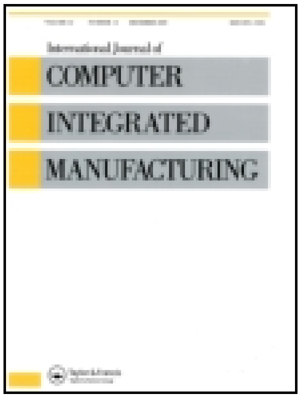

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CIM-OSA: computer integrated manufacturing—open system architecture

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Abstract. CIM-OSA provides an enterprise modelling framework. First the business requirements of the enterprise are captured and, starting from these requirements, the physical CIM system is derived. In addition, CIM-OSA provides a set of concepts supporting the development of the CIM system and a set of services supporting the running of the CIM system.

1. Introduction

The CIM-OSA architecture is developed by a research project which has been set up by the Commission of the European Communities in the framework of its ESPRIT program. The project is carried out by the AMICE consortium, grouping 21 companies: AEG (FR Germany); Aerospaciale (France); Alcatel (France); APT Nederland BV (The Netherlands); British Aerospace (UK); Bull (France); Cap Sesa Innovation (France); Digital Equipment (FR Germany); Dornier (FR Germany); Fiat (Italy); GEC (UK); Hewlett-Packard (France); IBM Deutschland (FR Germany); ICL (UK); Italsiel (Italy); Philips (The Netherlands); Procos (Denmark); Selenia Autotrol (Italy); Siemens (FR Germany); Volkswagen (FR Germany); WZL-Aachen University (FR Germany).

2. Computer integrated manufacturing

Today, worldwide competition between manufacturing enterprises has significantly increased. To survive, to grow and to maintain the margins of profit, they have to compete on price, quality and delivery time.

Facing those challenges, a manufacturing enterprise can combine several strategic weapons to consolidate its competitive position. Some of these are: optimization of the production process; development of a technology management focusing on innovation and internal technology transfer; education of employees; and integration of the enterprise. Even if most of those topics are strongly interrelated; computer integrated manufacturing (CIM) deals mainly with the last issue: integration of the enterprise.

A manufacturing enterprise consists of various departments or divisions, each of them containing combinations of people, computers and machines. An optimal use of those resources requires they are part of a CIM system able to master the action flow and the information flow.

- Mastering the action flow provides the decision makers with up-to-date information, allowing them to take dynamic decisions. This results in a higher degree of planning flexibility and in a reduction of inventory and work in progress.
- Mastering the information flow allows a better integration of the product life-cycle (definition—design—production—maintenance) due to the ability to exchange information between the different steps. This results in a shorter time span needed to bring a new product to the market.
- Together, mastering action and information flow improves the quality of the products, due to avoidance of errors, increases the flexibility of the system and allows the production of greater varieties of customised products, due to increased production flexibility.

The CIM system characterized by the properties described above should in addition be easy to build and flexible to update. Therefore, it has to provide the system designers with guidance for building and updating new systems according to new or updated business objectives. This guidance is based on the reusability of the knowledge gained during previous experiences inside the enterprise and on new developments in the field of methodologies and standardization. This 'knowledge integration' avoids loss of time and improves the quality of the resulting manufacturing system.

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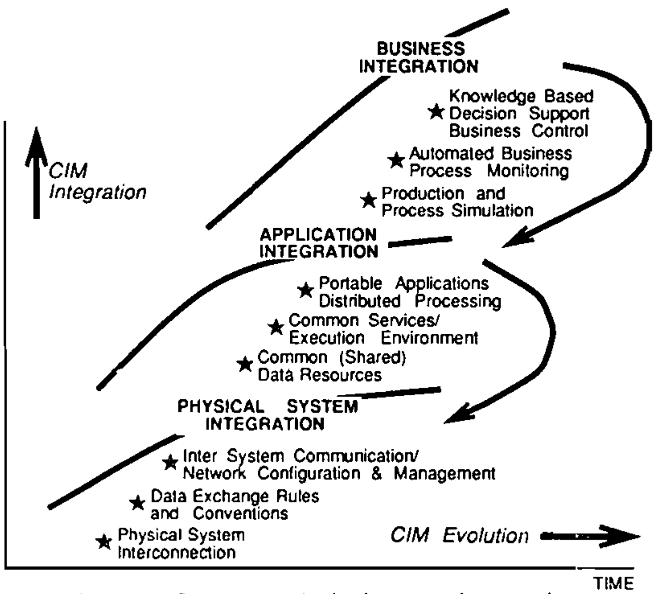

Figure 1. Steps towards the integrated enterprise.

3. CIM-OSA: computer integrated manufacturing—open system architecture

A CIM system assumes an integration process which is built up from different levels (Fig. 1).

The first level is the physical system integration because the interconnection of physical systems (computers, robots, NC-machines, etc.) from different vendors is the first problem met on the way towards integration and because it is essential for attaining higher levels of integration. The need for physical system integration has been recognized for a long time, and even though a number of concepts and realizations like OSI, MAP, etc., have already been developed, a considerable effort is still required.

According to and partially in parallel with the progress made at the level of the physical system integration, the next level of integration is pursued. This level, application integration, deals with: information exchange between applications; transportability of applications between different physical systems; distribution of applications; and standardized user interfaces. Until now, only limited efforts such as STEP, ODP, etc., have been directed towards application integration.

The highest level of integration, business integration, deals with the integration of the different business functions (design, production, marketing, finance, etc.) within the enterprise. It is important to note that these business functions are concerned not only with the running operational system but also with building the future system. In fact, a CIM system has a dynamic behaviour, as it is updated and changed according to the evolution of the enterprise's business requirements and the available technology.

4. The CIM-OSA approach

Using the three-level integration process as background, the CIM-OSA approach can be explained as follows.

