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Design of computer integrated manufacturing and educational system using decision support system, and case base reasoning in concurrent engineering environment

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Abstract

The main objective of this paper is to address the concept and design of a computer integrated manufacturing (CIM) and intelligent educational system in concurrent engineering environment for Saipa Automotive Industry in Iran. In order to increase speed of design and process planning and manufacturing, a feature based approach and case base reasoning technic for acquiring design specification and compare with previously designed 'features and retrieve related process planed and modify for new parts. In order to design and plan effectively, one must have a view of how the enterprise works in CIM environment, and what information needs. In this paper we will discuss a general model, in terms of its functions, what each area does, and how each area interacts with the others. we will also discuss the support functions, administration, application development and decision support functions that are common to almost every enterprise. We will also describe the architectural requirements for implementing a computer integrated manufacturing strategy in computer based concurrent engineering environment and how this architecture can support the entire enterprise in terms of its functional, information resource and organizational needs.

Keywords: CIM, Edecation, Auto Industries, Manufacturing

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1. Introduction

The arrival of the information Age or information society was first announced by some social radicals such as McLuhan[1] and kohyama [2]. Despite the fact that the long awaited "social revolution" has not happened [3-5], there is growing evidence to suggest that society is becoming more and more information oriented [6-7]. However this does not mean that sufficient attention has been paid to the increasing need for quality information and its effective management. In response to the fast changing manufacturing environment, a research project[8] was set up which seeking to identify patterns that existed in the sector of non standard route manufacturing (NSRM) emerging as a result of market polarization[9]. Some of the findings have been documented in previous articles [10-12]. The continuing expansion of translational economic activities and the market globalization [13] have in recent years resulted in a broadened scope of competition strategies [14]. An increased diversity of consumer demands [15,16], and shortened product life cycles[17].

To day global markets are very complex and turbulence and characterized with shorter product life cycles, increased domestic and international competition, rising labour and raw material costs, technological innovations and internal organizational changes. These are just some of the challenges faced by todays manufacturing Companies and process enterprises. In order to overcome these challenges, and manage manufacturing effectively, the enterprise must seek new ways to lower product costs, improve product quality, shorten lead times, reduce inventory and respond more quality to customer and market demands on an international basis.

The conventional solution to these challenges is automation of different function area in manufacturing Companies. To days many enterprises are taking advantage of automation through the implementation of information technology tools such as: Computer Aided Manufacturing (CAM), Computer Aided Design (CAD), Computer Aided Engineering (CAE), Material Resources Planning (MRP), Computer Aided Quality Control (CAQC), Automatic Storage and Retrieval System (ASRS) and Administrative and decision support tools. Today's

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increasingly competitive manufacturing environment is forcing many enterprises to re-evaluate the impact of different island of automation systems, they are discovering the need for integration of those island of automation, and business-driven information systems, which enable different departments to work more closely with each other. These systems: a) Aid design engineers to consider constraints and capabilities of automated plant floor equipment at Process of design products; B) allow process planners with access to design and manufacturing data and bills of material and routings so that production plans and schedules are planed more accurate; C) allow communication lines extend to all internal department and suppliers and customer; D) allow integration of all internal function and suppliers and customers.

Computer integrated manufacturing system (CIM) is a complex and dynamical system containing many functions from customer orders to finished product, including marketing, design engineering, process planning, scheduling and budget, production, financial planning, purchasing, management, sale and other functions of manufacturing organization. Computer integrated manufacturing (CIM) is aim of many manufacturing organization. CIM is not a single technology; it is a collection of many technologies. There is no single definition for CIM in the literature; it is defined in many different ways.

