DOMAIN SPECIFIC MODEL FOR INTEGRATED SCHEDULE RELATED INFORMATION AND SAFETY INFORMATION

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ABSTRACT

During the various phases of the A/E/C life cycle, several kinds of project data will be generated, shared, and updated by many project participants. In particular, these participants will store and retrieve the schedule information according to their needs. This is the due to the fact that the schedule information is subject to several kinds of project constraints. Therefore, many researchers have been attempting to realize the object-oriented integrated environment for linking CAD and planning or scheduling systems, or the knowledge-based expert systems for planning and scheduling.

On the other hand, at the construction planning and construction management stage, safety management is a one of the key issues in avoiding the delay of construction work. Therefore, Shimizu Corporation has been developing an accident prevention system.

This paper describes the development, present status and future directions for the integrated environment between scheduling information, and an accident prevention system using domain specific models in Shimizu Corporation.

1. INTRODUCTION

As Clients' requests become more diverse and extensive than ever, it is necessary to concentrate all the company's efforts and to encourage cooperation among different divisions in the A/E/C industry. In the past, development of information systems was basically focused on increasing efficiency of particular domain tasks, but was not efficient enough to respond to current problems. Therefore, a new method of developing collaborative and integrated information systems is required to synthesize resources in order to achieve total efficiency. However, it is difficult to generate, share, and maintain project data during the various phases of the A/E/C project life cycle from design to construction. In particular, the schedule information needs to be stored, retrieved, manipulated, and updated by many project participants, each with his/her own information needs. As stated earlier, these participants evaluate, simulate, and calculate the schedule information with several kinds of project constraints, such as site area, uses of facility, material cost, structural and construction methods, temporary facility, labor cost and so on.

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Therefore, the idea of using the object-oriented product model or knowledge-based expert system for planning and scheduling has been proposed by many researchers.
On the other hand, safety management for the construction planning and management, is a one of the key issues in avoiding the delay of construction work. However, there are not enough databases or computer-based systems which provide the safety information to the construction planner or construction manager. Therefore, Shimizu Corporation has been developing an accident prevention system called SAPS-1(Shimizu Accident Prevention System-1)[Ito 95b] that uses data from over 1,000 past accident cases as a database.
Past accident information or data should be used at the construction planning or construction management stage for safety management or accident prevention, because most accident cases contain schedule related information. Therefore, Shimizu Corporation proposes the integration of planning and scheduling system with an accident database, using an object-oriented scheduling model.
The work described in this paper is still in process. The paper will conclude with a layout of future plans and generalizations of the integration of object-oriented scheduling model and safety management systems.

2. DOMAIN SPECIFIC MODEL

A number of computer-based systems 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 achieved. 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 for the A/E/C industry.
Therefore many researchers in the universities have been attempting to develop a product model or a project model using object-oriented methodology. On the other hand, some researchers have been attempting to realize a integrated system using a product model or a project model. However, there are few results to support a global product or project model which is shared by the various participants or many applications of an actual A/E/C process.
In the A/E/C industry, several kinds of modeling research have been proposed to provide the integration environment, such as PMAPM(Object-Oriented Project Model for A/E/C Process with Multiple-Views) [Ito 90, 91, 93, 94] and ICPS[Yamazaki 95]. In particular, research on PMAPM, the author has been trying to provide the common process model and common product model for any type of A/E/C project. However, it is very difficult to apply this prototype model to the actual project, because there are many existing computer-based applications in the industry and these applications have no object-oriented data structure or interface to the object-oriented databases. Therefore, PMAPM could show the capability of data sharing as the common product model using own interfaces, but

could not show the power of system integration with existing applications in the industry. On the other hand, the result of research should be proved the ability in the real world in order to continue the research and development in future. Then, we classified the product model into the following four types:

- **Common Product Model**, supports whole project life cycle and any participants of project.
- **Domain Specific Product Model**, supports whole project life cycle and limited participants work in same domain, such as scheduling, cost and so on.
- **Process Specific Product Model**, supports limited process and limited participants work in same process, such as sales, architectural design, structure engineering and so on.
- **Application Specific Product Model**, supports limited application domain.

