Industrie 4.0 Based Customized Mass Production Overview

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***Abstract* — The future of automation is being written today. What is meant by “robotic natives”? What role does “decentralized intelligence” play in Industrie 4.0? The digital transformation and the change that this will bring forth in our worlds of production raise a lot of questions. After the late 90s the idea of mass customization in industry is present. The main goal is to handle the consumer demand for customized products. Recent developments in research, engineering and technology enable industries to move from profitable linear assembly lines to profitable non-linear, dynamic assembly lines to satisfy such a demand. Industrie 4.0, a German governmental initiative, encourages industries to use interconnected Cyber-Physical Systems (CPSs) to create context-sensitive and decentralized factory environments. CPSs in combination with tracking technologies and a component based assembly line can create a factory environment that allows customers to change their requirements during assembly-time. Such change is typically not considered in the domain of manufacturing. In modern software engineering projects, agile techniques allow customer change during the entire development phase. Such change results in customer oriented, customized software products. In this paper we describe the development of an Agile Factory prototype. The developed Agile Factory prototype transfers agile software engineering techniques to the domain of manufacturing. It explores the impact and feasibility of customer changes during assembly-time using a commercially available software framework. The assembly line of the Agile Factory is component based, using track able mobile worktables in combination with stationary workstations.**

Keywords—IoT; Industrie 4.0; Mass production; Cloud computing

I. Introduction

Industrie 4.0 was one of the future projects adopted in the „Action Plan High-tech strategy 2020” by the German Federal Government in 2010. This encouraged the business associations BITKOM, VDMA and ZVEI to establish the platform Industrie 4.0 in 2013 [28][27]. In 2015, the platform Industrie 4.0 was expanded with support of the Ministry for Economic Affairs and Energy and the Ministry of Education and Research. More actors from the private sector, business associations, unions, research organizations and political institutions joined. Today, a total of over 300 players from 159 organizations are active in the platform. All countries have launched Industrie 4.0 initiative, Germany and US first, followed by China, Japan and rest of Europe [2][1].

Fig. 1. Worldwide initiatives & related investment announced [9]

The platform Industrie 4.0 already carries out intensive dialogues at international level: There is a close link to the EU Commission and the G20 countries in terms of European workshops, lectures, publications etc. The Ministry of Economic Affairs and the platform Industrie 4.0 support the European Commission in its efforts to build a network of national initiatives at European level and to promote activities on industry 4.0 across Europe[6][5][7].

The platform also maintains numerous links with stakeholders outside Europe. One example is the Standardization Council i4.0, in which German industrial associations and standardization organizations, together with international organizations, initiate and coordinate standards for digital production. The platform is also co-operating with the Industrial Internet Consortium (USA), the Alliance Industrie du Futur (France) and the Robot Revolution Initiative (Japan). Furthermore, the platform agreed on a memorandum of understanding (MoU) with China and developed a joint action plan [4][3].

A. *Big Data*

Data are the new oil. The term "Big Data" refers to quantities of data that are too large or too complex, that change too quickly or are too weakly structured for them to be evaluated with manual and conventional methods of data processing [18]. In this context, experts talk about an inconceivably large data volume of currently more than 8 zeta bytes – with an increasing tendency. A substantial proportion of this already comes from the Internet of Things (IoT) and from the ever more numerous sensors in machines and vehicles [8][10][11]. Data are increasingly being generated in real time. In connection with Industrie 4.0, however, it is the ability to evaluate and process this flood of data that is of paramount interest. That is how Big Data become Smart Data. The challenge is therefore not only for IT systems to be able to handle heterogeneous data correctly but also for them to analyze the data in order to create a reliable basis for business decisions – preferably in real time. Only in this way can processes be controlled intelligently and adapted to changing parameters. Taking the metaphor further, Big Data is thus the new oil of the 21st century.