For instance the following definitions are shown some of the various definition of CIM appeared in the literature survey. According to Banerjee [18] CIM is a methodology whose goal is to integrate by the use of computing and associated technologies, such as communications hardware and software, to plan, co-ordinate, monitor and control all activities of a manufacturing organization so that the overall goals of the company could be achieved. According to Ranky [19] CIM is mainly concerned with the information processing tasks at all level of the factory and its management". According to Peter Vail [20]" the goal (of CIM) is to tie all the various computers, programmable controllers, and other programmable devices found in the factory into one integrated network or system wherever it

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is operationally advantageous and profitable to do so". According to Ford et al [21] CIM is a business strategy, rather than an automation or computer strategy. Its aim is the integration of business functions to operate effectively in accordance with business goals. According to Khorami [22] CIM " is combination of individual systems with in the manufacturing organization into an integrated whole. This combination is strongly affected by the needs of data transmissions network and advanced control system". According to Panayotti [23], in his lecture note " CIM computer integrated manufacturing is more of a philosophy of system integration than a name applied to an individual product- the CIM philosophy of the automated factory is too broad to be satisfied by any individual vendor.

CIM is sometimes integrated quite narrowly as the integration of shop floor systems- CNC machines, robots, Plc s etc". According to Frick et al [24]" In recent years, experiences from introducing elements of computer integrated manufacturing have brought a recognition, that implementation of CIM should be balanced, regarding technological and organizational issues, to obtain true competitive benefits". Computer integrated manufacturing (CIM) is combination of three words: 1. Computer and network, 2. Computer Integrated, and 3. Manufacturing.

2. Computer

Computer is a device which can accept data through input devices such as Keyboard, and process data and produce useful information through its output devices such as printer, monitor and etc. Computers are powerful tool apply to the most effective areas within a manufacturing organization. Computer gets piece of data and does quickly and surely something with it. It can also compare received data and programming data and produce the result and causes some functions. Computers can assist all functions within manufacturing organization such as marketing, finance, planning, design engineering, scheduling inventory control, bill of material process planning, production management and etc. Computer is a

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device which can be easily used for communication so that any body even children can use computer.. Computer is part of our life in schools, offices, and more and more part of manufacturing processes and organizations. Computer is essentially machines which manage a large amount of detailed information rapidly and surely and can cope with complexities. Networks are a communication technology, and collection of interconnected computers within manufacturing organization.

2.1. Computer Integrated

Computer integrated means all computerized functions within the manufacturing organization are tied together on the other hand all isolated computerized, all stored data and all computers within the manufacturing organization are linked together. Integrations of computerized functions causes many benefit for manufacturing organizations, for instance reduce the lead time, increase productivity, decrease production cost, designer can get feedback from production and major customers and facilitate manufacturing and production tasks. Integration can be achieved by creating bridge between individual applications. Integration usually "shares ' a collection of data between two applications. For example a bridge between engineering CAD/CAM application to download an NC program to a production planning and plant operations may be used to provide a share of the production schedule to the plant floor system. Another bridge permits Engineering and production planning allows these two functions to share a bill of material.

2.2. Manufacturing

Manufacturing is a process by which raw material converting into product which has more value. Manufacturing in its broad sense including raw material, machining assembly, test inspection, tools, fixtures and etc. for instance bicycle is a product that is made out of steel.

2.3. Computer integrated manufacturing

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embraces all functions within the manufacturing organization. It embraced the following function:

1. Computer Aided Design (CAD)

2- Computer Aided Process Planning (CAPP)

3. Computer Aided Manufacturing (CAM)

4. Computer Aided Production Management (CAPM)

5. Computer Aided Quality Control (CAQC)

6- Material Required Planning (MRP1)

7- Manufacturing Required Planning (MRP11)

8- Automatic Storage & Retrieval System (AS/RS)

9- Management Information System (MIS)

10. Computer Aided Business System (CABS)

In any manufacturing organization, there is a unique set of business processes that is performed to convert row material to finish product. In this regard, flexibility is very important. Flexibility means being responsive to changing market conditions. Flexibility allows the enterprise to meet customer needs with higher- performance, lower-costing products on a more timely basis. Flexibility allows the enterprise to meet needs with higher-performance, lower-costing products on a more timely basis. Finally, flexibility means being responsive to changing market conditions. In design and implementation of CIM, it is necessary to increase Manufacturing ability to manage changing conditions and flexibility, in order to implement information technology.

3. Saipa's CIM Model

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Saipa Automotive industry is one of the two main players of the Iranian auto Industry. Saipa itself comprises a number of auto manufacturers who have cooperated with different companies in the world over the past 25 years to promote the Iranian auto industry. In Saipa corporation, there is a unique set of business processes that is performed to convert row material to finished products including marketing, design engineering, processes planning, production, finance, administration, quality assurance and etc.