Figure-1 shows the classification of the product model in the A/E/C industry.

3. DOMAIN SPECIFIC SCHEDULING MODEL

There are many research results about the integration systems related to the schedule information such as integration between CAD systems and planning systems, or integration between planning systems and scheduling systems. However, most of these integration are still prototype environment and it is not enough to utilize to the real project in the industry. On the other hand, Shimizu Corporation has been developing several kinds of schedule related computer-based systems for each participants as follows:

- **PREPLAN**[Ito 95a]: Knowledge-based expert system for evaluating the preliminary construction period using at the project planning process or early design process.
- **STDPLAN**[Ito 95a]: Knowledge-based expert system for evaluating the standard construction term using at the end of detail design process, estimation process and early construction planning process. This system was used by many construction planner and construction manager on the DOS environment and implemented on the Microsoft Windows environment in 1994.
- **NETMAIN**[Ito 95a]: Conventional network diagram system using at the construction planning process and construction management process. This system was started to deliver to the construction site on September, 1994 and over 300 systems delivered until end of June, 1995.
- **PMNG**[Ito 95a]: Conventional bar chart diagram system using at the construction management process for managing the program and progress of work at the construction site. This system was started to deliver to the construction site on August, 1993 and over 700 systems delivered until end of June, 1995.

These application did not have enough communication or information sharing mechanism each other. Therefore, we proposed the object-oriented scheduling model as a domain specific sub model of PMAPM in order to share the schedule

related information among them. This idea can prove the concept of system integration using the object-oriented product model with the existing conventional applications and databases.
The result of this approach can prove the concept of system integration with common product model, because each domain specific product model is defined as a subset of common product model. Figure-2 shows the scheduling information flow among above applications with scheduling model.
In PMAPM, there are many kinds of building elements defined as an object with properties and there are many kinds of views defined as an object which are according to the view points of each participant of the project.
From the process point of view, an A/E/C project consists of many stages corresponding to the view definitions in PMAPM model, such as project management view, general view, project planning view, sales view, design view, estimation view, construction view, facility management view and so on. For each view object, we can further define object subclasses according to the participants work as sub-views. Therefore, the differences between process model description and product model description in PMAPM are as follows:

- To define an object hierarchy describing the physical and non-physical building elements used in the design and construction of a facility as a product model and these objects have not only a graphical information but also their properties and its relationships with other objects.
- To define an object hierarchy describing the project work or participant's view point used through the project life cycle as process model and these view objects consist of not only the data but also many kinds of methods, functions and rules in order to extract or update the information according to each participant's need.

In PMAPM, using a combination of these separated models, multiple participants of a project are sharing the same information of the facility and they can extract or update the information according to his/her own view by this object-oriented multiple-view approach.
Therefore, it was not so difficult to develop the scheduling model as a domain specific product model by extracting the schedule related information through the concept of view functions in PMAPM. Currently, this scheduling model has no interface to the CAD systems, then scheduling model dose not contain the graphical element information, such as location of elements, size of columns, relationship between elements and so on.
Figure-3 shows the comparison of model structure between PMAPM and scheduling model.

4. ACCIDENT PREVENTION SYSTEM

For the A/E/C industry:

- maintaining the quality of facilities,

- maintaining the safety of labor on the construction site,
- maintaining the timely contract completion,
- and reducing the cost of construction,

are very important issues through the project process. Therefore, a number of computer-based systems have been developed for the A/E/C industry. However many of these systems can only be utilized within narrow application domains. For example:

- The system for computer-aided design or drafting, support the high quality of design and documentation.
- The system for cost estimation or site accounting, support the cost management of projects.
- The system for construction planning and scheduling, support the program and progress of work.

However, there is not enough computer-based software which supports the safety of construction, and provide the accident prevention information *before* construction work.

