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MIGRATION İSSUES OF SCADA SYSTEMS TO THE CLOUD COMPUTING ENVIRONMENT (REVIEW)

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Abstract

The paper deals with the migration of SCADA (Supervisory Control and Data Acquisition) systems widely used in the monitoring and management of the oil and gas industry to the cloud computing environment. There arise various problems in data collection, transmission, and processing because of traditional SCADA systems being very expensive, inflexible, and complicated scalability. The transferring of the SCADA system's applications to the cloud environment reduces costs and improves scalability. The purchase of hardware and software is carried out at a lower cost than its installation and maintenance. In the article, the usage of cloud-based SCADA systems has been proposed for easy, safe, reliable and quick collection and processing of data from facilities installed in the oil and gas industry.

Keywords:
Oil and gas industry;
SCADA systems;
Cloud computing;
Cloud services;
Cloud models;
Security.

Introduction

The oil and gas industry is an important sector for energy consumption and has a great influence on the world economy. The oil and gas industry involves the processes of exploration, production, transportation, and sale of oil products. Fuel, oil, and gasoline constitute the main part of this industry’s output. Oil is a raw material for the production of many chemical products, including medicines, solutions, fertilizers, pesticides, and plastics. As the demand for natural fuels grows day by day, the oil and gas companies are forced to develop new technologies and improve operations to increase productivity.

The use of information technology in the innovative management system of the oil and gas industry is one of the most actual and important problems. As known, the development level of scientific and technical progress has led to the use of new management and control models in the oil and gas industry that satisfy more advanced and modern standards.

To increase efficiency and competitiveness, the usage of new modern technologies that improve the results and reduces the costs is very important. Here, the collection of more comprehensive and accurate information and the control problems’ solution plays an important role in the production process. Operative data management can be considered one of the important areas affecting the development of the oil and gas industry. The fields such as increasing the speed of oil exploration and detection process, increasing oil production and reducing equipment failures, safety and environmental risks caused by equipment defects or operator errors, etc. are constantly developing with the usage of cloud technologies. In the oil and gas complex the use of cloud technology in the systems based on sensors and actuators can be considered as a way to implement the right strategy in the collection and management of information. We will achieve management efficiency, effective decision-making, production improvement, and increase of competitiveness by the application of this technology.

The use of cloud-based SCADA systems increases in order to automate systems, grow efficiency and income opportunities in the oil and gas industry. The amount of data generated in these industrial systems can be measured in PBytes (petabytes). Traditional information technologies is not able to perform the requirements for big data analysis, accelerated processing, delays, reliability, security, confidentiality, and network scalability. The usage of cloud-based SCADA systems in solving these problems can be considered a prospective solution. On the other hand, the use of cloud-based SCADA systems provides an increase in economic efficiency.

Related works

In paper [1] the installation of SCADA applications (software) in a cloud computing environment, not in traditional computer systems

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has been presented. In this case, there is no need to update computing resources, instead, it is proposed to use the cloud infrastructure if necessary. At the same time, the article shows that some problems, such as reliability, security, and computing, which may prevent the application of the SCADA system in the cloud, still stay unresolved. In the paper [2] the new cloud-based SCADA system suggested by Microsoft for the oil and gas company has been analyzed. In the presented system the connection problems of the Human-Machine Interface (HMI) station to the Remote Terminal Unit (RTU) terminal was considered. Only the usage of the user station has been proposed for easy access to the report required by the final user.

