科技资料

COMMUNICATIONS FOR MANUFACTURING

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Preface

Open Communications, essential for cost-effective Computer Integrated Manufacturing (CIM), was the subject of a congress sponsored by the Commission of the European Communities, DG XIII (Telecommunications, Information Industries and Innovation) at Stuttgart's Annual Machine Tool Fair. Experts from Europe, Japan and North America addressed the industrial needs for open systems for manufacturing and explained the technological solutions enabling a multi-vendor environment and full integration from design to manufacture.

The congress was modular to allow a selection of relevant sessions. The first day was aimed at policy makers who determine strategy and decide on technological investments. The second day was aimed at those responsible for applying the technology and needing an up-to-date technical understanding and awareness of future trends.

The work of ESPRIT project 2617, Communications Network for Manufacturing Applications (CNMA), was highlighted and explained. ESPRIT is an industry-driven, Community-funded research and development programme in information technology, and CNMA is a flagship project of the ESPRIT-CIM programme. The project is led by the British Aerospace and comprises users from the aerospace and automotive industries (Aeritalia, Aerospatiale, Magneti Marelli and Renault), vendors (Bull, GEC, Nixdorf, Olivetti, Robotiker and Siemens) and the universities of Porto and Stuttgart, together with the systems integrator Alcatel-TITN and the research body Fraunhofer IITB.

CNMA aims at furthering the development and adoption of industrial communications standards for CIM. It has commissioned several experimental and industrial pilot sites and gained a lot of practical experience on network architectures and on the use of OSI communication for the management, control and integration of manufacturing processes.

The Communications for Manufacturing congress was organised by the CNMA project team and CIM-Europe. CIM-Europe is an information and awareness activity of ESPRIT. Its function is to consolidate and enhance the effects of ESPRIT-CIM by disseminating information on progress and achievements of the programme. Further information on CIM-Europe's activities can be obtained from: CIM-Europe Secretariat, 200 rue de la Loi (office Breydel 9/54), B–1049 Brussels, Belgium.

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Contents

ACHIEVING CIM, USER PERSPECTIVES

CIM SYSTEMS COMMUNICATIONS AT FIAT AUTOMOBILE DIVISION

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Summary

The increasing demand and competition in the manufacturing automation market are changing the approach to CIM implementations. Integration and therefore Factory Networking Systems are playing a more important role.

The aim of this paper is to present a management overview of the experience achieved, in the implementation of Factory Wide Communications, by FIAT Automobile Division (FIAT Auto) and planned evolution.

1. Introduction

The complexity of operations implied in Computer Integrated Manufacturing (CIM) projects is continuously increasing, due to the rate at which business and technological changes are taking place.

In order to gain competitive edge a manufacturing enterprise must define an integrated and heteroneous CIM architecture that will allow high quality productions at reasonable costs, reducing the lead time from product concept to marketplace delivery.

Viceversa a slow development of an efficient integration, that is computer-to-computer and computer-to-device communications, has inhibited the full evolution of CIM systems.

As an obvious consequence, interconnection/integration methods, and therefore communication solutions, must be developed between all components in order to define a complete CIM system that can be easily upgraded and reconfigured following market and competition demands.

The paper, after a summary on CIM architectures and communications in FIAT Auto (Chapter 2), points out, in Chapter 3, the experience gained by FIAT Auto in two projects; one in a production area, and the other in the area of engineering.

Finally, Chapter 4 describes planned evolution in the area of Factory Wide Communications, with emphasis on the most important FIAT Auto requirements.

2. CIM Architectures and communications

Several reference models for CIM architecture have been developed by the standardization committees, working groups and singular companies. Generally they have been realized with reference to constraints such as: simplicity, modularity and applicablility to a wide variety of industrial applications, taking into consideration also inter- connectivity problems, openess to new technology and independency from the computer and automation techniques in use nowadays.

Focusing on Manufacturing, one of the most referenced frames, is the ICAM (International Computer Aereospace Manufacturing) architectural model, where CIM activities are classified in 5 layers, each one identified by its functions, as shown below.

Table 1: ICAM Reference Model

LAYERS	NAMES
Layer 4	Enterprise
Layer 3	Factory/Plant
Layer 2	Cell/Area
Layer 1	Controller/Device
Layer 0	Actuators/Machinery

Table 1: ICAM (International Computer Aerospace Manufacturing) Reference Model

At the base of the Model is Layer 0, which is concerned with the real prodution machinery, where the actual production takes place. Numerical Controllers, Robot Controllers, Programmable Logic Controllers, AGV Controllers, etc., are the devices managing the production, and are included in Layer 1 of the model.

