Category: Concepts, Trends, and Challen ges

Internet Technologies in Factory Automation

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INTRODUCTION

One of the most important changes in the technological and economic environment of industrial firms is the increasing diffusion and strongly increasing commercial use of Internet technologies in manufacturing. Both formal and empirical studies verified the significant increase in productivity through intraorganizational applications of modern information and communication technologies in manufacturing processes (Barua & Lee, 2001).

Early industrial applications of Internet technologies were limited to single, unconnected solutions for distributed Computer-Aided Design (CAD) systems or telecooperation. Now Internet technologies may reach into the automation and control levels of every assembly line. Therefore, it is not surprising that applications of Internet technologies in production processes on the shop floor increase, and automation-technology suppliers combine Internet technologies more and more into their products. While production concepts, such as lean production, world-class manufacturing, and agile manufacturing, inevitably disregard this development, new production concepts arise that fundamentally consider the application of Internet technologies on the shop floor.

BACKGROUND

Internet Technologies for Manufacturing

Usually the term Internet technologies is understood in the context of the well-known Internet as the technological basis of a global information and communication network. Often, there is no differentiation between company internal and external applications. Indeed, the WWW (World Wide Web) is the most popular, and for almost everyone an observable application of Internet technologies. However, the term Internet technologies does not prejudge an external relevance. Yet, the internal application of these technologies focuses on intranets for office information systems. In the future, the main industrial application area of Internet technologies is in field-area networks (FANs).

FANs are real-time, capable networks on the field level (shop floor) of industrial firms' communication systems for the interconnection of automation devices, for example, assembly lines, production cells, or single machines (e.g., Schnell, 2003). Requirements for the FAN are, in particular, real-time ability, a high transmission speed, high reliability, and electro-magnetic compatibility. Depending on the nature of the business and the underlying technological concept, different types of FANs are applied. For our purposes, we can differentiate two major groups of FAN: (a) a FAN that is based on field buses, and (b) a FAN that is based on Internet technologies. Field buses are a substitute for the individual wiring of sensors and actuators within automation technologies. They offer a continuous communication infrastructure on the field level. Those that are well known include, for example, systems such as Profibus, DeviceNet, CAN Open, and SERCOS. The second group represents the industrial application of Internet technologies and is mainly based on (industrial) Ethernet.

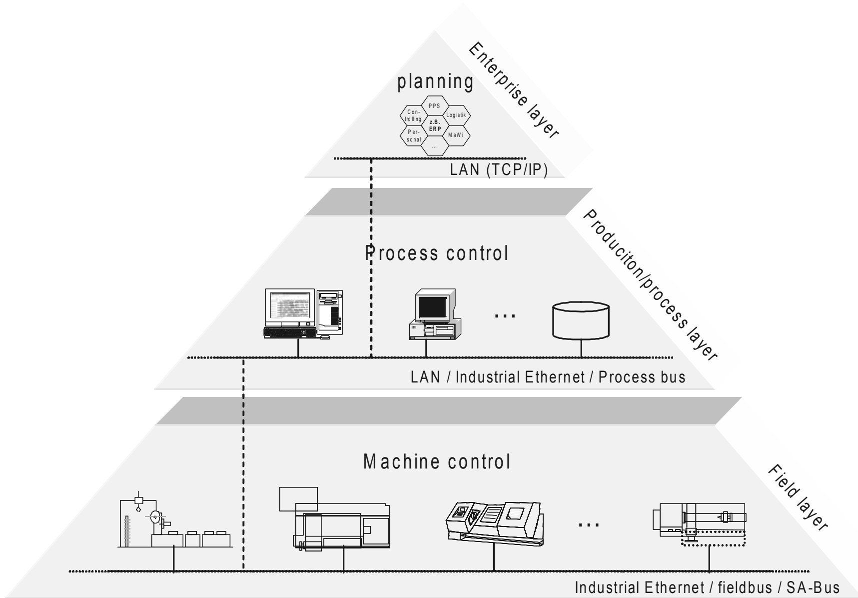
INDUSTRIAL APPLICATION OF INTERNET TECHNOLOGIES

Applicability of Internet Technologies

For the research of the network infrastructures in production environments, a hierarchical arrangement has to be carried out on the implemented network and/or bus systems on the different layers of the enterprise. An automation pyramid most adequately represents this hierarchical arrangement. Although there are automation pyramids with up to seven layers in engineer-scientific literature (e.g., Schnell, 2003), the three-layer pyramid in Figure 1 provides a good overview of the different industrial applications of Internet technologies.

The highest layer is the enterprise layer, in which the enterprise planning occurs, for example, within an enterprise resource planning (ERP) system. In this environment that is mainly dominated by office applications, local-area networks (LANs) are applied, for example, based on Ethernet and the TCP/IP (transmission-control protocol/Internet protocol) suite. This layer is cross-linked with the production and/or process layer. On this layer,

Figure 1. Automation pyramid (Blecker, 2005)



manufacturing execution systems (MESs), for example, are applied to provide a logical connection between the planning and production process layers. Furthermore, production-near dispositive tasks are processed by the production control. Control centres are implemented here. Industrial field-bus systems (process busses) are employed as the network infrastructure. From a technical viewpoint, Ethernet networks and/or the local-area networks of the office environments are also purposeful on the production or process level (Schnell, 2003). Recently, Internet technologies were implemented based on the industrial Ethernet. The real-time equipment on the field level are cross-linked often with the aid of field buses, for example, the different variants of ProfiBus.

Yet, field buses as a traditional network technology are still dominating in production processes, for example, the ProfiBus concept of Siemens Automation & Drives Group. In the future, Internet-based FAN will complement or even replace field buses. Since 1985, industrial firms have utilized Ethernet on the shop floor. Industrial Ethernet especially reduces the technological limits that have existed up to now to the applicability of Internet-based FAN or even the replacement of field buses. Industrial Ethernet is based on the relevant international standards (e.g., IEEE 802.3). It is adjusted to the specific environmental conditions, for example, regarding electromagnetic compatibility, shaking, moisture, and chemical resistance. In some sectors, Ethernet and industrial Ethernet are already the de facto standards, for example, in the automotive industry, process industry, and plant engineering.

The technological improvement of industrial Ethernet and/or Internet technologies in general does not necessarily enable a total replacement of field buses. On the one hand, some applications or existing machinery still need FANs that are based on field buses. On the other hand, field buses such as ProfiBus evolve toward a convergent, interconnective infrastructure, for example, as in ProfiNet. Hence, even where Ethernet cannot replace field buses, Internet technologies connect the different assembly lines together and transfer detailed data from the shop floor to the office and vice versa. Internet technologies are especially useful for the networking of production lines with each other, as well as for the data transfer from the technical systems in the production to the enterprise systems in the administration and vice versa as it is shown by numerous initiatives in factory automation. Consequently, a comprehensive application of Internet-based FAN enables the expansion of existing intranets in office automation to all production processes, especially manufacturing. Enabling technologies, such as Web services, active technologies, and industrial frameworks (based on .NET or Sun ONE), will support intelligent manufacturing technologies and a homogeneous network from offices on the enterprise level to manufacturing devices on the field level. These platforms have an enormous potential to reduce (transaction) costs within the production system (Blecker, 2005). Therefore, Internet technologies become a ubiquitous network: an omnipresent information infrastructure in the complete industrial firm.

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