Simulation frameworks to embedded fabricate systems

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Abstract. The objects of this article are the simulation frameworks to design the embedded fabricate systems. An embedded fabricate system is a part of a modelling factory (MF) and an additive factory. It is proposed to solve the problem of synthesizing the embedded fabricate systems in an automated way. The simulation frameworks are a component of the software of an MF specializing in the development of digital copies of new enterprises. The simulation framework is implemented on the basis of industrial automation methods and can be configured for the synthesis of embedded fabricate systems of different types. Structural options for simulation frameworks are proposed. The automation components are distributed within the simulation frameworks depending on the embedded fabricate systems life cycle. The use of simulation frameworks allows to achieve improved performance characteristics of embedded fabricate systems.

1. Introduction

An actual understanding of the product life cycle (PLC) implementation has led to the revision of the existing system of life cycle stages (LCS) within the classical concept. Today the traditional types of LCS are transformed, which leads to a smoothing of each stage boundaries [1, 2]. In the design of enterprises, various automation systems of a new generation are introduced which ensure the stages of PLC within the framework of the promising industrial concepts [3, 4].

The promising industrial concepts provide for the development and implementation of new methods and tools that ensure the use of embedded fabricate systems (EFS) with computing-enabled and virtual techniques at all LCS [5, 6]. The technical re-equipment of classical enterprises is now recognized as ineffective, and therefore, it is necessary to develop progressive enterprises that introduce EFS with multi-sensing [7, 8].

In the engineering, a modelling factory (MF) specializes in the development of virtual models that are sufficient in their properties to implement the product manufacturing stage [9, 10]. The products manufacturing is carried out in an additive factory (AF) using EFS. The promising industrial concepts involve the synchronous interaction of the MF and AF resources in the realized of PLC at the exchange of electronic data blocks [11, 12].

The practical implementation of the promising industrial concepts today is carried out at the level of theoretical research and modeling of different technological operations, in connection with which the topical issue is to develop new simulation frameworks that automate the synthesis of the MF and AF techniques [13, 14].
2. Simulation framework to fabricate systems of the MF
The organization of an MF involves the creation of a simulation framework, the options of which provide developers with automated support for the synthesis of fabricate systems. The simulation framework consists of hardware (computer facilities) and software (computer-aided design systems) that automate the activities of developers. The simulation framework to fabricate systems of an MF is shown in Figure 1.

The simulation framework to fabricate systems of an MF includes [15, 16]:
- the product-twin creation standards which correspond to the actual industrial standards and help to prepare the manuals for different types of product engineering;
- experimental methods of mathematical tests for the project-twin in a computerized modelling software;
- MF designer hardware and software performed as the industrial automatizing resources, etc.

Figure 1. The simulation framework to fabricate systems of an MF.
Each component of the simulation framework to fabricate systems is used by the human of the MF at a certain stage in the PLC. As part of the specialization of the MF, a stage of marketing research and a stage of designing the functional structure of the MF are carried out.

As a result of marketing research, the requirements of the technical specifications for the development of the fabricate systems are formed (specified). The object of design at an MF can be both a simple product and a higher order EFS, for example, an AF. The design stage in an MF involves the implementation of different procedures, as a result of which manuals of the development product are generated.

The correspondence of the PLC stages, methods and process tools, as well as automation components (functional cells with dashed lines), which are part of a simulation framework in the MF, is shown in Figure 1 by oriented lines.

3. Simulation framework to fabricate systems of the AF
A fabricate systems with EFS is an integral part of the dual resource AF. The specific of unmanned manufacturing involves the implementation of most production scenarios in real-time robotics. To fuzzy-logic control EFS in the close-loop an AF, a computerized simulation framework to fabricate systems must be created.

![Diagram](image-url)

**Figure 2.** The simulation framework to fabricate systems of an AF.
The development of a simulation framework to fabricate systems is carried out at the MF as part of a synthesis project of the AF as a whole. The simulation framework to fabricate systems of the AF is shown in Figure 2.

The simulation framework to fabricate systems of an AF includes [17, 18]:

- the robust algorithms for performing processes and scenarios of manufacturing products, which are supposed to be put into production at an AF;
- the family of multi-station and multi-product embedded fabricate systems with open architecture and supporting real-time automatic control methods;
- the innovate techniques for the communication of EFS with support of cellular technique and industrial additive methods used in self-recovering systems, which have the property of portability to hardware-independent processing platforms of an AF, etc.

The correspondence of the LCS, methods and process tools, as well as automation components (functional cells with dashed lines), which are part of a simulation framework in an AF is shown in Figure 2 by oriented lines.

4. Conclusion
The proposed configurations of simulation frameworks to fabricate systems are intended for implementation as part of a specialized modelling system. Simulation framework is a brainware of MF computer-aided design systems. The structural complexity of the MF and AF does not allow today to implement modelling systems on industrial computers with available computing performance. The necessary performance for modeling innovative processes of the MF and AF is possessed by quantum computers, the functionalities of which are actively increasing.

Obviously, the implementation of the promising industrial concepts are not limited to the only design of fabricate systems. Embedded technologies of the MF and AF are drivers that ensure the progressive development of parallel industries and implement the scientific progress on a global industry.

References
[1] Panesar A, Ashcroft I, Brackett D, Wildman R and Hague R 2017 Additive Manufacturing 16 98-106
[2] Zhang Y, Zhao M, Zhang Y, Pan R and Cai J 2020 European Journal of Operational Research 283(2) 491-510
[3] Junliang W, Chuqiao X, Jie Z, Jingsong B and Ray Z 2020 Robotics and Computer-Integrated Manufacturing 61 101854
[4] Farsi M, Erkoyuncu J A and Rajkumar D S 2019 Simulation Modelling Practice and Theory 94 14-30
[5] Chen Z, Xiansheng Q, Eynard B, Jing L, Jing B, Yicha Z and Gomes S 2019 Robotics and Computer-Integrated Manufacturing 59 373-384
[6] Guo D, Zhong R Y, Lin P, Lyu Z, Rong Y and Huang G Q 2020 Robotics and Computer-Integrated Manufacturing 63 101917
[7] Zhang Z, Wang X, Zhu X, Cao Q and Tao F 2019 Robotics and Computer-Integrated Manufacturing 60 12-22
[8] Adane T F, Bianchi M F, Archenti A and Nicolescu M 2019 Journal of Manufacturing Systems 53 212-233
[9] Chang P-C, Lin Y-K and Chiang Y-M 2019 Reliability Engineering and System Safety 188 103-109
[10] Zhao Z, Lin P, Shen L, Zhang M and Huang G Q 2020 Advanced Engineering Informatics 43 101044
[11] Mennenga M, Cerdas F, Thiede S and Herrmann C 2019 Procedia CIRP 80 637-642
[12] Unglert J, Jauregui-Becker J and Hoekstra S 2016 Procedia CIRP 57 374-379
[13] Mittal K K and Jain P K 2014 Procedia engineering 69 1125-29
[14] Sibanda V, Mpofu K, Trimble J and Kanganga M 2019 *Procedia CIRP* **84** 948-953
[15] Avram O and Valente A 2016 *Procedia CIRP* **57** 461-466
[16] Brad S and Murar M 2015 *Procedia CIRP* **30** 498-503
[17] Elmasry S S, Youssef A M and Shalaby M A 2014 *Procedia CIRP* **17** 410-415
[18] Jian B, Demoly F, Zhang Y and Gomes S 2019 *Procedia CIRP* **84** 159-164