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TRANSACTION AND IMPLEMENTATION STANDARDS IN AEC/FM INDUSTRY

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ABSTRACT: This paper presents an ongoing research project that aims to define transaction and implementation standards for data exchanges within the Architectural, Engineering, Construction, and Facility Management (AEC/FM) industry. Given the fragmented nature of the AEC/FM domain, information sharing and management have been major problem areas for decades. Information exchange can generally be described in terms of individual information transactions.

Several efforts are underway to standardize the content of data exchange transactions without attempting to standardize the transactions themselves. Standardization of the transactions will potentially provide better communication, increased quality and productivity, and reduced costs, delays and legal suits in the industry.

1. INTRODUCTION

Information exchange has been a main problem area in the Architectural, Engineering, Construction and Facility Management (AEC/FM) industry. Information exchange can be described in terms of individual information transactions. The goal of this research is to define transaction and implementation standards in the AEC/FM industry.

In general, any communication or interaction between different parties can be described as a transaction. Some examples include the following:

- On-line purchasing of materials
- Requests for information on a job site
- Reporting inspection results

These transactions can be standardized into activities performed by different participants, aimed at achieving different business objectives. Increasingly, information is exchanged electronically, and it is these electronic transactions in which we are specifically interested.

Transaction standards are not generally required for human-to-human communication where the participants have a high capacity to "interpret" the transaction semantics. However, transaction standards are useful for electronic transactions that require more formally structured information; and they are critical for any fully or partially automated transactions.

2. BACKGROUND

Organizations have used electronic aids to support their data processing tasks since 1954. It was not until the end of the 1970s that the utilization of Computer Based Information Systems (CIBS) became pervasive. Automatic exchange of data between remote applications that belong to different organizations is called electronic Data Interchange EDI. (Pfeiffer 1992). In the AEC/FM industry, many computer applications are used. However, there are still many challenges facing the design and development of Computer Integrated Construction (CIC) systems (Russell and Froese, 1997). One of

the main barriers to the globalization of the AEC industry is the lack of a standard language for data exchange. Product and process model data standards are required to provide the unifying language through which integrated computer systems for architecture, engineering, and construction can converse (Froese, 1996).

3. PRODUCT DATA STANDARDS

Various research projects have developed building data models to serve as standards in the AEC/FM industry. The most important initiatives on standardization of the product models are the International Organization for Standards (ISO) STEP standard 10303 for Product data representation and exchange on a broad (multi-industry) scope, and the International Alliance for Interoperability (IAI) specifically within the AEC/FM domain.

STEP standards aims to represent information about products in different industries. The objective is to provide a neutral mechanism to be able to describe product data independent from any specific system throughout the life cycle of the product.

STEP technology is being used in many industries such as automotive and electronics. It is comprised of many different parts. The Building Construction Core Model (BCCM) Part 106 is intended to be used as a unifying reference for building construction Application Protocols AP's. These standard models could be exchanged using the STEP physical file format for simple file exchange or STEP Standard Data Access Interface SDAI for on line file exchange.

The IAI (http://cig.bre.co.uk/iai_uk) is a global consortium for architecture, engineering, construction, and facility management that develops data standards for AEC/FM projects called the Industry Foundation Classes IFC's (Froese, Yu, 1999).

The intention of the IFCs is to define how real things such as doors, walls, etc. and abstract things such as spaces, processes, etc. should be represented electronically. IFCs build on results from STEP. An increasing number of commercial software products support IFCs. Work on new releases continues and the potential for use in the industry is increasing. Efforts in recent years through ISO and the IAI have been focusing on defining the syntax and semantics of a standard language. The IFC's and/or the more recent aecXML effort could be the basis of the future development of the common language for data exchange in AEC/FM industry. As part of the process of developing the product data standards, the

developers define common business transactions or scenarios that could use the data standards. However, these transactions are usually defined in an ad-hoc way to help support the development processes. In other industries, it has been recognized that it is useful to define the transactions themselves as a standard. The product data standards define the "content" of a transaction, the transaction standards define the "context" of the transaction. To our knowledge, no efforts have previously been made to establish similar standard business transactions within the AEC/FM industry.

