Information reservation of cyber-physical production of the Industry 4.0

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Abstract. An actual task has been studied to organize informative reserving of the production data and link channels in the Industry 4.0 smart factory. Informative reserving principles in a digital company are done by duplicating informative link channels into a single company communication environment. Connection channels duplicating creates the production division informative redundancy for the technological operations completion results data. The smart factory informative reserving increase company functionality reliability and provides functional and informative smart factory functionality. There are schemes of cyber and physical production components informative reserving and types of connection channels are defined which are used as primary and reserve lines of the information transmission. There are ways of informative reserving based on the technologies of Bluetooth, Ethernet and Internet of Things (IoT). Main way of cyber and physical production informative reserving is done in system level and is duplicating of the IoT wireless channel with a wired channel of the Ethernet connection and transmitting of duplicating messages. Auxiliary way of cyber and physical production informative reserving is done in local level of the production data exchange among cyber an physical systems with a Bluetooth channel.

1. Introduction

One of the most important property of the Industry 4.0 [1, 2] production company is the company informative transparency. The smart factory informative transparency is the personnel possibility to monitor the item manufacturing technological operation completion state at any stage of the technical cycle [3].

To realize the company informative transparency they must create the company communication infrastructure which grants the operator access to the production data which characterizes item manufacturing technological processes [4]. The communication infrastructure unites the cyber and physical systems, cloud resources, operator access means to the company industrial net and other production components [5, 6].

Computerized communication infrastructure makes in automatic way some smart factory item manufacturing processes but the system access control to the production components has some risks of the company informative security [7, 8]. So along the task of the CPS machine reserving in a cyber and physical production there are also tasks of the company informative security including the tasks of
the resources and production data informative reserving [9, 10].

The informative reserving is applied in production if a technological line has a great number of cyber and physical systems (CPS) to generate homogeneous production data but with different physical principles. The sources of such production data are measuring detectors of sensor net and controllers connected to the company communication environment [11].

The CPS production data informative reserving principle is an intentional redundancy of connection channels, data processing centers and information sources for the production division stable conditions of working if some components are failed [12]. Informative reserving is the ability of cloud applications to process a restricted volume of production data without any loss of accuracy and cyber and physical systems [13] control algorithms resistivity. Cyber and physical production informative reserving can be done in two levels of control:

- in the system level of production components interaction, cloud services and applications;
- in the local level of some cyber and physical systems interaction.

2. Informative reserving in the system level

Cyber and physical production informative reserving scheme in the system level is given in figure 1.

Cyber and physical production informative reserving in the system level is done by duplicating of the industrial Internet of Things (IoT) wireless communication environment with the wired channels of Ethernet connection. If transmitter and receiver fail which are parts of a CPS and provide the connection with the channels of IoT the information data exchange for this CPS will be conducted through a channel of Ethernet. Both connection channels provide CPS connection in parallel to the cloud services and applications. This way of cyber and physical production informative reserving is to transmit production data to the cloud centers of processing which makes available the BigData technology for cloud services and applications.

The informative reserving of cyber and physical production in the system level is the highly-reliable way to increase the functional safety of the Industry 4.0 smart factory. But anyway if the production data processing center analytical component fails the functionality of the entire company production division can be paralyzed.

3. Informative reserving in the local level

An effective way to increase the cyber and physical production reliability is an informative reserving in the local level of some CPSs interaction. The cyber and physical production informative reserving scheme in the local level is given in figure 2.
Cyber and physical production informative reserving in the local level based on CPS interaction in wireless link channels with the protocols of Bluetooth, a channel duplicating the Industrial Internet of Things. The link channel of Bluetooth helps to organize informative interaction of neighboring CPSs installed in production with a short distance from each other.

CPS interaction with channels of Bluetooth must be viewed as a mean of control of the product being manufactured when a CPS may check the result of the done operation to provide the next processing of details. When transmitting and receiving pieces of CPS IoT information exchange fail the CPS interaction will continue with a channel of Bluetooth. A feature of the Bluetooth channel is an ability to transmit data for a short distance that the CPS information exchange could be done in pairs. Within a technological section Bluetooth protocols interaction of CPSs is done in chain with neighboring CPSs in the information exchange radio channel.

Exceptionally if a CPS channel of IoT and Ethernet fails such a CPS will access cloud services and applications with Bluetooth and with working means of data transmitting to the neighboring CPS.

![Figure 2. Cyber and physical production informative reserving scheme in the local level.](image)

Difference in the pass-through ability of the link channels of Ethernet, IoT and Bluetooth may create a production realization with informative redundancy and time redundancy. The temporal redundancy is a way of production data reserving when technological operation completion state information is transmitted to the control computerized system several times (For highly-productive link channels). Multiple transmission of production information increases the data accuracy being circulated in a smart factory. Production data integrity and accuracy is the most important property of computerized control system information.

A feature of informative reserving in cyber and physical production is the CPS digital twins in the company virtual environment organized in the level of cloud services and applications. CPS digital twin has the full information similarity to the original (CPS physical device) which is for calculation processes organization and CPS control processes in cyber and physical production in the company virtual environment. The company virtual environment is for imitation modelling of technological processes which happen in CPS real working chambers which together with CPS detector data provides the increased accuracy of the assembly units manufacturing with the methods of complex information processing.

Together with cyber and physical technological equipment digital twins the smart factory cloud environment contains the parts digital twins being manufactured in production. Parts digital twins are an electronic technical documentation represented in the level of mathematical, program, construction and technological models which describe item different properties. The part digital twin is a model being developed in time which improvement depends on the data received from the exploitation of the manufactured before items. So cyber and physical production is an informative data connection of return which characterizes quality and specifications of the items being manufactured. The item digital
twin models are used in calculations of the items being manufactured parameters being realized in the smart factory virtual environment. The application of item digital twins duplicating the physical samples of the items being manufactured is a special form of the Industry 4.0 cyber and physical production informative reserving.

4. Conclusion
Cyber and physical production projection with reserved components is a science and practical task which solution lies with the methods of the linear programming. Methods of the linear programming (simplex-method, artificial basis methods and other) helps to optimize the maximum number of CPS placement including duplicating CPSs in a particular site of a smart factory. Initial data for automatic production projection with the methods of linear programming are the lengths of a smart factory sides (production division), dimensions of all CPSs and distances between each CPS pair and also distances among CPSs and external elements of the company.

Digital informative technologies implementation in smart factories creates the necessary conditions of the electronic documentation inside the company and production company interaction with its agents of production cooperation. Standardizing and creating types of program interfaces and environments to unite the profile smart factories into distributed virtual companies (virtual factories) for the item mass production.

Electronic documentation acceptability (digital models) in the technological cycle «projection-production» helps to integrate the virtual factories projection companies (digital factories) to form the finished structure of the Industry 4.0 in the format of a factory of the full cycle of the item manufacturing. Information spaces of separate companies unification into a single virtual factory creates the informative redundancy of project and production data which based on the BigData algorithms must be converted to informatively reserved project and production data to increase reliability and informative safety of a digital company functioning.

Technological operations completion processes documentation in the Industry 4.0 smart factory is done in virtual environment company servers. Each cyber and physical systems including the transport CPS and production control computerized system during the functionality of scenarios which content is written in special files in the digital cloud. Scenario files analysis is done by the operator in the smart factory running in field works or in the stage of malfunctioning search, which are consequences of cyber and physical equipment failures.

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