
FUNDAMENTALS OF IoT - FIoT

UNIT-I

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ECE,NRCM

Content

- Introduction to Internet of Things
- Characteristics of IoT
- Physical Design of IoT
- Functional Blocks of IoT
- Sensing
- Actuation
- Basics of Networking
- Communication Protocols
- Sensor Networks

Definition of Internet of Things

- A Dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual things have identities, physical attributes and virtual personalities and use intelligent interfaces and are seamlessly integrated into the information network, often communicate data associated with users and their environments.

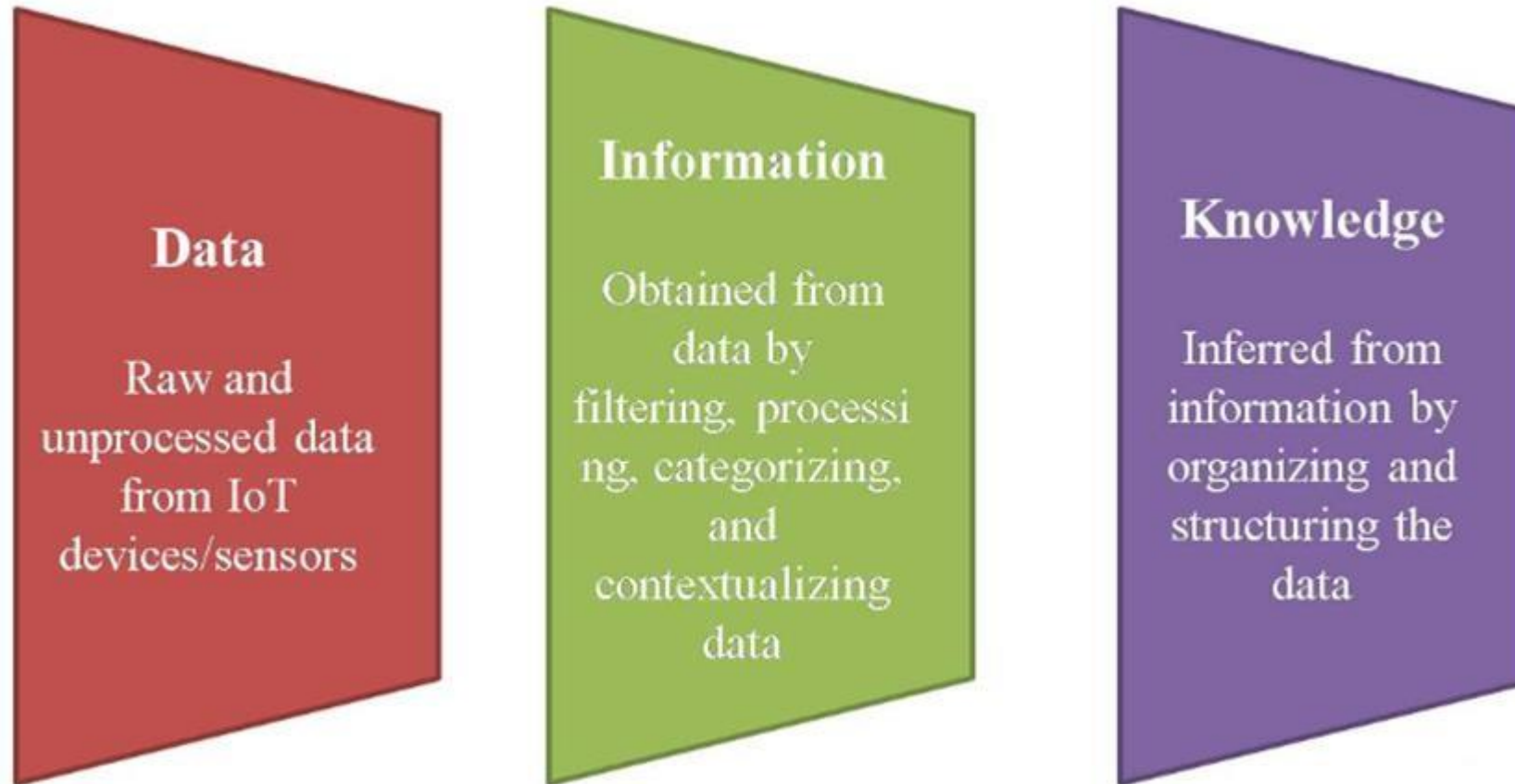


Fig: Inferring information and knowledge from data

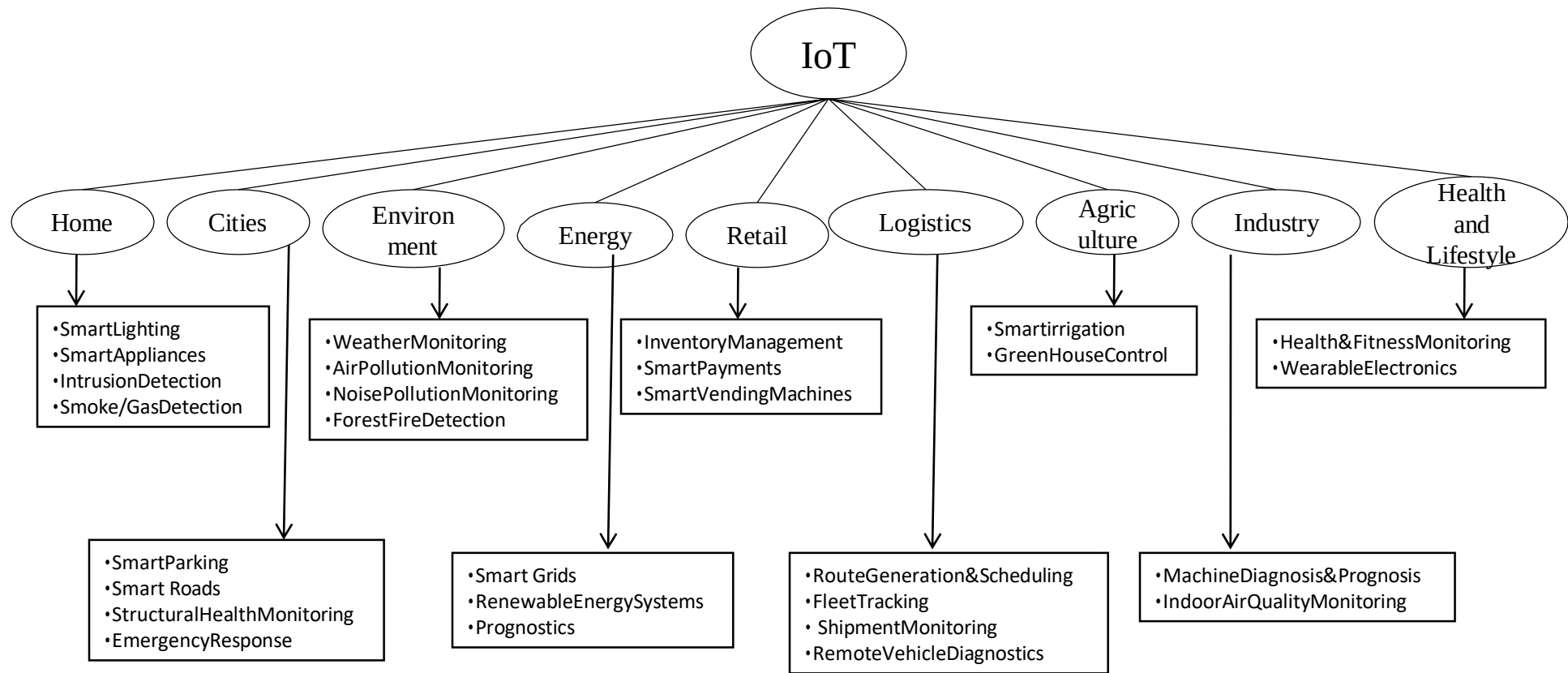


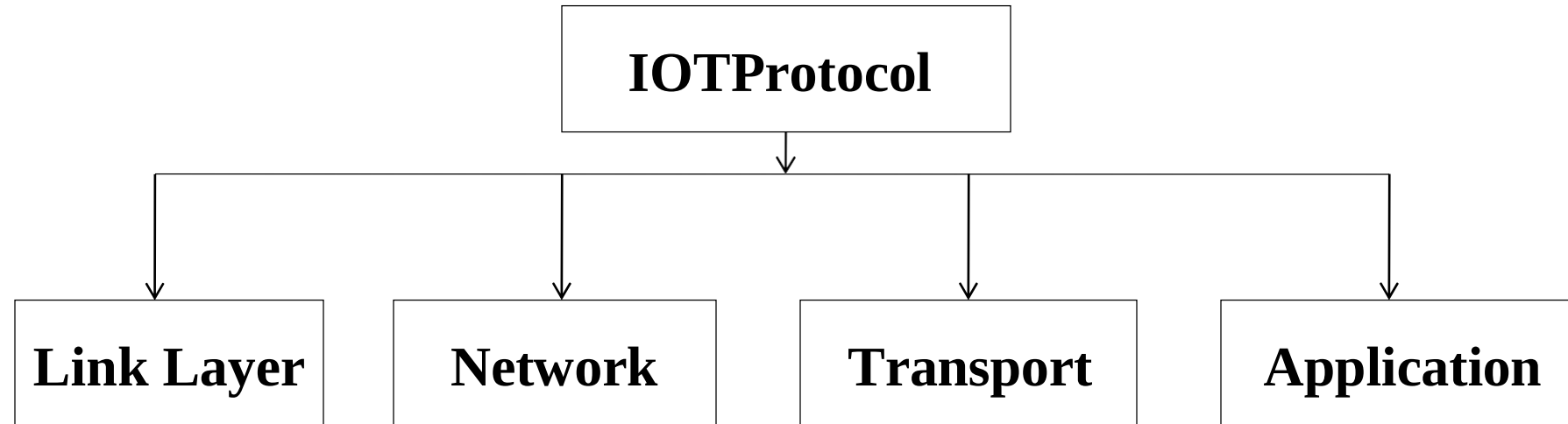
Fig: Applications of IoT

Characteristics of IoT

1. Dynamic&SelfAdapting
2. SelfConfiguring
3. InteroperableCommunicationProtocols
4. UniqueIdentity
5. IntegratedintoInformationNetwork

Physical Design ofIoT

1. ThingsinIoT
2. IoTProtocols



1. LinkLayer

- i. 802.3-Ethernet
- ii. 802.11-WiFi
- iii. 802.16-WiMax
- iv. 802.15.4-LR-WPAN
- v. 2G/3G/4G-MobileCommunication

2. Network/InternetLayer

- i. IPV4
- ii. IPV6
- iii. 6LOWPAN

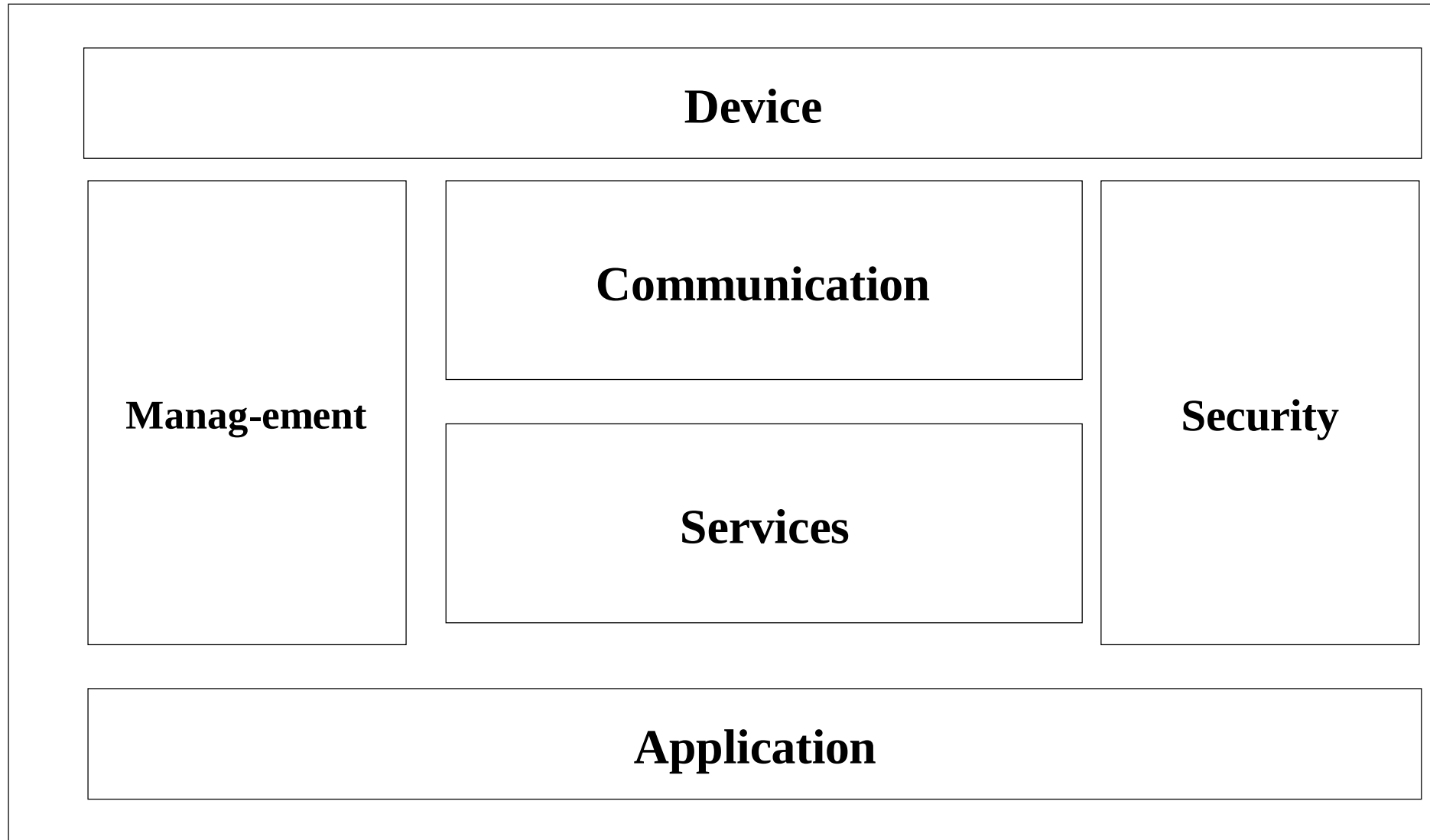
3. TransportLayer

- i. TCP
- ii. UDP

4. ApplicationLayer

- i. HTTP
- ii. COAP
- iii. WebSocket
- iv. MQTT
- v. XMPP
- vi. DDS
- vii. AMQP

Logical Design of IoT



1. Device
2. Communication
3. Services
4. Management
5. Security
6. Application

IoTCommunicationModel

1. Request-Response
2. Publish-Response
3. Push-Pull
4. Exclusive-Pair

IoTCommunicationAPI's

1. REST–basedCommunicationAPI's

- i. Client– Server
- ii. Stateless
- iii. Cache– able
- iv. LayeredSystem
- v. UniformInterface
- vi. CodeonDemand

2. WebSocket–basedCommunicationAPI's

IoT Enabling Technologies

1. Wireless Sensor Networks
2. Cloud Computing
 - i. Infrastructure-as-aService(IaaS)
 - ii. Platform-as-aService(PaaS)
 - iii. Software-as-aService(SaaS)
3. Big Data Analytics
 - i. Volume
 - ii. Velocity
 - iii. Variety
4. Communication Protocols
5. Embedded Systems

IoT Levels and Development Templates

1. Device
2. Resource
3. ControllerService
4. Database
5. WebService
 - i. Stateless/Stateful
 - ii. Uni-Directional/Bi-Directional
 - iii. Request-Response/FullDuplex
 - iv. TCPConnections
 - v. HeaderOverhead
 - vi. Scalability
6. AnalysisComponent
7. Application

IoTLevels

1. IoTLevels-1
2. IoTLevels-2
3. IoTLevels-3
4. IoTLevels-4
5. IoTLevels-5
6. IoTLevels-6

- SensorTechnology
- DifferentExamplesofSensorsasfollows
 1. HumiditySensor
 2. Light
 3. Acceleration
 4. VibrationsandShocks
 5. AngularAccelerationandchangesinDirection(Angle)
 6. LIDAR

1) An actuator is something that actuates or moves something. More specifically, an actuator is a device that converts energy into motion or mechanical energy. Therefore, an actuator is a specific type of a transducer.

2) Thermal Actuators One type of thermal actuator is a **bimetallic strip**. This device directly converts thermal energy into motion. This is accomplished by utilizing an effect called thermal expansion.

- Thermal expansion is the manifestation of a change in thermal energy in a material.
- When a material is heated, the average distance between atoms (or molecules) increases. The amount of distance differs for different types of material. This microscopic increase in distance is unperceivable to the human eye. However, because of the huge numbers of atoms (or molecules) in a piece of material, the material expands considerably and, at times, is noticeable to the human eye.

Basics of Networking

- Based on the network the area is divided as:
 1. LAN–Local Area Network
 2. PAN–Personal Area Network
 3. MAN–Metropolitan Area Network
 4. WAN–Wide Area Network

1. LAN-LocalAreaNetwork

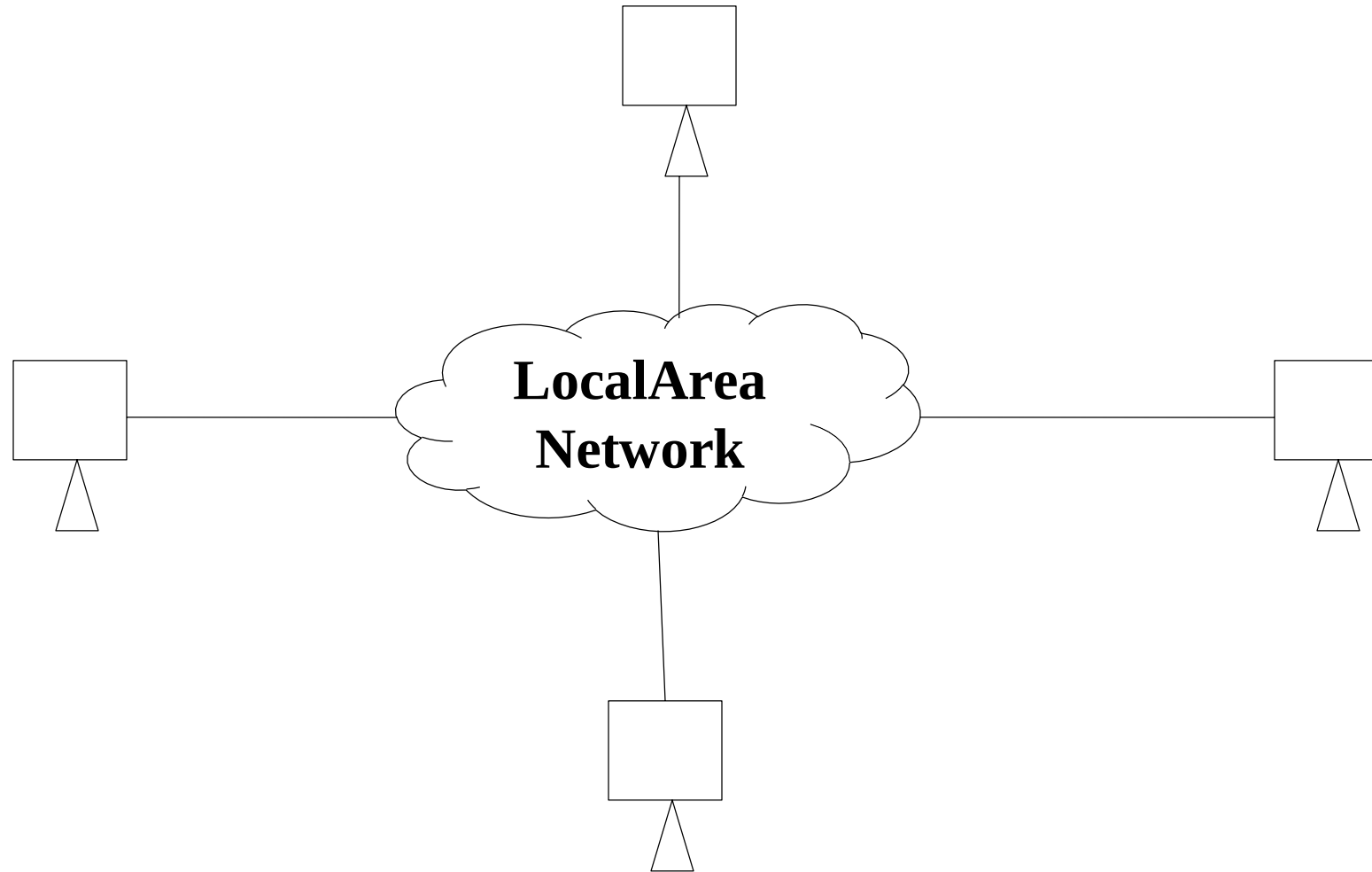


Fig:LAN-LocalAreaNetwork

1. LAN–LocalAreaNetwork

- Characteristics of LAN

1. Size
2. Transmission Technology
3. Network Topology

WAN-WideAreaNetwork

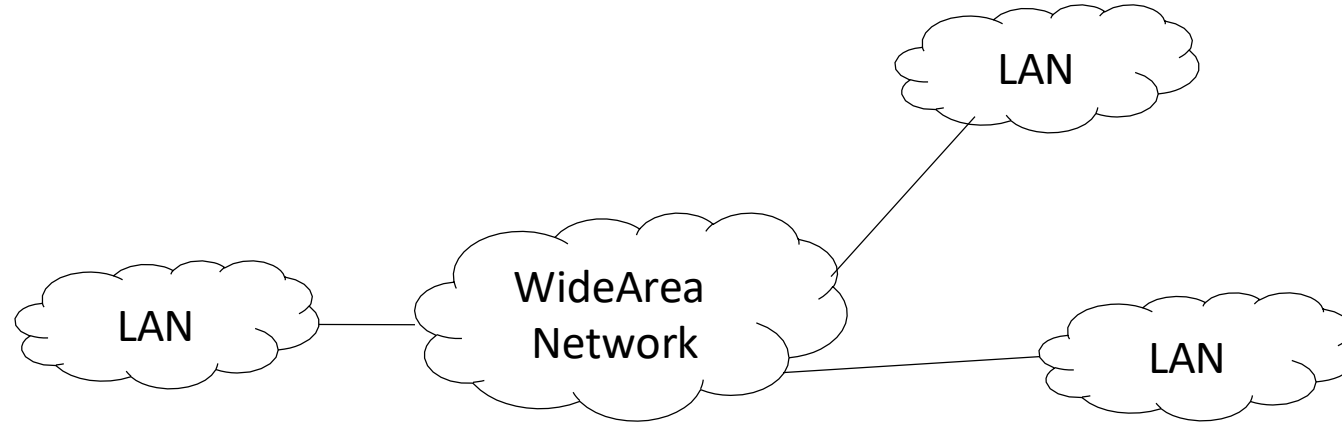


Fig:WAN-WideAreaNetwork

1. Point-to-PointWAN
2. SwitchedWAN

1. Point-to-PointWAN

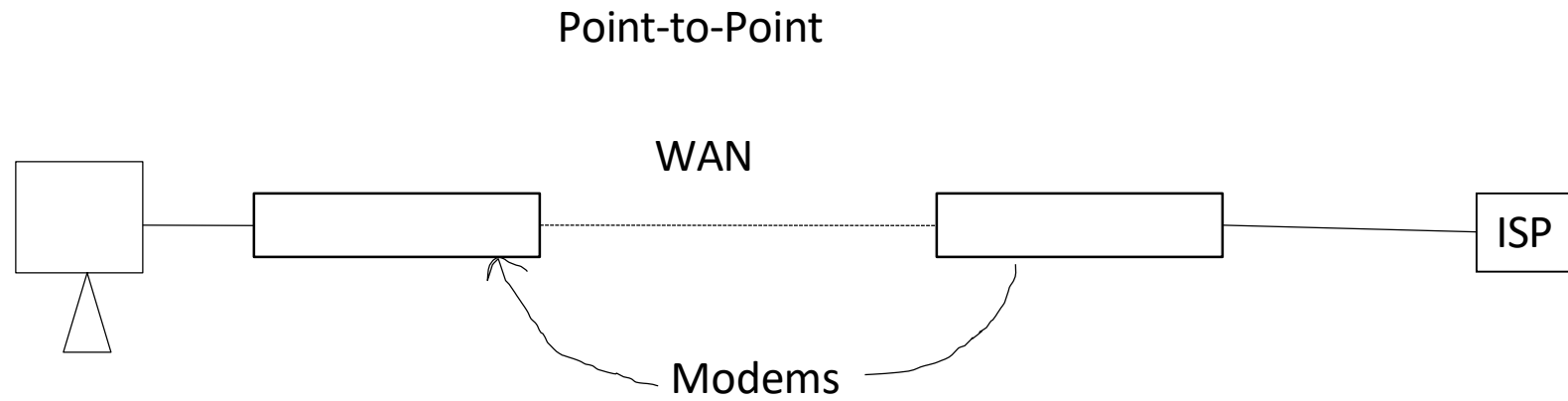


Fig:Point-to-PointWAN

2. SwitchedWAN

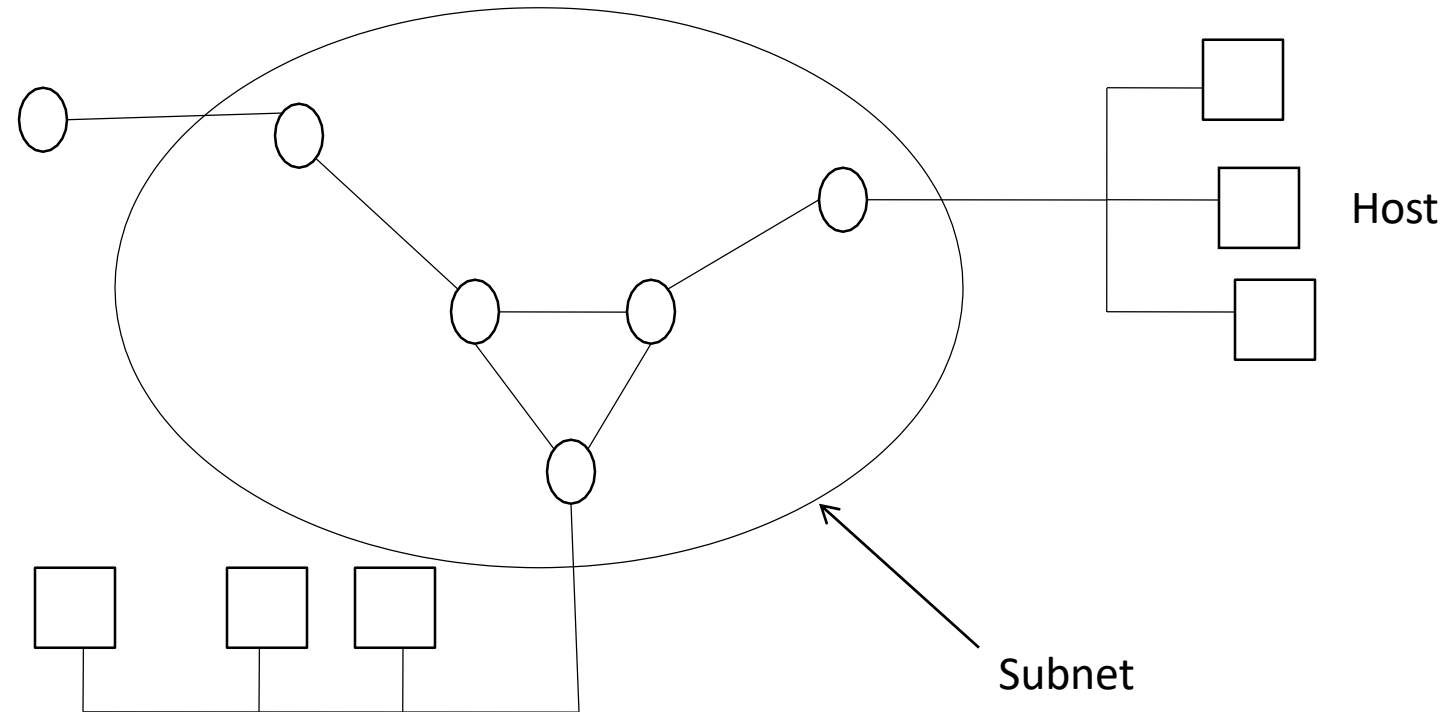


Fig:SwitchedWAN

- Several Topologies
 - i. Star Topology
 - ii. Ring Topology
 - iii. Complete or Square Topology
 - iv. Tree Topology
 - v. Irregular Topology

