A Sustainable Urban Collaboration Hub – SUCH

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Abstract

The challenge nationally and internationally, is to develop sustainable buildings and cities. To do that requires continuous information about the real estate and city properties. The information needs to be collected, stored, processed, integrated, extracted, visualized and interpreted. The proposal of this paper, the Sustainable Urban Collaboration Hub, SUCH, is based on the experience and results from the BIM Collaboration Hub and the research in the EU project InPro. It is expanding the scope of both CIC, Computer Integrated Construction, and BIM by defining the architecture and concepts of the virtual world. The development of SUCH is taking place at KTH in Stockholm, Sweden.

With projects becoming more and more complex, and the focus changing from files to a multitude of objects, a need for BIM repositories or BIM servers will become a necessity for the ability to manage changes and consolidations/synchronizations of heterogeneous applications. In addition to heterogeneous applications the support of heterogeneous data models will be an additional requirement as the scope of the information management expands from the individual building to groups of buildings and also to the infrastructure and civil works in cities.

A BIM standard like IFC can manage snap-shots of the information, but to manage the whole life cycle, there is a need for a standard like PLCS, Product Life Cycle Support, which supports some critical business needs faced by companies as they seek to implement Product Lifecycle Management (PLM) and other broad enterprise-based initiatives.

SUCH will extend the application of BIM to city blocks, cities and infrastructure. These domains have never had any sustainable support for data models and tools.

Keywords: BIM repository, IFC, PLCS, through life support, sustainability

1. Introduction

The challenge nationally and internationally, is to develop sustainable buildings and cities. To do that requires continuous information about the real estate and city properties. This information is of many kinds, such as material properties, energy consumption, concentration of air pollutants and flows of people. The information needs to be collected, stored, pro-

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cessed, integrated, extracted, visualized and interpreted, something that requires advanced information systems and deep domain knowledge.

BIM, Building Information Modelling, represents an important step in the development. What is still missing is the life-cycle perspective, i.e. the endurance dimension combined with BIM.

To date, BIM has mainly addressed buildings, but in the future there is a need for additional structured and open information related to infrastructure, roads and other constructions necessary for modelling real estates and cities. To monitor and control the real estates and characteristics of cities over time requires new and more sophisticated information systems that combine the benefits of BIM with the value of life cycle assessments (from requirements, planning, production, operation, and finally to recovery).

This paper relates to development and commercialization of such a system/platform, which extends the application of BIM to city blocks, cities and infrastructure. These domains have never had any sustainable support for data models and tools.

The goal is to develop a scalable platform that consists of a unique and effective web-based tool / system that supports monitoring, support and control of planning, construction, operation and management, and recycling of buildings and entire cities. Information is integrated, shared and analysed; ideas and proposals are developed, presented and communicated through the city planning processes.

To enable a long-term working collaboration, between the various stakeholders of the city, both integration and consolidation of information models in a common information platform is needed. BIM repository, BIM server, and Model Server are some of the names on this emerging concept.

2. BIM repositories

IFC, and many other exchange standards, can only handle snapshots of the information. In order to manage the entire life cycle of a construction, there is a need for standards like PLCS, Product Life Cycle Support (ISO 10303-239, 2012). The BIM Servers like the BIM Collaboration Hub (Tarandi, 2011) can secure collaboration both within the organization, as well as within Extended and Virtual Enterprises with their various actors involved. The PLCS standard, Figure 1, will enable linking of product information to maintenance information throughout the product lifecycle, called Through Life Support (TLS), which is applied in other industries, e.g. in the aerospace industry.