As the final objective of CIM-OSA is to ensure the integration of the enterprise at the level of the business functions, a top-down approach of the CIM integration process seems logical. First, the business requirements of the enterprise are captured in the Enterprise Model and, starting from these requirements, the Implementation Model (which is the physical CIM system) is derived. This derivation process ensures consistency between the business requirements and the resulting physical CIM system. This top-down approach is described in section 5.

Integration at the level of the business functions can only be reached if a sufficient level of integration between applications and physical systems is realized. Therefore, CIM-OSA started, in parallel with the top-down approach, a bottom-up effort focusing on the development of a set of services common to most CIM systems, the Integrating Infrastructure, which realizes application integration and physical system integration. The Integrated Infrastructure is described in section 6.

In addition to this top-down and bottom-up approach, CIM-OSA approaches the problem of the CIM integration process from a third viewpoint: supporting the building of the CIM system. This approach is essential because of the dynamic behaviour of a CIM system and is described in section 7.

5. Building a particular implementation model

5.1. *Levels of modelling*

CIM-OSA defines three main modelling levels: enterprise, intermediate and implementation (Fig. 2). The models built at these three levels are the Enterprise Model, the Intermediate Model and the Implementation Model. They represent three different stages in the building of the enterprise's physical CIM system, which we call the Particular Implementation Model. At each level, CIM-OSA provides architectural concepts or generic building blocks to build the appropriate model.

The enterprise modelling level describes in a business sense and terminology what needs to be done within the enterprise. This is the domain of the policy maker and his business requirements. The intermediate modelling level structures and optimizes the business and system constraints. This is the domain of system organizers and their enterprise organizations. The implementation modelling level specifies an integrated set of components necessary

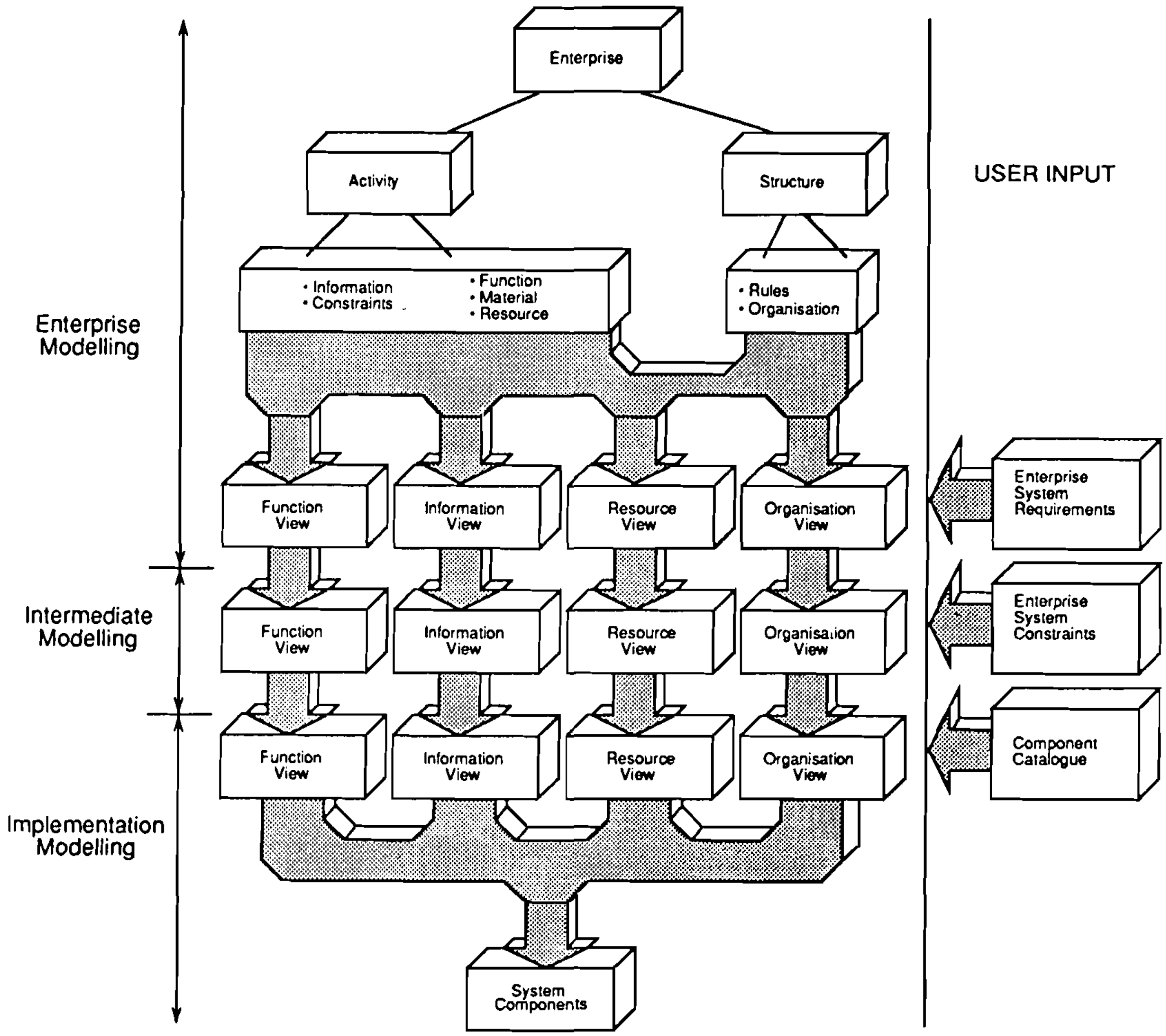

Figure 2. Levels of modelling.

for effective realization of the enterprise operations. This is the domain of the implementers and their system implementation.

