XML APPLICATION IN AEC INDUSTRY

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Abstract: The exchange and reuse of the information have become a much more critical issue for the success of the project management in the Architecture, Engineering and Construction (AEC) industry. The appearance of Extensible Markup Language (XML) provides a potentially well-adopted solution to alleviate the pain of data exchange. Based on XML, this research proposes an XML-based Distributed Construction Estimating System (XDCES) to reduce the redundancy and overload of cost estimating information exchange. Thus, information can be inputted once and reused where and when necessary. In this way, although, the focus of XDCES is on the estimating task, its conclusions are generally applicable to other forms of information exchange. In addition, this research surveys several existing XML applications in the AEC industry and proposes a framework for the ongoing aecXML, a framework for using the XML standard for electronic communications in the AEC industry.

Keywords: XML, aecXML, Estimating, Construction Automation, Project Management

1 INTRODUCTION

In the Architecture, Engineering, Construction (AEC) industry, a construction project starts from planning, design, estimating, bidding, construction, operation, to maintenance and rehabilitation. During the life cycle of a construction project, voluminous paper-based engineering drawings are usually created along its delivery processes for exchanging and sharing engineering information among related parties.

In other words, the AEC industry is information intensive. It needs accurate, reliable, and timely information regarding legal requirements, building codes and standards, cost codes, engineering drawings, manufacturer's specifications, site-specific data, past projects, etc. Therefore, the exchange and reuse of the information have become a much more critical issue for the success of a project.

Processing and storing them in electronic forms would be the first step. However, the lack of information sharing between software applications used by different parties would create the islands of automation in the AEC industry [1]. After all, what is information to one user could just as easily be data to another [2]. Hence, not only a shared information system but also a collaborative environment is needed to complete a construction project effectively and efficiently.

An idea solution, such as Extensible Markup Language (XML), is to present a standard information exchange format to different software applications or systems in such a way that it can be processed intelligently. Thus systems that have incompatible formats can still exchange information.

Based on XML, the objective of this research is to design and implement an information sharing mechanism between participants in the stage of estimating during a construction project's life cycle. In doing so, an XML-based Distributed Estimating System (XDCES) has developed to alleviate the effort of information exchanging.

The goals of XDCES is to provided an Internet-based Web application System, using XML to provide an interface for promoting the sharing of cost information during the construction project life cycle, thus information to be input once and reused where and when necessary

2. THE EVOLUTION OF WEB DOCUMENTS

2.1 Introducing XML

XML, which went public in November 1996, was designed under the auspices of the World Wide Web Consortium (W3C). The goal of designing XML is to enhance some jobs that HTML isn't built to handle but that really need doing. HTML is not bad for displaying text. But as Mr. Bray said; "For automated Web Processing – enriching documents in a way that enables computer programs to do something more with them – what's need is XML."[3]

Traditionally, a document was treated as a whole entity in which elements such as content, organization, and display are all merged into one unit. This idea still persists in most of today's WYSIWYG (what you see is what you get) word processors (such as Microsoft Word).

HTML documents separate the information from the format (stylesheet) and the document structure. However, HTML is still not enough for exchanging information in a right way which has been discussed in the above section.

XML provides a new model for storing information entails a distinction between content, organization, and display[2]. By separating base elements of a document, more efficient and advanced manipulations on information can be performed. Breaking systems into simpler pieces, understanding and enhancing each of them, and then combining all of them for a better performance is almost what engineering is about. XML follows the same philosophy by extending it to the world of information exchange. Fig 1 illustrates these three models and Table 1 shows ways of handling XML document elements.
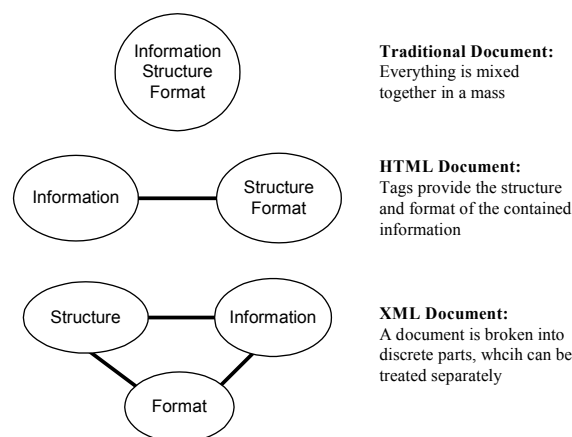

