Module - 1

Internet of things

* **Internet of things** :- The rapid increase in number of devices able to directly connect to Internet is leading to new ubiquitous - Computing paradigm.

→ Initially, the Internet connected to institutional hosts & Accredited terminals via specially developed gateways (routers)
The next Evolution of Internet is to connect all things & objects that have Embedded wireless connectivity to control system that support data collection, data analysis, decision making & Activation.

→ The IoT is a new type of Internet application that is trying to make the things info available on a globe scale using the Internet as the underlying connecting fabric.

→ The IoT has two attributes
  * being an Internet application
  * dealing with the thing's information.

→ The IoT can be described as a new generation information network that Enables seamless & Continous machine-to-machine (M2M) & Human-to-machine (H2M) Communication.

* **Low-End** :- at the low End of Spectrum, the things info is typically coded by the Unique Identification (UID) or Electronic product code (EPC)
The info is stored in radio frequency identification (RFID) tag. the info of things will be upleaded by non contact reading using RFID readers.

* **Mid-Range** :- mid range of Spectrum, one can find devices with Embedded intelligence (microprocessor) to perform a variety of data

* Device & gateway domain :- It composed of four Elements

→ M2M device :- A device that runs M2M application using M2M Service capabilities M2M devices connect to N/w domain in the four ways.

* Direct Connectivity
* Gateway as a N/w proxy

* Direct Connectivity → M2M devices connect to the N/w Domain via the access Network.
The M2M device performs the procedures such as registration, Authentication, Authorization, Mgmt & provisioning with Network Domain.

* Gateway as N/w proxy → M2M device Connects to the Network domain via M2M gateway.
M2M devices Connect to the M2M gateway using M2M area Network & gateway acts as proxy.

→ M2M Area N/w :- It provides Connectivity b/w M2M devices & M2M gateway
M2M area Network include personal area N/w technologies such as IEEE 802.15, Zigbee, Bluetooth, Etc.

→ M2M gateway :- A gateway that runs M2M apps using M2M Service Capabilities.
The gateway acts as a proxy b/w M2M devices & the Network domain.

* Network Domain :- It Composed of four Elements.

→ Access Network :- A Network that allows the M2M device & gateway domain to Communicate with Core Network.
Access Network Includes x DSL, HFC, Satellite, Wimax, W-LAN Etc.

, Core Network :- A Network that provides four capabilities

* Ip connectivity
* Service & N/w Control functions.

* Automative Applns :- IoT/M2M automative & transporation Applns focus on safety, Security, Connected navigation & other Vehicle Services.
These Applns typically IoT/M2M communication Modules that are Embedded into the Cars or transportation Equipment.

* bCall (Breakdown Call) :- Sends the Current Vehicle position to a Roadside assistance org & Initiates a Voice call.

→ "bcall triggen" is usually a Switch that is Manually pushed by the user in order to activate the Service.
"Enhanced bcall" Service allows Current Vehicle diagnostic info to be transmitted in addition to Vehicle position.

* Stolen Vehicle tracking (SVT) :- The goal of SVT s/m is to facilitate the Recovery of Vehicle in case of theft.

→ The SVT Service provider periodically requests location data from "Telematics Control unit (TCU)" in vehicle & interacts with police.

→ The TCU may also be capable of Sending out automatic theft alerts based on vehicle Intrusion or Illegal Movement.
TCU may also be linked to Engine Mgmt s/m [EMS] to Enable Immobilization or Speed degradation by Remote Command.

* Remote diagnostics :- Can broadly be grouped into the foll

* Maintenance Minder → based on Usage advising the owner that vehicle is due for Service.

* Health check → Either periodically or request from owner TCU compiles the vehicle Status using inbuilt diagnostic Reporting functions & transmits report.

* Fault triggered → When a fault is detected with vehicle, this triggers TCU & Sends info to dealer & Manufacturer.

