Application Reference Model</td>
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<td>ASP:</td>
<td>Application Service Provider</td>
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<td>BBS:</td>
<td>Bulletin Board System</td>
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<tr>
<td>CAD:</td>
<td>Computer Aided Design / Drafting</td>
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<tr>
<td>CASE:</td>
<td>Computer Aided Software Engineering</td>
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<td>CGI:</td>
<td>Common Gateway Interface</td>
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<tr>
<td>CIO:</td>
<td>Chief Information Officer</td>
</tr>
<tr>
<td>CORENET:</td>
<td>Construction and Real Estate Network</td>
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<tr>
<td>CSCW:</td>
<td>Computer Supported Collaborative Work</td>
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<td>DMI:</td>
<td>Data Markup Integration</td>
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<td>DOM:</td>
<td>Document Object Model</td>
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<td>EDMIS:</td>
<td>Electronic Document Management System</td>
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<tr>
<td>GLOBEMEN:</td>
<td>Global Engineering and Manufacturing in Enterprise Networks</td>
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<tr>
<td>GUI:</td>
<td>Graphical User Interface</td>
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<td>HTML:</td>
<td>HyperText Markup Language</td>
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<td>IAI:</td>
<td>International Alliance of Interoperability</td>
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<td>IDEF:</td>
<td>ICAM Function Definition Method</td>
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<td>IFC:</td>
<td>Industry Foundation Classes</td>
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<tr>
<td>IP:</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>ISDN:</td>
<td>Integrated Service Digital Network</td>
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<tr>
<td>ISO:</td>
<td>International Standards Organization</td>
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<tr>
<td>ISTforCE:</td>
<td>Intelligent Services and Tools for Concurrent Engineering</td>
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<td>IT:</td>
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<td>OMG:</td>
<td>Object Management Group</td>
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<tr>
<td>OOCAD:</td>
<td>Object-Oriented Computer-Aided Design / Drafting</td>
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<tr>
<td>PC:</td>
<td>Personal Computer</td>
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<td>PDA:</td>
<td>Personal Digital Assistant</td>
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<td>QFC:</td>
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<td>ReRFI:</td>
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<td>RFI:</td>
<td>Request For Information</td>
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<td>SDE:</td>
<td>School of Design and Environment</td>
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<td>Standard Generalized Markup Language</td>
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<td>SMS:</td>
<td>Short Message Service</td>
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<td>STEP:</td>
<td>Standard For The Exchange Of Product Model Data</td>
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<td>UML:</td>
<td>Unified Modeling Language</td>
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<tr>
<td>VO:</td>
<td>Variation Order</td>
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<td>W3C:</td>
<td>World Wide Web Consortium</td>
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<td>WAP:</td>
<td>Wireless Application Protocol</td>
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<td>WISPER:</td>
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<td>XSL:</td>
<td>eXtensible Stylesheet Language</td>
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<td>XML:</td>
<td>eXtensible Markup Language</td>
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SUMMARY

Web-based construction project management emerged with the popularity of the Internet. A Web-based project management system is a restricted network for project specific collaboration and communication. It supports information sharing, enables timely communication, and offers dynamic information for decision making. These solutions are provided by the Application Service Providers (ASPs). ASPs are commercial portal vendors who offer Web-enabled project management services in exchange of a certain amount of monthly service fees.

This research aims at proposing a conceptual model of Data Markup Integration (DMI) system for data exchange among Web-based documents for the construction project management. The system is able to extract useful data from the original documents, re-organize the information according to specific tasks and users, and display in an integrated webpage.

The thesis consists of four parts: collection of ASP features, identification of user requirements, conceptual modeling, and prototyping.

The study on current Web-based collaboration systems identifies 7 categories of ASP as-is features: general system; document management; workflow management; administration; user centric workplace; team communication; and ASP server performance. These features are, in general, useful. Limitations of the current systems are information overflow, fragmentation of information, and data incompatibility, etc. To overcome the limitations, 8 categories of ASP to-be features are analyzed: time and cost consideration; integration; intelligent search for
information; knowledge base and intelligence; customizability to persons; customizability to projects; scalability; and others.

The Web-based survey of user requirements in Singapore identified 4 categories of current features as “very useful”: document management; workflow management; administration; and team communication. These features have been incorporated in the conceptual model. Also regarded as “very useful” were 4 categories of to-be features: time and cost consideration; integration; intelligent search for information; and knowledge base. Among these features, integration through data markup has been incorporated in the research.

A conceptual model of DMI is built up. The model consists of 5 major packages: my project place; manage document; manage workflow; administrate project; and team communication. Each package contains some major use cases.

The processes of paper-based and DMI Request For Information (RFI) are compared to demonstrate the advantages of Web-based collaborations via DMI. Prototyping the RFI case also demonstrates technical feasibility of implementing the DMI system. It is found that the DMI process provides the convenience of ready, complete and integrated information in a timely manner, which helps the users to make decisions faster and more accurately, so that downstream parties can take actions faster. It also helps to keep track of the collaboration, reduce data re-inputting, and minimize errors.
CHAPTER 1 INTRODUCTION

1.1 RESEARCH BACKGROUND

Web-based construction project management emerged with the popularity of the Internet. The prompt development of commercial Web-based project management solutions is an industrial response to the fragmentation nature of the Architectural, Engineering and Construction (AEC) industry.

A Web-based project management system is a restricted network for project specific collaboration and communication. It supports information sharing, enables timely communication, and offers dynamic information for decision making. These solutions are provided by the so-called Application Service Providers (ASPs). ASPs are commercial portal vendors who offer Web-enabled project management services in exchange of certain monthly service fees.

This research identifies comprehensive functional requirements from the study of current Web-based collaboration systems provided by the ASPs, analyzes user requirements via a Web-based survey in Singapore. The survey identifies 4 useful as-is features and 4 to-be ones. Based on the requirement studies, the conceptual model of Data Markup Integration (DMI) is developed. At last, an actual Request For Information (RFI) case is studied to verify the usefulness of the conceptual model.

The research answers the following questions:

- What kinds of services do ASPs currently provide to the AEC industry?
• What are the specific requirements of the AEC industry upon Web-based collaboration?

• How should Web-based project management system develop in the future?

1.2 RESEARCH PROBLEMS AND RATIONAL

Current commercial Web-based management systems are document based. The problems with document-based systems are information overload and data incompatibility. Information overload causes a waste of time and energy of identifying crucial information from tons of irrelevant one. Data incompatibility arises because drawings, calculations, and schedules are produced by various specialized software, thus users have to switch between applications to get the fragmented information integrated in their minds (Figure 1.1).

Figure 1.1 Document-Based System: Fragmented Information (Source: Liston, Fischer & Kunz, 2000)
To solve the problems of information overload and data incompatibility, this study proposes a DMI system. The concept is to regard documents as information containers, so that information can be extracted and tailored in the way most convenient to a specific task or user. The core technology is a neutral file format, acting as a common language to facilitate data exchange and rapid location of the information. Figure 1.2 shows how data from various sources (forms, contracts, drawings, etc) are extracted and re-organized for specific users (project manager, executive) or tasks (cost control, progress report).

1 Neutral file format is for data exchange among different software. It is neutral because the data is readable to the software that shares the same data structure. The most accepted neutral file format at present is eXtensible Markup Language (XML).
1.3 RESEARCH OBJECTIVES

The aim of this research is to propose a conceptual model of the DMI system for data exchange among Web-based documents for construction project management. The system should be able to extract useful data from the original documents, re-organize the information according to specific tasks and users, and display in an integrated webpage.

The goal is to be achieved via the following objectives:

- To study current features provided by ASPs;
- To identify user requirements towards ASPs development;
- To build up a DMI conceptual model; and
- To prototype an actual RFI case to test the superiority of the DMI process, and to verify technical feasibility of the system.

1.4 RESEARCH SCOPE

Web-based project management solutions can be applied in two contexts: internal to an organization, or between two or more organizations. The study focuses on the inter-organizational collaboration, which is realized by Extranet.

Besides project collaboration, ASPs provide various services, including industrial information exchange, such as building products catalog, human resource database, etc. This research is concerned only with project collaboration related functions, especially data exchange of cross-company communications during the construction phase.
The life cycle of software development can be divided into seven phases: requirement determination; requirement specification; architectural design; detailed design; implementation; integration; and maintenance (Maciaszek, 2001). The research only involves the first two phases: requirements determination through Web-based survey and study of existing systems (Chapter 3 and 4, Appendix I and II); requirements specification through use case documentation of the conceptual model (Chapter 5, Appendix III). These two phases together are also called requirement analysis.

1.5 RESEARCH METHODOLOGY

Requirement determination is the first phase in the system development lifecycle. The purpose of requirement analysis is to provide a narrative definition of functional and other requirements that the stakeholders expect to impose on the implemented system. Requirements can be divided into two categories: functional and non-functional. Functional requirements are those that describe the scope of the system, the necessary business functions, which can be formally documented into specifications and use cases. Non-functional requirements are other special requirements, such as the required system’s ‘look and feel’, performance, security, etc (Maciaszek, 2001). Non-functional requirements are usually more general and are stated by non-technical stakeholders, therefore, they are also called user requirements. According to Maciaszek (2001), methods of requirements elicitation include: interviewing customers and domain experts; questionnaires; observation; study of existing documents and software systems; prototyping; joint application development; and rapid application development.
In this study, three methods have been chosen for requirement collection: study of existing systems, questionnaire survey, and prototyping (Chan, & Leung, 2003a). Functional requirements are collected from the study of existing Web-based collaboration systems (Chapter 3). Non-functional requirements are collected through a Web-based survey and informal interviews with the IT experts (Chapter 4). An application interface prototyping is used to demonstrate the conceptual model (Chapter 6). Several methods are adopted because no single method can gather all the requirements. In practice, functional requirements are collected by a system development team, which consists of domain experts, business analysts and customers. The aim of the study is to explain the concept rather than develop a concrete commercial product. Study of existing software systems, on one hand, provides sufficient knowledge of the major features of the current systems; on the other hand, provides the foundation for new concepts to be added on, i.e., the idea of DMI. Non-functional requirements are collected from current and potential ASP users, who have a general concept of the solution but are not concerned about technical details. A set of questionnaires is enough to collect their evaluations and general opinions. Prototyping the Graphical User Interface (GUI) is a straightforward way to demonstrate how the application will look like to the user. Therefore, the above methods are selected.

The language for conceptual modeling is Unified Modeling Language (UML). UML is selected because it is a visual modeling language for specifying, visualizing, constructing, and documenting the artifacts of software systems, which can easily map the conceptual model to software product.
The development of conceptual model is a kind of explorative research. A lot of effort is put into designing the system, or describing what should be included in the system.

1.6 ORGANIZATION OF THE DISSERTATION

The thesis consists of seven chapters. Figure 1.3 shows the logical relationships among the chapters. This chapter gives a general layout of the thesis. The other chapters are as follows:

Chapter two provides background for the research. General topics are discussed, such as analysis on IT related problems encountered by the AEC industry, research efforts worldwide and their limitations, methodologies applied by similar researches and justification on selection of methods for this research, etc.

Chapter three is an intensive study of ASP, resulting in a comprehensive list of features that ASPs currently provided, also called as-is features. Features that do not exist but should be included in the near future are defined as to-be features. As-is features provide the foundation for functional requirements identification. The discussion on to-be features provides directions for ASP future development. Also discussed are the benefits and obstacles of adopting ASP.

Chapter four discusses non-functional requirements, also called user requirements, which were collected mainly from a Web-based survey in Singapore. The most important task was to identify the useful as-is and to-be features. For as-is features, 4 categories are considered very useful: document management, workflow management, team communication, and administration. For to-be features, 4
categories are considered very useful: time and cost consideration, integration, intelligent search, and knowledge base. The conceptual model includes all of the 4 useful as-is features and 1 to-be feature: integration through data markup.

Figure 1.3 Flow Chart Denoting The Relationships Among The Chapters And Appendices.
Chapter five develops the conceptual model focusing on DMI. The model consists of 5 major packages: my project place; manage document; manage workflow; administrate project; and team communication. Each package contains several major use cases. The use cases that are most relevant to DMI are: Setup Project Website; Upload File; Search Topic; Manage Change; and View My Task. Activities in the following use cases have been iterated: Setup Project Website; Upload File; Search Topic; and Workflow of RFI.

Chapter six compares the processes of paper-based and DMI-based RFI to demonstrate the advantages of Web-based collaborations through DMI. Prototyping the RFI case also demonstrates technical feasibility of implementing the DMI conceptual model using XML technology.

Chapter seven presents major findings, conclusions, limitations and recommendations of the research.
CHAPTER 2 LITERATURE REVIEW

2.1 INTRODUCTION

This chapter provides an overview of theories and technologies related to the research. First, it touches on Information Technology (IT) related problems of fragmentation and data incompatibility in the Architectural, Engineering, and Construction (AEC) industry, and integration in managerial and technical aspects, followed by a brief review of Internetworking and its applications in the AEC industry. World-wide standardization efforts are discussed in two projects: the STEP (STandard for the Exchange of Product model data), and the IFC (Industry Foundation Classes). Two conceptual modeling methodologies, the STEP approach and the UML (Unified Modeling Language) approach, are discussed and justified. XML (eXtensible Markup Language) and the consortiums working with the AEC schemas are introduced and their limitations justified.

2.2 IT-RELATED PROBLEMS IN THE AEC INDUSTRY

2.2.1 Fragmentation

The AEC industry, in particular, is characterized by fragmentation (Howard et al., 1989), geographically, and functionally (O’Brien and Al-Soufi, 1993). Geographical fragmentation is caused by the fact that most of the construction projects are based on temporary collaborations of owners, architects, contractors, subcontractors and suppliers. In addition, the locations of the projects and the locations of these partners are usually geographically different.
Functionally, project partners assume different roles (horizontal fragmentation) throughout the entire construction process (vertical fragmentation) (Howard et al., 1989). Exchanges of information between major players such as project managers, architects, engineers, and contractors occur very frequently, in the forms of letters, change orders, drawings, etc. Due to fragmentation, coordination among various participants throughout the construction process can be a difficult task. Each party has its own database, exchanging information at the cost of doubled manual input (Figure 2.1).

Figure 2.1 Fragmentation During Project Phases And Among Participants (Adapted From Emmerik, 2000).
2.2.2 Data Incompatibility

One major problem for information exchange is data incompatibility, which means that files generated from different applications cannot be read by other applications. There are three kinds of incompatibility: incompatibility of application versions; incompatibility of homogenous information; and incompatibility of heterogeneous information.

Incompatibility of application versions refers to situations when files generated by a later version cannot be read by the same software of an earlier version. A company using Office 95, for example, may encounter problem with files generated by Office XP from another company.

Incompatibility of homogenous information occurs when files of the same format generated by different software cannot be fully interchanged among one another. For example, in the Computer Aided Design (CAD) domain, exporting “.dng” files generated by Microstation to “.dwg” ones by AutoCAD causes partial information lost. This in turn will cause problems when drawings are exchanged electronically, since every party may use different software.

Incompatibility of heterogeneous information refers to problems encountered when files of different formats cannot be exchanged with one another. The construction industry involves various formats of information, such as CAD drawings (.dwg, .dng, .dxf), office documents (.doc, .xls, .ppt) and other textual documents (.pdf, .txt), images (.jpg, .gif, .tif, .bmp), 3D (3-Dimensional) models (.3ds), movies (.mov, .avi), webpages (.html, .asp), emails (.eml), etc. Incompatibility of heterogeneous information leads to data re-input from one system to another, reducing accuracy and efficiency. Therefore, it is the focus of many integration researches.
2.3 INFORMATION INTEGRATION

There are many perspectives of integration against fragmentation and data incompatibility (Figure 2.2). On top of the hierarchy are managerial and technical integration (Dias, 2001; Fischer, & Kunz, 1995; Haag, Cummings, & Dawkins, 1998). Managerial integration puts an emphasis on the collaboration among the value chain (Barua, Chellappa, & Whinston, 1996; Castle, 1999). Technical integration focuses on data interoperability of software applications that supports different disciplines (Zhu, 1999).

![Figure 2.2 Hierarchy Of Information Integration.](image)

2.3.1 Managerial Integration

It is argued that the AEC industry is not able to use IT strategically because companies view IT as a technological issue, rather than a business one (Betts, 1999). The subject of Computer Supported Collaborative Work (CSCW) is concerned with
the strategic use of IT from the management perspective (Löwnertz, 1998). Two sub-
topics on CSCW are discussed here: process redesign and concurrent engineering.

2.3.1.1 Process Redesign

Process redesign of organizational functions and operations is defined as “the
fundamental rethinking and radical redesign of business processes to achieve dramatic
improvement in critical, contemporary measures of performances, such as cost,
quality, service, and speed” (Hammer and Champy, 1993).

Hammer (1996) claims that problems lie not in the performance of individual
tasks and activities, but in the processes, i.e., how the units fit together into a whole.
The realization of dramatic improvement of business performance through
organizational process redesign rather than tactical and operational improvement calls
for new methodology to handle business operation, among which is the extensive

![Figure 2.3 Process Redesign And Return On Investment (Source: Fallon, 2000).](image-url)
applications of IT. By changing the ways people work and taking advantages of IT to deliver competitive advantage, business fortunes increase dramatically rather than incrementally, as depicted in Figure 2.3 (Betts, 1999; Fallon, 2000; IDC, 2000).

2.3.1.2 Concurrent Engineering

The concurrent engineering concept is defined as a systematic approach to the integrated concurrent design and construction of products, the consideration of related downstream aspects, and the elimination of non-value adding activities (Abduh, 2000). It aims at promoting collaborative teamwork by integrating all project participants that plan, design, produce, maintain, and support the project over its life cycle. Collaboration through the Internet shortens communication time, minimizes data input error, and improves information quality.

2.3.2 Technical Integration

The purpose of technical integration is to solve the problem of data fragmentation. Most approaches fall into two categories: the back-end and the front-end integration. The back-end integration happens at a low system level, so that data and information generated within the same database system do not have the data fragmentation problem. The front-end integration happens at the “front” of different system that does not share anything at the system level. It is based on sharing a neutral data format that is independent of any system.
2.3.2.1 Back-End Integration

A large group of international model-based projects applies the back-end integration strategy, which include ATLAS (ATLAS, 1992), RATAS (Björk, 1989; Penttila, & Tiainen, 1991), CIMSteel (Watson, & Crowley, 1994), COMBINE (Augenbroe, & Levis, 1991; Dubois, Flynn, Verhoef, & Augenbroe, 1994), ATLAS (Poyet, 1994), COMBI (Katranuschkov, 1994), and WISPER (Faraj, Alshawi, Aouad, Child, & Underwood, 2000), to name a few. They present the building project as a "process of activities" leading to the elaboration of a "product". Based on the focus, these can be classified as “product modeling” and “process modeling” (Zhong, 1998; Hughes, 1991). Both attempt to produce computer implementable data models expressed by formal representation such as IDEF0, IDEF1x, NIAM and EXPRESS (Ameziane, 2000). These projects are relatively large, complex and difficult to implement. Most of them include pre-defined rigid data structure that is either too comprehensive for industrial applications, or too inflexible for actual cases.

2.3.2.2 Front-End Integration

Electronic document management systems (EDMS) creates an environment within which disparate forms of information can be linked together to achieve easy access and control in the context of a project or organization (Figure 2.4). It addresses the following aspects of data management (Sun and Aouad, 1999; Löwnertz, 1998): Efficient location and delivery of documentation; Ability to manage documents and data regardless of the original system or form; Ability to encompass and integrate with existing computer or paper based systems in the context of a construction project; Control of access, distribution and modification of documents, with the
ability to mirror existing company procedures; Provision of tools to edit documents and add markup information whatever the source of the document; and Support of both paper-based and digital documentation, including importing of scanned documents.

EDMS manages information in the document level, in which documents are regarded as black boxes. The system has no knowledge about the internal structure or content of the document. It manages a document only based on the meta-data attached to it. EDMS is a type of shallow front end integration.

The other strategy, Data Markup Integration (DMI) through a third party, i.e. a neutral data format, is arising with the development of international standardizations (e.g., STEP, IFC,) and the emergence of the eXtensible Markup Language (XML). It regards a document as the information container so that data is marked up and can be extracted from within (Zhu, Issa, & Cox, 2001). This strategy is preferable because of its simplicity and extensibility.
DMI is simple because it does not involve a complex database level structure to accommodate everything, which is most back-end integrations trying to do. At the same time, DMI is extensible since the schema of XML can be defined according to specific domain knowledge. For example, there are ebXML for ebusiness (ebXML, 2001), MathXML for mathematics, and ifcXML for the AEC industry (Liebich, & Adachi, 2000). It also allows designers to easily create their own customized tags to include new requirements.

2.4 INTERNETWORKING AND APPLICATION

Internetworking is a comprehensive term for the concepts, technologies, and generic devices that allow people and their computers to communicate across different kinds of networks.

2.4.1 Internetworking Technology

Internetworking, which is commonly called internet, actually includes Internet, Intranet and Extranet. The Internet is a global connection of special function computers called “servers” that are linked to share information with the user computers called “clients”. Originating from 1960s, the Internet became popular in 1990s, with the application of user-friendly browsers, search engines, support languages, and the proliferation of Internet Service Providers (Lucas, 1997).

An Intranet is a mechanism for sharing information and delivering data from corporate databases to the local area network (LAN) desktop (Barkowski, 1999). Intranets use Web technology and are restricted networks for intra-organizational
information and resource sharing. Advantages are full control of information against external attacks, and sharing IT facilities, e.g. printers, scanners, etc.

An extranet is a private network that uses the public telecommunication system to securely share part of a business's information or operations with suppliers, vendors, partners, customers, or other businesses. An extranet can be viewed as part of a company's intranet that is extended to users outside the company (Whatis, 2002). In the AEC industry, an extranet links the owner, designer and contractor into a project specific Website for information sharing. The use of Extranet enhances the accessibility of project documentation to all participants, imposes cohesion and order on the massive amounts of project data, thus reduces cost and shortens project duration.

2.4.2 Internetworking Applications

Internetworking is ideal for the AEC industry since it is cheap, widely available and not too difficult to use. Currently there are four types of Web-based applications for the AEC industry: the fee-based project management service; the build-it-yourself solutions; the Web-enabled software (Zhu, 1999); and the national or regional wide Web platforms (Scherer, 2000).

The subscription fee-based project management services are provided by professional IT companies called Application Service Providers (ASPs). Examples are Autodesk (Autodesk, 2001), Citadon (Citadon, 2002), Constructw@re (Constructware, 2001), to name a few. Benefits include low implementation cost, few IT expertise needed, easy application upgrade, simple system requirements.
Limitation is that information is under the control of a third party. Major concerns are information security, data accessibility, and service quality.

The build-it-yourself solutions are suitable for extremely large companies, so that they can tailor the application to best fit their business environment and maintain their own business style. The limitations are obvious: lots of investment, outsourcing and long development cycle. Example is Bechtel (Bechtel, 2002), etc.

Web-enabled software refers to the whole-set Web-based solution that are bought and maintained by construction companies, which is a balance of the former two. It reduces the need for outsourcing, shortens the development cycle and, at the same time, retains the sensitive information under the supervision of in-house technical staffs. Limitations are higher initial cost, and greater know-how requirement of the staff. Example is TurnerTalk (Turner, 2003), etc.

