Bridging MAP to Ethernet

The Manufacturing Message Specification is the key to integrating various local area network systems based on the OSI model (Open Systems Interconnect). The European CNMA MAP definition brings together MAP token bus and carrierband systems, Ethernet, and X.25 wide area networks, setting the stage for a single, all-encompassing networking scheme.

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(As stated in the article that begins on p 53: "MAP segments may be bridged to Ethernet segments, and different protocols such as OSI, DECnet, and TCP/IP may even exist on the same bus simultaneously." The following article looks further into the expanded use of MAP protocols running on Ethernet and suggests that in the future, MAP's Manufacturing Message Specification will be available on practically any network architecture.)

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The standardization of industrial communications is bringing open, manufacturer independent communication systems within reach. Driving this trend are the efforts of numerous standards organizations as well as projects like the development of the Manufacturing Automation Protocol (MAP) in the U.S., and its sibling in Europe, the Communications Network for Manufacturing Applications (CNMA). Both projects use basically the same framework—the Basic Reference Model for Open Systems Interconnection (OSI), as defined by the International Standards Organization (ISO). The one difference is that CNMA adds Ethernet to the list of OSI supported networks *(Fig. 1)*.

Considering the fact that many of the installed proprietary communications systems today are Ethernet based (using DECnet or TCP/IP protocols), this one difference is very significant. It means that IEEE 802.4 (token passing) MAP-based systems must communicate with existing Ethernet networks through a gateway—which increases the cost of the system due to added systems integration work and specialized software and hardware. CNMA, on the other hand, solves this problem by adding Ethernet and X.25 support down at the network level, and by bringing in MAP's Manufacturing Message Specification (MMS) to the application layer *(see Fig. 1)*.

Many, though, believe that MAP, too, will eventually add Ethernet support—with the help of companies such as AEG, Digital Equipment Corp., Hewlett-Packard, and the like who have announced support of MMS protocols on IEEE 802.3 Ethernet. The addition of Ethernet support to MAP would allow U.S. manufacturers to adopt MAP networking gradually through the use of less expensive bridges and routers (as opposed to gateways).

This article details the role MMS plays in networking schemes, and discusses the advantages of MAP/CNMA networking implementations—using pilot projects in Europe as examples.

MAP, MMS, and Ethernet

MMS (or ISO 9506, also known as EIA RS-511) is the most important part of MAP in terms of reducing the investment needed to build homogeneous automation systems with heterogeneous devices. For most users, this investment in-

Fig. 1: The CNMA architecture brings Ethernet IEEE 802.3 to the MAP/OSI specification. The LLC1 (logical link control) portion of layer 2 hides the application from the concerns of whether the physical network uses token passing or collision sensing (Ethernet). The transport layer (4) also hides MAP, CNMA, and TOP networks from the application.

<table>
<tr><td rowspan="5">7</td><td rowspan="2">MMS comparison standards ISO CD 9506/1, /2)</td><td rowspan="4">File Transfer, Access, and Management (FTAM) (ISO 8571)</td><td colspan="3">Network management NMT</td><td rowspan="3">Directory service (ISO 9594)</td></tr>
<tr><td>CM ISO CD</td><td>PM WN N3313</td><td>FM WD N3312</td></tr>
<tr><td rowspan="2">Manufacturing Message Specification (ISO 9506/1, /2)</td><td colspan="3">CMIS/CMIP (ISO DIS 9595-2/9596-2)</td></tr>
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Hiding Ethernet (8802/3) and token bus (8802/4)</td></tr>
<tr><td>1</td><td>X.21/X.21 bis</td><td colspan="2">CSMA/CD 10M bits/s (ISO 8802/3)</td><td colspan="3">Token bus (ISO 8802/4) Broadband 10M bits/s Carrierband 5M bits/s</td></tr>
<tr><td></td><td>MAP, TOP, CNMA</td><td colspan="2">TOP, CNMA</td><td colspan="3">MAP, CNMA</td></tr>
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cludes engineering efforts, decision making, implementation, training, and the maintaining of plant-wide communication systems.

What is MAP without MMS? Hardly anything, really. MMS is the primary application standard of MAP. It specifies more than 80 services that are independent of the network. What this means to an application is that the network itself is actually hidden or transparent. Thus, to a PLC that receives a downloaded program from a host device on the network, neither the PLC nor the host care about the physical connection between them or the underlying network software protocols. Whether it's token bus or Ethernet, the PLC receives the same program.