In the article [3], the replication of the SCADA system has been described by using clouds in the researches and all SCADA components (except field devices) have been represented as a united service. The field devices are connected to the cloud-based SCADA system directly or (with auxiliary devices) via the network. Many cloud servers have been used in the system, and the storage of multiple copies of the SCADA master application in several clouds has been proposed to ensure resistance to failures. Many cloud servers have been used in the system, and the storage of multiple copies of the SCADA master application in several clouds has been proposed to provide error resistance. In [4], to present each SCADA component as a service and their placing through the Local Directory Service (LDS) has been proposed. The LDS involves available SCADA resources, access methods, and illustrations. This approach is very useful and allows users to extend the SCADA system by adding new features to existing services or assign new ones according to demands and verified requirements. The article [5] identifies security issues as a major problem in the integration of SCADA systems to the cloud. In this type of environment, we observe higher security risks, such as keeping confidential information out of the control of the organization. The article [6] outlines the advantages of SCADA systems based on cloud computing to increase the reliability of the traditional SCADA system in the oil and gas industry, to organize their hardware and expand and utilize the resource. In the paper [7] the problems of industrial SCADA systems in the cloud environment were analyzed. Here, some recommendations for the security of cloud-based SCADA systems and the most successful practices in this field are presented. In [8], two conceptual models for the usage of SCADA systems in cloud computing (Hybrid Cloud) environments have been proposed. In the first stage, SCADA applications are fully processed in a hybrid cloud. In the second stage, SCADA applications were launched on a separate software server directly connected to devices located on the SCADA network. In the article, the security problems of SCADA and cloud computing have also been discussed. In paper [9], a cloud computing-based SCADA system to increase resource utilization, reliability, and oil and gas pipeline availability in SCADA systems has been proposed. In the article, software for SCADA system based on cloud computing has been proposed and information on the implementation of the private cloud platform SCADA has been given. In [10], different scenarios and software for performance evaluation of cloud-based SCADA have been proposed. The main structural problems were identified according to the results of the evaluation and instructions were given for their solution, and the general advantages of cloud-based SCADA systems were presented. In the paper [11], an experimental study has been presented on the transfer of the SCADA system to the cloud using the IaaS (Infrastructure as a service) service. In the paper [12], the features of cloud-based SCADA systems was regarded as a technology with low-cost information technology, dynamic allocation of resource in real-time, flexibility and scalability. In [13], the different ways in the migration of SCADA applications to cloud servers have been analyzed and the advantages of cloud-based SCADA systems have been shown. In the article [14], by examining security problems in the field of data storage on cloud servers, a method was proposed to prevent unauthorized access to the data of users (organizations) by cloud administrators. In [15], the integration problems of the oil and gas industry to cloud computing was analyzed. They note that the migration of SCADA applications to the clouds creates various difficulties. The paper [16] analyzes the migration of oil and gas industry applications to the cloud and investigates security problems when transferring data to open clouds.

Conceptual model of SCADA systems and its problems

Two main problems exist in the monitoring and control systems used in the oil and gas industry. One of them is the collection and storage of data, and the other one is the analysis and processing of data. In the oil industry, generated data include seismic data, drilling data, input data, as well as production data for oil and gas wells. These different types of information are collected at the data source level. Professional archiving and quality management are required for data format and design. Data sources and applications for different sectors are provided at the data source level. Also, here, the original data source for a high-level cloud-based database is provided. The technological process of the oil and gas industry can be divided into three main sectors [17-19]. The first sector includes exploration, drilling, and production processes. Here, first, the potential underground or underwater crude oil, natural gas fields and potential hydrocarbon reserves are explored and investigated then in the second stage, explored wells are drilled and the hydrocarbons are extracted from hydrocarbon reserves in oil or gas fields. These hydrocarbons provide extraction of crude oil or crude natural gas to the surface. Seismic data volumes in the field of oil exploration and production have already exceeded Pbytes (PB). The upstream (production) level of the oil and gas industry is characterized by big data. Thus, big data analysis were first applied at the upstream level of the oil and gas industry. Afterwards, big data analysis gradually began to be applied in the oil transportation, processing, chemical, and business sectors. The application of information technology to oil and gas production is mainly carried out in the field of seismic data processing, drilling, production data processing, and predictive analytics. Currently, in the process of analysis and prediction, oil and gas companies have difficulty in producing a rational data model with uncertain datasets. For this purpose, they investigate patterns and try to find ways of solutions through the analysis of big data. Oil companies, the service sector, and drilling contractors obtain the data in real-time and provide monitoring of equipment using thousands of surface and underground sensors.

In the second sector, the transportation of crude oil or oil products is carried out. Pipelines, rails, tankers, trucks, tanks and many other transport systems are used for transportation of crude oil and hydrocarbons from production and wells to hydrocarbon and oil processing fields. At the middle level of the oil and gas industry, big data are mainly associated with the oil and gas transportation sector. Here, specific data from oil and gas pipelines are collected in real-time, managed, analyzed and presented. Thus, big data provides a monitoring service and performs intelligent control (dispatcher) function in every aspect of oil and gas transportation.

