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FACILITIES MANAGEMENT CORE MODELS

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ABSTRACT

Facilities Management (FM) covers a broad range of industry functions and processes involving large dollar values. However, the use of Information Technology (IT) in FM has, to date, remained slow. Due, in part, to the unavailability of information about the facilities, few comprehensive computer systems are available that can effectively help facilities managers in decision making processes. In fact, little research has been done to clearly define the basic and common information requirements for general FM functions. Having summarized the general functions in FM practice, this paper proposes a strategic solution for integrating IT in FM: the development of Facilities Management Core Models (FMCM). The paper first reviews the standard models being developed by major international efforts for Architecture, Engineering, Construction and Facilities Management (AEC/FM) and explains the relationships between the standards and FMCM. The FMCM development methodology is then described followed by discussion of the major development steps. The requirements and scope of FMCM are presented, the types of the models are explained, and the development procedure is shown using typical industry processes. The paper also discusses FMCM implementation issues. In addition to supporting the development of FM applications and integrated systems, it is believed that this research will contribute to the major international data standard development efforts for AEC/FM.

INTRODUCTION

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Facilities Management is a broad area that includes a variety of functions, each comprising many industry processes (Table 1). Although FM possesses great potential for adopting information technologies (IT), the current use of computer applications in the area is still sparse, and their development is slow. One of the major problems in applying IT to FM is the lack of as-built information which would be required by the applications. Little research literature has clearly indicated what types of information are needed and how the data structures should be defined for the FM functions.

This paper intends to propose a strategic solution for adopting IT in FM functions by providing Facilities Management Core Models (FMCM). FMCM are a set of data entities that represent real world objects in computer format and that are needed for the support of general FM functions. The major objectives of FMCM are: 1) to support the development of FM computer applications by providing guidelines for information requirements; 2) to support the development of integrated FM information systems (Froese, Rankin, and Yu 97) by providing fundamental data structures for object data repositories; 3) to support the development of database systems that can be directly queried and updated by facilities managers in decision making processes; and 4) to support the development of systems that deal with life cycle building information object management (Yu and Vinet 97).

This paper first summarizes general functions and processes of Facilities Management. It then focuses on the development of FMCM starting with the discussion on standard models and their relationships with FMCM. A detailed description of the development methodology of FMCM is then demonstrated. Following along the line of the development procedure, the paper presents the common information requirements of the general FM functions, as well as the scope and types of the FMCM models. Finally, FMCM implementation issues are discussed. It is believed that this research will be a contribution to the development efforts of international data standards.

FACILITIES MANAGEMENT CORE MODELS (FMCM)

Facilities Management Functions

Facilities management activities oversee a large proportion of building properties and assets that represent huge dollar values (NRC 96). FM functions cover a broad range of management and design activities in terms of time, cost, and scope (BOMA 97, CFM 97, IFMA 97). Facilities managers have to make decisions during the course of the FM processes on a daily basis. Table 1 presents the major FM functions and processes.

FMCM Objectives

Currently, most of the FM processes are performed manually. One of the reasons is that much of the information about the facilities is not available in electronic forms that support the development of and that can be used by FM software applications. This in turn causes an extreme lack of FM computer applications compared to the rest of the domains in the AEC/FM industry (Yu and Vinet 97). In fact, no literature references have clearly indicated what types of information are needed for FM and how they should be defined.

To resolve this problem, this paper proposes a strategic solution for using Information Technology (IT) in general FM practice -- the Facilities Management Core Models (FMCM). The primary idea of FMCM is to capture the basic information entities and their relationships needed by the FM functions and processes. The objectives of FMCM can be summarized as follows:

- ***Support the development of FM computer applications***
FMCM provide a guideline of the information requirements for the FM functions. They also provide a specification for data sharing requirements for the applications that are intended to be able to share and exchange object data with other AEC/FM applications.
- ***Support the development of integrated FM information systems***
An integrated FM information system is the system that supports various FM processes (Froese, Rankin, Yu 97). These processes are allowed to share the information about the building, FF&E and occupants that are represented and stored in the system. The development of FMCM can be used to support the data models needed in the integrated systems.
- ***Support the development of database systems***
Many of the FM decision making processes are based on querying the databases that contain information about the facilities, assets, occupants and organizational units. The databases can also be used for the FM computer applications to retrieve and update facility information. The data structures of the database objects can be developed according to the entities and their relationships defined in FMCM.
- ***Support the development of systems that deal with life cycle building information object management***
The information objects about the buildings are not created at one time; rather they are developed through the life cycle of the project (Yu and Vinet 97). During each phase of the life cycle, many types of objects are created, modified or deleted, and not all of them may be needed for FM processes. The development of FMCM can help in identifying which objects should and which should not remain and be transferred from the construction phase to the building operation phase for FM use.