A closer look at the OSI model

The OSI model forms a framework for the development of communication protocol standards *(Fig. 1)*. Specifications for layers 1 to 4 define reliable data transmission with error detection and correction. Layers 5, 6 and 7 define standard language protocols between devices exchanging application information (e.g., our downloaded PLC program). *(Figure 1 shows the MAP, TOP [Technical and Office Protocol] and CNMA architectures.)*

OSI allows for more than token bus

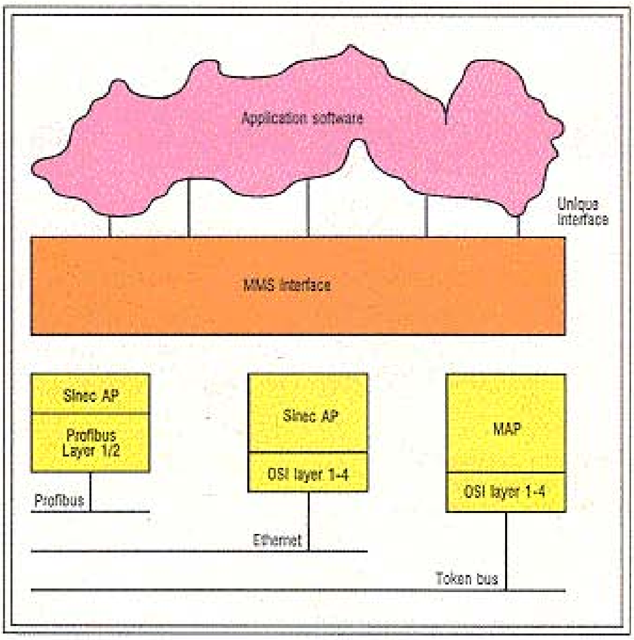
The OSI architecture allows for more than one local area network (LAN) definition below layer 2. One, and only one, of these, LLC1 (according to ISO 8802/2), hides both the token bus (8802/4) and Ethernet (8802/3). The services provided to the *network* layer (layer 3) are the same for both. And above all of this, the *transport* layer (layer 4) hides the different networks. That is, token bus, Ethernet, and X.25 wide area networks all use the same services. OSI, then, makes it possible to communicate among network types without losing functionality. All layers above 4 are absolutely independent of the transport-oriented layers one through four.

As we've seen, MMS does not specifically require a token bus network. It can run transparently on Ethernet or other networks. In addition, the same MMS interface must be able to support different applications. The migration philosophy, as shown in *Fig. 2*, is one means of doing this—a means that is being adopted by several automation vendors, including Siemens. It's very important that applications can access a remote system independently of the network used, and this configuration provides it.

Putting OSI, MAP, and CNMA together

A successful MAP/CNMA pilot plant at the University of Stuttgart ISW is shown in Fig. 3. The plant uses the following LANs to link devices:

1. IEEE 802.3—Carrier Sense Multiple Access with Collision Detection (CSMA/CD, aka Ethernet), operating at 10M bit/s with ¼-mile cable segments.
2. IEEE 802.4—Token Bus Broadband, operating at 10M bit/s, modulated onto a broadband cable system that can be shared with other technologies such as cable TV, terminal multiplexers, etc. This technology provides the backbone for media cable systems up to and beyond six miles in length.
3. IEEE 802.4—Token Bus Carrierband, operating at 5M bit/s. Typical carrierband systems may use cable lengths between 55 and 800 yds depending on the number of attached stations and trunk cable type. In addition, access to remote sites is necessary via Wide Area Networks. CNMA, therefore, works with X.25 links as well.



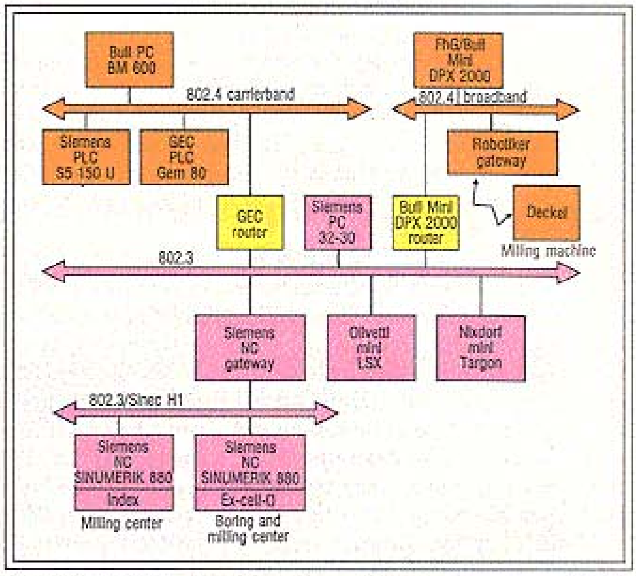


Fig. 2 (top): Migration of once proprietary systems towards OSI and MMS based systems means that applications won't care what the network layer is. They'll be able to receive and send data as though they were located in the same rack.