Then, various processed products are transferred to the third sector. This sector involves the processing and purification of crude oil. The application of big data at the downstream level of the oil and gas industry mainly focuses on the management of filling stations, analysis of sales activities, analysis of customer behavior and their preferred factors and marketing strategy. At this stage, hundreds of petrochemical products, including gasoline or fuel gained from crude oil, kerosene, aviation fuel, diesel fuel, heating devices, oil, lubricants, wax, asphalt, natural gas, and liquefied petroleum gas are offered to consumers. Thus, the upstream levels of the oil and gas industry are engaged in exploration and production, the middle level of the industry the storage and transportation are carried out, and the downstream level concerns the processing and chemical industries, as well as sales. Thus, the SCADA system is used effectively to manage the above-mentioned technological process of the oil and gas industry in three main sectors. SCADA systems are industrial control and management systems that centrally manage and control geographically distributed technical devices. SCADA system collects data in real-time, performs local or remote control. The system provides comprehensive monitoring for production operation in real-time. With the help of the system, important reference information for production, control, and management is provided. These systems are widely used in industrial fields such as energy systems, oil production and processing, natural gas distribution, water and sewage treatment, and transport systems [20].

SCADA systems manage technological processes in real-time based on big data achieved from drilling rigs, transmitters or other control sensors. In real-time data is collected from well fields, the well itself and underground sensors to maximize resource utilization and increase production efficiency, optimize drilling methods, improve operational performance and provide specific geological supervision. Analysis of data collected in related areas can increase the efficiency of drilling and accomplishment activities. The SCADA system can continuously control devices distributed over a large area and manage devices remotely from the control center, and in this way, the management efficiency, energy-saving, and costs reduction can be developed.

The structural scheme (conceptual model) of the SCADA system is shown below (fig.1). The SCADA system consists of the following 4 levels. The hierarchy of the SCADA system is determined according to the interaction of its components and their connection with external networks [21-23].

- Level 0 - the sectors of oil and gas industry
- Level 1- level of transmitters (sensors) and executing mechanisms
- Level 2- the level controllers
- Level 3- control of the production process and level of management.

Level 0 consists of the oil and gas industry, drilling production, transportation, and processing sectors. Level 1 consists of transmitters (sensors) that record different parameters of the system, devices that manage the parameters of the system, as well as actuators that affect the parameters according to the task. Device controllers in level 2 process signals from field devices and generate appropriate instructions for these devices. They include Remote Terminal Units (RTU), Programmable Logic Controllers (PLC), Distributed Control Systems (DCS) and Intelligent Electronic Devices (IED) that perform local control of actuators and sensor monitoring. These devices receive data from low-level, pre-process it, give control commands to actuators according to a programmed monitoring algorithm, and implements data transfer with Level 3.

Level 3 is the control and monitoring center of the system. The processing results in level 2 are sent to the control center in level 3 for further analysis and monitoring of the responses. At this level, the collection, processing, and storage of data gained in the middle-level, visualization of current and archival data in a suitable form for the operator (diagrams, graphs, etc.), enter to operator instructions, reporting on the results of the process and interchange of high-level information is implemented. At this level, the production process is monitored, communication with lower-levels is provided from where the data is collected, and visualization and monitoring of the

