Network architectures and protocols of M2M communications

I V Khasambiev¹, E A Guseva²

¹Chechen State University named after A.H. Kadyrov, 364015, 17a Dudaev Boulevard, Groznyy, Russian Federation
²Irkutsk National Research Technical University, Lermontov Street, 83, Irkutsk, 664074, Russian Federation

E-mail: fizelectronika@mail.ru

Abstract. The issues of building the architecture of M2M networks and managing M2M services using the capabilities of the IMS platform are considered. Introduction. M2M (Machine to Machine) is a complex of technologies that provide automatic interaction between devices (things) without human intervention. The Internet of Things is not a single technology, but a whole system of technological solutions. It is a global network infrastructure, which consists of computer networks of physical objects, the traditional IP Internet, and various devices connecting these networks.

1. Introduction
Computing networks of physical objects consist of "smart" sensors and drives (actuators), united into a computer network (personal, local and global) and controlled by a central controller [1]. There are a number of industries that will benefit most from the implementation of these technologies: housing and communal services, transport, mining, manufacturing, healthcare, renewable energy, smart homes, smart cities, etc. The development of M2M technologies and applications will allow them to become the main innovative direction in the development of the mobile ecosystem [2]. To provide and manage M2M services, both specialized M2M backbone networks created by M2M service providers and the operators' infrastructure for managing mobile networks EDGE/HSPA/LTE based on the IMS platform can be used. IMS is the implementation of services in IP-based communication networks, which represents the transition from classical telecommunication technologies to Internet technologies. IMS is a key step in the evolution of operators towards the creation of a new generation communication network, which implements the principle of the availability of the entire range of services, both for mobile subscribers and for subscribers of the fixed access network [3, 4]. The IMS platform is a cost-effective solution that allows you to introduce a huge range of new services for subscribers with minimal costs, including taking into account their individual needs. The cost-effectiveness of the solution is based on the versatility of the components, the use of standard interfaces, and the possibility of integration into the operator's existing network [5].

2. Materials and Methods
Access networks to M2M services are supposed to be created both on the basis of the use of fixed access networks and mobile networks. The use of a fixed access network to connect M2M end devices to the network of an M2M service provider is common, and the physical connection includes wired
communication lines with M2M end devices. Typically, these wire lines are used to connect users and provide basic communications services over the public switched telephone network (PSTN) or broadband data network [6-8].

The main elements of the architecture of M2M networks are divided into three domains [3]: M2M device domain (capillary network domain); network domain (the core of the M2M core network) and application domain. In addition to these domains, the M2M network includes a corresponding access network and transport network, which are built on the basis of 3GPP and NGN networks. The interaction of various domains of the M2M network is shown on Figure 1.

M2M devices allow you to quickly take advantage of M2M services and domain network functions. An M2M device can be connected to an access network either directly or through an M2M local network and an M2M gateway.

M2M LANs provide connectivity between M2M devices and M2M gateways using PAN technologies. M2M gateways provide M2M devices with guaranteed interworking and connectivity to the network and application domains. Access networks allow an M2M device domain to provide connectivity to the core of the M2M network (core network). The functionality of M2M access networks is based on the capabilities of existing access networks (xDSL, HFC, PLC, VSAT, GERAN, UTRAN, LTE, W-LAN, and WiMAX) and allows you to expand both the list of services and their capabilities.

The transport network provides the transport of data between the network domain and the application domain. The functional capabilities of transport networks in M2M networks are based on the capabilities of existing transport networks and, like access networks, allow expanding the list of M2M services and their capabilities. The M2M core network provides IP connectivity of the M2M network elements, service and network management functions, interworking, roaming, and ensures network security. The functionality of the M2M core network builds on the corresponding functionality of the existing 3GPP CN core networks. The functionality of the M2M network can be either special, supporting M2M applications, or general, supporting network-wide capabilities: data collection and aggregation, delivery of multicast messages, etc.

The interfaces mIa, dIa, mId of the M2M network based on the principles of open interfaces provide interaction between the application domain and the M2M core network, between the application and functional level of the domain of M2M devices, between M2M devices and the M2M gateway, respectively. The IMS Core multimedia services subsystem has all the functionality of the
core network, allowing the implementation of the service functional characteristics of the M2M network when interacting with applications of M2M devices and core network applications of the access network. The main functions of the M2M core network, built on the IMS platform, include [4] registration, authentication, authorization, storage of the network subscriber database, session management, network policy management, NAT procedure, etc.

