

PMAPM: An Object Oriented Project Model for A/E/C Process with Multiple ViewsPMAPM : An Object Oriented Project Model for A/E/C Process
with Multiple ViewsKenji Ito¹, Kincho H. Law² and Raymond E. Levitt³

Abstract

Generating, sharing and maintaining project data among multiple disciplines and throughout a project life cycle is difficult in many industries, but particularly so in the highly fragmented Architecture/Engineering/Construction (A/E/C) industry. Presently, the A/E/C industry does not have a commonly accepted standards for project data exchange which might allow applications to share the many kinds of graphical and non-graphical data produced and needed in the various stages of the A/E/C process. In Object-oriented programming, objects inherit attributes - describing both their state and behavior - from more generic objects in a "frame-based" or abstraction hierarchy with each domain specific view, offers a powerful new approach for sharing information and knowledge in the A/E/C process. This paper describes the development of PMAPM, an object-oriented project model designed to facilitate information sharing among multiple disciplines and across project stages from planning to the design, construction and management of a facility, and from architectural to structural and mechanical design. The feasibility of using this model for information transfer from CAD to various knowledge-based expert systems will be demonstrated. We will also discuss in details the current status and future directions for PMAPM.

Keyword

Object-Oriented Programming, Project Model, AI, Knowledge-based Expert System, Relational Database, Multiple View, Frame, A/E/C Process, CAD.

1. Introduction

Large amounts of information are generated and consumed during the various phases of a project life cycle from planning to design, construction and management of the facility. Sharing and maintaining these project data among multiple disciplines and throughout a project life cycle is a complex and difficult task. The project data needs to be stored, retrieved, manipulated, and updated by many participants, each has his/her own view of the information. A number of computer-based systems such as CAD, analysis and simulation software have been developed for the A/E/C industry. However many of these systems can only be utilized within narrow application domains. Efforts have been attempted to integrate these application software by linking systems and providing data transfer interface so that a richer communication among applications of different domains can be realized. Most of these efforts are still in their early stages of development. We believe that a project model that can properly describe a facility and is accessible by multiple participants of different disciplines is a very important ingredient for integration. The object-oriented paradigm offers many useful features to facilitate the description of a constructed facility and allows us to define different kinds of objects. In addition, the relationships among the objects are defined not only for inheritance, demons or methods of an object but also to facilitate the search of information.

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In building design, we can benefit from using databases for storing a large amount of independent but interrelated data about design elements and their relationships. The objects observed in a building project are best modeled by an object-oriented model. Elements (such as columns and beams) can be defined as individual object types, and their properties (such as length and weight) are defined as attributes. Operations on the objects can be defined using methods. Many researchers have attempted to develop product model or project model using the object-oriented methodology. [Eastman 90], [Garrett 89], [Ito 89, Ito 90], [Law 86, Law 87], [Penttila 89], [Sanvido 89] and [Sause 90]. However there are too few results to realize a global product or project model which that are shared by the various participants or the many applications of an A/E/C process. In this paper, we describe an object-oriented concept for modeling the product design information as well as the processes using a multiple view approach. The scope of our research is to establish an object-oriented project model supporting multiple views that are shared by the various participants of an A/E/C project. The objective is an eventual development of an integrated system which includes activities from project planning to the design, estimation, construction and facility management. The object-oriented project model is intended to link CAD systems, relational database, knowledge-based systems and other conventional application software; these applications can easily be treated as a view-function embedded in a view-object. We believe that this object-oriented multiple-view approach is sufficiently flexible to support the development of a project model for an integrated environment for planning, design, construction and management of a constructed facility.

2. An Object-Oriented Project Model Supporting Multiple Views (PMAPM)

The object-oriented project model (PMAPM) described herein is an extension of a project model (PMAP) initially developed as a vehicle to share project information for a mid-rise building project between a CAD system and two knowledge-based construction planning systems [Ito 89, Ito 90]. While PMAP was implemented using Framekit, PMAPM has been implemented using Allegro Common Lisp, Parmenides and FRulekit, developed by CMU, on a Macintosh II computer. The system supports not only graphic information but also the non-graphic or attribute information including the relationships among the building elements. In this section, we first review the basic capability of PMAP. We then describe the extension of the model to support multiple views and the implementation of multiple purpose object.

