WEB-BASED CONSTRUCTION PROJECT DOCUMENT INFORMATION CENTER TO SUPPORT PERFORMANCE IMPACT ANALYSES

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Abstract: Contemporaneous documents are favored in claims litigation or arbitration over any *after the-fact* proofs like expert witnesses. Each contracting group in a project enterprise creates, manages, and stores its documents, using proprietary methods and systems. This has proven to be an expensive exercise when effecting court-ordered document exchanges during *discovery periods*. To solve this problem, a solution is developed in this research, entitled Web-Based Construction Project Document Information Center (CPD***ICenter***), which allows all project groups the opportunity to share a common document information architecture, and central document storage. CPD***ICenter*** is web-based to eliminate both the high communication costs and users' steep learning curves.

Keywords: Computer Integrated Construction, Document Management, Impact Claims, Project Information Modeling, Information Systems, Web Databases, Document Workflow.

1. INTRODUCTION

Construction impact claims are usually initiated to compensate for any performance deterioration suffered by the contractor or his subs. Such claims are a normal state of affair, the tedious part, however, is proving cause and responsibility for those impacts, and to estimate their consequential costs. This process relies heavily on the availability of contemporaneous documents from the construction stages/phases in question.

This paper focuses on the problem most claims analysts face [6], which is finding, collecting, and summarizing relevant construction documents necessary to analyze and support disputes. The bulk of any project's information resides mainly with documents of all types, such as work plans; schedules; cost breakdowns; reports; laboratory tests; specifications; contract agreements; minutes of meetings; daily site progress; non-conformance reports; rollover schedules; and resource utilization logs. Indeed, we find a sizable volume of any project's information in documents. Hence, any information about those documents, their contents and the events accompanying their issuance, does facilitate their retrieval. Claims experts undertaking the complex task of analyzing delays and cost impacts, must include, within the scope of their preparation, documentation prepared by as many trades, contractors, and/or sub contractors, as possible. Even if those trades do not appear to be involved in the dispute [3]. This means that in disputes, the attorneys and claims analysts will not and should not be content with documentation supplied only by their client. Instead, they have to seek other documentation and evaluate the consistency or the lack of it between the documents, as it may well provide both valuable evidence, as well as guidance for the attorney's overall view of the dispute. The solution proposed hereinafter is based on a new paradigm [5] developed in this research and makes it essential for all project groups to be part of the same document exchange framework, and to enlist or register all their documents-even internal and proprietary ones-within a central web based repository. This new information architecture entitled the *Construction Project Document Information Center* (CPD***ICenter***). This framework operates as a document-clearing house for all project groups. The CPD***ICenter*** web site offers a search facility as an integral part of other services such as document storage, retrieval, and general project information.

The project repository is to be owned and shared by all project groups. An independent information manager can be employed to run the information flow for that matter [4]. The collective documentation accumulated towards the closing out stages of a project provides valuable insight for future analysis and claims resolutions.

2. Problems With Current Systems

Typical problems involved in authoring, processing, and delivering information within large construction organizations [6] include:

1. Incompatible, or proprietary file formats
2. Expensive, non-intuitive or even non-existent viewing tools in need for frequent upgrading.
3. Documents distribution not compatible with contract requirements
4. Status is not up-to-date on many issues.
5. Difficult access to critical documents.
6. Redundancy and duplication of information further complicating document version control.

Solutions to those problems become within reach by developing document management and interchange standards. For that matter, Web technology promises [1] to help unblock the information flow, redesign business processes, and improve productivity for all users.

3. CPDICenter Architecture

Problem is broken down into two cores: communications, and document information modeling. Currently, there is no system that captures documents from all groups and renders them to post-construction impacts' analyses [6]. The CPD***ICenter***'s generic Web-Based communications framework binds all groups, as shown here in Figure 1. This framework is adaptable to any project organization or delivery method, and works for a single-site project as well as geographically dispersed projects. The CPD***ICenter*** can be paid for and managed collectively by all groups, or alternatively an independent Information Manager can be employed [4] to control information flow and manage project deliverables according to schedule.