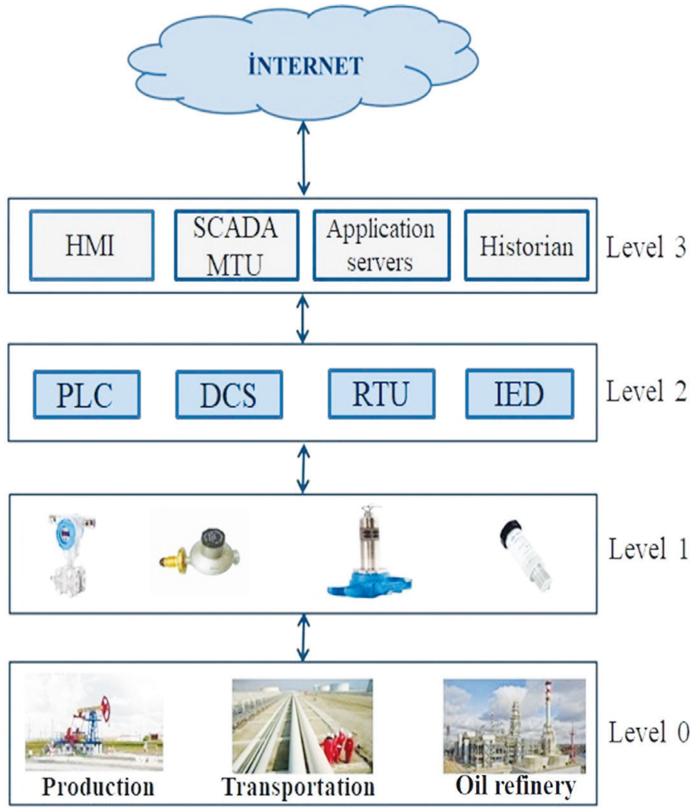

Fig.1. Multi-level conceptual model of SCADA system

technological processes are implemented. This level consists of the Human Machine Interface (HMI) and SCADA Master Terminal Unit (MTU) workstations. SCADA is the main control server computer that commands the devices (RTU, PLC, DCS, IED) located at the 2nd level of the MTU system, collects the required data, stores, processes and implements the archiving of data. After receiving the data, the system independently compares the results with the specified parameters of the controlled indicators and informs the operator using alarms, which allow taking the necessary measures in case of evasion of the task. HMI is used to monitor the system visually. The control center collects and analyzes the information received from the fields, presents it in the HMI consoles and generates reactions based on the detected incidents, the operator (dispatcher) makes decisions based on it. HMI provides local monitoring to technological devices.

The SCADA system is widely used in the management of technological processes in the oil and gas industry. However, existing SCADA systems have the following problems [24]:

• Reliability problems of the system. The SCADA system consists of servers located in the control center to carry out monitoring and control. Here, data on the monitored object, its condition and warning information are collected and processed in real time. Currently, Hot Standby is used to provide reliability in SCADA systems. When the main server is running online, the auxiliary server monitors the operation of the main server and receives information from the main server to keep the data sequence between the main server and the auxiliary server. When the main server fails, the auxiliary server immediately takes over the main server's function and becomes the main server, and the repaired main server becomes the auxiliary server. Central servers of SCADA system carry out the collection of data and management of all levels. For the normal operation of the whole SCADA system network, the provision of data transferring between the servers and the level controllers is very important. Thus, the reliability of the system cannot be ensured by a single reserve server. The number of servers increases as the scale of the system continues to develop. The existence of reserve servers creates problems causing the system to become more expensive and leading to an increase in the maintenance load.

• Distribution problem of load balancing on system servers. The number of servers located in the control center increases as the oil and gas industry joined to the SCADA system continues to grow. A large number of operations and data are processed on different servers. However, the processing load of servers varies depending on the nature of the received data. Thus, different servers have different loads, some servers are overloaded, and some remain empty. For this reason, we need to investigate new strategies for load balancing to improve system performance.

In recent years, cloud computing technologies are widely used in the effective management of systems in the oil and gas industry. Transferring (integration) control center of the SCADA system to the cloud-based SCADA system and the cloud control of the system increases efficiency.

Transfer of SCADA systems to the clouds

Cloud technologies are widely used to solve complicated problems based on computer networks and to create distributed computing systems for the management of technological processes. The systems with high computing and memory resources are created based on computer networks with high-speed communication channels. Utilizing high-speed communication channels, the usage of cloud computing services is more efficient for users of various organizations and enterprises. Cloud computing provides the creation and usage of computer technology infrastructure and software directly in a network environment. Through this technology, data is stored in cloud systems, processed, the running of processing programs and the review of results is provided. Cloud technology provides the transfer of memory system and software resources of server computers located in enterprises to the clouds, i.e. provides their combination as a common group. Generally, this technology provides them with its own computing and memory resources at the expense of its internal resources by user's requirements. Researches show that if enterprises use cloud technologies, there will be no need to purchase expensive devices (servers, computers, memory systems) and software to create control and monitoring systems. According to experts, the usage of this technology reduces the expenses spent on software and electricity by large companies several times.

Three main factors that attract users attention to cloud technology are the following [25]:

- unlimited possibilities of computing resources, i.e. the users being free from the pre-order and prediction of necessary resources;
- the absence of large expenses in the first stages of projects;
- payment for the actual service (pay-as-you-go).

Recently, cloud computing technologies are widely used in the management of various sectors of the oil and gas industry. Cloud computing technologies offer cloud services that provide data collection, storage, and processing for seismic exploration, drilling, production and management of other sectors.

