Model Networks for Internet of Things and SDN

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***Abstract*— The Model Networks have found widespread implementation in testing NGN-services. Currently, in a telecommunication sphere the concept of the Internet of Things (IoT) is widely recognized as a key. In this connection, it is advisable to use an approved approach for testing devices and applications of the Internet of Things based on model networks. The article presents the structure of the model network, created on the basis of the Laboratory of the Internet of Things in the State University of Telecommunication and a description of features of the network for a comprehensive research of the Internet of Things.**

***Keywords*— Model networks, Internet of Things, SDN, architecture, testing**

I. Introduction

Model network is a prototype of the current and projected network, which is built on the appropriate equipment with a given level of abstraction.

Usage of such network can carry out comprehensive testing of test equipment, both in normal operation and under load with stress regimes with the object of more efficiently and objectively evaluation of its characteristics [1]. Model networks can be used for testing the hardware and software products and applications that are parts of existing and future networks [2,3].

There are two types of model networks leased and distributed.

Leased network model is a fragment of Public Network, which is not related to other model networks. However, it can be connected to the corporate network or a public communication network. This type of network may be used for test operations and testing for interoperability with the hardware of the previous, current and next-generation communication network. The architecture of such a network should include at least two different types of node, united by one network connection. Thus, one of the nodes belongs to the model network, and the other is the equipment under the test.

The distributed model network consists of several model networks interconnected with channels of communication. For this purpose there are the public communication network, corporate networks, etc. This type of network is used to carry out the whole complex of test operations on compatibility and interoperability, as well as to test the parameters of QoS, requirements for interoperability with other technical means, the requirements for compliance with the measures of network and information security.

II. The Architecture of the Model Network of the Internet of Things Laboratory

The Internet of Things Laboratory was established in 2012 at the Department of Networks and data transmission in State University of Telecommunication [4]. In the laboratory 5-segments model network is launched that enables to carry out comprehensive testing of both real and virtual settings of the Internet of Things. In addition, the laboratory has a test bench for capture and subsequental analysis of the network traffic on any part of the network model. The block diagram of the model network is shown in Figure 1.

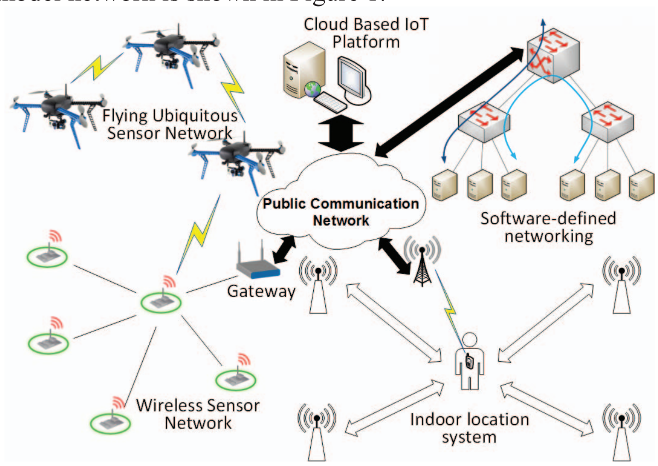

Figure 1. Block diagram of a model network Internet of Things Laboratory

As seen in Figure 1, the model network consists of five interconnected segments and enables the possibility to recreate the scenarios of intercomputer interaction and D2D communication, considered within the concept of 5G-networks.

Segment 1: The wireless sensor network is based on the self-organizing network: end node – router – coordinator. On the basis of this segment such problems can be worked out as power saving objectives, network security, clustering, administration schedules for data exchange. It should be noted that the wireless sensor network traffic with its own features can be signifed in varying degrees of self-similarity depending on sensor network applications [5,6]. In some cases, the detection of mass events traffic sensor networks can acquire properties of antipersistent [7].

Segment 2: Flying ubiquitous sensor network (FUSN) is built on the basis of public quadrocopters (in the laboratory are used quadrocopters 3D Robotics Iris+ model), which are used to collect data from the sensor fields and to deliver the data to the public communication network [8]. On the basis of this segment the following tasks can be accomplished: the research of the full life cycle of accommodation and service wireless sensor networks in remote areas [9], calculation of optimal trajectories for the collection of the data from the sensor nodes [10], detection of intentional electromagnetic interference on the network nodes and links, and the possible methods of uninstalling a sensor network at the final stage.

Segment 3: Indoor positioning system is built on the basis of the tags (Wifi, ZigBee, BLE), interacting with a smartphone user and enables to determine the exact coordinates of the person in the building, as well as to broadcast the data to a remote server through public communication network for visualization. On the basis of this segment, such problems can be worked out as developing algorithms for calculating the coordinates of the person in view of the interference signals, as well as its positioning in 3D-space [11].

Segment 4: Software-defined networking (SDN).

IoT is a challenging environment for network management in view of the large number of non-homogeneous resources. The main problem is the complexity of network convergence that is a difficult hardware configuration of this network environment. The network should provide the transfer of isolated traffic flows with different requirements for the network resources.