3.1. Adapting CPDICenter to Project Organization

In Figure 1, the CPDICenter is adapted to a traditional project delivery system of three main groups: General Contractor (GC), owner, and Consultant. In other systems, for example design build, the consultant's CPD***ICenter*** server will be merged with the Contractors' resulting in two web servers, instead of three, to manage document flows and storage. Servers are synchronized with each other's to ensure a uniform view of the CPD***ICenter*** services through a main website. The same generic CPD***ICenter***'s framework caters for a delivery system such as construction management agency. In the later case, the project management group will hookup to the main CPD***ICenter*** server, where the owner and the GC are linked. If the owner is managing the project with independent contracts with subs, suppliers, and engineering services, then three web servers will makeup the CPD***ICenter***, one for each of the engineering, contracting and suppliers groups-normally the owner is expected to join all of them.

3.2. CPDICenter Components

Each of the CPD***ICenter*** servers, shown here in Figure 2, has four major components: 1) Document Information database, 2) Mail Server, 3) Web Folders, and a 4) Workflow Engine. The web server communicates client side requests for documents and search queries to the database and web folders. The mail server distributes documents, and receipts of document deliveries. The workflow engine is entrusted with fulfilling document related procedures and processes, such as proper distribution, follow-

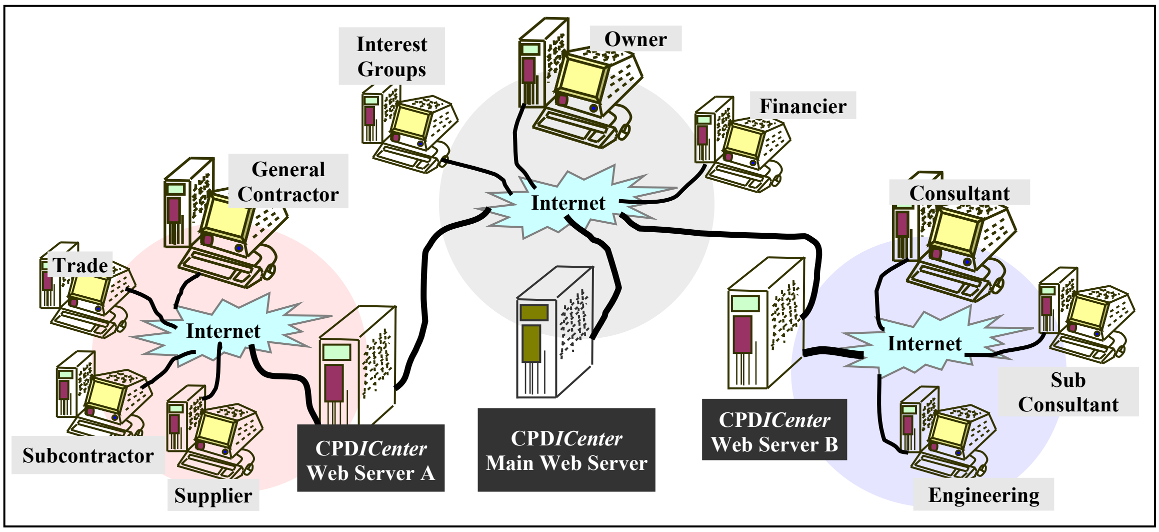

Figure 1. CPD***ICenter***'s Generic Communications Architecture

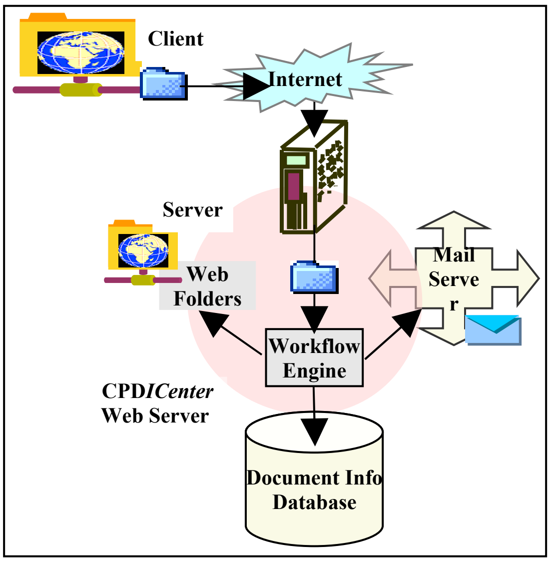

Figure 2. Server Components in a CPD***ICenter***

ups, initiation of routine reports (e.g. daily progress reports), and ensuring replies are complete with supporting plans and documents within the allowable periods stipulated in contracts or meetings. Each group will have its own web folder, with a master copy residing in the CPD***ICenter***. All web folders have the same directory structure, as it will be explained hereto after in this paper

4. Document Classification

