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MODERN PRODUCTION MONITORING IN AUTOMOTIVE PLANTS

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ABSTRACT - In today's automotive plants we find heterogeneous software systems for different types of tasks either for planning and the manufacturing operations. IT-systems used for factory planning are summarized as 'digital factory tools'. On the operating level software systems are not yet integrated and thus they support separate tasks such as production order control, production monitoring, sequence planning, vehicle identification, quality management, maintenance management, material control and others.

Due to the fact that the work share between OEM's and suppliers has moved for the benefit of the suppliers the OEM's have to focus more on logistics and supply chain management, even on the shop floor level. Today the staff on the shop floor level works with production monitoring tools that support manufacturing decisions only based on production quantities. In case of a facility breakdown or quality inspection results they only know that a certain number of vehicles is affected but neither the customer orders related to these vehicles nor their options, e.g. color, right hand-/left hand drive, sun roof, etc. It would be a great step forward for better and more transparent decisions if the shop floor people could take their decisions based on identified vehicles/customer orders rather than on undefined production quantities.

This means that in the years to come the above mentioned systems for production monitoring, maintenance management and logistics control will have to be integrated to allow better and more transparent decisions and to recognize the impacts from decisions on the shop floor e.g. on just-in-sequence parts to be provided to the line. Another driver for new software technologies is the increasing number of vehicle models combined with their shorter life cycles. IT-systems must be more flexible concerning changes and adaptations to the new models requirements.

In his paper the author describes a new approach to integrating the existing IT-systems for the benefit of the user on the shopfloor level.

MAIN SECTION - In today's automotive plants we find heterogeneous software systems for different types of tasks both for factory planning and the manufacturing operations. IT-systems used for factory planning are summarized as 'digital factory tools'. On the operating level software systems are not yet integrated and thus they support separate tasks such as production order control, production monitoring, sequence planning, vehicle identification, quality management, maintenance management, material control and others.

Due to the fact that the work share between OEM's and suppliers has moved for the benefit of the suppliers the OEM's have to focus more on logistics and supply chain management, even on the shop floor level. Today the staff on the shop floor level works with production monitoring tools that support manufacturing decisions only based on production quantities. In case of a facility breakdown or quality inspection results they only know that a certain number of vehicles is affected but neither the customer orders related to these vehicles nor their options, e.g. color, right hand-/left hand drive, sun roof, etc. It would be a great step forward for better and more transparent decisions if the shop floor people could take their decisions based on identified vehicles/customer orders rather than on undefined production quantities. However, production monitoring systems play a relevant role in supporting the manufacturing operations; and, what is more, they can be seen as the operational part of the digital factory (1) (see Figure 1).

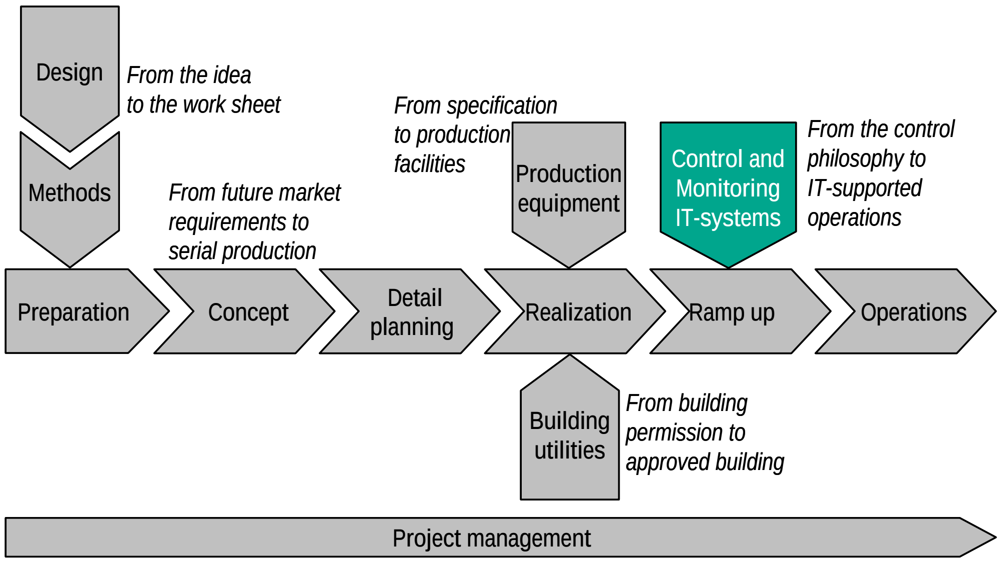

Figure 1: How production monitoring and control systems fit into the IT-processes of a car factory

