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SOME INFORMATION COMMUNICATION TECHNOLOGIES IN LOGISTICS AND SUPPLY CHAINS

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Abstract

The digitization process, imposed by the rapid development of electronics, the Internet, the availability of IT, new software, devices, networks, and platforms, is gaining an almost unlimited reach. The concept of process visualization initially appeared as a comprehensive term for obtaining and using data and information with the application of new information and communication technologies (ICT) in the economy and beyond, intending to fully characterize the process with specific key performance indicators (KPI), which would enable its users to better insight into the state of their processes, vehicles, devices, people, at any time, from any place, according to the principle of each-and-everyone. The paper presents systematized communication technologies and services in the cloud that are in use or under development. The division into groups of technologies was made according to the functions significant in logistics and supply chains. Some of the technologies analyzed are described in brief. The work aims to present to businessmen and researchers some of the new technologies that are significant for their areas of business and interest so that they can direct their activities toward that area.

Keywords: *Management, logistics, supply chain, services, cloud technology.*

1 INTRODUCTION

The term Industry 4.0 first appeared in 2011 in Germany. It is a term that interprets the vision of the future *Smart factory*. It can be defined as the embedding of sensors into smart devices and integrating them into digital and physical processes for direct communication. The essence is in the application of IoT, which represents the comprehensive connection of machines, products, systems, and people for mutual communication in the virtual market, managing each other, and creating a continuous connection between the virtual and physical world regardless of geographical and organizational boundaries. In parallel with the development of I4.0, the complexity of logistics also developed. Nowadays, Logistics 4.0 is in development aiming to become Smart logistics, which means Smart products and Smart services and requires the application of automatic storage and sorting systems with new

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software for managing warehouses, intelligent containers, greater use of self-propelled vehicles (AGV), the application of Robot-as-a-service (RaS) robots, drones for monitoring inventory status with faster scanning of bar codes from cargo, etc., which will fully support intelligent production. Work technology in supply chains (SC) develops in parallel with logistics. Now, SC4.0 requires the application of IoT/IIoT, the use of robotics, the use of Smart Environment Sensor (SenS) and SenS+, which are specific stereoscopic cameras for detecting obstacles during the operation of machinery and vehicles in intralogistics, machines and devices in production, the application of predictive analytics with the possibility of processing a large amount of data from all SC processes and for all users, the application of as much automation as possible, AI/ML, Blockchain and others. According to (Salem, 2018), the variety of devices and their interoperability requires mutual free communication, security, simplicity of installation, and ease of use. The author particularly mentions the importance of standardization of data and applications with a full-control approach (controlled, inoperable, or open source).

Digital transformation is the most significant business trend of our time and includes digital transformation:

- within a company through the digitalization of its business functions (bookkeeping, finance, TPS processes, digital self-driving vehicles...),
- between the company and its clients through the digitalization and transformation of relationship management to customers, marketing automation, electronic commercial business (E-com), through electronic ordering and payment, electronic data processing and exchange, electronic catalogs, etc.), and
- throughout the entire value chain of business networks, from suppliers of materials and finished products, procurement processes, distribution partners, banks, end users, and everyone participating in the global SC.

2 COMMUNICATION TECHNOLOGY IN LOGISTICS AND SUPPLY CHAINS

As a concept, network technology IoV (Internet of Vehicles) is a part of IoT/IIoT and represents the fastest-growing technology today. It is realized in most cases by the wireless transmission for analysis and data processing between different devices via communication networks (GSM, UMTS, HSPA, HSDPA, and LTE), hosting units for data processing, the user interface for data access, and their processing and analysis. Many communication technologies have been developed or are developing for the one-way or two-way exchange of data and information under the general name of Vehicle-to-Anything/Everything (V2X/C2X)[1] and Cellular Vehicle-of-Everything (C-V2X) radio technologies between vehicles and other entities that can affect the movement of the vehicle or vice versa. A series of specific communication technologies have been developed or are in development. Some examples are (Tahir, Leviakangas, & Katz, 2022):