i. StarTopology

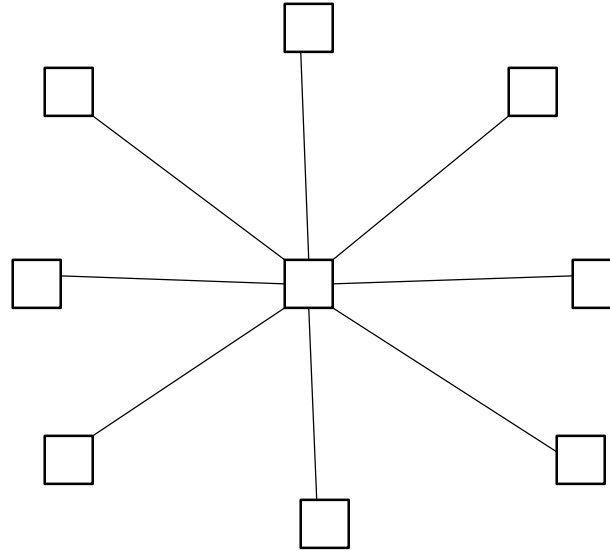
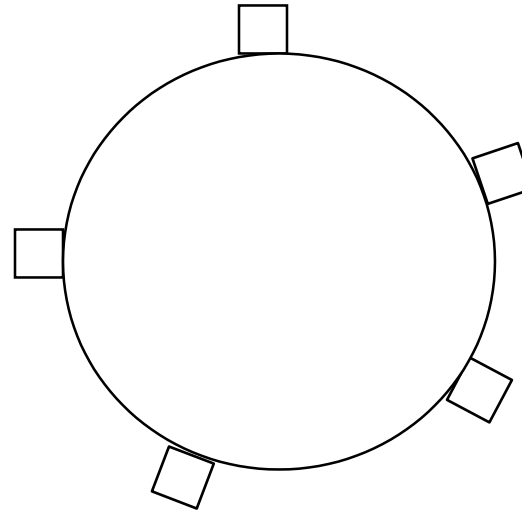
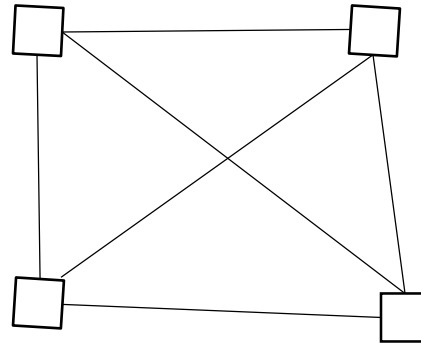


Fig:Star Topology

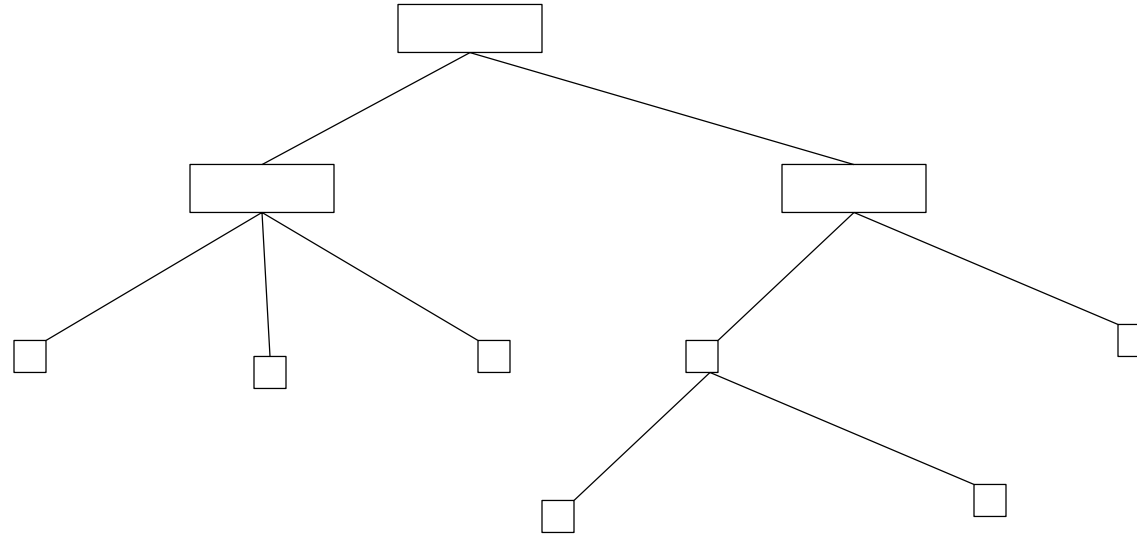
ii. RingTopology



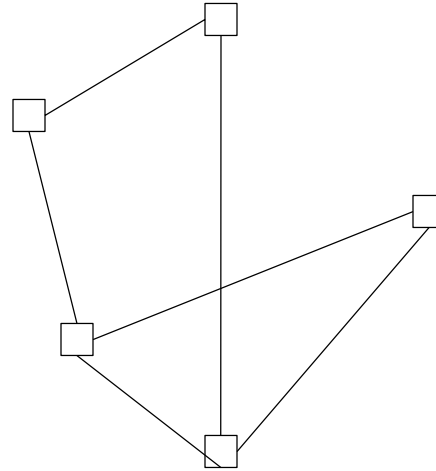
iii. CompleteorSquareTopology



iv. TreeTopology



v. IrregularTopology



MAN–MetropolitanAreaNetwork

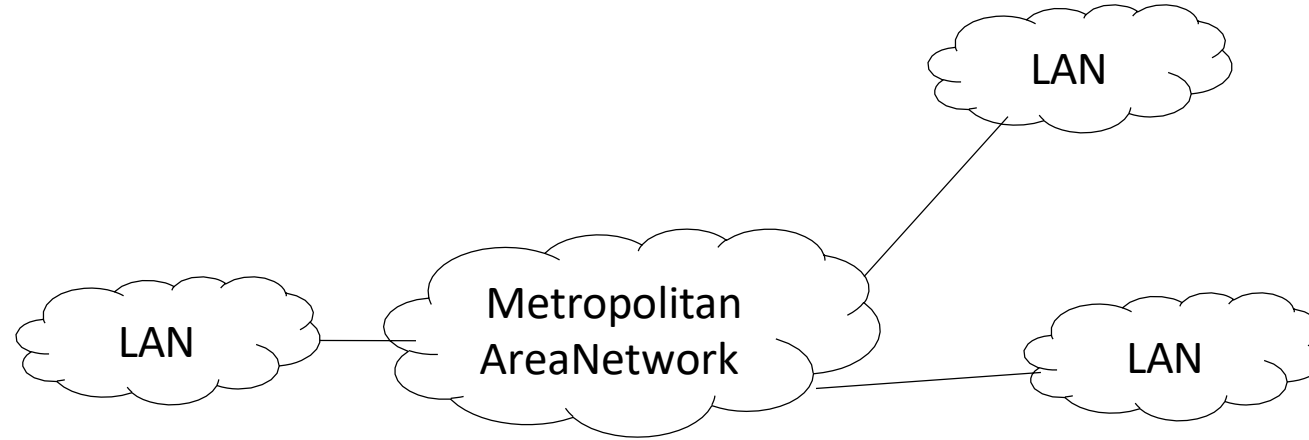


Fig:MAN–MetropolitanAreaNetwork

PAN–PersonalAreaNetwork

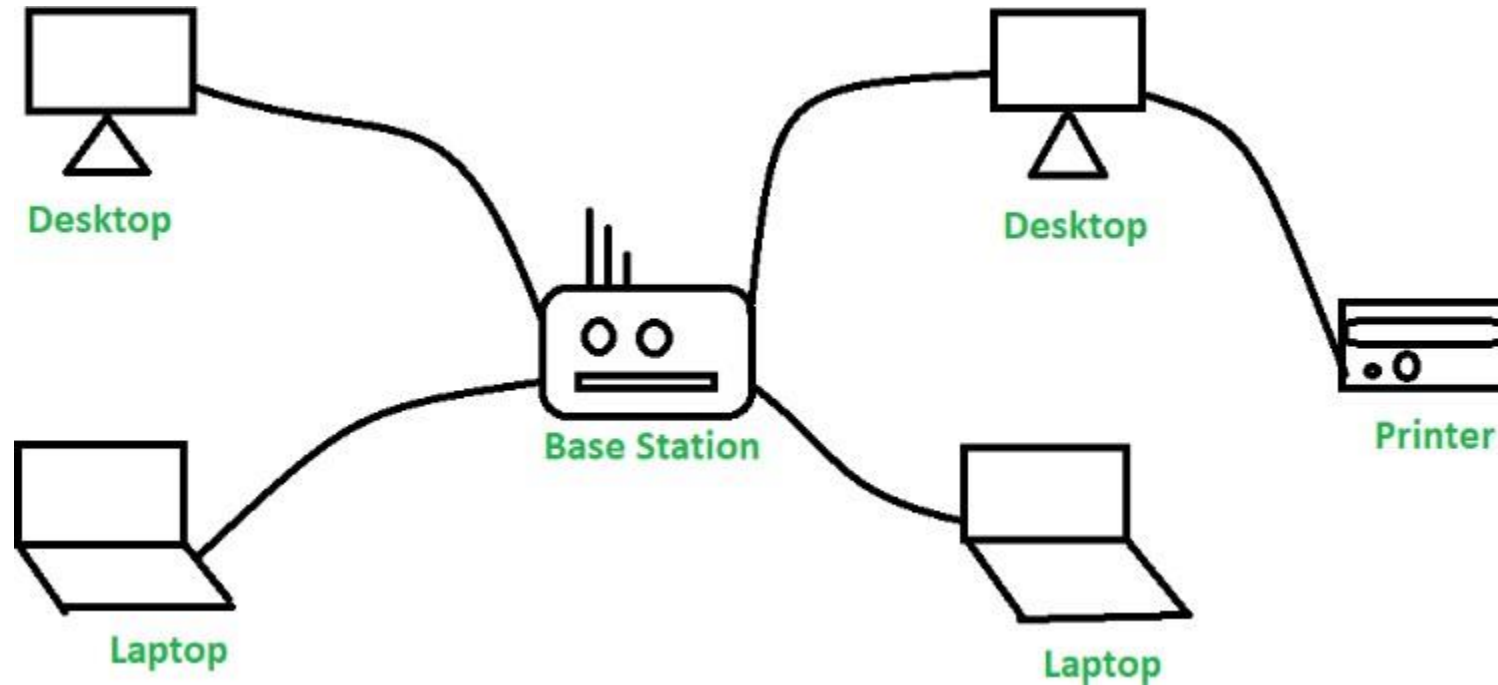


Fig:WiredPAN–WiredPersonalAreaNetwork

PAN–PersonalAreaNetwork

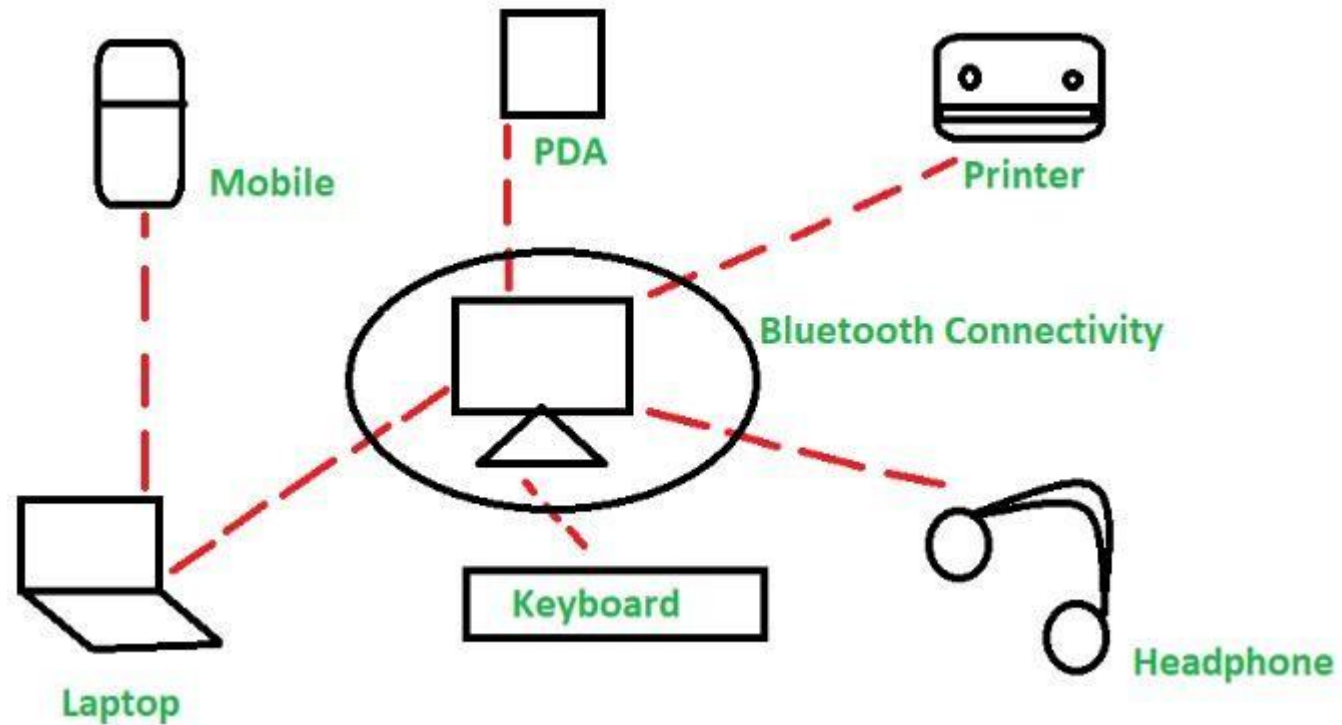
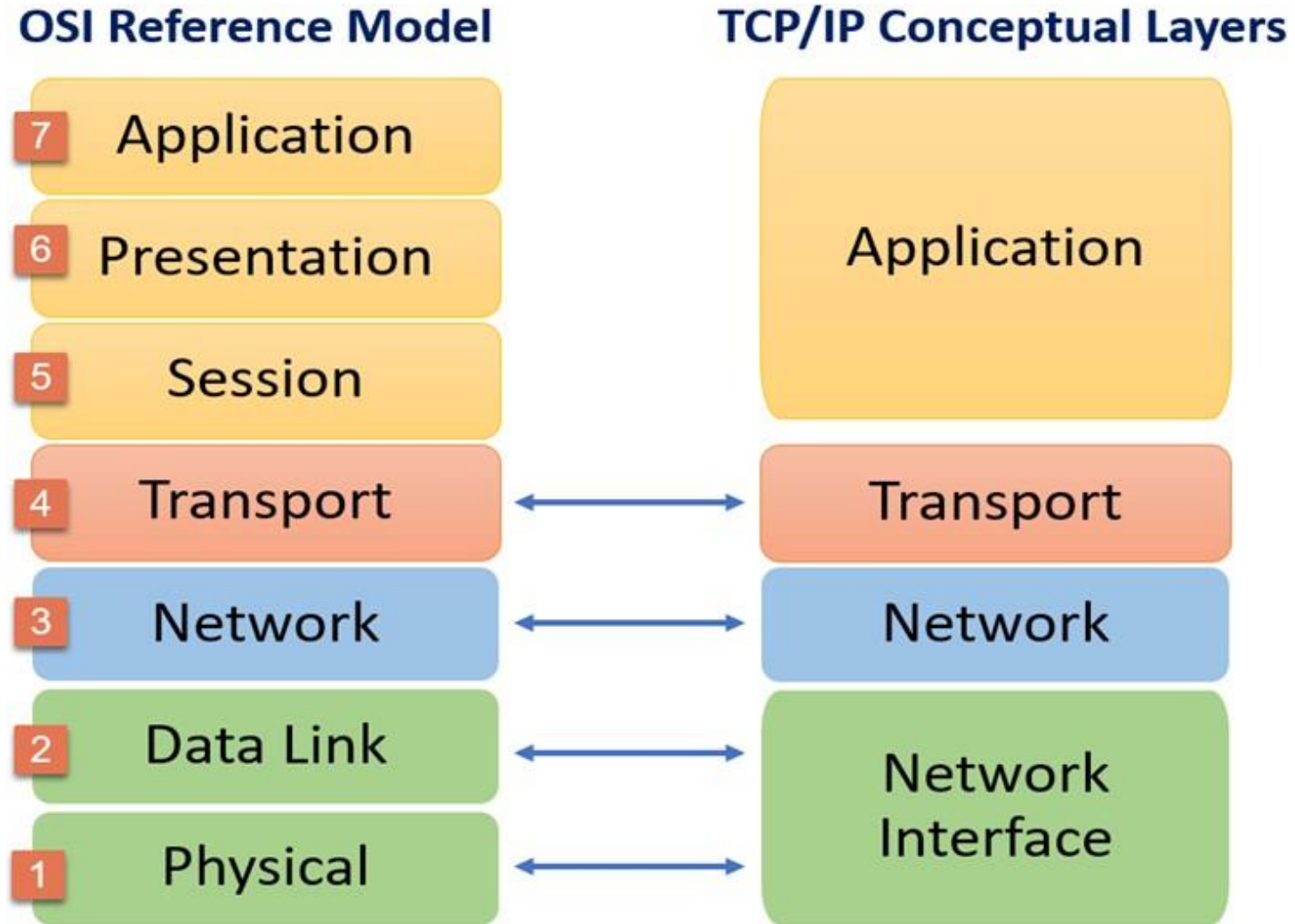
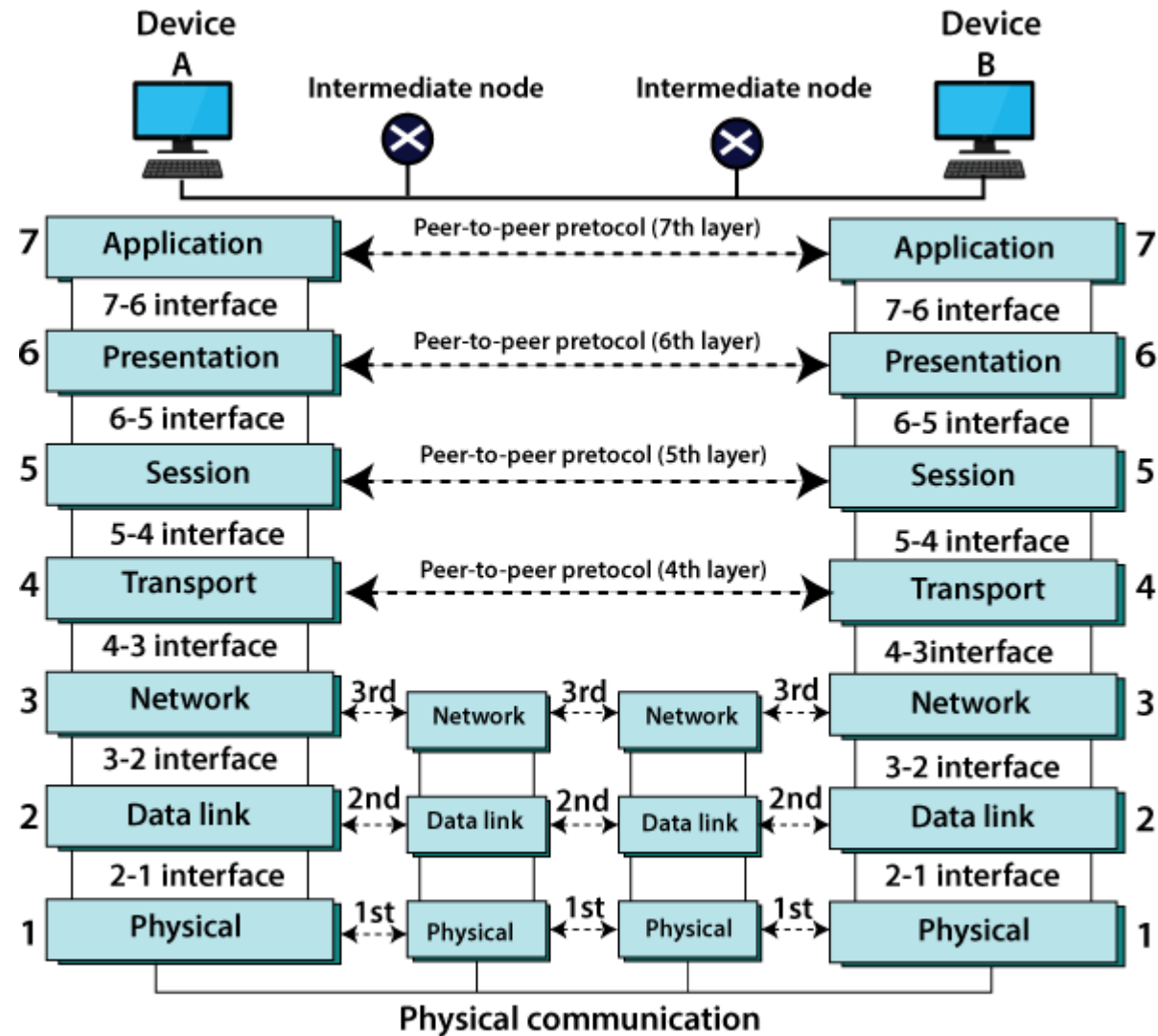