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CURRENT SITUATION CONCERNING INFORMATION TECHNOLOGY IN AUTOMOTIVE PLANTS

Currently a new generation of shop floor related software systems are developed - ‘manufacturing execution systems’ - to close the gap between today’s stand alone IT-solutions. However, it is evident that the software technologies applied today are not sufficient to integrate the existing software systems and bring out the required results, namely support of manufacturing decisions on the shop floor level regarding all relevant aspects of production equipment, quality issues, provided parts and shift output. The integration aspect is in the majority of cases supported by databases. It must be added that a couple of the above mentioned systems, especially those for production monitoring require real time data processing instead of database solutions, for they gather a large number of signals from the production equipment’s PLCs (programmable logistics controller). For real time applications database solutions are often not fast enough.

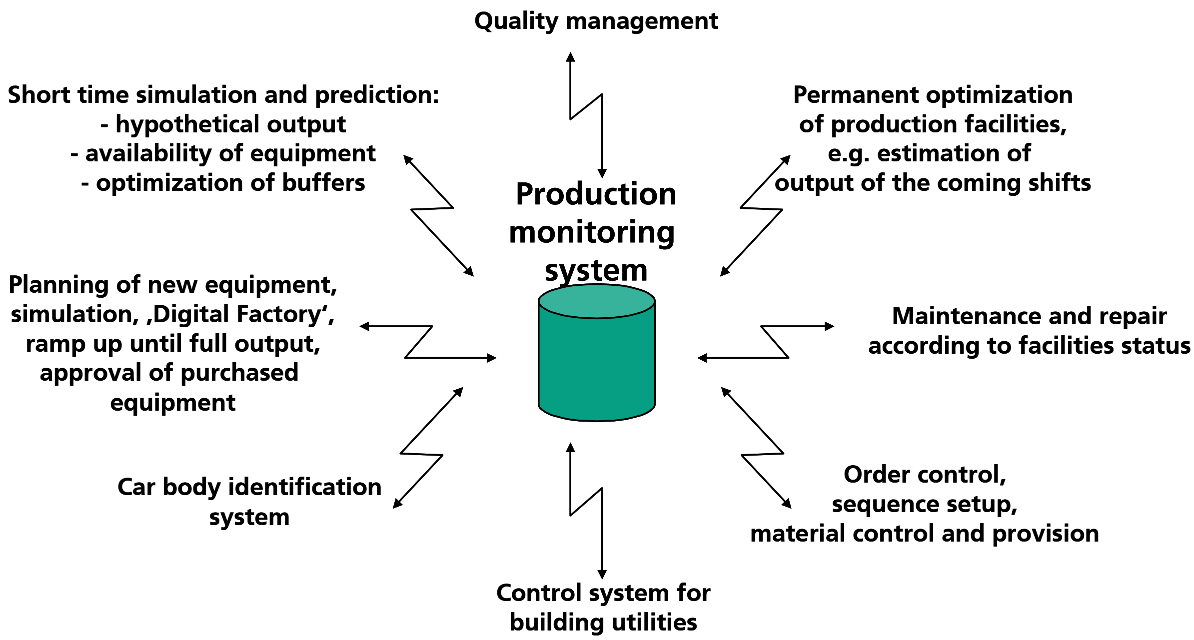

Figure 2: Examples for IT-systems in today's automotive plants

A second disadvantage of an integration by a database is the required data model for all related applications. This data model is relatively inflexible, especially in case of changes or extension of functionalities or new IT-systems to be added. Additionally there is no software supplier (compared to commercial IT-applications) who would be able to deliver all required modules for an automotive plant as a single source supplier (Figure 3).