To promote consistency amongst all participants, documents' folder trees are structured based on a uniform view of project information subjects. There are three main classes: A) Transactions, B) Proprietary, and C) Public. This classification carries with it connotations of access and viewing rights. Even when a document is registered and mapped by the CPD***ICenter***'s database, access to *proprietary* documents will be restricted to the group that created it. On the other hand, all groups in the project share documents from the *Public* class. *Transactions*' limited sharing policy permits access by groups issuing or receiving those documents. A sample of these documents class types are shown in Table 1. Document registration and collection starts from the day tender documents and invitation to bids are released to bidders; therefore, all bidding documents and addenda are included with documents from other construction periods. Retrieval and access is to be managed on three levels [5]: 1) document components/content level, 2) Document class type level and 3) the CPD***ICenter*** level. These access rules are construed from contract and condition clauses pertaining to documentation and document exchange procedures, also with much information about the roles each group member assumes.

Table 1. Sample Document Classes

Proprietary	Public	Transactions
❑ Expense Report ❑ Productivity Analysis ❑ Patented Method ❑ Rollover Schedule	❑ Contract Forms ❑ Standards, Codes ❑ Bid Invitation ❑ Site Instruction	❑ Change Orders ❑ Request for Information ❑ Payment Request ❑ Work Drawing

5. Document Storage Requirements

After documents are created, services are required to eliminate the burden on project groups and their members and workers to determine where they should be stored. To facilitate that, there should be automated routines that determine the specific location to store the document in [7]. This is analogous to determining the file and/or file cabinet that physically will store a document. The CPD***ICenter*** stores a document based on specific information about the group creating it, its content, and the business process or issue it supports. Also it is essential for the groups to know the cryptic *server\volume* or *directory\filename* naming structure in order to retrieve documents. As a substitute, documents' retrieval is based on meaningful parameters, and keywords that describe the contents of a document and its association to other events or documents in the project.

5.1. CPDICenter Document Web Folders

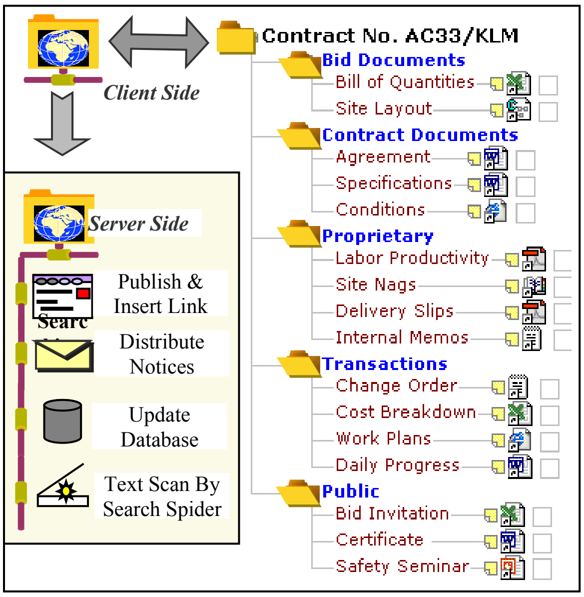

Figure 3. Storage Architecture using Synchronized Web Folders on both the Client and Server Sides