- Vehicle-to-vehicle (V2V), direct vehicle-to-vehicle communication, with the exchange of data and information in real-time with vehicles from the immediate environment at distances of up to 300m. The technology is used to transmit and receive data about current vehicle locations, speed between vehicles, and safe traffic communication, according to the ISO/TS 19091:2019 standard, are:
- Vehicle-to-infrastructure (V2I)/I2V or Vehicle-to-Roadside (V2R) communication with the infrastructure elements of the road (light signaling, line markers, parking space restrictions, etc.).
- Vehicle-to-pedestrian (V2P), communication with pedestrians and cyclists.
- Vehicle-to-network (V2N) technology enables the communication between cars, trucks, buses, traffic signals, and lanes, and unexpected events on the road with obtaining directions for further movement using mobile wireless networks such as Long-Term

[1] Depending on the language, two terms with the same meaning V (Vehicle, in the USA, in further notation) and C (Car, in Europe) are used.

Evolution (LTE), 3G but above all 4G) or C-V2X communication based on a cellular network (5GTN-5G Test Network)/IEEE 802.11p.

- Vehicle-to-grid (V2G) technology is still being developed. The idea is to use batteries in electric cars and trucks more efficiently as power sources in the electrical grid based on real-time power requirements. For energy exchange between electric vehicles (EVs and V2G batteries) and the public electricity grid, it is necessary to share the positional coordinates of the vehicle in communications:
  - Vehicle-to-building (V2B) energy exchange during the movement of the vehicle to the workplace (business building),
  - Vehicle-to-home (V2H) at home (apartment) when parking and
  - Vehicle-to-load (V2L), exchange at transshipment, loading and unloading points in warehouses and terminals.

  V2B and V2H support energy use in private homes and commercial buildings, while V2G responds to network conditions and thus supports the network. These technologies' application increases energy efficiency, and the total capacity of electricity production improves stability, reliability, and network efficiency. Bidirectional electronic converters, namely AC-DC (BADC) and DC-DC (BDC) are commonly used for easier G2V and V2G power transfer between the grid and EV battery. Bi-directional converters have been successfully developed and implemented in V2G systems. They help to achieve very efficient energy conversion. The growth of such converters and charging stations will help transition from conventional to electric vehicles, and ultimately lead to a green environment.
- Brain-to-vehicle (B2V), a technology pioneered by Nissan that connects the driver's brain to his car, still is not in use. This technology could radically change the future of driving and traffic safety.
- Platooning, the technology will connect two or more goods vehicles in a caravan to reduce fuel consumption and CO_2 emissions, improve safety with automatic braking, and increase efficiency.
- Vehicle-to-device (V2D), talking from vehicle to device via Bluetooth/Wi-Fi Direct, Apple CarPlay, and Google Android Auto applications,
- Vehicle-to-cloud (V2C), communication in the cloud about vehicle diagnostics and maintenance via electronic control unit Diagnostics over Internet Protocol (DiIP).
- Infrastructure-to-infrastructure(I2I) is a communication between infrastructural elements that are in contact with each other, placed on the road, and through which information about traffic situation control, traffic jams, and traffic accidents is delivered.

In SC, the situation is somewhat more complex because there are several subjects in the business organization: the cargo owner as the sender or his forwarder, the consumer as the end user of the goods (cargo), state authorities, customs, control, and insurance companies, etc.) and logistics providers providing different services from 1PL-5PL, Figure 1.

Business-to-business (B2B) technology refers to trade between companies on a wholesale basis. Close connected is the B2B subclass Business-to-employee (B2E), where the traffic focuses on managing activities within the company. If the business process involves a company and the retailer, it can be considered as the Business-to-client (B2C) model.

