VISUAL PRODUCT CHRONOLOGY AS A SOLUTION FOR ACCESSING BUILDING PRODUCT MODEL DATA

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SUMMARY

Building product modelling technology is principally aiming for solutions which are capturing the data of gradually developing buildings. In simple terms these solutions can be characterised as storages where the most recent data and its updates exist. At the moment IFC standard is providing a common starting point for sharing building product model data between various applications. Having this as a starting point one major current challenge is to build methods and practical tools for accessing building product models. Here the term access means both data input and different analyses over building product model data. For example, the user needs to find out all building components where changes have appeared during certain period and visualise those in an appropriate level of detail. It is considered that these types of operations shall provide a true basis for wide acceptance and impact of building product modelling technology. Visual Product Chronology is an application, which can be used for linking data from various sources with the objects of building product model and for analysing the content of the resultant data storage. Development of Visual Product Chronology is proving improved understanding of various problems and their potential solutions when we are on way to develop applications enabling versatile but an easy access of building product model data.

INTRODUCTION

In nowadays construction business building design and construction tasks are often heavily overlapping. In this very dynamic environment frequent changes, continuous data updating and decision making based on incomplete data are state of the art practice. In this situation the building data as a whole is developing in a very turbulent way. It seems that these characteristics of modern operations are here to stay and new solutions needs to help companies for gaining success in this environment.

Product Data Modelling (PDM) systems are to capture building data within the process discussed. Naturally during building project development phase and construction operations these data are still incomplete and are often reflecting the proportion of design and planning completed. However the understanding of this status of design and planning operations is invaluable for the project management purposes. For example, the likelihood for successful implementation of the following construction phase can be assessed based on the status of design and planning.

The short discussion above demonstrates the usefulness of analysing the data content of PDM systems in a time window. For this purpose a concept and its application termed Visual Product Chronology is under development by the authors. VPC is intended for understanding the gradual development of a building in a time window based on data captured on a PDM system. VPC as a method is particularly covering visualisations over the various data and their interdependencies. This is aiming for understanding the ongoing building process, analysing and communicating plans and schedules, highlighting the missing or incomplete data. For example this can include: required client decision making, percentage of work drawings completed, status of deliveries, visualisations of current active construction tasks and their flow and comparison of the work progress estimate to the planned progress. This example covers only some aspects relating to the building construction but there are these types of practical data accessing needs during the whole building life-cycle.

The IFC technology is an important starting point for forming a generic VPC method. Here the work covers the specification of VPC using IFC. The paper shall provide a description of the work completed so far and the presentation of the PDM system environment where the VPC prototype is being implemented.

BACKGROUND

The development of IFCs (Industry Foundation Classes) product data model standard driven by International Alliance for Interoperability (IAI) has covered various interdependencies of building objects and their classifications [IAI99]. The most recent official IFC versions are capturing in a growing manner different possible objects and their data that can add value to building operations when shared between different organisations and their people. However, the understanding over the sharable data is improving all the time and, accordingly, the IFC standard is under continuous development.

Basically within IAI interoperability has been defined as “an environment in which computer programs can share and exchange data automatically, regardless of the type of software or of where the data may be residing”. This has created substantial amount of efforts where various interoperable software packages and relating solutions are developed, eg. within BLISS project (Building Lifecycle Information System). Recently the developments towards IFC Model Server framework and solutions have gained increasing attention. These store IFC object model within the database system and runs on the internet (Adachi, 2001).

The development of the Visual Product Chronology system is also relating to so called 4D area providing solutions for linking schedules with building components. Examples of the recent developments in this area have been presented in (Aouad & Lee 2002), (Barrett, 2000), (Fischer & Cam, 2002) and (Koo & Fischer, 2000).

PURPOSE OF VISUAL PRODUCT CHRONOLOGY

The leading idea behind the Visual Product Chronology system is to provide a solution for planning and management through visualisation of the life-cycle of objects. VPC links together various data from different sources enabling analyses that can considerably help practitioners to identify potential problems and quality of present plans for carrying out construction operations (Figure 1).

The purpose of VPC as described above provides a starting point for research and development, which would study the forming of objects in PDM system and the typology of various logical linkages relating to this phenomenon.

