Computer simulation of M2M communication subscriber locating

Galina Kurcheeva
Novosibirsk State Technical University
Novosibirsk, 630073
kurcheeva@yandex.ru
Georgy Klochkov
Novosibirsk State University of Economics and Management
Novosibirsk, 630099
klgeorge@yandex.ru
Maxim Bakaev
Novosibirsk State Technical University
Novosibirsk, 630073
bakaev@corp.nstu.ru

Abstract

The potential for developing technologies of machine-to-machine communication for smart city projects to be implemented in Russia is discussed. The necessity of developing technologies connecting devices of different types within a given location is substantiated. A model and a statement of the problem specifying the location of an item in a machine-to-machine communication system (Machine-to-Machine, M2M) at the required scale are proposed. In the study, a systemic approach and a process approach are applied. The systemic approach allows separate machine-to-machine communication developments to be integrated into a smart city paradigm. The process approach allows the sequence of all the major technological and information processes to be implemented. In Russia, machine-to-machine communication has so far been developed for limited expanses. Implementation of the proposed model allows a transition to technologies which are close to mobile applications and which may ensure machine-to-machine communication in the smart transport, smart energetics, smart house subsystems, and other areas of the smart city system. This development is designed to enhance mobility and efficiency of work; therefore, its commercialization is likely, which, in its turn, requires expansion of user-friendly functionality, like design, graphical interface, and other functions, in accordance with the requirements of the information product consumer.

Keywords: machine-to-machine communication technology, smart city, model, business specification

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1 Introduction

The methodology of machine-to-machine communication is being implemented in different sectors and for different products. We have analyzed the examples of solutions of using the M2M technologies, which may be significant for their development and commercialization. The cases of implementing such solutions indicate that many business owners have to keep looking for ways to improve the existing products and to introduce new products and services [1], [2]. All the reviewed solutions refer to the function of tracking a subscriber's location in a given area [3].

This concept is implemented in all the products discussed, and software developers embed the logic of finding an object within a geo-fence into the architecture of their solutions.

As a rule, a geo-fence may have a shape of a polygon (for example, the territory of a city or factory) or a circle, which we use in this study. Various solutions are considered as competitive versions, relating to mobile telecommunications companies functioning in the territory of Russia: Megafon, MTS, VimpelCom, and Tele 2.

It is to be noted that the proposed technologies have only several direct competitors, which have certain weaknesses discussed in this study.

Identification and study of indirect competitors help businesses to find adjacent markets, which in the future may serve as new channels for searching for target users of subscriber tracking services. We have analyzed strengths and weaknesses of the already operating M2M services, which provide the possibilities of control and tracking of the location of objects in Russia, with the following bottlenecks revealed:

1. The proposed solutions are not universal in terms of the working architecture and in terms of working with accessible technologies like GPRS or GSM. They do now allow any switchovers among them; hence, a compromise should be reached, and one technology must be chosen;

2. Accessible solutions are purchased by clients as individual platforms, which cannot be split into component modules ready to be sold to the clients;

3. Unopened topographic maps (Google maps, Yandex maps) are used, the API of which are quite costly;

4. The client opportunities are limited to a standard set of functions – rating, sms-notification, and showing coordinates;

5. Only a standard set of the policies of storing geo-fence coordinates is available: a circle, a polygon, and a line;

6. The platform web-interface is often not clear and not comfortable for a user, and some competitors do not have it at all.

To consider the possibilities of improving existing systems, with dedicated business logic and graphical interface, we propose to use the platform for control, monitoring and managing M2M objects, which is based on the system as a web application for billing software systems for mobile operators.

The platform system makes it possible for any customer of a telecom operator (corporate clients, M2M service providers and services, individual entrepreneurs) to control SIM cards in any equipment.

The use of the platform allows M2M / IoT-clients of the operator and service providers to integrate closely with the infrastructure of the telecommunication operator in order to obtain the additional value of technological solutions [6].

We propose to enable a client to outline the desired geolocation site of the SIM card pool on the map and apply his/her own business logic to this area.

To formulate the problem, the authors developed an integrated scheme based on the IDEF0 methodology, which is used to create a functional model that reflects the structure and functions of the system, as well as the information flows and material objects that connect these functions.