According to four different viewpoints, each of the different modelling levels are described in terms of the function view, the information view, the resource view and the organization view. The function view focuses on the functional structure of the enterprise. The information view deals with the structure and the content of the information. The resource view describes and organizes the enterprise resources. The organization view fixes the organizational structures of the enterprise.

5.2. Enterprise modelling level

The enterprise modelling level builds a description of the business requirements of the enterprise. Until now, most efforts have been spent on the function view of the Enterprise Model.

Creating the Enterprise Model starts with the overall description of the total enterprise, identifying what has to be done, using the Business Process building block. A Business Process is the business user's view of what tasks are required to achieve the enterprise objectives. As it is usually necessary to describe a task by a series of sub-tasks, a Business Process can be expanded into a hierarchy of Business Processes which cooperate to produce the desired Business Processes Results of the higher level Business Process.

The Business Processes being defined, a set of Enterprise Activities is associated with each Business Process and a Procedural Rule Set is defined for each Business Process. The Enterprise Activities define the functionality of the enterprise. They are not part of any given Business Process, but are employed by one or more Business Processes. This relationship allows Enterprise Activities to be shared between different Business Processes. The Procedural Rule Set represents the flow of control between the lower level Business Processes and/or Enterprise Activities of the given Business Process. The Procedural Rule Set contains a series of statements, one for each Enterprise Activity or lower level Business Process in the cluster, to define what action is required upon their completion or termination. These building blocks ensure the separation of the functionality (Enterprise Activities) and the behaviour (Procedural Rule Set) making it possible to revise behaviour, in order to meet changing circumstances, without altering the installed functionality. Business Process Events trigger the execution of a Business Process by initiating the processing of the associated Procedural Rule Set. Business Processes are executed according to the flow of action expressed in the Procedural Rule Set and operate under the influence of external constraints, the Declarative Rules.

The Enterprise Model is finalized by expanding each Enterprise Activity into its constituent parts, which are the Inputs, Outputs and Transfer Function. The Transfer Function describes the actions required to produce the defined Outputs from the Inputs provided. It thus defines the dependency between Inputs and Outputs. Input and Output describe the information, the material and the resources the Transfer Function needs for its execution and produces as a result of its execution.

Inputs and outputs are categorized into three types, each with a specific purpose as follows.

- Primary Inputs are the objects to be transformed by the Transfer Function, and Primary Outputs are the objects resulting from the transformation. We distinguish for Primary Inputs and Outputs between information and material because of their different logistic properties: information can be easily replicated at several sites whilst material cannot.
- Secondary Inputs are constraints on the transformation such as information on responsibilities, process definitions, work instructions, product and production information, planning and control information, task completion criteria. The Secondary Output is the resultant status of the transformation itself.
- Tertiary Inputs are the means required to execute the tranformation, thus people with specific skills or experience, machines including NC-machines, robots, equipment and tools, and application programs. Tertiary Outputs are the unused parts of the resources and their resultant status.

To produce a working system which satisfies the business requirements, it is necessary to structure the information Inputs and Outputs of the Enterprise Activities. This structured overview is the information view of the Enterprise Model.

The building of the Enterprise Model includes defining the required resources as Tertiary Inputs of the Enterprise Activities. This set of Tertiary Inputs is to be restructured to provide a consistent view of all the resources needed. This resource view is the basis for the further organization of the resources in terms of physical location, and for identifying responsibilities.

5.3. Intermediate modelling level

To isolate the Enterprise Model from the Implementation Model and to reduce the impact of changes from one level to the other, CIM-OSA has defined an Intermediate Model (Fig. 2) which acts as a stable base between the business requirements definition (Enterprise Model) and the system description (Implementation Model).

At the intermediate modelling level, important developments have been made in the information view. All information managed by the enterprise is described along the lines of the three schema approach, as developed by the ANSI SPARC Data Base Management System Study Group and the ISO TC97/SC5/WG3. In addition, the technical information is structured using the CIM-OSA information management concepts.

5.3.1. CIM-OSA information management concepts. The universe of discourse of the enterprise, which is the set of objects on which the enterprise has to manage information, is typically perceived as containing a large number of real or abstract Enterprise Objects.

Simple Enterprise Objects may be modelled classically as single entities, where the adjective 'simple' does not apply to the object itself but to the sophistication of the model required to model it. Their characteristics are then depicted by a set of attributes.

Complex Enterprise Objects require a more elaborate model. They are generally described by a set of sub-models each addressing one aspect of the object, the Enterprise Object Views. Each of these Enterprise Object Views has an internal structure: it is composed of a set of interrelated elements which may be modelled using entities and relationships. An instance of such Enterprise Object View is a View Edition.

An Enterprise Object is described through several Enterprise Object Views. To each Enterprise Object View correspond many View Editions. The concept of Enterprise Object Edition relates to a collection of View Editions, corresponding to different Enterprise Object Views, so that these View Editions form a consistent whole and reflect the state of the Enterprise Object at a certain moment.

5.3.2. Three schema approach. The description itself of the Enterprise Object Views uses the three schema approach: external, conceptual and internal schema.

Conceptual schemata are developed at the intermediate modelling level and define the meaning of the information in an unambiguous way. Conceptual schemata are developed according to the Entity Relationship approach using entities, relationships and attributes for both entities and relationships. An entity is a concrete or abstract thing such as 'purchase order 75' or 'employee John Smith'. Each association between entities is a relationship. An attribute is the representation of a property such as 'date' for a purchase order of 'age' for an employee.

External schemata identify how the information described by the conceptual schema is perceived by its particular user which can be a person, a machine or an application program. These external schemata have been created while generating the information view at the Enterprise Modelling Level. In fact, the Inputs and Outputs which are part of each Enterprise Activity form the basis of the external schemata for that Enterprise Activity.

