A gentle introduction to Industry 4.0

Ivan Švogor, Ph.D.
University of Zagreb
Faculty of Organization and Informatics
Department of Information Systems Development
Email: isvogor@foi.hr

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Abstract—Although it has been long theorized, discussed, and researched, today we are finally witnessing the escape of Industry 4.0 from the laboratory setup into the real world. However, it seems that its impact is not fully understood by many business researchers and practitioners. Industry 4.0 is not merely digitalization and automatization of a manufacturing process, but a complete transformation of a manufacturing process as we know it. This white-paper provides a gentle introduction into the idea of Industry 4.0 and its implications for the near future.

I. INTRODUCTION

At the turn of the new millennium, informatization of business processes and organizations gained an unstoppable momentum towards the digizalization of a complete value chain, almost all aspects of the production process and resource management. In Europe alone, this trend continues today and its significance resulted in the claim of a new industrial revolution, commonly referred to as Industry 4.0, mainly due to its deep implications and potential for the manufacturing organizations. Furthermore, outside Europe, this trend has also been (erroneously) referred to as Internet of Things, Industrial Internet and Internet of Everything. While there are differences, for the purpose of this paper, this terminology could be considered synonymous and intertwined, mainly addressing the digital transformation of the manufacturing process (Fig. 1 shows the increasing interest for the Industry 4.0).
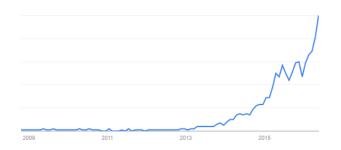

Fig. 1. Google Trends: popularity of Industry 4.0 over the years (2009 – 2016).

II. CHALLENGES OF THE INDUSTRY 4.0

The fundamental goal of the Industry 4.0, is the development of *smart-factories* which feature cyber–physical manufacturing systems, through the four key characteristics:

(a) *Vertical networking of smart production systems* – which enables the development of manufacturing factories which react incredibly quickly to the changes in demand, management of supplies and enable highly *customizable* products. Such factories are highly autonomous making all the production parameters modular, measurable, and manageable by deterministic algorithms or artificial intelligence.

(b) *Horizontal integration through a new generation of a global value chain* – which should allow for the manufacturing efficiency on a global scale using the interlinked environment that allows the value chain to become transparent between organizations in real time. With this, a new term of *product memory* is introduced, which refers to the tractability of the product through its each step of the manufacturing process.

(c) *Thorough engineering of the production process and the value chain* – which allows for the development and the manufacturing of the product to become an integral part of the product.

(d) *Rapid product development using new technologies* – which requires the development of manufacturing management methods which are highly autonomous, e.g. collaborative robotics systems, distributed sensor networks, artificial intelligence for production management, etc.

The aforementioned concepts require fundamental and thorough changes in the way we think and design the organizational architecture, along with its value chain and manufacturing process. The key enablers for the successful development and the transition of the organization are: *cyber–physical systems, internet–of–things, internet–of–services and smart–factories*, while these can be achieved by the following development principles: *interoperability, virtualization, decentralization, real–time simulation and development, service oriented production and high molecularity of the manufacturing process*.

Today, most of the technologies that allow for the idea of Industry 4.0 to become a reality exist, however there are still research areas that require further investigation and close collaboration between academy and industry, such as: computer system security, development of smart sensors, further development of additive manufacturing (3D printing), development

of new materials, (big–) data analysis tools and algorithms, green energy, autonomous and collaborative systems, logistics, customization, etc.

III. CONCLUSION

This paper briefly presents the idea of Industry 4.0 while highlighting important terminology, without presenting additional details. The popularity of this topic increases by the day and it is of particular importance for the researchers in the STEM field as it paves the way towards potential collaboration with industry, funded through European Horizon 2020 opportunities.

For further reading and deeper understanding of the impact of the Industry 4.0, the following resources are highly recommended:

1) **Industry 4.0**, *Challenges and solutions for the digital transformation and use of exponential technologies*, 2015.
2) **DLG Expert report**: *Industry 4.0, Summary report*, 2015.
3) **Deutsche Messe** (industrial examples): *Besucherguide Industrie 4.0*, 2015.
4) **Intel's report**: *Collaboration Accelerates the Internet of Things and Industry 4.0*, 2015.
5) **Germany trade & invest report**: *Industrie 4.0 Smart manufacturing for the future*, 2014.
6) **Ronald Berger Strategy Consultants report**: *Think act: Industry 4.0, the new industrial revolution How Europe will succeed*, 2014.
7) **PWC's report**: *Industry 4.0 - Opportunities and Challenges of the Industrial Internet*, 2014.
8) **Acatech, German National Academy of Science and Engineering report**: *Recommendations for implementing the strategic initiative INDUSTRIE 4.0*, 2013.
9) **Fraunhofer study**: *Produktionsarbeit der zukunft Industrie 4.0*, 2013.