Client-server technologies at the enterprises of Industry 4.0

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Abstract. The task is to project the distributed architecture of calculation net for a digital and smart factory of Industry 4.0. The calculation net architecture defines the calculation resources components and their interaction to organize designer project activity or to manufacture a set of items in a serial plant. You may use in Industry 4.0 factory calculation net architecture client and server technologies. All factory technological equipment is classified by the type of the operation being completed: thin client, thick client, universal client and server equipment. Thin client of cyber and physical production is the simplest communication device with installed software which functions as a terminal and being used by the operator. Thick client of cyber and physical production is a complete production machine (test equipment) which is capable to work automatically by the programmed algorithm. Universal client of cyber and physical production combines the properties of thin and thick clients. A cyber and physical system is a universal client example of the smart factory calculation net. Digital factory net thin client is a communication device with software which is used to control the modes of digital models virtual tests. Digital factory net thick client is a work station to conduct digital models virtual tests with your own calculation resources. Digital factory net universal client is a PC which is a part of the designer automatic work place and which is used to develop and create construction, program and technological documentation and also item digital models. Server equipment is a terminal server, data server and application server to exchange the information in multi-level hierarchy calculation net. Some schemes of digital and smart factories calculation net architecture are given.

1. Introduction

The implementation of digital informative technologies into item designing company projection activity and serial plants production activity led to [1, 2] the necessity to enhance the company calculation net. Traditional ways [3, 4] of distributed calculations and client exchange of project and production data were meant to create in a company a local calculation net with a central server for PC (Personal Computer) requests incoming to the designer automatic work places and requests from the technological equipment. This option of company calculation nets now is out of any possibility being developed further on the modern stage.

Perspective companies of Industry 4.0 (digital factory, smart factory) oriented [5, 6] to create distributed calculation nets the infrastructure elements of which are placed in the company cloud environment and as a part of production workshops technical support. The main client of calculation nets of Industry 4.0 project and production companies could be [7, 8]:


– cyber and physical systems for automatic completion of item manufacturing technological operations;
– automatic test equipment for physical tests of item being manufactured to prove the item quality;
– automatic work places PC with technical and software means to help the designer to prepare the item documentation;
– work stations (highly-productive industrial computers) which are used for digital models virtual tests with imitation modelling to prove the quality of item technical documentation;
– communication devices for project company designers and production company operators to control the item life cycle stages and other.

Different technical means and their software installed requires some new solutions [9, 10] form the calculation net architecture designers to optimize the net load among clients and information traffic of course circulated in the company. The best solution for project and production company calculation net architecture is to implement in the Industry 4.0 company infrastructure the client and server technologies [11, 12].

2. Smart factory distributed calculation net architecture

To unite different means of production with its integrated calculation resources into a single cyber and physical workshop with its own virtual environment they may use server and client technologies. Client and server technologies define the interaction order of clients into the company calculation net which are part of final devices category (clients) and also clients which are part of control devices category (servers) [13].

The scheme of distributed calculation net to unite the clients of the Industry 4.0 cyber and physical production is given in figure 1.

![Diagram](https://example.com/diagram.png)

**Figure 1.** Calculation net (architecture) of Industry 4.0 smart factory cyber and physical production (CNC – Computer Numerical Control, CPS – Cyber-Physical System, IoT – Internet of Things).
Calculation net architecture in its physical level of cyber and physical production can be described with three main types of final devices:

- thin client;
- thick client;
- universal client

united in a single wireless net of IoT with routers, commutators and other net equipment.

Hardware and software classification of the smart factory calculation net to client and server components is necessary to divide the calculation load and functions among information exchange process participants in production.

Thin client is a final calculation device with installed communication application (web-application) which provides production operator with the possibility to work in the terminal mode. Web-application is controlled with local operation system to load up and storage into the memory in its solid devices. Thin client contains minimum configuration of calculation resources and interacts with remote terminal server in the client and server mode.

Communication software gives the operator in production the human and machine interface of interaction described graphically in the user environment. To show the operator visually the results of user requests for communication software and also they may use the elements of augmented reality and virtual reality. A thin client cannot do mathematical operation to process project and production data and the requests of smart factory operator it can only re-direct all requests to the terminal server directly where they will be completed. A thin client example in cyber and physical production is a communicator (tablet, smartphone, laptop and other) functioning in a session with the terminal server with IoT protocols and which the operator can use to monitor the conditions of technological operations completion and situation control of the smart factory production activity. So the production operator is the initiator of an information exchange and the company calculation net which are done with software and technical means of a thin client.

