Development of a Support Tool for Rapid Application Integration of CIMS*

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Abstract CIMS applications in manufacturing enterprises need new advanced support tools for application integration. This paper the system architecture and functions for CIMS Application Integration Platform for Manufacturing Enterprises (MACIP). MACIP integrates a set of application software products and development tools as a complete system for CIMS implementation. The MACIP includes a communication system, a global information system, three domain application sub-integration platforms, an internet interface and an operation management and control system. The Client/Server structure, the object-oriented method and the agent technique were used in developing MACIP. Good system openness, scalability and maintenance are ensured by conforming to international standards and by using advanced system design software and management tools. MACIP can significantly reduce the implementation complexity, time and cost of CIMS.

Key words integration platform; CIMS; system architecture; object-oriented; application programming interface

Following the advent of mechanization and automation, manufacturing enterprises then entered into a new period of integration in the late 1980's which was characterized by Computer Integrated Manufacturing Systems (CIMS). In the 1990's, some new ideas and methods, such as concurrent engineering, agile manufacturing and virtual manufacturing, have enriched the CIMS methodology. However the new advances in CIMS results a great demand for CIMS integration technology and associated support tools.

In manufacturing enterprises, integration is the most important technology in the implementation of CIMS. However there exist many difficulties in CIMS application integration, such as:

(1) A large amount of various types of information stored in different locations.

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(2) The information systems are very complex with many different functions and tasks.

(3) The hardware and software environments are heterogeneous.

Traditional software development method, whereby applications are designed with functions, information processing, data structures and sometimes entire organizational systems are normally very difficult to modify. Current application integration methods developing data exchange interfaces for every application are not a satisfactory CIMS implementation method. Therefore, the current implementation efficiency is low and the process is tedious. It is very difficult to modify and maintain a CIMS once it is implemented.

All these problems restrict wide application of CIMS. The Integration Platform (IP) concept has been put forward to solve these problems with the development of many IP products. IP is a new kind of support tool for rapid application integration which can significantly reduce system implementation and maintenance costs. By providing common services and common application development tools, IP can hide the differences between hardware platforms, operating systems, and data storage methods. IP provides a unified integration interface, enabling users to quickly and efficiently integrate different applications in various computing environments. Thus, IP reduces the complexity of implementing CIMS and improves integration efficiency. Some typical IP products are BASEstar by Digital Equipment Company, DAE by IBM and CCE[1]. Although these IP products are very advanced, their support for CIMS implementation is still not good enough. One major reason is that they normally only provide an Application Programming Interface (API) for users, so that the user still must spend much time to compiling needed applications and integrating existing applications.

In the last 10 years, the China national high technology R&D plan has supported many research projects developing CIMS application software. Although these application products play an important role in enterprise management and production automation, they are not easily integrated into a comprehensive CIMS system. This paper introduces an integrated CIMS platform for manufacturing enterprises called MACIP (CIMS Application Integration Platform for Manufacturing Enterprises). The objective of MACIP is to provide common services, such as communication, data access, and operation management, software development tools and to integrate the 863/CIMS software products, thus offer manufacturing enterprises a complete solution for CIMS

implementation and integration. MACIP is a support tool for rapid implementation of CIMS.

1 MACIP System Architecture

MACIP is a support tool for rapid CIMS implementation. Its development is based on both on established CIMS system architecture and new software techniques. CIMOSA[2] (CIM Open System Architecture) is one of the most important architectures for enterprise integration. The development of CCE (Computer Integrated Manufacturing & Engineering Computing Environment) is based on CIMOSA. The most important software technique is the enabling technique which utilizes middleware concept to provide a common link between the applications and low level systems in common API form.

The design of an IP system architecture is closely related with its objectives. MACIP is an IP which supports not only the development and integration of applications, but also integration of the operation of CIMS. The MACIP system architecture is presented in Fig.1. MACIP uses Client/Server structures, Object-Oriented (O-O) modeling and programming, agent techniques and different kinds of APIs and Sub-Integration Platform (SIP) methods to improve its performance.

