Technology of hybrid telemetry network of the Internet of things "KUMIR-Net"

R Belousov¹, A Gapeenko¹, A Nikolaev², E Fiskin² and M Fiskina²

¹LLC "Scientific and Technical Center" KUMIR », 83a Lermontov street, office 201, Irkutsk, 664074, Russia
²Irkutsk National Research Technical University, 83 Lermontov street, Irkutsk, 664074, Russia
E-mail: belousov@ntckumir.ru

Abstract. This article is devoted to the development and implementation of information-measuring and analytical systems for enterprises in the energy sector and housing and communal services, specialized in accounting and monitoring the production, transmission and consumption of energy resources.

It is predicted that the global market for smart energy accounting systems as an important component of Smart Grid technologies will continue to show steady growth in the medium term. At the same time, the high growth rates of this market in the EU, China and the United States will be the key factors contributing to the global growth of demand for smart energy accounting systems.

The situation in the Russian Federation is developing with a certain delay in relation to global trends in the field of intelligent information and measurement systems. So, after a long discussion in the expert community, the law of 27.12.2018 N 522-FZ "on amendments to certain legislative acts of the Russian Federation in connection with the development of electric energy (power) metering systems in the Russian Federation" was adopted, which prescribes that from 2022, all electricity meters for commercial accounting in retail markets and utilities should provide free of charge a minimum set of functions for intelligent electric energy (power) metering systems. Requirements for an intelligent electricity metering system are formulated in the draft resolution of the government of the Russian Federation "Rules for providing access to a minimum set of functions of intelligent electric energy (power) metering systems". Directly to the system for collecting and transmitting data from metering devices are requirements for the functionality, procedure and protocols for the exchange of information, access, storage and data security. The development of such systems, taking into account the number of metering devices in Russia of about 100 million units, will probably be based on Internet of Things (IoT) technologies and will contribute to the development of these technologies both in Russia and on the world market. Overview of existing Internet of things technologies.

6LoWPAN. Standard for IPv6 communication over low-power wireless personal networks of the IEEE 802.15.4 standard. The purpose of the IEEE 802.15.4 standard is to offer the lower layers of the network base for networks such as wireless personal networks focused on low cost, low speed ubiquitous communication between devices. The emphasis is on the very low cost of communicating with nearby devices, with very little basic structure, in order to operate at a low energy level. The IEEE 802.15.4 standard does not define other higher layers and the compatibility of intermediate
layers — these are other solutions and standards that 6LoWPAN belongs to. 6lowpan's goal is to provide Internet of things devices with a cheap interface for connecting to the Internet. Application developers will determine the exchange protocols.

Advantages of the technology: an open standard for which cheap transceivers are produced by many electronics manufacturers, the frequency range of 800-900MHz is harmonized by regulators in many countries and one or another part of the range can be used in different countries of the world without obtaining permits for the use of radio frequencies. The competition of chip manufacturers, hardware and software solutions allows us to expect a reduction in the cost of Internet connection for Internet of things devices in the future.

Disadvantages: the end device requires support for the entire TCP/IP stack, which requires an advanced microcontroller / processor in the device, and also provides increased memory requirements. For cheap sensors, this can greatly increase the cost of devices. Another drawback is the low penetration of IPv6 networks both in the world and in Russia. According to the monitoring of IPv6 connections by Google, the penetration of IPv6 networks in the world in 2019 is 25%, in Russia-4.3%, in China-1.3%, in the CIS countries <0.3%. Therefore, traffic tunneling may be required to connect 6LoWPAN networks to the outside world, which is an additional cost.