2.1 PMAP - An Object-Oriented Project Model

In the PMAP model, an object represents a building element or a non-building element. Each building element consists of eight basic attributes: material, finish, size, position, rotation angle, offset and relation. The attributes of a non-building element include: project code, project name, user id, client name and site location. Included in each building element is its relationship with other elements. Some examples of the relationships between the building elements are:

- Girder is supported by Columns.
 - Door and Window are attached on Exterior or Interior Walls.
 - Space (Room) is consisted by Exterior or Interior Walls.
 - Floor is consisted by Spaces, etc.
- Four basic access mechanisms are available for the user to extract object data:
- Using the frame or slot access functions with methods embedded in the object.
 - Using the relationship among the building elements.
 - Using files as an interface for external application programs.
 - Using the graphic and text interfaces of PMAP.

PMAP has been used as an interface to various knowledge-based systems, a CAD system, and a relational database system. [Ito 89, Ito 90]

2.2 PMAPM - An Object-Oriented Project Model with Multiple Views

Each participant of an A/E/C project has his/her own view of the information about a constructed facility. In general, for each project, there is one facility and the object representing the facility has

only one physical value but many functional values depending on the various views of the information by the participants of different disciplines.

As shown in Figure-1, in PMAPM, a project can be viewed in terms of a global view (concerning with the social and labor types of information), a project view (defining the perspective view of various phases of a project) and an object view (defining the physical building elements of the facility). While the object view representing the physical elements is similar to the object hierarchy in PMAP (Object Oriented Project Model for A/E/C Process) [Ito 89], we introduce a global view and a project view in PMAPM to represent the functional views corresponding to the processes of an A/E/C project. In an object oriented programming environment, we can treat the views as objects defined with data and methods. In order to fully realize the model description of an A/E/C project, we need to consider not only a product-based description but also a process-based description should be needed. From the process point of view, a project consists of the following stages corresponding to the view definitions in the PMAPM model:

- Project Management View
- General View
- Project Planning View
- Design View
- Construction View, and so on.

The project management view (for the project manager) and the general view (to store the general information about the project) provide the high level control and support of project information. The other views about a project follow the various phases of an A/E/C process. For each view object, we can further define object subclasses; for example, the design view can be divided into architectural view, structural view, mechanical view, etc.. For each view, PMAPM needs to assign to the user the mode of access (i.e. update or read only). Most users (except for the project manager and PMAPM designer) are allowed to have limited access to the various views. For example, a sales person can access to the global-view, management-view, general-view, planning-view and sales-view with the read only mode but is allowed to access to sales-view and general-view with the privilege of updating the information. This view facility can facilitate the management and presentation of information to the users.

2.3 Multiple Purpose Objects (MPO)

In order to realize the multiple views that are needed to capture or update the model information, four kinds of objects are defined in PMAPM -- *data-object*, *scope-view-object*, *eval-view-object* and *create-view-object*. These four kinds of objects are collectively termed *multiple purpose objects*. In particular, the main purpose of *create-view-object* is to create a new process-based object or slot according to the user's operation, dynamically. Although PMAPM has its own object hierarchy which is designed to support a wide variety of building project. This hierarchy cannot exhaustively include all the possible views required by each project participant. PMAPM provides a method to define a new *data-object* or *scope-view-object* for each project or for each participant. By turning on a trace mode, PMAPM will make the trace of user's manipulation to extract the data from other objects and store the operation as functions in the new object. This concept of multiple purpose object provides the flexibility to accommodate unforeseen situations and to expand PMAPM's applications in the future.

