Appendix II

Development Considerations for the CIM Reference Model

STATEMENT OF OBJECTIVES FOR THE CIM REFERENCE MODEL

The reference model in conjunction with specific manufacturing requirements, objectives and design methodologies provides a framework for the architecture and design of the CIM system that implements a particular established plant manufacturing policy.

The resulting architecture will include the following*:

1. Definition of entities and related tasks.

2. Relationship between entities.

3. Required data flow between entities.

4. Definition of the data management structure and the data dictionary needs.

5. Interfaces to external influences.

One may consider the plant in many different ways when developing a model of its operation. The next section discusses the six different views that have been identified in the Committee's studies [120]. Views are converted into designs for a specific system through the system architecture. The architecture's considerations which must be included are defined below as: platform, communications, database management, scheduling and control, and human organization.

When developing a CIM Reference Model one may go from the specific to the generic, i.e., review several different specific plants from various industries and develop the generic commonality among them as shown in Figure AII-1. Note that the reverse path can be followed in developing a specific model (i.e., an automobile manufacturing plant or a paper mill) from the generic model. Another method is to list the generic functions directly as outlined in Table AII-I.

Table AII-II lists a group of basic principles involved in the model and which provide examination points to judge the generic qualities of the model. Table AII-III shows the interrelationship of the several views as described in this document.

VIEWS OF THE CIM REFERENCE MODEL

Six different (views) or dimensions along which one can review the factory have been identified [85]. They are listed below. They may not be truly orthogonal (i.e., distinctly different). In addition, available models in the literature are generally combinations of different views.

* The discrete industry model may also include physical material flow.

1. Scheduling and Control Hierarchy
   Exemplified by the model developed in the Purdue University steel plant hierarchical computer control project [90] and used in Chapter 3 of this document.

2. Implementation Hierarchy
   Exemplified by the ISO/OSI Communications Model. See Chapter 9, Figure 9-6 and associated discussion. This view highlights the application/support distinction. See Chapter 5 for a more general Implementation Hierarchy.

3. Functional Network
   Exemplified by the data-flow diagram. (This diagram may be a derivative of Nos. 1, 2 and 4). See Chapter 4.

4. Physics View
   Exemplified by the model of ISO/TC 184/SC 5/WG 1. See Appendix III.

5. Sequential View
   Exemplified by the flow chart, such as that of the ESPRIT project of the European Economic Community [120]. Not used in this text.

6. Metrics or performance views
   Exemplified by the models developed by the Digital Equipment Corporation (DEC) [45, 53] and ESPRIT. Not used in this text.

NOTE:
Further research may prove that the Sequential and Metric views are superfluous to the other four. Only the first four are discussed in this document.

DEVELOPMENT OF THE SYSTEM ARCHITECTURES

There are five architectures which can be defined in designing a particular configuration for a CIM information management and automation system [85]. Architectures define the interconnection of the elements of the systems. When combined with the specifications of these elements they comprise the design of the system. They are:

1. Platform:

   A. Hardware (computer and machines)

   B. Support software

2. Communications

3. Data management database, management of process data

4. Scheduling and control

5. Human organization (policy implementor management), human interface

TABLE AII-I

METHODOLOGIES FOR THE DEVELOPMENT OF THE CIM FUNCTIONAL REFERENCE MODEL

I. LIST THE FOLLOWING FOR CIM SYSTEMS IN GENERAL:

   1. GENERIC FUNCTIONAL ENTITIES OF THE FACTORY

      A. TASKS OF THE ENTITIES

      B. INPUTS NEEDED FOR EACH TASK (INFORMATION AND MATERIAL)

         1) SOURCE

         2) CHARACTERISTICS (ACCURACY, RATE, PRIVATE, PUBLIC, ETC.)