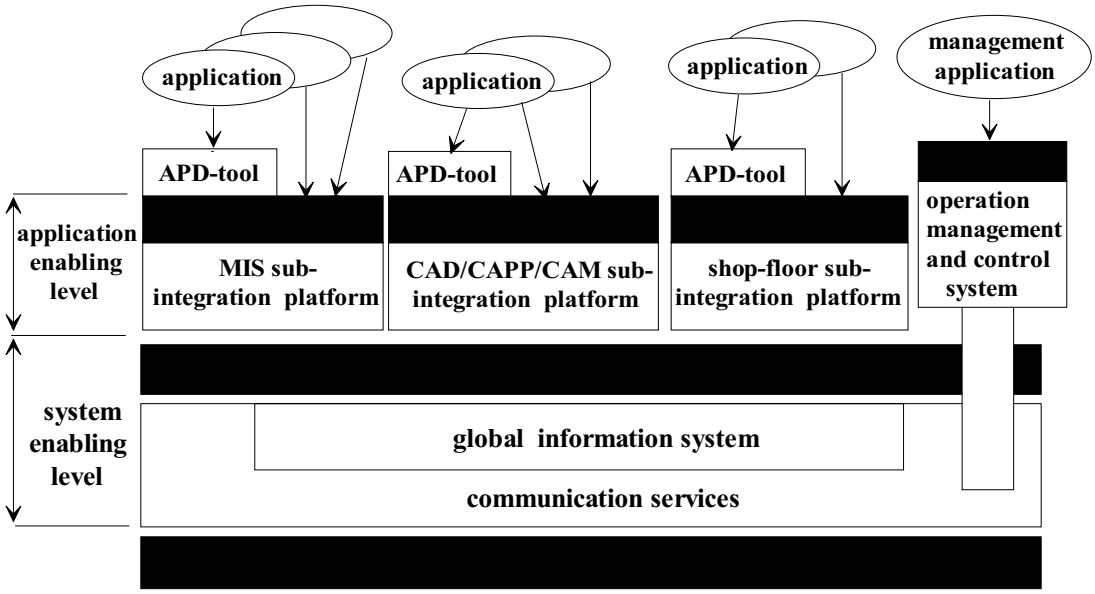

Fig. 1 MACIP system architecture

In this architecture, the interface handles information integration problems. MACIP has a multi-layer structure. The communication system and Global Information System (GIS) are defined in the system enabling level which provides basic functions for integration of the distributed computing environment, such as integration of different operating systems, database management systems and devices. These functions are provided in the form of Application Independent-API (AI-API). Application independence means that these functions are not designed for specific applications, but are general services for communication, data access, device access and file management. Three domain Sub-Integration Platforms are defined in the application enabling level which are MIS SIP, CAD/CAPP/CAM SIP and shop-flop control SIP. Each SIP is designed according to the requirements of the domain application and provides functions for applications in the form of Application Dependent-API (AD-API). The AD-API functions are designed specifically for quick and easy development domain specific application. These functions enable complete integration of the application. Application Development Tools (APD-tools) are designed and developed using the AD-API. Users can also develop applications using the functions provided by AD-API. Existing application are integrated by modifying its data exchange interface of program using AD-API functions.

An operation management system was also designed which uses AI-API functions to provide an Application Management-API (AM-API) for the users., Users Use AM-API to develop management applications which manage the IP resources and coordinate the integrated operation of the CIMS. The operation management system uses the agent technique for the application coordination, resource management and message handling tasks in the distributed computing environment.

The MACIP uses a Client/Server structure. MACIP uses object-oriented modeling method. The functions provided by the communication system are used by GIS to define an object-oriented global information model and to provide applications with basic object definition and object operation functions. The O-O model is designed according to the Object Database Management Group (ODMG) standard with extensions to include multiple database and file systems. Because the underlying database is still Relational DataBase (RDB), the GIS model provides drivers to connect every kind of RDB. GIS provides the user with an integrated view of all of the information using

mode integration and inter-operation between different RDBs and file systems. The domain SIP uses the basic GIS O-O model to construct application oriented O-O models. The MACIP O-O model is defined through Object Definition Language (ODL) and operated using Object Query Language (OQL). The O-O model can also be embeded into certain programming languages, such standard C, C++ (e.g., Visual C++), as a dynamic link library. Fig. 2 shows the GIS structure.