* Fleet Management → fleet owner wishes to track the vehicles to known over time, location & velocity in order to plan & optimize business operations.

* Communication Capabilities :- It is highly desirable for objects to support ubiquitous End-to-End Comm^n.

To achieve ubiquitous connectivity Human-to-object & object-to-object comm^n & N/w capabilities will need to be implemented in the objects (things).

→ Ip is considered to be key capability of IoT objects.

IPV6 auto-config & Multi-homing features are useful in this Context.

* Mobility Support :- Mobility-Enabled architectures & protocols are required. Some objects move independently, while others will move as one of group.

According to the Moving feature, diff tracking Methods are required

→ Mobile IPv6 (MIPv6) offers several capabilities that can address this requirement.

* Device power :- A key consideration relates to the powering of the "thing" Especially for Mobile devices.

→ M2M/IoT applns are almost invariably constrained by the foll factors:

* low-power consumption
* low-cost
* Small physical size
* Efficient comm^n Mechanism

A no of devices operate with a small battery, while other devices use a self-Energizing Energy source.

→ There are no of factors that must be considered in selecting the most suitable battery

* operating voltage level * Duty cycle * Service life
* Size, shape & weight * temp, pressure, Humidity & Environmental Conditions
* Safety & reliability * Maintance & Replacement * cost.