Internal schemata describe how the information described in the conceptual schema is structured and physically stored inside the computer system. The internal schemata are defined in the information view at the implementation modelling level.

5.3.3. Resource view and organization view. The resource view at the intermediate modelling level provides a set of resources necessary to satisfy the needs of the Enterprise Activities. CIM-OSA has introduced the building block Logical Cell for the definition of a group of resources required to support a set of related enterprise activities. The primary purpose of a Logical Cell is to identify collections of equipment and resources which are candidates for having a high degree of integration because they support groups of functions which require close or frequent interaction. They may be used to reflect a job-oriented structure or a process-oriented one.

The organization view at the intermediate modelling level describes the organization of the responsibilities for resources, information and business processes. These responsibilities have to be organized in order to satisfy the needs of the enterprise for decision making. The Organizational Cell is the CIM-OSA building block for grouping responsibilities within an enterprise. The Organizational Cell provides a basis from which decisions on the timely provision of resources and data needed for the execution of Enterprise Activities can be enabled and from which decisions can be made on the enterprise operation.

5.4. Implementation modelling level

The Implementation Model is the description of the physical CIM system including operational processes and physical components. It is created from the different views of the Intermediate Model by making technical choices as how the functionality is to be provided, how and where information is to be stored, and how the organizational aspects are implemented. Project work has concentrated on the function view, the information view and the resource view of this implementation modelling level.

The business requirements of the enterprise have been described at the enterprise modelling level in terms of Business Processes and Enterprise Activities. From this description, which is implementation independent, the function view at the Implementation Modelling Level is created.

The Business Processes and the Enterprise Activities, are translated into:

- a hierarchical structure of Implemented Business Processes representing the hierarchical control structure in the form of an executable Procedural Rule Set for every Implemented Business Process;
- a non-hierarchical pool of Implemented Enterprise Activities, the execution of which can be requested by the Implemented Business Processes; and
- a Tranfer Function for each Implemented Enterprise Activity. This function has an internal decomposition into operational units, the Implemented Functional Operations. They define the elementary actions to be performed by the physical environment.

This complex structure has now to be mapped on to a physical environment consisting of computers, machines and people, linked by multiple communication systems. These physical components belong to both the manufacturing technology area and the information technology area. They include people with their associated workplans, machines with their control programs and data processing equipment.

The abstract description of the distributed functionality of this physical environment requires a generic element able to describe distributed functionality. Therefore, CIM-OSA has introduced the Functional Entity concept.

- The Functional Entity is an abstract functional object able to send, receive, process (modify or interrogate), and optionally store information. It thus abstractly describes a behaviour and not real physical equipment.
- Communication between Functional Entities is transaction oriented. A Transaction is a single bidirectional exchange of messages from a requestor to its responding partner and from the responder to the requestor in that order. The Transaction includes three sequential steps: the requestor sends a request data unit to the responder, the responder acts upon the request and the responder sends a response data unit to the requestor. In general, the data units are structured types which can be called Protocol Data Units. The entirety of Protocol Data Units agreed between two partners together with the transaction oriented interaction rule, is called the Transaction Protocol.
- The Functional Entity concept is familiar with the object-oriented system modelling method. In this sense the Functional Entities can be considered to be Objects.

Using this concept, the physical environment is described as a structure of communicating Functional Entities which we call in this context the Implemented Functional Entities. These are the actors able to execute the elementary actions or Implemented Functional Operations. An Implemented Functional Entity describes the behaviour of a physical device providing the functionality and a control device connecting the physical device to the system which sends the instructions to be executed. According to their functionality, the Implemented Functional Entities are categorized into several types.

Implemented Machine Functional Entities handle the Implemented Functional Operations performed by machines. The physical device is a machine tool and the control device the programmed logical controller into which the NC program is loaded.

Implemented Human Functional Entities handle Implemented Functional Operations performed by people. The person interacts with the system through its terminal which is the control device.

Implemented Application Functional Entities handle the Implemented Functional Operations performed by application programs. The physical device is a computer and the control device a subset of the operating system which loads and triggers the application program.

Implemented Data Storage Functional Entities handle the storage and retrieval of data. The physical device is the storage device and the control device the computer with the DBMS or file manager attached.

Implemented Communication Functional Entities handle the sending and receiving of data. The physical device is the network and the control device the network controller and support system.

As the Implemented Functional Entities are abstract objects describing the required behaviour, they have to be supported by a set of physical components, the Implemented Component Set. Those sets are composed by choosing those CIM-OSA compliant products which meet or exceed the specifications. The resource view shows all the Implemented Functional Entities identified in the function view in connection with their supporting Implemented Component Sets.

Because each enterprise has its own specific requirements and its own specific implementation design, CIM systems will always differ. However, some functionality is generic and can be used in many CIM systems. In fact, execution control, resource management, distributed information handling and communications handling are general purpose functions.

To cope with this issue, CIM-OSA has designed the Integrating Infrastructure. This Implemented Functional Entity provides a set of generic functions and in addition it supports the integration of specific functions inherent to the particular CIM system. The Integrating Infrastructure is thus a contribution to reach the level of physical system integration and application integration as explained in the introduction of this paper. The Integrated Infrastructure is described in the following section.

6. Integrating Infrastructure

6.1. *Introduction*

A CIM system is a strongly distributed system. The global functionality is distributed among several nodes. The behaviour of a node is determined by the set of Implemented Functional Entities able to perform operations in that node. A node can thus range from a shop floor computer with the appropriate machines and human operators over a CAD system with its human designer to the administrative computer of the accountant.

The Integrating Infrastructure, introduced in the previous section, is an Implemented Functional Entity common to all nodes. It provides to each node a set of generic functions and supports the integration of specific functions, and it will be based as much as possible on existing or emerging standards. The Integrating Infrastructure together with the Implemented Functional Entities interacting with it are called the Integrated Data Processing Environment.