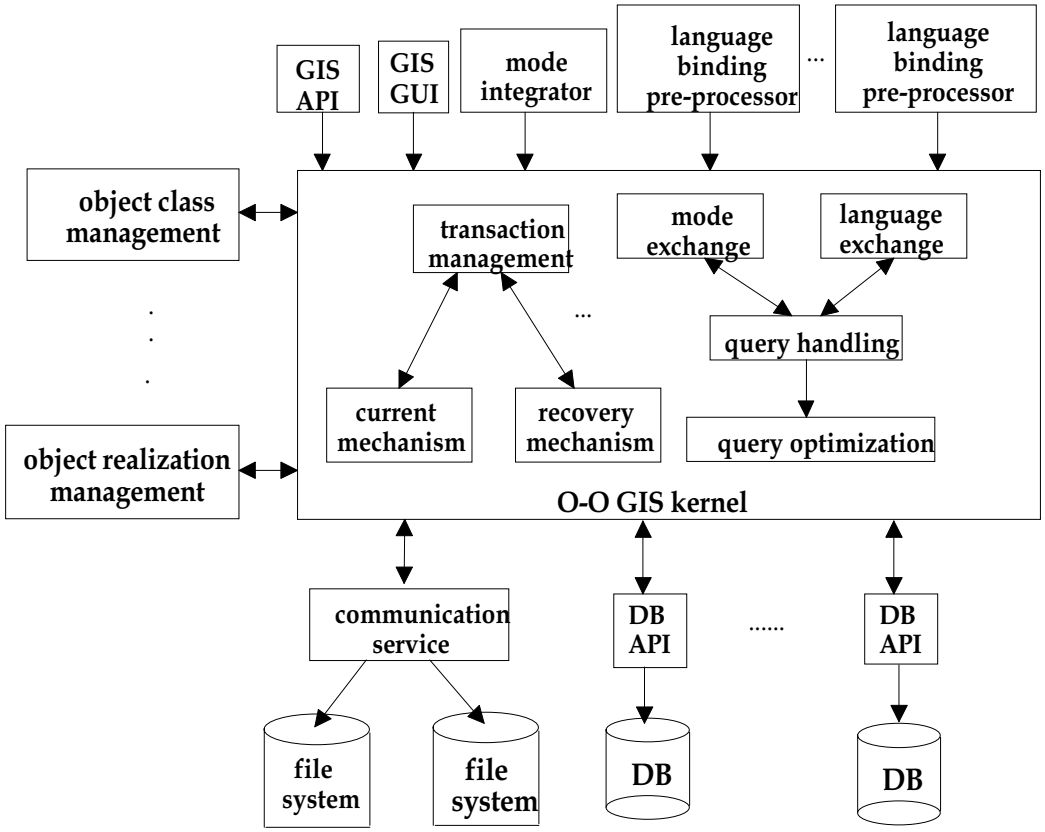

Fig. 2 GIS Structure

2 MACIP Functions

MACIP includes a communication system, a global information system, three domain application sub-integration platforms, an internet interface and an operation management and control system. MACIP has three types of functions, system functions, application functions and management functions.

The system functions are provided by the communication system and by GIS. The communication system provides four kinds of services:

1) basic communication services: data communication functions that are network protocols and operating systems independent.
2) common services: including directory service, message service, file transfer access and management, remote data access, remote procedure calls, etc.
3) application services: such as Manufacturing Message Specification (MMS) protocol based application communication services.
4) network management: the Simple Network Management Protocol (SNMP) is used to manage network load, error handling and safety.

GIS provides applications with a unified information view and information services. Its major functions are:

1) functions for integrating different information sources (RDBs and file systems).
2) functions for defining and maintaining the global information model.
3) functions for providing the data integration mode and interface (GIS-API).
4) functions for providing the GIS Graphical User Interface (GIS-GUI) as shown in Fig.2: GIS provides global sharing of information definitions and maintenance functions. These functions will be used by the users to define existing information resources into GIS, thus integrating the existing information system without changing existing programs.

In MACIP, there are four groups of application functions--MIS SIP, CAD/CAPP/CAM SIP, shop-floor control SIP and the Internet interface. MIS SIP provides AD-API which is used to integrate MIS applications and MIS development tools. The major functions of the Internet interface is to organize all the information so that it can be viewed on the internet by transferring the GIS data format into the HTTP data format. The aim of the Internet interface is to allow worldwide dissemination of information and acquisition.

Fig.3 shows the CAD/CAPP/CAM SIP structure. An engineering information management system was developed using the O-O product information share model to manage product design and to process planning data. It also provides integration interfaces with CAx application software and with other application domains (MIS and shop-floor control). The integration of CAD with the CAPP system is achieved through a STEP based product data share model. DXF and IGES based interfaces were also designed to transfer two-dimensional design information between different CAD

systems. Since the Product Data Management (PDM) system has been widely used in industry, an interface between the PDM software and GIS will be designed in CAD/CAPP/CAM SIP. The interface will be used to integrate PDM software with MIS (or MRPII) software to facilitate the current wide spread use of concurrent engineering.

