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Development of a platform for collecting information on the operation of technological equipment with the use of Industrial Internet of Things

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Development of a platform for collecting information on the operation of technological equipment with the use of Industrial Internet of Things

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Abstract. The article discusses the approach to collecting and aggregating data from sensors located on heterogeneous technological equipment using the principles of the industrial Internet of things. The main analytical data processing platforms are considered, the advantages of using ready-made and own solutions are shown. A practical example of the collection of parameters from a planer-milling machine with their subsequent analytical processing, which revealed the need for unscheduled technological maintenance of the spindle assembly, is presented.

1. Introduction

With the development of modern society, the means of collecting, processing and transmitting information have changed: an increasing number of people use mobile devices to work with information resources, and the global network and cloud technologies are used to access large amounts of data. The changes also affected the industry, where there was a transition from the automation of individual components and equipment to the concept of “smart” or intelligent manufacturing, a distinctive feature of which is the integration of production into a single digital ecosystem. Combining heterogeneous equipment from different manufacturers into a single network allows you to quickly obtain information about the operation of machine tools, robotic and other lines, and timely transmit information to the upper levels of production management, including ERP and MES [1-3].

In modern enterprises, diverse solutions from various manufacturers (CNC systems, PLCs, robots, etc.) are often used to control various technological equipment and solve automation problems. Such a variety of decisions within a single enterprise is determined by many factors, including the economic component [4,5]. The use of these principles of the acquisition of automation systems causes difficulties in collecting and aggregating information from these systems, since Each manufacturer uses its own proprietary data access solutions.

2. The concept of data collection using the Internet of things

In the current realities, one of the approaches used in the collection of telemetry from process equipment is to combine sensors with their own data transfer interfaces into a single information network. Such an organization makes it possible to reduce the influence of the human factor in checking the state of mechanisms (Figure 1.), carrying out technical and scheduled maintenance, and avoid equipment



breakdowns due to late detection of faults, which helps prevent unplanned downtime of equipment that directly affects productivity [6].

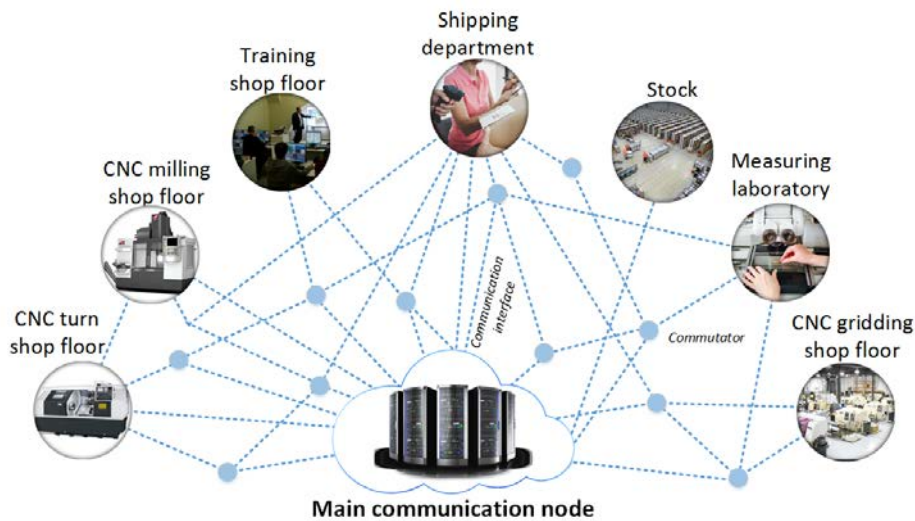


Figure 1. A possible option for combining industrial enterprise devices using IIoT

A further development of the concept was the industrial Internet of things (English Industrial Internet of Things, IIoT), which involves the integration of enterprise networks with industrial facilities connected to them, embedded sensors and software for data collection and processing [7]. Combining these objects into a single information space allows you to realize the possibility of remote control and management of objects in an automated mode, without human intervention. The introduction of IIoT technology at enterprises creates the conditions for real-time monitoring of the main production indicators of the state of individual components of the equipment in order to determine occurrences or predict possible irregular situations and take measures to prevent them [8].