B. *Cloud Robotics*

Nowadays smartphones, tablets and computers utilize data and processing power from the cloud as a matter of course like shared intelligence. In the context of Industrie 4.0, robots too will be able to access decentralized data in networks or in the cloud, thereby significantly boosting their performance and flexibility. The robot itself will only require a small chip to control functionality, motion and mobility. For the task at hand, specific services will be retrieved from the cloud or individual robots networked on an ad hoc basis to form temporary production teams [13][12]. In this way, specialists will become Universalists that can be used for a wide range of different manufacturing processes. Cloud robotics enables the implementation of a broad spectrum of different industry-specific applications via "Robotics as a Service®". Another effect of the cloud: robots learn from one another. If one robot encounters an obstacle, for example, it posts this information to the connected systems, which can use it to respond intelligently to the obstacle.

C. *Collaborative Robots*

Collaborative robots – sometimes also known as "cobots" for short – are robots that are capable of human-robot collaboration (HRC) and work hand in hand with their human colleagues. As collaborative robots operate without physical safeguards, they have to permanently calculate the risk of colliding with humans, constantly checking this via the robot controller. The strict safety requirements have been redefined in the revised EN ISO 10218 standard, parts 1 and 2, and in the ISO/TS 15066 specification initially drafted in 2010. Besides the robot itself, the standard also covers the adapted end-of-arm tooling with which the robot performs its tasks, and the objects moved with it. With the LBR iiwa, developers has made the world's first series-produced, collaborative lightweight robot for industrial applications ready for the market, thereby proving that the visions of Industrie 4.0 can be turned into reality.

D. *Cyber-Physical System (CPS)*

A cyber-physical system (CPS) is a "thing" in the Internet of Things (IoT) where physical world meets virtual world. It is a combination of mechanical, electronic and software components that communicate via a data infrastructure such as the Internet, react flexibly to external influences and exchange data with information systems and other CPSs. In future manufacturing facilities, cyber-physical systems will communicate with intelligent, networked industrial production and logistics units – also known as cyber-physical production systems (CPPS). The CPSs exchange information, trigger actions in production and reciprocally control themselves autonomously. This enables industrial processes in manufacturing, engineering, use of materials, supply chain management and life cycle management to be fundamentally restructured and optimized[19][22].

E. *Data Ownership*

The data belong to the originator, who owns the data. A principle that is regrettably contested in the cloud. The open exchange of data and information, however, is a vital ingredient of Industrie 4.0. To put this on a secure footing, it is necessary to create platforms that comply with high ethical standards conforming to German data protection laws. Particularly with a view to the horizontal networking of various companies within a production process, the question of data sovereignty is of central importance. With cloud solutions meeting the highest data security standards, developers offers unique platforms on the basis of which customers can exchange their own data with others or enrich them with new intelligence and additional information.

F. *Individualized Production*

Meeting every customer requirement is a key concept. Individualized, or customized, production refers to the concept of an intelligent, highly automated production system that allows high variance and dynamism in the product range with production costs at the level of mass production[14][15][20]. The goal is to resolve the conflict between the customer's desire for individualization and the process efficiency of production in an industrial setting. A batch size of 1 is the highest level of customized production. Besides proprietary solutions in the automotive sector, Industrie 4.0 with its universally networked production environments represents the world's most advanced approach for implementing customized production.

G. *Industrie 4.0*

Industrie 4.0, Smart Production or Internet of Things – even if the names and terms used vary from one country to another, they all share the same goal [17]. Production meets digitization. What is called for here is nothing less than a long-term transformation of our global perception of industrial production through the seamless connection of the digital and real worlds[13][18]. Developers and manufacturers are at the interface between these two worlds and is playing a decisive role in advancing this transformation as a thought leader and trailblazer for Industrie 4.0. It was back in the 1990s that robotics as a first mover recognized the potential to be gained by combining the world of IT with conventional automation technologies [35]. The German company was also the world's first robot manufacturer to develop open, interoperable and flexible systems on the basis of standardized mainstream technologies and to make them ready for the market. In collaboration with experts from diverse sectors, i4.0 developers are now already implementing highly flexible, digitized manufacturing processes that will open up new opportunities in a competitive environment and lastingly change the way we work and produce.