The national or regional wide Web platforms provide the super structure to enable multiple functions to be accessed via a single interface. It has broader scope than the last three solutions, and also involves more difficulty of integration among sub-divided functional modules. Examples are the CORENET project in Singapore (CORENET, 2001), and the ISTforCE project in Europe (Cerovsek and Turk, 2000).

The Construction and Real Estate Network (CORENET) is part of Singapore IT2000 plan for the construction industry that acts as the infrastructure to integrate the processes of design, procurement, building, and maintenance. The CORENET project has several components as shown in Figure 2.5 (CORENET, 2001): Integrated Submission systems (e-Submission, and e-approval); Integrated plan checking; BP expert; IT standards (CAD and classification standards); Legal framework for data
security; eBusiness enablers (eProcurement pilot and project Website pilot); and Information services (eCatalogue, product details library).

![Diagram of CORENET Project components]

Figure 2.5 Components Of The CORENET Project (Source: CORENET, 2001).

Intelligent Services and Tools for Concurrent Engineering (ISTforCE) is a European framework project (Cerovsek and Turk, 2000). Its goal is to design a Web-based services platform through which engineers at a given design or consulting company will access the services on the Internet and collaborate in real time. It aims at creating infrastructure on which real construction companies and virtual teams of construction companies can rent and customize services on a project by project basis, and where providers of engineering services can market their products.

The first solution, fee-based project management service, is the focus of this study. It facilitates the inter-organizational information sharing with affordable price, professional services, which sets the trend for Web-based project management. More importantly, it helps to reduce unnecessary data structure variety and standardize Web-based information exchange processes. Chapter 3 will discuss in details the features of ASPs, as well as benefits and obstacles of its adoption.
2.5 STANDARDIZATION

Standardization efforts in the area of product modeling have been related to two projects: the STEP (Standard for the Exchange of Product model data) by the International Standards Organization (ISO); and the IFC (Industry Foundation Classes) delivered by the International Alliance for Interoperability (IAI).

2.5.1 Standard For The Exchange Of Product Model Data

STEP (STandard for the Exchange of Product model data) is the informal name of the ISO 10303 standard series: Industrial automation systems – Product data representation and exchange, developed by ISO TC184/SC4. It was initiated by the manufacturing industry and adopted by the AEC. STEP intends to create an international standard for computer-based description and exchange of the physical and functional characteristics of products throughout their life cycle.

The development strategy of STEP is based upon the concept of Application Protocol (Santos and Hernandez, 2000). Within the building construction sector, four different work items including conceptual schemes are in progress. These work items are: Building Element Using Explicit Shape Representation (AP 225); Building Construction Core Model (Part 106); Building Structural Frame: Steelworks (AP 230); and Building Services: Heating, Vent. and Air Condition (AP228).

2.5.2 Industry Foundation Classes

IFC is delivered by IAI in parallel with STEP. IAI, started in 1994, is an international organization of over 600 AEC/FM companies and software vendors.
IFCs are universal codes for modeling building elements, which are shared by different kinds of software applications throughout the life cycle of buildings.

The IFC specifications have been developed following the STEP based implementation methods, especially the EXPRESS definition language (ISO 10303-11:1994) (ISO, 1994a) and the STEP physical file format (ISO 10303-21:1994) (ISO, 1994b).

The IFC model uses a strict referencing hierarchy. There are four conceptual layers (Figure 2.6). The first and lowest layer is Resource Classes, which are used by classes in the higher levels. The second layer provides a Core project model, containing the Kernel and several Core Extensions. The third layer is the Interoperability layer, which provides a set of modules defining concepts or objects commonly across multiple application types or AEC industry domains. These three layers together define the platform layer. The fourth and the highest layer is the Domain/Applications Layer, which provides a set of modules tailored for specific AEC industry domain or application types. This is also called extensible layer, because the schemas on this layer are extensible and new schemas can be defined on top of the platform for applications.

2.6 CONCEPTUAL MODELING METHODOLOGIES

There are two major conceptual modeling methodologies in the construction IT application domain: The STEP methodology, and the UML methodology.
2.6.1 The STEP Methodology

The development strategy of STEP is based upon the concept of Application Protocol (AP), which guarantees the independence of information requirement specifications from any particular implementation within an application domain (Poyet, 1995; Santos and Hernandez, 2000). The process of developing an AP includes the following activities:

- Development of Application Activity Models (AAMs);
- Development of Application Reference Models (ARMs);
- Development of Application Interpreted Models (AIMs).
Application Activity Models (AAMs) are the scope statement of the domain of the planned AP domain. It describes the application context and functional requirements. AAMs are described by process models using IDEF0\(^1\) diagrams.

Application Reference Models (ARMs) describe the information requirements and constraints for the specific AP. ARMs document the required data and relationships and are normally specified using EXPRESS-G\(^2\) (ISO, 1994a), IDEF1x\(^3\), or NIAM\(^4\) (Nijssen, et al., 1989).

The Application Interpreted Models (AIMs) specify the interpretation of the Integrated Resources to satisfy the information requirements of the AP described by the ARM. The AIMs are also specified using the EXPRESS language.

Although the STEP methodology has been used in the AEC domain for around 20 years, Santos and Hernandez (2000) pointed out its limitations, which are:

- Inconsistency among the models, especially between the AAM and AIM;
- High modeling knowledge requirements in order to interpret among the models, which add barriers to the communications among domain experts;
- Not fully computer oriented, which adds difficulty to the software development process.

Santos and Hernandez (2000) also proposed the use of a single modeling method for AP’s development, based on the recent and powerful modeling language – UML. They are mapping the STEP AP to UML for the AEC sector.

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\(^1\) IDEF0 stands for ICAM Function Definition Method.

\(^2\) EXPRESS-G is the graphic expression of EXPRESS, a language to express models in the STEP project.

\(^3\) IDEF1x also stands for ICAM Function Definition Method.

\(^4\) NIAM stands for Nijssen's Information Analysis Method.
2.6.2 The UML Methodology

Unified Modeling Language (UML) is a language for systems engineering (OMG, 2000). It is developed primarily from two of the most popular modeling formalisms for object-oriented modeling, OMT and Booch. It is chosen for this study because the language is rapidly being established as a de facto standard for object-oriented modeling, and has been adopted as an international standard within the OMG (Object Management Group) that develops the Common Object Request Broker Architecture. The technical details of UML will be discussed in Chapter 5.

2.7 EXTENSIBLE MARKUP LANGUAGE

Both XML (eXtensible Markup Language) and HTML (Hyper-Text Markup Language) are sub-sets of the mega-language SGML (Standard Generalized Markup Language). SGML is an international information coding standard developed by ISO in the early 1980s (Van Herwijnem, 1994). There are three types of tagging schemas in SGML, namely format tagging, structure tagging, and content tagging. HTML and XML apply format tagging and content tagging respectively. Since SGML is too complicated for commercial use, HTML prevailed as a simplified meta-language to depict Web contents in the 1990s. However, lack of information structure creates difficulty for dealing with large amount of information and precisely locating the needed one (Zhu, 1999).

The limitations of SGML and HTML can be overcome by XML. Instead of focusing on the presentation of information, XML focuses on the semantics of information that is displayed, and separates the content of a document from its presentation. XML is “extensible” because it allows designers to create their own
customized tags, enabling definition, transmission, validation, and interpretation of data between applications and between organizations. In this way, XML provides more user-friendly applications by allowing users to tailor presentations according to their ad hoc needs. XML 1.0 is the specification that defines what "tags" and "attributes" are. Beyond XML 1.0, "the XML family" is a growing set of module, which include XSD (XML Schema Definition), XLink, XPointer, XFragments, XSL (XML Stylesheet Language), DOM (Document Object Model), XML Schemas part 1 and 2, etc (W3C, 2001).

In the AEC industry, at least three consortiums are working on domain specific schemas: the bcXML (building and construction XML) developed by the European project eConstruct; the aecXML (architectural, engineering and construction XML) initiated by Bentley Corp, USA; and the ifcXML (industry foundation classes XML) developed by the IAI.

2.7.1 **BcXML**

BcXML is the outcome of the European project eConstruct. The goal is to develop the standards to support communication related to the procurement of materials, components, assemblies, documents, systems, services and equipments over national borders in Europe (Tolman et al, 2000; 2001). It provides the European building construction industry with a powerful and low cost communication infrastructure in three aspects: Supporting eCommerce between users and suppliers of building materials, components, systems and services; Integrating with eCommerce and Design/Engineering applications; and Supporting virtual market places over the borders of the individual European member states.
2.7.2 AecXML

The aecXML is an initiative of Bentley Systems in 1999, recently brought under the IAI North American Chapter. The purpose of aecXML was to enable communications between different software systems by establishing a standard way of structuring data for a construction project. By the time of its merge with IAI in 2001, it had only premature releases (aecXML, 2001).

2.7.3 IfcXML

IAI issued the first full release of its IFC information model in January 1997 (IFC 1.0). Several further releases have been issued since then (IFC1.5 in 1997, IFC1.51 in 1998, IFC2.0 in 1999, and IFC2.x in 2000). The latest version, IFC 2.x, is the first IFC release that includes parts of its definitions specified in XSD, as opposed to EXPRESS (IAI, 2001). To date, only the IFC content model was represented by XSD as an alternative exchange mechanism. The exchange of information via the STEP physical file format remains viable for all the areas of IFC (Liebich, 2001).

Though the above XML related projects may have profound impacts on project modeling and eCommerce in the AEC industry, none of them have focused on the project management information and developed any mechanism on tailored information presentation according to specific users or tasks. This study applies XML to present just enough information for a specific user or task, so as to reduce the burden of information overload, to integrate information in the Web-based front-end level in a flexible and extensible way.
2.8 SUMMARY

This chapter provides an overview of the theories and technologies related to the study. Two major problems of IT applications in the AEC industry are identified as fragmentation in general and data incompatibility in specific. Integration efforts have been made in both managerial and technical aspects but this study focuses on front-end technical integration applying DMI. Extranet is the Internetworking technology that enables project specific communication and collaboration in the AEC industry, preferably under the ASP model. Standardization efforts worldwide are reflected in two major projects, namely the STEP and the IFC.

Two major conceptual modeling methodologies are discussed, namely the STEP approach, and the UML approach. UML is selected as the modeling tool for this research because it is simple, intuitive, and widely accepted by the IT domain to facilitate the transfer from conceptual model to software development.

XML is a meta-language that enables Web-based data exchange. BcXML, aecXML and ifcXML are the developing domain schemas for the AEC industry. However, since they only address physical components and domain specific information but not construction documents, a new approach has to be develop to take into account how information should be tailored according to a particular task or user, which is the task of this study.
CHAPTER 3 FUNCTIONAL REQUIREMENTS OF ASPS

3.1 INTRODUCTION

The last chapter introduces internetworking technology and its applications in the AEC industry. Web-based collaborations provided by the ASPs are in favor since it is economical and technically easy to implement. More importantly it helps to standardize Web-based information exchange processes. This chapter describes the history and development of ASP, the current features and the features for future development. Adoption benefits and obstacles are also analyzed.

3.2 HISTORY OF ASP DEVELOPMENT

Figure 3.1 shows the IT development for construction. ASP evolved in 1998 and boomed in 2000. The first project Web solutions emanated from the concept of FTP servers. Project Website solutions vary in standard and capabilities; from solutions simply for static homepages and options for up- and download, to advanced solutions with dynamic update of searchable contents and integrated workflow management tools (Hartvig, 2001a).

A project specific Website is a private Website on an Internet server, where parties involved in a project can share documents, communicate, and carry out information related tasks in the collaboration processes. The most important advantage of ASP is to support process re-engineering through timely communication.
3.3 AS-IS FEATURES

The use of the Internet for project collaboration demonstrates great promises as a tool for increased productivity and business performance. Unlike Intranet, which is for the sole use of the architect or the contractor companies, an Extranet is shared by the entire project team - owners, designers, project managers, main contractors, subcontractors, inspectors, inspection agencies, and consultants.


Services and features provided by the ASPs vary greatly. The features discussed here are collected from various sources, including the introductions of the commercial ASPs (AutoDesk, 2001; Bricsnet, 2002; BIW, 2002; Buildingwork, 2002; Citadon, 2002; Constructware, 2001; Cosential, 2002; eRoom, 2002; Meridian, 2002; Primavera, 2002), third-party analysis on ASP development (Smith, 2000; Asptip, 2000a; ProjectAims, 2002a; 2002b), and academic research findings (Hartvig, 2001b, 2001c; Cohen, 2000; Castle, 1997; Abduh, 2000). The list of features that ASPs currently provide is divided into 7 categories: general system; document management; workflow management; administration; user centric workplace; team communication; and ASP server performance. Appendix I provides a comprehensive list and detailed descriptions of every feature that is currently available.

The category of general system includes some general features that do not fall into any specific category, such as public project webpages; project cloning; links to AEC industry information services; and Web camera on site, etc.

Document management contains features that manage files generated by various applications, which include remote viewing, printing and commenting of files through Web browsers; document revision control with file locking and check-in/check-out; handling external references for CAD drawings; and digital approval, etc.
A workflow is a process that involves collaboration among project players, e.g., the process of approving a change. Standardized workflow management is achieved through the use of Web-based forms and templates. Other features include integration with e-procurement; issues linking; automatic generation of customizable reports; and tasks management, etc.

Administration is done by the so called Chief Information Officer (CIO), whose duty is to manage the project Web throughout the whole process of Web site utilization. The features for administration include access control; auditing; set-up of project Website templates, workflow and other project specific business logics; and task allocation, etc.

A user centric workplace is similar to the desktop of an operation system, such as Microsoft Windows. It can be customized according to the user’s working habits. These features include customizable interface; headlines page; multiple languages support; multi-project support; drag-n-drop, and right-click, etc.

Team communication is Internet enabled communication, such as email, instance messaging, discussion forum, online conferencing, etc. These features provide supplementary information for formal communication. Compared to traditional communication means such as phone call, fax, and face-to-face meetings, the team communication features have the advantages of low cost, fast speed and traceable record.

Server performance is a very importance factor for evaluating the quality of ASP services. Since all services are Web-based, the availability of project Website, the browsing speed, the file transfer speed, the data security against external hackers, all these factors will have significant impacts on the project team’s activities.
3.4 TO-BE FEATURES

The to-be features are developed based on related research projects and literature about the current and future ASPs. In the ISTforCE project (Intelligent Services and Tools for Concurrent Engineering, Referred to Chapter 2), Cerovsek and Turk (2000) stated that a prototype Internet desktop system for engineers should have the following 5 requirements: it should be open enough to integrate with other service or tools, customizable to persons, customizable to projects, scalable, and extendable.

In the GLOBEMEN project (Global Engineering and Manufacturing in Enterprise Networks), Hannus and Kazi (2000) pointed out 5 managerial requirements: standards for external communication; short set-up time and low cost of the common working environment; short learning time of common tools; protection of proprietary knowledge; and support division of responsibilities between team members.

Also in the GLOBEMEN project, Laintinen and et al. (2000) stated the following user centered requirements: The users should be able to access and update the required information efficiently. Access to the ASP should be controlled according to the role of each individual in the process. The users should be provided with functionality to: search for valuable information in various sources, such as the Web, Intranet and local drives; quickly and easily obtain the information and knowledge that is relevant to their tasks and responsibilities; synthesize different pieces of information and organize existing knowledge; view the well-organized information from different perspectives depending on their roles in the process; accumulate acquired knowledge orderly for future usage; and generate reports for decision making.
Based on the study above, the to-be features of a Web-based construction project management system have been developed and classified into 8 categories:

- Time and cost consideration;
- Integration;
- Searching for information;
- Knowledge base and intelligence;
- Customizability to persons;
- Customizability to projects;
- Scalability; and
- Others.

3.4.1 Time And Cost Considerations

Time and cost considerations include short set-up time and low cost; and short learning time of common tools.

3.4.2 Integration

Integration has broad meanings. There are at least three types of integration:

Firstly, integration throughout project life cycle, with company database, and with project model\(^1\); Interoperability through AEC industry-wide standards for related information, allowing data sharing between any systems used by any project participant (e.g., STEP, IFCs, aecXML, etc.).

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\(^1\) A project model contains OOCAD, cost, scheduling and other building information of every building element. It is considered the ultimate way to realize data interoperability among different software applications throughout the project life cycle. OOCAD stands for Object-Oriented Computer-Aided Design.
Secondly, integration with solid modeling, virtual reality, and other visual technology.

Lastly, integration with the software environment that users are using to do their jobs, so as to reduce rework. The software environment includes the general office software (word, spreadsheet), design and project management tools (CAD, scheduling, accounting, invoicing, electronic bid management, task and resource scheduling, and online tracking of plans). For example, the automatic retrieval of meta data resided in word and excel files will reduce re-entering meta data when uploading files. Integrating contacts and calendars with users’ local system will avoid redundant input of contacts and tasks.

### 3.4.3 Intelligent Search For Information

Intelligent search for information means a quick access to and the efficient updating of required information; searching for valuable information in various sources, e.g., the project Web, the Internet, LAN and the local computer.

### 3.4.4 Knowledge Base

Knowledge base means accumulating acquired knowledge for future usage; incorporating decision support system, supporting what-if analyses; and generating reports for decision-making.
3.4.5 Customizability To Persons

Customization allows for personalized interfaces; displays information from different perspectives tailored to a user's role.

3.4.6 Customizability To Projects

Customization to projects means that the ASP solution is suitable for all kinds of projects varied in size, type and degree of complexity.

3.4.7 Scalability

Scalability means the ASP solution is usable for both low and high speed Internet connection, compatible with files generated by software of different versions, and extensible to accommodate developing applications.

3.4.8 Others

Other useful features include: protection of knowledge proprietary, and supporting division of responsibilities among team members.

3.5 ASPs in Singapore

By Year 2002, 5 major local ASPs are in use in the Singapore construction market: Cyber-IB (http://www.cyberib.com/), CXHub (http://cxhub.com/), HDBuilders (http://www.hdbuilders.com/), icFox (http://www.icfox.com/), and icx123 (http://www.icx123.com/). Among them, icFox forms a strategic partnership
with Citadon and applies its collaboration solution; while Cyber-IB partners with AutoDesk. The icx123 and CXHub are mainly information providers, who do not focus on project collaboration. HDBuilders has a local technology partner, who develops Web-based management solution targeting at the local contractors only. HDBuilders.com, the subsidiary of Singapore Housing and Development Board, extends its open bidding system (e-bidding) of public projects to main tenders, who can submit as many bids as required to arrive at a competitive bid. The Singapore local portals provide various services in e-commerce, e-project management and information exchange for the local construction industry. Their effectiveness and impacts on the construction industry are yet to be determined.

### 3.6 ASP BENEFITS

The main advantages of applying IT are improved productivity and business performance. Productivity refers to time, cost, quality, and added-value, etc. Business performance refers to communication, customer satisfaction, and competitiveness, etc. Besides, there are other advantages, such as availability of information and process redesign. This section reviews the benefits of applying ASP, and indicates that these general benefits also applied to the DMI system.

A client impact study carried by Constructware summarized ASP benefits in the following areas (Constructware, 2001): increasing productivity; improving risk management; reducing costs; and gaining a competitive advantage.

Cohen (2000) summarized five types of benefits mainly from the productivity prospect, which include: quality improvements; efficiency improvements; time improvements; new sources of revenue; and reduced direct costs.
A more detailed study by PricewaterhouseCoopers indicates the benefits for applying ASP solutions include (Wesek, Cottrez, and Landler 2000): improving project progress communication; providing real time access to information and reducing the response time for RFI, change orders and specifications clarification; shortening of the project life cycle; increasing ownership and accountability; and improving record keeping and documentation.

In summary of the above findings and other statements by the ASPs, the major benefits of applying Web-based project management can be classified into 5 categories (Wesek, Cottrez, & Landler 2000; Cohen, 2000; IDC, 2000; Constructware, 2001; BIW, 2002; Bricsnet, 2002; Citadon, 2002):

- Improved communication;
- Reduction on project life cycle time;
- Reduction on cost;
- Accountability and records; and
- Gaining competitive advantages.

### 3.6.1 Improved Communication

There are two factors for the consideration of improved communication: the quality of communication, and the overall time saving in the progress of communication.

Better quality of communication is achieved because Web-based project management allows users to collaborate with other project team members for better communication in an opened environment. Once they log in to the project Web, all
information accessible is right there for their usage. In addition, ASPs enable long-distance cooperation among project participants.

Time saving in progress communication is achieved because time spent on general project communication is shortened, keeping all members of the project team informed of the status of the project, issues and other information relevant to ensure project’s timely completion. Examples of activities include: meeting minutes, action items, creating filters/securities, project schedule updates, etc. Thirty to sixty percents of time saved is expected by professionals on project team in communicating project progress (Wesek, Cottrez, and Landler 2000).

3.6.2 Reduction On Project Life Cycle Time

Reduction on project life cycle time is achieved by three means: availability of information, time reduction of workflows, and time saving in data searching.

Information is available 24 hours a day, 7 days a week. Real-time availability of information reduces waiting time and searching time for information.

Turn-around time of workflows, e.g., RFI, VO (Variance Order), is shortened in submitting a query and receiving a response from another member of the project team. Wesek, Cottrez, and Landler (2000) examined that 30%-60% reduction on turn-around time can be achieved.

Time saving in document creation, filing, searching for documents on specifications and elements of design can be up to 50% (Wesek, Cottrez, and Landler 2000).
3.6.3 Reduction On Cost

There are many aspects of reduction on cost, such as immediate and long term cost savings, improved procurement process and increased revenue by earlier completion of project.

Immediate cost reduction of printing, faxing, mailing, courier services, travelling can be perceived on average 20%-30% of actual costs saved (Wesek, Cottrez, and Landler 2000).

Long-term cost savings are achieved through reductions in mistakes and re-work, and by avoiding unnecessary project delays.

Improved procurement process provides the opportunity to search for best deals and purchasing supplies online.

The time saving advantage leads to earlier completion of project, which in turn generates increased revenue. Tenants are able to occupy site ahead of schedule and begin paying rent sooner than anticipated. Project team can begin working on another revenue and fee generating project.

3.6.4 Accountability And Records

Accountability and records refers to improved documentation, which include increased transparency of documents; increased ownership and responsibility of project parties; better documentation of project life cycle history; and decreased legal risk and prevention of construction claims.
Increased transparency of document means that any team member can view all accessible project information at any time.

The ownership and responsibility of project parties are increased because tasks allocated are clearly documented in a central repository, which is accessible to every member.

Better documentation of project life cycle history means project history and life cycle is documented and succinct audit trail is available for reference.

Legal risk is decreased and construction claims are minimized because there is less opportunity to shift responsibility and take legal recourse. Should disputes arise, the audit trail feature can help identify exactly when particular items of information were created, discussed and amended.

### 3.6.5 Gaining Competitive Advantages

Competitiveness is gained by established standards, accumulated knowledge, integrated information, better and faster decision-making, and improved partner relationships and customer satisfaction.

Establishing Standards ensures that data created by one project participant can be used and re-used by others without conversion or reformatting.

