Business Process Management of Virtual Enterprise based on Augmented Reality

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Abstract

Authors proposed a generalized structure of the information space for a virtual enterprise and developed the architecture of its core-virtual office using augmented reality (AR). The article reveals the essence and significance of virtual enterprises and their management. The basic principles of virtual enterprises are defined. The structural scheme of the organization of virtual enterprise management by means of the augmented reality is presented. The main features that reveal the meaning of the concept of "virtual office of a virtual enterprise" are identified. The paper offers a generalized structure of the information space of a virtual enterprise with augmented reality and developed the architecture of its main virtual office using augmented reality. Implementation of the information space of a virtual enterprise with augmented reality is possible with the help of the following blocks of the control system: complex process models; process optimization algorithms; dynamic model of operational management. The main components of the virtual office architecture of a virtual enterprise with the use of augmented reality are presented. The main resource for managing a virtual office is the enterprise knowledge base, in which employees can quickly find information to make the right decision and understand each other. Based on the simulation experiment, the equation of the online store (as an example of a virtual enterprise) in modes without and using augmented reality is compiled. The creation of models and the modeling process itself takes place in the AnyLogic modeling environment. The results of the experiment confirmed that the use of augmented reality can reduce the processing time of orders in three times. All 1000 orders are processed in 17 hours. Manpower was fully utilized. Further research will be the development of an integrated virtual environment for virtual enterprises using augmented reality.

Keywords 1

augmented reality, virtual enterprise, virtual office, simulation model.

1. Introduction

The development of the global economy and the emergence of information and communication technologies have given rise to a new – virtual structure of enterprise organization. A virtual enterprise (VE) is a temporary alliance of enterprises that come together to share core competencies and resources to better organize a multi-project business to realize market opportunities and whose collaboration is based on networking. A virtual organization is formed by selecting of human, economic, material, organizational, scientific, technical and other resources from different companies and their integration using computer networks. This one makes opportunity of creation a flexible and active organizational system, which is more adapted to the fastest release and timely delivery of a new product to the market.

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That is, the creation of a virtual enterprise means the integration of unique experience, production capabilities and advanced technologies of partner companies to implement a project that cannot be performed by each of the partners separately. In this today, augmented reality comes to the aid of virtual enterprises. World sales of goods and services related to augmented and virtual reality technologies, from 11.4 billion dollars. In 2017 will increase to almost 215 billion dollars. in 2021, according to IDC analysts [1]. Thus, the average market volume will grow annually by 113.2%.

There are already companies in the world that are actively investing in augmented reality, companies usually implement this technology for specific scenarios to solve certain business problems. It is primarily about increasing productivity and increasing efficiency. In the coming years, augmented reality will master a number of specific areas: on-site service, logistics, warehousing, repair, design, management and many other areas.

In addition, the development of practically implemented augmented reality models and substantiation of proposals for business process management of a virtual enterprise based on them remain unresolved.

2. Related Work

The system [2] performs local face detection and face tracking on a device (e.g. a smartphone) and then refers to a cloud service to recognize faces based on the user's personal contact list (gallery). Authors [3] describe how to use AR for enriching the Konzerthaus Berlin printed media. It has been studied [4] that construction management students easily perceive augmented reality, which has a cognitive benefit in educational institutions. Authors [5] proposed to implement AR for improving the Grow Box System in smart house within IoT environment. The effects of using AR in joint project management teams with special attention to motivation and emotional activation have been studied [6]. The methodology of using AR and implementation in real industrial research in cooperation with a small enterprise in the sector of used electronic and electrical equipment and waste (UEEE / WEEE) is proposed [13].

In [14] augmented reality user interfaces and control of automated systems based on information about user activity and preliminary preparation of information are presented. Authors [15] developed the concept of VR hypermodel solution for visualization, navigation and interaction with ArchiMate models and business process modeling notations in VR is presented.

In [8] the Enterprise Architecture Framework for Cities has been proposed to support their reasonable maneuverability in spatial data to create value-added services through a variety of shared networks or virtual enterprises that span organizational boundaries. In [9] the so-somatic solution for assessing the readiness of joint technologies for Industry 4.0 for virtual enterprises is proposed. A Reference [10] presents international social entrepreneurship as a form of social entrepreneurship that uses innovative technologies supported by information and communication technologies and a network with international partners as a virtual network of enterprises to create social and economic values abroad. In [11] a proposal is considered based on the digital economy to create environmentally friendly virtual enterprises and implement the correspondent solutions for products and services. In [16] an integrated information system is developed for modelling the changes of key parameters of IT projects using cloud data warehouses and was proposed a method for analyzing the effects of changes on the terms of project execution. In [17] was developed the strategy of proactive formation of project team competencies within an industrial enterprise to form a project team considering the accumulated experience and knowledge of its participants.

In general, it can be noted that despite the importance of the research, the above references do not offer specific concepts of virtual enterprise management based on augmented reality. Therefore, the purpose of this paper is to improve the management of business processes of a virtual enterprise on the basis of augmented reality.