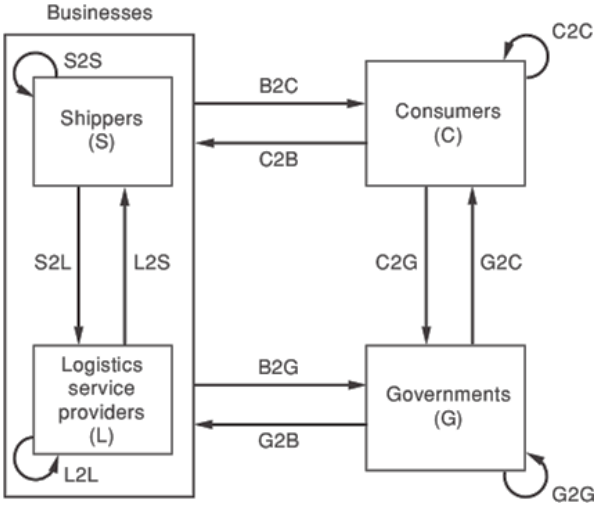

Figure 1. Possible forms of communication in logistics and supply chains
Source: (Yoshimoto & Nemoto, 2005)

In the transaction between the company and the end user, in the Direct-to-consumer or Direct 2 Consumer (D2C) notation, the transaction is carried out without intermediaries, where the companies will build, market, sell, and deliver the product directly to the customer at a lower prices than the intermediaries who use traditional retail business models and maintain end-to-end control of business operations. In commercial business, it is often necessary to provide the appropriate documentation accompanying the goods from state authorities, such as transit permits, quality certificates, insurance of goods, etc., whereby companies communicate with state authorities that issue documents, and vice versa. Such technologies are Business-to-Government (B2G), Customer-to-Government (C2G), Government-to-Customer (G2C) and (Government-to-Government (G2G). Consumer-to-Consumer (C2C) technology), achieved when wholesalers directly sell goods or services to end consumers online and perform consulting services, various auctions and transactions, personal services, etc., and all by the Law on Electronic Commerce. The mentioned communication technologies are implemented in both directions, directly P2P (Peer-to-Peer) and online via the Internet.

3 SERVICE APPLICATIONS IN THE CLOUD

Recently, the integration of computing into Cloud Computing Services (CCS) has been increasing, achieving elasticity in the use of the service. It is based on the pay-per-use principle and low financial inputs but results in shorter service time, change of responsibility in risk management, and easy accessibility. Complex and huge calculations are shortened, and demand for storage space is reduced. Management is without expensive hardware infrastructure, expensive software systems, etc. The paradigm of Everything-as-a-service (XaaS) implies computing in the cloud in which the services of various business functions companies provide with the use of appropriate tools, software, infrastructure, databases, etc. The paradigm of Everything-as-a-service (XaaS) implies computing in the cloud in which the services of various business functions companies provide with the use of appropriate tools, software, infrastructure, databases, etc. the Application Service Provider (ASP), Cloud Service Provider (CSP), Complete Solutions Provider, or Communication Service Provider (CSP) (Duan, et al., 2016). It is very significant to choose a quality CSP provider that can adapt and manage existing and develop new cloud and general business applications, IIoT, and batch computing/ processing. Sharma, Chang, Tim, Wong, and Gadia (2019) proposed a CNNC classification based on the intuitiveness of the scientific approach. They considered two types of service applications. The first group contains the term cloud in its name (Cloud, NNClouda), and the second does not have the word cloud (NN-No Name). Regarding big data in the cloud, the following technologies belong to the first type of applications: CloudKit, Cloud Datastore, Light Cloud, Cloudera, and others. The 1010Data System, Algeraix System, Azure Document DB, and Datameer belong to the second type.

From the perspective of logistics and SC, it is acceptable to view cloud services through several functions:

A. Surveillance Security Service (SSS), as: Device-to-Device (D2D), Device-to-Cloud (D2), Device-to-Gateway (D2G), Security-as-a-service (SecuaaS/SaaS), Identity and Policy, Management-as-a-service(IPMaaS), Cybersecurity-as-a-service (CaaS) and/or Crimeware-as-a-service (CaaS).