H. Internet of Automation (IoA)/Internet of Robotics (IoR)

Basis for efficient production. Both the Internet of Automation (IoA) and the Internet of Robotics (IoR) make use of defined open communications and data standards to network interoperable production processes even across company boundaries. In the IoR for example, robots, the App Store or Play Store, connectivity and monitoring tools are networked to form a highly efficient production environment in which analog and digital devices can easily communicate with one another [33][34]. In the near future, it will be possible for all the cyber-physical elements involved in the automated manufacturing process to be networked in the IoA and to communicate with the IoR.

I. Internet of Things (IoT)

Everything communicates with everything else. Like Industrie 4.0, the Internet of Things (IoT) presupposes a network of physical objects – devices, vehicles, buildings and other items – which are fitted with electronic components, software and sensors, all of them being linked interoperable via the Internet[16][21][36]. Unlike Industrie 4.0, the IoT rather non-selectively refers to all things that could be connected to the cloud. The IoT thus also encompasses the private domain, including, for instance, the already well-known "smart home" applications. Strictly speaking, the smart factories of Industrie 4.0 along with all their production and logistics processes are a part of the IoT. Experts forecast that the IoT will comprise 50 billion objects by the year 2020.

II. Mass Customization with Intelligent, Modular, and Adaptive Production Technology

The intelligent factory of the future is a production facility in which manufacturing systems, robots, logistics systems, products and their components are largely able to organize themselves autonomously [22][24][23]. The smart factory is undergoing a paradigm shift towards an entirely new production logic: smart products, components, tools and machines are unambiguously identifiable, can be localized at all times and are aware of their history, their current status and multiple ways to the desired goal. With the smart factory's high degree of flexibility, customization with a batch size of 1 will become reality in the context of industrial mass production [25][26][21]. To achieve this, the production systems must, on the one hand, be networked vertically, for example with business processes within factories and companies. On the other hand, they must also be linked horizontally across company boundaries – from the purchase order through to outbound logistics – to create distributed value creation networks that can be controlled in real time [31][32][30].

