

# Internet of Things

B.C.A II Semester Mangalore University

## **Solved Question Bank**

**K. Praveen Kumar M.Sc (Computer Science)**

**Assistant Professor,  
Department Of Computer Science,  
St. Mary's College, Shirva - 574116**

© ALL RIGHTS RESERVED

No part of this publication can be reproduced or stored in a retrieval system or transmitted in any form or by any means without the prior written permission of the Authors and Publishers.

**First Edition: December 2020**

**Price: 90/-**

**Pages: 8+80=88**

**Published by: MYOWN Printers**

**DTP by: K. Praveen Kumar**

## **PREFACE**

This book has been structured to help the students of B.C.A (semester – choice based credit) of Mangalore University. This book contains the Detailed Syllabus of the Internet of Things, and Question Bank Questions of the II Semester B.C.A. It is particularly well suited for beginning college-level students as a Study material book for an introductory IoT course, as a supplementary notes or as an effective independent-study guide to the only Mangalore University B.C.A. Computer Graduates.

My sincere thanks go to all my well-wishers, for their constant encouragement and support.

I sincerely and whole heartedly thank all my B.C.A Students for their Suggestions and Co-operation.

I am grateful to MYOWN Printers for undertaking of this book.

Suggestions for improvement of this book will be gratefully accepted.

Shirva,  
05-04-2020

K. Praveen Kumar

**Detailed Syllabus**  
**MANGALORE UNIVERSITY**  
**Bachelor of Computer Applications (BCA)**  
**Degree Programme 2019-2020 Onwards**  
**II SEMESTER BCA– BLOWN UP SYLLABUS**  
**Elective -II: Expanded Course BCACE 186 E1: Internet of Things**

Unit - I		
Topic	Chapter	Sub-sections
<b>Internet of Things Overview:</b> IoT Definition , IoT vision ,smart and hyper connected devices, IoT conceptual framework, IoT Architectural view, Technology behind IoT , Components of IoT system, ,Development tools, APIs and Device interfacing components , Platform and integration tools, Sources of IoT, M2M communication, M2M architecture, Software and Development tools, IoT examples (In 1.7.1 only common features) <b>Design Principles for Connected Devices:</b> Introduction, Modified OSI model for IoT / M2M systems, ITU-T reference model, Communication technologies: Wireless technology: (only Near field, RFID, Bluetooth, WiFi, GPRS/GSM, Wireless USB) Wired Communication Technology : (Only introduction about UART/USART, SPI, I2C bus, Wireless USB, Ethernet) <b>Design Principles for Web :</b> Web Communication protocols for connected devices, Message Communication protocols, Communication Gateway protocols-SOAP, REST, HTTP RESTFUL and WEBSOCKETS <b>(Exclude all the examples)</b>	Chapter 1	1.1 to 1.7 [Exclude: Fig. 1.3, 1.5, 1.8, 1.9, 1.11 and Sections. 1.6.2, 1.6.3]
	Chapter-2	2.1 ,2.2,2.2.1, 2.3,2.3.1,2.3.2 [Exclude: Fig. 2.4, 2.5, 2.6, 2.7 ]
	Chapter-3	3.1, 3.2(Pg. No. 79 & 80),3.3.1, 3.4(Only the purpose of specified protocols) [Exclude: Fig. 3.1, 3.8]
Unit - II		
<b>Internet Connectivity</b> -Introduction, Internet connectivity, Internet based communication, IP addressing in IoT(IP Address, Static IP address, Dynamic IP address, DNS,DHCP, IPv6)	Chapter-4	4.1,4.2 ,4.3( Only Pg. No.124), 4.4, 4.4.1,4.4.2

<b>Data Acquiring and storage:</b> Organising the data Transactions on stored data.	Chapter-5	5.2, 5.3, 5.3.1 to 5.3.5, 5.4 [Exclude Fig. 5.3]
<b>Sensors</b> : Introduction , Sensor Technology(Only Analog sensors and Digital sensors, Examples of sensors), Industrial IoT and Automotive IoT(connected cars, vehicle to Infra structure, Autonomous cars), Actuator, RFID technology: RFID IoT system, Principle of RFID, Technological challenges, Security challenges,Wireless sensor network technology: Definition, context based node operation, Security challenges. <b>(Exclude all the examples)</b>	Chapter-7	7.1, 7.2, 7.2.1(PNo. 233, 235, 239) 7.2.2,7.3.1,7.3.2, 7.4,7.6,7.7,7.7.1, (PNo 273, 274, 282) [Exclude all Figures]
<b>TEXT BOOK</b> : Internet of Things: Architecture and Design Principles by Raj Kamal Mc Graw Hill Education		
<b>Reference Books:</b> <ol style="list-style-type: none"> <li><b>IoT Fundamentals</b> by David Janes , Ganzalo , Patrik , Rob Barton and Jeromey Henry</li> <li><b>Internet of Things</b> by Saurabh Gupta</li> </ol> <b>Internet of Things: A Hands-On Approach</b> by Arsheep Bahga , Vijay Madisetti		

### Question Bank Questions

#### UNIT I

#### 2 Marks questions

1. Define IOT.
2. Expand RFID, GPS, NFC, WSN, REST, PDU, MTU, MCU, SOAP, GPRS, GSM, CSMA/CD, UDP, and URL. (Any 2 can be asked)
3. Write the equation that represents IoT conceptual framework for the enterprises suggested by Oracle
4. What are sensors? List different types of sensors
5. What is firmware?
6. Define middleware.
7. Differentiate IoT and M2M
8. What is microcontroller? List any two microcontrollers used in IoT
9. List any four applications that can be deployed in smart home.
10. Define gateway. List different types of gateways?
11. What is the purpose of communication gateway?
12. What is the purpose of Internet Gateway?
13. Write any two features of Bluetooth.
14. List any four IoT Operating systems.
15. What is URL? Give example.

16. Write the use of Broker in communication
17. What is the use of web socket?
18. What is the use of Application Programming Interface (API)?
19. What is the purpose of Resource Directory?
20. Mention the purpose of Message Cache.
21. What is URI? Specify the purpose of URI.
22. Mention the purpose of Message Queue.
23. What is transcoding?
24. What is Star network?
25. What is Mesh Network?
26. What is the purpose of Coordinator in IoT communication?
27. What are Master and Slave in case of IoT Communication?
28. What is the use of Router?
29. Mention the use of Proxy.
30. What is Resource Registry?

### Questions for 3 or more marks

1. Write a note on smart and hyper connected devices. 3
2. Explain the equation that represents IoT conceptual framework for IoT architecture suggested by Oracle. 6
3. Explain an IoT reference model suggested by CISCO for general IoT system. 6
4. List and explain major components of IoT systems 6
5. List and explain popular IoT development boards. 6
6. List the functions of fitness tracker wearable devices 4
7. Explain general IoT Framework with block diagram 6
8. Explain the role of four layers in Smart –City architecture 6
9. Explain any six hyperconnected wearable smart watches 6
10. Write a note on NFC 6
11. Explain sensors, actuators and software used for building Smart Home. 3
12. Write a note on WiFi. 3
13. Explain IETF six layer modified OSI model for IoT with block diagram 6
14. Write the features and communication modes used in NFC 4
15. Explain any six features of Bluetooth 6
16. Explain
  - a) Polling and observing      b) Client-Server System
  - c) Publish-Subscribe          d) Push-Pull
  - e) Message Cache              f) Message Queue
 (Any 2 maybe asked for three marks each)

17. Write a note on      a. Wireless USB              b. Ethernet              6
18. Explain      a. Client-Server system      b. Publish-Subscribe              6
19. List different protocols used in message communication. Write the features of any two.              6
20. Write a note on              6
  - A. Bluetooth
  - B. Wired USP
  - C. Wireless USB
  - D. UART/USART
  - E. I2C bus
  - F. Ethernet (Any two may be asked)
21. Write the purpose of GET, POST, PUT and DELETE with respect to RESTful HTTP.              4
22. Explain two types of environments for routing data over web      4

## UNIT II

## 2 Marks questions

1. Define socket.
2. What is IP address? Give example.
3. What is Static IP address?
4. What is dynamic IP address?
5. What is IP address? List two types of IP addresses
6. Differentiate unicast and multicast address.
7. What is anycast address?
8. What is the use of data center?
9. What is Port?
10. What is Interactive Transaction Processing
11. Give examples for Streaming Transaction Processing.
12. What is Real-time Transaction Processing?
13. What is Business Intelligence?
14. Expand
  - a) OLTP
  - b) LIDAR
  - c) SOA
  - d) IIOT (Any two may be asked)
15. Differentiate Passive and Active device data
16. Differentiate NTC and PTC.
17. Write a note on Industrial IoT
18. Write a note on Automotive IoT?
19. What is the purpose of Actuator
20. What is V2I Technology
21. List any four examples for applications of Actuators.

### Questions for 3 or more marks

1. List the actions that occur when data is being transmitted from one layer to other in internet based communication.. 4
2. Write a note on 6
  - a) IP Addresses
  - b)IPV6
  - c) DNS
  - d)DHCP
  - e) Data Acquisition
  - f) Data Centre Management
  - g)Spatial Storage
  - h)ETL
  - i)Data Validation
  - j)Batch Processing WSN (2 Marks each)
3. Explain different steps involved in DHCP functioning 6
4. List and explain different ways by which IoT data is generated 6
5. Explain categorization for Data Storage 3
6. Write any six tasks associated with server management 6
7. Write ACID rules of DBMS 4
8. List any five steps associated with Query Processing 6
9. List different features of SQL 6
10. List the components of NOSQL 6
11. Explain tasks associated with CEP 6
12. Write a note on Sensor Technology 4
13. Differentiate Analog and Digital Sensors 4
14. List different features of Connected Cars 6
15. What is V2I Technology? List different examples of V2I applications 6
16. List and explain any five applications of actuators 6
17. Explain different technical challenges related to RFID 4
18. List security challenges of RFID 6
19. List and explain security challenges associated with WSN 6
20. Explain the features of DDB. 3
21. Explain CAP theorem 3
22. Explain 3 classes of IPv6 addresses 4
23. Write a note on data acquisition and data validation. 6
24. Write a short on EIL 3
25. List any six context for reprogramming the actions of WSN mode 6
26. List any six examples of sensor. 6
27. Write a note on following transactions. 6
  - Online transaction processing(any 2 can be accommodate)
  - Batch Processing 3. Interaction Transaction 4. Real time system

## UNIT – 1

**2 Marks questions**

**Questions for 3 or more marks**

**Page Numbers 1-10**

**Page Numbers 11-40**



# Question Bank Questions

## UNIT I

### 2 Marks questions

#### 1. Define IOT.

The internet is a vast global network of connected servers, computers, tablets and mobiles that is governed by standard protocols for connected systems. It enables sending, receiving or communication of information, connectivity with remote servers, cloud and analytics platforms.

***Definition of IoT can be explained as follows:***

*Internet of Things means a network of physical things (objects) sending, receiving, or communication information using the Internet or other communication technologies and network just as the computers, tablets and mobiles do and thus enabling the monitoring, coordinating or controlling process across the Internet or another data network.*

*(or)*

*Internet of Things is the network of physical objects or 'things' embedded with electronics, software, sensors and connectivity to enable it to achieve greater value and service by exchanging data with manufacturer, operator and/or other connected devices. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet Infrastructures*

#### 2. Expand

**RFID-** Radio Frequency Identification (RFID),

**GPS-** Global Position System

**NFC-** Near Field Communication

**WSN –** Wireless Sensor Network,

**REST-** Representational State Transfer

**PDU-** Protocol Data Unit

**MTU-** Maximum Transmission Unit

**MCU-** Microcontroller Unit

**SOAP-** Simple Object Access Protocol

**GPRS -** General Packet Radio Service

**GSM** –*Global System for Mobile Communication*  
**CSMA/CD**- *Carrier Sense Multiple Access with Collision Detection.*  
**UDP**- *User Datagram Protocol* **and**  
**URL**- *Universal Resource Locator*

**3. Write the equation that represents IoT conceptual framework for the enterprises suggested by Oracle**

***Gather+Enrich+Stream+Manager+Acquire+Organise and Analyze= Internet of Things with connectivity to data centre, enterprise or cloud server.....1.2***

*Equation 1.2 is an IoT conceptual framework for enterprise processes and service based on a suggested IoT architecture given by Oracle.*

**4. What are sensors? List different types of sensors**

***Sensors:*** *Sensors are electronic devices that sense the physical environments. An industrial automation system or robotic system has multiple smart sensors embedded in it. Sensor-actuator pairs are used in control systems. A smart sensor includes computing and communication circuits.*

***Sensors are of two types.***

- *The first type gives analog inputs to the control unit. Examples are thermistor, photoconductor, pressure gauge and Hall sensor.*
- *The second type gives digital inputs to the control unit.*

**5. What is firmware?**

*Thingsquare Mist is an open-source firmware (software embedded in hardware) for us Internet-connectivity to the IoT. It enables resilient wireless mesh networking. Several*

*microcontrollers with a range of wireless radios support Things MIST.*

## **6. Define middleware.**

### ***Middleware***

- ❖ *OpenIoT is an open source middleware.*
- ❖ *It enables communication with sensor clouds as well as cloud-based 'sensing as a service' IoTaaS is a middleware which enables provisioning of communication stack for smart devices using IPv6, oBIX, 6LoWPAN, CoAP and multiple standards and protocols.*
- ❖ *The oBIX is standard XML and web services protocol oBIX (Open Building Information Xchange).*

## **7. Differentiate IoT and M2M**

- ❖ *IoT technology in industry involves the integration of complex physical machinery M2M communication with the networks of sensors, and uses analytics, machine learning, and knowledge discovery software.*
- ❖ *M2M technology closely relates to IoT when the smart devices or machines collect data which is transmitted via the Internet to other devices or machines located remotely.*
- ❖ *The close difference between M2M and IoT is that M2M must deploy device to device, and carry out the coordination, monitoring, controlling of the devices and communicate without the usage of Internet whereas IoT deploys the Internet, server, Internet protocols and server or cloud end applications, services or processes.*
- ❖ *M2M has many applications in fields such as industrial automation, logistics, smart grid, smart cities, health and defence.*
- ❖ *Initial applications of M2M were found in automation and instrumentation only, but now these include telemetric applications and Industrial Internet of Things (IIoT) as well.*

## **8. What is microcontroller? List any two microcontrollers**

## **used in IoT**

- ❖ *Most commonly used control unit in IoT consists of a Microcontroller Unit (MCU) or a custom chip.*
- ❖ *A **microcontroller** is an integrated chip or core in a VLSI or SoC. Popular microcontrollers are ATmega 328, ATmega 32u4, ARM Cortex and ARM LPC.*
- ❖ *An MCU comprises a processor, memory and several other hardware units which are interfaced together.*
- ❖ *It also has firmware, timers, interrupt controllers and functional IO units.*
- ❖ *Additionally, an MCU has application-specific functional circuits designed as per the specific version of a given microcontroller family.*
- ❖ *For example, it may possess Analog to Digital Converters (ADC) and Pulse Width Modulators (PWM).*

## **9. List any four applications that can be deployed in smart home.**

*A connected home has the following applications deployed in a smart home:*

- ❖ *Mobile, tablets, **IP-TV**, VOIP telephony, video-conferencing, video-on-demand, video-surveillance, Wi-Fi and internet*
- ❖ *Home security: Access control and security alerts*
- ❖ *Lighting control*
- ❖ *Home healthcare*
- ❖ *Fire detection or Leak detection*
- ❖ *Energy efficiency*
- ❖ *Solar panel monitoring and control*
- ❖ *Temperature monitoring and HVAC control*
- ❖ *Refrigerator network with maintenance and service centres*

## **10. Define gateway. List different types of gateways?**

*Gateway refers to software for connecting two application layers, one at the sender **and** the other at the receiver*

[application layer gateway (ALG)]. A **gateway** may be of different types.

- a. A **communication** gateway at device and gateway domain has capabilities as protocol-conversion during communication between two ends when each end uses distinct protocols.
- b. An Internet gateway may have capabilities besides protocol conversion **transcoding data**, device management and data-enrichment before the data communication over **the Internet**.

