

# WORKS PROJECT INFORMATION STANDARDS FOR THE HONG KONG CONSTRUCTION INDUSTRY

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## SUMMARY

Construction projects generate stacks of information throughout the entire life span of a project and particularly at the design and construction stages. With the state-of-the-art information technology, most of the information can be stored electronically using various software systems. However, there is a wide diversity of information standards which adversely affect electronic data interchange and software interoperability among stakeholders in a seamless manner. To tackle these problems, the Works Bureau of the Hong Kong Government has decided to establish the Works Project Information Standards (WPIS) and associated data infrastructures. This paper aims to provide an overview of the current major standards which are being adopted, and accordingly recommend the future research direction for the Works Bureau. The findings, evolved from the conceptualisation of a framework, indicate that web-based open-source industry specify standards including aecXML, bcXML and ifcXML would be the suitable WPIS. More importantly, it is identified that there are certain networks and organisations at overseas which are engaged in similar research projects. The development of WPIS should keep abreast with their work and dissemination.

## INTRODUCTION

The construction industry consists of multiple parties who generate enormous amounts of information for each construction project (CIRC 2001). Although information technology tools are widely adopted, information exchange among the parties is inconsistent. Most of the information is incompatible, unnecessarily duplicated and/or eventually lost as software applications cannot exchange data automatically (SIENE 2002). The International Alliance for Interoperability (IAI) stresses that "Computer programs that are used in building design, analysis and operation are used in a stand-alone manner and cannot exchange data directly, even when used by the same party." (IAI 2002). In fact, the problem of information interoperability has been facing by both the users and the software developers. Tse & Wong (2002) have tailor-made a Hong Kong based quantity measurement system to take off quantities from building services drawings. The results indicate that this system is on average 10 times faster and 14% more accurate than the manual approach, but the varying Computer Aided Design (CAD) layering standards adversely affect its practical application. This example is only the tip of the iceberg. There are cases in other application areas around the world (Zarli et al 2002, Jardim-Goncalves et al 2002, Nederveen et al 2002 and Ingirige & Aouad 2002). The ideal solution is to use a common standard for each type of information. Availability of appropriate information standards is a critical determinant, but enforcement is even more important. The case of Tse & Wong (2002) unveils the difficulties in enforcing ISO 15667 CAD layering standard by a building services contractor in Hong Kong. It is suggested that the Government, being the largest client in Hong Kong, can play a vital important role in this regard. The Construction Industry Review Committee (CIRC) of Hong Kong also recognizes that "...absent of a conducive environment due to the lack of common standards and a common data infrastructure ..... had inhibited a higher IT take-up in local construction ...." (CIRC 2001). Until recently, the Government announced an initiative to develop the Works Project Information Standards (WPIS) for public works projects. There is little question in enforcement, but the development/adaptation/selection of appropriate information standards needs critical research.

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Prior to the WPIS initiative, a research into information standardisation and interoperability in the Hong Kong construction industry has actually been committed by a research team in the Department of Building and Real Estate at the Hong Kong Polytechnic University. The key objective of this research project is to investigate and propose a standardised methodology of defining and structuring project information for local construction industry. It is directly relevant to the WPIS and therefore the research direction has been adjusted to keep abreast with the Government's initiative. The research is divided into three main stages. The first stage is a comprehensive literature review on how construction project information is structured in existing standards. The next stage will then formulate a theoretical model of information standardisation and interoperability for the construction industry in Hong Kong. Having formulated the theoretical model, the final stage will focus on model validation. The research project is now in the first stage and this paper aims to present the initial findings with due consideration to and recommendation for the Government's initiative.

