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FUNDAMENTALS OF INTERNET OF THINGS

B.Tech III-Year II-Sem (Open Elective) (JNTU-Hyderabad)

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UNIT - I

Q1. Define IoT. Write in brief about the IoT. **(Refer Unit-I, Q9)**

Q2. What are the main challenges of Internet of Things (IoT)? **(Refer Unit-I, Q12)**

Q3. What kind of information do Internet of Things (IoT) objects communicate? **(Refer Unit-I, Q14)**

Q4. What are the major privacy and security Issues in Internet of Things (IoT)? **(Refer Unit-I, Q15)**

Q5. Which of the devices are used to connect IoT devices to a home network? **(Refer Unit-I, Q18)**

Q6. Discuss in brief about the functional blocks of IoT. **(Refer Unit-I, Q20)**

Q7. Explain about sensor technology and list some examples of sensors. **(Refer Unit-I, Q21)**

Q8. Define computer network. How is a computer network different from other types of networks? **(Refer Unit-I, Q25)**

Q9. What is a communication protocol? Explain. **(Refer Unit-I, Q29)**

Q10. Discuss various components of a network. **(Refer Unit-I, Q28)**

Q11. Discuss about sensor network. Outline the features of wireless sensor networks. **(Refer Unit-I, Q31)**

Q12. Define some of the key terms and concepts of sensor networks. Also, discuss various subsystems of sensor nodes. **(Refer Unit-I, Q32)**

UNIT - II

Q1. Define M2M communication. Write about M2M communication and architecture of M2M. **(Refer Unit-II, Q9)**

Q2. Discuss various examples of software and development tools. **(Refer Unit-II, Q10)**

Q3. Illustrate the differences between IoT and M2M. **(Refer Unit-II, Q11)**

Q4. Discuss about interoperability in IoT. **(Refer Unit-II, Q12)**

Q5. Give a brief introduction to Arduino programming. **(Refer Unit-II, Q13)**

Q6. Describe basic Arduino setup for windows 7 and windows 8. **(Refer Unit-II, Q14)**

Q7. Illustrate the anatomy of an Arduino program and write in brief about shields. **(Refer Unit-II, Q15)**

Q8. How sensors and actuators are integrated with Arduino? Explain. **(Refer Unit-II, Q16)**

UNIT - III

Q1. What is Python? Explain the features of Python language. **(Refer Unit-III, Q9)**

Q2. Write steps to install python on windows. **(Refer Unit-III, Q11)**

Q3. Define control statements. Discuss about if statement. **(Refer Unit-III, Q12)**

Q4. Give a brief introduction about repetition structure. **(Refer Unit-III, Q14)**

Q5. Define operator. Describe different types of operators supported by Python with an example for each. **(Refer Unit-III, Q17)**

Q6. Explain the various datatypes in python. **(Refer Unit-III, Q18)**

Q7. Give a brief introduction to Raspberry Pi. Listout the peripherals of Raspberry Pi. **(Refer Unit-III, Q21)**

Q8. Describe implementation of Raspberry Pi with python. **(Refer Unit-III, Q24)**

Q9. Explain about interfacing Light sensor with Raspberry Pi. **(Refer Unit-III, Q26)**

UNIT - IV

Q1. Write in brief about Software Defined Network (SDN). **(Refer Unit-IV / Q13)**

Q2. Discuss about traditional network architecture. **(Refer Unit-IV, Q14)**

Q3. Illustrate the architecture and key elements of SDN. **(Refer Unit-IV, Q15)**

Q4. Write a short notes on data generation. **(Refer Unit-IV, Q17)**

Q5. Write a short notes on,

(i) Data validation

(ii) Data categorization for storage

(iii) Assembly software for events. **(Refer Unit-IV, Q18)**

Q6. What are the various ways of organizing the data? Explain. **(Refer Unit-IV, Q19)**

Q7. What is Analytics? Explain about analytics phases. **(Refer Unit-IV, Q20)**

Q8. Explain in detail about big data analytics. **(Refer Unit-IV, Q21)**

Q9. Illustrate the architecture of data analystics. **(Refer Unit-IV, Q22)**

Q10. Discuss about the design of Hadoop Distributed File System (HDFS). **(Refer Unit-IV, Q23)**

Q11. Discuss in detail about the building blocks of Hadoop. **(Refer Unit-IV, Q24)**

Q12. What are the things that need to be configured before running Hadoop? **(Refer Unit-IV, Q25)**

UNIT - V

Q1. Discuss about cloud computing. Also, list various services and usages of cloud platform. **(Refer Unit-V, Q11)**

Q2. List the advantages of cloud computing. **(Refer Unit-V, Q14)**

Q3. Discuss various cloud service models. **(Refer Unit-V, Q15)**

Q4. Explain different types of cloud deployment models. **(Refer Unit-V, Q16)**

Q5. Write short notes on sensor-cloud. **(Refer Unit-V, Q17)**

Q6. Discuss in brief about smart cities. **(Refer Unit-V, Q18)**

Q7. Explain in brief about smart homes. **(Refer Unit-V, Q19)**

Q8. Explain about connected vehicles. **(Refer Unit-V, Q21)**

Q9. Discuss about smart grid. **(Refer Unit-V, Q22)**

Q10. Explain about Industrial Internet of Things (IoT). **(Refer Unit-V, Q23)**

Q11. Write about agriculture in IoT. **(Refer Unit-V, Q24)**

Q12. Write short notes on activity monitoring. **(Refer Unit-V, Q26)**

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MODEL PAPER 1

B.Tech. III Year II Semester Examination

FUNDAMENTALS OF INTERNET OF THINGS

Time: 3 Hours

Max. Marks: 75

Note: This question paper contains two **Parts A** and **B**

Part A is compulsory which carries **25 marks**. Answer all questions in **Part A**.

Part B consists of 5 Units. Answer any one full question from each unit.

Each question carries **10 marks** and may have a, b, c as sub questions.

PART-A (25 Marks)

Solutions

1. (a) Define IoT. **(Unit-I / Q1)**

   (b) What are the components of IoT? **(Unit-I / Q5)**

   (c) List out any three differences between IoT and M2M. **(Unit-II / Q5)**

   (d) List out various software and development tools of M2M. **(Unit-II / Q4)**

   (e) What are Identifiers? **(Unit-III / Q2)**

   (f) Write short notes on Raspberry Pi interfaces. **(Unit-III / Q8)**

   (g) Explain why Namenode is considered as the most important node of Hadoop. **(Unit-IV / Q8)**

   (h) What are the three major operations of reducer code? **(Unit-IV / Q11)**

   (i) What is cloud computing? **(Unit-V / Q1)**

   (j) List out the applications of sensor cloud. **(Unit-V / Q4)**

PART-B (50 Marks)

2. (a) What kind of information do Internet of Things (IoT) objects communicate? **(Unit-I / Q14)**

   (b) What are the major privacy and security Issues in Internet of Things (IoT)? **(Unit-I / Q15)**

OR

3. (a) Which of the devices are used to connect IoT devices to a home network? **(Unit-I / Q18)**

   (b) Discuss various components of a network. **(Unit-I / Q28)**

4. Define M2M communication. Write about M2M communication and architecture of M2M. **(Unit-II / Q9)**

OR

5. (a) Give a brief introduction to Arduino programming. **(Unit-II / Q13)**

   (b) Illustrate the anatomy of an Arduino program and write in brief about shields. **(Unit-II / Q15)**

6. (a) Write steps to install python on windows. (Unit-III / Q11)

(b) Give a brief introduction to Raspberry Pi. Listout the peripherals of Raspberry Pi. (Unit-III / Q21)

OR

7. Define operator. Describe different types of operators supported by Python with an example for each. (Unit-III / 17)

8. (a) Write in brief about Software Defined Network (SDN). (Unit-IV / Q13)

(b) Write a short notes on,

(i) Data validation

(ii) Data categorization for storage

(iii) Assembly software for events. (Unit-IV / Q18)

OR

9. (a) Explain in detail about big data analytics. (Unit-IV / Q21)

(b) What are the things that need to be configured before running Hadoop? (Unit-IV / Q25)

10. (a) Discuss various cloud service models. (Unit-V / Q15)

(b) Write short notes on sensor-cloud. (Unit-V / Q17)

OR

11. (a) Explain in brief about smart homes. (Unit-V / Q19)

(b) Explain about Industrial Internet of Things (IoT). (Unit-V / Q23)

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MODEL PAPER 2

B.Tech. III Year II Semester Examination

FUNDAMENTALS OF INTERNET OF THINGS

Time: 3 Hours

Max. Marks: 75

Note: This question paper contains two **Parts A** and **B**

Part A is compulsory which carries **25 marks**. Answer all questions in **Part A**.

Part B consists of 5 Units. Answer any one full question from each unit.

Each question carries **10 marks** and may have a, b, c as sub questions.

PART-A (25 Marks)

Solutions

1. (a) Which of the communication protocols are used by IoT? **(Unit-I / Q3)**
   (b) Define 802.16 - WiMax. **(Unit-I / Q7)**
   (c) Define M2M communication. **(Unit-II / Q1)**
   (d) Write short notes on the following,
      (i) Syntactic interoperability
      (ii) Semantic interoperability. **(Unit-II / Q7)**
   (e) List out the comparison operators in python. **(Unit-III / Q4)**
   (f) List out any five peripherals of Raspberry Pi. **(Unit-III / Q6)**
   (g) What are the key elements of SDN? **(Unit-IV / Q3)**
   (h) Write a brief note on MapReduce. **(Unit-IV / Q9)**
   (i) Write short notes on smart grid. **(Unit-V / Q6)**
   (j) Define Smart Agriculture. **(Unit-V / Q10)**

PART-B (50 Marks)

2. (a) Define IoT. Write in brief about the IoT. **(Unit-I / Q9)**
   (b) Discuss in brief about the functional blocks of IoT. **(Unit-I / Q20)**

OR

3. (a) Define computer network. How is a computer network different from other types of networks? **(Unit-I / Q25)**
   (b) Discuss about sensor network. Outline the features of wireless sensor networks. **(Unit-I / Q31)**
4. (a) Discuss various examples of software and development tools. **(Unit-II / Q10)**
   (b) Illustrate the differences between IoT and M2M. **(Unit-II / Q11)**

OR

5. Describe basic Arduino setup for windows 7 and windows 8. **(Unit-II / Q14)**

6. (a) Define control statements. Discuss about if statement. (Unit-III)
(b) Describe implementation of Raspberry Pi with python. (Unit-III)

OR

7. Explain the various datatypes in python. (Unit-III)

8. (a) Illustrate the architecture and key elements of SDN. (Unit-IV)
(b) What are the various ways of organizing the data? Explain. (Unit-IV)

OR

9. (a) Discuss about the design of Hadoop Distributed File System (HDFS). (Unit-IV)
(b) Illustrate the architecture of data analystics. (Unit-IV)

10. (a) Discuss about cloud computing. Also, list various services and usages of cloud platform. (Unit-V)
(b) Discuss in brief about smart cities. (Unit-V)

OR

11. (a) Explain about connected vehicles. (Unit-V)
(b) Write about agriculture in IoT. (Unit-V)

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MODEL PAPER 3

B.Tech. III Year II Semester Examination

FUNDAMENTALS OF INTERNET OF THINGS

Time: 3 Hours Max. Marks: 75

Note: This question paper contains two **Parts A** and **B**

Part A is compulsory which carries **25 marks**. Answer all questions in **Part A**.

Part B consists of 5 Units. Answer any one full question from each unit.

Each question carries **10 marks** and may have a, b, c as sub questions.

PART-A (25 Marks)

Solutions

1. (a) Define actuator. (Unit-I / Q6)

(b) What is IoT connectivity? (Unit-I / Q4)

(c) List out the domains of M2M architecture. (Unit-II / Q3)

(d) Write in brief about Arduino. (Unit-II / Q8)

(e) Listout the features of python. (Unit-III / Q1)

(f) List out the keywords used in python. (Unit-III / Q5)

(g) What is data analytics? (Unit-IV / Q4)

(h) What is data validation? (Unit-IV / Q6)

(i) Write in brief about sensor cloud. (Unit-V / Q3)

(j) List out the advantages of industrial IoT. (Unit-V / Q8)

PART-B (50 Marks)

2. (a) What are the main challenges of Internet of Things (IoT)? (Unit-I / Q12)

(b) Explain about sensor technology and list some examples of sensors. (Unit-I / Q21)

OR

(a) What is a communication protocol? Explain. (Unit-I / Q29)

(b) Define some of the key terms and concepts of sensor networks. Also, discuss various subsystems of sensor nodes. (Unit-I / Q32)

How sensors and actuators are integrated with Arduino? Explain. (Unit-II / Q16)

OR

Discuss about interoperability in IoT. (Unit-II / Q12)

6. (a) What is Python? Explain the features of Python language. (Unit-III / 0
(b) Explain about interfacing Light sensor with Raspberry Pi. (Unit-III / 02

OR

7. Give a brief introduction about repetition structure. (Unit-III / 01

8. (a) Write a short notes on data generation. (Unit-IV / 01
(b) What is Analytics? Explain about analytics phases. (Unit-IV / 02

OR

9. (a) Discuss in detail about the building blocks of Hadoop. (Unit-IV / 02
(b) Discuss about traditional network architecture. (Unit-IV / 01

10. (a) List the advantages of cloud computing. (Unit-V / 01
(b) Explain different types of cloud deployment models. (Unit-V / 01

OR

11. (a) Discuss about smart grid. (Unit-V / 02
(b) Write short notes on activity monitoring. (Unit-V / 02

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UNIT 1

Syllabus

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

LEARNING OBJECTIVES

- ✓ Definition of IoT and its Characteristics
- ✓ Issues and Challenges in IoT
- ✓ IoT Devices and their Components
- ✓ Various Functional Blocks of IoT
- ✓ Concepts of Sensing and Actuation
- ✓ Different Communication Protocols Used for Data Transmission
- ✓ Sensor Networks and its Features.

INTRODUCTION

IoT can be defined as a method that allows internetworked devices and applications to communicate with each other. Examples of it are GPS based tracking, monitoring and controlling of devices, connected cars, wearable and personal devices communication, M2M communication and Industry 4.0.

The Internet is a global network of servers, tablets, mobiles and computers. It follows a set of standard protocols developed for connected systems. It allows to communicate (send, receive and connect) with remote servers, analytics platforms and cloud.

Sensor technology plays a key role in designing the sensors and respective circuits, electronic readers and devices. A sensor is an electronic device that receives a signal and responds with an electrical signal.

Actuator is a device which is used to achieve actuation which means producing physical changes such as linear and angular displacements. It is used to provide the actual motive force for the robot joints. It can also modulate the rate and power associated with changes in displacements. Actuators get their power from one of three sources i.e., electricity, compressed air and pressurised fluid.

PART-A SHORT QUESTIONS WITH SOLUTIONS

Q1. Define IoT.

Answer : Model Paper-I, Q1(a)

IoT can be defined as the method that allows internetworked devices and applications to communicate with each other. Examples of it are GPS based tracking, monitoring and controlling of devices, connected cars, wearable and personal devices communication, M2M communication and Industry 4.0.

The Internet is a global network of servers, tablets, mobiles and computers. It follows a set of standard protocols developed for connected systems. It allows to communicate (send, receive and connect) with remote servers, analytics platforms and cloud.

Q2. Write in brief about server end technology.

Answer :

The servers of IoT are data centres, databases, enterprise servers and application servers. They provide various software components which are as follows,

- Data gathering, organizing, analysing, integrating and identification.
- Online platforms.
- Device identification, management and access management.
- Usage of services, business processes and applications.

Q3. Which of the communication protocols are used by IoT?

Answer : Model Paper-II, Q1(a)

Bluetooth BR/EDR and Bluetooth Low Energy

The IEEE 802.15.1 standard protocol is followed by the Bluetooth devices for L1. Devices have two modes namely Bluetooth BR/EDR and Bluetooth low energy. The Bluetooth V4.2 is the latest version which provides extension of LE data packet size, secure convections, filter link layer policies, link layer privacy and extended scanner. The BTLE is called Bluetooth smart and covers a range of 150m at 10mw of power output with data rate of 1Mbps and setup time less than 6s. The later version is Bluetooth V5 that is released in June 2016.

ZigBee IP/ZigBee SE 2.0

The IEEE 802.15.4 standard protocol LI is followed by the ZigBee. The devices are part of WPAN devices network. The actuators, sensors, appliances, medical data systems or controls connecting to internet for business and service processes are also part of the WPAN with ZigBee end-point devices. The ZigBee IP has L1 layer PDU = 127B, low latency link layer connection, data transfer rate of 250 Kbps, RFD in ZigBee SE 2.0, IPv6 connectivity and other features.