Fig: WirelessPAN–WirelessPersonalAreaNetwork

OSI Reference Model vs TCP/IP Model





7 Layers of the OSI Model

Application

- End User layer
- HTTP, FTP, IRC, SSH, DNS

Presentation

- Syntax layer
- SSL, SSH, IMAP, FTP, MPEG, JPEG

Session

- Synch & send to port
- API's, Sockets, WinSock

Transport

- End-to-end connections
- TCP, UDP

Network

- Packets
- IP, ICMP, IPSec, IGMP

Data Link

- Frames
- Ethernet, PPP, Switch, Bridge

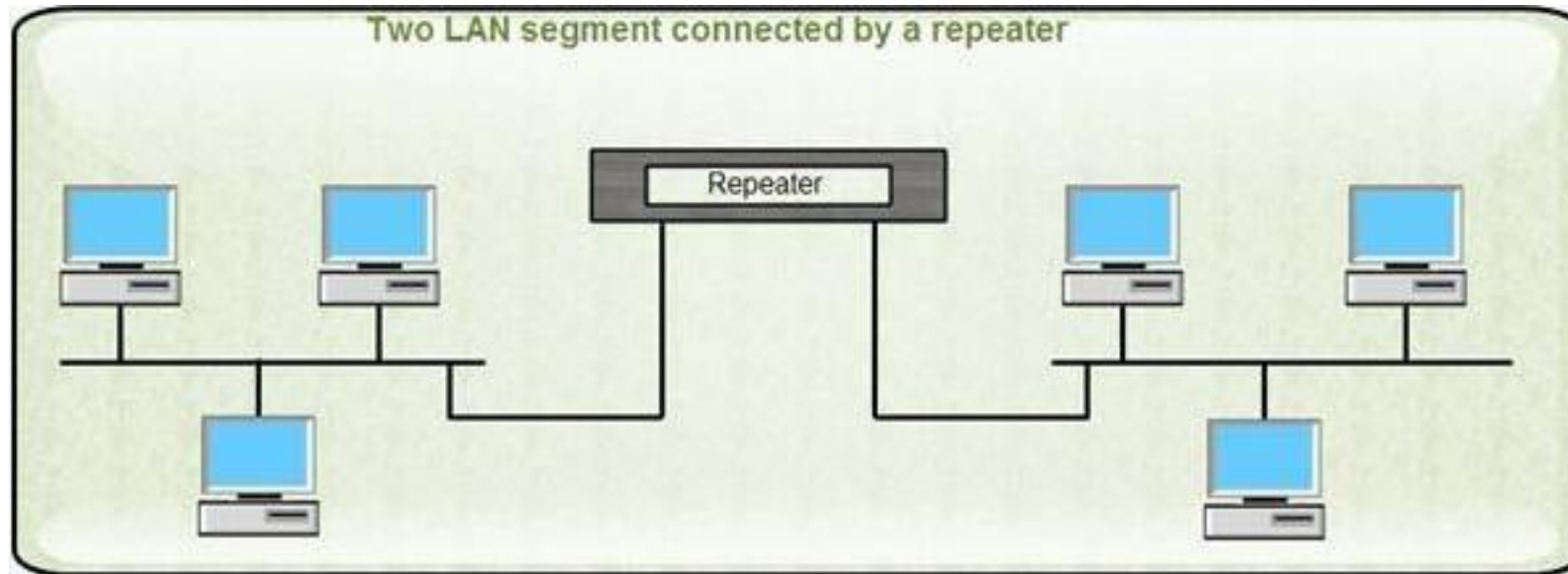
Physical

- Physical structure
- Coax, Fiber, Wireless, Hubs, Repeaters

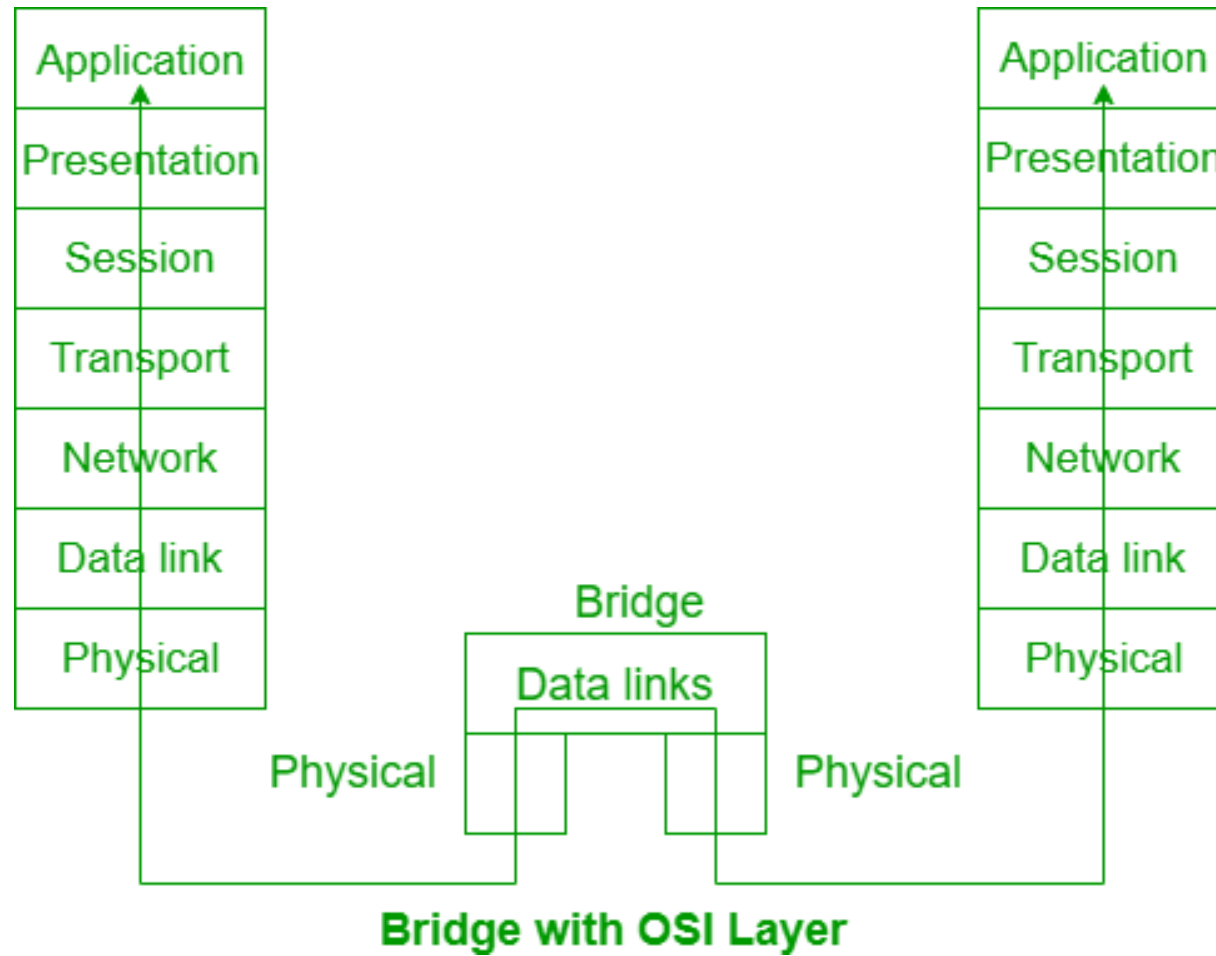
Different Components present in Network

1. Repeaters
2. Bridges
3. Router
4. Gateways
5. Brouters
6. Switches

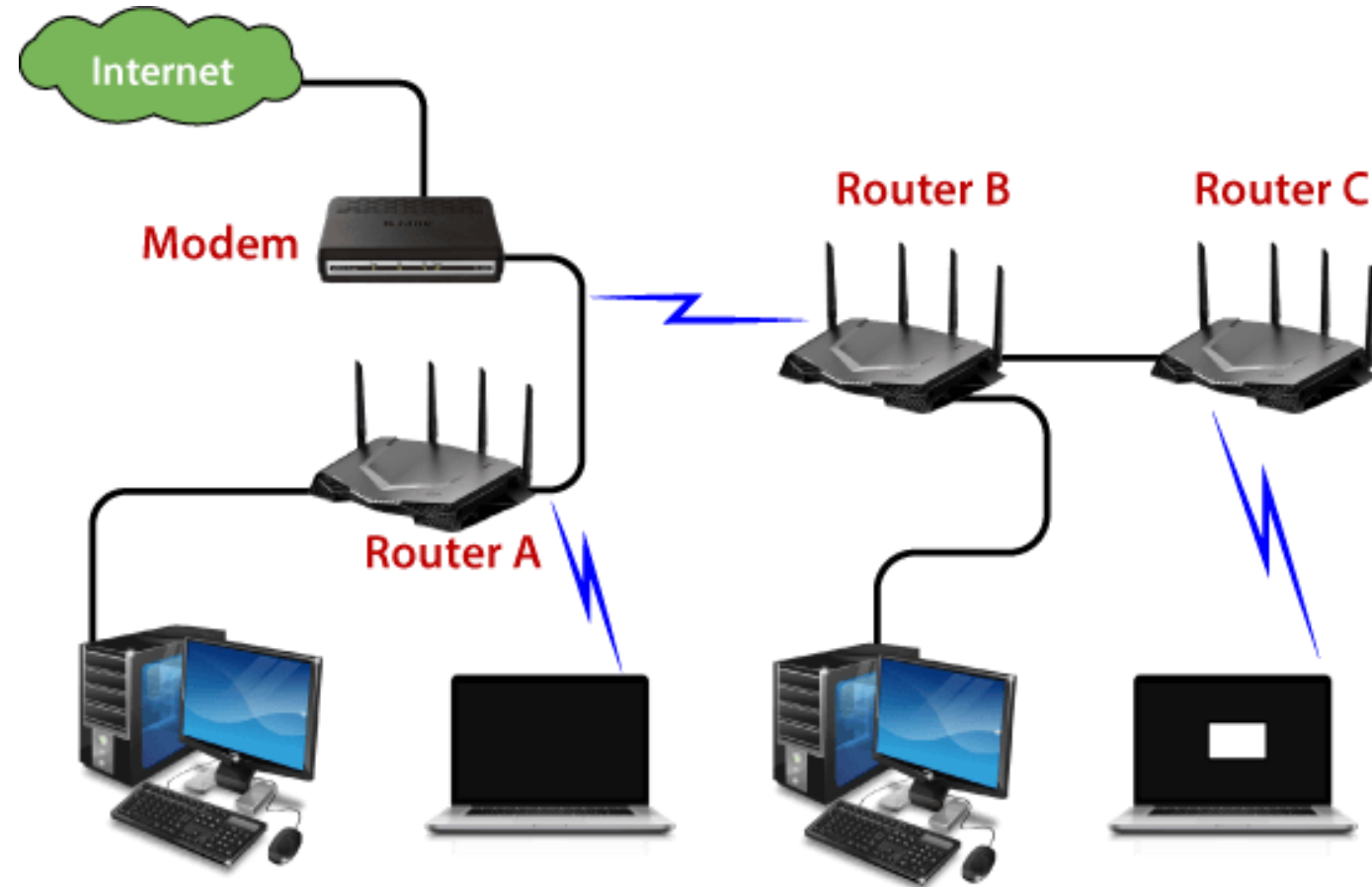
Repeaters



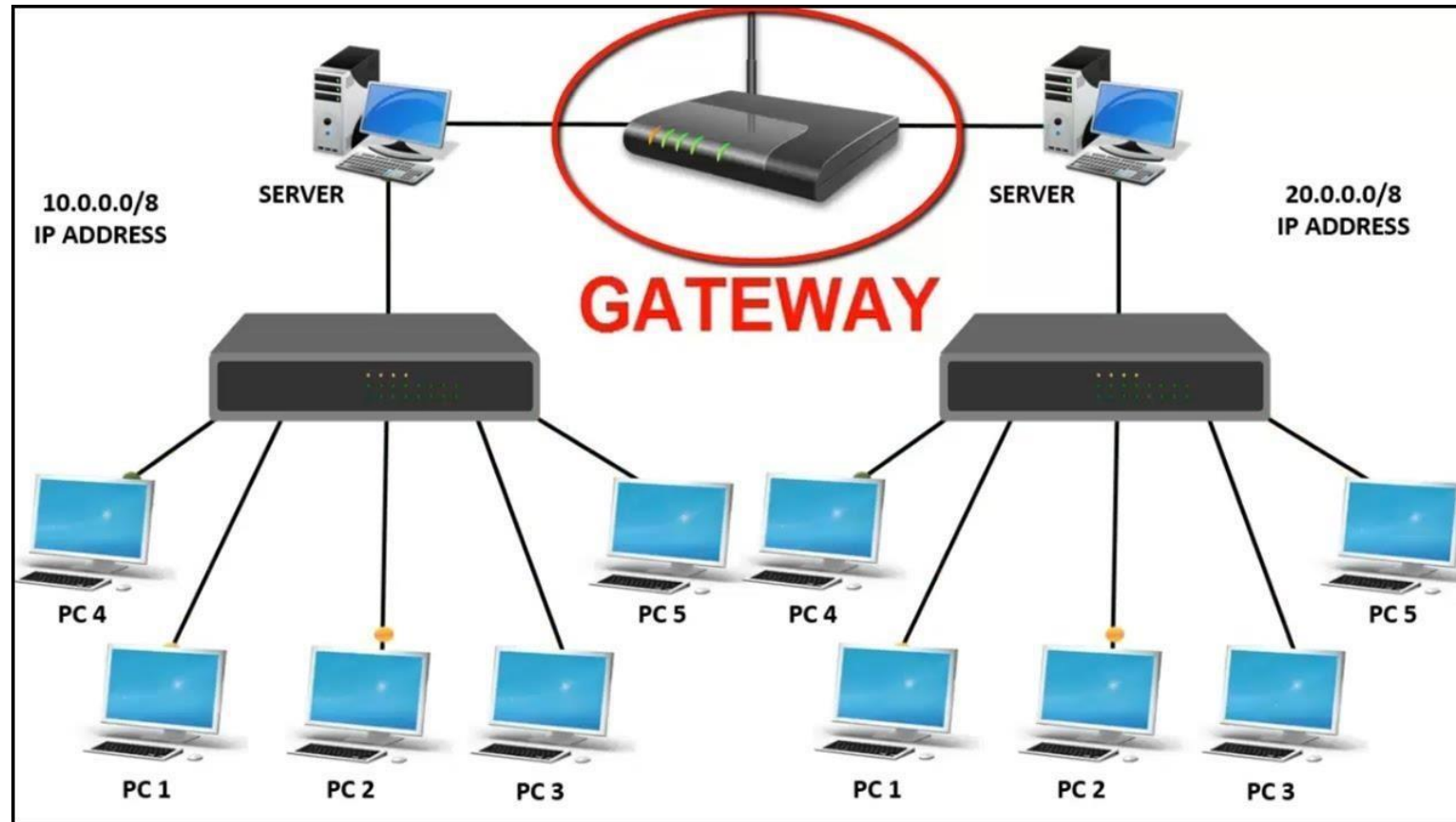
Bridges



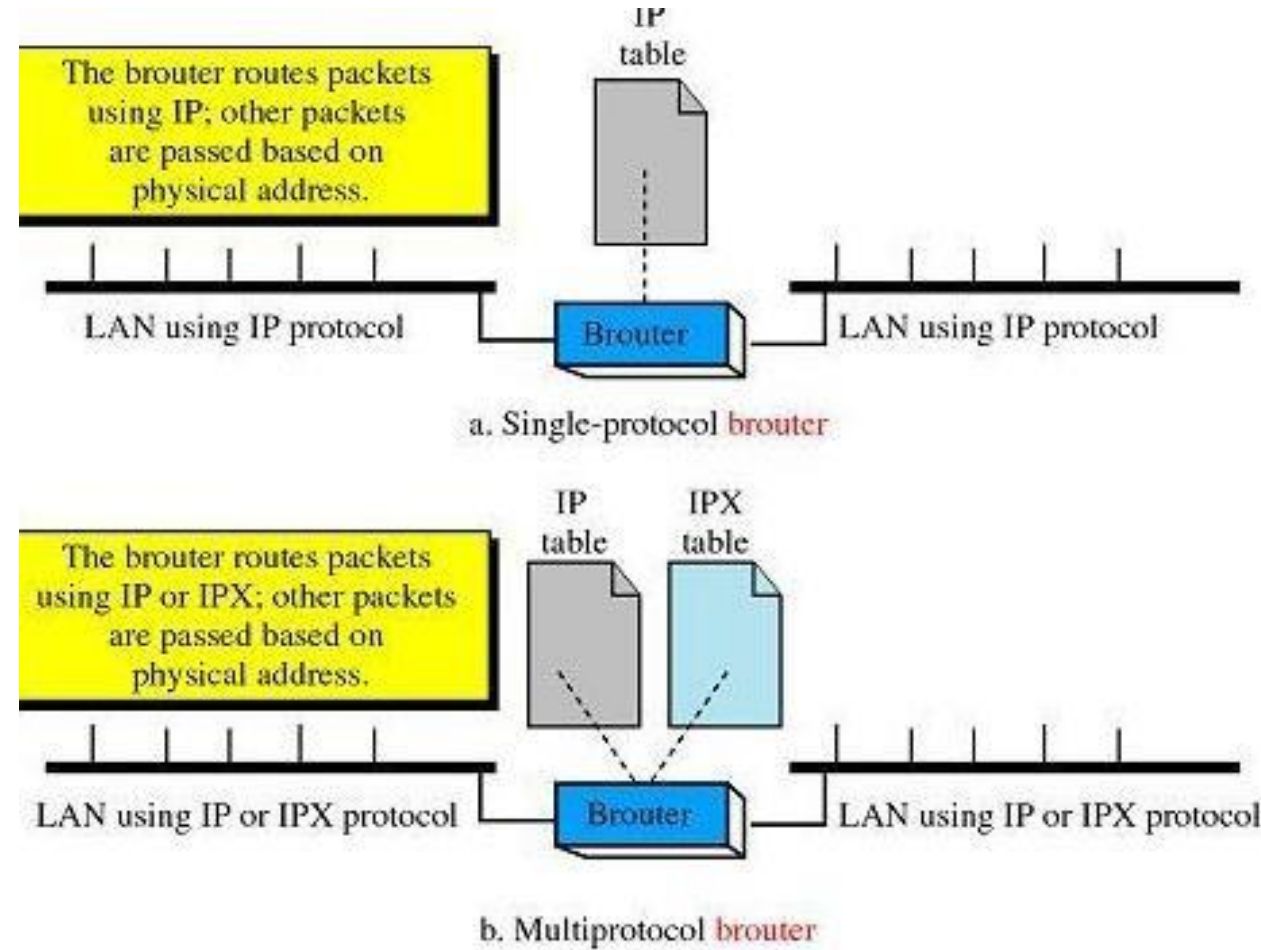
Router



Gateways



Brouters



Switches

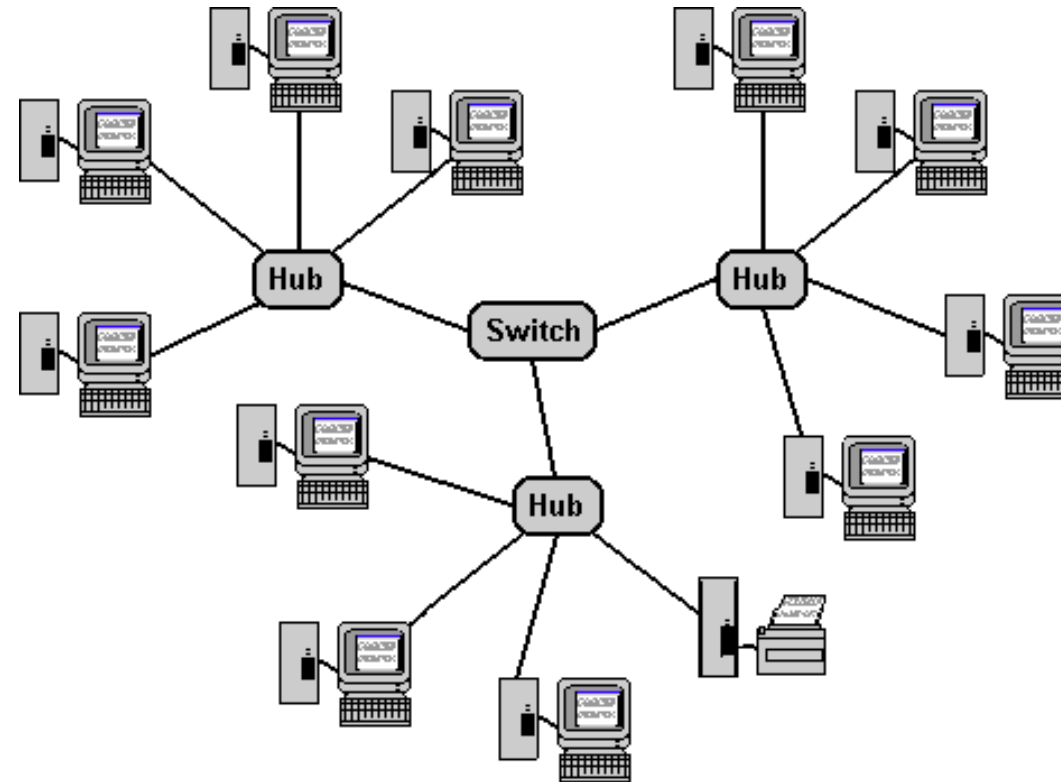


Fig:Switches

1. DataSequence
2. FlowControl
3. ErrorControl
4. DataFormatting
5. DataRouting
6. LogInformation
7. Connectionestablishandtermination
8. PrecedenceandorderofTransmission
9. DataSecurity

Different terminologies used in message communication protocols



1. Request/Response(Client/server)
2. Publish/Subscribe(pubsub)
3. ResourceDirectory(RD)
4. ResourceDiscovery
5. Registration/Registrationupdate
6. Pull(subscribe/notify)Data
7. PollingorObserving
8. Push(Publish/subscribe)Data
9. MessageCache
10. Message Queue
11. Information/Queue

Sensor Networks

Different types of Networks present, they are:

1. WSN
2. MANET
3. VANET
4. Cognitive Radio Networks

1. WSN

Elementsof WSN

A typical wireless sensor network can be divided into two elements. They are:

1. SensorNode
2. NetworkArchitecture

SensorNode

A Sensor Node in a WSN consists of four basic components. They are:

1. PowerSupply
2. Sensor
3. ProcessingUnit
4. CommunicationSystem

Differentsubsystemsofsensornodes

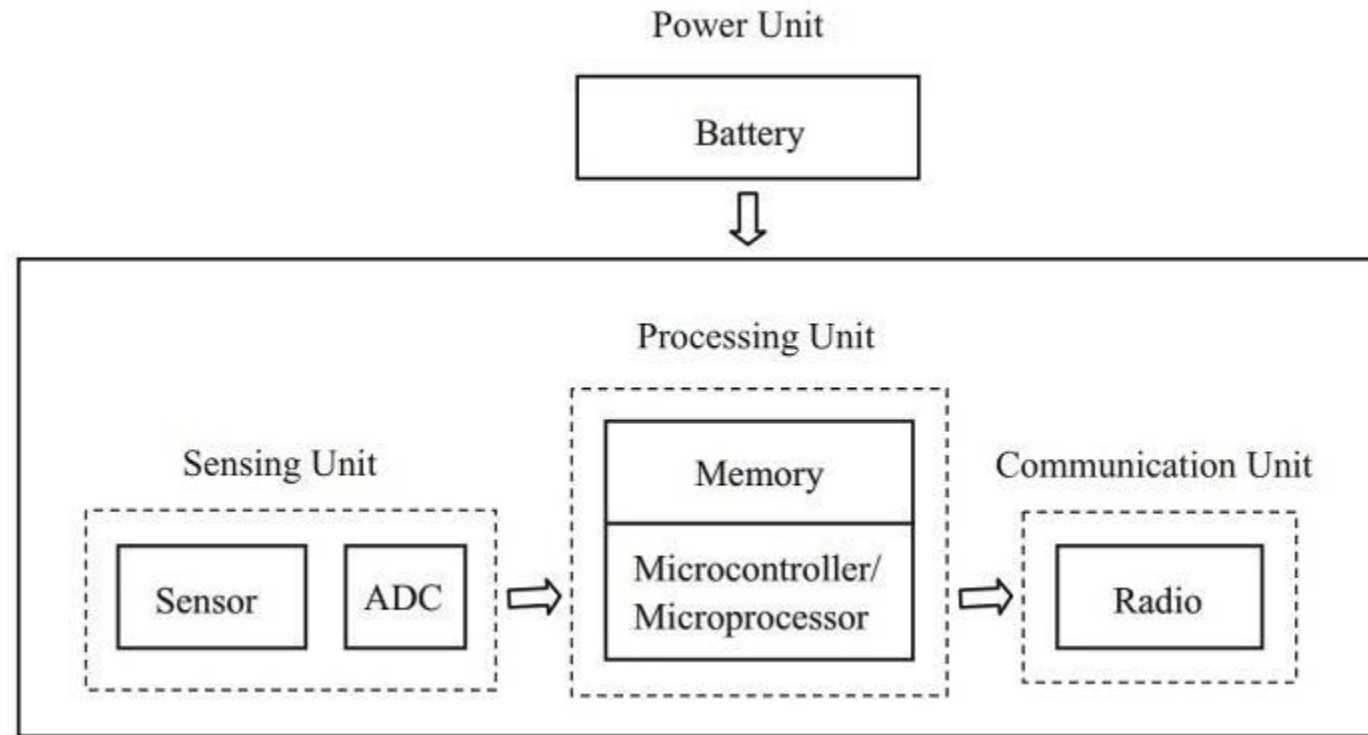


Fig:Differentsubsystemsofsensornodes

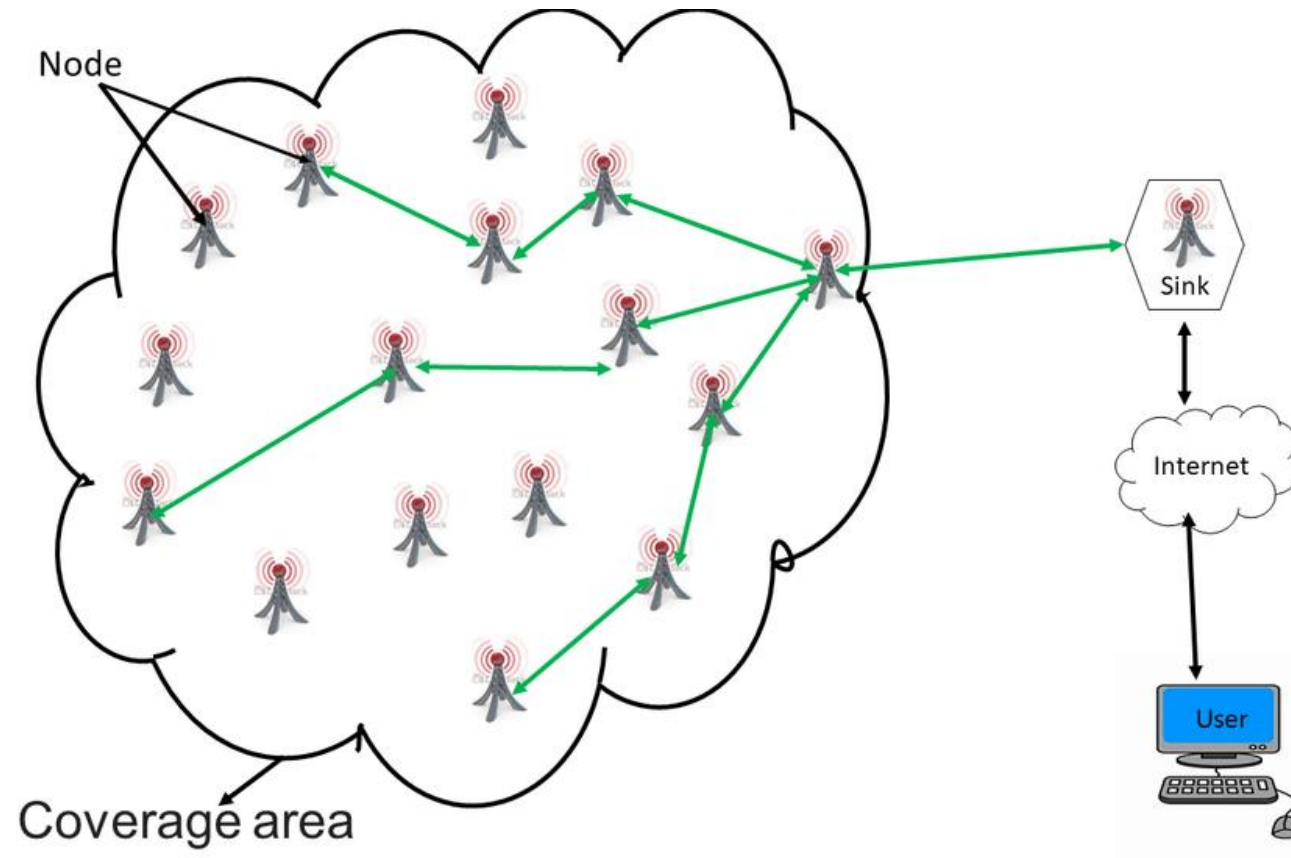


Fig:WSN

2. MANET

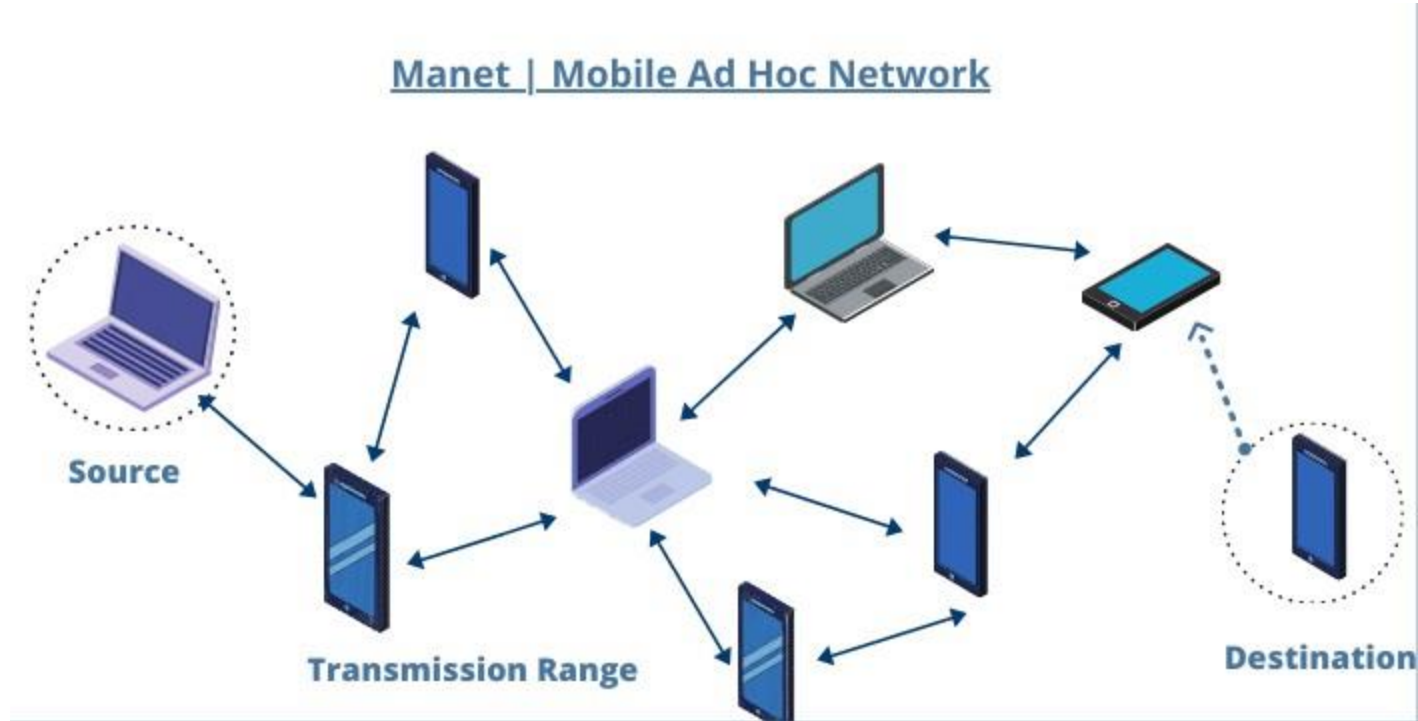


Fig:MANET

3. VANET

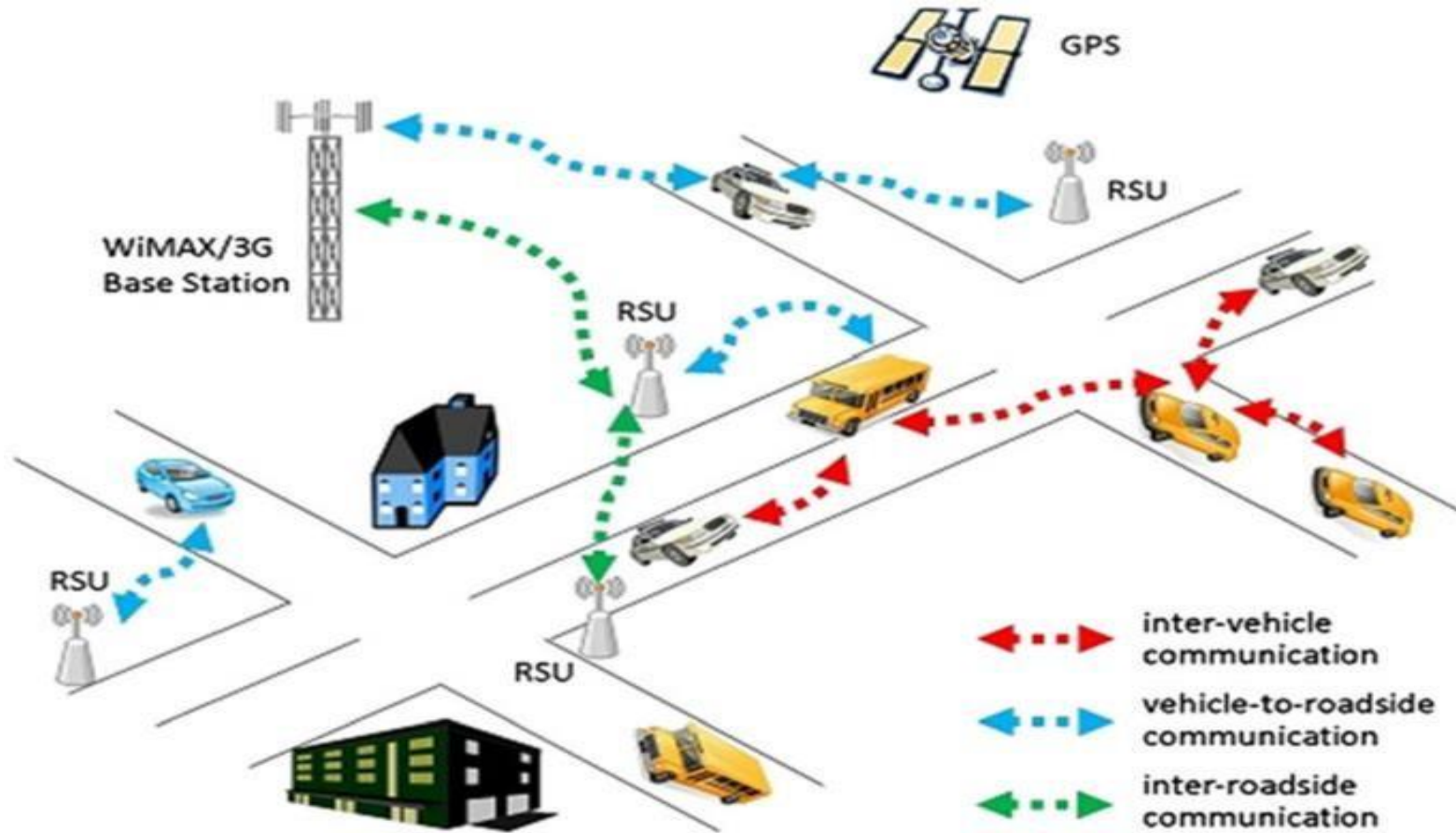


Fig:VANET

4. CognitiveRadioNetworks

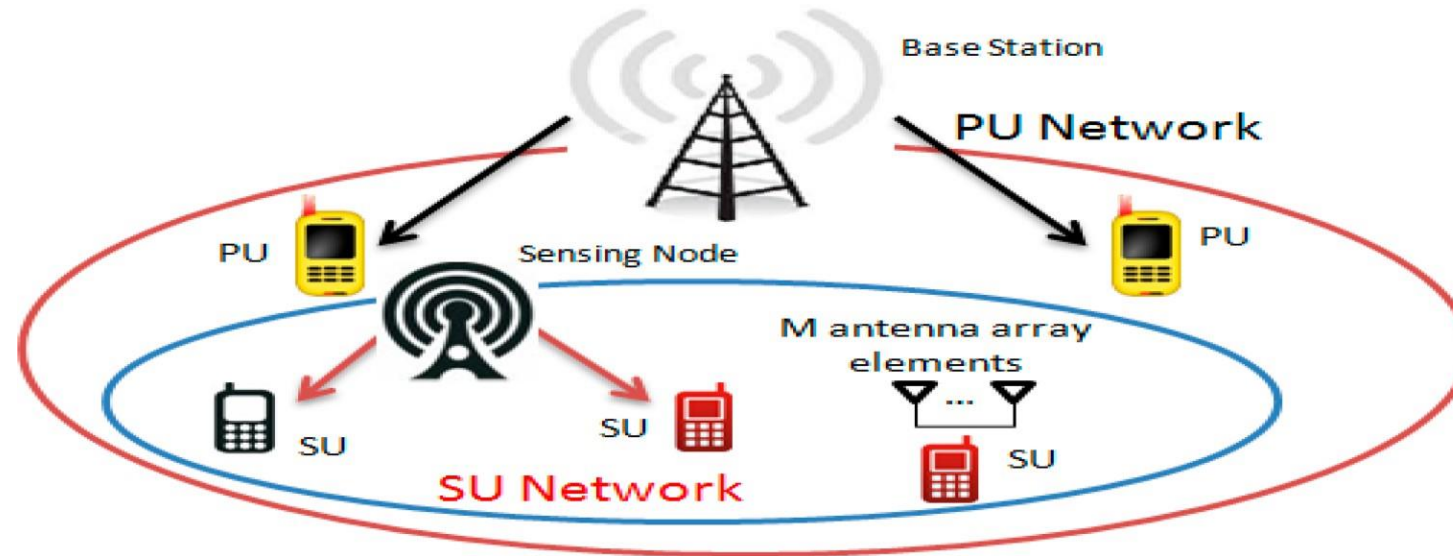


Fig:Cognitive RadioNetworks

Important Questions

1. Define IoT? Write in brief about IoT?
2. What are the main challenges of IoT?
3. What are the security issues in IoT?
4. What are the privacy things we are providing in IoT?
5. Explain the functional blocks of IoT?
6. What are the characteristics of IoT?
7. Explain about sensor technology and list some examples of sensors?
8. Define computer networks? How is this network different from other networks?
9. Explain Communication Protocol?
10. Discuss various components of a network?
11. Discuss about sensor network? Outline the features of wireless sensor networks?
12. What are the subsystems of sensor nodes in sensor networks?
13. What are the applications of IoT?
14. List a few sensors and networks which we are using in IoT?

THANKYOU

FUNDAMENTALS OF IoT - FIoT

UNIT-II

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ECE,NRCM

- Machine–to–MachineCommunications
- DifferencebetweenIoTandM2M
- InteroperabilityinIoT
- IntroductiontoArdunioProgramming
- IntegrationofsensorsandActuatorswithArduino

Machine-to-Machine Communications

- Machine to Machine communications, often termed M2M/IoTis going to be the next generation of Internet revolution connecting more and more devices on Internet.
- M2M communications refer to automated applications which involve machines or devices communicating through a network without human intervention.
- Sensors and communication modules are embedded within M2M devices, enabling data to be transmitted from one device to another device through wired and wireless communications networks.

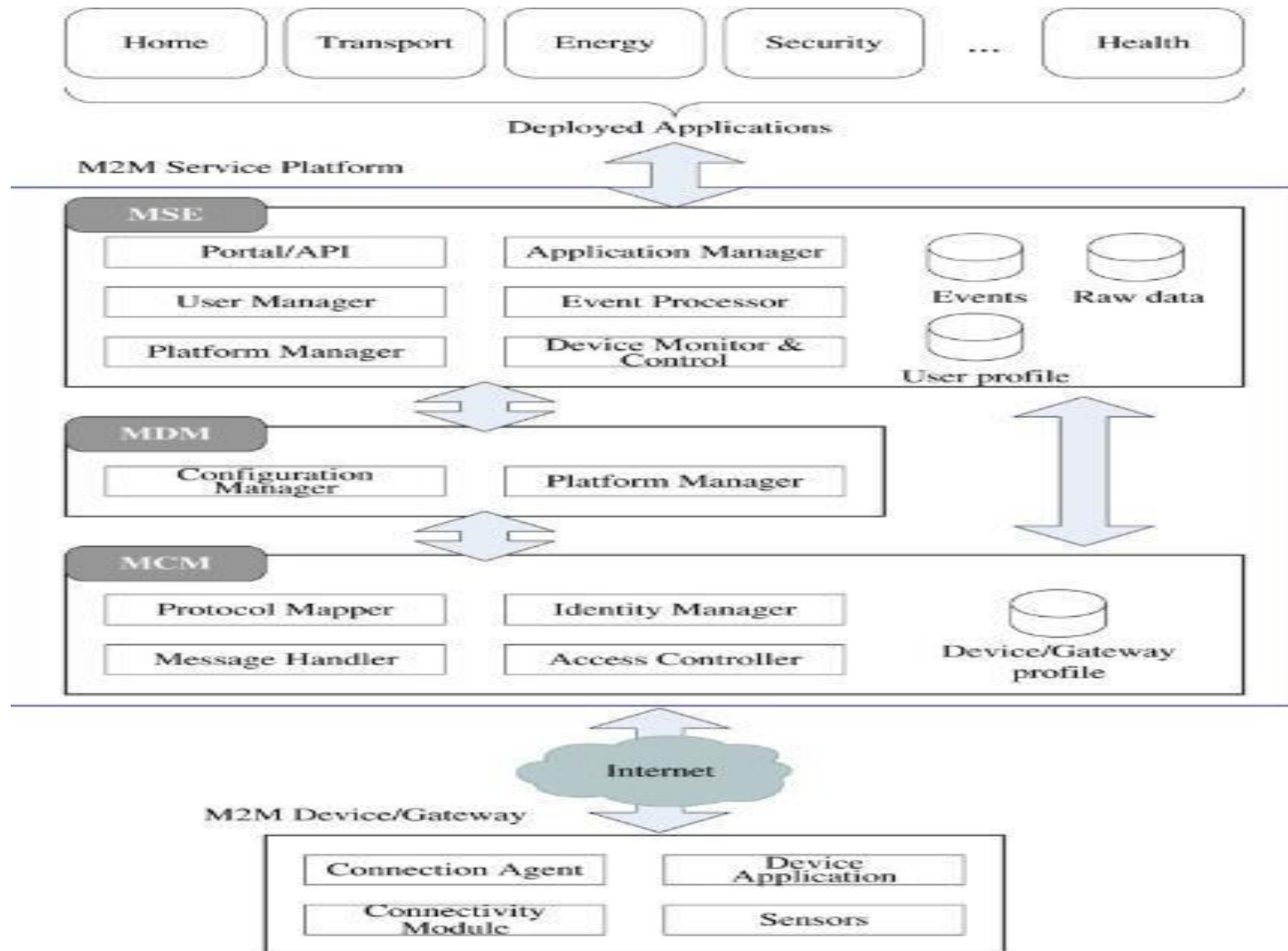
Machine–to–Machine Communications

- M2M is expected to revolutionize the performance of various sectors, businesses and services, by providing automation and intelligence to the end devices, in a way that was never imagined before.
- It may be applied to robots and conveyor belts on the factory floor, to tractors and irrigation on the farm, from heavy equipment to hand drills, from jet engines to bus fleets; from home appliances to health monitoring; from Smart Grid to Smart Water; every piece of equipment, everywhere.
- It can bring substantial tangible social and economic benefits by giving more efficient and effective services to the citizens.

M-2-MApplications



M2MArchitecture



Difference between IoT and M2M

M2M	IoT
Machines	Sensors
Hardware-based	Software-based
Vertical applications	Horizontal applications
Deployed in a closed system	Connects to a larger network
Machines communicating with machines	Machines communicating with machines, humans with machines, machines with humans
Uses non-IP protocol	Uses IP protocols
Can use the cloud, but not required to	Uses the cloud
Machines use point-to-point communication, usually embedded in hardware	Devices use IP networks to communicate
Often one-way communication	Back and forth communication
Main purpose is to monitor and control	Multiple applications; multilevel communications
Operates via triggered responses based on an action	Can, but does not have to, operate on triggered responses
Limited integration options, devices must have complementary communication standards	Unlimited integration options, but requires software that manages communications/protocols
Structured data	Structured and unstructured data

- The ability of IoT systems & components to interact with each other and share data is called Interoperability.
- This applies to internal communication among various components among various systems.
- It is the key factor to allow various devices to exchange data & work collaboratively.
- It is a key feature of IoT without which, many benefits of IoT cannot be achieved.
- For ex: consider a bus application that can evaluate optimal routes.
- The application takes help from interoperation with traffic monitoring service of city to obtain the less congested routes.
- With this, the bus application provides a precise, complete and useful service to the user.
- Some of the types of interoperability are as follows.

Interoperability in IoT

1. Syntactic Interoperability
2. Semantic Interoperability
3. Technical Interoperability
 1. OneM2M
 2. ARM
 3. IoT
 4. Alljoyn

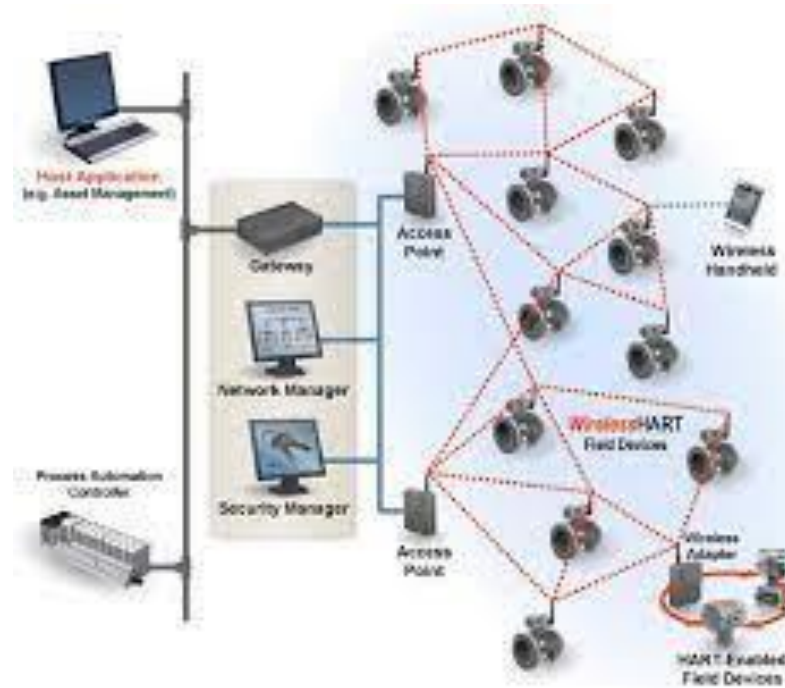
Introduction to Arduino Programming

Blink.ino

```
void setup()
{
  pinMode(12,OUTPUT);
}

void loop()
{
  digitalWrite(12,HIGH);
  delay(1200);
  digitalWrite(12,LOW);
  delay(1200);
}
```

Integration of sensors and Actuators with Arduino



Important Questions

1. Discuss about IoT and M2M?
2. Write the difference between IoT and M2M?
3. Write about Arduino and Arduino Programming
4. What is M2M communication? Discuss about M2M Architecture?
5. Discuss about interoperability of IoT?
6. How are sensors and actuators integrated with Arduino?
7. Discuss about the anatomy of an Arduino program and also write short notes on shields?

THANKYOU

FUNDAMENTALS OF IoT - FIoT

UNIT-III

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- Introduction to Python Programming
- Introduction to Raspberry Pi
- Interfacing to Raspberry Pi with basic peripherals
- Implementation of IoT with Raspberry Pi

Introduction to Python Programming

- [Python](#) is a widely used general-purpose, high level programming language. It was created by Guido van Rossum in 1991 and further developed by the Python Software Foundation. It was designed with an emphasis on code readability, and its syntax allows programmers to express their concepts in fewer lines of code.
- Python is a programming language that lets you work quickly and integrate systems more efficiently.
- There are two major Python versions: **Python 2 and Python 3**. Both are quite different.

Introduction to Python Programming

Beginning with Python programming:

- **Finding an Interpreter:**
- Before we start Python programming, we need to have an interpreter to interpret and run our programs. There are certain online interpreters like <https://ide.geeksforgeeks.org/> that can be used to run Python programs without installing an interpreter.
- **Windows:** There are many interpreters available freely to run Python scripts like IDLE (Integrated Development Environment) that comes bundled with the Python software downloaded from <http://python.org/>.
- **Linux:** Python comes preinstalled with popular Linux distros such as Ubuntu and Fedora. To check which version of Python you're running, type "python" in the terminal emulator. The interpreter should start and print the version number.
- **macOS:** Generally, Python 2.7 comes bundled with macOS. You'll have to manually install Python 3 from <http://python.org/>.

Introduction to Python Programming

Features of Python:

1. Object-Oriented Programming Paradigm
2. Easy to Learn
3. Easily Readable
4. Easily Maintainable
5. Uses High-level Data Structure
6. Extensibility
7. Portability
8. Robust
9. Possesses the Right of a memory Manager
10. Interpreted and (Byte) compiled language
11. Scalability
12. Effective Rapid Prototyping tool

Introduction to Raspberry Pi

1. Division(/,//)
2. Modulus(%)
3. Exponentiation(**)
4. Addition(binary(+)operation)
5. Subtraction(binary(-)operator)
6. Nochange(unary(+)operator)
7. Negation(unary(-)operator)

Python Arithmetic Operators

Arithmetic operators are used with numeric values to perform common mathematical operations:

Operator	Name	Example
+	Addition	$x + y$
-	Subtraction	$x - y$
*	Multiplication	$x * y$
/	Division	x / y
%	Modulus	$x \% y$
**	Exponentiation	$x ** y$
//	Floor division	$x // y$

Python Comparison Operators

Comparison operators are used to compare two values:

Operator	Name	Example
==	Equal	x == y
!=	Not equal	x != y
>	Greater than	x > y
<	Less than	x < y
>=	Greater than or equal to	x >= y
<=	Less than or equal to	x <= y

Keywords used in Python:

- | | |
|------------------------------------|-----------------------------------|
| 1. And | 17. <u>If</u> |
| 2. <u>As</u> | 18. <u>Import</u> |
| 3. <u>Assert</u> | 19. <u>In</u> |
| 4. <u>Break</u> | 20. is |
| 5. <u>Class</u> | 21. <u>Lambda</u> |
| 6. <u>Continue</u> | 22. <u>Not</u> |
| 7. <u>Def</u> | 23. <u>Or</u> |
| 8. <u>Del</u> | 24. <u>pass</u> |
| 9. Elif | 25. raise |
| 10. <u>Else</u> | 26. <u>return</u> |
| 11. <u>Except</u> | 27. True |
| 12. False | 28. <u>try</u> |
| 13. <u>Finally</u> | 29. <u>while</u> |
| 14. <u>For</u> | 30. <u>with</u> |
| 15. <u>From</u> | 31. <u>None</u> |
| 16. <u>Global</u> | 32. <u>yield</u> |

ControlStatements:

- Decisionstructures/controlstatements
- Ifstatement
 - Thekeyword'if'
 - Anexpressionoracondition
 - Multipleconditionalexpressions
 - TheCode
 - Singlestatementcode
- If-elsestatement

Basicstyleguidelines:

1. Comments
2. Indentation
3. Documentation
4. Selecting identifier names

How to write and execute a program in python?