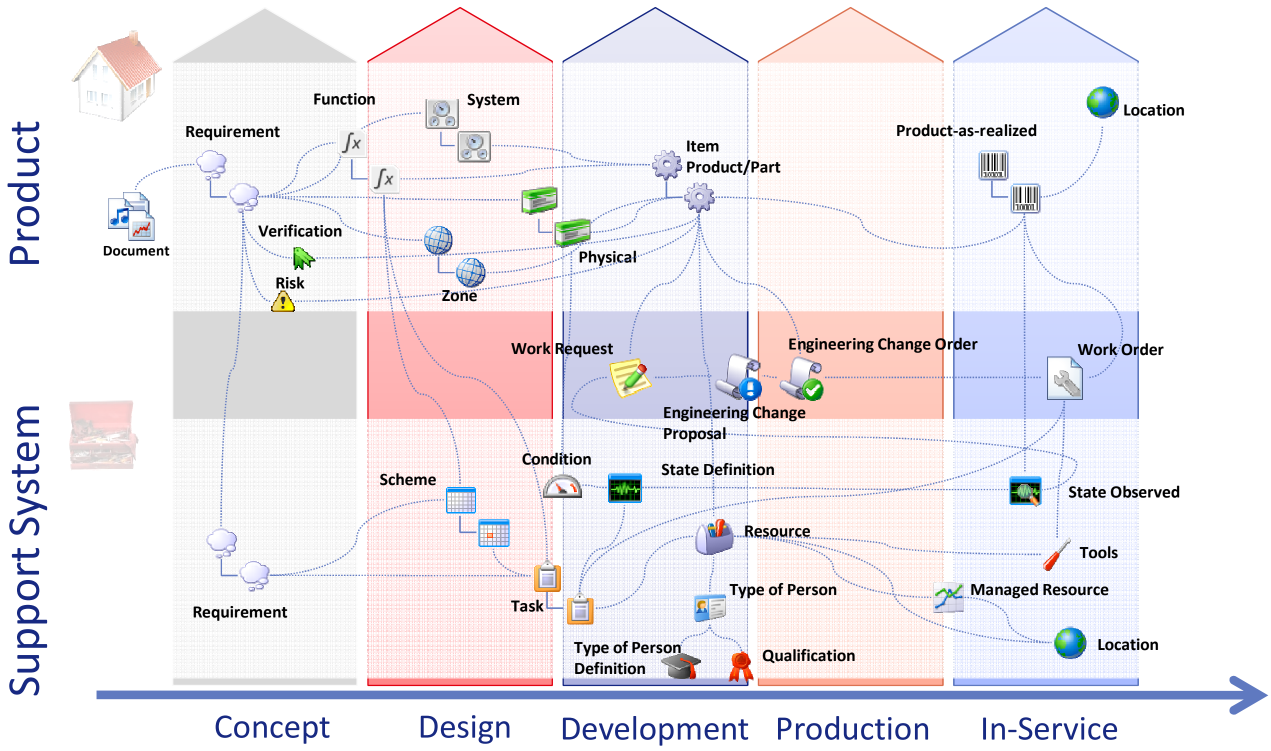

Figure 1: ***Main Business Objects of the PLCS standard.***

Now this is applicable also for the construction and real estate sector, as demonstrated in the EU project InPro (Tarandi & Houbaux, 2010; Tarandi, 2011) by the implementation of the BIM Collaboration Hub. For the construction sector TLS is a new approach and has few international and national implementations. Only a few platforms based on the open international standard PLCS are available today, and in these cases only limited support is utilized.

In the discussion of justification for BIM utilization, Jung and Joo (2011) compare two current views on structuring information and processes in the construction industry – Computer Integrated Construction, CIC, and BIM. They formulate a framework to capture characteristics of different aspects for comparison of the business benefits of different solutions. Their findings show that both these ways of looking on the tools and activities are converging and also being depending on the distinct characteristics of organizations and projects. The CIC view focuses on the integration of multiple dimensions, like 3D, time and cost. Without a common data model as a base, it proves to be difficult. The same is valid for BIM, when it comes to the need for a common data model. According to Jung and Joo (2011) there is no significant difference between the concepts of CIC and BIM.

The proposal of this paper, the Sustainable Urban Collaboration Hub, SUCH, is based on the experience and results from the BIM Collaboration Hub and the research in the EU project InPro. It is expanding the scope of both CIC and BIM by defining the architecture and concepts of the virtual world, the Mirror World (Gelernter, 1992), where the objects – representing building elements, spaces, and processes of the real world are the information carriers rather than the existing authoring and managements tools of today's industry. "You will look into a computer screen and see reality" (Gelernter, 1992).

Eastman et al. (2011) identify the common information repository – the BIM server – as one promising emerging solution. They argue that the “evolutionary change in the AEC field from managing files to the managing of information objects has only begun to take place”. With projects becoming more and more complex, and the focus going from files to the multitude of objects – very management and granularity dependent – a need for BIM repositories or BIM servers will become a necessity for the ability to manage changes and consolidations/synchronizations of heterogeneous applications.

Eastman et al. (2011) add the transaction granularity and frequency on the project, building, object, and attribute as fundamental for the configuration of BIM servers.

In addition to heterogeneous applications the support of heterogeneous data models will be an additional requirement as the scope of the information management expands from the individual building to groups of buildings, and also the infrastructure and civil works in cities.

The requirements on a BIM repository, according to Eastman et al. (2011), include:

- User access control
- Representation of users associated with a project
- Read, store, and write native data models
- Read, store, and write open standard model data
- Manage object instances and read, write and delete them
- Support product libraries for incorporating product instances
- Support storing product specifications and maintenance/service information
- Store e-business data, for costs, suppliers, etc.
- Provide model exchange capabilities for remote users, e.g. web access
- Manage unstructured forms of communication

Based on the arguments for a BIM Collaboration Hub, by Tarandi and Houbaux (2010), and Dumoulin, Benning, and Tulke (2011), the list can be extended by:

- The complete object model
- Aggregating models provided by different disciplines
- Exporting and importing partial models
- Managing workflows and changes
- Exchanging information with the hub using a neutral exchange format, e.g. IFC

The limited integration of information and automation systems supported by BIM applications of today are described in the CIB white paper on IDDS, Integrated Design & Delivery Solutions (Owen, 2009). To implement IDDS requires improvements in work processes, technologies and people’s capabilities to span the entire lifecycle of the building creation related processes including environmental issues (Owen, 2009).

3. The Sustainable Urban Collaboration Hub

The development of the Sustainable Urban Collaboration Hub, SUCH, see Figure 2, is now on-going at the Royal Institute of Technology, KTH, in Stockholm, at the department of Project Communication. It is partly funded by Vinnova, the Swedish Governmental Agency for Innovation Systems, in the program “Sustainable Attractive Cities” (Vinnova, 2012).