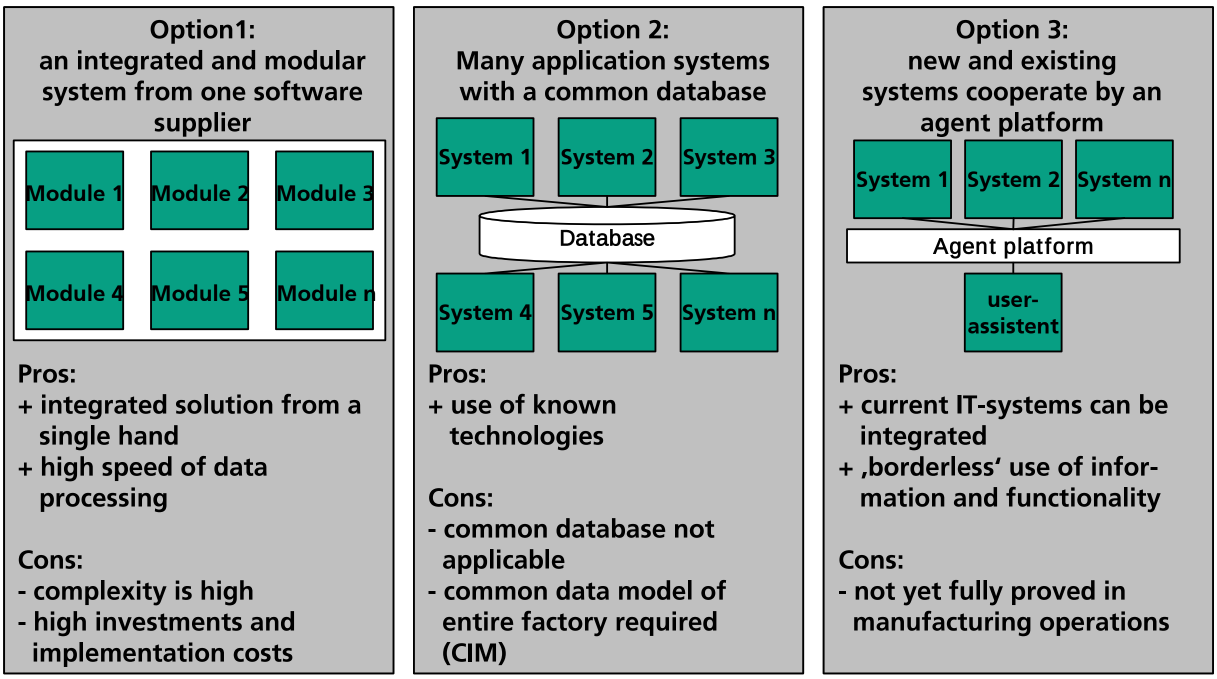

Figure 3: Possibilities for OEM's to integrate different software systems

In the late 1990ies a team from the Fraunhofer IPK developed for an Asian OEM a first concept where some of the above mentioned IT-systems, especially those on the cell manufacturing level were integrated (see Figure 4). Being ahead of their time the Fraunhofer people designed a cell manufacturing system that combined production monitoring, quality control, maintenance / repair and tracking information for each shop: press, body, paint and trim shop. Applying the available software technology of that time the affected plant went into operation in 1998.

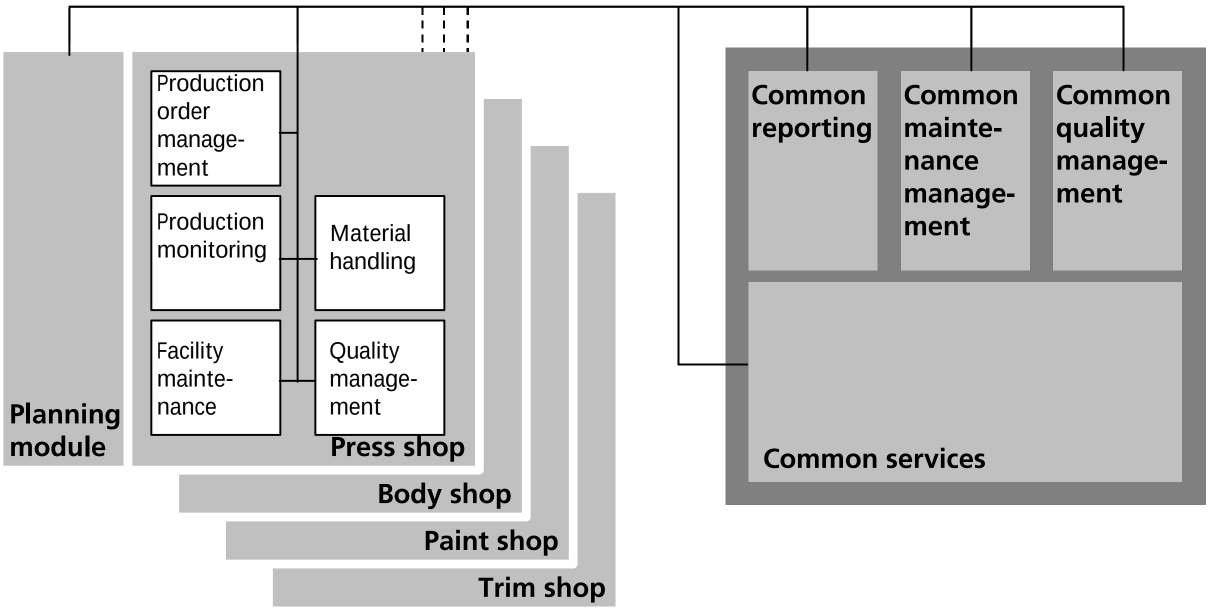

Figure 4: Overview over the cell manufacturing concept developed by Fraunhofer IPK (2)

Today it is evident, that new software technologies have to be used to really integrate IT-systems for production equipment, quality issues, provided parts and shift output and to keep up the existing software functionalities.

