PIAS: A CITIS-BASED INFORMATION SHARING SYSTEM

Tsung-Heng Liu, Shang-Hsien Hsieh, Yie-Ting Chen, Choung-Houng Wu

Department of Civil Engineering, National Taiwan University, Taipei, Taiwan

Abstract: CITIS (Contractor Integrated Technical Information Service) is a standard originated from the U.S. Department of Defense. It defines a set of functions for sharing contractually required digital information between the owner and contractors. This research develops a project-oriented information sharing system, named PIAS (Project Information Acquisition Service), which supports not only CITIS functions for information sharing but also workflow management services for handling the document flows among users. The characteristics of the A/E/C industry, such as lots of participants and complex processes, are considered in the development of PIAS. In addition, for the reason of software reuse and system scalability, PIAS is designed and implemented using object-oriented techniques and is built in a 3-tier distributed system architecture.

Keywords: CITIS, Workflow, Information Sharing, Object-Oriented, Distributed System

1. INTRODUCTION

A construction project usually involves many participants during its life cycle and requires circulation or exchange of a huge volume of documents among these participants. Traditionally, these documents are printed on papers and delivered via mail using manpower. As the complexity and scale of modern projects continue to increase, the storage and management of these paper-based documents have encountered increasingly more serious problems, such as difficult to index, large storage requirement, prone to version inconsistency, and so forth.

To address these problems, the U.S. Department of Defense (DoD) has promoted a strategy named CALS [1], which stands for Continuous Acquisition and Life-Cycle Support. The key concept of CALS is to digitize and standardize the logistical documents to facilitate information sharing. In addition, a standard based on the CALS strategy called CITIS (Contractor Integrated Technical Information Service) [2] has been proposed to promote sharing of contractually required information. It defines a set of functions to facilitate electronic access to and delivery of contractually required digital information between the owner and the contractors.

In this work, the CITIS services are further integrated with workflow management services to support not only the electronic management and sharing of contractually required documents in the A/E/C industry but also the automation of document delivery and handling process. A project-oriented information sharing system, called PIAS (Project Information Acquisition Service) has been developed to experiment and demonstrate the integration of the CITIS services and workflow management services for better document sharing and processing in a construction project. PIAS provides an open environment for all participants of a construction project to share their documents electronically. It also supports the document-flow management during the lifecycle of an A/E/C project.

2. CITIS AND WORKFLOW MANAGEMENT

CITIS [2] is a standard originated from the U.S. Department of Defense. MIL-STD-974 defines CITIS as "*a contractor developed service which provides electronic access to and/or delivery of contractually required Contract Data Requirements List (CDRL) data to users [2]*." The term "CDRL data" means the data required to be delivered to fulfill the terms and conditions of the contract between the contractor and the owner. CITIS services include information services, data configuration management, data item index, security, and access control. Based on these services, a CITIS service provider should implement core functions and parts of tailorable functions that are specified in the contract. All of CITIS services and functions are listed in Table 1.

Although CITIS is originally designed for U.S. military projects, instead of for construction projects, it still serves as a good foundation for development of information sharing systems in the A/E/C industry. However, the CITIS core functions are mainly designed for simple auditing processes between the owner (i.e., the government) and the primary contractor and are not suitable for construction

projects that usually involves complex auditing processes. Therefore, this work designs and employs workflow services to drive the CITIS functions so that complex construction processes can be handled.

Table 1 CITIS services and functions [3]

CITIS Services	● Information services ● Data configuration management ● CITIS security ● Data item index ● Data exchange standards
CITIS Core Functions	● Acknowledge ● Approve or disapprove ● Comment ● Notice of delivery ● Receive ● Search ● Store ● View
CITIS Tailorable Functions	● Application ● Archive ● Combine ● Download ● Edit ● Forward ● Package ● Query ● Sort ● User groups

Workflow Management Coalition [4] defines workflow as "*the automation of a business process, in whole or part, during which documents information or tasks are passed from one participant to another for action, according to a set of procedural rules.*" It also defines a workflow management system as "*a system that defines, creates and manages the execution of workflows through the use of software, running on one or more workflow engines, which is able to interpret the process definition, interact with workflow participants and, where required, invoke the use of IT tools and applications.*"