Documents' sprawl to various project locations without discernable directory structure complicates maintenance functions for backing up and archiving files. A storage architecture is required that ensures access, by any group, to documents throughout the project organization. The architecture will define where and how to store documents. Quintessentially, this architecture would define which cabinet (i.e. file/server) a document belongs to. Storage management routines should enforce storage of documents to centralized storage locations. This will simplify maintenance functions for backing up files. Web folders with preset folder tree structures, mapped according to the document classification discussed earlier, are distributed to all project groups. Each group oversees two web folders, one in-house (client side) and a master folder kept at the CPD***ICenter***'s server (server side), as shown in Figure 3. When a new document is created, it is inserted in the proper directory at the client side with the workflow instructions pertaining to the claim issue at hand. For example, a document workflow log would include steps for distribution, delivery receipts, annotations, reviews, holding period, reply period…etc. The main functions associated with the web folders are illustrated in Figure 3. They include, document distribution, workflow, database updating, and automated text scanning for website keyword search engine. Both client and server side folders are constantly synchronized. Documents' information goes to the database, and a link is inserted in the CPD***ICenter***s web pages or directories, pointing any queries or keyword searches to the location of the document and its web folder. This minimizes storage space, and maintains a single central location for every document.

5.2. Content Management

XML (extended Markup Language) recently is making a strong presence in the area of *Content Management* for web-based publishing. Documents can be constructed from distributed information sources. The CPD***ICenter*** builds on the usefulness of this technology, which allows a wide range of customization of documents' contents using real-time production data coming from various sites. Moreover, it proves helpful when a weekly or monthly progress report needs to be written, by then the engineer will not find it hard to locate the proper information sources, because a simple routine (program code usually Java ®Script) links the XML tagged fields-within a document as seen here in Figure 4-with data from sources like production databases, reports, site messages, incident reports, labor utilization charts, equipment logs…etc.

5.3. XML to Structure Data in Documents

XML is used to structure data in a hierarchical fashion. HTML (Hyper Text Markup Language) is used to present the data to the user. XML is a system and database independent language that could be interpreted by any software language or system [2]. An XML and HTML sample listing is developed here in Figure 4. For example, a Document Object Model (DOM) based on Java®Script or Java® can accommodate the data structure, so that if the group member entry that is cited in the Listing of Figure 4 was the seventh member record from the second project group on a page, one could reference the value of the last name this way:

Doc.employee (7).group(2).name(0).last(0).value.

A key feature of XML is that it conveys the structure and the meaning of the data from which it came [8]. In XML representation, there is no description of how to display the content [9]. While this might at first appear to be undesirable, the separation of semantics from visual representation makes possible several benefits to construction documents, as listed below.

```
<HTML>
 <Head>
  <Title>Members</Title>
  </Head>
 <Body bgcolor="#BBCCAA">
 <Div align="left">
  <Table cellpadding=2>
  <Font="+1"><TR><Th><pre>…

<Project>
 <Title>New Plant</Title>
  </th>
<Tr><td>
  <Group>
   <Member>

  <Name>
   <FIRST>Eshbili</FIRST>
    <MIDDLE>M</MIDDLE>
     <LAST>Cobari</LAST>
  </NAME>

  <I><Site>Green Oak
  <EMAIL>COBARI@project.cpdicenter.com
  </Email>
   <PHONE>123-456-7890</PHONE>
    <FAX>123-456-7890</FAX>
     <Sector>N33</sector>
      <Site:ID >999</Site:ID>
  </Site></I>

  <Role><OL>
   <LI><ORG>Contractor A</ORG>
   <LI><Function>PM</Function>
   <LI><MAILSTOP>4711
   <LI><Street>Adventure</street>
   <LI><City>Montreal</City>
   <LI><Code: Post>H4H-2H9</Code>
  </OL></Role>

     </Member>
   </Group>
  </Project>

   </td><pre></font>
  </Table></div>
  </Body>
</Html>
```