3. Virtual Enterprise Management with AR

For a virtual enterprise, the functioning of a virtual team and a virtual office is important. In a virtual team, members are geographically distant from each other and connected through electronic

communication channels, performing common tasks using applications to support group work. enterprise based on the principles of teleworking, which means work outside the office, for example, work at home, mobile work. This is why the use of augmented reality (AR) is important for a virtual enterprise.

Virtual enterprises are based on the following principles:

first – the rejection of the enterprise territorial integrity;

secondly – partners for the production of a joint product exist as long as their supplies meet quality standards and the manufacturability level;

third – in the global economy, partners must be sought around the world;

fourth – it is profitably to have a flexible structure of enterprise, with maximal efficient in using of existing and acquired resources;

fifth – in the conditions of fast development of technologies it is unprofitable to invest big money in purchasing of equipment or large buildings, especially if it is not known what volume of production will be let out;

sixth – it is desirable to reduce non-production costs, this is primarily related to management.

To build an effective virtual enterprise, it is necessary to solve two basic tasks:

- develop a functional and organizational framework of the virtual enterprise (determine the rules of virtual enterprise and form a model of a combined information space);
- develop an operational management system designed to solve the problems of operational distribution of individual technological operations in accordance with available resources of the participants of the virtual enterprise (agents) and further coordination of activities in the process of fulfilling the customer's order.

The issue of management system development is the most complex, as process management in a virtual enterprise is associated with a number of features: unstable system structure and related management flexibility requirements, the processes complexity increases many times due to cooperation of different enterprises, expanding search space due to the increasing degree of processes complexity, the presence of several distributed sources of information that must be coordinated in real time using AR (Fig. 1).

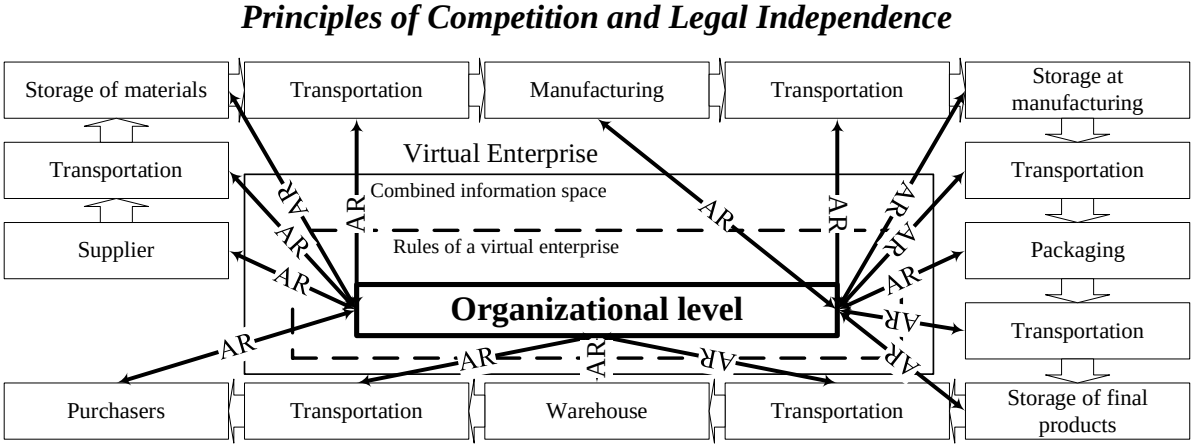

Figure 1. Block diagram of the organization of virtual enterprise management using AR

The introduction of information technology should be accompanied by a change in business processes and enterprise's principles. This led to the emergence of the process modeling stage in transition to new forms and the creation of a methodology for changing processes, the introduction of process management principles in enterprises and obtaining a basis for the introduction of information technology[18-26].

The Internet and Web 2.0 technologies are potentially relevant for internal collaboration and knowledge management for both the virtual office and the virtual enterprise. This has led to the

widespread establishment and use of so-called corporate social networks, which are internal tools of Web 2.0. Typically, these internal networking jobs are available through the most common devices: browsers on laptops and desktops or other portable devices such as iPads or smartphones. However, technological advances are further pushing the boundaries of IT availability. In particular, smart glasses with AR, are the latest advances in information and communication technologies. For example, smart AR glasses are worn like regular glasses, and include virtual information in the user's field of vision, the so-called information "at hand" during operation. Bright examples are Google Glass, Elbit / Everysight Raptor, Microsoft HoloLens, or Epson Moverio.

The virtual enterprise management system should be built taking into account of two main aspects: on the one hand, the network approach; on the other hand, combined system should be formed to provide the necessary communications to all employees and virtual enterprise systems to support the necessary work processes.

The information space of a virtual enterprise is an environment for the integration of various information systems and the basis for coordinating the activities of agents of a virtual enterprise.

Previous analysis showed that the architecture of the information space of a virtual enterprise with AR should include the following elements (Fig. 2) functional "core" and a common "virtual" information space.

The key element (functional core) of the presented architecture is the center of business process management and coordination, in particular:

- planning and managing the execution of customer orders (analysis of the external environment, configuration of the process of creating value and distribution of work between agents);
- analysis of the implementation of processes (identification of the causes of deviations of the actual values of individual elements of the processes with the planned);
- accumulation of information on the best process configurations for further use and improvement.

