AN XML BASED STANDARD TO ENABLE BULK PROJECT DATA TRANSFER BETWEEN HETEROGENEOUS SYSTEMS

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SUMMARY*: The objective of the work reported in this paper was the development of an XML based standard which would enable project data, such as contacts, drawings, documentation, instructions and emails, to be transferred between collaborative systems provided by different software vendors and used by construction organisations. The primary aim being to create a transfer mechanism which would allow project data transfer without modification of existing collaborative system deployed by vendors. This paper discusses the business and technological needs for such a transfer capability between collaborative systems, by examining the current use of these tools and related problems encountered by clients. It sets out the main components that underlie the majority of construction specific collaborative systems which forms the basis of the generic collaborative system model which has been developed, contrasting this with previous data exchange efforts. This paper shows how the XML Schema was developed and the procedures undertaken to ensure that it could be utilised by the maximum possible set of vendors. It sets out the best practice procedure for implementations by vendor organisations and the required testing to confirm a successful transfer. The paper also highlights some of the practical problems that were encountered when transferring projects between heterogeneous systems during the project and in subsequent deployments of the solution. Finally, the paper concludes with methods of taking the work forward as a foundation to allow for greater interoperability between systems in the future.*

KEYWORDS*: Data Exchange, XML Schema, Construction, Project Collaboration, Enterprise Content Management, Collaborative Software, NCCTP*

1. INTRODUCTION

Project collaboration has an important role to play in an industry that relies on multi-company teams. In the construction sector these teams are regularly formed, restructured and reformed on a project by project basis resulting in a need to flexibly integrate different personnel and operating systems. Add to this the need to extract project data into each company's own systems or a commercial decision to migrate information between collaboration systems and the need for a project data transfer capability becomes clear. This was recognised by the users and system vendors as a basic requirement and one which required technical collaboration between competitors if the wider market was to be able to address this requirement. Therefore, in 2003 the Network of Construction Collaboration Technology Providers (NCCTP), an organisation of vendors, Table 1, was founded. The NCCTP members provide collaborative solutions to construction organisations primarily in the UK, although member's solutions are used on projects throughout the world (NCCTP, 2004). Collaborative systems provided by participating organisations range from project extranets that can be utilised on a single project basis,

through to enterprise wide systems. Several collaboration software vendors provide both project and enterprise solutions. Initially comprised of seven vendors, the NCCTP's first project was to develop a vendor neutral XML based specification that would enable the transfer of project data form one system to another, the outcomes of which are reported here. Since its initial inception three additional vendor organisations have joined and are participating on the continuing efforts towards greater standardisation within the industry, (Aconex, 2005, BCL, 2004, NCCTP, 2005).

Table 1: NCCTP Current Member Organisations

Vendor	**Vendor's link to NCCTP**
4Projects	http://www.4projects.com/
Aconex	http://www.aconex.com/Corporate/News/Latest-News/Aconex-Joins-The-NCCTP.html
Asite	http://www.asite.com/partners.shtml
BIW	http://www.biwtech.com/cp_root/h/Media_Centre/BIW_helps_found_NCCTP/272/
Business Collaborator	http://www.groupbc.com/
CadWeb	http://www.cadweb.co.uk/aboutus/?partners
Causeway Technologies	http://www.causeway.com/corpoverview/affiliations.htm
Sarcophagus	http://www.sarcophagus.co.uk/

The bulk project data exchange specification described in this paper was designed to seek a solution to the operational need to be able to extract data from a collaboration system and transfer this to either an alternative collaboration system or into an archive. This was addressed from the perspective of an existing range of deployed solution used on construction projects. By fitting the proposal to these systems, rather than trying to define an ideal model of a collaborative system, it would be easier for vendors to implement the resulting standard with their current products. This approach has benefited from the maturing of collaboration technology as earlier interoperability efforts were arrived at from a more theoretical view point or based on a single application. One example of this was the Project Information Exchange (PIX) standard developed in 1998 under the Construction Industry Trading Electronically (CITE) initiative (Cole, 2000). This provided a detailed data standard for the electronic exchange of documents, drawings, instructions and certificates between project participants. This was intended to provide a data language which project partners and technology providers could adopt. However, over the next few years technology progress allowed this approach to be updated centred on the emerging collaboration platforms.

This paper presents the work done in creating the NCCTP bulk data exchange standard and its implementation by collaborative system vendors. It sets the context of this work by initially describing the current collaborative systems used by the construction sector, and then examining the industrial need for bulk project data exchange. It then examines the previous work done in defining a generic model of a collaborative system and how this relates to the model constructed by the NCCTP, for data transfer. The paper then shows the stages involved in transferring project data from one collaborative system to another, which were discovered through inter-organisational testing, followed by the potential barriers which exist to achieving effective transfer. Finally the paper suggests possible future work which could build on the research presented in this paper.