<XML>
<HTML>

Figure 4. Joining Data structure (XML) & Representation (HTML) in a Document

1. Ideal for passing data from server to browser, also from application to application.
2. XML is database-neutral, which can connect heterogeneous databases while updating, and querying records.
3. A construction XML vocabulary of tags will provide a standard way for construction project groups to describe and exchange data among databases, schedules, progress reports…etc.
4. With added data context, search engines could retrieve a specific portion of a file much faster eliminating numerous irrelevant matches.
5. Project members can manipulate data views on the client-side and select several records by different attributes, without requesting data from the server each time.
6. Different data views are specifiable based on users' roles and data access rights in a project.

6. CPDICenter Search & Retrieval

Project groups will be able to search and retrieve documents from their project using the CPD***ICenter***'s search pages, illustrated here in Figure 5. The website supports four search methods:

1. *Parametric Search*: queries the database for records of documents that are associated with project members, events, sites, claim issues, incidents, impact causes, cost items, Work Breakdown Structures (WBS), other referenced documents like contracts and specification, clauses, and other sources of effect on a claim.

2. *Keyword or Meta Search*: the website search engine scans with a spider (program) all text and contents and develops rosters for fast retrieval based on a keyword or Boolean search.

3. *Subject Directories*: documents by virtue of their inclusion in a certain directory in a group's web folder, inherit-both implicitly and explicitly-a contextual classification. This classification defines the document type; group issuing the document, purpose of issuance, its recipients, events in the project calendar, status of disputes, sites, and project components.

4. *Web Folders*: documents are searched in a logical and hierarchical fashion. Users dig deep into the tree structure of a specific web folder -see Figure 3. Users in this case target a certain group's Web folder. This search redeems a wider spectrum of documents and users will see only documents they have access to.

6.1. Document Information Database design

A relational logical data model is developed for the web database [5], and cross-references documents with entities and/or events from the project. Information entities include: Contract clauses, member roles, project components, specifications, and business rules pertaining to claims [5]. Some issues necessitate documents to be collated in subject matter folders. For example, a change order usually is accompanied by schedules, plans explaining implementation, detailed quantity estimates, and probably amendments to contract compensation clauses. Such associations are charted as well into the document information database model.

7. Advantages of the CPDICenter

1. Lean and flexible architecture scalable to any number of project groups and organizations by adding or removing extensions to CPD***ICenter***.

2. Enterprise-wide binder that gives all parties a common communications framework, and reliable storage of all documents including communications, and production-critical folders.

3. Requests for clarification and information by any group can be posted to the concerned group's website immediately without delay, and replies are tracked through the CPD***ICenter***s databases and workflow engine.

4. Creates a new baseline for project document control, storage, and exchange.

5. Works for large-scale projects with distributed operations.

Figure 5. CPD***ICenter*** Website Screen Showing Part of the Search and Directory Services.

6. Project groups access up-to-the-minute versions of any document, and multiple users can browse and annotate the same document simultaneously.

7. Central document information database houses contextual information about every event in the project calendar, and relates documents to facts from those events.

8. Summary & Conclusions

The construction industry is plagued with impact disputes. In construction, *contemporaneous* documents, *from all project groups*, are the key to proving causes of impacts, any ensuing delay costs, and successful disputes resolutions and settlements. A new paradigm is developed in this research-the Web-Based Construction Project Document Information Center (CPD***ICenter***)-to allow all project groups the opportunity to share a common document management architecture, and a central document storage. It also eliminates difficulties in accessing critical documents published by any group. This CPD***ICenter*** operates as a document-clearing house for all project groups; it retains documents from any group in a Web database, and furnishes them to users with a web browser and an Internet connection. This creates a new baseline for project-wide document management. A Central document database houses information about every event in the project and relates documents to facts from those events.

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