Development Concept of Networking Controller "S-MAC"

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1. Introduction

Sanyo Denki announced its "Multiple Interface Declaration" in November 1996, and six months later announced development of "S-MAC" the controller correspond to support the movement toward the FA open architecture. We describe the development concept behind "S-MAC" and compare its features with the conventional NC.

2. Development Concept of "S-MAC"

There is no specific "S-MAC" product as such; rather, the term refers to an entire system consisting of hardware and software that is integrated in accordance with the needs of clients. In other words, an "S-MAC" system is achieved when open-architecture components are integrated into a system. The approach of gathering the world's leading technologies and products into an open system to suit the needs of the client is a total solution approach. An analogy can be found in the world of music, with Sanyo Denki conducting "S-MAC" orchestra to produce an FA open architecture masterpiece.
Fig. 1 shows the concept of "S-MAC" The eight keywords indicate the features of "S-MAC" on the development side. For users of "S-MAC" the following four points are important in "S-MAC" development.
(a) What is the purpose of "S-MAC" development?
(b) What are the merits to users of "S-MAC"?
(c) Are there sufficient technologies (engineers) to support "S-MAC"?
(d) What is the basic configuration of "S-MAC"?
Fig. 2 shows the relation between these four aspects of users and the eight keywords. This report describes the eight keywords in turn in order to clarify the concept of "S-MAC"
(1) Proposal and presentation (From demonstration to introduction of "S-MAC")
"S-MAC"is the control system that will be organized by the initiative of users. The proposal and presentation as shown in Fig. 3 will be followed when a system is going to be built by integrating an open architecture network, control language for the open architecture, and personal computer resources such as WindowsNT.
(2) Total Solution ("S-MAC" is an integrated total control system including servo actuators.)
Fig. 4 shows the system diagram constructed by intelligent FA components. Sanyo Denki provides solutions for areas marked in black and gray. The core of our solution is the open architecture implemented by the motion bus and the sensor bus, and personal computer software. The FA system is constructed by gathering world's leading products and technologies.
At present, the motion bus and the sensor bus are unified into SERCOS and CAN (conforming with DeviceNet). The motion bus and the sensor bus can support JEMANET, M-NET and ARCNET upon request, as described in our Multiple

Interface Declaration.
(3) Open Architecture ("S-MAC"is an open-architecture controller)
"S-MAC"consists of the three categories of Type A, B and C. Each of these is an open architecture. In other words, "S-MAC" controller offers an open architecture in both the FAN (Field Area Network) and software. (Refer to Fig. 5)
(4) Software ("S-MAC"is based on software)
Fig. 6 shows the software implemented to the general PC based controller (Type B). "S-MAC"achieves an open architecture with the three communication media of software 0, 2 and 4, and the API that is software 1. An NC in which software 3 is absorbed by software 1 as a motion-cardless-NC (full software controller) is "S-MAC"Type C.
In software 1, general-purpose compiler languages such as C++ and VC can be used. In Type A, the control (object) language of CODE (software of Cimetrix Inc., U.S.A.) can be used, and in Type C, that of SML (software of AI Inc., U.S.A. customized by Sanyo Denki) can be used, thus greatly shortening the software development time. At the same time, merits to users are so great in preventing machinebuildersand usersexpertise from leaking externally when the control software is made open to clients.
*"S-MAC" Types A, B and C will be described in separate section.
(5) Network (Field network = on-site network)
The plug-and-play approach, in which equipment such as telephones, facsimiles, personal computers, word processors and power switch boards can be connected to public telephone lines by modular jacks and then operated on-site, is becoming popular. "S-MAC" features the same plug-and-play concept by using SERCOS and CAN. (Refer to Fig. 7)
SERCOS is a transmission network that transmits motion functions and I/O at 2, 4 or 10 Mbps. It was developed in Germany and made open by IEC1491.
CAN was also developed in Germany and made open by ISO11898. CAN is a low-cost system but is slow when compared with SERCOS, and used for data transmission.
The networking controller has the following two features.
(a) System integration from multiple vendors

- The servo actuators of any manufacturer can be freely used by the same software.

(b) Integration by network
- Every component of all controllers such as IO devices, PLCs, and sensors can be connected to the same network. These components can be readily added and removed.

- Cabling is reduced, and the ability to withstand severe environments is greatly improved.

(6) Worldwide technology (global open architecture technology)
We have entered into alliances with many corporations to form the association shown in Fig. 8 for developing "S-MAC".
(7) Simulation (3D simulation and go)
The basic philosophy of "S-MAC"is that of an open architecture, and the tool used to achieve it is a simulator using 3D computer graphics. The kinematics of various machines, equipment and devices are modeled by 3DCG and used to develop "S-MAC"that clients require. In Type A, this tool is integrated with "S-MAC" This simulator is designed for checking mechanical motions and interferences during program development, and is also used as a monitor while the system is operating. In addition, by simply drawing mechanisms using the 3DCG and inputting

parameters and functions, the virtual system starts operating immediately. "S-MAC" Type A is thus designed for "simulation and go."
Using 3DCG and the JAVA language, "S-MAC" can be installed on an Intranet and integrated with a production control system. It can also be connected to the Internet to enable remote servicing and upgrading of software versions, and can be used to build a virtual factory by which factories are integrated and operated from a remote site. "S-MAC" Type A is closest to the virtual factory. Fig. 9 shows the concept and simulation display.
The above description has described the concept of "S-MAC" , "S-MAC" Type A can even exceed the designers imagination in some respects. The concept of Types B and C also greatly change depending on the usersspecifications.
Fig. 10 shows several examples of the basic model for the respective types.