**11. What is the purpose of communication gateway?**

- a. A **communication** gateway at device and gateway domain has capabilities as protocol-conversion during communication between two ends when each end uses distinct protocols.

**12. What is the purpose of Internet Gateway?**

- a. An Internet gateway may have capabilities besides protocol conversion **transcoding data**, device management and data-enrichment before the data communication over **the Internet**.

**13. Write any two features of Bluetooth.**

- A. Auto-synchronisation between mobile and other devices when both use Bluetooth.
- B. BT network uses features of self-discovery, self-configuration and self-healing.
- C. Radio range depending on class of radio; Class 1 or 2 or radios: 100 m, 10 m or 1 m used in device BT implementation.
- D. Support to NFC pairing for low latency in pairing the BT devices.
- E. Two modes—dual or single mode devices are used for IoT/M2M devices local area network.

- F. IPv6 connection option for BT Smart with IPSP (Internet Protocol Support Profile).*
- G. Smaller packets in LE mode.*
- H. Operation in secured as well as unsecured modes (devices can opt for both link-level as well as service-level security or just service level or unsecured level).*
- I. AES-CCM 128 authenticated encryption algorithm for confidentiality and authentication (Refer Example 2.4).*
- J. Connection of IoT/M2M/mobile devices using BT EDR device to the Internet with 24 Mbps Wi-Fi 802.11 adaptation layer (AMP: Alternative MAC/PHY layer) or BT-enabled wire-bound connection ports or device. MAC stands for media access control sublayer at a data-link layer/sublayer.*

#### **14. List any four IoT Operating systems.**

- ❖ *Examples of OSs are RIOT, Raspbian, Alljoyn, Spark and Contiki.*
- ❖ **RIoT** *is an operating system for IoT devices.*
- ❖ *RIoT supports both developer and multiple architectures, including ARM7, Cortex-M0, Cortex-M3, Cortex-M4, standard x86 PCs and TI MSP430.*
- ❖ **Raspbian** *is a popular Raspberry Pi operating system that is based on the Debian distribution of Linux.*
- ❖ **AllJoyn** *is an open-source OS created by Qualcomm. It is a cross platform OS with APIs available for Android, iOS, OS X, Linux and Windows OSs. It includes a framework and a set of services. It enables the manufacturers to create compatible devices.*
- ❖ **Spark** *is a distributed, cloud-based IoT operating system and web-based IDE. It includes a command-line interface, support for multiple languages and libraries for working with several different IoT devices.*
- ❖ **Contiki OS** *is an open-source multitasking OS. It includes 6LoWPAN, RPL, UDP, DTLS and TCP/IP protocols which are required in low-power wireless IoT devices. Example*

*of applications are street lighting in smart cities, which requires just 30 kB ROM and 10 kB RAM.*

**15. What is URL? Give example.**

*Universal Resource Locator is generally used for retrieving a resource(s) by a client. The saved resources may be at a document or at a remote server accessed using Internet protocols. An example of a URL is <http://www.rnhhe.com/> for a set of resource directories, resource repositories and resources on the McGraw Hill Higher Education server.*

**16. Write the use of Broker in communication**

*Broker denotes an object, which arranges the communication between two ends; for example, between the message publisher and subscriber. Or for example taking the request from a source and sending the response received back for that source after arranging the response from another object, such as a server*

**17. What is the use of web socket?**

*A WebSocket denotes an API for bidirectional communication that has much less header size than HTTP communication and lower latency compared to HTTP approach of unidirectional communication at an instant.*

**18. What is the use of browser?**

*Browser is a client software which displays hypertext that enables navigation to the Hypertext links shown on the user screen, and which displays GUIs of the apps, display form, display server responses, and so on.*

**19. What is the use of Application Programming Interface (API)?**

**Application Programming Interface (API)** refers to a software component, which receives messages from one end; for example, from an application or client or input. An API may consist of GUIs (button, check box, text box, dialog box). An API may get input to or from a server or a user. It then initiates actions and may send the messages, for example, to application software, server or a client at the other end etc.

**20. What is the purpose of Resource Directory?**

**Resource structure or resource directory** refers to a structure or collection of resources, applications, containers and groups, which may each have an attribute, access right, subscription and discovery.

**21. Mention the purpose of Message Cache.**

**Message Cache**

- Cache means storing when available and can be used later on when required.
- Messages cache is useful in an environment of short or prolonged disconnections of a service.
- A message can be accessed once or more times from a cache.

**22. What is URI? Specify the purpose of URI.**

**Universal Resource Identifier** is generally used for saved resources, such as contacts or address book. Example of a URI is /Contacts/First\_Character\_R/ for a set of resource directory contacts having resource repository First\_Character\_R for contacts with first character R and resources giving information about a contact. Another example is URI sensorNetworkj/sensorID\_N/temperature for a temperature value. The value is at a resource directory sensorNetworki for a sensor network, which stores sensor data for a sensor of id sensorID N.

**23. Mention the purpose of Message Queue.**



### ***Message Queue***

- *Message queuing means storing the messages (data) in sequence from devices or endpoints so that when connection state changes then messages can be forwarded.*
- *Forwarding is done using the first-in first-out method for a resource type. A message forwards only once from a queue. Separate queues are formed for each resource type.*
- *The messages are forwarded to the registered devices or endpoints and to the subscribed devices or endpoints.*
- *A separate registered device or endpoint list and a separate subscription list is maintained and used for each resource type.*
- *Forwarding takes place only after matching the subscription from a list.*

#### **24. What is transcoding?**

*Transcoding means coding or decoding before data transfer between two entities.*

#### **25. What is Star network?**

*Star network denotes the number of nodes interacting with a coordinator or master node.*

#### **26. What is Mesh Network?**

*Mesh network denotes the number of nodes that may interconnect with each other.*

#### **27. What is the purpose of Coordinator in IoT communication?**

*Coordinator denotes the one that connects to a number of end-points as well as routers in a star topology and forwards the data stack from one attached end point/router to another.*

#### **28. What are Master and Slave in case of IoT**

## **Communication?**

***Master** refers to the one who initiates the pairing with the devices in a star topology network.*

***Slave** means one that pairs with a master, uses the clock signals from master for synchronisation and uses address assigned by the master at the beginning.*

### **29. What is the use of Router?**

***Router** refers to a device or node capable of storing paths to each destination to which it has logical links. The router sends the data stack according to the available path or paths at a receiving instance.*

### **30. Mention the use of Proxy.**

***Proxy** refers to an application which receives a response from the server for usage of a client or application and which also receives requests from the client for the responses retrieved or saved at proxy*

### **31. What is Resource Registry?**

*A resource may have **resource registry**, which means it is usable after a resource instance is registered at the registry, and unusable when not-registered or when de-registered.*

- *A resource can be updated. A resource can be used when an application uses resource discovery.*
- *A resource can be updated.*
- *A resource can be used when an application uses resource discovery.*
- *A resource may have a resource repository.*
- *Repository refers to subfolder, folder or director), which contains the resources and their instances.*
- *A resource can have a resource directory, which directs to resource repository.*

## Questions for 3 or more marks

### 1. Write a note on smart and hyper connected devices. 3

- ❖ *Smart Devices are devices with computing and communication capabilities that can constantly connect to networks.*
- ❖ *For example, a city network of streetlights which constantly connects to the controlling station as shown in figure 1.1 for its services.*
- ❖ *Another example is hyper connected RFIDs.*
- ❖ *An RFID or a smart label is tagged to all consignments.*
- ❖ *This way many consignments sent from a place can be constantly tracked.*
- ❖ *Their movement through remote places, inventories at remote locations, sales and supply chain are controlled using a hyper-connected frame work for Internet of RFIDs*

### 2. Explain the equation that represents IoT conceptual framework for IoT architecture suggested by Oracle. 6

- *A single object (umbrella) communicating with central server for acquiring data. The following equation describes a simple conceptual framework of IoT.*

***Physical object + Controller, Sensor and Actuators + internet = Internet of Things .....1.1***

- *Equation 1.1 conceptually describes the Internet of umbrellas as consisting of an umbrella, a controller, sensor and actuators, and the Internet for connectivity to a web service and a mobile service provider.*
- *Generally, IoT consists of an internetwork of devices and physical objects wherein a number of objects can gather the data at remote locations and communicate to units managing, acquiring, organizing and analyzing the data in the processes and services*
- *Example 1.2 showed the number of streetlights communicating data to the group controller which connects to the central server using the Internet.*
- *A general framework consists of the number of devices communicating data to a data center or an enterprise or a cloud server.*

- *The IoT framework of IoT used in number of applications as well as in enterprise and business processes is therefore, in general, more complex than the one represented by Equation 1.1.*
- *The equation below conceptually represents the action and communication of data at successive levels in IoT consisting of internetworked devices and objects.*
- ***Gather+Enrich+Stream+Manager+Acquire+Organise and Analyze= Internet of Things with connectivity to data centre, enterprise or cloud server.....1.2***
- *Equation 1.2 is an IoT conceptual framework for enterprise processes and service based on a suggested IoT architecture given by Oracle.*

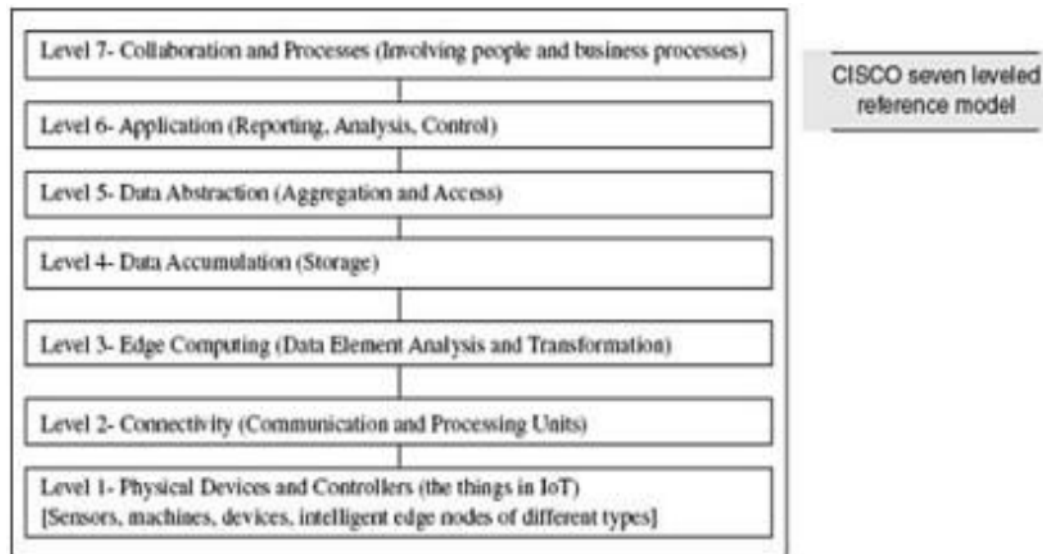
***The steps are as follows:***

1. *At level 1 data of the devices(things) sing sensors or the things gather the pre data from the internet*
2. *A sensor connected to a gateway, functions as a smart sensor (smart sensor refers to a sensor with computing and communication capacity). The data then enriches at level2, for example by transcoding at the gateway. Transcoding means coding or decoding before data transfer between two entities.*
3. *A communication management subsystem sends or receives data streams at level 3*
4. *Device management, identity management and access management subsystems receive the device's data at level 4*
5. *A data store or database acquires the data at level 5*
6. *Date routed from the devices and things organizes and analyses at level6. For example, data is analyzed for collecting business intelligence in business processes.*

### **3. Explain an IoT reference model suggested by CISCO for general IoT system. 6**

- A. An IoT system has multiple levels (Equations 1.1 to 1.3). These levels are also known as tiers. A model enables conceptualization of a framework.***

*B. A reference model can be used to depict building blocks, successive interactions and integration. An example is CISCO's presentation of a reference model comprising seven levels (Figure 1.4).*



**Figure 1.4 AnIoT reference model suggested by CISCO that gives a conceptual framework for a general IoT system**

***An architecture has the following features:***

- *The architecture serves as a reference in applications of IoT in services and business processes.*
- *A set of sensors which are smart, capture the data, perform necessary data element analysis and transformation as per device application framework and connect directly to a communication manager.*
- *A set of sensor circuits is connected to a gateway possessing separate data capturing, gathering, computing and communication capabilities.*
- *The gateway receives the data in one form at one end and sends it in another form to the other end.*
- *The communication-management subsystem consists of protocol handlers, message routers and message cache.*
- *This management subsystem has functionalities for device identity database, device identity management and access management.*
- *Data routes from the gateway through the Internet and data centre to the application server or enterprise server which acquires that data.*

- *Organization and analysis subsystems enable the services, business processes, enterprise integration and complex processes*

#### **4. List and explain major components of IoT systems      6**

*Major components of IoT devices are:*

1. **Physical object** with embedded software into a hardware.
2. **Hardware** consisting of a microcontroller, firmware, sensors, control unit, actuators and communication module.
3. **Communication module:** Software consisting of device APIs and device interface for communication over the network and communication circuit/port(s), and middleware for creating communication stacks using 6LowPAN, CoAP, LWM2M, IPv4, IPv6 and other protocols.
4. **Software** for actions on messages, information and commands which the devices receive and then output to the actuators, which enable actions such as glowing LEDs, robotic hand movement etc.

#### **Sensors and Control Units**

##### **Sensors**

*Sensors are electronic devices that sense the physical environments. An industrial automation system or robotic system has multiple smart sensors embedded in it. Sensor-actuator pairs are used in control systems. A smart sensor includes computing and communication circuits.*

**Sensors are of two types.**

- *The first type gives analog inputs to the control unit. Examples are thermistor, photoconductor, pressure gauge and Hall sensor.*
- *The second type gives digital inputs to the control unit.*
- *Examples are touch sensor, proximity sensor, metal sensor, traffic presence sensor, rotator encoder for measuring angles and linear encoders for measuring linear displacements.*

##### **Control Units**

- *Most commonly used control unit in IoT consists of a Microcontroller Unit (MCU) or a custom chip.*
- *A **microcontroller** is an integrated chip or core in a VLSI or SoC. Popular microcontrollers are ATmega 328, ATmega 32u4, ARM Cortex and ARM LPC.*
- *An MCU comprises a processor, memory and several other hardware units which are interfaced together.*
- *It also has firmware, timers, interrupt controllers and functional IO units.*
- *For example, it may possess Analog to Digital Converters (ADC) and Pulse Width Modulators (PWM).*

### **Communication Module**

- ❑ *A communication module consists of protocol handlers, message queue and message cache.*
- ❑ *A device message-queue inserts the messages in the queue and deletes the messages from the queue in a first-in first-out manner.*
- ❑ *A device message-cache stores the received messages.*
- ❑ *Representational State Transfer (REST) architectural style can be used for HTTP access by GET, POST, PUT and DELETE methods for resources and building web services.*

### **Software**

- ❑ *IoT software consists of two components—software at the IoT device and software at the IoT server.*

### **Middleware**

- ❖ *OpenIoT is an open source middleware.*
- ❖ *It enables communication with sensor clouds as well as cloud-based 'sensing as a service' IoTaaS is a middleware which enables provisioning of communication stack for smart devices using IPv6, oBIX, 6LoWPAN, CoAP and multiple standards and protocols.*
- ❖ *The oBIX is standard XML and web services protocol oBIX (Open Building Information Xchange).*

### **Firmware**

- ❖ *Thingsquare Mist is an open-source firmware (software embedded in hardware) for us Internet-connectivity to the IoT. It enables resilient wireless mesh networking. Several microcontrollers with a range of wireless radios support Things MIST.*

### **Operating Systems (OS)**

- *Examples of OSs are RIOT, Raspbian, Alljoyn, Spark and Contiki.*
- *RIoT is an operating system for IoT devices.*
- *RIoT supports both developer and multiple architectures, including ARM7, Cortex-M0, Cortex-M3, Cortex-M4, standard x86 PCs and TI MSP430.*
- *Raspbian is a popular Raspberry Pi operating system that is based on the Debian distribution of Linux.*
- *AllJoyn is an open-source OS created by Qualcomm. It is a cross platform OS with APIs available for Android, iOS, OS X, Linux and Windows OSs. It includes a framework and a set of services. It enables the manufacturers to create compatible devices.*
- *Spark is a distributed, cloud-based IoT operating system and web-based IDE. It includes a command-line interface, support for multiple languages and libraries for working with several different IoT devices.*
- *Contiki OS<sup>7</sup> is an open-source multitasking OS. It includes 6LoWPAN, RPL, UDP, DTLS and TCP/IP protocols which are required in low-power wireless IoT devices. Example of applications are street lighting in smart cities, which requires just 30 kB ROM and 10 kB RAM.*