**LoRaWAN.** Patented high-budget radio channel technology from the American company Semtech. It allows you to achieve a long communication range and high connection density (up to 5000 devices per BS). LoRaWAN is one of the wireless technologies that provide an environment for collecting data from various equipment: sensors, counters, and sensors, i.e. Internet of things devices. In this case, the specification does not define data representation models — this is left to the manufacturer of the final solution. Advantages of the technology: Long range of radio signal transmission compared to other wireless technologies used for telemetry (up to 10-15 km). High network scalability over large territories. No need to obtain a frequency resolution and pay for the radio frequency spectrum. Disadvantages: With a variety of manufacturers of base stations and modules for terminal equipment, everything is based on Semtech microcircuits, which presents some concerns when introducing any restrictions on their supply. The lack of competition in the production of chips can lead to an increase in their cost in comparison with similar technologies. The technology provides high characteristics of the radio channel only at low data transfer rates (tens of bits per second). At speeds of 9600 bps or more, the performance of the radio channel is comparable to 6LoWPAN. Nevertheless, in electricity meters operating under the SPODES protocol (DLMS / COSEM), it is necessary to transmit data packets that are rather large by the standards of LoRa, and long delays can lead to breaks in sessions.

**NB-IoT.** Internet of things technology aimed at mobile operators. Cellular communication standard for telemetry devices with low data exchange volumes. Developed by the 3GPP consortium as part of work on new-generation cellular network standards. Designed to connect a wide range of Autonomous devices to digital communication networks. For example, medical sensors, resource consumption meters, smart home devices, and so on. Deployed over existing LTE or GSM (EC-GSM-IoT) networks. Advantages of the technology: flexible management of power consumption of devices, huge network capacity (up to 100,000 devices per 1 BS), low cost of devices, increased sensitivity of receivers compared to LTE. The coverage area during deployment will be equivalent to the entire service area of the mobile operator. In a mass application, the communication quality will obviously be better than that of 6LoWPAN or LoRaWAN due to the licensed frequency range.

Disadvantages of the technology: higher power consumption and higher cost of modules than 6LoWPAN and LoRaWAN due to more complex circuitry, the subscription fee is “for the device” and not for the “base station”.

Summarizing the above, it can be argued that the currently known IoT technologies are focused on high-density radio communication systems with low energy consumption so that the final device can operate on batteries up to 10 years. The KUMIR-Resource information-measuring system has been developed by the team of the KUMIR Research and Development Center since 2014 and is the product of a deep modernization of the KUMIR-TeploCom Information-Measuring System, developed in 2008. However, more than 10 years of experience in the field of automation and dispatching utilities.
and energy, as the most popular category of customers, shows that the use of the radio channel in absolutely all cases is an economically unjustified strategy. Often, metering devices can be grouped into a wired cluster and already connect it wirelessly. The use of the 868 MHz radio channel in the city is often limited by the terrain and in many cases this justifies the use of mobile communications as a better and more reliable communication channel. When automating industrial facilities, it is often necessary to derive the readings of dozens of devices from one or more technological rooms within the same building - a hybrid (wired + wireless) connection is also advisable here. In Yakutia, for dispatch projects, we had to use VSAT technologies several times, because the quality of mobile Internet did not allow us to achieve the desired quality of communication with the object. Thus, to reduce the cost of connecting and servicing IoT devices and applications, it is necessary to develop a hybrid network architecture, on the one hand transparent for IoT applications, and on the other hand, efficient and reliable in any communication environment.

Also, existing IoT technologies do not offer specifications for typical applications (sensors, sensors, switches, servos, etc.). This forces equipment manufacturers to develop their own protocols even for typical applications, which results in the incompatibility of products from different manufacturers among themselves.

The product being created is the technology of the KUMIR-Net Internet of Things hybrid telemetry network. The main purpose of the product is a tool for creating large platforms of the Internet of things with different physical levels of data transfer. The prerequisites for the creation of the technology were the fact that most developers of technologies for the Internet of things are guided by the same principles of the functioning of the network, the same requirements as for conventional Internet devices, but with a focus on low power consumption. This approach does not fully meet the current state of affairs and inhibits the development of IoT technology. The main problem of modern IoT technologies is that due to the presence of the IoT interface, the device increases in price several times, for example, electricity meters with a wired RS-485 interface, which measure not only electricity consumption (kW * h), but also quality parameters (voltage, current, frequency, power factor, etc.) cost in Russia 2500-3500 rubles. Depending on the manufacturer, and with IoT interface (GPRS, NBioT, Ethernet) - 5500-6500 rubles. The situation is even sadder in the segment of cheap devices (temperature sensors, pressure sensors, motion sensors, etc.) - from the price without IoT - up to 500 rubles, with IoT - from 2500 rubles.