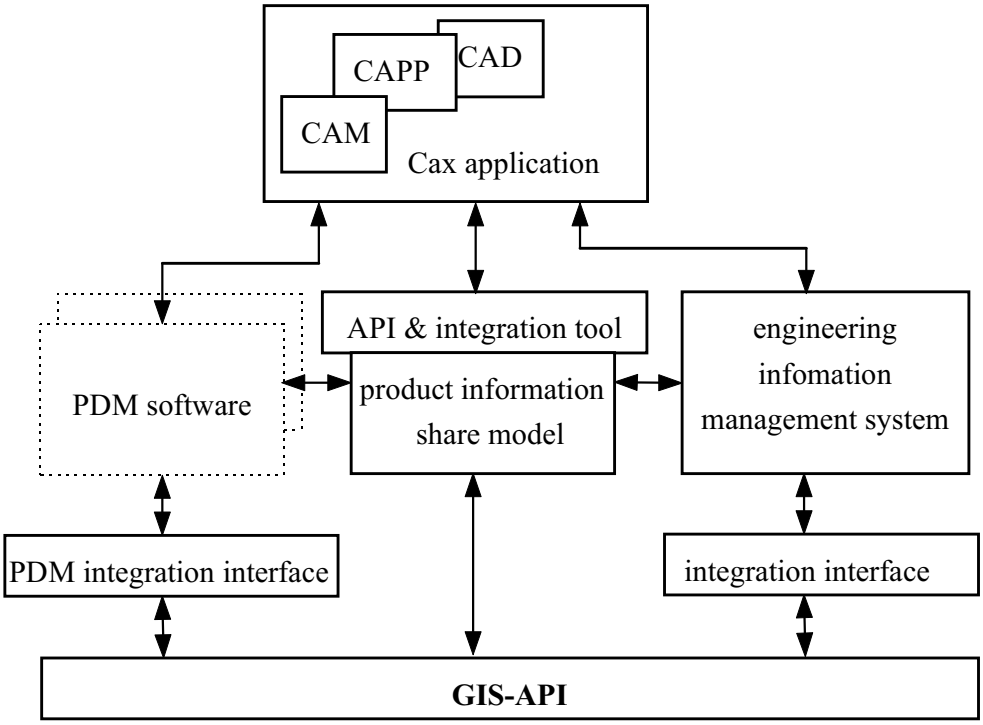

Fig. 3 CAD/CAPP/CAM SIP structure

Fig.4 shows shop-floor control SIP structure. The objective of the shop-floor control SIP is to provide a flexible and agile structure for users to develop suitable shop-floor control and management systems. Besides the data access services provided by GIS, this SIP includes a Virtual Manufacturing Device (VMD) engine based on MMS (manufacturing message specification) protocol. The VMD interfaces can integrate any MMS protocol compatible devices.

The shop-floor control SIP includes a control kernel that controls and coordinates all shop-floor control applications. The shop-floor control SIP also includes an integrated modeling tool that uses Petri net modeling theory and has an objective modeling interface. The graphical objective interface enables engineers to easily and quickly model the shop-floor system without needing to know Petri net theory. An EXPRESS standard based neutral file sharing mechanism transfers modeling data

between the Petri net and the objective model. Work-form data management is used to integrate shop-floor real-time data connected with the control of manufacturing devices. The development tool is used to develop shop-floor applications using the functions provided by the communication system and GIS. The control kernel, the modeling tool, the work-form management and the development tool together provide the user with a complete support system for the developing shop-floor controllers.