Standard Models for AEC/FM

This section reviews two major international standards being developed in the AEC/FM industry and explores the relationships between these standards and FMCM. They are: the Industry Foundation Classes (IFC) developed by the International Alliance for Interoperability (IAI) (IAI 96), and the Standard for the Exchange of Product Data (STEP), part 10303 (ISO-STEP Part 1) developed by the International Organization for Standards (ISO).

The IAI is an industry based consortium. Its goal is to develop the IFC, which are standards for exchanging project data between different computer applications (IAI 97a). The IAI identifies the common information needs of the different industry domains represented by the IFC Core Models, and uses a Domain Extension Model approach to fulfill the particular information requirements of the specific domains (IAI 97a).

The ISO-STEP is another major international standard effort. The aim of STEP is to develop different sets of Application Protocols (AP) that define essential entities for applications to share and exchange data. Among the many parts of the STEP standard, the Building Construction Core Models (BCCM) (ISO-STEP Part 106) and Building Data Representation And Exchange (AP225) (ISO-STEP Part 225) provide important models that should be useful for FM applications.

Both standards capture appropriate sets of core entities about buildings and projects such as building components and systems. These models are necessary for data sharing between applications for different domains, for example, between architecture and

construction management. However, according to the currently developed models, they do not yet provide a clear set of models that identity the basic entities for FM functions. Despite the IFC's Extension Domain Models approach, there are still inevitably many entities in the core models that are not needed for FM. On the other hand, while the AP's in STEP are supposed to represent all and only necessary entities for certain application areas, there are to date no AP's for FM. The development of FMCM will thus resolve the shortcoming of the IFC and could possibly contribute to STEP by proposing an AP for FM applications. Nevertheless, FMCM will still be developed based on the models developed in the standards since both have already captured basic building entities that are essential to FM. Not only will this take the advantages of, but also harmonize FMCM with the standards ensuring the applications developed based on any of the models are interoperable.

FMCM Development Methodology

The development of the models will adopt both top-down and bottom-up analysis. First, from a top-down perspective, major functions and processes of FM are identified. Information requirements for each function will then be analyzed. Using this methodology, the scope and the level of complexity of the model will be defined at an early stage. This will help the model developers plan and manage the overall development and determine appropriate modeling techniques. Based on the top-down analysis, a set of base entities will be identified at a very high level, which are in fact the conceptual models (Yu 95, Yu and Froese 97). The conceptual models can be used as references for further development in different ways depending on the modeling techniques determined. For example, the top level models can be used to derive lower level models for different views of the entities from different application areas (Yu and Froese 97). They can also be used as Application Reference Models (ARM) for developing Application Interpreted Models (AIM) if the STEP methodology is chosen (ISO-STEP Part 1).

After the top-down analysis, information requirements for typical industry processes of each FM function are determined by analyzing the process steps at lower levels. From the bottom-up, detailed information entities and attributes are defined. Also, the entities defined at upper levels should be used, referenced and re-examined.

Information Requirements for FM Functions

One of the basic requirements of these functions is the availability of the information about the facilities, i.e., data about the buildings and their elements such as stories, walls, windows, spaces, and building systems. This information is increasingly created (and modified) starting from the early stage of the design processes and continuing throughout the entire life cycle of the project. During the course of the information development, there are huge amounts data generated. However, in the building operation phase, the FM functions require only a portion of them.

Many of the FM functions such as asset management and space planing deal with building assets (i.e. furniture, fixture and equipment (FF&E)) and people (i.e. building occupants). Thus, the information about these objects is also needed.

The people who occupy and use the facilities usually belong to certain types of organizational units such as companies, departments, etc. They either own, rent or are assigned to the spaces. Information about these organizational units and their relationships is essential and affects most of the FM functions. Some of the functions deal with departmental units directly such as space management. Many of the FM activities like

furniture maintenance inevitably involve work interruptions that must be resolved in collaboration with the departmental managers. Thus, the information on the organizational units is also one of the basic requirements of general FM functions.

Additionally, since the nature of FM is to plan, manage and control, the computer applications that deal with FM should also be able to represent and utilize information elements such as plans, schedules, resources, controls, work tasks and types as well as basic data type structures such as time, duration, cost, etc. (PMI 96). Consequently, data entities and structures about these fundamental management resources are also required by most FM functions.