The thing is that they are trying to turn an IoT device into an Internet site with all the associated costs. The creation of our technology is aimed at solving this problem. In the sense of creation, it should provide interaction between terminal devices and IoT applications in a single infocommunication space based on the KUMIR-Net protocol, while application developers can abstract from data transfer technologies and focus on describing application logic, and equipment developers - on the device’s hardware. The introduction of technology will generally help to reduce the cost of creating and managing large networks of process equipment, telemetry and telealarm systems. The technology also includes the possibility of building hybrid networks: on the basis of generally accepted Internet technologies, local field networks of bus topology with random access, as well as on the basis of wireless LPWAN and PAN networks.

Methods and methods for solving problems to obtain the expected characteristics

1. Creating a simple protocol for exchanging data with IoT technological devices with low requirements for end devices, due to which their low cost will be ensured. Creating transport layers for the protocol on top of the CAN field bus and on top of the radio channel of the IEEE 802.15.4 standard - as the most common and cheapest way of radio channel data transmission.

2. Creation of the implementation of a fail-safe cluster with the ability to scale horizontally with a capacity of at least 5 million end devices, which ensures reliable functioning of the IoT ecosystem.

3. Creating simple API libraries for integrating end devices into the network to reduce the labor costs of developers of Internet of things equipment, metering devices, etc.

4. Creation of simple API libraries for integration into the network of applications for processing data from end devices and metering devices.
The goal of STC Kumir LLC’s efforts to develop a protocol for the Internet of things, a field network protocol, an 868 MHz radio protocol and integrate Kumir-Resource IMS into the developed technology is to create a distributed intelligent information-measuring system (IMS), intended primarily for energy distribution organizations of Russia and neighboring countries. But this does not exclude the possibility of using the KUMIR-Resource platform as a combination of hardware and software technologies in various IoT applications in the future.

The leaders in the smart metering market are currently leading international companies such as Siemens, Itron, Landis + Gyr, Honeywell, and American ElectSolve. In Western Europe, German Cuculus, Dutch Energywox, Italian Ferranti are active. Due to the similarity of working conditions and goals, the Indian provider Fluentgrid, offering its products (IMS MDMS) and services in Central Asia and EMEA (markets of the Middle East, Europe and Africa), can become a definite beacon in the field of market promotion efforts. In Russia, the companies offering AIIS KUE for OREM and the retail market are: NPO Mir, AIIS KUE of the Energomera concern, LLC Matritsa (AIIS KUE Smart Ims for the retail market), CJSC Telecommunication and Telemechanics Systems (integrated system AIIS KUE / ASDTU), EnergoKapitalServis LLC (AIIS KUE AlfaCenter), etc. As a top-level software, energy sales organizations use widely distributed products such as AlfaCenter, Pyramid, Energosfera, as well as solutions of their own development. The requirements put forward by the "Rules" for intelligent accounting systems, in terms of data collection, transmission and storage systems, are most closely aligned with the modernized information-measuring system IMS "Kumir-Resource".

IMS “Kumir-Resource” can be used as a vertical industrial IoT platform for energy retail organizations in Russia and neighboring countries - in particular, those consumers who are looking for simpler and cheaper solutions that differ from the offers of large industrial IoT vendors (such as GE, Itron or Siemens).

Wireless communication networks and the upgraded Kumir-Resource platform can become the basis for large-scale IoT solutions, including smart metering and smart networks, street lighting, electric transport and security, etc. This is possible because most of the IoT applications are related to different parts of the technological stack of IMS “Kumir-Resource” (radio components, sensors, network hubs, databases, servers).

