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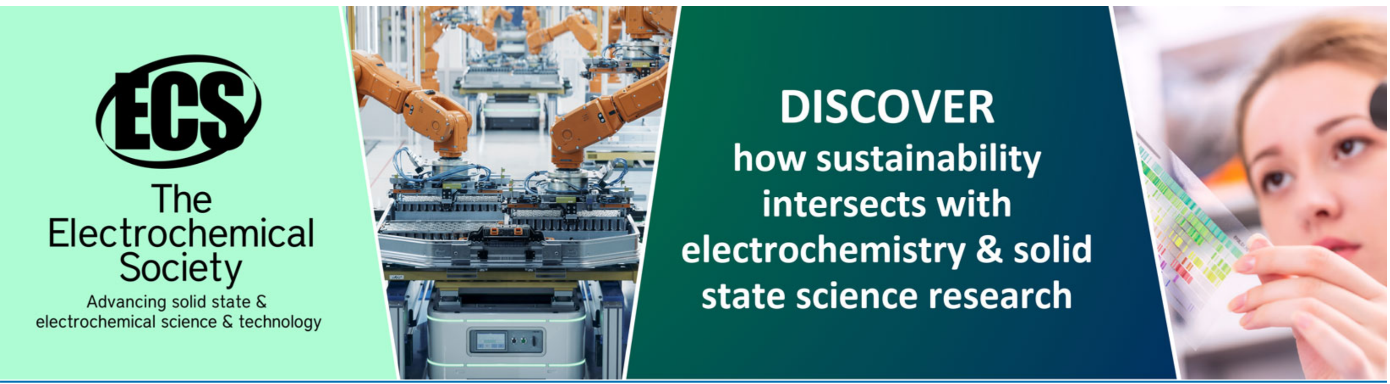

Features of application of informational networks in the field of transport infrastructure

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Abstract. The concepts of universality and general applicability of information networks as well as the issues of using networks in specific directions are considered in the article on the example of the convergence of transport infrastructure and information networks. An analysis of modern information networks has been carried out and the following three main directions have been identified: infrastructure as a service, platform as a service, software as a service. The basic principles of convergence of information networks and transport infrastructure are presented on the example of a transport and logistics system. The issues of use of the modern information technologies for continuous monitoring of transport infrastructure are considered.

1. Rationale

It is difficult to imagine the modern world without text messages, photos and videos exchange using the Internet. Recently, the voice messages have become popular. In addition, if any information is urgently required, the user can always use search services such as Bing, Google, Yandex.

The Internet today provides many opportunities for users - ordinary people like you. And on the first glance it seems that the Internet is a new entertainment area. Let's expand the understanding of this indisputably important element of our daily life.

This article will focus on one of the most promising and very important area of development of global networks (including the Internet) - their integration into the transport networks [1].

First of all several concepts, including networks, convergence, integration will be defined it will be explained how these concepts relate to the topic.

The main objectives of this study are:

- Study of the concept of universality and general applicability of networks.
- Application of networks in specific directions on the example of the convergence of transport infrastructure and information networks.

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2. Analysis of the modern information networks

Modern information networks are very different from those that could be seen 10-15 years ago.

At the very beginning of the development of these technologies, it was nothing more than the transfer of simple text messages. In addition, the cost and complexity of connecting to such a network was impracticable for ordinary users, and there was no corresponding infrastructure. There were only several small "islands" which (in most cases) were not connected to each other.

Over time, networks and related technologies began to be developed; it became possible to transfer not only text, but also other data - pictures, audio and even video information. Moreover, networks have become more accessible to ordinary users. The infrastructure began to expand and physical technologies appeared to provide users with a sufficiently high speed of access to the network. In particular, today's record for the data transfer rate is 178 Tbit/s, but, unfortunately, this speed will not be available to users in the near future. Talking about ordinary subscribers it shall be mentioned that access speed in Japan is 10 Gbit/s, and in the USA is 400 Gbit/s [2].

Today networks gain a widespread use. In fact, the modern network can be viewed as a single multi-level information space that provides ordinary users and companies with many different services (if it is viewed on a global scale). And it is not only about simple data transmission, but also about providing subscribers with various services and distributed computing.