Figure 1. Traditional, HTML, XML document models

Table 1. Handleing XML document elements

Elements	Description
Format	XSL, XML Stylesheet Language HTML. DHTML with CSS language CGI with custom script
Structure	DTD, Document Type Definition XML Schema
Information	The data encompassed by the XML tags. Such as: <Movie>October Sky</Movie>

2.2 aecXML

Obtaining benefits from XML depends the acceptance it will gain. To achieve the big picture that many XML experts have drawn to us, providers of similar information must all agree on a common XML schema.

While many other industries are developing their domain specific XML schemas. In AEC industry, an aecXML Organization had announced a preliminary specification, aecXML Framework v0.87[4]. The aecXML framework is designed for project and business-to-business communication for architecture, engineering, construction, and facility management (AEC+FM) transactions.[5]

In aecXML organization, there are currently seven working groups under the aecXML domain committee. Each working group is led by the representative from different major AEC software venders and Application Service Providers(ASPs). Table 2 lists the names of each working group and its chairman.

Table 2. Current aecXML working groups

Working Group	Chairman	Company
Catalogs	Ari Gordon-Schlosberg	HeavyWare
Design/Specification/Schedule/Cost	Tom Chmielenski	Bentley Systems
Facility Management Operations & Maintenance	Dr. Mehdi Khalvati	VISCOMM
Procurement	John Twigg	Twigg Consulting
Project Management	Larry Chen	Bidcom Inc.
Project News	Gregory Nowak	CIG/McGraw-Hill
Plant	Pat Cichanski	InStep Software

On the 2nd aecXML working meeting held on January13, 2000, aecXML announced to be adopted by IAI (International Alliance for Interoperability) which has been working on another AEC standard, IFC (industry Foundation Classes). These two standards, IFC and aecXML, will inevitably have some overlaps. But in fact, they are mutually related. The aecXML is designed for all the non-graphic data involved in the construction industries. On the other hand, the IFC was originally designed to model the 3D CAD information.

As Mr. Bhupinder Singh, a developer at Bentley System Inc., explained: "aecXML is for talking about things, not modeling them. We can use it to agree what 'door' means, but aecXML won't describe doors or model them."

During the writing of this research, the latest version of aecXML, v0.87, was published in September 1999 and version 1.0 is expected to be released in the 4th aecXML working meeting in early October 2000.

3. INDUSTRY CASES STUDY

3.1 Heterogeneous Database Synchronization

Very often, a single data source doesn't store all required information. Thus, the ability to gather data from multiple and/or incompatible data sources becomes more and more critical. The extensibility and flexibility of XML allow it to describe data contained in a wide variety of heterogeneous data source, from Web pages to data records.

The US General Services Administration (GSA), one of the largest building owners in the world, in cooperation with Bidcom, Inc., an Internet based construction management ASP, demonstrated a proof of concept project, eGate-AEC, that allows data exchange between remote systems using aecXML over the Internet. GSA can query and retrieve updates of projects hosted by Bidcom and make them available through its internal reporting system.

This proof of concept project is to demonstrate the feasibility of exchanging information from remote systems using aecXML. Through eGate-AEC, GSA can get the most updated project information from Bidcom via Email, which contains the valid aecXML instance in the Email body. And then GSA saves the received XML instance into its internal database systems for further processing. Key features of eGate-AEC project including:[6]

♦ Implements aecXML v0.87
♦ Server-to-Server based communication
♦ Allows existing systems to communicate w/o modification
♦ Used for remote data queries and for database synchronization
♦ Replicates only portions of databases

3.2 Data Exchange

While different systems are designed for different unique purposes, they still want to share some common information. XML makes it possible to create new architectures that provide enormous newly shared capabilities to a variety of applications. A good example of that is the XML Seamless Logons Project, which is upon and running between Bidcom Inc. and PurchasePro Inc., one of the major business-to-business (B2B) service companies in US.