      C. OUTPUT OF EACH TASK (INFORMATION AND PHYSICAL OBJECTS)

         1) RECEPTOR

         2) CHARACTERISTICS

   2. GENERIC INTEGRATED DATABASE NEEDS OF THE FUNCTIONAL ENTITIES

   3. GENERIC COMMUNICATIONS NEEDS OF FUNCTIONAL ENTITIES

   4. GENERIC INFORMATION PROCESSING NEEDS OF THE FUNCTIONAL ENTITIES

continued

Table AII-I continued

II. MAKE AN EMPIRICAL COMPARISON OF THE OVERALL REQUIREMENTS DERIVED FROM SEVERAL DIFFERENT INDUSTRIES.

TABLE AII-II

BASIC PRINCIPLES USED FOR DEVELOPMENT OF THECIM REFERENCE MODEL

1. PRINCIPLE OF [AUTONOMY] LEADING TO A MODULAR SYSTEM WITH HIGH *COHESION* AND LOW *COUPLING*. AUTONOMY MEANS THAT INDIVIDUAL UNITS ARE AS INDEPENDENT IN ACTION AS OVERALL INTEGRATION CAN PERMIT.

2. PRINCIPLE OF [LOCALITY] LEADING TO DISTRIBUTED PROCESSING AND *TIME-PHASED DECOMPOSITION*. LOCALITY MEANS THAT UNITS IN THE SAME GEOGRAPHICAL REGION TEND TO WORK CLOSELY TOGETHER. A UNIT WORKS MORE CLOSELY WITH ITS NEIGHBORS THAN WITH THOSE MORE DISTANT.

   NOTE: ITEMS 1 AND 2 REFER TO THE APPLICATION FUNCTIONAL ENTITIES OF THE SYSTEM IN QUESTION.

3. THERE WILL BE NO APPLICATION BIAS.

4. THE OVERALL SYSTEM SHOULD BE STRUCTURED TO LIMIT THE COMPLEXITY OF EACH ENTITY. THE RESULTING SIMPLICITY FACILITATES:

   A) HUMAN COMPREHENSION

   B) COMPUTATIONAL LOAD

   C) PHYSICAL STRUCTURE

5. THE SYSTEM SHOULD EXHIBIT ARCHITECTURAL FLEXIBILITY TO PROMOTE THE INTRODUCTION OF NEW TECHNOLOGIES.

6. THE REFERENCE MODEL SHOULD SUPPORT MULTIPLE *VIEWS* TO EXPRESS DIFFERENT DIMENSIONS OF THE PROBLEM.

7. EACH *VIEW* HAS ITS OWN NATURAL STRUCTURE WHICH MAY OR MAY NOT BE HIERARCHICAL.

TABLE AII-III

RELATIONSHIP OF THE SEVERAL VIEWS AND ARCHITECTURES TO THE FUNCTIONAL ENTITIES

1. EACH OF THE ARCHITECTURES RELATES TO THE SCHEDULING AND CONTROL HIERARCHY VIEW WHICH DEFINES THE HIERARCHY LEVELS AND THEIR SPECIFIC TASKS AND FUNCTIONAL REQUIREMENTS. (SEE CHAPTER 3 AND FIGURES 3-1 AND 3-2). THE ARCHITECTURES THEN SPECIFY THEIR CORRESPONDING EQUIPMENT, PERSONNEL, SOFTWARE, ETC., REQUIRED TO FULFILL THE STATED NEEDS. THE FOUNDATION AND MANUFACTURING SPECIFIC FUNCTIONAL ENTITIES ARE COMPRISED IN THE RESULTING ARCHITECTURES.

2. THE IMPLEMENTATION HIERARCHY VIEW SHOWS HOW THE REQUIRED FOUNDATION FUNCTIONAL ENTITIES INTERFACE TO PRODUCE EACH MANUFACTURING SPECIFIC FUNCTIONAL ENTITY. SEE CHAPTER 5 AND FIGURE 5-1.