Each A/E/C project has own planning and period of construction by various types of labor, material, equipment and construction methods. However, each activity of construction work has similar contents of work or situation and similar accidents have happened. The reason of these accidents came from the luck of past experiences, but there is not enough mechanism to provide the historical accident information to the construction manager. In Shimizu, we preserved past accident data as a paper document and we started to store from 1990 over 3,000 accident data as an image processing data. However, the information about those accidents can be used by head office employees not by branch offices or construction sites. Then we could not provide enough information to the construction site, timely. It means that historical accident data stored as an image processing data was only used for the analysis of accident and not for the accident prevention to the future project.

Therefore, we have been attempting to build the useful accident database which provides any type of past accident information for the construction manager's request since 1993. We finished to store over 1,000 past accident information into relational database until June, 1994 with a database retrieving system called SAPS-1(Shimizu Accident Prevention System-1). This system was started to deliver to the construction site on July, 1994 and over 300 systems delivered until end of June, 1995. Figure-4 shows the project process using the accident prevention system.

5. INTEGRATION OF SCHEDULING INFORMATION

Safety management with the accident prevention system supports the increasing quality of facilities, and reducing the duration and cost of construction, because this system identifies the risks of construction work *before* and *during* the

construction management stage. On the other hand, in PMAPM, construction planner and construction manager can retrieve and use the schedule information not only to consider the construction management but also to consider the safety management through their view object's functions. Therefore, Shimizu Corporation started to integrate the scheduling model with accident database for evaluating the safety with scheduling. Current integrated environment provides the list of past similar accidents information from accident database according to the ongoing project schedule information, such as the type of activities, type of equipment, kind of materials, labor skill, environmental information and so on. Schedule information will be stored and updated by each planning system or scheduling system according to the project process and integration between the past accident database will provide the past accident information according to the amount of the schedule information and quality of the schedule information in the scheduling model.

This is the first step of information integration using domain specific product model and this environment integrates the two knowledge-based expert systems, two conventional systems, relational database and object-oriented product model in the real business world.

Figure-5 shows the schematic image of integrated system using the object-oriented scheduling model.

6. CONCLUSION

This paper described an object-oriented domain specific product model that supports multiple views for building projects and this model is the subset of common product model. Currently, this domain specific model has been implemented to the selected construction site as the prototype system and will be started to deliver to the current application users within this year.

During the course of developing the object-oriented scheduling model, many benefits of using an object-oriented paradigm have been found to describe domain specific product model and to provide multiple views of the project process. Particularly, with the definition of domain specific multiple views, I can analyze and recognize the various requirements throughout the A/E/C process. Furthermore, this domain-based approach is very useful to discover the information flow among the participants from different disciplines.

Finally, the purpose of this work is to realize the integrated system using an object-oriented product model to 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 per each discipline and their needs to the domain specific product model so that the common product model with multiple views can be established as the union of the domain specific product models.

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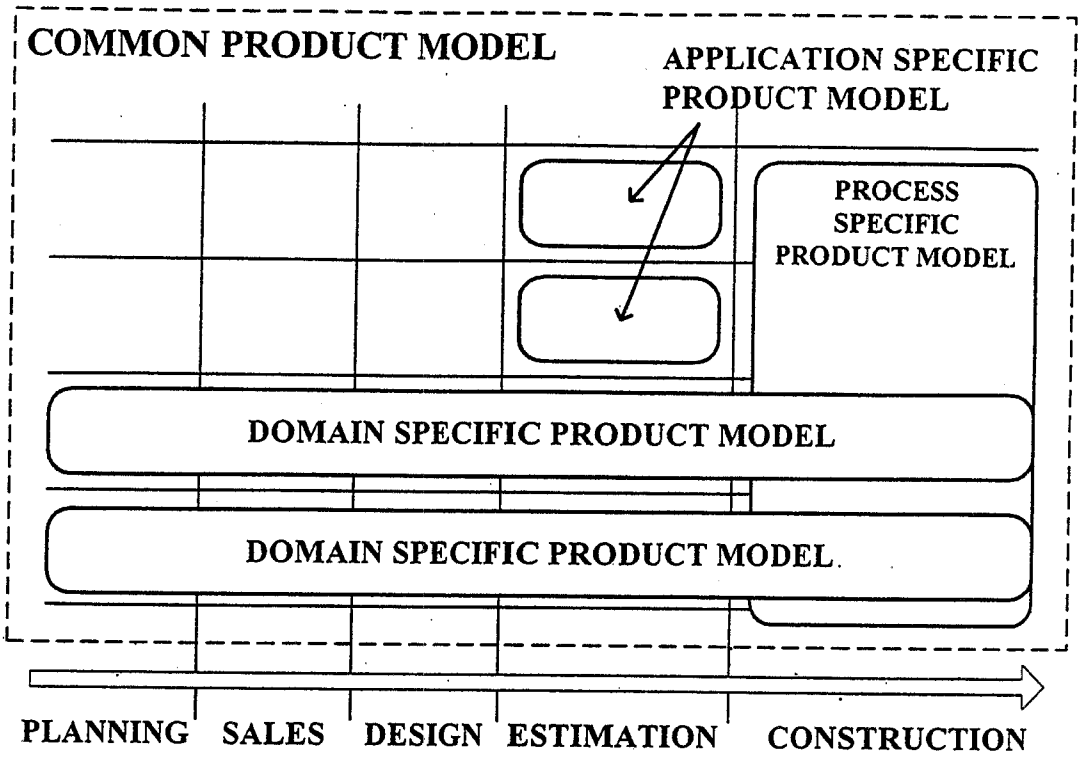


