Cyber-physical production information environment

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Abstract. Information environments that ensure the automation of industrial processes are used for the management of production structures by the control methods of technological indicators. For intelligent operations management, a variety of communication channels are used to bring together sensor networks and integrated (optimized) workflows of data and products. Regulation of the production process involves hierarchical management mechanisms that provide information environment tools to monitor compliance with the specified technological parameters of equipment and achieve a stable balance in the interaction of software and hardware systems. The influence of the hierarchy of control systems on production processes is realized in the regulators localized in cyber-physical systems, and in the central regulator, which corrects the corrections of control actions. Multistage control is a function of an information environment that regulates technological processes. Due to the discreteness of the control processes of the central regulator, the equipment subordinate to the vertical hierarchy system is corrected by messages transmitted in the format of a time sequence in the communication channels. Feedback as a subject of the information management process solves a particular production problem, corresponding to maintaining the quality of manufactured products in the dynamics of registration of disturbing influences by measuring means of the sensor network. The structure of the information environment is proposed, considered on the example of management processes for one piece of equipment in cyber-physical production.

1. Introduction
The cyber-physical production (CPP) information environment is a projection object, which organization is based on the looping and cyclic state of measuring and controlling processes, which happen in special function cyber-physical systems (CPSSs) [1, 2]. The CPS work subject as much as materials is information (data), which are used simultaneously to manufacture an intellectual product with different constructive and technological properties. The CPS information activity completing the one type production operations with machine technologies tools means to translate heuristic methods of production tasks solutions in hierarchy system control methods, which correspond the CPP target of the object functioning [3, 4].

The control theory position stable CPS structure includes the different technological complexity, which state is being controlled in real time with a sensor net [5]. The CPS organizing state is done in formats of CPS subsequent connection with technological operations and parallel connection of
information and controlling processes [6]. The CPP structure connections dynamics is justified with CPS operation coordination mechanisms influence in the horizontal hierarchy level and CPS information concord influence in the hierarchy vertical level. Interaction synchronizing among systems and CPP sub-systems, which complete the processes of the item being manufactured general and unit assembly is provided with control function, which is target-ly oriented to support the given CPS technological modes balanced in each elementary operation characteristics (properties) [7, 8].

The CPS control function adaptation is justified with the industrial object reaction on the technological processes changing conditions, which after disturbances reflect external and internal factors of the CPP environment [9]. The CPS ability increase to adapt is done through virtual regulators models being implemented in the CPP information environment, which completes a continuous operation analysis of technological processes [10, 11].

All CPP technological processes digitalizing in the information representation level provides the hierarchy control system within the closed infrastructure based on CPS regulators combination made by different manufacturers. The Industry 4.0 cyber-physical context views a CPS as a discrete control system functioning with some technological modes with an information net within which the data is being translated [12, 13]. The traffic characteristics being transmitted through the net and control system regulation procedures of the connection channel queue defines the CPS servicing quality being corrected with applications in importance degrees with messages being transmitted [14, 15].

The traffic control and its priority differentiation are made with the regulation mechanisms, which combine the being controlled and guaranteed servicing quality technologies. Connection net of each CPS servicing agreement in the CPP information environment is done with wireless channels of the Internet of Things (IoT), which is combined with the wired Ethernet channel [16, 17]. The tides priorities require the same servicing and is defined with sending and receiving CPSs with the package marking (tides) being routed with the net units [18]. The information transmission environment traffic prioritizing in net routers is done with protocols of soft and hard CPS servicing quality solutions, which generate and process different information data tide classes (applications, control commands, work processes signatures, operation system renewal, the equipment condition parameters telemetry and other). The packages positions in the queue and ways of net traffic priority control are made with CPS settings and connection channels units, which control the CPP resources [19, 20].

2. Information and technological CPP concept

The information and technological CPP concept is a combination of plans and ready solutions to construct a unique type of industrial objects, which are prioritized in the Industry 4.0 and which unite calculation, communication and control processes of CPS. The CPP multi-aspect representation is based on the new technics and advanced technologies implementation, which are the single cyber-physical environment physical and virtual components different combinations into the industrial object information system based mostly on the CPS calculation net and perspective science researches of the applicable telecommunication infrastructure field.