## **BACKGROUND OF WPIS**

Over the years from 1998 to 2000, there was a wave of non-compliance construction incidents in Hong Kong. This led to a great public concern over the quality of the construction industry. In April 2000, the Construction Industry Review Committee (CIRC) was formed by the Chief Executive of the Hong Kong Special Administrative Region. The objective of the CIRC was to conduct a comprehensive review on the problems and to recommend corrective measures (CIRC 2001). Through a nine-month in-depth investigation and consultation, CIRC published a report entitled "*Construct for Excellence – Report of the Construction Industry Review Committee*"<sup>4</sup> in January 2001. As addressed by the CIRC Report, one of the deficiencies is the lack of common standards and a common data infrastructure in the local construction industry. Accordingly, CIRC recommends that "the industry should give priority to set common standards and developing a common data infrastructure for seamless electronic communication among stakeholders." (CIRC 2001). The Works Bureau, being a Government policy bureau responsible for public works, subsequently commissioned a consultant to carry out an Electronic Services Delivery (ESD) Strategy in February 2001. This consultation study further affirms that there is no communication infrastructure across different participants in the fragmented construction industry (Works Bureau 2002). The prime objective of the ESD is, therefore:

*"...to provide the means for project participants to communicate with one another over the internet, through an open standard that enables the software solutions chosen by them for particular purposes, e.g. project management, to be interoperable." (Works Bureau 2002).*

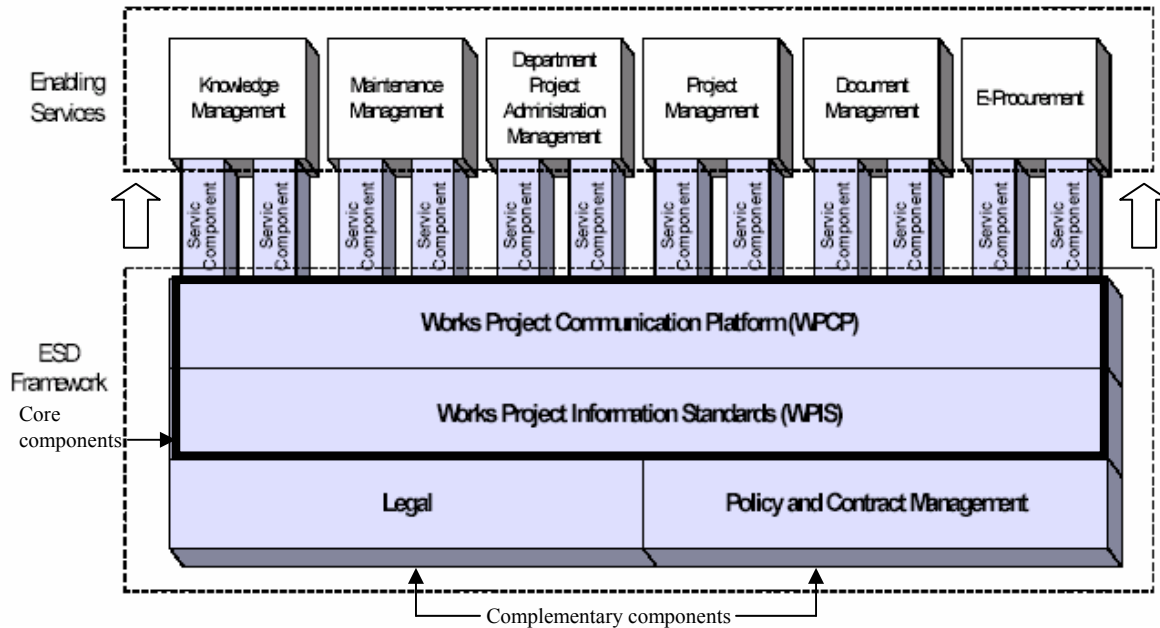
In respond to the recommendation of the CIRC report, the consultancy study proposed an ESD framework to deliver six enabling services<sup>5</sup> in January 2002. As shown in Figure 1, the Works Project Information Standards (WPIS) and the Works Project Communication Platform (WPCP) are the core components of the ESD framework. However, successful implementation of WPIS and WPCP relies on appropriate revision of legal provisions (e.g. general conditions of contract) as well as policy arrangements (e.g. technical circulars and project administration handbook). Thus WPIS and WPCP will be complemented by "Legal" and "Policy and Contract Management" components. With regard to WPIS, the study suggests a set of data domains<sup>6</sup> to be covered when defining the standards. Works Bureau (2002) stresses that the tentative strategy is to adopt the Extensible Markup Language (XML) to the above data domains and it will see whether overseas initiatives can be applied in Hong Kong. The current progress of the ESD is just over the consultation period and moving forward to the implementation programme. The CIRC report and the initiative from the Works Bureau of the Hong Kong Government have clearly indicates the need for common standards and a data infrastructure for the Hong Kong construction industry.