Figure-1: Classification of the Product Model

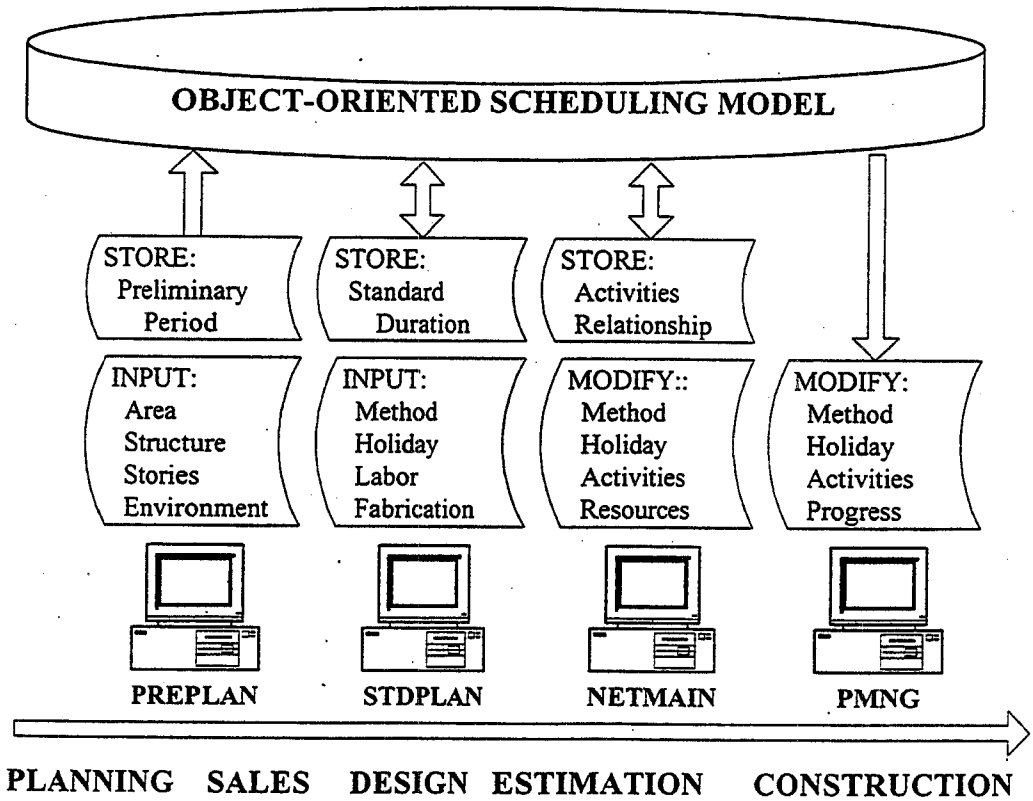
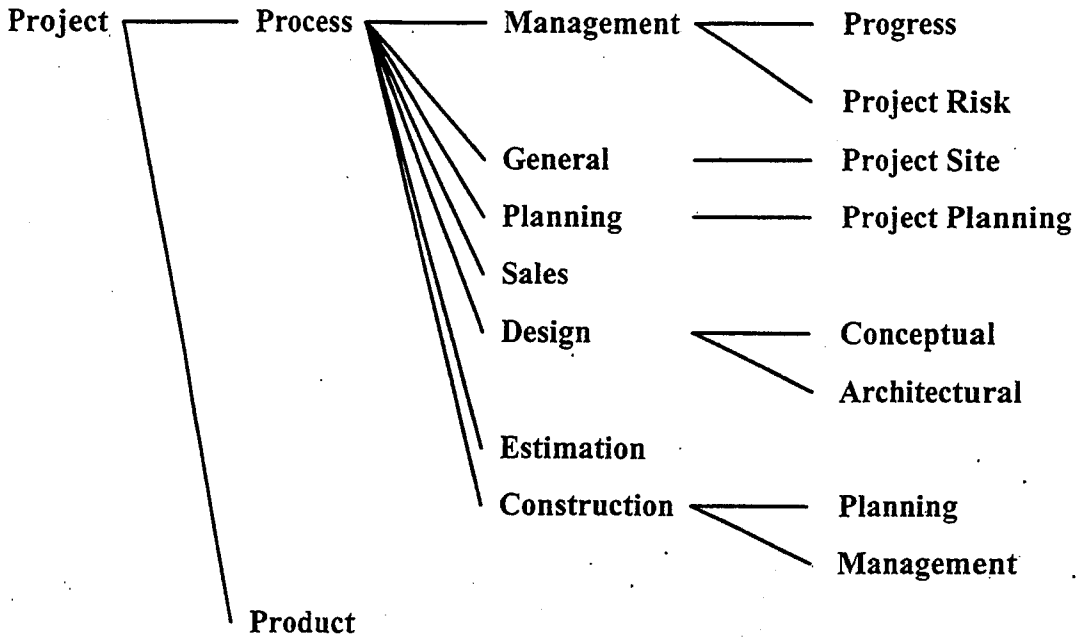


