The e-objects family in simulation of mechatronic facilities

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Abstract. The very impotent modern industrial problem is to design a family of the mechatronic facilities electronic objects (e-objects). E-objects are an software of description of real mechatronic robotic objects being used in the engineering and production of future facilities. E-objects are placed in the cloud and let real mechatronic robotic objects to be described adequately and the properties of intelligent robotic systems (IRS), the properties of the device being manufactured, the properties of engineering and production processes, etc. To project e-objects is a component of the synthesis project problem of the future mechatronic robotic facilities. A family of e-objects, which are adequate for the product life-cycle is shown. The product life-cycle is shown. The place of each e-objects family are defined to realize product life-cycle.

1. Introduction

The simulation technologies development of the mechatronic robotic facilities led to creation of a new electronic objects (e-objects) family, which together form the future industrial facilities ecosystem \([1, 2]\). Mechatronic robotic \([3, 4]\) e-objects are virtual objects functioning with emerging technologies or the cloud components for intelligent robotic systems (IRS), which are equal to real IRS of the facilities infrastructure \([5, 6]\).

To develop e-objects and to implement them as the mechatronic robotic facilities cloud resources is done for automatizing \([7, 8]\):

- processes for mechatronic engineering facilities designers to complete procedures to synthesize complicated devices;
- processes to complete mechatronic manufacturing facilities within IRSs;
- processes to support of products exploitation being completed as the mechatronic facilities results of functioning.

Automation of the processes implemented at various stages of the product life-cycle is achieved by eliminating the manual labor of developers of engineering enterprises and replacing his with robotic automatic facilities and simulation tools using which key cloud procedures for developing and manufacturing products are carried out \([9, 10]\).

Engineering facilities implements e-objects, which helps the designer to create new forms of the devices and its manufacturing technologies based on the procedures being formed with emerging standards \([11, 12]\).
Manufacturing facilities implements e-objects, which helps the human and IRS to use the artificial intelligence methods to control devices manufacturing automatically [13, 14].

Exploiting facilities implements e-objects, which helps the customer to control the device transportation in the supply chains of its elements, service centers support to repair and maintain the devices, etc. [15, 16].

2. The e-objects family

The e-objects of mechatronic robotic facilities simulation can be classified as [17]:

- in the specialization of mechatronic facilities in device life-cycle;
- by the type of robotic operation being done by the agent (human, IRS, etc.) in the engineering or manufacturing;
- by the type of the engineering or manufacturing result represented as a e-object;
- by the type of mechatronic resource, which agent (humane, IRS, etc.) uses to prepare technical manual or to manufacture a device.

In the industry there are the following types of the e-objects actual for the simulation of mechatronic robotic facilities:

- an e-company, which is a industry organization oriented to project, production or exploiting. The e-company family includes: device e-engineering, e-manufacturing, e-exploiting;
- an e-process, which is supporting for sequences of project and production procedures, which are requirement to synthesize emerging forms of the device description, him to manufacture or exploitation. E-processes are subdivided into e-projection, e-production and e-logistics according to the area of the mechatronic facilities;
- an e-model, which is a form of an engineering facilities and manufacturing agent cloud description, which participate in particular of device life-cycle. An engineering or manufacturing infrastructure agent is mechatronic facility designers, IRS, device exploiting factories, etc. The e-models are subdivided into e-profile, device e-replica, e-shadow, e-twin;
- an e-resource, which is a service form being used by the engineering mechatronic facility and manufacturing infrastructure agent to prepare device electronic manual, to manufacture an device or to support an device in exploitation. The mechatronic robotic facility e-resources are e-bases (data e-banks and knowledge e-banks). The mechatronic infrastructure includes e-platforms, e-machines, e-devices and e-codes, which are placed in the cloud.

The e-objects family in simulation of mechatronic facilities is shown in figure 1.

An e-engineering is a process to synthesize the device description as an e-model being done in the mechatronic robotic facility using a IRS. The e-engineering base is simulation technologies and cloud tests technologies of products.

An e-manufacturing is a device automatic production process using software and industrial IRS family. The e-manufacturing is a component of the mechatronic process and function with robotics technology.

An e-logistics is a process of the computer control for assembly units supply chains and the device in general among subjects inside one big company or among companies (holding), for example, between an engineering and manufacturing facilities.

An e-replica is the first iteration of the e-model being completed as electronic documentation, which are subjects for simulation testing.

An e-shadow is an intermediate iteration of the e-model, which privately describes the device properties. An e-shadow includes chemical and mathematical equations, optical and radio-electrical schemes, design drawings and technological descriptions.