Wi-Fi

The technology called Wi-Fi makes use of IEEE 802.11 protocol and allows WLANs. The devices of it can connect offices, universities and enterprises by using home AP/Public hotspots. It allows the distributed WLAN network connections through Internet. It also allows networking of the sensors, actuators, home networking, automobiles, computers, tablets, printers, mobiles etc. The Wi-Fi interfaces are connected to each other or to an Access Point (AP) or wireless router through Wi-Fi PCMCIA or PCI card / built in circuit card by using base station or AP, WLAN transceiver etc.

Q4. What is IoT connectivity?

Answer : Model Paper-III, Q1(b)

IoT connectivity can be defined as the way of connecting sensors and IoT connected devices to a data processing module. It is one of the major challenges of IoT. There is no single IoT connectivity technology exists to fulfill the requirements of various IoT use cases. However, there are 20 to 30 options available with their respective advantages, disadvantages and features. Some of the IoT solutions available in 2019 are as follows,

1. Wi-Fi
2. Bluetooth
3. Mesh network
4. Ethernet.

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Q5. What are the components of IoT?

Answer :

Model Paper-I, Q1(b)

The four major components of IoT devices are as follows,

1. **Software**

It is used for actions on messages, data and commands which the devices will receive and generate to the actuators with this the actions like robotic hand movement, glowing LED's etc.

2. **Hardware**

It indicates components like microcontroller, control unit, firmware, sensors and communication module.

3. **Physical Object**

It refers to embedding the software into the hardware.

4. **Communication Module**

It is a software that has device API's and device interface used for the communication over network circuit/ports and middleware to build communication stacks through CoAP, IPv4, IPv6, 6LoWPAN and LWM2M etc.

Q6. Define actuator.

Answer :

Model Paper-III, Q1(a)

Actuator is a device which is used to achieve actuation which means producing physical changes such as linear and angular displacements. It is used to provide the actual motive force for the robot joints. It can also modulate the rate and power associated with changes in displacements. Actuators get their power from one of three sources such as electricity, compressed air, pressurised fluid.

The various examples of actuators are as follows,

(i) LED

(ii) Light sources

(iii) Piezoelectric vibrator

(iv) Piezoelectric speaker

(v) Solenoid.

Q7. Define 802.16 - WiMax.

Answer :

Model Paper-II, Q1(b)

IEEE 802.16 is a standard for WiMAX which is a Wireless Metropolitan Area Network (WMAN). WiMAX is an acronym for worldwide Interoperability for Microwave Access. IEEE 802.16 examined both licensed and unlicensed band of 2-66 GHz, which is the standard of fixed wireless broadband supporting mobile broadband application.

WiMAX forum was established in June 2001 to organise and improve the equipment that will be well suited and interoperable with other standards. In 2007, Mobile WiMAX equipment was expanded with the standard IEEE 802.16e, offering mobility and roaming access, IEEE 802.16e standard uses OFDMA technique. The prerequisite of OFDMA technique is good performance in Non Line of sight connection.

Q8. What is a wireless sensor network?

Answer :

The mobile ad hoc network of smart sensors with communication, networking and computational features is referred to as wireless sensor networks. Smart sensor is the one which has computational and logical abilities. However, wireless sensors make use of radio frequency transceiver for communication purpose. This transceiver helps the node to send and receive the packets from the nodes closer to it.

PART-B ESSAY QUESTIONS WITH SOLUTIONS

1.1 INTRODUCTION TO INTERNET OF THINGS, CHARACTERISTICS OF IoT

Q9. Define IoT. Write in brief about the IoT.

Answer : Model Paper-II, Q2(a)

IoT can be defined as the method that allows internetworked devices and applications to communicate with each other. Examples of it are GPS based tracking, monitoring and controlling of devices, connected cars, wearable and personal devices communication, M2M communication and Industry 4.0.

The Internet is a global network of servers, tablets, mobiles and computers. It follows a set of standard protocols developed for connected systems. It allows to communicate (send, receive and connect) with remote servers, analytics platforms and cloud.

A thing in English persists various meanings and uses. In dictionary, it is defined as a physical object, an activity or situation, an action or idea etc. Examples of it are a table, chair, street light etc. These are the things as objects where as reference to an action "Such a thing is not expected from her" and reference to a situation "such things are multiple in that region".

The Internet of things from some other source is defined as the network of physical objects or things including sensors, software, electronics, operators etc. It is defined as vision in which the things become smart and function such as computing, communicating using embedded devices with remote objects or persons or NFC (Near Field Communication) etc.

Vision means making the things smart, intelligent and behave like alive.

Q10. List out the entities that provide diverse technology environment and entities considered for five levels behind IoT system.

Answer :

The entities that provide a diverse technology environment are examples of technologies. They are also involved in IoT.

- Software (RIOT OS, Contiki OS, Things square Mist firmware, Eclipse IoT).
- Integrated Development Environment (IDE) to develop device software, firmware and API's.
- Communication (NFC, ZigBee, WiMax, 2G/3G/4G, Power Ethernet, RFID, 6LowPAN, UWB. WiFi).
- Hardware (ARM mBed, Intel Galileo, Beagle Bone Black, Wireless SoC, Bosch XDK110, Intel Edison and Arduino Raspberry Pi).
- Network backbone (IPv4, IPv6, 6LowPAN and UDP).
- Protocols (HTTP, XMPP, CoAP, RPL, RESTful, MQTT).
- Internetwork Cloud Platforms/Data Centre (Nimbits, Xively, AWS IoT, IBM BlueMix, Sense, Azure, Thingworx, Open HAB, CISCO IoT, TCS CUP, Iox and Fog).
- Machine learning algorithms and software. Example of machine learning software is GRoK of Numenta Inc. It uses the machine intelligence for analyzing the streaming data from clouds, exposing the anomalies.

It can learn from data and can extract action from GROK's data models output. It can even perform high level of automation to analyze the streaming data.

The entities that are considered for the five levels behind IoT system are as follows,

1. Sever and web programming to enable web applications and web services.
2. Cloud platform enabling storage, product development platforms and computing prototype.
3. Device platform that contains device hardware and software to use a microcontroller and software for device APs and web applications.
4. Online transaction processing, predictive analytics, data analytics, online analytics processing and knowledge discovery that enables wider applications of IoT system.
5. Connecting and networking (Connectivity protocols and circuits) for enabling the internetworking of devices and physical objects such as things and for enabling internet connectivity to remote servers.

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Q11. What is server-end technology? Discuss the major components of IoT system.

Answer :

Server-end Technology

The servers of IoT are data centres, databases, enterprise servers and application servers. They provide various software components which are as follows,

- Data gathering, organizing, analysing, integrator and identification.
- Online platforms.
- Device identification, management and access management.
- Usage of services, business processes and applications.

Major Components of IoT System

The four major components of IoT devices are as follows,

1. **Software**

It is used for actions on messages, data and commands which the devices will receive and generate to the actuators with the actions like robotic hand movement, glowing LED's etc.

2. **Hardware**

It indicates components like microcontroller, control unit, firmware, sensors and communication module.

3. **Physical Object**

It refers to embedding the software into the hardware.

4. **Communication Module**

It is a software that has device API's and device interface used for the communication over network circuit/ports and middleware to build communication stacks through CoAP, IPv4, IPv6, 6LoWPAN and LwM2M etc.

The other components of the IoT system are as follows,

Sensors and Control Units

1. **Sensors**

The sensors are the electronic devices that are capable of sensing the physical environments. They are used in control systems where smart sensors are used in robotic system and industrial automation system. A smart sensor contains communication and computing circuits. A sensor can measure the temperature, humidity, acceleration in accelerometer, magnetic fields in compass etc.

There are two types of sensors, one provides analog inputs to control unit. The Hall sensor, photoconductor, photo gauge and thermistor are the examples of it. The other type of sensor provides digital inputs to the control unit. Examples of it are touch sensor, traffic presence sensor, metal sensor etc.

2. **Control Units**

The control units of IoT have Microcontroller Unit (MCU) or custom clip embedded in them. The MCU consists of firmware, functional I/O units, processor, memory, interrupt controllers and application specific functional circuits. The MCU for example might contain Pulse Width Modulators (PWM) and Analog to Digital Converters (ADC).

3. **Operating Systems**

The operating systems used in IoT are AllJoyn, Contiki, Spark, Raspbian and RIOT. The AllJoyn is an open source cross platform that contains API's for OSX, Windows Operating Systems, Android, iOS and Linux. Contiki is an open source multitasking OS containing UDP, DTLS, 6LoWPAN, TCP/IP and RPL protocols. Spark is a web based IDE distributed and cloud based OS. The Raspbian is the Raspberry Pi operating system that depends upon Debian distribution of Linux. The RIOT is an OS that has support for multiple architectures and developer.

4. **Middleware**

The open IoT is an open source middleware that allows to communicate with cloud based 'Sensing as service' and sensor clouds. It provides communication stack for smart devices through OBM, CoAP, 6LoWPAN, IPv6 multiple standards and protocols.

5. **Firmware**

An example of middleware is things square used for true internet-connectivity to IoT. It is supported by various microcontrollers with a set of wireless radios. It supports wireless mesh networking flexibly.

Q12. What are the main challenges of Internet of Things (IoT)?

Answer : **Model Paper-III, Q2(a)**

Some of the main challenges of Internet of Things (IoT) are as follows,

1. **Security**

Security is considered as one of the major challenges in IoT. As the number of connected devices increased, the chances of security vulnerabilities will also increase. The data stored in IoT devices could be corresponding to user privacy identity. Thus, it is required to protect the data in the devices else it can be prone to hacking and various attacks. Although it is expensive to provide security in every IoT device, it must be required to secure the user data on the devices.

2. **Standards**

The IoT devices require good standards and best practices in order to work effectively. The lack of standards may result in consequences such as poorly designed products. These inturn results in networking issues. So, implementation good standardization is required to develop a good connected device.

3. **Privacy**

It is an important issue in the Internet of Things. The IoT devices consists of sensitive information of users such as name, address, DOB, health card details, credit card information etc. So, there is a possibility of information leak while transmitting the data to a cloud for processing through unauthorized access or third party. This issue needs to be resolved to safeguard personal data or private information stored by users on a connected device.

4. **Regulation**

In IoT, there are regulatory and legal issues which are need to be considered. The lack of regulation may results in internet-related issues. If these issues exists, then there will be effect on the quality of service.

Q13. What kind of information do Internet of Things (IoT) objects communicate?

Answer : **Model Paper-I, Q2(a)**

The type of information that IoT objects communicate is based upon the nature of the respective objects. Some times, the information can be easy and some times complex. Consider an example of a smart thermometer. It consists of one effective sensor that is used to provide temperature to the remote weather - monitoring center or system. Whereas a wireless clinical device consists of multiple sensors to provide information about the body temperature, body pulse, blood stress etc., to a medical service company with the help of smart phone or a computer.

Smart objects can build the systems that are connected with the system and informs the fats and a set of instructions. This type of communication allows to use the smart systems everywhere. The smart systems allows the user to handle the processes from the remote areas. Consider an example of smart home system. This system is used to control and monitor the home appliances, computers, cameras, TV's etc., from remote areas. In this system, the objects communicate complex information in order to provide the functionality.

Q14. What are the major privacy and security Issues in Internet of Things (IoT)?

Answer : **Model Paper-I, Q2(b)**

Privacy Issues of IoT

The major privacy issues incase of IoT are as follows,

1. **Eavesdropping**

Generally, the connected devices help the hacker to monitor the home of a user virtually. The R&D team of Germany has achieved this by stopping the unencrypted data sent from a smart meter device to know what TV program a particular user is watching at a particular time.

2. **Too Much Data**

The amount of data generated by IoT devices per day is large. According to a research done by a Federal Trade commission, it is known that approximately 150 million discrete data points are generated by less than 10,000 users a day. Thus, they can have more number of entry points to theft the sensitive data.

3. **Unwanted Public Profile**

Generally, most of the users accepts the "terms and conditions" provided while installing an application in an IoT device, without going through the complete details. This means that, the user himself/herself granting the permission to access their data.

4. **Consumer Confidence**

All the above mentioned issues will create a depression on consumer's confidence which may lead to avoiding the Internet of Things (IoT) from its original capacity or capability.

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Security Issues of IoT

The major security issues in IoT are as follows,

1. **True Security**

   True security means other than securing the original devices. To achieve this, while developing an application the developers should develop the security into the application as well as the network devices that are used to connect these devices.

2. **Security Against Attackers**

   According to a survey conducted by AT&T, among 5000 companies, it is known that 85 percent of the companies are ready to develop IoT devices whereas only 10 percent of them are ready to develop IoT devices with a security against attackers.

3. **Public Perception**

   Public perception is one of the main security issues of IoT. According to Icontrol state of the smart home study (2015), 44 percent of American users are worried about losing of information through their smart home devices and 27% of American users are worried about the theft of information. This makes some of the users not to buy the IoT devices.

4. **Vulnerability to Hacking**

   The researchers are easily entering into on-the-market and real devices with their enough energy and time. Thus, they are capable of duplicating their efforts.

1.2 PHYSICAL DESIGN OF IoT

Q15. Illustrate the importance of things in IoT with a block diagram of its physical design.

Answer :

"Things" in IoT are referred to the IoT devices with unique identifications. They tend to possess the capabilities such as sensing, actuating and monitoring.

The IoT devices are also capable of extracting, processing and sending data from other devices to centralized servers or cloud based application backends. Other than this, they can work on certain tasks in local and some other tasks in IoT infrastructure depending on the constraints such as communication processing/memory capabilities, speed etc. Data can be exchanged between IoT and other devices or applications. The figure depicts the block diagram of an IoT device.

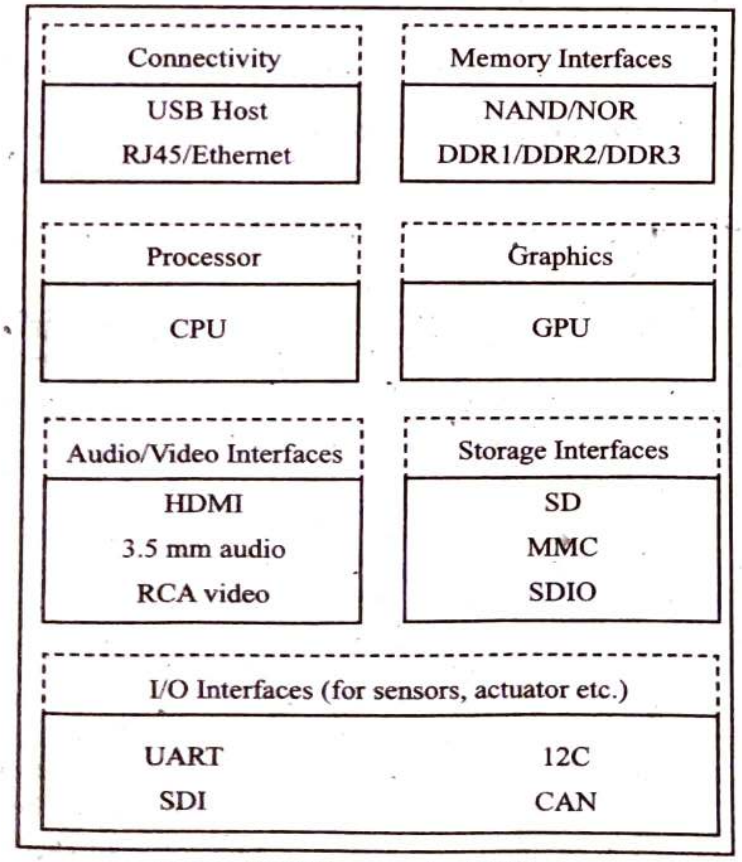


Figure: Block Diagram of an IoT Device

The above figure contains various interfaces to connect with other devices connected over wired and wireless network. They consists of the following,

(i) I/O interface for sensors

(ii) Interfaces for internet connectivity

(iii) Audio/Video interfaces

(iv) Memory and storage interfaces.

Initially, the IoT device gathers different types of data from the sensors which are on-board or attached externally. This data is used in the data communication among various devices or cloud-based servers/storage. The actuators play an important role in allowing the connected sensors to communicate with other physical entities available in the scope of devices. There are different types of IoT devices such as wearable sensors, smart watches, LED lights, automobiles and industrial machines. These are depicted in the below figure.