The developed process model of the system architecture has certain advantages, compared to the above-indicated direct and indirect competition, namely:

1. The use of a platform for the system's architecture, which is currently functioning and which has already been tested as a universal platform, suitable for any types of connecting technologies (GPS, GPRS, GSM): this provides certain benefits, compared to the existing competition;

2. The use of innovative technologies of finding object coordinates, communication protocols, and open 'free' topographic maps.

2 Developing the process model

Modeling with IDEF0 tools is the first step of studying any system. In this case, sources and users of information may be presented; they provide a possibility to analyze completeness and connectivity of the information flows [4]. 1 illustrates a general diagram for a system of tracking a M2M subscriber in the given location.

The system's functional blocks are decomposed as follows.

The use of the system begins on the part of the web-interface, and the web-browser is the system's mechanism, where the user manipulates the set of the opportunities provided. Pushing any area of the web-interface space, buttons, windows, checkboxes, pop-up menus and tips, icons, marks, and other elements described in the system's documentation, a user sends queries to the client's side of the user interface to the software-hardware part of the system. Shown below is the decomposition of the IDEF0 system of tracking a M2M-subscriber in a given area (Fig.1).

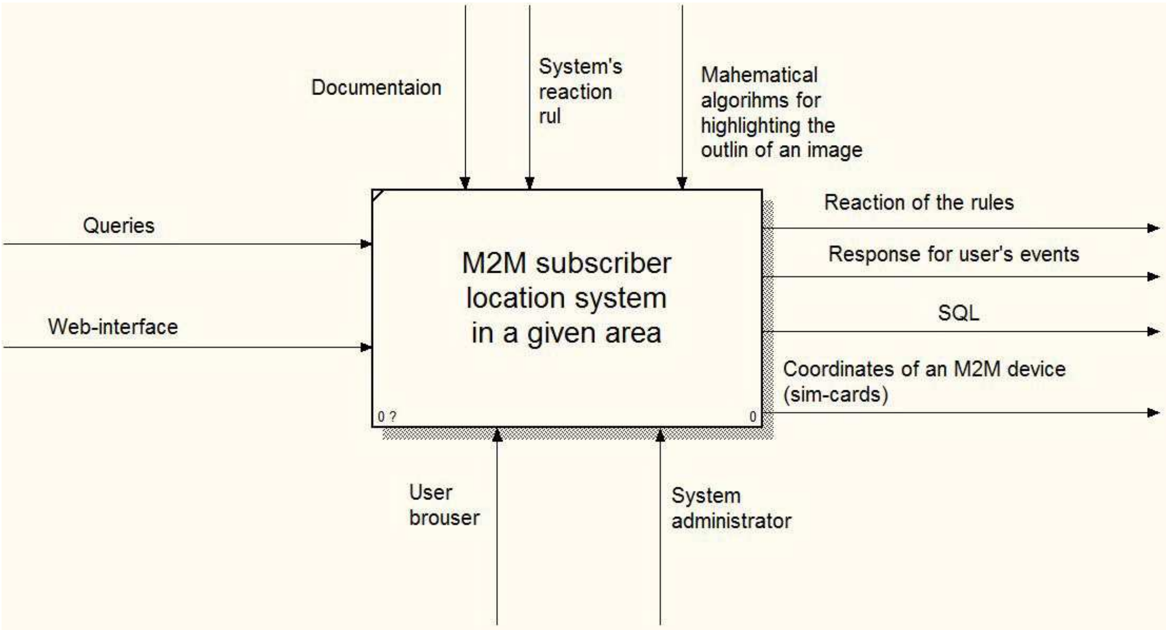

Figure 1: An IDEF0 diagram of the tracking system of a M2M subscriber in a given area

A system administrator is a user, to whom the extended functionality is accessible, and he/she exercises control over the system's operation; therefore, he/she acts as the system's mechanism. Both the system administrator and the user may set the rules of reaction to registered events and the system's reactions based on the user's account and the devices owned by the user, sensors, or SIM cards.

The control 'Mathematical algorithms for highlighting the outline of an image' is a dedicated item on the IDEF0 diagram. Such algorithms of the developed system are designed to optimize the program code in the software-hardware component of the system. On the part of the interface, the user outlining the geo-fence does not see the way all the consecutive coordinate points are accumulated into a single pool of queries, which transfers the dynamic coordinates to the system logic, where the script system processes these queries and stores them by the chosen algorithm of outlining the image control.