3. THE FUNCTIONAL NETWORK VIEW (ALSO CALLED THE DATA-FLOW OR INFORMATION-FLOW GRAPH) SHOWS THE INTERACTION OF THE MANUFACTURING SPECIFIC FUNCTIONAL ENTITIES AND THE EXTERNAL INFLUENCE ENTITIES COMPRISING THE INFORMATION MANAGEMENT AND AUTOMATION SYSTEM INCLUDING THE INFORMATION FLOW BETWEEN THEM. SEE CHAPTER 4 AND FIGURES 4-1 TO 4-15.

4. THE PHYSICS VIEW RELATES MATERIAL AND INFORMATION TRANSPORT AND TRANSFORMATION IN THE CIM SYSTEM WITH THE REQUIRED CONTROL FUNCTIONS. SEE APPENDIX III.

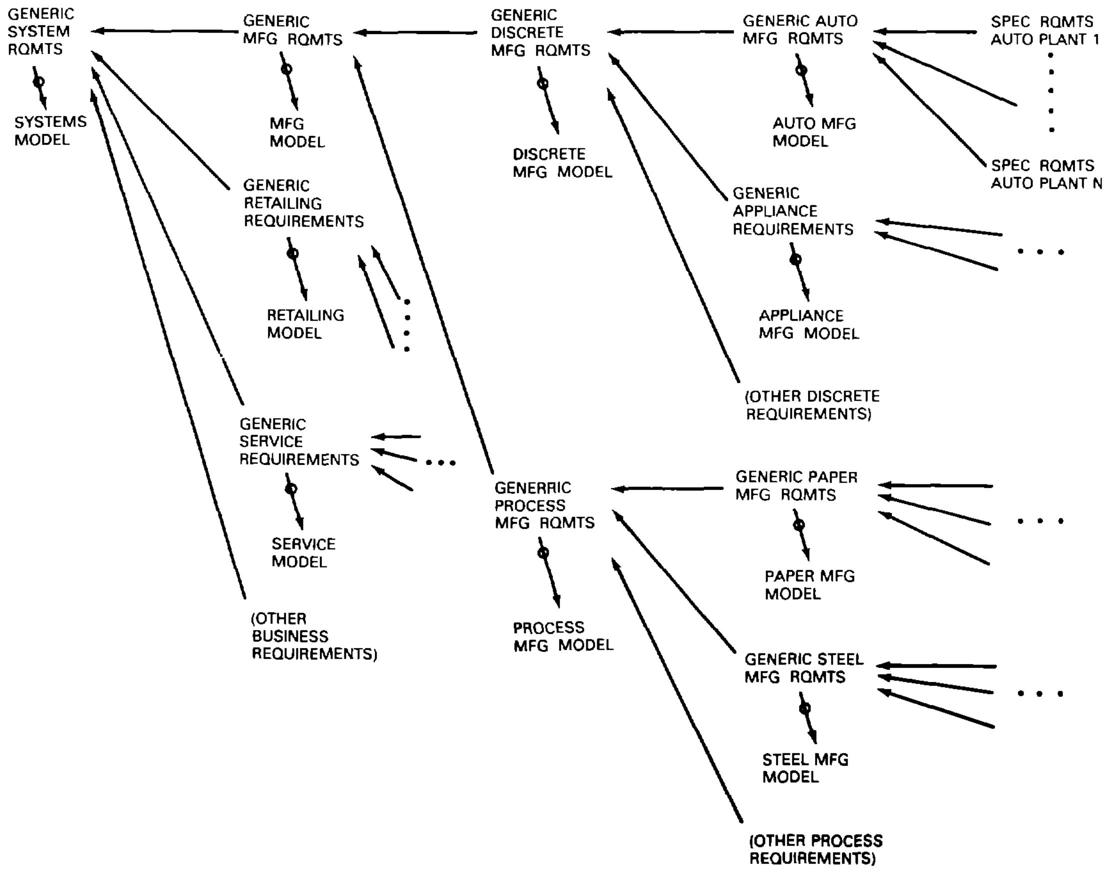

Figure AII-I Empirical development of the CIM Reference Model from the requirements of different industries.