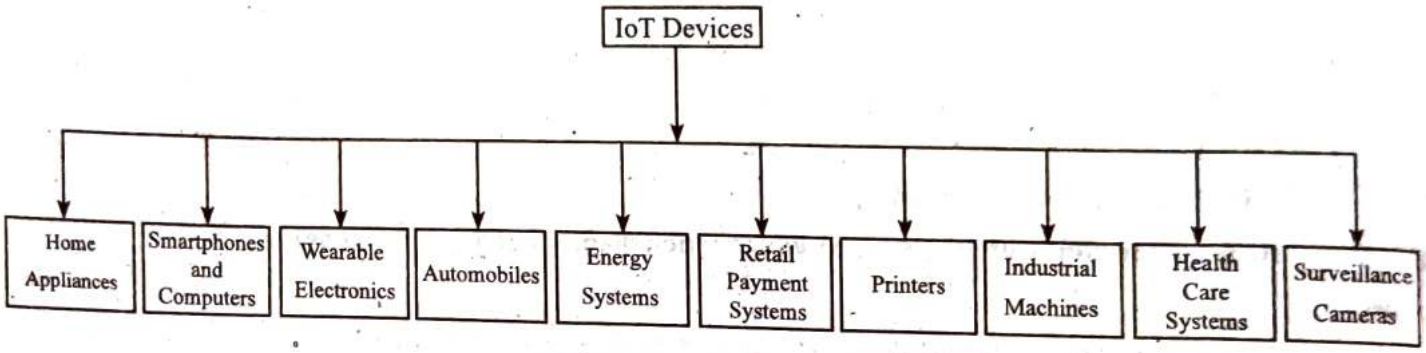


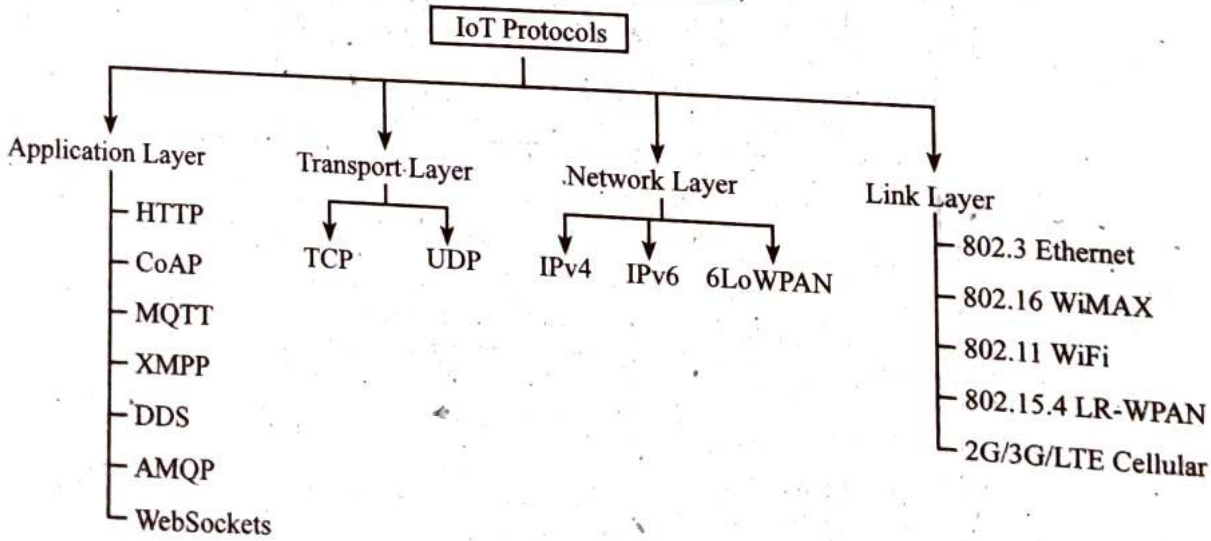
Figure: Types of IoT Devices

All types of devices listed in the above figure produce data that is processed by data analytics systems and help in taking appropriate actions that are to be performed locally or remotely. For example, the data generated by a sphygmomanometer helps in determining the blood pressure levels of the patient when processed.

Q16. Explain different types of protocols of IoT.

Answer :

There are four types of protocols available in IoT. They are as follows,



1. Link Layer

Link layer protocols illustrate the process of transmitting data over physical layer of the network. The vicinity of this network would be the network connection that is locally integrated and the host is connected. Multiple hosts on a link can exchange data packets through link layer protocols. Moreover, the link layer instructs the process of coding and signaling the packets through a hardware device on a medium connected to host. Different types of link layer protocols are as follows,

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(i) **802.3 Ethernet**

This protocol offers various wired Ethernet standards for the link layer. For example, the standards such as 802.3.i, 802.3.j and 802.3ae are associated with 10BASE-T, 10BASE-F and 10 Gbits respectively over different mediums. All these standards offer data rates ranging from 10 Mbps to 40 Gbps and even higher than this.

(ii) **802.11 WiFi**

This protocol offers communication standards related to WLAN along with additional information about the link layer. For example, the standards such as 802.11a, 802.11b/802.11g, 802.11n, 802.11ac and 802.11ad tend to operate in 5 GHz, 2.4 GHz, 2.4/5 GHz, 5 GHz and 60 GHz respectively. All these standards offer the data rates ranging from 1 Mbps to 6.75 Gbps.

(iii) **802.16 WiMax**

This protocol offers broadband standards that are wireless along with additional information related to the link layer. These standards offer data rates ranging from 1.5 Mbps to 1 Gbps.

(iv) **802.15.4 LR-WPAN**

This protocol offers standards that provide low-cost wireless personal area networks. These standards act as the building blocks of high level communication protocols like Zigbee. These standards offer data rates ranging from 40 kbps to 250 kbps.

(v) **2G/3G/4G Mobile Communication**

The mobile communication is classified based on different generations such as 2G, 3G, 4G etc. They help the IoT devices in providing communication medium over cellular networks. These standards offer data rates ranging from 9.6 Kbps to 100 Mbps.

2. **Network/Internet Layer**

The network layer protocol is used for the transmission of IP datagrams between source and destination networks. It offers various functions such as packet routing and host addressing. The IP datagrams hold addresses of source as well as destination where the host can be located through addressing schemes such as IPv4 or IPv6.

(i) **IPv4**

The IPv4 header contains a number of words including 160-bits and optional extended words (i.e., n – 5). Extension is required to perform certain actions by using the data stack from or for the transport layer.

Features of IPv4

1. IPv4 header contains five words of size 160-bits and two additional words called option and padding words of variable size. These extended words are used only when they required. The maximum number of words that the data stack sends to the network layer is, $v = (n + len)$ where, $v \leq (2^{14} - n)$.
2. The fourth and fifth words in header are known as source address and destination address.
3. Only a single data packet can communicate in one direction at a time.
4. The data stack in a IP layer is known as "IP Packet". When UDP is used as transport layer protocol, the IP packet has no assurance in reaching the target. When TCP is used as transport layer protocol, the IP packet is assured to reach the destination/target.
5. The transmission in Internet protocol layer is half duplex unacknowledged about the data flow from an internet layer to other internet layer at two different ends.

(ii) IPv6

IPv6 was developed and designed to overcome the limitations of IPv4.

Features of IPv6

The features of IPv6 are as follows,

1. It provides huge addressing space.
2. It handles security, mobility and configuration characteristics of a device.
3. It provides extra optimizations to deliver the services with the help of subnets, routers and interfaces.
4. It provides jumbo grams (i.e., big size datagrams).
5. It provides the extensibility of options.
6. It allows route aggregation over the internet hierarchal address allocation. It restricts the expansion of routing tables.
7. It uses the expanded and simple versions of multicast addressing.

(iii) 6LoWPAN

6LoWPAN is the abbreviation of Internet Protocol version 6 over Low Power Wireless Personal Area Network. It is used by data stack at adaptation layer before transferring to the IPv6 internet layer. The 6LoWPAN interface serial port is used in IEEE 802.15.4 WPAN devices for connectivity.

The IEEE 802.15.4 devices are the nodes with low power and speed. They use 6LoWPAN as an adaptation-layer protocol. These devices are known as the WPAN nodes of a multiple device mesh network.

The devices with low power are required to restrict the data size. Fragmentation and data compression are used to reduce the size of the data. Reassembly, header compression and fragmentation are some of the important features of 6LoWPAN. If the fragmentation of data is done prior to the communication process, then a fragment header contains 27-bits in which datagram is of size 11-bits and datagram tags of size 16-bits are included. The fragment comprises of header 8-bits that contains datagram size, datagram tag and offset. The reassembly time limit of fragment is set to 60 seconds.

3. Transport Layer

The transport layer protocol is responsible for the transmission of messages from one end to the other end without the concern of underlying network. This layer offers various functions such as flow, congestion and error controls. Different types of transport layer protocols are as follows,

(i) TCP

TCP is a connection oriented and most commonly used protocol in the transport layer. It is mainly used by the transport layer when the receiver accepts the data segment sequence number and sends back the remaining data segment sequence numbers to the receiver. TCP can also be used to process the data segment from application layer port and transfers only the segment part. In a TCP stream, the size of the data to be transmitted depends on the network traffic. If the traffic is high, few data packets are sent to the receiver-end of the Internet layer L3.

(ii) UDP

The Universal Datagram Protocol (UDP) is used for unacknowledged data flow from the receiver and the application datagram needs to transfer data over the internet and when the datagram size is limited to 2^{16} bytes. Here, datagram refers to a message which does not have any relation with the preceding and succeeding messages.

4. Application Layer

For answer refer Unit-I, Q17.

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Q17. Explain about application layer.

Answer :

Application Layer

Application layer protocols are used for interfacing between applications and low layer protocols to offer exchange of data over the network. They allow process-to-process communication through ports. Some of the application layer protocols are as follows,

HTTP

Hypertext Transfer Protocol (HTTP) is used by Web browsers and Web servers to communicate with one another(default port number is 80). Universal Resource Locator(URL) is the way representing an address of a system. The URL can be in string form(like www.yahoo.com) or in the number format(like 122.120.1.8). Clients can use the URL to contact the server. By issuing the HTTP GET command, the Web browser can inform the server of what data it wants like text, images etc., (this is called setting MIME(Multiple Internet Mail Extension) type).

HTTPS

When HTTP is taken over SSL, HTTPS is obtained. It is nothing but the combination of HTTP and SSL. The HTTPS is employed inorder to have a secure communication between web browser and a web-server. All contemporary web browsers incorporate HTTPS and it operates based upon web-server that substantiates HTTPS communication.

The basic difference noticed by the web-browser user is that the URL i.e., Uniform Resource Locator address is initiated with https:// but not with http://. The usual port utilized for HTTP connection is port 80 but when HTTPS is specified, the port used is 443 which activates the SSL.

FTP

FTP (File Transfer Protocol) is used to access files by FTP. FTP is a standard internet protocol through which internet users can upload files from their computers to a website or download files from a website to their PCs.

TELNET

The TELNET protocol is used to create connection between two remote machines. It is used on the internet or local area networks to provide a 2-way (bidirectional) interactive text-oriented communication facility between a client and a host using a virtual terminal connection.

Other Ports

The familiar port numbers are reserved by Internet Number Assigned Authority (IANA). The port numbers range between 0 to 1023. Here, the number '0' indicates that it is the host by itself. The registered port numbers ranges from 1024 to 49,151 and the unregistered port numbers ranges from 49,152 to 65,535. The port number of an unregistered server is above 5000.

Constrained Application Protocol (CoAP)

Constrained application protocol is a web transfer protocol which is specifically designed to fulfil the requirements of constrained devices. It runs on devices that support UDP protocol.

Since CoAP is a web transfer protocol it depends on RESTful architecture. This architecture provides request/response interaction between the endpoints of application. It is mainly developed for IoT and M2M applications for sending messages over UDP protocol. It employs client-server communication model. Initially client sends request to the server and then server sends response to the client. However, CoAP is more essential for constrained devices because traditional protocols like HTTP are too heavy for IoT applications.

MQTT

MQTT stands for Message Queuing Telemetry Transport protocol. It is an open source protocol used for machine to machine or IoT connectivity. This protocol was initially developed by IBM who later donated it to 'M2M' Paho project of eclipse. MQTT v3.1.1 and MQTT-SN v1.2 are the versions of MQTT.

MQTT-SN v1.2 is used by sensor networks and non TCP/IP networks. It allows expansion of MQTT protocols for wireless sensor networks, sensor and actuator devices and their networks.

AMQP

The Advanced Message Queuing Protocol (AMQP) is an open standard which communicates between applications through messages. Instead of device management AMQP is placed around message management. Advanced Message Queuing Protocol (AMQP) defines three architectures. They are,

1. AMQP command architecture
2. AMQP transport architecture
3. AMQP client architecture.

Q18. Which of the devices are used to connect IoT devices to a home network?

Answer : Model Paper-I, Q3(a)

The cloud devices that are used to connect IoT devices to a home network are as follows,

1. Cloud server
2. Home gateway.

1. Cloud Server

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

2. Home Gateway

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

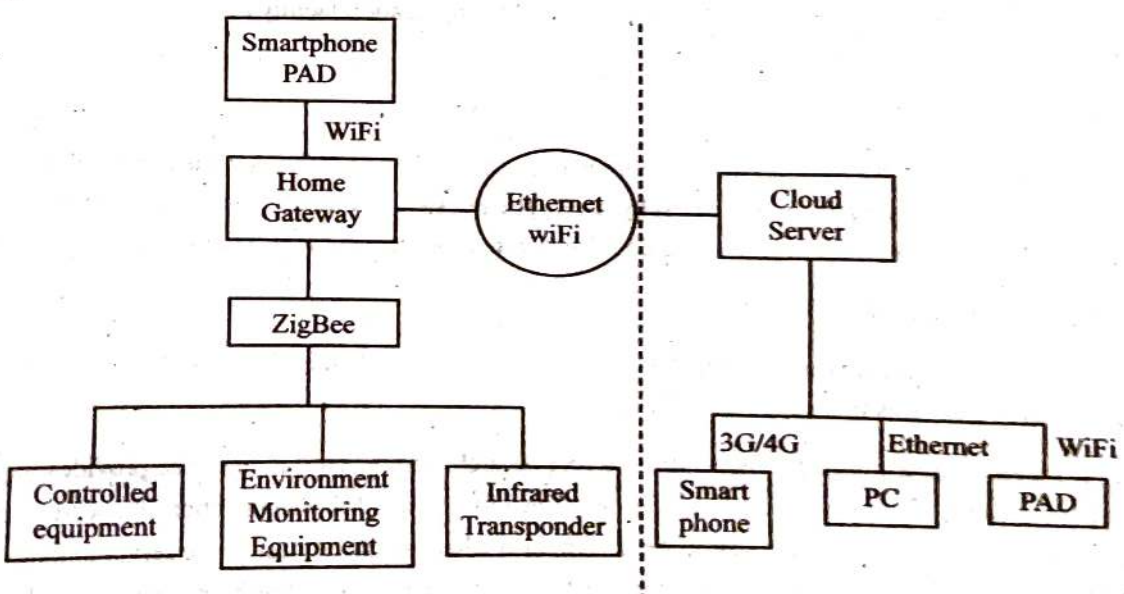

Figure: Design Diagram of Smart Home System

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19. **Write about examples of IoTs.**

nswer :

The examples of IoTs include various wearable devices like sleep monitors, watches, fitness trackers and heart monitors. arious devices of such type are produced by Garmin, Fitbit and other companies.

Wearable Smart Watches

The examples of wearable watches depending upon IoT concept are as follows,

) **Apple Watch**

The Apple ismartwatch contains certain applications like health and fitness, Nike, Running to track morning or evening uns etc. It has the following features,

- Updating names and emails
- Measuring heart rate
- Allowing to run music while exploring through parks without using phone
- Allowing chat with others
- Making payments through payment wallets
- Finding and tracking a taxi
- Controling Apple TV.

(ii) **Microsoft Wrist Band 2**

The Microsoft wrist band 2 provides the following features,

- It helps in productivity through message notifications, calendar and email.
- It is compatible with iOS devices, Windows and Android devices.
- It includes sensors such as GPS, UV, 3-axis accelerometer, optical heart rate, gyrometer, ambient light, galvanic skin response skin temperature and Barometer.

(iii) **Samsung Galaxy Gear Smartwatch**

The Samsung Galaxy Gear Smartwatch provides the following features,

- It includes GPS
- It contains WiFi and Bluetooth connectivity options and navigational features like assist walking.
- It has two inch curved display and supports calling as well as messaging.
- The S Health App will measure the heart rate and the UV will monitor and inform the user about the food time, resting time etc.

2. **Smart Home**

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

3. **Smart Cities**

The concept of IoT is applied on Internet of everything inorder to develop smartcities.

