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The way to distributed PLCs

The IEC 61131 allows only a restricted realization of distributed controls. Does it become easier by integrating network variables?

INTRODUCTION

More and more periphery units are equipped with PLC functions, from an intelligent sensor up to a motion control with an integrated PLC. As the program functions are now in the periphery, process data can e.g. be preprocessed. Therefore it is possible to reach fast reaction times as they often could not be achieved by remote I/Os via fieldbus. However distributed control concepts are still avoided in these days because the current tools to program the communication functions often only offer low support. Bus configuration and PLC programming often have to be coordinated by a high effort. This results in less transparent programs and complicates the diagnosis for commissioning and in case of an error.

A further aspect to avoid distributed program structures is the uncertainty if the data exchange among the programs is fast and safe enough. Therefore the handling of distributed control architectures has not reached the level so far which is essential for a wide acceptance of such systems.

The quest for an increasing integration in fabrication lines, however, clearly limits the central control. The combination of single machine stations to one flexible fabrication line requires that their control islands are able to exchange data among each other and so form a distributed control system.

ETHERNET FORMS THE BRIDGE

The efficiency of the traditional fieldbusses is not sufficient enough for the fast PLC-to-PLC communication as it is necessary for distributed PLC systems. In this context, many discussions used to be held if Ethernet was the right solution for a data exchange under deterministic conditions. It became clear that Ethernet - due to its high performance and wide distribution in the IT-world - had many advantages and therefore was a good choice. New developments like the switch technology even predestine the Ethernet as a network for hard realtime communication.

Another aspect is: Ethernet has recently also encroached the sensor- and actor sector. For this reason Ethernet can be used as a unique bus system from the sensor/actor level via the horizontal level up to the top level. Therefore CPU chips with an integrated Ethernet link and the trend of sinking costs for switching on create the basic conditions for an economical realization of distributed PLC solutions.

LIMITLESS COMMUNICATION

Part 5 of the international programming standard IEC 61131 defines communication function blocks. Using the language means of the IEC 61131-3 they enable the communication and the variable exchange among PLCs. Unlike part 3 of the IEC 61131, the function blocks of the IEC 61131-5 have not gained much acceptance so far. The most important reason is the restricted possibility to implement the FBs orientated to the MMS standard (manufacturing message specification) on the fieldbus systems established in the market. In general, their layer 7 services of the ISO/OSI model only offer subsets of MMS. For this reason the modern PLC world is characterized by manufacturer-specific communication FBs which are not compatible to each other.

The IEC 61131-5 FBs have a great disadvantage for the programming of distributed PLC systems: each FB has to be programmed explicitly for each PLC. Every change in the distribution structure requires enormous program changes which is a less comfortable and less flexible solution for distributed applications. The advantage of communication function blocks is the program-controlled data exchange between two controls. Therefore new solutions are essentially necessary for a PLC system with any number of participants which is easy to handle.

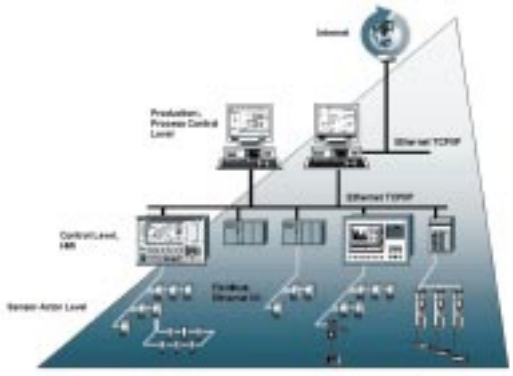

Figure 1. In this hierarchy model, operation, visualization and PLC are on the same level. Ethernet and TCP/IP are favorites. In the sensor-actor level, however, the classical fieldbusses are still preferred.

IEC 61499 AND OTHER APPROACHES

Currently the IEC 61499 is being discussed as a successor standard of the IEC 61131. An essential part of the IEC 61499 is the consideration of distributed systems. However, the realization of the models requires intelligent tools hiding the complexity of this standard from the user. Single approaches in regard to this aspect only cover parts of aspects and are also still less practicable. For this reason the introduction and acceptance of the IEC 61499 might still take quite a long time.

Many approaches for an improved handling of distributed PLC systems go into the direction of an automatic distribution of the programs. It shall be possible to program a machine or installation without considering the program distribution. The association of the program segments to the individual controls and the organization of the data exchange are done automatically. Experiences from the history of parallel processors, however, show that compilers with automatic distribution principles are very complex and do not always lead to the expected advantages. Moreover, the programmer has to rely too much on the correct functionality of the system, as there is often a lack of operation possibilities for an error analysis and -handling.

