Service-oriented approach for Internet of Things

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Abstract. The new era of industrial automation has been developed and implemented quickly, and it is impacting different areas of society. Especially in recent years, much progress has been made in this area, known as the fourth industrial revolution. Every day factories are more connected and able to communicate and interact in real time between industrial systems. There is a need to flexibilization on the shop floor to promote higher customization of products in a short life cycle and service-oriented architecture is a good option to materialize this. This paper aims to propose briefly a service-oriented model for the Internet of things in an Industry 4.0 context. Also, discusses challenges of this new revolution, also known as Industry 4.0, addressing the introduction of modern communication and computing technologies to maximize interoperability across all the different existing systems. Moreover, it will cover technologies that support this new industrial revolution and discuss impacts, possibilities, needs, and adaptation.

Introduction

Industry 4.0 is a trendy topic today. To demonstrate the relevance of this theme, the largest meeting of the world's leading leaders involving governments, corporations, international organizations, civil society and academia met at the annual meeting of the World Economic Forum in Davos, Switzerland, in January, between 20 and 23, (2016) had as its central theme "Mastering the Fourth Industrial Revolution" (ECONOMIC, 2016).

The world is evolving at speed never saw before, where new trends and technologies are developed daily and incorporated into our everyday lives. This has an impact on many different areas, the real world and virtual reality continue to merge, and allied to this modern information and communication technologies are being combined with traditional industrial processes, thus changing the various production areas. Traditional companies have realized that customers are unwilling to pay large amounts for incremental quality improvements. As a consequence, many companies, especially the industries have to adapt their production with the focus on customized products and fast market time, always with lower cost and higher quality. Especially in recent years, with the progress made in this area, it is believed that we are experiencing the fourth industrial revolution.

When talking about this new revolution, also known as Industry 4.0, we are often talking about the introduction of modern communication and information control technologies, with increasingly intelligent devices. In a factory, it is sought to maximize the interoperability between all the different existing systems. This interoperability is the backbone of making a factory more flexible and intelligent, as different subsystems are now able to communicate and interact with each other. These changes are important steps to meet most of today's industrial facility needs, such as the increasing demand for highly customized products, improving resource efficiency and higher throughput.

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This article aims to propose briefly a service model for the Internet of things in an Industry 4.0 context. Therefore, cover the history of industrial evolution and to highlight that we live in a silent industrial revolution that is due to advances in several areas, especially Internet and Communication Technologies (ICT), and which areas lead these changes.

2. Service-oriented approach for industrial automation systems

The traditional life cycle of products is decreasing specially high-technology products, with a short life on the market, a steep decline stage and the lack of a maturity stage. The change become constant and industrial companies should be ready for it. The Industry 4.0 concept brings the costumer as an active role in the life cycle of product.

To accomplish Industry 4.0 vision and concept, it is necessary to enlarge interconnectivity of Cyber-Physical Systems (CPS). According to Lee(2008), "CPS are integrations of computation and physical processes. Embedded computers and networks monitor and control the physical processes, usually with feedback loops where physical processes affect computations and vice versa." A low-coupling approach can allow these smart devices to an asymmetric communication between physical devices and with associated information counterparts or virtual devices. The vertical and rigid structure of traditional automation systems are not satisfactory anymore. SOA is an interesting approach to overcome these limitations

The need to overcome challenges in industrial and the need for constant innovation, which must be addressed and managed with the latest and best engineering and IT practices. Companies have the challenge of adapting their planning and manufacturing systems to produce in a more integrated, flexible, reconfigurable and with better collaboration (MORAES, LEPIKSON et al., 2015).

Originally from the IT area, focusing on high-level management alignment, Service-oriented Architecture (SOA) is currently a widely accepted approach for both business and enterprise systems integration. SOA promotes discovery, low coupling, abstraction, autonomy, and service composition that is based on open web standards and which can make an essential contribution to the field of industrial automation (COLOMBO, 2013). SOA allows customers to access services without the knowledge or control over their actual implementation because it abstracts the complexity involved. Service Oriented Architecture (SOA) is a paradigm that has rapidly grown as a standard solution for publishing and accessing information in an increasingly ubiquitous world with a ubiquitous Internet.

This new approach, which uses intensely defined interfaces and standard protocols, allows developers to encapsulate functions and tools as services in which clients can access without knowledge or control over their application (COLOMBO, BANGEMANN et al., 2014). SOA establishes an architecture model that aims to improve efficiency, interoperability, agility and productivity by positioning services as the primary means throughout the logical solution. SOA enables support for achieving the associated strategic objectives that are implemented through computational services with positive impact in the shop floor.

The concept of service is defined in figure 3. The dissemination of SOA on the factory floor is facilitated by the installation of service-oriented protocols at equipment interfaces. With this, the devices have greater ease of integration and greater offer of composition of services.

The types of promoted services will be classified, according to (COLOMBO, BANGEMANN et al., 2014), in:

- Atomic Services: Elementary services that can be promoted by a single resource.

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• Composed Services: Services that require the interaction of more than one element of production and are offered as a single service to the customer.
• Configuration Services: Update services, insertion of a new production element, download of new production rules, and that do not return data to the client, being the responsibility of the production managers.

