Computer Science 773

Robotics and Real-time Control

COMMUNICATIONS

VERY LOCAL :

The original way of connecting up hardware devices, and one which is still necessary at the real device interface, is the direct connection between computer and machine.

Nowadays the computer is (almost ?) always a microprocessor or microcontroller. (A microcontroller is just the same as a microprocessor, except that it has different provision for input and output, typically directed towards easier interrupt handling, single-bit addressing, more channels, etc. If nothing else, that emphasises the importance of communications in control systems !) Even with a microcontroller, it is fairly unusual to find exactly the communication facilities you want built in, so it is almost always necessary to use an *interface adapter* of some sort.

Communication is carried out by interrupts or polling methods. It is generally not very standardised, and has to conform to any peculiarities of the machine concerned. Because of that, every instance is unique, and there is not a lot of discipline to it, other than that necessarily imposed by the hardware involved. It is best to use this sort of connection only in very localised areas, for preference within individual machines.

LESS LOCAL :

A more disciplined, and much more versatile, sort of connection relies on some standard communications bus. The big advantage of this sort of connection is its generality; provided that the bus is used in a sensible way, a device once provided with a bus interface is much easier to connect to other machinery than if every device has its own peculiar connection quirks.

Our laboratory has a little bit of STEbus, and documentation thereon. Have a look at it.

NOT VERY LOCAL :

For wider range connections, such as might be required between machines in a factory, buses are likely to be too sensitive to interference unless very carefully shielded. Network connections are more reliable, and are used for longer-range links; a standard protocol called *Manufacturing Automation Protocol* (MAP) was developed, and became quite widely observed by manufacturers of manufacturing machinery. The standard is based on the ISO Open Systems Interconnection (OSI) standard; an oldish diagram of the specifications of the levels is shown below.

LAYERS	***FUNCTION***	***MAP SPECIFICATION***
USER PROGRAM	APPLICATION PROGRAMS (Not part of the OSI model)	MMFS/EIA 1393A (RS511)
LAYER 7 APPLICATION	PROVIDES ALL SERVICES DIRECTLY COMPREHENSIBLE TO APPLICATION PROGRAMS	ISO CASE KERNEL DP 8650 FTAM, EIA RS 511 ISO/DP 8571
LAYER 6 PRESENTATION	TRANSFORMS DATA TO/FROM NEGOTIATED STANDARDISED FORMATS	NULL AT THIS TIME FUTURE ISO/DP 8823
LAYER 5 SESSION	SYNCHRONISE & MANAGE DATA	ISO SESSION KERNEL ISO/IS 8326 ISO/IS 8327 CONNECTION ORIENTED SUBSET
LAYER 4 TRANSPORT	PROVIDES TRANSPARENT, RELIABLE DATA TRANSFER FROM END NODE TO END NODE	ISO TRANSPORT CLASS 4 ISO/DIS 8072 ISO/DIS 8073
LAYER 3 NETWORK	PERFORMS MESSAGE ROUTING FOR DATA TRANSFER BETWEEN NON-ADJACENT NODES	LINK LEVEL CONTROL CONNECTIONLESS TYPE 1 ISO/DIS 8802.2
LAYER 1 PHYSICAL	ENCODES & PHYSICALLY TRANSFERS MESSAGES BETWEEN ADJACENT NODES	TOKEN ACCESS, BROADBAND MEDIA OR BASEBAND MEDIA ISO/DIS 8802.4

MAP has developed and evolved, to produce (among other things) MMS, the Manufacturing Message Specification. Here is a short account of MMS, from a document produced by SISCO, which also interprets many of the abbreviations in the table above. If you're interested to know more, try the original document – it goes on for 49 pages.

What is MMS?

MMS (Manufacturing Message Specification) is an internationally standardized messaging system for exchanging real-time data and supervisory control information between networked devices and/or computer applications in a manner that is independent of: 1) the application function being performed or 2) the developer of the device or application. MMS is an international standard (ISO 9506) that is developed and maintained by Technical Committee Number 184 (TC184), Industrial Automation, of the International Organization for Standardization (ISO).

The messaging services provided by MMS are generic enough to be appropriate for a wide variety of devices, applications, and industries. For instance, the MMS Read service allows an application or device to read a variable from another application or device. Whether the device is a Programmable Logic Controller (PLC) or a robot, the MMS services and messages are identical. Similarly, applications as diverse as material handling, fault annunciation, energy management, electrical power distribution control, inventory control, and deep space antenna positioning in industries as varied as automotive, aerospace, petro-chemical, electric utility, office machinery, and space exploration have put MMS to useful work.

The History of MMS

In the early 1980s a group of numerical controller (NC) vendors, machine builders and users working under the auspices of committee IE31 of the Electronic Industries Association (EIA), had developed draft standard proposal #1393A titled "User Level Format and Protocol for Bidirectional Transfer of Digitally Encoded Information in a Manufacturing Environment". When the General Motors Corporation began its Manufacturing Automation Protocol (MAP) effort in 1980, they used the EIA-1393A draft standard proposal as the basis for a more generic messaging protocol that could be used for NCs, programmable logic controllers (PLC), robots and other intelligent devices commonly used in a manufacturing environments. The result was the Manufacturing Message Format Standard (MMFS). MMFS was used in the MAP Version 2 specifications published in 1984.