All manufacturing Companies such as saipa enterprises shares the same set of high-level objectives and manufacturing data; including 1) developing strategy, policy, and business and financial plans and directions; 2) design and implementation of CIM which use computer hardware and software and information technology to integrate all enterprise functions and to achieve those objectives and increased productivity, cost-effective and responsiveness throughout the enterprise. CIM accomplishes this by addressing each of the major functional areas of the manufacturing enterprise such as: marketing, design and process engineering, Production, finance, management, quality assurance and etc. Integration of these functions and allocating appropriate resources to them requires the ability to share and exchange information about the many events that occur during the various phases of the business process.

All enterprise information systems must be able to communicate and exchange information with each other. And, in addition, they must make systems differences transparent to users. There must also be the means to capture data close to its source, then share this data across functional areas, at contractors and even customers. To meet this need, the CIM environment requires a dynamic network of distributed application solutions and enabling functions. These solutions and enablers may reside on independent system platforms and require data from various sources. Some may be general- purpose platforms, while other may be tailored to specific application and system environments.

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However, the result should be an environment that encompasses the total information requirements of the enterprise from developing its business plans to shipping its products. When CIM implemented in Saipa, the benefits can extend far beyond the plant floor and its manufacturing processes. They extend into each of the functional areas of the Saipa corporation. In marketing and Product support, CIM helps manage customer satisfaction by allowing electronic order entry from customers through faster response to customer inquiries and changes and with more accurate sales projections.

In design and process engineering, CIM benefits include quicker design, development, process simulation and testing faster. In Production Planning, CIM offer more accurate, realistic production scheduling, manage and control the expediting, cancelling and rescheduling of production capacity and purchase orders. In distribution and Logistics, CIM helps plan requirements, manage the flow of products improve efficiency of shipping; vehicle and service scheduling allocate supply to distribution centres and expedite processing of returned goods**.** CIM also offer benefits to all other functions.

The Saipa model defines terms of its functions and data requirements, generally, operations and functional management may be divided into separate departments, each with its own objectives, responsibilities, resources and productivity tools. In order the enterprise to operate efficiently and profitably, these departments must perform in concert in an integrated continuous fashion. Properly implemented, CIM can create a systematic network out of these insulated pockets of productivity. But to understand how this can be done, we must examine the elements of an enterprise model and see how its various functional areas work independently and with each other. Creating a model of the enterprise can help identify business processes. It can also help determine which information is critical to a successful CIM implementation. This section describes the building blocks of Saipa model. In order to describe the Saipa model, we have created a circular factory that incorporates the functional areas. This is illustrating in Fig.

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1. Saipa CIM model, in order to be useful, it requires to provide open and easy access to application developers and systems integration and information systems and system software developer.

One of the important steps in application integration is to provide for sharing information between multiple applications. A directory of shared data elements is required to manage information needed by the enterprise's business processes. This directory provides a single point of control for capturing and storing Saipa's shared data.

CIM Architecture model of managing data sharing Saipa through a single point of control is illustrate in Fig. 2. This provides consistent data definition for all function of Saipa Corporation. The requirements for integration in Saipa Corporation are three blocks of communication; data management and presentation each have their own set of technical requirements. This is illustrated in the first ring of fig.4 and fig. 5.

Communications:

The delivery of Saipa's data to different functions, systems, devices and people, is an important aspect of a CIM model, because industrial environment brings together a wide range of technologies, systems and computer systems. Fig. 5 illustrates how CIM Architecture model of Saipa answers the saipa's integration needs and provides a core of common services. These services support all areas of Saipa from its common support functions to its highly specialized Saipa's processes.

Data management:

Data management in Saipa Corporation is very particularly critical in today's Saipa environment, since there are so many different data bases, formats, and storage and access techniques in Saipa Corporation. Data management includes how data is defined, how different data elements are related, where data is stored and who has access to that data. In Saipa many

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functions are used to convert raw material to finished products. In this regard a wide range of devices and information requires producing different types of automobiles.