6.2. Client-service model

The Client-Service Model structures a distributed functionality into Functional Entities called Service Agents which provide services and Client Agents which request services. This Functional Entity concept is the same as that applied for the description of the function view of the Implementation Model in terms of Implemented Functional Entities.

A Service System (Fig. 3) is a complex, distributed Functional Entity that performs a set of services by means of Service Agents within the Service System. The set of services provided by a Service Agent are made visible to its Client Agents through an Access Protocol. This protocol is inherently asymmetric. One or more Service Agents of the same type, distributed through a network, may interact to perform the requested service. In that case they cooperate by means of an Agent Protocol. Such interactions are not seen by the Client Agents of the Service Systems.

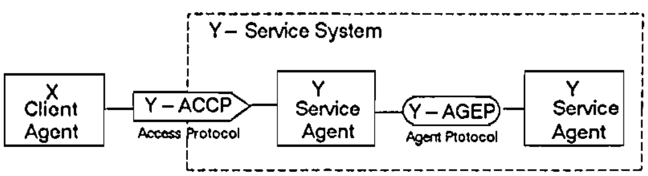

Figure 3. Client-service model.

6.3. The services of the integrating infrastructure

6.3.1. Overview of the integrating infrastructure. The whole functionality of the Integrating Infrastructure is logical distributed among different Services, each of them offering a set of related functions. Those Services can be grouped into the Business Process Management Services, the Front End Services, the System Wide Information Management Service and the System Wide Exchange Service (Fig. 4)

The Business Process Management Services are Business Process Control, Activity Control and Resource Management. These services realize the necessary link between the Integrating Infrastructure and the rest of the Implementation Model. They provide the services supporting the execution of the Particular Implementation Model. They manage the execution of the Implemented Business Processes and Implemented Enterprise Activities and manage the use of the resources.

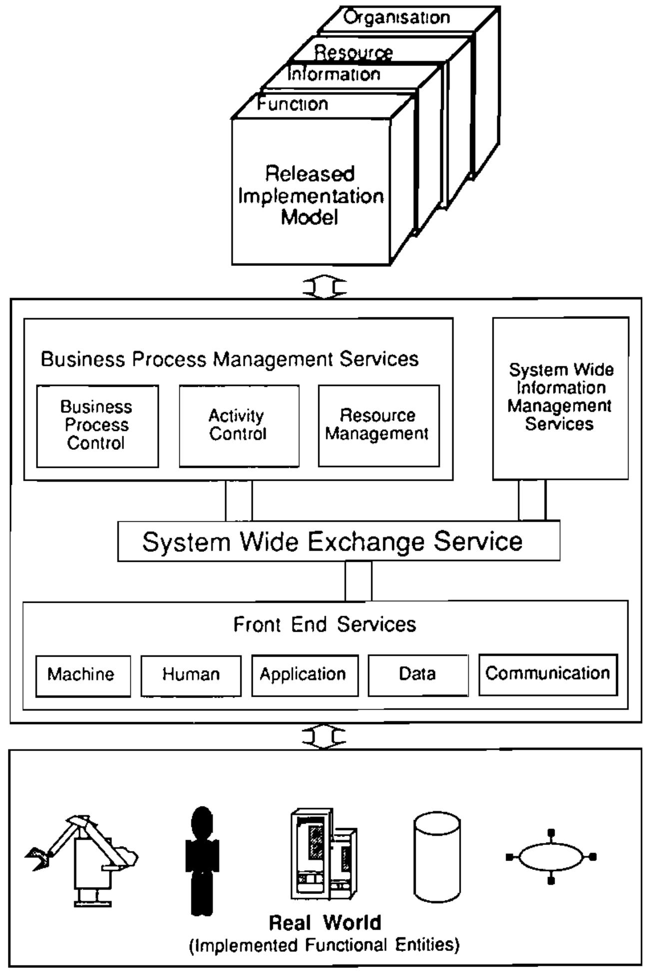

Figure 4. Services of the CIM-OSA integrating infrastructure.

The Front End Services are Human Front End, Machine Front End, Application Front End, Data Front End and Communication Front End. Their purpose is to present to the Implemented Functional Entities behind them, the rest of the system in a homogeneous way and, conversely, to present these Implemented Functional Entities homogeneously to the rest of the system.

System-Wide Information Management provides data and information access protocols, and ensures consistency, data integrity and integration accross the system. The System-Wide Exchange Service enables intra-node communication. The interaction between the Services is based on the Client-Service Model and their services are accessible through Protocols.

6.3.2. The services. Business Process Control. The purpose of Business Process Control is to manage the execution of

Implemented Business Processes. To achieve this it controls the sequencing and synchronization of its constituent Implemented Enterprise Activities by invoking the Procedural Rule Set specifying the flow of action. Business Process Control provides the services to transfer the control of an Implemented Business Process from one CIM-OSA node to another CIM-OSA node. It provides the services to control the release of new Implemented Business Processes and Implemented Enterprise Activities.

Activity Control. The purpose of Activity Control is to manage the execution of Implemented Enterprise Activities. To achieve this, it controls the flow of action in the execution of an Implemented Enterprise Activity by determining the sequence and synchronization of the constituent Implemented Functional Operations. It provides the services to transfer the control of an Enterprise Activity from one CIM-OSA node to another CIM-OSA node.

Resource Management. Resource Management is a distributed service which has the purpose of overall, system-wide, management of the enterprise resources as required for the proper execution of Implemented Business Processes and their constituent Implemented Enterprise Activities. Such management may be achieved in either a centralized or distributed manner (according to user choice), by assigning responsibility for given (sub)sets of resources to specified Resource Management services.