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<sup>4</sup> Hereinafter called "CIRC Report"

<sup>5</sup> including knowledge management, maintenance management, department project administration management, project management, document management and e-procurement

<sup>6</sup> CAD and GIS standard, correspondence, photo album and picture, accident report, request for information, site diary, site instruction, test request, contract rate statistics, bills of quantities, works orders, etc....



Source: Works Bureau (2002)

**Figure 1** Block diagram of Works Bureau's initiative

## OVERSEAS INITIATIVES IN INFORMATION STANDARDS

Although information standardisation and interoperability have become well established in other industries such as automotive and aerospace (Gollnitz et al 2001), the construction industry seems to be fairly behind them. According to the Network on Information Standardisation, Exchanges and Management in Construction (SIENE), there are some 15 different types of information standards in the construction industry (SIENE 2001). The following sections will study the background and general concept of the major standards including XML (and related SGML and HTML), ebXML, bcXML, aecXML, ebXML, IFC, ifcXML, STEP, CITE and EDIFACT.

### SGML (ISO 8879:1986<sup>7</sup>)

SGML (Standard Generalised Markup Language) was introduced in 1980 and became an international standard (ISO 8879) in 1986 (IXSUG<sup>8</sup> 2002). It is a document information system intending for the re-use of information by defining (markup) documents in electronic form that are device-independent, system-independent, language-independent and application-independent (Smith 1992). In simple sense, a document is saved as a straight text file with formats using special streams of ASCII characters known as markups (Edwards 2002). Thus SGML is also known as "Metalanguage – language for describing other languages" (Smith 1992 and ISXUG 2002). In fact, the Internet world's HTML (HyperText Markup Language) and the state-of-the-art XML (Extensible Markup Language) are rooted in SGML (Byran 1997 and OASIS<sup>9</sup> 2002). Thus the importance of SGML lies with its concept for formalising solutions (e.g. HTML and XML) in the context of computerised information management.

### HTML

HTML is the standard text-formatting language for documents published on the Internet. It was unveiled in 1989 according to the rules defined in SGML (Byran 1997 and Encarta 2002). In other words, it is a language which converts paper documents into web pages. Although an informative web page can be built and well presented with HTML, the information is served up raw and is difficult to be analysed, extracted, sorted, styled and customised (ISXUG 2002). As elaborated by Smith (1992), embodied in SGML are the logical structure and the layout structure which refer to the elements (or

<sup>7</sup> ISO 8879:1986 Information Processing – Text and Office Systems – Standard Generalised Markup Language

<sup>8</sup> International SGML/XML Users' Group (ISUG)

<sup>9</sup> Organisation for the Advancement of Structured Information Standard (OASIS)

contents) of the information and the styles of presentation associated with the information respectively. Therefore HTML makes the most use of the layout structure of SGML. Rubinsky and Maloney (1997) points out that "...HTML taps only a small fraction of SGML's potential.". HTML is simply too simple and unstructured to support communications because it only supports freedom data exchange (eConstruct 2000).