1.3 FUNCTIONAL BLOCKS OF IoT

Q20. Discuss in brief about the functional blocks of IoT.

Answer : **Model Paper-II, Q2(b)**

Functional blocks of IoT helps in sensing, communicating, actuating, identifying and managing the IoT system. The functional blocks of an IoT device are illustrated in the below figure,

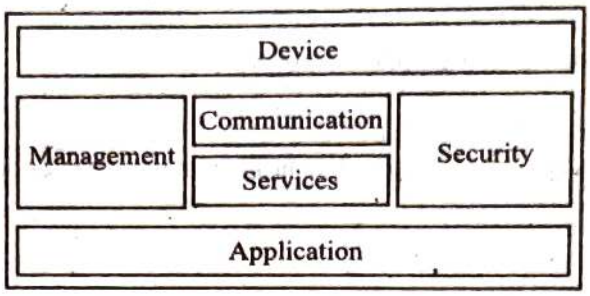

Figure: Functional Blocks of IoT

1. **Device**

   The devices of IoT are responsible for performing various functions such as sensing, monitoring, control and actuation.

2. **Communication**

   The communication block is responsible for handling the communication in an IoT system.

3. **Management**

   The management block is responsible for performing different functions that help in guiding the IoT system.

4. **Services**

   An IoT system makes use of various services of IoT to monitor and control the device, publish data and discover the device.

5. **Security**

   The security functional block is responsible for providing security to IoT system through various security functions such as authentication, authorization, data security, content and message integrity.

6. **Application**

   The applications of IoT are responsible for providing an interface through which users gain control as well as monitor different aspects of IoT systems. They also allow to observe the system status and processed data.

1.4 SENSING, ACTUATION

Q21. Explain about sensor technology and list some examples of sensors.

Answer :

Sensor Technology **Model Paper-III, Q2(b)**

Sensor technology plays a key role in designing the sensors and respective circuits, electronic readers and devices. A sensor is an electronic device that receives a signal and responds with an electrical signal. A sensor can sense different parameters like,

1. Physical parameters such as light, metal, energy, heat, smoke, pressure.
2. Acceleration, speed, orientation, angle etc.
3. A microphone can sense the change in the sound and also used to record the sound (like music or voice).

These parameters can be sensed and converted into electrical energy.

A sensor consists of electronic circuit connected to the input which is used to receive the output of the sensor that is in accordance with the change in the physical condition. A smart sensor is a sensor that consists of electronic circuit in it with some computing and communication capabilities. Analog sensor is used to compute the changes in the parameters on the basis of a reference or a condition and results the value of the sensed parameters after some appropriate calculations. In digital sensors, the changes in the parameters with respect to a reference or condition can be represented in the form of 0's and 1's.

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Examples of Sensors

The different examples of sensors are as follows,

1. **Humidity Sensor**

Humidity sensor also known as hygrometer is used to sense and measure the water vapours or moisture in the air in terms of percentages. The relative humidity is the ratio of water vapours in the air to the highest possible content of water vapours in the air at a particular temperature. The humidity above 90% indicates that it is a rainy day.

2. **Light**

A photoconducter is used to sense the intensity of the light. The sensor displays a drop in resistance with the nearby light. On the other hand, the p-n junction photodiode or photo transistor is also used to measure the intensity of the light.

3. **Acceleration**

A Micro-Electro-Mechanical Sesnsor (MEMS) is used to measure the linear acceleration a_x, a_y, a_z across the three axes x, y, z with the help of capacitive change in the axes.

4. **Vibrations and Shocks**

A MEMS can also be used to sense and measure the vibrations and shocks by the variations that occurred due to the piezoelectric effect.

5. **Angular Acceleration and Change in Direction (Angle)**

A Gyroscope is used to sense and measure the change/variation in the angular velocity i.e., angular acceleration and change/variation in the direction (i.e., angle). An application is used to read the measurements with the help of a gyroscope or accelerometer and the system starts computing as programmed.

6. **LIDAR**

LIDAR (Laser Imaging, Detection and Ranging) sensors and Laser 3D imaging technology is used to turn on the remote sensing and imaging. It detects the distance by focusing the laser light on target. The sensor is used to sense the reflected laser light that enables the measurement of distance.

Q22. Explain the concept of sensing the real world.

Answer :

Sensing the Real World

For answer refer Unit-I, Q21, Topic: Sensor Technology.

A sensor is used to sense a physical change when it exposes a measurable change in a characteristic circuit parameters on the change in the surrounding, physical state on a condition.

Analog Sensors

Analog sensor makes use of sensor with the respected electronic analog circuit. It is used to produce the analog outputs according to the physical environmental parameters like pressure, temperature, humidity, proximity or magnetic field. The resistance of the sensing component results a small change depending on the physical environmental variables, pressure or strain etc. If the pressure increases on a pressure sensor then the strain on the sensor will be increased. For example, a flex sensor of length 2.2 inch or 4.5 inch shows results the change in resistance across the sensor trip because of the change in path and deflection of the sensing resistor.

The analog output from a sensor circuit can be measured as given below,

(i) Initially, the sensor output is sent to signal conditioning-cum-amplifying circuit (SC) as an input.

(ii) The output of SC will be sent to ADC as an input.

(iii) ADC produces the digital output in the form of 8 or 12 bits which can be read using the microcontrollers.

(iv) By using the microcontroller readings and computations, it produces the sensed parameter value and displays the physical condition of the sensor at surroundings.

Serial Port Interface

The main advantage of serial port interface with ADC is that the ADC 8 or 10 or 12 bit of output will be sent as an input to the interface and the interface provides the input to the serial port at microcontroller.

Analog to Digital Converter

It is an analog sensor circuit that is connected to a signal conditioner amplifier and then to an Analog to Digital Converter (ADC).

Sampling ADC

Sampling is a process that an ADC is used to accept the input signals in particular periodic intervals and converting them into digits. Here, the interval will be provided according to the signal frequency and other requirements. There are many applications of ADC such as, the sampling ADC receives the signals from microphone for the recording sensor while recording a music, or voice.

Signal Conditioning Amplifier

Signal conditioning amplifier is used to amplify a signal at input and also to add or subtract the offset voltage in such a way that the minimum V_{in} (min) should be 0 V and the maximum V_{max} (max) should be V_{ref} at the outputs of SC.

Digital Sensors

A digital sensor is a sensor with the respected electronic circuit or component that produces the digital output of 0's and 1's (in binary form) or 1 and 0. The output can be read using ports in a microcontroller. This circuit helps in sensing the change in the physical state or condition or change in the set of physical states and conditions.

Sensing of an On-Off State

The digital output of on-off state detection requires a number of conditions. It requires a circuit or microcontroller to read the output. There are many applications that use sensing of an on-off state.

Examples

(i) Sensing the filling of water in a water tank and providing an emergency alert.

(ii) Sensing of petrol filling in the vehicle tank.

(iii) Sensing the traffic in a specific street.

Q23. Write about network of networks of sensors and actuators.

Answer :

For answer refer Unit-II, Q16.

Q24. Explain the concept of participatory sensing.

Answer :

According to Deborah Estrin, Participatory Sensing is defined as a process that allows individuals and communities to adopt well sophisticated mobile phones and cloud services in order to perform systematic data collection and analytics so that it can be used in knowledge discovery.

In the process of participatory sensing, a participant could be sensors employed in mobile phones. Mobile phones include various sensors such as camera, temperature and humidity sensors, an accelerometer, compass, infrared sensors, NFC sensors, microphone, bar or QR code readers and GPS. Mobiles interact over the internet using sensed information associated with time, date and location stamps.

Various applications of participatory sensing are data collection regarding weather, pollution, environment, waste management. It also includes data about road faults, urban mobility, traffic congestion, health concerned to individuals as well as group of people and disaster management like flood, fire and so on.

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The several challenges involved in participatory sensing are,

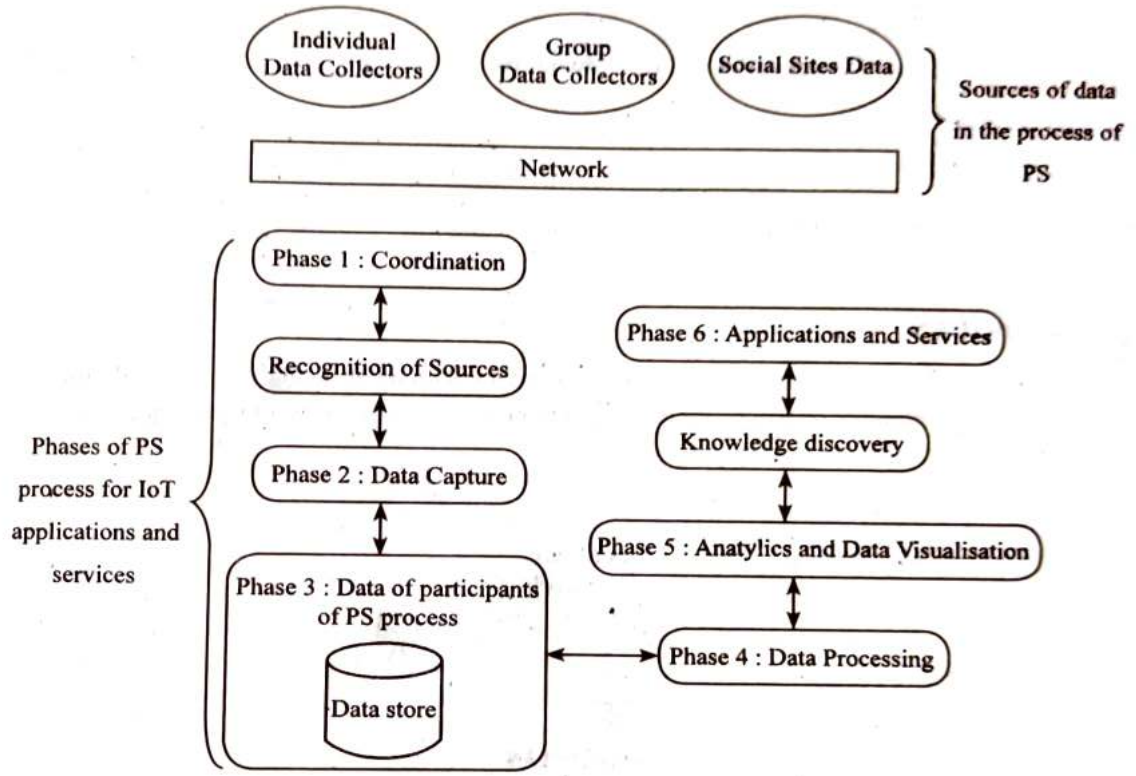
(i) Security

(ii) Privacy

(iii) Reputation

(iv) Poor incentives to participants.

The following figure illustrates various sources of data involved in the process of participatory sensing along with various phases involved in it.



Phase 1

This phase involves co-ordination where in participants organize soon after locating the data sources.

Phases 2 & Phase 3

In these phases, data capture, communication as well as storage on servers or cloud takes place.

Phase 4 & Phase 5

In these phases, data processing and analytics, visualisation and knowledge discovery takes place.

Phase 6

This phase involves initiation of respective actions.

1.5 BASICS OF NETWORKING

Q25. Define computer network. How is a computer network different from other types of networks?

Answer :

Model Paper-II, Q3(a)

Computer Network

A computer network refers to a network in which several computers placed at different locations are interconnected with each other. This interconnection is possible either by communication medium or communication device through which the data can be shared or transmitted among multiple computer systems. The system that transmits the data to the other systems within a network is referred to as a server, whereas, the systems that receive or accept the shared data are referred to as nodes.

Computer Network Different from Other Types of Network (Distributed System)

In distributed system, the users will not have any idea of the basic organization and existence of various autonomous computers. It will only run the applications or commands, the whole responsibility of choosing the right process or and transferring data to it lies with the operating system. On the other hand, in computer networks, the users will be aware of the autonomous nodes present in the networks. The user has to manually log on to the remote machine and transfer files and data, nothing is done automatically by the operating system. But at present even computer in the network are being connected using wireless networks.

Q26. Categorize the network based on their sizes.

Answer :

The networks based on the size are categorized into following types,

1. Local Area Network (LAN)
2. Wide Area Network (WAN)
3. Metropolitan Area Network (MAN)
4. Personal Area Networks (PAN).

1. Local Area Network (LAN)

A Local Area Network (LAN) is a privately owned network having its links in a single office, building or campus. LANs are designed to allow personal computers or workstations in an organization, to share resources (e.g., printers) and exchange information.

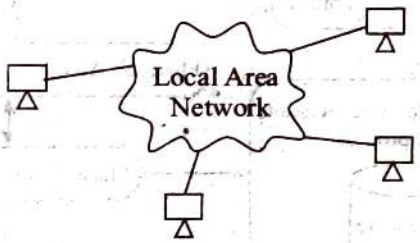


Figure (1): LAN

Characteristics of LAN

The three distinguishing characteristics of LANs are,

(i) Size

LANs are limited in size upto a few kilometers. The advantage of a limited size is that, in the worst case transmission time bounds are predictable. It is simpler in design which simplifies network management.

(ii) Transmission Technology

The transmission technology used in LANs often consist of a single cable to which, all the machines are connected. Traditional LANs operates at speeds of 10 to 100 Mbps. Newer LANs may run at speeds of upto hundreds of megabits/sec.

(iii) Network Topology

Various LAN topologies are possible for broadcast LANs. The two most common topologies are bus and ring topologies.

2. Wide Area Network (WAN)

A Wide Area Network (WAN) spans a very large area that comprises a country, a continent or even the whole world.

The two types of WANs are,

(i) Point-to-point WAN

(ii) Switched WAN.

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(i) **Point-to-point WAN**

A point-to-point WAN is the simplest WAN that connects a computer to a small LAN or to an internet Service Provider (ISP) as shown in figure (4). This type of WAN provides internet access to a computer.

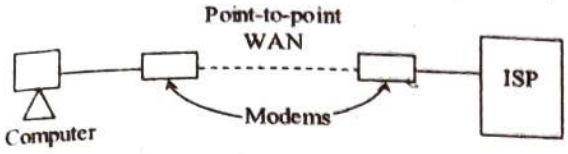


Figure (4): Point-to-point WAN

(ii) **Switched WAN**

The switched WAN is a complex WAN, that connects the hosts (or end systems) to the subnet. The subnet consists of transmission lines and switching elements. The router is a switching element which connects two or more transmission lines and also connects to another LAN or WAN. In a WAN, unlike LAN where the transmission medium is shared, the transmission media is not shared so any computer can send data at any time. The transmission mechanism of WAN is based on the concept of packet store-and-forward.

When data arrives from the sender on an incoming line router, the switching element stores it in its buffer it then, chooses an appropriate outgoing line to forward it over the output line. If two routers are not directly connected, then packet is received and stored at each intermediate routers along the path until the required output line is free and then forwarded. The subnet using this concept is called a 'point-to-point', 'store-and-forward' or 'packet-switched' subnet. Figure (5) shows a switched WAN.

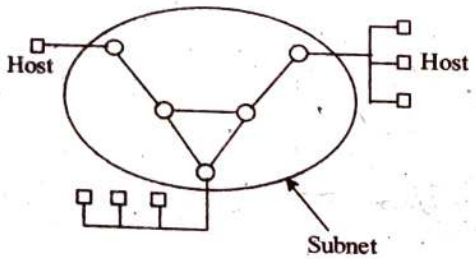
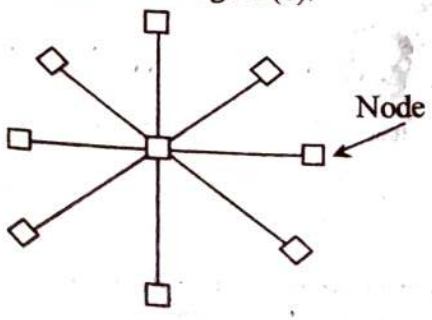
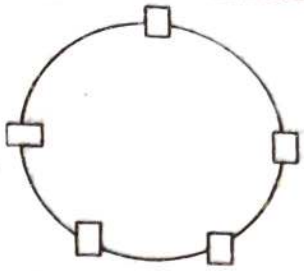


Figure (3): Switched WAN

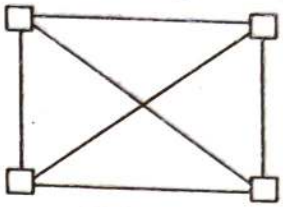
Unlike LANs, that usually have symmetric topologies, WANs typically have irregular topologies. Several possible topologies are shown in the figure (6).



