52. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

PROCCEDINGS | 10 - 13 September 2007

FACULTY OF
COMPUTER SCIENCE AND AUTOMATION

COMPUTER SCIENCE MEETS AUTOMATION

VOLUME I

Session 1 - Systems Engineering and Intelligent Systems

Session 2 - Advances in Control Theory and Control Engineering

Session 3 - Optimisation and Management of Complex Systems and Networked Systems

Session 4 - Intelligent Vehicles and Mobile Systems

Session 5 - Robotics and Motion Systems

TECHNISCHE UNIVERSITÄT
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Bibliografische Information der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbiografie; detaillierte bibliografische Daten sind im Internet über **http://dnb.ddb.de** abrufbar.

ISBN 978-3-939473-17-6

Impressum

Herausgeber:	Der Rektor der Technischen Universität Ilmenau Univ.-Prof. Dr. rer. nat. habil. Peter Scharff
Redaktion:	Referat Marketing und Studentische Angelegenheiten Kongressorganisation Andrea Schneider Tel.: +49 3677 69-2520 Fax: +49 3677 69-1743 e-mail: kongressorganisation@tu-ilmenau.de
Redaktionsschluss:	Juli 2007
Verlag:	Technische Universität Ilmenau/Universitätsbibliothek Universitätsverlag Ilmenau Postfach 10 05 65 98684 Ilmenau www.tu-ilmenau.de/universitaetsverlag
Herstellung und Auslieferung:	Verlagshaus Monsenstein und Vannerdat OHG Am Hawerkamp 31 48155 Münster www.mv-verlag.de
Layout Cover:	www.cey-x.de
Bezugsmöglichkeiten:	Universitätsbibliothek der TU Ilmenau Tel.: +49 3677 69-4615 Fax: +49 3677 69-4602

Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.

Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

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52nd Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
10 – 13 September 2007

Olaf Sauer / Miriam Ebel

Engineering of production monitoring & control systems

Abstract

Adaptivity and interoperability of production equipment present extensive difficulties in business practice today, particularly if production systems are modified.
Production systems are adapted continually as products change, as capacities have to be re-adjusted owing to varying demands or as more efficient manufacturing technologies are applied. In practice modifications in production plants do not only result in equipment being shifted physically within a plant. Rather, they cause adjustments in the software of controlling machinery and equipment, for example programmable logic controller (PLC), as well as in the information technology (IT) which superposes the direct facility control, monitors automated plants or plans and controls the allocation of equipment. CIRP, the international organization of production scientists, considers this capability to undergo permanent change to be the strategic competitive advantage of plants and production systems in the future.

1 Introduction

At the same time, manufacturers of machinery and equipment have to re-adjust themselves continually to the individual 'company standards' of their customers who are the operators of the plants. One of the standards Fraunhofer IITB is facing in its projects is DaimlerChrysler's 'IntegraDCX' standard.
This standard comprises

- components such as PLCs, drives, etc.,
- automation functions such as ProfiNet,
- a methodology for equipment diagnostic such as plant visualization,
- distribution to production sites and supplier of equipment,
- support, e. g. 1st, 2nd and 3rd level and
- a staff training concept.

The standardization of components includes

- requirements for function blocks of PLCs and
- naming conventions for PLC variables.

Due to the benefit of such a standard for plant operators like DaimlerChrysler, other operating companies are likely to develop similar company standards in the near future – which is a big challenge for medium-sized machinery and equipment manufacturers. These ‘company standards’ including the above mentioned requirements have implications for machinery and equipment manufacturers with regard to

- naming conventions of PLC variables and function blocks,
- equipment components to be used,
- investment in engineering (CAE) and plant software,
- automation systems to be used,
- the proceeding of mechanical and electrical engineering and
- methods and tools of PLC programming.

Ultimately, this can result in equipment manufacturers losing their unique features and their own, cost-cutting standardization potentials.

Owing to the specific requirements of plant technology that results from the multitude of production tasks there is a nearly endless variety of machinery controls, software versions and manufacturing execution systems today. Whenever the equipment is changed, the software has to be adjusted as well, which results in high costs for the manufacturing industry.

Today 'digital factory' tools are mainly used to plan production systems, whereas operational processes are assisted by manufacturing execution systems which support the functional operation on the shop floor (figure 1).