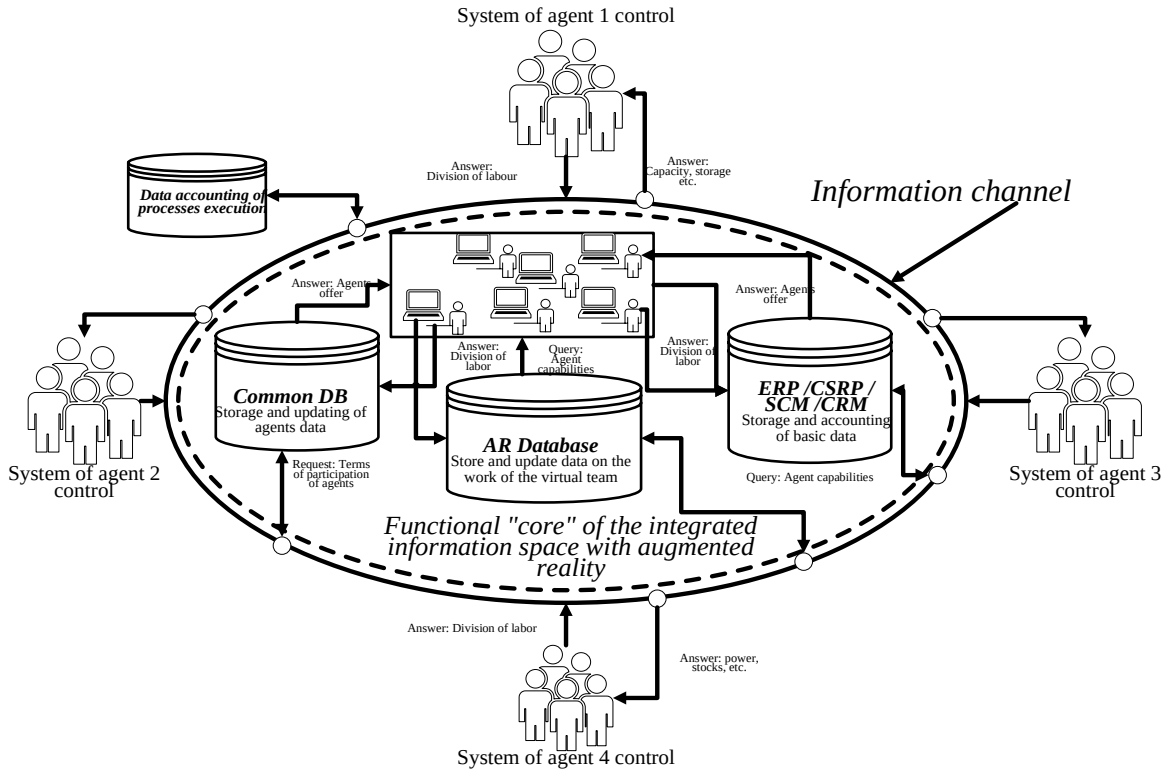

Figure 2. The general scheme of architecture of information space of the virtual enterprise with AR

The virtual enterprise coordination center can be implemented in the form of a virtual office with AR, which ensures the functioning of the virtual enterprise on the basis of computer networks in real time, taking into account the territorial distribution of virtual enterprise objects. Based on this, the virtual office architecture of a virtual enterprise using AR includes the following main components (Fig. 3):