Let's analyze the services used for the management of cloud-based SCADA systems. Currently, the services proposed by cloud systems include three services [25, 26]: Software as a service (SaaS), Platform as a service (PaaS) and Infrastructure as a service (IaaS). IaaS is a widespread service model. IaaS providers allow customers to deploy and run SCADA software on cloud servers as on their own IT infrastructure. IaaS provides virtual servers, memory, network and other computing resources. Users pay only for the resource they use and can use additional online resources if needed. Customers do not manage or monitor the cloud infrastructure used but can control over operating systems, memory, hosted applications, and network components. PaaS is a set of software and production devices located in the provider's infrastructure. PaaS service is a virtual platform that allows users to use operating systems and special software applications (Apache, My SQL, etc.) located on virtual servers (consisting of physical servers). Users apply these devices to create applications over the Internet. In the SaaS service, the user can access the cloud servers via network channels without loading the resident part of the software applications on his computer. Software applications run on the SaaS provider's cloud server and send the results of calculations to the user. Thus, the user does not buy the software and he uses it to solve the problem if necessary and pays the needed price for the usage. Currently, providers only offer functions such as components for specific SCADA applications, virtualization and archiving (history) reports like SaaS.

At the conceptual level, there are three main types of cloud architecture: public (open) cloud, private cloud and hybrid cloud [27, 28]:

A public cloud is a cloud infrastructure designed for public mass. Public clouds are offered to Internet users by cloud providers. They are created outside the corporate network and users are deprived of managing and controlling their data existing in the cloud. User's data management and security problems are carried out by cloud providers. Users pay for the resource they use. In this type of cloud, users use the standard configurations proposed by cloud providers. Comparing to other clouds, the selection of different computing resources in this type of cloud creates problems for users.

Private cloud - is an infrastructure created to use computing cloud services within any organization. The organization can itself manage the cloud or entrust it to other organizations too. Mainly, the cloud is created within the organization and managed by its employees. The operating costs of such clouds are more expensive than those of other types of clouds as the creation, development, and management of private cloud infrastructure are carried out by organizations. Security issues in private clouds are higher compared with other clouds.

Hybrid clouds - are created from a combination of clouds mentioned above. A group of users uses internal clouds, and another group uses public clouds. Hybrid clouds are created from the combination of public and private cloud infrastructures. In this type of clouds, management is distributed between the organizations and public (state) clouds. In hybrid clouds, a part of the service is performed by the organization in private clouds and another part by the public organization in the public cloud. This type of cloud is mainly used at the seasonal periods of the organization's activity (when the workload increases). In other words, if the internal infrastructure of organizations is unable to cope with current problems, then some of these issues (for example, unprocessed statistical data that are not currently needed by the organization) are transferred to public clouds. Also, users' access is provided to private cloud sources through the public cloud. Thus, cloud computing consists of hardware and software and is the Internet service that allows Internet users to use remote computer resources (computing and memory resources, software and data, etc.) through a suitable web interface. Also, the use of cloud technology for companies solving complex problems is recommended. This technology can identify and form the computing and memory resources required to manage complex technological processes in a short period.

In systems implemented by these three service models, the scalability is fast and economical, as the purchasing, deployment, and configuration of new servers and software by the organization (user) does not include here. When more computing power or memory is required for the data, the user requires resources from the provider as many as he needs and pays for it. Companies don't need to obtain a lot of hardware and software licenses. Instead, they can provide new resources when needed or desired. Instead of multiple servers located in different geographical areas, the cloud offers its opportunities. Companies only pay for the memory they use. Creation of IT infrastructure is generally very time-consuming. Acquiring, installing, configuration, and testing of these systems can last about months. Alternative cloud resources are accessible in a short period, and the resources required can allow experiment and error tests to be performed. The user can easily switch to the previous configuration if there exists a problem with any update. SCADA system projects performed on-spot require significant costs, resources, and time. Besides, the existence of large unsuccessful results is not excluded. The creation of cloud-based SCADA systems can be implemented in a short time with a minimal or very little financial cost, so it is considered less risky.