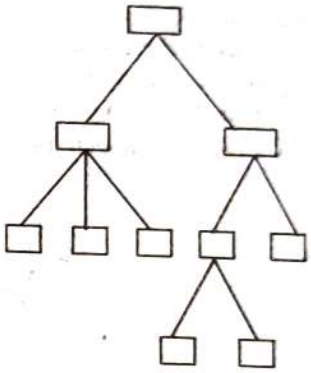
(a) Star



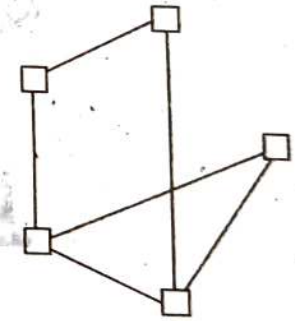
(b) Ring



(c) Complete



(d) Tree



(e) Irregular

Figure (4): WAN Topologies

Another possibility of WAN is the wireless WAN, that is becoming more and more popular. In such WANs the router has an antenna, that helps in sending and receiving data.

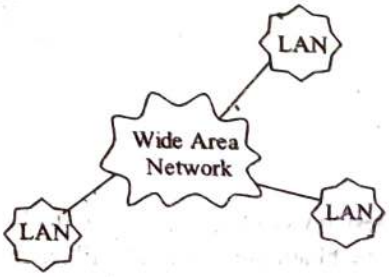


Figure (5): Wide Area Network

3. Metropolitan Area Network (MAN)

A Metropolitan Area Network (MAN) is a network similar to LAN, but larger than LAN and smaller than WAN. The area covered by a MAN is upto a city, which might be either privately owned by a group or publicly utilized. It is mainly designed for customers who spread over a city and need a high-speed connection to the Internet. A MAN can support both data and voice. An example of a MAN is the cable television network that provides high-speed data connection to the Internet. A MAN is a single network with one or two cables to which all the computers are connected. It does not contain any switching elements.

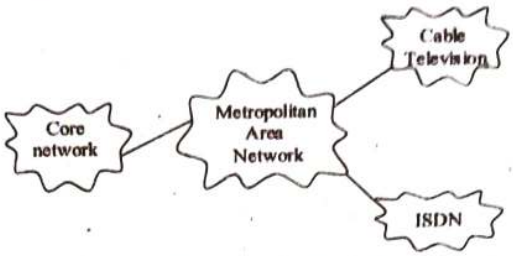


Figure (6): Metropolitan Area Network

4. Personal Area Network (PAN)

The Personal Area Network (PAN) is a network that interconnects several computing devices to be used by an individual. These devices must be located physically together and connected for sharing the data, hardware internet connection etc. It helps to communicate and transmit data among multiple hardware devices using one computer. A computer by default will communicate with mobile computer such as PDA, mobile phone and electronic equipment such as camera, scanner, printer etc. All the hardware components in a PAN can be connected through wire or wireless method.

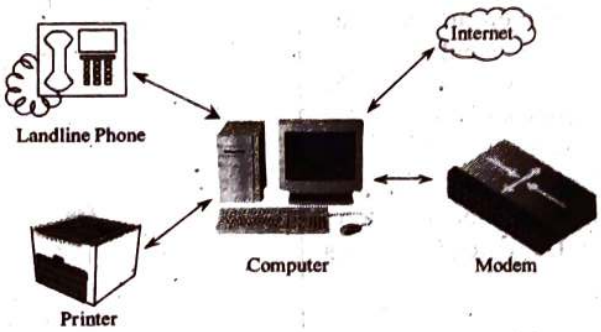


Figure (7): Wired PAN

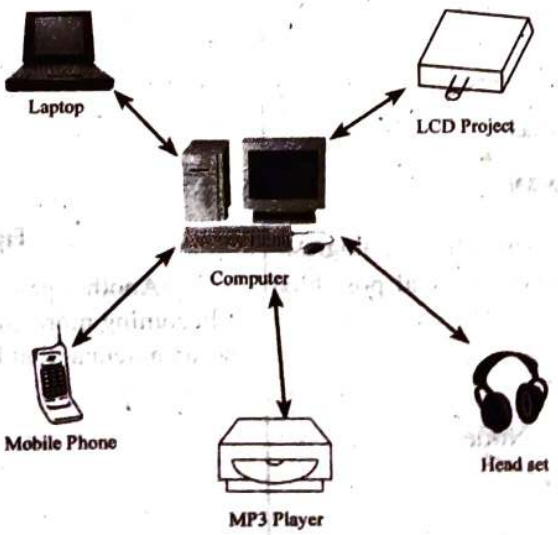


Figure (8): Wireless PAN

In wireless PAN the devices need to be in the radio vicinity of each other in order to create a communication medium among them. The bluetooth protocols allow them to form a network only when they are in the vicinity of each other. A device can then find out the services offered by other devices and then obtains them.

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Q27. Draw the layered architecture of the OSI reference model and write two services provided by each layer of the model.

Answer :

OSI Reference Model

This model was developed by the International Standards Organization (ISO) for connecting open systems. Hence, it is called Open Systems Interconnection (OSI) reference model. Open system is a system open for communication with other systems. This model has seven layers, which is shown in the following figure.

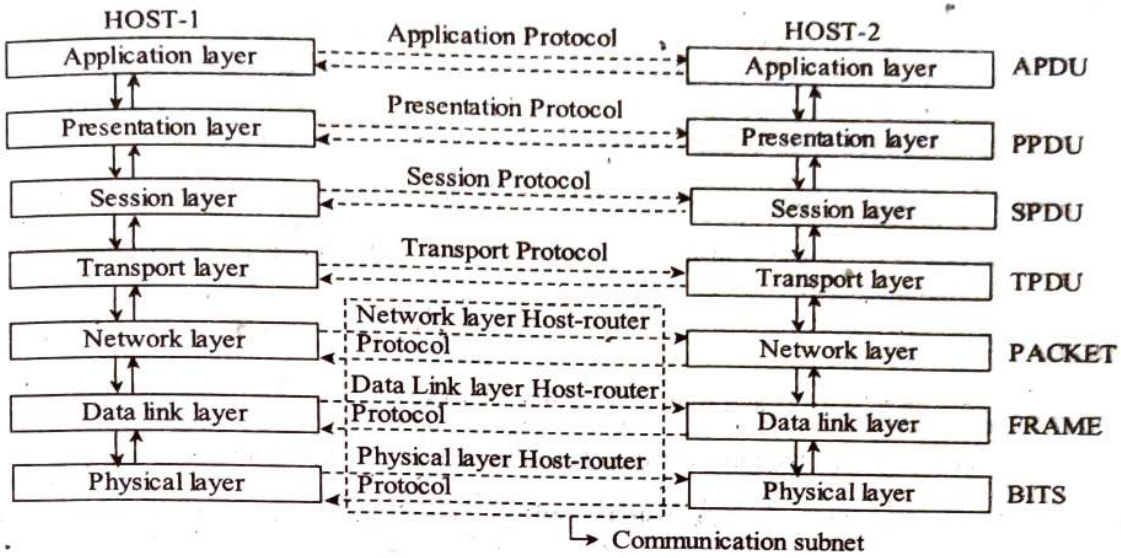

Figure: OSI Reference Model

1. **Physical Layer**

(i) It is the first layer of OSI model.

(ii) It deals with the transmission of information in the form of raw bits over the communication channel.

Here, at the time of transmission, data is converted into electrical/optical signal and sent to the destination device. And when receiver receives them, it is again converted back to data. The type of connections supported between devices across network are ethernet, token ring etc.

(iii) Its design issues include mechanical, electrical and procedural interfaces along with the underlying physical medium.

Example

What is the mode of communication? How much voltages are used to denote logic 1 and logic 0? etc.

2. **Data Link Layer**

(i) It is a layer above the physical layer whose function is to receive data from network layer, break the input data into (data) frames and take care of acknowledgments.

(ii) It regulates the flow of traffic in case of fast sender transmitting to a slow receiver.

(iii) It provides an error-free transmission for the network layer and solves the problems that results from frames (i.e., damage, lost and duplication).

(iv) It maintains the device address called MAC sublayer (i.e., a sublayer of DLL) which provides controlled access to the shared channel.

3. **Network Layer**

(i) It lies above the data link layer.

(ii) It routes packets from source to destination by applying routing algorithms.

(iii) It controls the entire operation of the subnet besides controlling congestion.

(iv) It also maintains the accounting information about the data sent by each user.

(v) It establishes the connections with other heterogeneous networks.

4. Transport Layer

(i) The transport layer lie above session layer. It is responsible for accepting data from the session layer, dividing it into small pieces (TPDUS), if required and passing these pieces to the network layer and assure the correct reception of data at the other end.

(ii) It sets up and terminates the connections across the network thereby regulating the flow of information.

(iii) It also multiplexes the data and establishes multiple connections, when a high throughput is desired.

5. Session Layer

(i) Session layer is responsible for conducting sessions among various users on different machines.

(ii) It manages the dialogue control in case of half-duplex communication.

(iii) It prevents the occurrence of simultaneous operation at both sides by using a service called 'token management'.

(iv) Data synchronization is also provided by inserting checkpoints into the data stream, so that only the data after the last checkpoint is retransferred in case of a system crash.

6. Presentation Layer

(i) This layer is concerned with the syntax and semantics of the information transmitted.

(ii) It converts the information between the representations used in individual computers and globally accepted standards.

(iii) It performs operation like encryption, decryption and compression on data.

7. Application Layer

(i) This layer lies above the presentation layer and is close to end uses.

(ii) It provides interface between user and computer hardware.

(iii) It contains the implementation of various protocols used for user interaction such as, Telnet, FTP, SMTP, etc.

Q28. Discuss various components of a network.

Answer : Model Paper-I, Q20

Following are some of the common components of a network,

1. Repeaters

Repeater refers to a communicating device, which is used at the physical layer of the OSI reference model. It consists of two ports using which two segments (logical area of a network) of a network can be connected. However, if several segments are to be connected then multiple repeaters must be used. The main purpose of using repeaters is to enhance the extensibility factor of LAN network. This device is generally preferred when the distance between two communicating systems is large. This is because, repeaters amplify the strength of the signals (which decreases during the transmission) such that the strength of signal being transmitted is equal to the actual strength of signal.

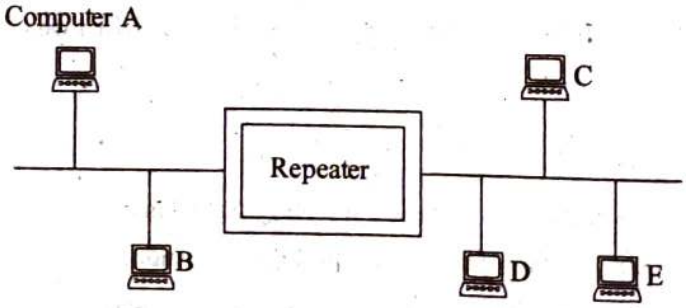

Figure: Repeater Connecting Two Network Segments

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2. **Bridges**

A bridge is an electronic device used to connect multiple LANs. The bridges are operated at the data link layer

Suppose, there exist a pair of ethernet LANs for interconnection. One approach is to connect them by using a repeater, but this would not be a workable solution. An alternative way to connect two LANs is by bridge. With the help of a bridge, device frames can be forwarded from one ethernet LAN to another. The bridges typically operate in the physical and the data link layers of the OSI model. The role of the bridge is to divide a large network into smaller segments.

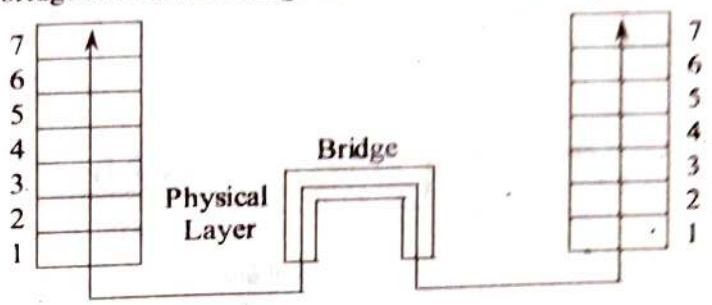


Figure: Bridge in the OSI Model

3. **Router**

A router is an interconnecting device which is used to connect varied networks that uses different technologies, media, frame formats etc. It can be employed at the network layer of the OSI model to perform its operation i.e., to transmit the packets based on the IP addresses. Basically, the routers are used to connect the networks such as LAN to LAN, LAN to WAN or WAN to WAN. Each router includes processor, I/O interface and memory. The packets are forwarded to the destination computer through the shortest route within a network.

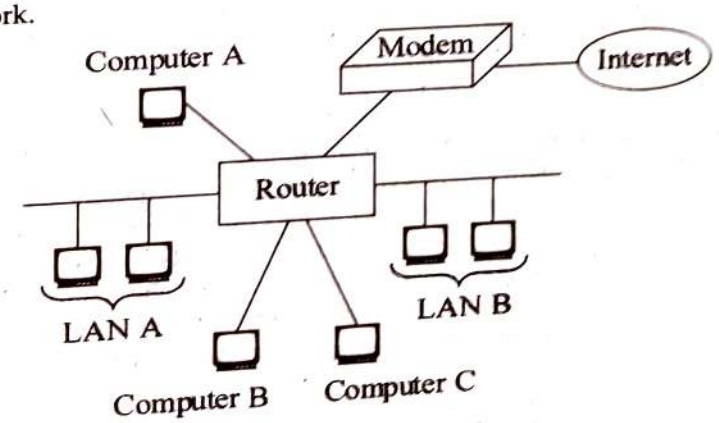
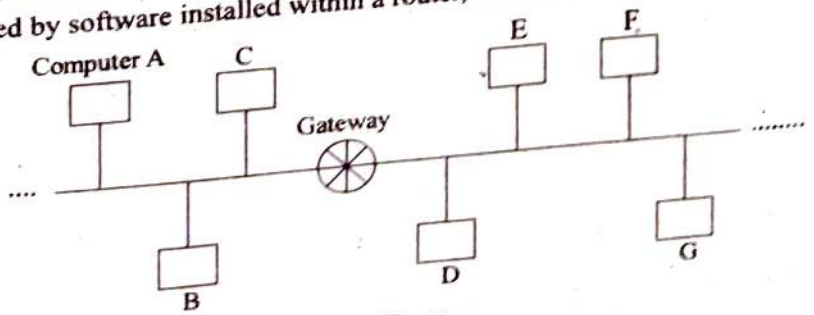


Figure: Router Connecting Heterogeneous

4. **Gateways**

Gateway is a device which is used to connect two networks of different kinds. It is implemented at the transport layer and is used to convert protocols among the networks. It is employed in firewall mechanism. If a packet is forwarded to one protocol, it accepts the packet and converts it for another protocol. It has the ability to translate the messages from one form to another form. Gateway is implemented by software installed within a router, but it can also be implemented in hardware or in both.



Figure

5. Brouters

A brouter is a network device which operates as both bridge and router. It functions at network layer as well as data link layer. It serves as routers for routable protocols and as bridges for non-routable protocols.

Brouter can be single-protocol brouter or multiprotocol brouter. When a single protocol brouter receives a packet belonging to its corresponding protocol then it either acts as a router and transmits the data using network layer address or acts as a bridge and sends the data using data link layer address. Similarly, when a multiprotocol brouter receives a packet belonging to its respective protocol then it forwards the data using network layer address and passes it using data link layer address.

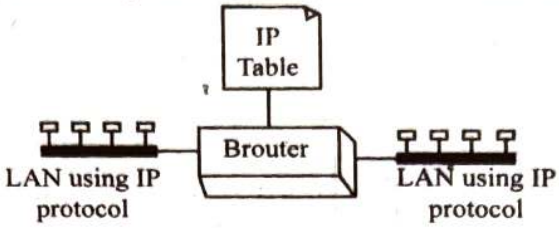


Figure: Single Protocol Brouter

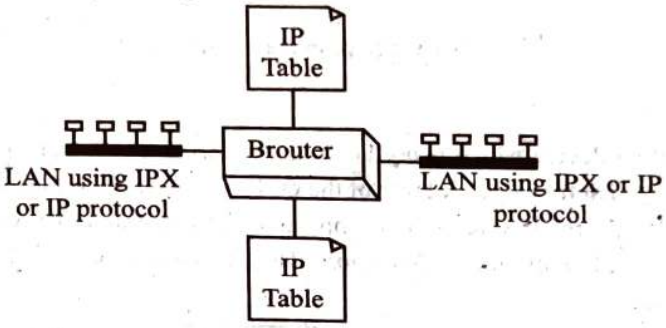


Figure: Multiprotocol Brouter

6. Switches

Switch is a network connecting device which also contains multiple ports that connects multiple computers within a network or among different segments of the same network hence, it is also called as multiport bridge. The data is taken as a frame (but not as a signal) since the switch operates at the data link layer of the OSI reference model. Instead of broadcasting the data, it directly send from source to destination computer. When a switch receives the data frame from the source computers, it checks the MAC address of the frame which identifies the destination computer and deliver the frame to the port connecting the destination computer with the same MAC address. Once the data frame is received by the destination port, switch will reconvert the frame into signal and forward it to the destination computer attached to it. Hence, switch is a multiport bridge that is capable of filtering and regenerating the signals.