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3. Three Types of "S-MAC"

"S-MAC"consists of three categories, called Types A, B and C. Each Type is described below in terms of (1) target market, (2) basic specifications, and (3) hardware configuration.
(1) Target markets of Types A, B and C
The NC world, long dominated by the G code for conventional machine tools, encompasses many general industrial machines such as packaging machines, according to a greatly changing environment. Many Asian countries have also started to enter the NC business.
"S-MAC"is basically a software-based & networking NC that expands the range of application of the conventional NC both in the upstream and downstream directions. This concept is achieved by introducing the concept of plug-and-play into the LAN and FAN (Field Area Network) of personal computers, using unique languages (SML, CODE). Thus, a form of FA Intranet control system is realized. System Types A and C form the core concept of "S-MAC" (Fig. 11)
(2) Basic specifications of Types A, B and C
The respective specifications of "S-MAC"Types A, B and C are shown in Fig. 12.
The common specifications of "S-MAC" Types A, B and C are shown in Fig. 13.
(3) Hardware configuration of Types A, B and C
As examples, Type C having a 4-axis system, Type B having a 4-axis system with CAN I/O, and Type A having a 16-axis system are shown with their respective hardware configuration and software configuration.
(a) Type C: 4-axis, SERCOS
An example configuration of 4-axis synchronous control is shown in Fig. 14. This configuration can be applied to vari-ous types of general industrial machines such as packaging machines, bending machines and loaders/unloaders.
When the running of multiple CPU becomes possible with WindowsNT/4.0, the host HMI and controlling CPU can be integrated into a single unit which further reduces cost.
When switches, lamps and PLCs are connected externally using the bridge of SERCOS-CAN, the controller environment will become even more open.
(b) Type B: 4-axis, SERCOS, CAN
The same configuration as the conventional personal computer NC is used.
However, the 3-layer hierarchy of "FA-specification personal computers,"" Motion block" and "Actuator+I/O+others" are not used as they are in the conventional NC. The "Actuator+I/O+others" is connected using a motion network, in principle. An example of using the two networks: motion network and sensor I/O network, is shown in Fig. 15. This configuration is practical as there are many components available for the field network at present. This configuration can be applied to

general-purpose machine tools and sheet metal punching machines. The general-purpose robot controllers can also be integrated into this configuration by using robot languages.
(c) Type A: 16-axis, 3D simulation, remote services
An example of a configuration for integrating NC as a single system is shown in Fig. 16. Machine cells, composite machines and multiple numbers of machines can be easily controlled and integrated into a system if connected by a network. In addition, a simulator using 3-D computer graphics is installed as standard. The 3DCG simulator, the servo actuator and I/O operate on the same database, thus creating a "simulation and go" system. This configuration is more like an FA system than NC.
Support software for providing remote services by LAN and WAN is also being developed so that the configuration can be accessed from personal computers.

4. Application Examples of "S-MAC"

We have described the concept of "S-MAC"with several examples. Next, we describe practical applications for actual systems.
The first example is the application of the Type C for a food packaging machine. The Type C has the highest performance of the three Types of "S-MAC" in implementing a fully software-controlled system.
(1) Problems in packaging machinery business (countermeasure for diversification and cost reduction)
The machines for the pillow type packaging now use an electronic shaft instead of the conventional mechanical shaft drive as the types of food have become more diverse. As a result, the cost of the controller typically now accounts for 50% or more of the total cost of the entire system (refer to Fig. 17). Use of "S-MAC" Type C could reduce the cost of the controller and thus increase the cost-performance of the system. Reducing the cost of the controller effectively reduces the cost of the system, which can be achieved by using a full-software controller, thus allowing greater variety of food shapes. "S-MAC" Type C thus fully solves the problem.
(2) Outline of system to be investigated
The machinery of the system to be investigated is shown in Fig. 18. Six major issues are addressed when replacing the conventional PLC and the motion card system by "S-MAC" Type C.
(3) Conventional system and the Sanyo Denki's proposed system
The conventional system is shown in Fig. 19 and the Sanyo Denki's proposed system using "S-MAC"Type C is shown in Fig. 20. The blocks that are shown by shadow have already been opened.
When we compare Fig. 19 with Fig. 20, we can notice that there are extensive difference regarding the range that has been opened. As shown in Fig. 19, there had been no ways in the conventional system other than the method to depend on the outside controller manufacturers to develop the motion programs and sequence programs. On the other hand, all blocks of the Sanyo Denki's proposed system as shown in Fig. 20, are made open from the controller manufacturers to users. When users develop software by themselves, they can prevent various know-hows from outflowing to the outside competitors. When we review our situation in the past that users could not prevent various know-hows from outflowing to the outside competitors through the controller manufacturers, the movement to open architecture brings a large merit to the specialty manufacturers.
(4) Software of Sanyo Denki's proposed system
The structure and functions of the SML control language that is used in the controller block are shown in Fig. 21 and Fig. 22, respectively. SML is an object-oriented programming language that facilitates programming of complicated

operation programs of the 5-axis system in which all devices must work in coordination, as shown in Fig. 18 and Fig. 22.

All functions that are related to synchronized operation shown in Fig. 22 can be defined using parameters so that the motion program can be easily developed using the interactive setup tool in the SML development environment.

①Software of panel computer block

WindowsNT, PLC open architecture, panel replacement software, and C++ or VC can be used as the operating system.

The software can be used for the following applications.

(a) Operation and monitor of packaging machines
(b) Unwind and sealing
(c) Drivetrain control (feeding, crimper, etc.)
(d) Parameter settings such as temperature and tension
(e) Fetching operating parameter information and error information
(f) Communication with host system, etc.

②Software of controller block

(a) Because SML (including SRX) is a control language based on angle (angular speed), the functions of machines using rollers can be easily described.
(b) To synchronize the crimper and sealing by means of reading marks, the registration correction of SML itself is used.
(c) All software is excuted by means of SERCOS IDNs, so modification can be done simply by adding the correspond-ing modules.
(d) "S-MAC"can easily interface with panel and PLC software tools, thus making it easier to implement switches, meters and adjustment controls by means of software.
(e) Since SML can be freely provided to users, users can protect their expertise from being leaked externally.