The Industry 4.0 CPP object projection strategy is a technical re-equipment, company modernizing or reconstruction, which requires technological environment transition from the park equipment arrangement to individual CPSs, which are parts of information and measuring and controlling sub-systems, which are sensitive to the package transmission time in the net channels. Application of different environments (wired and wireless) of the traffic distribution organized as digital telecommunication systems, which let get in order CPP information tides to provide context and controlling CPS functioning.

A balanced technological environment for calculation and net loads unites different classes of terminal devices (CPSs, detectors and other) related to an uninterrupted production processes cycle. The information environment and telecommunication infrastructure final options, which are to be implemented in the company are based on a particular control tasks class solution expanded with virtual regulators models received after an Industry 4.0 innovations technological audit. The CPP information
environment is given in figure 1. The environment components interaction example is given, which is actual for one CPS unit control.

![Diagram of CPP information environment](image)

**Figure 1.** The CPP information environment (with one CPS unit control example).

3. **CPS virtual and physical control**

The CPS condition intellectual registration through a technological parameters measuring system is an element of modernization and modern industry innovation development approach. To calculate the complex controlling commands values applied to the CPP objects with an interrupted technological cycle they use CPSs with data telemetry control function. The automatic loops tactical events creation connected to the technological information collection system is done in the virtual company resources level or beyond the operational space with production CPSs measuring detectors and engineer CPSs of anti-fire alarm system.

The central regulator address influence on a CPS when in the measuring results some deviations from the established indications. To compare vector measurements and values received from the educative models is the CPP process controlling element. The information nets application to transmit the measured data increases the CPS infrastructure monitor capabilities within which they guard a single principle (order) of the CPP resources control.

The technological process local control resource is the electro-motion gear microcontroller programmed to standardized production operations plurality, which are completed in parallel calculations modes. The CPS industrial automatics executive level contains heterogeneous measuring, calculation, net, controlling and other equipment elements. The CPP automatics informative level is placed in the central regulator, which puts some additional restrictions on the CPS control functions.

The coordinated CPP control calculation environment is concentrated in the company virtual space and contains resources, which emulate the technological processes. The electronic control is to copy production tasks the corresponding calculation and connection services done with semantics, which
logically divide net agents in the CPS groups, which activity is described with information and operation processes models. The end CPS and their groups control system considers calculation resources as cloud or fog servers, which the CPS technological load and connection channels information load profiles. The active adaptive intellectual net concept in the system of edge, fog and cloud calculations, which is done with server controlling resources division mechanisms and data bases storage resources (knowledge).

Technological changes up to modern Industry 4.0 requirements mean to complete production processes, which require the control accent position change for the CPS groups, which are shown in the company data base as some attributes with functional capabilities characteristics. The technological tasks redistribution in the production reconfiguration process is done with the CPS net calculators addresses list, which in the data base register without operation system or applications reloading placed in edge, fog or cloud units.

4. Conclusion

Task solutions related to information system implementation in the CPP infrastructure is based on the local architecture loops creation for the automatic control systems, which calculation processes are divided into separate classes of measurement and regulation technological operations. To integrate processes and a CPS means to organize a parallel work of measuring, calculation and control components, which action coordination is done with a group regulator. The components oriented architecture provides an increased task parallelism for the plurality of controls accepted by a regulator received after disturbance influences or measuring processing.

The control and measuring objects information system architecture similar to a CPP is based with adaptive structure with detectors in the feedback channels principles with different time data exchange cycles. The net environment integrating system provides CPS controlling messages transportation and commutation with active connections with integrated systems, which engage the modified autonomous technologies of edge calculations. To define technological processes control and system corrections they use dynamic measurement range detectors, which do not reduce accuracy or CPP work stability.

The technological devices configuration settings equipped with a CPS as an entire CPP component is done through a net, which lets for a central regulator interact with not an individual CPS but with its combination. The CPP structure dynamical change-ability as a control aspect is provided by implementing the feedback variables in the information system, which provides multi-time CPS completion of functional complicated tasks to take away collisions, which are critical for technological systems working in real time.

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