## **5. List and explain popular IoT development boards. 6**

### **Popular IoT Development Boards**

- ❑ *Arduino Yun: Arduino Yun board uses microcontroller ATmega32u4 that supports Arduino and includes WiFi, Ethernet, USB port, micro-SD card slot and three reset buttons. The board also combines with Atheros AR9331 that runs Linux.*



- ❑ **Microduino:** *Microduino is a small board compatible with Arduino that can be stacked with the other boards. All the hardware designs are open source.*
- ❑ **Intel Galileo:** *Intel Galileo is a line of Arduino-certified development boards. Galileo is based on Intel x86 architecture. It is open-source hardware that features the Intel SOC X1000 Quark based Soc.*
- ❑ *Galileo is pin-compatible with Arduino. It has 20 digital I/O (12 GPIOs fully native), 12-bit PWM for more precise control, six analog inputs and supports power over Ethernet (PoE).*
- ❑ **Intel Edison:** *Intel Edison is a compute module. It enables creation of prototypes and fast development of prototyping projects and rapidly produces IoT and wearable computing devices. It enables seamless device internetworking and device-to-cloud communication. It includes foundational tools. The tools collect, store and process data in the cloud, and process rules on the data stream. It generates triggers and alerts based on advanced analytics.*
- ❑ **Beagle Board:** *Beagle Bone based board has very low power requirement. It is a card-like computer which can run Android and Linux. Both the hardware designs and the software for the IoT devices are open source.*
- ❑ **Raspberry Pi Wireless Inventors Kit (RasWIK):** *RasWIK enables Raspberry Pi Wi-Fi connected devices. It includes documentation for 29 different projects or you can come up with one of your own. There is a fee for the devices but all of the included code is open source, and you can use it to build commercial products as well.*

## **6. List the functions of fitness tracker wearable devices      4**

*Examples of IoT usages are wearable devices such as watches, fitness trackers, sleep **monitors and** heart monitors etc. Fitbit (for example, Fitbit Alta **fitness tracker**), Garmin and other companies manufacture many such devices. Microsoft (Microsoft band might soon be discontinued), Xiaomi and other*

manufacturers make tracking bands. A fitness tracker wearable band has the following functions:

- ❑ Track steps, distance, calories burned and active minutes
- ❑ See scats and time with a bright OLED tap display
- ❑ Automatically track how long and how well you sleep and set a silent, vibrating alarm
- ❑ Personalize with interchangeable metal, leather and classic bands
- ❑ Get calls, texts and calendar notifications at a glance when the phone is in a defined range.

Clothing and accessories nowadays incorporate computer and advanced electronic technologies. The design of watches, rings and bands often includes practical functions and features

## 7. Explain general IoT Framework with block diagram 6

- ❖ Figure 1.2 shows a general framework for IoT using smart and hyper connected devices, edge computing and applications.
- ❖ A device is considered at the edge of Internet infrastructure.
- ❖ Edge computing implies computations at the device level before the computed data communicates over the internet.

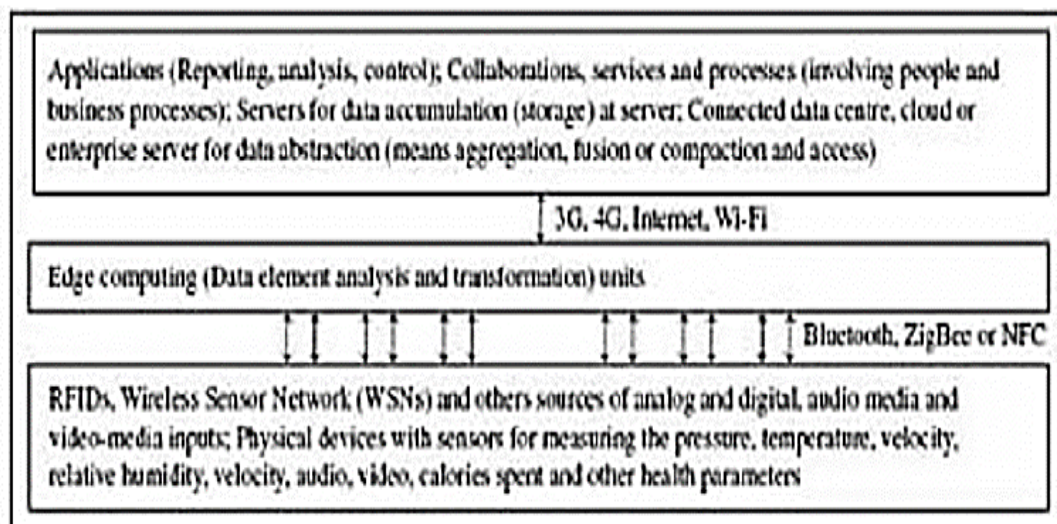


Figure 1.2 A general framework for IoT using smart and hyperconnected devices, edge computing and applications

- A general framework consists of the number of devices communicating data to a data center or an enterprise or a cloud server.

- *The IoT framework of IoT used in number of applications as well as in enterprise and business processes is therefore, in general, more complex than the one represented by Equation 1.1.*
- *The equation below conceptually represents the action and communication of data at successive levels in IoT consisting of internetworked devices and objects.*
- ***Gather+Enrich+Stream+Manager+Acquire+Organise and Analyze= Internet of Things with connectivity to data centre, enterprise or cloud server.....1.2***
- *Equation 1.2 is an IoT conceptual framework for enterprise processes and service based on a suggested IoT architecture given by Oracle.*

***The steps are as follows:***

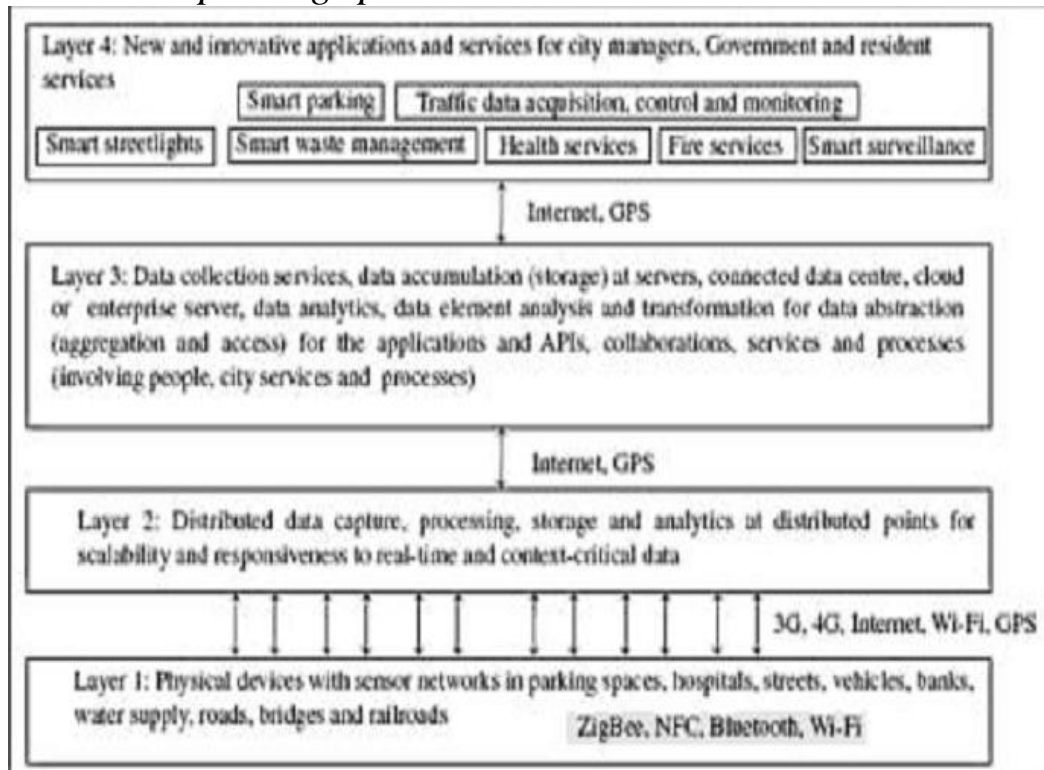
1. *At level 1 data of the devices(things) sing sensors or the things gather the pre data from the internet*
2. *A sensor connected to a gateway, functions as a smart sensor (smart sensor refers to a sensor with computing and communication capacity). The data then enriches at level2, for example by transcoding at the gateway. Transcoding means coding or decoding before data transfer between two entities.*
3. *A communication management subsystem sends or receives data streams at level 3*
4. *Device management, identity management and access management subsystems receive the device's data at level 4*
5. *A data store or database acquires the data at level 5*
6. *Date routed from the devices and things organizes and analyses at level6. For example, data is analysed for collecting business intelligence in business processes.*

## **8. Explain the role of four layers in Smart –City architecture 6**

### ***Smart Cities***

*The IoT concept extends to Internet of Everything (IoE) for developing smart cities. A four-layer architectural framework developed at CISCO for a city is as follows (Figure 1.12):*

*Layer I consists of sensors, sensor networks and devices network in parking spaces.*



**Figure 1.12 Four-layer architectural framework developed at CISCO for a city**

1. Hospitals, streets, vehicles, banks, water supply, roads, bridges and railroads. Bluetooth, ZigBee, NFC, Wi-Fi are the protocols used at this layer.
2. Layer 2 captures data at distributed computing points where data is processed, stored and analysed.
3. Layer 3 is meant for central collection services, connected data centres, cloud and enterprise servers for data analytics applications
4. Layer 4 consists of new innovative applications, such as waste containers 'monitoring, WSNs for power loss monitoring, bike sharing management and smart parking. Smart parking refers to services for motorists that informs

*them about the nearby parking services with vacant spaces in advance.*

*Smart cities are becoming a reality with innovations being adds each year.*

## 9. Explain any six features of hyperconnected wearable smart watches

6

<i>Samsung Galaxy Gear Smart watch</i>	<i>Apple Watch features</i>	<i>Microsoft Wrist Band 2 features</i>
<ul style="list-style-type: none"> <li>• Two-inch curved display</li> <li>• Ability to make a phone call (completely independent of an actual smartphone) or send a text</li> <li>• Wi-Fi and Bluetooth connectivity options</li> <li>• GPS enabled</li> <li>• S Health App measures heart rate and UV monitors and inform: the wearer of a goodtime to eat, when he/she has had enough exercise and a good time to take rest</li> <li>• Has navigational features to assist walking</li> </ul>	<ul style="list-style-type: none"> <li>• Apple iSmartwatch has App. like Nike</li> <li>• Running to track morning or evening runs and health and fitness. it can Track walks</li> <li>• Measure heart rate</li> <li>• Make payment using payment wallet</li> <li>• Enable listening to songs while exploring parks without phone</li> <li>• Enable chat with family</li> <li>• Update email</li> <li>• Find a taxi</li> <li>• Update news</li> <li>• Navigate for long car trips</li> <li>• Control Apple TV</li> <li>• Set/reminders for baseball games to be watched</li> </ul>	<ul style="list-style-type: none"> <li>• Fitness tracking</li> <li>• Can help with productivity by displaying email, calendar and message notification</li> <li>• Works with windows phone, IOS devices and Android devices</li> <li>• Sensors: optical heart rate, 3-axis accelerometer, gyrometer, GPS, ambient light, UV, skin temperature, capacitive sensor, galvanic skin response, barometer</li> </ul>

## 10. Write a note on NFC

6

### *Near Field Communications:*

*1. Near-Field Communication (NFC) is an enhancement of ISO/IEC<sup>2</sup>14443 standard for contact-less proximity-*

card. NFC is a short distance (20 cm) wireless communication technology.

2. It enables data exchange between cards in proximity and other devices.
3. Examples of applications of NFC are proximity-card reader/RFID/IoT/M2M/mobile device, mobile payment wallet, and electronic keys for car, house, office entry keys and biometric passport readers.
4. NFC devices transmit and receive data at the same instance and the setup time (time taken to start the communication) is 0.1 s.
5. The device or its reader can generate RF fields for the nearby passive devices such as passive RFID.
6. An NFC device **can** check RF field and detect collision of transmitted signals.
7. The device can check collision when the received signal bits do not match with the transmitted signal bits.
8. Features of an NFC device are:
  - Range of functioning is within 10 to 20 cm.
  - The device can also communicate with Bluetooth and Wi-Fi devices in order to extend the distance from 10 cm to 30 m or higher.
  - The device is able to receive and pass the data to a Bluetooth connection or standardised LAN or Wi-Fi using information handover functions.
  - Device data transfer rates are 106 kbps, 212 kbps, 424 kbps and 848 kbps (bps stands for bit per second, kbps for kilo bit per second).

Three modes of communication are:

**Point-to-point (P2P) mode:** Both devices use the active devices in which RF fields alternately generate when communicating.

**Card-emulation mode:** Communication without interruption for the read and write as required in a smart card and smart card reader. FeliCa<sup>™</sup> and Mifare<sup>™</sup> standards are protocols for reading and writing data on the

card device and reader, and then the reader can transfer information to Bluetooth or LAN.

**Reader mode:** Using NFC the device reads passive RFID device. The RF field is generated by an active NFC device. This enables the passive device to communicate

## **11. Explain sensors, actuators and software used for building Smart Home. 3**

- ❑ *Sensors and actuators manage a smart home with an Internet connection.*
- ❑ *Wired and wireless sensors are incorporated into the security sensors, cameras, thermostats, smart plugs, lights and entertainment systems.*
- ❑ *Do-it-Yourself (DIY) sensors and actuators, include smart plug, motion detector, door/window detector, smoke detector, energy meter interface (electric, gas, water), remote control (built-in authentication), smart relay, surveillance camera, Wireless Hi-Fi speakers, HUE LED lights, electric utility meter etc.<sup>24</sup>*

*A connected home has the following applications deployed in a smart home:*

- ❖ *Mobile, tablets, IP-TV, VOIP telephony, video-conferencing, video-on-demand, video-surveillance, Wi-Fi and internet*
- ❖ *Home security: Access control and security alerts*
- ❖ *Lighting control*
- ❖ *Home healthcare*
- ❖ *Fire detection or Leak detection*
- ❖ *Energy efficiency*
- ❖ *Solar panel monitoring and control*
- ❖ *Temperature monitoring and HVAC control*
- ❖ *Refrigerator network with maintenance and service centres*

### **Home Automation Software**

- *Intel-based intelligent gateway enables creation of a home automation system offered by service providers for telephony, mobile, cable, broadband and security.*

- *OpenHAB (open Home Automation Bus) enables the smart home devices that communicate via home. It has a companion cloud computing service called my openHAB. It runs on a Java-enabled system.*
- *The Thing System enables the smart home devices which communicate and are controlled via home.*
- *The language used is Node.js.*
- *It deploys a Raspberry Pi and consists of software components and network protocols for all Internet-connected things at home.*