Competitive advantages of the created product, comparison of technical and economic characteristics with domestic and foreign analogues:

1. Wireless solutions. 868 MHz radio channel transceiver as part of the KUMIR-Resource system

The decision to develop an inexpensive domestic radio channel transceiver in the public range of 868 MHz was made primarily based on the conditions for leveling non-trade restrictions and risks. The concept of the transceiver was developed taking into account the analysis of the existing wireless systems on the market (Sigfox and its Russian counterparts, LoRaWAN and NB-IoT) and the possibility of further transferring the development of STC Kumir LLC to the domestic element base.

The design took into account both the strengths and limitations of the radio channel transceivers and systems on the market. So:

Sigfox has a unidirectional transmission channel, which does not allow it to be used in systems with accurate time synchronization and organization of balance accounting of resources.

LoRaWAN is the closest to the radio channel solutions of Kumir-Resource LLC. The system also provides bidirectional signal transmission, but has several disadvantages:

- the time synchronization procedure of base stations does not allow making them inexpensive, which makes the system as a whole more expensive;
- in systems on the market with LoRaWAN radio modules (868 network, etc.), the signal from the primary devices is transmitted to the concentrators exclusively via the radio channel. Such a solution in the conditions of a complex urban radio environment makes the installation of monitoring systems for meter readings and IoT unpredictable and costly;
- licensing the production of microchips of the LoRa standard in the USA and the supply of microchips from a single manufacturer (Semtech) does not allow us to talk about import substitution.
of systems based on this standard and carries the corresponding limitations and risks;

The method of increasing the noise immunity and stability of communication by expanding the dynamic range is a strong point of the LoRa standard. But in tests, NTC" KUMIR" LLC achieves similar results using noise-resistant coding based on reed-Solomon codes, without expanding the signal spectrum. At the same time, the effective channel speed is 37.5 kbit / s versus 30 kbit/s for LoRa.

Mobile operators with NBoT solutions, with appropriate modernization of the software of mobile base stations, can significantly expand their sales due to the scope of smart measurements and IoT. But here they encounter several significant obstacles, the main of which is the need to equip primary devices with SIM cards and pay for the mobile traffic of each of the end devices, which significantly increases their price and, ultimately, the cost of the system as a whole.

All of the listed competitive systems are also characterized by a lack of specification of the “Internet of things” itself as an infocommunication object platform, which gives rise to incompatibility between devices of the same purpose produced by different manufacturers.

2. Multiresource execution of IMS "KUMIR-Resource"

IMS "Kumir-Resource" was originally designed as a system for remote monitoring of measurement data of electric and heat energy, gas, hot water and cold water. At present, the Kumir-Resource system supports more than 80 metering devices with the potential for introducing almost any meter with open protocols. This opens up opportunities for the potential Customer to choose metering devices for future use.

Those. the energy sales organization, deploying IMS "KUMIR-Resource" in the housing estate to monitor the readings of electricity metering devices, gets the opportunity to include monitoring of gas, hot water, cold water and heat consumption in its data transmission system. At the same time, it can transfer data to specialized resource providers for an additional fee, earning additional money. Such a solution is a serious competitive advantage of IMS Kumir-Resource among Russian companies developing the IMS KUE direction and not having the ability to include monitoring of gas, heat and water meter readings in their systems.

In general, multi-resource execution of information-measuring systems is a development trend in this area abroad.

3. Hybrid solution for circuit implementation of IMS "KUMIR-Resource"

The possibility of using wired and radio channel solutions in the IMS “Kumir-Resource” allows you to flexibly vary design decisions.

In some cases, based on the configuration, relative position of buildings and radio coverage, the most appropriate option is to use the radio channel as the main method of transmitting data from primary metering devices. These are mainly open spaces - rural settlements, SNT, garage cooperatives, etc.

In conditions of dense urban development, radio noise and reinforced concrete walls create significant difficulties in the operation of 868 MHz radio channel systems, such as LoRaWAN (868 network) and LPWA (Sigfox and Russian counterparts - Strizh and Vaviot). In this case, the most appropriate and least costly hybrid solution is to transfer the data of the home metering devices to the lifting concentrators using a radio channel (PAN system) and further transmitting the information to a GSM modem or the Internet using a wired bus.