## XML

In order to efficiently transmit SGML documents over the Internet, discussions were started to develop a subset of SGML, which is now called XML, in 1996 (Bryan 1997). According to Walsh (2002), XML is a mechanism to identify structures in vector graphic, e-commerce transactions, mathematical equations, object meta-data and other kinds of structured information. IXSUG (2002) describes XML as "... a lightweight cut-down version of SGML which keeps enough of its functionality to make it useful but removes all the optional features which make SGML too complex to program for in a Web environment." IXSUG (2002) clearly distinguish the difference of HTML and XML with an example in a computer business, it is hereby modified as follows:

In HTML:	In XML:
<p>&lt;p&gt;100x100 mm white glazed ceramic tiles &lt;br&gt;HK Tiles Company Ltd. &lt;br&gt;\$20/pc</p>	<p>&lt;product&gt; &lt;model&gt;100x100 mm white glazed ceramic tiles&lt;/model&gt; &lt;supplier&gt;HK Tiles Company Ltd.&lt;/supplier&gt; &lt;unit rate&gt;\$20/pc&lt;/unit rate&gt; &lt;/product&gt;</p>

Source: Modified from IXSUG (2002)

**Table 1** A simple comparison of HTML and XML

If an Internet browser supports HTML and XML, both of the above sets of information may look the same on the screen. However, the computer can identify the nature of each piece of information with the aid of extended markups or tags (e.g. model, supplier, unit rate, etc..) in XML. IXSUG (2002) comments that "HTML tells how the data look like, but XML tells you what it means.". As quoted from Cameron G. Smith<sup>10</sup>, "...XML is exciting as it provides an ideal mechanism for overcoming the historic difficulties of data exchange across application and organizational boundaries,...." (SteelBuild 2000). This in turn facilitates exchange and interoperation of information. However, XML requires the definition of schema<sup>11</sup> or library or specification by individual industries. It is clearly emphasised by SIENE that "XML is not an information standard although there is confusion as to what it really is. XML is simply a data structure" (SIENE, 2001). Therefore, there exist a number of subsets including ebXML, aecXML, bcXML and ifcXML. The general orientation and position of these subsets are as follows:

### ebXML

ebXML (Electronic Business XML) is a joint initiative of the United Nations (UN/CEFACT) and the Organisation for the Advancement of Structured Information Standards (OASIS). It took one and a half years to publish seven technical specifications (ebXML 1.0) in addition to a number of technical reports and white papers in May 2001 (Walsh 2002). According to ebXML (2002), the mission is "To provide an open XML-based infrastructure enabling the global use of electronic business information in an interoperable, secure and consistent manner by all parties." In January 2002, the Government of Hong Kong funded US\$1.2 million to the Centre of E-Commerce Infrastructure Development<sup>12</sup> (CECID) to use ebXML to develop e-commerce software infrastructure and conduct pilot projects in Hong Kong (CECID 2002). It indicates the globalisation potential of ebXML.

### bcXML

bcXML (Building and Construction XML) is the product of eConstruct initiated by a group of European construction-related organisations in 2000. It consists of a specification which defines the framework

<sup>10</sup> CEO of Meridian Project Systems (MPS)

<sup>11</sup> "A *schema* is a model for describing the structure of information. It's a term borrowed from the database world to describe the structure of data in relational tables. In the context of XML, a schema describes a *model* for a whole class of documents." Walsh (1999)

<sup>12</sup> A research centre of the Department of Computing and Information Systems of the Hong Kong University.

for the definition of bcTaxonomy and an XML vocabulary in the building and construction industry (eConstruct 2000, eConstruct 2002). The shortcoming of bcXML is that eConstruct was only a two-year research project which had been finished already. The maintenance and sustainability are in question. eConstruct (2000) realises the threat of ebXML and takes into consideration of the future implementation of and bridging with ebXML.

## **aecXML**

aecXML (Architecture, Engineering and Construction XML) was publicly launched by Bentley Systems, Inc. in August 1999 and subsequently under the administration umbrella of the International Alliance for Interoperability (IAI) as a working domain (SteelBuild 2000 and Harrod 2000). Zhu (2001) states that the objective of aecXML "... is to establish procedures, rules and policies for managing and developing aecXML schemas ....". An XML schema is described as the structure of an XML document (W3C 2002).