Table 2 shows a primary analysis of the information requirements for general FM functions (where “x” indicates an information requirement by the corresponding function).

FMCM Requirements

The types of the information captured from the functional analysis described in the previous section suggest the basic requirements of FMCM. Based on the FMCM objectives as additional criteria, the requirements of FMCM can be summarized as follows:

- They must represent the basic entities and their relationships about buildings, building elements, and building systems.
- They must represent only those entities that are often needed by FM functions; they should exclude objects generated and used only by non-FM domain applications such as construction activities or resources.
- They must represent assets (i.e. FF&E) and occupants, organizational units such as companies and departments that are assigned spaces, and basic management resource entities.
- They must be generic enough to represent all the information required by different FM functions supporting different formats and views. This requirement is to support data sharing and exchange among the various FM applications (Yu 95).

Scope of FMCM

Based on the top-down information requirement analysis, the scope of the FM Core Models can be determined by identifying the basic entities and their categories according to their different potential usage. The use of categorization is not for classifying entities in the sense of modeling, but rather, to help identify the overall scope of the models and plan the development of the modeling project.

Two basic categories of model types are proposed: *shared models* and *reference models*. The shared models include entities which are likely to be shared and exchanged by different applications at run-time. These entities usually represent physical objects that are the focus of most FM processes. They can be directly used, shared and exchanged between the processes. Figure 1 lists some examples of the shared models for the FM functions.

The reference models for the FM functions fall into two sub-categories: *management resource models* and *modeling resource models*. The management resource models provide basic entities that must be used in most of the typical management activities, such as plans, schedules, work, work types, and so on. In a FM application, the instances of these entities are created for particular management processes such as project planning and scheduling or cost estimation. However, they are not always shared by other processes at run-time. In other words, they are used as data structure references to create process-based objects. The

modeling resource entities provide some basic data structures for defining the attributes of other models. For example, the *cost* is needed for most product entities, while *time* and *duration* are needed for most process entities. A complete set of FMCM should contain all of the entities in the categories described in Figure 1.

FMCM at a Conceptual Level

The top-down methodology generates models at the conceptual level (Yu and Froese 97, Froese 94), which should be based on the scope defined . At this level, only the basic entities and their relationships need to be identified. The attributes of the entities, however, do not have to be determined, objectified relationships do not have to be defined, and low level objects do not have to be derived. This means that the models at the conceptual level are only intended to provide a base model set. Refinement and detailed modeling are performed at the bottom-up phase (Yu 95) (refer to next section).

Figure 2 presents a simplified set of conceptual models for FMCM using EXPRESS-G (ISO-STEP Part 11) (where links that do not have a name represent aggregation relationships). As shown in the figure, some categories defined in the scope phase can still remain the same in the conceptual models, except that the reference models entities can be used in other models, especially those in the modeling reference models.

Model Refinement From Process Analysis

After the entities and their basic relationships have been defined at the conceptual level, the bottom-up analysis can be performed to provide further information requirements and to examine the validation of the conceptual models using typical industry processes. In Figure 3, two industry processes are selected: Occupancy Planning (IAI 97b) and Asset Maintenance Planning. Each of the processes are simplified as consisting of four major steps. Each step requires and generates information that can be matched to the model entities or their attributes. As shown in the diagram, some entities are used to define objects shared by the two processes such as the *space*, *FF&E*, and *occupant*. There are, however, also some other entities that are used as references to create management objects used by one process such as the *cost*, *time*, *plan*; they do not need to be shared by the other process. This process analysis confirms the entities defined at the conceptual level and defines the attributes for each the entity. Additionally, the analysis refines the models by requesting more detailed entities, attributes and objectified relationships. Figure 4 depicts the new entities required that could be added to the conceptual models (Vanier, Lacasse, Parsons 96).

FMCM Implementation

This research is only in its early stage; however, it can be predicted that the final version of FMCM will contain different sets of models at different detail levels. The FMCM implementation can be performed based on all the levels in a variety of ways (Yu 95). For example, the conceptual models can be used as a reference guide for defining data objects for particular applications that require enough specific information that is not defined in FMCM, but that still intend to maintain interoperability with others. Moreover, the models at lower levels can be used directly for applications that require similar information definitions. In addition, shared databases can be developed based on these models containing the generic object data for the various FM processes to share.

Since FMCM are intended to be compliant with the standards defined in either IFC or STEP, objects generated from other discipline applications such as an architectural

program could also be transferred into the FM application if the former is also standard-compliant.