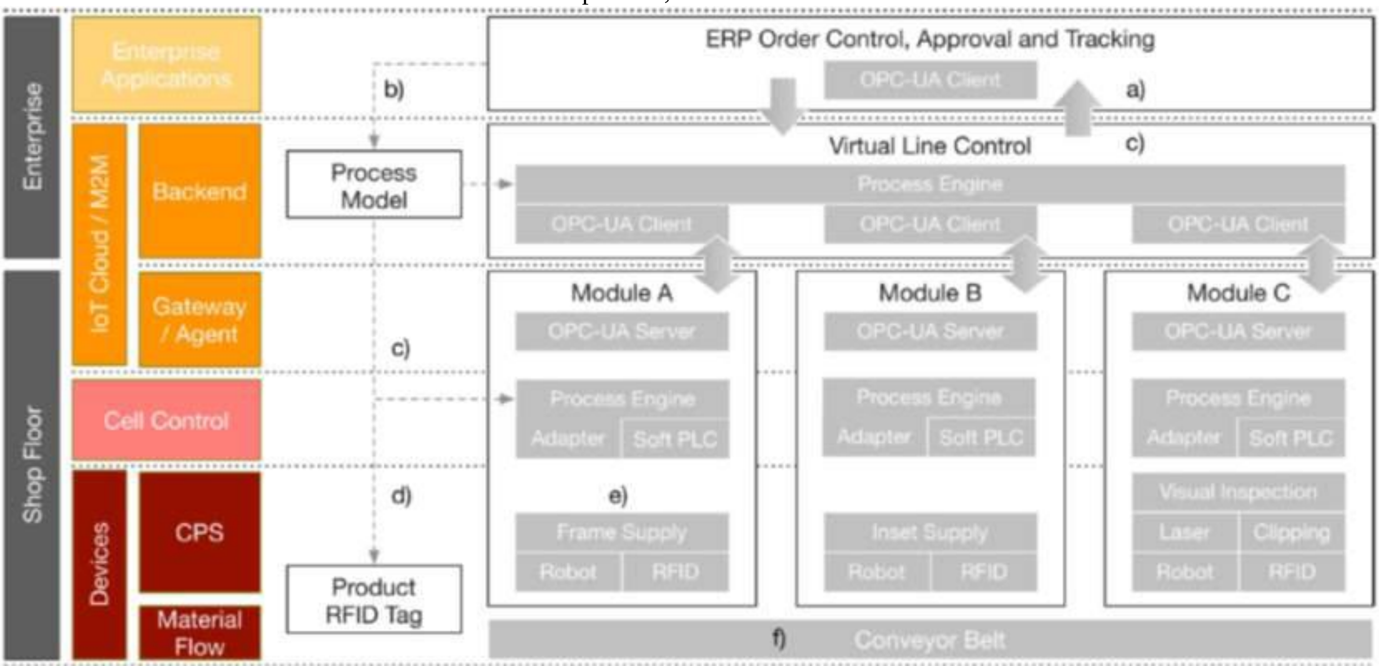

Fig. 2. Detailed Operational Concept for Industrie 4.0 [17]

New, intelligent platforms will be created for the implementation of Industrie 4.0. They will support collaborative industrial processes and use their services and applications to network people, things and systems [27][17][18]. The result will ensure greater flexibility and a continuous flow of information: smart platforms will document the entire business process, work safely and reliably at all levels, and support mobile end devices and collaborative production, service, analysis and forecast processes along the entire digital supply chain [29][37]. For the smart factory, the developers already have modular software architectures in its portfolio, based on mainstream technologies and prepared for the entire evolutionary process of Industrie 4.0. The Java platform of the developing environment makes it ideally suited to future app-based programs.

III. CONCLUSIONS

Customization, digitization, responsible use of natural resources and demographic changes are the megatrends that will need to be mastered in the coming decades. With a forecast world population of 8 billion by the year 2025 and 10 billion by 2060, ever more customer requirements of increasing diversity will need to be satisfied. At the same time, demographic changes will be confronting industrialized and emerging countries with economic and social challenges over the long term. Humanity is thus facing a fundamental paradigm shift which will undoubtedly have far-reaching consequences for our worldwide economic systems. That is why Industrie 4.0 does not describe a purely technical innovation scenario but rather a way in which intelligent technology can help to overcome the global challenges of the 21st century. As a thought leader and trailblazer for Industrie 4.0, the developers are working on production environments which increase economic efficiency while also using resources responsibly, which make high-quality goods more affordable and which are instrumental in sustainably improving human working conditions in factories. The ability of humanity to handle the future will be determined by a responsible and sustainable approach to natural resources. In a just world, it may be assumed that ever more people will want to be supplied with ever better products. Flexible, intelligent and networked production as envisaged in Industrie 4.0 offers the opportunity of using raw materials more efficiently and more sustainably along the entire value creation chain and recycling them to a great extent for the sake of the planet.

REFERENCES

[1] Á. Bálint, J. Sárosi, "The Design and Implementation of a Radio Controlled Led Lighting System", Analecta Technica Szegedinensia, Vol 10, No 1, pp. 29-34, 2016.

[2] Arndt M., Wille S., de Souza L., Fortes Rey V., Wehn N. and Berns K. : Performance evaluation of ambient services by combining robotic frameworks and a smart environment platform, Robotics and Autonomous Systems, 61(11), 1173-1185, 2013,

[3] Atzori L. , Iera A., Morabito G. and Nitti M. : The Social Internet of Things (SIoT) – When social networks meet the Internet of Things: Concept, architecture and network characterization, Computer Networks, 56(16), 3594-3608, 2012,

[4] Borgia E. : The Internet of Things vision: Key features, applications and open issues, Computer Communications, 54, 1-31, 2014,

[5] Chiu S.H., Urban P.L. : Robotics-assisted mass spectrometry assay platform enabled by open-source electronics, Biosensors and Bioelectronics, 64, 260-268, 2015,

[6] D. Dobrilovic, B. Odadzic, Z. Stojanov, V.Sinik, „Testing Zigbee RF module applicability for usage in temperature monitoring systems", Proceeding of 22nd Telecommunications Forum Telfor (TELFOR), pp 415-418, 25-27 Novembar, Belgrade, Serbia, 2014.