1. Using python's command line window
2. Using python's IDLE graph window
3. From system prompt

Various datatypes in python:

1. Numeric datatypes

1. Integer
2. Floatingpoint
3. Boolean
4. Complex

2. String datatypes

3. List datatypes

4. Tuple datatypes

5. Dictionary datatype

Python statements need to follow rules and symbols:

1. Comments
2. Module
3. Newline
4. Colon
5. Semicolon
6. Indentation

Introduction to Raspberry PI, Interfacing Raspberry PI with Basic peripherals:



1. Power input
2. USB ports
3. Ethernet ports
4. Processor and RAM
5. GPIO pins
6. DSI (Display Serial Interface)
7. CSI (Camera Serial Interface)
8. SD card slot
9. HDMI output
10. Audio/Video output

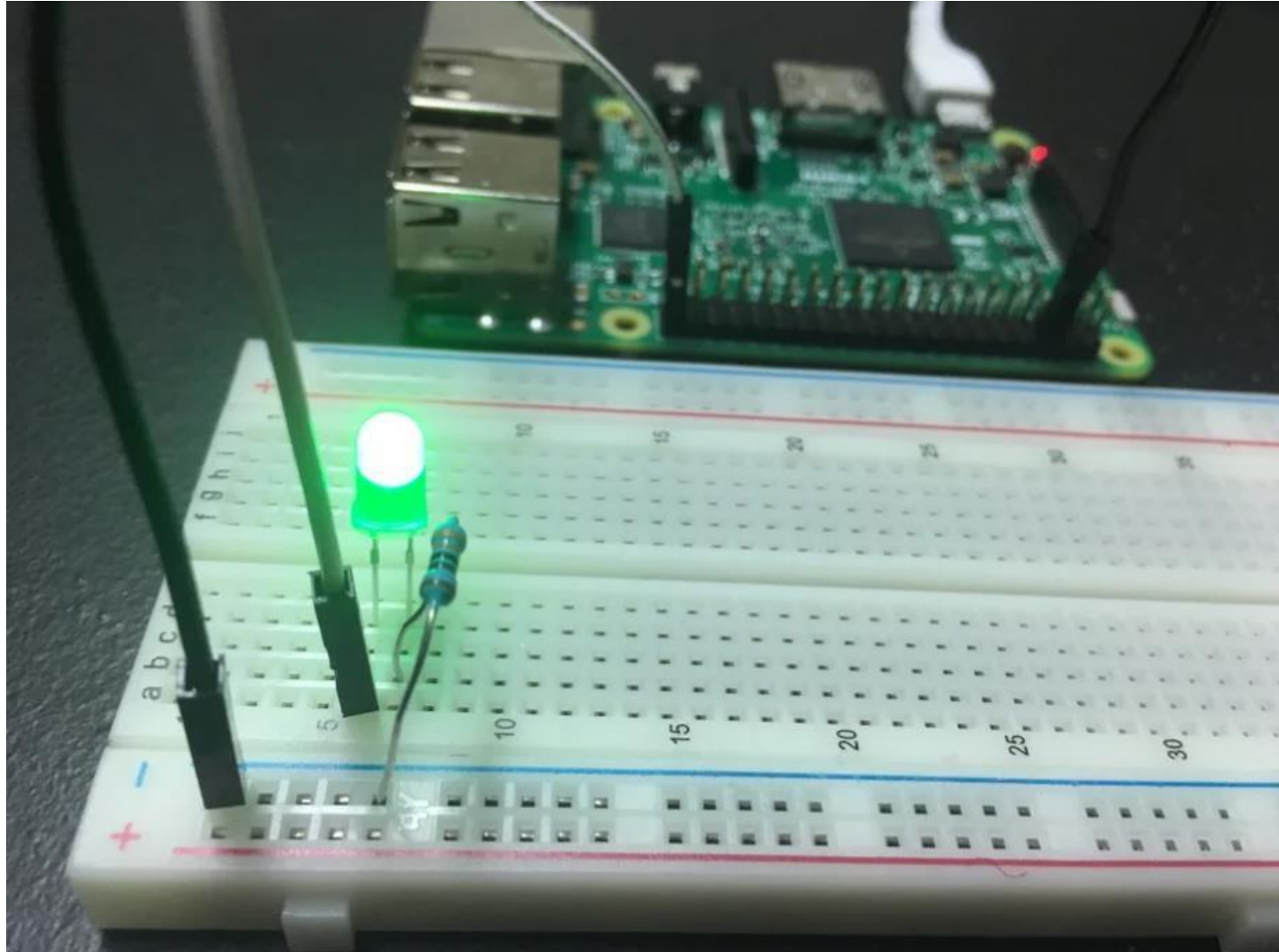
Versions/FlavorsofRaspberryPI:

1. Raspbian
2. RaspBMC
3. Areh
4. RISCOS
5. Pidora
6. OpenELEC

RaspberryPIInterfaces:

1. I2C
2. Serial
3. SPI(SerialPeripheralInterface)
 - a. ChipEnable(CE0)
 - b. ChipEnable1(CE1)
 - c. MISO(MasterInSlaveOut)
 - d. SCK(SerialClock)
 - e. MOSI(MasterOutSlaveIn)

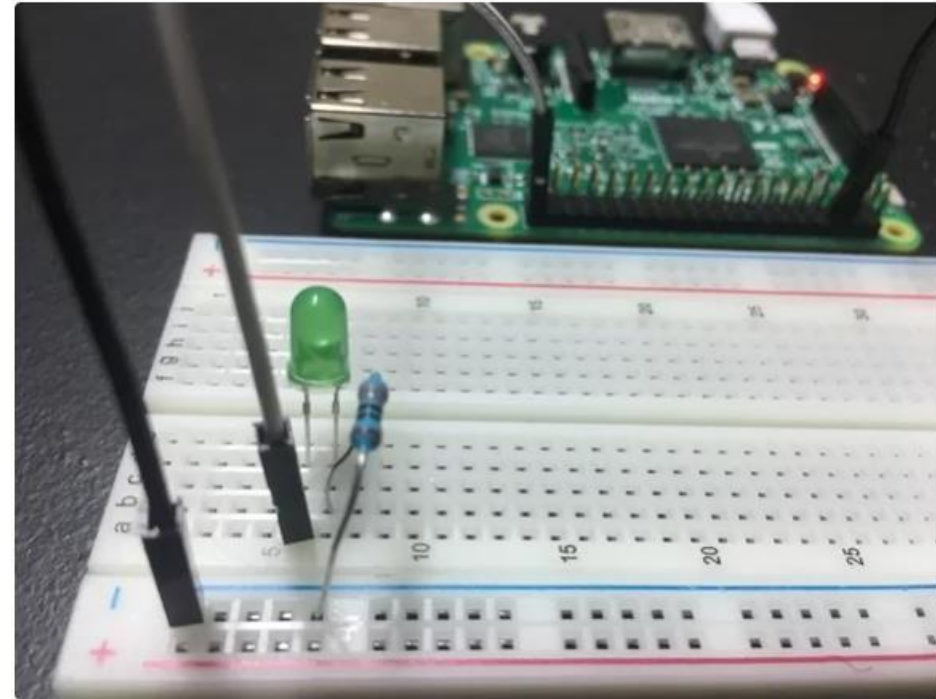
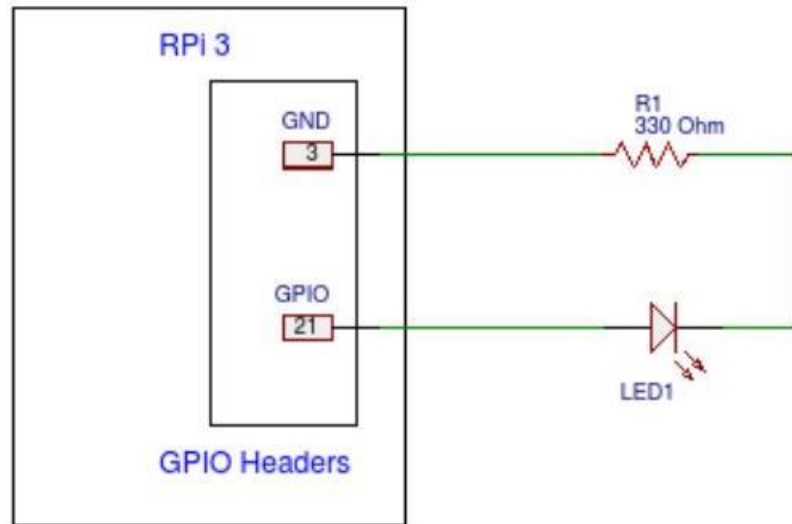
Implementation of IoT with Raspberry PI:

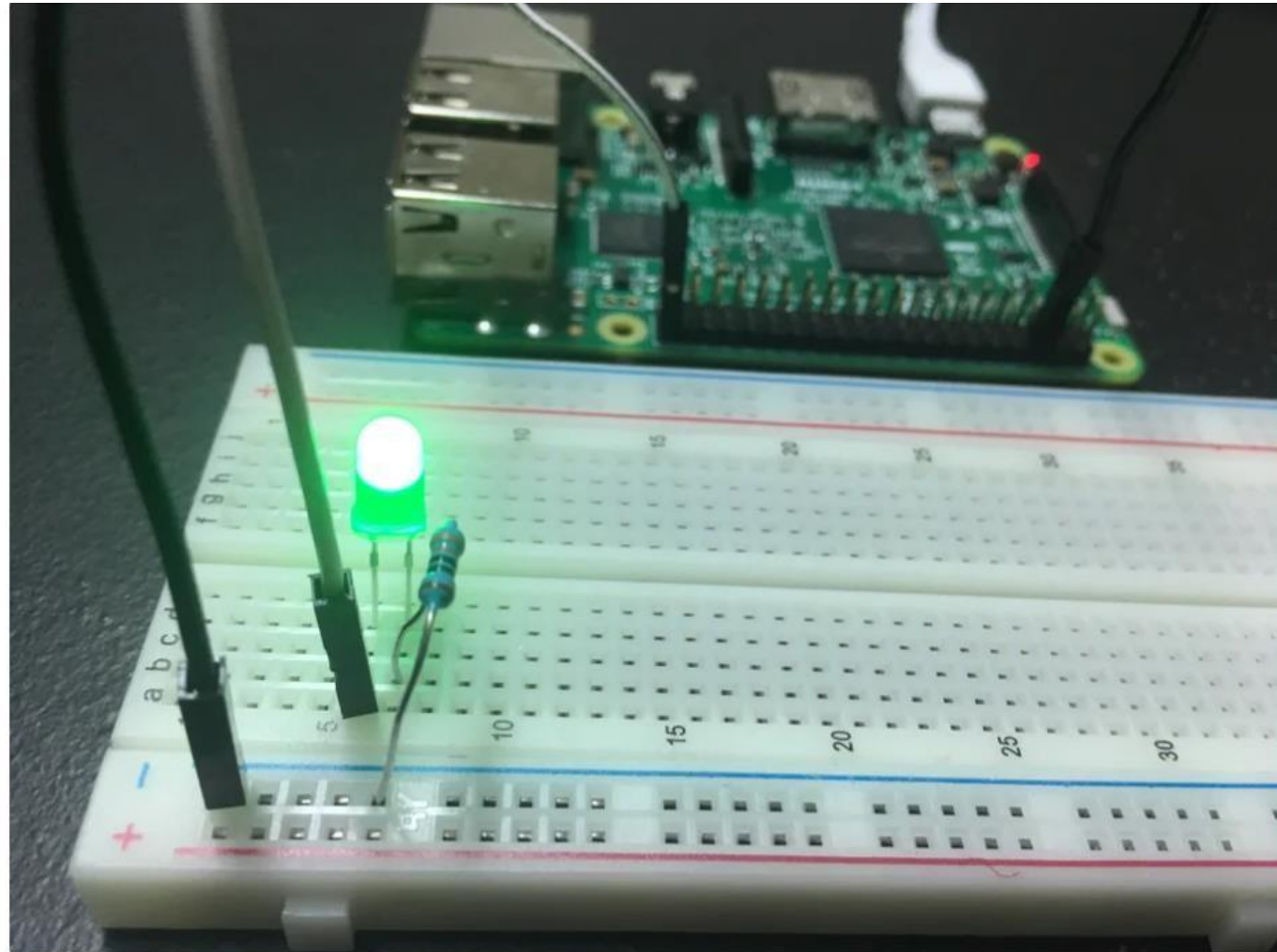


You'll need the following components to connect the circuit.

1. Raspberry Pi
2. LED
3. Resistor-330ohm
4. Breadboard
5. 2 Male-Female Jumper Wires

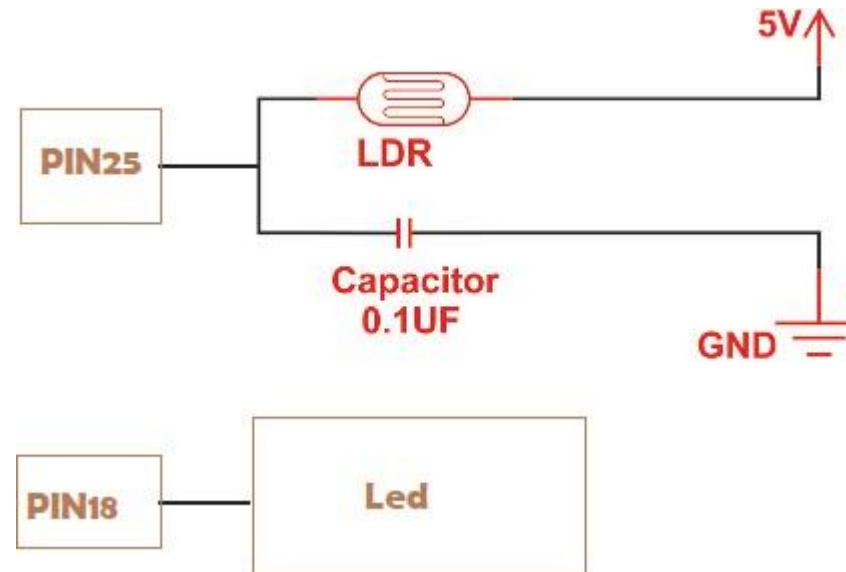






- ```
import RPi.GPIO as GPIO
import time
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)
GPIO.setup(21,GPIO.OUT)
print "LED
on"GPIO.output(21,GPIO.HIGH)
time.sleep(10)
print "LED off"
GPIO.output(21,GPIO.LOW)
```

# Interfacing Light Sensor with Raspberry PI:



```
Example code Interfacing a light Sensor (LDR) with Raspberry Pi
#Iotbyhvm.ooo -Explore TechBytes

import RPi.GPIO as GPIO
import time

GPIO.setmode(GPIO.BCM)
ldr_threshold = 1000
LDR_PIN = 18
LIGHT_PIN = 25

def readLDR(PIN):
 reading = 0
 GPIO.setup(LIGHT_PIN, GPIO.OUT)
 GPIO.output(PIN, False)
 time.sleep(0.1)
 GPIO.setup(PIN, GPIO.IN)
 while (GPIO.input (PIN) ==False):

 reading=reading+1

 return reading

def switchOnLight (PIN):
 GPIO.setup(PIN, GPIO.OUT)
 GPIO.output (PIN, True)

def switchOffLight (PIN):
 GPIO.setup(PIN, GPIO.OUT)
 GPIO.output (PIN, False)
while True:
 ldr_reading = readLDR(LDR_PIN)
 if ldr_reading < ldr_threshold:
 switchOnLight (LIGHT_PIN)
 else:
 switchOffLight (LIGHT_PIN)
 time.sleep(1)

#Iotbyhvm.ooo -Explore TechBytes
```

# Important Questions

---

1. What are the features of Python?
2. Write the list of operators in python?
3. Write a short note on Raspberry PI? Mention how many peripherals are present in it and explain them?
4. Define control statements? Discuss about if statement?
5. What are the basic style guidelines? Explain data types in python?
6. What is Raspberry PI? List the commands we use in it?
7. Write about the implementation of Raspberry PI with Python?
8. Explain about interfacing Light Sensor with Raspberry PI?

# THANKYOU

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# FUNDAMENTALS OF IoT - FIoT

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## UNIT-IV

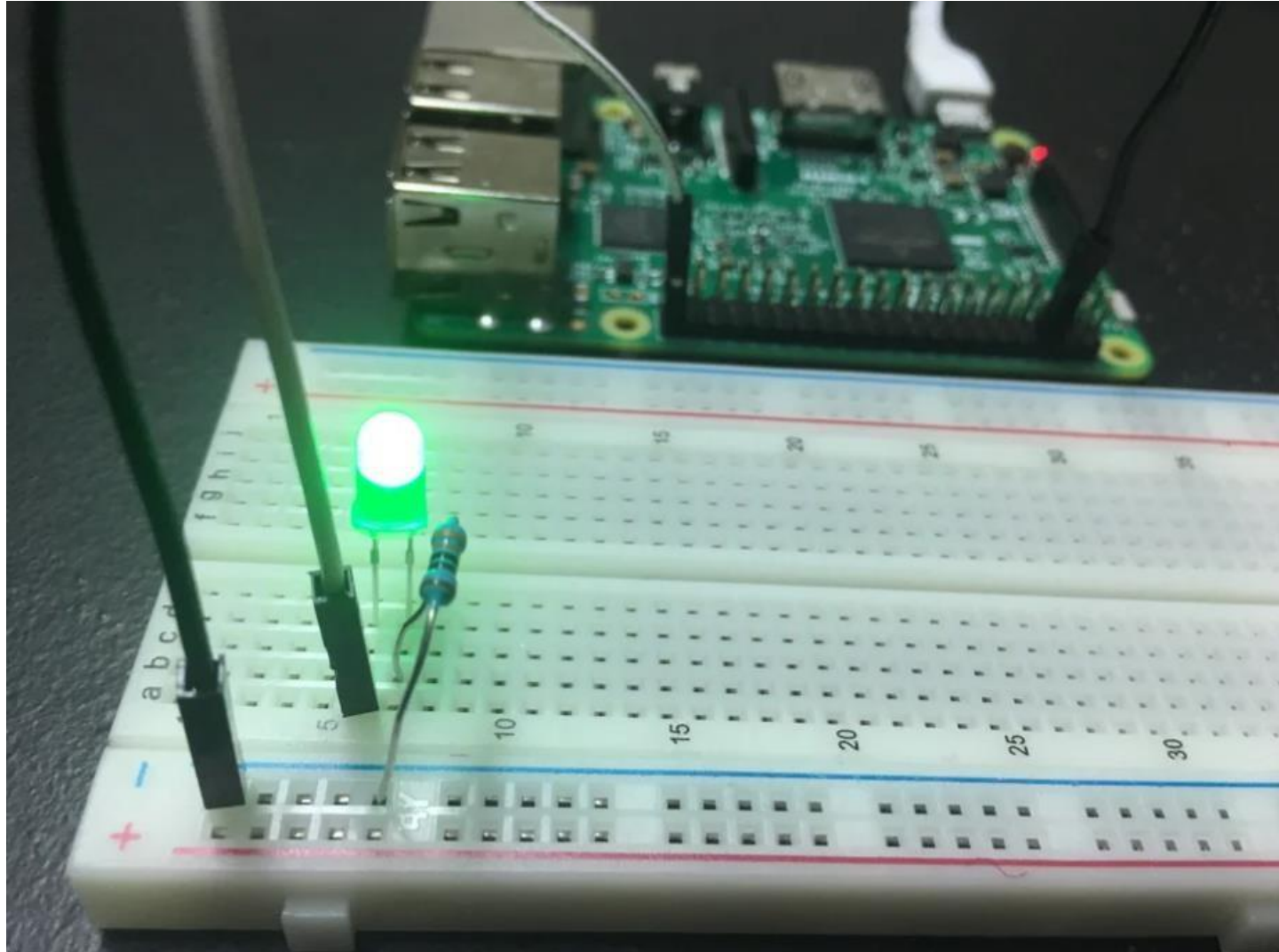
**Dr M Shoban**

**ECE,NRCM**

- Implementation of IoT with Raspberry PI
- Introduction to Software Defined Network (SDN)
- SDN for IoT
- Concept of Data Handling and Analytics



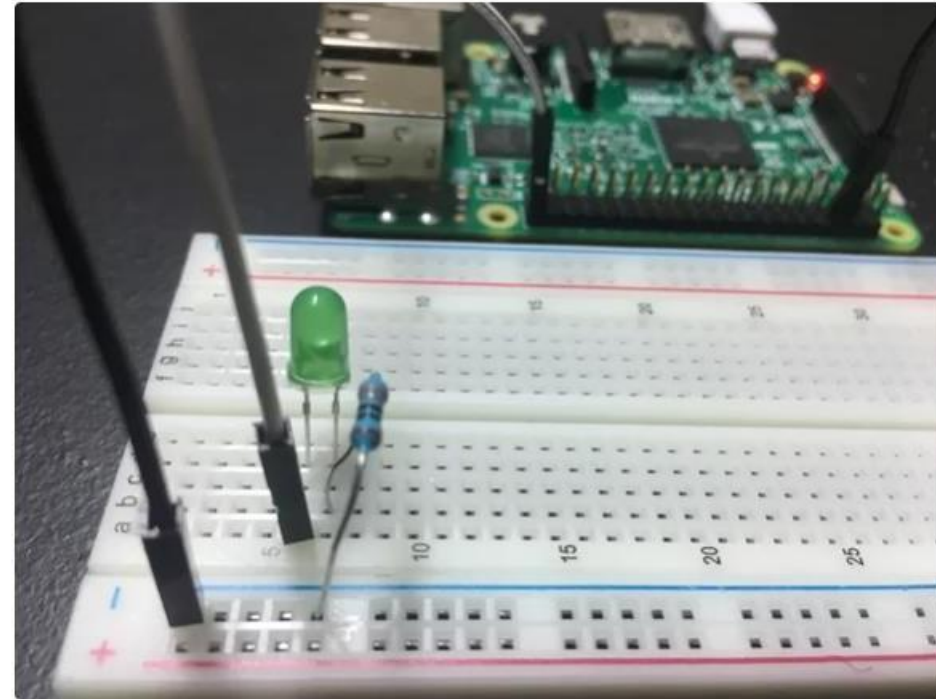
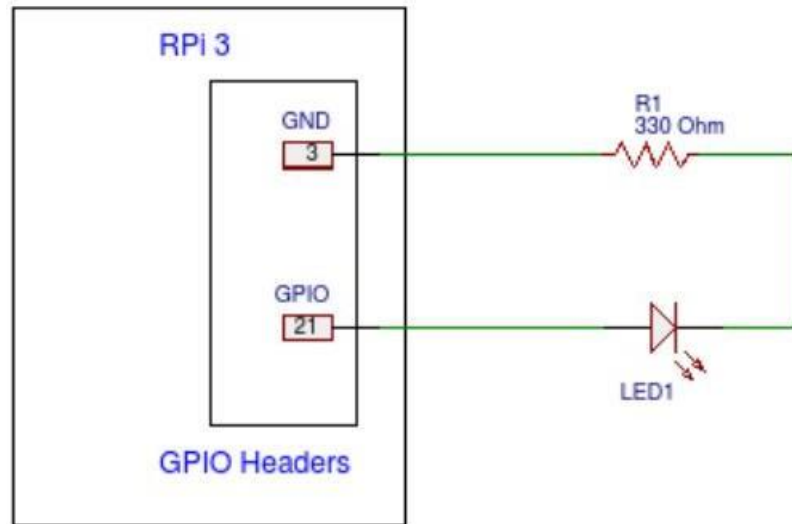
# Implementation of IoT with Raspberry PI:

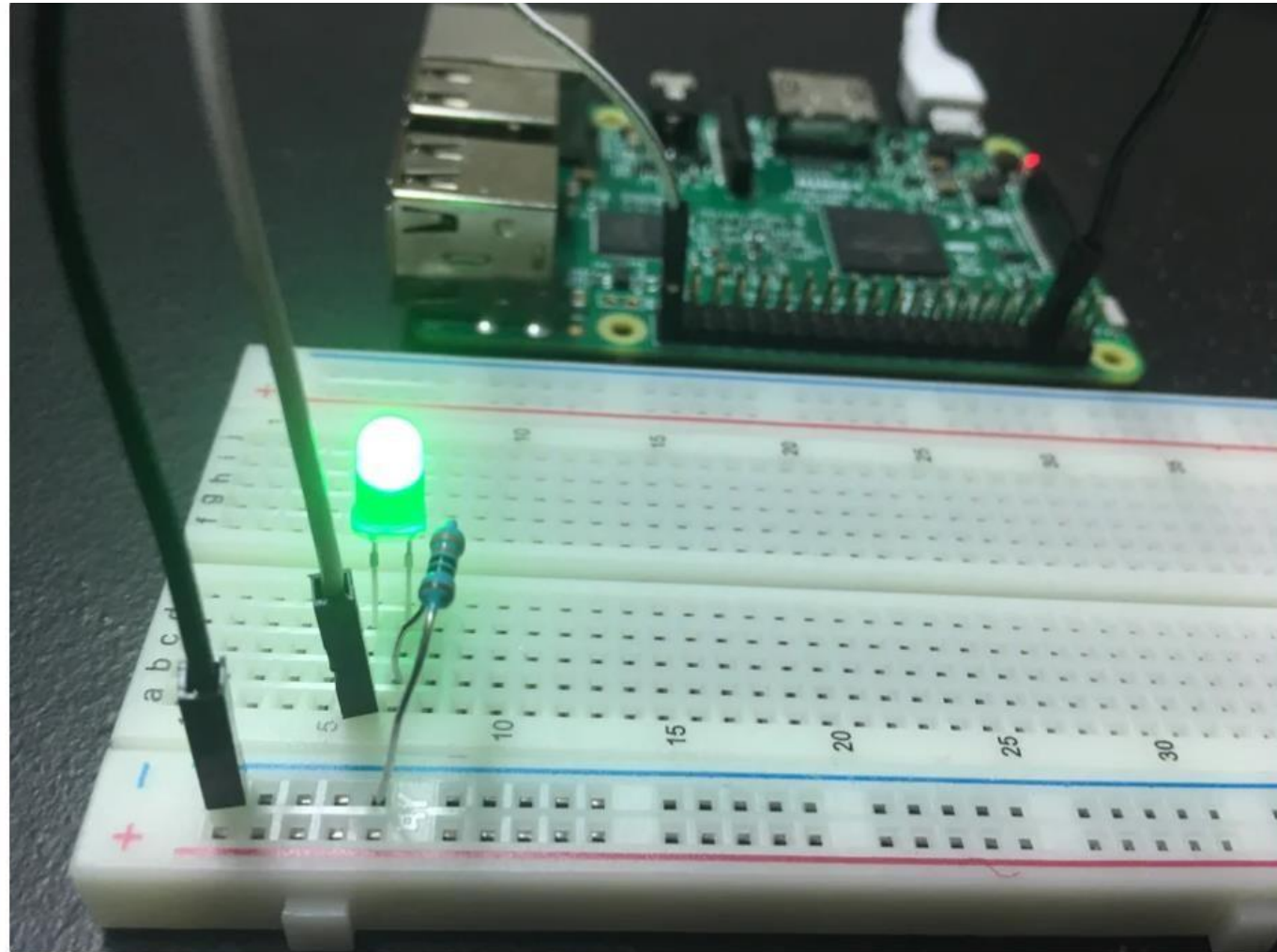


You'll need the following components to connect the circuit.