Let's assume it's useful to bring some of the existing operational IT-systems of an automotive plant together: the user would be badly off for the variety and abundance of functionalities. This aspect means that only with the help of user oriented assistant software that make available the required functions and information for a specific working activity the users on the shop floor level are supported efficiently to take the required and expected decisions.

SOFTWARE AGENTS APPLIED IN SERIAL PRODUCTION

A very promising technology to integrate the existing software systems, their functionalities and to add assistant systems for the shop floor's staff are software agents. On the academic field agent technologies have a long tradition but their use in production and real time applications is yet very limited. One of the first promising applications is described by authors from DaimlerChrysler (3, 4) who have implemented a manufacturing cell for cylinder heads and other engine parts that is completely controlled by a software agent based system. The manufacturing cell works in serial production and has led to excellent results concerning capacity utilization and smoothed production. However, on the field of production monitoring, maintenance management and their cooperation with logistic oriented IT-systems there is still much room for application of software agent technology.

The development team at the Fraunhofer Institute for Information and Data Processing (Fraunhofer IITB) has developed an agent based production monitoring system and connected it to an assistant system which simulates on a short term basis the output of an automotive shop for the next three shifts (5). With the help of this assistant the shop floor personal is able to foresee the impact of any kind of disturbance caused by unexpected changes in the production equipment, the buffers and the material flow systems, e.g. conveyors, skids, etc. That helps the manufacturing people to take better short term decisions concerning shift capacities, less or more staff in the next shifts, assignment of workers to the line, etc.

The agent based production monitoring system is a new version of the Institute's existing system (6) in DaimlerChrysler's Bremen plant, where it monitors and controls the body shop, the paint shop and the assembly shop either from a central control room (see Figure 5) or from decentralized control panels on the shop floor. The functionalities of the current software system called 'ProVis' compared to the agent based system have almost remained the same, but the various system's modules have been wrapped and enabled to communicate via a standard agent platform.

Examples for these modules are

- the different input-/output channels for the process data submitted from the PLCs,
- process variables such as production amount, status of line buffers, switches, etc., that are computed in the monitoring server,
- the interfaces between the monitoring server and its clients,
- archive-functions that are conducted in a separate archive server and
- information clients with interfaces either to the above mentioned assistant system and other services, e.g. radio-/alarm server.

Control room C-class trim shop
DaimlerChrysler AG, Bremen plant

Photo: DaimlerChrysler

Control room trim shop Golf V
VW AG, Wolfsburg plant

Photo: VW

Figure 5: Central monitoring and control rooms

An example for the layout of such a new production monitoring and control system which is now open to be connected to IT systems related to logistics, quality management or building utility control is shown in Figure 6. With this architecture it is possible to cooperate and communicate with other existing IT-systems and, what is more, to have their functions used by the production monitoring system's agents. With agent based monitoring and control systems in automotive plants it will be feasible in the coming years to step forward to 'plug and produce' procedures for more and more intelligent production systems.

