Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications:

Hasti Hajipara (92100133052)

Jatan Sanghvi (92100133021)

Abstract:

In the era of rapidly growing technologies and machines replacing humans, there is a need of machine-to-machine communication to achieve innovative solutions of the problems.

This also enables and solves the data management precise decision-making problems. As a result, a new class of applications can be manufactured.

The machine-to-machine communication can be called the first phase of IOT as it provides the base to bridge the machine and

devices with different technologies effectively.

This communication(M2M) also utilizes data in such a way that it can be relied to take decisions where humans cannot think such as different types of complex simulation.

It enables this technology to also fulfil the relational gaps between data analytics and cloud.

INTRODUCTION:

Developing number of actual items are being connected to the Web at a remarkable rate understanding the possibility of the Internet of Things (IoT). Basic Example: HVAC (Heating, Ventilation, and Air Conditioning) monitoring and control systems that enable smart homes. In 2010, the number of Internet connected objects had surpassed the earth's human population

There are also other domains and environments in which it can play a remarkable role and improve the quality of our lives. It also enables physical objects to see, hear, think and perform jobs by having them “talk” together, to share information and to coordinate decisions. It can bring new innovative solutions to both domain specific application (Vertical-market) and domain independent applications (Horizontal-market). With many advantages it also has some problems which can be solved such as:

1)Security and privacy are other important requirements for the IoT due to the inherent heterogeneity of the Internet connected objects and the ability to monitor and control physical objects

2) Proper Management and monitoring of the IoT should take place to ensure the distribution of high-quality services to customers at an efficient cost.

3) Tremendous number of objects willing to connect to the Internet should be considered in many underlying protocols and in this some protocols are suggested to resolve this issue.

IOT Architecture:

There is a critical need for a flexible layered architecture to be able to interconnecting billions or trillions of heterogeneous objects through the Internet. Different types of architecture such as: Three-layer, Middle-ware based, SOA based, five layers.

- The basic architecture is a 3-layer architecture which contains Application, Network and Perception layers.
- The most common architecture used among them is the 5-layer architecture model which consists of Object layer, Object Abstraction layer, Service Management, Application layer, Business layer

5-Layer Architecture:

1) Object Layer:

1. This layer includes sensors and actuators to perform different functionalities such as querying location, temperature, weight, motion, vibration, acceleration, humidity.
2. The big data created by the IoT are initiated at this layer

2) Object Abstraction Layer:

1. Object Abstraction transfers data produced by the Objects layer to the Service Management layer through secure channels
2. cloud computing and data management processes are handled at this layer

3) Service Management Layer:

1. It pairs a service with its requester based on addresses and names.
2. this layer processes received data, makes decisions, and delivers the required services over the network wire protocols.

4) Application Layer:

1. The application layer provides the services requested by customers
2. The importance of this layer for the IoT is that it has the ability to provide high-quality smart services to meet customers' needs

5) Business Layer:

1. It manages the overall IoT system activities and services
2. This layer is hosted on powerful devices due to its complex and enormous computational need
3. this layer compares the output of each layer with the expected output to enhance services and maintain users' privacy

IOT Elements:

- IoT building blocks helps to gain a better insight into the real meaning and functionality of the IoT.

  IOT=Identification+Sensing+Communication+Computation +Services+ Semantics.

1)Identification:

i. provide a clear identity for each object within the network.
ii. Identification is crucial for the IoT to name and match services with their demand.
iii. Some IoT Methods like electronic product codes (EPC), ubiquitous codes (uCode) and some addressing methods of IoT objects include IPv6 and IPv4.

2) Sensing:

i. IoT sensing is the process of gathering information from connected things within a network and relaying it back to a data warehouse, database, or cloud.
ii. Smart sensors, actuators, or wearable sensing devices can all be used as IoT sensors.

3) Communication:

i. In order to provide certain smart services, the IoT communication technologies link together heterogeneous items.
ii. When lossy and noisy communication channels are present, IoT nodes should function with little power.
iii. Wi-Fi, Bluetooth, IEEE 802.15.4, Z-wave, and LTE-Advanced are a few examples of communication protocols used for the Internet of Things. Additionally, several special communication technologies including Near Field Communication (NFC), RFID, and ultra-wide bandwidth are in use (UWB).

4) Computation:

i. The "brain" and computational power of the IoT is represented by processing devices (such as micro-controllers, microprocessors, SOCs, and FPGAs) and software applications.
ii. Several hardware platforms, including Arduino, UDOO, Friendly ARM, Intel Galileo, Raspberry PI, Gadgeteer, BeagleBone, Cubieboard and T-Mote Sky, were created to run IoT applications.
iii. Cloud Platforms form another important computational part of the IoT.

5) Services:

i. IoT services can be categorized under four classes: Identity-related Services, Information Aggregation Services, Collaborative-Aware Services and Ubiquitous Services.
ii. Smart health-care and smart grids fall into the information aggregation category and smart home, smart buildings, intelligent transportation systems (ITS), and industrial automation are closer to the collaborative-aware category

6) Semantics:

i. In the IoT, semantic refers to the capability of various machines to intelligently extract knowledge in order to provide the necessary services. Knowledge extraction includes discovering and using resources and modelling information.
ii. Also, it includes recognizing and analysing data to make sense of the right decision to provide the exact service.