The transfer of SCADA systems to the cloud reduces the cost of SCADA systems, provides higher reliability and increases functionality. Cloud-based SCADA allows users to view the system through devices such as smartphones and tablets in addition to reducing costs and eliminating problems with infrastructure hardware. Cloud-based SCADA systems are created based on public or private models of cloud technologies. Public (open) cloud infrastructure creating by any organization is sold to the society (organizations) as a service. Private cloud infrastructure is accessible only for a specific organization (client). Hybrid clouds consist of public and private clouds providing transportation of data and applications.

Cloud-based SCADA systems based on cloud computing technologies are created in two ways [29, 30]:

Applications implemented at the 2nd and 3rd levels shown in the conceptual model of the SCADA system (fig.1) are performed on computer devices located in the buildings where the system is created (company, organization, etc.). They communicate directly with the control center in the cloud and are transmitted to a cloud server for data storage. This model is widely used. The control functions of SCADA applications are isolated from the controller network, connected to cloud services, which allow performing some applications of the SCADA system (process visualization, reports, remote access, etc.). Such applications are typically used in public cloud infrastructure (fig.2).

Applications implemented in the 3rd level, shown in the conceptual model of the SCADA system (fig.1), are performed by servers located in the cloud and connected remotely to the control network. This model is suitable for distributed SCADA systems. The controllers connect to SCADA applications (servers) running in the cloud over the WAN (Wide Area Network,) Internet. Such applications are typically used in private and hybrid cloud infrastructures (fig.3).

The advantages of cloud computing technology in the oil and gas industry can be summarized as follows: first, it develops resource utilization. Second, cloud computing offers a free download, installation, and time-limited service that reduces the costs of IT industry. Third, cloud computing has a great advantage in terms of high reliability for the storage of data copies and the management of generated data in the oil and gas industry in real-time.

Cloud computing technologies also involve a variety of devices and software to provide the information requirements of the oil and gas industry, in addition to providing the mass storage of data and sharing solutions. Also, data integration technologies are used to manage any type of data and information in a unified and effective way and eliminates access restrictions on various areas existing in the oil and gas industry.

Cloud computing technology provides group activity and distant visualization at the office of the oil company, its branches, and even remote areas. There arises a need for high-performance computer tools to increase the existing computing capacity of oil companies and to process seismic data generated by seismic sensors and to minimize the time spent on visual analysis. Companies using cloud services can apply high-performance virtual machines to answer these requirements.

Recently, the amount of data generated in the oil and gas exploration and production sector has increased significantly. Seismic data is considered as big data. An effective system for managing seismic data, as well as a high-productivity and large-capacity storage is required. The study of seismic data is considered an important part of effective drilling management [18]. Thus, cloud-based SCADA systems play an important role in the effective management of these three sectors of the oil and gas industry.

In cloud-based SCADA systems arise risks connected with reliability and security [30]. The structure of cloud computing platforms is usually more homogeneous than traditional computing centers. In such systems, configuration control, gaps testing, and security audits are implemented easily. In

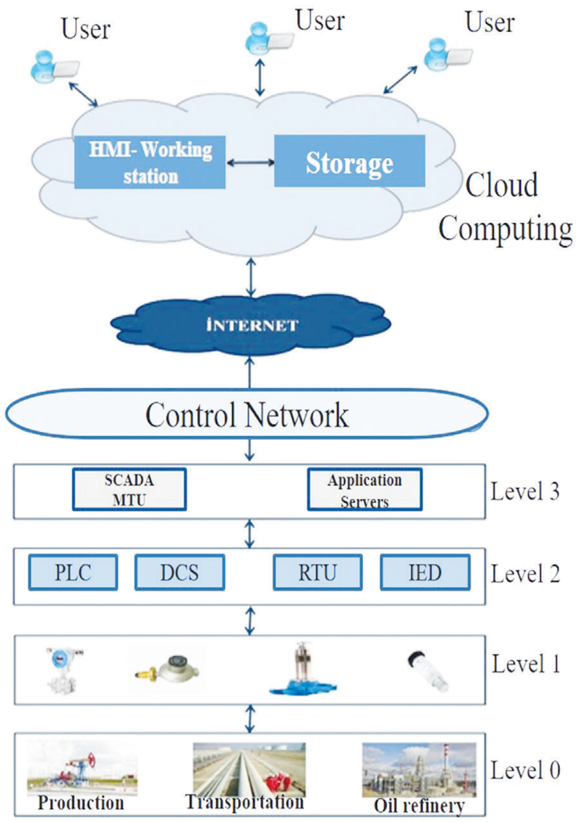

Fig.2. Cloud-based SCADA system which operates locally and provides the implementation of some applications (process visualization, reports, remote access, etc.).