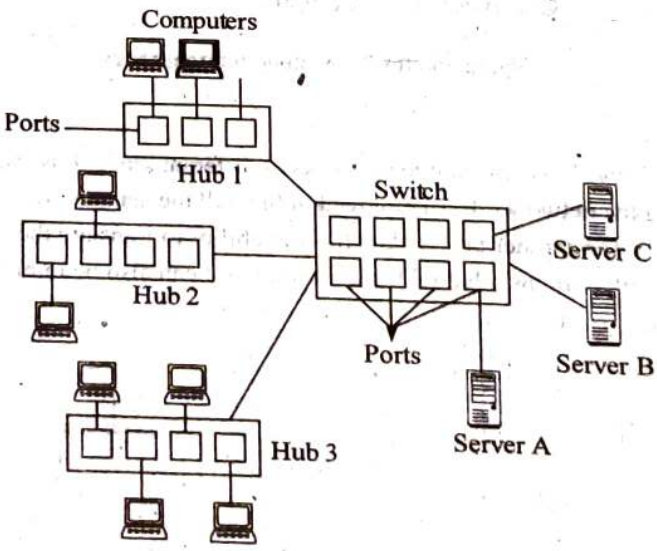


Figure: Switch Connecting Multiple Computers and Servers in a Network

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1.6 COMMUNICATION PROTOCOLS

Q29. What is a communication protocol? Explain.

Model Paper-III, Q3(a)

Answer :

Communication Protocol

Communication protocol refers to a set of communication rules using which the data can be efficiently exchanged or transmitted among several computers. It also provides formatting rules which defines the way of packaging the data into sent and received messages, header and its field along with their meanings.

The different communication protocols used for the data transmission are,

(i) **Data Sequencing**

This protocol is used to fragment a long message into small number of data packets of fixed size. These packets are thus sequentially transmitted from sender to receiver without any error or fault.

(ii) **Flow Control**

This protocol is used to control the flow of data to be transmitted between sender and receiver. Generally, the speed of transmission of all the computers is not equally efficient. Thus, the data is transmitted between a fast sender and slow receiver.

(iii) **Data Routing**

This protocol is used to identify an efficient route between the source and destination so as to transmit the data.

(iv) **Error Control**

This protocol is used to detect and remove the errors that occur during the data transmission. Thus, the data is transmitted without any error.

(v) **Data Formatting**

These are the rules which specify the way of packaging the data into sent and received messages.

(vi) **Precedence and Order of Transmission**

These are the rules which provides assurance that each of the node gets an opportunity to use the communication channel as well as the other network resources depending on the priority assigned to them.

(vii) **Connection Establishment and Termination**

These are the rules that specifies the establishment, maintenance and termination of the connection takes place when two different nodes within a network wants to interact with one another.

(viii) **Data Security**

These are the rules that specifies the process of providing message security as well as privacy while sending and receiving messages over the network.

(ix) **Log Information**

These are the rules which specifies the types of log information that has to be maintained by the system. Wherein, this information can be used for applying charges to the user depending on the usage of the network resources.

Q30. What are the different terminologies used by message communication protocols?

Answer :

The different terminologies used by message communication protocols are as follows,

1. **Request/Response (client/server)**

The process of requesting a resource and sending response to an object is known as request/response message exchange. When an object makes a request for a resource, a protocol provides the header words such that every field of the header translates the request at the receiver object or server.

2. **Publish/Subscribe (pubsub)**

The process of publishing messages by a service is referred as publish/subscribe message exchange. For instance, weather telecast service publishes weather reports messages for the potential receivers.

This type of service can be used by single or multiple clients/brokers. A client can receive service messages by subscribing for a specific service. The pubsub protocol specifically functions for publishing messages and accepting the subscription made by the authentic/registered devices.

3. **Resource Directory (RD)**

This directory service is used for storing data and values for every type of resource. The resources access the stored data from RD by using URI for the resource.

4. **Resource Discovery**

This discovery service is used for advertising the information of a resource like types of the resources available and its states at frequent intervals. A client uses resource discovery service for searching the resource type and then registers a resource for availing resource directory service.

5. **Registration/Registration Update**

The term registration refers to a receiver registering a service. When one or more devices registers with a service then a device gains access over specific resource and receives published messages. But, it is necessary that service provider or service receiver must be authenticated before getting registered with a service.

Registration updates refers to the process of updating and unregistering one or more end points (client or server) or devices.

6. **Pull (Subscribe/Notify) Data**

Pull data service is used for pulling a message, value, resource or data of resource type by registration and subscription. Initially, a client pulls a resource then the server manages the information about the state of a resource. If the state of resources changes the server notifies the client and then the client pulls the resource again on the change.

7. **Polling or Observing**

Polling or observing refers to the process of determining the location from where the new message has arrived or checking the availability of a message or if any updates are available or any of the message information needs to be refreshed by determining the current status of information state. When messages are saved at database server then client can perform polling by using GET method of REST architecture and server uses POST method.

8. **Push (Publish/Subscribe) Data**

Push data service refers to the process of pushing a message or information or data at regular intervals. For instance, provider of the mobile service pushes temperature and location information at regular intervals for the potential receivers. When compared to the polling service push service is more efficient specifically incase of sending notifications or alerts.

9. **Message Cache**

Cache refers to the hardware component which is used for storing the data so that future requests made by a client can be served quickly. In other words, the data stored in cache can be used later whenever needed. It is helpful in short or prolonged service disconnections.

10. **Message Queue**

Message queuing refers to the process of data storage in the similar form as received from devices or client/server. This service is used so that messages can be forwarded when the state of the connection changes. A message can be sent only once from a queue by using FIFO method. Each resource type has separate queue, separate registered device and separate subscription list.

11. **Information/Query**

A client makes request for a resource by using a query and server responds to the client's request by replying to the query. The query processing uses database or resource directory resources.

1.7 SENSOR NETWORKS

Q31. Discuss about sensor network. Outline the features of wireless sensor networks.

Answer :

Sensor Networks **Model Paper-II, Q32**

WSN comprises large number of sensors that are mostly implemented in certain areas where there is a necessity of situation to be monitored. These sensors are involved in various sensing tasks such as temperature, sound, vibration and so on. However, the output of these sensors is transmitted to a sink (a central gathering node) after realizing a particular environmental situation and performing in-network processing on the sensed data. This sensor also encourages inter communication through multi-hop wireless communication links and transfers the sensed data to the sink. The sink then receives the data and performs the further processing and analysis. However, wireless sensor networks can be used for various applications that deal with monitoring, control and surveillance.

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The sensor network is quite different from other networks. The sensor nodes in sensor networks are generally based on broadcast communication paradigm, whereas the other networks such as ad-hoc networks make use of point-to-point communication. However, the sensor nodes are confined to certain limit of power, computational capacities and memory. Due to the excessive amount and large number of sensors, the sensor nodes are not identified universally. In addition, the various sensor nodes are several orders of magnitude.

These nodes are highly implemented and inclined to failures as well. However, the sensor network topology keeps on changing on regular basis.

Features of Wireless Sensor Networks

The design features of wireless sensor network include,

1. Energy limitations
2. Resistance to node failure
3. Scalability
4. Deployment
5. Quality of Service (QOS).

1. Energy Limitations

The energy is one of the major concerns in the wireless sensor networks. The sensor nodes uses chip devices that runs on batteries which are the common means to acquire energy. However, at times the batteries may not facilitate the required amount of power for longer sustenance. So, therefore, mechanism is necessary for efficient utilization of energy resources for long term use.

2. Resistance to Node Failure

The failure of nodes is also another concerns of energy losses in WSN. The wireless sensor networks are dynamic in nature and exhibits tolerance to node failures. The caused of the node failures could be depleted batteries, intruder attacks and environmental factors such as fire, flood etc. Therefore such factors can effect the topology of the networks. Hence, the nodes must be tolerant and robust in nature.

3. Scalability

It is defined as the ability of a network to retain its performance irrespective of its size. A wireless sensor network comprises of a very large number of nodes and therefore scalability is a very important aspect. Scalability is affected generally by address or routine table entries and these information should be restricted by limiting the resource of sensor nodes. It is observed that number of nodes compared to large number of nodes, resulting in considerable efficiency.

4. Deployment

The sensors nodes can be deployed in distinct ways, which is characterised by requirement, application and environmental factors. The sensor nodes can be set up randomly across the monitoring field or sensor field, which then remain stationary in most of the applications. To substantiate the WSN functionality, various deployment strategies and necessary communication protocols are incorporated depending upon the existing network topology.

5. Quality of Service (QoS)

The QoS is one of the major factors in WSN. It is mainly concern with the reliability of the networks. Therefore, ensuring the quality service is the basic requirements in achieving any application goals.

Q32. Define some of the key terms and concepts of sensor networks. Also, discuss various subsystems of sensor nodes.

Answer : **Model Paper-III, Q3(b)**

Concepts of WSN

There are several concepts that are used while developing the techniques for sensor nodes. Few of them are as follows,

(i) Sensor

The conversion of physical matter such as sound, light and heat to any other signal or electrical signal is referred as sensor. These signals can be handled using an apparatus in the future.

(ii) Sensor Node

Sensor node is said to be a basic unit of a sensor network comprising of memory, processor, wireless modem power supply and on-board sensors.

(iii) Routing

Routing refers to discovering of routes for a source node to reach its destination node present in the network.

(iv) In-network

In-network is a type of processing which processes the data and integrates it with the data from where it has been produ

(v) State

State represents the snapshot of the physical environment or a system. Physical environment refers to locations, speed which the source is moving and number of signal sources whereas system itself refers to the network state.

(vi) Task

Tasks can be of various types either high level tasks or application tasks. High level system task are sensing, communicati processing and resource allocation. Whereas, application tasks refers to detection, classification, localization and tracki of the data.

(vii) Detection

Detection is a process of checking the availability of a physical phenomenon. It is done by using threshold based dete which sets a flag as soon as it detects the presence of physical phenomenon more than required.

(viii) Resource

Resources are nothing but sensors, processors, node energy reserves, communication links and on-board memory whi will be allocated to the tasks, in order to make best use of it and to enhance the performance.

(ix) Sensor Tasking

Sensor tasking is the process of assigning the sensors to a specific task. It also assigns sensors to control of sensor ma which control them using the buttons ON/OFF, PAN/TILT in order to perform the task.

(x) Geographic Routing

Geographic routing is the process of routing the data depending upon the geographical attributes which includes locatio or regions.

Subsystems of Sensor Node

The different subsystems of sensor node are,

1. Sensing unit
2. Processing unit
3. Communication unit
4. Power unit.

1. Sensing Unit

Combination of sensor and ADC forms the sensing unit, which is used for converting analog to digital signals. It contai two components.

(i) Sensor

(ii) ADC.

2. Processing Unit

Processing unit holds the responsibility of performing assigned sensing tasks. It contains two components.

(i) Memory

(ii) Microcontroller.

3. Communication Unit

Communication unit behaves as a communication channel between the sensor node and network. It consists of radi transceiver.

4. Power Unit

Power unit acts as source for power. It makes use of batteries.

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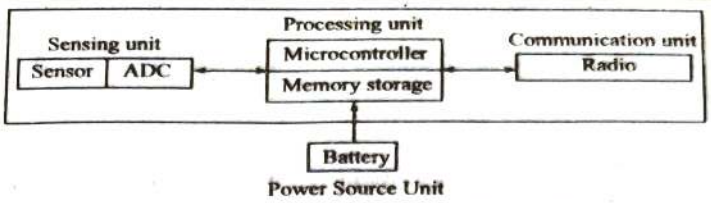

Figure: Different Subsystems of a Sensor Node

Q33. Mention the applications of wireless sensor networks.

Answer :

The wireless sensors networks are used in the wide area of applications are as follows,

1. **Habitat Monitoring**

Monitoring of habitat involves the following methods,

- Data reduction by adopting the technique of zero crossing rate.
- Localizing by adopting the technique of beam forming based on TDOA (Time difference of arrival).
- Classifying the target by adopting the technique of cross-correlation between the calculated reference and acoustic signals.

For example the communication in the Grand Duck Island Monitoring Network (GDIMN) can be achieved as follows,

Grand Duck Island Monitoring Network

It is a two-tier network architecture deployed by UCB (University of California at Berkeley) and IRL (Intel Research Laboratory) in 2002.

In this architecture, the sensor nodes in the patch network transmits the data to transit network through a gateway which inturn forwards the information to the base station. The base station transmits the information using the satellite link, at every interval of 15 minutes by replicating it at the Berkeley's database.

The sensor network can be accessed by the two different types of users in two different ways. The remote users access the replicated database in the Berkeleys where as the local users uses PDA-style devices to interact with the sensor network.

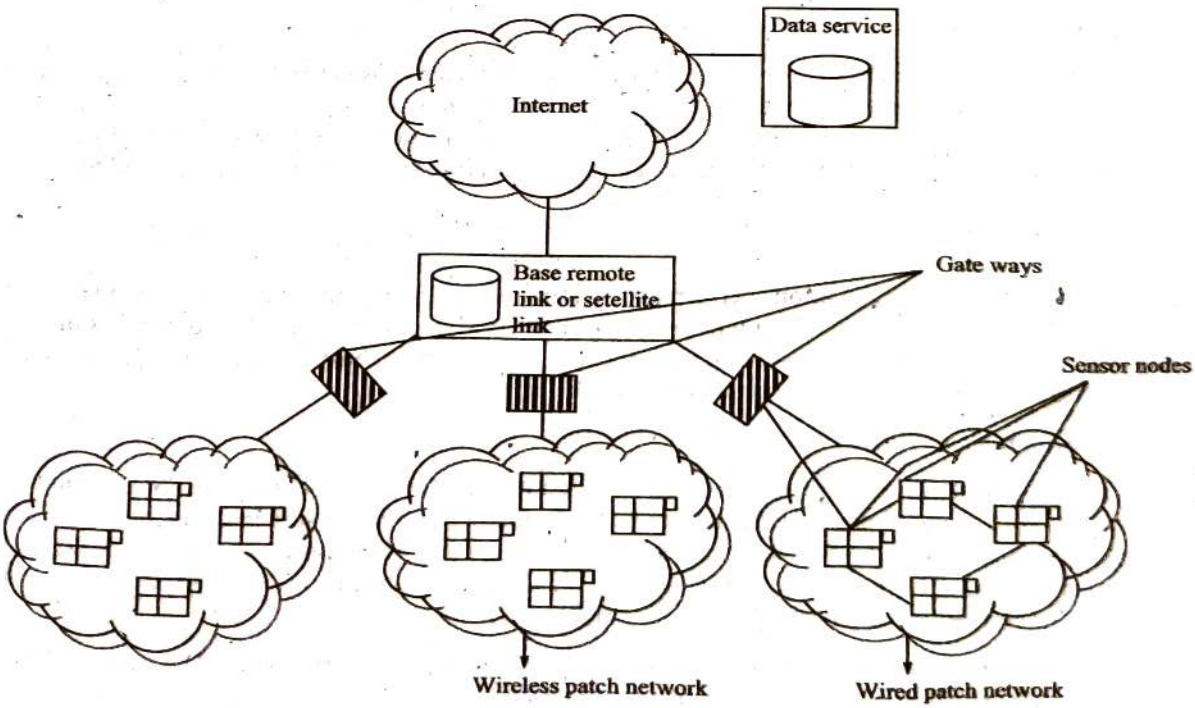

Figure: Grand Duck Island Monitoring Network

Remote Ecological Micro-sensor Network

It is a wireless network consists of environmental sensors. The purpose of this network is to determine the reasons for the growth of endangered species of plants in a specific area but not into the neighbouring areas.

2. Environmental Monitoring

Environmental monitoring involves the supervising of quality of air and landfill. The landfill in the area which is filled with the house held and industrial solid wastes.

The different methods involved in monitoring landfill are,

- Drilling the collection well periodically.
- Gathering the samples of gas in air tight bags.
- Inspecting off-site waste treatment operation.
- Allowing the process to take long time for completion.