Next, there is the Layer 2 (Cell/Area), at which groups of machine controllers are respectively managed or controlled and monitored. Factory wide operations such as: production management, scheduling, maintainance and quality controls take place in Layer 3. At the top (Layer 4) is the Enterprise level, where responsabilities lies for the Enterprise mission and a set of functions such as: financial planning, facilities planning and activities coordination with external bodies.

Focusing on Engineering, computer based architectures organized in four layers are generally taken into account. Enterprise, Engineering-Plant, Workgroup and Workstation are the general names of the layers. These are devoted respectively to: Enterprise computing, Engineering-Plant computing and storing, and computer-aided programming at Workgroup and Workstation level.

Communications

Communications are becoming more and more important in the definition of CIM computer architecture. Three main kinds of networks must be considered:

o Enterprise Networks: the corporate data highway connects plants at different sites to the corporate headquarter through Wide Area Networks (WANs) or Metropolitan Area Netwoks (MANs). High-speed digital networks such as PSDNs/ISDNs (Packet Switched Data Networks / Integrated Service Data Networks), or high-bandwidth optical connectivity will become more and more common.
o Manufacturing Plant and Engineering-Plant Networks: Typical communication functions such as: file transfer, message exchange, program-to-program, virtual terminal and resource sharing are used. Broad-or-baseband backbone Local Area Networks (LANs) are the solutions mainly considered.

o Cell and Workgroup Networks: Focusing Manufacturing, due to the heterogeneity of the connected devices, ranging from simple sensors to complex machining centers and also performance requirements, this is one of the most critical areas. Generally devices are integrated by means of point-to-point connections or LANs. Concerning Engineering, due to the fact that only computer based systems are present, that is Workstations, LANs are the normal interconnection systems.

3. FIAT Auto Implementations

The first significant FIAT Auto experience in Factory Wide Communications dates back to 1985 when the concept of a main Factory Network was deployed for the automation of FIRE engine assembly in the Termoli plant. Later on in 1987, a number of large LANs were installed in FIAT Auto plants, covering different automation areas.

In the following paragraphs two implementations, in the areas of manufacturing and engineering are briefly described.

Cassino Manufacturing Plant

The CIM Architecture of the Cassino plant, as shown in Figure 1, is structured following the FIAT Auto CIM Reference Model, which is based on the ICAM frame.

In the area of networks, two different approaches have been implemented. A FIAT Auto communication standard, based on DECnet protocols as the factory backbone, that is used for communications between the various computers of the Cell and Plant levels. Different proprietary networks, implementing the cell networks, for the integration of device controllers and cell controllers.

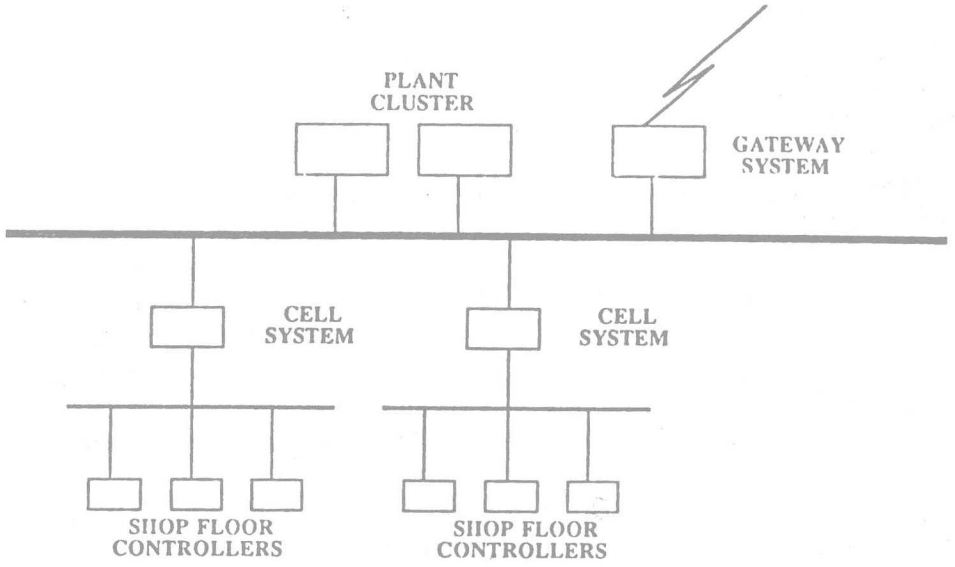

Figure 1: CIM Architecture of the Cassino Manufacturing Plant

FIAT Auto has developed a protocol named CABERnet to solve communication problems related to message synchronization, data delivery independence from receiver status, data integrity and restart features. CABERnet, considering the OSI reference model, is a protocol at the Application layer based on Digital DECnet, and is used to integrate the cell and the plant Controllers. The access methods and the media are respectively: Ethernet or CSMA/CD and IEEE 802.7 (Institute of Electrical and Electronics Engineers) broadband coaxial cable.