[7] D. Dobrilovic, Z. Stojanov, V. Brtka, Z. Čović, N. Bilinac, "Software Application for Analyzing ZigBee Network Performance in University Courses, unpublished, submitted to the IEEE 12th International Symposium on Intelligent Systems and Informatics in June 2014.

[8] Distefanoa S., Merlinoc G. and Puliafitoc A. : A utility paradigm for IoT: The sensing Cloud, Pervasive and Mobile Computing, 17(1), 1-39, 2014,

[9] Flores Saldivar, et al. Industry 4.0 with Cyber - Physical Integration: A Design and Manufacture Perspective. in International Conference on Automation & Computing. 2015. University of Strathclyde, Glasgow: IEEE.

[10] Griecoa L.A., Rizzoa, A., Coluccia S., Sicaric S., Piroa G., Di Paolab D. and Boggiaa G. : IoT-aided robotics applications: Technological implications, target domains and open issues, Computer Communications, 54(1), 32-47, 2014,

[11] Gubbia J., Buyyab R., Marusica, S. and Palaniswamia M. : Internet of Things (IoT): A vision, architectural elements, and future directions, Future Generation Computer Systems, 29(7), 1645-1660, 2013,

[12] Gyorgy Terdik, Zoltan Gal (2013): Advances and practice in Internet of Things: A case study, Proceedings of IEEE 4th International Conference on Cognitive Infocommunications (CogInfoCom 2013), Budapest, Hungary, December 2-5, 2013, ISBN: 978-1-4799-1544-6, pp. 435-440.

[13] Gyula Mester, Szilveszter Pletl, Gizella Pajor and Imre Rudas, Adaptive Control of Robot Manipulators with Fuzzy Supervisor Using Genetic Algorithms. Proceedings of International Conference on Recent Advances in Mechatronics, ICRAM'95, O. Kaynak (ed.), Vol. 2, pp. 661–666, ISBN 975-518-063-X, Bogazici University Bebek, Istanbul, Turkey, August 14-16, 1995.

[14] Gyula Mester, Neuro-Fuzzy-Genetic Trajectory Tracking Control of Flexible Joint Robots. Proceedings of the I ECPD International Conference on Advanced Robotics and Intelligent Automation, pp. 93-98, Athens, Greece, September 6-8, 1995.

[15] Hermann, M., T. Pentek, and B. Otto, Design Principles for Industrie 4.0 Scenarios: A Literature Review. Technische Universitat Dortmund, 2015. 01(3): p. 4-16.

[16] Internet of Things [Online]. Available: http://www.intel.com/content/www/us/en/internet-of-things/overview.html [Last accessed: July 2016].

[17] MacDougall, W., Industrie 4.0 Smart Manufacturing for the Future. Mechanical & Electronic Technologies, Germany Trade & Invest, 2014(2): p. 40.

[18] Nyikes, Z., Rajnai, Z. "The Big Data and the relationship of the Hungarian National Digital Infrastructure", International Conference on Applied Internet and Information Technologies, ICAIIT 2015, pp. 6-12, Zrenjanin, Serbia, 2015.

[19] S Csikós, "Robot Remote Control over the Internet", 28th International Conference Science in Practice, pp. 41-43, 3-4 June, Subotica, Serbia, 2010.

[20] Sárosi J., Bíró I., Németh J. Cveticanin L.: Dynamic Modelling of a Pneumatic Muscle Actuator with Two-direction Motion Mechanism and Machine Theory, 2015, Vol. 85, ISSN 0094-114X, pp. 25-34

[21] Simon János, "Concepts of the Internet of Things from the Aspect of the Autonomous Mobile Robots", Interdisciplinary Description of Complex Systems Vol.13 No.1, pp. 34-40, 2015.

[22] Simon János, Goran Martinović, "Distant Monitoring and Control for Mobile Robots Using Wireless Sensor Network", Proceedings of the Conference CINTI 2009, pp. 1-9, Budapest, Hungary, 2009.