VPC system is taking advantage of a database where IFC product data is stored. This product data is created gradually using various IT tools, for example CAD systems, specific design software packages, planning and scheduling software and tools for site data gathering. In particular, the current version comprises the use of IFC 2.0 compliant CAD package and scheduling software (e.g. MS Project) for setting up IFC building product model that shall be next studied and developed further with VPC application.

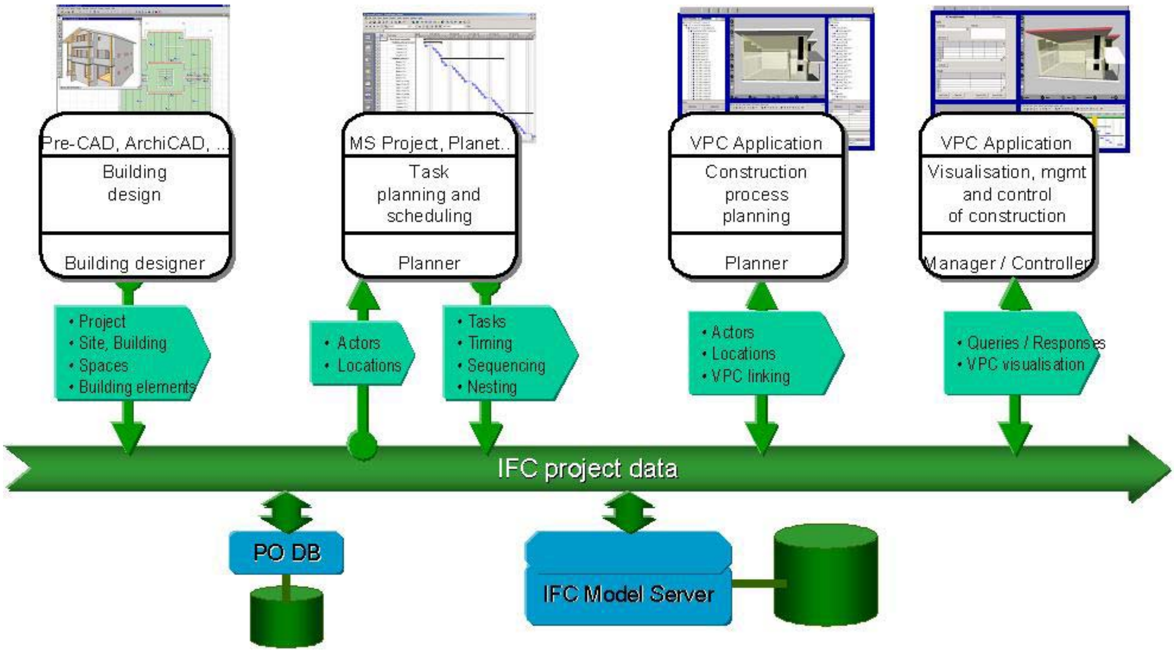


Figure 1 Flow of using Visual Product Chronology across gradually developing building product model data

LINKER

Visual Product Chronology (VPC) tool is divided into two components; VPC Linker and VPC Analyzer. With the VPC Linker, different objects are linked to each other to describe the various constraints of the building construction process. The VPC Analyzer then provides results of diverse analyses based on the constraints added in the VPC Linker. The results are displayed visually if applicable.

Linker is used to combine the IFC 2.0 3D building model together with the project schedule (MS Project at this point). This module is also used for updating the timing data when the schedule is updated. After linking the 3D model and fourth dimension (time), the resultant 4D model is saved in the IFC 2.0 format.
The linker module can be used also as a schedule preparation tool. This means that the user can show the construction sequences by selecting buildings components from the 3D visualisation on display. This can clearly improve the understanding of the detailed sequence of construction operations. This user interface is composed of four main parts:

1. *IFC Object browser*
2. *Property window for viewing detailed data of the selected IFC objects*
3. *Schedule object browser*
4. *Property window for viewing detailed data of components and for he selected schedule objects*
5. *Interactive 3D viewer for displaying selected components*
6. *Schedule viewer for displaying the schedule in barchart form*

