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ORGANIZATION OF MANAGEMENT AND STRUCTURE IN LOCAL NETWORKS INTERNET OF THINGS

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Internet of Things (IoT) symbolic formula is given. The analysis of management technologies both in the network structures of infocommunications, based on the NSMP, and on local networks of the Io T. Two approaches for implementing the management process in infocommunication networks are shown: one is based on creating special software tools, the second is based on the working with data describing the network device. The basic operations of SNMP are given. Four levels of IoT in local network structure are described: smart sensors, network vehicles, services, and applications. Structure of local network of IoT which includes smart sensors, transport environment, services and applications information representation in network use semantic web are considered.

The structure of multi-agent system (MAS) of milk farms analyzing in Leban (MASMFA) for monitoring of production quality. MASMFA structure has many agents such as quality milk sensors, agents of communications, data base, analysis of the information received from sensor agents, decision-making. This system implements the functions to ensure the required class of milk quality and based on IoT local network construction. The information algorithm processing in such IoT is proposed. Milk sensor shell be periodically queried, their values will be recorded in the server database. The decision-making subsystem will issue data on milk quality to the farm administrator on a mobile device. The server structure will be implemented using a cloud service. Implementation this Internet of things network is being developed using LTE technology.

Key words: *network management, Internet of things, smart sensors, transport networks, services, applications, structure*

Introduction

The Internet of things is based on three basic principles. First, the ubiquitous communication infrastructure, second, the global identification of each object, and third, the ability of each object to send and receive data via a personal network or Internet to which it is connected. In its most general form from an infocommunication point of view, in which Internet of things can be written as the following symbolic formula [1]:

$$IoT = Sensors + Data + Networks + Services$$

The Internet of things is a global network of computers, sensors, and executive devices that communicate with each other using Internet Protocol (IP). To solve a specific application task, the server communicates via Internet with a group of small devices that have various sensors connected to them [2–3].

To build a practical local Internet of things system, consider the management organization, structure, and modeling tools of IoT [4–5].

Management technology in network structures

There are two main approaches to implementing the management process in infocommunication networks: the first one is based on creating and using special software tools for managing a specific network device; the second is based on the working with data describing the network device [6, 7]. In this case, the data stream is used as the impact, not the control stream. The data flow, in contrast to the control flow, allows to build a more universal, although more limited in its capabilities, management model. Its main advantage is its independence not only from the OS, but also from the specific hardware implementation of the managed device. In order to create a unified approach to managing equipment connected to IP networks, the Simple Network Management Protocol (SNMP) was developed. From the management point of view, the entire network can be divided into a management system and management objects. The control system includes a set of computing tools designed to generate control actions and analyze information on the basis of which a decision on management is made. Management objects are resources that need to be managed (active network equipment, workstations, servers, etc.).

The control system consists of a control station and a set of auxiliary tools (probes, analyzers, applications, etc.). Usually, the control station is a fairly powerful computer with specialized software. An important element of the control station is the description of the control objects (the station itself can act as a control object). In SNMP-compatible management objects, a special software module is implemented, which is called an agent. Agents collect information about the managed devices they work on and make this information available to network management systems (NMS) using the SNMP. The basic concept of SNMP is that all information necessary for device management is stored on the device itself (it can be a server, modem, or router) in Management Information Base (MIB). SNMP, as a direct network protocol, provides only small set of commands for working with MIB variables. In order to monitor the operation of a certain network device, it simply need to access its MIB, which is constantly updated by the device itself, and analyze the values of necessary variables. SNMP technology consists of three parts:

– Structure of Management Information (SMI);
– Management Information Base (MIB);
– SNMP itself, which defines the rules of interaction between the Manager and agents.

The control information structure defines the rules for describing this information. The formal description of objects is performed using the Abstract Syntax Notation One (ASN 1) language. To set the name of an object, just specify its identifier (Object Identifier), which is a sequence of integers. All identifiers are organized as leaves of a large tree. At the top level of the tree, there are three main nodes: iso, ccitt, and joint-iso-ccitt, which belong to different standard organizations. The iso subtree contains the org identifier (a node that is the root of various organizations subtrees), one of whose sub-nodes is the Department of Defense (DOD). It is believed, although not officially recorded, that the first node in DoD subtree is Internet. Thus, the «internet» object has the ID «1.3.6.1»: internet OBJECT IDENTIFIER:: = {iso(1) org (3) dod(6) 1}.