The modern user has the ability to connect over the network to applications in the cloud. It simplifies the organization of automated workstations for company employees.

Talking about cloud technologies, it is worth to note that three areas are relevant today:

- IaaS - infrastructure as a service. It is one of the most flexible cloud computing options. In this case, the client is provided with access to virtual servers and networks, and the client himself decides "how" and "for which purpose" it will work. For organizations, this is a very convenient service - there is no need to buy expensive physical devices and implement physical infrastructure, which, in addition to the complexity of creation, is also far from easy maintenance [3].
- PaaS - platform as a service. With this approach, the provider provides the client with virtual operating systems in the existing infrastructure. The flexibility is lower than IaaS, since the provider manages the operating system and infrastructure, while the client can manage only his own applications, but this option is much cheaper and does not require the advanced administration. An example of such a service is a web server or a database server.
- SaaS - software as a service. It is the least flexible option. In this case, the provider provides the client with access to specific applications, while independently managing the basic settings. The client can only use such software. Email and office applications can be mentioned as an example. This service is suitable for solving a narrow range of tasks [4].

The services described above have the organization and maintenance of information infrastructure greatly simplified for companies, since during use of these services, the provider assumes a part of the responsibility for its performance.

In addition, talking about modern networks such direction as a software-defined networking (SDN) shall not be forgotten. A feature of such networks is their flexibility. The essence of the technology lies in the abstraction of software from physical devices. It allows controlling the behaviour of the network (which is determined by programmability) and to implement centralized control of network resources [5].

In fact, such a network consists of three levels, interacting to each other through special APIs [1] (figure 1):

- The application layer is, in fact, the applications which are intended for users, as well as a set of services that provide (for example) security and load balancing.
- Control level - the main task of this level is policies definition and control of the traffic in the

network.
- The infrastructure layer is the physical network hardware.

It is also shall be noted that the SDN architecture allows for the implementation of the various vendors interaction. Due to the open APIs, the support is provided for completely different services (SaaS, network applications), also due to the open APIs it is possible to develop new applications that take into account the peculiarities of the network and that are able to adapt to the network state [6].

Modern network technologies can be described for a very long time. They forge ahead and are developing very actively. Every year, a lot of international and national level conferences are held around the world. At the each of these conferences there are reports about some new product or technology.

The next part of the article will be focused on a specialized area of networks application (transport infrastructure).

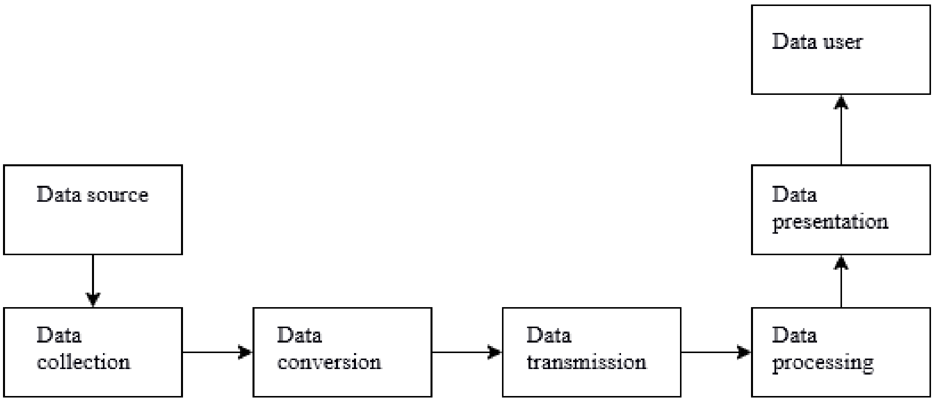

Figure 1. Stages of data movement from source to consumer.

3. Convergence of information networks and transport infrastructure

Before starting on the direct unification of these seemingly unrelated areas, it is necessary to identify at least some of the existing problems:

- Increasing of traffic intensity.
- The level of motor transport safety.
- The quality of logistics systems for transport companies and forwarding agents.