the infrastructure environment of traditional SCADA systems, the failure of both the primary and reserve servers leads to a complete failure of the system. In a cloud environment, if any cloud computing nodes fails, then the other nodes can perform the functions of the failed nodes. For companies with a unified management infrastructure, cloud service reserves and recovery policy procedures are of great importance. The storage of reserves in different geographic areas is more reliable as in most cloud providers. Data stored in the cloud can be easily accessed, recovered faster, and can usually be more reliable. Updates are implemented in a distributed form in real-time without user intervention. This can save time and increase system security.

Despite the above-mentioned advantages, cloud-based SCADA systems have two serious security risk factors - Quality of service (QoS) and cybersecurity risks [11, 31, 32].

QoS refers to the operation of the system, as well as its reliability and availability. Most SCADA systems have strict requirements for delays, packet loss, and bandwidth. The strictest requirements on delays are given at low levels and in controller networks. The use of public cloud services increases the risk of non-fulfilment of these requirements, as the user cannot control the operation of the network. As this makes an obstacle to SCADA operations carried out in real-time the increasing and unpredictable delays become a problem.

The security problems of complex real-time systems require network security, management theory, and general analysis of physical systems and the existence of common concepts. This problem becomes more complicated in migration to the clouds.

Cyberattacks against SCADA systems can be classified as follows: hardware attacks, software attacks, and communication system attacks [11]. The SCADA control center operates on the basis of information received from controllers (control devices). Attacks that make threats to process control are aimed at altering control data or obstructing data transmission. Cloud-based SCADA systems are exposed to the same cybersecurity risks as other cloud-integrated systems. Data stored in the cloud usually falls into an open distributed environment.

Systems based on cloud computing technologies have more advantages than systems based on traditional IT models. However, there exist some problems connected to security and other issues mentioned above. Open (public) cloud migration requires the transmission of control over data, as well as control over components of the system that were previously under the direct control of the organization, to the control of the cloud provider. In this case, organizations that transfer data with high-security requirements to the cloud should determine together with the provider how that data will be managed and stored securely.

Security risk management is a periodic process consisting of several stages: the analysis of risks by identifying vulnerabilities and threats, the estimation of risks, the decision-making on risk level, the

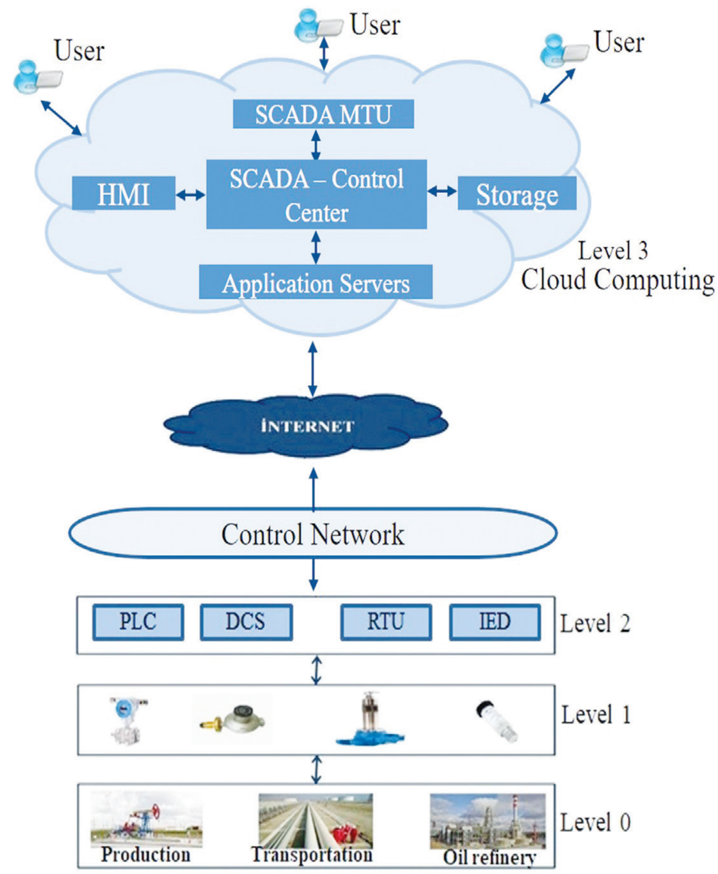

Fig. 3. The cloud-based SCADA system applications operating in the cloud

identification and implementation of measures to reduce risks.