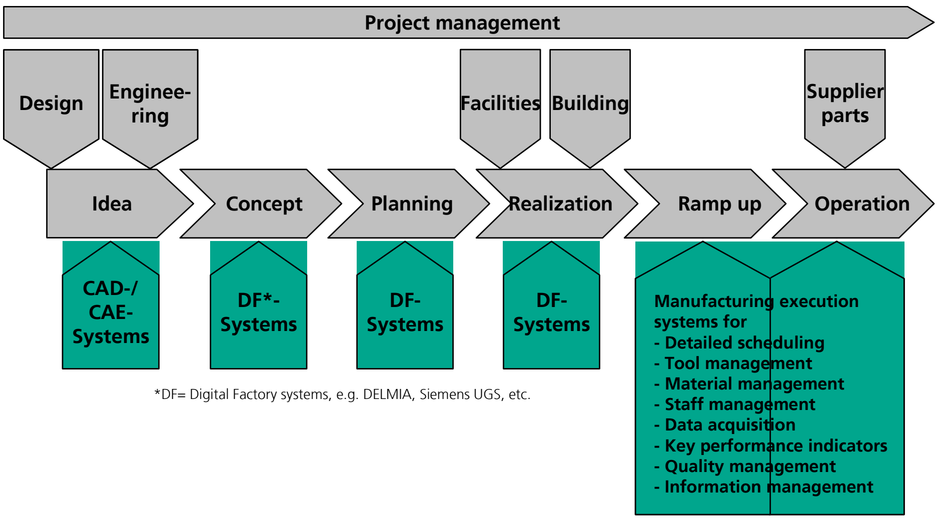

Figure 1: Cooperation between IT systems supporting planning and operation [Sr04]

Up to now, there has been no standard protocol between manufacturing plants, their controls and the super ordinate IT ruling, for instance, the structure and contents of the capabilities and states of manufacturing equipment transmitted to the controlling or monitoring software. In contrast to this, there are a few standards for the integration of field devices into the industrial network, e. g. Industrial Ethernet, ProfiBus, ProfiNet, etc. However, most of these standards refer to the relevant network protocol or the supplier, i. e. only to Siemens PLCs or other brands.

In the future, information stored in 'digital factory' tools will be used to parameterize manufacturing plants and super ordinate IT systems as well as to start and operate them virtually. This aims at having the corresponding operational IT systems fully available when the modified or new production plants start up (figure 2).

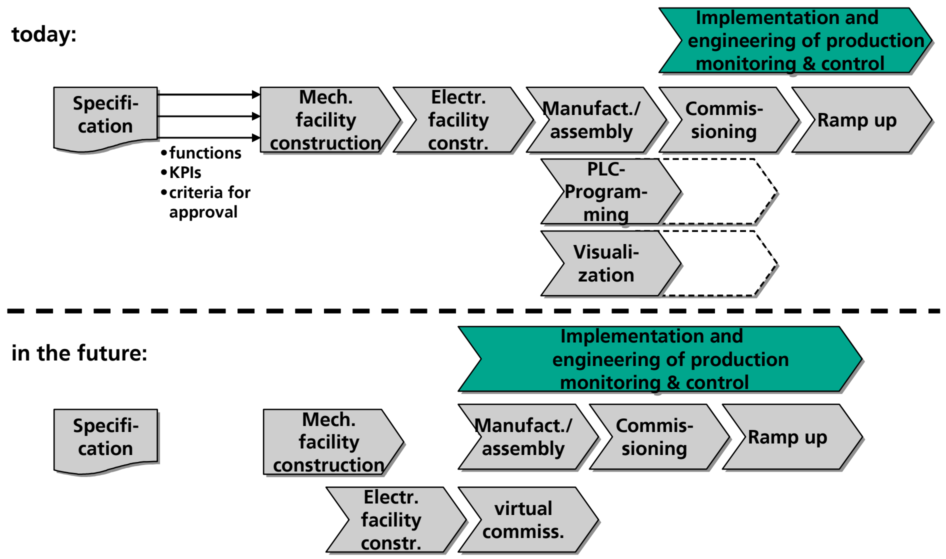

Figure 2: The early coupling of planning and operation aims at an early start up of shop-floor-related IT systems.