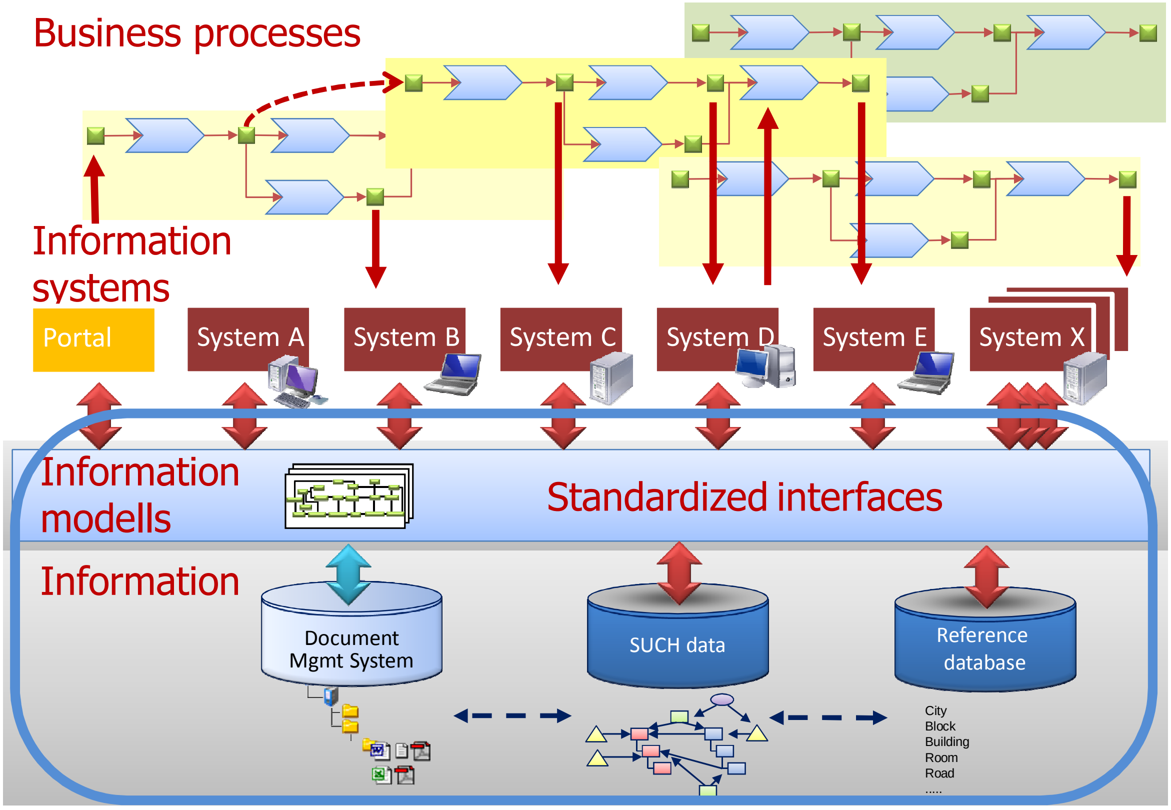

Figure 2: The architecture of the Sustainable Urban Collaboration Hub, SUCH

A further development of the BIM Collaboration Hub for building design, production, operation and management to also include cities and infrastructure, supporting analyses, evaluations, and guidance towards sustainability goals will be the result. The different applications and associated methodology will be productified and packaged by actors in society through the access to relevant and valid life-cycle oriented information.

With a collaborative environment and developed methodologies, software support and defined information content, conditions are created for development of new services, see Figure 3, where the real world and the mirror world are related by e.g. sensors.

The base for SUCH is the result from the InPro project – Open Information Environment for Knowledge-based Collaborative Processes throughout the Lifecycle of a Building – which was a project within the 6th framework of the European Commission ending in November 2010 (Sebastian, 2011). One result of InPro was the BIM Collaboration Hub (Tarandi, 2011), which was the platform for the model-based and collaborative work over the life cycle of the construction, in InPro mainly buildings. The implementation of the BIM Collaboration Hub was based on the model server Share-A-space from Eurostep (2012).