→ The Architecture Encompasses a number of models as follows

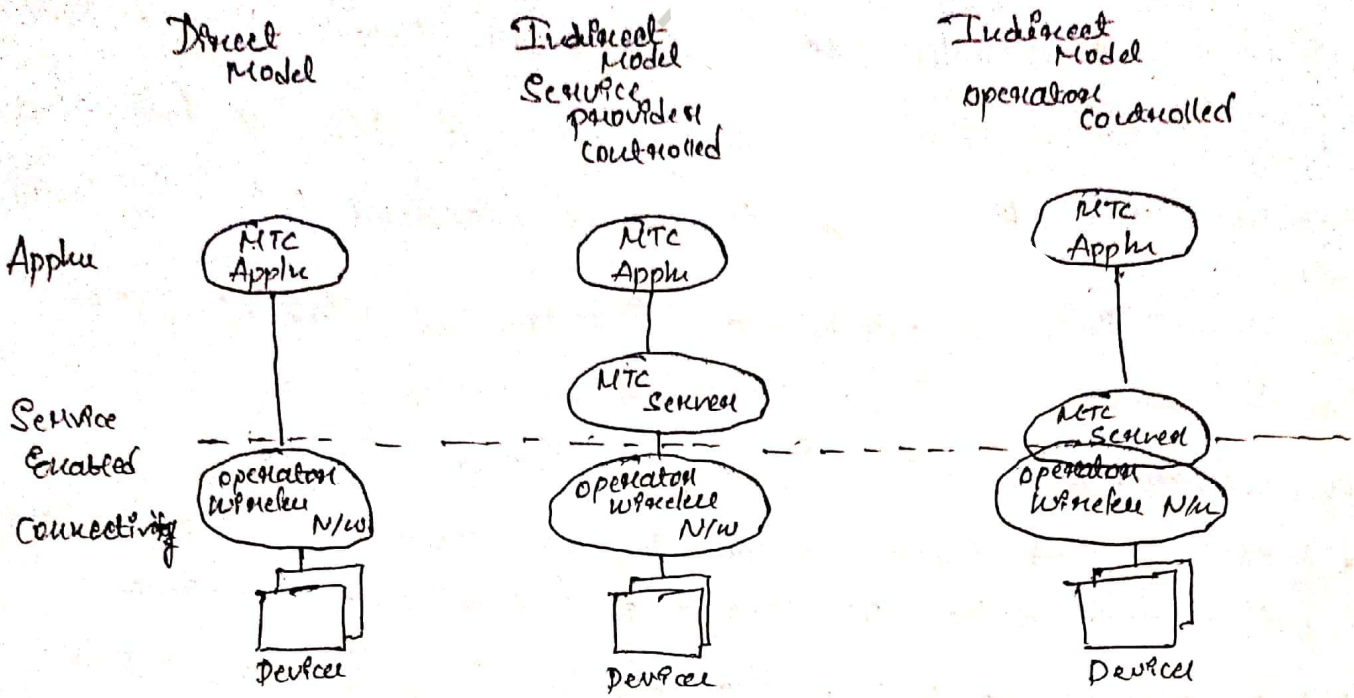


Fig M2M in 3gpp Service models

* Direct Model → direct Commn provided by 3gpp operator. The MTC Appln connects directly to operator N/w without the use of any MTC Server.

* Indirect Model → MTC Service provider Controlled Commn. the MTC Server is an Entity outside the operator Domain.

3gpp operator Controlled Commn, the MTC Server is an Entity inside the operator domain.

* hybrid Model → the direct & Indirect Models are used simultaneously in hybrid Model.