2. CURRENT COLLABORATIVE SYSTEMS

Collaborative systems in general refer to a set of web based technologies which enable employees from a number of different organisations to share information effectively while working on a construction project or a series of projects. *FIG. 1* from (Wilkinson, 2005) shows how collaborative systems have changed the way project participants communicate information during the project, from the traditional direct exchange, to a repository model. These technologies are primarily: document management; version control; workflows; drawing management; viewing; mark-up of drawings; searching and permission based access to content. Collaborative systems are known for their high availability and 24/7 access to information, allowing construction organisations to work effectively on projects located throughout the world. Since their inception as hosted project extranets they have expanded into a number of different forms, each of which is best suited for a particular situation, including enterprise and hosted enterprise varieties which are discussed below.

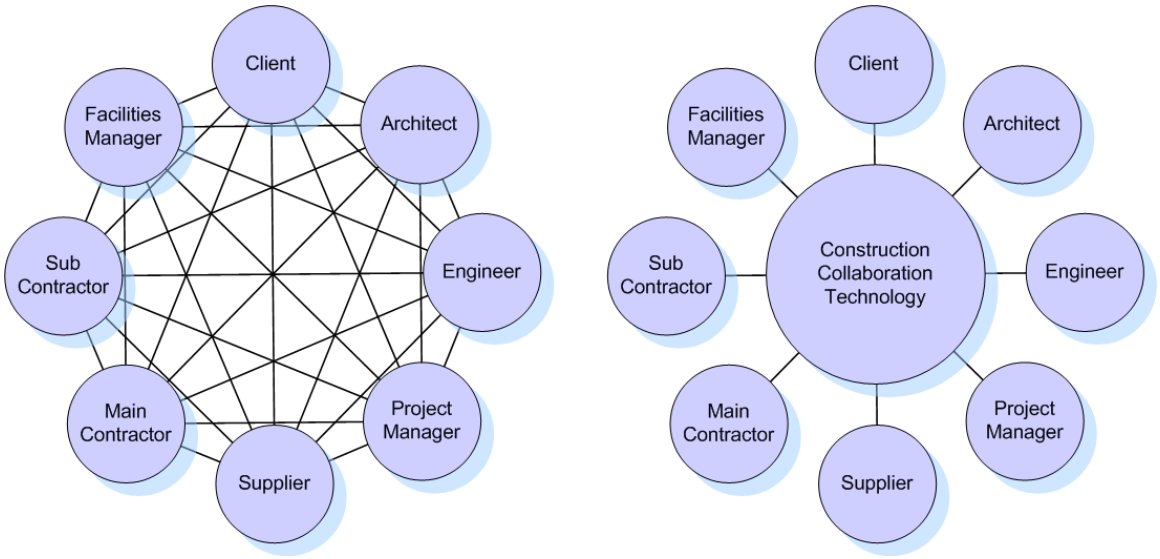

FIG. 1: Traditional Project Communication (left), and Project Communication using Collaborative System (right) (Wilkinson, 2005)

2.1 Hosted Extranet Solutions

Hosted extranet solutions provide a collaborative environment where project data is held in a remote secure location by the actual software vendor, with all infrastructure and applications managed by the vendor. *FIG. 2* illustrates this model of multiple self contained projects being accessed by multiple clients over the internet. Normally deployed on a per project basis some bulk agreements do exist, especially with clients who do a large number of construction projects (4Projects & Tesco Express, 2003). Its independence of any of the parties which are collaborating on the project is a major advantage of this type of collaborative solution. However by their nature extranet solutions are usually shared amongst a large number of different companies working on different projects, which can affect system performance at peak utilisation times where Internet bandwidth is limited.