The required information in Saipa Corporation must have a consistent way to distribute and present information to different functions and people at computer terminals or workstations, machine, tools, robots, sensors, bar code readers, automated guided vehicles, and part storage and retrieval systems. The range of this information covers everything from simple messages between people to large data arrays for engineering design applications.

Today's saipa environment, presentation occurs on displays that utilize different technologies. Asa resoult, the same information is often treated differently by individual applications. By using these blocks, Saipa architecture CIM model can provide a consistent base for integrating the saipa's product, process and business data. It can define the structure of hardware and software and services required to support the Saipa's complex requirements.

Concurrent Engineering (CE):

Concurrent Engineering (CE) is a systematic approach to integrated product development that emphasizes the response to customer expectations. It embodies team values of co-operation, trust and sharing in such a manner that decision making is by consensus, involving all perspectives in parallel, from the beginning of theproduct life cycle. One the other hand concurrent Engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including, manufacturing and support. The concurrent engineering method is a new design management system and well-defined systems approach towards optimizing engineering design cycles.

Concurrent engineering has been implemented in a multitude of companies, organizations and universities. The basic premise for concurrent engineering revolves around two concepts. The first is the idea that all elements of a product's life-cycle, from functionality, producibility, assembly, testability, maintenance issues, environmental impact and finally disposal and

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recycling, should be taken into careful consideration in the early design phases. The second concept is that the preceding design activities should all be occurring at the same time, or concurrently. The overall goal being that the concurrent nature of these processes significantly increases productivity and product quality, aspects that are obviously important in today's market. This philosophy is key to the success of concurrent engineering because it allows for errors and redesigns to be discovered early in the design process when the project is still in a more abstract and possibly digital realm. By locating and fixing these issues early, the design team can avoid what often become costly errors as the project moves to more complicated computational models and eventually into the physical realm.

As mentioned above, part of the design process is to ensure that the entire product's life cycle is taken into consideration. This includes establishing user requirements, propagating early conceptual designs, running computational models, creating physical prototypes and eventually manufacturing the product. Included in the process is taking into full account funding, work force capability and time, subject areas that are extremely important factors in the success of a concurrent engineering system.

Case Base Learning(CBR):

Case-based reasoning (CBR), broadly construed, is the process of solving new problems based on the solutions of similar past problems. An auto mechanic who fixes an engine by recalling another car that exhibited similar symptoms is using case-based reasoning. A lawyer who advocates a particular outcome in a trial based on legal precedents or a judge who creates case lawis using case-based reasoning. So, too, an engineer copying working elements of nature, is treating nature as a database of solutions to problems.

Case-based reasoning is a prominent kind of analogy making.It has been argued that case-based reasoning is not only a powerful method for computer reasoning, but also a pervasive behavior in everyday human problem solving; or, more radically, that all reasoning is based on

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past cases personally experienced. This view is related to prototype theory which is most deeply explored incognitive science. Case-based reasoning has been formalized for purposes of computer reasoning as a four-step process: First step is Retrieve: Given a target problem, retrieve from memory cases relevant to solving it. A case consists of a problem, its solution, and, typically, annotations about how the solution was derived. For example, suppose Fred wants to prepare blueberry pancake Being a novice cook, the most relevant experience he can recall is one in which he successfully made plain pancakes.

The procedure he followed for making the plain pancakes, together with justifications for decisions made along the way, constitutes Fred's retrieved case. Second step is Reuse: Map the solution from the previous case to the target problem. This may involve adapting the solution as needed to fit the new situation. In the pancake example, Fred must adapt his retrieved solution to include the addition of blueberries. Third step is Revise: Having mapped the previous solution to the target situation, test the new solution in the real world (or a simulation) and, if necessary, revise. Four step is Retain: After the solution has been successfully adapted to the target problem, store the resulting experience as a new case in memory. SMART is a support management automated reasoning technology for Compaq customer service.