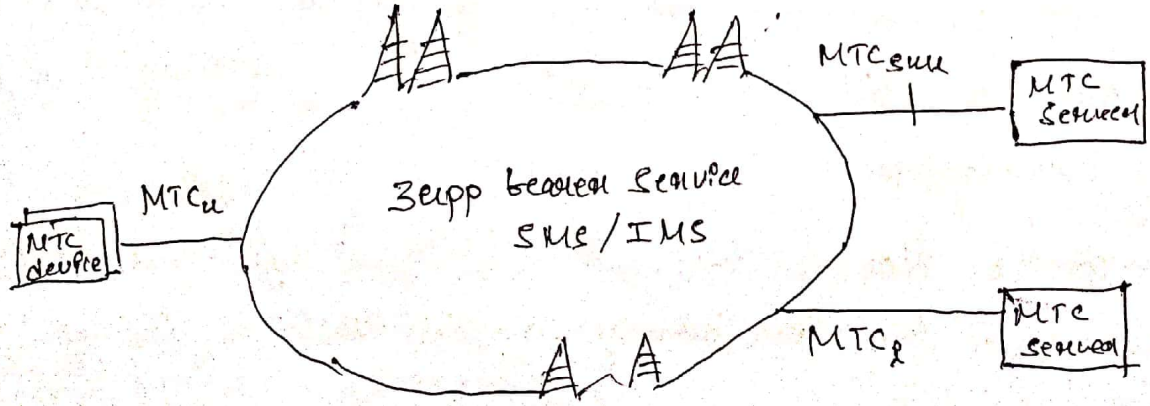


Fig M2M in 3gpp Architecture

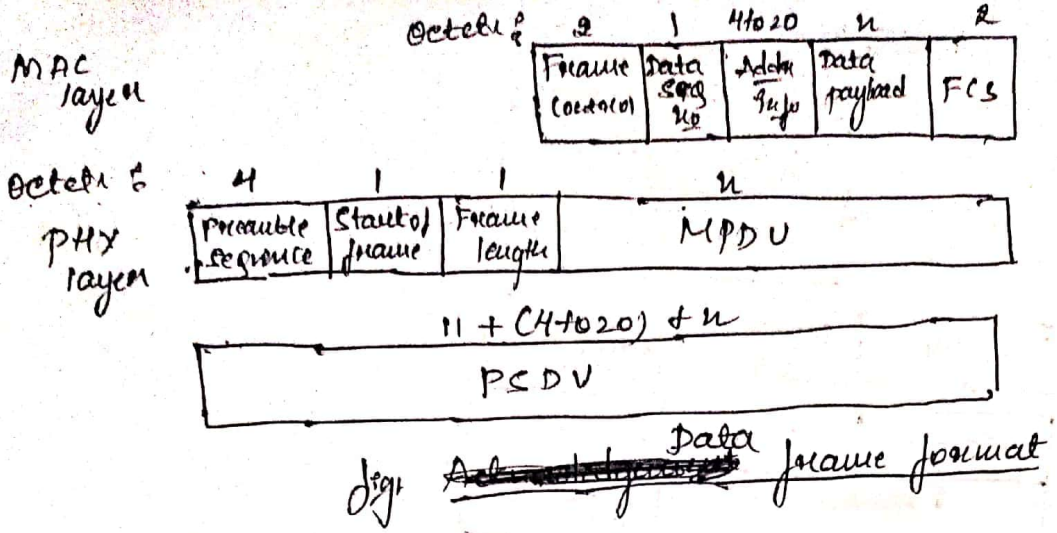


fig: Data frame format

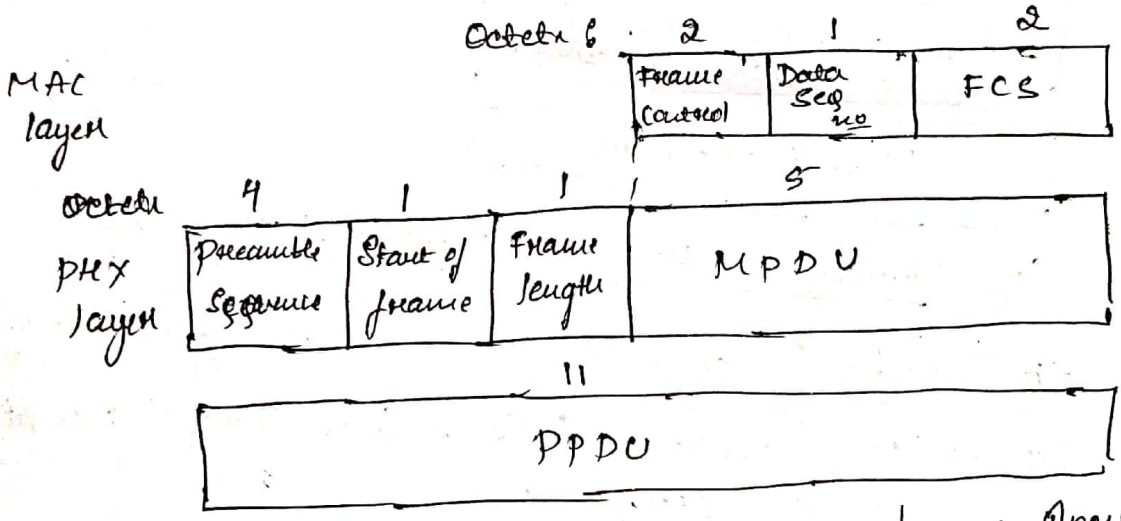


fig: Acknowledgement frame format

* Bluetooth HDP :- Bluetooth System for Medical applications made use of proprietary implementations & data formats.
typically Bluetooth Applns are not interoperable across the vendors. to address the interoperability issue Bluetooth HDP has been released.

→ HDP (Health Device profile) provides several Critical features
* Control channel connection / Disconnection
* Data link creation / Deletion
* Data link abort / reconnection
* Data transmission
* Clock synchronization

* Cities (Smart parking)

The purpose of a Smart parking is to detect the no of Empty parking Slots & send the info over the Internet to Smart parking Apps backends.

These Apps can be accessed by drivers from Smartphones, tablets or from in-car navigation sys.