4. OBJECTIVES

The main objectives of this research can be summarized as follows:

Analysis of transactions use in the industry

- Trace the growth of the usage of the standards in the AEC/FM industry.
- Identify and utilize the result of similar efforts within other industries.
- Identify the major benefits of a standard language for data exchange in AEC/FM industry.
- Demonstrate the role of IFCs as the syntax and semantics of the standard language.

Develop a framework for transaction standards in AEC/FM:

- Classify different transactions in the AEC/FM industry.
- Investigate specific issues surrounding the potential for transaction standards for AEC/FM
- Provide a standard template for transaction standards for AEC/FM.

Develop specific prototype transaction standards:

- Analyze a special process as it happens in the industry (as is).
- Identify a better, more effective way to do the same process (to be).
- Define transaction specifications for a particular topic area within AEC/FM.

Demonstrate the use of transaction standards in a prototype system:

- Create a prototype system that uses the transaction specifications to support a range of business transactions between various system components.

5. AN EXAMPLE IN IT

As an example from outside of AEC/FM, RosettaNet (<http://www.rosettanet.org>) is an initiative with the aim of developing electronic business interfaces for the electronics industry. RosettaNet builds upon the Internet and XML to define 3 layers of standards: Partner Interface Processes (PIPs) that formalize the characteristics and requirements for specific transactions between parties; dictionaries that define the properties of the products, partners and business transactions; and implementation frameworks that specify data exchange implementation details. In the AEC/FM industry, the data dictionaries have been defined, but the other levels of business exchange (transactions and implementations) are still left for different partners to agree upon among themselves in an ad hoc manner. Existing standards within commerce do not cover the full range of the data exchanges that happen in the AEC/FM industry.

6. CLASSIFICATION OF TRANSACTIONS IN THE AEC INDUSTRY

Thamhain and Wilemon (1986) stated that communicating effectively among task groups was the third most important factor for the success of a project. Communication is defined as the sending and receiving of information between team members. (Thomas et al.1998)

Communication theory defines a set of basic elements of any communication process: the sender, the receiver, the message, channel, media, communication barriers and filters, and the feedback.

The process of exchange of the information in the AEC/FM industry takes place throughout different stages of a project between different participants (sender, receiver). The data content (the message) of these exchanges may be related to various physical parts of the building. Due to the broad range of these transactions, a classification system should exist to categorize them.

It should be noted that due to the content of the specifications of the Transaction standards, it is not necessary to categorize them based on all of the elements of communication theory. Some parts of the elements will fit in the implementation framework of the standards such as the transport layer. The classification will be based on the field of transaction, the type of the document exchanged, the sender and receiver and their roles in the project life cycle, and the stage of the project that the transaction takes place. Also the data content of the document may be

classified based on the existing classification systems in AEC industry.

6.1. Existing Classification Systems In AEC Industry

Different classification systems exist in the construction industry. "A construction information classification system (CICS) provides a common method of improving coordination of information for design, construction, and management" (Kang and Paulson 1997). Construction Index/Samarbetskommitten for Byggnadsfragor (CI/SfB) has been used in many countries as well as Masterformat in North America. Unifomat is another classification system, which is complementary to Master format. It classifies the information into nine level-one items. CI/SFB, however, can not represent many new construction technologies introduced during the last 20 years that have passed since the last revision (Kang, Paulson 2000). Therefore, the ISO technical committee (TC59/SC13 WG2) developed a new international framework in 1994, which organizes the information related to the construction industry in eight facets, including facility, space, element, work section, construction products, construction aids, management, and attributes. Unlike the existing Construction Information Classification Systems (CICS) that provide only a Work Breakdown Structure (WBS), the new ISO classification covered construction management and products, and expanded into life cycle information. The National Building Specification Services (NBS) in 1997 completed a new CICS called Uniclass. For civil engineering projects, Uniclass gained a significant improvement, which focused more on architectural projects.