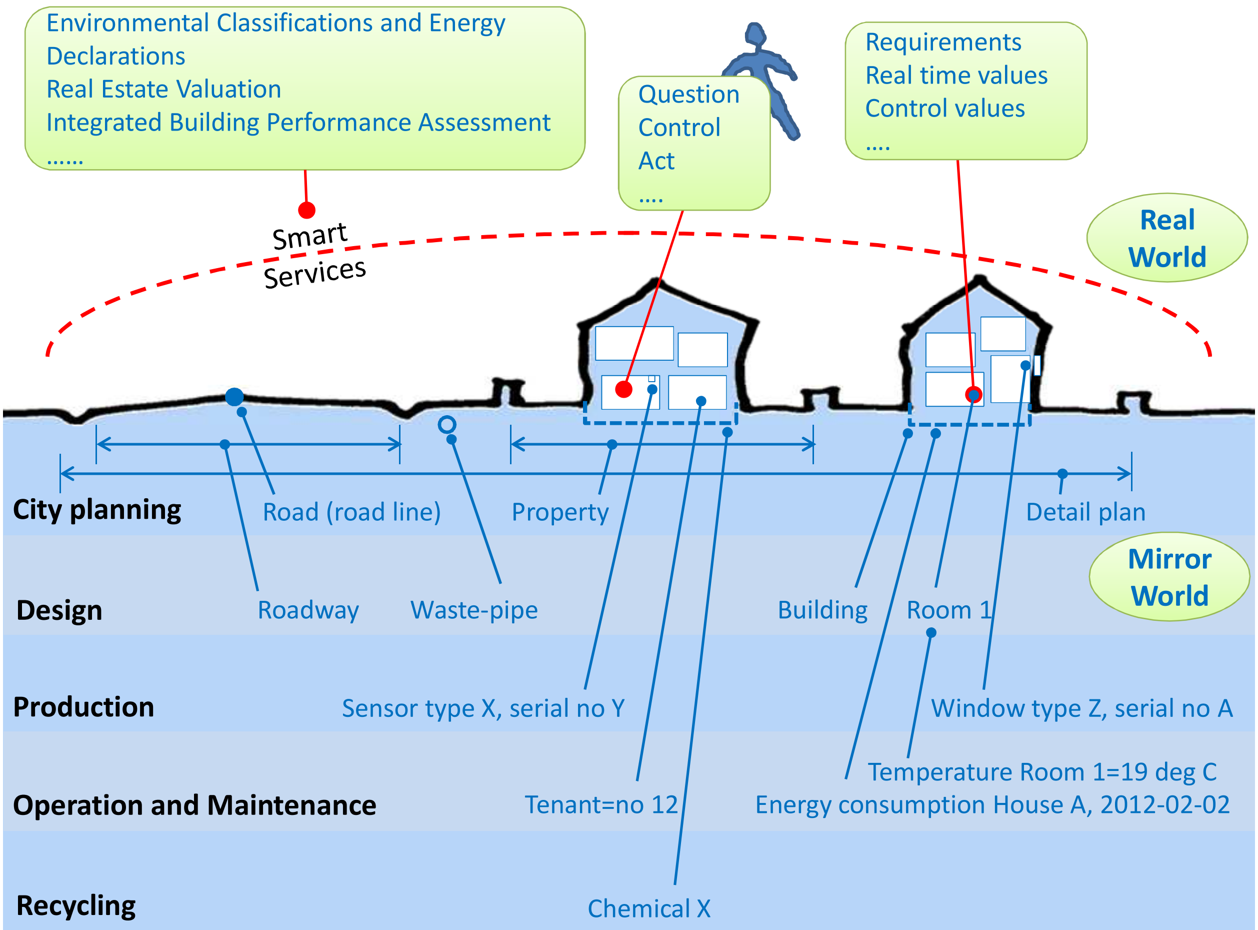

Figure 3: ***Information in the Mirror World, with services for the Real World. (The values of properties are examples only)***

The different views on information models and their usage in the industry confirm that the SUCH proposal is in line with them and fulfil most of the requirements. With design change proposals and workflows related to the object model, an efficient platform can be built.

The BIM Collaboration Hub was based on the open BIM standard IFC 2x3 (buildingSMART, 2011), and PLCS, Product Life Cycle Support, ISO 10303-239 (ISO, 2012) an open exchange and sharing standard was added as the framework to support the life cycle related information exchanges, not covered by IFC. In the InPro work, with all the key processes defined for early project phases, structured requirements, documents and information from other data models than IFC needed support and linking to the building information. This need to extend the scope of BIM has also been identified in the development of the IDDS white paper, where it is described as the next step in the evolution (Owen, 2009). In the definition of the scope for SUCH, the need for extending the BIM model into support of blocks, cities and infrastructures was evident.

The need for managing multiple heterogeneous data models was identified and the solution was to continue with the work started in InPro. Multiple data models to map to one common and neutral information model, PLCS, where the commonly agreed concepts are the targets. These targets were in the BIM Collaboration Hub the concepts corresponding to the building and spatial elements of the IFC data model, (buildingSMART, 2011).

3.1 Mappings from IFC data models to the BIM Collaboration Hub

The mapping of IFC to PLCS is one central function of the BIM Collaboration Hub. The typical IFC structure is shown in Figure 5 to the left. To the right is the corresponding high level structure mapping to PLCS. In the mapping, all the object geometries are treated as individual files linked to the objects. In the IFC mapping, the files are self-consistent IFC files. Reference geometry is taken out of the files to give location and rotation to the individual object.