In the software realization of API, we identify two functional blocks: a tracking system and a geo-information system (GIS). The blocks perform the function of a generator of multiple http-queries based on an asynchronous principle.

The interface for the tracking system is used for obtaining information about the subscriber's location, the subscriber's device and the characteristics of this device. These are also sets of scripts, functions, and procedures, which also process http-queries and provide the required information about the object's location, further to be depicted on the map (GIS). Such script systems have close technical relations with the levels of sensors and gauges and generate the required information by technologies of data transfer in the networks, such as GPRS, GSM, and GPS.

Speaking generally about a geo-fence, this is a set of coordinate points, which are stored in a common data array. It is impossible immediately to process an entire geo-fence from the viewpoint of program realization, but it is not difficult to process an individual point. Therefore, when we make a query in order to locate geo fence coordinates, the API dynamically sends a set of points to the tracking system, with simultaneous queries regarding determination and storage of the coordinates of the geo fence on GIS, which, in its turn, after processing the data send multiple http-queries to the data bus, the diagram of the decomposition of which is shown in the figure.

A geo-information system (GIS) is the main source of changes in the client-service system, which updates the interface. As a rule, a geo-information system is always external software, as implementation of such large projects implies development of the graphical image of the map itself and of the client communication interface – an external API.

The logic of the M2M platform is designed for automate management of objects and processes based on machine-to-machine communication technologies and the Internet of Things [5], [6]. The main goal is to manage connections of devices having embedded SIM cards, as well as to manage the client's expenditures related to the services provided, including the service realized in the given process model.

Thus, based on the developed and described process model "Systems of tracking an M2M subscriber in a given location" the solution architecture is further developed.

3 Development of solution architecture for tracking a subscriber in a given location

The proposed solution relating to development of the architecture of the service offering control, monitoring, and management of M2M objects in a given location is based on a systematized line of products developed by a large Russian company *Peter-Service* (now *Nexign*), the first and the largest developer of billing software systems for telecom operators.

The proposed Connectivity Management Platform (CMP) is a complex platform which enables the telecom subscribers having an available set of tools to exercise effective control over the IOT (M2M)–devices and their management. The embedded analytical functions reduce the maintenance costs and open opportunities for low-income IOT subscribers. The customers may trace down the condition of the distributed devices (SIM-cards) attached to individual subscribers online, manage the devices at the level of BSS or the infrastructure and detect failures in connecting IOT devices to the network.

The use of this platform allows the M2M/IoT-customers of an operator and the service providers to achieve closer integration with the telecom operator's infrastructure to obtain additional opportunities for the available technological solutions [7].

Analysis and systematization of the existing developments in the area of machine-to-machine interaction (M2M) at the level of solving the task of tracking an object in a given area are required in designing a 'smart city'. In Russia, machine-to-machine interaction developments exist only in geographically limited areas. Developments of such a type are designed to improve mobility, to enhance productivity and to raise the people's living standards.

Apart from the size of the territories, the insufficient precision of tracking an object in a given area is a substantial limitation for developing the technology of machine-to-machine communication in the 'smart transport', 'smart energy', 'smart house' and the other aspects of a smart city. The model's development allows transition to technologies close to mobile applications for their type. Commercialization is possible, which, in its turn, requires expansion of such user-friendly functions as design, graphical interface, and other functions, in accordance with the needs of an information product user.

The 'smart house', 'smart transport', trade and financial services, and the industrial segment are the most interesting and promising areas for applying such interaction [8] [9].

The Connectivity Management Platform (CMP) for M2M makes it possible for any client of the communication operator (corporate clients, providers of M2M services and individual business owners) to exercise control over SIM cards in any device or equipment. No matter where a SIM card is located (for example, in remote or hard-to-reach equipment) and what it looks like (a classical SIM card, a microSIM card or a thermochip), the client of a mobile operator receives a unique offer to organize an automated SIM card management process and to take an opportunity to obtain exhaustive information about the status of the SIM cards online using the modern architecture of the web-interface.