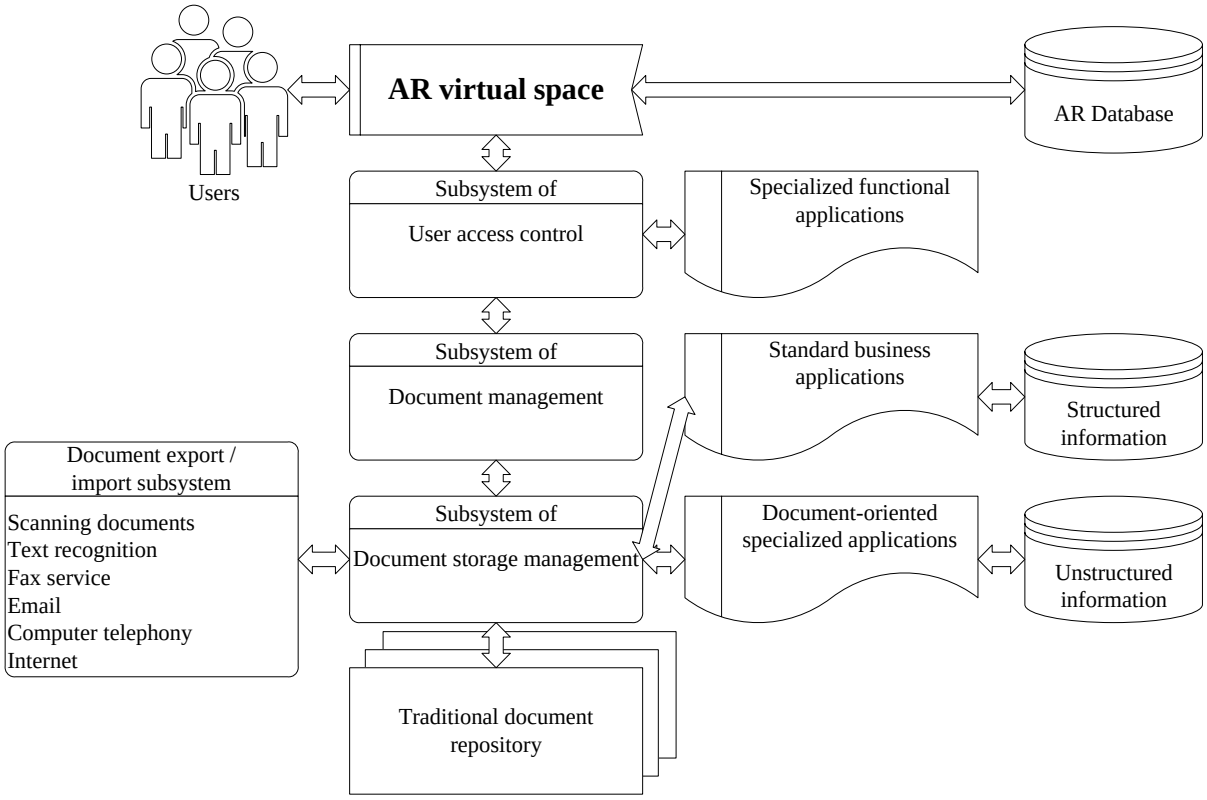

Figure 3. Virtual office architecture using AR

- local networks and the Internet;
- international standard for data exchange, for example for STEP (Standard for the Exchange of Product model data);
- application interoperability standards, such as Common Object Request Broker Architecture (CORBA) standards;
- AR object description standard – ARML 2.0 language.

The main features that reveal the meaning of the concept of "virtual office of virtual enterprise" are the following:

- integration of the best tools and experience in different companies within the strategically appropriate management team of company;
- organization of business around key processes (end-to-end business processes of the projects and products life cycle);
- education of autonomous working groups, ensuring cooperation and coordination of individuals and teams, spatially distant from each other;
- temporary nature, flexibility, the possibility of rapid education, development, restructuring and disbandment at the right time;
- a combination of decentralization and centralization in management with the predominant development of decentralized (distributed) management, the priority of coordination;
- the widest possible distribution and flexible redistribution of power, decision-making at all levels of the organizational hierarchy, a combination of communication ascending and descending;

- organization of specialists' group interaction using computers, including "meeting on the network" and coordinated workflows, ensuring the free exchange of ideas within and between the organizational hierarchy levels;
- development of heterogeneous computer environments and networks, using of client-server architecture, the use of groupware (classware).

Software-communication environment of the virtual office is based on continuous information support of the company's life cycle.

The information support of the virtual office can have different basic technology of information transmission and storage. Paper documents, letters and notes, bulletin boards, corporate newspapers, telephones – all this is a traditional technology for information storing and transmitting. From the information point of view, communication is the knowledge search and transfer within business processes. There are three major groups of methods for managing information support of business processes, including:

- Representation of office and managers activities in terms of resources (finance, inventory, staff), while ensuring resource management and control.
- Presentation of the office work and managers as a system of business processes. Here the central concepts are: process, function, data, event. The main purpose of management for these methods is to ensure coordination of events and functions.
- Representation of the office and managers as a system of small teams of staff who solve a common problem, and in the role of organizing factors are knowledge and effective communication.

The main resource of management is the knowledge base of the enterprise, in which employees can quickly find information to make the right decision and understand each other. This base concentrates the team's collective experience and creates the context of corporate communications. The main purpose of management is to ensure coordination, communication and rapid search for information for independent decision-making.

4. Simulation of Business Processes of Virtual Enterprise Management with AR

An important resource for managing a virtual enterprise is a knowledge base in which can be quickly found information to make the right decision. However, the development of a single information space of a virtual enterprise is a labor-intensive and costly project, so it is worth evaluating the benefits of using AR in the management of a virtual enterprise.

Conducting a conference in the developed AR Remote Assistant, will look like following (Fig. 4). Development of video chat for project management of a virtual enterprise is carried out in Unity3D. Unity Editor has a simple Drag & Drop interface that is easy to customize, consisting of different windows, so it is possible debugging of 3D visualization directly in the editor.

The developed application gives only a small part, the possibility of AR using in project management. Therefore, for further development it is necessary to consider opportunities: in working with documentation processes, displaying best practices in the project, frequently asked questions, error analysis, contact information and others. That is, the information that users need, as they say "at hand" during operation.

Consider this on the example of the business process of planning and managing the execution of customer orders (see Figure 2) in the online store – a kind of virtual enterprise. For the experiment, we will simulate the functioning of the online store in the normal mode (without the use of AR) and in the mode using AR, which will reveal the amount of time spent from ordering goods to delivery to the customer. The creation of models and the simulation experiment itself was implemented in the AnyLogic modeling environment.