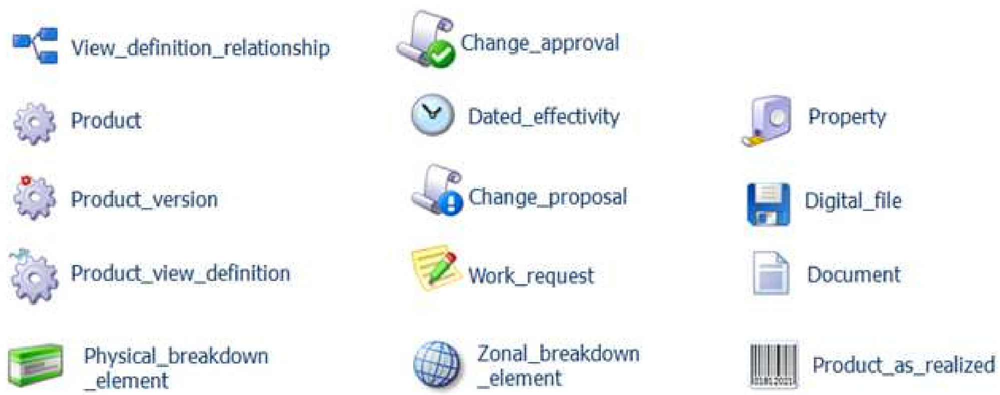

Figure 4: Legend – PLCS concepts

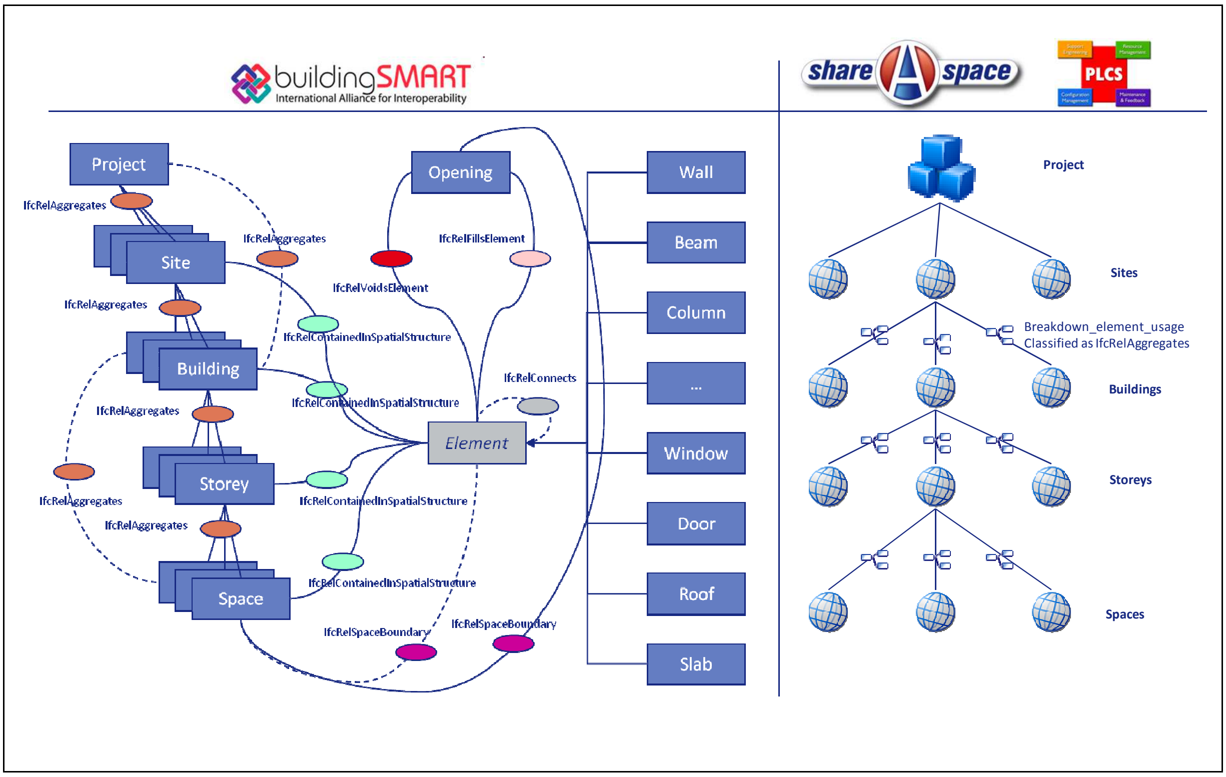

Figure 5: Typical IFC data exchange file structure and high level structure mapping

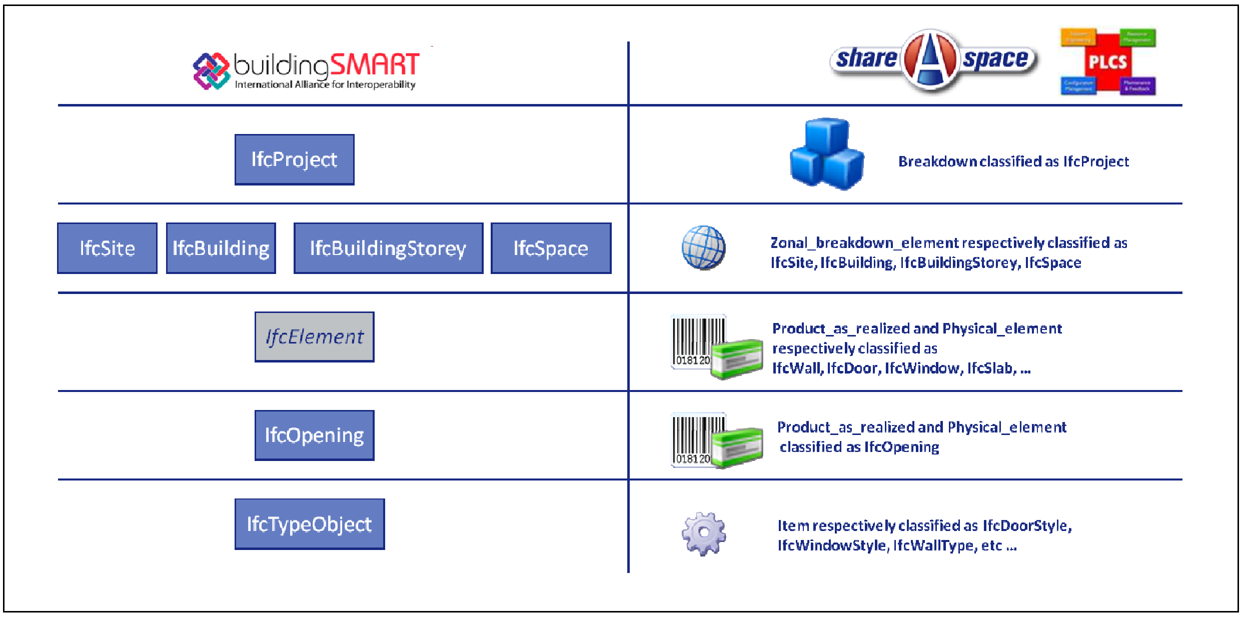

Figure 6: High level mapping from IFC to PLCS/SAs

The concepts of IFC are mapped to corresponding generic concepts of PLCS, see Figure 6. In the following figures, a number of important PLCS structures are illustrated for IFC model examples. In Figure 7, a Wall with the identifier 231 has 2 versions v1 and v2. v1 exists in the architecture design view, v2 exists in the architecture design and structural design views. The relationships are ordered and have different meanings if they are between versions or between views.