Seamless Logons project was designed to allow PurchasePro's clients, such as Bidcom Inc., to store their user information on their internal web site and exchange the user information to the PurchasePro system without the user having to re-enter in another set of login name and password. The data exchanged between them is formatted in XML. The following items can occur when PurchasePro receives the XML data from the Clients Hosts[7].

♦ A new User will be added to the PurchasePro.com system
♦ A current User will be logged into the PurchasePro.com system
♦ A current User's profile will be updated on the PurchasePro.com system

3.3 XML-based Project Management System

One of the on-line construction management services provided by Bidcom Inc. is called Project Management Service, which includes a full set of workflow processes that streamline the management of the information flow across the construction project life cycle.

The key technology of separating workflow process and the business data is applying different XSL style sheets on the same XML document. That enable the underneath workflow engine to attach appropriate "read-only" or "read/write" rules to each workflow document, ensuring data integrity and security. An example of the workflow diagram for requests for information (RFIs) is shown in Figure 2[8].
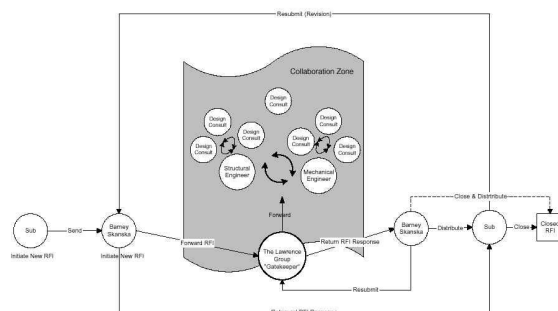

Figure 2. Business Process Management for RFIs[7]

4. XDCES

4.1 Computer Applications in Construction Estimating

Computers and the network are very helpful in preparing the cost estimates used by construction managers, general contractors, and subcontractors. The area at which they best apply include six stages; (1) Project location and tracking, (2) Collection of cost and productivity data, (3) Quantity take-off, (4) Establishment of work methods and productivity rates, (5) Estimation of direct and indirect costs, (6) Compilation, analysis, and bidding[9].

4.2 Architecture of XDCES

The construction information flow during the project life cycle can be divided into the vertical information flow and the horizontal information flow. The information input into and generated from the estimating phase stands on the vertical information flow. Meanwhile, the information interchanged among parties that involved in the estimating stage stands on the horizontal information flow. Thus, a potentially well-adopted common data format, such as XML, can be an ideal lubricant to smooth both processes.

In this research, based on the XML, a conceptual XML-based Distributed Construction Estimating System (XDCES) is created and introduced. In XDCES, four kinds of different parties, including the construction cost related information provider, the AEC DTDs provider, the client, and the contractor are involved.

In XDCES, any server can work for a client or collaborate with other servers. The XML document is used to deliver and interchange the data between servers. Thus a server can immediately understand the structure of the data that it is receiving and can deal with it accordingly.

For the information flow between the server and client, once the server either stores the results from other servers or generate the query result from the database in XML format, then, by associating the document with the appropriate stylesheet (CSS, XSL, or HTML), the server sends back the formatted information (Web page) to the client. Figure 3 shows the architecture of XDCES and illustrates the information flow between parties of it. Several screen shots for a case study of XDCES are shown Figure 5 in the end of this paper.
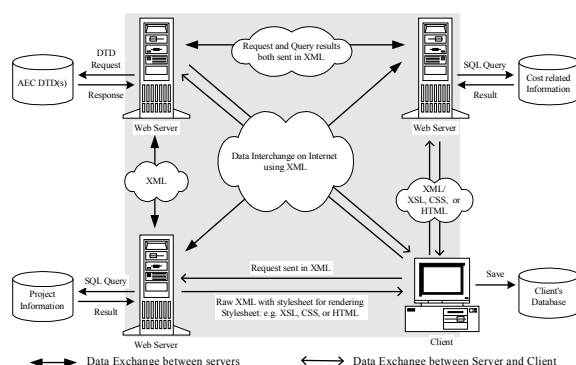

Figure 3. The conceptual XDCES architecture [10]

5. CONCLUSION

The appearance of XML provides a potential universally accepted data format for exchanging information. The AEC industry, particularly, can benefit from it. Not only are current data exchange and reuse practices inefficient, but also a huge amount of redundant resources and works are dealing with these problems.