Figures 5 and 6 show the process of ordering goods in an online store as an object that can be a virtual enterprise, here is the ordinate – the number of orders, here is the abscissa-time, h.

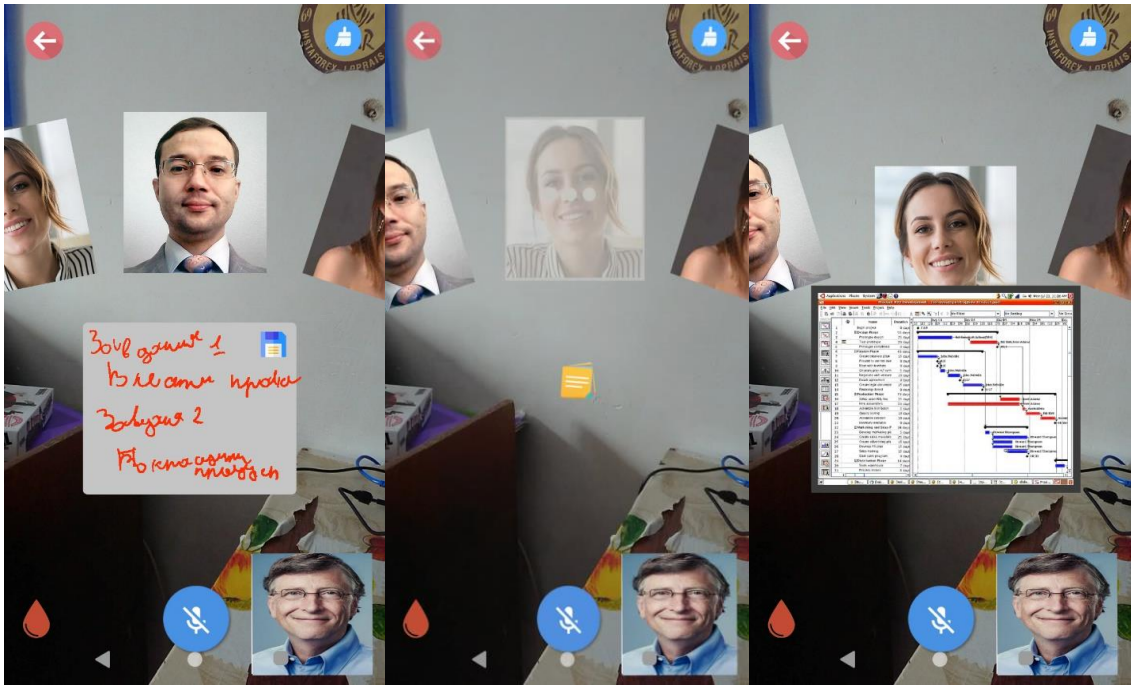

Figure 4. Conference in AR Remote Assistant

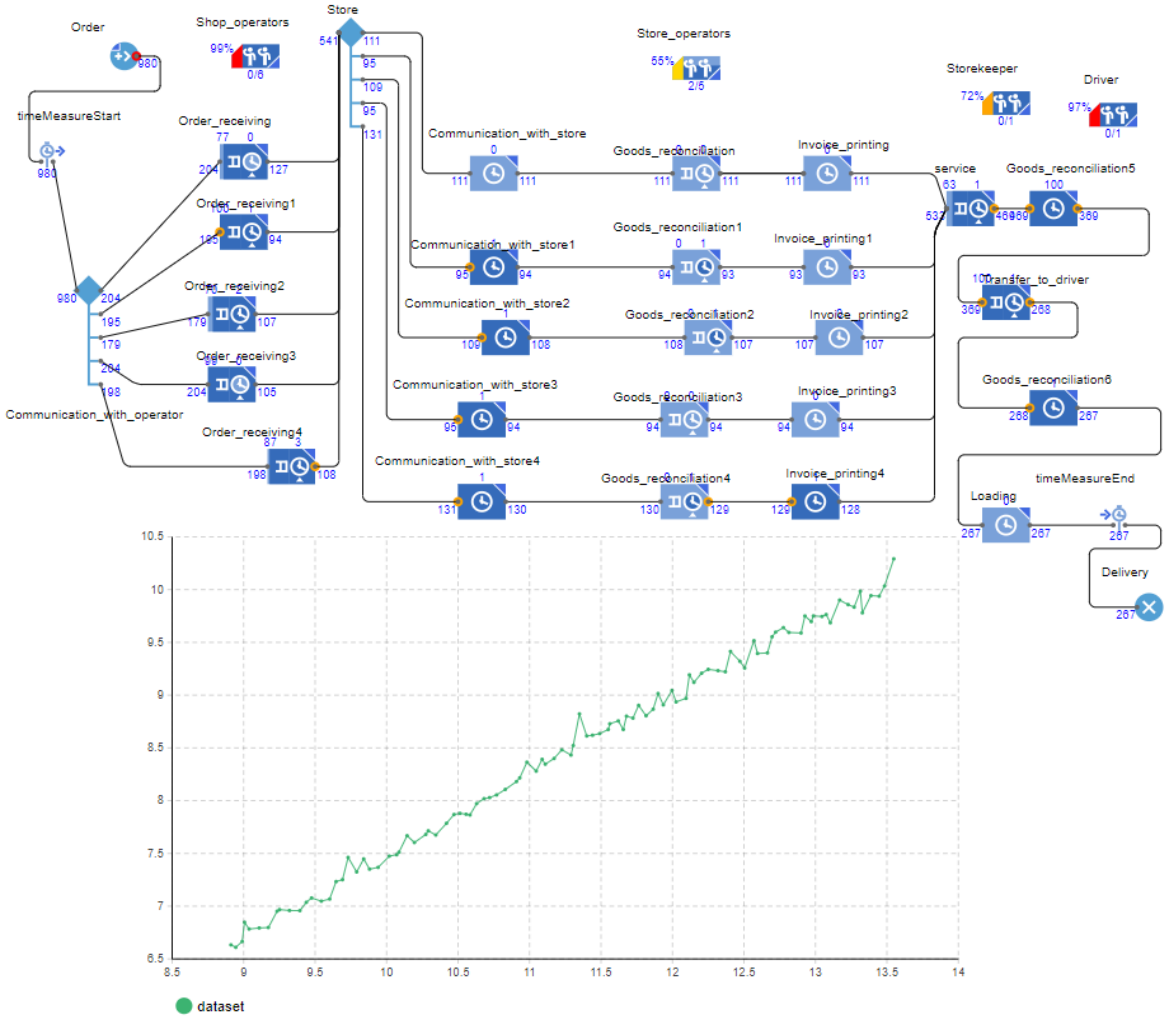

Figure 5. Process modeling of online store operation without using AR

At the first stage, customers form an application. Orders are transferred to operators (5 people) who accept orders and contact the store operators (5 people), who check the availability of goods in store and print invoices. Invoices are handed over to the store operator (1 person), who inspects the goods with the invoice and transfers it to the driver for delivery (1 person). The driver of delivery again compares the goods with the consignment note and transfers them for loading, after which the goods are delivered to the customer.

Therefore, we will perform modeling for 1000 orders (Fig. 4), for modeling we selected data from the popular site Rozetka [12], which states that 70 orders are processed per hour. An error occurred after 267 processed orders, due to the fact that the store operators were overloaded and did not have time to process the order. Accordingly, the simulation of the model suspended for 13.5 hours of operation of the online store. Of course, it can increase the number of operators, but this will lead to constant additional costs.

Consider the structure of the model of the online store using AR (Fig. 6). After receiving the order, the operator with the help of AR verifies the goods in the warehouse and forms an invoice directly in the system, which significantly reduces the cost of time. Next, store operator and driver of delivery in the accelerated mode (due to the presence of AR) perform the operations described above.

