戴姆勒－克莱斯勒公司正在其Bremen的工厂对新的生产监控系统进行投资
DaimlerChrysler is investing in new production monitoring and control systems at its Bremen plant

生产监控

实时工厂信息系统很快可以将自动化和物流结合起来Olaf Sauer 博士，Fraunhofer 信息和数据处理研究所

Production monitoring and control

Real time factory information systems will soon be able to co-ordinate automation and logistics By Dr Olaf Sauer, Fraunhofer Institute for Information and Data Processing

今天的汽车工厂为了对制造过程进行支持，安装了一系列独立的软件系统来对生产订单控制、流程监控、顺序规划、车辆识别、质量管理、维护管理和材料控制进行管理和监控。但在大多数汽车工厂，这些系统并未进行集成，因此还不能够相互协调，而且系统与系统之间不能进行交换信息，因此也就不能做到资源共享。

生产监控系统（PMCS）在自动化操作方面占据着核心地位。这些系统将生产设备和可编程逻辑控制器（PLC）产生的信号采集并结合起来，对相关的情况进行控制，并进行可视化和为设施的运转提供功能。这些系统的优点在于，它们可以对数据进行实时管理，并且真正实现了工厂信息的共享化，因为几乎所有的终端都拥有了对信息进行访问的权利。

尽管对流程信号和环境的操作和可视化被誉为是所谓的SCADA系统的主要功能，但实时信号处理和和生产车间接口连接的主要工作是由PMC系统完成的。这些功能通常是通过面向对象的系统实施的，通过标准化的协议和环境建立接口。

Fraunhofer信息和数据处理研究所（Fraunhofer IITB）在为汽车厂开发新型的PMC系统方面有30多年的历史。2005年，戴姆勒-克莱斯勒公司在德国Bremen的工厂为其C级车订购了新一代的PMC系

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

统。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。

车间的工人通过生产监控系统从PLC系统采集数据，以对制造过程进行实时控制。这些系统可以帮助那些只基于产量的生产决策。当因生产设施发生故障而停工或发现质量问题时，他们所能知道的仅仅是有一定数量的车辆受到了影响，而无法对和这些车辆相关的顾客订单或一些重要的细节如颜色和规格等进行辨别。这是因为，过程监控系统并不支持任何与产品或订单相关的信息。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，那就是：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（如产品ID、顾客或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，这些识别系统可以对车身以及一些由生产顺序决定需要量（just-insequence）的零部件进行识别和跟踪。

但是车身识别和跟踪还是有很大的改进余地，例如对制造过程中错过的周期、固定的读/写点，和漏掉的反馈进行检查时，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下运行的，所以它无法保证所有相关的零部件都能相互联系，在这样的前提条件下，每个子系统应该保证至少在某个时间段内应进行自动化运转。

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厂有一个中央控制室，可对车身、涂装和总装车间进行控制，但其他的工厂的系统的集中度没有这么强，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，和特定的操作系统之间保持独立性就非常很重要，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。

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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 usually 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

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保证相邻的IT系统，如质量管理、维护和修理、顺序日程、车身识别等之间的相互协调性应该越简单越好。这些程序之间的联系可以帮助以对车间发生的意外干扰作出更准确的反应，并加大了生产相关信息的透明度。

如果这些MES系统是来自于不同的软件提供商，就会出现一些问题。因为迄今为止，还没有一种标准化的通信方式来服务于这些系统之间，因而就会出现一些由于误解通信概念而产生的问题。

所有目前正在运转的系统的工程环境通常只局限于单一的系统：对于工厂的规范、信号类型和信号线路等信息还没有建立统一的存储机制。单一系统的运转所需的大部分信息不得不重复地提供给子系统的工程部分。这就导致了不必要的工程成本。由于采用手工输入，这样还容易发生错误，特别是在对工厂进行配置时。

在今后几年里，许多汽车制造商的装配线将由带自觉（self-aware）功能的设备和可变编程逻辑控制器（PLC）组成。这些设备和控制器具备理解它们的功能和被运作的方式的能力。有些装配机器人已经具备了Web服务器的功能，其状态可以被可视化和重新设置。