A workflow management system is usually composed of several major components and interfaces as shown in Fig. 1. The workflow enactment service consists of one or more workflow engines to create, manage, and execute workflow instances. The interfaces around the workflow enactment service are workflow API functions to access and regulate the enactment service. Process definition tools are used to define workflow processes, including the relationships of activities, participants, criteria to start or terminate the process, etc. Both interfaces 2 and 3 are defined for the enactment service to invoke and/or control other applications. Interface 5 is used to connect the administration and monitoring applications, and

Interface 4 is used to connect with other workflow enactment services.

3. PROJECT INFORMATION ACQUISITION SERVICE

In this work, Project Information Acquisition Service (PIAS) [5] is proposed to integrate the functions of CITIS and workflow. The workflow services are used in PIAS to boost the CITIS functions related to review and transference of documents. CITIS defines a set of functions for an information sharing system and requirements for a document management system. Although there are many approaches for sharing information and managing documents, the CITIS approach is selected here because it has been employed successfully in the U.S. DoD's projects and is closer to our requirement in managing information in a construction project following a contract.

To implement the CITIS functions, the concept of Electronic Document Management (EDM) is introduced first. Electronic document management can be divided into two major approaches: the information-level and document-level approaches. The information-level approach describes and represents document information through an object model before storing it in an integrated database. The document-level approach treats each electronic document as a black box, and the aim of computer-supported management is to enable storage, retrieval, versioning, and approval of the entire document [6]. PIAS focuses on document-level sharing and management and follows the document-level EDM approach.

Furthermore, for the users' convenience, PIAS applies web technologies to avoid the installation of applications. For future system scalability and extensibility, PIAS employs the distributed architecture with software components. For better system maintenance, PIAS is designed and implemented using the object-oriented method.

In summary, the features of PIAS include:
● It is a web-based project-oriented information management center that manages documents for a construction project and is designed for all participants involved in the project,
● It is compliant with CITIS functions plus the workflow services, and
● It uses emerging information technologies to promote user-friendliness, system extensibility, and system maintainability.

4. DESIGN OF PIAS SYSTEM

PIAS integrates workflow services into CITIS services to address the requirement of handling complex processes in the A/E/C industry and to

automate the processes of document delivery. According to the guideline of n-tier architecture design [7], PIAS system can be roughly divided into 3 tiers: data tier, business logic tier, and presentation tier, as shown in Fig. 2. Components in the data tier are in charge of dealing with databases, and provide the database services to the business logic tier. The business logic tier manipulates the data tier services to fulfill the requirements from the presentation tier. The presentation tier uses the business objects in the business logic tier to interact with and serve end users.

4.1 Data Tier

PIAS is designed using the object-oriented method but is implemented using a common relational database. To satisfy object-oriented principles, the data tier in PIAS must do more than database accesses. Thus, the design issues of the data tier are:

● To make transient objects persistent,
● To handle data mapping between object-oriented models and relational databases,
● To activate objects from databases, and
● To support transaction without losing data consistency.

According to the results of object-oriented analysis [5], the data objects are designed as eight classes. Their relationships are shown in Fig. 3, and their descriptions are provided in Table 2.

4.2 Business Tier

In the business tier, business objects provide services to presentation tier by manipulating the objects in data tier. The considerations of designing business objects are summarized as follows:

● Business objects are functionality-oriented: For providing services to the presentation tier, each object should be designed following the system use cases. The system use cases are abstracted into 6 classes: DocumentAccess, Messenger, UserInformation, UserManagement, Workflow, and WorkMonitor. The first four classes are designed for common users, and the last two classes are designed for administrators. The contents of these classes are shown in Table 3.
● Business objects operate the transactions: Because logic processes are kept in business objects, business objects should manipulate data objects to complete transactions according to their designed missions.