IoT COMMON STANDARDS:

- Different groups have been created to provide protocols in support of the IoT including efforts led by the World Wide Web Consortium (W3C), Internet Engineering Task Force (IETF), etc.
- the IoT protocols into four broad categories, namely: application protocols, service discovery protocols, infrastructure protocols and other influential protocols

1) Application Protocols:

i. **Constrained Application Protocol (CoAP):**
  - CoAP modifies some HTTP functionalities to meet the IoT requirements such as low power consumption and operation in the presence of lossy and noisy links

ii. **Message Queue Telemetry Transport (MQTT):**
  - MQTT aims at connecting embedded devices and networks with applications and middleware. The connection operation uses a routing mechanism (one-to-one, one-to-many, many-to-many) and enables MQTT as an optimal connection protocol for the IoT and M2M

iii. **Extensible Messaging and Presence Protocol (XMPP):**
  - XMPP allows users to communicate with each other by sending instant messages on the Internet no matter which operating system they are using. XMPP allows IM applications to achieve authentication, access control, privacy measurement, hop-by-hop and end-to-end encryption, and compatibility with other protocols.

iv. **Advanced Message Queuing Protocol (AMQP):**
  - AMQP requires a reliable transport protocol like TCP to exchange messages
  - AMQP defines a layer of messaging on top of its transport layer. Messaging capabilities are handled in this layer. AMQP defines two types of messages: bare massages that are supplied by the sender and annotated messages that are seen at the receiver.

v. **Data Distribution Service (DDS):**
  - DDS relies on a broker-less architecture and uses multicasting to bring excellent Quality of Service (QoS) and high reliability to its applications. Its broker-less publish-subscribe architecture suits well to the real-time constraints for IoT and M2M communications

2) Service Discovery Protocols:

i. Data Distribution Service (DDS):

- mDNS inquires names by sending an IP multicast message to all the nodes in the local domain.
- All devices in the network that obtain the response message update their local cache using the given name and IP address

ii. DNS Service Discovery (DNS-SD):

- DNS-SD utilizes mDNS to send DNS packets to specific multicast addresses through UDP. There are two main steps to process Service Discovery: finding host names of required services such as printers and pairing IP addresses with their host names using mDNS

3) Infrastructure Protocols:

i. Routing Protocol for Low Power and Lossy Networks (RPL):

- The IETF routing over low-power and lossy links (ROLL) working group standardized a link-independent routing protocol based on IPv6 for resource-constrained nodes called RPL
- A Destination Oriented Directed Acyclic Graph (DODAG) represents the core of the RPL that shows routing of nodes.

ii. 6LowPAN: Low power Wireless Personal Area Networks:

- Datagrams enveloped by 6LoWPAN are followed by a combination of some headers. These headers are of four types which are identified by two bits: (00) NO 6LoWPAN Header, (01) Dispatch Header, (10) Mesh Addressing, and (11) Fragmentation

iii. IEEE 802.15.4:

- The IEEE 802.15.4 protocol was created to specify a sub-layer for Medium Access Control (MAC) and a physical layer (PHY) for low-rate wireless private area network

iv. Bluetooth Low Energy:

- BLE allows devices to operate as masters or slaves in a star topology. For the discovery mechanism, slaves send advertisements over one or more of dedicated advertisement channels. To be discovered as a slave, these channels are scanned by the master. Except for the time when two devices are exchanging data, they are in sleep mode for the rest of the time.

v. EPC global:

- The Electronic Product Code (EPC) is a unique identification number which is stored on an RFID tag and is used basically in the supply chain management to identify items.
- EPCs are classified into four types: 96-bit, 64-bit (I), 64-bit (II) and 64-bit (III)

vi. LTE-A (Long Term Evolution—Advanced):

- LTE-A encompasses a set of cellular communication protocols that fit well for Machine-Type Communications (MTC) and IoT infrastructures especially for smart cities where long term durability of infrastructure is expected

vii. Z-Wave:

- Controllers manage the slaves by sending commands to them. For routing purposes, a controller keeps a table of the whole network topology

4) Other Influential protocols:

i. Security:

- The emergence of new protocols and architectures in support of the IoT points to new security problems and this concern should be considered in all layers of the IoT from the application to the infrastructure

ii. Interoperability:

- The IEEE 1905.1 standard was designed for convergent digital home networks and heterogeneous technologies. It provides an abstraction layer that hides the diversity of media access control topologies while not requiring changes in the underlying

QOS (Quality of Service) CRITERIA;

i. **Availability**
ii. **Reliability**
iii. **Mobility**
iv. **Performance**
v. **Management**
vi. **Scalability**
vii. **Interoperability**
viii. **Security and Privacy**

THE NEED FOR BETTER HORIZONTAL INTEGRATION BETWEEN APPLICATION LAYER PROTOCOL:

We define resource-rich devices as those that have the hardware and software capability to support the TCP/IP protocol suite

- IoT devices can be classified into two major categories; namely: resource-constrained and resource-rich devices
- We define resource-rich devices as those that have the hardware and software capability to support the TCP/IP protocol suite
- Devices that do not have the required resources to support TCP/IP cannot interoperate easily with resource-rich devices that support the TCP/IP suite
- Here the use of gateway comes into the picture. An intelligent gateway should allow for programmers to control the wire protocol traffic as needed to optimize the performance based on the specific needs of the given application
- Most IoT applications are low-rate but the large number of IoT devices participating on a single application will result in having

the network elements to deal with “mice” flows. A deeply re-programmable gateway can also offer an opportunity to perform data and flow aggregation to limit the number of flows that the network elements have to handle

Conclusion:

This paper has provided various protocols for machine to machine(M2M) communication i.e. first phase of IoT to enable it to deliver innovative and a new class of application. The importance and need of horizontal integration. The market opportunities for IoT based products. Some concepts like gateway, advance long term evolution, etc to enhance the perspective of the reader regarding IoT and its related technologies. The importance of big data, Fog computing and Cloud Computing.