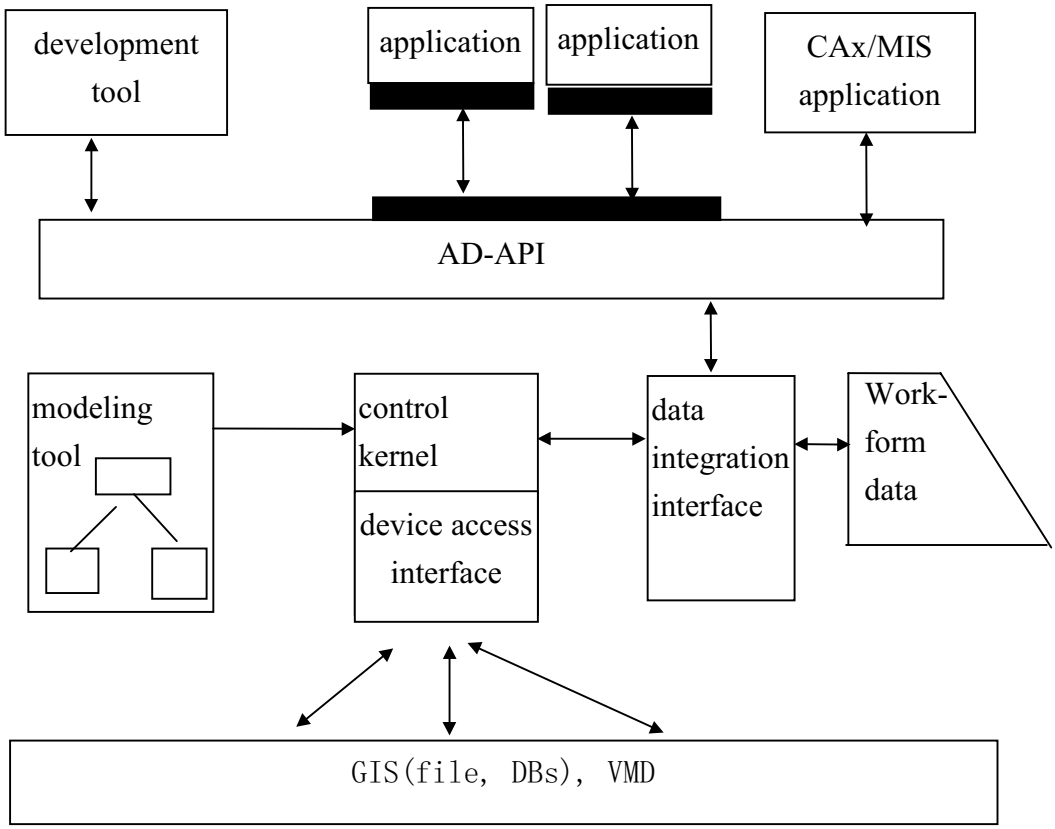

Fig. 4 shop-floor control SIP Structure

MACIP management functions are realized by the operation management and control system which include:

1) user, application and data authority management and safety control.
2) system configuration, software and resource management.
3) application coordination and message mechanism management based on agent protocol.

A suitable CIMS can be quickly and efficiently implemented using the functions provided by the MACIP.

3 MACIP development environment

MACIP was designed and developed in the multi-vendor heterogeneous computing environment depicted in Fig. 5. The network protocol is TCP/IP. The application level protocol is MMS for shop-floor control applications. The MACIP environment includes a Shu-Guang server, two workstations, a PC server and a number of PCs. These computers use three major operating systems, IRIX (UNIX), Windows NT and Windows. Three major RDBs, Oracle, Sybase and SQL Server were used to store information.

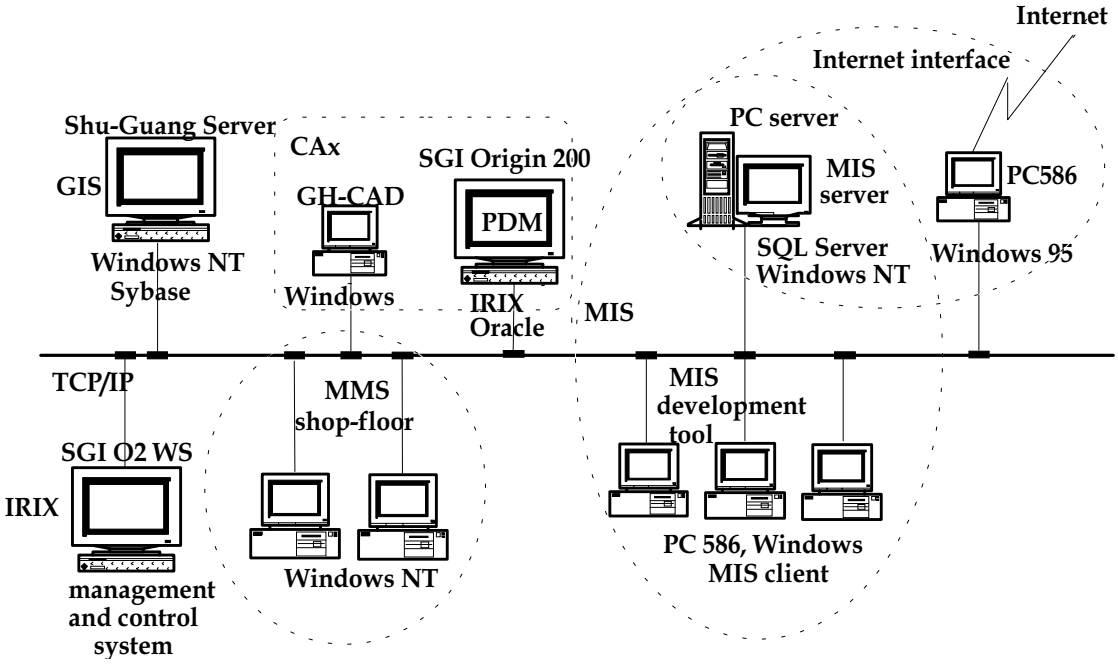

Fig.5 Development environment of MACIP

In the MACIP environment, the communication system, the GIS and the operation management and control system were distributed over different computers.