The cloud-based SCADA system has the following advantages comparing with traditional SCADA systems:

• The adding of new devices is provided to the system if required or needed. For the company, the obtaining, installing and running of software and hardware cost cheap.

• Users can easily obtain the additional resources they need on a cloud server without installing an additional device.

• Updating existing applications and adding new applications to the system is implemented easily.

• Easy access to memory resources for the storage of big data generated in system management.

• Ensuring system reliability and security by creating reserve servers in the cloud.

•The users access to data hosted on cloud servers connected to the Internet in real-time.

• Cloud-based SCADA systems allow for efficient use of resources, low energy consumption, also provide rapid deployment of new services and reduction of overall costs.

Thus, the transfer of traditional SCADA systems applications to the cloud environment allows us to reduce costs, increase the scalability and make it more attractive to users in terms of hardware. At the same time, the costs of obtaining, installing, maintaining the hardware and software required for monitoring and management systems are decreased by the reduction of technical staff.

Conclusion

In the article, the opportunities, advantages and problems of cloud-based SCADA systems based on cloud technologies in the oil and gas industry has been analyzed. The migration of traditional SCADA systems to cloud systems has been analyzed. The transfer ways of SCADA systems to cloud computing environments are presented. The advantages of different cloud models and services used in cloud migration strategies have been given. The cloud-based SCADA systems being economically efficient has been confirmed. The transfer of SCADA systems application to the cloud environment is more attractive to users in terms of reducing costs, increasing scalability and providing hardware. Also, in the paper, the decrease of costs in obtaining, installing, maintaining the hardware and software by the reduction of technical staff have been presented.

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Вопросы миграции SCADA-систем в среду «cloud computing» (обзор)

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Реферат

В статье рассматриваются вопросы миграции SCADA-систем (Supervisory Control and Data Acquisition), широко используемых для мониторинга и управления нефтегазовой промышленностью, в среду облачных вычислений. Поскольку традиционные SCADA-системы очень дороги, негибки и трудно масштабируемы, существует множество проблем со сбором, передачей и обработкой данных. Перенос приложений SCADA-системы в облачную среду снижает затраты и улучшает масштабируемость. Приобретение, установка и поддержка аппаратного и программного обеспечений обходятся сравнительно дешевле. В статье предлагается использовать облачные SCADA-системы для простого, безопасного, надежного и быстрого сбора и обработки данных, полученных с объектов, установленных в нефтегазовой промышленности.

Ключевые слова: нефтегазовая промышленность; SCADA-системы; облачные вычисления; cloud сервисы; cloud модели; безопасность.

SCADA sistemlərinin «cloud computing» mühitinə miqrasiya məsələləri (icmal)

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Xülasə

Məqalədə neft-qaz sənayesinin monitorinq və idarəedilməsində geniş istifadə olunan SCADA (Supervisory Control and Data Acquisition) sistemlərinin cloud computing mühitinə miqrasiya edilməsi məsələlərinə baxılmışdır. Ənənəvi SCADA sistemləri çox bahalı, qeyri-çevik, miqyaslaşması çətin olduğundan məlumatların toplanması, ötürülməsi və emalında çoxsaylı problemlər yaranır. SCADA sisteminin tətbiqlərinin bulud mühitinə köçürülməsi xərclərin azaldılmasına, miqyaslaşma imkanlarının yaxşılaşdırılmasına imkan yaradır. Texniki və proqram təminatının alınması, quraşdırılması və saxlanılmasına nisbətən daha aşağı xərclə həyata keçirilir. Məqalədə neft və qaz sənayesində quraşdırılmış obyektlərdən məlumatların asan, təhlükəsiz, etibarlı və sürətli toplanması və emal edilməsi üçün bulud əsaslı SCADA sistemlərindən istifadə olunması təklif olunur.

Açar sözlər: neft-qaz sənayesi; SCADA sistemləri; cloud computing; cloud xidmətləri; cloud modelləri; təhlükəsizlik.