We hope to describe the details of SML in a future issue, but simply list below some typical objects (motion program statements)

a. ABS_MOVW
b. CALCULATED_PROFILE
c. DRIVE_TRAIN
d. EVENT
e. FILE_DEFINED_PROFILE
f. GEARED_PROFILE
g. HOME_MOVE
h. IDN
i. IO_ANALOG
j. IO_BOOLEAN
k. JOG_MOVE
l. MOTOR
m. PLS
n. REGISTRATION
o. REGISTRATION_CORRECTION
p. REL_MOVE
q. TIMER
r. USER_DEFINED_PROFILE

5. Conclusion

We have described "S-MAC" from the basic principle to its applications in terms of the development concept We have given only an overview of "S-MAC"system, and have intentionally omitted several issues that would require several pages to explain, particularly the hardware elements. In future, we hope to describe the SML control language for the Type C system in greater detail, especially its real-time operating capability. Type A CODE system also needs a more detailed description. We will also give more details of SERCOS and CAN when we report on application examples of "S-MAC"

* Names of companies, products, and registered trade marks are those of the respective companies.

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Fig.1 Overview of "S-MAC"

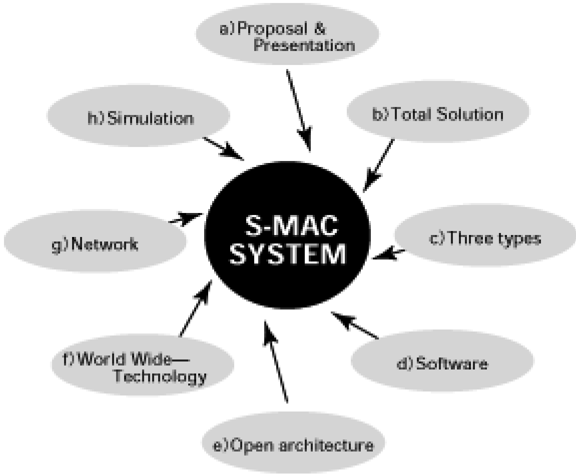


Fig. 2 Relation between four aspects for users and the eight keywords

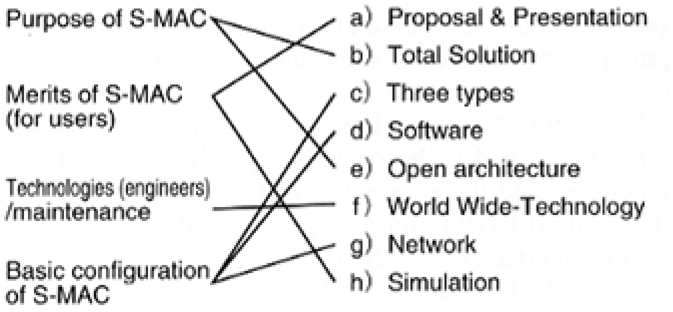


Fig. 3 Introduction procedure of "S-MAC"

Location	Clients'offices	Clients'factories / end users	Sanyo Denki engineering department	Sanyo Denki proposal room / Clients'offices	Clients'offices
Timetable	Clients'offices / our proposal room		Within a week	Half day to one day	
Person in charge	Sales staff and SR	SR and CS dept.	Sales staff, SR and CS dept.	Sales staff, SR and CS dept.	Sales staff and SR
Contents	• Software, FAN for open architecture • Demonstration of Type A, B and C • Examples of installation, etc.	• Confirmation of external interface specification • New function • Operation, input and enviroment,etc.	• Selection of Type A or B or C, up to approximate specifications • Presentation using 3 DCG and preparation of model • Estimation (delivery time and cost)	• Explaining our proposal sheet using 3 DCG, model and previos examples • Questions and answers, up to minor changes	• Signing of contract or memorandum with confirmed specification sheet • Confirmation meeting before starting the project

SR：System Realizer　CS dept.:Control System dept.

Fig. 4 CIM hierarchy and scope of proposal

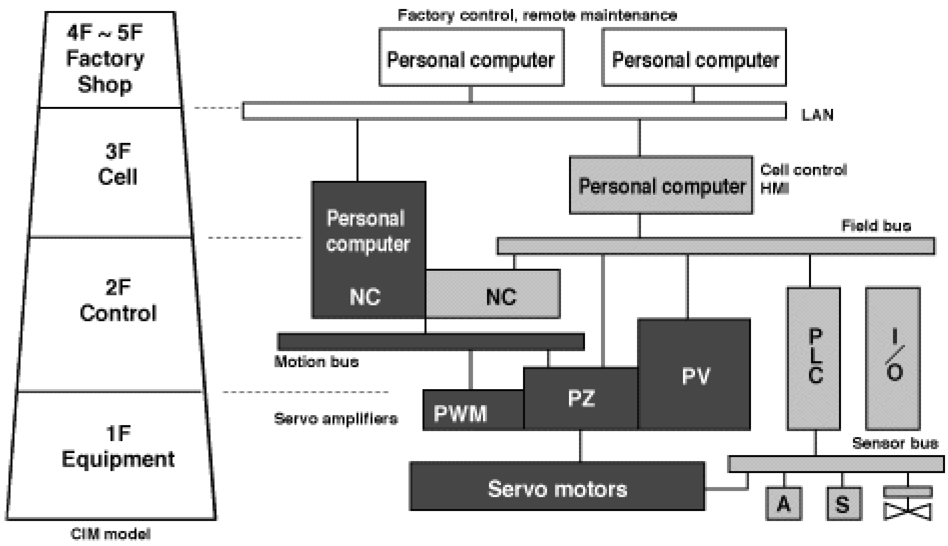
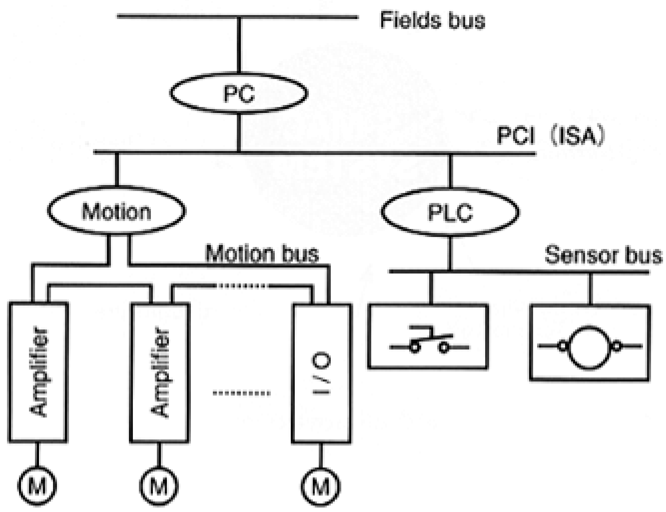