Decision supporting systems:

In Saipa's CIM model, all functional areas are supported by a layer of common application services and tools. In Saipa's CIM model and its business functions are represented by the second ring in Fig. 4. and FIG. 6. which support functions or applications. This ring support for accessing, summarizing, selecting and analyzing the data required to manage Saipa enterprise. The common support functions is divided into following three individual areas: `1) administrative support which provides general business or office support such as creating documents, communicating with suppliers, tracking finance, scheduling meeting and etc. 2) decision support which clarifies and presents critical information to decision makers and

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product designers and manufacturing engineers. 3) Application development support which creates the applications necessary to keep all aspects of the enterprise functioning smoothly and efficiently.

Integration of all functional areas in Saipa's corporation:

In this section we describes the building blocks of Saipa CIM model where all functions work closely and communicate interactively in order to convert raw material to finished products. The model is based on current saipa's organizational chart. This is represented by the third ring in fig. 4 and fig. 1.

Marketing: marketing acts as the Saipa's primary contact with its customers. To help meet the key objectives of increasing product sales, marketing personnel perform several tasks: market research and forecasting demand and sales, analysing sales, tracking performance of products, marketing segments, sales personnel and advertising campaigns… developing and managing marketing channels, controlling profits and revenues managing sales personnel, sales plans and promotions.

After product has been delivered to the customer, product support activities such as field support, warranty and claims management, and product installation must be performed. Input comes from business management and customers. Output goes to customers, product development, customer order servicing and master production planning. Design and Process Engineering: This area involves design of product and design of process.

Design of Product: Design of product includes activities such as preparing product specifications and processing requirements, drawings, materials or part lists, and bills of material for new products or engineering changes. In this area, the availability of laboratory analysis tools, computer aided design, computer aided engineering (CAD/CAE) tools and group

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technology applications on workstations are helping to reduce product development time, increase productivity and improve quality. Product design input comes from marketing, research and development and plant operations. Its output including: product specifications, manufacturing control requirements, which can be drawings, text and messages – are directed to design of process and engineering release control.

Design of process: this functional area creates process control specifications, manufacturing routings, quality tests and statistical quality control specifications, and numerical control (NC) programming. Computer aided process planning (CAPP) programs and group technology applications also available on workstations for routing, similar parts have helped streamline these functions. Expert systems have also been used to supplement traditional product testing and defect-analysis processes. This area is also responsible for the application of new manufacturing technologies such as work cells, conveyor systems and robots.

Planning: This function includes establishing goals and strategies for finance, marketing, engineering, production, plan automation information systems and etc. planning consists of five related business processes. These processes consolidate and conform demand, orders, forecasts and resource constraints to production plans, developing detailed schedules. These plans or schedules are then made available to the participating and appropriate functional areas. Some of these functional areas would include: Finance, Marketing, Engineering design and process, Production, Quality Assurance, Administration.

Quality Assurance, test and inspection: Quality assurance, test and inspection including factions such as: Testing items and products to make sure they confirm to specifications is the main activity in quality test and inspection. This includes analysing and reporting results quickly in order to reduce scrap, rework and recycle costs. Quality test and product specifications are input from engineering. The chief output includes purchased item inspection and product test

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results to production process and production management, quality test and inspection activity reports to cost accounting, and rejected part and product dispositions to material transfer.

Production operation: Production consists of a few activities including: production management, material receiving, storage, production process, quality test and inspection, material transfer, product shipping, plant maintenance and plant site services. Production process functions include managing the production process, processing materials, fabricating parts, grading or reworking components, assembling final products, and packaging for distribution**.**

Finance: finance including financial planning and management. In developing financial resource plans, enterprise goals are established. Among the functions are planning costs, budgets, revenues, expenses, cash and investments. Input includes financial goals and objectives established by management as well as summarized financial data received from all areas of the enterprise. The output includes financial reports to stockholders, departmental budgets and general ledger accounting. Data may consist of text and graphics as well as numbers.

Administration: Saips's services consist of office personnel, management information services, personnel resources and public relations. These services require extensive administrative support tools, such as text processing, decision support and graphics tools. But since input and output will be exchanged throughout the enterprise, it is imperative that these tools are integrated with the enterprise's other systems.

Economic: This function including activities such as: managing of internal account, managing ownership and, management of corporations under affiliation and control, and management of the office of board of control.