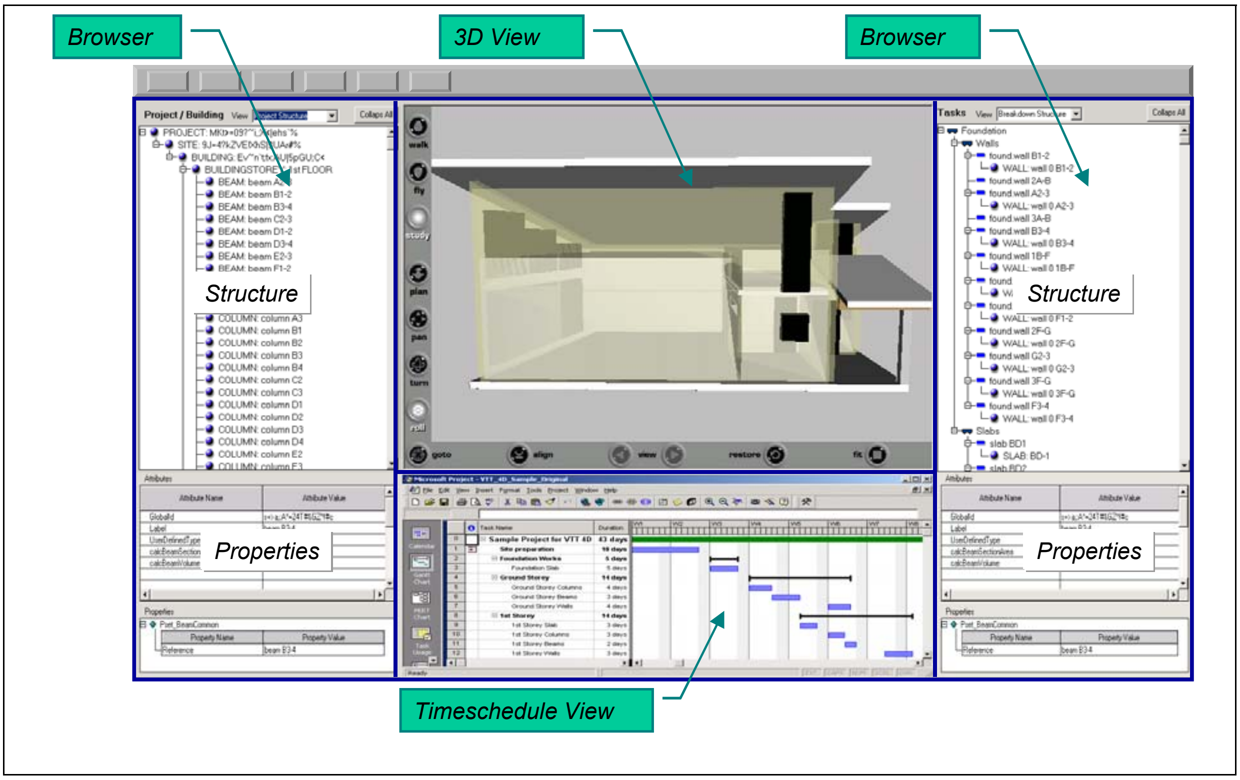


Figure 2 User interface of VPC Linker module

Only imagination and also to some extent IFC schema limits the type of objects that can linked. At the moment with VPC it is possible to link:

1. Geometry objects
2. Tasks
3. Actors
4. Locations

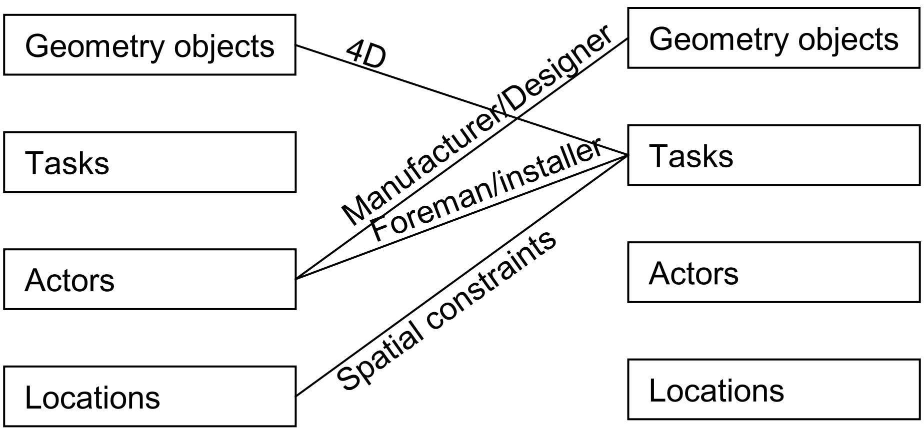


Figure 3 Current VPC use cases

Geometry objects - tasks

The traditional construction process visualisation, known as 4D, is created by linking 3D geometry objects and corresponding task. Typically a number of objects are linked to one task. It has proven to be very difficult to select the right objects just using a text list of objects. Hence, in the VPC Linker, the 3D view was introduced to be used also in selecting objects. Now the user either selects the objects in the list or in the 3D view and then links them to the task representing the realisation of those objects. It is possible to also link one geometry object to several task because typically in building construction many objects are revisited in the later phases of the process. For instance, a column is installed in the structure installation phase. Then perhaps the potential errors in the surface are corrected. Finally it will be painted or covered with some surface in the final phases of the process.

Actors – tasks

The linkage between actors and tasks have many potential applications; it can show the subcontractor who will realise a certain task or it can used to indicate the responsible foreman among the contractor organisation.

Locations – tasks

One of the most significant sources of problems during the construction process is the spatial congestion at the site. Different tasks require different amount of space when realised. For instance, a carpet installation typically reserve very large areas while installing radiators consume only a limited space for a short period of time. When the required space (=location) can be linked to the tasks, it is possible to study the optimal time buffer between tasks.

Actors – geometry objects

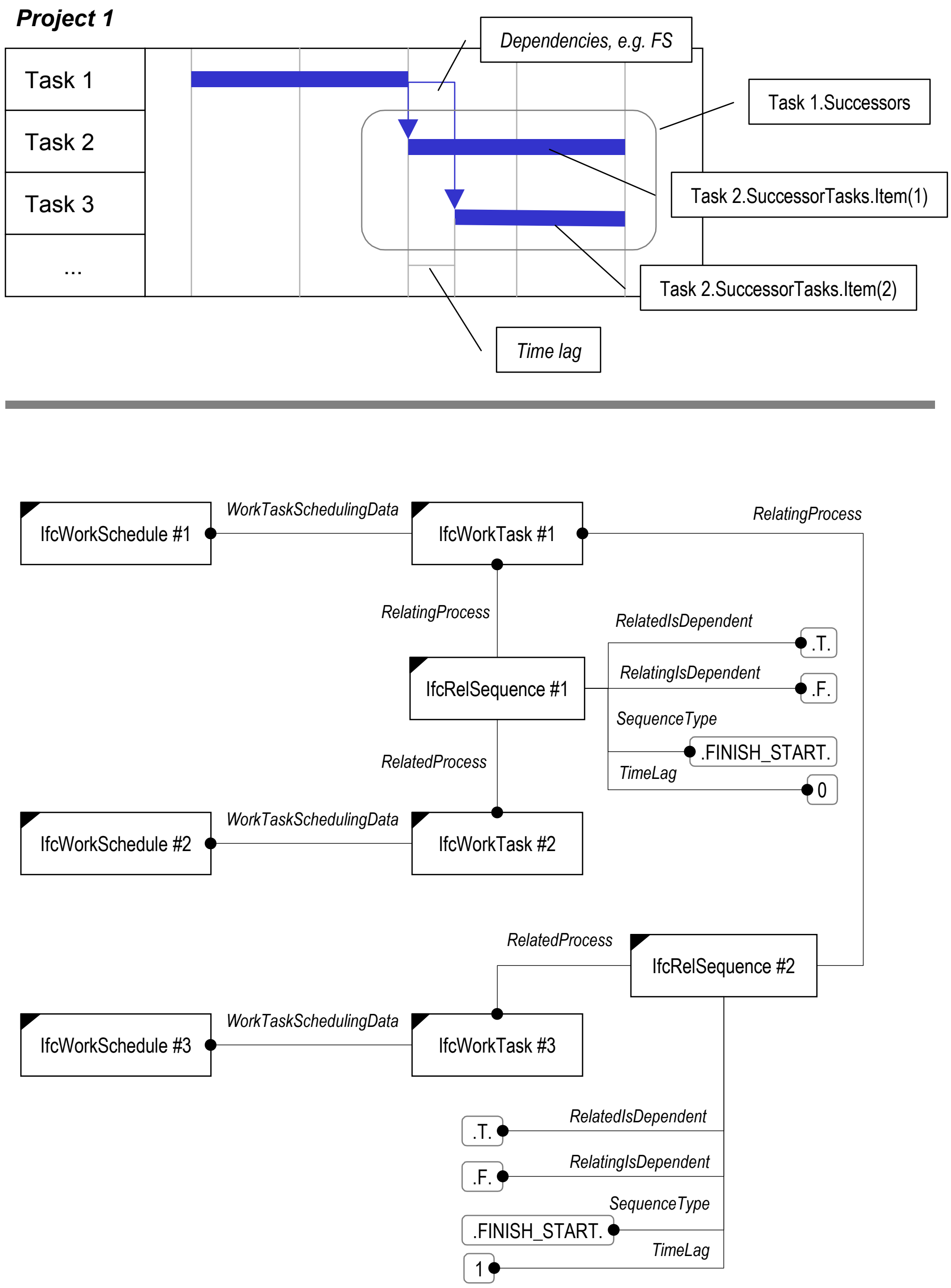
Linking actors and geometry objects can be used for showing: 1) person or organisation responsible for designing certain object or 2) manufacturer of the object.