Fig. 5 Various open-architecture bus lines and control software



Field bus	:PROFIBUS,Fip,P-NET,INTERBUS-S,
	ARCNET LONWORKS,JEMANET,M-NET
Sensor bus	:CAN,DeviceNET,SDS
Motion bus	:SERCOS,MACRO
PC(HMI)	:Windows NT/4.0,DOSV+RTKernel,QNX...OS
	SML(TYPE C),CODE(TYPE A),C++,VC...LANGUAGE
PLC	:ISaGRAFetc.

Fig. 6 Application software at each level of "S-MAC"

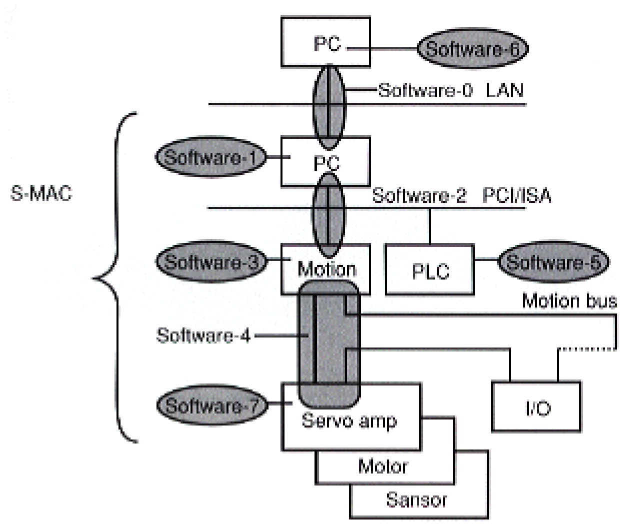


Fig. 7 Concept of networking controller
and plug-and-play

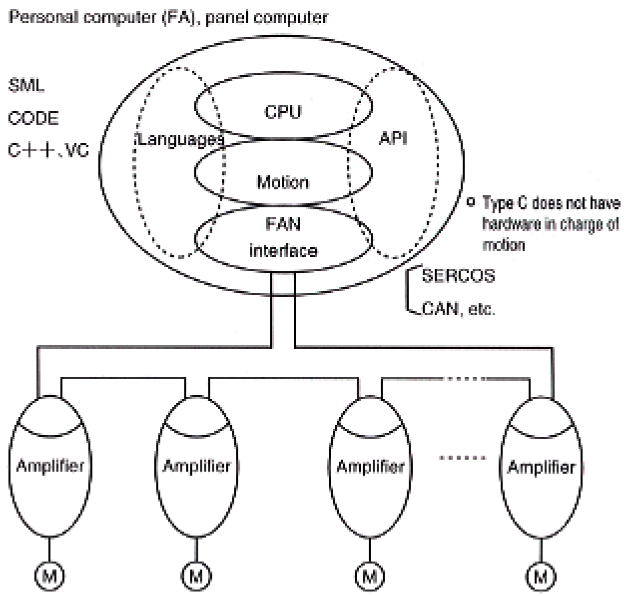


Fig. 8 Associations and enterprises in alliance with Sanyo Denki

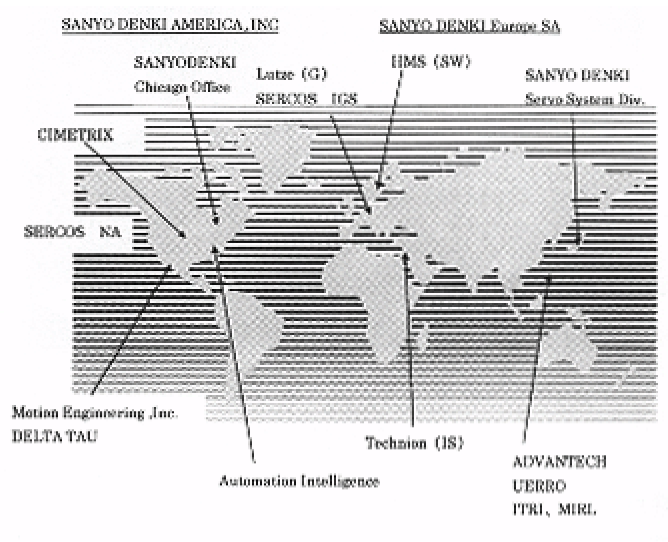
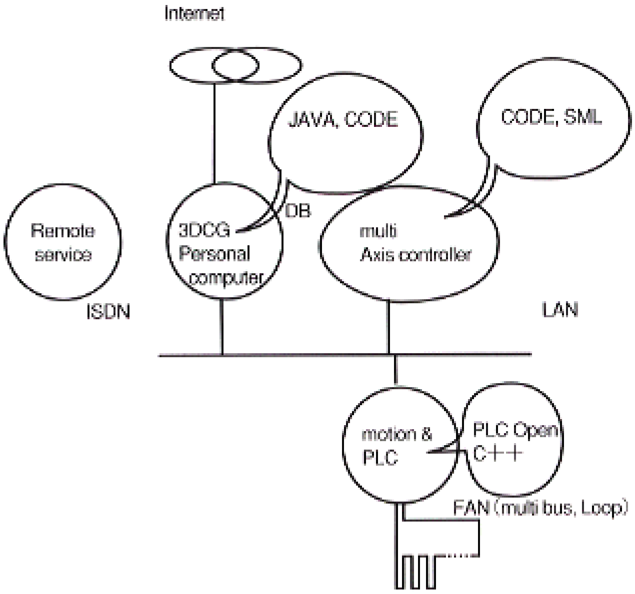