To perform this the gas sensors are interfaced with the wireless radio and custom-mode devices that obtain the sensed data for further inspecting and processing. In addition to this, the sensor in large quantity are spreaded area to monitor the risky air pollutants such as carbon monoxide lead, nitrogen dioxide, particulates of nitrogen dioxide, sulphur dioxide, methane, compounds of sulphides and ammonia.

Observation and Forecasting System of Environment

EOFS is a system which is distributed over a very large geographic area. Its responsibility is to sense, model and forecast the environmental conditions such as pollution, flooding, earth quakes, cyclones etc. It is an integration of three units,

(a) Sensor station

(b) Centralized processing farm

(c) Distribution network.

3. Drinking Water Quality

To monitor and model the quality of water, a monitoring system, consisting of sensors that performs spatial-temporal data mining, using the technology called in situ sensing is developed.

In addition to this, several data mining techniques performed on the databases storing the information about quality of water. These techniques are used for controlling the level of chlorine in the water.

4. Disaster Relief Management

An innovative sensor network has been introduced to deal with the attacks caused by terrorists, earthquakes, storms, floods and fires. All the sensors present in this network are deployed at homes, offices and other areas. They gather information from under normal conditions and continuously updates the control database servers connected through back bones. Whenever any disaster occurs the connectivity among the control databases is achieved through the low-flying aerial vehicles or satellites. The sensor nodes transmits the information through the predetermined routes.

5. Soil Moisture Monitoring

Sensors are also used to monitor the various performance parameters of the soil moisture. For example, a custom moisture sensor have been developed that is interfaced with a wireless board named Mica 2 Mote. This board consists of a rain gauge that wakes up the sensors from sleeping mode. It also saves the energy and achieves the robustness and durability by reducing the need of clock synchronization, time stamping, time setting and clock-drift.

6. Health Care Monitoring

Health care monitoring, tracks and inspects the doctors and patients in the hospital, manages drug administrators inspects the data belong to human physiology. All these functions can be performed using the sensors in different ways. For examples, an artificial retina has been developed using the SSIM (Smart Sensor and Integrated Microsystems). The blind and the limited vision patients use this artificial retina. Apart from this, the applications such as inspecting the glucose level in body, identifying the organs, identifying the availability of concern are the part of health care monitoring.

It also involves the penetration of wireless biomedical sensors inside the human body. The fixed sensors are used for inspecting the food and water in the cattle. It uses accelerometer to calculate the intra-rumenal movement in the cows and characterizes the feeding cycle.

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7. **Building, Bridge and Structural Monitoring**

The sensors are also used in inspecting and monitoring the health of bridges, highways and buildings. The stress, humidity, temperature and vibration of civil infrastructure can be analyzed by using the scatternet based on bluetooth. To inspect the cracks occurring in the bridge decks made by concrete and monitor the corrosion and strain of the reinforcement in the structures made by concrete, a sensor based on fiber optic has been introduced.

Wireless acceleration sensors are used to inspect the risks such as house breaking fires, gas leaks, damages, structural degradation etc, that can occur in the buildings.

A special kind of sensor called super glue and angular strain are used to estimate the corrosion in steel bars. To monitor the human circulatory pulses and signals, a ring sensor which can be wearable but non-invasive has been introduced. The designing of acoustic sensors involve the usage of small hair-like sensors. The hair-like sensors are magnetic in nature and can be converted easily into pressure detecting arrays by the fabrication process.

8. **Smart Energy and Home/Office Applications**

To enhance the efficiency of energy-provision chain, a network called societal-scale is used. It is an integration of three infrastructures i.e., energy generation, distribution and consumption.

Many electronic appliances are being used in the households that lead to the provision of better home mechanization.

9. **Body Area Network**

To measure the human body parameters, a new and special kind of sensors and transducers have been introduced. They sense the body characteristics parameters precisely and effectively in a non-invasive manner. The different types of sensors and transducers and their functionalities are listed below,

(i) **Micro Sensor Array Define in Schwiebert 2001**

- Used in artificial retina
- Recognizes the cancer
- Sensor the general health
- Senses the level of glucose
- Senses the organ.

(ii) **Wearable Sensor Vest Defined in Knight 2005**

- Calculates, updates and sends physical characteristics such as movement, temperature and heart rate.

(iii) **Accelerometers and Audio Sensors**

- Calculates the physiological, environment and behavioural parameters to sense the daily life partners of human.
- Combines information from other sensors.
- Filters the gathered information by segmentation process.
- Sums up and interprets the filtered information for identifying an event.

(iv) **Wearable Computing Network Defined in Kimel 2005**

- Remotely sense the improvement of physical therapy carried out at home.
- Specifies the range of human body's motion by initiating a prototype with the help of electroluminescent strips.

(v) **Wearable Sensor Network Defined in Harada (2004)**

- Monitors the life of battery.
- Calculates communication delay and data throughput.
- Detects information about environment.
- Consists of bluetooth-based network and a huge scatternet network for administrating the home electric appliances.

(vi) **Multi-resolution Flat Sensors Defined in Christensen 2005**

- Acquires resolution depends on the area of interest.
- Introduces the content regarding information.
- Surveys the entire event at once when positioned into the soldier's helmet.

(vii) **Indoor/Outdoor Wearable Navigation System Defined in Ran 2004**

- Provides the vocal interfaces from the blind people
- Uses the vocal command to transfer the mode from indoor to outdoor and vice versa.

UNIT 2

Syllabus

Machine-to-Machine Communications, Difference between IoT and M2M, Interoperability in IoT, Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino.

Learning Objectives

- ✓ Machine-to-machine Communications
- ✓ The ways in which IoT and M2M differ from each other
- ✓ Providing Interoperability in IoT
- ✓ Basic Concepts of Arduino Programming
- ✓ Integration of Sensors and Actuators with Arduino.

Introduction

Machine to Machine (M2M) communication acts as a means of communication among same type of physical objects or devices. Every machine in this communication contains a smart device that can track the data status of machine and perform various functions. Here, the communication can be wired or wireless. Various communication protocols include XMPP, LwM2M, 6LoWPAN, MQTT etc. M2M is similar to IoT when the devices sent/receive data without Internet. The difference here is that, M2M does not necessarily uses Internet whereas IoT is completely based on Internet.

Arduino is an open source hardware platform which is available to be used by hobbyists and enthusiasts across the globe to develop projects.

PART-A SHORT QUESTIONS WITH SOLUTIONS

Q1. Define M2M communication.

Answer : Model Paper-II, Q1(c)

M2M stands for Machine to Machine which acts as a means of communication among same type of physical objects or devices. Every machine in M2M system contains a smart device that can track the data status of machine and perform various functions. Here, the communication can be wired or wireless.

Various communication protocols are XMPP, LwM2M, 6LoWPAN and MQTT. A 48-bit IPv6 address is assigned to every communication device.

Q2. Write in brief about IoT and M2M.

Answer :

IoT technology offers physical machinery, M2M communication and binds networks of sensors together. It makes use of knowledge discovery, software machine learning and analytics. The M2M is similar to IoT when the smart devices get the data that is sent to other devices or remote machines without internet. M2M needs to establish connection between the devices and provide communication, control and coordination among them without internet. In contrast, IoT uses internet server or cloud applications, server, internet protocol and processes or services. The applications of M2M include logistics, smart grid, industrial automation, defence, smart cities, health, telemetric applications and industrial internet of things.

Q3. List out the domains of M2M architecture.

Answer : Model Paper-III, Q1(c)

The domains of M2M architecture are as follows,

1. **M2M Device Domain**

   It contains entities such as communication interface, physical devices and gateway. The communication interface refers to a port or subsystem that extracts input from one end and sends the data to another.

2. **M2M Network Domain**

   It contains device identity management, device management, M2M server and data analytics.

3. **M2M Application Domain**

   It contains application of services, analysis, monitoring and device network control.

Q4. List out various software and development tools of M2M.

Answer : Model Paper-I, Q1(d)

Various examples of M2M software and development tools are as follows,

1. **Mango**

   It is one of the open source web based software. It supports meta points, database, multiple protocols and platform, user defined events and import/export.

2. **Device Hive**

   It is a type of M2M communication framework which is considered as an integration tool used to provide connection between IoT and devices. It contains web-based management software to create security rule based e-networks as well as monitoring devices.

3. **Mainspring**

   It is provided by M2M labs as a resource framework and developing tool to build M2M applications.

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Q5. List out any three differences between IoT and M2M.

Answer : Model Paper-I, Q1(c)

	IoT (Internet of Things)	M2M (Machine-to-Machine Communication)
1.	IoT deals with sensors automation and acts as an Internet platform.	M2M provides direct communication between machines.
2.	The communication protocols used in IoT are HTTP, MQTT, XMPP, AMQP, DDS, COAP and web sockets.	The communication protocols used in M2M are proprietary or non-IP based. They include Zigbee, ModBus, M-Bus, Bluetooth, wireless M-Bus, Z-wave, 6LoWPAN, PLC etc.
3.	The main focus of IoT is on software. The IoT devices make use of special software for collecting sensor data to interface with cloud via IP based communication and for analyzing the data.	The focus of M2M is more on hardware along with the embedded modules.

Q6. Define interoperability.

Answer :

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

Q7. Write short notes on the following,

(i) Syntactic interoperability

(ii) Semantic interoperability.

Answer : Model Paper-II, Q1(d)

(i) Syntactic Interoperability

The ability of systems to accurately interpret the message structure of shared data and read the contents of message with or without knowing the meaning is called syntactic interoperability. An example of this type of interoperability is smart city system that can receive data from data center and can recognise the data format to extract data from message.

(ii) Semantic Interoperability

The ability of systems to interpret the content and meaning of exchanged data is called semantic interoperability. It is offered by various semantic technologies and knowledge management systems. An example of semantic interoperability is enabling smart city system to extract the data received from some other system to understand its meaning and generate meaningful information.

Q8. Write in brief about Arduino.

Answer : Model Paper-III, Q1(d)

Arduino is an open source hardware platform which is available to be used by hobbyists and enthusiasts across the globe to develop projects. It is accompanied with ATMEGA microcontroller to process data and offer proper working of IoT system. It is possible to program Arduino multiple times to develop different types of IoT projects with different types of code.

Arduino is considered as the brain of systems processing data from sensors. It offers simple and robust development board. It is reliable and allows the electronics world to be programmable.

PART-B ESSAY QUESTIONS WITH SOLUTIONS

2.1 MACHINE-TO-MACHINE COMMUNICATIONS, DIFFERENCE BETWEEN IoT AND M2M

Q9. Define M2M communication. Write about M2M communication and architecture of M2M.

Answer : Model Paper-I, Q4

M2M Communication

M2M stands for Machine to Machine which acts as a means of communication among same type of physical objects or devices. Every machine in M2M system contains a smart device that can track the data status of machine and perform various functions. Here, the communication can be wired or wireless.

Various communication protocols are XMPP, LwM2M, 6LoWPAN and MQTT. A 48-bit IPv6 address is assigned to every communication device.

M2M to IoT

IoT technology offers physical machinery, M2M communication and binds networks of sensors together. It makes use of knowledge discovery, software machine learning and analytics. The M2M is similar to IoT when the smart devices get the data that is sent to other devices or remote machines without internet. M2M needs to establish connection between the devices and provide communication, control and coordination among them without Internet. In contrast, the IoT uses internet server or cloud applications, server, internet protocol and processes or services. The applications of M2M include logistics, smart grid, industrial automation, defence, smart cities, health, telemetric applications and industrial internet of things.

M2M Architecture

The architecture of M2M contains three domains,

1. **M2M Device Domain:** It contains entities such as communication interface, physical devices and gateway. The communication interface refers to a port or subsystem that extracts input from one end and sends the data to another.
2. **M2M Network Domain:** It contains device identity management, device management, M2M server and data analytics.
3. **M2M Application Domain:** It contains application of services, analysis, monitoring and device networks control.

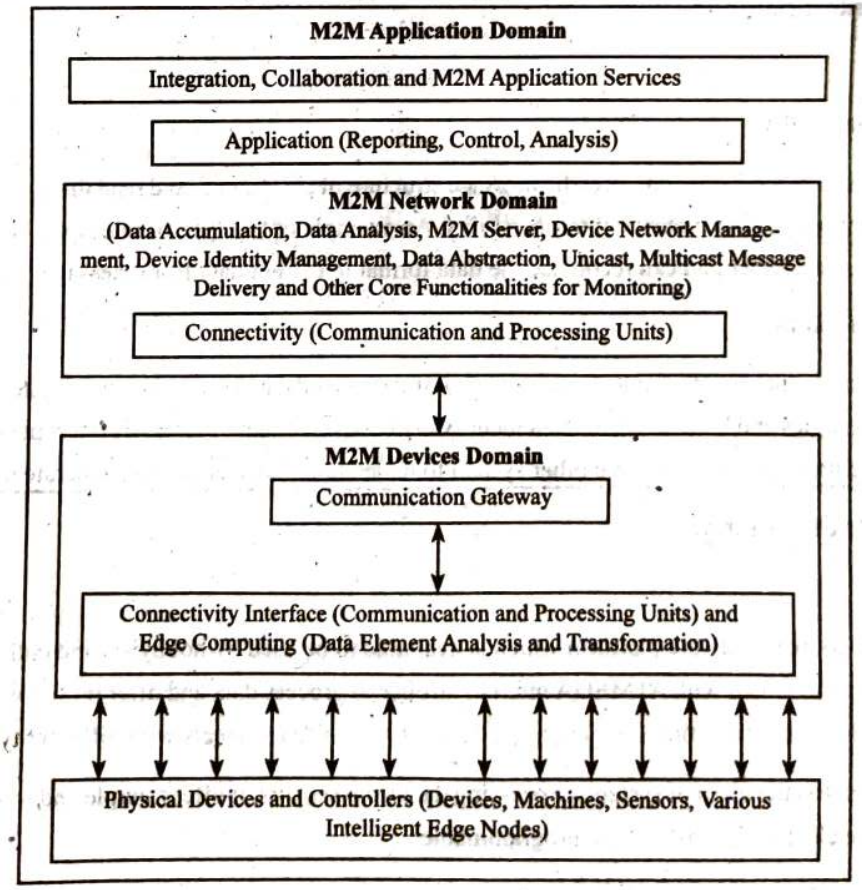

Figure: Domains in M2M Architecture

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Q10. Discuss various examples of software and development tools.

Answer : Model Paper-II, Q4(a)

Various examples of M2M software and development tools are as follows,

1. **Mango**

It is one of the open source web based software. It support meta points, database, multiple protocols and platform, user defined events and import/export.

2. **DeviceHive**

It is a type of M2M communication framework which is considered as an integration tool used to provide connection between the IoT and devices. It contains web-based management software to create security rule-based e-networks as well as monitoring devices.

3. **Mainspring**

It is provided by M2M labs as a resource framework and developing tool to build M2M applications. It provides the following services,

- Normalization and validation of data.
- Interaction between applications and devices.
- Apache Cassandra and Java programming.
- Functions such as data retrieval and long term data storage.
- Providing flexible models of devices along with their configurations.
- NoSQL database.

4. **Open M2M Protocols, Frameworks and Tools**

Various frameworks, tools and open protocols are as follows,

- The 3GPP study group is involved for analysing security properties of M2M equipment and automatic SIM activation including subscription change and remote provisions.
- The standards collection of MQTT-OASIS, XMPP and LwM2M-OMA for protocol.
- Standards of weightless group and wireless spaces for M2M.
- Different projects of eclipse M2M industries are tools, frameworks, koneki and eclipse SCADA available as open standard of communication protocols.
- The development of ITU-T Focus group M2M standardization for M2M service layer.

Q11. Illustrate the differences between IoT and M2M.

Answer : Model Paper-II, Q4(b)

	IoT (Internet of Things)	M2M (Machine-to-Machine Communication)
1.	IoT deals with sensors automation and acts as an Internet platform.	M2M provides direct communication between machines.
2.	The communication protocols used in IoT are HTTP, MQTT, XMPP, AMQP, DDS, COAP and web sockets.	The communication protocols used in M2M are proprietary or non-IP based. They include zigbee, ModBus, M-Bus, Bluetooth, wireless M-Bus, Z-wave, 6LoWPAN, PLC etc.
3.	The main focus of IoT is on software. The IoT devices make use of special software for collecting sensor data to interface with cloud via IP based communication and for analyzing the data.	The focus of M2M is more on hardware along with the embedded modules.
4.	"Things" in IoT are physical objects holding unique identifiers which can sense and interact with either the external environment or internal physical state. The IoT system contains heterogeneous things.	M2M systems contain homogenous machine types in M2M area network.
5.	The data in IoT is extracted into cloud. This data is analyzed and stored in cloud database by the analytics component. The results are visualized through cloud based applications.	The data in M2M is extracted in point solutions and on-premises storage infrastructure.
6.	Devices need Internet for communication.	Devices does not need Internet for communication.
7.	Scope in IoT is very large due to wide range of devices.	Scope in M2M is limited to few devices.
8.	Data in IoT is accessed by cloud applications like enterprise, analytics, management and remote diagnosis applications.	Data in M2M is accessed by on premises applications like service management, on-premises enterprise and diagnosis applications.