The SNMP is a simple request–response protocol. SNMP messages are embedded in UDP datagrams. The basic operations of SNMP:

– Get_request – get the value of the specified variable or information about the state of the network element;
– Get_next_request – get the value of a variable without knowing its exact name (the next logical identifier in the MIB tree);
– Set_request – assign the appropriate value to the variable. Used to describe the action to be performed;
– Get_response – response to commands: Get_request, Get_next_request, and Set_request. It also contains status information (error codes and other data);
– Trap – response of a network object to an event or state change.

Management levels in network of IoT

Recommendation Y.2060 provides an Internet of Things (IoT) reference model that is very similar to the NGN model and also includes four basic horizontal levels) [8]. There are four levels of management in the IoT network: the application level; the support level for applications and services; the network level; and the device level (sensor + handler).

The IoT application level is not considered in detail in Recommendation Y. 2060. The application and service support layer includes capabilities for various IoT objects to process and store data, as well as capabilities required for certain IoT applications or groups of such applications.

The network layer includes network capabilities (access and transport network resource management, mobility management, authorization, authentication, and billing functions, AAA) and transport capabilities (providing network connectivity for transmitting IoT application information and services). The device layer includes the device's capabilities for retrieving information, preprocessing it, and gateway capabilities.

The capabilities of the device include direct exchange with the communication network, exchange through the gateway, exchange through the wireless dynamic ad-hoc network, as well as temporary stop and resume operation of the device for energy saving. The gateway features support multiple interfaces for devices (CAN bus, ZigBee, Bluetooth, Wi-Fi, etc.) and for access/transport networks (3G, LTE, DSL, etc.). Another feature of the gateway is support for protocol conversion, if the protocols of the device and network interfaces differ from each other [8].

There are also two vertical levels, the management level and the security level, covering all four horizontal levels. Vertical operational management capabilities include managing the consequences of failures, network capabilities, configuration, security, and billing data.

The main objects of management are devices, local networks and their topology, traffic and congestion on networks. The capabilities of the vertical security level depend on the horizontal level. The AAA functions, antivirus protection, and data integrity tests are defined for the application and service support level. For the network layer, there are options for authorization, authentication, and information protection of alarm protocols. At the device level, there are authorization, authentication, access control, and data privacy features.

In this case, the leading role is played by devices that can collect various information and distribute it over communication networks in various ways: through gateways and through the network; without gateways, but through the network; directly among themselves. Devices can have full-fledged control processors for processing data in the form of a «system-on-a-chip», including their own OS, a sensor / sensing unit for the environment, and a communication unit.

Structure of local network of IoT

The Internet of things belongs conceptually to the next generation of networks, so its structure is similar to the well–known four layer of NGN architecture, which includes smart sensors, transport environment, services and applications [1, 7].

The lowest level of the IoT structure consists of smart objects integrated with sensors. Sensors connect the physical and virtual (digital) worlds, providing real-time data collection and processing. Miniaturization, which reduced the physical size of hardware sensors, made it possible to integrate them directly into objects in the physical world. There are different types of sensors for the relevant purposes, for example, for measuring temperature, pressure, speed, location, etc. Sensors can have a small memory, allowing it to record a certain number of measurement results. The sensor can measure the physical parameters of the monitored object / phenomenon and convert them into a signal that can be received by the corresponding device [9].

Most sensors require a connection to a sensor aggregator (gateway), which can be implemented using a local area network (LAN) such as Ethernet and Wi-Fi, or a personal network (PAN) such as ZigBee, Bluetooth, and ultra-wide-band wireless communication over short distances (UWB – Ultra-Wide Band). For sensors that do not require connection to the aggregator, their connection to servers/applications can be provided using global wireless WAN networks such as GSM, GPRS, and LTE.

The large amount of data generated at the first level of IoT by miniature sensors requires a reliable and high-performance wired or wireless network infrastructure as a transport environment (network level). To implement a wide range of services and applications in IoT, it is necessary to ensure that multiple networks of different technologies and access protocols work together in a heterogeneous configuration. These networks must provide the required values for the quality of information transmission, especially for latency, bandwidth, and security. This layer consists of a converged network infrastructure that is created by integrating heterogeneous networks into a single network platform [9].

The service level contains a set of information services designed to automate technological and business operations in the IoT: support for operational and business activities (OSS/BSS – Operation Support System/Business Support System), various analytical information processing (statistical, data and text mining, predictive analytics, etc.), data storage, information security, Business Rule Management, Business Process Management, etc.

At the fourth level of the IoT architecture, there are different types of applications for the relevant industrial sectors and fields of activity (energy, transport, trade, medicine, education, etc.). Applications can be «vertical» when they are specific to a particular industry, as well as «horizontal» (for example, fleet management, asset tracking, etc.), which can be used in various sectors of the economy [10].