Fig. 9 Concept of "S-MAC"

Conceptul drawing of next generation "S-MAC"



Simulation display

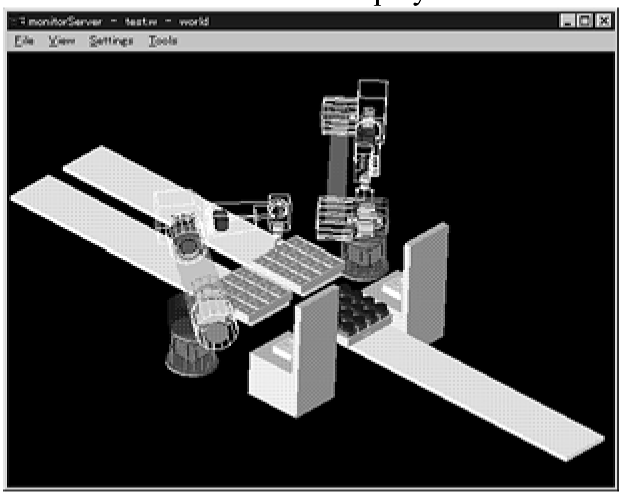
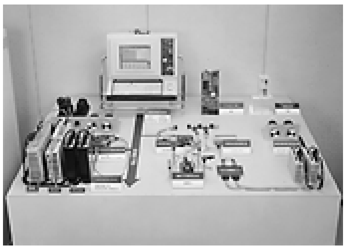


Fig. 10 Basic model of the respective Types

TYPE A

TYPE B



TYPE C

Fig. 11 Three Types of "S-MAC"and their target markets

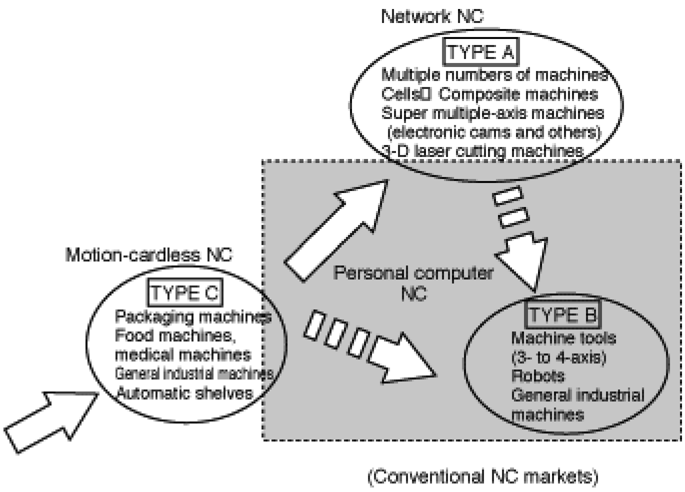


Fig. 12 Respective specifications of Types A, B and C

Target PC		TYPE A Networking NC	TYPE B PC based NC	TYPE C Motion Cardless NC
HMI	bus	ISA、PCi	ISA、PCi	ISA、PCi
	OS	WindowsNT、QNX	DOS、WindowsNT、Windows3.1	WindowsNT、Windows3.1
	Languages	CODE、C++、VC	C++、VC、G-code	SML、C++、VC
Motion		6 to 300 – axits	4 to 8 – axits	4 to 32 – axits
Network		SERCOS、CAN	SERCOS、CAN(analog/pulse)	SERCOS、CAN
PLC		SoftwarePLC、HardwarePLC	HardwarePLC	SoftwarePLC
Simulation		3D Simulation & go	2D Simulation and animation	2D Simulation and animation

Fig. 13 Common specifications between Types A, B and C

Specifications of PC	Same environmental withstand capability as CNC, RAS function and RT kernel, etc.
Functions of network	Parameters of SERCOS/communication speed of 2-, 4- or 10-Mbps, optical fibers, motions and amplifiers can be transmitted accurately in real time
	Low-cost network capable of CAN (conforming with DeviceNet)/1 Mbps, data transmission and PLC link
	JEMANET, M-NET, ARCNET and others
Description in high-level language	SML/Language suited machines for angles and angular speeds, such as SERCOS operation
	CODE/3D simulation function, motion and I/O can be described