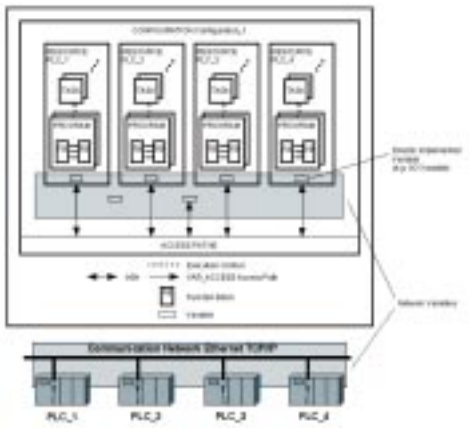

Figure 2. In the software model of the IEC 61131-3 network variables correspond to the global variables of a configuration.

NETWORK VARIABLES, A SIMPLE AND EFFECTIVE SOLUTION

When designing a distributed control architecture, the draftsman of a machine usually already knows which tasks the individual controls have to handle. Therefore the problem is not the association of the program parts but the data exchange among the controls which should be easy to organize. Whoever changes over to distributed PLC applications does not want to take care of an additional effort for the network configuration and programming of the data exchange. The program-technical solution of the machine functions should remain in the foreground. Network variables are the optimal solution for this requirement. With their help each information which is situated somewhere in a control can be used at any place. If it was possible to integrate network variables into the IEC 61131-3 world, this would be a further advantage.

AUTOMATIC DATA EXCHANGE BY IMPLICIT COMMUNICATION

The mechanism for the automatic data exchange is called implicit communication. From the beginning, the developers of KW Software had the aim to apply this data exchange also in highly dynamic processes. Furthermore it had to be considered that there were no early bottlenecks in big applications regarding a restriction of the data amount.

A communication network can be compared to a traffic network, as not only the width of the tracks is important that all information quickly and safely reaches its destination. A light transporter reaches its destination faster than a heavily loaded truck.

Figure 3. Application example: with the help of MULTIPROG® wt, four PLCs are connected to each other via network variables. The method to program with network variables is the same as with global variables. The data exchange among the controls is done automatically.

Transferred to the communication technology this means: preferably small data packages with low data amounts. Moreover there should be as less traffic as possible. Unnecessary data traffic, however, often appears in many cyclically working transmission mechanisms because the data are continuously transmitted, independent from the fact that they have changed or not. Therefore the requirement towards the PLC system is an exchange only of those data which have changed. As in practice only a low percentage of data in a whole network regularly change, the implicit communication serves for the fact that data are transmitted efficiently and therefore quickly and punctually reach their destination.

For this reason network variables represent a virtual process image offering the same current information quite simultaneously to each PLC in the network. The effective organization of the data traffic also allows extensive process images and a high number of participants.

Network variables integrated into IEC

The IEC 61131-3 knows global variables with different validity areas. The top level for the declaration of global variables is called "Configuration". A Configuration can include several PLCs corresponding to the level "Resource". Network variables can be defined as normal global variables within a Configuration in the IEC 61131 programming system MULTIPROG® wt by Klöpper und Wiege (KW) Software. All available IEC 61131-3 data types including "Strings" as well as user-defined data types of the kind "Struct" and "Array" are allowed. Network variables also enable a direct access on local inputs and outputs of a PLC. It is also possible to initialize network variables with initial values. A further language part of the IEC 61131-3 are the access paths which are declared by "VAR_ACCESS" within a Configuration. VAR_ACCESS offers a means to fix named variables which have been created for the access by communication function blocks (status, ustatus, read and write) of the IEC 61131-5. The peculiarity of the network variable principle is, however, the fact that besides the single declaration no further programming measures are essential to use them on any PLC in the network. The system automatically takes care of the data exchange to update the network variables in the network.

In autumn 1999, KW Software would like to present prototypes of MULTIPROG® wt and the PLC system ProConOS® realizing the integration of network variables into the IEC 61131 world. By the network variable update with the help of the implicit communication, the programming of distributed PLCs shall become as easy as in case of a single control.

MANAGEABILITY AND ROBUSTNESS ARE DECISIVE

There are several important aspects to make a distributed control system robust and manageable. First it must be considered that each PLC in the network can be asynchronously started and stopped. In the commissioning of a distributed PLC installation, this characteristic offers the possibility to add the individual controls one after the other. So the installation can also be operated supposing that not all participants in the network are available. Therefore the production can be also maintained if a machine module in a fabrication line is defective and its function is temporarily taken over by a manual workspace. A further aspect is the data consistency. Within a program flow the used network variables should not be changed from outside. No values should be written onto the network either. A statement about the speed of the network data update should be given before the completion of a distributed control program. The maximum update duration of time-critical signals is especially important. Models which promise a determination of such statements by an offline analysis are very complex and therefore hardly realizable. For this reason the programmer has to rely on the determination of the performance by measurements. Therefore a highly efficient system must have a diagnosis automatically providing performance measurement data ■

Since his electronics studies in Paderborn, Michael Petig has been working at KW Software where he is responsible for the development of PLC systems.