Seven layers of computer network for Saipa's CIM Model:

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Local Area Network (LAN) can be used to link suppliers and all Saipa's Companies and customers to saipa corporation. This is shown in Fig. 7. Saipa's computer network architectures are based on the seven layers of standard OSI model, namely the Reference Model of OSI defined by ISO. The model is intended to facilitate writing software that can transport easily from network to another.

Since each layer performs a specific communication task, an application program written to interact with an upper layer function does so even when changes are made to lower layers. Thus, layering makes application programs adaptable to various computers with minimum changes. The model has seven layers, as shown in Fig. 8.

The end-user or the application "resides" in the highest layer (7). Data originates at the application layer of sender, passes downwards through each layer to the physical layer, and then "out" on the medium.

On arrival at the receiver's physical layer, the data moves up through the layers to reach the receiver at the application layer. Each layer at the sender end usually adds a header, and sometimes a trailer, to frame the data passed to it by the higher layer. At the receiving end, these headers and trailers are moved by the appropriate layers so that the end user receives only the original data. Saipa needs to share information throughout its corporation, this is shown in Fig.9.

Conclusion

In this paper a general model of computer integrated manufacturing and educational system using decision support system, and case base reasoning in concurrent engineering environment is designed. The support functions, administration, application d and decision support systemd that are common to almost every enterprise are discussed. The author described the architectural requirements for implementing a computer integrated manufacturing

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strategy in computer based concurrent engineering environment and how this architecture can support the entire enterprise in terms of its functional, information resource and organizational needs.

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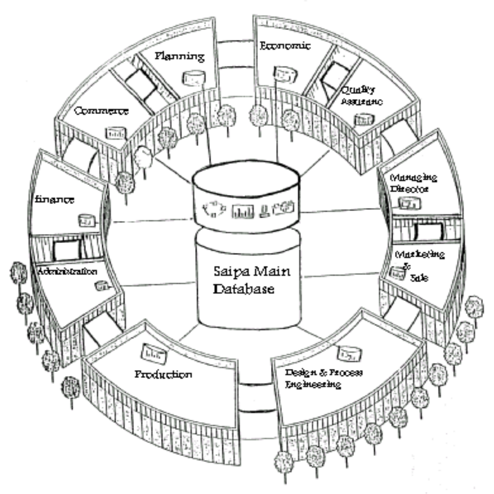	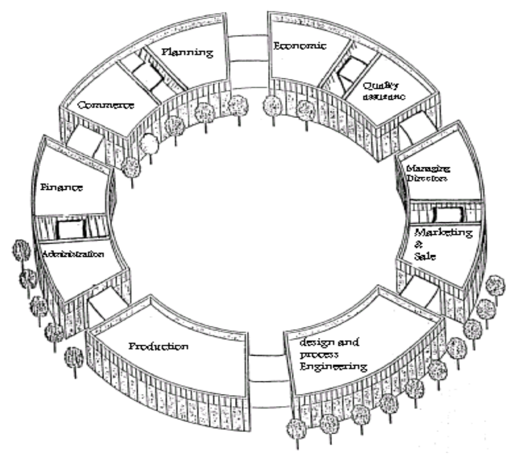
Fig. 2. Managing data in Saipa model in CIM menvironment	**Fig. 1. Saipa enterprise model of CIM**
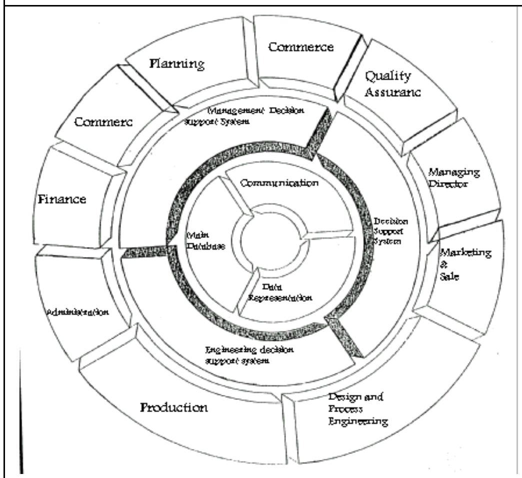	
Fig.4. The elements of CIM and educational system in Saipa model	**Fig. 3.Managing data bases through three individual storage functions**