Circuitry IMS "KUMIR-Resource" allows you to apply and combine radio and wire solutions, depending on the situation. A specific placement option is developed when analyzing the radio environment, geometry and material of buildings, based on the choice of the most economical option.

IMS "Kumir-Resource" has been in commercial operation in its current form since 2012. Time has shown the correctness of the basic decisions on the architecture of the system, the choice of the base operating system and database management system, the "cloud" solution of the interface.

The proposed integration of IMS Kumir-Resource into the technology being created will not affect the foundations of existing software, but will add new communication protocols and support for hybrid technology, improving fault tolerance and service availability.
4. Integration of lower and upper level software and promising services for energy retail organizations

At present, over 80 metering devices are integrated in the IMS “Kumir-Resource”. In this case, the integration of meters with open protocols in the system, as a rule, is resolved within 2 weeks.

NTC Kumir LLC flexibly solves the problems of end-to-end data transmission to existing systems of commercial electricity metering (AIIS KUE) and billing. For this, the customer is offered an open API for developing interaction drivers with existing systems through the Kumir-Resource data hub or can independently develop interaction drivers with customer's top-level applications that are currently in operation or promising.

NTC LLC Kumir is a developer and manufacturer of software and hardware for remote monitoring systems of metering devices. Because of this, it sells both software and devices of its own production on the market.

Conclusions

Thus, the modernization of the architecture of the IMS “Kumir-Resource” will make it possible to scale the system to the requirements of electricity suppliers for large systems. This will make it possible to deploy IMS “Kumir-Resource” as a basic system of intellectual resource accounting when implementing the Law of December 27, 2018 No. 522-FZ.

References

[1] Overview of wireless communication protocols for the Internet of things https://iot.ru/promyshlennost/obzor-protokolov-besprovodnoy-svyazi-dlya-interneta-veschey
[2] Moskalenko T A, Kirichek R V and Kucheryavy A E 2017 Review of Internet of things protocols Information Technologies and Telecommunications 5 ISSN 2307-1303. http://www.it.sut.ru
[3] Aleshin C V, Balaev M O and Vlasyuk V V Software and hardware solutions for the Internet of things technology https://cyberleninka.ru/article/n/programmno-apparatnye-resheniya-dlya-tehnologii-interneta-veschey
[4] Novitsky N 2015 Pipeline energy systems: methodological and applied problems of mathematical modeling (Novosibirsk) p 476
[5] Belousov R A, Pinkin A A, Fiskin E M and Fiskina M M 2015 The possibilities of “Kumir-Resource” system for SMART GRID and apartment level energy accounting EURO-ECO Das Internationale Symp. «Ökologische, Technologische und Rechtliche Aspekte der Lebensversorgung» pp 15-16
[6] Amelin A A, Belousov R A, Fiskin E M 2016 IMS "KUMIR-Resource" as the basis for Smart Grid Improving the efficiency of energy use in Siberia 2 pp 461–466 ISBN 975-5-8038-1120-0 (T2) 978-5-8038-0837.
[7] Belousov R, Fiskin E and Fiskina M 2018 Integrated Systems for Commercial and Technological Control of Energy Resources Consumption in Urban Areas and Businesses in Russia E3S Web of Conf. Scopus 39
[8] Nikolaev A, Belousov R, Fiskin E and Fiskina M 2019 Development of equipment for monitoring the lake Baikal water area E3S Web of Conferences Scopus Volume 102
[9] Chupin V R and Dushin A S 2019 Parameter optimisation for new and reconstructed systems of water supply and distribution for ensuring consumer's uninterrupted water supply Proceedings of Universities. Investment. Construction. Real estate 9(4) pp 790–803
[10] Kulkov V N, Solopanov E Yu and Kamalov R T 2019 Using immobilised sludge for wastewater treatment and its air regeneration Proceedings of Universities. Investment. Construction. Real estate 9(3) pp 522–529
[11] Pupyrev E I and Chupin V R 2019 Features of regional development of water disposal systems in the central ecological zone of the Baikal natural territory Proceedings of Universities. Investment. Construction. Real estate 9 pp 354–363