1. Raspberry Pi
2. LED
3. Resistor-330ohm
4. Breadboard
5. 2 Male-Female Jumper Wires

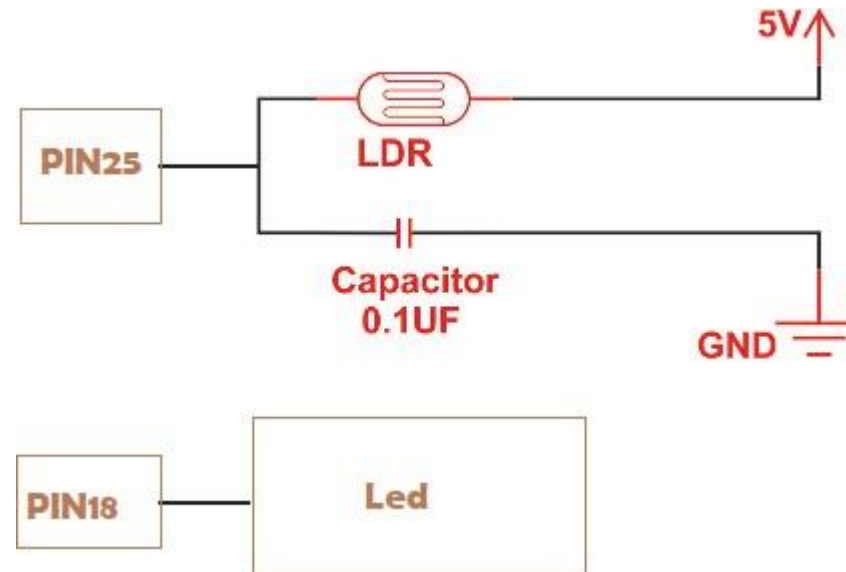






- ```
import RPi.GPIO as GPIO
import time
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)
GPIO.setup(21,GPIO.OUT)
print "LED
on"GPIO.output(21,GPIO.HIGH)
time.sleep(10)
print "LED off"
GPIO.output(21,GPIO.LOW)
```

Interfacing Light Sensor with Raspberry PI:




```
# Example code Interfacing a light Sensor (LDR) with Raspberry Pi
#Iotbyhvm.ooo -Explore TechBytes

import RPi.GPIO as GPIO
import time

GPIO.setmode(GPIO.BCM)
ldr_threshold = 1000
LDR_PIN = 18
LIGHT_PIN = 25

def readLDR(PIN):
    reading = 0
    GPIO.setup(LIGHT_PIN, GPIO.OUT)
    GPIO.output(PIN, False)
    time.sleep(0.1)
    GPIO.setup(PIN, GPIO.IN)
    while (GPIO.input (PIN) ==False):

        reading=reading+1

    return reading

def switchOnLight (PIN):
    GPIO.setup(PIN, GPIO.OUT)
    GPIO.output (PIN, True)

def switchOffLight (PIN):
    GPIO.setup(PIN, GPIO.OUT)
    GPIO.output (PIN, False)
while True:
    ldr_reading = readLDR(LDR_PIN)
    if ldr_reading < ldr_threshold:
        switchOnLight (LIGHT_PIN)
    else:
        switchOffLight (LIGHT_PIN)
    time.sleep(1)

#Iotbyhvm.ooo -Explore TechBytes
```

Interfacing Light Sensor with Raspberry Pi :-

A Light Dependent Resistor (LDR) which is a light sensor can be interfaced with Raspberry Pi by connecting one end to 3.3v and other end to 1M capacitor and GPIO pin. Apart from this an LED is also connected to pin 18 so that it can be turned on/off based on the light sensed.

The python code to control LED based on light sensed using LDR is as follows.

```
import RPi.GPIO as GPIO
import time
GPIO.setmode(GPIO.BCM)
LDR_thr = 1000
LDR_PIN = 18
LIGHT_PIN = 25
```



```

define readLoR(PIN):
    read = 0
    GPIO.Setup(LIGHT-PIN, GPIO.OUT)
    GPIO.Output(PIN, False)
    time.sleep(0.1)
    GPIO.Setup(PIN, GPIO.IN)
    while (GPIO.Input(PIN) == False):
        read = read + 1
    return read
  
```

```

def switch on Light(PIN):
    GPIO.Setup(PIN, GPIO.OUT)
    GPIO.Output(PIN, True)
  
```

```

def switch off Light(PIN):
    GPIO.Setup(PIN, GPIO.OUT)
    GPIO.Output(PIN, False)
  
```

```

while True:
    ldr - Read = readLDR(LDR-PIN)
    if ldr-read < ldr-thr
        switch off light (LIGHT-PIN)
    time.sleep(1)
  
```

Introduction to Software Defined Network (SDN)

1. Software Defined Network is the method of separating data plane and control plane.
2. It then assigns the separated control plane to the centralized network controller.
3. The data plane consists of activities such as the outputs generated from data packets received from end users.
Ex:- packet transmission, duplication of packets to be used in multicasting and dividing and reuniting the data.
4. whereas control plane consists of activities required to perform the activities related to data plane.
5. But the activities of control plane does not contain any end user data packets. It can be actually referred as brain of the network.
Ex:- setting of policies related to packet handling and developing routing tables.

Types of SDN

1. OpenSDN
2. SDN by API's
3. HybridSDN
4. SDN overlay model

Advantages of SDN

1. It provides centralized management for the networking devices.
2. It provides efficiency, flexibility and scalability than any other networking.
3. It assures successful transmission and delivery of data.
4. It provides very low ~~cost~~ operational costs.
5. It allows to control & program the network through controller.
6. It provides security through controller since it holds security policies.

Traditional Network Architecture

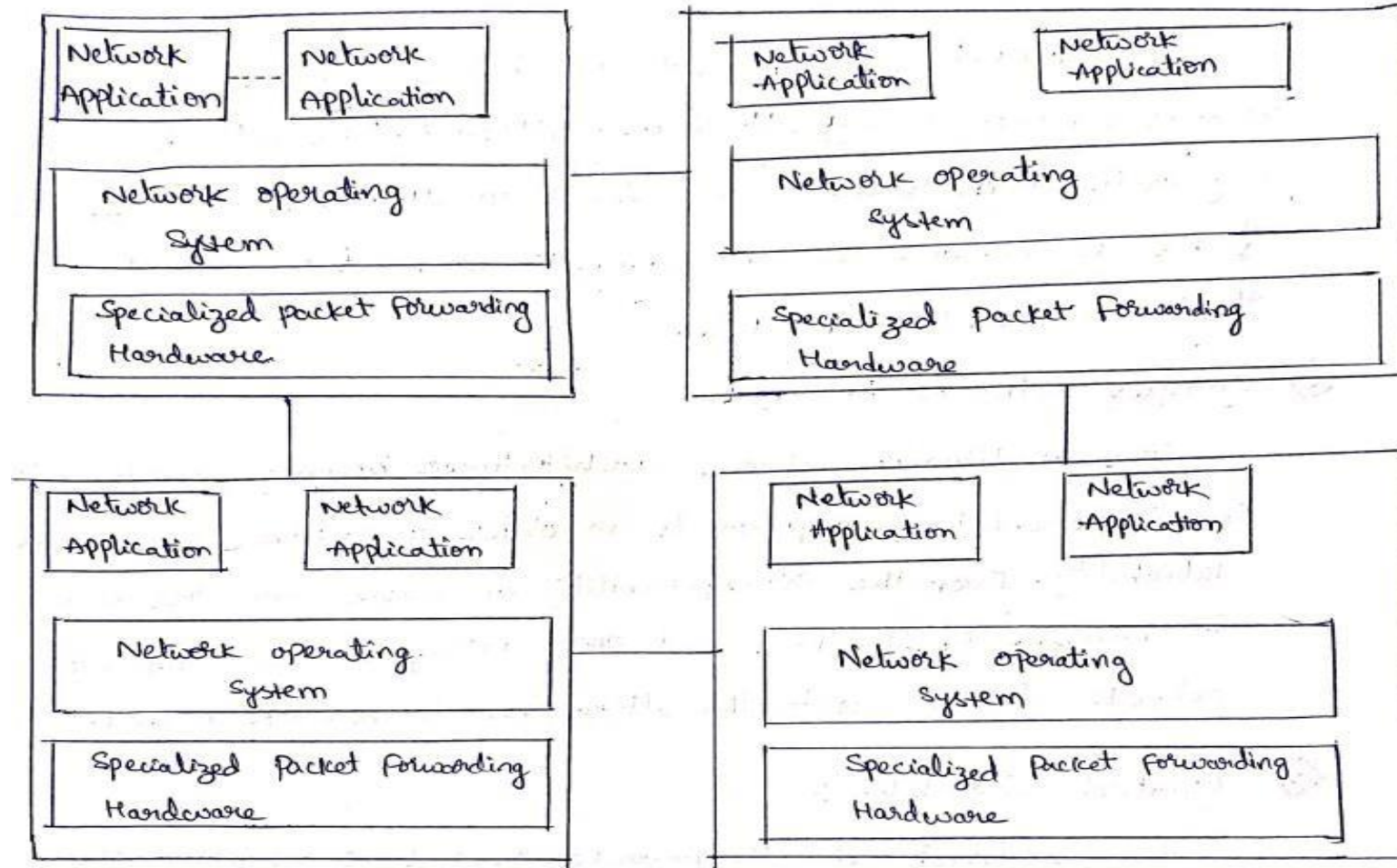
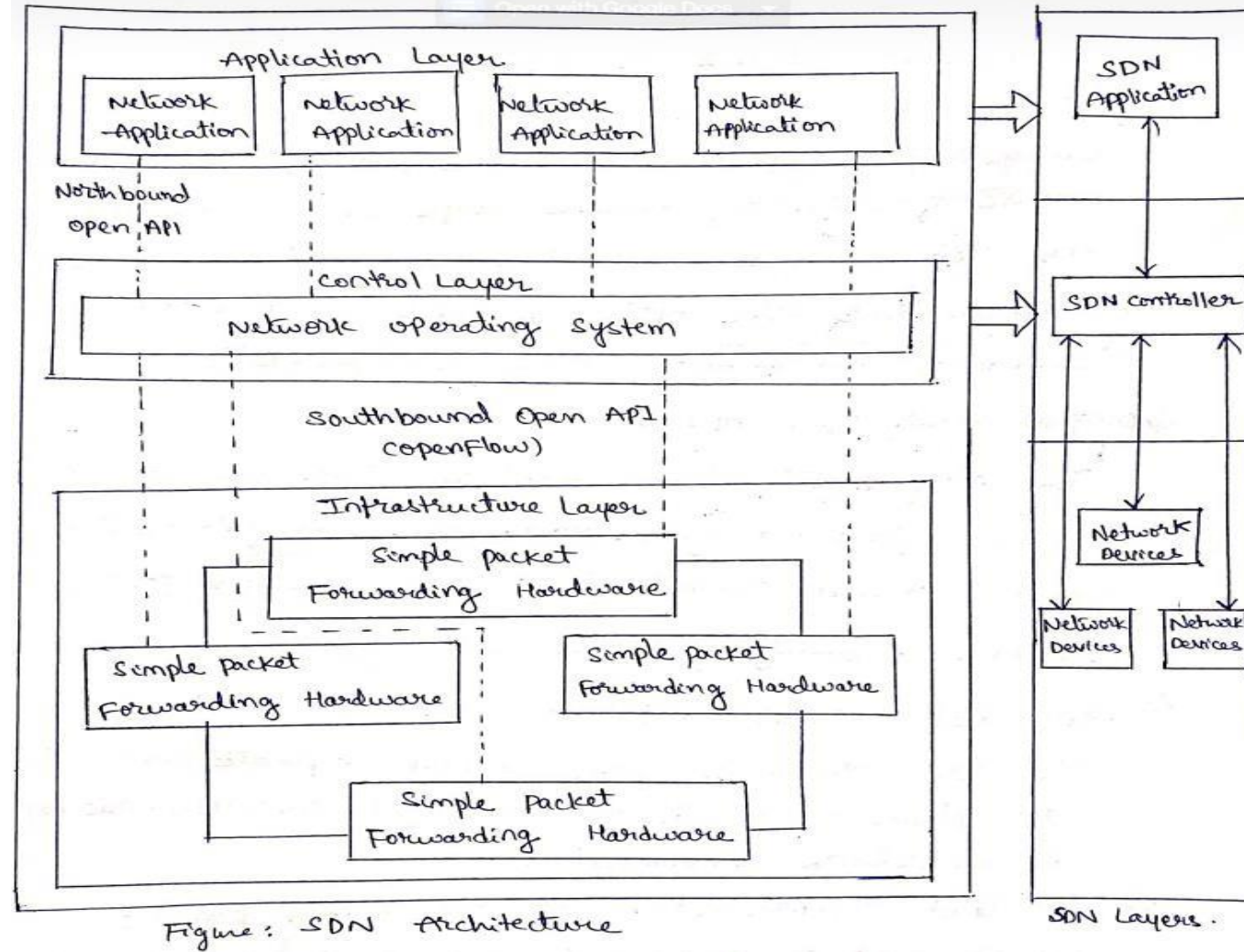


Figure: Architecture of Traditional Network

Limitations of Traditional Network Architecture

1. Management Overloaded
2. Complex Network Devices
3. Limited Scalability

The Architecture and key elements of SDN



- The key elements of SDN are as follows

1. Programmable open API's
2. Centralized Network Controller
3. Standard Communication Interface (openflow)

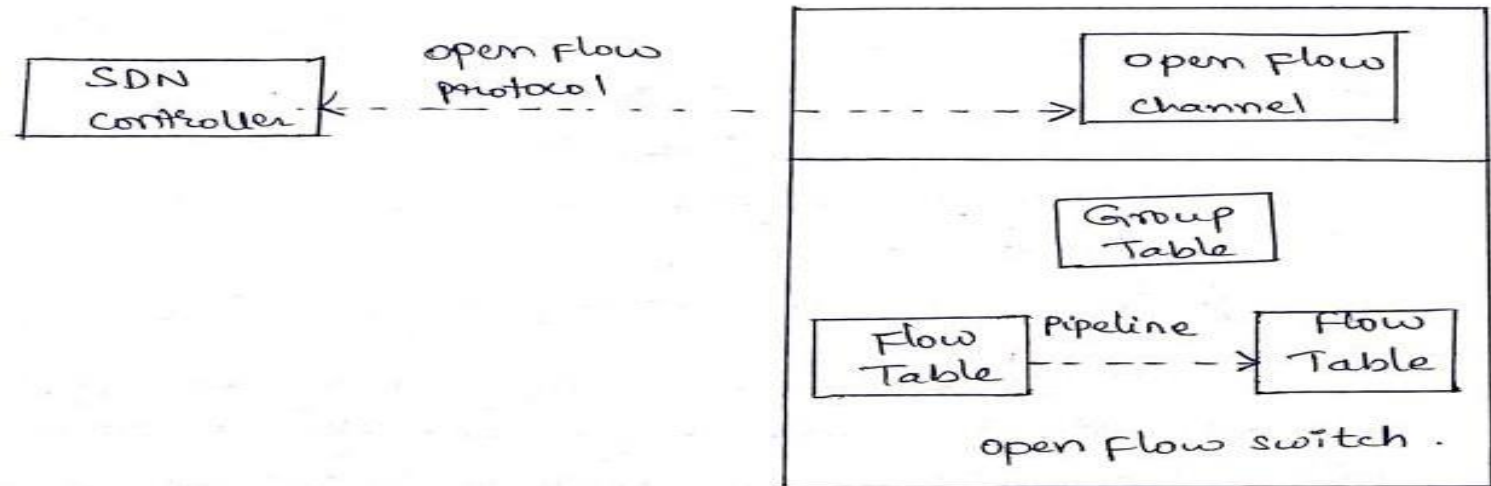


Figure : Open flow switch.

DataHandlingandAnalytics

1. DataAcquiring
2. DataOrganizing
3. DataAnalytics

- VarioustypesofDataAcquiring
 1. Database
 2. Relationaldatabase
 3. ObjecedOrientedDatabase
 4. DatabaseManagementSystem(DBMS)
 5. Distributeddatabase
 6. CAPTheorem

Analytics and Phase of Analytics

Analytics :-

Analytics refers to decision making which is completely based on facts instead of intuition. It acts as a key factor for the success of an enterprise as it provides business intelligence. Analytics are used to design or build models by selecting the appropriate data so the data must always be available & accessible. Further these models are first tested & then used for various processes & services. Moreover, analytics use various kinds of techniques to obtain new information. New parameters which add even more value to the data. Some of these techniques are arithmetic & statistical methods. Data mining, Machine learning etc.,

Phase of Analytics

1. Descriptive Analytics

1. Spreadsheets & Data Visualization
2. Descriptive Statics based reports and Data Visualization
3. Data Mining and Machine Learning

2. Predictive Analytics

3. Prescriptive Analytics

1. Event Analytics
 1. Category, 2. Action, 3. Label, 4. Value
2. In Memory Data Processing & Analytics
 1. In memory and on store Row Format option
 2. In memory and on store Column Format option
3. Real Time Analytics Management

- Big Data analytics is a process used to extract meaningful insights, such as hidden patterns, unknown correlations, market trends, and customer preferences. Big Data analytics provides various advantages —it can be used for better decision making, preventing fraudulent activities, among other things.
- The big data analytics like Hadoop, NoSQL and Cassandra will support the big data architectures/infrastructures.

DataanalyticsArchitecture

- DataanalyticsArchitecturehas4layers
 1. DataSourceelayer
 2. DataStorageandDataprocessinglayer
 3. DataAccessingandQueryprocessinglayer
 4. DataServicesandAdvancedAnalyticslayer

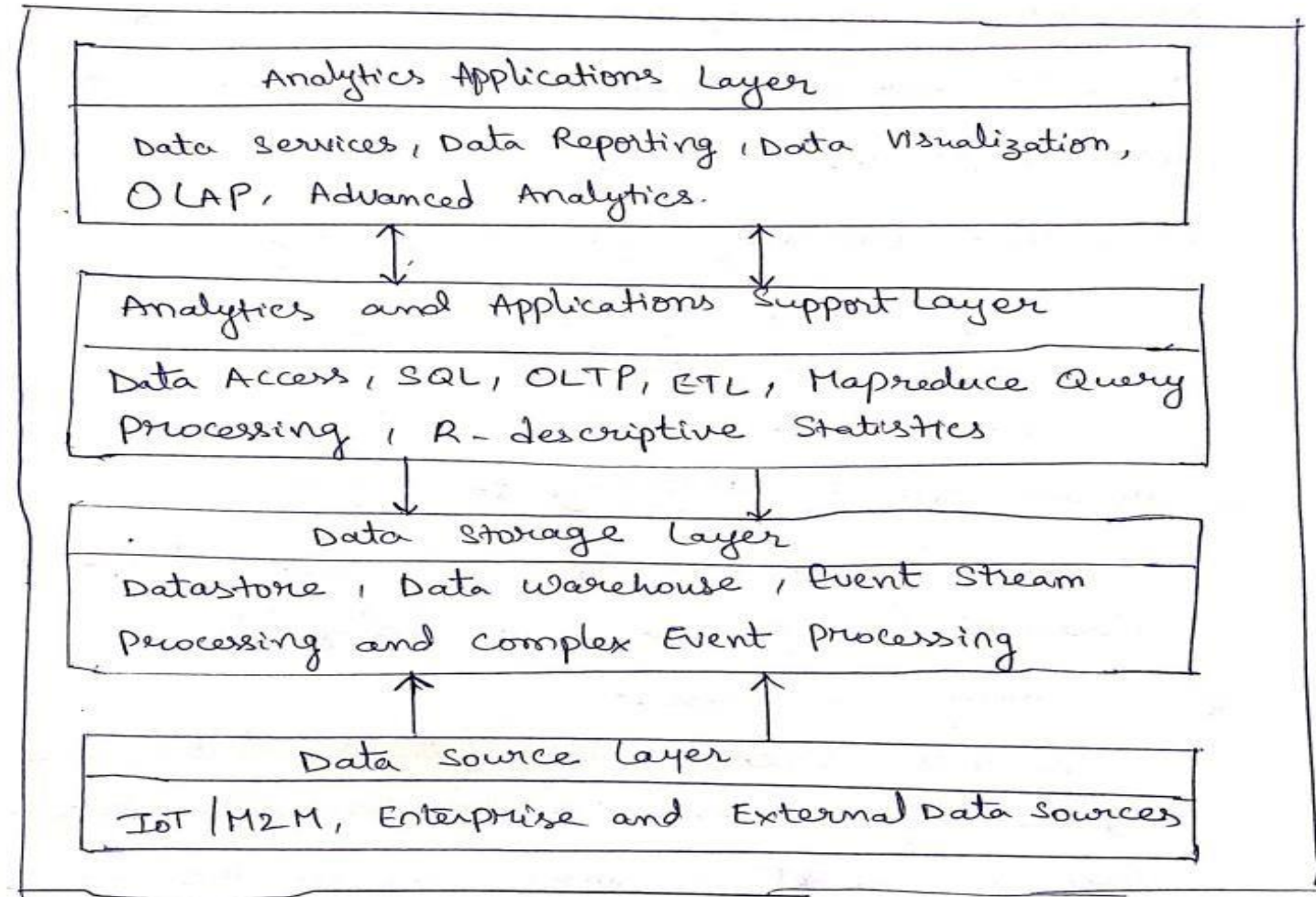


Figure: Architecture of Data Analytics

Design of Hadoop Distributed File System (HDFS)

- The HDFS provides support for the following
 1. Storing files of large size
 2. Streaming data access
 3. Commodity hardware

Building Blocks of Hadoop

The Building blocks of Hadoop are nothing but the daemons that are distributed over different machines of the network and carry out their associated functionality.

The building blocks (or) daemons of Hadoop are,

1. NameNode, 2. Datanode, 3. Secondary NameNode,
4. JobTracker, 5. Task Tracker.

TaskTracker

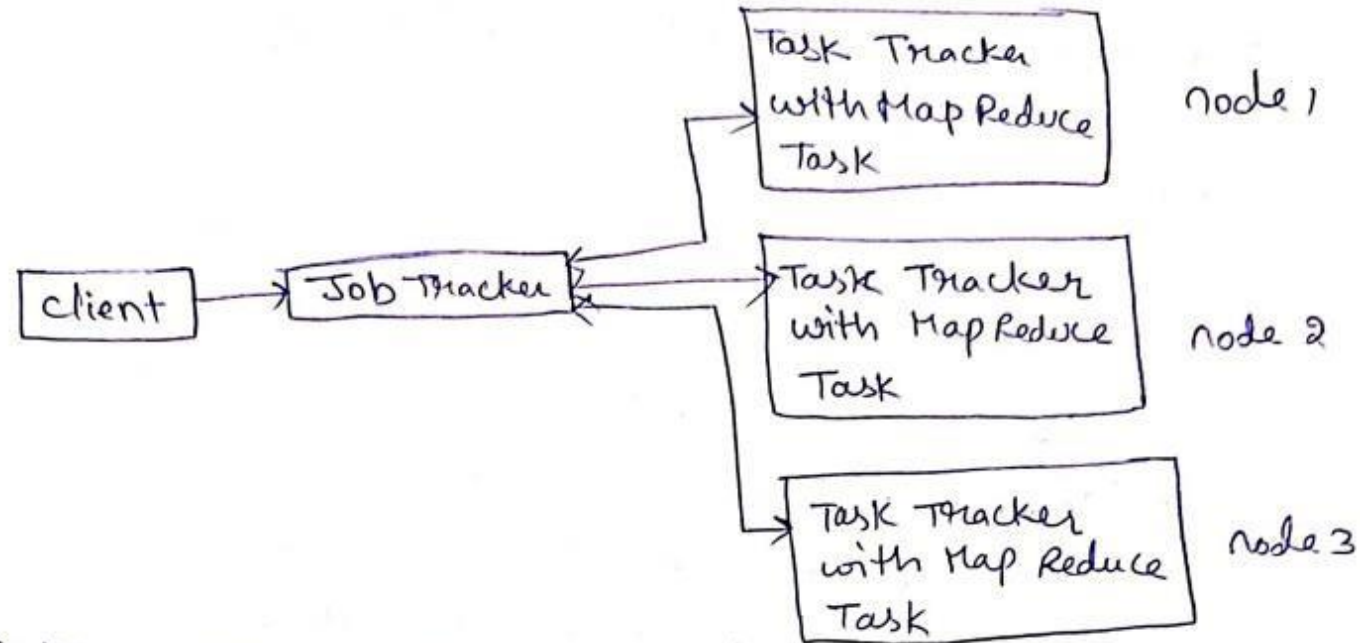


Figure : communication process between JobTracker & Task Tracker.

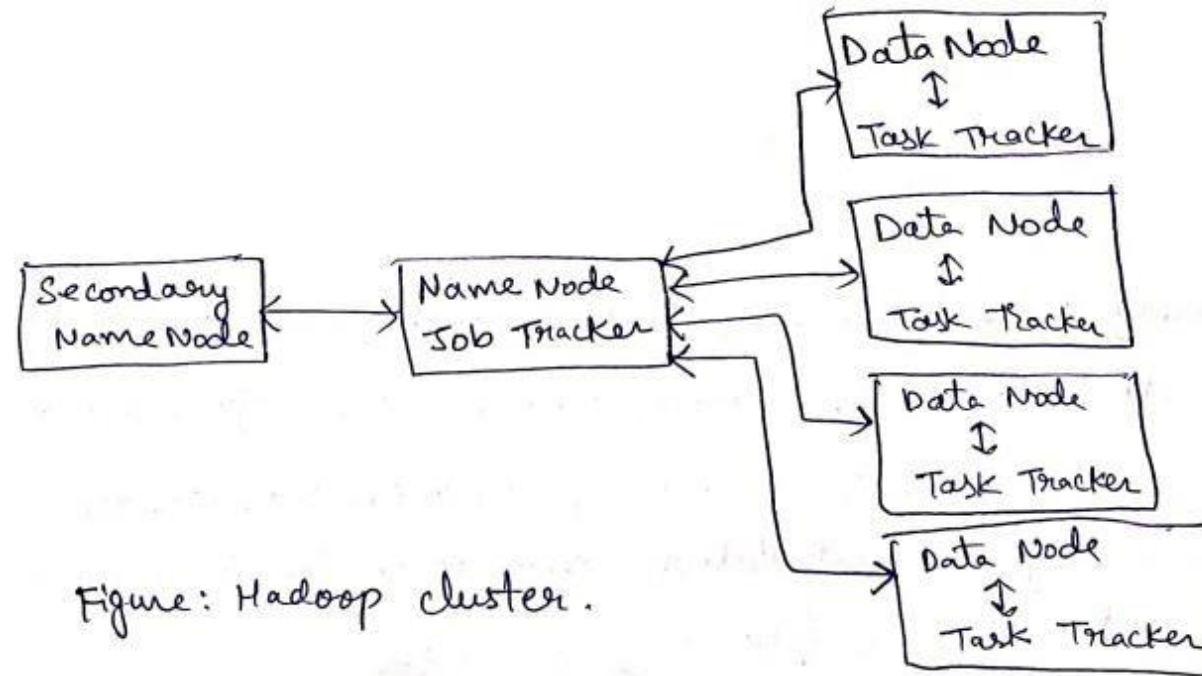


Figure: Hadoop cluster.