3. Using Analytical Platforms for Data Collection, Aggregation, and Storage

The development of industrial control systems allows you to combine individual machines, modules, workshops and control systems into a common network - Intranet, within the enterprise. This opens up broad possibilities for analysis, processing, and also aggregation of data accumulated at all stages of the process equipment operation. Storing the received volume of unstructured data and providing the necessary infrastructure for processing them on the production site is a financially unavailable task for most enterprises [9-11]. These capabilities provide: cloud services and platforms based on them (cloud computing) and serverless computing (serverless). These services allow you to build a scalable, flexible, and economically viable computing solution architecture.

Cloud platforms can be divided on several grounds: financial - paid and freely used; by the size of the developer's company - large, medium and small; by the availability of analytical tools - having tools or providing only a network node for data storage. Of the major players in the market are: AWS IoT (Amazon), Azure IoT (Microsoft), Google Cloud IoT (Alphabet). At the same time, according to the Eclipse Foundation, as part of the Attribution 4.0 International study (CC BY 4.0) and a comparison of cloud computing trends for cloud platforms for 2018 for the Internet of things: AWS received 51.8% of developer IoT votes (31.8% in 2017), Microsoft Azure voted 31.2% of developers (14.2% in 2017), proprietary clouds received 19.39% of the vote, Google Cloud IoT received 18.8% (10.8% in 2017). There is also a large number of open IoT platforms (OpenRemote, Home Assistant, OpenIoT, etc.), but their popularity is decreasing every year. This is due to the fact that the giants of cloud computing can offer streamlined services for data collection, storage and analytics with a variety of tariff plans.

Considering the industrial Internet of things in the field of automation of technological processes should pay attention to the type and amount of data transmitted from various sensors (physical and virtual), which are installed on dissimilar equipment. A large amount of unstructured information needs

special filtering and interpretation algorithms. Often, this task is the highest priority even in comparison with the task of collecting data from heterogeneous equipment.

In addition to providing computational capabilities, one of the important directions for the development of the Industry 4.0 concept is the processing and analysis services for unstructured large-scale data [12]. The purpose of these types of processing is to provide the end user with convenient for review the type of analytical data obtained from information flows. For this purpose, analytical platforms are presented on the market, for example, business intelligence systems such as QlikView, Klipfolio, Power BI, Tableau. Each of these platforms has distinctive features and is capable of analyzing data on the state of technological processes in real time, processing gigabytes of information and presenting it in a convenient form, for example, in the form of diagrams, graphs, and advanced systems support predictive analytics reports [13].

4. Development of the scheme of interaction of the main components of the proposed solution

The researches presented in the article were conducted using the Microsoft Azure IoT platform, which represents a set of cloud services that are ready, which simplifies the interaction between devices and the cloud in the early stages of development. Azure allows you to connect virtually any device to the cloud service, authenticate using specialized keys (sas tokens), provides local storage for each IoT device, and also supports popular data transfer protocols (MQTT, HTTPS, AMQP, etc.). Microsoft Azure IoT leases computational power on demand (Amazon's lambda functions, "Functions" in Azure), which is more economically advantageous for small tasks as compared to purchasing local computing systems [14,15].

Sensors (temperature, vibration, humidity) and data from the control system (virtual sensors: data from drives, PLC) can be considered as elements of the "Internet of things" concept [16]. An important feature of the data transmitted from the control object can be not only the ability to accumulate them in the cloud, but also the ability to display in "real time", in this case, the data must arrive synchronously, which distinguishes these systems from corporate applications, in which it is customary to work with data in asynchronous transfer format.

The organization of synchronous data transfer imposes constraints on the computing power required, in this case the system should have a substantial supply of computing resources, allowing not to lose data due to server overloads, locks at the database level, connecting new devices and other irregular situations. The capabilities of synchronous (online synchronization) organization of data transfer and database recording are provided by the scalable Azure cloud architecture. As part of the creation of a separate copy of the computing module, you can specify the size and volume of expansion during peak loads, as well as the ability to significantly increase the computing power by notifying the owner, for example, by e-mail upon receipt of its approval.

Figure 2 shows the structural scheme of the proposed solution. The left shows target platforms for connecting sensors. It can be either single-board computers Raspberry Pi3, Orange Pi or Omega2, as well as cheaper solutions, for example, modules with ESP8266 for transferring information to the network, transfer of information directly from the CNC system (virtual sensors) is also considered.