Knowledge is carried forward to future projects, because features are configured and customized to address the unique business processes of each enterprise, providing standard templates that leverage industry best practices, encapsulating lessons learned on previous schemes, promoting continuous performance improvement.
Web-based project management provides integration and data exchange with other enterprise systems, such as project accounting, allowing firms to leverage their investments in those systems while ensuring that all systems are on the same page at the same time.

Better and faster decision-making is achieved since real-time information improves forecasting and decision-making.

Improved partner relationships and customer support is achieved since Web-based project management helps to develop trust with up-to-date information and transparent process management.

3.7 OBSTACLES TO ADOPTION OF ASP

According to Castle (1999), there are 4 categories of obstacles for adopting ASPs:

- Economic considerations;
- Organizational changes;
- Lack of ASP standards; and
- Other obstacles.

3.7.1 Economic Considerations

Economic considerations concerns about the uncertainty of return on investment. Although there has been many surveys showing overall cost reduction and performance improvement, firms are slow to adopt ASP, not only because of the
high investments in hardware, software, services and training, but also of organizational investment such as process redesign.

### 3.7.2 Organizational Changes

Organizational changes include leadership and consensus; balance of power; team composition; and trust development.

Effective implementation of ASP requires leadership from the client, and consensus all parties involved in the project. Although building owners consider the ultimate beneficiaries of the building process and the most effective advocates for the ASP, most of them do not recognize the potential benefits of ASP, nor to make it a requirement for participation in the project.

Applying ASP potentially changes the current balance of information power, shifting more power to the managers. Project information flows are much more transparent. Owners can track minute-by-minute activity of designers and construction contractors. General contractors can track minute-by-minute activity of their subcontractors. It has been suggested that to alleviate such concerns, an independent outside party (project information manager) be appointed to manage the project data.

A typical building process consists of several major stages: project definition, design, construction and operation. Each stage may involve a different set of specialized firms. Each new comer has to adjust to a new working relationship. In the nature of the building process, the opportunities for learning and efficiency gains that arise from stabilizing the work routine and perfecting repetitive tasks are limited.
Many people concern about applying ASP will only increase repeating information input, since they have to put information in the local system as well as the project system.

The trust on ASPs cannot be achieved without difficulty. Since mission-critical data are placed in the hands of the ASPs, it brings great concerns if the ASP fails to stay in business throughout the life of the project. Moreover, a user will completely lose contact with the project information in case he or she cannot be connected to the ASP.

3.7.3 Lack Of ASP Standards

Lack of ASP standards arises from the competitions of the various ASP portals and lack of dominant players in the AEC industry.

For the AEC industry, the IT vendors with the largest market share are also the most attractive to potential users. As AutoCAD dominates the CAD market, potential users are more likely to pay more for using this product than the others so as to avoid compatibility problems. To date, there are still more than a dozen leading figures pushing to be the leader in the ASP market, although the market has gone through quite a lot of mergers, acquisitions and failures. Many potential users are reluctant to commit to an ASP until there are only a few survivors (Chan, & Leung, 2003b).

Inter-organizational information systems have been successful in many industries, partly because of a major player with sufficient market share to demand participation of its suppliers. However, in the fragmented AEC industry, such a
A dominant player does not exist. In the near future, the lack of standards is likely to create a tremendous amount of confusion and slow down the adoption of ASP.

### 3.7.4 Other Obstacles

Other obstacles include legal barriers; underdeveloped IT infrastructure; and dissatisfaction with ASP performance.

### 3.8 SUMMARY

This chapter answers the question of what services ASPs currently provide to the AEC industry. The chapter reviews the features that current commercial project Websites provide. There are 7 categories of as-is features, which include general system; document management; workflow management; administration; user centric workplace; team communication; and ASP server performance.

This chapter also analyses 8 categories of features under development, which acts as general research directions of Web-based solutions. These categories are: time and cost consideration; integration; intelligent search for information; knowledge base and intelligence; customizability to persons; customizability to projects; scalability; and others. This chapter also analyses the benefits and obstacles of adopting ASP.
CHAPTER 4 EMPIRICAL STUDY OF USER REQUIREMENTS

4.1 INTRODUCTION

The last chapter systematically describes many features of ASP solutions. This chapter evaluates these as-is and to-be features from the user’s perspective. Non-functional requirements were collected through a Web-based survey conducted in May 2002. There are 4 categories of as-is features and 4 to-be ones that were regarded as very useful by the respondents.

While ASP has been in practice for years in Europe and North America, it is not yet a common practice in the Singapore construction industry. The purpose of the Web-based survey is to find out the general awareness and requirements towards IT and ASP of the high educational level professionals in the Singapore AEC industry (Chan, & Leung, 2003b). This chapter describes the survey in three parts. Firstly, survey methodology is about the details of how the survey is prepared and carried out. Secondly, data analysis is about the methods used to analysis the data. Thirdly, overall findings and analysis are discussed. Appendix II is the Web-based questionnaire.

4.2 SURVEY METHODOLOGY

4.2.1 Sample

Given the fact that Web-based project management is still a pilot study, the survey focuses on the high educational level professionals in the AEC industry, rather than on the general practitioners. The invitation email was sent to 284 graduate students in the School of Design and Environment (SDE), National University of Singapore. Among the 47 received responses, 30 are complete and valid. The other
17 incomplete ones are excluded from the analysis. The response showed that only several respondents had the experience with ASP. To the majority, however, ASP was still a new concept. It might be for this reason that 17 potential respondents did not finish the survey. The graduates are selected because they have enough construction knowledge, and are among the most likely persons that are actively involved in IT applications in construction. Their working backgrounds and experiences are wide enough to represent the sound of the industry in Singapore.

4.2.2 Web-based Survey

The survey was conducted via the Internet (http://annaliang.hypermart.net/). A pilot survey was conducted with 2 practitioners and 4 graduate students to troubleshoot the format and content problems in the questionnaire. Results of the pilot survey were excluded from the final analysis. In the final survey, invitation email was sent to 284 graduate students in SDE. Their email addresses are collected from the class roster of graduate courses in SDE and the mailing list of a construction IT seminar.

The survey was conducted as Web-based rather than paper-based because webpages, with hyperlinks and java scripts, can explains ideas in an intuitive way via multimedia. Feedbacks from the pilot survey indicated that if lacking of examples, the respondents did not fully understand the ASP features explained in plain texts. With java scripts, definition of a jargon is automatically displayed when a respondent points to it. With hyperlinks, the Web-based form provides screen shots and animated demonstrations as live examples to explain almost every ASP feature, which can never be achieved by paper survey (Figure 4.1).
4.2.3 Confidentiality

The survey was anonymous. The four general questions asked in part 1 were for statistical classification. At the end of the survey, the respondents were asked whether they would like to receive the survey report. If their answers were yes, they were asked to provide either an email address or a mailing address. This information was kept confidential and excluded from the analysis.

4.2.4 Survey Organization and Design

There is no existing suitable questionnaire for the survey. Adopting partly from the works of Castle (1999), Rivard (2000), Froese & Waugh (1991), and Waugh,
Froese, & Pierre (1996), the author designed the questionnaire specifically for this study (See survey questionnaire in Appendix II). The survey consists of three parts:

Part 1, general information, consists of 4 general questions of the respondents’ working background. The information is for statistical classification.

Part 2, general uses of IT and networking, consists of 7 questions about the use of IT and Internet in their practice. The information provides the background of IT applications in the Singapore construction industry.

Part 3, uses of ASP, consists of 10 questions about the uses and expectations of ASP in Singapore.

The Web-based questionnaire consists of 7 pages (Figure 4.2):

Page index.html introduces the survey. A click on “Go to Survey Page” will lead the respondents to the next page.

Page part1.htm, part2.htm, and part3.htm are the three parts of the survey. When the respondent clicks “Submit”, the cgi script examines whether all required fields are filled up. If so, it saves the answers, sends an email to the surveyor, and brings the respondent to the next page. Otherwise, it displays page oops.htm and urges the respondent to go back and answer all the questions in that page.

Page analysis.htm asks whether the respondent would like to receive the survey analysis. They can choose to receive by email, by mail or not to receive. For either of the former two, they are asked to provide an email address or a mailing address respectively. When the respondent clicks “Submit”, the cgi script examines whether all required fields are filled up. If yes, it saves the answers, sends an email to the
surveyor, and brings the respondent to page thanks.htm. Otherwise, it displays page oops.htm and urges the respondent to go back and answer all the questions in that page.

![Flowchart of Survey](image.png)

Figure 4.2 Flowchart Of The Web-Based Survey.

Page thanks.htm indicates that the respondent has completed the survey successfully.

Page oops.htm is called by the cgi script when the respondent fails to fill up all required fields. It also urges the respondent to use the “back” button of the Web browser to go back to that page and redo.
4.2.5 Technical Details

The webpages were written with the software of Macromedia Dreamweaver 4.0 and Microsoft Frontpage 2002.

Cgi script was used to process the data. CGI stands for Common Gateway Interface. It is a standard way for a Web server to pass a Web user's request to an application program, and to forward the received data to the user (Whatis, 2002). The cgi script used in this survey is downloaded from bignosebird.com (http://bignosebird.com/). It is used for two purposes: to process the data collected from the survey form; and to send the data to the specified email address.

Two java scripts are used in the questionnaire. One is for automatic presentation of a jargon when the respondent points the curser at it. This script is downloaded from dynamicdrive.com (http://www.dynamicdrive.com). The other is to pop up a new window with to show a graphic example when the respondent clicks at a hyperlink. It is built by javascript.com (http://www.javascript.com/).

4.2.6 Survey Distribution

The survey was distributed to the potential respondents via an invitation email containing the hyperlink to the survey Website.

4.2.7 Potential Sources Of Biasness

There are several potential sources of biasness in the survey.
The survey was set anonymous to free the respondents from concerns of releasing sensitive and identifiable corporate information. The respondents were expected to complete the survey at one try. There was no formal mechanism to prevent double entry except manual check of the respondents’ IP (Internet Protocol) addresses and responding time. The responses were collected by the cgi script and sent to the researcher by email. For any complete response, the researcher received 4 emails (for part 1, 2, 3, and report inquiry respectively) from the same IP address within certain close duration, say half an hour. Theoretically a respondent can try many times if using different IPs. In reality, however, respondents were bothered by the length of the questionnaire and some quitted before finishing all three parts, instead of attempting a second try. These incomplete responses were discharged from the analysis.

The samples are graduate students in the SDE. Most of them are part time students by course work, with years of working experience in the Singapore construction industry. Several of them are full time research students or international students. These people are among the highly educated professionals in the industry, and therefore cannot precisely represent the general situation of the Singapore AEC industry. Their overall attitude in favor of IT is expected to be a bit ahead of the common practitioners.

To the Singapore construction industry, ASP is still a concept rather than a common practice. For a pilot study like this, it is impossible to find sufficient experienced users to complete the survey. The questionnaire is therefore designed to ask both current and potential users of their experience or expectations towards ASP.
The result turns out to be more of expectation than of experience because only a few respondents have the experience.

However, the biasness is still regarded acceptable because the purpose of the survey is only to identify the most useful categories of as-is and to-be features of ASP discussed in Chapter 3.

### 4.3 DATA ANALYSIS

From the perspective of statistical analysis, the number of observations should be at least 30 for the sampling distribution to be approximated by a normal distribution (Levine, Berenson & Stephan, 1999). In this survey, valid responses happened to be 30, which is deemed to be large enough for meaningful statistical analysis.

For statistical purpose, a count is converted to percentage by the following formula:

\[
\text{Percentage} = \frac{\text{Count}}{30} \cdot 100
\]

The survey makes use of scaled responses to capture the subjective evaluations. For example, the possible answers to question 3.6 included “Very Useful”, “Useful”, “Neutral”, “Not So Useful”, “Not Useful At All”, and “Not Sure”. To compute the mean value for the rating, a numeric value is assigned to each response – 5,4,3,2, 1 and 0, with 5 to the highest rating (“Very Useful”) and 1 to the lowest (“Not Useful At All”), while 0 to “Not Sure”. The same technique is applied to all other scaled
responses throughout the survey analysis. The mean scale is calculated by the following formula:

\[ MeanScale = \frac{\sum_{i=1}^{n} Scale_i \cdot Count_i}{\sum_{i=1}^{n} Count_i} \]

4.4 OVERALL FINDINGS AND ANALYSIS

4.4.1 Part I Respondent Profiles

Among the 30 respondents surveyed, 23.3% are clients, 50% are consultants, 16.7% are contractors and 10% are the academics. None of the respondents is a supplier or manufacturer (Figure 4.3). It is not clear whether it is due to sampling or responding bias that suppliers and manufacturers are absent. One possibility is that they are more interested in e-procurement rather than project collaboration, which is outside the scope of this study.

Twenty-six point seven percents of the respondents are senior executives, 50% are construction-related professionals, 13.3% are site management staffs, 10% are full-time students, but no one is IT-trained (Figure 4.4). Seventy percents of the respondents have 2 to 10 years of construction-related working experience, 23% have been working for more than 10 years and only 7% have less than 2 years working experience (Figure 4.5). The above findings reveal that the respondents are construction domain experts, rather than IT experts. They have sufficient working experience and construction related knowledge to understand the usefulness of IT and ASP as a tool for their work. Therefore, they are suitable for non-functional requirement collection, but not functional ones.
4.4.2 Part 2 General Use Of IT And Networking

Among the 30 respondents, 80% reported that their companies have homepages on the Web, most of which are for company introduction (70%), customer services (33.3%), recruitment (26.7%) and business marketing (23.3%). Project collaboration occupies 16.7%. The 10% respondents selecting others indicated the functions are for online project cost management and information sharing, which actually fall to the project collaboration category. However, only 3.3% or one respondent indicated that their homepage is for open tendering, while no respondent use it for e-procurement (Figure4.6).
Figure 4.6 Purpose Of Company Homepage.

All respondents have one or more means to access the Internet from work. A few years ago, modem was a most popular means (Rivard, 2000). Today, ISDN (Integrated Services Digital Network) and broadband constant connections are becoming more and more affordable. Among the respondents, 44% reported using constant connections in their firms, 33% using ISDN, and the remaining 23% using modem. No one is using wireless connection (Figure 4.7).

For internal information system, 87% of the respondents’ firms have their local area network. For maintenance of the IT systems, 30% of the respondents’ firms have full-time IT management staffs, 40% have IT staffs with other responsibilities, and the remaining 30% don’t have such an employee. Approximately 82.7% of all the employees in the respondents firms are using computer for their work, 76.4% of them are using email and 57.2% accessing Internet for their work. However, using wireless devices to access the Internet for work, such as WAP (Wireless Application Protocol) phone or PDA (Personal Digital Assistant), is not a common case (Figure 4.8).
Most of the construction related documents are still exchanged in traditional means of paper mail (74.6%) and fax (44.2%). However, exchanging documents using email has become a common practice (43.3%) (Figure 4.9). The respondents believed that applying IT has a significant impact on speeding up information transfer (4.5). They also considered that applying IT can provide more useful information, reduce mistakes in documentation, decrease construction variations and lower difficulty of project coordination (Figure 4.10).
4.4.3 Part 3 Uses Of ASP

4.4.3.1 Acceptance Of ASP

Two thirds of the respondents stated that they were using or intended to use ASP to exchange information among the project team. However, their colleagues' overall willingness to use the solution is most likely to be neutral or slight involvement (3.7).
Major perceived benefits of adopting ASP include: cost saving, efficiency, better communications, and well-organized and complete documentation (Figure 4.11). The use of ASP has not been required by client, nor regarded as the means for competition. Major concerns are high investment costs, risk on data security, greater know-how required from staff, and IT infrastructure constraint (Figure 4.12).

This means that the development of ASP in Singapore is still in an initial stage. People are more concerned with investment and infrastructure than the solution itself. However, standardization has also been addressed as a major concern, which demonstrates the urge for a common platform for heterogeneous information exchange.

![Major Benefits Of Using ASP](image)

Figure 4.11 Major Benefits Of Using ASP.
4.4.3.2 Awareness Of ASP

The result of general awareness of ASP is a bit disappointing. Among the listed 5 local ASPs and 11 international ASPs, only 3 respondents had used one or more international solutions. Two people knew two solutions that were not listed. Five people didn’t know any of the 16 ASPs. Most respondents learned about 3 to 5 ASPs. None of the 5 local ASPs were used by the respondents for collaboration purpose (Figure 4.13).

As for the three Internet-based construction services in Singapore, about half of the respondents learned about the Corenet E-Information (50.0%) and the Corenet E-
Submission System (46.7%) (Referred to Chapter 2). Only 36.7% learned about the e-bidding services of HDBuilders.com (Referred to Chapter 3) (Figure 4.14).

![Overall Awareness of ASPs](image)

Figure 4.13 Overall Awareness Of Asps.

![Awareness of Local Services](image)

Figure 4.14 Overall Awareness Of Local Services.

Very few of the respondents have knowledge about ASP. Players in the construction industry are aware of the C21 thrust (Construction 21 Committee, 1999)\(^1\).

\(^1\) Construction 21 is a Singapore government report, which identifies the strategic thrusts towards the Singapore construction industry in the 21st century. It is specified in its recommendations to raise the use of IT, in particular the Corenet project.
To the practitioners in Singapore, it is a matter of time to standardize the business processes with greater use of IT. They are, in general, aware of the potential power of the Internet, but are actually waiting for the technology to be commonly accepted by the industry, like the ubiquity of AutoCAD, before they are willing to put efforts into implementation in their firms, as one respondent commented:

“Until standardization is in place - at least down to 2 major system and at least 99% certainty of the ASP's long term survival to protect our investment and reduce disruption to service, it would be difficult to convince management to adopt ASPs. I suspect that at this moment, many CEO's are giving the ok without being fully aware of the risks.”

4.4.3.3 Expected Impacts On Time

By adopting the ASP, the amounts of time on all the 8 listed activities are expected to be reduced. Some are expected to be shortened greatly, while others slightly (Figure 4.15).

Among the three physical activities (attending meetings outside your firm, making site visits, traveling overseas), the time spent on traveling overseas is expected to reduce mostly (3.8)\(^2\). This means that ASP is expected to be most useful when applied to projects that are across national borders. Time spent on making site visits is expected to be reduced slightly (3.3). It is unclear whether the respondents were unaware of the site Web-cam feature of the ASP, or they did not believe that Web-cam could substitute physical visits.

\(^2\) Numbers in parenthesis in this chapter refer to the mean score obtained from the survey.
Among the three communication means (making telephone calls, writing email, and faxing), time on faxing is expected to reduce greatly (4.0). Time on making telephone call will also reduce much (3.8), but on writing email will only reduce slightly (3.5). This is because faxing is one of the most popular means of communication. About 44.2% of construction documents are exchanged through faxing (Figure 4.9). The document warehouse function of ASP acts similar to the document exchange by faxing. Therefore, it is possible that ASP will partly substitute faxing. Email has become a common practice in the Singapore construction industry (43.3% of construction documents are exchanged via email (Figure 4.9); about 76.4% of the employees in the respondents’ firms are using email for their work\(^3\)). The trend is that people will prefer email to phone call when written records are needed. They will also prefer email to faxing when a softcopy is better than a hardcopy. Therefore, time on writing email is not expected to reduce much after applying ASP.

Two “soft” activities, searching for project documents (4.3) and tracking project activities (4.4), are expected to be most efficient with the help of ASP. This is true

\(^3\) Calculated from Questions 1.3 and 2.5.
because ASP provides well-organized and complete documentation, which eases the search of information and the tracking of project activities.

### 4.4.3.4 Evaluation Of As-Is Features

The 7 categories of as-is features are the same as those in Chapter 3. Major features are also listed in each category, with a screenshot hyperlinked from a commercial ASP Website (Figure 4.1). The respondents were asked to evaluate each category, instead of each feature.

**Mean Scale of As-is Features**

<table>
<thead>
<tr>
<th>Category</th>
<th>Mean Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>General System</td>
<td>4.0</td>
</tr>
<tr>
<td>Application Support / Document Management</td>
<td>4.4</td>
</tr>
<tr>
<td>Workflow Management With Templates</td>
<td>4.4</td>
</tr>
<tr>
<td>Administration</td>
<td>4.3</td>
</tr>
<tr>
<td>User Centric Workplace</td>
<td>4.0</td>
</tr>
<tr>
<td>Team Communication</td>
<td>4.4</td>
</tr>
<tr>
<td>Capability, Stability And Security Of ASPs</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Figure 4.16 Evaluation Of ASP As-Is Features In Terms Of Mean Scales.

Four of the 7 categories were considered very useful: document management (4.4); workflow management (4.4); administration (4.3); and team communication (4.4) (Figure 4.16). They are exactly the cornerstones of a collaboration system. The four categories will be further iterated in the conceptual model in Chapter 5.
4.4.3.5 Evaluation Of To-Be Features

Among the 9 listed categories of to-be features identified in Chapter 3, 4 are considered very useful: time and cost consideration (4.2); integration (4.2); intelligent search (4.2); and knowledge base (4.1) (Figure 4.17). The improvements of these features are most likely to have the interests from the common users. They represent the research directions in the future.

![Figure 4.17 Evaluation Of ASP To-Be Features In Terms Of Mean Scales.](image)

4.4.3.6 Comments On ASP

Comments on ASP are designed as open questions in which the respondents can type whatever they want to say. Typical comments are of the benefits, obstacles of using IT and especially the ASP, and suggestions on ASPs.

4.5 SUMMARY

This chapter discovers the specific requirements of the AEC industry upon IT and Web-based collaboration. The tendency of IT applications is towards a greater computerization of the business processes. It is clear from the survey that the most significant impacts of IT on the construction industry are faster information transfer,
reduction in difficulties in project coordination, better communications, and easier and faster access to common data. Although the Internet has been adopted by most firms surveyed, a lot of information is still exchanged in its traditional means.

Email is the most common electronic means of exchanging information, but it is somehow hindered by huge graphic data files that slow down the speed of information transfer. There is a great need to develop some fast and powerful network systems that can handle this type of data, and large text documents without sacrificing on the speed of transfer or downloading time from the Internet so as to encourage more user participation.

The development of ASP in the Singapore construction industry is still in an initial stage. Major perceived benefits of adopting ASP include: cost saving, efficiency, better communications, and well-organized and complete documentation. Major concerns are high investment costs, risk on data security, greater know-how required from staff, and IT infrastructure constraint. By adopting the ASP, the amount of time spent on various project management activities is expected to be less.

The result of general awareness of ASP is a bit disappointing. Due to a low awareness of ASP and Internet-based services, the evaluations of ASP features are more of expectations than of facts.

Some ASP as-is features that were regarded very useful were identified: document management; workflow management; administration; and team communication. The categories of ASP to-be features that were considered very useful include: time and cost consideration; integration; intelligent search; and knowledge base.
With the advancements made, the remaining obstacle is a mind set change of the players in adopting new technology for their work in the construction industry.
CHAPTER 5 CONCEPTUAL MODEL DEVELOPMENT

5.1 INTRODUCTION

The last chapter identified 4 useful as-is features and 4 to-be ones of ASPs through a Web-based survey. This chapter incorporates the 4 as-is features and 1 to-be feature, integration through data markup, into the conceptual model. Only 1 to-be feature has been included due to research scope and time limit, which is both the contribution and the limitation of the study.