Figure-2: Scheduling Information Flow

CLASS HIERARCHY OF PMAP MODEL



CLASS HIERARCHY OF SCHEDULING MODEL

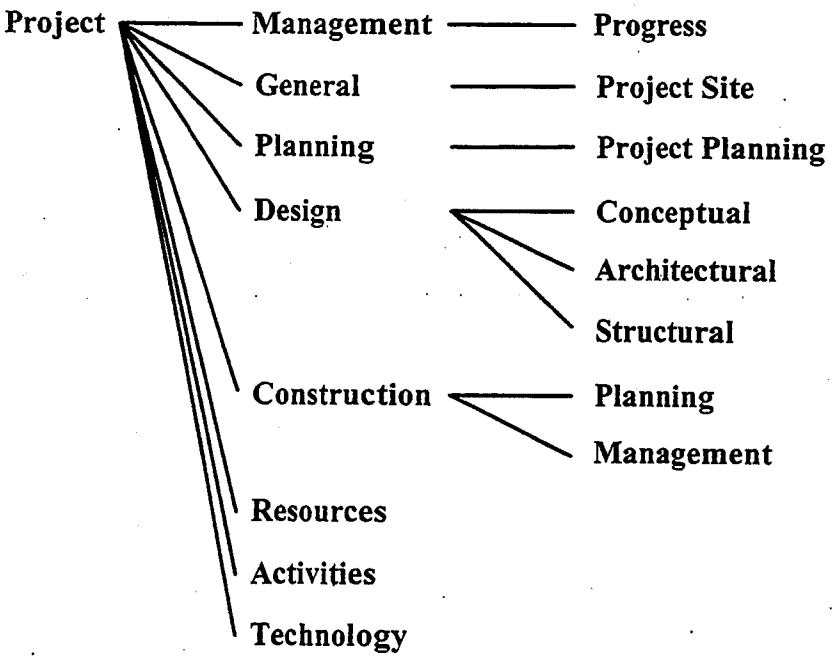