→ The process diagram of Smart parking sys

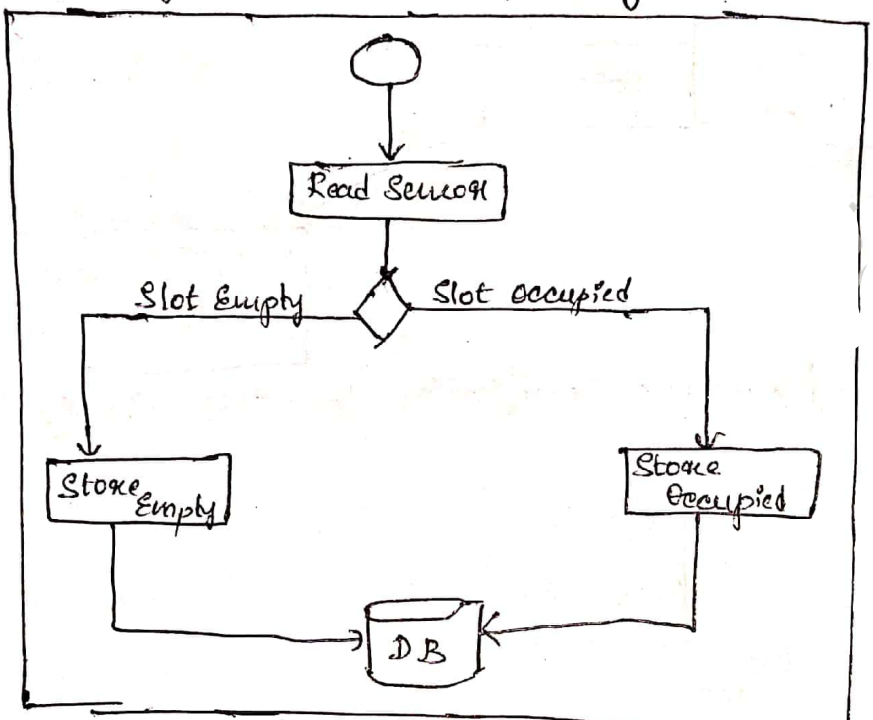
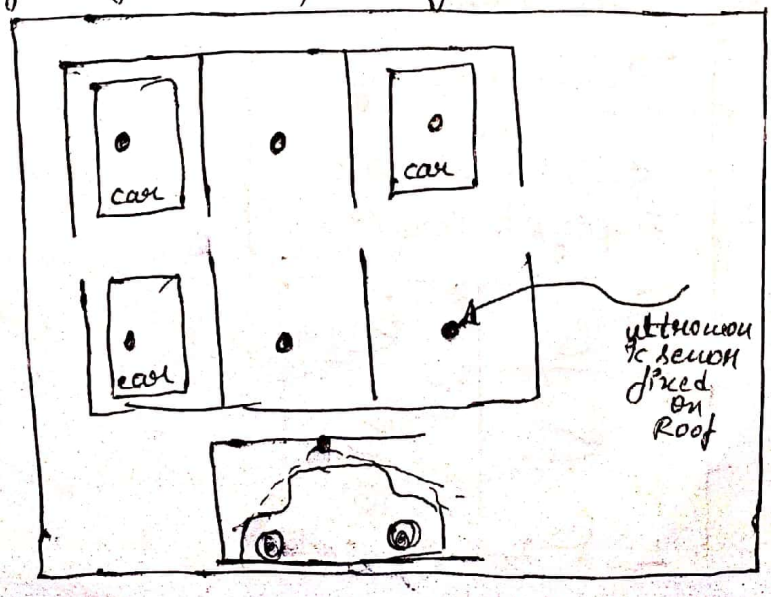


fig: process specification of Smart parking sys

Each parking slot has an ultrasonic sensor fixed above, which can detect the presence of a vehicle in the slot. Each sensor is read at regular intervals & the state of parking slot.

→ Deployment Design of Smart parking



```
Setup Controller()
While true:
    run controller()
    time.sleep(10)
```

* Forest fire detection :- IoT based forest fire detection System use a no of Monitoring node deployed at diff locations in a forest. Each Monitoring node collects Measurements on ambient Conditions (temp, Humidity) to predict whether a fire has broken out.

→ The Implementation of forest fire detection s/m with Multiple End node & one Co-ordinator node.
The Each node perform Sensing & the Co-ordinator node collects data from End node & sends to the cloud.

→ The End node includes a Raspberry pi & DHT-22 temp & Humidity sensor.
An XBee Module is used for wireless comm b/w End-node & Coordinator node.