3. Integrated system environment by PMAPM

PMAPM is designed as a kernel of the integrated system for A/E/C process and there are altogether five different ways that one can store the data into PMAPM:

- Enter data using the textual interface of PMAPM.
- Create and store data using graphical interface of PMAPM.
- Transfer data from the relational database system; presently, ORACLE is used for storing cost, actual result, personnel and client information in the PMAPM environment.
- Transfer data from a CAD system, such as CIFECAD [Ito 89].
- Create and store data using method or rule.

These interface facilities allow PMAPM to capture project information from the participants of different disciplines who are involved in an A/E/C project. PMAPM obtains most of the physical object information about a building from CIFECAD. The major building elements of the architectural and structural design can be defined using CIFECAD and the information about these objects are stored under the object-view in PMAPM. During the project, there will be information conflicts among the project participants. These conflicts are stored as constraints in views and propagated and resolved by the constraint management system in PMAPM.

Presently, PMAPM has been used as an interface to various knowledge-based expert systems or conventional systems which will be used at the design and construction stage.

OARPLAN [Darwiche 88]: OARPLAN is a prototype knowledge-based construction planning system. OARPLAN needs the design data to generate the activities in a project and to generate the needed sequencing constraints among the activities. That is, OARPLAN has its construction-planning-view, which is defined in PMAPM, for extracting information from PMAPM. In fact, a user can use OARPLAN from the construction-planning-view of PMAPM through the system menu.

FCOST [Ito 90]: FCOST consists of two basic modules, FINISHES and FINISHCST. FINISHES is a knowledge-based counseling system which evaluates the finishing material based on the usage of the room and grade of the building. This information can be directly accessed through of the architectural-view of PMAPM. FINISHCST is a cost estimation system which calculates the preliminary finish cost using the information from the detail-cost-view.

DURATION [Ito 90]: DURATION consists of a set of rules to evaluate the construction duration from the total area, floor area, building structure, ground condition, etc.. A user can use DURATION from the management-view of PMAPM.

4. Conclusion and Discussion

This paper described an object-oriented project model that supports multiple views for building projects. Currently, PMAPM has been implemented to include the basic model hierarchy, which consists of Global View, Project View and Object View, as described in Figure-1 and integrated with various applications as described in this paper. Various interfaces to store and access information from PMAPM have also been developed and illustrated (Figure-2). During the course of developing PMAPM, many benefits of using an object-oriented paradigm have been found to describe a project model and to provide multiple views of the project model. Particularly, with the definition of multiple views, we can analyze and recognize the various requirements throughout the A/E/C process. Furthermore, this process-based approach is very useful to discover the information flow among the participants from different disciplines. In summary, we have demonstrated two important concepts:

- The usefulness of an object-oriented project model for system integration in an A/E/C project -- we need not only a product model but also a project model.
 - The usefulness of the multiple view concept for the project model -- we need not only a product-based model description but also process-based description of a constructed facility.
- Finally, the purpose of this work is to realize the plausibility of an object-oriented project model that can be referenced by multiple disciplines throughout the A/E/C process. In order to achieve this purpose, continuing effort is needed to evaluate the requirements of each discipline and their needs from PMAPM so that the high level project model with multiple views can be established.

