Production monitoring and control

Real time factory information systems will soon be able to coordinate automation and logistics

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Today's automotive plants are equipped with a range of individual software systems to support manufacturing operations. Production order control, process monitoring, sequence planning, vehicle identification, quality management, maintenance management and material control have to be managed and monitored. In most factories these systems are not integrated and they do not exchange information that might be of interest to more than one application.

Production monitoring and control systems (PMCs) play a central role in automation. These systems gather signals produced by production facilities and programmable logic controllers (PLCs), combine them to control relevant contexts, visualise them and provide functionalities to operate the facilities. Their strength is that they manage data in real time and allow access to factory information from almost any terminal inside the plant.

While visualisation and operation of process signals and contexts are well-known functions of so-called SCADA systems, the main work of real-time signal processing and interfacing to production plants is done by PMCs. These are usually implemented as object-oriented systems, interfacing with their environment via standardised protocols.

The Fraunhofer Institute for Information and Data Processing (Fraunhofer IITB) has almost 30 years experience in developing novel PMCs for automotive plants. In 2005 DaimlerChrysler's Bremen plant in Germany ordered a new generation of PMCs for its C-Class car. Production of the new vehicle starts in early 2007, but the system is already in operation as engineers ramp-up the facilities.

Shop floor workers use production monitoring and control systems that collect data from PLCs allowing them to control manufacturing processes in real time. These systems support manufacturing decisions that are based only on production quantities. In the case of a facility...
新车型的生产将于2007年上半年开始，但实际上在工程师还在对其设备进行调试的时候，PMC系统已经在运行了。

由于生产过程监控系统PLC系统采集数据，以对制造过程进行实时控制。这些系统可以提供生产过程的实时反馈，但当生产设备发生故障或停工时，他们所能了解到的仅仅是一些生产线的设备受到的影响，而无法对这些设备相关的顾客订单或一些重要的细节如颜色和规格的执行进行辨别。这是因为，过程监控系统并不提供任何与产品相关的信息。为了克服这一弱点，新一代的与生产相联系的IT系统即将问世。这就是：制造执行系统（MES）。

在进行实时数据处理时，MES方法可以在过程监控工具和带有产品信息的系统之间建立联系，例如产品ID、顾客订单数据和生产序列等）之间建立联系。这一联系的关键在于目标识别系统。在汽车行业，这些识别系统可以提供车辆以及一些由生产过程决定的需要的零部件进行识别和跟踪。

但是，汽车识别和跟踪还是有巨大的改进余地，例如在制造过程中错过的周期、固定的读/写点和焊缝的反馈进行检查时，加入了很多不必要的车身跟踪计算、PLC信号和纸张信息扫描系统。

由于PMC系统通常是在高度分布式的软硬件环境运行的，所以它无法保证所有相关的系统都能互联，这些系统的前提条件下，每个子系统通过保证至少在某个时间段内应进行自动化生产。

PMC系统应能提供工厂所需的所有途径。戴姆勒-克莱斯勒的Bremen厂有一个中央控制系统，可对车身、涂装和总装车间进行控制，但与其他的工厂的系统的融合度没有那么强，它们有时采取的是混合途径。

在一个非集中式的结构中，车间的操作工作站可完成一些可视化和操作任务。在这种情况下，特定的操控系统需要独立性就非常重要，因为微软公司的Windows系统将来必须和Linux以及其他操作系统建立联系。breakdown or detected quality errors they only know that a certain number of vehicles are affected.

They cannot identify the customer orders related to these vehicles or important details such as colour and specification. This is because process monitoring and control systems do not hold any product or order related information. To overcome this weak point a new generation of production related IT-systems is going to be established: manufacturing execution systems (MES).

In the case of real-time data processing the MES philosophy leads to a link between process monitoring tools and those systems that carry product information such as product ID, customer order data and production sequences. The key to this link is object identification systems. In the automotive industry these are tools that identify and track car bodies as well as some just-in-sequence components.

Car body identification and tracking has a high potential for improvement, such as detection of missing cycles, fixed read/write points, missing feedback from the manufacturing process, and is thus completed by redundant systems for body tracking calculation, PLC signals and scanning of paper information.

Facing the fact that PMCs are usually operated in highly distributed hardware and software environments, where a continuous connection of all components involved cannot be guaranteed, the implementation of each subsystem needs to be able to operate autonomously at least for a certain span of time.

A PMC has to be able to provide whatever approach the factory needs. DaimlerChrysler's Bremen plant has one central control room for its bodyshop, paintshop and final assembly, but other factories' control facilities are not so centralised, sometimes taking a mixed approach.

In a decentralised structure, the operation stations on the shopfloor are able to perform visualisation and operation tasks. In such cases, it is important to be independent from special software operating systems, because in the future, Microsoft Windows applications will have to be connected to Linux systems and others.