B. Services of using networks, devices, and sensors with data collection and their processing in a multi-cloud environment, as Infrastructure-as-a-service (IaaS), Things-as-a-service (ThingS), Storage-as-a-service (StaaS/SaaS), PaaS (Platform-as-a-service), Software-as-a-service (SaaS), Sensing-as-a-service (S2aaS), Hardware-as-a-service (HaaS), Sensor-as-a-service (SenaaS), Desktop-as-a-service (DaaS), Network-as-a-service (NaaS), Telematics-as-a-service (TaaS), Quantum as a Service (QaaS), Workspace-as-a-service (WaaS), Ethernet-as-a-service (EaaS), Failure-as-a-service (FaaS), Sensor Event-as-a-service (SEaaS), Application-as-a-service (AaaS) Testing-as-a-Service (TaaS), and Laboratories-as-a-service (LaaS) .

C. Services of unified (joint) communication management of companies with different functions, such as Supply Chain-as-a-service (SCaaS), Logistics-as-a-service (LaaS),

Accounting-as-a-service (AaaS), Object-as-a-service (ObaaS), Mobility-as-a-service (MaaS), Business-Process-as-a-service(BPaaS), Integration-as-a-service(IaaS), Business Integration-as-a-service (BIaaS/BIaS), BI/BIaaS (Business Intelligence-as-a-service), Business Framework-as-a-service (BFaaS), Unified-Communications-as-a-service (UCaaS), Cloud-Based Analytics-as-a-service (CLAaaS), Mobility-as-a-service (MaaS and/or MobiaaS), Forensics-as-a-service (FEaaS) and/or Digital Forensics-as-a-service (DFaaS), Sensing and Actuation-as-a-service (SAaaS), Surveillance-as-a-service (VSaaS), Information-as-a-service (IaaS).

D. Database Services, Data-as-a-service (DaaS), Data Integrity-as-a-service (DIaaS), Database-as-a-service (DBaaS/DaaS), Continuous Analytics-as-a-service (CaaaS) Data Mining-as-a-service (DMAS/DMaaS), Management/Governance-as-a-service (MaaS and GaaS), and Cloud-Based Analytics-as-a-service (CLAaaS).

E. Backend as a Service, Backend as a Service (BaaS), Mobile-backend-as-a-service (MbaAS).

Figure 2. Interdependence of basic cloud technologies

Source: (Linthicum, 2009, pp. 6-11)

From the IT aspect, the development of services on the *Internet base* practically has no capacity limitations (Wang, Lei, & Shang, 2021). Figure 2 shows the characteristics of the basic technologies and their interdependence.

Testing-as-a-service (TaaS) technology enables the collection, updating, and evaluation of data for specific processes or products performed by consultants or service providers, with the fulfillment of objectives set in test objectives.

Management/Governance-as-a-service (MaaS and GaaS), MaaS enables start-up companies to solve specific development problems. GaaS enables the transition from traditional, paper-based government systems to a digital, centralized service delivery model in partnership with industry, citizens, and other stakeholders.

Application-as-a-service (AaaS) enables the use of computer software applications as a remote service on the user's request via the Internet by the ASP as a service provider.

Process-as-a-service, Business-Process-as-a-service (BPaaS) refers to a specific service leased through cloud technologies and a global IP network. It includes combining several service options to fully automate the business process, which helps companies plan for greater efficiency and comprehensiveness in their operations and achieve business goals.

Information-as-a-service (IaaS), information as a service is any combination of the exchange of data and the activities of people who use the obtained information to effectively support operations, management, and decision-making in real-time, according to an entity (customer, product, etc.).

Database-as-a-service (DBaaS/DaaS) is one of the most sought-after cloud services due to the large amount of data from IoT/IIoT and other sources. The technology does not require physical hardware setup, software installation, or database configuration, which allows users to scale,

perform, and perform backups and more without their database, reducing overall business costs.