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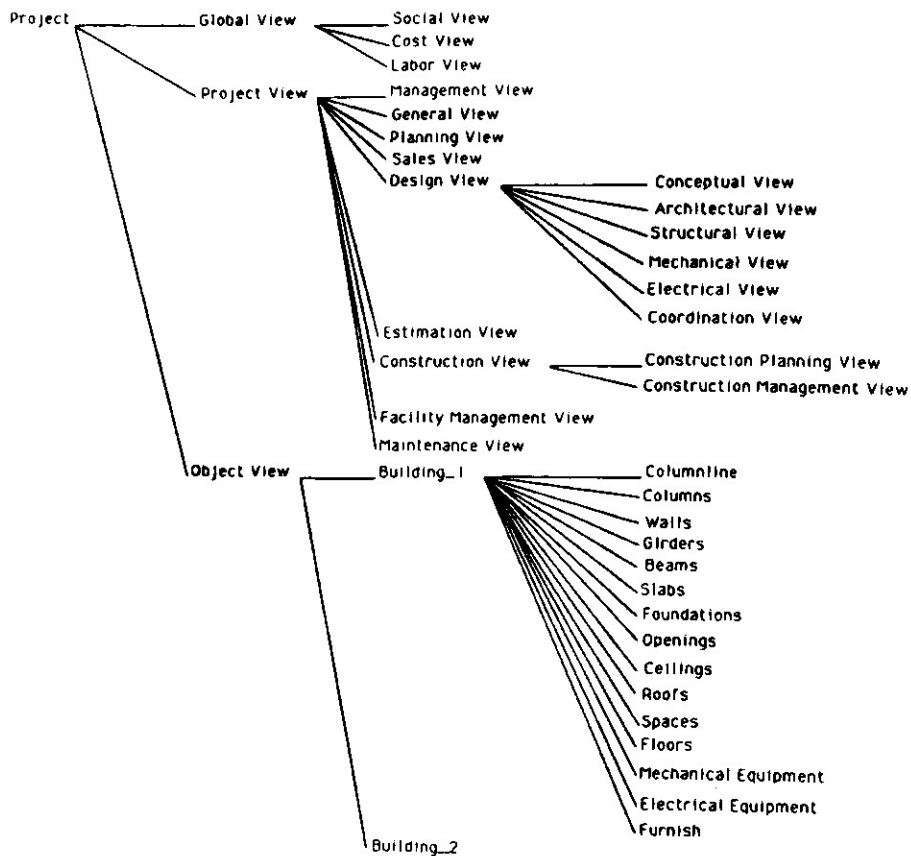


Figure-1 View-Object Hierarchy of PMAPM

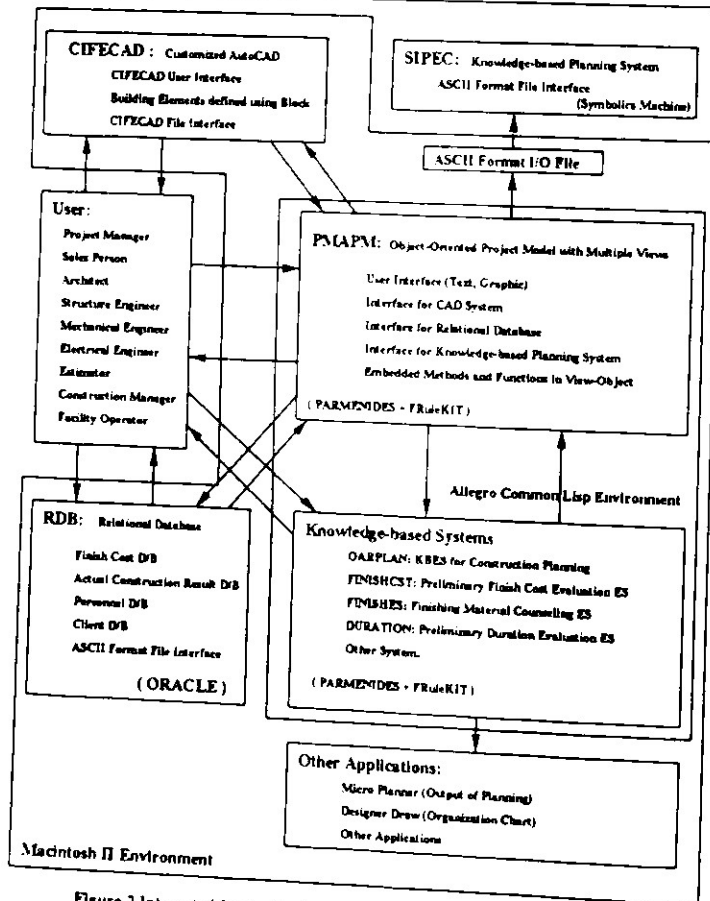


Figure-2 Integrated System Environment using PMAPM (Jun, 90)