ELECTRONIC BUSINESS IN THE BUILDING-CONSTRUCTION INDUSTRY: PREPARING FOR THE NEW INTERNET

Prof. Frits P. Tolman[1], Dr H. Michel Böhms[2]
1 Delft University of Technology
2 TNO Building and Construction Research

ABSTRACT: The paper presents the objectives and initial results of the 5th Framework eConstruct project curiously enough given the number IST-10303. The aim of E-Construct is to develop, implement, apply and disseminate an XML vocabulary (bcXML) for the European Building-Construction industry. This Communication Technology will provide the European Building-Construction industry with a powerful but low cost communication infrastructure that:

- Supports electronic business between Clients, Architects and Engineers, Suppliers (of components, systems, services and resources), Contractors and Sub-contractors,
- Is integrated with eCommerce and Design/Engineering applications, and
- Supports virtual construction enterprises over the boarders of the individual European member states.

Meaningful electronic communication in the Building-Construction industry has been the subject of many research and development projects in the past. The result of all these efforts however are practically zero. The problem is that past projects primarily tried to support the Design/Engineering stages. Unfortunately Designers and Engineers are not really powerful players in the industry and certainly not sufficiently strong and well organised to produce and implement a suitable communication standard that also involve other, more powerful, players like Clients, Contractors, Suppliers and Project Managers.

eConstruct will primarily be supporting eCommerce or eBusiness type of applications, taking account of the upcoming XML hype, and hopes to include PDT elements subsequently.

One of the main targets of eConstruct is to provide eCommerce over the boarders of the different European member states, taking account of national languages, classification and code systems.

KEYWORDS: Building-Construction, B2B E-Commerce, XML, bcXML

1. THE PROBLEM

1.1 The problem in Building-Construction

Many problems in the Building-Construction industry (BC) arise from miscommunication. Information is too often late, incomplete, erroneous or out of date, resulting in extra cost and time (rework), increased health and safety risks (accidents), and added waste with accompanying discontent and mistrust within the working partnerships sometimes leading to expensive legal actions. Because the Building-Construction industry works with very small margins, cutting the waste that results from miscommunication with only a few percent will strongly increase the competitiveness of the industry.

One of the 'solutions' to the communication problem is to increase the use of appropriate Communication Technologies (CT). CT is playing already an important role in all the high and medium tech industries. Building and Construction however is lacking behind in the uptake of CT. One of the missing links is a suitable Building-Construction communication language tailored to the needs of the industry.

After twenty years of research and development, meaningful electronic communication in the Building-Construction Industry is still not possible, at least not in general. Only in limited cases are there standards for communication available, for example for exchanging electronic technical drawings, or for procurement of construction products. Integral, vendor independent, support for the complete chain, or even of a realistic part of the chain is not available.

Some of the reasons for this lack of success are:

- Fragmentation of the industry and lack of rich and powerful international market leaders, like in Aerospace or Automotive,
- National governments are not likely to invest in the development of international standards,
- Large international contractors and clients are not investing (enough) in international standardisation,
- International CAD vendors are unable to support the many differences encountered in each individual country,
- And – last but not least – the fact that ISO STEP communication standards developments usually follows a top down approach that may take quite some time.

1.2 The problem with current Communication Technology

Building-Construction processes and the resulting artefacts become more complex every year. Increased pressure on time, cost and quality demands improved communication. One of the solutions that seem to work in other sectors of the industry is the use of a suitable CT (Communication Technology). However 20 years of R&D still did not bring the BC industry what it needs, a communication technology that is cheap, open, safe and powerful. One of the reasons for this lack of success is the fact that existing communication technologies do not fit well with the nature of our industry; they often need international standards, powerful machines and networks, and support of a large group of software vendors. Besides the reasons described above - that also in the future might hamper the growth of CT usage in de industry - there is also a purely technical reason for the lack of success, i.e. the limitations of the current Internet.

Though Internet (plus Intranet and Extranet) potentially forms the ideal open, low cost communication platform for the Building and Construction industry, in practice Internet is only used in a limited way. The most important reasons are insecurity, insufficient bandwidth and insufficient structuring of information. Insecurity because it is not possible to guarantee that (1) the receiver of an attachment has indeed received it in good order or (2) nobody from outside the company is also reading the emails, or attachments. Insufficient bandwidth because communication of large amounts of data (common in BC projects) is not yet supported as required. Insufficient information structuring because the current Internet

language HTML only supports freeform data exchange, an intermediate language that supports specific needs of the BC industries is not available.