MapReduce

Map Reduce is a data processing model used to handle large amount of data distributed over the network. It is capable of processing the distributed data parallelly. It provides two methods namely, Map() and Reduce(). Map() method is responsible for performing operations like filtering and sorting whereas, the Reduce() method is responsible for performing summary operations like count. The programs that are based on MapReduce can be implemented in different languages in hadoop.

Weather Dataset :-

A program that handles the process of mining the data associated with weather is referred to as weather dataset. This data is captured by sensors on hourly basis and by considering different locations globally. In this way huge amount of data is collected for the purpose of analyzing it with the MapReduce. An example of such data is the information provided by NCDC (National Climate Data Center). It follows ASCII format to save its data in the database in the form of records. This type of format is capable of carrying field of both constant and variable lengths. The data can be formatted in the following way,

Each field in this record can be defined as follow,

Field	Description
23759	Identifier to represent weather station
23062015	Date
0530	Time
+47213	*1000 degrees latitude
+23121	*1000 degrees longitude
+523	Elevation in meters
470	Direction of wind in degrees
3	Quality code
S	Southern direction
750	Sky ceiling height
1	Quality code
S	South
15000	visibility distance
1	Quality code
S	South
15000	visibility distance

1	Quality code
N	Towards north
12	Temperature of air in celsius
1	Quality code
-14	Temperature of dew point in celsius
1	Quality code
12139	Atmospheric pressure in hectopascals
1	Quality code.

Example of Mapper code in Hadoop

Example :-

Consider an example java program that computes the number of words in a file to illustrate the use of mapper code.

```
import java.io.IOException;
import java.util.StringTokenizer;
import org.apache.hadoop.io.IntWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapreduce.Mapper;
```



```

public class WordCountMapper extends Mapper<Object,Text;
    Text, IntWritable>
{
    private static final IntWritable iw = new IntWritable(1);
    private Text w = new Text();
    public void map(Object key, Text value, Context cnt) throws
        IOException, InterruptedException
    {
        StringTokenizer t = new
        StringTokenizer(value.toString());
        while (t.hasMoreTokens())
        {
            word.set(t.nextToken());
            context.write(w, iw);
        }
    }
}

```

ReducerCode

Reducer Code :-

Reducer is capable of reducing the intermediate values all of them which share the key to smaller set of values. A Reducer in MapReducer performs three major operations. They are,

1. Shuffle
2. Sort
3. Reduce

Consider an example java program that computes the total number of words in a file to illustrate the use of reducer code.

```
import java.io.IOException;
import java.util.StringTokenizer;
import org.apache.hadoop.io;
import org.apache.hadoop.io.IntWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapreduce.Reducer;

protected void reduce (KEYIN Key, Iterable<VALUEIN>
    values, org.apache.hadoop.mapreduce.Reducer.Context
    context throws IOException, InterruptedException

public class WordCountReducer extends Reducer<Text,
    IntWritable, Text, IntWritable>
{
```

```

IntWritable cnt = new IntWritable();
public void reduce (Text key, Iterable <IntWritable>
    values, context con) throws IOException, InterruptedException
{
    int total = 0;
    for (IntWritable value : values)
    {
        total += value.get();
    }

    cnt.set (total);
    con.write (key, cnt);
}
}

```

Important Questions

1. Define SDN?
2. What are the key elements of SDN?
3. What is Data Validation?
4. What is Mapper code? What is the general format of it?
5. Write in brief about software Defined Network (SDN)?
6. Explain in detail about the functions that are required for IoT applications?
7. Write short notes on a) Data Validation b) Data Categorization for storage c) Assembly software for events?
8. Illustrate the Architecture of Data analytics?
9. Discuss in detail about the building blocks of Hadoop?
10. Define MapReduce? Discuss about Weather dataset?
11. Write short notes on reducer code?

THANKYOU

FUNDAMENTALS OF IoT - FIoT

UNIT-V

Dr M Shoban

ECE,NRCM

- Basic concept of cloud computing
- Definition and Applications of Sensor-cloud
- Usage of IoT in smart cities and smart Homes
- Usage of connected vehicles approach smart Grid
- Industry IoT with its Advantages
- Case studies on Agriculture
- Healthcare and Activity Monitoring

cloud computing can be viewed as a model for distributing information Technology. In order to gain access to the resources from internet without depending on direct connection with the server, the model can easily retrieve resources via web-based tools and applications. Here, the information which is to be accessed is stored in clouds and it gives the privilege to the user to access the information whenever and from where ever they want.

Basic concept of cloud computing

Cloud computing can be viewed as a model for distributing information technology. In order to gain access to the resources from Internet without depending on direct connection with the server. The model can easily retrieve resources via web-based tools and applications. Here, the information which is to be accessed is stored in clouds & it gives the privileged to the user to access the information whenever and from where ever they want. Thereby, allowing the users to work remotely. In general cloud computing is nothing but the use of computing resources such as hardware and software which are distributed as a service across the network. It centralizes the data storage, processing, and bandwidth which in turn provides efficient computing process to the users.

Services and usages of cloud platform

The various services offered by the cloud platform are as follows,

- 1) It provides infrastructure for devices storing huge amount of data, RFID's, automobiles, industrial plant machines and device networks.
- 2) It offers capabilities of computing like IoT and analytics.
- 3) It provides collaborative computing & sharing of data store.

The usage of cloud platform involves connecting devices, APIs, data, persons, applications and services, businesses, enterprises and XAAs to the Internet.

A conceptual framework of the internet cloud is described by the equation given below.

Internet cloud + clients = user applications & services without boundaries and walls

List different techniques of data collection, storage and computing in cloud computing paradigm

The Various technologies of data Collection, Storage and Computing are as follows,

- i) Devices or sensor networks data collection at the device web server.
- ii) Local files
- iii) Dedicated data store at co-ordinating node.
- iv) Local node in a distributed DBMS.
- v) Internet connected data Center
- vi) Internet connected server
- vii) Internet connected distributed DBMS nodes.
- viii) Cloud infrastructure and services.

The following figure illustrates different techniques of data Collection, Storage and Computing.

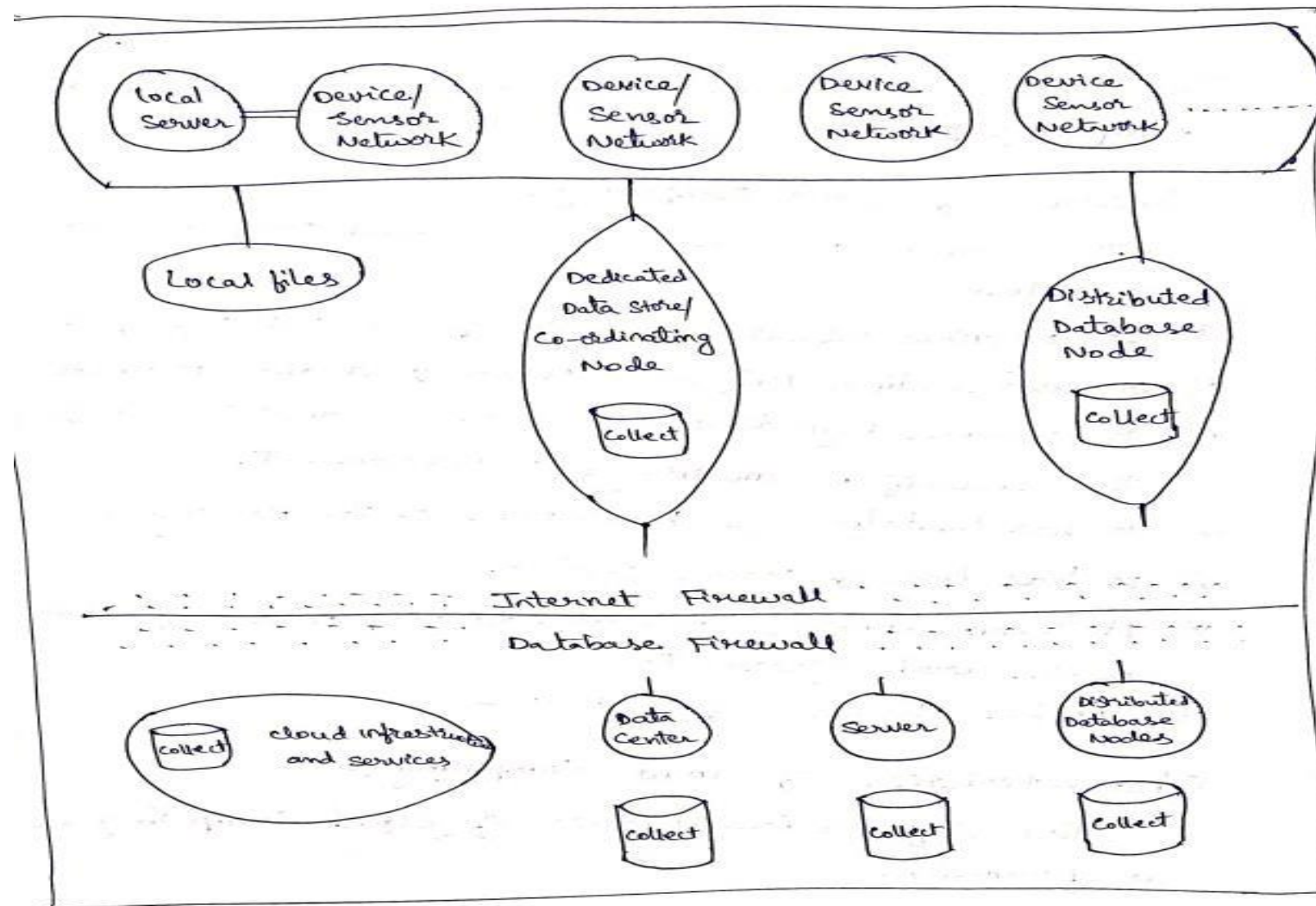


Figure : Techniques of Data Collections, Storage and computing

Concernsofcloudcomputing

The various concern of using cloud computing are as follows,

- i) It requires internet connection of constant high speed.
- ii) It uses multiple APIs and protocols at distinct clouds.
- iii) It requires High trust as well as low risk regarding the security in multitenant environment.
- iv) It has limitations or restrictions on the existing services.
- v) It has loss of users control.
- vi) It is non-delivery according to performance defined in service level agreement.
- vii) It has chances of data loss.

Characteristicsofcloudcomputing

The key characteristics of cloud computing are as follows,

1. It offers services to specific consumers and small business because these services help them to minimize their capital expenditure.
2. It allows the customer to access the cloud computing services regardless of their location or devices.

Characteristicsofcloudcomputing

3. It employs multi-tendency concept that allows sharing of resources and cost among large numbers of users. Due to which the efficiency of under utilize systems increase, peak load capacity increase.
4. It provides high reliability because service providers make use of many unnecessary sites.
5. It offers high scalability depending upon the fluctuating demands of the users.
6. It provides high level of security to the customer resources and infrastructure which is maintained by service providers.
7. It employs dedicated security staff and protection policies in order to keep the customer data safe and secure.
8. It employs data protection policies and access to data is obtained only to authenticated users. However, the security mechanisms used for audit log are extreme which does not allows many customer to access.

Advantages of cloud computing

1. Cost Effective
2. Storage capacity
3. Enhanced performance
4. Flexibility
5. Security
6. Convenience
7. Data backup and recovery
8. Ease of group collaboration

Various cloud service models

1. Software-as-a-Service(SaaS)
 2. Platform-as-a-Service(PaaS)
 3. Infrastructure-as-a-Service(IaaS)
 4. Data-as-a-Service(DaaS)
- A simple equation describing the cloud computing is as follows
$$\text{Cloud Computing} = \text{SaaS} + \text{PaaS} + \text{IaaS} + \text{DaaS}$$

Software-as-a-Service(SaaS)

① Software -as-a-Service (SaaS)

It is one of the form of cloud computing that supports multiuser architecture in order to deliver application via browser to thousands of users. In contrast to other managed service SaaS emphasizes mostly on end users; in order to fulfil their requirements. Moreover, in SaaS computing the customers need not have to invest on any servers or in software licensing as there all are taken care by service providers. These service providers experiences low cost with just one product in relative to the traditional hosting model.

Platform-as-a-Service(PaaS)

② platform -as-a service (PaaS)

PaaS is a web service which is closely connected to SaaS & is considered as a distinct form of SaaS. Unlike SaaS, it provides the user only a platform for work, but not applications to work. In order to use the functionality over the internet, these services provides only application program interfaces rather than large number of applications. Therefore, this distinct form of cloud computing provides many development environments to programs, analyst and software engineers. When the general model for this was implemented, the developers designed many applications specifically to be run across API's infrastructure and then later they made it available to the users through internet.

Infrastructure-as-a-Service(IaaS)

③ Infrastructure as a Service (IaaS) :-

The delivery of computer infrastructure to customer in the form of Service is known as "Infrastructure as-a-Service". It enables a user to access all the resources of computer remotely. IaaS also known as "Service provided" provides services like database, storage capability, development of application, processing of application and security. These services are provided either by,

- (a) Dividing the very large physical infrastructure resource into smaller virtual resource, or
- (b) By providing the complete virtual machine as it is along with an operating system so that the consumer can access it.

Data-as-a-Service(DaaS)

④ Data-as-a-Service (DaaS) :-
Application user or developer can access the data residing at data center on demand. In Data-as-a-Service model, the data warehouse or data store can be accessed by means of internet on demand thereby paying rent to an enterprise based on the usage. The service provider of data center is responsible for data center management, control, scaling, 24x7 power, maintenance, physical security, data replication and mirror nodes & systems.

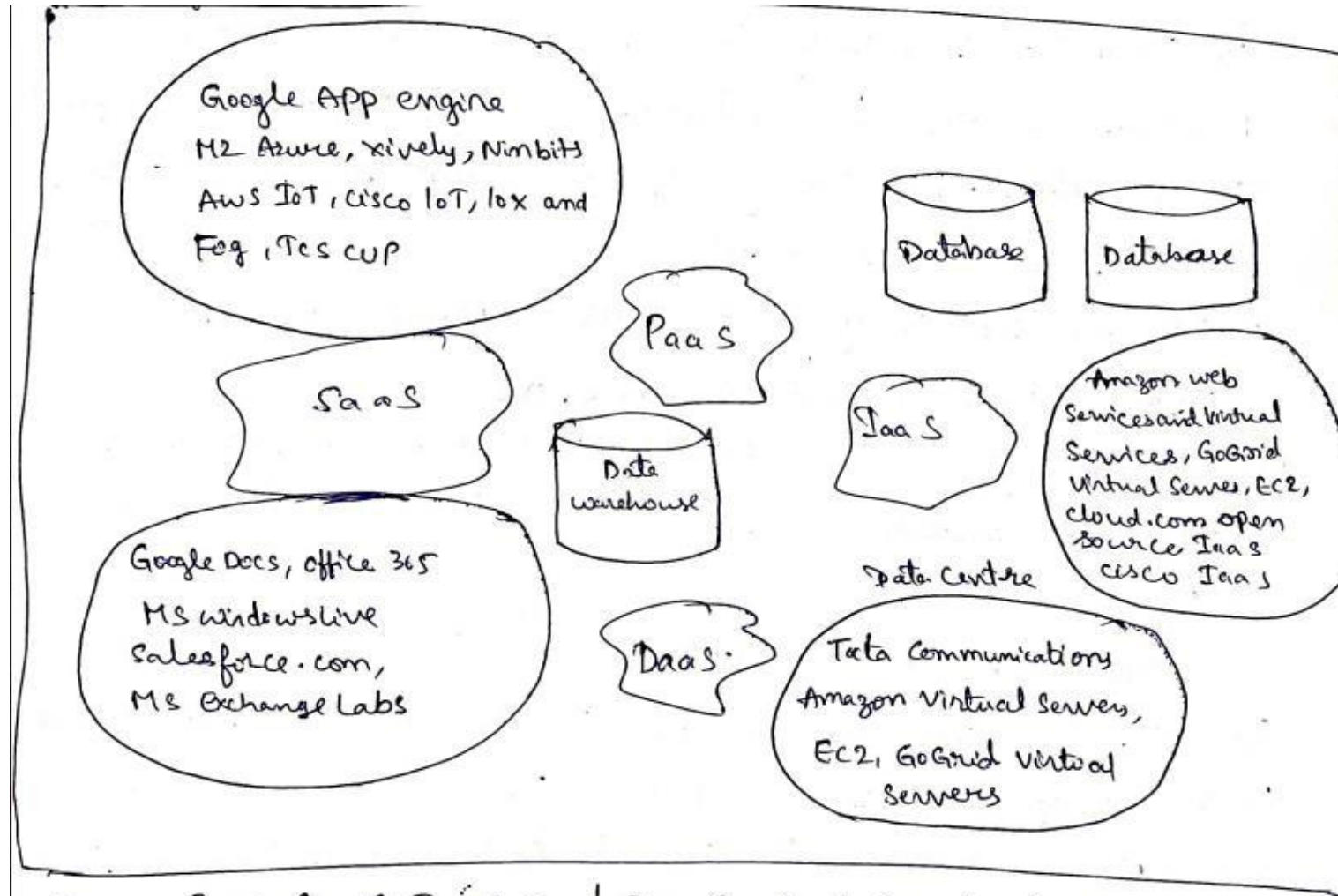


Figure: PaaS, SaaS, IaaS and DaaS cloud Service Models.

Different types of Cloud development model

1. Public cloud
2. Private cloud
3. Hybrid cloud
4. Community cloud

① Public cloud:-

Public cloud is a type of cloud in which general public is given power to use the third-party services. The public needs to pay their providers depending on the services that are being used. Basically, Third party provider share their resources with one or many customers. This type of cloud is preferred by many organizations because the popular public cloud vendors had developed their infrastructure in such a way that they contain large amount of data centers. Thereby, providing the users with the flexibility of increasing (scaling) their resources with low cost. However the only factor that is to be considered while using (accessing) the services of public cloud is the security and data governance.

② private cloud

private cloud is the type of cloud in which the organisation is alone responsible for using (operating) the cloud infrastructure i.e., instead of providing third party services to the customer, the internal cloud provides their own services that are present within their boundary. When compared to public cloud, private cloud provides good performance and is highly secure. However, this cloud is relatively expensive.

Hybridcloud

③ Hybrid cloud :-

Hybrid cloud is the combination of both public & private cloud. This type of cloud is preferred whenever there is heavy workload or any hardware facts. Private cloud

provide services by combining their systems with third party provide of public cloud services. This cloud allows the organization to keep the data secured with firewalls (i.e., private cloud) and less secured data on the public cloud.

④ community cloud :-

Community cloud is a type of cloud in which the organizations having identical requirements share their services.

Sensor-Cloud, Smart Cities and Smart Homes

Sensor- cloud :-

Sensor cloud is a unique platform that supports visualization, remote management and sensor data storage over cloud computing technologies. Use of these technologies offers rapid visualization, data scalability and user programmable analysis. The basic features of sensor cloud are as follows:

1. It allows unlimited data to be stored offering reliability equal to redundant data stored three times.
2. It allows data of sensor data streams to be stored for longer duration.
3. It ~~allows the~~ offers the feature of Math Engine that helps in development & deployment of data along with its processing and analysis of apps which are present in the cloud.

4. It allows the viewers to navigate large volumes of data through time series visualization and graphing tool generating faster response.
5. It allows the users to generate alerts through scripting feature SMS and email alerts.

Applications of Sensor Cloud

1. Telematics
2. Agriculture and Irrigation Control
3. Google Health
4. Wildlife Monitoring
5. Transportation and Vehicle Traffic Application

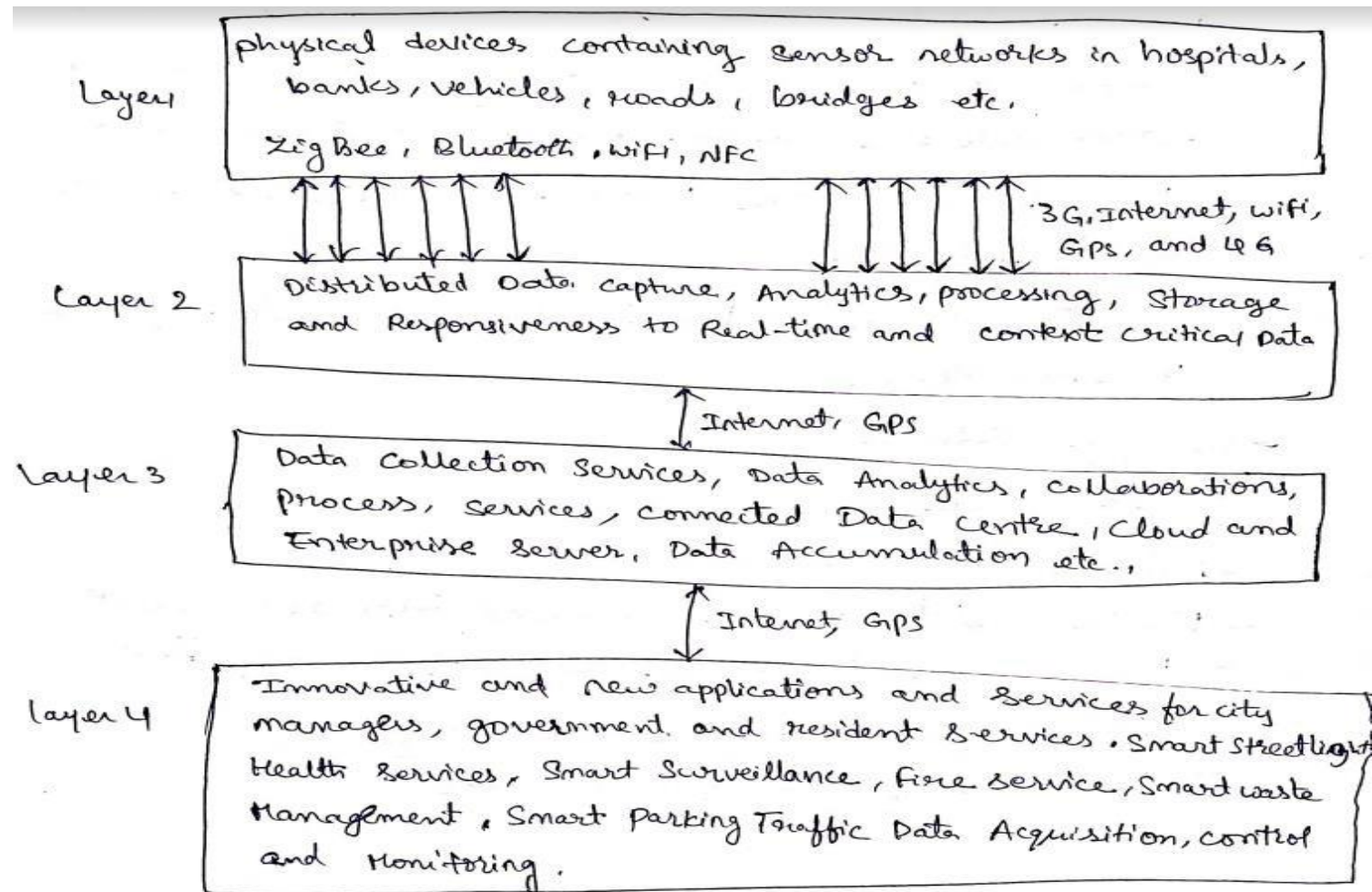


Figure : Architectural Four layer Framework for smart cities

Smart Homes :-

A smart home can be managed by the sensors and actuators through internet connection. The wired and wireless sensors are embedded into cameras, smart plugs, entertainment systems, lights, thermostats and security sensors. The actuators and do-it-yourself (DIY) sensors contain smoke detector, energy meter interface, remote control, surveillance camera, HUE LED lights, electric utility meter etc.

The connected home includes the below applications in smart home.

- * Energy Efficiency
- * Lighting control
- * Automated meter reading
- * Mobile, tablets, video-on-demand, WiFi and internet
- * Home security : Access control & security alerts
- * Solar panel control & monitoring
- * Detection of the fire or leaks.