The proprietary networks such as Allen-Bradley Data-Highway, Texas TIway and COMAU HERMESlink are used to connect a large number of Programmable Logic Controllers, CNC Controllers and Robot Controllers to the cell controllers, named HERMES and developed by COMAU.

The resulting Cassino network architecture is impressive: more than 12 Km of broadband network, and about 1 square Kilometer of plane surface are totally covered by the network, about 150 nodes are directly connected to the factory network (VAX, MicroVAX and PDP systems, Personal Computers, Terminal Servers and SNA Gtw) and more that 1000
devices are connected to the total network (backbone and cell) system .

FIAT Auto Central Engineering

The Fiat Auto Product and Process Engineering Departments have in the last few years been developing a large Technical Office sistem devoted to activities such as: Computer-Aided Design (CAD), Engineering (CAE), and Design-Manufacturing (CAD-CAM).

The architecture, depicted in Figure 2, is based on a layered structure composed of four main layers, respectively: Enterprise, Engineering-Plant, Workgroup and Workstation. Systems at Workgroup and Workstation layers, are generally referred as computing "islands".

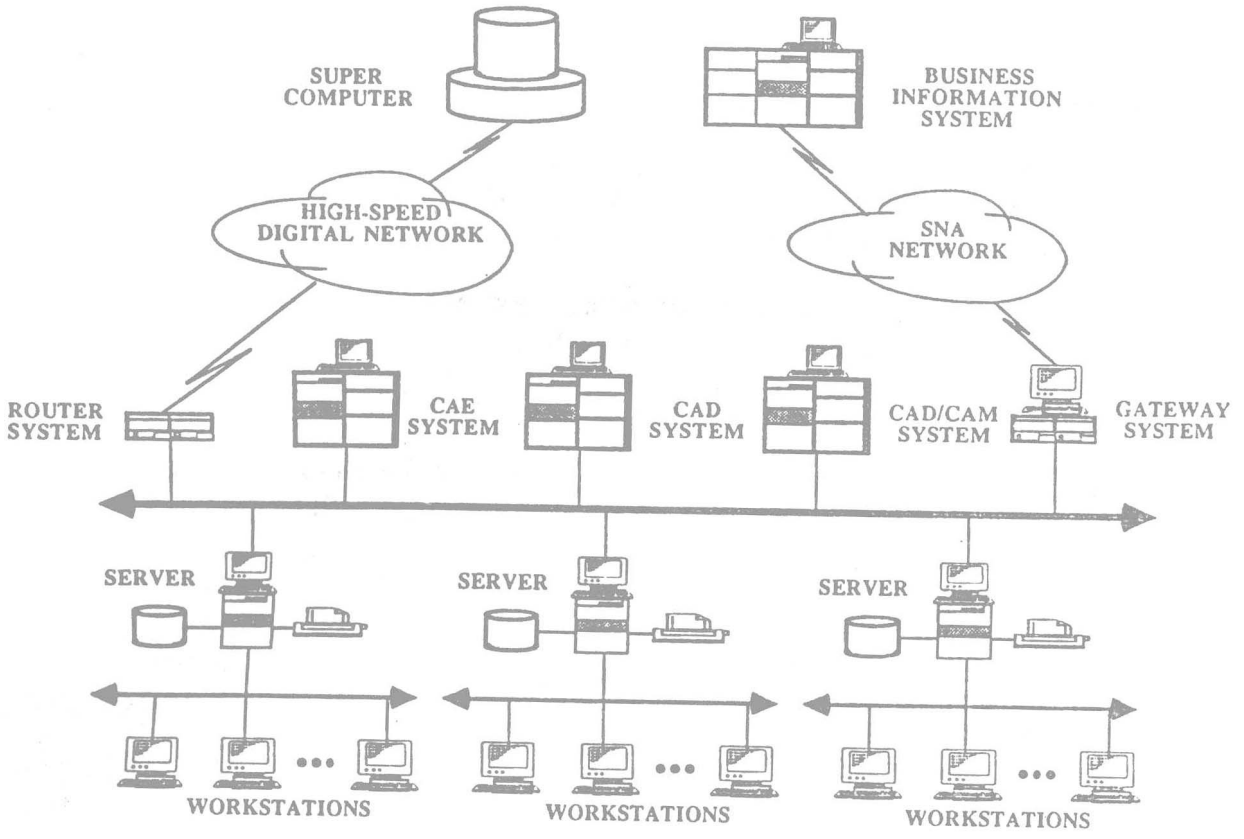

Figure 2: Computing Architecture of FIAT Auto Central Engineering

Enterprise and Engineering-Plant computing nodes, based on VAX systems and a Cray system, are mainly used for Engineering computation and as a central database store for the CAD systems.