2. THE SOLUTION: INTERNET II

2.1 XML

Internet is going to change. The first results of the development of Internet II are arriving. Internet II will be operational in Y2000. A strongly improved language, called XML (eXtensible Mark-up Language) will succeed HTML. With XML[1] it is possible to overcome the technical limitations of the current Internet. One of the improvements is the increased flexibility due to the use of a meta-language that allows the exchange of data together with the data format. It is also possible to develop and use specialised languages based on XML that support the needs of a particular type of industry or sector. These XML languages, called XML vocabularies, can be tailored to the needs of a group of applications. Two examples of vocabularies that already exist are CML, from Chemical Mark-up Language and OFX, from Open Financial Exchange. CML supports important notions for the Chemical industry and allows direct communication of molecule structures and such. OFX is already being used for secure remote banking. In the future all kinds of XML vocabularies will become available.

2.2 bcXML

eConstruct proposes to develop a new communication technology for the European Building and Construction industry, tentatively called bcXML (Building-Construction Mark-up Language) and to use that for the development of a number of applications. The core project will be the development of bcXML vocabularies plus translators for each of the countries that participate in the project. The LexiCon developed by STABU and BAS in the Brite-Euram CONCUR-project will provide the starting point for the semantical content of bcXML. Besides the obvious integration that follows from the application of a common vocabulary, the following applications will be taken into account:

Development of electronic libraries of construction products like materials, components, assemblies and systems, that support information ordering according to the information provider. Libraries of larger objects can use descriptions of components contained in the libraries of their suppliers, without duplicating the information[2]. There are several options available to tackle the problem. The first application is to use bcXML only as the exchange mechanism that allows component vendors to use any of the available formats. An alternative is to use bcXML directly to describe the electronic libraries.

Development of neutral product models made up of bcXML defined library objects. It is also possible to communicate and visualise complete product models without duplicating the procedures that describe the components. This means that one of the existing product model formats (presumably IAI-IFC) will be augmented with some bcXML processing features.

---

[1] When we mention XML, we also mean related developments like XSL, XML Schema, XLink and XPointer, XQL, X3D and other vocabularies like OFX, WIDL, and what the future will bring.

[2] Essentially information providers, i.e. construction material vendors, electrical and mechanical engineering companies, manufacturers of assemblies and parts, can stay responsible for their own information (and maintain that information on their own computers). For instance a vendor of kitchen systems can use the information provided by his suppliers without having to copy it. The same holds for the supplier of taps, who buys his tap leathers somewhere else.

Development of information landscapes and Virtual Reality as front-end for co-operative design, engineering and realisation of complex projects. One of the new XML related developments is X3D, a VRML97 subset 3D shape representation language. The combination X3D and bcXML will provide a very powerful Virtual Reality environment for Concurrent or Co-operative Design and Engineering in the Building and Construction industry. All the partners involved in a construction project, both in design and realisation, will be able to use one common, server based VR model to extract the information they need, or to include the information they produce. Because this model will always be up-to-date, the quality of the inter-discipline communication in a construction project will greatly improve.

3. THE E-CONSTRUCT PROJECT

3.1 Project objectives

Essentially the project contributes to the improvement of information logistics in the Building-Construction industry. Inadequate information logistics - getting the right information in the right place, on the right time and in the right format – is what causes most problems. By improving the information logistics the project helps to realise better construction processes and artefacts with lesser failures, at lower cost, and with lesser burden on the environment. The project also supports low cost and wide spread communication over the national borders and thus helps to increase the competitiveness of the European Building-Construction industry on the European and international markets. By using Internet, the technology becomes available for everybody, not only for the large and rich contractors, but also for the small and medium sized companies. By developing translators for all the European countries, communication between project partners of different countries improves, the market for construction products expands and the competitiveness the European Building and Construction industry increases.

In order to achieve that the Building-Construction industry can benefit from the new possibilities provided by the new Internet, the eConstruct project wants to investigate how Internet II can be used to improve electronic communication, and to pave the way for the next century.