Fig. 3 (bottom): This pilot plant combines IEEE 802.4 MAP broadband, carrierband, and two IEEE 802.3 Ethernet LANs. Connected together are Siemens and GEC PLCs, and various computers, routers, gateways, and NCs from several vendors.

Why this technology will catch on

Providing a range of networks (not restricted to token bus) supporting MAP's MMS allows users to select the network that best suits their application and implementation considerations. Such considerations might include:

- The topology to implement,
- Whether services should share the same cable,
- The geographical area to be covered,
- The installed base (often broadband in the U.S., and mostly CSMA/CD Ethernet in Europe),

(Text continued on p 61)

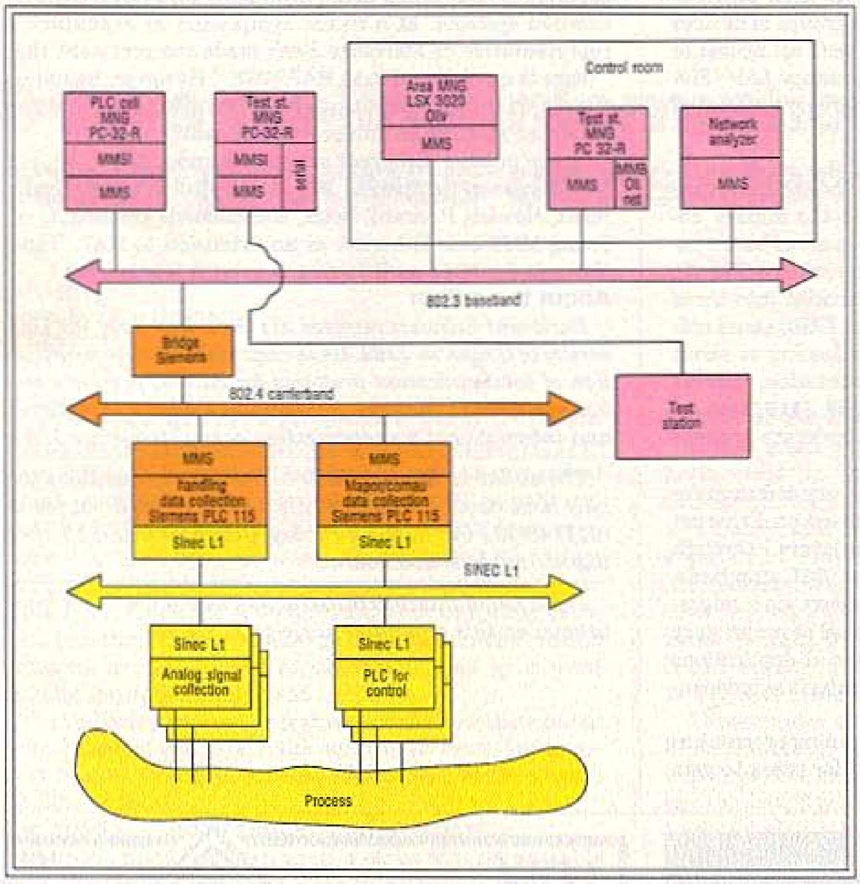


Fig. 4: The Magneti Merelli pilot plant combines MAP carrierband, Ethernet baseband, and Sinec L1 networks under the MMS umbrella.

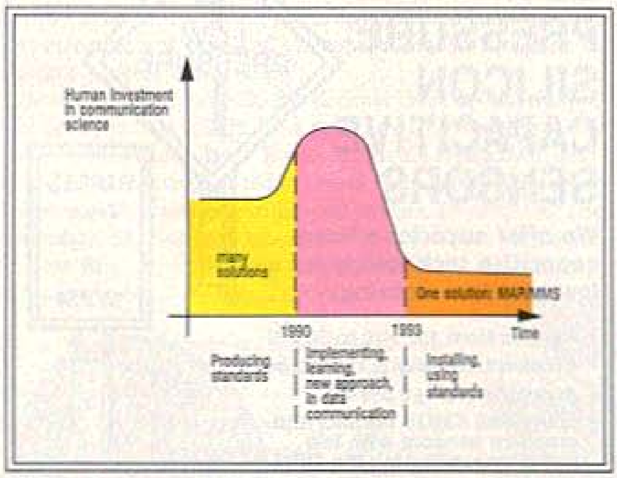


Fig. 5: The human investment in communication science will decrease as more implementations are completed and standards are finished. MAP/MMS will provide one solution from the many proprietary solutions that went before.