On target platforms, a special script is launched that contains the keys to generate the sas token and device communication with the IoT Hub Center in the cloud: URI = 'IotMachineHubCenter.azure-devices.net', KEY = '6qiVw88oG9H=', and also the device id, its access policy to database and database id: IOT_DEVICE_ID = 'rpi3_1', POLICY = 'rasp_sensors', DB_DEVICE_ID = 1. Configuring devices, configuring policies occurs in Azure IoT Hub Center, which allows developers to focus on organizing data collection from local devices.

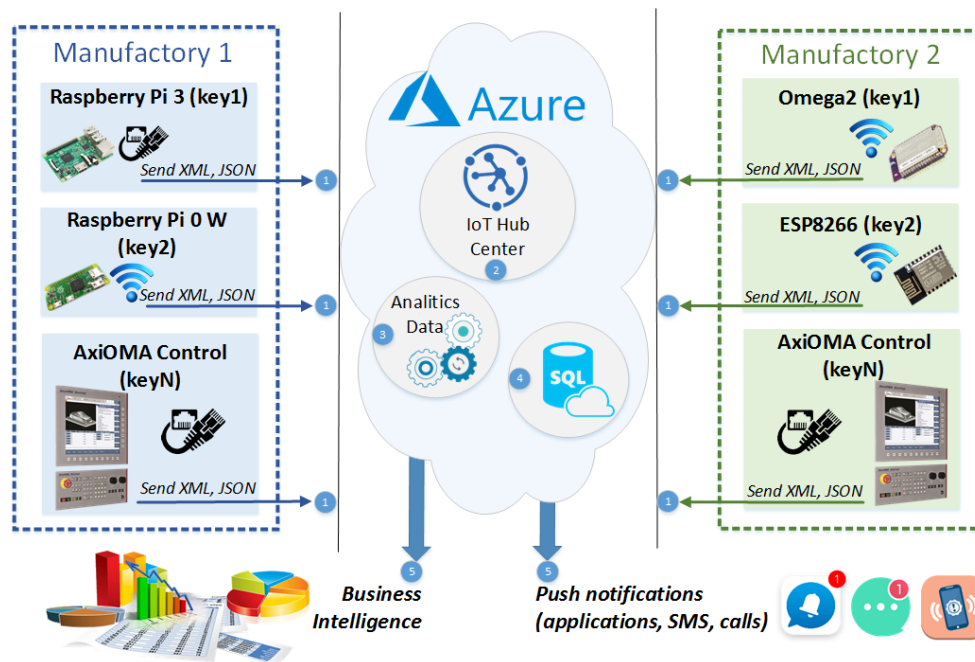


Figure 2. Structural scheme of the proposed solution

5. Practical implementation of the “Industrial Internet of Things” concept on the example of receiving data from a planer-milling machine

For testing on the running equipment, three devices were selected: RaspberryPi3, Raspberry Pi0 and Omega2. These devices are in a different price range and differ in the amount of computing resources. At the same time, the amount of computing resources is an important factor influencing the possibility of using the developed solution in industrial projects. Different types of sensors are connected to the devices to determine environmental parameters (temperature and humidity), which were installed in several target zones: in the electrical cabinet - PLC zone and actuators; in the spindle node and near the working area of the machine. On each of the devices, a script is running in the Python language, which implements communication with the IoT Hub Center, from where data enters the database and the Analytics Data service, which allows you to verify large data streams. Analytics Data allows you to extract information from data streams for specific patterns and relationships [17]. Templates are intended: to save the data source in the database, create reports in Azure Analytics after starting the transfer of data from the devices to the IoT Hub Azure.

The analytics module searches for the required template described in a SQL-like language, for example, data transmitted in JSON format is matched with attributes created in a relational database, and input attributes and database fields are uniquely matched. Each device is given a connection key (policy), which is indicated in the input data source and by which it determines how the database is accessed. Device policies are conveniently combined by device type (physical or virtual sensors), assigning a unique identification to the transmitting device (transmit a unique id).

In the proposed version, various data from sensors connected to the Raspberry Pi2 and Pi0 with their attribute1, attribute2, as well as the data arrival time and the unique equipment id are expected. The second template describes the acquisition of data from sensors connected to the Omega2.

The project used the MSSQL database, the structure of which is not tied to a specific equipment (Figure 3). This structure is useful when integrating data transferred from local objects to Azure storage and using the capabilities of the Analytics Data module.