## 12. Write a note on WiFi.

3

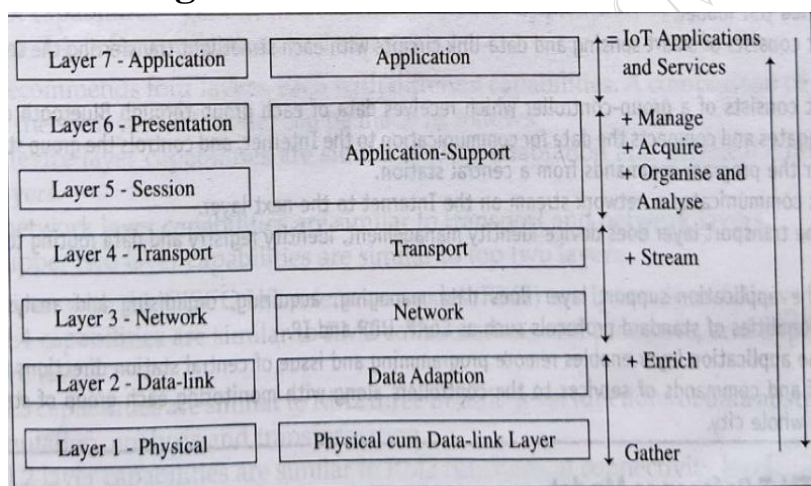
### Wi-Fi

- ❑ *Wi-Fi is an interface technology that uses IEEE 802.11 protocol and enables the Wireless Local Area Networks (WLANs).*
- ❑ *Wi-Fi devices connect enterprises, universities and offices through home Access Points (AP)/public hotspots.*
- ❑ *Wi-Fi connects distributed WLAN networks using the Internet.*
- ❑ *Automobiles, instruments, home networking, sensors, actuators, industrial device nodes, computers, tablets, mobiles, printers and many devices have Wi-Fi interface.*
- ❑ *They network using a Wi-Fi network.*
- ❑ *Wi-Fi is very popular.*
- ❑ *The issues of Wi-Fi interfaces, APs and routers are higher power consumption, interference and performance degradation*
- ❑ *Wi-Fi interfaces connect within themselves or to an AP or wireless router using Wi-Fi PCMCIA or PCI card or built-in circuit cards and through the following:*
  - ❖ *Base station (BS) or AP*
  - ❖ *A WLAN transceiver or BS can connect one or many wireless devices simultaneously to the Internet.*



- ❖ **Peer-to-peer nodes** without access point: Client devices within Independent Basic Service Set (IBSS) **network** can communicate directly with each other.
- ❖ It enables fast and easy setting of an 802.11 network.
- ❖ Peer to multipoint nodes with Basic Service Sets (BSSs) using one in-between AP point or distributed BSSs connect through multiple Aps
- ❖ Connectivity **range of each BSS** depends on the range of wireless bridges and antennae used and environmental conditions.
- ❖ Each BSS is a Service Set Identifier (SSID)

### 13. Explain IETF six layer modified OSI model for IoT with block diagram 6



**Figure 2.1** Seven-layer generalised OSI model (on left) and IETF six layer modified OSI model for IoT/ M2M (in the middle), and similarity with the conceptual framework Equation 1.2 (on right) for IoT applications and services

- ❖ Figure 2.1 shows a classical seven-layer OSI model (on the left) and the modifications in that model proposed by IETF (in the middle).
- ❖ Data communicates from device end to application end. Each layer processes the received data and creates a new data stack which transfers it to the next layer.
- ❖ The processing takes place at the in-between layers, i.e. between the bottom functional-layer to the top layer.

- ❖ *Device end also receives data from an application/service after processing at the in-between layers. Figure 2.1 also shows a similarity with the conceptual framework in Equation 1.2:*
- ❖ ***Gather + Enrich + Stream + (Manage + Acquire + Organise + Analyse) = IoT Applications and services***
- ❖ *New applications and services are present at the application layer 6.*
- ❖ *A modification to this is that the application-support layer 5 uses protocols, such as CoAP.*
- ❖ *IoT applications and services commonly use them for network communication.*
- ❖ *The CoAP protocol at the layer is used for the request/response interactions between the client and server at the network.*
- ❖ *Similarly, the application-support layer may include processes for data managing, acquiring, organising and analysing which are mostly used by applications and services.*
- ❖ *Modifications are also at the data-link layer 2 (L2) and physical layer 1 (L1).*
- ❖ *The new layers are data-adaptation (new L2) and physical cum data-link (new L1).*
- ❖ *The data-adaptation layer includes a gateway.*
- ❖ *The gateway enables communication between the devices network and the web.*
- ❖ *A physical IoT/M2M device hardware may integrate a wireless transceiver using a communication protocol as well as a data-link protocol for linking the data stacks of L1 and L2.*

#### **14. Write the features and communication modes used in NFC      4**

***Features of an NFC device are:***

- *Range of functioning is within 10 to 20 cm.*

- The device can also communicate with Bluetooth and Wi-Fi devices in order to extend the distance from 10 cm to 30 m or higher.
- The device is able to receive and pass the data to a Bluetooth connection or standardised LAN or Wi-Fi using information handover functions.
- Device data transfer rates are 106 kbps, 212 kbps, 424 kbps and 848 kbps (bps stands for bit per second, kbps for kilo bit per second).

**Three modes of communication are:**

**Point-to-point (P2P) mode:** Both devices use the active devices in which RF fields alternately generate when communicating.

**Card-emulation mode:** Communication without interruption for the read and write as required in a smart card and smart card reader. FeliCa™ and Mifare™ standards are protocols for reading and writing data on the card device and reader, and then the reader can transfer information to Bluetooth or LAN.

**Reader mode:** Using NFC the device reads passive RFID device. The RF field is generated by an active NFC device. This enables the passive device to communicate

## 15. Explain any six features of Bluetooth 6

*Its features are:*

- ☐ Auto-synchronisation between mobile and other devices when both use BT. BT network uses features of self-discovery, self-configuration and self-healing. Radio range depending on class of radio; Class 1 or 2 or radios: 100 m, 10 m or 1 m used in device BT implementation.
- ☐ Support to NFC pairing for low latency in pairing the BT devices.
- ☐ Two modes—dual or single mode devices are used for IoT/M2M devices local area network. IPv6 connection option for BT Smart with IPSP (Internet Protocol Support Profile).

- ❑ *Smaller packets in LE mode. Operation in secured as well as unsecured modes (devices can opt for both link-level as well as service-level security or just service level or unsecured level).*
- ❑ *AES-CCM 128 authenticated encryption algorithm for confidentiality and authentication (Refer Example 2.4).*
- ❑ *Connection of IoT/M2M/mobile devices using BT EDR device to the Internet with 24 Mbps Wi-Fi 802.11 adaptation layer (AMP: Alternative MAC/PHY layer) or BT-enabled wire-bound connection ports or device. MAC stands for media access control sublayer at a data-link layer/sublayer.*

## **16. Explain ( Any 2 may be asked for three marks each)**

### **a) Polling and observing**

#### ***Polling or Observing***

- *Polling means finding from where new messages would be available or whether new messages are available or updates are available or whether the information needs to be refreshed or finding the status if the state information has changed or not.*
- *When messages store at a database-server, then polling can be done by a client who uses the REST architecture GET method and server uses the POST.*
- *A state may refer to a connection or disconnection, sleep, awake, created, alive (not deleted), old values persisting or updated with new values (GET + OBSERVE).*
- *Observing means looking for change, if any, of a state at periodic intervals (OBSERVE).*

### **b) Client-Server System**

*Client refers to a software object which makes request for data, messages, resources or objects. A client can have one or more object instances. A client may also have an API or many APIs for enabling the communication to ther server. A client*

*can be at a device or application on a network or Internet connected web, enterprise server or cloud.*

c) **Server** is defined as a software which sends a response on a request. The server also sends messages, alerts or notifications. The server has access to resources, databases and objects. A server can be on a device or can be on a separate computer system, not necessarily on Internet connected web.

#### **d) Publish-Subscribe**

*Publish/subscribe or PubSub message exchanges differ from request/response. A service publishes the messages; for example, a weather information service publishes the messages of weather reports for the potential receivers. A group controller publishes the messages; for example, measured values of ambient light conditions, traffic density or traffic presence (Example 1.2). :*

- *A service can be availed by one or more clients or brokers.*
- *When a client subscribes to the service, it receives messages from that service.*
- *A publish/subscribe messaging protocol provisions for publication of messages and reception on subscription (PUT and GET methods) by the registered or authenticated devices.*
- *Publication may be for measured values, for state information or resources of one or more types.*
- *Subscription is for a 'resource-type (or for a topic). A separate subscription is required for each resource-type or topic.*
- *An example of resource type is measured values of ambient light condition in the smart streetlights example.*
- *Another resource type is traffic presence or absence on the street.*
- *Another resource type is lighting function report; functioning is proper or fault exists in the light.*

#### **e) Push-Pull**

### ***Push (Publish/Subscribe) Data***

- *Push means a service that pushes the messages or information regularly.*
- *Interested device or endpoint or potential receiver receives these pushes.*
- *For example, a mobile service provider pushes the temperature and location information regularly for the potential receivers (registered mobile services subscribers) (PUT).*
- *Push is efficient compared to polling, particularly when notifying or sending alerts.*
- *This is because there can be many instances when polling returns no data.*
- *Pull is efficient compared to polling or PUSH when certainty exists that within a reasonable time interval the server returns no data.*

### ***Pull (Subscribe/Notify) Data***

*Pull means pulling a resource, value, message or data of a resource-type by registering and subscribing. Pull may be using GET or on initiating OBSERVE. The server maintains state information for a resource and notifies on change of state. Client pulls again the resource on the change.*

### **f) Message Cache**

#### ***Message Cache***

- *Cache means storing when available and can be used later on when required.*
- *Messages cache is useful in an environment of short or prolonged disconnections of a service.*
- *A message can be accessed once or more times from a cache.*

### **g) Message Queue**

#### ***Message Queue***

- *Message queuing means storing the messages (data) in sequence from devices or endpoints so that when connection state changes then messages can be forwarded.*

- Forwarding is done using the first-in first-out method for a resource type. A message forwards only once from a queue. Separate queues are formed for each resource type.
- The messages are forwarded to the registered devices or endpoints and to the subscribed devices or endpoints.
- A separate registered device or endpoint list and a separate subscription list is maintained and used for each resource type.
- Forwarding takes place only after matching the subscription from a list.

**17. Write a note on    a. Wireless USB    b. Ethernet    6**  
**Wireless USB**

*Wireless USB is a wireless extension of USB 2.0 and it operates at ultra-wide band (UWB) 5.1 GHz to 10.6 GHz frequencies. It is for short-range personal area network (high speed 480 Mbps 3 m or 110 Mbps 10 m channel). FCC recommends a host wire adapter (HWA) and a device wire adapter (DWA), which provides wireless USB solution. Wireless USB also supports dual-role devices (DRDs). A device can be a USB device as well as limited capability host*

**Ethernet:**

*Ethernet standard is IEEE 802.2 (ISO 8802.2) protocol for local area network of computers, workstations and device LANs. Each frame at a LAN consists of header. Ethernet enables the services of local device nodes, computers, systems and local resources, such as printers, hard disks pace, software and data.*

***Features of Ethernet network are:***

- ❑ *Uses passive broadcast medium and is wired connections based Formatting of frame (serially sent bits as PDU of MAC layer) is according to IEEE 802.2 standard Uses a 48-bit MAC address assigned distinctly to each computer on the LAN Address Resolution Protocol (ARP) resolves a 32 bit IP address at Internet device LANs.*
- ❑ *Each frame at a LAN destination host media address.*

- ❑ *Reverse Address Resolution Protocol (RARP) resolves 48 bit destination host media address into 32 bit IP addresses for Internet communication.*
- ❑ *Uses wired bus topology, and transmission speeds are 10 Mbps, 100 Mbps (unshielded and shielded wires), 1 Gbps (high-quality coaxial cable), 4 Gbps (in twisted pair wiring mode) and 10 Gbps (fiber-optic cables). Uses MAC-based on CSMA/CD (Carrier Sense Multiple Access with Collision Detection).*
- ❑ *The CSMA/CD mode is half-duplex (wired mode) which means transmit (Tx) and receive (Rx) signals can be sent on the same wire or data path.*
- ❑ *Each one connected to a common communication channel in the network listens and if the channel is idle then transmits.*
- ❑ *If not idle, it waits and tries again.*
- ❑ *A mode is full-duplex in case of optical-fibre-based Ethernet that transmits and receives signals separated on dedicated, one-way channels.*
- ❑ *Uses transmission data stack into frames at MAC layer, and each frame includes a header.*
- ❑ *The header's first eight bytes specify a preamble.*
- ❑ *The preamble is for indicating start of a frame and is used for synchronisation.*
- ❑ *Then the header has next six bytes' destination address and then six bytes of the source address.*
- ❑ *Then next six bytes are for the type field.*
- ❑ *These are meaningful only for the higher network layers and define the length of the data stack to the next layer.*
- ❑ *Next, minimum 72 bytes and maximum 1500 bytes of data follow the length definition.*
- ❑ *The last 4 bytes are for CRC (Cyclic Redundancy Check) for the frame sequence check.*

## **18. List different protocols used in message communication.**

**Write the features of any two.      6**

Following are the protocols used in message communication



- ❑ **CoAP-SMS and CoAP-MQ**
- ❑ **MQTT Protocol:**
- ❑ **XMPP (Extensible Messaging and Presence Protocol)**

### **CoAP-SMS**

- *CoAP-SMS is a protocol when CoAP object uses **IP** as well as cellular networks and uses SMS.*
- *It is an alternative to UDP-DTLS over ROLL for CoAP object messages and when using cellular communication.*
- *SMS is used instead of UDP + DTLS by a **CoAP client or server**.*
- *A CoAP client communicates to a mobile terminal (MT) endpoint over the General Packet Radio Service (GPRS), High Speed Packet Access (HSPA) or Long Term Evolution (LTE) networks using CoAP-SMS protocol.*

### **CoAP-MQ:**

*CoAP-MQ is a message queue protocol using a broker and RD. Roles of CoAP endpoints have roles as a client and server. The server also provisions for forwarding to the subscriber and proxy services. The figure also shows that RD services are resource discovery, directory and the object registration services. The device objects communicate using the CoAP client and Server protocols and CoAP web objects using DTLS as security protocol and UDP for CoAP APIs.*

### **MQTT Protocol:**

*Message Queuing Telemetry Transport (MQTT) is an open-source protocol for machine-to-machine (M2M)/IoT connectivity. Word 'telemetry', in English dictionary, means measuring and sending values or messages to far off places by radio or other mechanism*

- *IBM first created it and then donated it to M2M 'Paho' project of Eclipse. A version is MQTT V3.1.1. MQTT has been accepted 2014 as OASIS (organization for the Advancement of Structured Information Standards) standard MQTT protocol is used for connectivity in M2M/IoT communication.*

- A version is *MQTT-SN v1.2 Sensor networks and non-TCP/IP networks*, such as ZigBee can use the *MQTT-SN*. *MQTT-SN* is also publish/subscribe messaging protocol. It enables extension of the *MQTT* protocol for *WSNs*, the sensor and actuator device and their networks.
- The objects communicate using the connected devices network protocols such as ZigBee.
- Web objects also use *MQTT* library functions and communicate using *IP* network and *SSL* and *TLS* security protocols for subscribing and publishing web APIs.

**Features of XMPP are:**

- ⌚ *XMPP uses XML.*
- ⌚ *XML elements are sent in the open-ended stream within the tag <stream> and corresponding end tag </stream>.*
- ⌚ *Three basic types of XMPP stanzas (elements) are:*
  - *message*
  - *presence*
  - *iq (information/query, request/response)*
- ⌚ *Extensibility to constrained environment messaging and presence protocols as well as IP network messaging.*
- ⌚ *Extensibility of request-response (client-server) architecture to iq (information through querying), PubSub messaging, Chat room MUC messaging and other architecture (where group of people exchange information when present in a chat room), decentralised XMPP server.*
- *XMPP server set by anyone on the following standards recommended and using XSF xeps; for example, XMPP-IoT server, and XMPP M2M server for messaging between the machines.*
- *Authentication by SASL/TLS, and support from intelligent and business analyst applications, and processing through XMPP server and gateway for connecting device network with IP network.*

**19. Write a note on**

**6**

**A. Bluetooth**

***Bluetooth BR/EDR and Bluetooth Low Energy:***

- **Bluetooth** devices follow IEEE 802.15.1 standard protocol for LI (physical cum data-link layer)
- BT devices form a WPAN devices network. Two types of modes for the devices are **Bluetooth BR/EDR (Basic rate 1 Mbps/Enhanced Data Rate 2 Mbps and 3 Mbps)** and **Bluetooth low energy (BT LE 1 Mbps)**
- A latest version of Bluetooth v4.2.
- BT LE is also called Bluetooth smart.
- Bluetooth v4.2 (December 2014) provides the LE data packet length extension, link layer privacy and secure connections, extended scanner and filter link layer policies and IPSP.
- BT LE range is 150 m at 10 mW power output, data transfer rate is 1 Mbps and setup time is less than 6 s.
- Bluetooth v5, released in June 2016, has increased the broadcast capacity by 800%, quadrupled the range and doubled the speed.
- A device may have provisions for single mode BT LE or dual mode BT BR/EDR (Mbps stands for Million Bits per second). Its features are:
  - Auto-synchronisation between mobile and other devices when both use BT.
  - BT network uses features of self-discovery, self-configuration and self-healing.
  - Radio range depending on class of radio; Class 1 or 2 or radios: 100 m, 10 m or 1 m used in device BT implementation.
  - Support to NFC pairing for low latency in pairing the BT devices.
  - Two modes—dual or single mode devices are used for IoT/M2M devices local area network.
  - IPv6 connection option for BT Smart with IPSP (Internet Protocol Support Profile).
  - Smaller packets in LE mode.
  - Operation in secured as well as unsecured modes (devices can opt for both link-level as well as service-level security or just service level or unsecured level).