2 Trends in shop-floor-related IT systems

With reference to the enterprise-wide IT hierarchy, the efforts described below address the manufacturing control and – in part – the cell level (figure 3). Currently, it is expected that these systems will turn into factory information hubs in the years to come, both in discrete manufacturing and in the process industry. Nevertheless, their market share does not exceed 5 % to 10 % today, whereas the annual growth rate is projected to amount to approximately 11 % by 2010. Against this background, the efforts described in this article can be regarded as driving forces behind manufacturing execution systems because they contribute significantly to ensuring that shop-floor-related IT and plant controls are able to communicate in an automated and supplier-independent way.

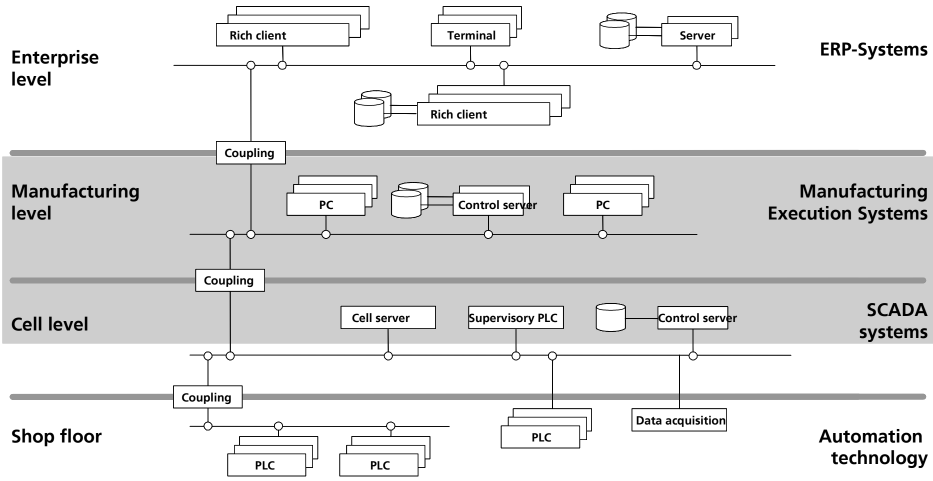

Figure 3: IT levels in manufacturing (Source: Betriebshütte, based on VDI guideline 5600, green paper)

The following section will deal with the trends that can be identified for tomorrow's MES systems. Two of these trends, namely trend 1 and 3, will be highlighted by means of examples because they are relevant for the closer integration of the ‘digital factory’ and shop-floor-related IT systems. In this context Simulation in the sense of concurrent realtime simulation is gaining more and more importance. It allows to forecast the effects of modifications to the process at any time, given the increased complexity of production and IT.

Tomorrow's manufacturing execution systems will be characterized by

- full integration with the ‘digital factory’, aiming at being ready to plan any time,
- simulation as a front-end in the sense of concurrent realtime simulation, allowing a quick response to unexpected events
- vertical integration with the manufacturing level, making use of standard plug-and-work mechanisms
- horizontal integration through service-oriented structure and consistent data management
- scalability including the support of decentral self-organizing production (RFID instead of factory data acquisition)
- ‘human-centered’ thanks to the task and role-specific provision of information to users

Trends 1 and 3 will be highlighted in this article.

3 Current projects to link the ‘digital factory’ and MES

3.1 Overview

The foreseeable integration of planning and operation calls for research and development as well as standardization services, e. g. the development of interfaces between system environments. The Fraunhofer Institute for Information and Data Processing (IITB) and its 'Monitoring & Control Systems' business unit focuses on making data of the ‘digital factory’ available for manufacturing execution systems. This implies, for instance, that data necessary for the engineering of MES systems are collected from ‘digital factory’ tools in a neutral exchange format such as XML and made available to the MES engineering. The ‘digital factory’ stores information on plant structure, plant parameters manufacturing processes and the arrangement of equipment. MES engineering also requires information about the topology and topography of production plants their parameters and manufacturing processes as well as PLC programs and variables.

The efforts of the Fraunhofer IITB are aimed at developing a kind of Universal Serial Bus (USB) for production. Yet unlike the well-known universal interface for personal computers, the conditions and requirements in the field of production are far more complex than for PCs.