By co-ordinating the developments of national vocabularies and a "neutral" vocabulary, information exchange over the European and international borders is possible, thus contributing to a European Building and Construction industry.

3.2 Project partners and work programme

The consortium consists of three types of partners: R&D Organisations (TNO, CSTB), IT-Vendors (Nemetschek, EPM) and End-Users (Taylor Woodrow, Betanet). The STABU is partly end-user oriented (it is a Specification organisation) and partly an IT-Vendor (together with the Dutch BAS group).

The start date of the project is 1st January 2000. It will initially run for two years with potential extension period of one year. The general project management is done by Taylor

Woodrow, the technical project management is the responsibility of TNO/TUD. In order to achieve its goal eConstruct's work-plan is divided into nine Work Packages:

WP1 Starts with an investigation into the current state-of-the-art of XML and related standards developed by the World Wide Web Consortium (W3C). Besides XML itself there are a large number of related components that might play a role. Examples are the linking mechanism provided by XLink and XPointer that supports a multiple bi-directional linking mechanism. Besides basic technology also related developments of XML vocabularies will be evaluated.

Based on the knowledge gained in this exercise the bcXML development will be approached from two sides. The syntax will follow existing XML vocabulary examples, and the semantics will follow from the end-user requirements and the LexiCon development work done in the Brite-EuRam CONCUR project. Extending the semantics included in the LexiCon in the project domain (including work methods, resources, etc.) and in related areas like Civil Engineering will be part of the project. The semantics of bcXML will be defined in STABU's LexiCon tool and later expressed and detailed in "XML Schema" schemas, the DTD-alternative for data-driven exchange. Once a "neutral" set of BC semantics is available the project partners will define bi-directional translations in their national languages, classification and coding systems. These national bcXML flavours can be used to understand data provided by suppliers all over Europe.

bcXML version 0 (initial) release, to be finished in the first year, will provide a first starting point for the application developers. Only with bcXML version 1 a beta (draft) release will become available. Version 3 will be a stable (final) release (all the results of WP1 will be in the public domain).

WP2 Enhances the software infrastructure on both client and server side beyond standard (generic) XML-support found in today's Internet Browser and Servers.

WP3 Concentrates on the application of bcXML to enhance the relations between BC professional (like designers and engineers) that use AEC CAxx systems.

WP4 Does the same as WP3 but now for the server side involving suppliers of construction materials, products, systems and services that have (or can make) their information available in electronic libraries.

WP5 Treats the aspect of communication which involves multiple classifications, languages and/or coding systems. The result is a converter which support this communication over the project life-cycle and over the boarders.

WP6 Focuses on the development and application of Virtual Reality Project Information Landscapes as common information front-ends for BC project information. These front-ends (probably implemented in X3D) will describe the projects in their current and future states and can be used over the net by all the partners and authorised third parties involved to get a common view on the state of the project and to find the required information.

WP7 Uses and Validates the project results via dissemination and implementation at the two industrial end-user sites. This effort will be achieved in co-operation with the Procure project also co-ordinated by Taylor Woodrow. The aim of Procure is to implement improved

procurement in the companies involved in the project, using existing technology. eConstruct will be able to draw upon resources of Procure.

WP8 Provides the required project- and technical management and co-ordination. This work package also addresses all external relationships.

WP9 Will explicitly assess and evaluate the project's progress. External evaluators of relevant initiatives will be included.

3.3 Initial results

3.3.1 How does bcXML relate to other developments and standards?

At the time of writing (March 2000) the kick-off meeting just took place. The most heated discussions concentrated on the following two question: (1) how does bcXML relate to other developments and standards (IAI IFC, eacXML, ebXML, ...)?, and (2) what IS bcXML and what can/will we do with it? Let's give a short overview of the current turbulent scene…

eConstruct is not the only project that tries to develop XML technology for the Building and Construction industry. Among others, the follow four related initiatives are currently being studied in detail: GEN, aecXML, EDI and mainstream Java developments. Our findings are as follows.

Generic XML-Technology

XML (http://www.w3.org/XML/) is a true hype. Standardisation is relatively fast. The fundamental standard (XML 1.0) is a recommendation and related standards are in a draft status, which will soon be stabilised. Especially we want to mention XML Schema, the XML language for defining data structures which will be used in eConstruct for the specification of bcXML.