- *AES-CCM 128 authenticated encryption algorithm for confidentiality and authentication (Refer Example 2.4).*
- *Connection of IoT/M2M/mobile devices using BT EDR device to the Internet with 24 Mbps Wi-Fi 802.11 adaptation layer (AMP: Alternative MAC/PHY layer) or BT-enabled wire-bound connection ports or device. MAC stands for media access control sublayer at a data-link layer/sublayer.*

## **B. Wired USB**

**Wired USB:** *Universal Serial Bus (USB) is for fast serial transmission and reception between the hosts, the embedded system and distributed serial devices; for example, like connecting a keyboard, printer or scanner.*

- ❖ *USB is a bus between the host system and a number of interconnected peripheral devices. Maximum 127 devices can connect with a host.*
- ❖ *USB standard provides a fast (up to 12 Mbps) as well as a low-speed (up to 1.5 Mbps) serial transmission and reception between the host and serial devices.*
- ❖ *Both the host and device can function in a system.*
- ❖ *USB three standards are USB 1.1 (1.5 and 12 Mbps), 2.0 (mini size connector) 480 Mbps, 3.0 (micro size connector) 5 Gbps and 3.1 (super speed 10 Gbps).*

**Features of a USB are:**

- ❑ *USB data format and transfer serial signals are Non Return to Zero (NRZI) and the clock is encoded by inserting synchronous code (SYNC) field before each packet.*
- ❑ *The receiver synchronises bit recovery clock continuously.*
- ❑ *The data transfer is of four types—controlled data transfer, bulk data transfer, interrupt driven data transfer **and** isosynchronous transfer.*
- ❑ *USB is a polled bus.*

- ❑ *Polling mode functions as: A host controller regularly polls the presence of a device as scheduled by the software.*
- ❑ *It sends a token **packet**.*
- ❑ *The token consists of fields for type, direction, USB device address and device **end-point number**.*
- ❑ *The device does handshaking through a handshake packet, indicating successful or unsuccessful transmission.*
- ❑ *A CRC field in a data packet permits error detection.*
- ❑ *A USB supports three types of pipes— Stream with no USB-defined protocol is used when the connection is already established and the data flow starts.*
- ❑ *Default control is for providing access.*
- ❑ *Message is for control functions of the device.*
- ❑ *The host configures each pipe with the data bandwidth to be use transfer service type and buffer sizes.*

## **C. Wireless USB**

### **Wireless USB**

*Wireless USB is a wireless extension of USB 2.0 and it operates at ultra-wide band (UWB) 5.1 GHz to 10.6 GHz frequencies. It is for short-range personal area network (high speed 480 Mbps 3 m or 110 Mbps 10 m channel). FCC recommends a host wire adapter (HWA) and a device wire adapter (DWA), which provides wireless USB solution. Wireless USB also supports dual-role devices (DRDs). A device can be a USB device as well as limited capability host*

## **D. UART/USART**

### **UART/USART seriral Communication**

*A Universal Asynchronous' Transmitter (UART) enables serial communication (**transmission**) of 8 bits serially with a start bit at the start of transmission of a byte **on** serial*

**Transmitter Data (TxD) output line.** Serial means present one after another at successive time intervals

Asynchronous refers to all bytes in a frame transmit, which can result in variation in time interval spacing or phase differences between successive bytes and in-between wait interval. This is because clock information of transmitter does not transmit along with the data. The receiver clock also does not synchronize with the data. Further, successive set of bytes may wait after transmission till an acknowledgement is received from the receiving end

- The intervals of each transmit bit are controlled by a clock.
- When the clock, period is  $T = 0.01 \mu\text{s}$ , then period for transmission of a byte on TxD =  $10 T = 0.1 \mu\text{s}$ .
- A byte's transfer rate is 1 MBps.
- Reciprocal of  $T$  in UART is called Baud rate.
- When an additional bit appends between stop bit and last bit of the byte, then  $T = 0.11$
- An additional bit can be used to identify the received byte on the serial line as the address or data.
- It can be used for error detection.
- UART receives the byte at RxD (transmitter data) input line.
- An Universal Synchronous Asynchronous Transmitter (USART) enables serial communication (transmission) in synchronous as well as asynchronous modes.
- Synchronous means all bytes in a frame transmit with equal time spacing or equal phase differences.

## **E. I2C bus**

### **I2C Bus:**

- ❑ A number of device integrated circuits for sensors, actuators, flash memory and touchscreens need data exchanges in a number of processes.
- ❑ ICs mutually network through a common synchronous serial bus, called inter-integrated circuit (I2C).

- ❑ *Four potential modes of operation (viz. master transmit, master receive, slave transmit and slave receive) for I2C bus device and generally most devices have a single role and use two modes only.*
- ❑ *The I2C was originally developed at Philips Semiconductors. There are three I2C bus standards: Industrial 100 kbps I2C, 100 kbps SM I2C and 400 kbps I2C*
- ❑ *I2C bus has two lines that carry the signals-one line is for the clock and one is for bidirectional data.*
- ❑ *I2C bus protocol has specific fields.*
- ❑ *Each field has a specific number of bits, sequences and time intervals between them*

## **21. Write the purpose of GET, POST, PUT and DELETE with respect to RESTful HTTP. 4**

*RESTful HTTP system feature is that communication is over the HTTP and use verbs (commands) same as in HTTP, namely GET, POST, PUT and DELETE.*

### **RESTful HTTP Verbs**

*REST interfaces usually involve resource repositories with identifiers. For example device Network/device or /Temperature App, which can be operated upon using standard verbs as follows:*

- ❖ *GET command is to get a list of the URIs for resource repository of the resources and perhaps other details of the members in the repository. GET retrieves a representation of the resource item (means addressed member) of the repository. Representation is expressed in an appropriate Internet media type.*
- ❖ *POST command creates a new entry in the resource repository for the resources. The new entry's URI is assigned automatically and is usually returned by the operation. An option which is not generally used considers the resource item as a repository on its own right and create a new entry in it (not generally used).*

- ❖ *PUT command which replaces the entire resource repository with another resource repository or replaces the resource item of the repository (or if it does not exist, then create it).*
- ❖ *DELETE command from client retrieves web objects and sends data to remote servers.*

## **22. Explain two types of environments for routing data over web 4**

*Data of connected devices routes over the web in two types of communication environments. The environments are:*

- ***Constrained RESTful Environment (CoRE):*** *IoT devices or M2M devices communicate between themselves in a Local Area Network. A device typically sends or receives IOs of bytes. The data gathered after enriching and consolidating from a number of devices consists of 100s of bytes. A gateway in the communication framework enables the data of networked devices that communicate over the Internet using the REST software architecture.*

- *Devices have the constraint in the sense that their data is limited in size compared to when data interchange between web clients and web servers takes place using HTTP, Transmission Control Protocol (TCP) and Internet Protocol (IP).*
- *Another constraint is data-routing when Routing Over a network of Low power and (data) Loss (ROLL). ROLL network is a wireless network with low power transceiver. Another constraint is that the devices may sleep most of the time in low Power environment and awaken on an event or when required (on client initiative). Devices connectivity may also break for long periods, have limited up intervals in loss environment, and have limited data size.*

- ***Unconstrained Environment:*** *Web applications use HTTP and RESTful HTTP for web client and Web server communication. A web object consists of 1000s of bytes. Data routes over ipnetworks for the Internet. Web applications and services use the IP and TCP protocols for Internet network and transport layers.*



# **UNIT - II**

**2 Marks questions**

**Page number 42-49**

**Questions for 3 or more marks**

**Page number 50-80**

## UNIT II

### 2 Marks questions

#### 1. Define socket.

*Socket is a software interface to the network that links to data stack using a port protocol and an IP address. Internet data can be considered as communicating between the sockets. Application data can be considered to flow between the sockets at sender and receiver.*

#### 2. What is IP address? Give example.

*An Internet Protocol (IP) address is a numerical label assigned to each device connected to a computer network that uses the internet protocol for communication. An IP header consists of source and destination addresses, called IP addresses. The Internet generally uses IPv4 addresses. IoT/M2M use IPv6 addresses. **IP Address example***

- ☐ *IP version 4 address consists of 32 bits. However, it can be considered as four decimal numbers separated by dots.*
- ☐ *For example, 198.136.56.2 for 32 bits—11000110 10001000 0011100000000010.*
- ☐ *Each decimal number is decimal value of an Octet (= 8 bits). IP addresses can be between 0.0.0.0 to 255.255.255.255; total  $2^{32}$  addresses due to 32-bit address.*
- ☐ *Three separate fields with a decimal number each for each set of 8 bits are easier to use.*

#### 3. What is Static IP address?

##### *Static ip address*

*A static IP address is the one assigned by the Internet service provider. The service provider may provide an individual just one address. When a company has a number of hosts, a service provider may provide a class C network address consisting of a group of 254 ( $2^8 - 2$ ) IP addresses.*

#### 4. What is dynamic IP address?

##### *Dynamic IP address*

*Once a device connects to the Internet, it needs to be allotted an individual IP address. Then the device connects to a router, the router and device use the DHCP (Dynamic Host Control Protocol) which assigns an IP address at an instance to the device. This address is called dynamic IP address. When a device disconnects or switches off or the router boots again, then the dynamic IP address is lost and a new allocation takes place when the device reconnects.*

## **5. What is IP address? List two types of IP addresses**

*An Internet Protocol (IP) address is a numerical label assigned to each device connected to a computer network that uses the internet protocol for communication. An IP header consists of source and destination addresses, called IP addresses. The Internet generally uses IPv4 addresses. IoT/M2M use IPv6 addresses*

*Two types of IP addresses are:*

- *Static IP Address*
- *Dynamic IP Address*

## **6. Differentiate unicast and multicast address.**

*IPv6 addresses are classified into three classes.*

- a. Each class differs in primary addressing and routing methods.*
- b. An interface may be at a distinct node.*

***Unicast address** is for a single network interface.*

- c. 48 bit or more in unicast specify routing prefix.*
- d. 16 bit or less specify a subnet id.*
- e. 64 bit are interface identifiers.*

***Multicast address** means an address used by multiple hosts, which acquires the multicast address destination by participating in the multicast distribution protocol among network routers. A packet with multicast address delivers to all interfaces that have joined the corresponding multicast group.*

## **7. What is anycast address?**

***Anycast address** means address of a group of nodes or interfaces.*

- a. A packet sent to an anycast address is delivered to just one of the member interfaces.*
- b. One may be the nearest host.*
- c. Nearest is measured according to the routing protocol's definition of distance.*

## **8. What is the use of data center?**

- ▶ *A data center is a facility which has multiple banks of computers, servers, large memory systems, high speed network and Internet connectivity.*
- ▶ *The center provides data security and protection using advanced tools, full data backups along with data recovery, redundant data communication connections and full system power as well as electricity supply backups.*
- ▶ *Large industrial units, banks, railways, airlines and units for whom data are the critical components use the services of data centers.*
- ▶ *Data centers also possess a dust free, heating ventilation and air conditioning (HVAC), cooling, humidification and dehumidification equipment, pressurization system with a physically highly secure environment.*
- ▶ *The manager of data center is responsible for all technical and IT issues, operations of computers and servers, data entries, data security, data quality control, network quality control and the management of the services and applications used for data processing.*

## **9. What is Port?**

***Port** is an interface to the network using a protocol that sends an application layer data stack to the lower layer for transmission. The port receives the data stack at the receiver's end from the lower layer. Each port uses an assigned number according to a protocol which is used for transmission or reception at the application layer. For*

*example, port 80 is assigned number to HTTP, an application layer protocol.*

## **10. What is Interactive Transaction Processing**

### ***Interactive Transactions Processing***

- ▶ *Interactive transactions processing means the transactions which involve continued exchange of information between the computer and a user. For example, user interactions during e-shopping and e-banking. The processing is just the opposite of batch processing.*

## **11. Give examples for Streaming Transaction Processing.**

### ***Streaming Transactions Processing***

- ▶ *Examples of the streams are log streams, event streams and twitter streams. Query and transactions processing on streaming data need specialized frameworks. Storm from Twitter, S4 from Yahoo, SPARK streaming, HStreaming and flume are examples of frameworks for real-time streaming computation frameworks.*

## **12. What is Real-time Transaction Processing?**

### ***Real-time Transactions Processing***

- ▶ *Real-time transaction processing means that transactions process at the same time as the data arrives from the data sources and data store. An example is ATM machine transactions. In-memory, row-format records enable real-time transaction processing. Row format means few rows and more columns. The CPU accesses all columns in single accesses in SIMD (single instruction multiple data) streams processing.*

## **13. What is Business Intelligence?**

*Business intelligence is a process which enables a business service to extract new facts and knowledge and then undertake better decisions. The new facts and knowledge follow from the earlier results of data processing, aggregation and then analyzing those results,*

#### **14. Expand**

**a) OLTP:** *Online Transactions Processing (OLTP)*

**b) LIDAR:** *LIDAR (Light + Radar) [Laser Imaging, Detection and Ranging] sensors*

**c) SOA:** *Service Oriented Architecture*

**d) IIOT:** *Industrial Internet of Things (IIoT)*

**(Any two may be asked)**

#### **15. Differentiate Passive and Active device data**

##### ***Passive devices data:***

- ▶ *Data generate at the device or system, following the result of interactions.*
- ▶ *A passive device does not have its own power source.*
- ▶ *An external source helps such a device to generate and send data.*
- ▶ *Examples are an RFID (Example 2.2) or an ATM debit card (Example 2.3).*
- ▶ *The device may or may not have an associated microcontroller, memory and transceiver.*
- ▶ *A contactless card is an example of the former and a label or barcode is the example of the latter.*

##### ***Active devices data:***

- ▶ *Data generates at the device or system or following the result interactions.*
- ▶ *An active device has its own power source.*
- ▶ *Examples are active RFID streetlight sensor (Example 1.2) or wireless sensor node.*
- ▶ *An active device also has an associated microcontroller, memory and transceiver.*

#### **16. Differentiate NTC and PTC.**

- ❖ *A component called thermistor, shows larger changes in resistance within narrow environment temperature range (120°C to -90°C):*

- ❖ An **NTC** thermistor shows **negative temperature coefficient** which means a drop in the resistance value with rise in temperature.
- ❖ Thermistor finds applications in home automation or in sensing the clouds.
- ❖ The output of thermistor connects to the circuit of a signal conditioning amplifier, ADC and then to microcontroller serial port, similar to the circuit in Figure 7.1 except that in place of a resistance-bridge, a thermistor circuit is used.
- ❖ A temperature sensor is called **PTC**, when it exhibits a **Positive Temperature Coefficient**.
- ❖ Resistance value of a PTC resistor rises with rise in temperature.
- ❖ A thin wire of platinum or other metallic alloys shows linear changes with its temperature.
- ❖ These can be used for sensing temperature and measuring the values over very wide ranges of temperatures, say (0-1600°C).