Today, SDN technology is one of the best problem solutions of resource management IoT [12.13]. SDN network virtualization implements an ideology in which the control plane of a network device is separated from the data plane. This provides the desired balance between the degree of centralized control through SDN-controller and decentralized operations, such as routing flow. SDN enables strict requirements for quality of service for the maximum possible number of threads (QoS requirements for the new thread without violating the requirements for existing streams) and ensure maximum utilization of the network.

Thus, this segment of the model network enables tasks to study the interaction protocols IoT with public communication network and benchmarking testing SDN- controller with allowance for traffic IoT [14].

Segment 5: Cloud IoT-platform is built on the basis of IoT - service «Go+ IoT University Solution», which enables to organize the user interaction with the Internet of Things on the basis of a convenient Web interface, set the algorithms of devices and control commands based on the Big Data and Data mining from IoT-sensors [15]. The platform «Go+ IoT University Solution» enables to organize interaction between the devices and the applications on the basis of well-known IoT protocols. On the basis of this segment, there is a problem of the Internet of Things applications and application development for cloud analysis of Big data and issuing commands to support systems and decision-making [16].

III. Test Beds Structures

In the Laboratory it is possible to conduct the research and testing for the following technologies: Ethernet, WiFi, ZigBee, 6LoWPAN, RPL, Bluetooth Low Energy, Lora, RFID, SAW, for these purposes have the radio modules with interfaces UART, SPI, etc.

The minimum configuration of the model network should include the following constituent elements:

- at least two transit nodes, simulating the behavior of nodes public communications network or the local area network, given the opportunity to use equipment from different manufacturers;
- communication network in the allocated model network having the ability to use different techniques, given the use of equipment from different manufacturers;
- server simulation processes in public communications networks, is the site of the transit network, simulating the processes in the various segments of the public communications network;
- researched Internet of Things with power supplies and a set of appropriate measuring equipment;
- management server, which provides monitoring and overall network management and testing process, the generation of traffic flows, storage and processing of the intermediate test results, the formation of the final report, etc.
- SDN-controller providing integrated management model network segments;
- an interface to create a stable channel of communication between the transit network and test equipment, with the ability to use a wide range of data transmission technologies.

The block diagram of the base part model network is shown in Figure 2.

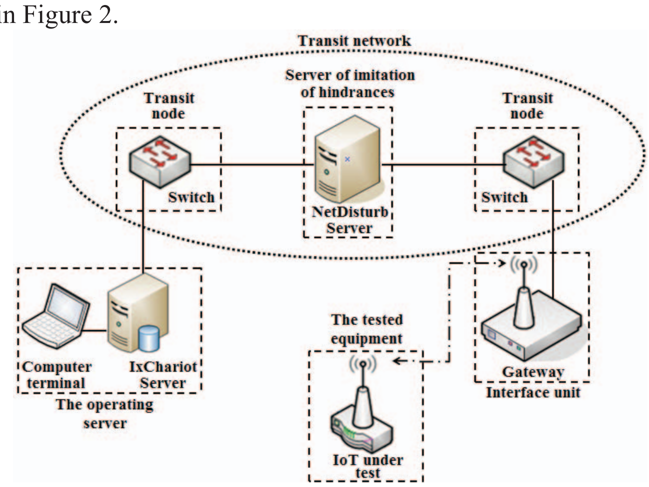

Figure 2. Block diagram of the base part model network

It should be noted that this diagram shows only one of the possible variants of the model network's basic part.

In order to ensure maximum reliability of the test or to ensure that the architecture of the model network is the architecture of the customer's network, it is possible to quickly reconfigure the network to include additional components of the composition of its elements, and redistributing traffic flows.

The typical structure of the test on the model network's basis.

In the development of testing methods it is advisable to follow the reference model of the Internet of Things, the proposed ITU-T Recommendation Y.2060 [17].

This model includes 4 layers:

- application layer;
- support services and application support layer;
- network layer;
- device layer.

The typical structure of testing the interaction between the Internet of Things with public communication network based on the model network is shown in Table 1.

TABLE 1. THE STRUCTURE OF THE PERFORMANCE TESTING INTERNET OF THINGS

Name of the test	**Performance testing of Internet of Thing**
Level of test (Y.2060)	Device level
Type of test	Testing for compliance
The purpose of the test	To conduct a comprehensive stress test the hardware of the Internet of Things.
Test procedure	1. To initiate the transmission of multiple data streams through IoT under test. 2. To run the performance of all applications available on the IoT under test. 3. To evaluate the parameters of CPU, memory, operating temperature of the main sites.
Expected results	In operation under the load all parameters are within the limits stated by the manufacturer.

IV. CONCLUSIONS

In conclusion, it should be noted that the use of the model networks will provide a comprehensive study of the peculiarities of devices, applications, and protocols of the Internet of Things.

Using the model network enables network operators and service providers to build the network for the Internet of Things application service close to optimal manner, and make the necessary correction in the development of the network through a full-scale simulation of different situations, including contingency.

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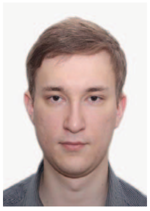

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