The various islands, generally composed of a Server system and a number of Workstations, are mainly devoted to CAD development, CAE computation, and recently some of these have been devoted to the development of CAD-CAM programming.

All systems at the Engineering-Plant, Workgroup and Workstation layers are interconnected by means of a network based on baseband Ethernet, while high-speed digital networks are used to integrate computing systems at Enterprise Layer.

Due to the heterogeneity of systems installed, specifically, Cray and VAX systems at the Plant level, SUN and Computervision at the islands level, the Transmission Control Protocol/Internet Protocol (TCP/IP) has been chosen as the only possible solution, even if, in some case, some proprietary protocols such as DECnet are used.

4. Communication architecture evolution

For the future, FIAT Auto is looking for Factory Wide Communications solutions that will ensure higher interoperability among extremely heterogeneous devices and higher capability to cover the whole plant layout in a flexible way.

Optical Fiber, Open System Interconnection and Wide Area Networks are the strategic areas in which FIAT Auto is investing.

Optical Fiber

Optical Fiber technology is growing as an interest in the sector of industrial local area network, due to the multiple advantages they offer such as the followings:

o total immunity from elettro-magnetic and elettro-static noise,

o total isolation from electric noise, coming from power suppy lines,

o easy definition of complex/redundant topology,

o high bit-rate.

Recently a number of optical fiber standards have been designed in the IEEE 802 project. Particularly an optical fiber solution has been provided both for the three leading IEEE 802 standards: Ethernet, Token-Passing Bus and Token-Passing Ring.

One solution that is in the final stage of standardization is named Fiber Data Distributed Interface (FDDI). FDDI was designed by the American National Standards Institute (ANSI) by several dozen partecipating computer and telecommunications companies. FDDI uses a token-passing access scheme on a optical fiber media to achieve a speed of 100 Megabits per second (Mbps), which is an order of magnitude faster than Ethernet's speed of 10 Mbps.

FIAT Auto, in order to include fiber optics and in particular the FDDI in his industrial network strategy, is planning a migration path with the following milestones:

o to lay standardized optical fiber,

o to use optical fibers as a high-speed interconnection system for Ethernet networks,

o to define a full FDDI network as the backbone for an extensive industrial factory.

Open System Interconnection

The previous chapters have emphatized that two different solutions are nowadays widely used in FIAT Auto, respectively: proprietary, which uses many protocols such as DECnet, CABERnet and HERMESlink in the manufacturing environment, and a multivendor-one based on TCP/IP protocol in the engineering environment.

The final objective, in the area of Factory Wide Communications, for FIAT Auto is however an industrial network architecture, that will ensure an high interoperability among extremely heterogeneous devices.

The main prerequisite in order to achieve this objective is to define a network architecture based on Open Systems Interconnection (OSI). OSI is a data communication architecture, based on the ISO/OSI Reference Model, which allows for communication between systems conforming to the OSI standards. The OSI Reference Model has been developed by ISO (International Standard Organization) and is followed by the majority of information technolgy vendors.

Focusing on Application protocols, FIAT Auto is considering as candidate protocols for its OSI strategy, the most relevant protocols that have been standardized, or are in the final stages of standardization, such as:

o Manufacturing Message Specification (MMS) and MMS Companion Standard, as standard protocols at the Cell level,

o File Transfer Access and Management (FTAM), as standard file access system in multivendor environment,

o X.400, and X.500 as a standard solution for the Message Handling System and the Network Management and Directory Services in a multivendor enviroment,

o ISO/TP (Transaction Processing), as a protocol for the transaction processing environment.

The proprietary networking scheme, however, will continue to be selected in the future for some specific situations such as: i) when a single vendor is predominant in a certain area, ii) when exceptional performance is required, and iii) when it is not justifiable to remove existing networks.

Particular care will also be devoted to the migration of TCP/IP applications. Infact, even if TCP/IP offer a limited set of services such as: SMTP (Electronic Mail for ASCII text) ii) FTP (File Transfer for binary and ASCII) and iii) Telnet (Remote login to arbitrary hosts) it is however today the only networking solution to interconnect computers in a multivendor environment.

Wide Area Network

Emphasis will be placed in the future especially in Computer Integrated Enterprise (CIE) Technology. This means a lot of interest will grow in the area of Wide Area Networks.

Solutions such as Electronic Data Interchange (EDI), Odette (Organization for Data Exchange through Tele-Transmission in Europe) and the afore mentioned standard X.400, will play an important role in all the Wide Area Network solutions in FIAT Auto, both for inter-company and intra-company communications.

5. Conclusions

In summary, the lesson learnt by FIAT Auto in CIM Communication implementation indicates that Factory Wide use of de-facto or de-jure standard based networks always repays in terms of investment, flexibility, etc., while non standard compliant solutions always prove to be expensive and unflexible.

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