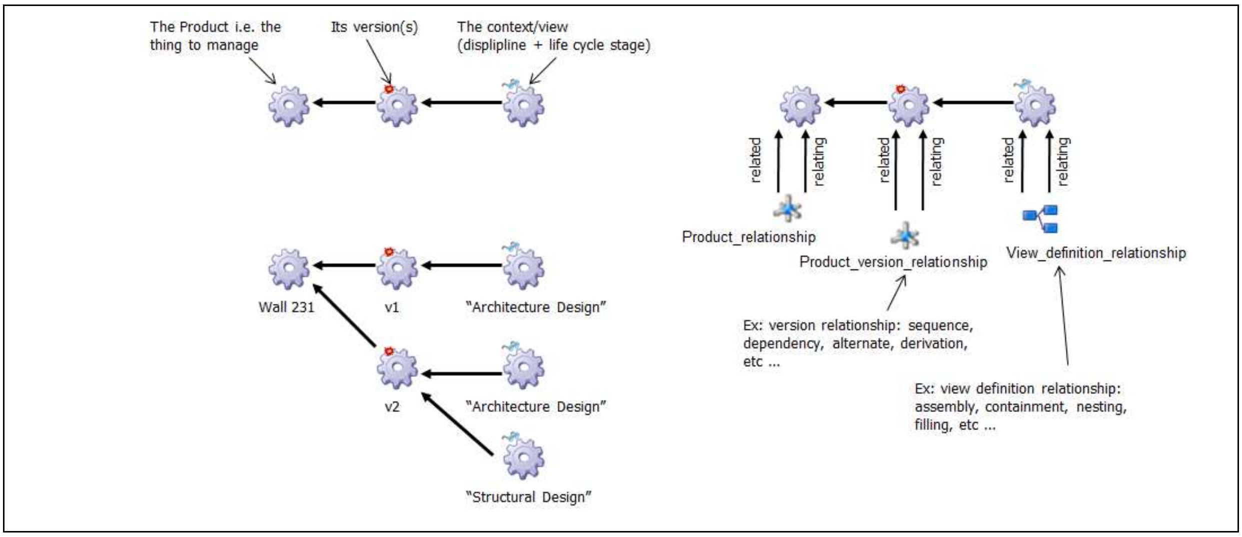

Figure 7: Products – product/version/view and relationships

Figure 8, illustrates how properties and documents are assigned to a product in the context of a view. The version v1 of the wall 231 has the properties (height and length) in the "Architecture Design" view and has 3 thermal properties in the "Thermal Design" view. The version v1 of the document YXZ is assigned to the version v1 of the wall 231 in the context "Architecture Design". This document version has 2 digital_files (one in html format and one in pdf format). Assembly relationships in PLCS are subtypes of view_definition_relationship, see Figure 9. This enables the definition of an assembly in the context of a view.

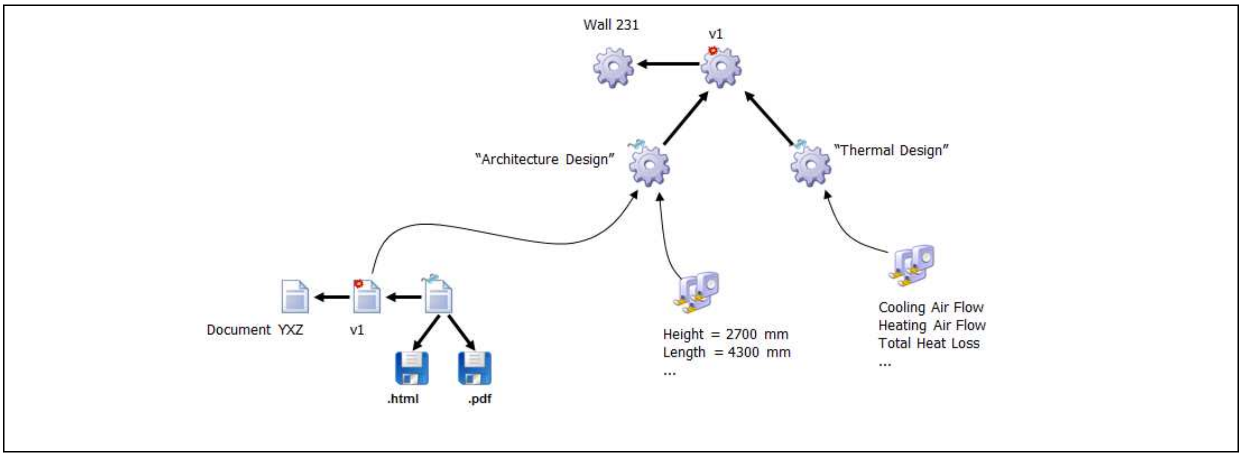

Figure 8: Products – properties, documents

In this example, the version v1 of the Wall 231 is nested by the version v2 of the Opening ABC in the "Architecture Design" view. If an effectivity is assigned on the assembly relationship, the validity of this structure can be controlled. It could be a proposed start date to indicate a proposal.

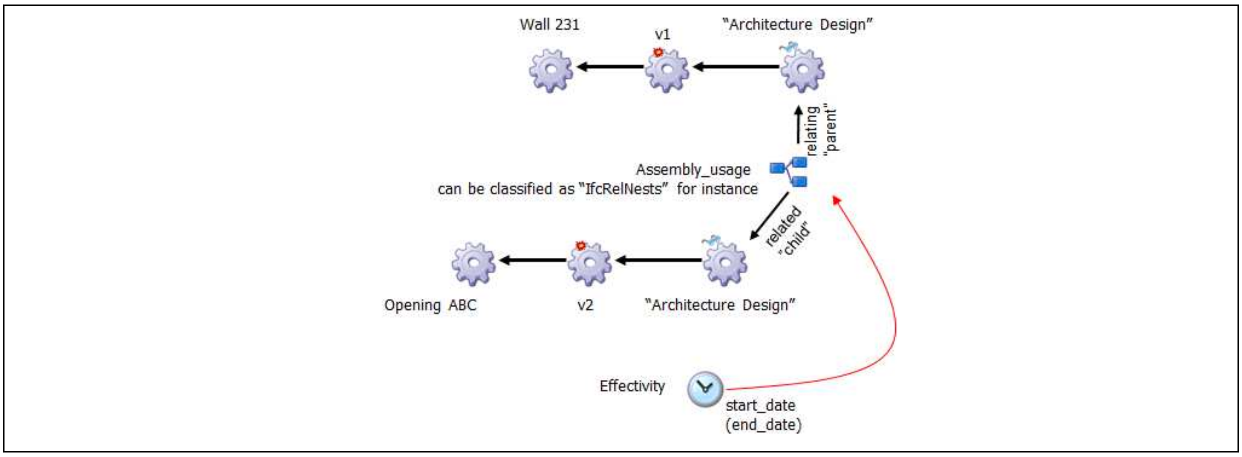

Figure 9: Assembly / structure / breakdowns – effectivity controlled

In Figure 10 and Figure 11 two examples of mapping between IFC and PLCS are shown.