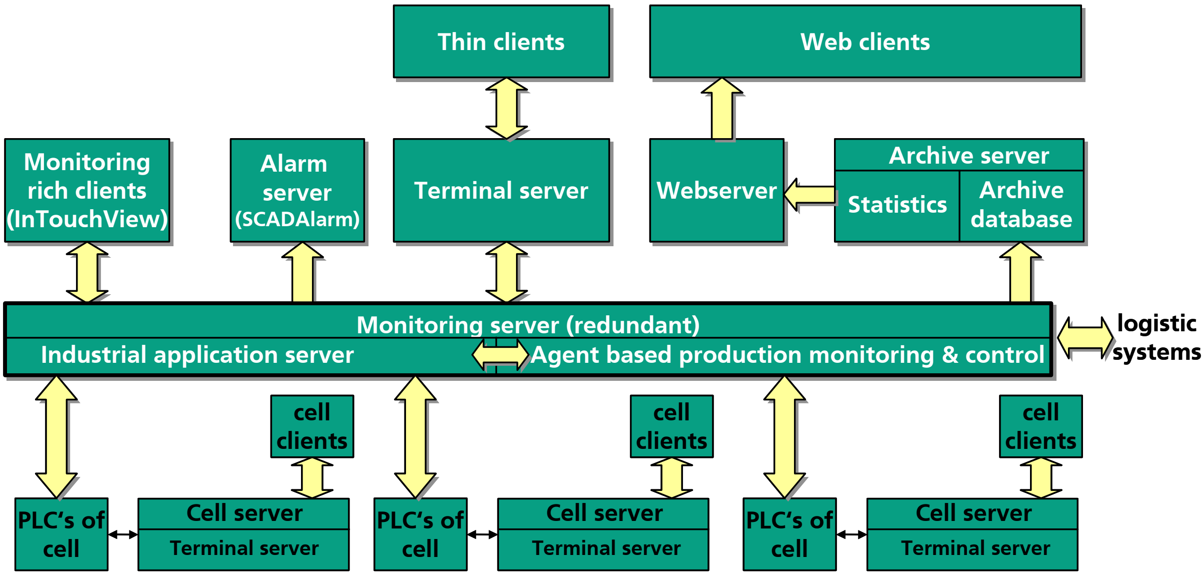

Figure 6: Example for an agent based production monitoring and control system using some commercial application, e.g. for visualization (SCADA)

As one example for the above mentioned assistant systems the IITB implemented a software that simulates for the three coming shifts the production output regarding all actual production breakdowns delivered by the production monitoring system as well as the buffer status calculated according to the current production output (Figure 7).

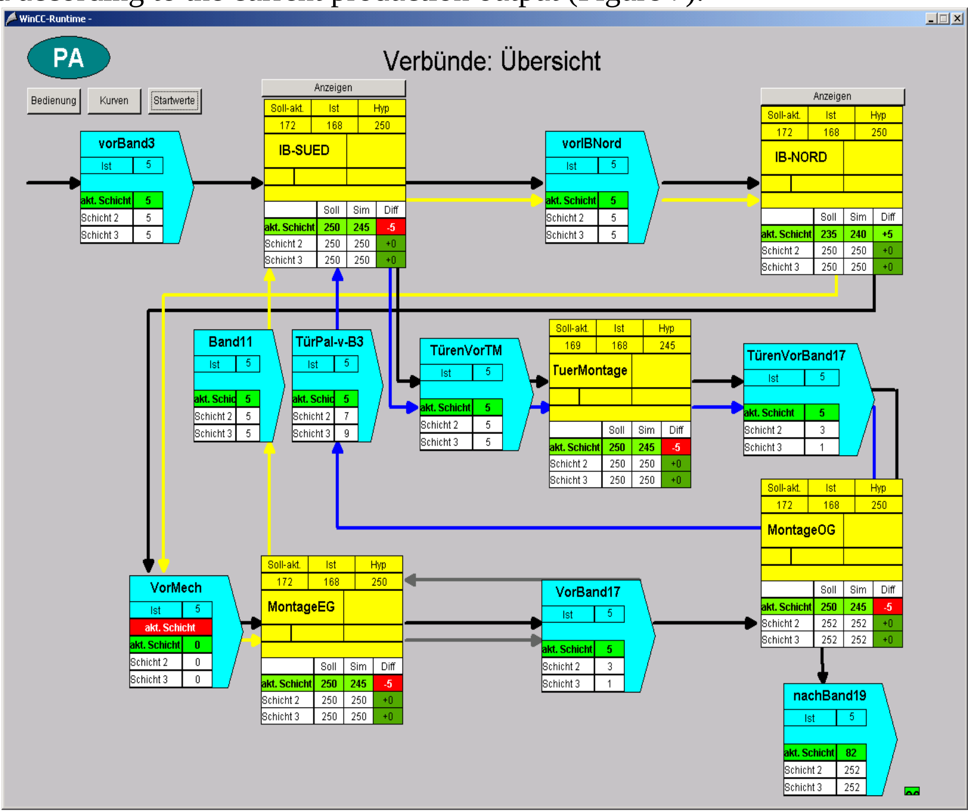

Figure 7: Short time simulation system as production assistant tool connected to the production monitoring system

The interface shown in Figure 7 is WinCC. With the help of this assistant software which is connected to the monitoring systems by a software agent, the shop floor people can react quickly and correctly to failures on the shop floor level. They are now able to adjust line speed, work force for the coming shifts and take other measures to keep the output as high as possible.

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