This chapter first introduced the terminology of the Unified Modeling Language (UML), including symbols, structure of a UML model, and modeling strategies. Next, the main use case of the conceptual model is described, followed by further descriptions of some elements that are most related to Data Markup Integration (DMI). A detailed documentation of the conceptual model is included in Appendix III.

5.2 THE UML MODELING METHOD

UML is a language for systems engineering (OMG, 2000). It is chosen for the development of the conceptual model because it is rapidly established as a de facto international standard for object-oriented modeling. There are many CASE (Computer Aided Software Engineering) tool that supports UML, among which is Rational Rose that has been applied by this study. UML provides a series of diagrams (Hannus and Kazi, 2000), such as use case diagram, class diagram, object diagram, sequence diagram, collaboration diagram, statechart diagram, activity diagram, component
diagram, deployment diagram, and package diagram. The conceptual model in this study includes mainly the following diagrams:

- Use Case diagram that describes functionality provided by a system to external integrators (e.g., Figure 5.5);
- Activity diagram that describes the behavior in response to internal processing (e.g., Figure 5.9);
- Collaboration diagram that describes the flow of messages, focusing upon the relationships between the objects (e.g., Figure 6.3).

### 5.2.1 The UML Modeling Approaches

There are two UML approaches of conceptual modeling: the use case driven approach, and the class driven approach. The use case driven approach describes the system from the external user’s point of view and is most suitable for domain knowledge analysis. The class driven approach describes from the system designer’s point of view and is for technical development at a later stage (Schneider, & Winters, 2001). This study applies the use case driven approach, since conceptual modeling is at an early stage of the development cycle. Use case driven approach is emphasized, if not recommended, by UML (Maciaszek, 2001).

The graphical model of use cases is supplemented with narrative descriptions and with sequence or collaboration diagrams for individual use cases. These additional descriptions and diagrams define steps and objects needed for each use case to occur.
Chapter 5 Conceptual Model Development

The conceptual model of this study mainly involves four elements: actor, use case, activity, and package.

An actor is a group of people or a system that is outside of the system and interacts with the system. Each actor defines a particular role. To interact with the system, an actor must initiate at least one use case. An actor is represented by a stick figure (Figure 5.1).

A use case describes a specific way of using a system. The identified use cases describe the functionality performed by the system as a result of a request from an actor. Use cases provide a way to capture the requirements about the system, communicate with the end-users and domain experts, and test the system (Bjork, Huovila, and Hult, 1993). Use cases are the main representative modeling elements in the study. A use case is represented by a labeled oval (Figure 5.1). Extend is a relationship between two use cases. Where A extends B, it means A describes more specific behavior and B the general version of that behavior.

An activity diagram is used to graphically represent the flow of events of a use case. It is a lower level representation for detailed description of the use case. An
activity is represented by a round-corner rectangle (Figure 5.2). An activity diagram depicts a start state, activities that the system performs, decisions that determine which activity is performed next, and one or more end points.

Figure 5.2 Activity Diagram.

Packages serve to partition the model. They are the clusters of highly related modeling elements, such as use cases and classes. They are used to model higher level representation. A package is represented by a rectangle with a small rectangle attached on the top left (Figure 5.3).

Figure 5.3 Packages.

For complete explanation of the UML terminology and symbols, please refer to Maciaszek (2001).
5.2.2 Use Case Documents

Use case modeling is tightly integrated with requirements determination. Textual requirements in the requirements document need to be traced down to use cases in the specifications document. A system can consist of numerous use cases. System level use case can also be divided to subordinate use cases. Use cases are documented using templates. Table 5.1 is a typical use case document template (Schneider & Winters, 2001), which is adopted by this study. Appendix III follows this format to document the conceptual model.

Table 5.1 Use Case Document Template (Adapted From Schneider & Winters, 2001).

<table>
<thead>
<tr>
<th>Context Diagram</th>
<th>A small use case diagram showing the use cases and their relationships.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use Case Name</td>
<td>The name of the use case.</td>
</tr>
<tr>
<td>Brief Description</td>
<td>Usually a paragraph or less. May include the priority and status of this use case.</td>
</tr>
<tr>
<td>Actors</td>
<td>Actors involved in the use case.</td>
</tr>
<tr>
<td>Main Flow</td>
<td>The flow of events that is normally executed.</td>
</tr>
<tr>
<td>Alternative Flows</td>
<td>Other flows of events that might be executed if the main flow is not.</td>
</tr>
<tr>
<td>Activity Diagram</td>
<td>A diagram of the flow of events or some significant or complex part of the flow of events.</td>
</tr>
<tr>
<td>Pre-Conditions</td>
<td>A list of conditions that must be true before the use case starts.</td>
</tr>
<tr>
<td>Post-Conditions</td>
<td>A list of conditions that must be true when the use case ends, no matter which path is executed.</td>
</tr>
<tr>
<td>Subordinate Use Cases Diagram</td>
<td>A small use case diagram showing the subordinate use cases of this use case.</td>
</tr>
<tr>
<td>Subordinate Use Cases</td>
<td>A section for each subordinate use case with its flow of events.</td>
</tr>
</tbody>
</table>
Chapter 5 Conceptual Model Development

The use case document evolved with the development progress. In the early stage, only a brief description is written. Other parts are written gradually and iteratively. A complete document emerges at the end of the requirements specification phase (Maciaszek, 2001).

5.3 MAJOR ACTORS

Actors can be regarded as classes, therefore, they have attributes and operations. The actors identified in this study are: **ASP, CIO, and User**. **ASP** is the platform and service provider.

**CIO** (Chief Information Officer) is the platform administrator. Its duty is to manage the project Web throughout the whole process of Web site utilization. Since the information manager controls the entire project information, it is suggested that this person shall come from a third party of the project, such as a staff of the ASP, so as to remain unbiased to all parties of the project. In practice, the administrator could be the client, the project manager, the main contractor, or any main player of the project who is in charge of the administration of project information. **User** is the one who uses the ASP services.

**User** is a generic class, which is inherited by **Client, Project Manager, Designer, and Contractor**. **Designer** is inherited by **Architect and Engineer**. **Contractor** is inherited by **Main Contractor and Sub-contractor** (Figure 5.4).

Inherit is a relationship among classes, which is represented by a hollow arrow pointing from the son class towards the father class. Different son classes inherit the
same generic attributes of their father class while having specific attributes distinct from each other.

According to the roles of the users, their rights to access certain information is different. For example, the sub-contractor is not supposed to know the contract between the client and the main contractor.

![User Inheritances](image)

**Figure 5.4 User Inheritances.**

### 5.4 THE MAIN USE CASE

Chapter 4 identifies the four most useful categories of features: document management, workflow management, team communication, and administrate project. They are incorporated in the conceptual model as four packages. In addition, *My Project Place*, the use-centric workplace, is also included as a package. DMI is incorporated all over the model and not as a specific package. The next few paragraphs discusses the main use case (Figure 5.5) and how the components inside are relevant to DMI.
5.4.1 Setup Project Service

The use case Setup Project Service is to set up the infrastructure for the project, which initiates the use of a project Website.

Figure 5.5 Main Use Case.

5.4.2 Setup Project Website

The use case Setup Project Website is to set up the framework for the Website (Figure 5.6). It defines the standardized templates to manage document and workflow (Define Document Directory, Define Document Templates, Define Workflow Templates, etc). It also defines the business logics for the system to execute (Define Business Logic, Assign Group Permission Right, Define User Interface, etc). A template determines the standard and structure of a portfolio. When the user creates a new file, the system obtains certain data from the template. Using a template can quickly create project
wide standards and reduce time-consuming data entry. A standardized template based on XML (eXtensible Markup Language, will be discussed in Section 6.4), such as a form for RFI, defines the meaning of each input field, which can be easily interpreted by the system. For example, the inputs in the field of “From” are saved in XML format as:

```xml
<From>
  <ActorSelect>
    <Person>YS Liu</Person>
    <Organization>Position of staircase handrail</Organization>
  </ActorSelect>
</From>
```

Figure 5.6 Setup Project Website.

### 5.4.3 Setup User

The use case Setup User is to setup the profile of the users that can access the project Web and their rights to access information. It is possible to keep sensitive information from being reached by restricting some users’ access rights.
### 5.4.4 Log In

The use case Log In is to verify the user. It also acts as the access to personalized Headline page and all functional packages (Figure 5.2).

### 5.4.5 Package Manage Document

The package Manage Document should be able to manage various types of file, such as drawings, schedules, cost, customized documents, to name a few (Figure 5.7). It should also be able to handle the files by allowing uploading, viewing, searching, commenting, and printing (Figure 5.8). There are three features that are related to DMI: Upload file, Search file and Search topic.

**Figure 5.7 Manage Document Inheritance.**  **Figure 5.8 Manage Document.**

**Upload file** is for file uploading. Meta-data of the file, such as author, date, and description, is required to key in by the document author, so as to ease the search of the file on the project Website. With meta-data, the file can be searched by...
various criteria. The meta-data is saved in XML format. The process of uploading a file is shown in Figure 5.9.

Search file is for file searching (Figure 5.10). With meta-data, the system can neatly present various search result based on the user’s search criteria other than full text, such as by description, or by category, e.g., draft drawing, shop-drawing. It enhances the quality of searching by presenting the most targeted file to the user.
Search topic is for integrated presentation (Figure 5.11). It is the most important use case to demonstrate how XML enabled collaboration system differs from others. It searches related information in the project Website, and integrates the search result into a single webpage. This means user can extract useful pieces of information from all sources in the project Website and put them together for analysis and decision making. It shortens the time on information searching and organizing, allows user to concentrate on information analyzing and decision making.

The user can search a topic based on various criteria marked up by XML, such as “handrail” as the type in a quotation, or comments by a specific author in the series of an RFI. User can browse through the search result and marks useful items. The marked information can be saved for future use. XML compatible information can be copied and pasted to the Saved Items. XML incompatible information can be viewed in specialized viewers or plug-ins (Refer to Section 6.4.4 for discussion on XML compatibility). When the user gets enough information, he or she can review the saved items, indicates how the information should be displayed, which should be saved for permanent use, and which should be linked to the Workflow Management for short-term use. Chapter 6 will explain this concept in an example of Request For Information case.
5.4.6 Package Manage Workflow

In the package Workflow Management (Figure 5.12), standardized workflow is realized through information templates and automatic execution of business rules. A workflow consists of several tasks. Tasks are small jobs that the project manager assigns to the project users, such as responding to a Request For Information (RFI), approving a Variation Order (VO), etc. When one task finishes, the system automatically brings the next. When all tasks are finished, the workflow ends. The benefit of automatic workflow management is to speed up the communication and confirmation on decisions.

The use case Manage My Work Package provides various tools to facilitate each user to manage workflows that are related to him or her. In such a way, the
information resides in different documents can be managed according to a user’s need, and can be integrated to handle workflows.

![Diagram of Package Management Workflow](image1)

**Figure 5.12 Package Management Workflow.**

In Chapter 6 an RFI case is prototyped to validate the conceptual model. The general process of RFI is discussed here. A user, be it the designer, project manager, or contractor, can manage the RFI by initiate it or respond to it. An RFI could be extended to a Variation Order should the change be approved (Figure 5.13).

![Diagram of Manage Change](image2)

**Figure 5.13 Manage Change.**
Figure 5.14 shows the workflow of an RFI. The use case begins when the User initiates a new RFI. The system displays the webpage for RFI input.

![Workflow of RFI](image)

When the User finishes all input, the system saves the RFI to its database. If the initiator indicates a party to answer the RFI, the system sends a notification to that party. If not, the system sends the notification to the Project Manager, so that he or she will assign the task to a responsible party.

The responsible User receives the notification, views the RFI, and answers the RFI. The system saves the answer, notifies the initiator and the Project Manager. If the initiator is satisfied with the answer, he or she closes the RFI and the workflow ends. If further clarification is needed, the responsible User adds his or her comments and redirects the RFI back to the initiator for clarification.
If the responsible User is unable to answer the RFI, he or she adds new comments, redirects the RFI to a User who can answer the RFI. The new responsible party goes through viewing and replying RFI or redirecting it to another responsible party, until one party answers the question to the satisfaction of the initiator.

5.4.7 Package Team Communication

While Manage Workflow is a formal way to manage collaboration, Team Communication can act as less formal discussion (Figure 5.15). The features of BBS (Bulletin Board System), instance messaging, online conference, and email provide speedy and traceable means to record informal discussions, which can be formally documented into the workflow management, or serve for decision-making. Team communication thus simplifies the processes of workflow. Inputs in team communication are also saved in XML format, and therefore, are traceable by using Search Topic.

Figure 5.15 Team Communication.
5.4.8 Package My Project Place

My Project Place is a personalized work station (Figure 5.16). Every user can view his or her own tasks, and job related information. This simplifies the users’ environment, allows the user to concentrate on relevant information. It is possible with XML technology because the system tailors the information to suit the users’ need.

5.4.9 Administrate Project

In a workflow, each task automatically starts after its precedent finishes, given that the tasks are assigned to the responsible parties by the Project Manager. This is done through the package of Administrate Project (Figure 5.17). The preset business rules define the framework of who is responsible to do what by the deadline of when, and what if the task is not finished on time. The project manager only needs to fill in the specific items for each collaborative workflow.

Figure 5.16 My Project Place.
SUMMARY

This chapter describes the conceptual model for Web-based construction project management. Use cases and packages that are most relevant to DMI are highlighted, which will be further discussed in Chapter 6. A complete conceptual model is documented in Appendix III.
CHAPTER 6 PROTOTYPING OF REQUEST FOR INFORMATION

6.1 INTRODUCTION

The last chapter describes the conceptual model from the system viewpoint. This chapter prototypes the Request For Information (RFI) to verify its usefulness of the Data Markup Integration (DMI) system. Prototyping the RFI case also demonstrates technical feasibility of implementing the DMI conceptual model using XML technology. There are two reasons for choosing RFI for prototyping. Firstly, it is a common and typical document in project collaboration. Secondly, it is scalable, each of which can involve from few to many parties, which is typical for Web-based collaboration (Leung, Chan, & Issa, 2003).

6.2 THE REQUEST FOR INFORMATION SCENARIO

The RFI scenario presented here is a real case of an MRT (Mess Rapid Transit) project in Singapore. As instructed by the information provider, names of the companies and persons are replaced by fictitious ones.

In this design-and-build project, the Main Contractor (company MC) acts as the project manager. The Architect (company AR) serves for MC. The Client (company CL) is a government agency in charge of national MRT projects. CL supervises the project, dealing with major decision making, and authorizing changes to the project work. In company MC, YS Liu is the Project Manager (PM), and M Ang is the
Quantity Surveyor (QS). K Foo is the Qualified Person (QP) and chief architect in AR. In company CL, C Tan is the PM, and R Chee is the QS (Table 6.1).

Table 6.1 Person, Role And Company

<table>
<thead>
<tr>
<th>Name of Person</th>
<th>Role of Person</th>
<th>Name of Company</th>
<th>Role of Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>YS Liu</td>
<td>PM</td>
<td>MC</td>
<td>Main Contractor</td>
</tr>
<tr>
<td>M Ang</td>
<td>QS</td>
<td>MC</td>
<td>Main Contractor</td>
</tr>
<tr>
<td>K Foo</td>
<td>QP</td>
<td>AR</td>
<td>Architect</td>
</tr>
<tr>
<td>C Tan</td>
<td>PM</td>
<td>CL</td>
<td>Client</td>
</tr>
<tr>
<td>R Chee</td>
<td>QS</td>
<td>CL</td>
<td>Client</td>
</tr>
</tbody>
</table>

Note: PM = Project Manager; QS = Quantity Surveyor; QP = Qualified Person.

The RFI was about the location and material of a staircase handrail. The handrail could not be built as shown in the original drawing, due to position conflict with the steel column footings (Figure 6.1). Since steel type was not specified in the original drawing, MC also wanted to clarify the type of stainless steel to be used (Type 316 or Type 304).

The actual process was paper-based (Figure 6.3), in which information was exchanged via faxing. This process is simulated in the DMI environment (Figure 6.4).
The paper-based and DMI-based processes are explained and compared (Table 6.2). They are modeled using UML collaboration diagrams (Section 5.2).
Table 6.2 Comparison Of Paper-Based And DMI Processes.

<table>
<thead>
<tr>
<th></th>
<th>Paper-Based Process</th>
<th>DMI Process</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>YS Liu created an RFI and proposed his own solutions (Table 6.3). Drawing of the proposed solution was attached with the RFI and faxed to K Foo (Figure 6.1, Figure 6.4).</td>
<td>YS Liu logs in to the system, creates and submits a new RFI (Figure 6.5). Drawing of the proposed solution is uploaded to the Web site. The RFI contains a link to that file. The system notifies K Foo and C Tan concurrently.</td>
<td>In the DMI process, the RFI can be responded concurrently by more than one party, so as to shorten the total responding time.</td>
</tr>
</tbody>
</table>
| 2 | K Foo received the fax. He manually compared the proposed drawings with the original drawing to find out the cause of change. K Foo responded:  
Question 1: Proposed solution is not ideal; Pedestrian might hit stump, better hack the kerb.  
Question 2: T304 is used in general occasions, while T316 in high-cautery or high-humidification situations. T304 is acceptable to designer.  
Later he called YS Liu and learned that the kerb could not be hacked. He waited till the weekly site meeting, investigated the site situation, and added a third comment after question 2: You have confirmed kerb is structural and can not be hacked. Build it as proposed. K Foo faxed the RFI back to YS Liu. | K Foo views the RFI online. He reviews the drawings by simply clicking the URL that links to the files. The two drawings are shown on the screen for him to compare (Figure 6.6).  
K Foo can use BBS to create a discussion on whether the kerb can be hacked. He can also request YS Liu to send site photos to him via Web-Cam. When he needs to add a new comment, he can add it in the answer to question 1.  
K Foo responds:  
Question 1: Proposed solution is not ideal; Pedestrian might hit stump, better hack the kerb. You have confirmed kerb is structural and can not be hacked. Build it as proposed.  
Question 2: T304 is used in general occasions, while T316 in high-cautery or high-humidification situations. T304 is acceptable to designer.  
K Foo submits his comments. The system informs YS Liu and C Tan that K Foo’s new comment is available. | In the DMI process, references are available by simply clicking at the URL that links to the file. This shortens the time to manually look for the references.  
In the DMI process, the architect can make decisions faster because Web-Camera reduces his physical visits to the site.  
In the paper-based process, additional information is recorded according to chronological order, i.e., the third comment was added after the second comment. While in the DMI process, information can be recorded according to logical order, i.e., the third comment is an answer to question 1, so it is added between the first and the second comments. |
<p>| 3 | YS Liu faxed the RFI to C Tan for comment.                                           | -                                                                            | The DMI system automatically informs the relevant parties to view the information. |</p>
<table>
<thead>
<tr>
<th></th>
<th>Paper-Based Process</th>
<th>DMI Process</th>
<th>Comparison</th>
</tr>
</thead>
</table>
| 4 | C Tan reviewed the RFI and requested a quotation for the two materials. He called K Foo to discuss the RFI. K Foo told him there were no better solutions for Question 1, and no regulation restriction for the type of steel to be used. C Tan then commented:  
  Question 1:  
  No comments. Agree with AR.  
  Question 2:  
  Please provide quotation.  
  The RFI was faxed back to YS Liu. | C Tan reviews the RFI and requests a quotation for the two materials. He can also use telephone, BBS, instant messaging, email, or other communication means to discuss with K Foo or YS Liu before he comments. When C Tan submits his comment, the system notifies both YS Liu and K Foo. | Informal discussions are important to the final decision making. In a paper-based process, there are limited means, such as telephone and face-to-face discussion, in which information is hard to be recorded. In the DMI process, informal discussions can be carried out via various means and recorded as part of the whole project information. For example, discussions on BBS have been proved to be efficient and traceable. |
| 5 | YS Liu forwarded the request to M Ang, the QS of MC, instructing her to provide a QFC to the QS of CL. | YS Liu adds his comment and forwards the RFI to M Ang, the QS of MC. | In the DMI process, YS Liu does not need to repeat the question to M Ang, because Ang can review the question and drawings to find out where the handrail locates. |
| 6 | M Ang prepared a separated Quotation For Change (QFC) for R Chee, the QS of CL, to approve (Table 6.5). In order to provide the QFC she manually looked for the handrail item in the original quotation (Table 6.4).  
  The QFC was faxed to R Chee. Other employees in CL might have viewed the file before it reached R Chee. | M Ang creates a new Quotation For Change (QFC) and submits it to the system. In order to provide the QFC she instructs the system to find the original quotation for her, copies the handrail item, and pastes it to the new QFC.  
  The QFC is embedded in M Ang’s Response to RFI (Figure 6.7). The system notifies R Chee, the QS of CL to view it. M Ang can set the QFC as private, which means only she and R Chee, the explicit receiver, can view the content. | The DMI process provides the convenience to copy and paste information from one file to another. This reduces data re-input, which in turn reduces the chances of errors.  
  In the paper-based process, the RFI and QFC are separated. While in the DMI process, they are integrated. Both the information provider and receiver enjoy the convenience of reviewing the whole set of information, instead of integrating the information from fragmented documents.  
  In the DMI process, sensitive information can be set as private, which means only the information provider and explicit receivers can view the content. |
### Table 6.2 Comparison Of Paper-Based And DMI Processes (Continued)

<table>
<thead>
<tr>
<th></th>
<th>Paper-Based Process</th>
<th>DMI Process</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>R Chee reviewed the QFC, looked for relevant items in the original quotation, compared them and submitted a cost impact report to C Tan.</td>
<td>R Chee compares the items in QFC with the original quotation by clicking the URL that links to the file. He submits a cost impact report to C Tan, recommending him not to change the material.</td>
<td>In the paper-based process, both M Ang and R Chee search the handrail item in the original quotation. This repeat is a waste of time. In the DMI process, R Chee can easily refer to the original quotation because the system saves the source of information from M Ang’s activity.</td>
</tr>
<tr>
<td>8</td>
<td>C Tan chose Type 316, and signed on the quotation page. The quotation page was faxed back to YS Liu.</td>
<td>C Tan chooses Type 316 by responding to the RFI. A notification is sent to YS Liu.</td>
<td>In the paper-based process, since RFI and QFC are separated, C Tan comments on the decision in the QFC, instead of the RFI. This can easily cause argument due to information lost. In the DMI process, the QFC and other references are either link to or embedded in the RFI. All comments are integrated in the RFI log.</td>
</tr>
</tbody>
</table>
| 9 | YS Liu added his confirmation note to the RFI:  
  *Question 1:* AR confirms if stump can not be hacked, handrail is to offset to 200mm from parapet wall.  
  *Question 2:* CL confirms using Type 316 S.S. for the railing.  
  YS Liu circulated the last RFI to each party for documentation, including C Tan, R Chee, K Foo, M Ang and himself (Table 6.3). | YS Liu adds his summary note and closes the RFI. Notification is automatically sent to every party, including C Tan, R Chee, K Foo, M Ang, and YS Liu himself. They can review the RFI and related comments in an integrated webpage called Summary Of Request For Information (Figure 6.8). | In the paper-based process, every fax is a new result to the RFI. In order to see the whole process, the parties have to document every result. Information receivers can not access the information until it is disseminated by the provider. While in the DMI process, the system documents both the process and the result for every party to review. Even informal discussions can be linked to the summary, if they are regarded as important. Information is always available to both the provider and the receivers. |
In the paper-based process, MC proposed his questions and recommendations of the RFI. The RFI was faxed to AR for clarification, then to CL for comment. They used phone calls and site meetings to discuss this RFI, before they wrote down their comments and faxed back to MC. MC marked his summary note and faxed back to each party, then he installed the handrail.