Information representation in network

The idea of the Semantic Web is the direction of development of the world wide web (WWW), the purpose of which is to present information in a form suitable for machine processing. The term Semantic Web was first introduced by Tim Berners-Lee (inventor of the world wide web) in may 2001 [11]. The concept of the semantic web was adopted and promoted by the world Wide Web Consortium (W3C). In a conventional web based on HTML pages, the information is embedded in the text of the pages and extracted by a person using a browser.

The semantic web involves recording information in the form of a semantic network using ontologies. Ontology is understood as a formal explicit description of concepts in the subject area (classes) under consideration. The ontology together with a set of individual instances of classes, forms a knowledge base. Thus, the client program can directly extract facts from the web and draw logical conclusions from them. The semantic network works in parallel with the regular network and on its basis, using the HTTP and URI identifiers [12].

Application of Internet of things technology

The modern manifestation of the Internet of things is communication between machines (M2M) via wireless communication. In Europe, this technology is already used in agriculture to track real-time movements of cattle. In addition to tracking the movement of livestock, farmers receive automatic notifications about the status of animals. M2M communication devices equipped with SIM cards are installed in the stalls and in the field, and special sensors are attached to the animals that collect information and transmit it to the data collection device. This device immediately sends the necessary information to the farmer via SMS. Animal health data can be monitored not only via SMS, but also online via the GPRS channel that links monitoring systems to the data center. In Europe, this app is already used by about 4 thousand farms [1]. For decision making various intelligent technologies can be used [12].

Proposals

The authors propose the structure of multi-agent system (MAS) of milk farms analyzing in Libyan (MASMFA) monitoring of quality of production. Information about MAS is describe in [13]. Using proposals for organizing intelligent multi-agent information processing [14], the composition of the system's agents was determined. MASMFA structure has many agents such as sensors, communication, data base, analysis of the information received from sensor agents, decision-making. System implements the functions to ensure the required class of milk quality and allows to implement an IoT local network. To build such a IoT local network, the approaches described in article [15] will be used. Milk quality sensors will be periodically queried and their values will be recorded in the database server. The decision-making subsystem, processing the database content, will issue data on milk quality to the farm administrator on a mobile device. The server structure can be implemented using a cloud service. This network will be based on the principles of information transfer via LTE technology [16].

Conclusion

1. The analysis of management technologies in the network structures of Infocommunications, based on the NSMP, and in local networks of the Internet of things is performed. Four levels of the Internet of things local network structure are described: smart sensors, network vehicles, services, and applications.

2. The issues of identification of devices in the network, information security and practical implementation of international standards and recommendations are relevant. To logically build a network of IoT, it is necessary to develop models and algorithms for building local network management systems for agriculture implementation.

3. The structure of a multi-agent system for studying the quality of milk from farms in Lebanon is proposed. For its implementation, the Internet of things network is being built using LTE technology.

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ОРГАНИЗАЦИЯ СТРУКТУР И УПРАВЛЕНИЯ В ЛОКАЛЬНЫХ СЕТЯХ ИНТЕРНЕТ ВЕЩЕЙ

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Дана символическая формула интернета вещей (IoT). Проведен анализ технологий управления как в сетевых структурах инфокоммуникаций, основанных на протоколе SNMP, так и на локальных сетях Интернета вещей. Показаны два подхода к реализации процесса управления в инфокоммуникационных сетях: один основан на создании специальных программных средств, второй – на работе с данными, описывающими сетевое устройство. Приведены основные операции SNMP. Описаны четыре уровня IoT в структуре локальной сети: интеллектуальные датчики, сетевые транспортные средства, службы и приложения. Рассмотрена структура локальной сети Интернета вещей, которая включает в себя интеллектуальные датчики, транспортную среду, сервисы и приложения для представления информации в сети использования семантик веб.

Рассмотрена структура мультиагентной системы (МАС) анализа работы молочных ферм в Ливане (МАСМФА) для мониторинга качества продукции. Структура МАСМФА имеет множество агентов, таких как агенты качества молока, агенты связи, базы данных, агенты анализа информации, полученной от агентов датчиков, агенты принятия решений. Данная МАС реализует функции по обеспечению требуемого класса качества молока и основана на построении локальной сети Интернета вещей. Предложен адгоритм обработка информации в такой сети Io T. Молочные сенсоры будут периодически запрашиваться, их значения будут записываться в базу данных сервера. Подсистема принятия решений будет выдавать данные о качестве молока администратору фермы на мобильном устройстве. Серверная структура реализуется с использованием облачного сервиса. Реализации этой сети IoT разрабатывается с использованием технологии LTE.

Ключевые слова: *сетевое управление, интернет вещей, умные сенсоры, транспортные сети, сервисы, приложения*

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