In fact, these issues have been discussed for a long time and many possible solutions have been presented, but the most promising is the digitalization of the transport industry. There are several different directions: use of geoservices, intelligent transport systems, development of special digital platforms for the transport sector [7]. These issues were discussed in detail at the St. Petersburg International Economic Forum [1].

In general, for the digitalization of this industry, it is necessary to understand how this digitalization shall be proceeded. This issue shall be considered using a generalized example.

Several important stages in the transition from source to consumer can be distinguished recounting the principles of information transfer. A brief description of each stage is given below:

- Data collection is the transfer of various properties of objects to the information system.
- Data transformation is the reversible conversion of data to the form required for subsequent transmission, processing or storage.
- Data transfer is the use of different transmission media to transfer data from one part of the

system to another.
- Data processing is the application of mathematical and logical laws with the aim of either obtaining another form of data, or obtaining answers to the posed questions.
- Data storage is writing of data to a storage device.
- Data presentation is the process of converting of data into a form that is convenient for the consumer.

Different devices and technologies are used at the each stage. Considering the transport industry, the traffic participants (cars, pedestrians, etc.), static regulatory elements (signs, markings, etc.) are the sources of data [8].

The following technologies can be used to collect data from these objects:

- Global positioning systems (GPS and GLONASS) shall be used to determine the location of objects for example, in the form of GPS trackers or beacons.
- CCTV camera systems shall be used for the object recognition.
- CCTV cameras can also be used to collect statistical data (for example, the load level of a specific road section), but the use of the RFID system is much more efficient (vehicles are equipped with RFID tags, and the system of controllers with readers records the number of vehicles in the detection area). The feature of RFID tags is that they allow storing in their memory not only a conditional identifier, but also some additional information, for example, VIN (vehicle identification number) and state registration number.
- For interaction with traffic markings, vehicles can also be equipped with specialized cameras, and for working with signs, signs can also be equipped with radio tags with a special identifier (and, if necessary, additional parameters), which will allow vehicles to record a specific sign.

The next step after collecting the data is converting it into a form that is convenient for processing. The exact method will depend on the source, but the most convenient method is to digitize the data and then transfer it to the data processing center (DPC).

The volumes of data are huge, and they must be transferred as quickly as possible. In this case, it makes sense to use distributed processing. For example, data affecting the behavior of vehicles must be handled by the vehicle itself, while data for global traffic control using dynamic control elements (traffic lights, barriers) must be sent to the data center [9].

In this case, the most effective will be use of the SDN infrastructure, which will provide maximum control over the transfer of such a volume of traffic to the DPC. Moreover, open APIs will allow to develope such solutions that will interact directly with sensors, cameras and other data collection elements in such a way that data, depending on the priority or on the state of a particular network segment, is transmitted along the most efficient route. Moreover, such networks are able to provide the fast transmission of control signals to the actuators, and therefore a high response rate.

Also, during use of a set of software-defined networks, geosystems, neural networks and specialized software, it becomes possible, to significantly improve logistics, and to implement such electronic document management systems for transport companies that will automatically receive a part of the data [10].

Subsequent data processing can be implemented in various ways, depending on the specific task. For example, forecasting and analysis tasks can be solved by neural networks, and decision making by vehicles, depending on the situation, can be implemented through artificial intelligence built into the on-board computer.

4. Findings

Modern intelligent transport systems are capable of solving many problems, including the task of managing traffic flows and improving the road safety. But their implementation is possible only in case of interaction of a whole set of technologies, which include information networks (precisely in their modern representation), cloud technologies, technologies for software design and implementation.

An intelligent transport system can include various technologies, systems and models, but its efficiency depends on the amount of accumulated traffic information, the quality and speed of its transmission to the data centre, as well as the quality and speed of processing of this data, therefore, each element of such a system plays a significant role.

Unfortunately, today these technologies are quite difficult to implement. They require highly qualified specialists from various fields and significant financial costs, therefore, at this stage, they can only be developed in the large cities.

Nevertheless, progress forges ahead and today the large projects in the field of ITS are started up. For example, on May 28, 2020 PJSC Rostelecom and National Telematic Systems announced the creation of a joint venture for the development of intelligent transport solutions for the state, regions and municipalities [3].

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