The current opportunities the platform offers are the following.

For the platform user – management of M2M SIM cards through the integrated management center, by using the graphical user interface (GUI) or the application procedural interface (API); management of SIM cards, hardware, network activity; control of communications expenditures; automatic response to events and notifications; generation of non-billing reports; and system administration.

The tasks for the telecom operator are to ensure provision of M2M services to its customers using the M2M platform; to exercise customer support of the platform users; and system administration (Fig.2).

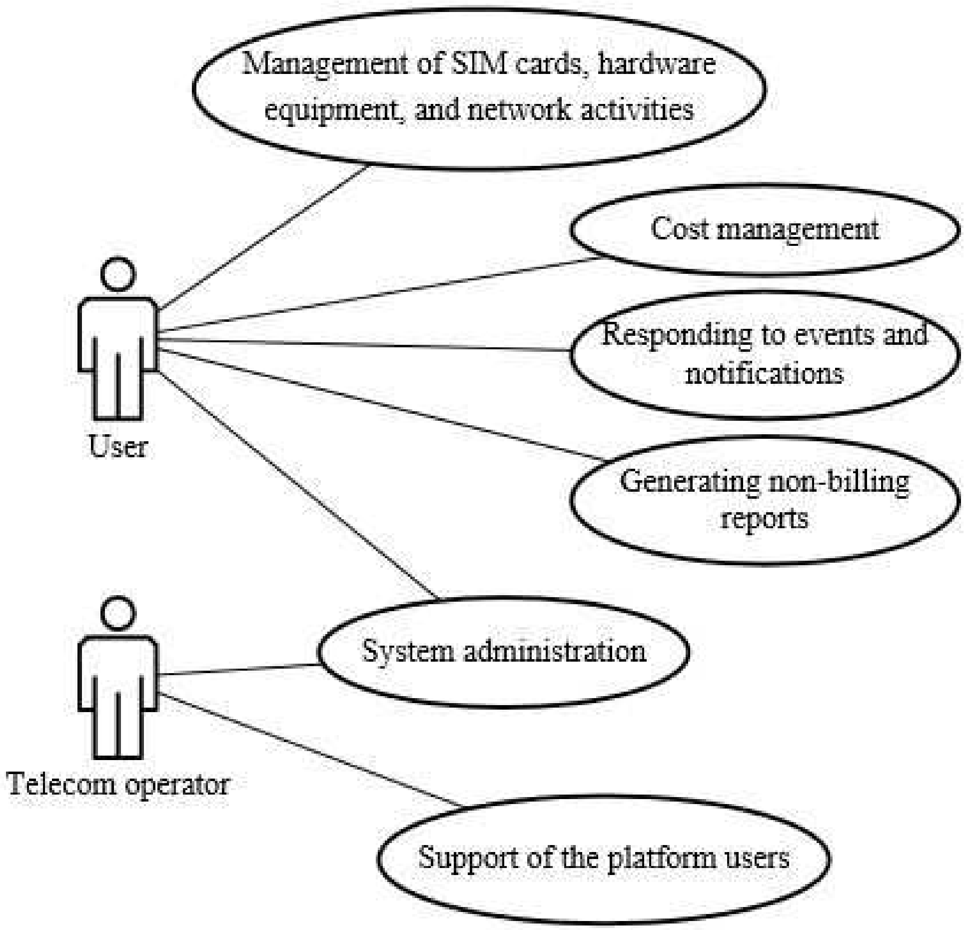

Figure 2: A diagram of use cases

The architecture of this solution consists of a definite number of components (modules), based and developed on the use of the most advanced software technologies. The system consists of the following modules.

1. M2M API: The application procedural interface for communication with M2M (M2M API) implements the possibilities of close integration with the telecom operator's infrastructure to exercise management, control, and monitoring.

2. Notification: a module ensuring wide opportunities for monitoring M2M SIM cards, which allows monitoring of the attributes of SIM cards, connections between SIM cards and devices, etc.

3. M2M Core: a module including automation of all the business processes based on the M2M principle. Its main task is to manage, monitor and control M2M connections and SIM cards embedded in remote equipment.

4. Limit Management: a module for management and control of the scope of used services and available funds for data transfer along the M2M channels.