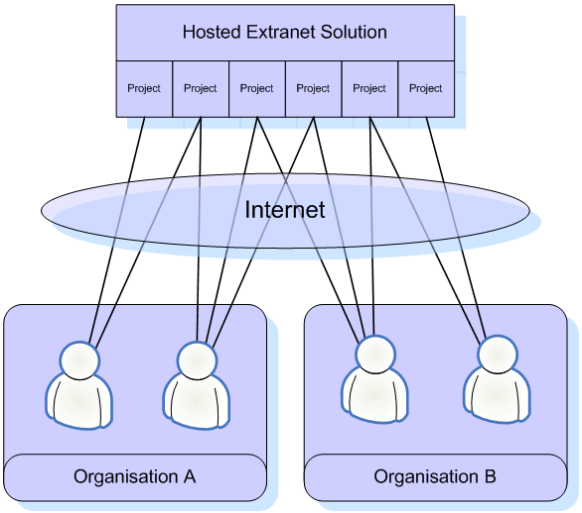

FIG. 2: Hosted Extranet Solution

2.2 Enterprise Solutions

Enterprise Solutions are collaborative environments installed and operated by companies themselves. The software is provided by a software vendor but is managed by the company's own staff. Examples include Buzzsaw Enterprise Server (AutoDesk, 2004), Causeway Enterprise Content Management (Causeway, 2007) and Enterprise Collaboration from Business Collaborator (BCL, 2007). These systems allow for multiple projects to be managed collaboratively and are more readily integrated into the company's other existing systems. Similarly, as the system belongs to the client it can be customised to their specification, which is not

always possible when using a shared extranet solution. Advantages, such as the ability to run unlimited numbers of projects and cross project information access for internal users, that this flexibility can bring are highlighted by ARUP who deploy Causeway's Collaborative solution as their own application service provider (ASP) service called ARUPLink (Cutler 2006). However since they are operated by a particular construction organisation, they are not seen as being as independent as a vendor hosted solutions, since the operators have access to the backend of the system.

Enterprise solutions deployed by companies in their own right fall into two sub-categories: those just used by a company's own employees, who access from within the intranet, ***FIG. 3*** and those shared with 3rd party organisations, ***FIG. 4***, which generally is accessible by the internet as well. When an organisation uses an enterprise solution for only internal staff they usually work with a number of hosted extranet solutions as well, to enable collaboration between their organisation and other project participants.

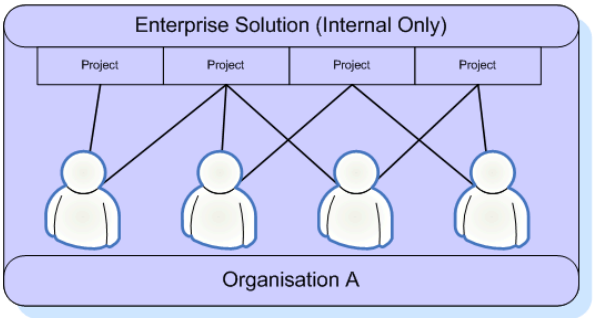

FIG. 3: Internal Only Enterprise System

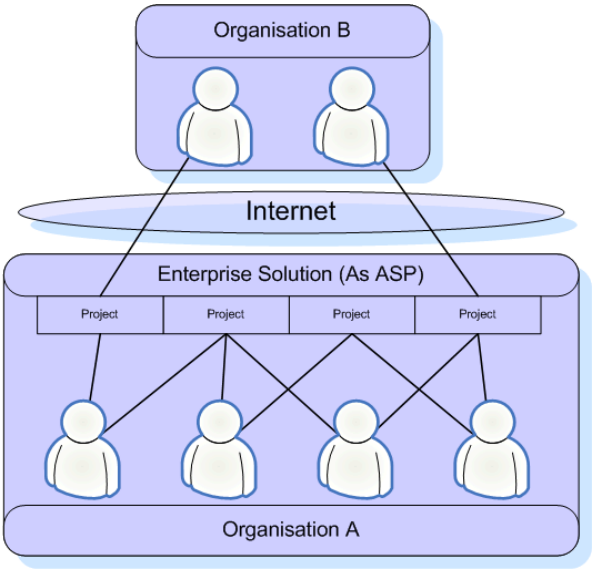

FIG. 4: Shared Enterprise System

2.3 Hosted Enterprise Solutions

Hosted enterprise solutions are collaborative environments that are operated by the collaborative software vendor for the sole use of a single client or a single project. The service is managed and maintained by the vendor similar to an extranet system, but since it is single use, it can be customised according to the client or project's individual requirements. They differ from project extranets as they do not require 24/7 availability, but only that which is required by the customer. However, they are more expensive then their shared equivalents as specific software and hardware needs to be purchased. With extranets these costs are shared amongst all users.

3. THE INDUSTRIAL NEED FOR THE ABILITY TO TRANSFER PROJECT DATA BETWEEN COLLABORATIVE SYSTEMS

The need for a mechanism to bulk transfer project data between different systems can be seen from both the perspective of client (Collaboration User) and vendor (Collaboration Solution Provider) with each seeking different positive outcomes from the data transfer capability. Vendors are collectively keen to increase the utilisation of collaborative products. Clients are seeking to work effectively and collaboratively in a secure and predictable environment that supports their project information management requirements. Recent reports (Birkby and Nugent, 2002) suggested that the provision of an effective data transfer capability should be included in the contracts between vendors and clients. The following two sections examine in more detail the need from each stakeholder group.