## **IFC & ifcXML**

IFC (Industry Foundation Classes) was released by the International Alliance for Interoperability (IAI) in 1997. It is an object model representing information content and structure that needs to be shared and exchanged. That means the model provides a formal specification of requirements for the software houses to develop IFC-compliant software applications across all disciplines (IAI 2002). The IFC object model is represented electronically using the EXPRESS language<sup>13</sup> defined by ISO. Data exchange can then be implemented by STEP. Thus, IFC is a subset of STEP. It leads to a common misunderstanding about the co-existence of IFC and XML (Liebich 2001). As mentioned, XML is simply a data structuring language (like EXPRESS) which requires the definition of schema or library or specification (i.e. the object model) by individual industries. Thus the IFC object model can well be fitted into XML. In view of the growth of XML, IAI started to develop the ifcXML which bind the original IFC EXPRESS schema to XML schema in early 2001 (IAI 2002).

## **STEP (ISO 10303)**

The STEP (Standard for the Technical Exchange of Product Model Data) is officially documented as ISO 10303 and the initial release was published by the International Organisation for Standardisation in 1994. It aims to provide a mechanism that is capable of describing product data throughout the life cycle of a product, independent from any particular system (ISO 2002). Reschke and Tucker (1996) further elaborates that STEP creates data interchange formats and standardised application programming interfaces (APIs) that enable the flow of product data between different software applications. The primary difference to SGML and its family standards is that STEP is the standard for representation and interchange of product data<sup>14</sup> (Shaw 1999) whereas SGML deals with product documentation<sup>15</sup> (Smith 1992). In fact, engineering enterprises such as McDonnell-Douglas, Boeing, Rolls-Royce (Owen 1997), BMW, Volvo and Bosch (Ungerer and Buchanan 2002), etc. have adopted STEP with success. The use of STEP, facilitated by some sorts of Product Data Management (PDM) systems and Interfaces, enables the transfer of product data between development partners and facilitates integration with the CAD systems (Gollnitz, et. al. 2001, Ungerer and Buchanan 2002). As compared to the manufacturing industry, the construction industry is considerably fragmented (CIRC 2001) and its products (i.e. buildings and infrastructures) may vary significantly from one project to the other. The adaptability of STEP would need further investigation.

## **CITE**

CITE (Construction Industry Trading Electronically) is not a standard. It is an organisation which was formed in the UK in 1995. With the collaboration of the professions, contractors, sub-contractors and suppliers, CITE has developed a set of information exchange standards and associated software for working on invoices, quotations, tenders, project information, etc.. CITE claims that the standards can

<sup>13</sup> ISO 130311 (Part 11) – "...consists of language elements which allow an unambiguous data definition and specification of constraints on the data defined and by which aspects of product data can be specified." (ISO 2002)

<sup>14</sup> Originally designed for 3-D CAD models in the product design and manufacturing world. "Product data is most often associated with the description of the processes of design and manufacture. The data it encompasses is most frequently associated with the physical aspects of products." (ISO 1995)

<sup>15</sup> Originally designed for any documents in the publication world. "Product documentation, on the other hand, is more frequently associated with the description of the processes of operation, maintenance, and other user-oriented activities." (ISO 1995)

be in the formats of flat file ASCII, EDIFACT and XML. In addition, CITE also accredits other commercial software which adopt CITE standards for interoperability (CITE 2002). The idea of CITE is in line with the objective of common standards and interoperability, but companies have to become paid-members before enjoying the benefits. It is not as comparable as the free open standards of XML and STEP.

## **EDI and UN/EDIFACT**

EDI (Electronic Data Interchange) is also not a standard. It is a concept of transferring structured data from one organisation to another via an electronic link between computers (Leyland 1993), which was initiated in mid-1960s by a group of transportation, grocery and retail companies (Millman 1998). Over the decades, many EDI standards have evolved from different arena but only the UN/EDIFACT (United Nation/Electronic Data Interchange for Administration, Commerce and Transport) and ANSI X12 (American version of EDIFACT) are widely recognised (GOT EDI 2002). Although EDI has been applying in business to business context in many sectors including the Government (Inland Revenue 2002), it has a number of limitations. Millman (1998) mentions that “One major complaint consistently haunting EDI is its high cost of acquisition and implementation” resulting from buying EDI-enabled software, setting up the dedicated networks or value-added networks (VAN) services, paying annual software maintenance contracts and ongoing telecommunication charges. EDI is inflexible, expensive and therefore mostly available in large companies where the cost can be offset by the increase in efficiency (Millman 1998, eConstruct 2002).