Storage-as-a-service (SaaS/StaaS) is a technology where a company uses public cloud storage or rents another's infrastructure to store data. (Intel, 2023) StaaS can be used to provide storage of blocks, files, folders, and other types of data. It can be based on quantity or a service level agreement.

Infrastructure-as-a-service (IaaS) represents the technology of renting other people's Cloud Data Centers (CDCs) and the complete infrastructure, through CSP. With direct access via the Internet, users are enabled to design and create a physical IT infrastructure in a virtual environment, which can use any application and run it without modifications to the hardware owner's infrastructure, which means that it has full control over all resources, virtual networks, warehouses, vehicles.

Security-as-a-service (SaaS/SECaaS), cyber-security services include cloud and database protection, VoIP security, and general network security. The responsibility for this service belongs to the relationship between CSPs and the Communication Service Customer (CSC).

Integration-as-a-service (IaaS) in B2B relationships requires connecting on-premises data with data residing in cloud-based applications, with which businesses develop, maintain, and manage custom integrations for various cloud systems and applications.

Platform-as-a-service (PaaS) service represents the use of leased platforms located somewhere on a remote server with direct access through a browser. Users do not need to have an operating system and specific tools installed on their local computers, which significantly reduces capital investments. The technology uses Blockchain (Aulbach, 2011, pp. 2-4).

From the aspect of logistics and SC, in addition to the mentioned technologies, the following are significant: Logistics-as-a-service (LaaS), based on integrated business models with a complete logistics service. Supply Chain-as-a-service (SCaaS) is a marketing service that helps to create a campaign for a supplier to customers. Accounting-as-a-service (AaaS) provides accounting services using cloud services. Mobility-as-a-service (MaaS) technology enables the connection of services by transport and mobility technologies in a package, which ensures adaptability to the needs of end users. Telematics-as-a-service (TaaS) allows companies to pay only for the actual use of the used equipment without the initial investment in telematics equipment. Surveillance and security technologies (D2D, D2C, and D2G) play a significant role in traffic in the exchange of data between vehicles, vehicles and clouds, and vehicles and gateways (Sun, 2014).

The mentioned technologies include a wide range of different standards, such as architecture standards, sensors, communication protocols, application requirements, identification standards, security and data processing standards, standards of various platforms, etc. The importance of standardization is significant because of its advantages. According to Muhonen (2015, pp. 29-38), protocols are crucial. The best examples are Java Message Service (JMS), Message Oriented Middleware (MOM) protocol for sending messages between two or more users, Transport Layer Security (TLS), Secure Sockets Layer (SSL), OSI Model, and many others.

4 CONCLUSION

Managing and mining large amounts of data, especially from sensor systems, pose many challenges to traditional approaches. The cloud computing concept has emerged as the most sought-after destination that promises to effectively solve many problems in the cloud environment by sharing IT resources and services. The paper provides an overview of communication technologies and new services based on the cloud. They are still under development or were created in the last decade. Some significant and applied services are considered according to their applicability in the IoT paradigm. Big data management technologies are observed and are still increasing. Each technology is specific in terms of its software, data storage and processing, and cloud computing mechanism. New ICTs, in IoT/IIoT, lead to numerous advantages in doing business, e.g.:

- providing better services,
- receiving and processing data and information in real time,
- reducing the impact on the environment,

- enabling the application of new approaches and methods with easier real-time management and more efficient use of data,
- making processes visible and realizing the full business integrations,
- increasing safety, security, and business efficiency, etc.

The new vision of ICT is realized by using IoS (Internet of Services). It is achieved by using a network platform that provides support to services and makes it possible to combine different services and providers (ASP, CSP, and ISP). The essence is in a completely decentralized way of exchanging online services and digital products on P2P networks, which allows programmers to develop large-scale dApps with the possibility of supporting many users, with a series of innovations for specific measurement and interaction between instruments and measurement techniques. Future work needs to expand the discussion on new services and analytics from the point of view of integrating new technologies in different domains based on the hybridization of static and dynamic schemes.

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