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SOME ISSUES OF APPLICATION OF INTERNET OF THINGS IN THE OIL AND GAS COMPLEX

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1. Introduction

Locating modernized solutions is an urgent task serving to increase the productivity and competitiveness of the oil and gas complex (OGC). The use of modern information technologies in this direction is constantly developing, which provides an increase in the speed of exploration and detection of oil, an increase in oil production and a reduction in risks to health, human security, and the environment. The Internet of Things (IoT) in the OGC, as in all industrial sectors, has great prospects from an economic point of view [1, 2]. However, the use of this technology makes it necessary to solve a number of scientific, theoretical, and technological problems. The article is dedicated to study of these issues and the development of a conceptual model for the use of IoT in the Azerbaijani oil company SOCAR.

The main technical factors of the formation and development of IoT include the following:

- Evolution of mini, micro, and nano-sensor production technologies with the ability to collect various information (temperature, pressure, vibration, distance, position, angle of rotation, chemical composition of the substance, etc.) from the control and management facilities;
- Transition to IPv6 technology, which removes restrictions on the number of sensors and devices that are connected;
- Introduction of wireless communication technologies that enable to directly extract information from sensors installed in the real measurement zone of parameters of various technological processes;
- Development and improvement of cloud, fog, and dew structures that help to store large volumes of information and enable the application of complex analytical tools such as Big Data, Data Mining, OLAP, Pattern Recognition, etc.

The key element of IoT is the sensor network topology. Sensor networks consist of local nodes. Each node is equipped with a sensor for data acquisition, a microprocessor for initial processing of data and development of control actions on actuators and a transceiver for receiving or transmitting data to the next node in the hierarchy [3]. As a rule, nodes of sensor networks operate in continuous mode or in a mode on demand. In the first mode, the network node uninterruptedly receives the data and sends it online or after the primary processing to the neighboring or central node. In the second mode, the node is in hibernation mode, waiting for the command from the neighboring or central node. Wireless devices are traditionally connected through the radio frequency spectrum. RFID, Bluetooth, Wi-Fi, ZigBee are usually used at the level of short-range nodes (hundreds of meters within one field), while cellular or satellite communication is used for long-range wireless communications (offshore platforms, main pipeline monitoring systems). Unambiguously, the transition to Internet Protocol version 6 (IPv6) will allow to have a unique IP address for each sensor, node or device. However, there are problems associated with several aspects of implementing IPv6, which include security management, the implementation of interfaces supporting the dual IPv6 and IPv4 environment and the adoption of new standards. In recent years, various solutions have been developed based on the SCADA, M2M, and WSN dispatching and data collection systems. In [4], examples are given of devices for monitoring the state of equipment, in the production of petroleum products, monitoring of pipelines, cathodic protection stations for pipelines, detection of corrosion, wellhead monitoring, pumping installations, the system when drilling oil wells. So it is suggested to use sensors distributed along the entire length of the pipeline at fixed points for in-pipe inspection, but it is not possible to perform a measurement very close to a leak. In the technology of IoT, the physical parameters measured by the sensors can become the basis for predicting the maintenance of the equipment according to its actual state.

2. Description of Technological Processes in OGC

It is necessary to pass several stages of technological processes in the OGC before the final products derived from oil and natural gas will be offered to the consumer. At the first stage, a search for potential hydrocarbon fields (oil and natural gas), exploratory drilling and other works is performed. The second stage consists of the extraction of raw materials, that is, the extraction of oil or natural gas from the earths interior from offshore platforms or on land. At the third stage, raw materials are transported and delivered to consumers for further processing. For example, extracted oil with impurities passes through pipelines and is pumped into primary battery tanks, where oil is separated from gas, and water. The crude oil is then stored in storage tanks, from where it travels through oil trunk pipelines to oil refineries, to other storage tanks, tanker vessels or tank wagons for transportation. Pumping stations are installed at regular intervals along the entire length of the route to pump oil through the pipelines. Pumps are used to initiate and maintain pressure, overcome friction, account for the difference in altitude along the length of the route, and other factors. In the fourth stage, oil or natural gas is processed to produce final products such as gasoline, kerosene, jet fuel, diesel fuel, fuel oil, lubricating oils, liquefied gas, plastics, and other materials. These technological processes occur in the three main sectors of the OGC or as it is customarily called, Upstream, Midstream, and Downstream.

3. Proposed Conceptual Model on IoT Basis

Since the emergence and development of microprocessors and network devices, the possibility of using microcontrollers, supplemented by sensors and mechanisms, has been actively studied to ensure greater reliability, efficiency, and security of production processes in the OGC (geological exploration, drilling, extraction, processing, transportation, etc.), as there is a high level of financial, environmental, and humanitarian risks. Traditionally, information flows processing and management in oil and gas producing enterprises occur on three levels. At the lower level, data monitoring, data collection from sensors and primary processing of information for the purpose of developing control actions on oil and gas production facilities is carried out in real time with the help of local-group devices. Replacement of conservative and mostly manual control and monitoring devices and the provision of production, transportation and processing processes in the OGC with new, easy-to-install sensors allows for continuous automatic control of technological processes, registration and storage of data, and remote configuration. Thus, it is possible to increase reliability, security, energy efficiency, and influence on environmental indicators, such as gas emissions, leaks and spills of primary raw materials. At the next level, decisions are made on optimizing processes, determining the frequency of repair activities to reduce downtime and optimizing maintenance intervals for units and assemblies, ensuring efficient operation, etc. Unplanned downtime due to equipment breakdowns that lead to loss of time and finances can be reduced through introduction of intelligent maintenance systems. The upper level is the level of the company on which the analysis (big data processing) is implemented, which results in the coordination of activities that are part of the company of enterprises and structures to achieve overall efficiency, measures are taken to increase security and reduce risks. A concept of IoT [5] determines the development of industry in the coming years. A prerequisite for the operation of any production facility, including the OGC within the framework of this concept, is the direct information interaction of various types of facilities equipped with various sensors, the availability of intelligent devices that can transmit data, make decisions and interact with each other. A concept model based on IoT can be presented at the following levels:

- Level one. Control object with built-in sensors.
- Level two. Gateways controlling data flows. They can also perform primary processing and release of control actions for level one.
- Level three. Clusters of real-time data processing.
- Level four. Cloud infrastructure, which includes a processing center and a database.

The main stages of technological processes are spatially-distributed. They are grouped into clusters according to certain features; data is processed in clusters without the need to transfer to the cloud. Thus, there is a redistribution of the load from the cloud service to fog computing. To increase the reliability and efficiency of management in case of failures or channel congestion, virtual cross-links are created between the corresponding nodes: gateway-gateway, gateway-fog, and fog-fog.

4. Conclusion

Currently, the OGC faces new production problems, especially against the background of a decline in oil prices. Finding new ways to increase efficiency and competitiveness, improve results, and reduce costs is an urgent and important task. Here a special role is assigned to the control and collection of detailed and accurate data and information on the production process. The use of IoT in these processes is the most optimal strategy. IoT has the potential capabilities to manage the main processes for the three sectors of the OGC with more efficient and reliable results. The processing of large data collected using new technologies can be performed using the capabilities of cloud technologies, Big Data, and data mining technology, and the obtained results will provide operational and look-ahead control, thereby increasing production efficiency.

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