5. M2M Web: a module for managing M2M SIM cards by way of a graphical interface (an M2M-portal). It is implemented as a web-application working in any standard browser.

6. Online Charging: a module for ensuring balance control and management of the services status in the online mode.

7. Online Rating: a module for rating the costs of services in the online mode managing the cost calculations based on information about the duration and the scope of the services provided.

8. Rate Management: a module for managing services and their combinations, rate plans and packages offered by the operator to ensure maintenance of full cycles of business processes.

9. Mediation: a module for collection, aggregation, and processing of information coming from the telecommunications equipment and network devices to ensure its further billing.

Consider the model of generating the end product-service more closely within the systems in question.

To ensure implementation of its inherent functions, the product-platform (which we will name IMC for M2M – An Integrated Management Center for M2M) is integrated with several adjacent systems providing billing information, information about the network activity of a SIM card, a mapping service, or, in other words, a geoinformation system (GIS), and services of dispatching SMS texts and e-mails, which are part of the event control and reaction system. We can present the above-mentioned data relating to statement of solution architecture, using the function methodology IDEF0 (Fig.3).

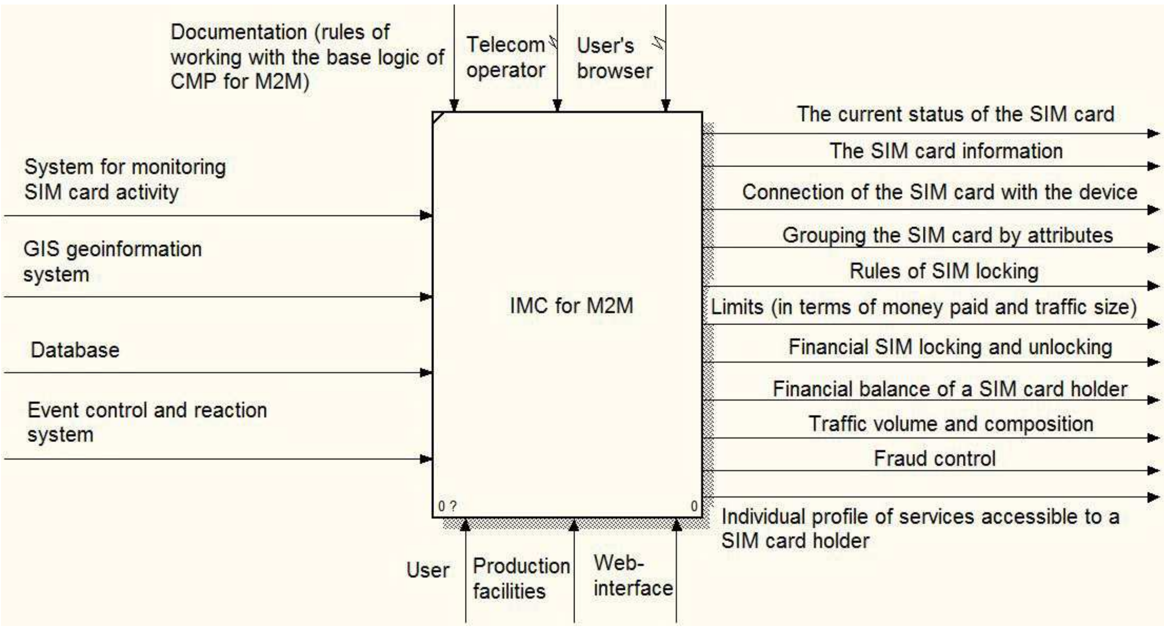

Figure 3: IDEF0-model AS-IS

The input data flows imply connections among external systems involved in implementation of many specific tasks. External systems are, as a rule, presented by external software, or a system of modules developed in the framework of the solution architecture contained in the Connectivity Management Platform (CMP) for M2M.

We propose to add the solution of the problem of the subscriber's tracking in the given location to the opportunities offered by the platform. Consider the model of generating the end product in the framework of the systems in question (Fig.4).

The system of tracking a subscriber in the given location contains the following logic (Basic logic of M2M integrated management center) for generating the web-interfaces for the M2M integrated management center (M2M IMC), as well as the basic styles and configuration XML-files, allowing setting of customized interfaces.