An e-twin is the final iteration of the e-model completed as a set of different device properties descriptions and which passed positively all types of simulation testing. An e-twin is a device description form, which in their properties is adequate to the real device.

An e-profile is a congregation of data to characterize the device being projected (being manufactured) or a specialist of mechatronic factory. A device e-profile contains its characteristics, results of the device
tests, device transportation data in exploitation, etc. A company specialist e-profile contains its personal data and defines the specialists access rights to the robotic facilities resources.

![Diagram of e-objects family in simulation of mechatronic facilities]

**Figure 1.** The e-objects family in simulation of mechatronic facilities.

A e-machine is a cloud computer, which is a part of the robotic facilities infrastructure and is capable of completing the functions of the thin, thick or universal client in the production within IRS.

An e-code is a software component (software documentation) of the device. An e-code is used to organize the engineering and manufacturing infrastructure technical agent control.

An e-device is a communication software resource is used to organize smart grids in the robotic facilities cloud. A smart grid of e-company is a component of mechatronic robotic infrastructure.

An e-platform is a set of e-machine and software, which are used to organize the processes of e-engineering, e-manufacturing and e-logistics of the devices. An e-platform resources are made with cloud server. An e-platform software include different e-models.

Data e-bank is a set of electronic materials include set of manuals to operate the engineering and production processes. The engineering and production data e-bank includes e-models obtained by the human from the previously made projects.

Data e-bank is a data bank, which contains ontology forms of description in the high emerging technologies. Knowledge data e-banks are used in e-companies for project, production and exploitation, to support humans informatively in all device life-cycle.

### 3. The e-objects in the device life cycle

The e-objects interaction scheme of the industrial ecosystem is shown in figure 2.

The initial e-object which is necessary to initialize the device engineering is the device e-profile which contains electronically all types of requirements given to the device being designed. The device e-profile is placed in the cloud and is available to human. Each designer is known in the e-company cloud with corresponding an e-profile. A human e-profile has some personal data of specialist and their access rights settings to the e-company resources.
Device engineering in a company is done by designers using e-objects like: e-process, data e-bank (knowledge), e-infrastructure. Mechatronic facility e-infrastructure is a set of interacting e-machine and software given to the designer a necessary bunch for project. An e-processes define the designer actions sequence as a result of which there must be a set of device manuals. Mechatronic data e-bank (knowledge) contains standards.

The result of the device engineering is a set of documentations, which generally is a type of device e-object known as a e-model. The device e-model according to the projection stage could be represented with e-objects like: e-replica, e-shadow, e-twin.

The electronic device model final iteration (e-twin) transmit to robotic manufacture. Mechatronic facility primary production process stages are done using e-objects of three types: e-infrastructure, e-process and data e-bank (knowledge).

![Diagram](image)

**Figure 2.** The e-objects interaction scheme of the industrial ecosystem.

Manufacturing infrastructure contains robotized machines of industrial IRS family. Mechatronic e-processes define robotic operations sequences, which must be done with IRS. Data e-bank (knowledge) is used by production infrastructure agents to provide IRS support in the device manufacturing.

The production process monitoring is done in a mechatronic facility by a human is represented in the cloud with an e-object like an e-profile. Mechatronic facility operator e-profile contains specialist
personal data and access rights settings for the production operator to the IRS.

Mechatronic facility functioning result is a device. Quality certificate is a component of the device e-profile. Quality certificate is done electronically according with the standards for each manufactured device sample.

Device transmit to exploitation, which life-cycle stages are realized in the industry. Device exploitation is done by mechatronic facility specialists represented in the cloud with corresponding e-profiles. Exploitation facility is based on application e-objects like: e-infrastructure, e-process, data e-bank (knowledge).

Device exploitation and evaluation of the device quality indications monitoring results are formed by the device designers propositions to correct device e-models.

4. Conclusion

The world tendency for the industrial led today to the creation of new IRS family. Such components are e-objects being implemented in all device life-cycle.

The e-objects family is defined by the types of emerging technologies and types of IRS hardware and software being used in e-companies. Today the e-objects cannot be classified definitively. With the development of technologies, methods and means of automatized new types of e-objects will be formed to increase the quality indications of e-companies.

The majority e-objects have the cascading property. So e-infrastructure could be formed as a result of interacting e-machines groups equipped with e-codes, interacted through peripheral e-devices. In industry an e-objects interaction form ecosystems, which include different e-companies.

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