Once the service is defined, it is important to highlight the interface . Interfaces are layers that guide the registration, discovery, provisioning, and management of services. Interfaces abstract the complexity of the network and data model, and allow the client and server to communicate satisfactorily, and data exchange occurs. Data exchange may be synchronous or asynchronous. Unlike the current model of industrial automation, creating services in the devices will introduce the concept of events, where there is no predetermined cycle time, being in charge of the customer's need. The interfaces help the composition of services and reuse of components already developed.

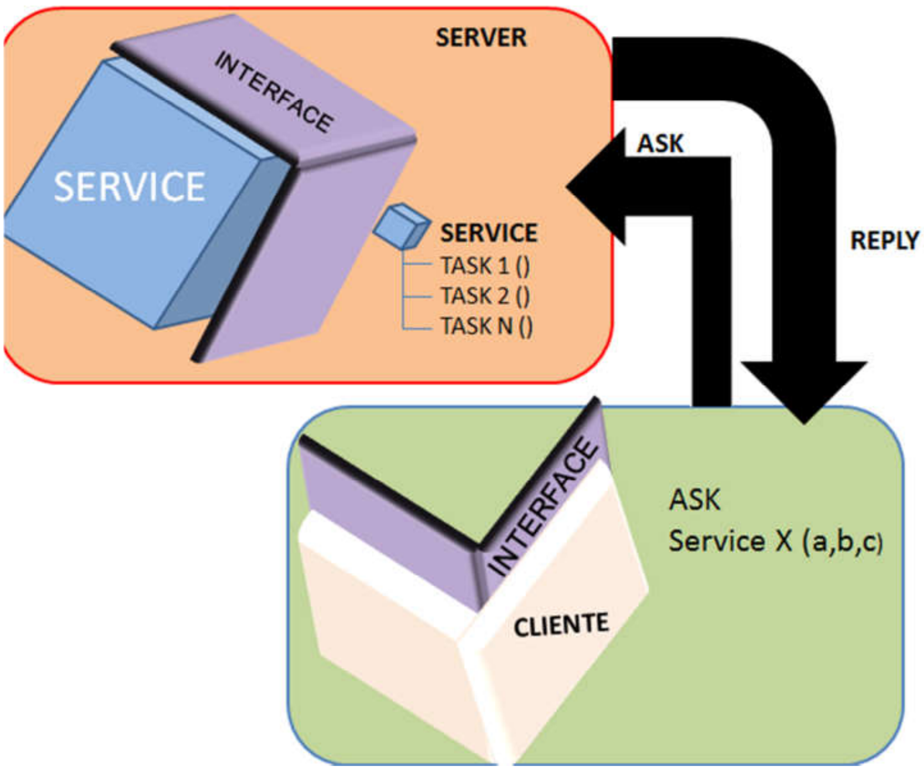

Figure 1 – Description of Service concept

A distributed vision of services and a new interaction between cyber-physical systems and the interoperability between these management systems as ERP or MES is shown on Figure 4.

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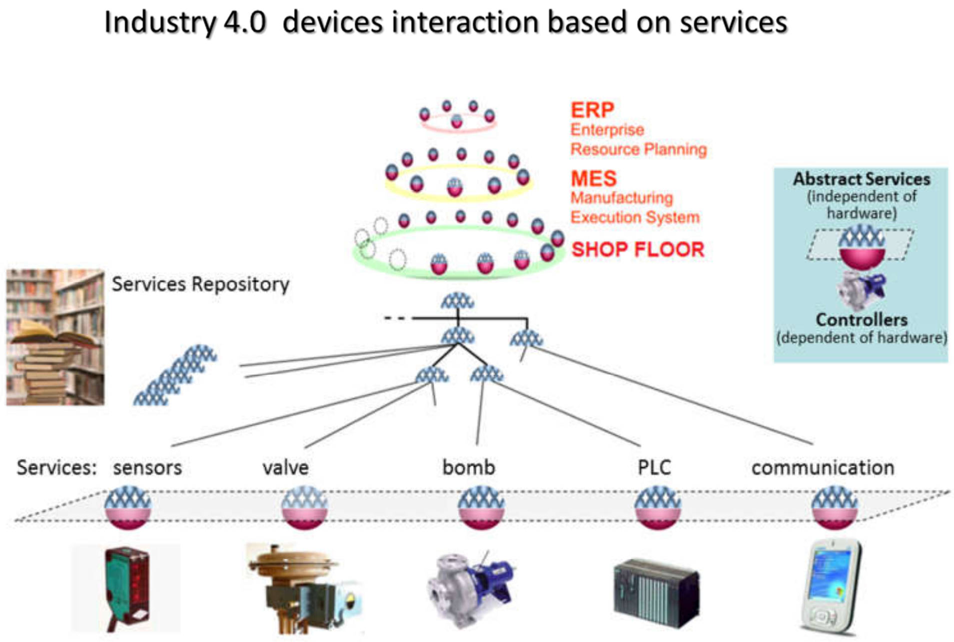

Figure 2 – Service model in Industry 4.0

Service in automation industry(shop floor) is the union of a hardware part that can be real or virtual and a logical part called abstract service that encapsulates the details and via an interface allows another devices or systems access and exchange data to execute procedures from upper-level managers.