The 'traditional' application of XML is through the development of Document Type Definitions (DTDs). This technology however is by no means the only possibility. Alternatives to DTDs are: DCD, from Document Content Definition, XML Data and recently XML Schema, an extended language that supports the modelling of data types and specialisation via super/sub types.

Other important accompanying XML standards are XLink (advanced hyperlinking) and XPath/XQL for addressing and questioning your XML docs on a higher level than the low-level Application Programming Interface (API) DOM. Another promising technology for software interoperability is SOAP (Simple Object Access Protocol), a combination of HTTP and XML, which could overcome problems with and potentially replace solutions like OMG CORBA/IIOP, MS COM+ and Sun Java RMI.

Finally also the XML developments in the Java world are being studied carefully. Java and XML are truly compatible technologies that enforce each other's strength. Sun's Java Platform will more and more include direct support for XML and related technologies.

XML-Support / E-Commerce / EDI

Numerous organisations are developing XML vocabularies and XML related products. (i.e. Microsoft's Internet Explorer 4/5 already supports XML). XML developments in E-

Commerce are moving fast. Several proposals for E-Commerce oriented vocabularies (cXML from Commercial XML, and tpaML from Transaction Partner Agreement Mark-up Language) are already submitted for standardisation, others will follow shortly (XDI, GEN, and more).

Also the EDI world is turning to XML as the new technology for Internet based communication. Several initiatives have been identified, however one specific problem in this area is that most countries have supported national EDI developments and institutions. eConstruct wants to be compatible with these developments.

Furthermore, the United Nations body for Trade Facilitation and Electronic Business (UN/CEFACT) and the Organization for the Advancement of Structured Information Standards (OASIS) have joined forces to initiate a worldwide project to standardize XML business specifications. UN/CEFACT and OASIS have established the Electronic Business XML Working Group to develop a technical framework that will enable XML to be utilized in a consistent manner for the exchange of all electronic business data. Industry groups currently working on XML specifications have been invited to participate in the 18-month project.

aecXML / IAI
Also in the Building and Construction industry other initiatives take place. Bentley Systems in the USA took the initiative to start the aecXML development (http://www.aecxml.org). aecXML is an XML-based language used to represent information in the Architecture, Engineering and Construction (AEC) industry. This information may be resources such as projects, documents, materials, parts, organizations, professionals or activities such as proposals, design, estimating, scheduling and construction. It is intended to be used as an XML namespace and to facilitate information exchange of AEC data on the Internet. The current schema (working draft 0.87) is described in "XML Data". This development is brought under the flag of the International Alliance for Interoperability (IAI) that is also responsible for the development of the Industry Foundation Classes (IFC), an open format for the exchange of building data. bcXML could play the role of the non-US counterpart taking into account the typical European requirements.

eConstruct and the IAI decided to co-operate in the development of bcXML and aecXML, but to remain independent, at least for some time. The three main reasons are: (i) in the US the language and classification problems are far less then in Europe, (ii) eConstruct is not focusing on support for design/engineering, but on support for E-Commerce and (iii) bcXML will not be limited to Buildings, but also targets i.e. Civil Engineering.

GEN
GEN, from Global Engineering Network, is a European initiative that started already in 1994. The goal is to provide an electronic marketplace for engineers. GEN, and sub projects like GENIAL, PROCAT, GOM and GENIS are all developing, implementing and applying specific models that are being made available in XML. For Europe GEN is interesting because it recognises the language and classification gaps that hinder communication over the national borders.

Product Data Technology (PDT)
"Traditional" product data exchange initiatives like ISO STEP (Technology and Modelling) and IAI IFC (using STEP Technology) have teams working to at least link to the new XML-

developments. A lot of discussion is going on about the role of XML: will it replace STEP Technology (i.e. XML Schema takes over EXPRESS, DOM/XQL takes over SDAI, XML itself takes over SPPF or is the power of STEP Technology still superior and XML for publication only?).

For generic XML-Technology the case is relatively simple: The W3C will develop and prescribe these standards. But how about the jungle of overlapping schemas? It seems sometimes that the one who comes first wins (not the best). There are two main organisations at the moment which try to structure this jungle to a certain extent: the Microsoft-based BizTalk initiative and the more neutral/independent UN/OASIS ebXML initiative. They both form repositories for schemas and frameworks for their content.