→ The Controller Service on the End node obtains the Sensor reading Every 10 seconds & writes the data to XBee Module which sends the data Co-ordinator node
Controller Service on Coordinator node receives the data from all node & stores the Measurement in cloud.

* python code for forest fire detection s/m

End node

```
import time
import datetime
import serial
import Adafruit_DHT

dev_type = 22
dht_pin = 24
Adafruit_DHT.init()
def read_DHT_Sensor():
    temp, Humidity = Adafruit_DHT.read(devtype, dht_pin)
    return temp, Humidity
def write_xbee(data):
    xbee = serial.Serial(port)
    xbee.write(data)
    temperature + "," + Humidity + ","
```

* Starting Hadoop Cluster → The next step is to start the Hadoop Cluster.
If the Hadoop cluster is correctly installed, configured & started, the status of Hadoop Daemons can be viewed using the Admin web pages for Daemons.

* Using Hadoop MapReduce for Batch Data Analysis
Batch analysis is done to aggregate data (computing mean, Max, Min, etc) on various timescales.

→ The data collection retrieves the sensor data collected in the cloud database & creates a raw data file suitable for processing by Hadoop.

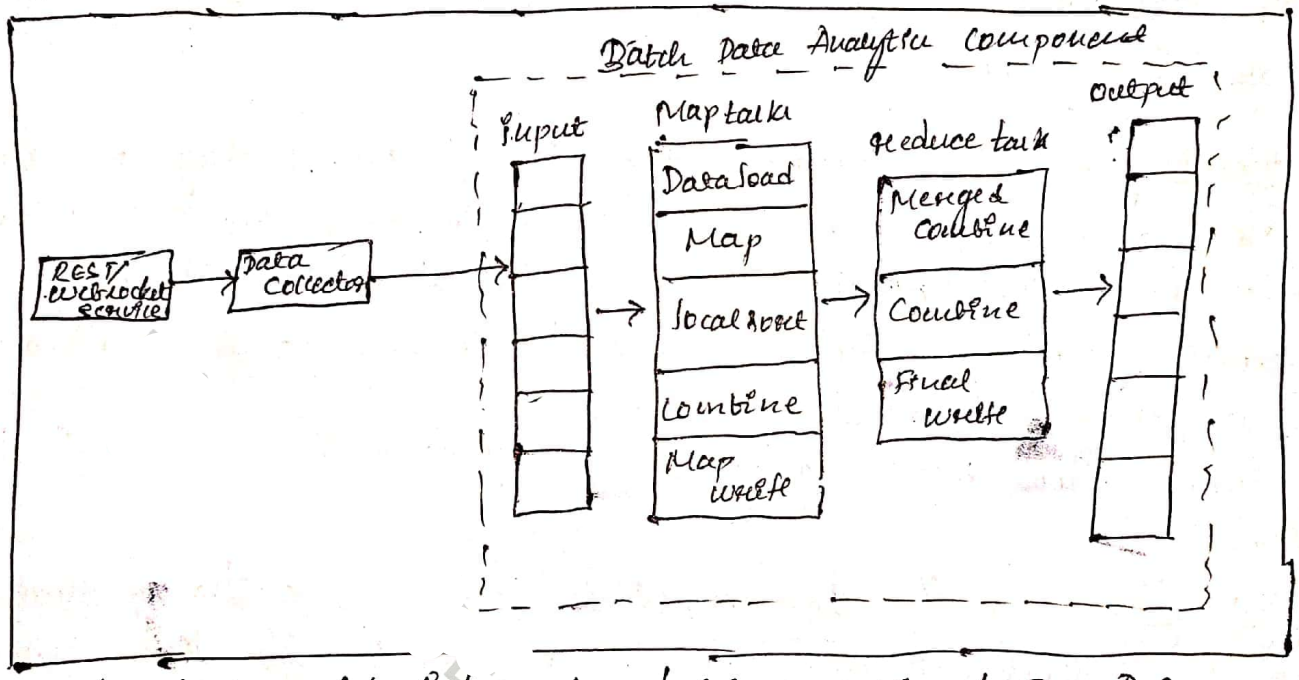


Fig: Hadoop MapReduce for batch analysis of IoT Data

→ For the forest fire detection Example, the raw data file contains of raw sensor reading with timestamp shown below:

"2020-02-24 10:15:32", 37, 44, 31, 6
⋮
"2020-02-24 10:15:33", 38, 46, 71, 2

→ The Map program reads the data from "Standard Input (StdIn)" & splits the data into timestamp & individual sensor readings. The Map program emits key-value pairs where key is timestamp.

→ The Stream is Consumed & processed by Storm Bolt. The Storm Bolt use a Decision tree classifier for making the predictions.

* Structural Health Monitoring Case study :- Structural Health Monitoring System (SHM) use a N/w of Sensors to Monitor the Vibration levels in Structures such as "bridges" & "buildings". The data collected from these sensors is analyzed to asses the health of Structures.

→ The SHM System use 3-axis accelerometer sensors for Measuring the Vibrations in a Structure.
The accelerometer data is collected & Analyzed in the cloud.

→ The deployment Design for SHM system is

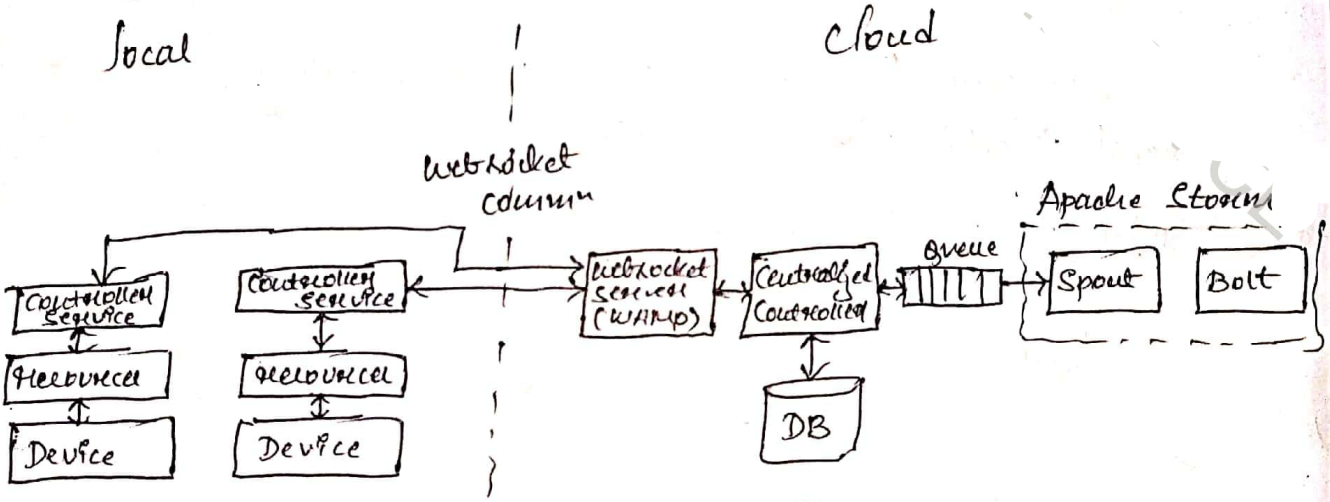


fig: Deployment Design of SHM

→ Discrete fourier Transform (DFT) is useful for Converting a Sampled Signal from time domain to freqency domain which make the analysis of Signal easier.

→ using DFT cannot reveal the transitions in Spectral Content, Short Time Fourier Transform (STFT) is better suited for revealing the changes in Spectral content Corresponding to the SHM data.

→ The function of STFT of Each windowed section

$$X[n, w] = \sum_{m=-\infty}^{+\infty} x[m] * w[n-m] e^{-jwn}$$