A Study of IoT with Implementation and Testing Methods

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Abstract—*The Internet of Things (IoT) is the new concept for the network development. The enormous number of the things requests to investigate the networks interoperability as one of the important parts of IoT implementation. IoT uses standards and protocols that are proposed by different standardization organizations in message passing within session layer. The competent testing is the general matter for networks interoperability support. So, this paper surveys IoT implementation requests the test bed creation.*

Keywords— *Internet of Things, Zigbee,LoWPAN, Z-Wave, Test bed.*

I. INTRODUCTION

Internet of Things (IoT) is ―internet property among physical devices and everyday objects‖. It's introduced by Kevin Ashton of Procter & Gamble in 1999. The items might be radio-frequency identification (RFID) tags, actuators, mobile phones, sensors and alternative devices that are capable of connecting with internet. Internet of things (IoT) has expanded tremendously due to constant innovations in hardware, communication networks and software solutions [1, 2]. Huge number of devices are communicating with each other through internet and generating massive collections of data. For fast processing of data and to get faster response fog computing technologies were introduced Application layer protocols plays a vital role among these factors. HTTP and HTTPS protocols are extensively used protocols to make communication with other servers through internet. HTTP appropriate for computing devices with high-power, faster processing unit and strong communication mediums. But IoT devices have slower processing unit and low-power.

Few light-weight protocols have created for IoT devices at application layer level. They are AMQP (Advance Message Queuing Protocol) and DDS (Data Distribution Services), CoAP (Constrained Application Protocol), MQTT (Message Queuing measuring Transport), XMPP (Extensible Message and Presence Protocol). These protocols support forced devices for message exchange. In reality one electronic messaging protocol is not enough to supply all communication services as a result of protocols uses totally different communication models.

II. OVERVIEW OF IOT

A) Architecture of IOT

A generic IoT design includes 3 layers: application, transport, and sensing. However, an additional elaborated design is typically adopted wherever 5 layers are outlined [3]:

1. *Perception layer:* also known as the 'Device Layer'. Sensor devices and physical objects belong in it.
2. *Network layer*: also known as 'transmission layer'. It is responsible for securely transferring data from sensing devices to the information processing system.
3. *Middleware layer:* responsible for service management and provision of interconnection to the system database. It receives data from the network layer and stores it to the database. Tis layer processes information, performs ubiquitous computations, and makes automatic decisions based on the outputs.
4. *Application layer*: provides global management of the provided applications considering the objects information which was processed in the Middleware layer.
5. *Business Layer:* responsible for the management of the whole IoT system, including services and applications

B) Technologies of IOT

The IoT vision can be supported by a variety of exciting technologies for different kinds of applications. This section is dedicated to presenting and compiling the most appropriate IoT technologies.

1. *BLE,* referred to as Bluetooth good, a part of the Bluetooth v4.0 and therefore the recent v4.2 stack, is a world personal space network protocol engineered for sending tiny information items occasionally at low rates with considerably low power consumption per bit. It constitutes a light-weight version of the classic Bluetooth destined for low energy resource-limited devices.
2. *ZigBee* may be a short-range radio communication normal for embedded devices and constitutes a mesh native space Network (LAN) protocol, initially developed for building management and automation. Equally to Bluetooth, ZigBee incorporates a massive installed operation base, though most likely a lot of in industrial deployments.

3. *Z-Wave* could be a low energy radio frequency (RF) technology for sub-GHz communications. it is a mesh networking protocol, typically adopted for home automation, security systems, and lighting controls. Z-Wave employs a less complicated protocol than another alternatives, which permit quicker and easier development.

4. *6LoWPAN* is defend for devices that are IEEE 802.15.4 compatible and with efficiency encapsulate IPv6 long headers in IEEE 802.15.4 little frames. Particularly developed for building and residential automation, IPv6 offers the basic transport scheme to make complicated management systems and to attach with devices cost-defectively via an occasional energy wireless network.

5. *LTE-A* is commonplace for mobile communications and a big improvement of the LTE standard, by that specialize in higher capability. The enhancements of LTE-A compared to LTE concern the sweetening of spectral potency and network capacity as well as the power potency and therefore the operator value reduction.