The service functional characteristics of the M2M core network are implemented in the form of the corresponding functional modules, which are defined by the ETSI standard for the functional architecture of the M2M network. To identify and register an M2M device in the M2M core network, it must be configured with one Private User Identity (IMPI) and one Public User Identity (IMPU), which defines the M2M device's unique network number (ID). The IMPU identifier is used to identify information coming from the M2M device (for example, authentication data) and stored in the IMS Core subsystem of the core network (for example, for use in the registration procedure for an M2M device).

3. Results and Discussion
Promising M2M models that are in demand in the M2M services market are services of monitoring systems for housing and communal services and energy consumption, security systems, medical services, transport management, automation of industrial processes, and other applications.

Here are the main models for the implementation and implementation of M2M services [5, 9]:

- Intelligent measurements in homes and non-residential premises.
- Electronic health.
- Consumer electronics management.
- Transport control automation.
- Automation of city transport management.

The Smart Measurements in Homes and Non-Residential Premises model implements the latest advances in grid technology and energy conservation. Allows you to manage with high efficiency all energy and resource sensors in homes and offices, industrial premises, minimizing the consumption of heat, electricity, water, gas, as well as remotely monitor the level of consumption of these resources, manage their consumption, billing and cost optimization [10-14].

The e-health model is the most socially-oriented model. The current situation in healthcare is characterized by a significant need for the use of M2M devices, which is determined by the fact that in the population over 60 years old, there is an increase in chronic diseases and patients require daily monitoring of their health status. Therefore, the use of medical sensors and devices for monitoring the health of patients based on M2M technologies is one of the main applications of M2M services in the future.

The Consumer Electronics Management model is becoming more and more in demand to improve the ability to manage and group consumer electronic devices and devices resources. In consumer electronics, thanks to M2M technology, embedded processors and SIM cards have appeared, and it becomes possible to manage and exchange information. This model allows you to solve the tasks of monitoring all objects in your home environment, control stocks and automatically request consumables for household appliances, link photos and video cameras with social networks, automatically visit electronic libraries, etc [15-17].

The “Automation of transport control” model allows information exchange between traffic control devices and vehicle control devices on the basis of M2M networks to ensure traffic safety (car collisions), control groups of cars, manage traffic routes and prevent theft of goods and vehicles [18-20].
The model "Automation of city transport management" solves the problems of managing urban traffic flows, the operation of traffic lights, monitoring and controlling the operation of urban public transport, controlling the illumination of city highways and city streets, and a number of other tasks.

Mobile access of M2M end devices to the network of an M2M service provider is usually provided by wireless connection of M2M devices to the base station of the mobile network, providing flexibility, security, and high reliability. One of the advantages of using mobile access in M2M networks is the ability to connect both mobile and fixed M2M devices. This allows the M2M service provider to use the M2M service delivery platform for both mobile and fixed M2M devices.

4. Conclusion
One of the areas of activity of mobile operators may be the acquisition of the status of a service provider of M2M services. The presence of the IMS platform in the operator's network infrastructure will make it possible to quickly and efficiently deploy M2M networks, manage traffic, and provide numbering and addressing of M2M devices based on IMS functionality. The development of M2M technologies and applications will allow them to become the main innovative direction in the development of mobile ecosystems.