3.1 The Vendor's need for data transfer

Through the implementation of a project data exchange standard, the vendor community is collectively seeking to change some of the perceptions held by clients about the providers of collaborative tools by addressing the concern raised, about ensuring uninterrupted access to project data, and the inability to move between systems (lock in) described by those who have reviewed this subject (Birkby and Nugent, 2002, Hampton, 2001, McBride, 2003, Berning and Flanagan, 2003). The standard is therefore aimed at increasing confidence in the tools by providing a mechanism for the extraction of project data from one system and easy importation into another.

Increasingly the larger users of collaboration solutions have begun to select a single system to help to manage all of their projects in a single environment. These companies having spent large sums of money on systems and training staff on how to use these systems will require the ability to migrate their pre-existing projects from other systems to the one that they have purchased. This barrier to use of collaborative systems was highlighted by the (NCCTP, 2006) 'Proving Collaboration Pays' Survey where 67% of respondents identified training on different tool as a significant barrier to use. Further work (Yeomans et al, 2005) had found that the reluctance to retrain to use new tools has lead to difficulties for system users. This can create a negative perception of collaboration technology.

3.2 The Client's need for data transfer

In an attempt to meet the improvement targets demanded by Egan, (Egan, 1998) the UK Construction sector has increasingly been employing project extranet technology to manage the vast amount of information generated during a project. In the initial stages of this drive many construction organisations developed their own solutions. As the complexity of solutions grew, these were largely replaced by offerings from specialist software vendors. The move towards using a service provided by a third party raised a number of concerns about the reliability of the solutions, i.e. ensuring continual access to project data, and the business models operated by the vendors, with the services still be running throughout the life of the project.

Construction companies were concerned that once a particular service had been selected for a project, they were effectively locked in as it would be exceedingly difficult to get the data out into any other system. Additionally when the concept of enabling data transfer was first discussed, many of the vendors of collaborative software were still largely unproven (Krojevski, 2001). This coupled with industry publications questioning the financial predicament of some providers (Building, 2004), continues to affect confidence in the collaboration provider industry. Client's confidence in collaborative products has been further shaken by some early high profile failures of providers, and then their inability to access their data (Holden, 2001).

The growth of the sector increased the number of collaborative software solutions available to be adopted. At the same time, industry watchers, such as Gartner, have been predicting consolidation. This thinking has been reinforced by Lane (Lane, 2003) who in his analysis of the collaboration industry expected that the UK collaborative software market would consolidate to around 3 main vendors. Those vendors leaving the marketplace would need to transfer their remaining active client projects to the vendors continuing to operate.

4. GENERIC COLLABORATIVE SYSTEM MODEL

Enabling Project Data transfer between heterogeneous systems requires a conceptual model of how data is structured. (Bjork, 1993) presented a model of how documents were stored in such a system. (Rezgui and Cooper, 1998) then progressed the subject further by examining the workings of different document management

systems, going on to present a migration from document-based to model-based information representation and structure. However this was contradicted by (Hajjar and AbouRizk, 2000) who put forward an alternative approach which moved away from the shared model approach to document management. Their work on a definition of organisation, document data and project based data specifically customised for the construction sector. (ISO, 2000a) attempted to standardise the metadata associated with documents and (ISO, 2000b) focused on construction related documents. Most of these attempts to standardise the data however were not flexible enough for data transfer needs.

The wide spread emergence of XML as a data exchange platform, has lead to many new XML based data exchange standards for the construction industry such as ifcXML (IAI, 2001) and aecXML (IAI, 2004). While the aecXML initiative was aimed at producing a collection of transaction schemas, ifcXML did offer storage and transfer capabilities applicable to Collaborative systems. The Leeds University (2002) DocLink specification then extended the ifcXML model and applied this to the transfer of documents and associated metadata between collaborative systems, developing a series of data transfer transactions that could be executed in near real-time.

In contrast to previous work the generic model of a collaborative system designed by the NCCTP members, reverse engineers the existing structure of vendor repositories to use as a foundation, allowing vendors to more easily conform as no restructuring of their data is required. The NCCTP approved XML schema for project data exchange splits all exported collaborative projects into three distinct sections, project metadata and project specific configuration, the actual documents and structures which exist in the project (project objects), and the people who interact with these objects (project participants). A Diagram showing the main classes and their relationships of the NCCTP XML based Standard can be seen in ***FIG. 5***, and are further described in the following sections.

Examining the NCCTP XML schema in finer detail project metadata and configuration is a series of XML elements which are used to define the characteristics of the project which has been exported, and can be used by any importing utility to interpret the data it is importing into the collaborative system. Examples of project configuration could include the agreed set of purposes a revision of a drawing can be issued for, or if the system stores access control lists at the file, revision, document level or combination of these.