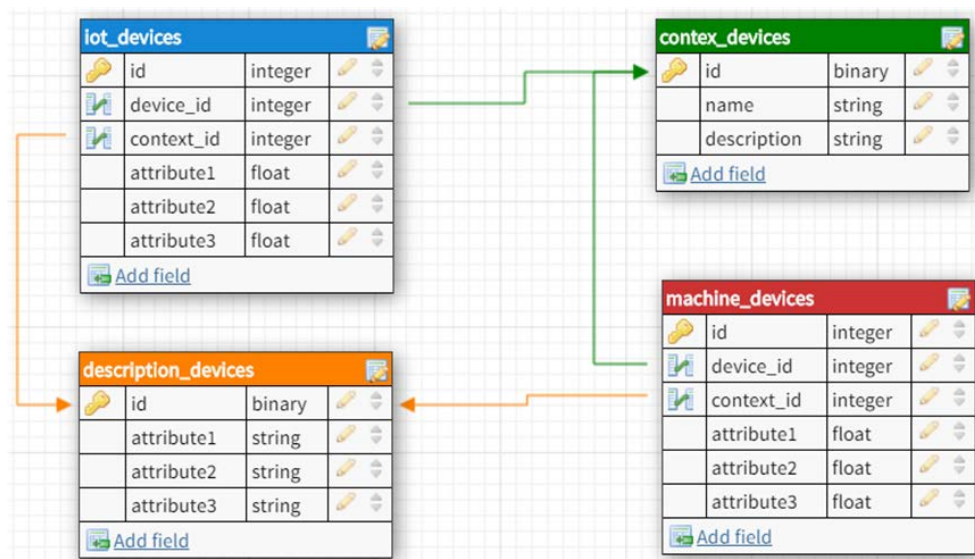


Figure 3. Structural scheme of the proposed solution

The database structure is optimized for the expected information flows from the connected devices: raspberry_devices, machine_devices. Attributes in the tables have contex_devices links to the description_devices table, which stores the exact definition of the received parameter for a specific device with a specific context. The devices table stores a description of device parameters. The organization of data storage in such a structure allows you to create new tables for previously unknown data sources.

The tests were carried out on a vertical planer-milling machine at idle for an hour (Figure 4). During this time, it was found that the ambient temperature had risen by 1.19 degrees: from 24.06 to 25.25; the temperature in the zone of operation of the drives rose by 7.82 degrees, in the PLC zone - by 5.8 degrees. In the spindle assembly, the temperature has risen by more than 20 degrees, which is significant, given the fact that the work was performed at idle speed.

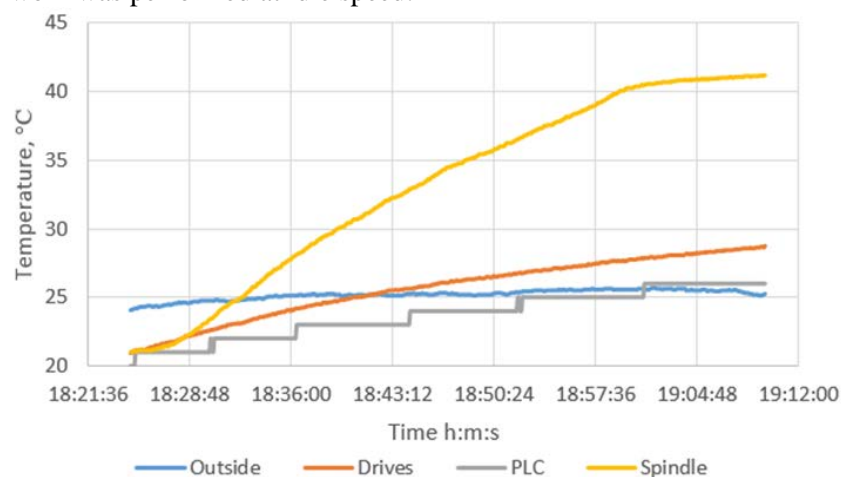


Figure 4. Data Analytics

Based on the tests carried out, it was concluded that it was necessary to check the cooling system of the spindle assembly, which revealed a number of faults, which led to extraordinary maintenance.

6. Conclusions

The introduction of IIoT technology at enterprises creates conditions for real-time monitoring of the main production indicators of the state of individual equipment components in order to determine the occurrence of irregular situations or predict their possible manifestation.

The proposed approach to collecting and aggregating data in the Microsoft Azure IoT cloud service was applied on the basis of a milling planer and allowed us to determine an irregular situation - overheating of the spindle node. This error was corrected due to unscheduled technological maintenance of equipment.

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