References
[1] Khasambiev I V, Khazhmuradov M A and Daudov I M 2017 Models and means of resource management in distributed telecommunication systems *Youth, Science, Innovations* 103–110
[2] Tikhvinsky V O 2011 Prospects and models of services in M2M networks *Connect! Communication World* 2 86–91
[3] Tikhvinsky V O 2011 Using an IMS platform for service management in M2M networks *Electrosvyaz* 2 41-46.
[4] Vidyayev I G, Martyushev N V, Ivashutenko A S, Bogdan A M 2014 The resource efficiency assessment technique for the foundry production. *Advanced Materials Research* 880 141–145
[5] Pashkov E N, Martyushev N V, Masson, I A 2014 Vessel ellipticity and eccentricity effect on automatic balancing accuracy. *IOP Conference Series: Materials Science and Engineering* 66(1) 012011
[6] Balanovskiy A E, Astafyeva N A, Kondratyev V V, Karlina A I 2021 Study of mechanical properties of C-Mn-Si composition metal after wire-arc additive manufacturing (WAAM). *CIS Iron and Steel Review* 22 66–71
[7] Ksenz N V, Yudaev I V, Tararanov M A, Sidorcov I G, Semenikhin A M, Chernovolov V A 2019 Determination of the Efficiency of the Operation Mode of Nonflowing Installation for Electroactivation of Water and Aqueous Solutions. *International Journal of Automation Technology* 13(4) 539-544
[8] Sysoev I A, Kondrat’ev V V, Zimina T I, Karlina A I 2018 Simulation of the Energy States of Electrolyzers with Roasted Anodes at Elevated Currents. *Metallurgist* 61(11-12) 943–949
[9] Kondratiev V V, Karlina A I, Guseva E A, Konstantinova M V, Kleshnin A A 2018 Processing and Application of Ultra disperse Wastes of Silicon Production in Construction. *IOP Conference Series: Materials Science and Engineering* 463(3) 032068,
[10] Gabov V V, Zadkov D A, Stebnev A V 2016 Evaluation of structure and variables within performance rating of hydraulically powered roof support legs with smooth roof control *Eurasian Mining* 2 37-40. doi:10.17580/em.2016.02.09
[11] Konyukhov V Yu, Perymakova D N, Oparina T A 2021 Numerical simulation of the size, quantity and shape of non-metallic inclusions in rails. *Journal of Physics: Conference Series* 2032 012071
[12] Gabov V V, Zadkov D A 2018 Mathematical model of simple spalling formation during coal cutting with extracting machine. *Journal of Physics: Conference Series* 1015(5) doi:10.1088/1742-6596/1015/5/052007
[13] Suslov K, Piskunova V, Gerasimov D, Akhmetshin A, Lombardi P, Komarnicki P 2019
Development of the methodological basis of the simulation modelling of the multi-energy systems. *E3S Web of Conferences* **124** 01049

[14] Konstantinova M V, Olentsevich A A, Konyukhov V Y, Guseva E A, Olentsevich V A 2021 Automation of failure forecasting on the subsystems of the railway transport complex in order to optimize the transportation process as a whole. *IOP Conference Series: Materials Science and Engineering* **1064** 012020

[15] Kondrat’ev V V, Gorovsky V O, Kolosov A D, Kononenko R V, Konyukhov V Y 2020 Description of the complex of technical means of an automated control system for the technological process of thermal vortex enrichment. *Journal of Physics: Conference Series* **1661** 012101

[16] Suslov K, Shushpanov I, Buryanina N, Ilyushin P 2020 Flexible power distribution networks: New opportunities and applications. *SMARTGREENS 2020 - Proceedings of the 9th International Conference on Smart Cities and Green ICT Systems*, pp. 57–64

[17] Konyukhov V Y, Permyakova D N, Oparina T A 2021 Perspective for the use of industrial waste in lubricating compositions to reduce wear in friction pairs. *Journal of Physics: Conference Series* **2061** 012046

[18] Voropai N, Ukolova E, Gerasimov D, Suslov K, Lombardi P, Komarnicki P. 2019 *A Study on Cost-Effectiveness of Energy Supply Based on the Energy Hub Concept*. Proceedings of 2019 IEEE PES Innovative Smart Grid Technologies Europe, ISGT-Europe 2019, 2019, 8905736

[19] Suslov K, Solonina N, Stepanov V 2015 A principle of power quality control in the intelligent distribution networks. *Proceedings - 2015 International Symposium on Smart Electric Distribution Systems and Technologies*, EDST 2015, pp. 260–264, 7315218

[20] Afanaseva O, Ilyushin Y 2018 Analysis and synthesis of distributed icedrill heating control system of mountain reconnaissance drilling rig. *International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM*, 2018, 18(2.2), pp. 41–48 DOI: 10.5593/sgem2018/2.2/S08.006

[21] Rapatskaya L A, Tonkikh M E, Ustyuzhanin A O 2020 Natural reservoir as a geological body for storing helium reserves. *IOP Conference Series: Earth and Environmental Science* **408** 012060. https://doi.org/ 10.1088/1755-1315/408/1/012060