The RFI was about a simple question. The information was circulated between three parties and five persons. However, the RFI had been faxed for at least 5 times, each of which new comments were added. At last, the handwritings on the RFI were blurred and difficult to distinct. Confirmations on the two questions were made separately (AR confirmed the position of handrail on RFI, while CL confirmed the material on QFC), if not for MC’s the summary note. This could have easily caused arguments since CL’s confirmation was not documented on the RFI.

Figure 6.4 Proposed Detail Drawings Of The Parapet.
Table 6.3 Request For Information Form.

<table>
<thead>
<tr>
<th>REQUEST FOR INFORMATION (RFI)</th>
<th>Page 1 of 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>To: K Foo (AR)</td>
<td>MC RFI No: RFI/FNCAS/1522</td>
</tr>
<tr>
<td>Location Of Works On Site: (Area, Gridlines, Level Etc)</td>
<td>S/C Company:</td>
</tr>
<tr>
<td>Entrance 1 of GB Staircase</td>
<td>Raised by (Name):</td>
</tr>
<tr>
<td>Subject: Handrail position and material at GL (RA) side parapet</td>
<td>S/C RFI Reference:</td>
</tr>
<tr>
<td>Date issued to MC:</td>
<td></td>
</tr>
<tr>
<td>Query:</td>
<td></td>
</tr>
</tbody>
</table>

The original design of handrail along GL(RA) is 80mm away from the parapet wall. Since the position does not coincide with the steel column footing at this position, the handrail should be at least 200 mm away from the wall. Please confirm the distance.

Handrail material is not specified in the original design. Please confirm whether Type 316 or Type 304 is to use.

Drawings/Specifications Reference: C709

<table>
<thead>
<tr>
<th>Originator (Name &amp; Signature): Y.S. Liu</th>
<th>Answer required by: 20 / 10 / 2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response:</td>
<td></td>
</tr>
<tr>
<td>Question 1: Proposed solution is not ideal; Pedestrian might hit stump, better hack the kerb.</td>
<td></td>
</tr>
<tr>
<td>Question 2: T304 is used in general occasions, while T316 in high-cautery or high-humidification situations. T304 is acceptable to designer.</td>
<td></td>
</tr>
<tr>
<td>K Foo You have confirmed kerb is structural and can not be hacked. Build it as proposed. K Foo 24/10/2001</td>
<td></td>
</tr>
<tr>
<td>Question 1: No comments, agree with AR.</td>
<td></td>
</tr>
<tr>
<td>Question 2: Please provide quotation. C Tan 28/10/2001</td>
<td></td>
</tr>
<tr>
<td>Question 1: AR confirms if stump can not be hacked, handrail is to offset to 200mm from parapet.</td>
<td></td>
</tr>
<tr>
<td>Question 2: Client confirms using Type 316 S.S. for the railing. Y.S. Liu 30/10/2001</td>
<td></td>
</tr>
</tbody>
</table>

By (Name): __________________ Signature: __________________ Date: __ / __ / ___
Table 6.4 Part Of The Original Quotation.

<table>
<thead>
<tr>
<th>S/n</th>
<th>Description</th>
<th>Qty</th>
<th>Unit</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.0</td>
<td>RAILING</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.1</td>
<td>Fabricate, supply and install galvanized mild steel railing to P.P. Complex comprising top and bottom rail, decorative balusters, bars, anchor bolt and all welded together hoisted and fixed in position including filling smooth junction.</td>
<td>1</td>
<td>Item</td>
<td>7000.00</td>
<td>7000.00</td>
</tr>
<tr>
<td>15.2</td>
<td>Fabricate, supply and install type 316 stainless steel railing to planter boxes and foot stomping area comprising top and bottom rails, balusters, bar, steel posts, anchor bolt and all welded together hoisted and fixed in position including filling smooth junction.</td>
<td>1</td>
<td>Item</td>
<td>14000.00</td>
<td>14000.00</td>
</tr>
</tbody>
</table>

Table 6.5 Quotation For Change Form.

<table>
<thead>
<tr>
<th>MRT Project</th>
<th>Description</th>
<th>Qty</th>
<th>Unit</th>
<th>Rate</th>
<th>Amount (S$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>28/10/2001</td>
<td>Deduction Fabricate, supply and install type 316 stainless steel railing to planter boxes and foot stomping area comprising top and bottom rails, balusters, bar, steel posts, anchor bolt and all welded together hoisted and fixed in position including filling smooth junction.</td>
<td>1</td>
<td>Item</td>
<td>14000.00</td>
<td>14000.00</td>
</tr>
<tr>
<td></td>
<td>Addition Fabricate, supply and install type 304 stainless steel railing to planter boxes and foot stomping area comprising top and bottom rails, balusters, bar, steel posts, anchor bolt and all welded together hoisted and fixed in position including filling smooth junction.</td>
<td>1</td>
<td>Item</td>
<td>8500.00</td>
<td>8500.00</td>
</tr>
</tbody>
</table>

Comment

*Please use T316.*
*C Tan 30/10/2001*

By (Name) __________ signature __________ Date __/__/____
To simulate the paper-based process, activities in the DMI process are intentionally designed to be close to the actual ones. To simplify the process, the activity of system automatic notification is abridged from the collaboration diagram (Figure 6.4).

The RFI and related responses are neatly documented in chronological order. References are easy to find since they either are embedded in the RFI or can be accessed by clicking at the hyperlinks. All responses are documented in the RFI to reduce arguments stemmed from ambiguity. Responsible parties can concurrently respond to the RFI, instead of one after another. The process can be tracked at anytime. This not only reduces total response time, but also minimizes unnecessary delay of the whole process due to one party’s temporary absence.

To summarize the benefits of the DMI process in the RFI scenario, it provides the convenience of ready, complete and integrated information in a timely manner, which helps the users to make decisions faster and more accurately, so that the downstream parties can take actions faster. It also helps to keep track of the collaboration, reduce data re-input, and minimize errors. The key benefit of the DMI process is the availability of information integration, in the manner of extracting useful information from referred files and integrating to the original RFI for decision making.

According to the theory of process redesign (Hammer & Champy, 1993) discussed in Chapter 2, the ultimate benefits of IT applications are achieved through organizational process re-design, instead of tactical and operational improvements. In other words, an analysis on how to apply the DMI system as a whole to simplify a process is more meaningful than to break it down and simulate the paper-based process. Nevertheless, comparison and analysis on the RFI processes demonstrate some general
characteristics of the DMI system (Leung, Chan, & Issa, 2003). Later in Section 6.4.5, analysis of the RFI case will be extended to the overall conceptual architecture of information exchange (Figure 6.16).

### Request For Information

<table>
<thead>
<tr>
<th>Number</th>
<th>MRT/112034525</th>
</tr>
</thead>
<tbody>
<tr>
<td>From</td>
<td>YS Liu</td>
</tr>
<tr>
<td>To</td>
<td>K Foo</td>
</tr>
<tr>
<td>Co</td>
<td>C Tan</td>
</tr>
<tr>
<td>Date</td>
<td>18/10/2001</td>
</tr>
<tr>
<td>Location of Work</td>
<td>Entrance 1 of GB Staircase</td>
</tr>
<tr>
<td>Subject</td>
<td>Handrail position and material at GL (RA) side parapet</td>
</tr>
<tr>
<td>Discipline</td>
<td>Architectural</td>
</tr>
<tr>
<td>Category</td>
<td>Drawing Discrepancies</td>
</tr>
<tr>
<td>Importance</td>
<td>Normal</td>
</tr>
<tr>
<td>Date Required</td>
<td>20/10/2001</td>
</tr>
</tbody>
</table>

**Question 1: Handrail position**
The original design of handrail along GL(RA) is 80mm away from the parapet wall. Since the position of the handrail does not coincide with the steel column footing at this position, the handrail should be at least 200 mm away from the parapet. Please confirm the distance.

**Question 2: Handrail material**
Handrail material is not specified in the original design. Please confirm whether Type 316 or Type 304 is to be used.

**Suggestion**
See attached drawings for handrail position.
Type 304 is recommended.

**Comments**

Figure 6.5 RFI Created By YS Liu.
Chapter 6 Prototyping Of Request For Information

Figure 6.5 RFI Created By YS Liu (Continue).
Figure 6.6 Part Of RFI Responded By K Foo.

Figure 6.7 Part Of RFI Responded By M Ang.
### Summary Of Request For Information

<table>
<thead>
<tr>
<th>Number</th>
<th>MRT/112034525</th>
</tr>
</thead>
<tbody>
<tr>
<td>From</td>
<td>YS Liu (MC)</td>
</tr>
<tr>
<td>Date</td>
<td>18/10/2001</td>
</tr>
<tr>
<td>Time</td>
<td>9:00 a.m.</td>
</tr>
<tr>
<td>1</td>
<td>Responded By</td>
</tr>
<tr>
<td></td>
<td>K Foo (AR)</td>
</tr>
<tr>
<td>Date</td>
<td>24/10/2001</td>
</tr>
<tr>
<td>Time</td>
<td>2:31 p.m.</td>
</tr>
<tr>
<td>2</td>
<td>Responded By</td>
</tr>
<tr>
<td></td>
<td>C Tan (CL)</td>
</tr>
<tr>
<td>Date</td>
<td>28/10/2001</td>
</tr>
<tr>
<td>Time</td>
<td>11:01 a.m.</td>
</tr>
<tr>
<td>3</td>
<td>Responded By</td>
</tr>
<tr>
<td></td>
<td>YS Liu (MC)</td>
</tr>
<tr>
<td>Date</td>
<td>28/10/2001</td>
</tr>
<tr>
<td>Time</td>
<td>11:10 a.m.</td>
</tr>
<tr>
<td>4</td>
<td>Responded By</td>
</tr>
<tr>
<td></td>
<td>M Ang (MC)</td>
</tr>
<tr>
<td>Date</td>
<td>28/10/2001</td>
</tr>
<tr>
<td>Time</td>
<td>2:18 p.m.</td>
</tr>
<tr>
<td>5</td>
<td>Responded By</td>
</tr>
<tr>
<td></td>
<td>R Chee (CL)</td>
</tr>
<tr>
<td>Date</td>
<td>29/10/2001</td>
</tr>
<tr>
<td>Time</td>
<td>9:43 a.m.</td>
</tr>
<tr>
<td>6</td>
<td>Responded By</td>
</tr>
<tr>
<td></td>
<td>C Tan (CL)</td>
</tr>
<tr>
<td>Date</td>
<td>30/10/2001</td>
</tr>
<tr>
<td>Time</td>
<td>3:09 p.m.</td>
</tr>
<tr>
<td>7</td>
<td>Closed By</td>
</tr>
<tr>
<td></td>
<td>YS Liu (MC)</td>
</tr>
<tr>
<td>Date</td>
<td>30/10/2001</td>
</tr>
<tr>
<td>Time</td>
<td>5:15 p.m.</td>
</tr>
</tbody>
</table>

**Location of Work**: Entrance 1 to Garden Bridge Staircase  
**Subject**: Handrail position and material at GL (RA) side parapet  
**Discipline**: Architectural  
**Category**: Drawing Discrepancies  
**Importance**: Normal  
**Date Required**: 20/10/2001

**Question Raised by YS Liu (MC) 18/10/2001 9:00 a.m.**  
**Question 1**: Handrail position  
The original design of handrail along GL (RA) is 80mm away from the parapet wall. Since the position of the handrail does not coincide with the steel column footing at this position, the handrail should be at least 200 mm away from the parapet. Please confirm the distance.

**Question 2**: Handrail material  
Handrail material is not specified in the original design. Please confirm whether Type 316 or Type 304 is to be used.

**Suggestion**  
See attached drawings for handrail position.

**Type 304 is recommended.**

**Link Files**

1. [drawings/shopdrawings/details/C709.dwg (MC v1)] - Proposed drawing
2. [drawings/shopdrawings/details/C709.dwg (AR v1)] - Original drawing

**Response By K Foo (AR) 24/10/2001 2:31 p.m.**

**Answer**

**Question 1**: Proposed solution is not ideal. Pedestrian might hit stump, better hack the kerb. You have confirmed kerb is structural and can not be hacked. Build it as proposed.

**Question 2**: T304 is used in general occasions, while T316 in high-cautery or high-humidification situations. T304 is acceptable to designer.

---

Figure 6.8 Summary Of RFI.
Response By C Tan (CL) 28/10/2001 11:01 a.m.

Answer

Question 1:
No comments, agree with AR.

Question 2:
Please provide quotation.

Response By YS Liu (MC) 28/10/2001 11:10 a.m.

Comment

Question 2:
Please provide quotation to the QS of CL.

Response By M Ang (MC) 28/10/2001 2:18 p.m.

Answer

Please refer to attached file

Link File

1 (Private information, not available for review.)

Response By R Chee (CL) 29/10/2001 9:43 a.m.

Answer (Private information not available for review.)

Response By C Tan (CL) 30/10/2001 3:09 p.m.

Answer

Question 2:
Please use the original material T316.

Response By YS Liu (MC) 30/10/2001 5:15 p.m.

Comments

Question 1:
AR confirms if stump can not be hacked, handrail is to offset to 200mm from parapet wall.

Question 2:
Client confirms using Type 316 S.S. for the railing.

This RFI is Closed by YS Liu at 30/10/2001 5:15 p.m.

Figure 6.8 Summary Of RFI (Continued).
6.3 USE CASES INVOLVED

This section will analyze how the functional units in the DMI system collaborate among one another to serve information integration. In Chapter 5, the conceptual model of the DMI system was presented. The system consists of 5 packages and some top level use cases. Each use case may consist of several subordinate use cases (Appendix III). Table 6.6 summarizes the use cases involved in the DMI RFI process, as well as the information they provide.

Since internal collaboration of the DMI system is out of the scope of requirement analysis, it is not discussed here. To complete a workflow, such as a RFI, it requires many functional units of the system to interoperate, which should be carefully considered in the system design stage. The key for information integration is the assistant tools provided by the system to finish the task. On top of the Response To Request For Information (ReRFI) page are menus of Search Topic, Search File, Highlight, etc. These functional units belong to different packages but have been put together to assist users accomplishing their jobs. By invoking Search Topic, user looks for relevant references, extracts useful information, and uses the information to create new information for the current task. In other words, the system integrates relevant functional units as assistant tools according to the task, i.e., ReRFI. By invoking these tools, a user can search for relevant information, creates new information, and finish the current task.
### Table 6.6 Use Cases Involved In The DMI RFI Process.

<table>
<thead>
<tr>
<th>Package</th>
<th>Use Case</th>
<th>Information</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Setup User</td>
<td>Information access rights</td>
<td>Controlling information access rights. For example, K Foo has no access right to the Quotation and the QFC.</td>
</tr>
<tr>
<td>2</td>
<td>Login</td>
<td>Login page</td>
<td>Verifying user; retrieving user profile, displaying user specific Headline page.</td>
</tr>
<tr>
<td>3</td>
<td>My Project Place</td>
<td>View What’s New</td>
<td>Providing summary of new arrival items.</td>
</tr>
<tr>
<td>4</td>
<td>My Project Place</td>
<td>View My Task</td>
<td>Tasks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Displaying tasks that user is responsible for.</td>
</tr>
<tr>
<td>5</td>
<td>Manage Workflow</td>
<td>Manage Change</td>
<td>Summary of Changes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Providing summary of change items.</td>
</tr>
<tr>
<td>6</td>
<td>Manage Workflow</td>
<td>Manage RFI (Response To)</td>
<td>Providing RFI and Response to RFI forms, and the summary page when the RFI is closed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RFI</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Manage Document</td>
<td>Upload File</td>
<td>C709.dwg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Uploading the drawing for proposed solution.</td>
</tr>
<tr>
<td>8</td>
<td>Manage Document</td>
<td>View File</td>
<td>C709.dwg (MC v1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C709.dwg (AR v1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Displaying files, either embedding the file to the RFI, or opening it in a new window, depending on how the link provider wants it to display.</td>
</tr>
<tr>
<td>9</td>
<td>Manage Document</td>
<td>Search Topic</td>
<td>Search results of handrail, integrated QFC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Providing search results of handrail, integrating the selected item (15.2) to the new QFC.</td>
</tr>
<tr>
<td>10</td>
<td>Manage Document</td>
<td>Manage Cost</td>
<td>Quotation, QFC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Repositing the original Quotation and the QFC.</td>
</tr>
<tr>
<td>11</td>
<td>Team Communication</td>
<td>BBS</td>
<td>BBS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Recording informal discussions of whether the kerb can be hacked or not.</td>
</tr>
<tr>
<td>12</td>
<td>Administrate Project</td>
<td>Manage Activity</td>
<td>Activity log</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Assigning tasks to the responsible parties.</td>
</tr>
</tbody>
</table>

### 6.4 EXTENSIBLE MARKUP LANGUAGE

In the previous sections the DMI system was described via demonstration of user interfaces. This section will discuss system architecture. The key is XML technology. XML acts as the neutral file exchange format in the system. There are many tools to
develop XML. The interface prototype is developed using XMLspy (XMLspy, 2002), which is also applied on the development of ifcXML by IAI (Liebich, 2001; Liebich, & Adachi, 2000). Since XML is platform independent, the system can be developed on any platform that supports the development tools, though in this study it was developed on Windows ME on a Fujitsu notebook with Pentium III 900 CPU and 256 RAM.

### 6.4.1 XML In The Scenario

Figure 6.9 shows the document exchange architecture of the Web-based RFI scenario. The webpages discussed above are dynamic HTML (HyperText Markup Language) transformed from the document XML by the document XSLT (eXtensible Stylesheet Language Transformations). The document XML file is defined by the document XSD (XML Schema Definition). Between the document XSD and the ifcXSD (Industry Foundation Classes XML Schema Definition. Refer to Section 2.7), there is a schema mapping process done by specialized applications, such as Microsoft BizTalk. The ifcXSD defines the ifcXML document. Since all Web-based documents can ultimately be transformed into ifcXML, data in different ifcXML documents can be exchanged with one another.

Figure 6.10 is an example of data exchange between the QFC and the ReRFI (Response to Request For Information). Since they are ultimately transformed into ifcXML files, an Xlink in the ReRFI pointing to the QFC results in a portion of the QFC data appearing in the ReRFI file. The rest of this section describes the ReRFI file as an example of the process, and analyzes the ReRFI schemas (ReRFI.xsd), the ReRFI XML file (ReRFI.xml), and schema mapping (between the ReRFI.xsd and the
ifcReRFI.xsd). For systematic description of the XML terminologies, please refer to W3C (2001)).

6.4.1.1 Schemas For Response To Request For Information (ReRFI)

Schema defines the hierarchy of data structure. For example, the From tag contains ActorSelect, which in turn contains Person and Organization. The following segment of codes represents the hierarchy of XML schema:

```xml
<xs:element name="From">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="ActorSelect" type="ActorSelectType">
        <xs:sequence>
          <xs:element name="Person"/>
          <xs:element name="Organization"/>
        </xs:sequence>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
</xs:element>
```

Figure 6.9 Document Data Exchange.

Figure 6.10 Document Data Exchange Between ReRFI And QFC.
Figure 6.11 shows the top level elements of a ReRFI. ReRFIs is the root element. Each ReRFIs contains one or more ReRFI. Each ReRFI contains one RFI, one Responses and one MyResponse. RFI is the original question submitted by YS Liu. Responses is the group of previous responses, which consists of one or more Response. Responses is optional because it does not appear to the first respondent (K Foo). MyResponse is the response by the current user, which consists of one Response. The data structure of RFI and Response are defined as complex types, so that they can be used repeatedly. A complex type is a global component that can be reused somewhere in the schema.

Figure 6.12 shows the expanded RFI complex type, the data structure of which is the same as that of the original RFI, i.e., the form submitted by YS Liu.

![Figure 6.11 Top Level Elements In ReRFI Schema.](image)

By expanding the Response complex type, the schema is shown in Figure 6.13. Within this complex type, there are two nested complex types: ActorSelect and LinkFile, expanded and circulated in shadowed boxes.
The LinkFile complex type is to handle references. Figure 6.14 shows its schemas. The ActorSelect complex type is to distinguish among message senders and receivers. Figure 6.15 shows its schema. Source codes of the complete ReRFI schema can be found in Appendix IV.

Figure 6.12 RFI Complex Type In ReRFI Schema.
Chapter 6 Prototyping Of Request For Information

Figure 6.13 Response Complex Type In ReRFI Schema.

Figure 6.14 LinkFile Complex Type In ReRFI Schema.

Figure 6.15 ActorSelect Complex Type In ReRFI Schema.
6.4.1.2 XML File For The Response To Request For Information

When the schema is defined, XML files are generated by filling in the content in the schemas. For example, in the From field of the RFI, Person is “YS Liu”, Organization is “MC”. The XML codes are as followings:

```xml
<From>
  <ActorSelect>
    <Person> YS Liu </Person>
    <Organization> MC </Organization>
  </ActorSelect>
</From>
```

Figure 6.16 shows both the hierarchy and the content of the XML file. The complete source codes of the ReRFI XML file can be found in Appendix IV.

6.4.2 XML Presentation

XSL stands for Extensible Stylesheet Language. It consists of two parts: XSLT and formatting objects. XSLT is used to transform an XML document to HTML, XML, WML or any other text-based document. Moreover, the same XML document can be published in different formats depending on the user or the task it serves. For example, the QFC embedded in M Ang’s ReRFI is marked as private, therefore only M Ang and R Chee can view the content in the QFC. For other user, the XSLT render the information as “private information is not available for review” and skips translating the QFC (Figure 6.8).
Figure 6.16 XML File Of ReRFI.

The XSLT codes to transform the “from” tag are as follows:

```xml
<table>
  <tr>
    <td>From: </td>
    <td><xsl:value-of select = "ActorSelect / Person" /></td>
  </tr>
  <tr>
    <td>Company: </td>
    <td><xsl:value-of select = "ActorSelect / Organization" /></td>
  </tr>
</table>
```
The HTML codes transformed by the XSLT of the “from” tag are as follows:

```
<table>
  <tr>
    <td> From: </td>
    <td> YS Liu </td>
    <td> Company </td>
    <td> MC </td>
  </tr>
</table>
```

6.4.3 Schema Mapping Between IfcXML And Document XML

IfcXML v1.02 is the IAI (International Alliance of Interoperability) "recommended standard" to convert IFC2x and beyond releases into XML schema specifications (IfcXML, 2002). Since IFC specification is receiving international interests and implementation efforts as the data model for the AEC (Architectural, Engineering and Construction) information exchange, IfcXML intends to be the commonly agreed content and structure of the AEC domain in the XML community.

However, the structure of the ifcXML schema is very complex and elaborated. Direct use of the ifcXML schema to define document schema is neither convenient nor performance optimum. Therefore, it is necessary to establish a mapping mechanism between the document schema and the ifcXML schema, so that information collected from one kind of document can be exchanged with that from another kind.