During the initial usage of MMFS, it became apparent that a more rigorous messaging standard was needed. MMFS allowed too many choices for device and application developers. This resulted in several mostly incompatible dialects of MMFS. Furthermore, MMFS did not provide sufficient functionality to be useful for the Process Control Systems (PCS) found in continuous processing industries. With the objective of developing a generic and non-industry specific messaging system for communications between intelligent manufacturing devices, the MMS effort was begun under the auspices of Technical Committee Number 184, Industrial Automation, of the International Organization for Standardization (ISO).

The result was a standard based upon the Open Systems Interconnection (OSI) networking model called the Manufacturing Message Specification (MMS). A Draft International Standard (DIS) version of MMS was published in December 1986 as ISO DIS 9506. The DIS version of MMS (Version 0) overcame the problems with MMFS but had not yet been advanced to the status of an International Standard (IS). Faced with a publication deadline of November 1988, the MAP technical committees referenced the DIS version of MMS for the MAP V3.0 specification. In December 1988, the IS version of MMS (Version 1) was released as ISO 9506 parts 1 and 2. It was not until after the development of backwards compatibility agreements by the National Institute of Standards and Technology (NIST) that the IS version of MMS was referenced by the MAP V3.0 specifications

The MMS Standard

The MMS standard (ISO 9506) is jointly managed by Technical Committee Number 184, Industrial Automation, of ISO and the International Electrotechnical Commission (IEC)

and consists of two or more parts. Parts 1 and 2 define what is referred to as the "core" of MMS. Part 1 is the service specification. The service specification contains a definition of 1) the Virtual Manufacturing Device (VMD), 2) the services (or messages) exchanged between nodes on a network, and 3) the attributes and parameters associated with the VMD and services. Part 2 is the protocol specification. The protocol specification defines the rules of communication which includes 1) the sequencing of messages across the network, 2) the format (or encoding) of the messages, and 3) the interaction of the MMS layer with the other layers of the OSI model. The protocol specification utilizes a presentation layer standard called the Abstract Syntax Notation Number One (ASN.1 – ISO 8824) to specify the format of the MMS messages. MMS provides a rich set of services for peer-to-peer real-time communications over a network. MMS has been used as a communication protocol for many common industrial control devices like CNCs, PLCs, and robots. There are MMS applications in the electrical utility industry such as in Remote Terminal Units (RTU), Energy Management Systems (EMS) and other Intelligent Electronic Devices (IED) like reclosers and switches. Most popular computing platforms have MMS connectivity available either from the computer manufacturer or via a third party. Some of the computer applications available include Application Programming Interfaces (API), graphical monitoring systems, gateways, and drivers for spreadsheets, word processors, Application Enablers (A/Es) and relational data base management systems (RDBMS). MMS implementations support a variety of communications links including Ethernet, Token Bus, RS-232C, OSI, TCP/IP, MiniMAP, FAIS, and can connect to many more types of systems using networking bridges, routers, and gateways.

Benefits of MMS

MMS provides benefits by lowering the cost of building and using automated systems. In particular, MMS is appropriate for any application that requires a common communications mechanism for performing a diversity of communications functions related to real-time access and distribution of process data and supervisory control. When looking at how the use of a common communications service like MMS can benefit a particular system, it is important to evaluate the three major effects of using MMS that can contribute to cost savings: 1) Interoperability, 2) Independence and 3) Access.

Interoperability is the ability of two or more networked applications to exchange useful supervisory control and process data information between them without the user of the applications having to create the communications environment. While many communication protocols can provide some level of interoperability, many of them are either too specific (to brand/type of application or device, network connectivity, or function performed –- see Independence below) or not specific enough (provide too many choices for how a developer uses the network).

Independence allows interoperability to be achieved independent of:

The Developer of the Application. Other communications schemes are usually specific to a particular brand (or even model in some cases) of application or device. MMS is defined by independent international standards bodies with participation from many leading industry experts and vendors.

Network Connectivity. MMS becomes THE interface to the network for applications, thereby isolating the application from most of the non-MMS

aspects of the network and how the network transfers messages from one node to another.

Function Performed. MMS provides a common communications environment independent of the function performed. An inventory control application accesses production data contained in a control device in the exact same manner as an energy management system would read energy consumption data from the same device.

Data Access is the ability of networked applications to obtain the information required by an application to provide a useful function. Although virtually any communications scheme can provide access to data at least in some minimal manner, they lack the other benefits of MMS, particularly Independence (see above).

MMS is rigorous enough to minimize the differences between applications performing similar or complimentary functions while still being generic enough for many different kinds of applications and devices. Communications schemes that are not specific enough can result in applications that all perform similar or complimentary functions in different ways. The result is applications that cannot communicate with each other because the developers all made different choices when implementing.

While many communications schemes only provide a mechanism for transmitting a sequence of bytes (a message) across a network, MMS does much more. MMS also provides definition, structure, and meaning to the messages that significantly enhances the likelihood of two independently developed applications interoperating. MMS has a set of features that facilitate the real-time distribution of data and supervisory control functions across a network in a client/server environment that can be as simple or sophisticated as the application warrants.

REFERENCES.

MAP : G.G. Wood : "Are your controllers talking the same language ?", *Automation and Control* **18#5**, 41-44 (May, 1987).

MMS : *Overview and Introduction to the Manufacturing Message Specification (MMS)*, SISCO, Inc.,1995. (See http://www.sisconet.com/techinfo.htm)

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