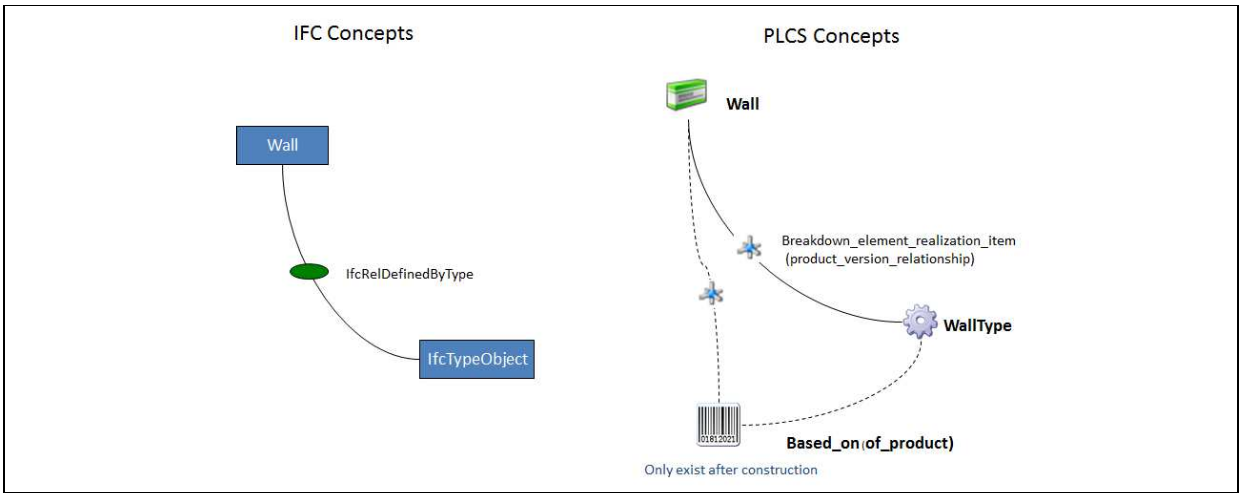

Figure 10: Mapping IFC to PLCS – Wall with type definition

The first illustrates how the physical_breakdown_element, the type, and also the realized product are related for a wall. In the second example the representation of a wall with an opening is presented.

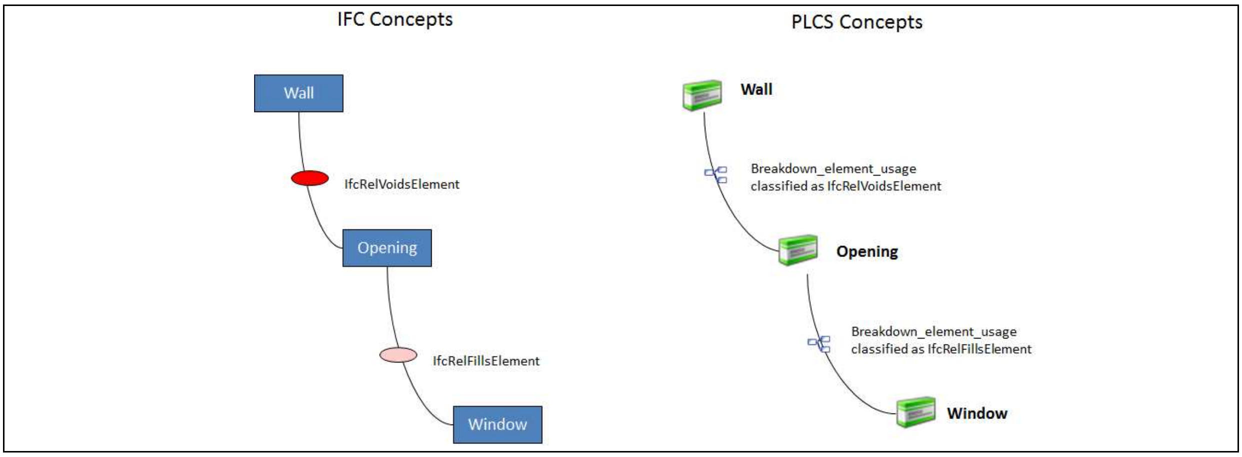

Figure 11:   Mapping IFC to PLCS – Wall with window

3.2 Mapping from heterogeneous sources with different taxonomies/ ontologies

In Inpro the mapping was done between the IFC data model and the PLCS generic breakdown structures for zonal and physical breakdown elements. IfcSite, IfcBuilding, IfcBuildingStorey and IfcSpace are all mapped to zonal_breakdown elements. For another type of construction, like roads with their specific spaces like lane spaces etc., the mappings can also be done to zonal_breakdown elements with their specific classifications attached. In the PLCS data model these different object structures can then be linked using the View_definition_relationship, classified for specific usages. In Figure 12 the mapping of a new data model X to the PLCS data model is illustrated.