Fig. 14 Type C 4-axis system configuration drawing

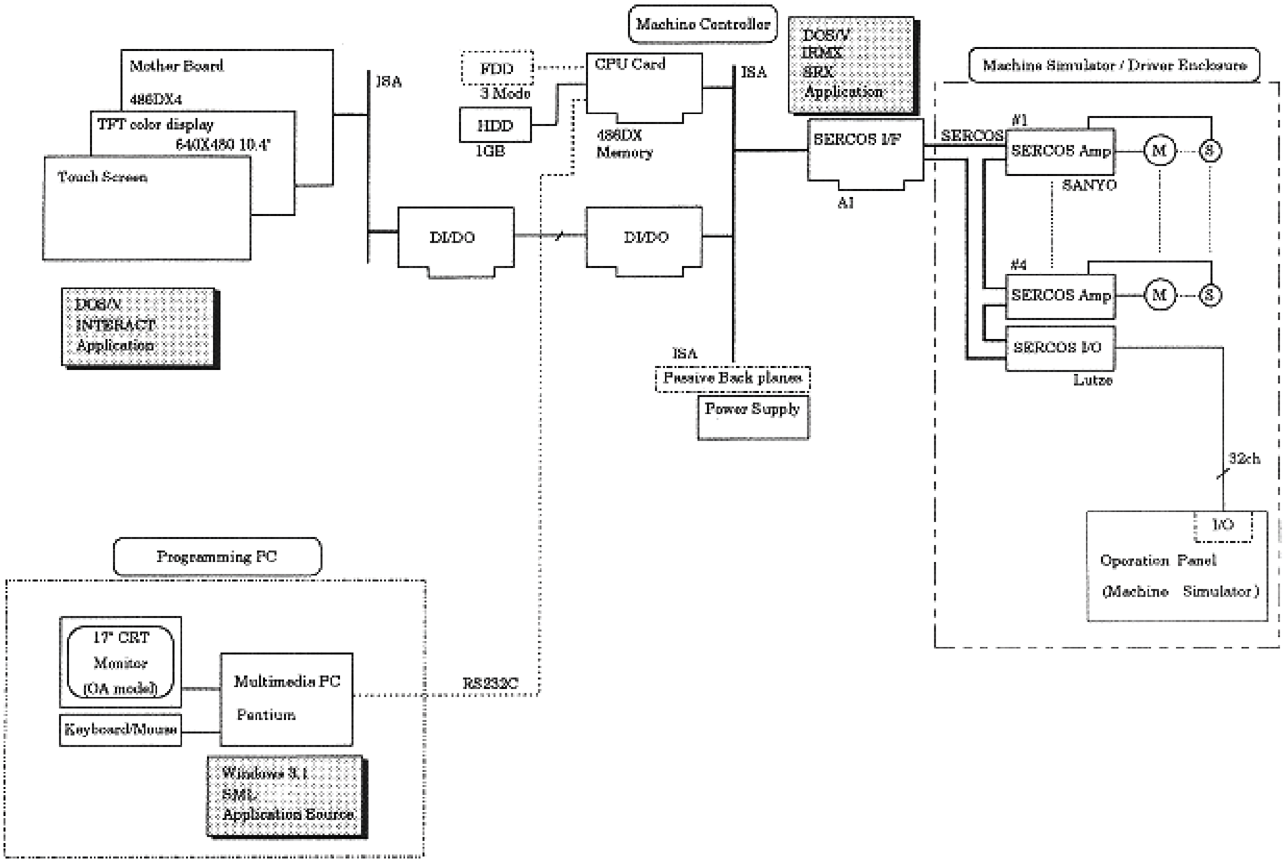


Fig. 15 Type B 4-axis system configuration drawing

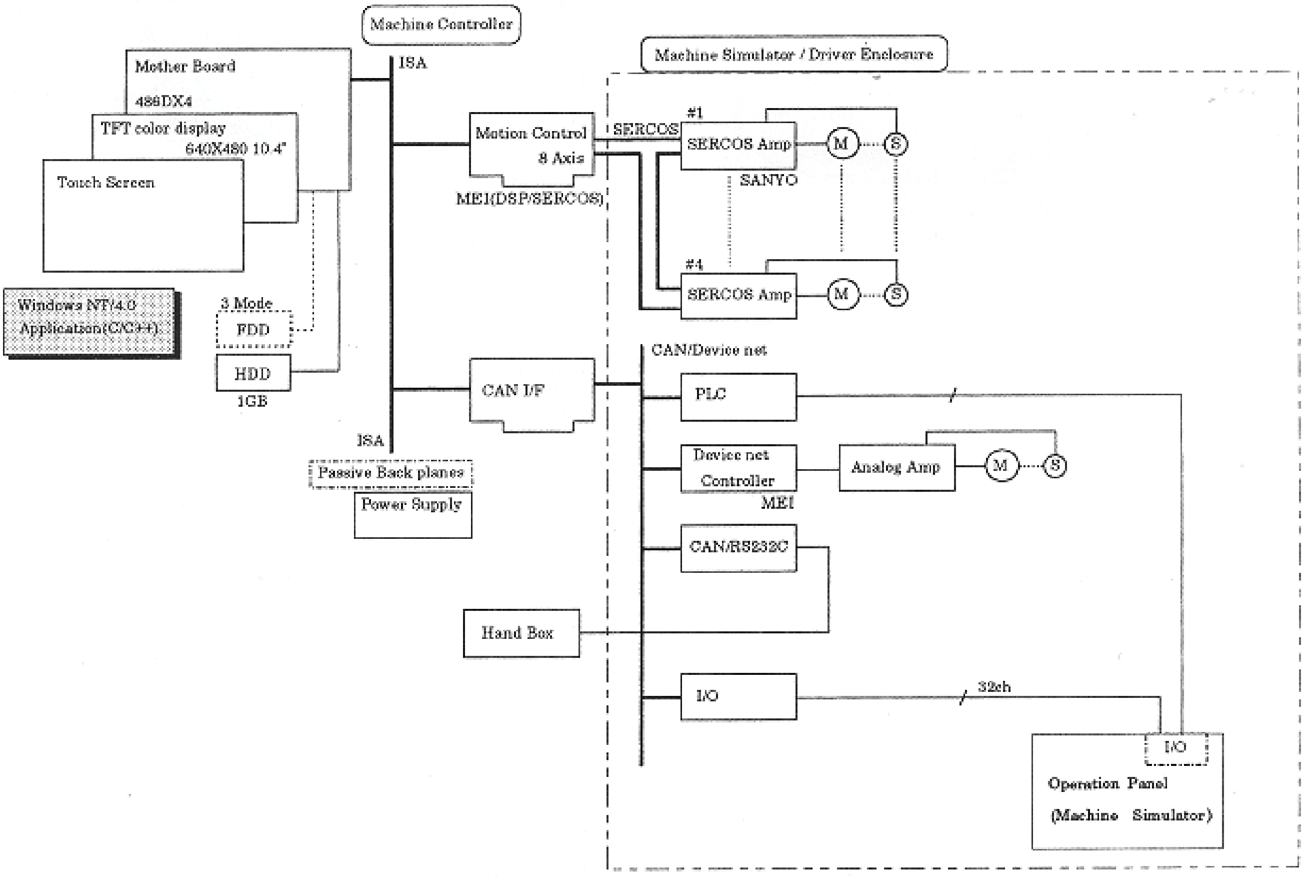


Fig. 16 Type A 16-axis system configuration drawing