A thick client is an end calculation device with installed application software oriented for the information processing. The thick client interacts with IoT net with a server by the technology of client and server. For a thick client a server is a remote data storage (production data, technological process algorithms, programs of numeric control and other) and a thick client process all the data and show the results to the operator with its own calculation resources. A thick client example in the Industry 4.0 production is a piece of automatic test equipment which with commands of the control program downloaded from the factory cloud environment initiates a check of the manufactured item resistance to the external factors influence. Work mode of test equipment is programmed by the smart factory operator according to its technical documentation. Functionality of compressors, gears, refrigerator and other test equipment is controlled with modes and algorithms as some codes of the control program.

A universal client is an end calculation device which is capable to work with the operator as a terminal and is capable to produce items automatically with integrated calculation means. A universal client example in Industry 4.0 smart factory client and server architecture is a cyber and physical system. Thick client function of cyber and physical system is supported with integrated controller to complete technological operations in the work chamber with algorithms of numeric control. CNC program is placed in a remote application and is delivered to the cyber and physical systems through the net according to the technological operations to be completed in production to manufacture the item. Thin client function in cyber and physical system is a terminal interface placed in the CPS control which is used for CPS programming by the operator in production.

The server part of the smart factory net infrastructure has a terminal server, application server and project and production data server placed in the company cloud environment (virtual). Application server and data server gives the operator and cyber and physical and test equipment access which are active internet agents to the company data bases. If the server part is divided in some independent servers it increases significantly the productivity of cyber and physical production calculation net in general. The server part software supports the multi-user mode of information exchange so that why
server resources of the smart factory cloud environment may connect a significant number of cyber and physical systems.

Client and server technologies to organize smart factory calculation net help to create environments of information exchange which can be scaled. Calculation net scaling is of module nature of the net constitution and it helps to increase the number of clients from different platforms and installed software without making the net topology being too complicated. In this case you need to make work together platforms and applications as a part of the same production company. To unite cyber and physical, test and communication equipment from different manufacturers and of different hardware platforms and operation systems (Windows, Linux, iOS and other) into a calculation net they need single communication protocols (for example TCP/IP protocols, Transmission Control Protocol/Internet Protocol). Universal communication protocols unify operator access methods and production equipment methods to the data with standard interface supported with hardware and software (communication software, operation systems and other) of cyber and physical systems.

3. Digital factory distributed calculation net architecture

A scheme of Industry 4.0 digital factory distributed calculation net architecture is given in figure 2. The net main components are: server equipment, thin, thick and universal clients connected to the wireless IoT net.

![Diagram of Industry 4.0 digital factory distributed calculation net architecture](image)

**Figure 2.** Industry 4.0 digital factory distributed calculation net architecture (CAD – Computer Aided Design).

Digital factory thin client is a communication device (tablet, smartphone) with installed web-application which is controlled by the operation system. Digital factory thin client function is to support designer project procedure oriented for digital replicas tests, item digital shadow and digital twin with modelling and virtualization. Web-application is for designer man-machine interface which supports Humane-to-Machine (H2M) technologies to control remotely modes and types of the item tests in the company.
Digital factory thick client is a work station (industrial computer) with its own calculation resources which is used for virtual tests of item digital replica, digital shadow and digital twins. Virtual tests are conducted with digital modelling placed in solid devices of universal clients. Virtual tests of digital models are done with tests and scenarios placed in server equipment. The virtual tests are controlled by the digital factory designer with technical and program means of a thin client.

Digital factory universal client is a computer (instrument PC) which is a part of the designer automatic work place with installed software for:

– automatic item designing and creation of construction, program and technological documentation;
– preparation of item 3D (D - Dimension)-model and its components and other.

Web-application of universal client provides the interaction of Industry 4.0 digital company designer and the server equipment to set up program components of automatic work place.

4. Conclusion

Industry 4.0 project and production company calculation net productivity is depended significantly on the pass-through ability of the wireless channels of IoT connection and the server equipment calculation resources. Also the productivity is highly depended on the number of net clients, transferring traffic volume and the number of hierarchy levels of calculation resources to divide company business logistics, project and production data, program applications and clients.

The increased network productivity in the net level must be done with implementation in the company not only wireless nets but also optical fiber nets to transfer the data. Optical fiber net can support data transferring industrial standards with Ethernet protocols and can be used to connect the stationary cyber and physical system and test equipment in production. An end communication device (tablet, smartphone and other) may preserve the information exchange with wireless channels of IoT connections.

Structural decisions how to increase calculation net productivity in the company is based on division of cloud environment server part into several independent components. Those components of high productivity are for user requests functioning in terminal mode and client serving who ask for company data base information can be done with application servers and data servers. This kind of approach will help to implement in companies highly-productive calculation nets which traffic among servers and clients is controlled with program and technical means (routers, commutators and other).

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