O-O design and development tools were installed on server and client computers. These tools included O-O design software tool (Rational Rose), version management software (PVCS), O-O software development tool (OpenRoad), etc.

MACIP will integrate a number of application software products, such as production-oriented software platform[3], rapid application development integrated support system[4], MRPII software (JW-MRPII and LM-MRPII), decision supporting

system(BusinessObject), CAD software (GH-CAD, Pro/E), PDM software(Metaphase) and WEB browser software.

4 Conclusions

This paper describes the MACIP system architecture, functions and development environment. During its development period, O-O methods and existing standards, such as ISO/OSI, MMS, STEP, IGES, EXPRESS and ODMG were extensively used in developing MACIP to ensure the openness of the IP. A software design and development norm based on O-O methods has been designed. A set of systematic support tools is used to guaranty the standardization of the whole development process.

MACIP provides a complete solution for the rapid implementation of CIMS in manufacturing enterprises by:

1) providing an integrated set of application software produces that provide a system prototype for CIMS.
2) providing a set of application development tools such as the MIS development tool and shop-floor control application development tools.
3) providing a set of APIs, both AI-API and AD-API that enable users to quickly modify existing applications and to integrate them with other applications.
4) providing a graphical user interface, GIS-GUI, for defining and maintaining existing information resources.
5) providing effective resource management and coordination applications.

The development of MACIP will promote CIMS applications in Chinese companies. Its development and application will also contribute to the formation of Chinese software products.

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CIMS 应用集成快速支持工具的设计与开发

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摘要 制造业企业的 CIMS 应用迫切需要先进的应用集成支持工具。本文介绍了制造业 CIMS 应用集成平台（MACIP）的系统体系结构和功能。通过集成一批应用软件和提供应用开发工具，MACIP 为企业实施 CIMS 提供了一整套解决方案。该集成平台由通信系统，全局信息系统，三个应用领域子集成平台，Internet 集成接口和平台运行管理和控制系统组成。在 MACIP 的设计开发中，采用了先进的客户/服务器结构，面向对象的方法和代理技术。通过遵循相应的国际标准和使用先进的软件设计，管理和开发工具，保证了所开发的 MACIP 具有良好的系统开放性，可伸缩性，并且易于维护性。使用 MACIP 可以显著降低 CIMS 的实施复杂性，减少实施时间和实施费用。