Each project participant who interacts with the objects contained within the project is stored as a separate XML element within the parent Users element shown in ***FIG. 5***. The user element contains a number of child elements which allows information on the user to be stored; these elements include common user related information such as first name, last name, phone number, email address etc. All user elements must belong to a single organisation, which represents the company they are currently working for. However users from multiple organisations can be added to any number of groups which allow for easy application of user rights to objects contained in the project.

In the NCCTP XML schema project documents are held in an infinitely deep folder structure, with each document acting as a container which can hold one-to-many revisions, and revisions holding one-to-many files. This one-to-many relationship was required since different collaborative systems allow for different numbers of revisions and files to be stored in their document objects. Further to allow for different systems to hold audit history and access control lists at different levels within the document/revision/file structure these elements can be added to each. All references to the users, groups, organisation or other objects which interact with the objects are made via referencing the unique id attribute which is assigned to each object.

To allow for vendor specific data to be exported into a compliant XML document the NCCTP XML schema includes built in extensibility which allows for custom XML tags to be added as children to defined XML elements like, organisation, user, folder, document, revision, file etc. Vendors, while importing the data from the XML Format can choose if they would like to include this additional data.

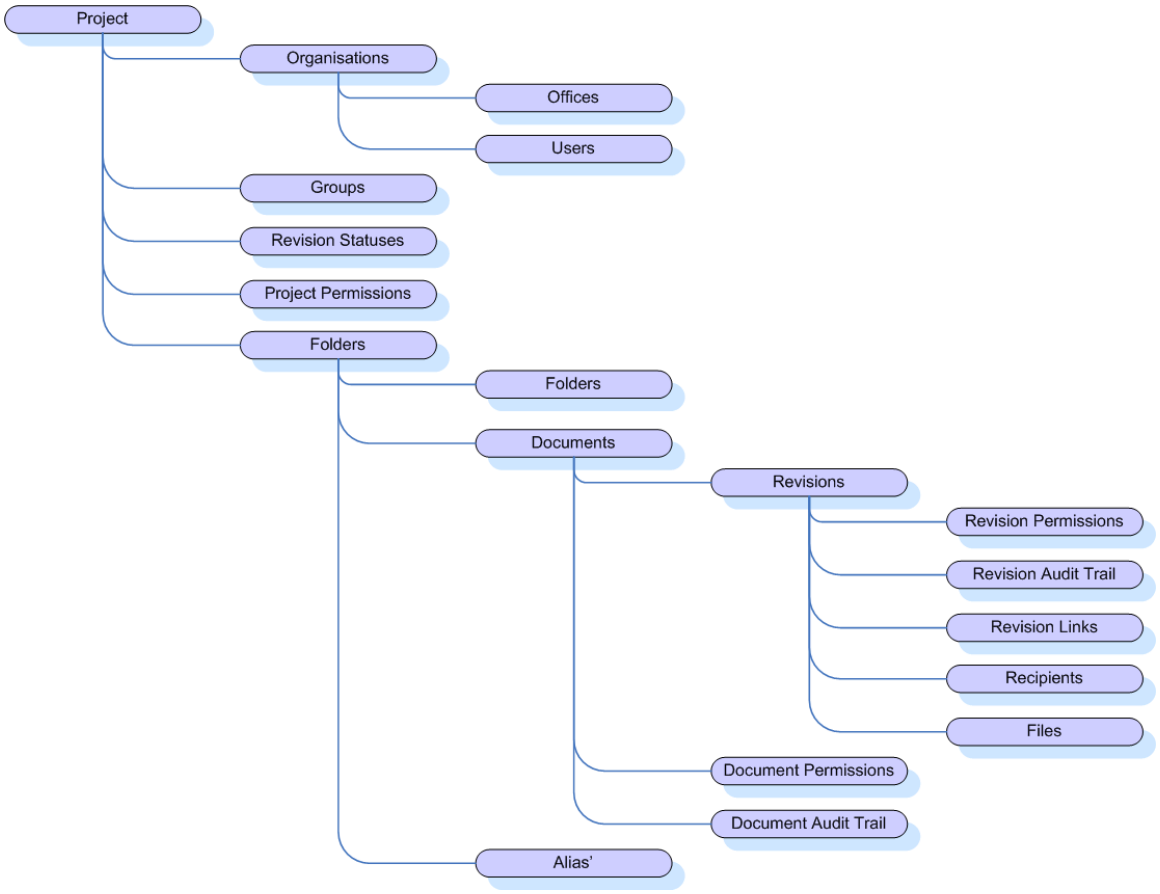

FIG. 5: Main Classes of NCCTP Standard

4.1 Implementation of the Bulk Exchange Standard

To ensure that the proposed standard was suitable to allow project data to be exchanged between any collaborative systems it was important that the application vendors implemented this within their systems as early as possible in the project. The NCCTP used a series of implementation workshops to improve the XML based standard and ensure that it meets the needs of all the vendors without the need for modifying their collaborative systems. Between each workshop individual vendors would attempt to implement the latest revision of the standard then bring any issues they encountered for discussion and rework on the XML Schema at the next workshop.