Table 6.7 shows the mapping of the ReRFI schema to the ifcXML schema. Although ifcXML intends to be the data exchange schema, it is by no means a complete one. As introduced in Chapter 2, IFC is extensible at the domain / application layer. New schema can be defined on top of the platform for application. To realize one-to-one schema mapping between the document and the ifcXML, extension of the ifcXML schema is necessary. Weise, et al. (2002) extended the IFC
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project model for structural systems. This study follows their methodology to extend the ifcXML. The document schema similar to RFI and defined by ifcXML is PurchaseOrder. This study follows the schema structure of PurchaseOrder to define that of RFI. In Table 6.7, the schemas with “(ext)” are extended schemas. There are many versatile commercial software for schema mapping, among which is Microsoft BizTalk.

Table 6.7 Schema Mapping Between IfcXML And ReRFI XML.

<table>
<thead>
<tr>
<th>XSD of ifcXML</th>
<th>XSD for ReRFI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Element</strong></td>
<td><strong>Element</strong></td>
</tr>
<tr>
<td>Root</td>
<td></td>
</tr>
<tr>
<td>Object</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>ProjectOrder</td>
<td></td>
</tr>
<tr>
<td>ReRFIs (ext)</td>
<td>ReRFIs</td>
</tr>
<tr>
<td>ReRFI (ext)</td>
<td>ReRFI</td>
</tr>
<tr>
<td>RFI (ext)</td>
<td>RFI</td>
</tr>
<tr>
<td>OrderNumber</td>
<td>Number</td>
</tr>
<tr>
<td>Ref_No (ext)</td>
<td>Ref_No</td>
</tr>
<tr>
<td>IssuedBy</td>
<td>From</td>
</tr>
<tr>
<td>ActorSelect (cpx)</td>
<td>ActorSelect (cpx)</td>
</tr>
<tr>
<td>Represent (ext)</td>
<td>Represent</td>
</tr>
<tr>
<td>ActorSelect (cpx)</td>
<td>ActorSelect (cpx)</td>
</tr>
<tr>
<td>IssuedTo</td>
<td>Submit</td>
</tr>
<tr>
<td>To</td>
<td></td>
</tr>
<tr>
<td>ActorSelect (cpx)</td>
<td>ActorSelect (cpx)</td>
</tr>
<tr>
<td>additionalContacts</td>
<td>Cc</td>
</tr>
<tr>
<td>ActorSelect (cpx)</td>
<td></td>
</tr>
<tr>
<td>issuingDate</td>
<td>Date</td>
</tr>
<tr>
<td>issuingTime (ext)</td>
<td>Time</td>
</tr>
<tr>
<td>Location (ext)</td>
<td>Location</td>
</tr>
<tr>
<td>Subject (ext)</td>
<td>Subject</td>
</tr>
<tr>
<td>Discipline (ext)</td>
<td>Discipline</td>
</tr>
<tr>
<td>Category (ext)</td>
<td>Category</td>
</tr>
<tr>
<td>Importance (ext)</td>
<td>Importance</td>
</tr>
<tr>
<td>requestedFinishTime</td>
<td>Required_Date</td>
</tr>
<tr>
<td>QuestionDescription (ext)</td>
<td>Question</td>
</tr>
<tr>
<td>Suggestion (ext)</td>
<td>Suggestion</td>
</tr>
<tr>
<td>remarks</td>
<td>Comments</td>
</tr>
<tr>
<td>DocumentInformationRelationship</td>
<td>LinkFiles</td>
</tr>
<tr>
<td>relatedDocuments (cpx)</td>
<td>LinkFile (cpx)</td>
</tr>
<tr>
<td>Responses (ext)</td>
<td>Responses</td>
</tr>
<tr>
<td>Response (ext) (cpx)</td>
<td>Response (cpx)</td>
</tr>
<tr>
<td>MyResponse</td>
<td>MyResponse</td>
</tr>
<tr>
<td>Response (ext) (cpx)</td>
<td>Response (cpx)</td>
</tr>
</tbody>
</table>

Note: ext = Extended; cpx = Complex Type.
Table 6.7 Schema Mapping Between IfcXML And ReRFI XML (Continued).

<table>
<thead>
<tr>
<th>XSD of IfcXML</th>
<th>XSD for ReRFI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complex Type</td>
<td>Complex Type</td>
</tr>
<tr>
<td>ActorSelect</td>
<td>ActorSelect</td>
</tr>
<tr>
<td>Person</td>
<td>Person</td>
</tr>
<tr>
<td>Organization</td>
<td>Organization</td>
</tr>
<tr>
<td>relatedDocuments</td>
<td>LinkFile</td>
</tr>
<tr>
<td>DocumentInformation</td>
<td>Name</td>
</tr>
<tr>
<td>name</td>
<td>Name</td>
</tr>
<tr>
<td>documentId</td>
<td>FileID</td>
</tr>
<tr>
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Note: ext = Extended; cpx = Complex Type.

### 6.4.4 The Integrated Webpages

There are three kinds of integrated webpages: One is XML files with the same or similar schemas, such as the ReRFI pages; another is XML compatible files with different schemas, such as the QFC in M Ang’s ReRFI page; the rest is XML incompatible files, such as the CAD drawings in YS Liu’s RFI.
XML Files with Similar Schemas - Each ReRFI page (Appendix IV) is different from one another because previous responses are accumulated to the current ReRFI. When a ReRFI page is submitted to the system, it processes only the MyResponse part, and saves it in the Responses. To generate a new ReRFI webpage, the system reads the original RFI and puts the contents into the RFI part of the ReRFI.xml file, reads data in the Responses and puts it to the Responses part, and leaves the MyResponse part empty. The XSLT file translates the XML file to HTML webpage. The empty MyResponse part is for user input and system processing when it is submitted.

XML Compatible Files With Different Schemas - Figure 6.7 shows M Ang’s ReRFI page, in which part of the QFC is embedded. The LinkFile element in the ReRFI provides the convenience to link references. If the reference file is XML compatible, the system extracts the useful part and saves it to the ItemReference element, so that when the XSLT comes across an ItemReference, it tells the system to invoke the XSLT of that document to explain that part and transfer the result to the current document.

XML Incompatible Files - If the reference is XML incompatible, the XSLT tells the system to invoke file viewers or plug-ins to display the file on the screen. The whole file is displayed. But it cannot be used to perform data exchange, since there are no defined schemas to explain the content.
6.4.5 Applications

The previous sections discussed the hierarchy structure and nesting relationship of XML schema. These two characteristics of XML determine its appropriateness as a neutral format for data exchange. Also discussed is the technical implementation of the processes between the webpage and the document XML, and between the document XML schemas and the ifcXML schemas. This method can be extended to include information re-organization, i.e., information in a document is broken down into elements, which is marked up with a schema. Elements initially resided in different documents are now extracted and clustered according to specific need of a user or a task. Figure 6.17 is an example of information exchange in which various types of information is transformed into XML and then integrated for selective displays according to the purposes of new documents. This architecture has realized the research objective stated in Chapter 1 (Compared Figure 6.17 with Figure 1.2).

![Diagram of Information Exchange Architecture Of The DMI System.](image_url)
It is assumed that various types of information are XML compatible, i.e., they can be translated into XML file by specialized parsers. Since XML is becoming the commonly accepted data exchange format in the IT industry, it is expected in the near future that information generated from specialized applications can be exported to XML format. Further discussion on the exchange between XML and the specialized file formats is out of the scope of this research, since it is the task of software development companies. This research only realizes one direction of information integration: embedding references to the current document. The potential of XML enabled DMI system is discussed as the extension of the research.

6.5 SUMMARY

Prototyping the RFI process demonstrates the methodology to build the DMI system to extract useful data from the original documents, re-organize the information according to specific tasks and users, and display it in an integrated web page. The research tests that Web-based information marked up by XML can be linked to one another. Data exchange among Web-based documents is feasible. A further amplification is on data exchange among XML compatible documents. If documents generated by specialized applications can be transformed into XML format based on ifcXML data model or other similar standards, data in these documents can be exchanged among one another in the DMI system.
CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

This chapter discusses major conclusions of the study, implications of the findings, research limitations, and recommendations.

7.2 GENERAL CONCLUSIONS

As discussed in Chapter 1, the aim of this research is to propose a Data Markup Integration (DMI) conceptual model for data exchanges among Web-based documents of construction project management. The system is able to extract useful data from the original documents, re-organize the information according to specific tasks and users, and display it in an integrated webpage.

The study answers three questions:

- What kind of services do Application Service Providers (ASPs) currently provide to the Architectural, Engineering, and Construction (AEC) industry (Chapter 3)?
- What are the requirements of the AEC sector towards Web-based collaboration (Chapter 4)?
- How should Web-based project management system develop in the future (Chapter 5 and 6)?

The study on current Web-based collaboration systems identifies 7 categories of ASP as-is features: general system; document management; workflow management;
administration; user centric workplace; team communication; and ASP server performance. These features are, in general, useful. Limitations of the current systems are information overload, fragmentation of information, and data incompatibility, etc. To overcome the limitations, 8 categories of ASP to-be features are analyzed: time and cost consideration; integration; intelligent search for information; knowledge base and intelligence; customizability to persons; customizability to projects; scalability; and others.

The Web-based survey of user requirements in Singapore identifies 4 categories of current features as “very useful”: document management; workflow management; administration; and team communication. These features are included in the conceptual model in Chapter 5. Also in the Web-based survey, 4 categories of to-be features are regarded as “very useful”: time and cost consideration; integration; intelligent search for information; and knowledge base. Among these features, integration through data markup is incorporated in the research.

Based on the above requirement analysis, a conceptual model is built up focusing on DMI. The model consists of 5 major packages: my project place; manage document; manage workflow; administrate project; and team communication. Each package contains some major use cases. The use cases that are most relevant to DMI are: Setup Project Website; Upload File; Search Topic; Manage Change; and View My Task. The following activities have been iterated: Setup Project Website; Upload File; Search Topic; and Workflow of RFI.

The processes of paper-based and DMI-based Request For Information (RFI) are compared to demonstrate the advantages of Web-based collaborations through
DMI. Prototyping the RFI case also demonstrates technical feasibility of implementing the conceptual model using XML technology. It is found that the DMI process provides the convenience of ready, complete and integrated information in a timely manner, which helps the users to make decisions faster and more accurately, so that downstream parties can take actions faster. It also helps to keep track of the collaboration process, reduce data re-inputs, and minimize errors.

### 7.3 IMPLICATIONS

Implications can be discussed in two aspects: the research result, and the research methods. The research is meaningful for Web-based project management in that it explores one direction for information integration by data markup. The methods of this study, such as Web-based survey, UML modeling, also deserve discussion.

In 1990s, Web-based project management systems emerged as an electrical repository of project documentation. For several years, there have been hundreds of commercial portals competing for the leadership in the market. Nowadays, technologies become matured and the concept of Web-based management has been gradually accepted by the AEC industry worldwide. In the near future, Web-based collaboration systems will be developed towards the platforms for automatic information exchange. Such a change has profound influences on both business process re-design and collaboration in the AEC industry. This research bridges the gap between present and future by exploring the possibility of DMI as one direction for the development of Web-based project management.
The conceptual model is based on XML enabled meta-data technology. Different from the current Web-based systems, which are still electrical repository of documents, the proposed system is able to extract useful data from the original documents, re-organize the information according to specific tasks and users, and display in an integrated webpage. The research redefines the meaning of information: Information is a set of data useful for decision-making. Not all data in a document is information for a specific user or a specific task. Therefore, it is important to filter the data in different documents and re-organize useful information to satisfy the need of a specific user or task. The research tests that Web-based information marked up by XML can be linked to one another. Data exchange among Web-based documents is feasible. A further extension is on data exchange among XML compatible documents. If documents generated by specialized applications can be transformed into XML format based on the ifcXML data model or other similar standards, the data in these documents can be exchanged among one another via the DMI system.

The research synthesizes a comprehensive list of features that current Web-based collaboration systems provide (Appendix I). Besides acting as a literature review of this study, the feature list provides criteria for evaluation of the commercial ASPs. An AEC company can first select from the list the most necessary features, and then evaluate whether a specific ASP can satisfy these requirements.

The method of Web-based survey explores the possibility of using Internet as a media to carry out academic research survey, which is quite new for the AEC industry in Singapore. At least two advantages of Web-based survey deserve mention: reduced time of response, and rich presentation of information. While a paper-based survey usually costs two months to collect responses, a Web-based one
only need two weeks. This allows more time on questionnaire design. More importantly, it allows the researcher to respond quickly before the survey details is out of the respondents’ minds. In a Web-based survey, explanatory information can be presented via multi-media, such as photos, animations and real-time demonstrations. It explains concepts in the most intuitive ways, while keeping the questionnaire concise.

UML is still new to project modeling researches in the AEC sector worldwide. Migration from the STEP approach to the UML approach facilitates collaboration between the AEC domain experts and the IT experts. A conceptual model developed using UML can be easily understood by the IT experts, erasing the need for model translations from one language to another, which is common in STEP methodology. This research applies the methodology of use case analysis in UML, and demonstrates that it is useful for conceptual modeling.

7.4 LIMITATIONS AND RECOMMENDATIONS

There are many limitations of this research due to time constraint and data unavailability. Three limitations and recommendations are discussed here: depth of user requirements, completeness of the conceptual model, and implementation of the system.

The user requirements obtained from the survey are very general. While it is acceptable for identification of useful features in this research, it is not sufficient for the actual development of a system. In practice, more specific requirements are obtained by the efforts of a software development team consisting of users, construction domain experts, and IT experts.
The conceptual model is not a complete one. It only contains use cases most relevant to the development of DMI. Nevertheless, a complete model can be built based on the current features studied in Chapter 3 and Appendix I.

Phases in the lifecycle of software development include requirement analysis, system design, implementation and evaluation. The research focuses mainly on requirement analysis. Study on the workflow of RFI presents a methodology for system design, but actual development of the system will involve much more than an individual’s effort. Value of the conceptual model is not fully realized until the whole system is actually built and tested.
REFERENCES


APPENDIX I ASP AS-IS FEATURES

I.1 GENERAL SYSTEM

The category of General System includes some general features that do not fall into any specific category. These include:

- Public project web pages;
- Project cloning;
- Links to AEC industry information services; and
- Web camera on site.

Public web pages provide information profiling and contact to the press, end users and neighbors. This is an attractive, automated marketing tool to present specific information about the projects and the companies to their potential customers.

Project cloning is to shorten the set-up time of a new project site by allowing selective cloning of folder structures, document security, groups, routing rules, and category information from an existing website.

The links to AEC industry information services include industry news, regulations, job markets, material catalogs, weather forecast, and other useful information.

Web camera on site shows the site photos, detailed photos, aerial photos, and video, etc. Transferring images from the site to the project web will not only improve the working environment of site managers, but also reduce time on visiting the site. A specific problem can be solved faster and work on site can start sooner because the architect or the engineer can solve the problem without having physically presented on the site. Some ASPs also provide automatic time-stamped image archiving of the pictures.

I.2 DOCUMENT MANAGEMENT

Document management contains features that manage files generated by various applications. There are many kinds of documents, among which the most important ones are drawings, cost and scheduling document.

Drawing related information includes schematics drawings, design development drawings, construction documents, construction sketches, shop drawings, models, master specifications, regulatory information, etc. Some ASPs allow designer to place detailed instructions on sequencing of construction, installation details, clarification of construction procedures, etc.
Documents in cost management include estimating and budgeting, bid packages, contracts and subcontracts, submittal packages, etc. Preferably the system should support integration with cost software to exchange cost data. Cost related and other sensitive information should be restricted to only the persons who have the right to view it.

Schedule related information include master schedule, progress schedule, planned schedule, actual schedule, progress report, delay analysis reports, daily progress reports, etc. Preferably the system should support integration with scheduling software to exchange scheduling data.

The main features of document management include the followings:

- Remote viewing, printing and commenting of files through web browsers;
- Document attributes;
- Parametric search;
- PDA / wireless input support;
- Document version log;
- Document revision control with file locking and check-in/check-out;
- Handling external references for CAD drawings;
- Directory structure;
- Digital approval; and
- Fax in.

In remote viewing, printing and commenting of files through web browsers, users do not need to have the applications that create the files. The viewers are either installed on the client computers, or integrated completely on the server side. This feature removes the incompatibility of software versions. There are two major kinds of viewers, namely CAD and GIS viewers, and 3D and VRML supported viewers. The functions of CAD and GIS viewers include zooming, redline marking, measuring distances and areas, turning on and off drawing layers, displacing CAD external reference links. The functions of 3D and VRML supported viewers include changing viewpoint, directions, and distance by a mouse click. With the viewers, 100 or more formats of files can be viewed by a web browser alone.

Documents can be printed as viewed in the browser using local printer. Blueprints and other drawings ordered online are sent to the office from a local printing house. Comments and redline markings are tied to file versions and stored outside the file, so that the actual file remains integrated.

Document attributes, also called meta data, are information about documents, i.e., title, authors, revision status, and version number. Users input the attributes in pre-defined fields before uploading a document. Meta data enables quick retrieval of documents, even if the specific filename is unknown.

To effectively locate the needed information, ASPs provide different methods to search, such as search by keyword, category, description, and full text, etc. Search by keyword means when the user keys in a keyword, the search engine finds the most matches. Search by category means the user browses through the categories that the web contains, clicks to sub categories for more precise need of search. An example is
Yahoo! Category. Search by descriptions means searching for a document using the description information, e.g., author, date. Full text search means searching in the entire content of the documents.

Wireless input provides the site superintendents, for example, the ability to record the RFI as the question is asked. The ASP is able to automatically put the RFI into action list for the person who needs to provide the answer.

Document version log indicates the information of documents and versions on the project web, such as name, author, and uploading time. Revisions of a document are published using the same file name as the first issue. This is to streamline different versions of a file and ease the search for updated files.

Document revision control with file locking and check-in/check-out means many users can access, view and comment upon the same documents simultaneously. However, only members with “write” access to a file can upload new version of that file.

External references are referenced drawings or files attached to a CAD drawing. To ensure the consistency of a drawing, some ASPs automatically combine and compress all x-ref of a drawing for uploading and downloading.

Currently the exchange of information is focused on locating the needed documents. The management of document directory structure is important. The CIO preset the structure so that documents can be easily and securely accessed by the right persons but not the others.

Digital approval is very useful in change management, e-procurement and sub-contracting. The core technology is electronic signature. Documents with electronic signatures of various parties (e.g., the client, the designer, the project manager) are kept in the database. Digital approval is legal in Singapore.

Some ASPs provide each project a unique fax number, where project members can send information to using a standard fax machine. The fax message is stored in digital format and can be viewed from Web browsers.

1.3 WORKFLOW MANAGEMENT

A workflow is a process that involves collaboration among project players, e.g., the approval of a change is a workflow because it involves submitting the change request by one party, and approving the request by another party. A workflow is composed of sequent tasks. A task is a small job assigned to a project player, such as submitting a RFI, or approving a Variation Order, etc. Standardized workflow management is achieved through the use of web-based forms and templates. The

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1 To get an electronic signature, a user registers with a third-party security firm (e.g., VeriSign, Entrust Technologies, or Check Point Software), which issues digital certificates to sign documents. When a document is sent, the receiver checks with the security firm to verify the sender’s identity. To prevent tampering and alteration, the certificate is encrypted and has validation period.
contents of workflow management include the followings: purchase order; payment requests; daily reports; progress reports; request for information; change order; transmittals; site documents; field notes; meeting minutes, etc. The features of workflow management include the followings:

- Document Templates;
- Integration with e-procurement;
- Issues Linking;
- Automatic generation of customizable reports; and
- Tasks management.

Document Templates allow to create standardized workflow documents from templates, and to track progress throughout the workflow. Templates can be customized at the time when the project website is set up.

Linking together issues, meeting minutes, change orders and many other items can save time for construction managers. This is a great disciplined control tools on larger projects.

Having an automatic generation feature for meeting notes and customized reports can ease the weekly progress meetings, and produce oriented information for problem solving. More advanced feature provides the ability to use current job data to predict future results of job trends, so as to find out problems before they become severe, e.g., time delay, cost overrun.

Tasks management allows tracking, sorting, and displaying of all tasks in the project. Responsible parties can access their own personalized at any time. Project managers can track status of the items through completion. Multiple subcontractors can be assigned responsibility for each task.

Integration with e-procurement, such as EDI, means electronic transferring bills, ordering and buying building products, and notifying field people when deliveries are expected.

Project control is a process of comparing the actual activities with the planned ones, and taking actions accordingly. This needs information form both documents and workflow management. In a traditional paper-based process, it is a big challenge to search useful pieces of information from piles of paper files alone, not to say mapping the fragmented information into one’s mind. To solve this problem, there are two features that Web-based workflow management should provide: linking relevant files together for a specific task, and generate reports according to the user’s need. A paper file can only be placed in one category, while an electronic file on the web can be referred via hyperlinks to as many files as possible. Grouping relevant information by hyperlinks means that once a file is updated, all files referring to it are updated. The ability to generate reports means the decision maker can learn the pattern of something from the past, and predict what will happen in the future. These two features will be discussed again in the conceptual modeling and prototyping in the later chapters.
I.4 ADMINISTRATION

Compared to traditional project management, it is necessary to have an information manager in the ASP solution acting as the administrator for the web (Cohen, 2000; Lee, 2001). It is called the Chief Information Officer (CIO). The duty of the CIO is to manage the project web throughout the whole process of website utilization. Since the CIO controls the entire project information and must be unbiased to all parties, it is suggested that he or she shall come from a third party of the project. In practice, however, the CIO can be the owner, the main contractor, the project manager, or any major player of the project acting as an information administrator. The features provided to the administration include the followings:

- Access control;
- Auditing;
- Set-up of project website templates, workflow and other project specific business logics; and
- Task allocation.

There are two kinds of access control: access to the project website, and access to a file or directory. Access to the project website is restricted to the partners that work on the project. The authentication of users is typically done by means of user accounts and passwords. Access to a file or a directory can be strictly controlled based on predefined roles of the users. This is useful to reduce information overload, and protect confidential information, such as contracts and invoices. Individual users’ access and rights are defined individually. A user can be assigned different rights for writing, accessing and deleting: read-only access to all or portions of the site or to particular types of documents or folders; upload and download permission; to modify and delete existing files (deleted files are placed to recycle bin forarchiving, but never deleted from the website.)

Users and their rights: Allocating users the access rights to the project site based on their roles not only secures the sensitive data on the site, but also simplified the user interface and fastens their search for information relevant to their jobs.

Auditing is used to keep track of users, their activities, and document transfer history on the project website. It is important in identifying and clarifying a chain of events by registering who uploads or downloads which files at what time.

Set-up of project website templates, workflow and other project specific business logics is to set up the framework for the project website to run efficiently. Standardized documents are generated from the pre-set templates. Tasks in a workflow start automatically one after another. Project notices are sent to selected groups of people who should be informed.

Although the setup of templates and business logics has created the standardized process for web-based project management, it is still necessary to administrate the project by allocating tasks to individuals, and checking whether the tasks are on time.
1.5 USER CENTRIC WORKPLACE

A user centric workplace is similar to the desktop of an operation system, such as Microsoft Windows. It can be customized by the users according to their specific working habits. It acts as the short-cut to the frequently used features and new information particular to a user. The features include the followings:

- Web browser and operation system supported;
- Customizable interface;
- Headlines page;
- Automatic refresh;
- Multiple languages support;
- Multi-project support;
- Drag-n-drop, right-click.