## **CONCEPTUAL FRAMEWORK OF INFORMATION STANDARDS FOR THE WPIS**

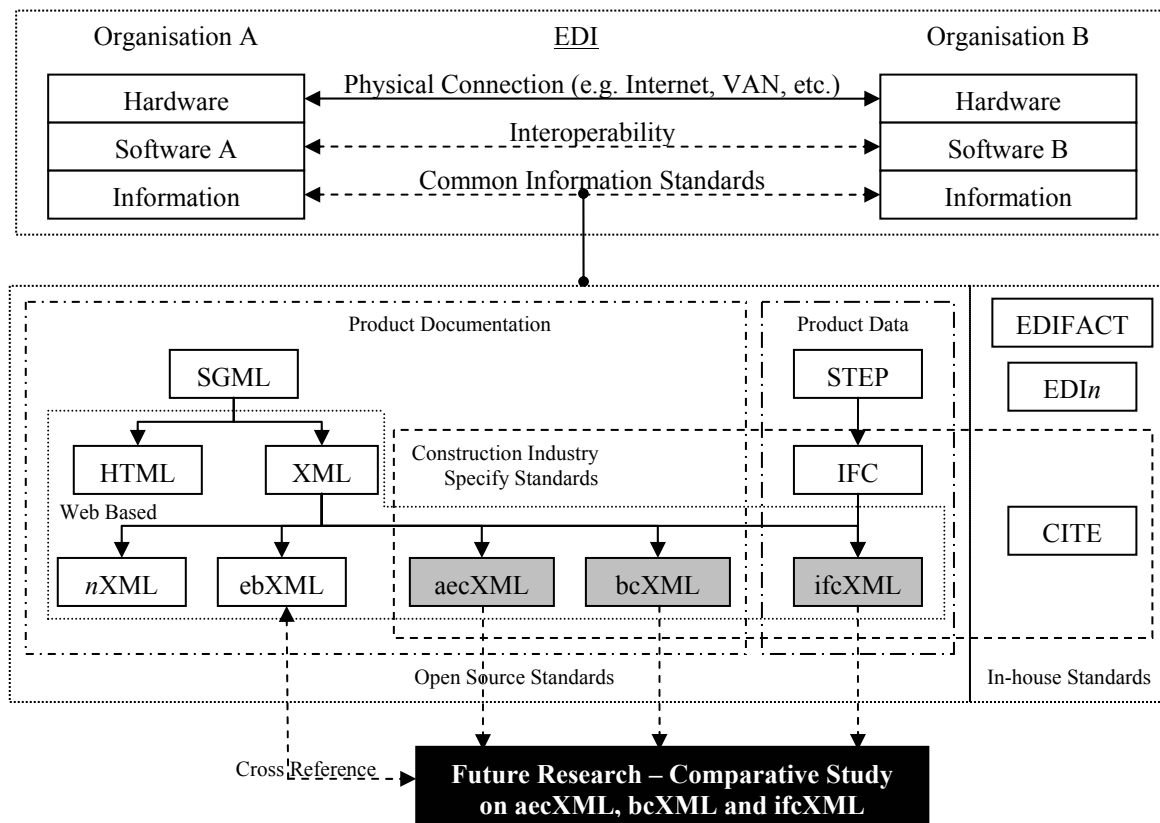
The literature review on the above information standards shows that it would not be a simple task to adopt overseas initiatives as the WPIS. As mentioned, XML is only a methodology of structuring data rather than an information standard. It is the various organisations which build the standards (e.g. bcXML, aecXML, etc.). Apart from that, SIENE (2001) also adds the following key problems as to the existence and use of current standards:

- *“There exists too many standards, and that people find it very difficult to keep up to the pace of development.*
- *There are too many overlaps between the standards.*
- *People are confused as to what they want to achieve with the standards.*
- *The scope and status of the standards is unclear as it is too broad.*
- *There are problems involved when using the standards in the fragmented construction industry.”*

Further investigation on the suitable WPIS rests on an in depth analysis of the operations, similarities and differentiations of these standards. Although the standards discussed before only show their background and fundamental interrelationship, it crucially sets the direction for further investigation. As diagrammatically depict in Figure 2, these standards are grouped into either open-source<sup>16</sup> standards or in-house standards. The formers are further divided into two mainstreams, namely SGML and STEP, for standardisation of product documentation and product data respectively. Underneath the SGML are HTML and XML, but it is clear that XML is the one which can deal with both information structuring and presentation. Since the basic concept of Works Bureau’s ESD is to enable project participants to exchange information over the internet via an open standard for software applications to be interoperable (Works Bureau 2002), therefore further investigation should focused on web-based open-source standards and in particular those standards specifically designed for the construction industry, i.e. aecXML, bcXML and ifcXML. Among them, priority will be given to ifcXML due to its ability to harmonise STEP and XML, but ebXML will be cross referenced as there is a new local initiative to use ebXML in Hong Kong.

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<sup>16</sup> The basic idea behind open source is that one can read, redistribute, and modify the source code for a programme for free. (Open Source Initiative 2002)



Note: *n* denotes that there are other classes along a particular standard, but this paper only focuses on the mainstream standards and those standards specially designed for the construction industry.

**Figure 2** Conceptual framework of current information standards

The information standards actually form part of the EDI which consists of organisations, hardware, software, physical connection and information. The interoperability of two or even more software applications, with regard to data exchange among organisations, depends on the consistence and integrity of the information standards being adopted. It is stressed that this paper is and the future research direction will only focused on information standards with an objective to propose suitable WPIS for the Works Bureau. There is strong evidence that this intention would in line with the global research and development towards a new generation of information exchange based on XML. The ICCI<sup>17</sup> cluster project in Europe collectively represents a number of current research projects in Information Communication Technology (ICT) in the construction industry (ICCI 2002). Zarli<sup>18</sup> et al (2002) highlights the evolution of new requirements for new applications, infrastructures and services over the Internet, which "...could generate a tangible step towards ICT-based enhanced automation, integration and communication, transforming the Internet as the central core of mission-critical infrastructures for business-critical processes.". The prodAEC<sup>19</sup> is another European network which is implementing a strategy towards a common open framework for product and business data exchange in the AEC sector (Jardim-Goncalves et al 2002). For long-term sustainable solutions, the development of WPIS should take the deliverables of these large scale overseas projects into account.

<sup>17</sup> ICCI – Innovation co-ordination, transfer and deployment through networked Co-operation in the Construction Industry

<sup>18</sup> Coordinator of ICCI

<sup>19</sup> prodAEC - European Network for Product and Project Data Exchange, e-Work and e-Business in Architecture, Engineering and Construction

## CONCLUSIONS

At an early stage of an on-going research project entitled "Information Standardisation and Interoperability in the Hong Kong Construction Industry", the objective of this paper is to present a review of the available project information standards and to identify the future research direction. This project is akin to a new initiative in developing Work Project Information Standards (WPIS) and associated software infrastructure by the Works Bureau of the Hong Kong Government. Through the literature review, a framework of information standards has been conceptualised. It is revealed that aecXML, bcXML and ifcXML would be the key standards for web-based data exchange. Future research should be focused on an in-depth study into these standards and their real life applications. As all of them are rooted in the XML family, identification of their similarities and differences is essential for the development of a theoretical model of information standardisation and interoperability. The model would be a helpful tool for harmonisation of existing project information standards. In respect of the WPIS, this paper recommends the Government to commit further studies before setting another or sticking to a particular standard and to keep abreast with the deliverables from overseas research projects.

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