4.3 Presentation Tier

The presentation tier, usually called GUI (Graphical User Interface), is the interface for communicating to and interacting with users. The

Table 2 Classes in Data Tier

Class	Description
User	Class User is the projection of system users in the real world.
Security	Class Security also keeps user's data that are related to system security, such as login name, password, permission group, etc.
Document	Class Document represents the entity of a CITIS document and contains document's attributes, such as ID, title, author, version, modification time, keywords, etc.
Permission	Class Permission is used to record users' privileges for accessing documents.
Comment	Class Comment is used to store the comments from reviewers, and other related information.
Process	The responsibilities of the class Process are to manage and to execute workflow processes.
Activity	An activity is a piece of work that forms one logical step within a process and includes the information of the process data, the task receiver, the task content, the due time, and so on.
Notification	A notification is the message that is dispatched to user by the workflow manager, i.e. class Process, when an activity is activated. Class Notification contains the information of the activated activity and the process.

Table 3 Classes in Business Tier

Class	Description
DocumentAccess	Class DocumentAccess is designed for high-level access of documents by using Document objects in the data tier.
Messenger	Class Messenger is used to receive tasks for users and to provide functions for sending messages between users.
Workflow	Class Workflow contains functions for creating and setting a workflow process.
UserInformation	Class UserInformation is used to provide information of users for GUI.
UserManagement	Class UserManagement is designed for administration of user information.
WorkMonitor	Class WorkMonitor provides

	monitoring of workflow processes for administrators.

components in the presentation tier could be executable programs or script-based web pages, such as ASP (Active Server Pages). After considering the trends of Internet solutions, the present work employs the ASP techniques in PIAS. ASP pages are written in HTML with embedded server-side scripts. Thus, a certain web server is needed to execute the scripts and to export parsed pages to the clients, and the client applications of PIAS can be any commonly available web browsers. The relationship between the clients and the PIAS presentation tier is shown in Fig. 4.

The primary functions of the presentation tier are to access documents, to receive/send messages or tasks, and to create work processes. The design requirements of the PIAS presentation tier are as follows:

● GUI should be designed in web page format to take advantage of the Internet technologies,
● Client-side scripts should be in charge of pre-processing users' inputs, and
● Server-side scripts should be responsible for interactions with process objects.

5. IMPLEMENTATION OF PIAS

The implementation of PIAS employs mainly the so-called Microsoft solutions. A PC running the Windows NT operating system is used as the development platform. In addition, the HTTP server, database server, and transaction server use the Internet Information Server (IIS) 4.0, SQL Server 7.0, and Transaction Server 2.0, respectively.

PIAS services are composed of COM components, and the user interfaces are built as web pages. The primary programming language used for implementing the COM components as well as the scripts in the ASP pages is Visual Basic 6.0.

Several implementation issues have been addressed in this work, such as document uploading, document vaulting, etc., in the present web-based environment. The discussions on these issues are not provided here because of limited space, but can be found in [5].

Figure 5 shows the page structure of the PIAS website. Figure 6 demonstrates one of the PIAS services, with which users can check in/out, view, and comment documents online.

6. CONCLUSIONS

A web-based project-oriented information sharing system for the A/E/C industry, named PIAS, has been developed and presented in this paper. PIAS integrates CITIS and workflow management system to improve sharing and management of electronic documents in the A/E/C industry, and to demonstrate a better information sharing system for the A/E/C industry. PIAS is a more advanced EDM system than those pure CITIS or workflow systems. On one hand, CITIS services in PIAS obtain helps from the workflow management system to make the documents flow automatically and to allow for monitoring progresses of reviewing tasks. On the other hand, from the workflow system's perspective, CITIS services provide better management of document states and promote information sharing to the public.

In addition, PIAS employs modern information technologies to provide an easy-access and user-friendly environment for the clients to perform document management, sharing, and delivery through Internet. It is also carefully designed with the considerations of future system scalability, extensibility, and maintainability.