Future tasks include adding a requirement object. They can be requirements for geometry objects (user requirements/performance requirements) or general requirements for other objects, e.g. required conditions for starting a task (Ballard & Howell, 1998).

Development of a linker program for putting together construction schedule model from scheduling software together with a standard IFC building model formed a significant part of the work performed. The linker program maps together timing data from the scheduling program with the selected building components (Figure 4). The developed mapping procedures consist the following Information within scope of the 4D Application Development consist of following:

- Workschedules;
- Tasks;
- Task timing, nesting of Tasks, and sequencing of Tasks;
- Task and Building element relationships;
- Building element grouping.

(a) Sequencing Tasks in MS Project



(b) Sequencing of Tasks in IFC R1.5.1
(Note: IfcOwnerHistory omitted for sake of clarity)

Figure 4 Task sequencing example and its mapping using IFC concepts (Note: only essential entity instance relationships and attributes shown), (Seren & Karstila, 2001)

VPC ANALYZER

The user interface of VPC Analyzer is actually a collection of various interactive tools that can be used for accessing appropriate data from the building product model and for visualising it in the format defined by the user. This user interface is composed of four main parts:

1. *3D viewer for displaying the components, processes and relating features of interest*
2. *Query dialogue for retrieving data from product model database*
3. *Visualisation configuration for selecting options for viewed components and processes.*
4. *Schedule viewer for displaying the schedule in barchart form*