6.2. Indexing The Transactions

A transaction classification system should be able to address all the possibilities that could occur for each of the applicable elements. For instance, the sender or receiver could have different roles such as the owner, the contractor, the engineer and etc. The type of the document that the transaction is transferring could be related to different stages of the project. The purpose of the document could also differ even if related to the same stage of the project. For instance, submission of a drawing could happen both in the definition and the implementation phases of the project. In the construction stage, a document might be a change order or an inspection report.

So for example, transaction “f01t02g04s01r03c14200” could mean that:

- 01 Field of transaction is document control
- 02 Type of the document is a submission of a drawing
- 04 The transaction belongs to the stage of construction and contract administration.
- 01 The sender is the manufacturer
- 03 The receiver is the project manager
- 14200 Considering Masterformat, the content of the document is about an elevator

6.2.1. Field Of Transaction

The field of a transaction could be any of the following:

Bidding, procurement, cost management, document management, quality management, scheduling, field administration, safety, environmental, design.

6.2.2. Type Of Document

Type of the document can be any of the following:

Purchase order, work order, submittal, transmittal, submission of drawing, correspondence, change order, submission of the lab results, application for payment, contract, bid package, meeting minutes, request for information, punch list, invoices, etc.

6.2.3. Stage Of The Project

The Construction Integration Summit (<http://www.csinet.org/technic/iii/cis1.pdf>) assumes different stages of the lifecycle of the project as:

Identification, predesign, design, bid-negotiation, construction, management, analysis.

The Building Projects Practice Manual Task Force (<http://www.bcprojectsmanual.com/>) divides the whole life cycle of a project to six different stages. These stages are:

- 1- Business Planning
- 2- Project Development
- 3- Documents for Construction or for Design-Build
- 4- Contract Tender and Award
- 5- Construction and Contract Administration
- 6- Acceptance and Commissioning

For different types of delivery systems these stages might overlap.

6.2.4. Role Of Sender Or Receiver

The sender or receiver may have different roles in the project. These roles could be any of the following:

owner, legal counsel, financial advisor, facility manager, commissioning agent, the lab representative, bidders, contractor, subcontractor, supplier, product representatives, manufacturers, building official, bonding agent, tradesman, contract administrators, design engineers, estimating, cost and schedule engineers, procurement and material control staff, safety and quality assurance or control staff, accounting staff, construction supervisors, project manager, equipment operators, workers, material delivery people, project manager. (<http://www.csinet.org/technic/iii/cis1.pdf>)

6.2.5. Data Content Of The Message

The data content of the message could be classified according to an established classification system such as Master Format or Uniclass. Different countries use their own classification systems and the efforts to provide a global classification system have not been implemented yet. Each country can implement the classification system that they are using in practice. For the North America and Canada, Masterformat could be considered.

7. TRANSACTION SPECIFICATIONS

The content of IAI Business Transaction Standards may be approximately as follows:

Introduction:

- The definition of the business process.
- The purpose of the transaction.
- Scope of the transaction expressed as UML Use Cases

Process Model/Data Flows:

- A flow diagram that uses UML Unified Modeling Language “swimlane” activity diagrams to demonstrate the sequences of document flows between participants, conditional logic, start/end/failure states, etc.
- Definitions of start and end states and partner roles.

Data Content

- Data contents of business documents, presented as a data model that will likely be drawn from existing data models (such as the IFCs), but is expressly presented in language appropriate to the data exchange domain. This data content model can then

be mapped to specific data model standards such as the IFCs in the “Bindings” sections below.

- Data Dictionary

Transaction Controls and Characteristics

- The maximum time allowed to acknowledge receipt, the maximum time allowed to acknowledge acceptance, maximum time allowed to perform a task, authorization requirements, etc.

Examples

Bindings to standard data models: Maps the data model to one or more standard data models such as the IFC’s, aecXML models, etc.

Bindings to implementation protocols: Maps the business transaction to specific messaging implementation mechanism, such as Biztalk messaging.

8. AN EXAMPLE CASE IN AEC INDUSTRY

A situation is assumed in which a high-rise building is constructed in a crowded city. There is not enough space for material storage on the ground around the building and the tower crane has to unload the material directly from delivery trucks to the active work areas. The project scheduler maintains a detailed crane usage and materials delivery schedule using CPM scheduling software. For each delivery, subcontractors must submit a delivery request form by fax and receive a notice allocating a specific delivery time.

