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Scalability in Internet of Things: Techniques, Challenges and Solutions

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Abstract - Internet of things is one of the fast increasing technology in today's world. IoT is basically a network of devices that are connected with each other through the web and can transfer and modify data with the help of sensors. With the development of the IoT we face a major challenge of scalability. Scalability is the ability of a device to adapt the changes in environment and meet the user need. It is a feature of a system or network whose lack can cause bad performance. In this paper we present what is scalability, types of scalability, how to achieve scalability and research and challenges.

Keywords: Scalability, Internet of things(IoT), horizontal scalability, vertical scalability, MQTT, CoAP, edge computing.

I. INTRODUCTION

In the latest years, with the development of IT, the Internet of Things has arrived to play an important role in our everyday lives, as well as the number of IoT sensors and actuators involved in industrial scenarios has also increased rapidly, which also increases the amount of data that is being transferred over internet [1]. In conventional cloud computing, all the data need to be uploaded to cloud, after computation, the results must be sent back to the devices and sensors. With the increasing data size the performance of the network will decrease.

A more critical problem arises with IoT that is time-sensitive, meaning a very short response time is not negotiable. This is because the computation process must be uploaded to the cloud. So, the result will be more latency in the networks. Scalability is a very important aspect that come with the new and useful advancements in technology that happen everyday. We need to make devices more scalable both horizontally and vertically. Horizontal scalability is deal with extending the capacity of the network by interfacing different hardware and software entities. Whereas, vertical scalability is concerned with adding resources in an existing system to increase the capacity. There are many aspects that need to be kept in mind for scalability in IoT. Some of them are: -

A. Features for scalability:

Scalability is the ability of a device to adapt the changes in the environment and meet the changing needs in the future. A very important aspect for scalability is the features that need to be kept in mind. Some features are business, marketing, hardware and software.

B. Challenges and issues:

With the increasing of technology in today's fast moving world, there come few problems in the process. Research challenges and issues constitute of the that problems or obstacles that we face during the process of scalability. We have focussed on various challenges such as storage, latency, packet loss, round trip time, cost etc.

C. Solutions:

A network or system may be scalable in different ways, to do so we must maintain and follow some steps which will facilitate scalability. This steps are referred as solutions of issues.

II. TYPES AND IMPORTANCE OF SCALABILITY

An Internet of Things connects with a huge amount of sensors, actuators and other devices for sharing information and a large number of applications via internet. It is the ability of a device to adapt the changes in the environment and meet the needs of the people. The main objective to make a device scalable is to meet the changing demands and it can not be static because the interest and taste of people changes with time as well as environmental conditions [2]. The importance of scalability is that it helps a system to work fast and smooth without any time delay and it makes a good use of available resources.[3]

Different types of scalability in context to IoT:

A. Vertical Scalability:

It is also referred as scale up approach which is the ability to increase capacity of existing hardware or software by adding more resources to it. It involves adding resources like storage, processing power and memory to an existing hardware and software to enhance the system capacity.

B. Horizontal Scalability:

It is also referred as scale out approach to enhance the performance of the network by adding instances to an

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existing server. This approach involves decreasing the server load rather than the increasing the capacity of the server.

III. ARCHITECTURE OF IOT

Data Management Layer
Application Layer
Network Layer
Perception Layer

Figure 1: four layer IoT Architecture

In fig1 there are four layers in IoT architecture [4]:

1. **Perception Layer:** It is characterised with the use of a number of digital devices that collect information and request information from networks. This the physical layer of the architecture.

2. **Network Layer:** It transmitted and processed all the data that are collected by devices. It is composed of online networks that help transfer data.

3. **Application Layer:** It is used to deliver all the application specific services to the user and it is responsible for distributing the learning content. For example, where users can control a light using an app.

4. **Data Management Layer:** It collects all data from learners and provides them with learning data.

Technology Background:

This section is very crucial to significantly improve scalability with industrially accepted standard protocols, such as Message Queue Telemetry Transport (MQTT) and Constrained Application Protocol (CoAP), in order to support adoption and integration with existing environment [5].