Nowadays there is not much problem for browser and operation system support. Most ASPs support both Internet Explorer and Netscape browsers. They also support both Macintosh and PC users.

Customizable interface means the displaced functions are standardized to ease the use of the project web; but the styles are customizable from project to project, including color schemes, logo placements, and front-page styles. Individual users can customize their display of documents on the screen. Their settings are saved for further use.

Upon login, a headlines page unique to each individual user highlights new information that the user should pay attention to, e.g., document newly uploaded, comments from other persons. It also directs the user to the tasks to do that day, e.g., attending a meeting, responding to a RFI, etc.

Automatic refresh means when files are changed, i.e., when new version of a file is uploaded by a user, the system will refresh the pages that contain the content of the file and the hyperlinks to it.

Multiple languages support is useful for international collaborations. Users can choose their own language as the website interface, just like Hotmail.

Multi-project support provides access to all projects that a particular user has rights to by a single ID and password. It also provides the ability to easily move from job to job and compare information among projects. Cross-project reporting allows higher-level users to view the same information about many projects in one report.

Drag-n-drop, right-click is used for uploading, downloading, and operating within the project web, which is similar to Microsoft's Windows Explorer that users are familiar with.
I.6 TEAM COMMUNICATION

Team Communication is Internet enabled communication, such as email, instance messaging, discussion forum, online conferencing, etc. These features provide supplementary information for formal communication. Compared to traditional communication means such as phone call, fax, and face-to-face meetings, the team communication features have the advantages of low cost, fast speed and traceable record. These features include:

- Correspondence logs;
- Email and messaging service;
- Update notification;
- Discussion forum;
- Online conference;
- Project Calendar; and
- Shared contact information.

Correspondence logs archive email, instant messages, and telephone calls in respective logs. For example, a Call log records phone conversations. The logs can be searched, Sort, and tracked.

Email and online instant messaging are services that ASPs generally provide. Email allows users to quickly and easily send messages to any or all project members without leaving the system. Instant messaging provides the convenience of instant discussions among concurrently online users. These messages can be either created on demand by users, or automatically generated by the system when specific events happen such as a new RFI submission.

Update notification helps users to avoid wasting time on checking the project web for changes. Online users can be notified by instant message integrated in the system. Offline users can also be notified automatically by email, fax, SMS (Short Message Service) to mobile phone, or PDA (Personal Digital Assistant). To avoid being disturbed from their work frequently, the users can specify the update notifications they would like to receive at various levels. The rules can be set by the administrator about who should be informed of what, or the users can specify the information that they want to be notified when updates happen.

Discussion forum allow the broadcast of general information to the entire team. Comments of a topic are displayed together, encouraging more discussions.

Online conference is a synchronous communication with white-boarding, netMeetings, and even web-cameras.

A calendar displaces personal schedules and project events for every single user. It also displaces scheduled timetable of meetings.

Contact information of project participants are listed for communication convenience, including name, job title, company name, address, telephone number, fax number, email address, etc.
1.7 ASP SERVER PERFORMANCE

Server performance is a very important factor for evaluating the quality of ASP services. Since all services are Web-based, the availability of project website, the browsing speed, the file transfer speed, the data security against external hackers, all these factors will have significant impacts on the project team’s activities. Server performance is assessed in many ways, which include:

- Down time;
- Firewall issues;
- System scalability and flexibility;
- Server capacity;
- Security during exchanges;
- Security on the server;
- Archiving;
- Technical support; and
- Training.

Down time is when the server is not available due to hardware problems or facility up-gratings. Since this will affect all people using the ASP, the vendor must ensure low down time, especially during working hours.

Firewall issues refer to whether special proxy settings and ports are needed for the application to work correctly. If special higher ports or migrating ports must be opened, it will severely compromise a corporate firewall.

The system must be able to scale from a few to thousands of concurrent users. A flexible system responds easily to user request, with the ability to have the system modified based on feedback.

There are two kinds of server capacity: processor and hard disk. Additional CPU and memory can be added to solve the problem of processing speed. As for storage space, many ASPs choose to host their data-center in a third-party database server, such as Exodus. This helps to prevent physical damage of the information. A study on return on investment indicated that by outsourcing web hosting, ASPs reported remarkable improvements in reliability, scalability, and accessibility (IDC, 2000). But network security methods must be imposed between the ASP and databased provider to prevent hackers from stealing the clients’ information.

Security during exchanges can be done by accessing the project website via Secure Socket Layer technology, which enables up to 128-bit encryption of all data transfers between the user and the web server.

Security on the server is to protect the server against hackers and prevent disclosure of clients’ information by firewall technology.

Redundancy in data storage can prevent many unexpected problems. Document backup should be carried out frequently (usually once per day) by the ASP or the database provider. At the milestones of a project or when the project is completed, documentation on CDs is delivered to the clients.
Technical supports should be provided during project setup. User manual, online help, telephone hotline should also be provided in case the users encounter any problems during implementation.

Training can be provided in terms of in-house training courses, seminars, and demonstrations, so as to shorten the organizational learning curve.
APPENDIX II SURVEY QUESTIONNAIRE

The survey consists of 7 web pages. The Unified Resource Locator (URL) and the content of each page are listed below:

- Page 1: Index;
- Page 2: Part 1 general information;
- Page 3: Part 2 general use of IT and networking;
- Page 4: Part 3 Use of ASPs;
- Page 5: Receiving survey analysis;
- Page 6: Success notification;
- Page 7: Error notification.

Page 1: Index (http://annaliang.hypermart.net/index.html).

Survey On Web-Based Construction Project Management

Dear Sir/Madam,

I am a postgraduate research student of the Department of Building, National University of Singapore. My research topic is about Web-based construction project management. The idea is to share information and enhance communication within the whole project team in a secured private network environment (also called Extranet or Project Specific Website).

While Application Service Provider (ASP) has been in practice for years in Europe and North America, I am interested in finding out the general attitudes of Singaporeans towards the ASP, as well as your awareness and requirements as a current or potential user.

Please feel free to contact me by dialling 9027 8987 for inquiry or clarification. If you are interested in the research findings, you can get them for FREE, by just filling your contact information at the end of the survey. I would be very grateful if you could respond by May, 2002.

Thank you very much for your participation.

Yours faithfully,

Leung Nga Na

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National University of Singapore
4 Architecture Drive, 117566
Email: sden0190@nus.edu.sg
Tel: 9027 8987
Appendix II Survey Questionnaire

Key words with brief explanations:

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASP (Application Service Provider):</td>
<td>A professional IT company that provides Extranet services for communication and information sharing.</td>
</tr>
<tr>
<td>Extranet:</td>
<td>A restricted private network that shares business information <strong>within a project team</strong> of clients, designers, contractors, suppliers, etc.</td>
</tr>
<tr>
<td>Intranet:</td>
<td>A restricted private network <strong>within an organization</strong> for information and resource sharing from corporate databases to the Local Area Network (LAN) desktop.</td>
</tr>
</tbody>
</table>

Go To Survey Page


The survey consists of **THREE parts**. Please answer **EACH** question before submitting your response.

**PART 1 GENERAL INFORMATION**

Note: Information collected in this part is for statistical classification only and will not release to others.

1.1 Type of company

☐ Public Agency/Developer/Owner

☐ Main Contractor/Subcontractor

☐ Consultant (Architect/Engineer/Quantity Surveyor/Project Manager, etc)

☐ Supplier/Manufacturer

☐ Others: __________________________

1.2 Which of the following best fits your job duty in your company?

☐ Owner

☐ Executive officer

☐ Construction-related professional

☐ Information Technology staff

☐ Site management staff

☐ Other: __________________________
1.3 How many people are employed by your company at your location (exclusive of site workers)?

1.4 How many years have you been working in the construction industry?

Page 3: Part 2 general uses of IT and networking (http://annaliang.hypermart.net/part2.html).

Part 1 has been submitted successfully.

Instruction: By placing your cursor on the UNDERLINED texts you can view their descriptions.

DON'T click on the texts. For example:

/intend to use ASP to exchange information among the team?

ASP (Application Service Provider): A professional IT company that provides external services for communication and information sharing.

(tick all applicable)

PART 2 GENERAL USES OF IT AND NETWORKING

2.1 Does your company have a home page on the Web?

☐ Yes ☐ No
Appendix II Survey Questionnaire

If yes, what is the homepage mainly for? (please tick all applicable)

☐ Company introduction  ☐ Project collaboration  ☐ Invitation to open tendering
☐ Recruitment  ☐ E-trading/selling  ☐ Product and service marketing/advertising
☐ Customer services/enquiry/feedback  ○ Other: ____________

2.2 By what means does your company access the Internet?

☐ Modem  ☐ ISDN  ☐ Broadband access (constant connection)  ☐ Wireless  ☐ No access

2.3 Does your company have any Internet/Local Area Network (LAN)?

☐ Yes  ☐ No

2.4 Does your company have an IT manager?

☐ Yes, full-time  ☐ Yes, with other responsibilities  ☐ No

2.5 What proportion of the staff (exclusive of site workers):

<table>
<thead>
<tr>
<th>Uses computers for work?</th>
<th>% of Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uses the Internet for work?</td>
<td>% of Staff</td>
</tr>
<tr>
<td>Uses e-mail for work?</td>
<td>% of Staff</td>
</tr>
<tr>
<td>Uses wireless online devices (WAP phone, PDA) for work?</td>
<td>% of Staff</td>
</tr>
</tbody>
</table>

2.6 How do you usually exchange the following documents with other companies?

<table>
<thead>
<tr>
<th>Documents</th>
<th>Paper Mail</th>
<th>Fax</th>
<th>Floppy/CD</th>
<th>E-mail</th>
<th>Project Web</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shop-drawings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specifications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bills of quantities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tendering/Quotations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purchase orders/invoices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scheduling/resource planning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meeting minutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requests for information/Change orders</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix II Survey Questionnaire

2.7 How does IT affect information management and project management?

<table>
<thead>
<tr>
<th></th>
<th>Increased Much</th>
<th>Increased</th>
<th>Same</th>
<th>Reduced</th>
<th>Reduced Much</th>
<th>Not Sure (Pls Explain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed of information transfer</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Volume of useful information</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Number of mistakes in documentation*</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Difficulty of project coordination*</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Number of variations in construction*</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

*If you choose "Increased" or "Increased Much" for these questions, you mean the situation going worse.

Submit


National University of Singapore

Part 2 has been submitted successfully.

Instruction: By placing your cursor on the UNDERLINED texts you can view their descriptions.

DON'T click on the texts. For example:

**Intend to use ASP to exchange information among the team?**

ASP (Application Service Provider): A professional IT company that provides Extranet services for communication and information sharing.

*tick all applicable*

**PART 3 USES OF ASP**

Note: ASP here refers to Application Service Provider, or a professional IT company that provides project specific web site services (Extranet) for communication and information sharing within the team of the owners, architects, engineers, contractors and suppliers.
3.1 Do you use/intend to use the ASP to exchange information among the project team?

☐ Yes  ☐ No

What major benefits do you expect from adopting the ASP? (Please tick all applicable)

☐ Cost saving  ☐ Keeping up with competition
☐ Efficiency  ☐ Required by bidding/clients
☐ Better communications  ☐ Well-organized and complete documentation
☐ Needs of telecommunication  ☐ Marketing/Brand developing
☐ Others: ____________________________

What are the major factors that might keep you from adopting the ASP? (Please tick all applicable)

☐ High investment costs  ☐ Insufficient interest/commitment from the management
☐ Difficulty in measuring profit  ☐ Extra work in the form of “unnecessary” data input
☐ Risk on data security  ☐ Not sure of the performance of the new process
☐ Too much information  ☐ Lack of standard causing coordination problems
☐ Greater know-how required from staff  ☐ Old ways work well and changes are unnecessary
☐ Waiting for more government support  ☐ Waiting the process to be more popular
☐ IT infrastructure/bandwidth constraint  ☐ Others: ____________________________

3.2 How would you characterize your colleagues’ general willingness to use the ASP?

☐ Active involvement  ☐ Slight involvement  ☐ Neutral  ☐ Mild resistance  ☐ Strong resistance

3.3 Have you ever used/learned about the following ASPs? (Please tick applicable)

<table>
<thead>
<tr>
<th>Local</th>
<th>Use For Collaboration</th>
<th>Use For Other Purposes</th>
<th>Learn About</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDBuilders.com</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>iceFox</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>teex123</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>CXHub</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Cyber-IB</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Others</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>International</th>
<th>Use For Collaboration</th>
<th>Use For Other Purposes</th>
<th>Learn About</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIW</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
### Appendix II Survey Questionnaire

#### 3.4 Have you ever used / learned about the following Internet-based construction services in Singapore?

<table>
<thead>
<tr>
<th>Service</th>
<th>Used</th>
<th>Learn about</th>
<th>Don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corenet e-info</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corenet e-submission</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDBuilders.com e-bidding</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 3.5 To what extent does / will the amount of time spent on the following activities change after adopting the ASP?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Much Less Time</th>
<th>Less Time</th>
<th>Same Time</th>
<th>More Time</th>
<th>Much More Time</th>
<th>Don't Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attending meetings outside your firm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making site visits</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travelling overseas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making telephone calls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Writing email</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faxing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Searching for project documents</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tracking project activities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If you have yet used any ASP, you may wish to view a Flash Demo describing the overall ASP features before answering Question 3.6 and 3.7.
3.6 How do you find / expect the usefulness of the following ASP features for construction project management? (You may CLICK on the URL to see an example of that feature.)

<table>
<thead>
<tr>
<th>General System</th>
<th>Very Useful</th>
<th>Useful</th>
<th>Neutral</th>
<th>Not So Useful</th>
<th>Not Useful At All</th>
<th>Not Sure (Pls Explain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public homepage introducing the project to the press:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Links to construction industry information services: (e.g. Corenet e-info):</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Web camera on site:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Application Support / Document Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supporting multiple file formats:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Remote viewing, printing and commenting of files:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Handling external reference for CAD drawings:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Digital approval of drawings and documents:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Searching documents with intended criteria, e.g. name, author:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Accessing project information using PDA:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Workflow Management With Templates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drawing management with version control:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Integration with cost and accounting software:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Integration with scheduling software:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Supporting change management:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Archiving daily communication:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Auto compressing files when up-/down-loading:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Administration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controlled access to site by user name and password:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Controlled access to files according to user's role:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Document log for versioning, revision control and access:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>User activity log showing login time, up-/down-loading, etc:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>User Centric Workplace</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Headlines page with new information highlights to individuals:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Multiple languages support (English, Chinese... ) for international projects:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Easy access to multiple projects with single user name:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Drag &amp; drop, right click:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Team Communication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Email and instant messaging services:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Document update notification:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Automatic refresh / real time data on the web page:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>E-bulletin board for announcements:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Discussion forum for opened discussions on issues:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Online conference:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Project Calendar/schedule:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Shared contact information:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capability, Stability And Security Of ASPs</th>
<th>Very Useful</th>
<th>Useful</th>
<th>Neutral</th>
<th>Not So Useful</th>
<th>Not Useful At All</th>
<th>Not Sure (Pls Explain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum system down time for technical maintenance:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>System scalability for speedy browsing and up-/down-loading:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Security during exchange (encryption):</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Security on the server (firewall):</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Frequent archiving to prevent accidental data lost:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
<tr>
<td>Technical support and training:</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
</tr>
</tbody>
</table>
3.7 In the future how necessary are the following features? (You may CLICK on the URL to see an example of that feature.)

<table>
<thead>
<tr>
<th></th>
<th>Critical</th>
<th>Very Necessary</th>
<th>Neccessary</th>
<th>Not So Necessary</th>
<th>Not Necessary At All</th>
<th>Not Sure (Pls Explain)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time And Cost Consideration</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short set-up time and low cost;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short learning time of common tools</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Integration</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration throughout project life cycle, with company database, and with project model;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration with solid modelling, virtual reality, and other visual technology;</td>
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<td>Supporting voice and video input and output;</td>
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<td>Quick access to and efficient updating of required information;</td>
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<td>Searching for valuable information in various sources, e.g., the project web, the Internet, LAN and the local computer;</td>
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<td><strong>Knowledge Base And Intelligence</strong></td>
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<td>Synthesizing different pieces of information;</td>
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<td>Accumulating acquired knowledge for future usage;</td>
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<td>Incorporating with decision support system, supporting what-if analyses;</td>
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<td>Generating reports for decision-making;</td>
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<td>Allowing for personalized interfaces;</td>
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<td>Displaying information from different perspectives tailored to a user's role;</td>
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<td><strong>Customisability To Projects</strong></td>
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<td>Suitable for all kinds of projects varied in size, type and degree of complexity;</td>
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<td>Usable for both low and high speed Internet connection;</td>
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<td><strong>Supporting division of responsibilities among team members.</strong></td>
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<td><strong>Other features:</strong></td>
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</tbody>
</table>
The last few questions (Q3.8, Q3.9, and Q3.10) are openly for your invaluable comments.

3.8 What are the most important benefits of using IT (and especially the ASP) in project management?

3.9 What are the most important obstacles of using IT (and especially the ASP)?

Managerial obstacles (human aspect):

Technical obstacles:

Others:
3.10 What are your suggestions or comments on ASP?

Page 5: Receiving survey analyses (http://annaliang.hypermart.net/analysis.html).

Part 3 has been submitted successfully

Would you like to receive the research analysis for FREE?

☐ Yes, please send me the results by email to

Name: ________________________________ (Optional)
Email address: ____________________________
Appendix II Survey Questionnaire

☐ Yes, please send the results by mail to

Name: ____________________________ (Optional)
Company: _________________________
Street: ___________________________
Zip code: _________________________
Country: Singapore

☐ No, Thanks. I will visit your homepage (http://www.geocities.com/yamaliang/research.htm) when the report is posted there in July, 2002.

Submit

Page 6 Success notification (http://annaliang.hypermart.net/thanks.html).

NUS
National University of Singapore

Thank You!

You have completed the survey successfully.

Interested in knowing more about me? Please visit my homepage:

http://www.geocities.com/yamaliang

Interested in knowing more about my school? Please visit the homepage of NUS:

http://www.nus.edu.sg
Page 7: Error notification (http://annallang.hypermart.net/oops.html).

Oops!

You missed some questions, which are very important to us.

Please click the "BACK" button of your browser and attempt EACH question in the form.
APPENDIX III THE CONCEPTUAL MODEL

III.1 MAJOR ACTORS

The actors identified in this study are: ASP, CIO, and User.

ASP is the platform and service provider.

CIO (Chief Information Officer) is the platform administrator. Its duty is to manage the project Web throughout the whole process of Web site utilization. Since the information manager controls the entire project information, it is suggested that this person shall come from a third party of the project, such as a staff of the ASP, so as to remain unbiased to all parties of the project. In practice, the administrator could be the client, the project manager, the main contractor, or any main player of the project who is in charge of the administration of project information. User is the one who uses the ASP services.

User is a generic class, which is inherited by Client, Project Manager, Designer, and Contractor. Designer is inherited by Architect and Engineer. Contractor is inherited by Main Contractor and Sub-contractor. (Figure III.1).

Client is the party that has the authority over the project and sets up the whole operation. It includes the investing company and its representative consultants, such as an architect, a quantity surveyor, a project manager, etc.

Project Manager is the party that is in charge of the project coordination. Some projects do not have a separate project manager. The role can be taken by the client’s representative, the project architect, the main contractor or other party who act as the project manager.
Designer is the party that provides design services to the project. Designer is a generic class, which is inherited by Architect and Engineer.

Architect is the party that designs the architecture. It provides the complete architectural design services in the form of drawings.

Engineer is the party that provides the services of structure design, mechanical engineering design, and other related design.

Contractor is the party that constructs the project. Contractor is a generic class, which is inherited by Main Contractor and Sub-contractor.

Main Contractor is the party that is responsible for the construction of the whole project. It usually sub-contracts part of its work to one or many sub-contractor.

Sub-contractor is the party that carries out part of the construction work, and has contract relationship with the main contractor or another Sub-contractor.

III.2 THE MAIN USE CASE

The main use case describes the major functions from the user’s perspective represented by five Packages: Manage Document; Manage Workflow; Team Communication; My Project Place; and Administrate Project (Figure III.2).

Context Diagram

Figure III.2 Main User Case.
**III.2.1 Setup Project Service**

**Actors**

ASP

**Brief Description**

The use case sets up the application infrastructure for the project.

**Main Flow**

The use case begins when the client submits registration and billing information to the ASP. The ASP sends a confirm message (by email or by mail) to the client. The ASP assigns a URL to the project, allocates database space to the project, and links the URL to the web-based services it provides.

**Activity Diagram**

![Activity Diagram](image)

Figure III.3 Setup Project Service.

**Pre-Conditions**

The project client understands the services and conditions of the ASP through discussion or negotiation. The client signs the contract with the ASP for web-based services.

**Post-Conditions**

If the use case was successful, the application services are ready for use. Otherwise, the system’s state is unchanged.

**III.2.2 Setup Project Website**

**Brief Description**

This use case is to set up default looks and functions for the website.
Appendix III The Conceptual Model

Actors

CIO

Main Flow

The CIO sets up the website framework based on templates provided by the ASP or past cases provided by the client. For Document Management, he defines the document directory, the document templates and creates the project portfolio with the templates. For Workflow Management, he defines business logic, assigns group permission rights to specific folders. He also defines the standard user interface. The business logics are the rules to govern the business processes, such as the process of change in Workflow Management, which will be discussed later.

Activity Diagram

![Activity Diagram](image)

Figure III.4 Setup Project Website.

Pre-Conditions

The Web services are available.

Post-Conditions

If the use case was successful, the website is ready for use. Otherwise, the system’s state is unchanged.

**III.2.3 Setup User**

Brief Description

This use case is to setup the profile of the users that can access the project web and their rights to access information.
Appendix III The Conceptual Model

Actors

CIO

Main Flow

The use case begins when the CIO clicks Add A User in Administration.

The system requests the CIO to assign a user name to the user, enter the user’s profile, including basic information and administrative permission information. When the CIO clicks Submit, the system saves the basic information and permission information, generates password and user ID, and emails the login information to the user including his user name, password and the project URL.

Basic information is whatever can be filled in or modified by the users themselves: Organization, True Name (user name is usually the true name, except there are more than one user of the same true names), Company Address, Telephone Numbers, Fax Number, Email Address, Website. Administrative permission information is what can only be changed by the CIO and the Project Manager once it has been created: the Role that the user plays in the project (e.g., Client, Quantity Surveyor, Architect, Engineer, Project Manager, Main Contractor, Sub-Contractor, Supplier, etc), the information access rights, unique member ID assigned by the system, etc.

Alternative Flows

The email can not access the user. The system informs the CIO of the error. That email address is highlighted for amendment.

Activity Diagram

Figure III.5 Setup User.
Pre-Conditions

The project space and project website are ready to use.

Post-Conditions

If the use case was successful, the user details are saved to the database. Otherwise, the system’s state is unchanged.

III.2.4 Log In

Brief Description

This user case is to verify the user. If the project is highly security concerned, digital signature can substitute the process of user name and password.

Actors

User

Main Flow

This user case begins when the User assesses the project website and requests login. The system displays the login page. The User types his user name and password. When he clicks on Submit, the system verifies the user name and password. If they are correct, the What’s New page is displayed.