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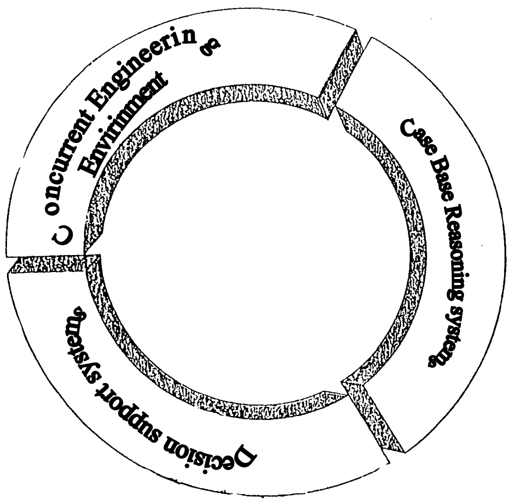

Fig. 6. Three common services support functional area case base reasoning, decision support systems and concurrent engineering environment

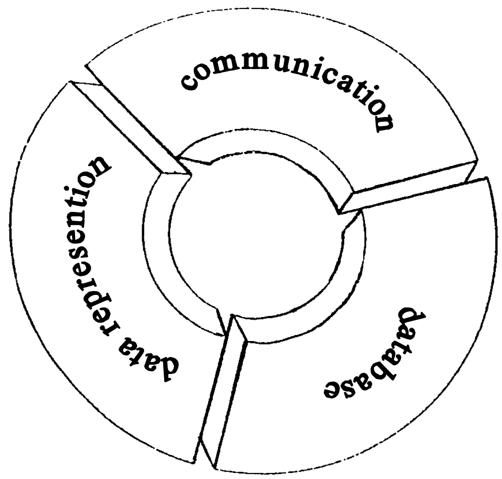

Fig.5. Elements of CIM support the information and data share in Saipa

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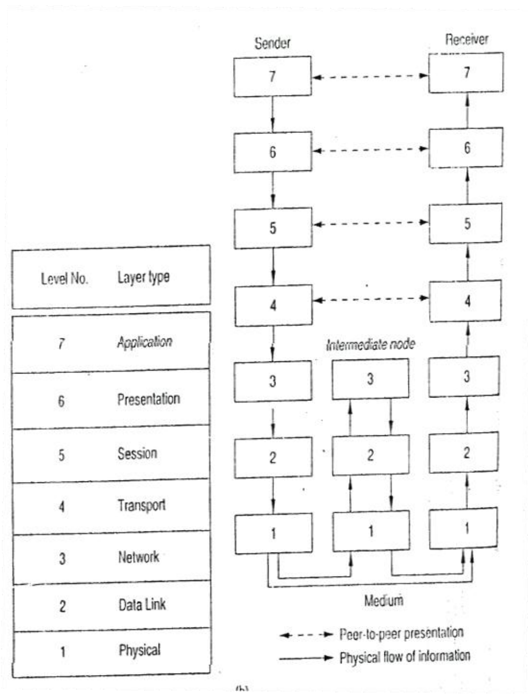

Fig. 8. seven layers of flow of information in OSI in CIM environment for Saipa model