The vision of plug and work between equipment and MES systems includes

- automated engineering of control systems and other MES systems resulting in earlier start-ups of software systems and fewer engineering errors
- provision of a technology defining an enterprise-wide namespace allowing machinery/equipment and IT infrastructure to communicate unambiguously about contents and meaning
- provision of mechanisms allowing new machinery/equipment to be identified automatically in a production system, including a description of the corresponding manufacturing capacity of the new machinery/equipment
- development of methods, procedures and software components enabling the automated integration of plants with the superordinate IT systems and mechanisms so that the information stored in the plant can be made available to these systems.

3.2 Status of the engineering of shop-floor-related IT systems

The current status of the engineering of new or modified production systems in superordinate IT systems is characterized by a large share of manual work.

Figure 4 shows a common example of the actual situation in today's enterprises, which is marked by system discontinuity and manual intervention when equipment and its controls are integrated in operational IT applications. The first step to enable communication is to publish the IP address of the control that has to be integrated on the network. Subsequently, the control-specific OPC server has to be announced to the client on which the operational application is running. The next step is to select all relevant variables from the set of variables provided by the OPC server and to link them with the process image created in advance. This is done manually using a browser (figure 4).

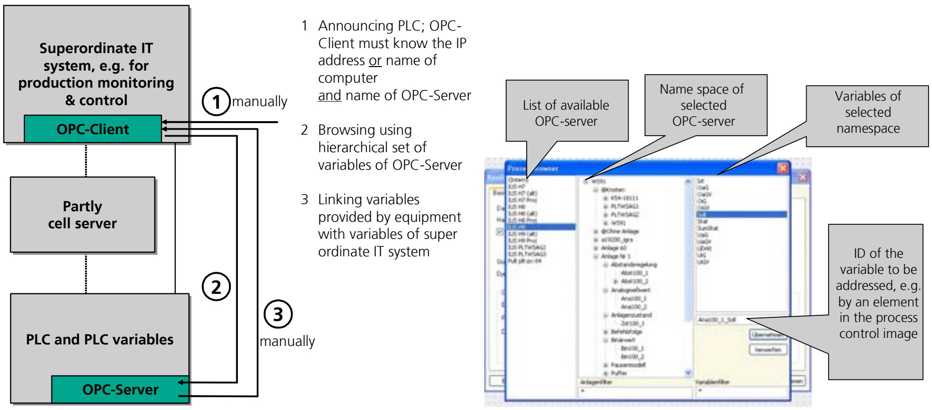

Figure 4: The example of PLCs illustrates the way equipment and its controls are integrated today.

In summary, the starting situation is characterized by a large amount of manual customizing as well as manual configurations of plant controls and super ordinate IT systems.

3.3 XML to support plug and work

IITB is specifically working on methods, software components and applications that can be standardized and that allow production equipment to be integrated into a production system simply, quickly and safely or modifications in equipment and its controls to be announced automatically to the production system and the super ordinate IT (figure 5). To this end, IITB's software engineers make use of existing standards, particularly CAEX (Computer Aided Engineering Exchange) to describe the static features of production plants and OPC-UA for dynamic components. CAEX is a process industry standard to describe the architecture and structure of process-engineered plants, whereas OPC-UA is used for control-relevant variables of which the values change dynamically during production.