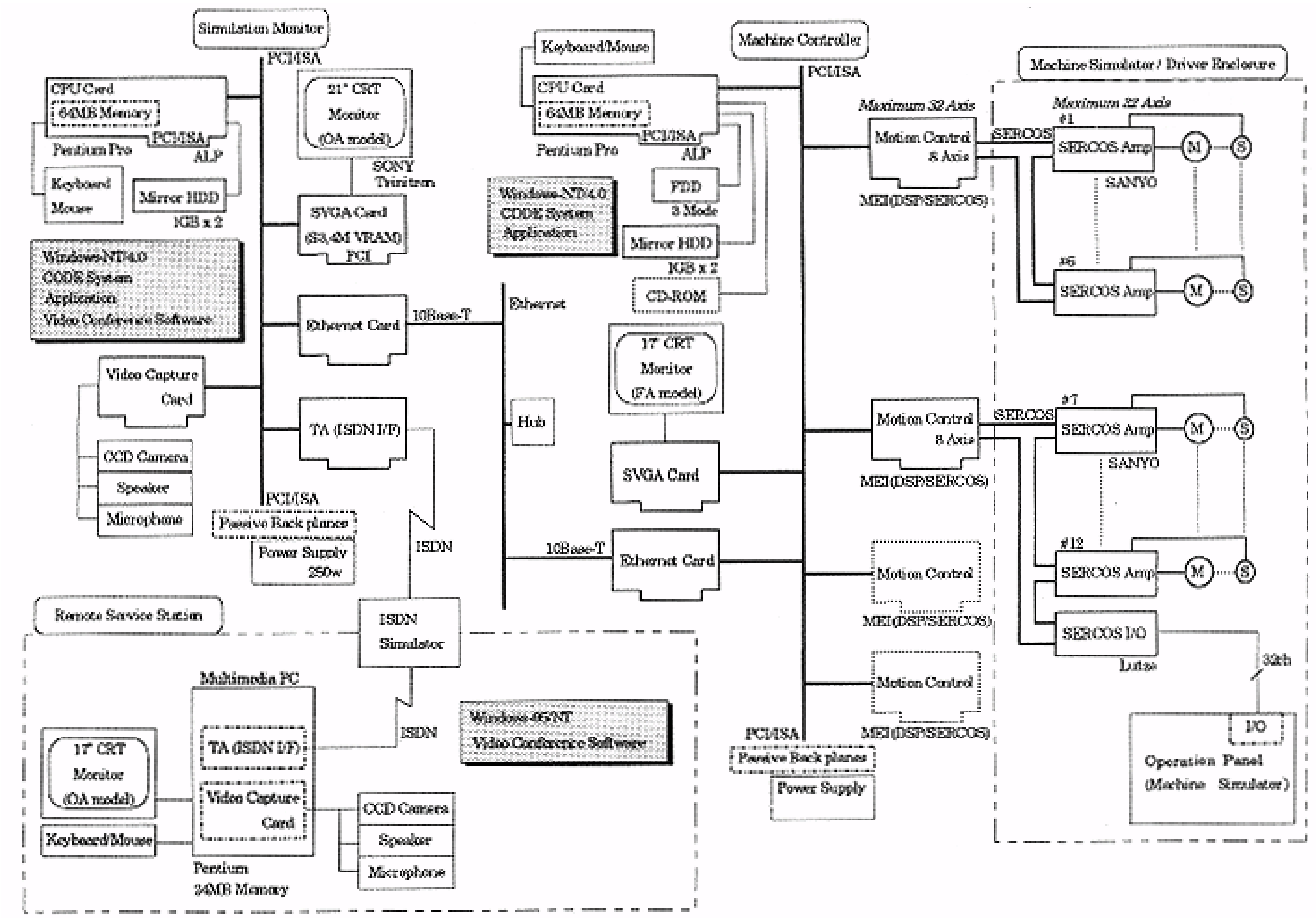


Fig. 17 History of cost ratio of mechanism block and control block of packaging machine (Examlpe in U.S.A)

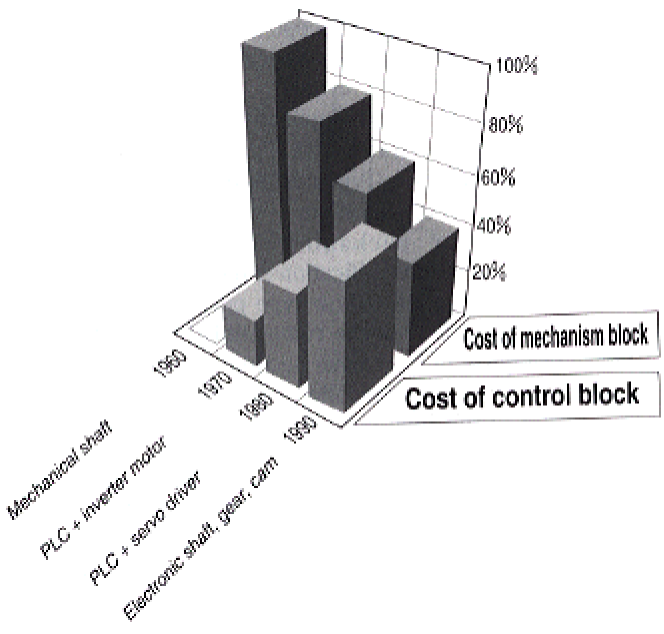
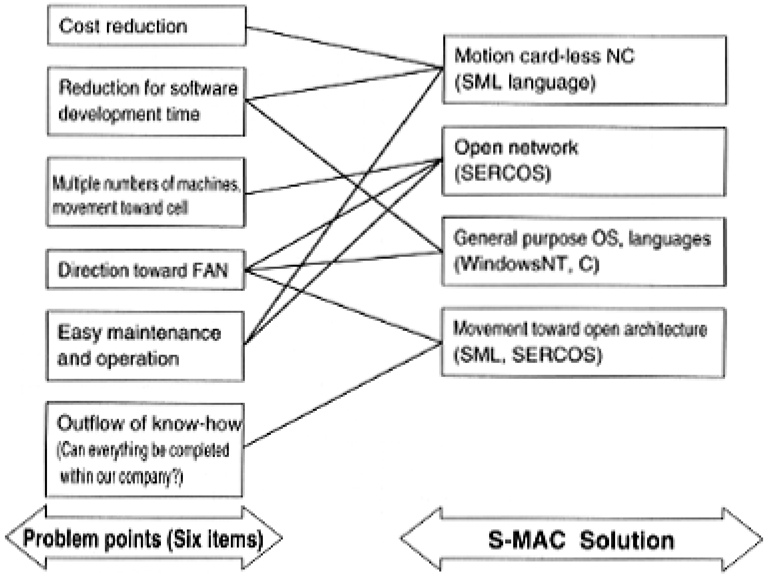