In industry 4.0, the integration is no longer vertical or horizontal, but rather collaborative and made throughout the entire life cycle between several elements of production, inputs, machinery, process computers that aim to monitor, control, and trace all stages of production. All stages and elements exchange real-time data in an autonomous and automated mode. In this scenario orchestration of software and physical (or virtual) elements through services should be rethought. And it is a significant open challenge.

All the shop floor elements offer their functionalities through services, being able to act as client or server depending on the process and the context, which services are described in the data model, that interconnect the factory floor with the corporate systems through common interfaces.

These components contribute to the Industry 4.0 concept by abstracting the complexity of the manufacturing system by modifying the interaction between the devices, facilitating adaptations and setup changes, and allowing for less human interference. For this purpose an internal database will be used and fed by all the components in the cloud with data: for example historical data, tags, IP addresses, last revisions about devices critical to the operation. External database may contain data on failures, maintenance procedures, shutdowns, documentation, data of controllers, configuration data, or other information considered relevant.

An important advantage of CPS is the processing capability is the prediction service. The prediction can perform prognostics and analyze not only the internal database, but uses data referring to performances of similar devices seeking similarities and functions below established standards, generating alert for the management. Furthermore, it seeks to infer future behavior, seeking to obtain the optimal point to carry out some preventive action and for this will inform the responsible technical manager or responsible. It seeks to implement a more effective predictive analysis in the detection of

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failures, causing the maintenance by a break or the unplanned stops are reduced, with more information one can plan and perform better actions.

Computational intelligence is another interesting capability. It has strong connection to the prediction, and will be responsible for reading, analyzing and inferring key data and information from the manufacturing process using mathematical algorithms and with the support of artificial intelligence it will automatically display notifications whenever there are defined patterns, Or it may introduce learning algorithms so that a better and assertive analysis can happen with human assistance. This component has as mission to analyze the internal database, and will make inferences seeking to promote greater autonomy and with greater capacity of reasoning, benefiting from the greater capacity of processing of the devices. It can use Big Data algorithms and data mining.

Another important aspect is the information Security. In a manufacturing system that can be accessed in real time, this item has high relevance, and must be guaranteed for reliable operation. The security strategy may be associated with the data model, since some already have data encryption (eg OPC UA), or the control system with rules of authenticity, availability and completeness. This component can be vigilant and have proactive identification of intrusions and cyber attacks, with an action plan for an integrated system with different heterogeneous sources.

According to Schoepf (2016), the pursuit of profitably producing affordable goods that fulfill customer demands is driving industrial automation systems towards:

- Distributed control and decentralized decision-making
- A redrawing of the classical automation pyramid such that approximately 80%of discrete control is transferred to the field level
- Modular, scalable solutions
- Shorter, more flexible production cycles
- Miniaturization of equipment and smaller production lines
- Parallel communication of process data with diagnostic and condition monitoring data without impacting standard processes

The industry 4.0 will provide an innovative collaboration and rules for elements to work together to achieve the common goal, to store data in the internal database, to feed the components of computational intelligence and the prediction component. For example, in a failure situation, the collaboration module is triggered and may contain rules for replacing services with others, shutting down operation, and/or triggering external elements or persons.

CPS is revolutionizing the way manufacturing is done by connecting more smart devices and sharing the information they produce to improve existing business models and enable new ones. Thereby progressing in solutions to the problems listed in chapter 1 of this thesis, increasing productive flexibility by facilitating the (re)configuration and integrating technologies of form efficient.

In the industry 4.0, machines, production lines and storage systems will collaborate within a network composed of cyber-physical systems (CPS). These systems are capable of autonomously exchanging information, triggering actions and controlling one another.

This article is focused on the interconnectivity of the shop floor elements in an Industry 4.0 context and briefly targeted technological aspects and limitations; SOA is a promising approach to overcome some of the typical rigid and vertical automation system.
Some open questions and challenges in Industry 4.0 were discussed, service-oriented approach in industrial automation has been explained and a service model in Industry 4.0 proposed. The model is

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linked to a service-oriented architecture with a modularized approach for the development of interfaces in the factory floor, seeking to materialize Industry 4.0 concepts.

Towards the development of Plug & Produce concept, the term “plug-and-play” means an expectation of ease of use and reliable, foolproof operation. It seems to be easy as a plug-and-play product, where someone can simply connect and turn on – and it works. The practical extension of plug-and-play products, when applied to industrial automation, has given way to the new term: plug-and-produce.

Plug-and-produce offers a path to increase flexibility, demanded by the global market. As well as energy efficiencies and reduce costs in the way goods are produced. As the industry has been working to get products to market faster and cheaper, easy and simple solutions are needed to enable adjusts and near-immediate implementation – with no special tools or highly trained engineers or electricians required. Future factories will implement plug and produce concept and will be flexible, having modular field-level devices, facilitating quick manufacturing changes. This is a key capability of the industry 4.0 companies.

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