A Network Management Approach for a Distributed Industrial Application and the Related Implementation


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Abstract- Local Networks are used to solve a great deal of problems related with industrial applications mainly at the Shop Floor and Field Level. This paper presents the implementation of a complete distributed industrial system comprising an industrial network, an intelligent industrial controller and the related network management.

Keywords- Industrial Networks, Shop Floor Level, Field Level, Distributed Control, Network Management, Periodic/Aperiodic Services

I. INTRODUCTION

Communications play an ever increasing role in solving problems in an industrial environment. Industrial applications impose a degree of complexity that is usually higher than that of ordinary applications, since they require the interconnection of functionally diverse devices (e.g. simple sensors and actuators, PLCs, CNCs, PCs, mainframes e.t.c.) which are spatially distributed and communicate with each other under time constraints.

Such extended requirements make the use of industrial networks mandatory. Different networks should be used in order to meet the specific requirements that the different levels in the industrial environment hierarchy impose. The two lower levels in this hierarchy are the Field Level, where interconnection takes place between field devices such as sensors, actuators and other instruments, and the Shop Floor Level, where interconnection between control devices such as PLCs, CNCs occurs. This hierarchy also involves the Plant and Corporate level where the devices interconnected are workstations and mainframes, the geographical distribution of which is extended, in many cases, to a global scale, encompassing advanced business functions (Management Information System integration).

At the Field Level, the use of a network simplifies the traditional point-to-point connections of the field devices by introducing a bus topology. Several industrial networks have been developed to solve problems at the Field as well as the Shop Floor Level. Presently there is an effort under the auspices of IEC/ISA SP50 Committee for the development of a fieldbus network standard. The most influential among the fieldbuses, that already exist, are the WorldFIP [1], the I.S.P./PROFIBUS [2] proposal and the P-net which have been proposed by CENELEC as the intermediate fieldbus standards in Europe, until they migrate towards the emerging standard. For further consolidation of this effort, WorldFIP and I.S.P. have formed the Fieldbus Foundation.

This paper illustrates the development of a generic network management that could be used to manage existing and future fieldbuses. It provides features such as Performance, Configuration and Fault Management. In addition, a graphical tool is also presented that deals with the configuration and the run-time observation of the industrial application in a user-friendly way.

This network management system has been installed in a number of industrial demonstrators that form a testbed for this module [7]. A complete network system has been developed consisting of the network management module mentioned above and the underlying industrial network. The industrial network used in the industrial demonstrators, presently installed, is based on an enhanced version of the INTEL BITBUS interconnection [3].

II. THE TESTBED INDUSTRIAL NETWORK AND THE CONTROLLER

The fieldbus network chosen is the BITBUS (IEEE 1118). This interconnect is a fully centralised and hierarchical architecture (master/slave) that relies on an order/reply message protocol between tasks running on the network nodes. These tasks are executed in the local memory of the controllers where processing functionalities are performed as well.

The protocol of the network implements only three of the seven layers of the OSI Reference Model [4], the Physical Layer (Layer 1), the Data Link Layer (Layer 2) and the Application Layer (Layer 7). This three layer architecture is dictated by economic and technical reasons.

The Physical Layer is based on the RS-485 standard with communication rates up to 2.4 Mbps. The Data Link Layer is a subset of the highly reliable IBM Synchronous Data Link Control (SDLC) standard.

Our implementation is based on the INTEL 8344 microcontroller [6], which is responsible for both the protocol implementation and the real time operating system, that allows us to establish node links to application layer software through standard sockets. Specifically it executes up
to eight tasks one of which deals with the communication aspects, while the other deal with the specific application processing aspects.

Finally, the Application Layer comprises a subset of the Manufacturing Message Specification (MMS) [5]. This subset of services includes Environment Management, Variable Management, Domain Management and Program Invocation Management services. The use of the MMS enhances the capabilities of the network protocol, as it provides a standardised way for sending messages, by making the interpretation of the data sent independent from the device that receives it.

Regarding the processing tasks, they may be viewed as a sequence of parametrical callings of function blocks that have already been defined and reside in the node memory area. The parameters of these blocks of code are essential for their functioning and according to their value alter the way they are executed. The capability to call the same function more than once in a task with different parameters adds further modularity to the application.

III. THE SYSTEM MANAGEMENT

A network management software has been developed to supplement the network protocol that has been used. This software uses the MMS services as an interface to the Application Layer. The network management services are divided into three categories: the Configuration Management, the Performance Management and the Fault Management services.

The system that has been implemented is variable driven. This means that variables have been defined on each node of the network, regarding signals that are needed in more than one nodes in the network. Each variable is produced in only one node but may be consumed in several nodes. Variable Management services of the MMS are used to read variables from the nodes they are produced in and to write them in all the nodes that consume them.

The values of the variables are transmitted via the network on strict time intervals that are predefined by the user. Therefore the approach followed can guarantee the critical timing required for variable transfer via the network, meaning the existence of a time interval during which the value of the variable must be updated. This ability makes the system capable of closing loops remotely. The ability of closing loops locally already exists as a result of the local intelligence.

Apart from the periodical polling and writing of variables, the system allows the transmission of messages through the network in an asynchronous way. These messages are usually of lower priority to the periodic commands, meaning that they will be serviced only when there are no pending periodic commands. Asynchronous messages that have higher priority than that of periodic ones are messages related to the configuration management (e.g. download of the task code to the control units, creation of tasks) and messages relevant to changes of function parameters. These asynchronous capabilities make the system extremely dynamic as it is easy to change its functionalities at run time and according to the user requirements.

Whenever no periodical or asynchronous messages exist, the system gathers statistical system information. Such information is, for instance, the waiting time for a message to be processed or the time it takes for an message reply to be received by the master.

The Fault Management diagnoses and handles errors ensuing during the network performance. If these errors are not related with an unrecoverable error like a damage of the physical link, the error handler is called. Otherwise, the user is informed about the nature of the failure and instructed about how to deal with it.

Finally, the Configuration Management uses the Domain Management and the Program Invocation Management services of the MMS subset, in order to perform the creation of the tasks in the control units of the network.

IV. CONFIGURATION AND OBSERVATION TOOL

In addition to the Network Management, a tool is provided that enables the implementation of a user interface to the Configuration Management. The idea behind this tool was to give to the user the ability to generate modular code for the local control units via parametrical calling of function blocks. As a consequence, we have a powerful configuration and observation tool to organise the distributed control application in a dynamic and flexible way. The main feature of this tool is the ability to define and interconnect network and control objects in a graphical way.

As a result of this functionality, it provides the Configuration Management, described above, with the code of the tasks needed to be downloaded to the control units, as well as with the structured information about the specific industrial application. The data periodically read from the nodes is stored in the global heap area of the master node. A database is created there based on the structures describing the industrial application. The data that is stored in this database may be provided to upper layer software via the rules of the Dynamic Data Exchange. Such upper layer software may be a visualisation application or a database management system. The accessibility of this database adds to the system flexibility.

The second use of this tool, deals with the observation of the application. This tool derives all the information it requires from the network database. It combines features of the configuration aspects mentioned above together with the visualisation aspects. More specifically, it gives the user the capability to observe data related with the control process, on a real time basis.

V. CONCLUSIONS

The system implemented comprises a three layer network protocol and a network management system. The former provides high reliability, low cabling and
interconnection costs as well as high flow of information. The latter manages a spatially and temporally distributed data base, provides a user friendly interface for the configuration of the application and is dynamic and open with a high degree of flexibility. Its genericity ensures the usability for other fieldbuses as well.

REFERENCES

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