The scheduler wants to implement a system to assist with this delivery planning. Subcontractors can submit a delivery request electronically, either through an on-line form, or through a “plug-in” to their scheduling system, and the information is automatically scheduled into an available time slot by the general contractor’s scheduling system.

The situation described is a case where electronic communication and submission of the documents is needed. The subs must write their request, print it, and fax it to the scheduler. Then the scheduler will receive the fax and check the time with the crane usage profile. He has to write a notice and fax it to the subs. If a sub has to cancel a time slot that has been assigned to him, or where other project participants want to check the crane usage, this process will not accommodate the situation in a desired manner.

By automating the transfer of the requests and responses, many problems could be prevented. Sometimes, when a time slot assignment must be changed for some reason, there is a possibility of a

better usage for that slot instead of letting the crane be idle for that period. The time savings that happens due to the fast transmission of the messages, instead of getting a print and then faxing the paper to the destination, could lead to a better performance and productivity for the whole project. In the long run, additional transparency of the project will affect the overall capacity of the company.

8.1. Assumptions

It has been assumed that different people that are using the system have established a business relationship and the system already recognizes them as eligible users.

8.2. Use Case 1

The subcontractor requests a delivery time slot. This action includes a check of the schedule and, in this use case, the response is positive. So the crane could be used for delivery at the time specified in the message. The system sends back an acceptance of the delivery message.

8.3. Use Case 2

The subcontractor sends a message and asks to use the crane for a time slot. The system checks the schedule. But this time the crane usage profile does not allow for delivery, so the system sends a message and rejects the request of the subcontractor.

8.4. Use Case 3

The subcontractor has received a message from the supplier about a problem that has occurred in the supplier’s batching plant. The supplier can not deliver the concrete at the time previously assigned. The subcontractor, knowing how the crane is needed for other purposes, instantly sends a message to the system and cancels the delivery. The system modifies the crane usage profile and sends a message for acceptance of delivery cancellation.

8.5. Use Case 4

The safety officer logs on from home at night and asks for a report about the usage of the crane for the next day. He is worried about the traffic rush hour in a street on one side of the building and would like to know beforehand how to handle the problem. The system sends a report about the locations of deliveries and the materials for the next day.

8.6. Use Case 5

The crane operator, who has been working hard for a while on this project, logs on the system. He feels that if he knows beforehand about when and where he has to operate the crane, he will be less stressed and will feel less fatigue. The system sends a report about the locations and volume of the material for the next day.

8.7. Use Case 6

A change has occurred in the schedule. To make the most use of the crane, another task has been assigned to the crane and one of the deliveries that was not very urgent has been cancelled. The system sends a notice of change to the related sub.

8.8. Transactions Associated With This System

The transactions associated with this system as described in the use cases are:

RequestDelivery
DeliveryAcceptance
DeliveryRejection
RequestDeliveryCancel
DeliveryCancellationAcceptance
RequestReportbyDate
SendReport
CancellationNotice
DeliveryChangeNotice
AcknowledgeReceipt, this transaction is not doing an action.

The DeliveryAcceptance is chosen as the central transaction to this system.

9. DELIVERY ACCEPTANCE

9.1. Definition

The delivery of the material at the specific time and location, which was requested in the RequestDelivery, has been accepted by the scheduler and the sub is allowed to perform the delivery.

9.2. Purpose

The purpose of this specification is to describe the transaction DeliveryAcceptance when a scheduler accepts that a sub may perform a delivery of material at the site at the time and location described in the RequestDelivery.

9.3. Start State

The start state is when the schedule is checked and a time slot has been assigned to the subcontractor.

9.4. End State

- (Succeed) If confirmation of receipt has been received.
- (Failed) If confirmation of receipt has not been received.
See Appendix.

9.5. Roles Definition

- Delivery performer: Any sub who performs the delivery.
- Delivery Assigner: The scheduler or the application that assigns the time requested by performer to be used by the crane for delivery of material.