(Text continued from p 58)

- Costs and preferences of network system types,
- The separate computing and automation environments.

MAP/CNMA allows any of its selected LANs to be combined to form a single logical network. This means that a device on one LAN can communicate with a device on another LAN. LANs are interconnected via bridges or routers. Bridges perform the interconnection of the LANs on layer 2, above the media access control (MAC). They also form one logical subnet in terms of administration of stations on the interconnected LANs. Routers may have two or more ports, one on each subnet. Routing is performed by receiving data on layer 3 from one subnetwork and transmitting it to another. Routers are used within CNMA to provide connections to remote sites via X.25 public packet networks.

CNMA implementation at Magneti Marelli plant

Perhaps the most important MAP/CNMA pilot program is Magneti Marelli's factory in San Salvo, Italy. The plant belongs to the Electromechanical division of Magneti Marelli, which produces starters, alternators, small motors, and batteries. One of the most modern of the division, the San Salvo plant has been practicing computer-integrated manufacturing (CIM) since the beginning of the 80s.

The CNMA system (*Fig. 4*) is installed in the final section of an actual alternator production line. Nineteen different kinds of alternators can be manufactured at a very high level of productivity. On the assembly line, rotors are automatically supplied from the Rotor Line. Stators are gathered in boxes, coming from the Stator Line. The line is composed of 24 stations. Multivendor control logic and different kinds of control are implemented in this highly productive, highly flexible line. Three main functions are performed:

1. The monitoring system collects data on machine productivity and behavior;
2. A tracking system traces all work in progress on the shop floor;
3. A diagnostic system collects detailed information on machine states.

The system includes both OSI and proprietary communications protocols connected by gateway devices, thereby demonstrating migration to OSI and MAP.

System benefits and considerations

As shown in Fig. 4, there are two different networks in the San Salvo plant – one an 802.4 carrierband, the other an 802.3 broadband. Though only one of these is required, the redundancy will create a more complete test of the new technology.

Summed briefly, there were three major areas of concern in integrating the existing system with the new CNMA environment:

1. Updating the electronics of existing PLCs and NCs both to make the connection to a network possible, and to manage the communication software beside the existing automation application;
2. Interfacing old mechanical relays with digital devices to

make data available from the station under their control;
3. Adding data collection units to connect groups of devices together. To be more specific, PLCs have been connected to a couple of master PLCs through a proprietary LAN (Siemens SINECR L1), and two robot controls are now managed by a PC equipped with DNC software.

Conclusion

As the MAP/CNMA pilot projects have shown, the introduction and acceptance of MAP/MMS into the market depends mainly upon the willingness on the part of both vendors and users to invest in communication science *(Fig. 5)*. We see the MAP/MMS activity as being divided into three distinct phases. In phase one (up to about 1990) standards were specified and validated. Phase two (lasting to about 1993) can be considered as the implementation, market promotion, and learning phase. After 1993, MAP/MMS installations should be widespread, and proprietary systems integrated into MAP systems.

Because of the mass of installed proprietary communication systems around the world—many based on Ethernet and standard communication software for layers 1 through 4 and 7 (MMS)—and the complexity of OSI standards, MAP/MMS will be introduced by most vendors via a migration path. Future networks will be composed of proprietary subnetworks integrated into MAP/MMS, and all applications will use the same MMS application layer interface independent of the network.

Yes, the wait for MAP is over, but the learning process has just begun. A lot of time will be required for users to gain experience in applying and maintaining MAP/MMS communication systems. At a recent symposium in Frankfurt, a representative of Mercedes Benz made the comment that "there is no alternative to MAP/MMS." However, he immediately qualified this statement by insisting that MMS on Ethernet must be an integral component.

Is the popular Ethernet supported under MAP? No, not yet. However, companies like AEG, Bull, Digital Equipment, Hewlett Packard, Retix, and Siemens are already offering MMS over Ethernet as an extension to MAP. Thus, the wait for MMS on Ethernet is over; it has arrived.

About the author

Karlheinz Schwarz received his Dipl.-Ing. from the University of Siegen in 1982. He is responsible for the specification of communication protocols for SINEC products and has represented Siemens Automation Division in national and international standardization committees since 1984.

The author will be available to answer any questions you may have about this article. He can be reached via fax at (011) 49-721 595 2326 on Friday, December 6 and 13, during normal business hours.

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