CONCLUSION

Identifying the problem of using Information Technology (IT) in Facilities Management (FM), the paper has proposed a strategic solution, that is the Facilities Management Core Models (FMCM). The ultimate goal of FMCM is to provide generic models for FM applications to share and exchange information and to support the development of integrated FM systems. FMCM will be developed based on the basic information requirements for general FM functions and typical industry processes. The methodology used for the development of the models will be a combination of top-down and bottom-up analyses ensuring the completeness and generalization of the models. In order to fulfill the objectives of FMCM, the models will eventually consist of a set of models at different detail levels so that different types of implementation can be performed. Additionally, FMCM will be compliant with either IAI-IFC or ISO-STEP. This stresses the fact that all of the applications based on any of the models can share the same set of objects. It is intended that this research will be a contribution to data standard development efforts in the AEC/FM industry.

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References

- BOMA (97), "Building Owners and Managers Association", <http://www.boma.org>.
CFM (97), "Center For Facilities Management", <http://www.dis.strath.ac.uk/guests/cfm/>.
Froese (94), "Developments to the IRMA Model of AEC Projects", Proceedings of the 1st Congress on Computing in Civil Engineering ASCE, Washington, DC, June 20-22, 1994.
Froese, Rankin, and Yu (97), "An Approach to Total Project Systems", accepted for ASCE Computing in Civil Engineering Congress, Philadelphia, 1997.
IAI (96), "End User Guide to Industry Foundation Classes, Enabling Interoperability in the AEC/FM Industry", 1996.
IAI (97a), "IFC Object Model For AEC Projects, Specifications Volume 2", IFC Release 1, 1997.
IAI (97b), "FM Project, FM-4: Occupancy Planning", draft proposal for IFC R2.0, 1997.
IFMA (97), "<http://www.ifma.org>", International Facilities Management Association.
ISO-STEP Part 1, "Overview and Fundamental Principles". ISO Standard 10301-1, International Organization for Standards, Geneva, Switzerland.
ISO-STEP Part 11, "EXPRESS Language Reference Manual", International Organization for Standards, Geneva, Switzerland.
ISO-STEP Part 106, "Building Construction Core Models (BCCM), T1.0", International Organization for Standards, Geneva, Switzerland.
ISO-STEP Part 225, TC184/SC4/WG3 N510 (T12), "Building Data Representation And Exchange", International Organization for Standards, Geneva, Switzerland.

- PMI (96), "A Guide to the Project Management Body of Knowledge (1996)". Project Management Institute (PMI), PMI Standards Committee, Upper Darby, PA.
- NRC (96), "Proposal For Establishing A Building Envelope Life Cycle Asset Management (BELCAM)", 1996.
- Vanier, Lacasee, and Parsons (96), "Modeling of User Requirements Using Product Modeling", 1996.
- Yu (95), "Application of Project Information Models to Computer-Integrated Construction", M.A.Sc. Thesis, Dept. of Civil Eng., University of British Columbia, Vancouver, B.C., Canada., 1995.
- Yu and Froese (97), "Implementation of AEC Core Reference Models In StartPlan", accepted by Canadian Journal of Civil Eng., Jan., 1997.
- Yu and Vinet (97), "AEC Object Management System (AEC/OMS), A Research Proposal for NRC-IRAP", NAOIKI Systems Inc. Jan., 1997.