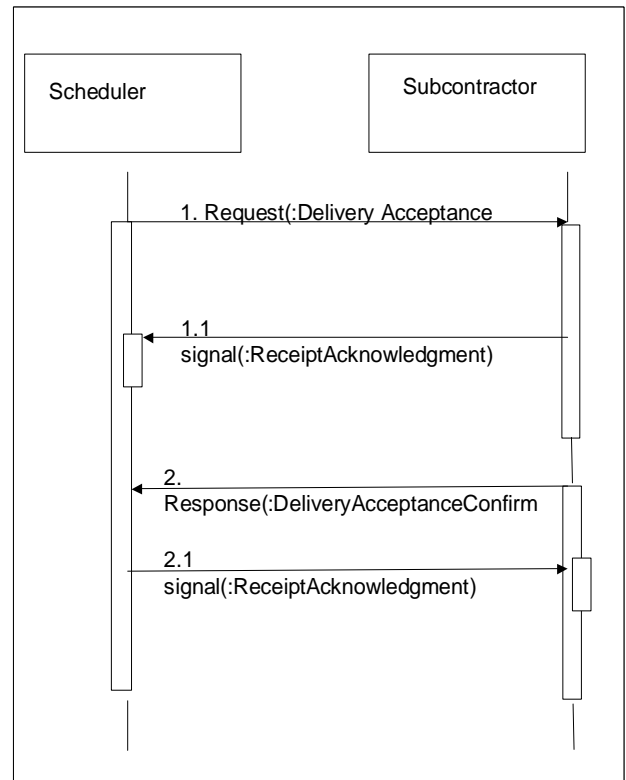
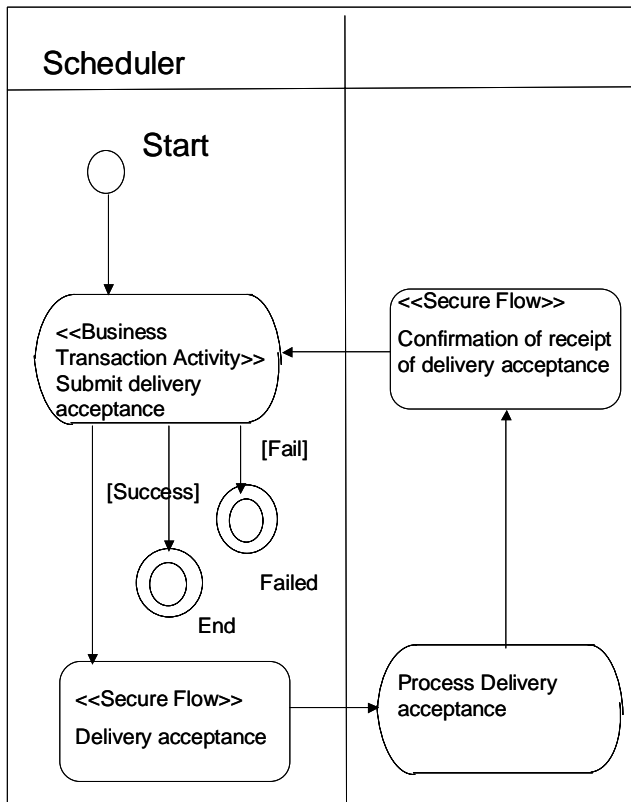
9.6. Communicating Components

The message exchange sequence and the table of controls are shown in the appendix.

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11. APPENDIX



Submission of the Delivery acceptance

Submission of the Delivery acceptance

No.	Name	Time to Acknowledge Receipt Signal	Time to Acknowledge Acceptance Signal	Time to Respond	Included in Time to perform	Authorization	Non-Repudiation	Secure Transport
1	RequestDelivery	2 hrs	N/A	24 hrs	Y	Y	N	N
1.1	Acknowledgement of receipt	N/A	N/A	N/A	Y	Y	N	N
2	Confirmation of receipt RequestDelivery	2 hrs	N/A	N/A	Y	Y	N	N
2.1	Acknowledgement of receipt	N/A	N/A	N/A	Y	Y	N	N

Submission of the Delivery acceptance