3.3.2 The second question is: what is bcXML and what will we do with it?

The main problem that bcXML will try to solve is the problem of semantical[3] object identification. This problem has been quite clearly stated as: "What makes a Column a Column?". A question not easily answered in the European context.

In Europe different countries not only use different languages but also different concepts, different technical solutions (concrete in Holland is different from concrete in Spain), different work methods, regulations and codes of practice. Luckily most concepts used in a country are nowadays expressed in classification and coding systems, though not always uniquely. For bcXML to be able to support meaningful electronic communication over the boarders of each country, translation and transformation of concepts is mandatory.

For the identification of concepts eConstruct will build upon the LexiCon, a development started in the Brite-Euram CONCUR project by the STABU in the Netherlands. The LexiCon tool will be adapted to the specific modelling needs of eConstruct and will be used as a end-user friendly interface to the data structures. Export to XML Schema data structures will be developed. eConstruct will not duplicate related efforts in PDT, like IAI-IFC and ISO-STEP, but try to focus on the typical strength of XML as a cheap, but powerful Communication Technology.

4. CONCLUSION

Improved communication and especially improved electronic communication in the Building and Construction industry is desperately needed. Too much money and effort is currently wasted. Too many errors and miscommunication burden the industry's competitiveness both nationally and internationally.

Until now there are basically two streams that try to provide BC with meaningful electronic communication. The first is the PDT-stream, based on ISO STEP Technology, that supports communication of technical design/engineering data. The second is the EDI-stream, based on EDIFACT Technology, that does the same with commercial trade data. Both streams rely on specific choices for Modelling and underlying Technology. Both developments are only very

---

[3] Semantical object identification means the common recognition of a concept.

limited successful. EDI is generally seen as too complicated, closed and expensive. And PDT, mainly starting with ISO STEP, is not really used in practise. The latest PDT modelling effort (re-using ISO STEP Technology), IAI-IFC, is more successful, but still a long way from acceptance and usage in practice.

With the arrival of the new XML-technology it seems possible to provide the industry at large with a new, low-cost, but powerful Communication Technology. A Communication Technology that will not replace the existing efforts, but enforce them. EDI goes XML that is for sure. The result will be a much more open electronic market place. And PDT will also join the XML bandwagon as can be deduced from the ISO STEP efforts to generate XML versions of their schemas, and from the fact the US started an XML project (aecXML) under the IAI flag (US Chapter). What eConstruct's role will be in the arena is not yet fully clear. We will develop an XML vocabulary (bcXML) for the European BC industry (supporting the many national languages, classifications, etc.), but not in isolation. eConstruct will co-operate with both the EDI-stream, the PDT-stream and the US aecXML development team. We hope to produce a Communication Technology that bridges the gap between commercial trade (EDI) and technical design/engineering (PDT) so that future users will be able to inquire about, offer, procure and deliver BC products, services and equipment over the Internet, crossing, if required, the national borders.

XML is a hype, and that shows. Every day brings news that might influence our strategy. At this point in time we are developing the bcXML meta model (what is it that we want bcXML to be able to do?) and compare it with the meta models of some related initiatives. Our primary focus in on E-Commerce type of support, "shopping" for instance. For the actual buying and selling we think EDI is irreplaceable. However in which form bcXML and EDI will co-operate is not clear. It might be possible to embed EDI messages in bcXML communications, but it is also possible that EDI will produce XML versions of their schema. eConstruct will also co-operate with IAI aecXML and hopes to share the largest common subset of elements.

REFERENCES
aecXML, http://www.aecxml.org/.
CITE, EDI in the UK, http://www.cite.org.uk/.
ebXML (UN/CEFACT & OASIS), http://www.ebxml.org/.
eConstruct, http://www.eConstruct.org/.
GEN (within CEN/ISSS), http://www.cenorm.be/isss/Workshop/gen/Default.htm.
General XML Ports, http://www.xml.org/, http://www.xml.com/.
Microsoft BizTalk initiative , http://www.biztalk.org/BizTalk/default.asp.
OASIS, http://www.oasis-open.org/.
tpaML (IBM), http://www.xml.org/xmlorg_resources/b2bxml.shtml.
XML, XSL and related technologies, http://www.w3.org/XML/.