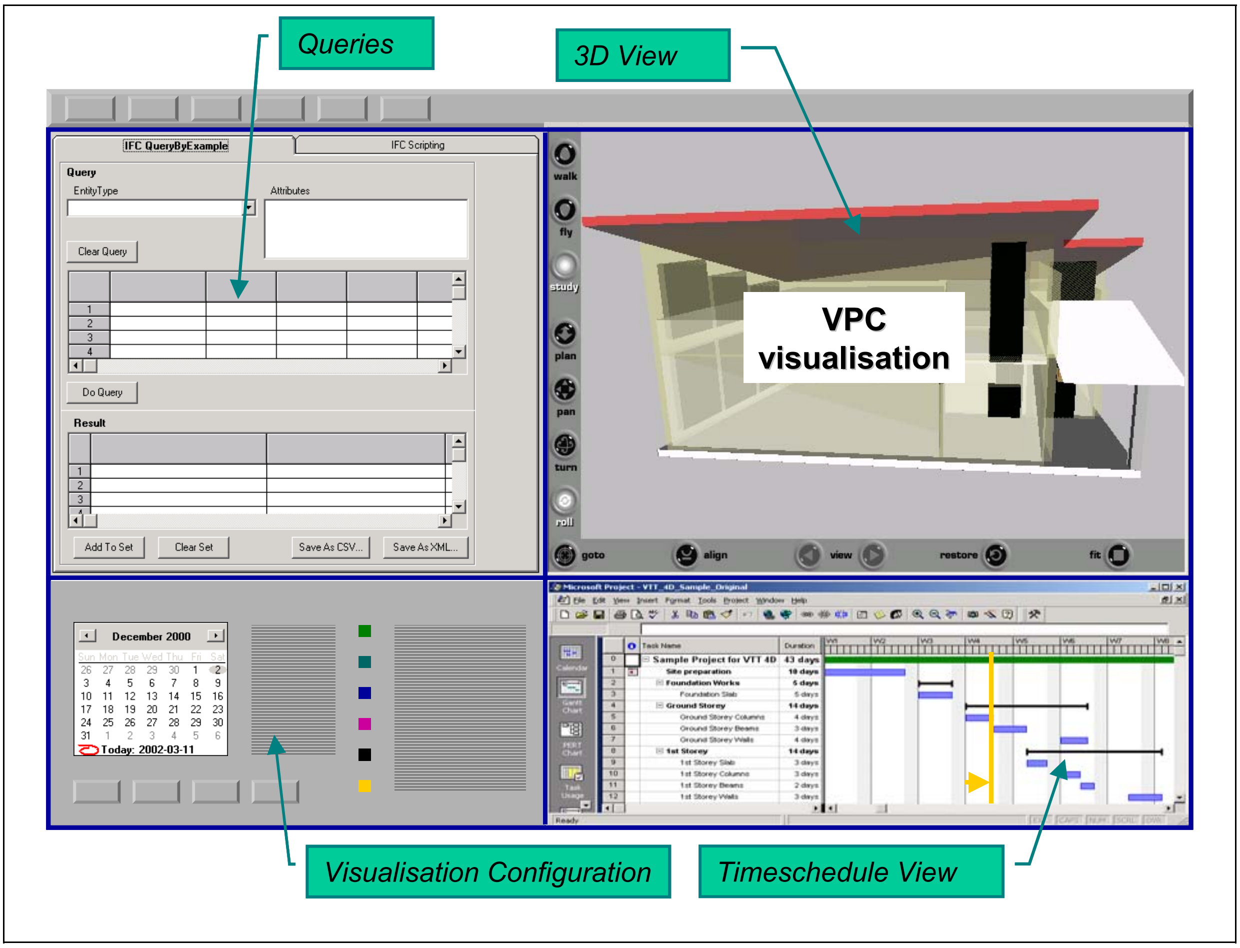


Figure 5 User interface of VPC Analyzer module

Based on the constraints added in the VPC Linker part, various analyses on the building product model can be done with the VPC Analyzer. In many cases the results of these analyses, or queries, are displayed in a visual format. The benefits of VPC approach are realised in this analysing phase. The most common and best-known analysis is the building construction process, 4D, visualisation.

This can be used for instance to attain a common understanding on the process among stakeholders, safety considerations and site logistics improvement. When the actors and tasks are linked, the user can ask when does the next task of a particular subcontractor start or who is responsible for supervising a certain task. If actors and geometry objects are linked, it is possible to evaluate which manufacturers need to informed if a change occurs concerning some object. Also, it is very important to understand what spaces are reserved in a particular moment of time.

CONCLUSIONS

The development of Visual Product Chronology is aiming for a flexible general-purpose tool for understanding the data captured on a PDM system. This is seen as a way towards a solution that links building product modelling technology to the operational needs of construction operations. The first step of this development has focused on design processes, procurement and site operations.

The work described has resulted in an improved understanding over the possibilities for linking scheduling and resource data into IFC building models. Such linking requires a generic mapping solution for different IFC concepts and objects with the world of resource planning and scheduling. A mapping solution has been developed for this purpose. Many types of practical queries over the IFC product model data are required for understanding its content. Standardised query procedures are being developed within the implementation of Visual Product Chronology.

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