6. *GSM* is an international system for mobile communications. It is used to describe the protocols for 2G digital cellular networking used by mobile phones. It's defined as a circuit switched technology that is intended for full-duplex voice telecommunication.

7. *3G* was the primary 'high rate' cellular network, whereas it constitutes an umbrella of standards that seek advice from variety of technologies that meet the IMT-2000 specifications. Email, net browsing, image sharing, video downloading, and different smartphone technologies appeared within the third generation.

8. *4G* is the family of cellular standards that followed 3G fashioned 4G and is the hottest technology used these days for mobile cellular information. Consistent with the individual specifications, the supported data rate of a connected customary must be a minimum of one hundred Mbps and up to 1 Gbps to pass the 4G needs.

9. 5G is destined to be subsequent generation of cellular network standards, aiming at higher outturn and lower latency. The realization and wide readying of 5G protocols is about round the year of 2020.

10. *SigFox* could be an international IoT network operator that is positioned between WLAN and cellular in terms of coverage. It operates within the ism bands of 900MHz and utilizes the Ultra narrow Band (UNB) technology. It's designed to handle alone low information rates of ten to 1,000 bps.

III. IOT IMPLEMETATION MODEL

Taking into consideration the current trends in the telecommunications industry, the Internet of things Laboratory was opened in St. Petersburg SUT in December 2012. Capabilities of Internet of things Laboratory for research, design, and testing under this concept are quite broad. The laboratory has equipment to build there is a test bed for testing wireless sensor networks, local positioning systems based on the IEEE 802.15.4a, also a long list of sensors, actuators and devices based on open hardware platforms (Arduino Yun, Intel Galileo, Raspberry Pi) were chosen. The laboratory uses the hardware and software that allows you to monitor network performance at all layers of model OSI, as well as to carry out simulation of wireless sensor networks using the software package Riverbed Modeler Wireless Suite, AnyLogic, ns2, ns3.

The test bed includes three segments: a segment of data collection, a local positioning segment, a segment of the storage and processing of data (Database server and Web server). On cable network is a connection based on the 10 Gbit Ethernet technology (10GBase-T). The Silicon Labs EM35x Development Kits and XBee Development Kit are used for organization the wireless sensor network data segment for purpose data collection based on ZigBee technology (Fig. 2). Segment for testing local positioning tasks is realized on the Nanotron development kit (nanoPAN5375), which allows students to develop their own firmware for applications related to indoor position system (Fig. 1). Recently, opportunities to realize SWARM-based networks on the basis of data sets are of great interest. In the laboratory, there is an equipment for a well-defined diagnosis of probabilistic and time features of network traffic that is transmitted in cable and wireless networks. For these purposes the instruments of Fluke Networks Company are used: cable analyzer DTX 1800, network analyzer EtherScope Series II Network Assistant (Fig. 4), as well as monitoring poppers—NetOptics TAP and software sniffer Tamosoft CommViewWiFi.

Fig 1. Development Kits.

Eclipse Mosquitto is an open source (EPL/EDL licensed) message broker that implements the MQTT protocol versions 5.0, 3.1.1 and 3.1. Mosquitto is lightweight and is suitable for use on all devices from low power single board computers to full servers. The MQTT protocol provides a lightweight method of carrying out messaging using a publish/subscribe model. This makes it suitable for Internet of Things messaging such as with low power sensors or mobile devices such as phones, embedded computers or microcontrollers. The Mosquitto project also provides a C library for implementing MQTT clients, and the very popular mosquitto_pub and mosquitto_sub command line MQTT clients.