Fig. 18 Problems and mechanism of pillow type packaging machine



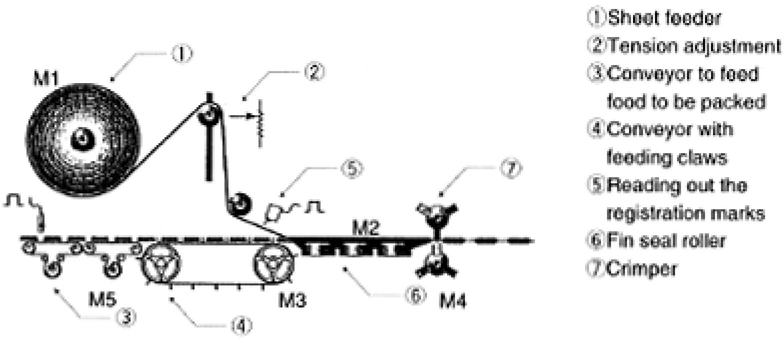


Fig. 19 Range of open architecture of conventional system

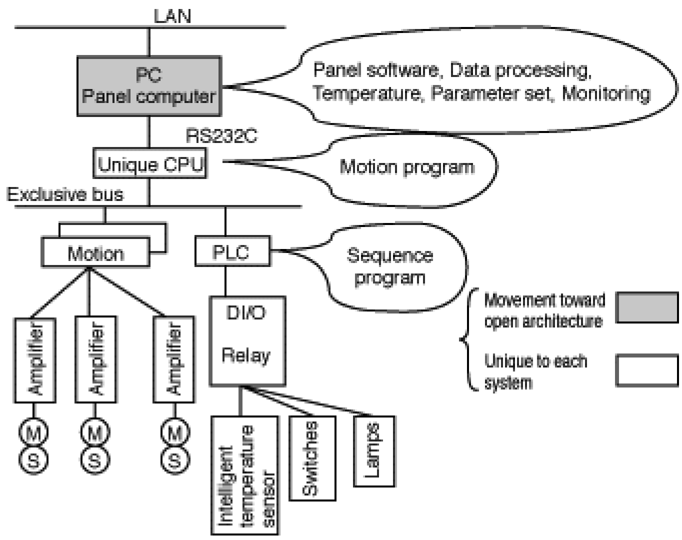


Fig. 20 Range of open architecture of
Sanyo Denki's proposed system

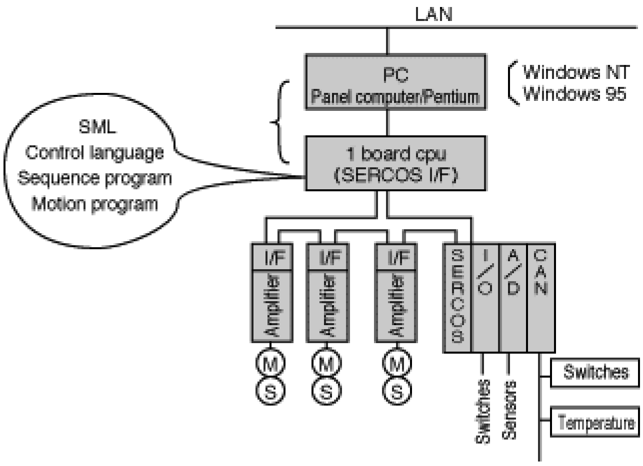


Fig. 21 Configuration of control software

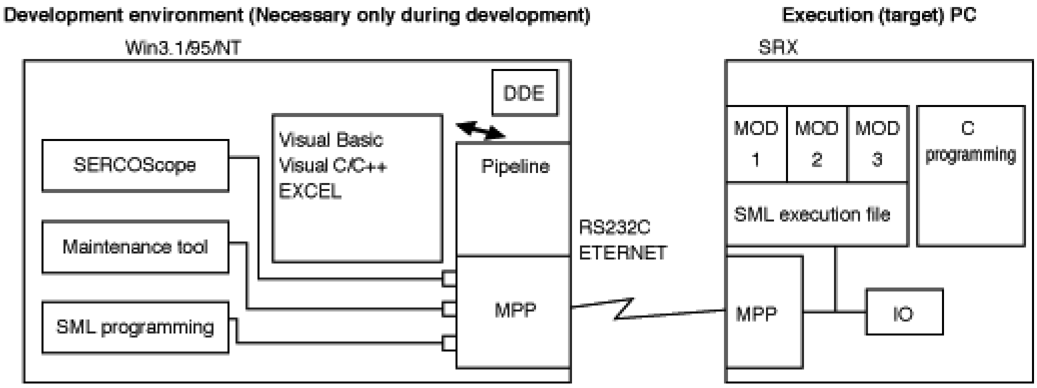


Fig. 22 Practical synchronizing control