In this research, the XDCES has been proposed to promote the efficiency and accuracy of sharing cost estimating information and keeping the information consistent. Although, the focus of XDCES is on the estimating task, the conclusion of it is generally applicable to other forms of information exchange in AEC industry. The benefits and characteristics of XDCES are summarized below:

♦ Real time and reusable cost information
♦ Flexible web application
♦ Client-side data manipulation

6. RECOMMENDATION

In XDCES, the importance of sharing information under a standard DTD has been proven. Therefore, a set of XML schemas that specify the terminology, grammar and layout of business messages that contain AEC-specific content is highly demanded. Auspiciously, an effort of creating aecXML framework is keeping going forward.

Since it is impossible to define a complete data model containing all information used in AEC industry. The scope of aecXML should compromise to contain enough elements and attributes for exchanging information between different participants during the construction life cycle. Second, in stead of putting all the elements and attributes in the same XML schema file, such as the current version of aecXML v0.87, aecXML needs an overall framework which defines the data to be exchanged between AEC participants, the processes ruling the exchange of that data, and the implementation guideline.

A proposed architecture of the aecXML Framework is described as following which features several components, including aecXML Foundation Schemas, AEC Interface Process Schemas, and the aecXML Implementation Framework.

6.1 aecXML Foundation Schemas

The aecXML Foundation Schemas are sets of schemas built on the aecXML Common Objects. Common Objects may be resources such as projects, documents, materials, parts, organizations, professionals, or activities such as proposals, design, estimating, scheduling and construction. Each of the aecXML Foundation Schemas is intended to be used as an XML namespace and to facilitate information exchange of AEC data on the Internet.

The aecXML Foundation Schemas are expected to be as completed as possible in the coming aecXML v1.0 release. Thus, in the first round of implementations based on aecXML, AEC software vendors and Application Services Providers could just ensure that software by the aecXML companies can receive aecXML-schema based XML data files and knows how to interpret them.

6.2 AEC Interface Process Schemas (AEC IPS)

Fundamental to AEC IPS is the exchange of business data between AEC participants during the project life cycle. AEC IPS are also a sets of schemas which include the query, the business transaction, and the communication messages. Those of above require (1) define 'as-is' use cases and (2) define 'business processes'. In addition, AEC IPS should comprise both human-readable and machine-readable using the sets of elements and attributes defined in the aecXML foundation schemas.

6.3 aecXML Implementation Framework

The aecXML implementation framework is a guideline to enable AEC participants and solution providers to create networked applications that can execute these electronic business processes by communicating according to strictly defined protocols, which can be those had been well-defined in RosettaNet[11], or Simple Object Access Protocol (SOAP)[12][13], or anything has been well-adopted.
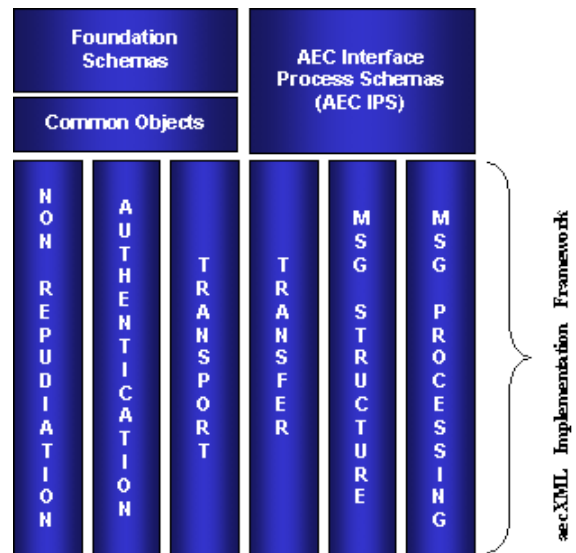

Figure 4. Proposed aecXML Framework.