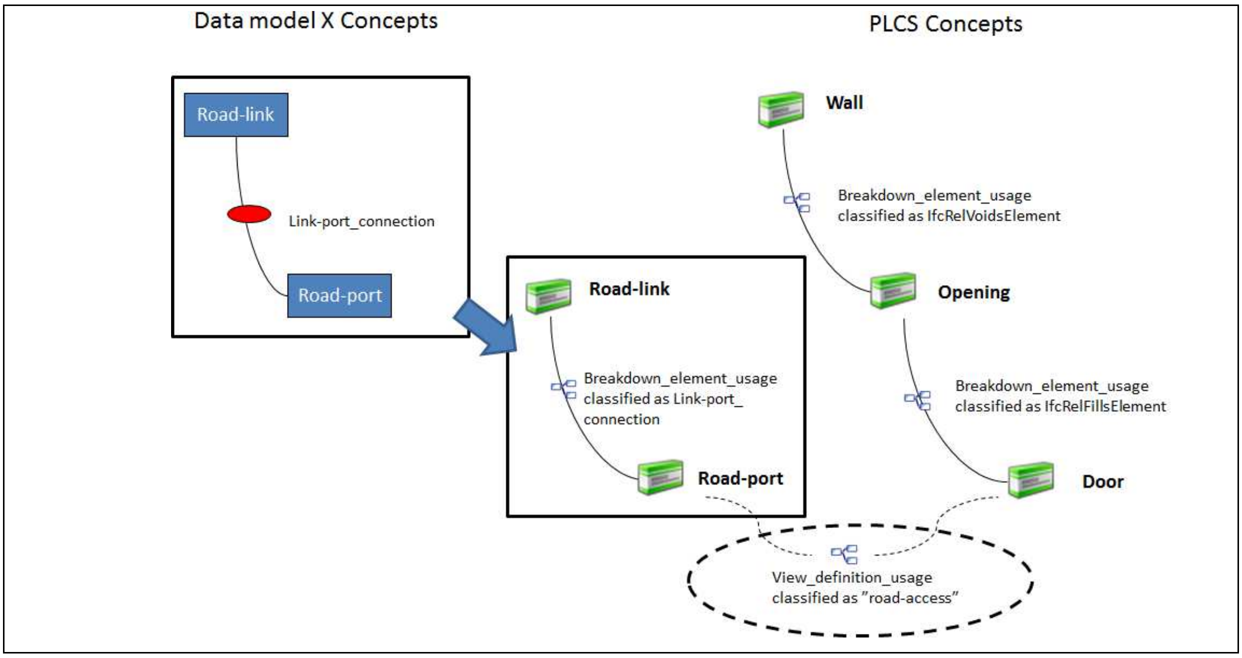

Figure 12:   Mapping of instances of data model X to PLCS and linking them

The instance example is then linked to an existing model object, Door, which can be automatically done if relationships or identities are associated with the imported data. Else, the linkage can be done manually through data base interfaces or by using other tools.

The number of possible data models for the Sustainable Urban Collaboration Hub is large to cover the area of interest. There are multiple overlapping data models for different phases of the life-cycle of constructions. In Figure 13, IFC and a number of other data models illustrate the possible extensions, overlaps and links between them. For each of them different exchange formats are used today.

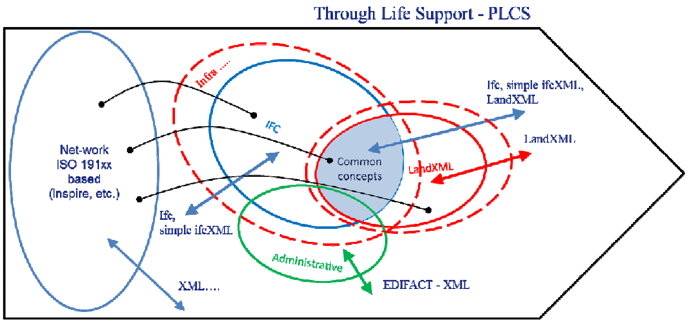

Figure 13: Integration of standards for buildings and infrastructure

The heterogeneous data models can be mapped to the common neutral through life supporting standard PLCS as illustrated by Figure 14.

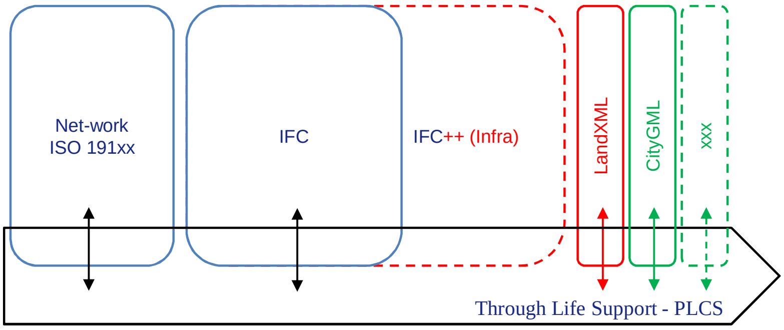

Figure 14: Integration of standards for infrastructure

All the concepts for the domain of interest must have a definition and name in PLCS, to be a valid alternative for mapping. E.g. there must be concepts for roads, road-links, road-nodes that are accepted by the users of the collaboration platform. Preferably this is based on existing open international standards. The concepts for the building domain are directly taken from the IFC standard (buildingSMART, 2011).

4. Conclusion

This paper presents the Sustainable Urban Collaboration Hub, a development based on the web-based Open ICT Platform, the BIM Collaboration Hub, from the InPro project. The architecture of the BIM Collaboration Hub with mapping of a generic data model to the through life supporting open international standard PLCS, opens for the integration of multiple heterogeneous data models/standards to enable the integration of information from different sources, phases and actors for the support of sustainable information for individual construction works and assemblies like cities.

The coming implementation will be done at KTH, Royal Institute of Technology, in Stockholm, Sweden. The platform will support multiple services, which will be defined and developed in cooperation with the construction industry.

One pre-requisite for implementing SUCH is to agree on common concepts for the domain – e.g. road, city block, and building, most of them to be taken from the IFC standard. Some potential problems and difficulties are lack of extensive classification of objects and properties, poor versioning of objects, and limited use of change management in applications and in the industry.

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