A. MQTT:

MQTT is a very light weight and efficient messaging protocol for the Internet of Things. It helps to achieve good scalability and support many applications in the IoT field and M2M domain. Every MQTT publisher act a sender and connect to an MQTT broker over TCP. And MQTT broker can connect to every MQTT subscriber to reduce latency and low bandwidth and power efficient. Moreover, it provides reliability to dynamically select one of the three QoS for message delivery:

- QoS0 – In this QoS the delivery of the message is not acknowledged and the message is not stored. It could be lost or copied. It is the fastest way to transfer message.
- QoS1 – In this QoS the message might be delivered more than one times, and can be copied before an acknowledgment is received by the sender. In this QoS message must be stored at the sender side, until received by the receiver.
- QoS2 – It is the extension of QoS1, it stored the messages at sender side as well as receiver side to avoid duplications.

Figure 2: Simple MQTT protocol communication structure

- **Broker:** As shown in fig2 a broker does the both of the work subscribing and publishing. Its main function is to receive the messages from the publisher and send them to subscriber.
- **Topic:** Every transmission on a network depends on a particular topic. It is like a path where one can publish or subscribe messages.

B. CoAP:

CoAP is a data transfer protocol for constrained devices. It allows devices to communicate over the internet by exchanging small messages on the UDP, that helps to save bandwidth.

It supports four types of message: confirmable, non-confirmable, acknowledgment and reset [8].

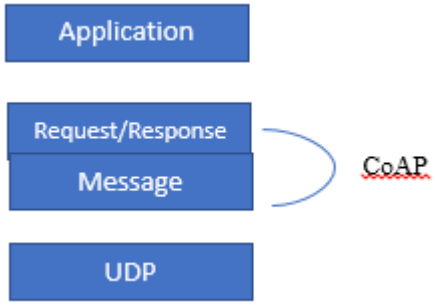

Figure 3: Simple CoAP protocol structure

As shown in fig3 there are two different layers are being used to make CoAP protocol: Request/Response and Message. The message layer deal with UDP and the Request/Response layer manages all the request and response from the application.

C. Edge Computing:

Edge computing refers to the computing that handles at the source of data. It moves processing power to the network edge and analyses the data where it is being collected. It reduces the internet bandwidth and addresses scalability over where the data is stored and transferred [6]. Rather than sending data to the cloud servers or centralized data centers, the computation process takes place on the device to reduce time and additional resources, because from there the processed data will be delivered faster to the destination.

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IV. RESEARCH CHALLENGES AND ISSUES

- In present, the era of IoT evolution everyday objects are connected with each other via Internet. The raw data which are obtained from these devices need cloud storage and big data analytics.
- The convectional IoT system uses high end storage and analyses resources. This may not be feasible for large scale network.
- As the conventional IoT system uses centralized cloud resources for data management and analysis, for large scale network the performance measurement such as round trip time, packet loss, bandwidth consumption will be highly affected [5].
- With the development of technology design challenges are also increasing. There have been issues regarding design like limited energy, limited computation power and limited memory which need to be sorted out.

SOLUTION STRATEGY:

- IoT can not only collect and analyses data but also store and manage those data for further use as well as other revisions in the future. The core system of IoT is located in cloud so that IoT is capable of saving and dealing with such a giant amount of data [8].
- Design a low cost distributed edge computing architecture for IoT which will enhance the performance of large scale IoT network [7].
- Use of edge computing will reduce the overall cost of data management and analysis.
- Edge computing platform will be placed near to the data generation field, hence it will reduce the round trip time of a packet loss and bandwidth. Also it will able to increase the throughput performance and will reduce the latency of the overall network.
- In order to achieve optimal cost in the life cycle of the IoT, maintainability must be considered in the design phase of the IoT.

V. CONCLUSION

With the development of IoT, it is very necessary to make it scalable. Scalability in IoT is very important aspects that make it more efficient and more reliable. The system will be adaptable to any environmental changes and user needs. From this paper, we can find out the importance of scalability, different types of scalability, techniques and protocols that help IoT devices to achieve scalability. We have shown the issues that are faced by IoT devices while making it scalable and also provided some solution strategy to overcome the issues.

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