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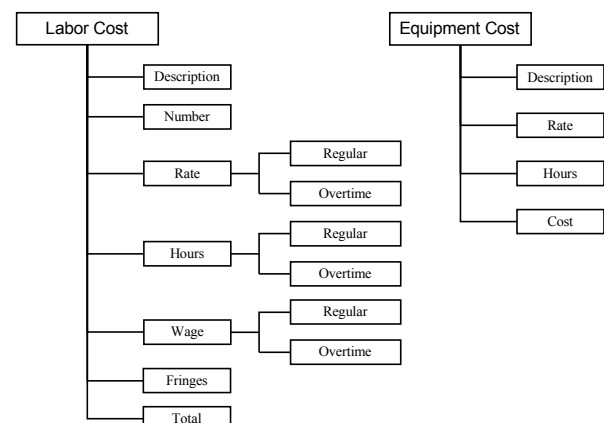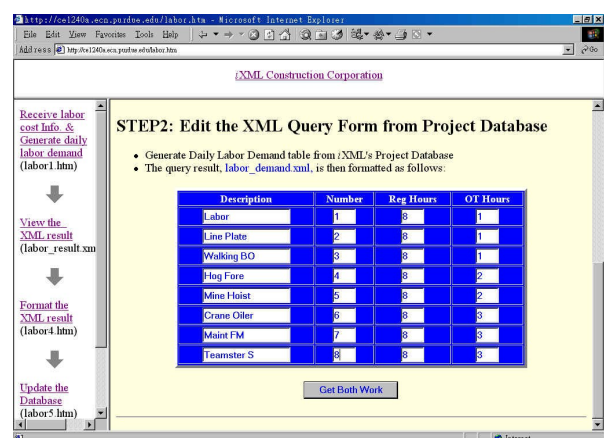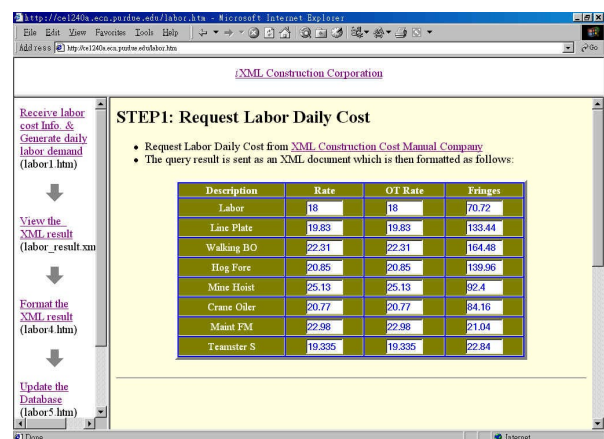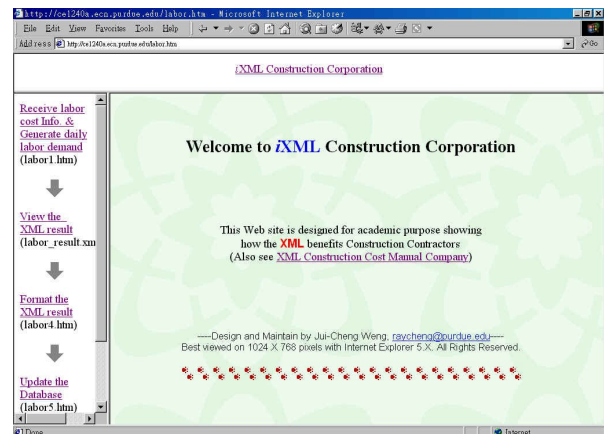[8] "Bidcom Training: Business Processes", Bidcom Inc. April 2000.

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iXML Construction Corporation

Welcome to *iXML* Construction Corporation

This Web site is designed for academic purpose showing how the **XML** benefits Construction Contractors (Also see XML Construction Cost Manual Company)

----Design and Maintain by Jui-Cheng Weng, raycheng@purdue.edu----
Best viewed on 1024 X 768 pixels with Internet Explorer 5.X. All Rights Reserved.