## 17. Write a note on Industrial IoT

### **Industrial IoT**

- ▶ Industrial Internet of Things (IIoT) involves the use of IoT technology in **manufacturing**- IIoT involves the integration of complex physical machinery M2M communication with the networked sensors and use of software, analytics, machine learning and knowledge discovery.
- ▶ Example of the functions of IIoT are refining the operations for manufacturing or maintenance, or refining the business model of an industry.
- ▶ IIoT applications are in the manufacturing, railways/mining, agriculture, oil and gas, utilities, transportation, logistics and healthcare services.

## 18. Write a note on Automotive IoT?

Automotive IoT enables the connected cars, vehicles-to-infrastructure technology, predictive and preventive maintenances and autonomous cars.

### ***Connected Cars Technology***

*Automotive vehicles can drive through roads with little or no effort at all. A connected car with the combination of GPS tracking and an Internet connection enables applications such as:*

- ▶ *Display for driver that enables driving through the shortest route, avoiding the congested route, etc.*
- ▶ *Customization of functioning of the vehicle to meet the driver's needs and preferences*
- ▶ *Get notifications about traffic*
- ▶ *Protecting cars against theft*
- ▶ *Weather and enroute destinations*
- ▶ *Keeping a tab on driver's health and behavior.*

### ***Vehicle-to-Infrastructure Technology***

*Automotive IoT enables Vehicle-to-infrastructure (V2I) technology. A vehicle communicates with other vehicles, the surrounding infrastructure and a Wi-Fi LAN. Examples of V2I applications are:*

- ▶ *Alerts and warnings for forward collision*
- ▶ *Information about blind spots*
- ▶ *Notification about a vacant parking space*
- ▶ *Information about traffic congestion on route to destination*
- ▶ *Stream live music and news.*

### ***Autonomous Cars***

*Driverless cars (also known as autonomous cars or robotic cars) have become a reality, these deploy LIDAR and laser 3D imaging technology*

## **19. What is the purpose of Actuator**

### ***ACTUATOR***

- ▶ *An actuator is a device that takes actions as per the input command, pulse or state (1 or 0), or set of I's and O's, or a control signal.*
- ▶ *An attached motor, speaker, LED or an output device converts electrical energy into physical action.*
- ▶ *Examples of applications of actuators are:*
  - ▶ *Light sources*
  - ▶ *LEDs*



- ▶ *Piezoelectric vibrators and sounders*
- ▶ *Speakers*
- ▶ *Solenoids*
- ▶ *Servomotor*
- ▶ *Relay switch*
- ▶ *Switching on a set of streetlights*
- ▶ *Application of brakes in a moving vehicle*
- ▶ *Ringling of alarm bell*
- ▶ *Switching off or on a heater or air-conditioner or boiler current in a steam boiler in a thermal plant.*

## **20. What is V2I Technology**

### ***Vehicle-to-infrastructure Technology***

*Automotive IoT enables Vehicle-to-infrastructure (V2I) technology. A vehicle communicates with other vehicles, the surrounding infrastructure and a Wi-Fi LAN. Examples of V2I applications are:*

- ▶ *Alerts and warnings for forward collision*
- ▶ *Information about blind spots*
- ▶ *Notification about a vacant parking space*
- ▶ *Information about traffic congestion on route to destination*
- ▶ *Stream live music and news.*

## **21. List any four examples for applications of Actuators.**

*Examples of applications of actuators are:*

- a. Light sources*
- b. LEDs*
- c. Piezoelectric vibrators and sounders*
- d. Speakers*
- e. Solenoids*
- f. Servomotor*
- g. Relay switch*
- h. Switching on a set of streetlights*
- i. Application of brakes in a moving vehicle*
- j. Ringling of alarm bell*
- k. Switching off or on a heater or air-conditioner or boiler current in a steam boiler in a thermal plant.*

### Questions for 3 or more marks

#### 1. List the actions that occur when data is being transmitted from one layer to other in internet based communication..

4

*When data transmits from layer<sub>i</sub> to the next layer<sub>j</sub>, following are the actions that occur:*

- ☐ *Each layer's processing of data is as per the protocol used for communication by that layer.*
- ☐ *Each layer sends the data stack received from the previous upper layer plus a new layer. header, and thus creates a fresh stack after performing the actions specified at that*
- ☐ *Layer<sub>i</sub> will specify new parameters as per protocol and create fresh stack for the subsequent lower layer.*
- ☐ *The process continues until data communicates over the complete network.*

*Thus, data transmits from layer<sub>i</sub> to the next layer/ ( $i > j$ ) when it transmits from the application layer to the physical layer.*

*When data is received at the next layer<sub>j</sub> from a layer. i.e. IoT device physical layer to the IoT application, the following actions are performed:*

- ☐ *Each layer performs the Processing as per the header field bits, which are received according to the protocol to be used for decoding the fields for the required actions at that layer.*
- ☐ *Each layer receives the data stack from the previous lower layer and after the required actions, it subtracts the header words and creates a new stack specified for the next higher layer*
- ☐ *The process continues until the data is received at the port on the highest application layer*
- ☐ *Upper layers use the header words alone.*
- ☐ *Lower layer, such as data-link layer protocol, such as Ethernet 802.3, provisions for the trailing bits also, in addition to the header words.*
- ☐ *Trailing-bits usage can be as error-control bits and end-of-the frame indicating bits.*

## 2. Write a note on

6

### a) IP Addresses

*An IP header consists of source and destination addresses, called IP addresses. The Internet generally uses IPv4 addresses. IoT/M2M use IPv6 addresses.*

#### **IP Address**

- ❑ *IP version 4 address consists of 32 bits. However, it can be considered as four decimal numbers separated by dots.*
- ❑ *For example, 198.136.56.2 for 32 bits—11000110 10001000 0011100000000010.*
- ❑ *Each decimal number is decimal value of an Octet (= 8 bits). IP addresses  $r$  can be between 0.0.0.0 to 255.255.255.255; total  $2^{32}$  addresses due to 32-bit address.*
- ❑ *Three separate fields with a decimal number each for each set of 8 bits are easier to use.*
- ❑ *Let's see an analogy with postal network addressing method. Consider an address:*

**McGraw-Hill Education,  
2 Pennsylvania Plaza,  
New York City,  
USA.**

*In the above example, three fields are separated by a comma and a new line each. A mail routes to the destination using the address.*

- ❖ *First the mail routes to USA, then to New York City, then to Pennsylvania Plaza and then the final destination. Similar are the actions, when a packets route to a destination IP address from a source IP address.*
- ❖ *Each device or node which communicates on the Internet must have an IP address.*
- ❖ *The number of nodes or devices can be very large.*
- ❖ *A communication framework communicates with number of sensors.*
- ❖ *Each sensor or device is assigned the addresses used internally.*
- ❖ *The framework communicates with the Internet with one IP address externally to the applications.*

- ❖ *One solution for a large number of nodes is dividing the network into Internet address and subnet address*
- ❖ *For example, 2 Pennsylvania Plaza, New York City, USA may be a globally visible address.*
- ❖ *Internally, the mail is to be directed to which individual at McGraw-Hill Education is decided by an internal distribution network, invisible to the outside world.*
- ❖ *Alternatively, New York City, USA may be a globally visible address.*
- ❖ *Internally, mail to be directed to which individual at McGraw-Hill Education, 2 Pennsylvania Plaza is decided by an internal distribution network, invisible to outside world.*
- ❖ *Internet address is visible to outside world means it is visible to the routers on the Internet.*
- ❖ *Subnet address is for use within the group internally and is invisible to the outside world.*
- ❖ *A subnet is a sub network consisting of number of hosts or nodes or devices or machines.*
- ❖ *A subnet mask and network 32-bit IP address after ANDing operation gives individual subnet address.*
- ❖ *Logical AND operation with complement of subnet mask with the address gives the host identifier on the subnet.*
- ❖ *IP address 198.136.56.2 is visible on the Internet. Number of servers, such as web server, mail server and FTP server are invisible and these have the same IP 'address globally and separate addresses internally on a subnet of server or nodes or devices.*
- ❖ *An IP address serves the purpose of uniquely identifying an individual network interface of a host.*
- ❖ *The interface locates on the network using that address.*
- ❖ *The address enables routing of IP packets between the hosts.*
- ❖ *IP addresses are present in fields of the packet header for routing.*
- ❖ *The header indicates both source and destination of the packet.*

## **b) IPV6**

### **IPv6 Address**

- ❑ *Devices (nodes) for IoT need large number of addresses. IPv6 uses 128-bit address.*
- ❑ *A hexadecimal digit represents 4-bit, 0 hex = 0000 binary to f hex = 1111.*
- ❑ *Therefore, 128-bit address has 32 hexadecimal digits.*
- ❑ *Eight sets of 4 hex-digits are each separated by a colon or dot in an IPv6 address.*
- ❑ *Example is 16-hexadecimal digits, 40a0: 0acb: 8a00:b372:0000: 0000:0000:0000.*
- ❑ *IANA manages the allocation process for IPv6 addresses; 64 bits in the last when all zeros then can be omitted.*
- ❑ *Devices in mesh network may use 6LoWPAN protocol at the adaptation layer and Ipv6 when communication framework communicates on the Internet using IPv6.*
- ❑ *Last 64 bits are interface identifiers.*
- ❑ *IPv6 addresses are classified into three classes.*
  - *Each class differs in primary addressing and routing methods.*
  - *An interface may be at a distinct node.*
- ❑ ***Unicast address** is for a single network interface.*
  - *48 bit or more in unicast specify routing prefix.*
  - *16 bit or less specify a subnet id.*
  - *64 bit are interface identifiers.*
- ❑ ***Anycast address** means address of a group of nodes or interfaces.*
  - *A packet sent to an anycast address is delivered to just one of the member interfaces.*
  - *One may be the nearest host.*
  - *Nearest is measured according to the routing protocol's definition of distance.*
- ❑ ***Multicast address** means an address used by multiple hosts, which acquires the multicast address destination by participating in the multicast distribution protocol among network routers. A packet with multicast address delivers to*

*all interfaces that have joined the corresponding multicast group.*

### **c) DNS**

#### **DNS**

- ☐ *Consider an IP address, 198.136.56.2 (11000110 10001000 00111000 00000010).*
- ☐ *It is difficult to remember or use.*
- ☐ *The domain name for the address is rajkamal.org.*
- ☐ *Access to Webserver hosted at the domain is made using the website name, http:// mail.rajkamal.org/.*
- ☐ *Access to mail-server hosted at the domain is made using the mail server name, http:// mail.rajkamal.org/. Another example of domain name is mheducation.com/.*
- ☐ *.com, .org, .in and .us are called Top Level Domain (TLD). A TLD can further be subdivided as .co.in or .gov.in. or .gov.uk.*
- ☐ *A registrar provides domain names at a certain cost per year. The DNS server at the Registrar has a control panel (cPanel) and can be configured using cPanel.*
- ☐ *Domain Names System (DNS) is an application which provides an IP address for a corresponding service from the named domain service.*

### **d) DHCP      3 marks**

#### **DHCP**

- ☐ *Dynamic Host Configuration Protocol (DHCP) is a protocol to dynamically provide new IP addresses and set subnet masks for the connected node so that it can use the subnet server and subnet router at the communication framework.*
- ☐ *IP addresses are configured. An administrator or user does this process. DHCP enables process of configuring IP addresses automatically at start-up.*
- ☐ *A node has a software component for sending requests to the DHCP server and receiving responses.*
- ☐ *The component is called DHCP client.*

- ❑ *DHCP client protocol communicates with a server.*

#### **e) Data Acquisition**

##### ***Data Acquisition***

- ▶ *Data acquisition means acquiring data from IoT or M2M devices.*
- ▶ *The data communicate after the interactions with a data acquisition system (application).*
- ▶ *The application interact and communicates with a number of devices for acquiring the needed data.*
- ▶ *The devices send data on demand or at programmed intervals.*

*Data of devices communicate using the network, transport and security layers*

- ▶ *An application can configure the devices for the data when devices have configuration capability. For example, the system can configure devices to send data at defined periodic intervals.*
- ▶ *Each device configuration controls the frequency of data generation.*
- ▶ *Application can configure sending of data after filtering or enriching at the gateway at the data-adaptation layer.*
- ▶ *The gateway in-between application and the devices can provision for one or more of the following functions—transcoding, data management and device management.*
- ▶ *Data management may be provisioning of the privacy and security, and data integration, compaction and fusion.*
- ▶ *Device-management software provisions for device ID or address, activation, configuring (managing device parameters and settings), registering, deregistering, attaching, and detaching.*

#### **f) Data Centre Management**

##### ***Data Centre Management***

- ▶ *A data centre is a facility which has multiple banks of computers, servers, large memory systems, high speed network and Internet connectivity.*

- ▶ *The centre provides data security and protection using advanced tools, full data backups along with data recovery, redundant data communication connections and full system power as well as electricity supply backups.*
- ▶ *Large industrial units, banks, railways, airlines and units for whom data are the critical components use the services of data centres.*
- ▶ *Data centres also possess a dust free, heating ventilation and air conditioning (HVAC), cooling, humidification and dehumidification equipment, pressurisation system with a physically highly secure environment.*
- ▶ *The manager of data centre is responsible for all technical and IT issues, operations of computers and servers, data entries, data security, data quality control, network quality control and the management of the services and applications used for data processing.*

### **g) Spatial Storage**

#### ***Spatial Storage***

- ▶ *Spatial storage is storage as spatial database which is optimised to store and later on receives queries from the applications.*
- ▶ *Suppose a digital map is required for parking slots in a city. Spatial data refers to data which represents objects defined in a geometric space. Points, lines and polygons are common geometric objects which can be represented in spatial databases. Spatial database can also represent database for 3D objects, topological coverage, linear networks, triangular irregular networks and other complex structures. Additional functionality for spatial databases enables efficient processing.*
- ▶ *Internet communication by RFIDs, ATMs, vehicles, ambulances, traffic lights, streetlights, waste containers are examples of where spatial database are used.*
- ▶ *Spatial database functions optimally for spatial queries. A spatial database can perform typical SQL queries, such as select statements and performs a wide variety of spatial*



*operations. Spatial database has the following features:*

- ▶ *Can perform geometry constructors. For example, creating new geometries*
- ▶ *Can define a shape using the vertices (points or nodes)*
- ▶ *Can perform observer functions using queries which replies specific spatial information such as location of the centre of a geometric object*
- ▶ *Can perform spatial measurements which mean computing distance between geometries, lengths of lines, areas of poly gons and other parameters*
- ▶ *Can change the existing features to new ones using spatial functions and can predicate spatial relationships between geometries using true or false type queries*

#### **h) ETL**

##### ***Extract, Transform and Load***

- ▶ *Extract, Transform and Load or ETL is a system which enables the usage of databases used, especially the ones stored at a data warehouse.*
- ▶ *Extract means obtaining data from homogeneous or heterogeneous data sources.*
- ▶ *Transform means transforming and storing the data in an appropriate structure or format.*
- ▶ *Load means the structured data load in the final target database or data store or data warehouse.*
- ▶ *All the three phases can execute in parallel.*
- ▶ *Data extraction takes longer time.*
- ▶ *Therefore, the system while pulling data, executes another transformation processes on already received data and prepares the already transformed data for loading.*
- ▶ *As soon as data are ready for load into the target, the data load starts.*
- ▶ *It means next phase starts without waiting for the completion of the previous phases.*
- ▶ *ETL system usages are for integrating data from multiple*

*applications (systems) hosted separately.*

### **i) Data Validation**

#### **Data Validation**

- ▶ *Data acquired from the devices does not mean that data are correct, meaningful or consistent.*
- ▶ *Data consistency means within expected range data or as per pattern or data not corrupted during transmission.*
- ▶ *Therefore, data needs validation checks.*
- ▶ *Data validation software do the validation checks on the acquired data.*
- ▶ *Validation software applies logic, rules and semantic annotations.*
- ▶ *The applications or services depend on valid data.*
- ▶ *Then only the analytics, predictions, prescriptions, diagnosis and decisions can be acceptable.*

### **j) Batch Processing 2 marks**

- ❖ *Batch processing means a transaction process in batches and in a non-interactive way.*
- ❖ *When one set of transactions finish, the results are stored and a next batch is taken up.*
- ❖ *A good example is credit card transactions where the final results at the end of the month are used.*
- ❖ *Another example is chocolate purchase transactions.*
- ❖ *The final results of sell figures from ACVMs can communicate on the Internet at the end of an hour or day.*

### **k) WSN 2 marks**

#### **Definition**

- ▶ *WSN (Wireless Sensor Networks) is defined as a network in which each sensor node connects wirelessly and has the capability of computation, for data compaction, aggregation and analysis.*
- ▶ *Each one also has communication as well as networking capabilities.*

- A WSN consists of spatially distributed autonomous devices (sensors).