Alternative Flows

If the user name and password are incorrect, the system prompts the user to try again. The user can click on Forget password and answer some questions. If the answers are correct, password is emailed to him. If the answers are not all correct, or if the user fails in three attempts, he is blocked and prompted to contact the CIO for help.

Activity Diagram

Figure III.6 Log In.
Pre-Conditions

The project website is ready to use. The User is assigned a user name and password for login.

Post-Conditions

If the use case was success, the What’s New page is displayed. Otherwise, the system’s state is unchanged.

III.3 PACKAGE MY PROJECT PLACE

Context Diagram

![Context Diagram](image)

Figure III.7 Package My Project Place

III.3.1 View What’s New

Brief Description

This use case displays new information relevant to the User, especially the tasks to complete that day. The system displays the tasks assigned to the User that day (meetings, site visit, RFIs that need to respond to, etc), comments on tracked items in BBS or the files he uploaded, which the User can choose to view.

Actors

User

Main Flow

The system displays the What’s New page with the following contents generated from the respective use cases:

New task, from the user case View My Task. When viewing the new task, the User can carry out the task by invoking the user case Manage My Task.
New Comment, from the use case Display New Comment. When viewing the new comments, the User can make his own comments by invoking the use case Comment File from the Manage Document package.

New Correspondence, from the use case Display New Correspondence. When viewing the new correspondences, the User can reply email by invoking the use case Manage Email from the Team Communication package.

My Schedule, from the use case Display My Schedule. When viewing my schedule, the User can also view the project schedule by invoking the use case View Project Calendar from the Team Communication package.

Alternative Flows

If there is no new items, the system informs the User no new items to view.

Subordinate Use Cases Diagram

Figure III.8 View What’s New.

Pre-Conditions

The User logs in the project website successfully.

Post-Conditions

If the use case was success, the new items being responded are marked as read items and placed to respective categories. The new items not being responded remain in View What’s New. Otherwise, they system’s state is unchanged.

III.3.2 Manage My Task

Brief Description

The use case is for the User to manage his own tasks.

Actors

User
Appendix III The Conceptual Model

Main Flow

The use case begins when the User clicks on Manage My Task. The system displays the User’s tasks.

The User can view his tasks, respond to the tasks. He can also organize the tasks by subject or by other user-defined criteria. When the task is done, he can close it.

Alternative Flow

Task does not exist. The system tells the User to manage his tasks later when they are assigned to him.

Sequence Diagram

![Sequence Diagram](image)

Figure III.9 Manage My Task.

Pre-Conditions

The User logs in the project website successfully.

Post-Conditions

The system updates its database. The read tasks are marked as Read. The responded tasks are marked Responded. The closed tasks are marked Closed.

III.3.3 Manage My Profile

Brief Description

The use case is for the User to manage his own profile, including to change his contact information, and to view his activities on the project website, etc.
Appendix III The Conceptual Model

Actors

User

Main Flow

The use case begins when the User clicks on Manage My Profile. He can do either of the following activities:

View My Profile, basic information set up by the CIO. If the user finds any changes in basic information, he can invoke the use case Update My Basic Information to change the particulars. If the change is of administrative information, such as changing his role in the project, he cannot change the item by himself, but can invoke the use case Request For Role change to submit his request to the CIO.

View My Activity Log, logs about the user’s activities on the project website, such recent time to log in and log off, uploaded and downloaded files, etc.

Subordinate Use Cases Diagram

![Subordinate Use Cases Diagram](image-url)

Figure III.10 Manage My Profile.

Pre-Conditions

The User logs in to the project website successfully.

Post-Conditions

The system remains unchanged if the User only browses through. The system updates its database if the user’s profile or role is changed.

Subordinate Use Cases

III.3.3.1 Request For Role Change

Brief Description

This use case is for the User to change the preset role in the project, such as from the Main Contractor to the Project Manager, so that his rights to access information are changed.
Appendix III The Conceptual Model

Actor

User

Main Flow

The use case begins when the User clicks on Request To Change Role. The system displays the form for his request. When he clicks Submit, the system sends the request to the CIO. After investigation with the higher level authority in the project, such as the client, the CIO approves the request and updates the user’s role. The system emails to inform the User his new role and access rights.

Alternative Flow

After investigating with the higher level authority in the project, the CIO rejects the request. The role remains unchanged. The system informs the User of the result, with the reasons presented by the CIO.

Activity Diagram

![Activity Diagram](image_url)

Figure 5.11 Request For Role Change.

Pre-Conditions

The User logs in to the project website successfully.

Post-Conditions

The system remains unchanged if the User only browses his profiles. The system updates its database if the user’s role is changed.
III.3.4 Manage Subscription

Brief Description

This use case is for subscription and un-subscription to the industry information services and to the tracked items in the project.

Actors

User

Main Flow

The use case begins when the User clicks on Manage Subscription. He can do either of the following activities:

View Available Industry Information. He browses through available industry information services on the Internet. If any topic interests him, he can invoke the use case Subscribe to subscribe to that service. The system bookmarks the URL for easy access to the service.

View Bookmarked Industry Information. He browses through the subscribed services. If he considers a service is no longer useful, he can invoke the use case Unsubscribe to delete the bookmark.

View Tracked File. The tracked files are organized in the categories of drawings, schedules, costs and other directories indicated by the CIO or the user himself. A file can only be tracked if the User has the access right to view it. If the User finds that a file is no longer needed to be tracked, he can invoke the use case Unsubscribe to delete it from the tracked list.

View Tracked Discussion. The tracked discussions are specific topics in the BBS that the project parties are discussing on. If a discussion is finished, the User can invoke the use case Unsubscribe to delete it from the tracked list.

Alternative Flows

There is no subscription to any industry information or project item. The system tells the User how to use these features.
Subordinate Use Cases Diagram

Pre-Conditions

The User logs in to the website successfully.

Post-Conditions

The system remains unchanged if the User only browses through the information. The system updates its database accordingly if the use case Subscribe or Unsubscribe is invoked.

III.4 PACKAGE MANAGE DOCUMENT

Context Diagram

Figure III.12 Manage Subscription.

Figure III.13 Manage Document.
**Appendix III The Conceptual Model**

**Manage Document Inheritance**

![Diagram of Document Inheritance]

*Figure III.14 Manage Document Inheritance.*

### III.4.1 Upload File

#### Brief Description

This use case is for file uploading. Meta data of the file is required to ease the search of the file on the project website once it is uploaded. User can once upload one file or a batch of files.

#### Actors

**User**

#### Main Flow

The use case begins when the User clicks on Upload File. The system displays the upload webpage. The User indicates the location of the file by typing the path or by clicking the Browse button to browse through the location. He indicates the category that the file should be uploaded to.

The system verifies whether the file format is valid for upload. It also searches its file index to see whether a file of the same name exists. The system assigns a version number to the valid format file, and displays default meta data for the user to review. It also prompts the User to fill in other meta data. When the User clicks on Submit, the system checks whether the file name has been changed by the User. If file name is not changed, it uploads the file to the database and updates file index for search. It also assigns a unique file ID to the file, saves the meta data and updates its topic index for topic search. The system will also informs the users who has required to track changes of that file.

#### Alternative Flows

The file format is invalid. The system prompts the User to upload a valid format file.
The file name is changed by the User, the system verify the file name again and assigns version number to the file, displays the default meta data, and prompts the User to fill in other meta data, if any.

**Activity Diagram**

Figure III.15 Upload File.

**Pre-Conditions**

The User logs in to the project website successfully.

**Post-Conditions**

If the use case was successful, the system updates its database.

**III.4.2 Search File**

**Brief Description**

This use case is for file searching. The system should only returns files that the User has access right to view.

**Actors**

User

**Main Flow**

This user case begins when the User clicks on Search Files. The system displays search page with various search criteria, such as:
Meta data: searching for a document using the meta data entered, e.g., author, date, description, etc.

Keyword: keying in a keyword, and the search engine finds the most matches.

Catalogue: browsing through the catalogues and sub-catalogues to locate information.

Full text: searching in the entire content of the documents.

When the User clicks on Submit, the system gets the search criteria, searches its file index, and returns the search result with links to the location of the files.

**Alternative Flows**

No match is found. The system returns the result and displays instructions for search.

**Activity Diagram**

[Diagram showing search process]

Figure III.16 Search File.

**Pre-Conditions**

The User logs in to the project website successfully.

**Post-Conditions**

The system remains unchanged, except counting the most frequent searches.

**III.4.3 Search Topic**

**Brief Description**

This use case is for integrated information search and display. The system should only return information that the User has access right to view.

**Actors**

User
Main Flow

This use case begins when the User click on Search A Topic. The system displays topic search page with various search criteria.

When the User clicks on Submit, the system gets the search criteria, searches its topic index, and displays the search result.

The User browses through the result and marks useful items. Information that is written in or can be transformed to XML format can be copied and pasted to the Saved Items. Information in XML incompatible format can be saved as the whole file is. The User can save the marked information for future use, or request another search.

When the User gets enough information, he can review the saved item list, indicates how he want the information to be displayed. The system displays the information in one integrated webpage.

The integrated webpage can be saved to the User Defined Document in Document Management for permanent use, or linked to the user’s My Work Package in Workflow Management for short-term use.

Alternative Flows

No match is found. The system returns the result and displays instructions for search.

Activity Diagram

Figure III.17 Search Topic.
Pre-Conditions

The User logs in to the project website successfully.

Post-Conditions

The system saves the search results and integrated webpages to its database.

III.5 PACKAGE MANAGE WORKFLOW

Context Diagram

III.5.1 Manage Change

Brief Description

This use case is to manage the changes in construction.

Actors

User

Figure III.18 Manage Workflow.
Main Flow

The use case begins when the User clicks on Manage Change. He can either manage Request For Information (RFI) or Variation Order.

Subordinate Use Cases Diagram

![Diagram](image)

Figure III.19 Manage Change.

Pre-Conditions

The User logs in to the project website successfully.

Post-Conditions

The change related information, including the form and comments from all parties, linked files and drawings, new files and drawings, is recorded under the ID of that change item.

Subordinate Use Cases

III.5.1.1 Manage RFI

Brief Description

This use case is to manage the Request For Information (RFI).

Actors

User

Main Flow

The use case begins when the User clicks on New RFI. The system displays the webpage for RFI input.

When the User clicks on Submit, the system saves the RFI to its database. If the initiator indicates a party to answer the RFI, the system sends a notification to that
party. If not, the system sends the notification to the Project Manager, so that he will assign task to the responsible party.

The responsible User receives the notification, views the RFI, and answers the RFI.

The system saves the answer, notifies the initiator and the Project Manager.

If the initiator is satisfied with the answer, he closes the RFI and the workflow ends.

**Alternative Flows**

If the RFI needs more clarification, the responsible User adds his comments and redirects the RFI back to the initiator. The initiator clarifies his question and submits it again.

If the responsible User cannot answer the RFI, he adds his comments, redirects the RFI to a User who can answer the RFI. The new responsible party goes through viewing and replying RFI or redirecting it to another responsible party, until one party answers the question. The system records the comments and history of information redirects.

If the initiator is not satisfied with the answer, he adds his comment and sends the RFI back to the responsible party. The responsible party goes through viewing and replying RFI or redirecting it to another responsible party.

**Activity Diagram**

![Activity Diagram](image)

Figure III.20 Workflow of RFI.
Appendix III The Conceptual Model

Pre-Conditions

The User logs in to the project website successfully.

Post-Conditions

The RFI related information, including the RFI form and comments from all parties, linked files and drawings, new files and drawings, is recorded under the ID of that RFI.

III.5.1.2 Manage Variation Order

Brief Description

This use case is to manage the Variation Order (VO) in construction. VO is usually generated from RFI.

Actors

User

Main Flow

The use case begins when the User clicks on New VO. The system displays the webpage for VO input.

When the User clicks on Submit, the system saves the VO to its database. If the initiator indicates a party to respond to the VO, the system sends a notification to that party. If not, the system sends the notification to the Project Manager, so as to assign task to the party that is responsible.

The responsible User receives the notification, views the VO, and approves the VO.

The system saves the approval, notifies the initiator and the Project Manager. If the initiator is satisfied with the answer, he closes the VO and the workflow ends.

Alternative Flows

If the VO needs more clarification, the responsible User adds his comments and redirects the VO back to the initiator. The initiator clarifies his VO and submits it again.

If the responsible User rejects the VO, he adds his reasons and comments, redirects the VO to the initiator. The use case ends.

If the responsible User approves the VO but he is not the person making final decision, the VO is forwarded to other responsible parties for approval. The other responsible parties go through viewing and approving the VO, or rejecting the VO, until the final decision is made.
Activity Diagram

Figure III.21 Workflow of VO.

Pre-Conditions

The User logs in to the project website successfully.

Post-Conditions

The VO related information, including the VO form and comments from all parties, linked files and drawings, new files and drawings, is recorded under the ID of that VO.

III.5.2 Manage My Work Package

Brief Description

This use case is to create personalized work package to include all related information to a work item, such as a RFI, or a Purchase Order (PO).

Actors

User

Main Flow

The use case begins when the User clicks on Create New Package. The system displays the webpage for package input.
The user indicates the name of the work package, adds links to workflow, documents, tasks, integrated files generated from topic search, and other necessary information. The system saves the above information under the ID of that workflow.

The user can edit the work package by adding and deleting links and files in the package as the work goes on.

**Activity Diagram**

![Activity Diagram](image)

Figure III.22 Manage My Work Package.

**Pre-Conditions**

The user logs in to the project website successfully.

**Post-Conditions**

The system saves the links in the work package and updates any edition to the links.

### III.6 PACKAGE TEAM COMMUNICATION

**Context Diagram**

![Context Diagram](image)

Figure III.23 Team Communication.
### III.6.1 View BBS

**Brief Description**

This use case is for informal discussion of a topic. Its use with Workflow Management can simplify the workflow processes.

**Actors**

User

**Main Flow**

The use case begins when the User clicks on View BBS. The system displays the most recent discussion topics.

The User can add a new topic to the BBS, or edit his posts.

The user can also read posted articles, respond to articles that need his reply. He may provide information to answer the question by referring a file, or invoking Search Topic to search integrated information.

**Subordinate Use Cases Diagram**

![Use Cases Diagram for View BBS](image)

Figure III.24 View BBS.

**Pre-Conditions**

The User logs in to the project website successfully.

**Post-Conditions**

All the posts are saved to the system.
III.7 PACKAGE ADMINISTRATE PROJECT

Context Diagram

Figure III.25 Administrate Project.

III.7.1 Setup User

See the use case Setup User in Main use case.
APPENDIX IV XML DOCUMENTS FOR RERFI

Chapter 6 presents schema and xml file of a Response To Request For Information (ReRFI). Here we present the schema and xml files of the Request For Information, the Response To Request For Information, the Quotation, and the Quotation For Change. All schema and xml files are edited with the software XMLSPY (XMLSPY, 2002).

IV.1 HTML FILE OF RERFI

Response To Request For Information

<table>
<thead>
<tr>
<th>Number</th>
<th>MRT/112034525</th>
</tr>
</thead>
<tbody>
<tr>
<td>From</td>
<td>YS Liu (MC)</td>
</tr>
<tr>
<td>Date</td>
<td>18/10/2001</td>
</tr>
<tr>
<td>Time</td>
<td>9:00 a.m.</td>
</tr>
<tr>
<td>To</td>
<td>K Foo (AR)</td>
</tr>
<tr>
<td>Cc</td>
<td>C Tan (CL)</td>
</tr>
<tr>
<td>Location of</td>
<td>Entrance 1 to Garden Bridge Staircase</td>
</tr>
<tr>
<td>Work</td>
<td>Handrail position and material at GL (RA) side parapet</td>
</tr>
<tr>
<td>Discipline</td>
<td>Architectural</td>
</tr>
<tr>
<td>Category</td>
<td>Drawing Discrepancies</td>
</tr>
<tr>
<td>Importance</td>
<td>Normal</td>
</tr>
<tr>
<td>Date Required</td>
<td>20/ Oct/2001</td>
</tr>
</tbody>
</table>

Question Raised by SY Liu (MC) 18/10/2001 9:00 a.m. -

Question 1: Handrail position
The original design of handrail along GL (RA) is 80mm away from the parapet wall. Since the position of the handrail does not coincide with the steel column footing at this position, the handrail should be at least 200 mm away from the parapet. Please confirm the distance.

Question 2: Handrail material
Handrail material is not specified in the original design. Please confirm whether Type 316 or Type 3X is to be used.

Suggestion
See attached drawings for handrail position.

Type 304 is recommended.

Link Files

1 /drawings/shopdrawings/details/C709.dwg (MC v1) - Proposed drawing -

Figure IV.1 HTML Webpage of ReRFI.
Date 24/10/2001

Answer Private

Question 1:
Proposed solution is not ideal; Pedestrian might hit stump, better hack the kerb.
You have confirmed kerb is structural and can not be hacked. Build it as proposed.

Question 2:
T304 is used in general occasions, while T316 in high-cauterity or high-humidification situations. T304 is acceptable to designer.

Co-Respondent

Comments Private

Link Files

Submit

Redirect

Figure IV.1 HTML Webpage of ReRFI (Continue).
IV.2 XML SCHEMA OF RERFI

Figure IV.2 ReRFI.xsd

Figure IV.3 RFI Type In ReRFI.xsd
Appendix IV XML Documents For ReRFI

Figure IV.4 Response Type in ReRFI.xsd

Figure IV.5 LinkFile Type in ReRFI.xsd

Figure IV.6 ActorSelect Type in ReRFI.xsd
IV.3 SOURCES OF RERFI SCHEMA

<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XML Spy v4.4 (http://www.xmlspy.com) by Leung Nga Na (NUS) -->
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"
attributeFormDefault="unqualified">
<xs:element name="ReRFIs">
  <xs:annotation>
    <xs:documentation>Comment describing your root element</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:sequence maxOccurs="unbounded">
      <xs:element name="ReRFI">
        <xs:complexType>
          <xs:sequence>
            <xs:element name="RFI">
              <xs:complexType>
                <xs:sequence>
                  <xs:element name="Number"/>
                  <xs:element name="Ref_No" minOccurs="0"/>
                  <xs:element name="From">
                    <xs:complexType>
                      <xs:sequence>
                        <xs:element name="ActorSelect" type="ActorSelectType"/>
                        <xs:element name="Represent" minOccurs="0" type="ActorSelectType"/>
                        <xs:element name="Submit">
                          <xs:complexType>
                            <xs:sequence>
                              <xs:element name="To">
                                <xs:complexType>
                                  <xs:sequence>
                                    <xs:element name="ActorSelect" type="ActorSelectType"/>
                                  </xs:sequence>
                                </xs:complexType>
                              </xs:element>
                              <xs:element name="Cc" minOccurs="0" type="ActorSelectType"/>
                            </xs:sequence>
                          </xs:complexType>
                        </xs:element>
                      </xs:sequence>
                    </xs:complexType>
                  </xs:element>
                </xs:sequence>
              </xs:complexType>
            </xs:element>
            <xs:element name="Date"/>
            <xs:element name="Location"/>
            <xs:element name="Subject"/>
            <xs:element name="Discipline"/>
            <xs:element name="Category"/>
            <xs:element name="Importance"/>
            <xs:element name="RequiredDate"/>
            <xs:element name="Question"/>
            <xs:element name="Suggestion" minOccurs="0"/>
            <xs:element name="Comments" minOccurs="0"/>
            <xs:element name="LinkFiles" minOccurs="0"/>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
</xs:element>
</xs:schema>
<xs:element name="Cc" minOccurs="0">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="ActorSelect" type="ActorSelectType"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>

<xs:element name="ReDirect" minOccurs="0">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="To">
        <xs:complexType>
          <xs:sequence>
            <xs:element name="ActorSelect" type="ActorSelectType"/>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
      <xs:element name="Cc" minOccurs="0">
        <xs:complexType>
          <xs:sequence>
            <xs:element name="ActorSelect" type="ActorSelectType"/>
          </xs:sequence>
        </xs:complexType>
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</xs:element>
</xs:sequence>
</xs:complexType>
</xs:element>
</xs:sequence>
</xs:complexType>
</xs:element>
</xs:sequence>
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</xs:schema>
IV.4 XML FILE OF RERFI

Figure IV.7 K Foo’s ReRFI.xml
### IV.5 SOURCE CODES OF RERFI XML

```xml
<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XML Spy v4.4 (http://www.xmlspy.com) by Leung Nga Na (NUS) -->
<ReRFIs xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="C:\My Documents\DemoWeb\RFI\ReRFI.xsd">
  <ReRFI>
    <RFI>
      <Number>MRT/112034525</Number>
      <Ref_No>RFI/FNCAS/1522</Ref_No>
      <From>
        <Person>YS Liu</Person>
        <Organization>MC</Organization>
      </From>
      <Submit>
        <To>
          <Person>K Foo</Person>
          <Organization>AR</Organization>
        </To>
        <Cc>
          <Person>C Tan</Person>
          <Organization>CL</Organization>
        </Cc>
      </Submit>
      <Date>18/10/2001</Date>
      <Location>Entrance 1 of GB Staircase</Location>
      <Subject>Handrail position and material at GL (RA) side parapet</Subject>
      <Discipline>Architectural</Discipline>
      <Category>Drawing Discrepancies</Category>
      <Importance>Normal</Importance>
      <RequiredDate>20/10/2001</RequiredDate>
      <Question>
        Question 1: Handrail position
        The original design of handrail along GL(RA) is 80mm away from the parapet wall. Due to the position conflict with the steel column footing at this side, the handrail should be at least 200 mm away from the wall. Please confirm the distance.
        Question 2: Handrail material
        Handrail material is not specified in the original design. Please confirm whether Type 316 or Type 304 is to use.
        Suggestion
        See attached drawings for handrail position.
      </Question>
      <Suggestion>
        See attached drawings for handrail position.
      </Suggestion>
      <Comments/>
      <LinkFiles>
        <LinkFile>
          <Name>C709.dwg</Name>
          <FileID>MRT112343</FileID>
          <Location>/drawings/shopdrawings/details/C709.dwg</Location>
          <Description>Proposed drawing</Description>
          <Display>Embed</Display>
        </LinkFile>
        <LinkFile>
          <Name>C709.dwg</Name>
          <FileID>MRT112056</FileID>
          <Location>/drawings/shopdrawings/details/C709.dwg</Location>
          <Description>Original drawing</Description>
          <Display>Embed</Display>
        </LinkFile>
      </LinkFiles>
    </RFI>
  </ReRFI>
</ReRFIs>
```

The original design of handrail along GL(RA) is 80mm away from the parapet wall. Due to the position conflict with the steel column footing at this side, the handrail should be at least 200 mm away from the wall. Please confirm the distance.

**Question 2: Handrail material**

Handrail material is not specified in the original design. Please confirm whether Type 316 or Type 304 is to use.

**Suggestion**

See attached drawings for handrail position.

Type 304 is recommended.
Question 1:
Proposed solution is not ideal; Pedestrian might hit stump, better hack the kerb. You have confirmed kerb is structural and can not be hacked. Build it as proposed.

Question 2:
T304 is used in general occasions, while T316 in high-cautery or high-humidification situations. T304 is acceptable to designer.