Machine Front End. The main purpose of the Machine Front End Service is to represent external data processing equipment such as Numerical Controllers, Robot Controllers, Programmable Controllers, etc., within a CIM-OSA node in an homogenous way.

Human Front End. The purpose of Human Front End is to connect consistently the human user (shop floor operator, CAD designer, manager, etc.) to the CIM-OSA system. This connection has to be implementation and application independent.

Application Front End. The purpose of the Application Front End service is to provide a defined set of services for the interaction between application programs and the Services of the CIM-OSA Integrating Infrastructure. This will facilitate the building of compatible application programs and will provide a higher level of stability for the application programs.

System-Wide Information Management. The purpose of System-Wide Information Management is to provide system-wide access of data to its clients. The clients may remain ignorant of actual data distribution. Therefore, System-Wide Information Management provides the data the clients request in the schema they specify or in a negotiated schema acceptable to them, whatever the actual storage schema is. System-Wide Information Management allows access after authorization checking and maintains data integrity. It supports the CIM-OSA information management concepts.

Data Front End. The purpose of the Data Front End is to support the Implemented Data Storage Functional Entities by providing local data storage and retrieval to be used in association with System-Wide Information Management, and enabling the insertion into CIM systems of DBMSs (Data Base Management Systems) or other means of data storage in a standardized fashion.

System-Wide Exchange. The purpose of the System-Wide Exchange Service is to provide the adequate service needed to implement Access and Agent Protocols occurring among the other Services. It enables its service users to remain unconcerned with the notion of CIM-OSA node and hence with any networking issue.

Communications Front End. The Communication Front End provides a means for the other Services to access transparently the OSI Environment or the private Communication Environment and enables the transfer of information using real communication systems.

7. Supporting the building of CIM systems

7.1. Introduction

The Enterprise Model describes the enterprise from the viewpoint of the business requirements defining what has to be done within the enterprise. The Implementation Model describes the physical environment of the enterprise, defining how the enterprise will operate. The CIM system, described by the Implementation Model, is thus developed by mapping the business requirements on to the physical environment. Consequently, the CIM system has to be changed or updated whenever a change occurs in the business requirements or in the physical environment.

The business requirements described by the Enterprise Model are subject to different kinds of changes: developing new products, updating existing products, changing production volumes or production speed, etc. Changes in the physical environment, affecting the Implementation Model, occur whenever new available technologies are introduced in the company.

A CIM system thus has a very dynamic behaviour. Changing and updating a CIM system is a continuous effort. Whilst today's system is in operation, its successors are in the process of implementation. Because of the importance of this dynamic behaviour, CIM-OSA has developed architectural concepts facilitating the building and updating of a CIM system and a build-time support toolset. Those are the subject of this section.

7.2. Architectural concepts

In previous sections, we have introduced CIM-OSA generic building blocks at each modelling level. At the enterprise modelling level. CIM-OSA defines generic building blocks such as Enterprise Activity and Business Process. At the intermediate modelling level CIM-OSA introduces Logical Cells, Enterprise Object, etc. Amongst the generic building blocks used at the implementation modelling level, we name the Integrating Infrastructure and the Implemented Functional Entities.

Those generic building blocks can be applied for building the appropriate Particular Models (Particular Enterprise Model, Particular Intermediate Model and Particular Implementation Model) of a specific enterprise. These generic building blocks have the widest application in CIM and are thus purely generic. Therefore, the catalogue of all the generic building blocks is called the CIM-OSA Generic Level. Analogously, the three Particular Models together are called the Particular Level (Fig. 5).

To support the building of CIM systems, CIM-OSA has defined an architectural level between the Generic Level and the Particular Level. This level, the Partial Level is composed of partial models, which are partial instantiated generic building blocks or sets of them. This means that they are applicable to a particular category of manufacturing enterprises in which they improve the economy of the CIM system design process because they are applicable to more specific but still generic areas of an enterprise. Partial models are macro-constructs generated from the basic building blocks of the Generic Level. The Partial Level is considered to be an open set which will be filled by standards, industry offerings and even internal work in particular enterprises.

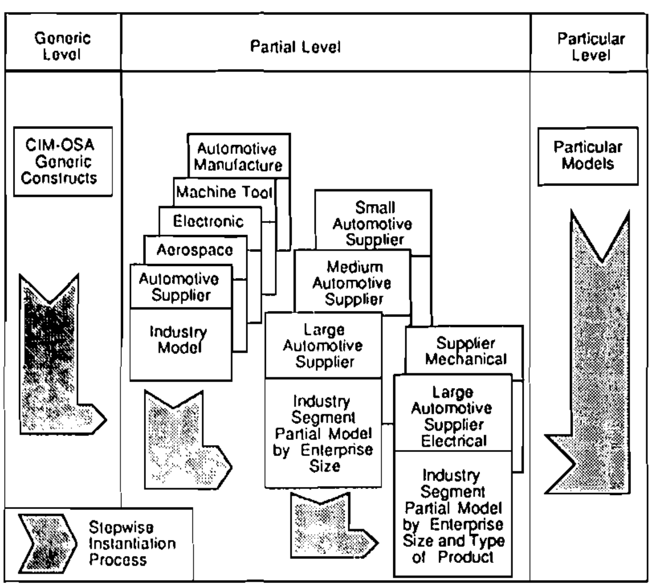

Figure 5. CIM-OSA partial level.

Partial models may be defined in a hierarchy as indicated in Fig. 5 where a set of partial models 'Automotive Suppliers' may be partially instantiated in a further subset according to enterprise size and even in a further subset according to type of business. The ideas behind the partial models are thus strongly based upon the object oriented approach.

The project has applied the CIM-OSA architecture to several real operational systems with the intention of verifying and validating the CIM-OSA architecture. During these efforts, some simple partial models such as Business Process Types, Enterprise Activity Types and View Types have been introduced.