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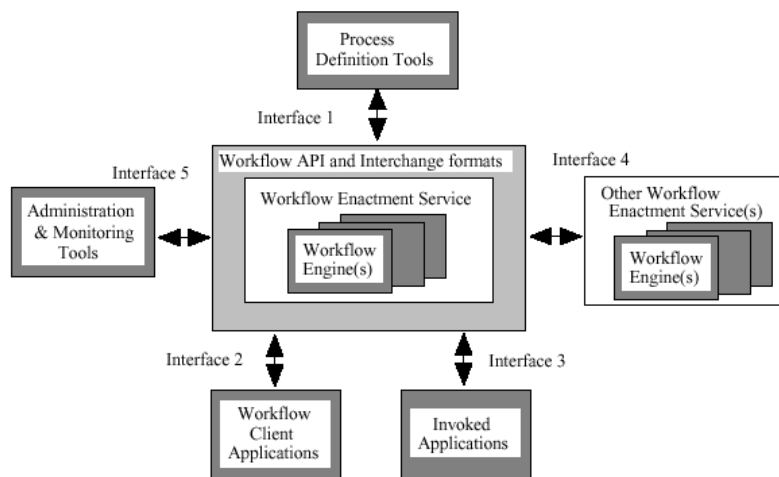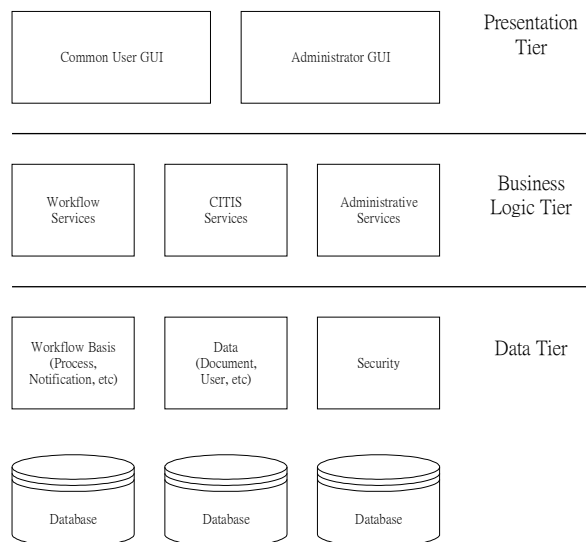
Figure 1 Workflow Reference Model [4]
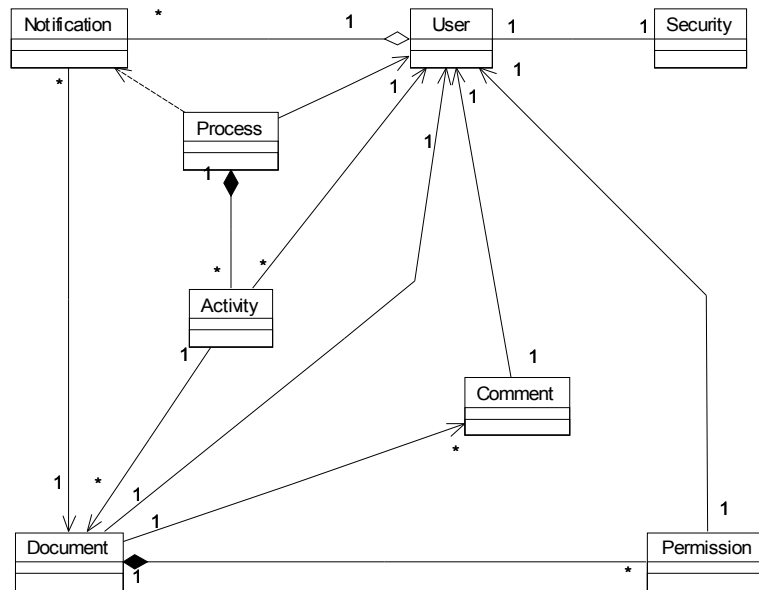