[23] Simon János, Zlatko Čović, Dalibor Dobrilović, "The Web of Things and Database Management Systems", Analecta Technica Szegedinensia, Vol 10, No 2, pp. 61-68, 2016.

[24] Gogolák L, Fürstner I, Nyitri D, Application of linear motors in mechatronic devices, RECENT INNOVATIONS IN MECHATRONICS (1-2) Paper 1. 4 p. 2016.

[25] Simon, J. : Optimal Microclimatic Control Strategy Using Wireless Sensor Network and Mobile Robot, Acta Agriculturae Serbica XVIII(36), pp. 3-12, 2013,

[26] Simon, J. and Matijevics, I. : Simulation and Implementation of Mobile Measuring Robot Navigation Algorithms in Controlled Microclimatic Environment Using WSN, Proceedings of the IEEE 9th International Symposium on Intelligent Systems and Informatics – SISY 2011, 275-279, Subotica, 2011,

[27] Vijaykumar S. and Saravanakumar S. G. : Future Robotics Database Management System Along With Cloud TPS, International Journal on Cloud Computing: Services and Architecture, 1(3), 103-114, 2011,

[28] Z. Gál, B. Almási, T. Dabóczi, R. Vida, S. Oniga, S. Baran, I. Farkas (2014): Internet of Things: Application Areas and Research Results of the FIRST Project, Infocommunications Journal, Volume VI, No 3, ISSN 2061-2079, pp. 37-44.

[29] Peter Šarčević, Vehicle classification using neural networks with a single magnetic detector, Issues and Challenges of Intelligent Systems and Computational Intelligence, pp. 103-115, 2014.

[30] Kuo-Ming Chao, A. James, A. Nanos, J. Chen, Sergiu-Dan Stan, I. Muntean, Giorgio Figliolini, P. Rea, C. Bouzgarrou, P. Vitliemov, J. Cooper, J. Capelle,"Cloud E-learning for Mechatronics: CLEM", Future Generation Computer Systems, Volume 48, pp. 46-59, 2015.

[31] Nandor Verba, Kuo-Ming Chao, Anne James, Daniel Goldsmith, Xiang Fei, Sergiu-Dan Stan, Platform as a service gateway for the Fog of Things, Advanced Engineering Informatics, 2016.

[32] Sárosi J., Measurement and Data Acquisition, University of Szeged, Faculty of Engineering, Szeged, ISBN 978-963-306-284-5, 100 p, 2014.

[33] Gyula Mester, Pletl Szilveszter, Gizella Pajor, Djuro Basic, Adaptive Control of Rigid-Link Flexible-Joint Robots, Proceedings of 3rd International Workshop of Advanced Motion Control, pp. 593-602, Berkeley, USA, March 20-23, 1994.

[34] Gyula Mester, Wireless Sensor-based Control of Mobile Robots Motion, Proceedings of the IEEE 7th International Symposium on Intelligent Systems and Informatics, SISY 2009, pp. 81-84, ISBN: 978-1-4244-5349-8, DOI 10.1109/SISY.2009.52911190, Subotica, Serbia, Sept. 25-26, 2009.

[35] Gyula Mester, Aleksandar Rodic, Autonomous Locomotion of Humanoid Robots in Presence of Mobile and Immobile Obstacles, Studies in Computational Intelligence, Towards Intelligent Engineering and Information Technology, Editors: Rudas Imre, Fodor Janos, Part III Robotics, Vol. 243/2009, pp. 279-293, ISBN 978-3-642-03736-8, DOI 10.1007/978-3-642-03737-5, Springer-Verlag Berlin Heidelberg, 2009.

[36] Róbert Sánta, László Garbai, Fürstner Igor: Optimization of heat pump system, Energy 89 pp. 45-54, 2015

[37] S. Maravic Cisar, P. Cisar, R. Pinter, Evaluation of knowledge in Object Oriented Programminh course with computer adaptive tests, Computers & Education 92-93: pp. 142-160, 2016.