Business Process Types describe a range of Business Processes which have a similar behaviour. A Business Process is built by instantiating a Business Process Type: the Business Process inherits the behaviour of the Business Process Type and some specific behaviour is added. Analogous for Enterprise Activity Types.

In the field of information modelling it is expected that many Enterprise View Edition Types or View Types will be defined for common disciplines such as mechanics, electronics, optics, software, logistics, etc. Those View Types will support the building of View Editions and thus facilitate the design of the Enterprise Objects.

7.3. Build-time support toolset

Besides the introduction of the partial models, CIM-OSA proposes a second aid to anticipate the dynamic behaviour of a CIM system: the Integrated Enterprise Engineering tools. These Integrated Enterprise Engineering tools support the different steps CIM-OSA has defined for the building of the Particular Implementation Model.

The use of such a toolset offers two important advantages. Firstly, these tools guide system designers through the whole design process allowing them to gain time and improve the quality of the system being built. Secondly, the use of the tools controls the manner in which the different CIM system design tasks are performed, ensuring the final consistency between the initial business requirements defined in the Particular Enterprise Model and the resulting physical CIM system described in the Particular Implementation Model.

The Integrated Enterprise Engineering toolset, which is graphically oriented, provides the system designer with a set of screen displays for menu selection or inputs and allows consistency checking. Some examples: design a new Business Process starting from the list of existing

Business Process Types; define the Inputs and Outputs of an Enterprise Activity supported by the list of the existing Enterprise Object Types; check the existence of the Enterprise Activities used by a Business Process; check the consistency of the inputs and outputs of the Enterprise Activities used by a Business Process, etc. Further requirements on the tools include real time behaviour, allowing the simulation of the effects of different strategies.

The Integrated Enterprise Engineering tools are developed themselves as a set of Implemented Business Processes and Implemented Enterprise Activities. The operational use of those tools thus requires the relevant services of the CIM-OSA Integrating Infrastructure.

8. Overview and summary of CIM-OSA

After describing the different CIM-OSA approaches, it is useful to give an integrated overview of CIM-OSA.

Figure 6 is an overview of the CIM-OSA enterprise modelling framework, showing the different steps of the CIM-OSA methodology for the building of the Particular Implementation Model, which is the physical CIM system. The Particular Models are built by instantiating generic building blocks defined in the Generic Level and/or partial models defined in the Partial Level. The Particular Implementation Model is derived from the Particular Intermediate Model, which in its turn is derived from the Particular Enterprise Model. Each model is described by its four views. These views are concerned with the functional aspects, the information aspects, the resource aspects and the organizational aspects of the model concerned. Because of the inter-relation of the different views, the process creating them is called the generation.

CIM-OSA provides two integrated environments for

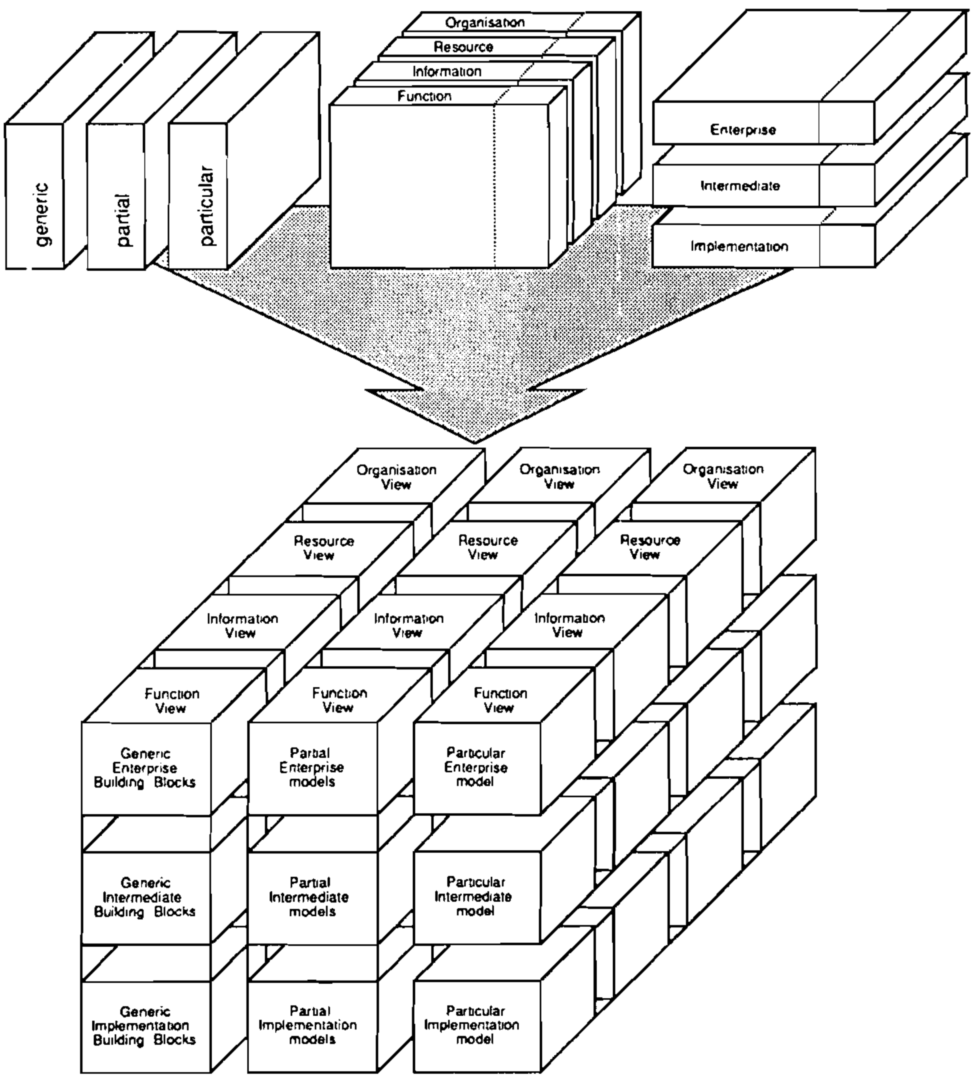

Figure 6. CIM-OSA enterprise modelling framework.

building and operating a CIM system (Fig. 7). The Integrated Enterprise Engineering Environment covers all build-time aspects, including design and maintenance of the CIM system. The Integrated Enterprise Operational Environment covers the run-time aspects of the CIM system and thus allows the execution of the Implemented Business Processes defined in the Particular Implementation Model.