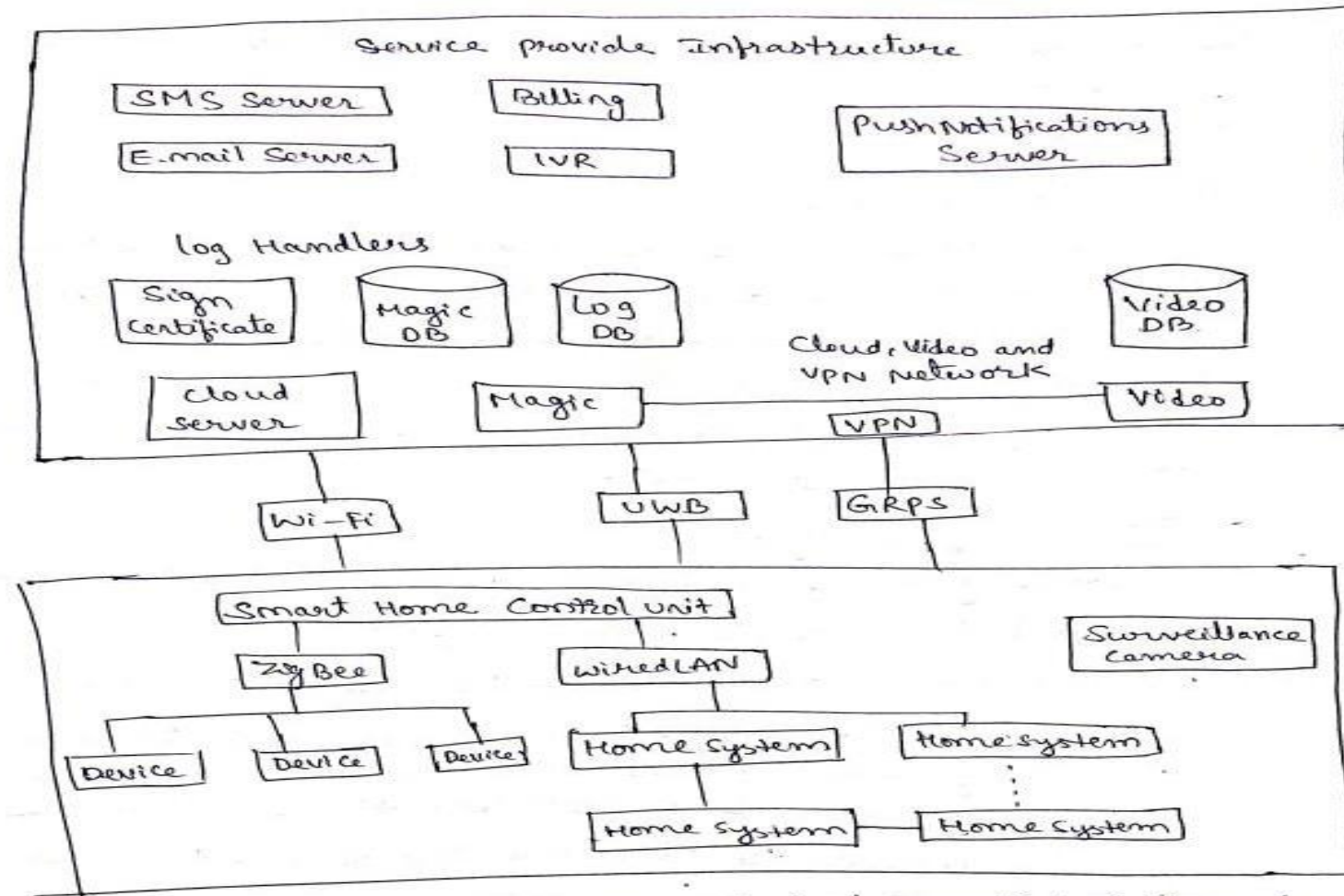


Figure: Architectural view of cloud Based IoT platform for Smart Home.

The devices are used to connect IoT devices to a home network:

1. CloudServer
2. HomeGateway

① Cloud Server :-

The Server consists of IP address of public network. It provides various services to the client whenever required and controls the system remotely. It acts as a medium between the home gateway and the control terminal for exchanging the data when the devices are handled by the user with the help of internet.

② Home gateway :-

Home gateway is considered as a control center for the smart home system. Generally, most of the users consider it as a small server because it provides services such as adding / deleting data, device status and controlling device actions. It is also used to handle the daily work of a controlled device. It provides the instructions to controlled devices and receives the present status for managing the devices. Some times, it acts as a client for the cloud server to request for some cloud services.

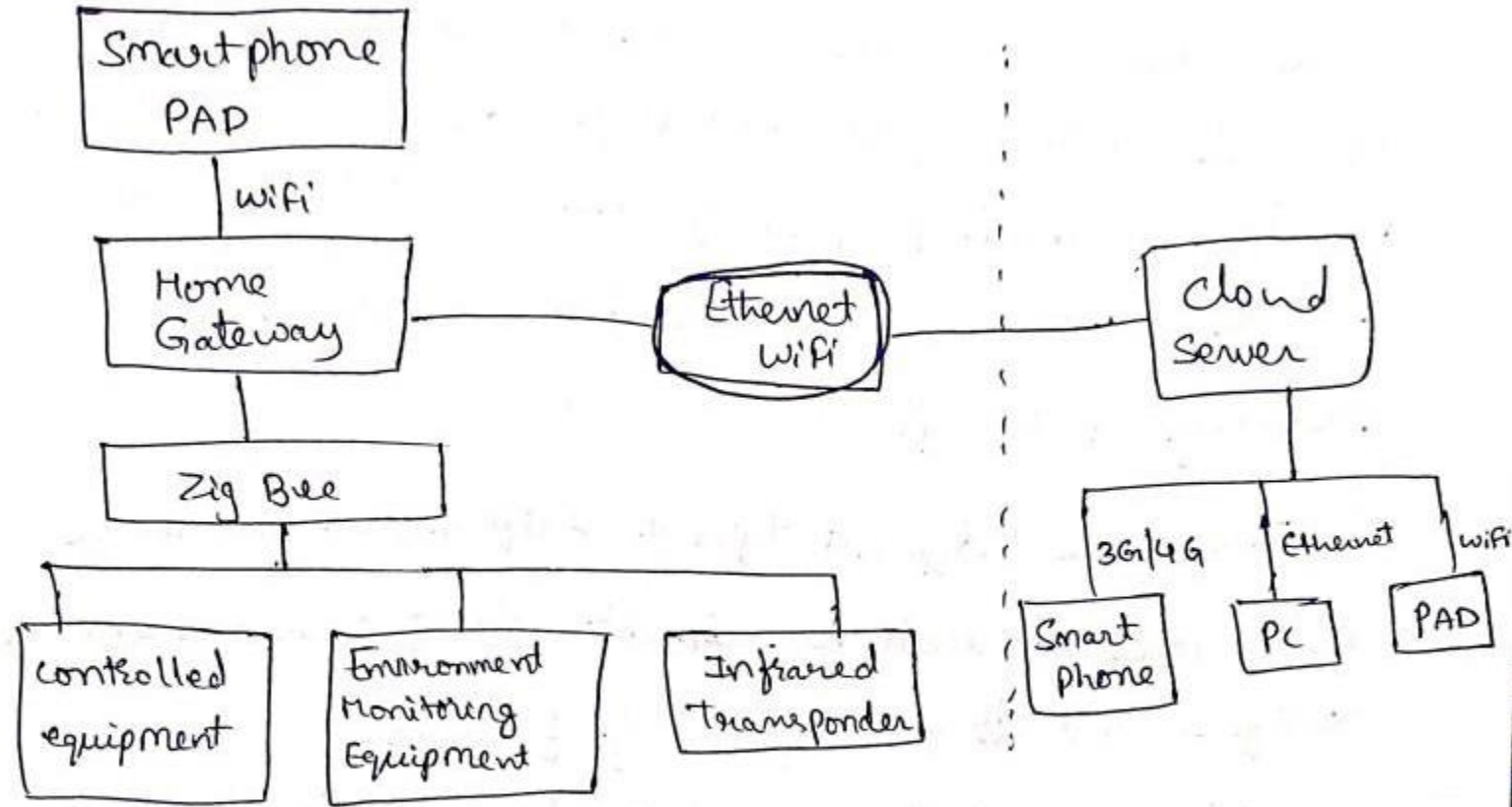


Figure :- Design Diagram of Smart Home System .

Connected Vehicles :-

Connected Vehicles refers to the vehicles which are capable of connecting to nearby devices wirelessly. They can exchange data to assist decision making. This type of dynamic data helps in improving safety aspects of vehicles. Typical data generated by connected vehicles include speed, direction, position and location. Data exchange between vehicles and devices helps in determining threats and hazards covering 360 degrees view and visualization with regard to other vehicles position. This again helps the drivers to drive carefully in accident prone areas and avoid accidents.

Different types of platform and applications

1. Rental car features
2. Dealership scales
3. Fleet management

① Rental car features :-

The car rental companies can gain knowledge about cars like distance travelled and maintenance requirements.

② Dealership sales :-

It offers services for building dealership network. It also helps in separating the older vehicles using connected services.

③ Fleet Management :-

It can be used to provide value added services such as tracking vehicle locations, managing vehicle maintenance etc., to the vehicles.

The Airbiquity Choro Service delivery platform is another cloud platform which is preferred for auto manufactures,

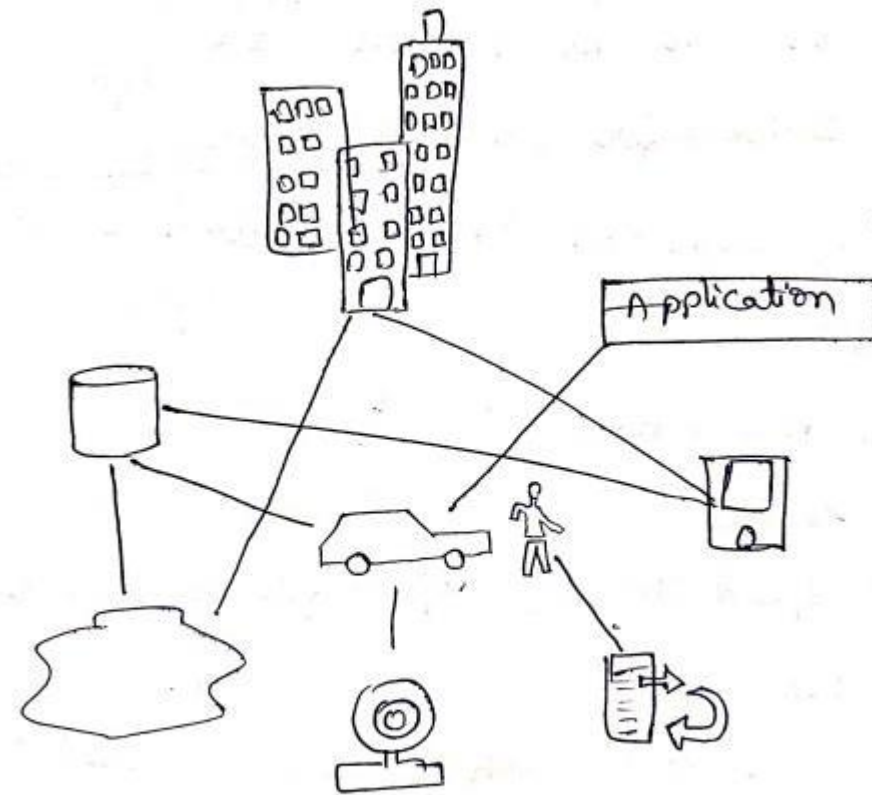


Figure: connected car

The drivers for connected cars ~~and~~ are depicted below,

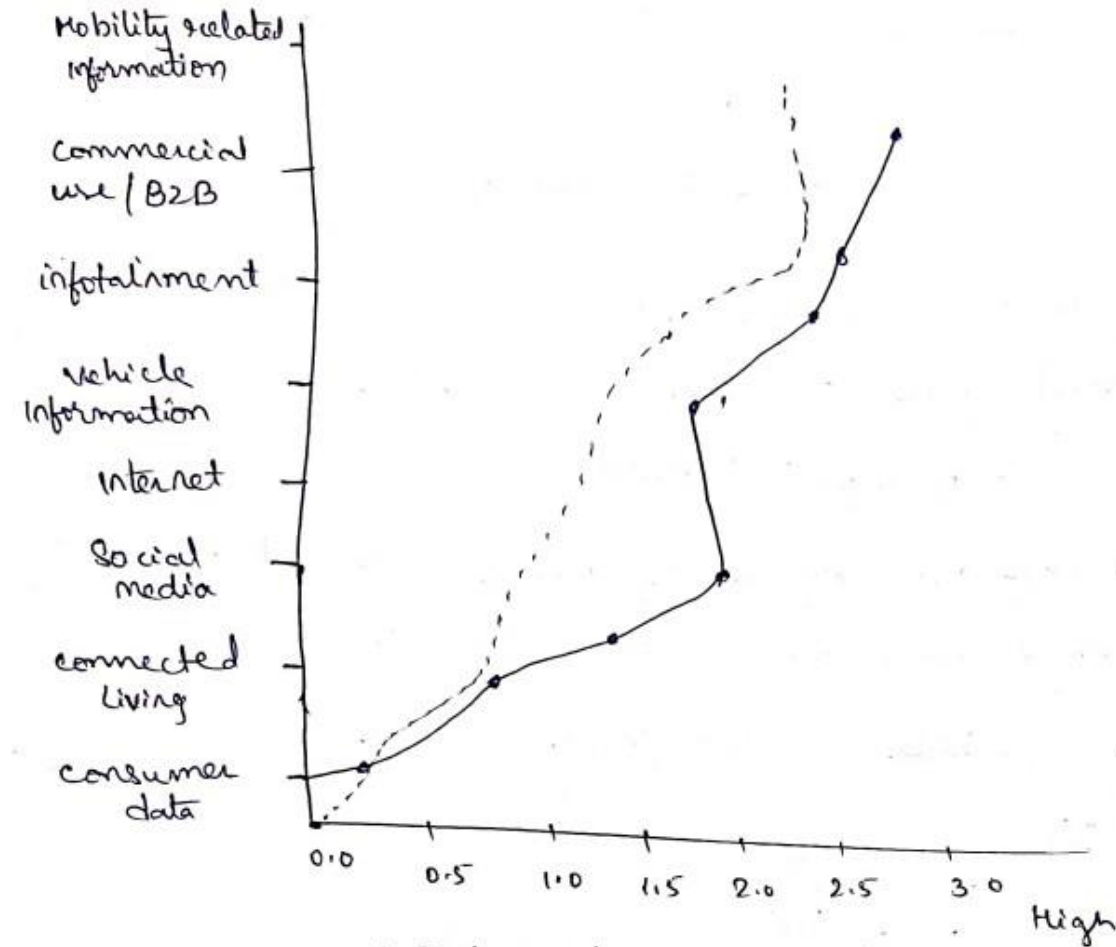


Figure : Drivers for connected cars.

The features of connected cars are listed below,

1. Infotainment
2. Social media interaction
3. Diagnostic Service
4. Customized speed related inputs for particular terrains
5. Safety Services
6. Ability for interacting with sensor-enabled cars in range and offer certain value added inputs such as traffic block on roads etc.,

Smart Grid :-

Smart grid refers to an electricity distribution network that makes use of smart meters to compute consumption of power. The smart grid applications can run on devices in network with the ability to adopt solar and wind energy depending upon certain constraints like power, cost and energy. Smart grid generates the data that is further processed and stored by the gateways. These gates help actuators in decision making. The network of smart grids contains a server called SCADA (Supervisory Control And Data Acquisition) that can extract and analyze the data. This data is forwarded to the power grids which evaluate fluctuations in usage of power. Additional micro grids are appended to SCADA in order to enhance security, rapid response, scalability and cost efficiency related to the power system. It also allows data collection from various power generators distributed over different locations to the main power grid.

There are three types of components such as the following.

1. Smart meters are the digital meters capable of tracking the energy consumption of user. It also provides alerts to user devices.
2. Meter data acquisition and management system is a software systems that gathers data from meters, analyzes usage metrics and then evaluates the bill.
3. Networks that provide two-way communication.

The Smart meters is prone to security attacks where they can be hacked to obtain critical consumption related data. The Smart grid networks and infrastructure components can also be attacked through some malware that can track the network related data. Such type of threats can be avoided to a maximum extent through intrusion prevention methods along with certain robust security practices in order to manage network usage tracking, browser patches etc.

The smart meters are implemented on smart grids with which validation and authentication can be assured.

Industrial IoT :-

Industrial IoT is also known as industrial internet. There was a sudden rise in the usage of IIoT because, it can perform tasks like data acquisition and communication more accurately than human beings. The major applications (building blocks) of IIoT are machine to machine communication (M2M), big data analysis, machine learning techniques etc. In manufacturing companies, IIoT is used in tracking & maintaining the supply chain, lowering the amount of energy consumption, performing quality control and assurance.

The connectivity among the production process parts including machines, systems, products and users

Advantages of Industrial IoT

of big data and cloud is provided by the IIOT. In future there will be a major role of data analytics, visualization software based systems, service platforms. The IIOT is also considered as an important component in Industry 4.0.

Advantages of Industrial IoT :-

1. It improves data collection efficiency, scalability and accuracy.
2. It helps many businessmen to make better decisions.
3. It is used to improve supply chain management.
4. It is used to reduce the cost because of the improved safety and repair issues.
5. It improves the connectivity by sharing more information.

Case Study : Agriculture, Healthcare, Activity Monitoring

Agriculture in IoT :-

Smart agriculture refers to the usage of IoT solutions in leveraging agricultural practices. the farmers can improvise the work ranging from livestock to crop farming through IoT-sensors for extracting the metrics related to environment and machines. IoT can improve agriculture in the following ways:

① Improved Quality and Volumes :-

A better control is achieved on production process including standards of crop quality and growth via automation

② Data Gathering through Smart Agricultural sensors :-

The data that is gathered through smart agriculture sensors is used for tracking the business state including performance, efficiency, equipments etc.

③ Increase in Business Efficiency Through Process Automation:-

Multiple processes over production cycle such as fertilizing, irrigation etc., can be automated through smart devices.

④ Cost Management and waste Reduction due to Increased control over production :-

The anomalies if any in crop growth or livestock health can be observed to evaluate the risks of losing products and can be mitigated.

⑤ Better control over internal processes yields to Decrease in production Risks:-

The product distribution can be planned by planned by for seeing the output of production.

usecases of IoT in Agriculture :-

The development companies need to focus on the following usecases to develop IoT applications for agriculture,

① Green House Automation :-

Manual intervention are used to control the green house environment in general. IoT sensors help farmers to obtain accurate real time information about green house conditions like lighting, temperature etc.

② Crop Management :-

The crop management devices can be devised just like weather stations across the field. They are actually used to collect certain crucial data like overall crop health, precipitation of leaf water and temperature. With this, crop growth can be monitored, anomalies can be detected and prevented.

③ Agricultural Drones :-

The agricultural drones are called as UAVs (unmanned Aerial Vehicles). They are not only used for surveillance but also used in planting crops, monitoring crops, agricultural spraying, countering infections and pests.

④ Monitoring climate conditions :-

The weather stations are equipped with various farming sensors that can extract data from environment and forward to cloud. This data is used in selecting appropriate crops, mapping climatic conditions etc.,.

Health care in IoT :-

Health care is one of the leveraging industries in which a number of devices are used to measure and manage various health parameters of humans. The approaches of M2M can be used in this field to remind patient, family and doctor about the medical conditions based on the data obtained from health readings. Health care sector mostly depends upon IoT and other technologies supporting IoT big data analytics and cloud computing. Usage of IoT in healthcare provides personalized healthcare providing services depend upon cultural, biological and social characteristics of a person.

① Clinical care :-

Some of the ill patients need to be observed constantly.

Such type of patients are kept in Intensive Care units (ICU).

This type of monitoring is possible by IoT driven non-invasive monitoring technology through sensors to extract physiological data related to different organs of patients. This data is forwarded to the care takers through gateways and wireless networks.

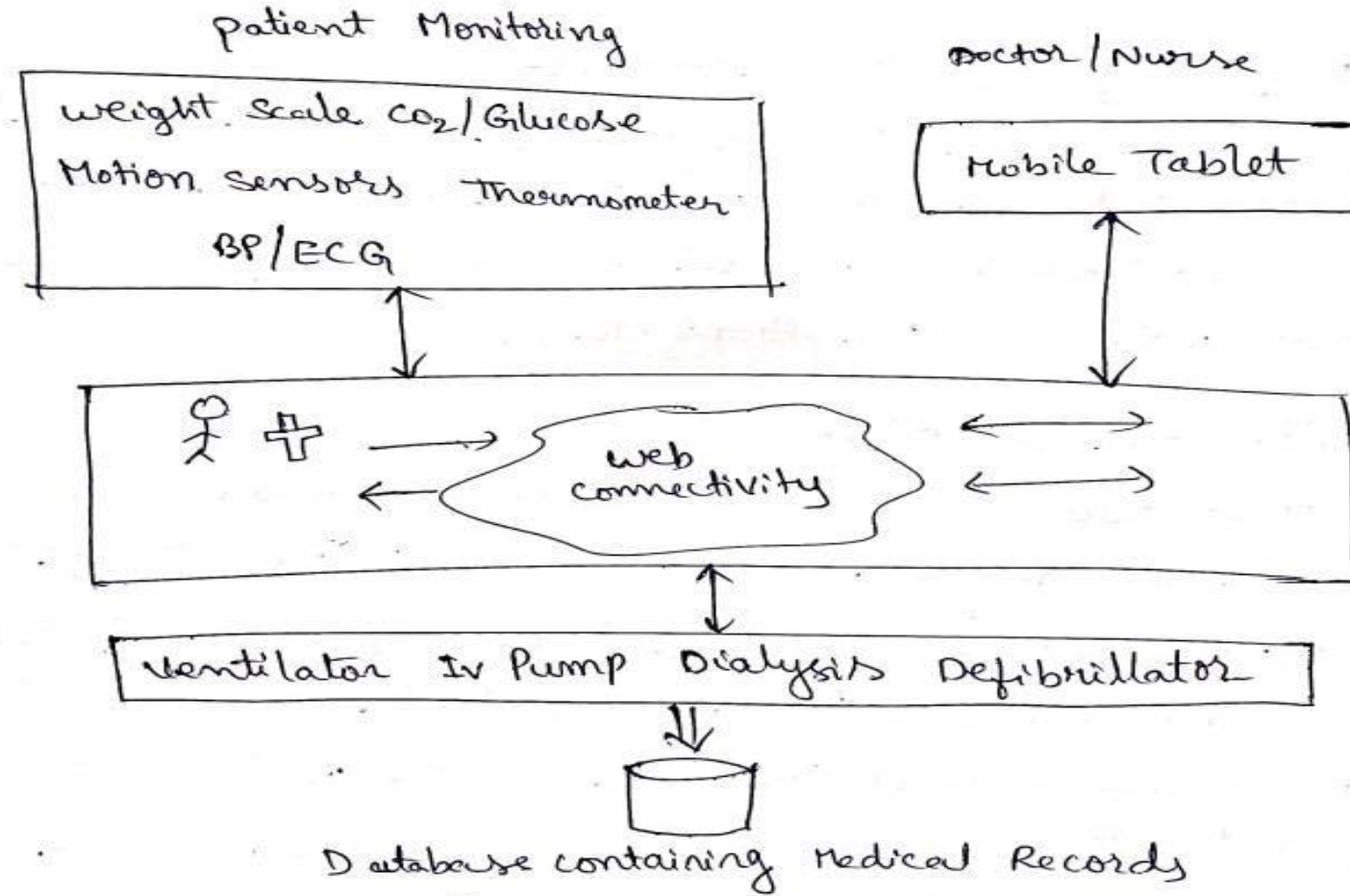


Figure :- clinical care system.

② Remote Monitoring :-

Health monitoring is made available to the patients through wireless solutions / sensors connected through IoT. Such type of wireless solutions gather status or response of different organs of patients through sensors and forward as inputs to complex algorithms for further data analysis. This data is again forwarded to doctors and health care professionals.

Types of Monitoring Devices :-

Different types of situations where monitoring is summarized are as follows,

1. Safety Monitors

- * personal safety and tracking devices
- * Fall detection device.

2. Activity Monitors

- * Speed measuring device
- * Step counting device
- * walking time measuring device
- * Time spent in sleep measuring device
- * Calorien spent measuring device

3. vital sign Monitors

- * blood pressure measuring device
- * Heart rate measuring device
- * Weight measuring device
- * ECG
- * pulse oximeters
- * Blood glucose measuring device.

4. Medication Monitors

- * smart pill dispenser
- * Medical adherence systems

The IoT based health care systems are used to provide special care for pediatric and aged patients. Such type of patients are monitored by tracking their activities, movements and physiological parameters. Monitoring and managing of chronic diseases such as diabetes, obesity, cholesterol & cardiovascular diseases is done through applications such as personal health & fitness management applications. The sensors and devices used in such applications are connected treadmill, weight sensors, heart rate, activity and pressure monitors.

Activity Monitoring :-

Activity monitoring is one of the important services associated with elderly care services. It acts as health care monitoring device. These monitors are used to monitor the health care vitals where the captured data is forwarded to doctors over a remote connection. This data helps the doctors to take appropriate decisions. Some of the sensors which are used to track the health vitals are as follows,

① Body Temperature Sensors :-

These sensors are used to detect the temperature of human body in order to identify various conditions such as heart stroke, fever etc.

② Blood Pressure Sensors :-

These sensors are used to obtain blood pressure of a patient in order to detect hypertension leading to heart attack.

③ Pulse Sensors :-

These sensors are used to read pulse of a patient in order to detect certain emergency situations such as ~~card~~ cardiac arrest, pulmonary embolisms and vasovagal syncope. The pulse can be detected from chest, fingertips, wrist etc.

④ Respiratory Rate Sensors :-

These sensors are used to read the respiratory rate or count of breaths of a patient in order to identify certain critical conditions like asthma attacks, lung cancer, tuberculosis, hyperventilation, apnea episodes etc.

⑤ Pulse Oximetry Sensors :-

These sensors are used to detect oxygen level in blood to diagnose the conditions like hypoxia.

The data extracted from the sensors is processed by devices for emergency care and then stored in cloud for future use.

Important Questions

1. List any four features offered by Nimbix PaaS services?
2. List out the applications in smart home?
3. Discuss in brief about industrial IoT?
4. Define smart Agriculture?
5. Discuss about cloud computing? Also, List various services and usages of cloud platform?
6. List the advantages of cloud computing?
7. Discuss various cloud services model?
8. Write short notes on sensor-cloud?
9. Explain about connected vehicles?
10. Discuss about smart grid?
11. Explain about industrial internet of things (IIoT)?
12. Write about agriculture in IoT?
13. Write short notes on activity monitoring?

THANKYOU