Figure-3: Compair the PMAP Model & Scheduling Model

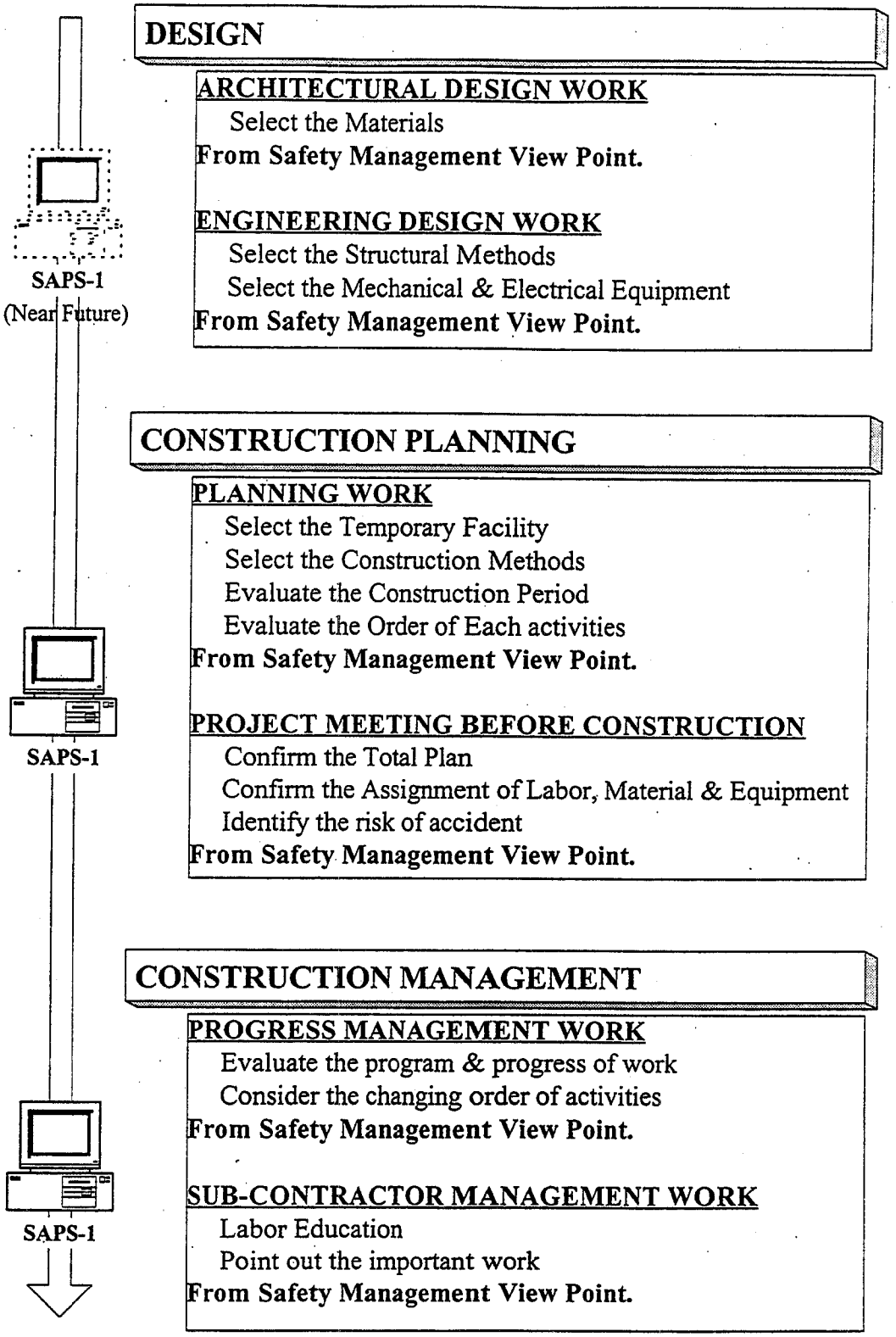


