

## Engineering of Distributed Control Systems

René Simon, Peter Neumann, Christian Diedrich, Matthias Riedl  
 {rsi,neu,chd,mri}@ifak.fhg.de  
 ifak e.V.  
 Steinfeldstraße 3 (IGZ), D-39179 Barleben, Germany

**Abstract** - Besides the functional view on distributed control systems, the engineering aspect becomes more and more important. Hard economical conditions in the Automation and Process Control Industry are making secondary processes as Product Data Management and System Engineering more relevant. It will be essential to integrate the whole engineering process. Here the transport of information without losses from one engineering (live cycle) phase to an other must be provided. It is proposed here to regard the distributed control system as a product as defined in ISO 10303 (STEP) and to use the already built infrastructure of STEP. The problem of describing the distributed control system is put down to describing product data (solved in STEP). This approach is validated by the reference implementation (MOVA).

### I. DISTRIBUTED CONTROL SYSTEMS

The classical measurement, control and actuator devices were based on simple physical principles (mechanical, hydraulic, pneumatic, electrical). Often they were used as stand-alone devices for relatively closed automation solutions. With the introduction of microprocessor technology and its fast spreading, the focus shifted from stand-alone devices to much more complex device systems. These systems of automation devices including their necessary communication systems are called Process Control Systems (PCS).

Process Control Systems provide control and supervision of production processes. They connect people (e.g. the operator) and machines. They consists of input / output devices, data processing units, human machine interfaces and communication systems.

1<sup>st</sup> generation PCSs are characterized by a centralized structure. A central device scans all relevant process data and computes the actuator values. There are two basic types of PCSs, one for process control and one for manufacturing [1]. Their internal structures are similar, the market (user) will decide about a possible fusion. This fusion and the transition from centralized to decentralized systems based on serial communication systems (e.g. fieldbus) are milestones of the development towards 2<sup>nd</sup> generation PCSs. This development hasn't been finished yet, but lots of solutions are emerging.

A non-interrupted engineering process on the basis of common information models and data exchange technologies is the primary requirement for the design of 3<sup>rd</sup> generation PCSs. These 3<sup>rd</sup> generation PCSs are called Distributed Control Systems (DCS) here. Why becomes the engineering process so important?

Traditionally, PCS are seen from a run-time point of view (function, device, system). The engineering aspect becomes more important due to its increasing complexity and costs involved. The following shows, which factors (from a device viewpoint) influence this complexity.

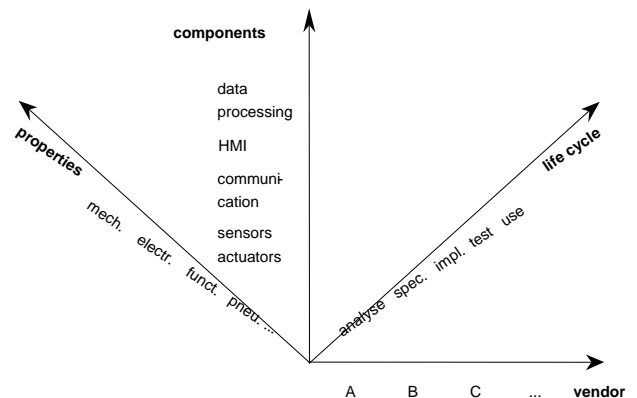


Fig. 1. Complexity engineering from device view point

The complexity results from several factors influencing the engineering process such as different device components (input / output, data processing, HMI, communication), process physics (mechanical, electrical, ...), live cycle phases and device vendors.

Today, the integration of these different worlds usually is done by building hardware and software interfaces and expensive commissioning processes based on trial-and-error approaches. This will become impossible under a true cost of ownership principle. The whole engineering process must be supported by integrated tools in order to avoid data losses and inconsistencies. The use of paper and even of electronic means don't provide a solution as long as common transfer syntax and standardized data models are not used.

## II. ISO 10303 - STEP

A product which has to be produced follows several life cycle phases (design, prototyping, production, maintenance). During each of these life cycle phases a certain set of information about the product must be provided to the user (respectively to the tools he is using). The total amount of information about a product equals the superset of information needed in each life cycle phase. These life cycle phase specific information overlap partly (e.g. the name of the product is always the same), some information are used only few times or even once. The tools for information processing (e.g. CAD systems) are often vendor specific, i.e. they work with their own internal data formats. In that way a continuous information flow accompanying the life cycle of the product becomes difficult or even impossible. That is especially true, if a co-operation behind enterprise borders is necessary (e.g. suppliers in the automotive industry). An interrupt of the information flow in the tool chain always means a loss of information, which can only partly be compensated by manual re-input (inconsistencies). This problem can only be solved if a vendor and life cycle independent product description is established.