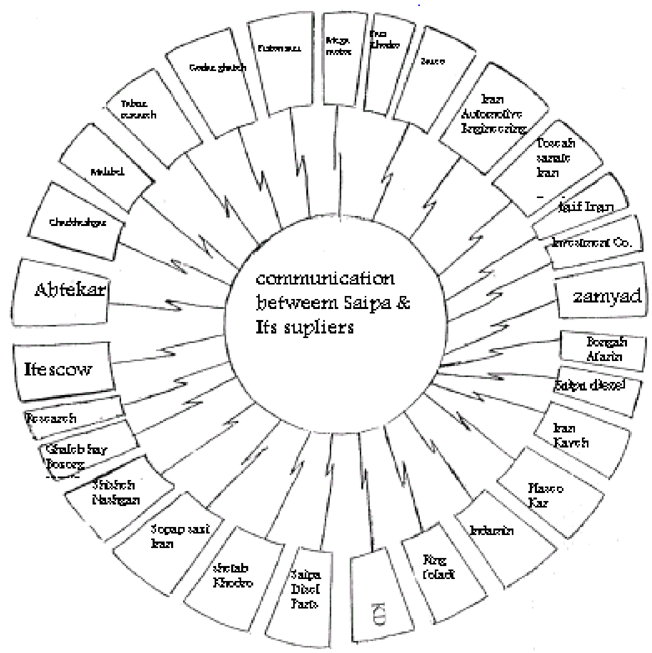

Fig. 7. Communication and consultation between Saipa and it's suppliers

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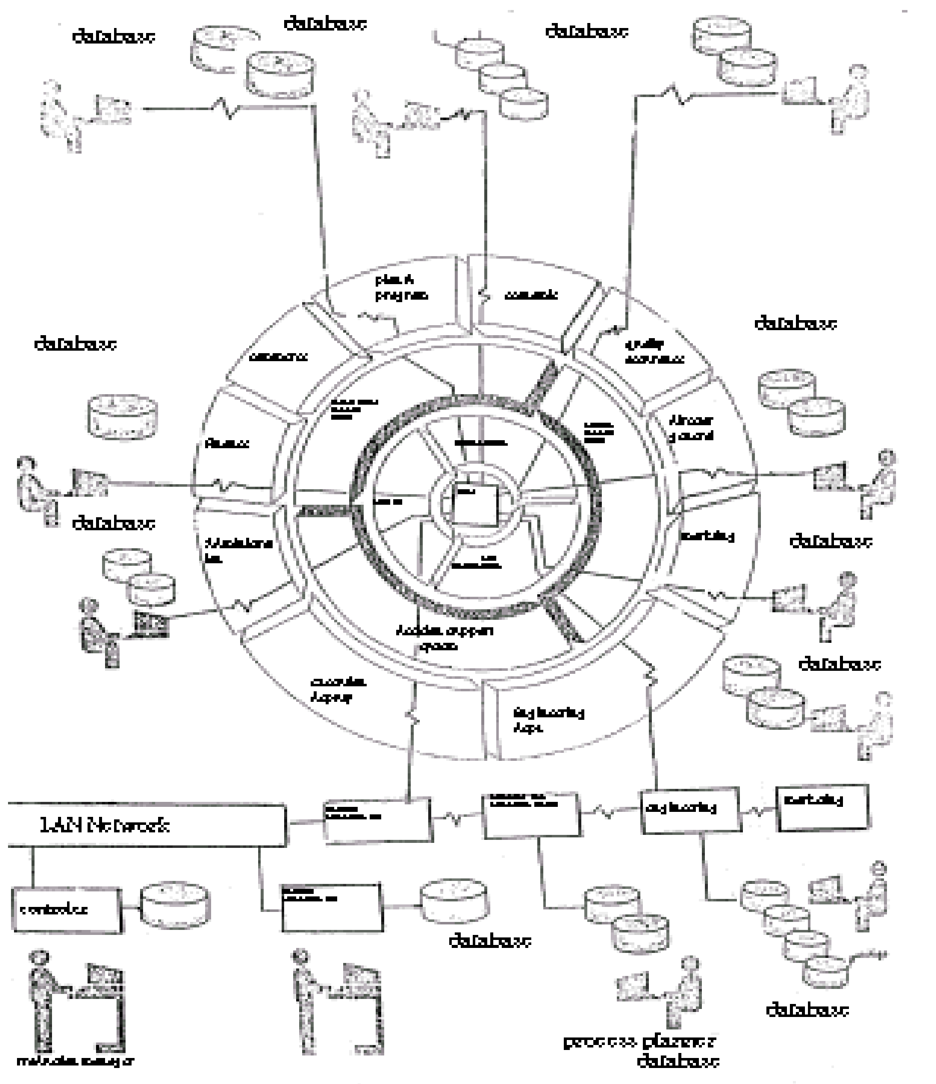

Fig. 9.data communication in CIM and educational learning systems