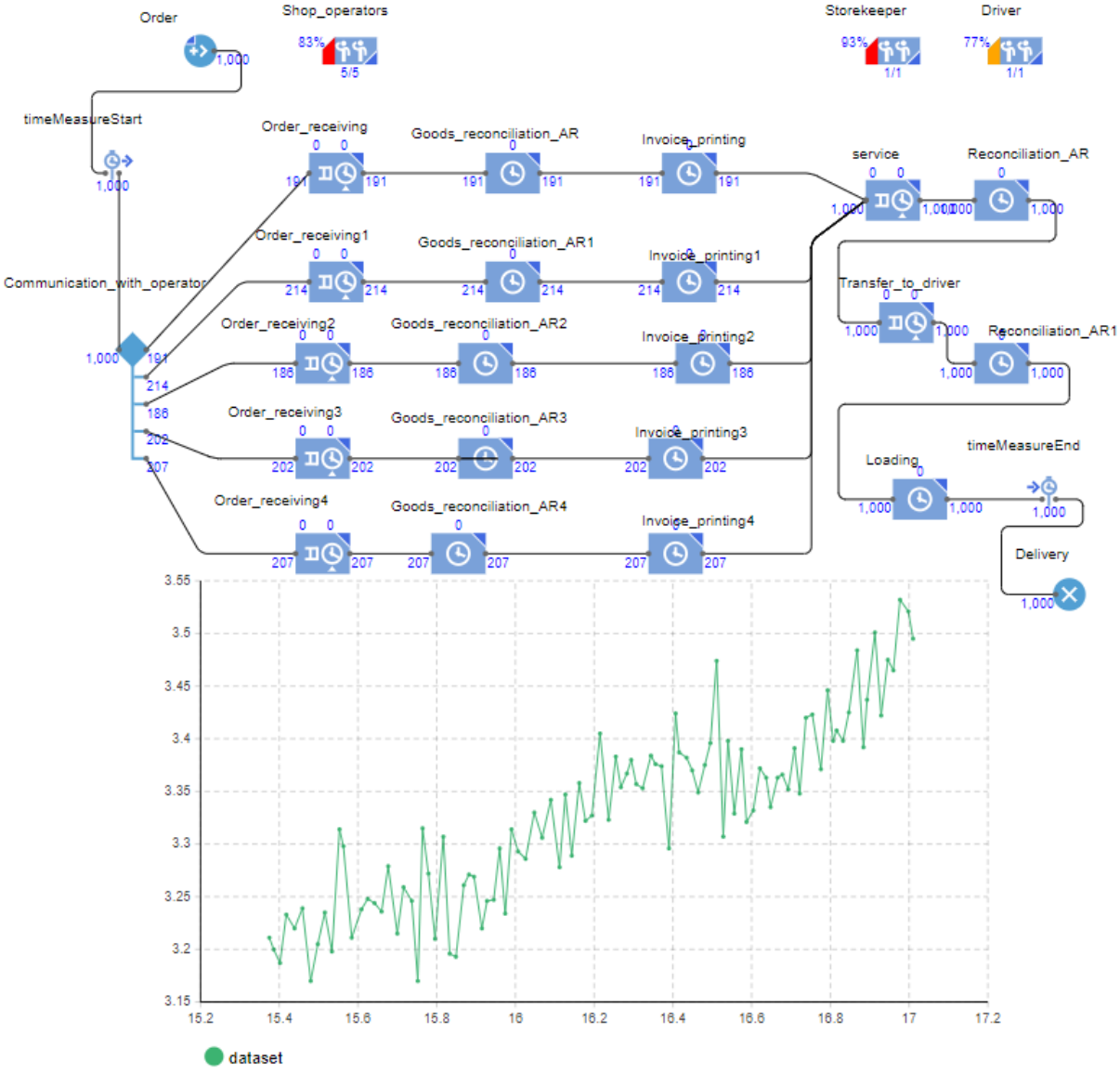

Figure 6. Process modeling of online store operation using AR

Next, we will simulate the work of the online store using AR (Fig. 6). The input data for modeling, selected the same as for the operation of the online store without the use of AR. All 1000 orders processed in 17 hours. Labor resources were fully used. If we compare both models (see Fig. 5 and Fig. 6), it is easy to calculate that the use of AR can reduce the processing time of orders by about 3 times. In addition, the use of AR makes it possible to reduce labor resources, namely the shop operator can easily perform the work of a store operator. Therefore, the use of AR in the work of the online store, allows three times faster to process orders compared to the existing approach. and makes it possible to increase the workload on employees to 109 orders per hour.

5. Conclusions

The generalized structure of the information space of the virtual enterprise is offered and the architecture of its core – the virtual office with the use of augmented reality is developed. The advantages of using AR in the management of a virtual enterprise are evaluated on the example of the business process of planning and managing the execution of customer orders within the online store – a kind of virtual enterprise. To do this, a simulation experiment was conducted and a comparison of the online store in modes without and using AR. It is shown that the use of AR can reduce the processing time of orders by three times. Moreover, the use of AR makes it possible to decrease labor resources, namely the store operator can easily perform the work of a warehouse operator. The direction of further research will be the development of an integrated virtual environment for virtual enterprises using augmented reality based on a virtual project approach-innovative web-based project management Software.

6. References

[1] International Data Corporation, URL https://www.idc.com/

[2] M. Kurze, A. Roselius, Smart glasses linking real live and social network's contacts by face recognition. In: Proceedings of the 2nd Augmented Human International Conference on AH'11, article no. 31 (2011) 1-2. doi: 10.1145/1959826.1959857

[3] J. Letellier, J. Reinhardt, P. Scholl, J. Sieck, & M. Thiele-Maas, Providing adittional cotent to print media using augmented reality. International Journal of Computing 17.3 (2018): 180-189. Retrieved from https://computingonline.net/computing/article/view/1038

[4] J. Kim, J. Irizarry, Evaluating the use of augmented reality technology to improve construction management student's spatial skills. International Journal of Construction Education and Research (2020): 1–18. doi: 10.1080/15578771.2020.1717680.

[5] V. Turchenko, I. Kit, O. Osolinskyi, D. Zahorodnia, P. Bykovyy, A. Sachenko, IoT Based Modular Grow Box System Using the AR. In: Proceedings of the International Conference Problems of Infocommunications. Science and Technology, PIC S&T'2020, 6-9 October 2020, Kharkiv, Ukraine.

[6] N. Schiffeler, V. Stehling, M. Haberstroh, I. Isenhardt, Collaborative Augmented Reality in Engineering Education. In: Proceedings of th International Conference on Remote Engineering and Virtual Instrumentation. Springer, Cham, (2019) 719-732.

[7] Virtual Project – Project Management download | SourceForge.net

[8] S.A. Petersen, Z. Pourzolfaghar, I. Alloush, D. Ahlers, J. Krogstie, M. Helfert, Value-Added Services, Virtual Enterprises and Data Spaces Inspired Enterprise Architecture for Smart Cities. In: Camarinha-Matos L., Afsarmanesh H., Antonelli D. (eds) Collaborative Networks and Digital Transformation. PRO-VE 2019. IFIP Advances in Information and Communication Technology, vol 568. Springer, Cham, (2019) 393-402. https://doi.org/10.1007/978-3-030-28464-0_34.