The CAD area first faced the problem to exchange product data. Hence several approaches are existing here to standardize the exchange (IGES, SET, VDAFS). All these activities were united under the umbrella of the ISO TC184 SC4 and resulted in the standard ISO 10303 "Industrial automation systems - Product data representation and exchange" [2]. The German DIN adopted ISO 10303.

The standard ISO 10303 can be divided into 4 major sections. The first section (description methods) comprises an introduction, an explanation of the most fundamental principles and the specification of the data description language EXPRESS with its variants (e.g. EXPRESS-G). Based on this, the second section describes the necessary implementation methods. These are the file exchange and an uniform data base access interface (SDAI). The third section (testing) is used to check real products (software tools) according to their conformity to the standard. Additional to the non-application dependent specifications of the sections 1-3 the fourth section contains data specifications for often used activities / application areas. These data specifications are organized in a hierarchical way. There are integrated resources e.g. for materials or form characteristics. Based on the integrated resources application resources are existing (e.g. for kinematics or drawing). These application resources are concretized by Application Protocols (AP) (similar to fieldbus profiles). There are e.g. Application Protocols for 2D CAD, ship building and electrotechnical design and installation [3]. The following figure shows the different aspects of the STEP approach.

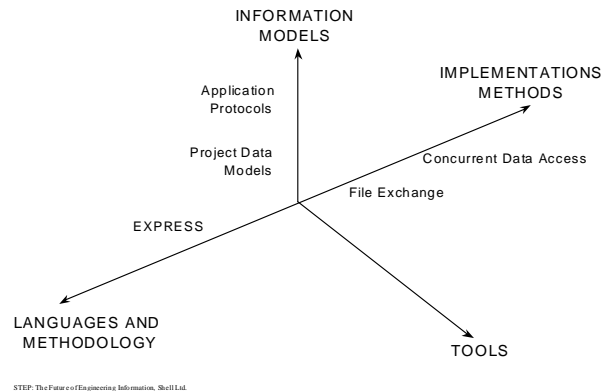


Fig. 2. STEP aspects

It is proposed here, to regard the Distributed Control System as a product as defined in ISO 10303 (STEP). Then all the methods and the already built infrastructure of STEP are available. The problem of describing the Distributed Control System is put down to the problem of describing product data. Basically, the problem of describing product data during their life cycle is solved by the standard ISO 10303 and the existing STEP infrastructure, even if a overall implementation into practice is still under construction. The following question must be answered

- Is the proposed approach justified, i.e. can STEP methods applied to Distributed Control Systems?
- Which expansions as regard contents, e.g. according to the existing Application protocols, must be carried out with ISO 10303?
- Which methodical expansions, e.g. according to the existing implementation methods, must be carried out with ISO 10303?
- Which additional tools, e.g. modifications of existing tools of both worlds, must be developed?
- Which steps are necessary to provide migration paths from already existing solutions?

## III. REFERENCE MOVA

To answer these questions it is necessary to carry out research and development projects including validations by end users. This is done by reference implementations as in "Advanced Control Network" (ACORN), "Modular, open and distributed Function Block systems for automation" (MOVA), and partly by "Network oriented application harmonization" (NOAH) activities.

The MOVA project follows a similar approach as the ACORN project, as far as the methodology for the data exchange between tools is concerned (STEP). Furthermore, a solution for the modularization and integration of the mechanical, electrical and control components in machine building based on IEC 61499 and IEC 61131 is found.

Main objective is the development of a technology in order to find a solution for the modularization and integration of the mechanical, electrical and control components in machine building and to get a non-interrupted engineering process in several departments of machine development in the companies. This project based on standards like IEC 61499, IEC 61131 and ISO 10103.

The idea is following: The output of the sales department is a list of modules of a machine. The development / project departments are working with this module list. Each of these departments is using a special "Mergetool".