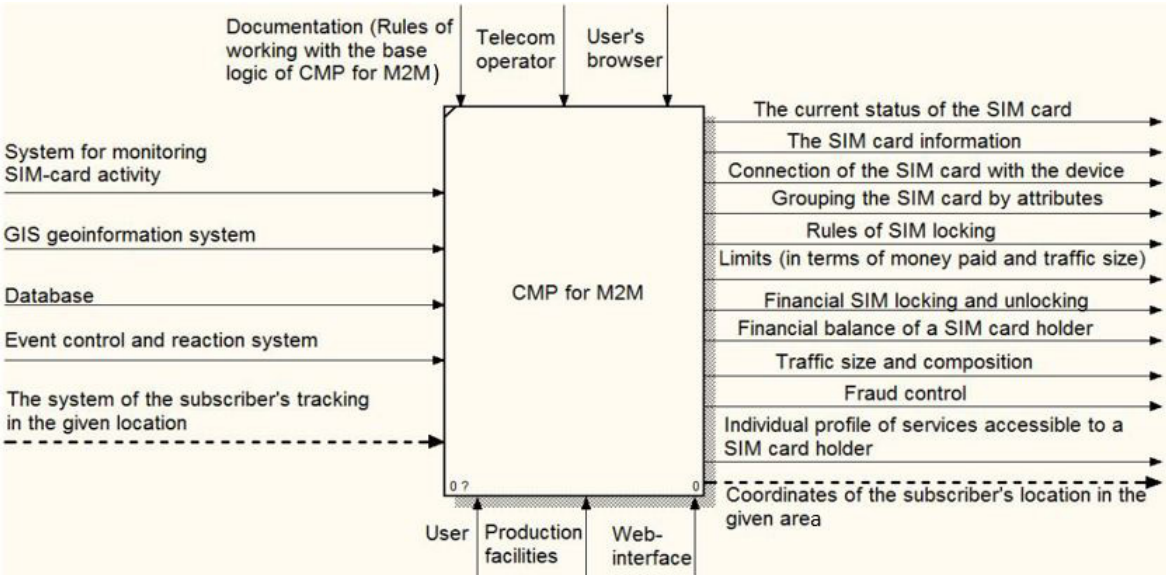

Figure 4: IDEF0-model AS TO-BE

4 Conclusions

The task of developing a control system for activities of an M2M subscriber and tracking the subscriber's location in the given area is extended to include the tasks related to the increase in the number of functions in the given area of studies and to improvement of user services. First of all, this is related to solution of tasks connected with designing subsystems of a smart city system, the issues of design and expansion of the possibilities of graphical applications to ensure improvements in the industrial and commercial processes.

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References

[1] Schneps-Schneppe, M., Namiot, D. Machine-to-Machine Communications: the view from Russia. *International Journal of Open Information Technologies*, Vol 1, No 1 (2013).

[2] Cerioni, F. Internet of Things: M2M for Service Providers. *Cisco, BRKSPM-2010* (2013). https://pdfs.semanticscholar.org/presentation/4454/aba719817aa5dc11ab45d2fa0abfeeb6e025.pdf, last accessed 2018/03/21.

[3] Krinkin, K., Yudenok, K. Geo-coding in Smart Environment: Integration Principles of Smart-M3 and Geo2Tag. *Internet of Things, Smart Spaces, and Next Generation Networking* (2013).

[4] J'son and Partners The market of M2M-communications in Russia and in the world (November 2012).

[5] Kurcheeva, G.I., Firsova, S.S. The concept of the Internet of things: management aspect. *In: The formation of the digital economy and industry: new challenges* pp. 157-175. (2018).

[6] ISO 37120:2014 Sustainable development of communities – Indicators for city services and quality of life.

[7] Moskalenko, T.A., Kirichek, R.V., Borodin, A.S. Industrial Internet architecture of things. *In: Information technology and telecommunications* , vol. 5. No. 4. pp. 49-56. (2017).

[8] Greengard S. Internet of things. The future is already here. *Alpina Publisher, Moscow* (2017).

[9] EIP-SCC Strategic Implementation Plan of the European Innovation Partnership on Smart Cities and Communities. https://eu-smartcities.eu/priority-areas, last accessed 2018/04/21.