[9] A. Ramzan, S. Cisneros-Cabrera, P. Sampai, N. Mehandjiev, N. Kazantsev, Digital Services for Industry 4.0: Assessing Collaborative Technology Readiness. In: Themistocleous M., Papadaki M. (eds) Information Systems. EMCIS 2019. vol. 381 of Lecture Notes in Business Information Processing, Springer, Cham, (2020) 609-622. https://doi.org/10.1007/978-3-030-44322-1_45.

[10] A. Javed, M. Yasir, Virtual social enterprise: modeling sustainability of an enterprise by digital intervention. World Journal of Entrepreneurship, Management and Sustainable Development 15.2 (2019): 182-196. https://doi.org/10.1108/WJEMSD-03-2018-0032.
[11] F.Z. Schardosin, C.R. De Rolt, A.M.L. Batista, C.A. Bier, A.A. Lentez, Green Virtual Enterprise Breeding Environment: A Proposal of Web Platform Model for a Circular Economy. In: Camarinha-Matos L.M., Afsarmanesh H., Ortiz A. (eds) Boosting Collaborative Networks 4.0. PRO-VE 2020. IFIP Advances in Information and Communication Technology, vol 598. Springer, Cham (2020): 71-80. https://doi.org/10.1007/978-3-030-62412-5_6.
[12] Rozetka Marketplace, URL https://seller.rozetka.com.ua/newseller/ua
[13] K. van Lopik, M. Sinclair, R. Sharpe, P. Conway, & A. West, Developing augmented reality capabilities for industry 4.0 small enterprises: Lessons learnt from a content authoring case study. Computers in Industry, Elsevier, 117, (2020): 103208.
[14] M. E. Carroll, Providing Augmented Reality User Interfaces and Controlling Automated Systems Based on User Activity Information and Pre-Staging Information. U.S. Patent Application No. 16/984,244 (2020).
[15] R. Oberhauser C. Pogolski, VR-EA: Virtual Reality Visualization of Enterprise Architecture Models with ArchiMate and BPMN. In: Shishkov B. (eds) Business Modeling and Software Design. BMSD 2019. Lecture Notes in Business Information Processing, Springer, Cham, vol. 356 (2019): 170-187. https://doi.org/10.1007/978-3-030-24854-3_11
[16] V. Pasichnyk, V. Lytvyn, N. Kunanets, R. Vovnyanka, Y. Bolyubash, A. Rzheuskyi, Ontological approach in the formation of effective pipeline operation procedures, in: 13th International Scientific and Technical Conference on Computer Sciences and Information Technologies, vol. 2, 2018, pp. 80–83.
[17] V. Pasichnyk, N. Kunanets, N. Veretennikova, A. Rzheuskyi, M. Nazaruk, Simulation of the Social Communication System in Projects of Smart Cities, in: Proceedings of the 14th International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT 2019, 2019, pp. 94–98.
[18] M. Odrekhivskyy, V. Pasichnyk, A. Rzheuskyi, V. Andrunyk, M. Nazaruk, O. Kunanets, D. Tabachyshyn, Problems of the intelligent virtual learning environment development. CEUR Workshop Proceedings 2386 (2019) 359–369.
[19] R. Kaminskyi, N. Kunanets, V. Pasichnyk, A. Rzheuskyi, A. Khudyi, Recovery gaps in experimental data. CEUR Workshop Proceedings 2136 (2018) 108–118.
[20] A. Rzheuskyi, H. Matsuik, N. Veretennikova, R. Vaskiv, Selective Dissemination of Information – Technology of Information Support of Scientific Research. Advances in Intelligent Systems and Computing 871 (2019) 235–245.
[21] R. Kaminskyi, N. Kunanets, A. Rzheuskyi, A. Khudyi, Methods of statistical research for information managers, in: Proceedings of the 13th International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT 2018, 2018, pp. 127–131.
[22] A. Kazarian, N. Kunanets, R. Holoshchuk, V. Pasichnik, A. Rzheuskyi, Information Support of the Virtual Research Community Activities Based on Cloud Computing, in: Proceedings of the 13th International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT 2018, 2018, pp. 199–202.
[23] A. Rzheuskiy, N. Veretennikova, N. Kunanets, V. Kut, The information support of virtual research teams by means of cloud managers. International Journal of Intelligent Systems and Applications 10(2) (2018) 37–46.
[24] E. Vasilevskis, I. Dubyak, T. Basyuk, V. Pasichnyk, A. Rzheuskyi, Mobile application for preliminary diagnosis of diseases. CEUR Workshop Proceedings, 2255 (2018) 275–286.
[25] A. Rzheuskyi, N. Kunanets, V. Kut, Methodology of research the library information services: the case of USA university libraries. Advances in Intelligent Systems and Computing 689 (2018) 450–460. doi:10.1007/978-3-319-70581-1_32.
[26] H. Lypak, V. Lytvyn, O. Lozynska, R. Vovnyanka, Y. Bolyubash, A. Rzheuskyi, D. Dosyn, Formation of Efficient Pipeline Operation Procedures Based on Ontological Approach. Advances in Intelligent Systems and Computing 871 (2019) 571–581.