During the implementation stage a number of test projects, defined below, were created by each vendor. These allowed for intra-organisation testing of the project data exchange solution. Through the transfer of these test projects a series of key steps were identified which formed the basis of any transfer of project data between collaborative systems. This common migration process is illustrated in ***FIG. 6***, with each step explained further in the remainder of this section.

The sample projects created by each vendor were used to test their ability to export a project created in their collaborative system to an NCCTP compliant XML document, which could then be used by other vendors to test their import routines. Exported projects were split into two types those which contained every object defined in the NCCTP XML Schema, which that vendor supported, and those used to test the scalability of export applications. The metrics of an example project to test functionality or export and import applications is outlined below.

- The exported XML Document must describe 1 project
- Which should contain a minimum of 5 User Accounts;
- Which are distributed amongst a minimum of 2 Organisations;
- With some users been added to a least 2 groups;

- The Project should contain folders in a hierarchy (if supported by the vendor);
- A minimum of 5 Documents.
- Which contain a minimum of one revision
- Which must contain a minimum of one file
- Access Control Lists must be defined on at least one of the following elements (Document/Revision/File)
- Audit History must be defined on at least one of the following elements (Document/Revision/File)

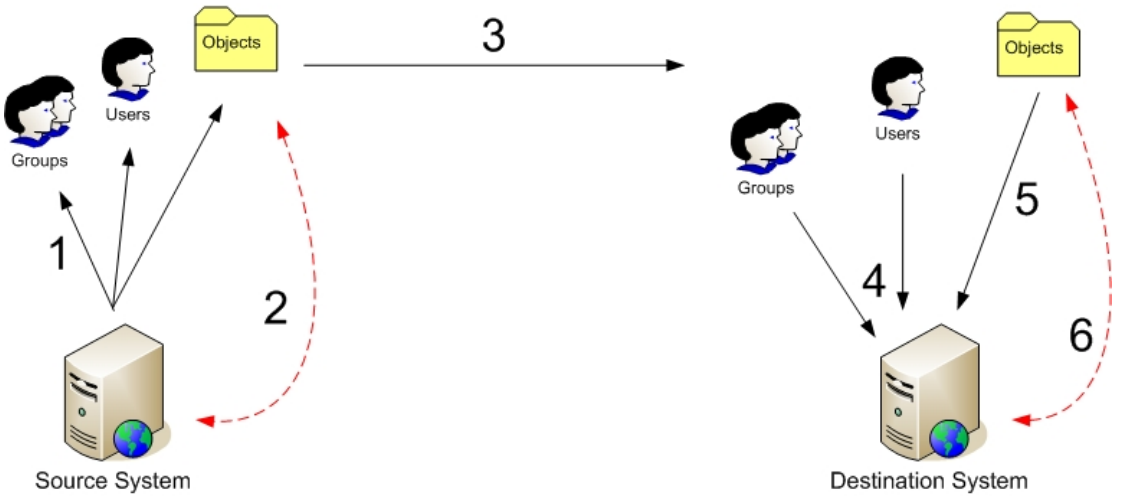

FIG. 6: Steps in the Bulk Transfer of Project Data

1) The selected project is extracted from source collaborative system and stored in the NCCTP XML format. This extraction includes all objects, files and versions along which the project participants and the groups are structured into.

2) A process is undertaken to verify that the extracted data is a true representation of the project as it existed in the source system. The level of verification done will depend upon the requirements of the client and the speed at which the transfer of data must be accomplished. During intra-organisational testing of the standard, vendors were required to complete detailed checklists to verify the data.

3) The method selected for the data transfer from source to destination system will depend on the quantity of project data and the speed the project has to be live on the destination system.

4) Importing/mapping of user and groups from the source collaborative system into the destination system. User or groups which already exist in the destination system will have to be mapped, while users and groups which do not exist will have to be created. When mapping users between source and destinations system care needs to be taken to ensure mappings are correct and that the same user could have different details on the two systems.

5) Objects, including folders, documents and revisions are imported into the destination collaborations system. User and group mapping information obtained from step 4 are used to recreate object access control lists and audit history.