Figure 2 PIAS System Structure

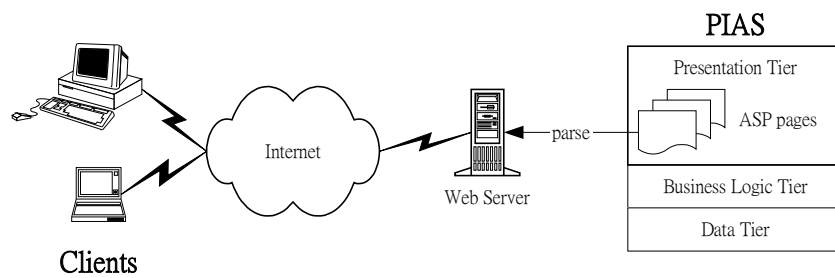Figure 3 Class Diagram for Data Tier

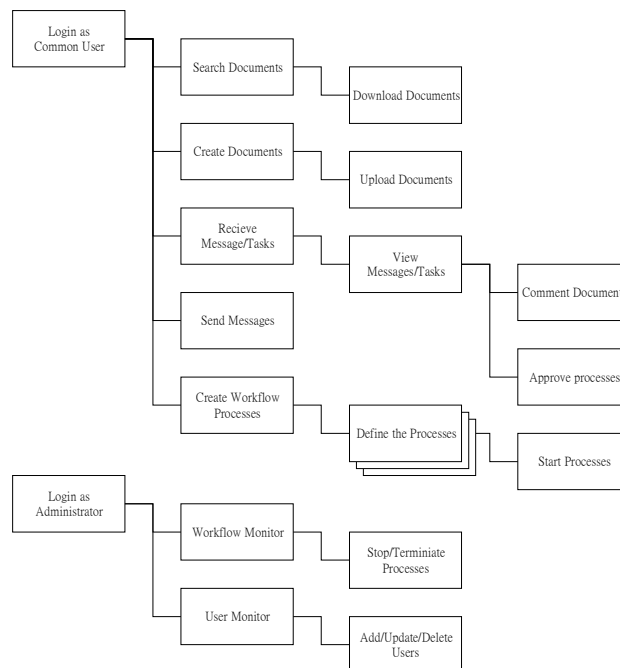Figure 4 Relationship between the clients and the PIAS Presentation Tier
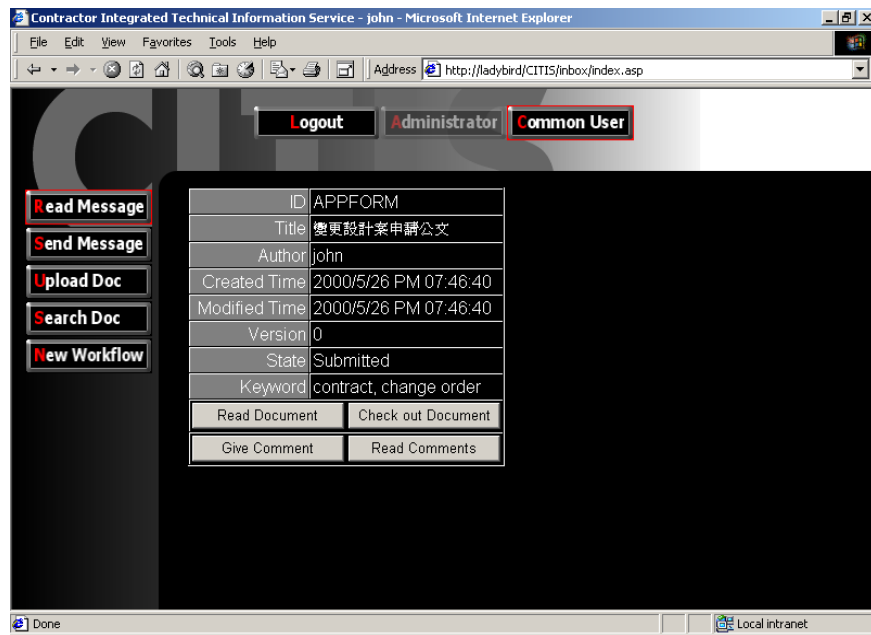

Figure 5 Page Structure of the PIAS Website

Figure 6 Services for Document Processing in PIAS