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Development of a Web Based Monitoring System for a Distributed and Modern Production

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Abstract

Web technologies have experienced a rapid development in recent years. In particular web browsers enhanced their abilities because of the improvement of JavaScript, CSS3 and HTML5. Hence, richer web-based software solutions with an increasing range of functions are available. By using responsive web design (RWD), a technology to display content without resizing on different screens, developers are able to support a diverse range of devices with small effort.
In order to enable a monitoring of the current status of a production system, signals of many different sensors, machine and production data are required. Combining microcontrollers with sensors to embedded sensors enables an efficient way to communicate with web services. Due to the strong decline of prices for semiconductor technologies, companies are able to set up production machines with these technologies at low costs.
This paper presents a way to set up a distributed manufacturing control system by using common web technologies like RWD and embedded systems. We discuss advantages and drawbacks of web-based software solutions and show a methodical approach for the use in a modern production system. Finally, the functionality of the method is proven within an application example.

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1. Introduction

The overall objective of this paper is to design a platform using common internet technologies in the area of cyber - physical production systems (CPPS). The described technical and architectural requirements have to be provided in order to realize:

- real time production planning and control by using sensor and event based algorithms,
- risk analysis and
- predictive maintenance for an integrated quality assurance.

These three tasks are offered as services and allow independent and flexible responses to changing environmental conditions. Therefore, a powerful software and hardware architecture is presented, which provides smart services on the basis of sensor data and a robust real-time communication. Starting from this communication architecture, the various services, such as event-based production planning and control, are conceptualized and the matching protocols for the communication are selected. The real-time requirements of industrial use cases are a crucial point, when using cloud services. For this reason, a short definition and an introduction to the limitations of real-time are given.

In total this paper presents an approach for a distributed manufacturing control system by using common web

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technologies like RWD and embedded systems. Finally, an exemplary implementation shows the feasibility of the concept.

1.1. Monitoring

Monitoring, by definition, means: systematic observing, detecting or measuring operations of a system and to detect changes [1]. It covers the detection of changes over a certain period of time using technical tools. It is essential, that data is recorded repeatedly at regular intervals. Thus, comparable conclusions can be obtained from the data.

Monitoring implies not only to observe a process. If there are any deviations from the desired course, it can be intervened in order to achieve a regular operation.

1.2. Soft- and Hardware Architecture

It is necessary to develop a suitable software and hardware architecture for Cyber-Physical Production Systems. Special challenges for the design of the architecture emerge because of the horizontal and vertical networking. The vertical networking allows single products to communicate with centrally provided services. This service can be made available within a company or across companies along the value chain [2].

Different architectures have already been developed in the field of research like shown in [3] or [4]. However, reuse of these architectures is not possible due to a lack of implementation templates. For a service-oriented platform the basic technologies such as the communication protocols (e. g. OPC UA, HTTP, …) have to be defined [5, 6]. Furthermore, safety aspects are becoming a focus for such designs [7]. On the one hand the functional safety architecture like the reliability of the system is important, on the other hand unauthorized access has to be prevented [7].

In summary it can be noticed, that the existing approaches of software and hardware architecture are not enough to meet the requirements of Cyber Physical Production Systems. Therefore, further research is required on architecture for a performant and robust information transmission of smart services.

1.3. Communication protocols

The resources and objects of a networked production have to communicate with each other and exchange data. The Transmission Control Protocol/Internet Protocol (TCP / IP) is a vendor independent communication protocol, which is a de facto standard for computer communication nowadays [8]. The reference model consists of four superposed layers [9].

The bottom layers 1 - 3 are responsible for the physical hardware connection, addressing and data transmission. The top level contains the Application layout. The most common protocol of this layer is the Hypertext Transfer Protocol (HTTP), which is the basis for the World Wide Web. Below the HTTP protocol and the increasingly used OPA - UA protocol are described.

1.3.1. HTTP

HTTP is a connection-oriented and stateless request-response protocol, where neither client nor server store information for further queries. A request is completely processed with a response [8]. Each HTTP message consists of two parts: the header, which contains information about the message and the body with the actual message.

In order to enable a tap-proofed communication, the HTTP Secure (HTTPS) protocol was developed. It is technically identical to HTTP, beside the difference that the communication takes place encrypted.

Both protocols distinguish between different methods. The most commonly used are described in Table 1.

Table 1. Common used HTTP methods

Method	Description
GET	By GET a resource is requested. Opening a web page, the browser performs the GET method.
POST	POST transfers data to the server and creates a new resource. E.g. sending contact form on a webpage sends an email.
PUT	With PUT the server changes an original resource. Can be utilized as “update” of content.

1.3.2. OPC-UA

The Open Platform Communication (OPC) Foundation created the same named OPC and standardized software interface which realizes the exchange of machine data between devices of different manufacturers. For some years exists the new OPC – Unified Architecture (OPC-UA) protocol which is standardized in IEC 62541. It is based on TCP and uses an optimized binary protocol in the application layer [10]. The web service is supported optional via HTTP (S), which facilitates the connection to browser applications.

Great emphasis has been put on the security aspects. Thus, on the one hand there is a mechanism, which denies unauthorized access to data and takes care that transmissions occur encrypted. On the other hand, it is ensured, that data is kept consistent. A manipulation or modification of process data is complicated by internal testing mechanisms.

1.4. Real time

To integrate intelligent objects/CPS in the industrial production environment, the requirements in the different production levels have to be fulfilled. Today, most production sites maintain roughly three levels, from the shop floor to the production (Manufacturing Execution Systems (MES)) up to the company management (Enterprise Resource Planning (ERP)) level. One reference architecture used to describe this structure is the information pyramid of automation [11]. The various tasks at each level lead to the different perception of the term “real time”.

Real time is defined by the ISO/IEC 2382 standard as the process of a computing system in which programs for processing accruing data are constantly ready. The term “ready” indicates that the processing results are available within a predetermined period [12]. A real-time system is