关键词 集成平台; 计算机集成制造系统; 系统体系结构; 面向对象; 应用编程接口

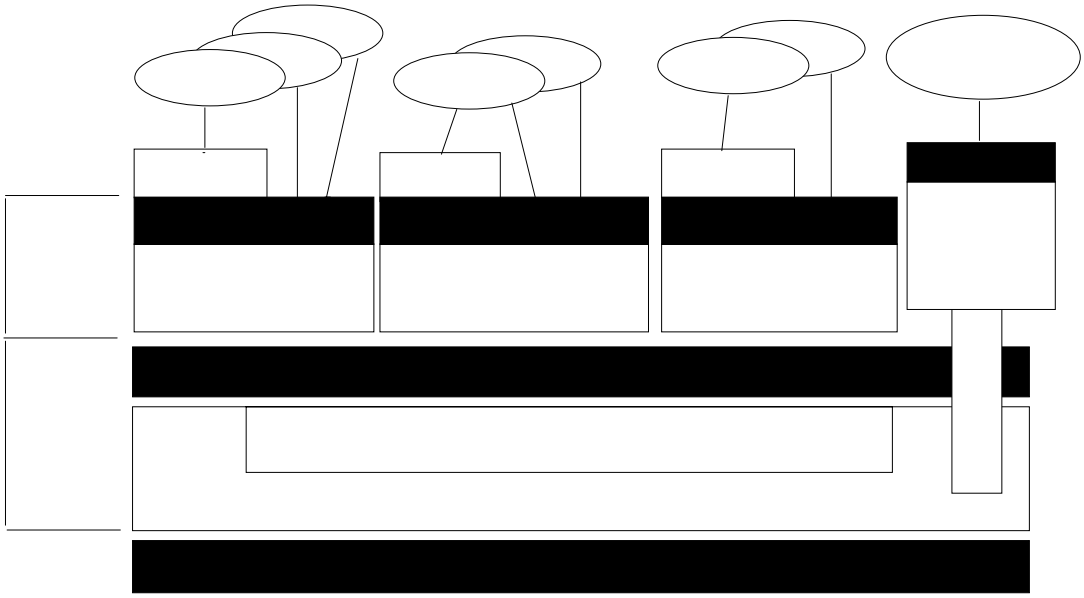

Fig. 1

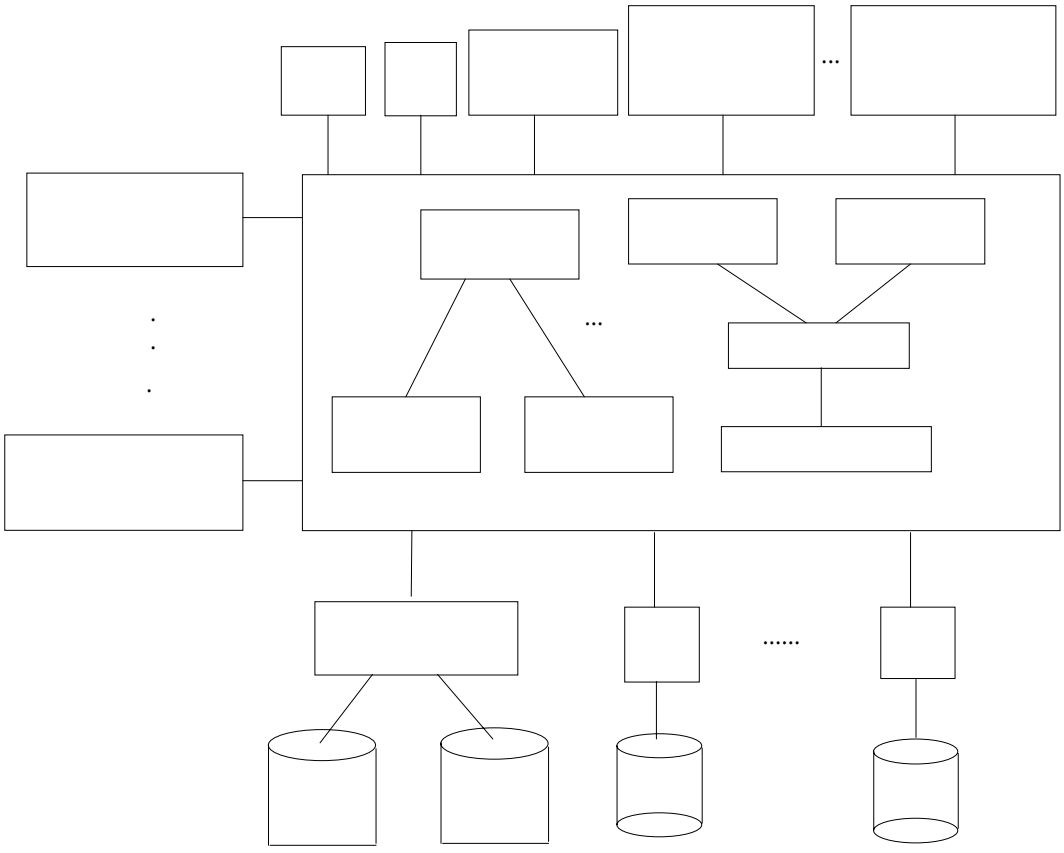

Fig. 2