Receive labor cost Info. & Generate daily labor demand (labor1.htm)

View the XML result (labor_result.xml)

Format the XML result (labor4.htm)

Update the Database (labor5.htm)

STEP1: Request Labor Daily Cost

- Request Labor Daily Cost from XML Construction Cost Manual Company
- The query result is sent as an XML document which is then formatted as follows:

Description	Rate	OT Rate	Fringes
Labor	18	18	70.72
Line Plate	19.83	19.83	133.44
Walking BO	22.31	22.31	164.48
Hog Fore	20.85	20.85	139.96
Mine Hoist	25.13	25.13	92.4
Crane Oiler	20.77	20.77	84.16
Maint FM	22.98	22.98	21.04
Teamster S	19.335	19.335	22.84

STEP2: Edit the XML Query Form from Project Database

- Generate Daily Labor Demand table from *i*XML's Project Database
- The query result, labor_demand.xml, is then formatted as follows:

Description	Number	Reg Hours	OT Hours
Labor	1	8	1
Line Plate	2	8	1
Walking BO	3	8	1
Hog Fore	4	8	2
Mine Hoist	5	8	2
Crane Oiler	6	8	3
Maint FM	7	8	3
Teamster S	8	8	3

Get Both Work

Labor Cost
- Description
- Number
- Rate
  - Regular
  - Overtime
- Hours
  - Regular
  - Overtime
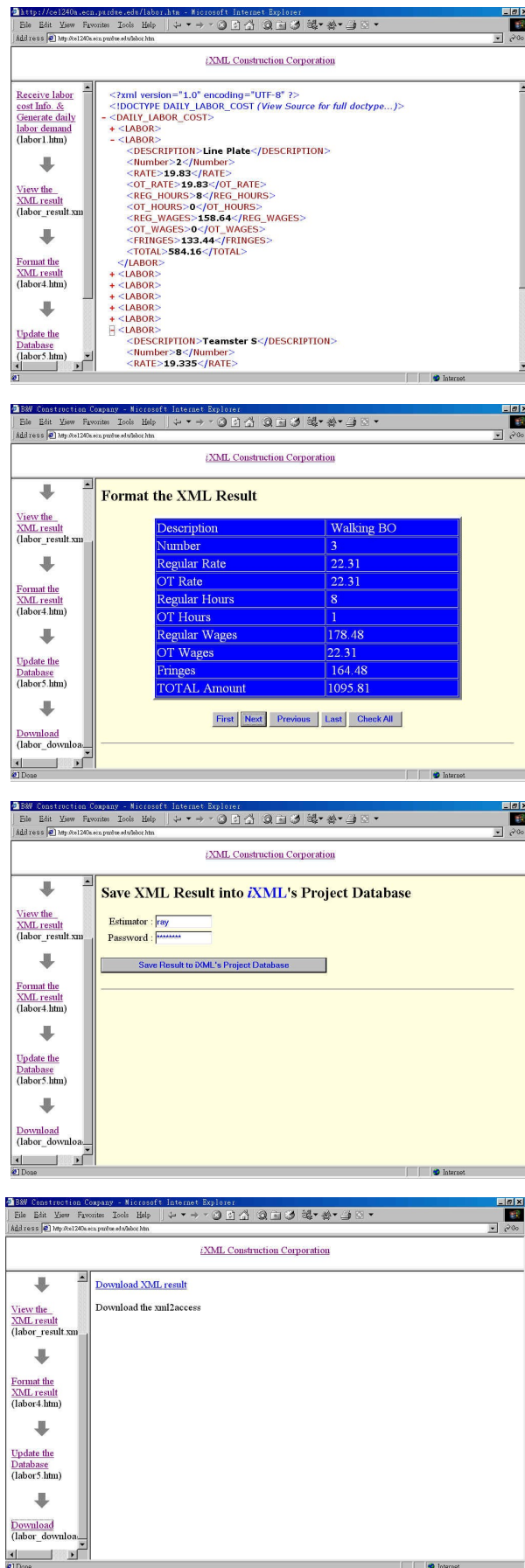- Wage
  - Regular
  - Overtime
- Fringes
- Total

Equipment Cost
- Description
- Rate
- Hours
- Cost

Figure 5. A Case Study for XDCES