Figure-4: Project Process Using the Accident Prevention System

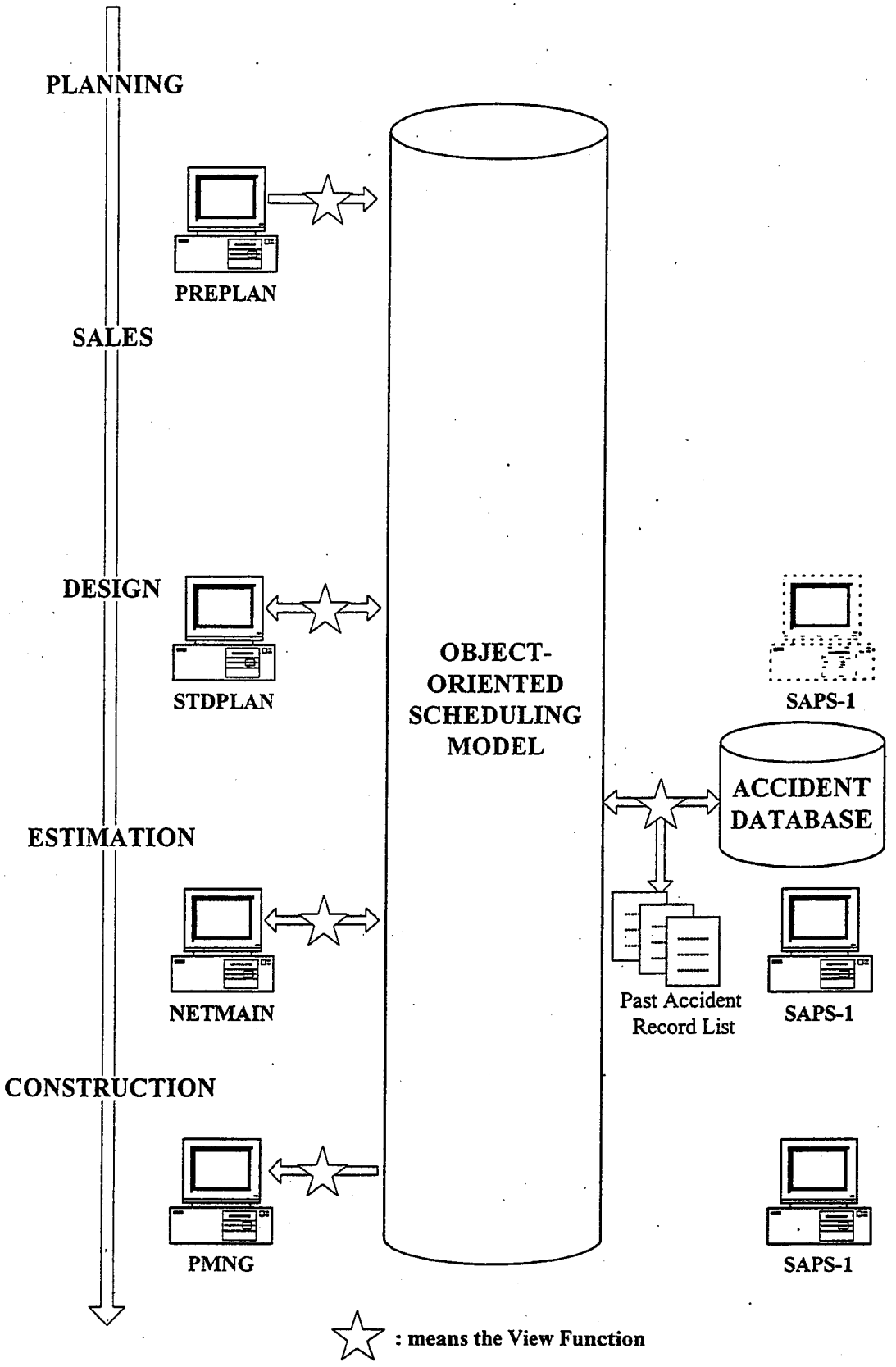


Figure-5: Schematic Image of Integrated System