6) A process is undertaken to validate that the information which has been imported into the system is a true representation of the project which was defined in the xml document(s). The level of verification done on the imported data before end users are allowed to interact with it once again will depend upon how quick the client wishes to get the project data accessible to users again. During intra-organisational testing of the standard, vendors were required to complete detailed checklists to verify the data.

4.2 Practical barriers to project transfer between different collaborative systems

Even with standards in place a number of issues remain that place pressures on organisations to remain with their current solution provider. Some of these issues can be addressed by providers by increasing the confidence in

transfer mechanism. Some issues are a direct result of the differences that exist between systems and therefore cannot readily be resolved since each system has been developed over years. Although fundamental application changes are unlikely in the short term, this cannot be ruled out given the market dynamics for increasing interoperability.

As the number of project participants increase, so the task of ensuring correct user, group and organisation mapping becomes an enormous task. Although automated utilities could be written, the risk of exposing documents to the wrong users is a significant risk and would not be acceptable. This has slowed progress in this area.

Different collaborative systems store object (where an object could be a document, drawing, person, etc.) access control lists (ACL's) at different levels. This could prove problematic if moving between systems that maintain differing levels of object attributes. ***FIG. 7***, shows an example of the potential data corruption which could occur when moving project data between systems, which support ACL's at the document level and revision level respectively. The figure shows that, when moving data to a more fine grained system scenario (1), no issues occur. However if data were transferred from a system that maintained details and controlled access to the level of each document to a system that only controls details and access control to document level, scenario (2), then the potential exists to expose content to the wrong users, or to remove access rights to objects which previously existed in the source system.