### **3. Explain different steps involved in DHCP functioning**

*Steps in the DHCP protocol for dynamically configuring the IP address and other networks are:*

- 1. DHCP client broadcasts a discover-request, known as DHCPDISCOVER*
  - 2. A DHCP server listens to DHCPDISCOVER and finds the configuration, which can be offered to the client. Server(s) send(s) the configuration parameters, including an IP address not presently in use, at the subnet. The configuration parameters are in the DHCPOFFER for the offered configuration.*
  - 3. The selected DHCP server creates and manages bindings. DHCP server also sets a time interval during which the offered IP address will be valid for the DHCP client node*
  - 4. The DHCP server confirms the binding through a message. It sends DHCPACK after creating the binding.*
  - 5. When the node with the DHCP client computer leaves the subnet, it sends DHCPRELEASE message. If the client does not send DHCPRELEASE within a specified time interval, then the server frees the created binding.*
  - 6. The server and client also use authentication protocols before considering the DHCPDISCOVER from a client and before accepting a DHCPOFFER, respectively.*
- The DHCP protocol guarantees that any assigned network address, at a given instant, is in use by either one DHCP client or none.*

### **4. List and explain different ways by which IoT data is generated**

*Data generated at devices that later on, transfers to the Internet through a gateway. Data generated as follows:*

***Passive devices data:***

- *Data generated at the device or system, following the result of interactions.*

- ▶ *A passive device does not have its own power source.*
- ▶ *An external source helps such a device to generate and send data.*
- ▶ *Examples are an RFID (Example 2.2) or an ATM debit card (Example 2.3).*
- ▶ *The device may or may not have an associated microcontroller, memory and transceiver.*
- ▶ *A contactless card is an example of the former and a label or barcode is the example of the latter.*

***Active devices data:***

- ▶ *Data generates at the device or system or following the result interactions.*
- ▶ *An active device has its own power source.*
- ▶ *Examples are active RFID streetlight sensor (Example 1.2) or wireless sensor node.*
- ▶ *An active device also has an associated microcontroller, memory and transceiver.*

***Event data:***

- ▶ *A device can generate data on an event only once.*
- ▶ *For example, on detection of the traffic or on dark ambient conditions, which signals the event.*
- ▶ *The event on darkness communicates a need for lighting up a group of streetlights (Example 1.2).*
- ▶ *A system consisting of security cameras can generate data on an event of security breach or on detection of an intrusion.*
- ▶ *The components and devices in an automobile generate data of their performance and functioning.*
- ▶ *For example, on wearing out of a brake lining, a play in steering wheel and reduced air-conditioning is felt.*
- ▶ *The data communicates to the Internet.*
- ▶ *The communication takes place as and when the automobile reaches near a Wi-Fi access point.*

***Device real-time data:***

- ▶ *An ATM generates data and communicates it to the*

*server instantaneously through the Internet.*

- ▶ *This initiates and enables Online Transactions Processing (OLTP) in real time.*

#### **Event-driven device data:**

- ▶ *A device data can generate on an event only once.*

- ▶ *Example are:*

*(i) a device receives command from Controller or Monitor, and then performs action(s) using an actuator. When the action completes, then the device sends an acknowledgement;*

*(ii) When an application seeks the status of a device, then the device communicates the status.*

### **5. Explain categorization for Data Storage 3**

*Following are three cases for storage:*

- ▶ *Data which needs to be repeatedly processed, referenced or audited in future, and therefore, data alone needs to be stored.*
- ▶ *Data which needs processing only once, and the results are used at a later time using the analytics, and both the data and results of processing and analytics are stored- Advantages of this case are quick visualization and reports generation without reprocessing. Also the data is available for reference or auditing in future.*
- ▶ *Online, real-time or streaming data need to be processed and the results of processing and analysis need storage.*
- ▶ *Data from large number of devices and sources categorizes into a fourth category called Big data. Data is stored in databases at a server or in a data warehouse or on a Cloud as Big data.*

### **6. Write any six tasks associated with server management**

**6**

*Server management means managing services, setup and maintenance of systems of all types associated with the server. A server needs to serve around the clock. Server management includes managing the following:*

- ▶ *Short reaction times when the system or network is down*

- ▶ *High security standards by routinely performing system maintenance and updation*
- ▶ *Periodic system updates for state-of-the art setups*
- ▶ *Optimized performance*
- ▶ *Monitoring of all critical services, with SMS and email notifications*
- ▶ *Security of systems and protection*
- ▶ *Maintaining confidentiality and privacy of data*
- ▶ *High degree of security and integrity and effective protection of data, files and databases at the organization*
- ▶ *Protection of customer data or enterprise internal documents by attackers which includes spam mails, unauthorized use of the access to the server, viruses, malwares and worms*
- ▶ *Strict documentation and audit of all activities.*

## **7. Write ACID rules of DBMS** **4**

### ***Atomicity, Data Consistency, Data Isolation and Durability (ACID) Rules***

- ▶ *The database transactions must maintain the atomicity, data consistency, data isolation and durability during transactions.*
- ▶ **Atomicity** means a transaction must complete in full, treating it as indivisible. When a service request completes, then the pending request field should also be made zero.
- ▶ **Consistency** means that data after the transactions should remain consistent. For example, sum of chocolates sent should equal the sums of sold and unsold chocolates for each flavour after the transactions on the database.
- ▶ **Isolation** means transactions between various tables like, 5.1 and 5.2, 5.2 and 5.3 and 5.3 and 5.1 are isolated from each other.
- ▶ **Durability** means after completion of transactions, the previous transaction cannot be recalled. Only a new transaction can affect any change.

## **8. List any five steps associated with Query Processing** **6**

## Query Processing

- ▶ *Query processing means using a process and getting the results of the query made from a database. The process should use a correct as well as efficient execution strategy. Five steps in processing are:*
- ▶ **Parsing and translation:** *This step translates the query into an internal form, into a relational algebraic expression and then a Parser, which checks the syntax and verifies the relations.*
- ▶ **Decomposition** *to complete the query process into micro-operations using the analysis (for the number of micro-operations required for the operations), conjunctive and disjunctive normalization and semantic analysis.*
- ▶ **Optimization** *which means optimizing the cost of processing. The cost means number of micro-operations generated in processing which is evaluated by calculating the costs of the sets of equivalent expressions.*
- ▶ **Evaluation plan:** *A query-execution engine (software) takes a query-evaluation  $p_{ja}$  and executes that plan.*
- ▶ **Returning** *the results of the query.*

## 9. List different features of SQL

6

- ❑ **SQL stands for Structured Query Language.** *It is a language for viewing or changing (update, insert or append or delete) databases. It is a language for data querying, updating, inserting, appending and deleting the databases. It is a language for data access control, schema creation and modifications. It is also a language for managing the RDBMS.*
- ❑ **SQL** *was originally based upon the tuple relational calculus and relational algebra. SQL can embed within other languages using SQL modules, libraries and pre-compilers. SQL features are as follows:*
- ❑ **Create Schema** *is a structure that contains descriptions of objects created by a user (base tables, views, constraints). The user can describe and define the data for a database.*
- ❑ **Create Catalog** *consists of a set of schemas that constitute*

*the description of the database.*

- ❑ Use **Data Definition Language (DDL)** for the commands that depict a database, including creating, altering and dropping tables and establishing constraints. The user can create and drop databases and tables, establish foreign keys, create view, stored procedure, functions in a database.
- ❑ Use **Data Manipulation Language (DML)** for commands that maintain and query a database. The user can manipulate (INSERT, UPDATE or SELECT the data and access data in relational database management systems.
- ❑ Use **Data Control Language (DCL)** for commands that control a database, including administering privileges and committing data. The user can set (grant or add or revoke) permissions on tables, procedures, and views,

## **10. List the components of NOSQL 6**

**NOSQL stands for No-SQL or Not Only SQL** that does not integrate with applications that are based on SQL. NOSQL is used in cloud data store. NOSQL may consist of the following:

- ▶ A class of non-relational data storage systems, flexible data models and multiple
- ▶ class consisting of uninterpreted key and value or "the big hash table"
- ▶ Class consisting of unordered keys and using the JSON
- ▶ Class consisting of ordered keys and semi-structured data storage systems. For examples in the BigTable, Hbase and Cassandra (used in Facebook and Apache)
- ▶ Class consisting of JSON ). For example in MongoDB<sup>6</sup> which is widely used for NOSQL)
- ▶ Class consisting of name and value in the text. For example in CouchDB
- ▶ May not require a fixed table schema
- ▶ The system offers relaxation in one or more of the ACID and CAP properties. Out of the three properties (consistency, availability and partitions), two are at least present for an application.



- ▶ *Consistency means all copies have same value like in traditional DBs.*
- ▶ *Availability means at least one copy available in case a partition becomes inactive or fails. For example, in web applications, the other copy in other partition is available.*

**Partition** means parts which are active but may not cooperate as in distributed databases.

## 11. Explain tasks associated with CEP

6 

- ❑ *Event Stream Processing (ESP) is a set of technologies, event processing languages, Complex Event Processing (CEP), event visualization, event databases and event-driven middleware. Apache S4 and Twitter Storm are examples of ESPs. SAP Sybase ESP and Esper Tech Esper are examples of CEPs. ESP and CEP does the following:*
  - ❑ *Processes tasks on receiving streams of event data*
  - ❑ *Identifies the meaningful pattern from the streams*
  - ❑ *Detects relationships between multiple events*
  - ❑ *Correlates the events data*
  - ❑ *Detects event hierarchies*
  - ❑ *Detects aspects such as timing, causality, subscription membership*
  - ❑ *Builds and manages the event-driven information systems.*
  - ❑ *CEP(Complex Event Processing) has many applications. For example, IoT event processing applications, stocks algorithmic-based trading and location-based services. A CEP application in Eclipse are used for capturing a combination of data, timing conditions and efficiently recognize the corresponding events over data streams.*

## 12. Write a note on Sensor Technology

4

- ❑ *Sensor technology is a technology used for designing sensors and associated electronic readers, circuits and devices.*
- ❑ *A sensor can sense a change in physical parameters, such as temperature, pressure, light, metal, smoke and proximity to an object.*

- ❑ *Sensors can also sense acceleration, orientation, location, vibrations or smell, organic vapours or gases.*
- ❑ *A microphone senses the voice and changes in the sound, and is used to record voice or music.*
- ❑ *A sensor converts physical energy like heat, sound, strain, pressure, vibrations and motion into electrical energy.*
- ❑ *An electronic circuit connects to the input at a sensor.*
- ❑ *The circuit receives the output of the sensor.*
- ❑ *The output is according to the variation in physical condition.*
- ❑ *A smart sensor includes the electronic circuit within itself, and includes computing and communication capabilities.*
- ❑ *The circuit receives energy in form of variations through currents, voltages, phase- angles or frequencies.*
- ❑ *Analog sensors measure the variations in the parameters with respect to a reference or normal condition and provide the value of sensed parameter after appropriate calculations.*
- ❑ *The change of states with respect to a reference or normal condition senses the states in the form of 0's and 1's in digital sensors.*

### **13. Differentiate Analog and Digital Sensors 4**

#### **Analog Sensors**

- ▶ *Analog sensors use a sensor and an associated electronic analog circuit.*
- ▶ *Analog sensors generate analog outputs as per the physical environmental parameters, such as temperature, strain, outputs as per the pressure, force, flex, vapours, magnetic field, or proximity.*
- ▶ *Resistance of the sensing component may show measurable changes with surrounding pressure or strain or magnetic field or humidity.*
- ▶ *Resistance of a pressure sensor increases on pressure which creates a strain on the sensor.*

- ▶ A flex sensor, for example, of 2.2 inch or 4.5 inch length, shows that its resistance across the sensor strip increases on flexing due to a changed path and deflection of the sensing resistor.
- ▶ The measurement of analog output from a sensor circuit is performed as follows— the sensor output is given to the input of a signal conditioning-cum-amplifying circuit (SC). The SC output is the input to an Analog-to-Digital Converter (ADC). The ADC gives a digital output; for example, 8 or 12 bits. This output is read using a microcontroller. Microcontroller reading and computation gives the value of the sensed parameter value and shows the physical condition around the sensor.

### **Digital Sensors**

- ▶ A specific electronic component or circuit gives digital output **1** or **0** (on-off state) or output of I's and O's as a binary number.
- ▶ A digital sensor uses the sensor and has an associated electronic circuit which gives digital output.
- ▶ The output **1** or **0** (Is and Os) is read through a port in a microcontroller. This circuit can be used for sensing a sudden change in specific physical state or condition or can be used for sensing a sudden change in specific set of physical states or conditions.

## **14. List different features of Connected Cars 6**

### **Connected Cars Technology**

Automotive vehicles can drive through roads with little or no effort at all. A connected car with the combination of GPS tracking and an Internet connection enables applications such as:

- ▶ Display for driver that enables driving through the shortest route, avoiding the congested route, etc.
- ▶ Customization of functioning of the vehicle to meet the driver's needs and preferences
- ▶ Get notifications about traffic
- ▶ Protecting cars against theft

- ▶ *Weather and enroute destinations*
- ▶ *Keeping a tab on driver's health and behaviour.*

## **15. What is V2I Technology? List different examples of V2I applications 6**

### ***Vehicle-to-infrastructure Technology***

*Automotive IoT enables Vehicle-to-infrastructure (V2I) technology. A vehicle communicates with other vehicles, the surrounding infrastructure and a Wi-Fi LAN. Examples of V2I applications are:*

- ▶ *Alerts and warnings for forward collision*
- ▶ *Information about blind spots*
- ▶ *Notification about a vacant parking space*
- ▶ *Information about traffic congestion on route to destination*
- ▶ *Stream live music and news.*

## **16. List and explain any five applications of actuators 6**

*Examples of applications of actuators are:*

- a. Light sources*
- b. LEDs*
- c. Piezoelectric vibrators and sounders*
- d. Speakers*
- e. Solenoids*
- f. Servomotor*
- g. Relay switch*
- h. Switching on a set of streetlights*
- i. Application of brakes in a moving vehicle*
- j. Ringing of alarm bell*
- k. Switching off or on a heater or air-conditioner or boiler current in a steam boiler in a thermal plant.*

### ***Light Source***

*Traffic lights are examples of function of light sources as actuators controlled by the inputs.*

### ***LED***

- ▶ *LED is an actuator which emits light or infrared radiation.*
- Uses of different colour LEDs, RGB (Red-Green-Blue)*

*LEDs, intensity variation of LED and colours, graphic and text jdisplay using big screens are actions which are controlled using the inputs.*

- ▶ *RGB LED has three inputs to control, i.e. R, G and B components and thus the composite colour. Pulse width modulated pulses control the LED light emission intensity.*
- ▶ *A microcontroller is used for generating PWM outputs.*

### ***Piezoelectric Vibrator***

*Piezoelectric crystals when applied in varying electric voltages at the input generate vibrations.*

### ***Piezoelectric Speaker***

- ▶ *A piezoelectric speaker enables synthesized music tunes and sounds.*
- ▶ *The appropriately programmed pulses generate the music, sounds/buzzers and alarms when they are the input to the speaker.*
- ▶ *A microcontroller is used for generating PWM outputs for actions using speakers.*

### ***Solenoid***

- ▶ *A solenoid is an actuator consisting of a number of cylindrically wound coils.*
- ▶ *The flow of current creates a magnetic field in proportion to the number of turns in the solenoid and the current in it.*
- ▶ *If a shaft made of iron is placed along the axis, then its motion **can** be, controlled by the input current, pulses and variations of current with time.*
- ▶ *It can create a sharp forward push, backward push and repeated to and fro motion.*
- ▶ *It can also create rotator motion from linear motion by using a Cam.*
- ▶ *A cam with linear shaft assembly is used in an engine to convert rotatory motion into linear motion and vice versa.*
- ▶ *A cam is an especially cut mechanical rotating object such that the radius linearly increases (from the centre) between  $0^\circ$  and  $180^\circ$  rotation and decreases between  $180^\circ$  and  $360^\circ$ .*

- ▶ *When a cam assembly rotates, then a linear shaft moves in forward and backward motions in each rotation.*

### **Motor**

- ▶ *A motor can be DC (direct current controlled) or AC (alternating current controlled).*
- ▶ *IO modules are readily available to receive the control digital inputs of I's and O's and deliver high currents.*
- ▶ *The dc or ac rotates the motor.*
- ▶ *A cam also converts rotator motion into linear motion when it rotates using a motor.*

### **Servomotor**

- ▶ ***Servomotor** is a geared DC motor for applications such as robotics. It rotates the shaft of a **motor**.*
- ▶ *The shaft of the **motor** can be controlled and positioned or rotated **through**  $180^\circ$  ( $+90^\circ$ ) degrees.*
- ▶ *The shaft's angular position is controlled through  $180^\circ$ , between  $-90^\circ$  and  $+90^\circ$  degrees.*

### **Relay Switch**

- ▶ *An electronic switch can be controlled by the input 1 or 0 from the port pin of microcontroller or through a push button switch and battery.*
- ▶ *The current flows through the switch or voltage applies through the switch depending upon the input state 1 or 0*
- ▶ *A relay switch makes mechanical contact when the input circuit magnetizes with a control circuit and pulls a lever to make the contact.*
- ▶ *The current flows through the switch or voltage applies through the switch depending upon the input state 1 or 0 from the port pin of a microcontroller or through a push-button switch and battery*

## **17. Explain different technical challenges related to RFID 4** **RFID technology challenges are as follows:**

- ▶ ***Interference:** When an organization uses a number of wireless systems, since RFID hotspot also requires wireless installation, the frequencies may interfere among the*

systems. The systems require effective mitigation from interference.