Example:

```
Activate Mode
```

```
mosquitto version 1.5.8 starting
Config loaded from
/var/lib/mosquitto/16354/mosquitto.conf.
Opening ipv4 listen socket on port 26354.
Opening websockets listen socket on port
36354.
Opening ipv4 listen socket on port 16354.
mosquitto version 1.5.8 terminating
mosquitto version 1.5.8 starting
```

```
Deactivate mode
mosquitto version 1.5.8 starting
Config loaded from
/var/lib/mosquitto/16354/mosquitto.conf.
Opening ipv4 listen socket on port 26354.
Opening websockets listen socket on port
36354.
Opening ipv4 listen socket on port 16354.
mosquitto version 1.5.8 terminating
mosquitto version 1.5.8 starting
Config loaded from
/var/lib/mosquitto/16354/mosquitto.conf.
Opening ipv4 listen socket on port 26354.
Opening websockets listen socket on port
36354.
Opening ipv4 listen socket on port 16354.
Reloading config.
Loading config file
/var/lib/mosquitto/16354/conf.d//log_debug.
conf
Reloading Config.
```

IV. SAMPLE TESTING METHODOLODY

As know, methods of testing and tests' specifications should be developed for the attestation, certification and production testing of wireless sensor networks.

The reliability requirements of these networks should follow from the conditions of their functioning as a part of public communications networks for the solution of using them in various applications. For today such requirements are substantially not yet been developed, but their occurrence is expected in the near future. It is rational to carry out the reliability tests, their methodology and equipment immediately. Compatibility testing structure and test specifications for interoperability testing technology ZigBee (IEEE 802.15.4) were developed by the department staff, graduate students, and masters.

1. Test Methods IEEE 802.15.4
   In view of the function peculiarities of the radio interface for testing, it is necessary to use high-precision test and measurement equipment to verify compliance with the frequency-spectral characteristics of the device under test. Usually manufacturers of measuring equipment such as Agilent, Tektronix, Lecroy et al. offer as part of the software to the oscilloscope and spectrum analyzer software for testing the Physical and MAC Layers IEEE 802.15.4. Table 1 shows the name of the tests that are most common among manufacturers of measuring equipment. During the test series of parameters that allow you to assess the conformity of the device under test specification IEEE 802.15.4 are checked. According to test results certificate of compliance or non-compliance device is formed. This type of test can be related to the testing of conformance.

2. Test Methods IEEE 802.15.4
   The typical scenario for testing the MAC layer is to measure the packet error rate (PER). PER is defined in the IEEE 802.15.4 standard as the percentage of transmitted packets which have not been detected correctly. During tests on devices set one and the same channel are submitted, then one of the nodes generates packets and the other node receives the packets. At the receiving node, the parameters are fixed: the order number sequence, PER, received power level (RSSI), a status packet delivery time length, etc.

Example:

```
>rx
{{(rx)} test start ('e'nd)}
#{{(rx)}
{num}  {seq} {per} {err}  {rssi}     {time}
{{67}  {67}   {0}    {0}    {-68}  {0x000F76A1} }
{{68}  {68}   {0}    {0}    {-67}  {0x000FDF20} }
{{69}  {96}  {29}  {115}    {-64} {0x000B4CEC} }
{{70}  {97}  {28}  {116}    {-63} {0x000BB56A} }
{{71} {152}  {54}  {144}     {-63} {0x00022885} }
{{72} {162}  {56}  {124}     {-64} {0x00063D73} }
{{73} {205}  {65}  {117}     {-64} {0x0007CAA3} }
{{74} {242}  {70}  {101}     {-64} {0x0006E4E0} }
{{75} {249}  {70}  {109}     {-63} {0x0009C053} }
{{76} {250}  {70}   {94}    {-64} {0x000A28D1} }
{{77} {254}  {70}   {79}    {-64} {0x000BCACA} }
{{(rx)} testend}
```

This type of testing allows to estimate the probability of the packets for a given device, and when you change the specification of the test it is well suited for benchmark testing. Currently, the Internet of Things Laboratory is developing applications for the operating system Contiki installs to sensor node which will allow to test and give an objective evaluation of the system under study.

V. CONCLUSION

We believe that because of the important position in the IoT Architecture, gateway is a crucial point for securing IoT. It has a potential to monitor what is going on with the devices or to check for the known malicious patterns in the communication. The purpose of designing this protocol is to use it in devices with restricted memory capabilities and limited processing power. The article describes the structure and composition of the laboratory test bench and partially—laboratory equipment for testing and prototyping.

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