Table 1: General Facilities Management Functions and Processes

Asset Management (i.e. FF&E) - Asset / Asset Value Tracking/Life Cycle Cost - Asset Document/Specification Management - Inventory/Warehouse Management - Asset Maintenance & Services Management Property Management (i.e. buildings and surroundings) - Advertising/Building Purchase - Building Suitability Assessment - Site Selection & Acquisition - Rental/Lease Management - Road/Transportation Access/Ground Maintenance - Public Relations Occupancy and Space Planning (incl. people and departmental units) - Floor Planning/Systems Furniture Design - Placement of Signs - Space Allocation, Assignment and Inventory - Moving People, and FF&E System Operation Control and Management (i.e. HVAC/electrical/mechanical/architectural) - Building Operation Cost/Efficiency - Energy Consumption Management - Performance Monitoring/Measurement - Hazardous Waste/Recycling Management - Disaster Recovery - Emergency Control Custodian/Janitor Management - Work Classification/Schedules/Assignment - Control of Supplies Facility Services (i.e. services provided for building occupants) - Mail & Messenger Services Management - Copy & Print Services Management - Records/Files Service/Management	Renovation and Remodeling (incl. building components like walls, spaces) - Cost Estimation - Work/Resource Planning and Control - Procurement Management - FF&E/Occupants Arrangement (i.e. in response to the renovation, etc.) Building System Maintenance (i.e. HVAC/electrical/mechanical/architectural) - Maintenance Planning, Scheduling and Cost Estimating (incl. annual and life cycle) - Exterior Maintenance (e.g. roofing, shell) - Interior Maintenance (e.g. painting, carpentry, carpeting, etc.) - Preventive Maintenance - Maintenance Budget Projection Cable Management - Tele/Data-communications Cabling - Computer Networking Management - Central Voice Operation - Trouble Allocating - Cable Installation Planning (e.g. cost/time) - Cable Installation Management/Control (incl. work interruption, move of people/FF&E) Security Management - Alarm Systems - Building Access Control - Locking Systems/Control of Keys - Lobby/Elevators Access Control Facility Planning & Surveying (i.e. long time facility planning) - Occupancy Audit - Facility Master Plan - Space Forecasting and Planning - Post-occupancy Evaluation - Financial forecasting
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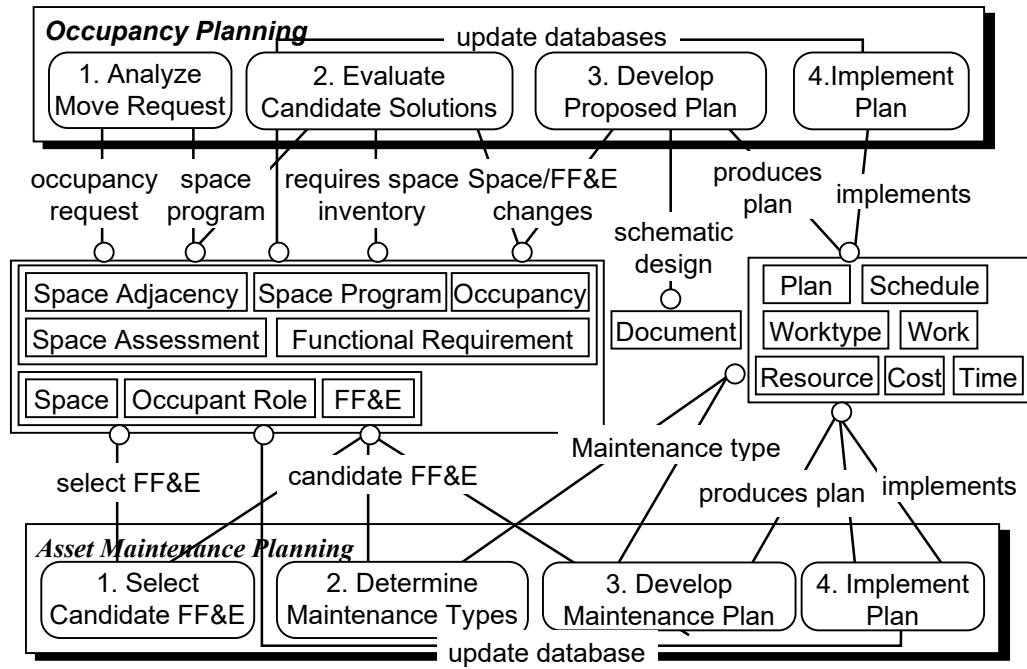


Figure 3: Process Information Requirements

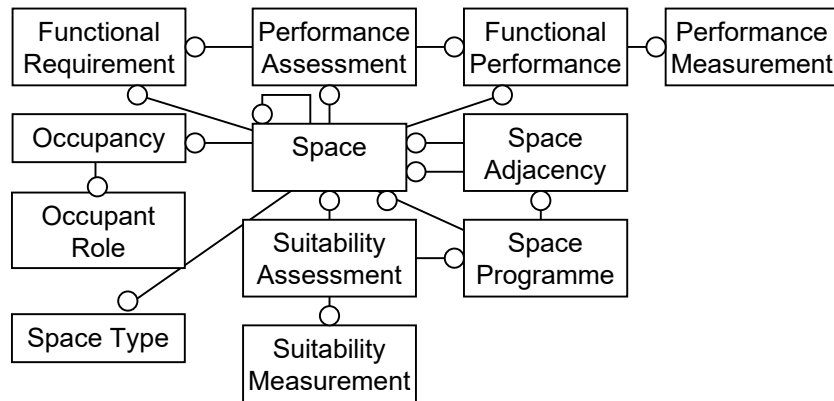


Figure 4: Refinement Models