- ▶ **Effective** implementation at data processing subsystem consisting of reader and tag protocols, middleware architecture and EPC standards
- ▶ Need of **low cost** tags and RFID technology
- ▶ Design robustness
- ▶ Data security

## **18. List security challenges of RFID 6**

### **Security Challenges**

*The issues associated with RFID security are:*

- ▶ *Discovery of foreign attacks (intrusions) and maintain overall data integrity*
- ▶ *Unauthorized disabling of a tag by a reader which is external, thus making the tag useless*
- ▶ *Unauthorized tag manipulation by a reader which is external, thus making the tag useless*
- ▶ *Cloning of the tag by an unauthorized entity*
- ▶ **Eavesdropping**, which means setting up an additional reader pretending to be a reader, belonging to the system
- ▶ *man-in-the-Middle attack: When an external object pretends to be either a tag or reader between system tags and readers*
- ▶ *Solutions can be encryption, tag deactivation on detection of intrusion, mutual authentication between the tag and reader, detection of the tag owner, use of read data analyzer and data cleaning*

## **19. List and explain security challenges associated with WSN 6**

**Security challenges are:**

- **Hello flood attack:** An attacker node sends hello messages repeatedly, and thus drains the energy of the attacked node.
- **Sybil attack** is an attack where a single node, presents itself as different entities at different times.

- **Selective forwarding attack** is an attack when the attacker node does not forward the attacked node messages on receiving.
- **Sinkhole attack** is when an attacked node behaves as an access point and receives the messages without forwarding them.
- **Wormhole attack** is an attack where the attacker node gives false information of distances of the destinations, thus forcing the attacked node to take longer paths.
- The longer path has high latency and thus high delivery delays of packets.

## 20. Explain the features of DDB.

3

### **Distributed Database**

*Distributed Database (DDB) is a collection of logically interrelated databases over a computer network. Distributed DBMS means a software system that manages a distributed database.*

*The features of a distributed database system are:*

- *DDB is a collection of databases which are logically related to each other.*
- *Cooperation exists between the databases in a transparent manner. Transparent means that each user within the system may access all of the data within all of the databases as if they were a single database.*
- *DDB should be 'location independent', which means the user is unaware of where the data is located, and it is possible to move the data from one physical location to another without affecting the user.*

## 21. Explain CAP theorem

3

### **Consistency, Availability and Partition-Tolerance Theorem**

- *Consistency, Availability and Partition-Tolerance Theorem (CAP theorem) is a theorem for distributed computing systems.*
- *The theorem states that it is impossible for a distributed*



computer system to simultaneously provide all three of the Consistency, Availability, partition tolerance (CAP) guarantees.

- ▶ This is due to the fact that a network failure can occur during communication among the distributed computing nodes.
- ▶ Partitioning of a network therefore needs to be tolerated. Hence, at all times either there will be consistency or availability.
- ▶ **Consistency** means 'Every read receives the most recent write or an error'. When a message or data is sought the network generally issues notification of time-out or read error. During an interval of a network failure, the notification may not reach the requesting node(s).
- ▶ **Availability** means 'Every request receives a response, without guarantee that it contains the most recent version of the information'. Due to the interval of network failure, it may happen that most recent version of message or data requested may not be available.
- ▶ **Partition tolerance** means 'The system continues to operate despite an arbitrary number of messages being dropped by the network between the nodes'. During the interval of a network failure, the network will have two separate set of networked nodes. Since failure can always occur therefore, the partitioning needs to be tolerated.

## 22. Explain 3 classes of IPv6 addresses 4

- ❑ IPv6 addresses are classified into three classes.
  - Each class differs in primary addressing and routing methods.
  - An interface may be at a distinct node.
- ❑ **Unicast address** is for a single network interface.
  - 48 bit or more in unicast specify routing prefix.
  - 16 bit or less specify a subnet id.
  - 64 bit are interface identifiers.
- ❑ **Anycast address** means address of a group of nodes or interfaces.

- A packet sent to an anycast address is delivered to just one of the member interfaces.
- One may be the nearest host.
- Nearest is measured according to the routing protocol's definition of distance.

□ **Multicast address** means an address used by multiple hosts, which acquires the multicast address destination by participating in the multicast distribution protocol among network routers. A packet with multicast address delivers to all interfaces that have joined the corresponding multicast group.

### **23. Write a note on data acquisition and data validation. 6**

#### **Data Acquisition**

- ▶ Data acquisition means acquiring data from IoT or M2M devices.
- ▶ The data communicate after the interactions with a data acquisition system (application).
- ▶ The application interact and communicates with a number of devices for acquiring the needed data.
- ▶ The devices send data on demand or at programmed intervals.

Data of devices communicate using the network, transport and security layers

- ▶ An application can configure the devices for the data when devices have configuration capability. For example, the system can configure devices to send data at defined periodic intervals.
- ▶ Each device configuration controls the frequency of data generation.
- ▶ Application can configure sending of data after filtering or enriching at the gateway at the data-adaptation layer.
- ▶ The gateway in-between application and the devices can provision for one or more of the following functions—transcoding, data management and device management.
- ▶ Data management may be provisioning of the privacy and

*security, and data integration, compaction and fusion.*

- ▶ *Device-management software provisions for device ID or address, activation, configuring (managing device parameters and settings), registering, deregistering, attaching, and detaching.*

### **Data Validation**

- ▶ *Data acquired from the devices does not mean that data are correct, meaningful or consistent.*
- ▶ *Data consistency means within expected range data or as per pattern or data not corrupted during transmission.*
- ▶ *Therefore, data needs validation checks.*
- ▶ *Data validation software do the validation checks on the acquired data.*
- ▶ *Validation software applies logic, rules and semantic annotations.*
- ▶ *The applications or services depend on valid data.*
- ▶ *Then only the analytics, predictions, prescriptions, diagnosis and decisions can be acceptable.*

## **24. Write a short on ETL**

**3**

### **Extract, Transform and Load**

- ▶ *Extract, Transform and Load or ETL is a system which enables the usage of databases used, especially the ones stored at a data warehouse.*
- ▶ *Extract means obtaining data from homogeneous or heterogeneous data sources.*
- ▶ *Transform means transforming and storing the data in an appropriate structure or format.*
- ▶ *Load means the structured data load in the final target database or data store or data warehouse.*
- ▶ *All the three phases can execute in parallel.*
- ▶ *Data extraction takes longer time.*
- ▶ *Therefore, the system while pulling data, executes another transformation processes on already received data and prepares the already transformed data for loading.*
- ▶ *As soon as data are ready for load into the target, the data load starts.*

- ▶ *It means next phase starts without waiting for the completion of the previous phases.*
- ▶ *ETL system usages are for integrating data from multiple applications (systems) hosted separately.*

**25. List any six context for reprogramming the actions of WSN mode 6**

- ❖ *Following may correspond to the context for reprogramming of the actions of the WSN nodes:*
  - *Past and present surrounding situations*
  - *Actions such as the present network*
  - *Surrounding devices or systems*
  - *Changes in the state of the connecting network*
  - *Physical parameters such as present time of the day*
  - *Nearest connectivity currently available*
  - *Past sequence of actions of the device user*
- ❖ *Previously cached data records*
- ❖ *Remaining memory and battery power at present*
- ❖ *A WSN reprogramming can be Over-The-Air (OTA), which means wirelessly modifying the codes in flash memory through an access point by the gateway, application or services.*

**26. List any six examples of sensor. 6**

***Examples of Sensors***

***Temperature***

- ▶ *A component called thermistor, shows larger changes in resistance within narrow environment temperature range (120°C to -90°C):*
- ▶ *An NTC thermistor shows negative temperature coefficient which means a drop in the resistance value with rise in temperature.*
- ▶ *Thermistor finds applications in home automation or in sensing the clouds.*
- ▶ *The output of thermistor connects to the circuit of a signal conditioning amplifier, ADC and then to microcontroller*

*serial port, similar to the circuit in Figure 7.1 except that in place of a resistance-bridge, a thermistor circuit is used.*

- ▶ *A temperature sensor is called PTC, when it exhibits a Positive Temperature Coefficient.*
- ▶ *Resistance value of a PTC resistor rises with rise in temperature.*
- ▶ *A thin wire of platinum or other metallic alloys shows linear changes with its temperature.*
- ▶ *These can be used for sensing temperature and measuring the values over very wide ranges of temperatures, say (0-160°C).*

### ***Humidity***

- ▶ *Humidity is measured in percentage.*
- ▶ *It is the relative percentage ratio (RH%) of content of water vapours in air compared to one changes for measuring in a situation of maximum possible water vapour content for the air temperature at the instance of measurement.*
- ▶ *Greater than 90% humidity signifies it is a rainy day.*
- ▶ *A capacitor sensor shows change in capacitance as a percentage of relative humidity changes.*
- ▶ *Readily available humidity sensors show output voltage proportional to RH%*
- ▶ *The sensor is given input supply at + and - (ground) potential terminals and it generates output  $V_{rh}$  as a function of RH%.*

### ***Distance***

- ▶ *Infrared (IR) sensor is useful for a 0.15 m to 0.8 m range of object.*
- ▶ *IR sensor works on the principle that when a narrow beam IR LED sends radiation at an inclined angle, the nearby phototransistor FPT receives the reflected radiation after travelling two times the object distance.*
- ▶ *The reflected radiation delay ( $= 2 \times 3.3 \text{ ns per m}$ ) between transmitted and reflected signal is proportional to the distance.*
- ▶ *The distance can be measured for object from 0.1 m to 0.8 m.*

- ▶ Above 0.8 m, the **reflected** intensity may be insufficient for detection and below 0.15 m, the time **interval** is less than 1 ns, which inhibits the detection.
- ▶ Readily available distance-based (IR) sensors shows output voltage **proportional to** distance (Sparkfun distance IR sensor).
- ▶ The sensor LED is given input supply **at** + and - ' (ground) potential terminals and IR-FPT along with internal circuitry generate **output**  $V_{dis}$  as a function of distance.
- ▶  $V_{dis}$  is directly given as input to the ADC and ADC **output** to microcontroller serial port.
- ▶ The computations give the distance.
- ▶ Alternatively, ultrasonic sensors send the pulses.
- ▶ The frequencies of ultrasonic waves are of few kilocycles.
- ▶ The detection of echo from ultrasonic pulses and an associated circuitry generate a signal proportional to the distance.
- ▶ Ultrasonic wave delay is 2 x 3 millisecond/meter in air as the speed of sound in air is 330 m/s.
- ▶ Long-range distances and any obstacles nearby can be detected using ultrasonic sensors. These sensors are used in industrial automation, rail tracks and oil pipeline faults.

### **Light**

- ▶ The sensor shows a drop in resistance with surrounding light.
- ▶ Alternatively, the p-n junction photodiode or phototransistor can be used to measure incoming radiation intensity incoming from a particular direction.
- ▶ the sensor circuit connects the signal conditioning amplifier, ADC and microcontroller.

### **Acceleration**

- ▶ A Micro-Electro-Mechanical Sensor (MEMS) detects linear accelerations  $a_x$ ,  $a_y$  and  $a_z$  along three axes x, y and z, respectively.
- ▶ An MEMS moves when a mass moves along a direction.
- ▶ A mechanical movement has three components.

- ▶ *The variations cause the variation in three capacitance values,  $C_x$ ,  $C_y$  and  $C_z$ .*
- ▶ *The value of each  $C$  depends on the space between two plane surfaces, which varies on acceleration along an axis.*
- ▶ *These capacitances are part of an electronic circuit and the resulting voltage variations give the  $a_x$ ,  $a_y$  and  $a_z$ .*
- ▶ *An accelerometer sensor is used in new generation mobile phones.*
- ▶ *The display screen image and menu items rotate and align horizontally or vertically on detecting the three components using the sensor when it rotates along with the phone.*
- ▶ *The accelerometer also detects up/down, right/left and front/back accelerations given to the device by the user.*
- ▶ *Sparkfun ADX335 is a readily available accelerometer sensor. The accelerometer is given input supply at + and - (ground) potential terminals and it generates three outputs,  $V_x$ ,  $V_y$  and  $V_z$  as a function of time. The computations give  $a_x$ ,  $a_y$  and  $a_z$ , the accelerometer circuit.*

### ***Vibrations and Shocks***

- ▶ *Alternatively, MEMS may use piezoelectric effect in place of capacitive change effects.*
- ▶ *The effect observed in certain specific Materials is accumulation of electric charges on surfaces due to mechanical compression of the piezoelectric material.*
- ▶ *The rate of change of number of charges with time implies a flow of current.*
- ▶ *Vibrations create repeated compression, and decompression.*
- ▶ *An associated electronic circuit generates output according to the intensity of vibrations.*
- ▶ *The circuit also senses the mechanical shocks.*
- ▶ *A user initiates the vibrations or shocks, or the device shakes when it falls, then the in-built sensor in the mobile senses these changes and the system takes action as programmed.*

**27. Write a note on following transactions.**

**6**

- **Online transaction processing(OLTP)**

*OLTP means process as soon as data or events generate in real time. OLTP is used when requirements are availability, speed, concurrency and recoverability in databases for real-time data or events. Example 5.4 gives the uses of OLTP in the application and network domain in Internet of ATMs (ATM of a bank) connected to a bank server.*

- **Batch Processing**

*Batch processing means a transaction process in batches and in a non-interactive way. When one set of transactions finish, the results are stored and a next batch is taken up. A good example is credit card transactions where the final results at the end of the month are used. Another example is chocolate purchase transactions. The final results of sell figures from ACVMs can communicate on the Internet at the end of an hour or day.*

- **Interaction Transaction**

***Interactive Transactions Processing***

► *Interactive transactions processing means the transactions which involve continued exchange of information between the computer and a user. For example, user interactions during e-shopping and e-banking. The processing is just the opposite of batch processing.*

- **Real time system      any 2 can be accommodate)**

***Real-time Transactions Processing***

► *Real-time transaction processing means that transactions process at the same time as the data arrives from the data sources and data store. An example is ATM machine transactions. In-memory, row-format records enable real-time transaction processing. Row format means few rows and more columns. The CPU accesses all columns in single accesses in SIMD (single instruction multiple data) streams processing.*