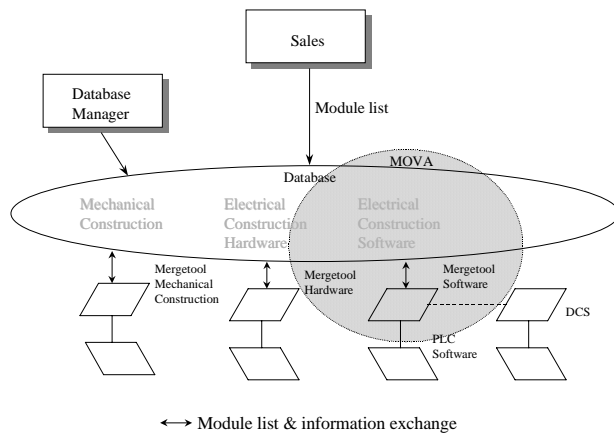


Fig. 3. Place of Mergetool Software in machine construction

The Mergetool Software got more than one interface. At the development phase, this tool generates from the module list a IEC 1499 based Function Block network, handles the distribution of these Function Blocks onto the PLCs and creates the necessary communication links. In order to do that, the Mergetool works with a library of rules for each module, for each IEC 1499 Function Block a. s. o.

The resulting program will be translated into IEC 61131 and then exported by means of FxF (File Exchange Format, STEP schema defined by PLCopen). We will use the schema PLCOPEN\_TEXTUAL\_CODE\_1.1.

Furthermore is it possible by user input to define blocks of the network, monitored or controlled by a process control system at runtime. These data will be exported by an additional FxF schema. It includes items for the description of IEC 61499 FB interfaces, IEC 61499 FB instances and items, describing the relationships between these instances to the real IEC 61131 FB instances.

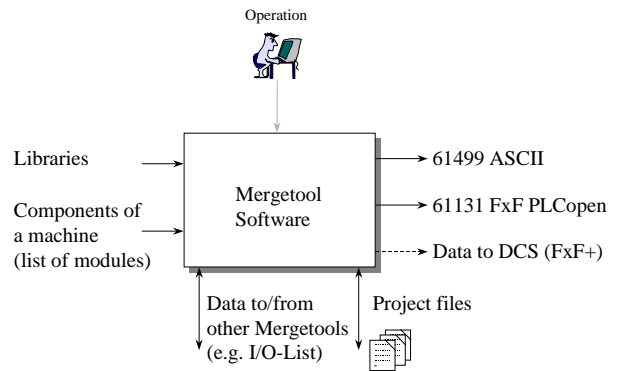


Fig. 4. Data flow around the Mergetool Software

#### IV SUMMARY

The following conclusions can be drawn:

- Using STEP within the engineering of Distributed Control Systems is a suitable approach. Basically, the requirements are met.
- The Application Protocols of STEP are quite complex. It is necessary to have access to the developers to do implementations or mappings. Especially the gap between the AAM and AIM (e.g. in AP212) are critical for the necessary understanding. Additionally, more integration between different Application Protocols is necessary, e.g. for the automation area, AP212, AP220, ... are relevant.
- The existing Implementation Methods (SDAI, file) must be extended (object oriented data base systems, XML)
- Profiles should be developed which tailor existing Application Protocols to the needs of certain fields (e.g. PROFIBUS or IEC 61499). This work must be done within the different user organizations, but coordinated under the STEP umbrella.

#### REFERENCES

- [1] Polke, M.: Prozeßleittechnik, Oldenbourg Verlag München, 1994.
- [2] STEP: Industrial Automation Systems - Product Data Representation and Exchange, ISO 10303.
- [3] West, M.: The Future of Engineering Information, SHELL Ltd., 1995.
- [4] Svemar, B.; Koechlin, J.-B.; Simon, R.; Zubimendi, E.; John, K.-H.; Brandl, Th.; Dahlström, L. E.; Gustavsson, L.; Salfati, R.: SIMPLE:

- Standardization of Interfaces between multiple Programming and Control Environments, Proposal for the Domain of Integration Manufacturing, ESPRIT, 1995.
- [5] Hörger, J.; Simon, R.; Nerke, R.: Field Architecture Reference Model, Brite EuRam Project BE95-479 ACORN, Deliverable D03.1, 1996.
- [6] Dr. Brownlie, I.; Herzog, R.; Simon, R.: Automatisierung mit Verteilten Systemen, atp - Automatisierungstechnische Praxis 39 (1997) 6, R. Oldenbourg Verlag, 1997.
- [7] Orzelski, A.; Petig, M.: Modular open distributed function block systems for automation: project MOVA, conference proceedings ICP'97, PLCopen, 1997.
- [8] ISO 10303-21, "First edition. Industrial automation systems and integration - Product data representation and exchange - Part 21: Implementation methods: Clear text encoding of the exchange structure", December 1994