The integration of neighbouring IT systems, such as quality management, maintenance and repair, sequence scheduling and car body identification should be made as easy as possible. A connection between these applications leads to better information to react on unexpected disturbances on the shop floor, as well as to higher transparency concerning production related information.

Difficulties arise if MES come from different vendors. Up to now there is no standardised communication for such systems and this leads to misunderstandings about concepts to be communicated.

The engineering environments of all concurrently running systems are especially specific to the single systems; there is no common repository for such things as plant specifications, signal types and signal wiring. A large part of the information needed to operate the single systems has to be provided redundantly to the
Engineering parts of the subsystems. This leads to an unnecessary engineering cost. It is also a possible source for errors due to manual data input, especially in cases of reconfiguring the plant.

In the years to come many carmakers' assembly lines will be composed of equipment and programmable logic controllers which are self-aware. They will understand the functions they can perform and the way they can be engineered. Some assembly robots already come with web servers, allowing their state to be visualised and reconfigured.

Assuming this trend continues to grow, "Plug-and-Produce" software components are likely to revolutionise the engineering of production systems. This raises the need for a standardised method of communication among different engineering systems. Software is becoming a key driver for manufacturing concepts that would have been impossible in the past.

Fraunhofer IITB's production monitoring systems experts are already working on intelligent engineering tools supporting plug-and-produce approaches. DaimlerChrysler's IntegraMCG concept supports this approach. The benefits are that new facilities can easily be added to production lines and the lines can be reconfigured far faster.

Production monitoring and control systems have to be able to visualise and operate their production plants in real time. Because of this they need very fast communications for signals and operation actions. Even so, a connection via usual bus systems is not necessarily possible at all times during the production process. Special autonomous features have to be implemented to assure the plant functions correctly.

For certain events, such as shift changes, the systems must handle a tremendous amount of data and signals in a very short space of time. Several hundred signals per second have to be communicated, gathered, sorted, combined and handed over to databases for evaluation.

Furthermore, a PMC has to provide several different protocols to underlying production lines, such as open process control, Microsoft and simple internet protocols. These implement different abilities, different formats, different frequencies of communication and different data structures. A PMC has to integrate all this information in real time.

PMCs can't be developed as stand-alone systems; there has to be a range of interfaces to related IT systems. These systems have usually evolved historically in the factories. For financial reasons, these cannot simply be replaced by newer, easier to integrate systems.

Because of this PMC systems need a platform to integrate with other manufacturing execution system components. Vendors such as Siemens, Wonderware and Rockwell Automation provide a platform for their own components, but it is not usually possible to operate different vendors' systems on the same platform. The system needs dedicated interfaces for each specific configuration for components coming from different vendors.
Integration is a challenge. In principle there are several ways of integrating concurrent systems which all have several advantages and disadvantages. Three possible options are vendor proprietary platform, the database centred approach and integration on a client platform.

DaimlerChrysler and Fraunhofer IITB have chosen to integrate using software agents. Agent platforms usually offer a standard method of communication among the agents hosted on the platform. Using ontologies for different subsystems assures the uniqueness of the concepts to be exchanged.

Starting from the proven object-oriented PMC ProVis.NT, which is in operation for DaimlerChrysler's current C-class car, Fraunhofer IITB has decided to use software agents as the means of integration when developing further PMCs or other MES components.

The architecture of the new production monitoring and control system, called ProVis Agent, is open for connection to IT systems related to logistics, quality management or building utilities control. The central monitoring server consists of a collection of cooperating software agents. Each of these agents covers one piece of functionality already contained in the ProVis NT system. It contains the functional treatment of different types of signals such as switches, analogue values, and distances, as well as working time models, alarming and statistical data.

The I/O-agent encapsulates different types of I/O-channels and allows the control room server to have a uniform look across all the signals delivered by underlying systems. A visualisation agent is used for interfacing with a variety of commonly used SCADA systems as well as with Fraunhofer's real-time visualisation tool ProVisVisu.

The benefit offered by the agents is that the PMC can connect itself to other shop floor related applications. Changes in the software can also be made more efficient than in object oriented software systems and the system as a whole can be maintained very easily.

The operating agent always provides the operating context for single signals or complex actions. This context may only be the name and operating mode of a single underlying plant. It may also be a combination of several signals of different types coming from several sub-plants.

The main objective is to provide the operator with all the information needed to perform even complex operations such as changing the working time model for different plants. At any time the operator must be in a position to correctly evaluate the consequences of their actions.

Today none of the production monitoring systems on the market can view both facilities behaviour and the product flow and logistics. But the two worlds are starting to move towards each other. To close the gap between these disciplines organisational borders have to be overcome inside the car plant. That means combining knowledge from production engineers and computer scientists.