假定这一趋势继续发展下去，这种“即接入即生产”（Plug-and-Produce）的软件组成部分有可能会在生产系统的工程设计方面引起一场革命。这将导致对不同工程系统之间标准化的通信方式的需求的增加。软件已经慢慢成为制造业新概念的关键推动力量，而这些新概念在以前是不可能被实现的。

Fraunhofer IITB的生产监控系统专家已经开始对支持“即接入即生产”（Plug-and-Produce）方式的智能工程工具进行研究。如戴姆勒-克莱斯勒的IngegraMCG概念就是支持这种方式的工具中的一种。这种方式的好处是可以很容易将新设备加入生产线，而且生产线被重新设置的速度也大大增加。

生产监控系统必须能实时地对生产工厂进行可视化管理和操作。因此，它们在进行信号通信和操作工程时必须要做到迅速。即便如此，也不一定能在生产过程的任一时刻都可以通过普通的总线系统建立联系。这个时候，就需要一些特殊的自治功能，来保证工厂的正常运转。

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 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.

对于某些操作，例如换档等，系统必须能在很短的时间内处理大量的数据和信号。每秒必须能对数百个信号进行传递、收集、分类、合并、并能将信号传送到数据库用于评估。

不仅如此，PMC系统必须能为对应的生产线提供几种不同的协议，例如开放过程控制、微软协议和简单的互联网协议等。这些协议可以完成不同功能、执行不同的数据格式和不同频率的通信以及实现不同的数据结构。PMC系统必须将所有这些数据进行实时的集成。

PMC不能按照孤立的系统进行开发，必须要通过一系列接口与相关的IT系统连接。从经济角度来考虑，这些IT系统通常都是工厂以前一直所采用的旧系统，而没有用更新，更容易集成的系统来代替它们。

PMC系统需要一个能将其与其它制造执行系统的组件集成的平台。一些设备提供商如西门子、沃达丰和Rockwell Automation为其各自的组件都提供了这样的一个平台，但如果是在同一个平台上操作不同提供商提供的系统是非常困难的。系统需要提供专门配制的接口来针对不同提供商提供的组件。

集成是一种挑战。原则上来说，有很多方法都可以将系统进行集成，它们各有其优缺点。其中有三种常用的方案分别是供货商专用平台、数据库中心法和在客户平台上进行集成。

戴姆勒-克莱斯勒和Fraunhofer IITB选择了采用软件代理来进行集成。代理平台通常为平台上托管的代理程序之间提供一种标准的通信方式。由于利用各个子系统本身的性质，互换概念的唯一性就可以得到保障了。

戴姆勒-克莱斯勒在其新的C级车上已经成功运用了面向对象的PMC系统ProVis.NT，Fraunhofer IITB也决定在开发更新的PMC 或其他MES组件时用软件代理来进行集成。

新的生产监控系统——Provis Agent的系统架构的连接对物流、质量管理或建筑物基础设施控制等IT系统都是开放的。中央监控服务器包括一些提供支持的软件代理。每个代理覆盖一种功能，而这些功能都已包含在ProVis.NT系统中。该系统包含对不同类型的信号，例如开关、模拟量和距离以及工作时间模型、警报和统计数据等的功能性处理。

输入/输出代理将各种类型的输入/输出通道进行封装，并允许控制室的服务器对相应的系统发来的信号进行统一的监控。可视化代理用于提供和各种常用的SCADA系统以及Fraunhofer的实时可视化工具ProVis.Visu之间的接口。

采用这些代理程序优点在于，PMC自身能和其他与车间有关的程序建立联系，对软件进行更改的效率也高于面向对象的软件系统，而且系统整体的维护非常容易。

操作代理一直为单一信号或复杂的操作提供操作环境。这些环境可以仅仅是某一对应的工厂的名称和操作模式，也可以是来自几个分厂的不同类型的信号的组合。

主要的目的是为操作人员提供所有需要的信息，以进行各种操作，甚至包括一些复杂的操作，如为不同的工厂更改工作时间模型等。在任何时候，操作人员都必须能对其行为的后果进行正确的估计。

今天市场上还没有能同时对工厂内的行为以及产品流和物流进行监控的生产监控系统。不过，这两个领域的集成已经开始了。为了消除这些系统之间的障碍，汽车厂必须首先打破厂内各部门之间的界限。这意味着将生产工程师和计算机专家的知识结合起来。

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 ProVis.Visu.

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. ■