The Integrated Enterprise Engineering Environment comprises the CIM-OSA Integrated Enterprise Engineering tools which are a set of Computer-Aided Engineering tools to support the application of the enterprise modelling framework resulting in the Particular Implementation Model. It also contains the relevant services of the CIM-OSA Integrating Infrastructure supporting the use of those tools and the basic data processing resources (people, services and devices) on which the Integrated Enterprise Engineering tools and the Integrating Infrastructure are implemented.

The Integrated Enterprise Operational Environment allows the Particular Implementation Model, built in the Integrated Enterprise Engineering Environment, to be executed after it has been released for operation. It contains the CIM-OSA Integrated Enterprise Operations which is the collective term for all application software by which the Implemented Business Processes, the Implemented Enterprise Activities, the application programs and all manufacturing specific functions are implemented. The Integrated Enterprise Operational Environment also includes the relevant services of the CIM-OSA Integrating Infrastructure supporting the execution of the Integrated Enterprise Operations. In addition, it contains those basic data processing and manufacturing resources

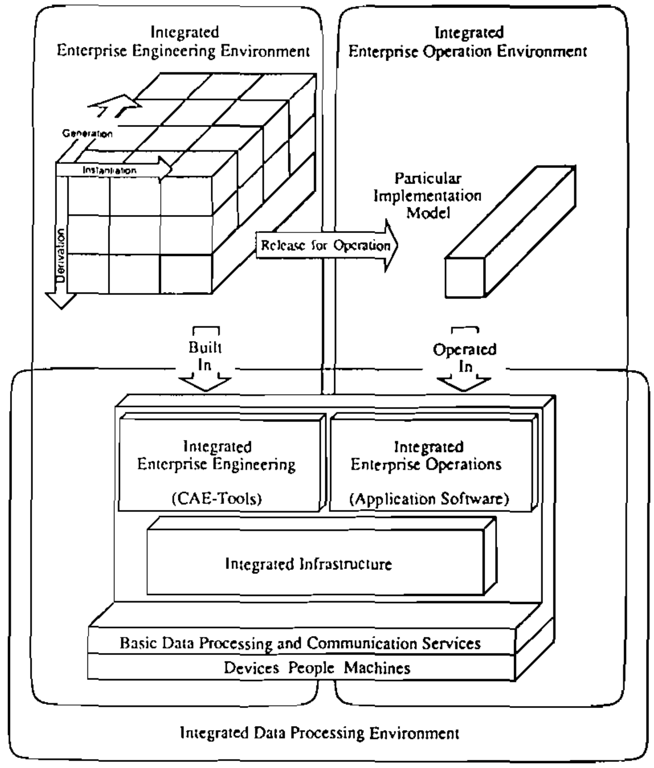

Figure 7. CIM-OSA environments.

(people, services, machines and devices) which have been defined in the Particular Implementation Model and those on which the Integrating Infrastructure is implemented.

Figure 8 shows both environments in an operational context.

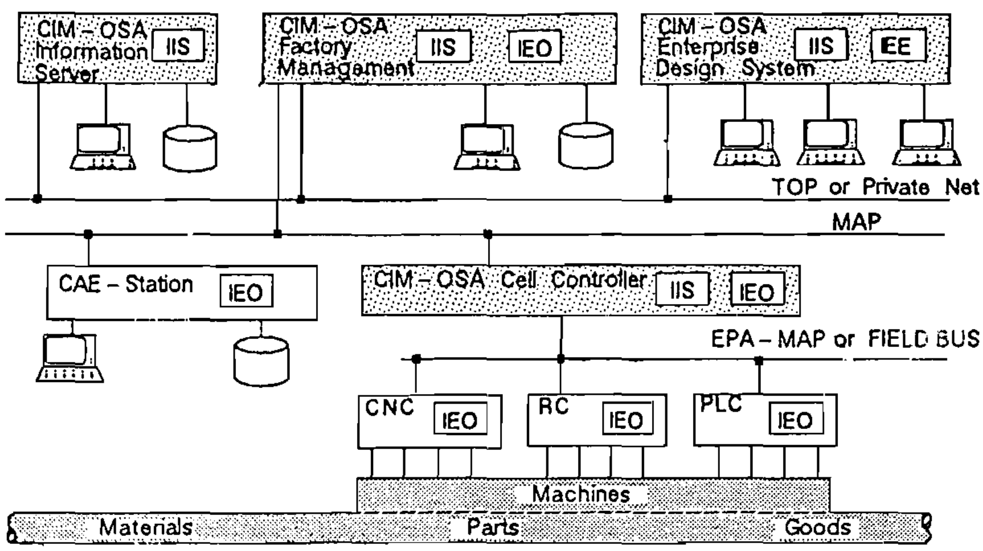

Figure 8. Using the integrated environments. IIS, Instance of the Integrating Infrastructure; IEE, Integrated Enterprise Engineering; IEO, Integrated Enterprise Operations.

9. References

This paper is based on the following documents.

AMICE, 1988, *CIM-OSA 0.5 Functional Design*, November (AMICE restricted).

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