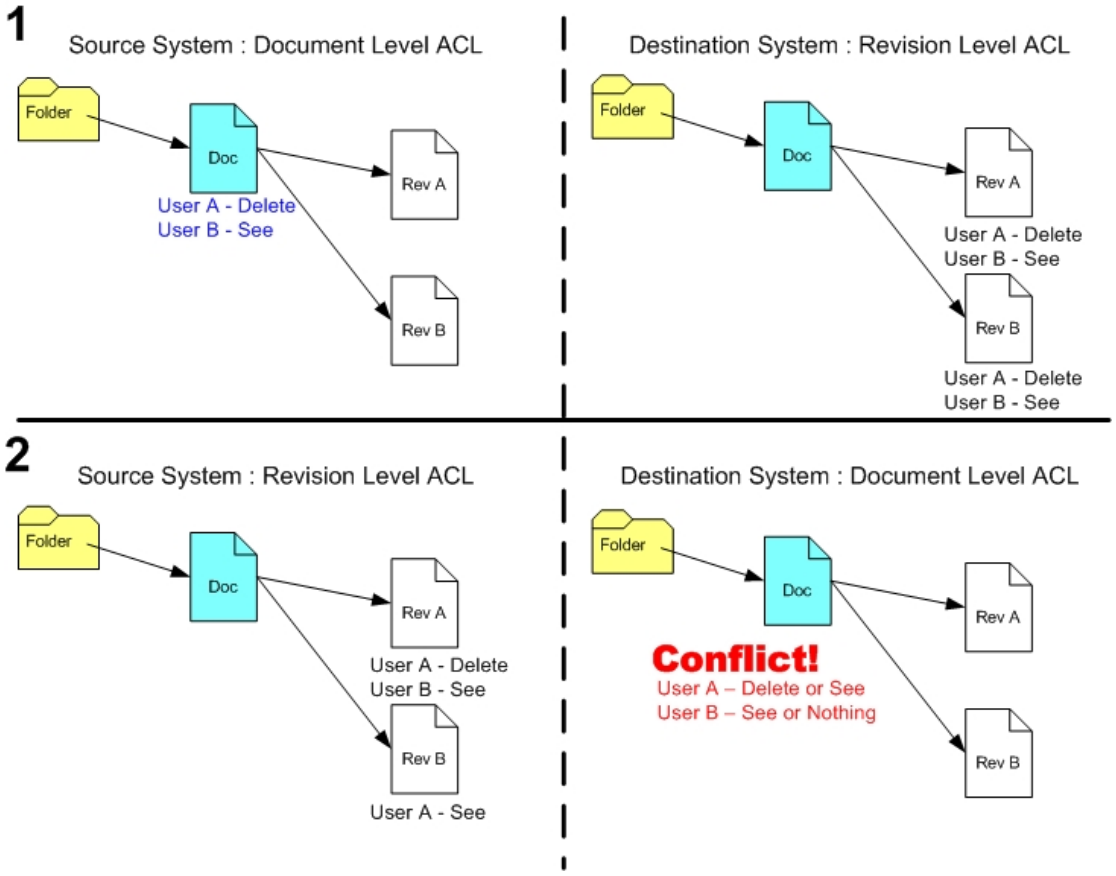

FIG. 7: Potential Data Corruption Issue when Migrating Access Control Lists

When transferring a large project between collaborative systems the amount of downtime required extracting, transferring and then re-importing the data may be too large to be acceptable to the client and their project partners. Additionally as each different collaborative system uses its own unique identity structures, project data will never appear exactly as it did in the originating system. This may discourage users from transferring data in anything other then a real emergency. With the change of user interface and the potential loss of productive work from such an incomplete transfer, including users not being familiar with the new interface, then the perception amongst users could be that data has been lost during the transfer process.

4.3 Practical Utilisation

Since implementing the NCCTP Bulk data exchange standard into their collaborative software, Causeway Technologies, a founder member of the NCCTP, have used the defined XML based format for migrating project data in the following scenarios.

- Moving projects from ASP systems to a company's own Enterprise system, to reduce the cost of hosting and enable project knowledge gained to be used by those who were not participants of the project hosted on the ASP.
- Moving live projects from Enterprise Systems which had no access for users external to the company to ASP environments where project collaboration could occur between multiple AEC organisations.
- Migrating projects from a bespoke document management system, to an NCCTP compliant collaborative system.
- Migration of project's from pilot servers to live environments after evaluation of software had been completed.

These types of examples of the data migration xml based standard being used within industry show that although migration requirements are not that common they do exist and that the designed XML schema is capable of transferring the data between systems.

5. FUTURE WORK

The work presented in this paper in defining a generic collaborative data format as used by the construction industry can form the basis of a number of different future research paths, as suggested below. This is especially possible since the standard devised is the collective work of the majority of the key technology providers and so there is a wide interest base in further enhancements. The following sections outline the three most likely future projects which would build on this work.

5.1 Extending the Standard

The current version of the standard covers the core components, common to all vendors which make up a collaborative system. This work could be extended to define some of the optional functionalities offered by some of the vendors, such as additional meta-data, work flow details and general data handling indicators, etc. This would make it easier for other vendors to recognise and utilise the features in the XML output. Currently these extensions can be exported by the vendor but the schema does not define how they should be stored in XML.

5.2 Incremental Project Updates

The incremental replication of project data across a number of different project collaboration systems is a logical extension of the initial work done on bulk exchange. This enhancement would allow for users to access, although not in real-time, elemental updates for changed project data through a familiar interface. This is a logical extension since the objects being updated on each system are those already defined by the NCCTP standard, documents, revisions, access control etc.

5.3 Real-Time Integration

Real-time integration of collaborative systems offer users the ability to manage, view, modify or even delete information stored in one collaborative systems when being accessed from a different collaboration system. Unlike incremental project updates, outlined in section 5.2, there is no requirement to duplicate the information on all such linked systems. Furthermore, none of the delays associated with the staged updating of information will be experienced. Through its common definitions, the NCCTP standard will help move towards this by offering vendors a generic way of describing the content which exists in their repository.

6. CONCLUSIONS

With the development and implementation of the NCCTP bulk project exchange standard, users of collaborative technology solutions now have the ability to migrate live projects should the need arise. This increases user confidence and reduces the risks associated with using such technology and equally increases confidence in the solution providers offering this capability. This standard allows for the common definitions currently in place to form the basis for a greater level of interoperability in the future. This is expected to allow initially for the

incremental exchange of data between collaborative systems, and eventually the potential for real time inter-working across platforms. This would allow access to project information using a familiar system without any loss of functionality.

The ability to transfer project data between systems also offers benefits in post project analysis for organisations using an enterprise wide system. Users throughout the organisation, not only those who participated on the project, would be able to gain access to the data through their usual application.

While the current standard is capable of transferring projects at any time during a project life cycle, it may only be practical to move this data at particular times. This may be due to the limitations around the down time required for the migration. Likely opportunities for the bulk transferring project data would therefore include:

- The user storing the projects is no longer able to offer the service so a new provider is required.
- A phase of the project is completed, and there is gap before the next phase starts.
- Project data is being transferred from an internal to an external system to allow for collaborative working with other organisations.

A standard now exists to support the bulk exchange of project data. This is a significant step forward but limitations outlined in this paper still need to be addressed if such transfers are to be undertaken without any loss of functionality. The functional differences between solutions cannot be resolved by the transfer standard and is probably a healthy state of affairs. The challenge is to continue the work that has been undertaken by the NCCTP and to look to an ongoing evolution of exchange capabilities in line with market requirements.

7. ACKNOWLEDGEMENTS

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