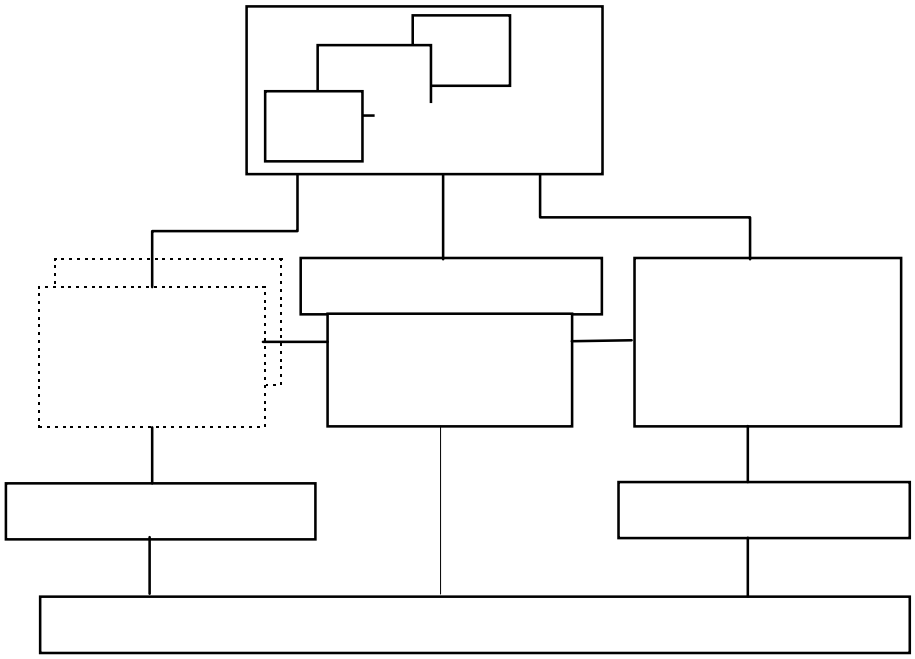

Fig.3

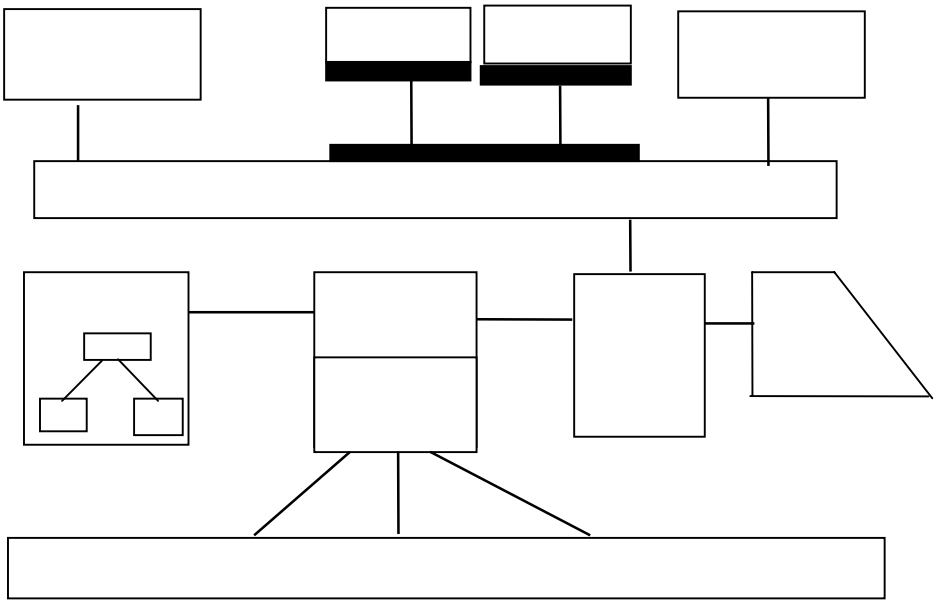

Fig. 4 shop-floor control SIP Structure

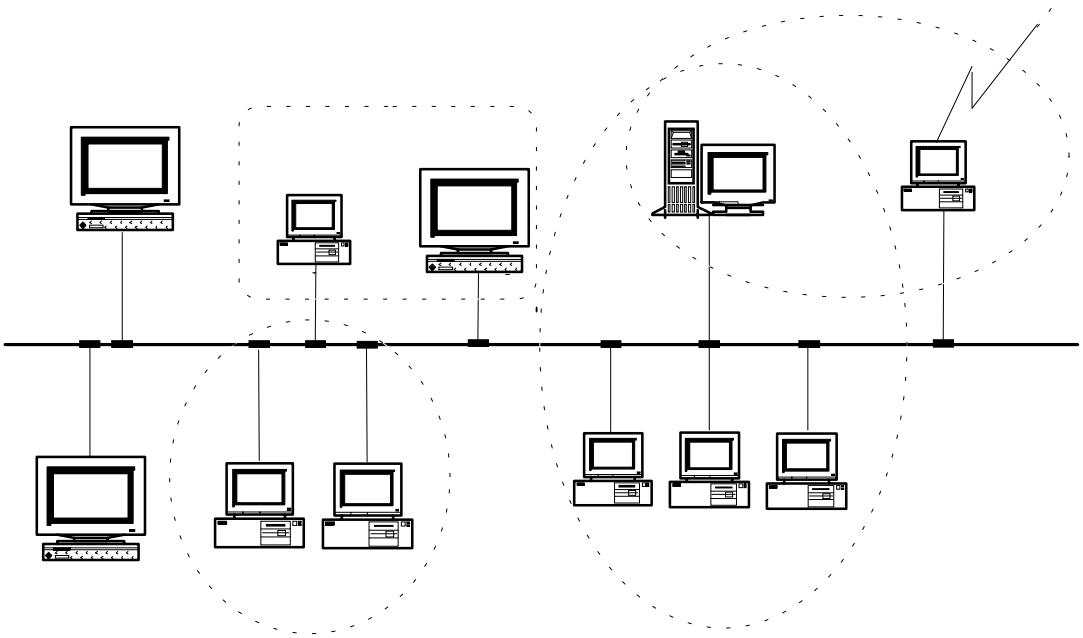

Fig. 5