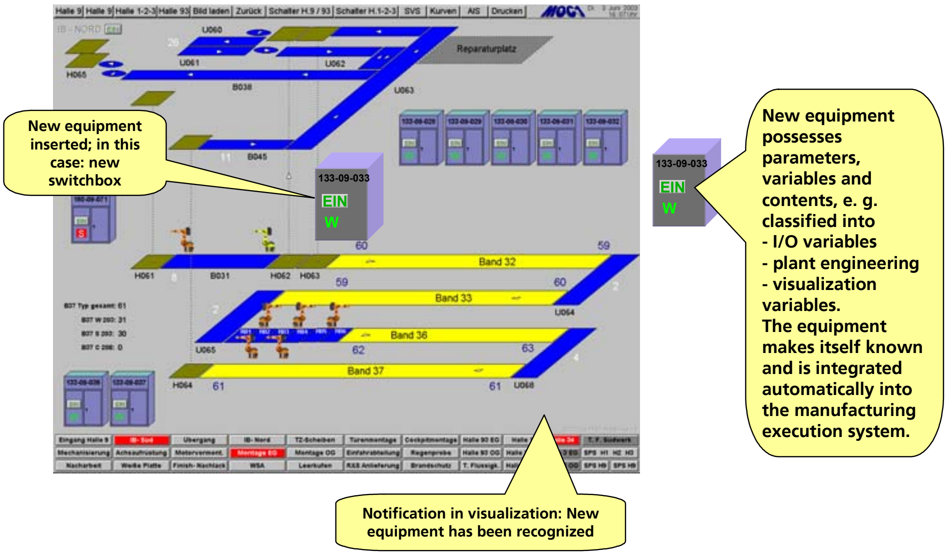

Figure 5: Plug and work of production equipment illustrated by the visualization of a plant monitoring system

In this process, equipment and its controls provide files describing their capabilities in a standardized format. The format chosen by IITB is CAEX, based on IEC-PAS-62424. By transformation, the files are classified into information relevant for system engineering and for visualization. This is used either to generate process control images or to transmit the information to a database, on the basis of which I/O and plant system engineering are generated for the process control image of the runtime system (figure 6).

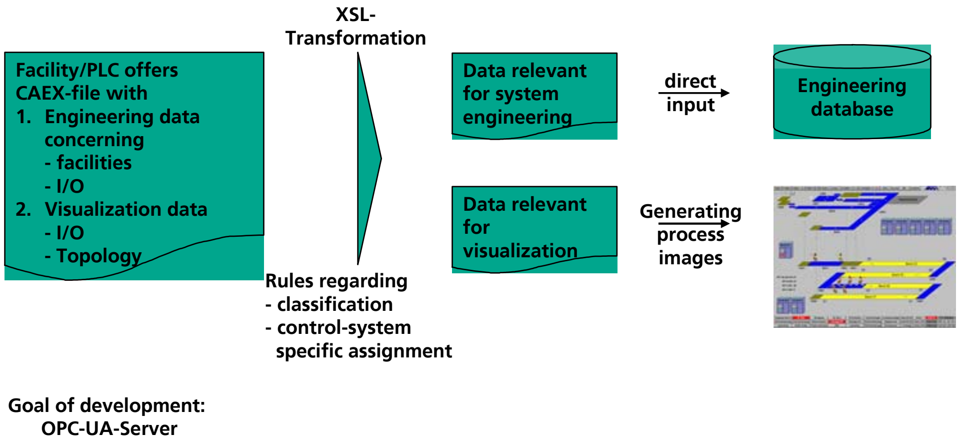

Figure 6: Application of XML standards for automated MES engineering

4 Outlook

The above mentioned work will be completed by the capability of using data from factory planning software tools. In this context, the most relevant data for automated engineering is topologic and topographic information such as the layout of factory halls, allowing to arrange the elements of process control images that need to be visualized correctly. In addition, PLC programs in the sense of plant logics are of importance. IITB is cooperating with the well-known suppliers of 'digital factory' tools make this information available and utilizable for MES systems.

References

[Dr04] Draht, R.; Fedai, M.: CAEX - ein neutrales Datenaustauschformat für Anlagendaten – parts 1 and 2. Automatisierungstechnische Praxis - atp volume 46 (2004) issue 2, pages 52-56 and issue 3, pages 20-27.

[Sr04] Sauer, O.: Einfluss der Digitalen Fabrik auf die Fabrikplanung. wt Werkstattstechnik online, issue 01/02, 2004, pages 31-34.

[Sr06] Sauer, O.; Sutschet. G.: ProVis.Agent: ein agentenorientiertes Leitsystem – erste Erfahrungen im industriellen Einsatz. VDE conference 2006, Aachen: Innovations for Europe. 23-25 October 2006, volume 2: pages 297-302.

[Sr07] Sauer, O.: Digitale Fabrik und MES. IT&Production: MES Wissen Kompakt 2007, pages 18-21.

[Sut01] Sutschet, G.: Störung im Griff. Ein Produktionsassistent für die Automobilfertigung. visIT 2 (2001), No. 2, pages 6-7.

[VDI4499] VDI guideline 4499, part 1

[VDI5600] Green paper of VDI guideline 5600

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