2.2 INTEROPERABILITY IN IoT

Q12. Discuss about interoperability in IoT.

Answer : **Model Paper-III, Q8**

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

1. Syntactic Interoperability

The ability of systems to accurately interpret the message structure of shared data and read the contents of message with or without knowing the meaning is called syntactic interoperability. An example of this type of interoperability is smart city system that can receive data from data center and can recognise the data format to extract data from message.

2. Semantic Interoperability

The ability of systems to interpret the content and meaning of exchanged data is called semantic interoperability. It is offered by various semantic technologies and knowledge management systems. An example of semantic interoperability is, enabling smart city system to extract the data received from some other system to understand its meaning and generate meaningful information.

3. Technical Interoperability

The ability of systems, components or applications to establish the communication and share messages without understanding the contents is called technical interoperability. It does not require the knowledge of data format but require the knowledge of network connectivity. It is actually related with elements which allow M2M (Machine-to-Machine) communication.

The relevant standards for IoT to solve the interoperability problem and allow compatibility between IoT systems are as follows,

(i) One M2M

It is a global standards initiative available for IoT and M2M communications. It works on service layer including technical requirements, data semantics, API and security solutions to allow IoT interoperability.

(ii) ARM

It is an IoT reference architectural model that is proposed by European research project IoT-A. It contains a set of building blocks representing the basic components and the components that allow creation of IoT interoperable system.

3. IoTivity

It is offered by open connectivity foundation as an open source framework allowing seamless interconnection and management of both wired and wireless devices from operating system or device manufacturer.

4, AllJoyn

It is an open source framework that enables devices to interact with machines without concerning about communication technology. It is mandatory in IoT system and an important and critical challenge to be solved in IoT. Many IoT systems are currently unable to communicate or interoperate. The reason behind this is the high heterogeneous nature of IoT systems. The IoT covers a wide range of devices, technologies, protocols, applications, systems and data. With this, global reference standard for IoT offers interoperability.

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2.3 INTRODUCTION TO ARDUINO PROGRAMMING

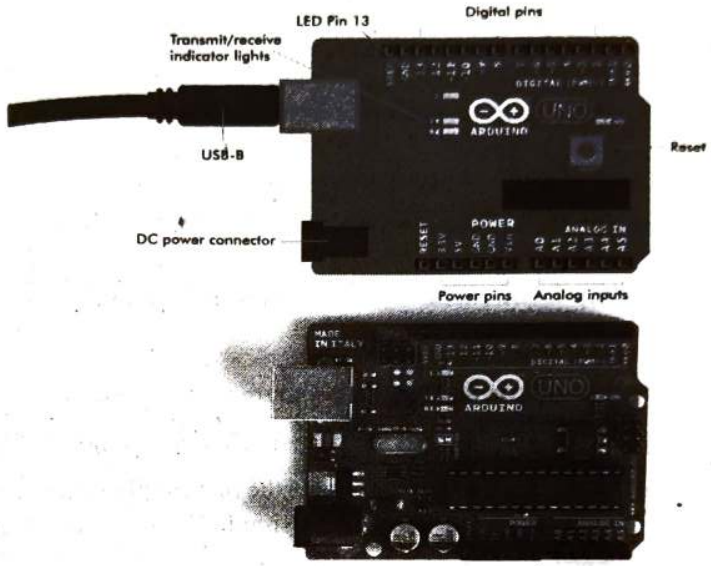
Q13. Give a brief introduction to Arduino programming.

Model Paper-I, Q5(a)

Answer :

Arduino is an open source hardware platform which is available to be used by hobbyists and enthusiasts across the globe to develop projects. It is accompanied with ATMEGA microcontroller to process data and offer proper working of IoT system. It is possible to program Arduino multiple times to develop different types of IoT projects with different types of code.

Arduino is considered as the brain of systems processing data from sensors. It offers, simple and robust development board. It is reliable and allows the electronics world to be programmable.



The requirements to start Arduino is an Arduino uno and USB cable. The software is however available for free. Initially, the Arduino development environment is required to be installed on the computer. Next, the USB cable is plugged in and the first program is uploaded. The only program to be installed on Arduino is the sketch to be run because Arduino does not have any operating system. The analog resistance sensors can be directly plugged into Arduino without the need for any external hardware since it posseses a built-in anolog-to-digital converter. The Arduino uno can easily get damaged with a wrong wire connection.

Q14. Describe basic Arduino setup for windows 7 and windows 8.

Model Paper-II, Q5

Answer :

The process of setting up Arduino on Windows is as follows,

1. Initially download latest version of Arduino software from http://arduino.cc/en/main/software.
2. Unizip the downloaded archive to a suitable location in the system.
3. Now, connect Arduino UNO to computer by using a USB cable. Arduino extracts power from USB without the need of external power supply.
4. Windows begins the installation process automatically and installs Arduino drivers. However, in certain reasons, installation may fail and show an error message. In such case, the below steps must be followed,
   (i) In Window explorer, right click on Computer and select Manage.
   (ii) In Computer Management, select Device Manager search for Arduino uno, right click on it and then select Update Driver software.
   (iii) Now select "Browse my computer for driver software". Go to Arduino folder that is extracted, then select arduino.inf in drivers directory and click on Next.
   (iv) Finally, Windows begins the installation of drivers.
5. Now double click on Arduino icon in unzipped folder and launch Arduino IDE.
6. Finally, test the installation.

Initially, load the test program.

blink.ino

```
void setup( )
{
    pinMode(12, output);
}
void loop( )
{
    digitalwrite(12, HIGH);
    delay(1200);
    digitalwrite(12, LOW);
    delay(1200);
}
```

After this, the following steps are followed,

1. Initially, select the serial port from drop-down menu i.e., a com port in Windows.
2. Now, select File → examples → 1. Basics → Blink.
3. Click on the Upload button in order to compile and upload program to Arduino.

The TX and RX lights in Arduino blink while uploading the program. The small light "L" blinks while running the program.

This indicates that successful installation and now user can create the first running sketch. If user gets stucked while running the code then it would be better to return to "Hello world" example. A simple Hello-world program is as follows,

```
void setup( )
{
    Serial.begin(9600);
    Serial.println("Hello World!");
}
void loop( )
{
}
```

Q15. Illustrate the anatomy of an Arduino program and write in brief about shields.

Model Paper-I, Q5(b)

Answer :

Anatomy of Arduino Program

An Arduino program begins with the execution of code in setup( ) function. Then the code present in loop( ) is repeated for infinite times until power is disconnected.

For remaining answer refer Unit-II, Q14, Topic: blink.ino.

The Arduino executes setup( ) when it boots. Then, the pin D13 is configured to output mode so as to make it controllable from the program. Once the setup( ) is completed, loop( ) is called infinitely. D13 is set to HIGH indicating that +5V is provided to it. The pins remain intact when delay occurs. During this time, L LED remains lit until D13 remain HIGH. In the next delay, D13 remain LOW and LED remains off. It would be one for a second and off for another second repeatedly.

Shields

Shields are boards that are connected on top of Arduino for enhancing its features so that it can be utilized more efficiently. Various types of shields are used to perform different tasks ranging from simple prototyping to more sophisticated shields like WiFi or Ethernet.

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As the shields are connected on top of Arduino using pin-to-pin connections, they minimize the need for extra wires. Certain shields specifically designed for prototyping and hence, they do not require electronics. They extract the Arduino header pins and make them adjacent to solderless breadboard. This is done to connect the jumper wires easily.

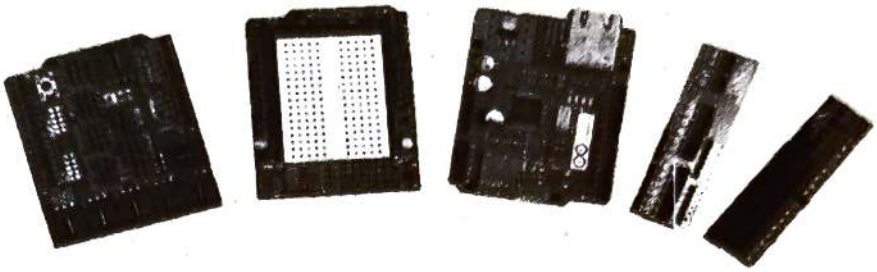

Figure: Shields

It is also possible to build customized shields so that easy-to-use and robust Arduino add-ons can be created.

2.4 INTEGRATION OF SENSORS AND ACTUATORS WITH ARDUINO

Q16. How sensors and actuators are integrated with Arduino? Explain.

Answer : **Model Paper-III, Q4**

Sensors are now a days becoming ubiquitous. Various technologies such as networking, communication, miniaturization etc., contribute to the success of sensing paradigm. They are now becoming small in terms of size to easily dispose, disappear and deft. So sensors which are of low cost, power and memory systems are becoming persuasive, pervasive and penetrative. They are now becoming smart there by conserving and preserving battery to extend its life.

The smart sensors can buffer and transmit data and are mainly useful for environmental and asset monitoring. A network of sensors, electronics, mobiles etc., is created to gather data and deposit in central repositories for posterior processing which illustrated below,

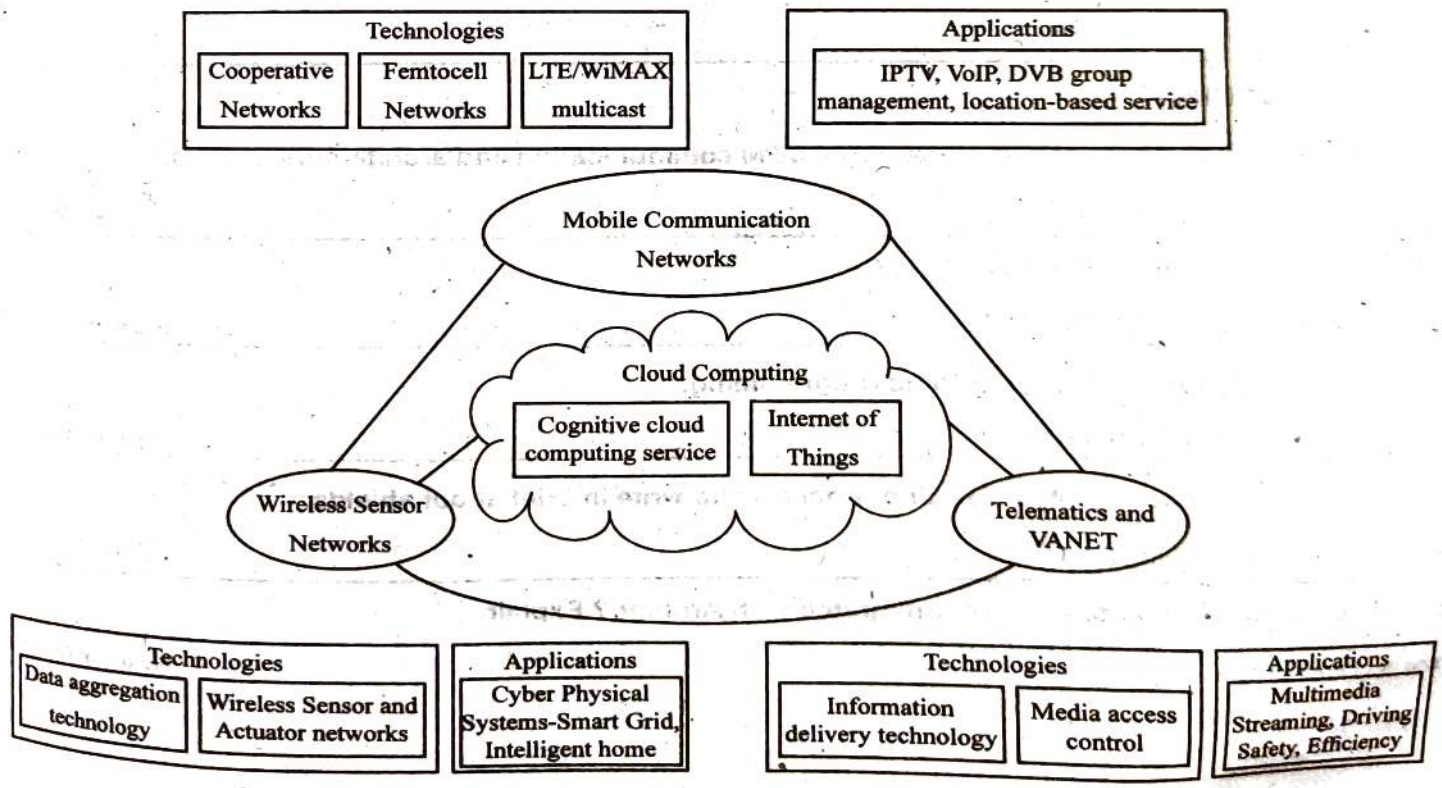

Figure: Network of Networks of Sensors and Actuators

The sensors have now become very important in daily life. They are interconnected to extract data from devices ranging from sensors to remote control systems. The middleware, brokers, connectors, drivers, sensor gateways, controllers etc., are incorporated to gather and transmit the data. The frameworks and platforms are used for increasing the speed of sensor-cloud integration to accumulate data in centralized location allowing cloud based data analytics. Actuation actually depends upon sensing.

Both actuators and sensors execute depending upon sensor findings and are the important participants for a smart environment. They receive sensor value based on which they respond. Integrating sensors and actuators therefore plays important part to set and sustain smart environments.

The wireless sensor network (WSN) is a type of network built by huge number of sensor nodes. Each node has a sensor for detecting various physical phenomena like light, heat, pressure, presence and gas. The WSN is one of the revolutionary information gathering technique to develop next-generation people-centric IoT applications.

The BSN's (Body Sensor Networks) are also considered as a challenge to IoT. They improvise quality of life and provide AAL (Ambient Assisted Living). They also provide assured health care for diseased, disable and debiliated people. The research in the area of BSN's holds low level hardware design to high level communication along with data fusion algorithms ranging upto top level applications.

IMPORTANT QUESTIONS

SHORT QUESTIONS

Q1. Write in brief about IoT and M2M.

Ans: For answer refer Unit-II, Q2. **Important Question**

Q2. List out any three differences between IoT and M2M.

Ans: For answer refer Unit-II, Q5. **Important Question**

Q3. Write in brief about Arduino.

Ans: For answer refer Unit-II, Q8. **Important Question**

ESSAY QUESTIONS

Q4. Define M2M communication. Write about M2M communication and architecture of M2M.

Ans: For answer refer Unit-II, Q9. **Important Question**

Q5. Discuss about interoperability in IoT.

Ans: For answer refer Unit-II, Q12. **Important Question**

Q6. Give a brief introduction to Arduino programming.

Ans: For answer refer Unit-II, Q13. **Important Question**

Q7. Illustrate the anatomy of an Arduino program and write in brief about shields.

Ans: For answer refer Unit-II, Q15. **Important Question**

Q8. How sensors and actuators are integrated with Arduino? Explain.

Ans: For answer refer Unit-II, Q16. **Important Question**

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UNIT 3

Syllabus

Introduction to Python Programming, Introduction to Raspberry Pi, Interfacing Raspberry Pi with Basic Peripherals, Implementation of IoT with Raspberry Pi

LEARNING OBJECTIVES

- ✓ Basic Concepts of Python Programming
- ✓ Raspberry Pi and its Peripherals
- ✓ Various Interfaces and Commands of Raspberry Pi
- ✓ Implementation of IoT with Raspberry Pi

INTRODUCTION

Python is a simple interactive, interpreted object oriented programming language, when compared to other programming languages, it is a very robust, elegant and a powerful language. Raspberry Pi is a device that comes in the size of equal to credit/debit card works like a mini computer and has the capability of performing tasks of a desktop computer. It is a low cost device which can run on different versions of Linux. It connects sensors and actuators with the help of I/O pins. Raspberry Pi can support both Linux and Python for its implementation. It allows any python program that can be executed on any machine. To support this, it uses GPIO pins along with various types of sensors and actuators and its interfaces. It utilizes the capabilities of GPIO pins to make it useful for IoT. The input obtained from sensors can be processed further and different actions can be performed on the input such as transferring data, sending an email etc.

PART-A SHORT QUESTIONS WITH SOLUTIONS

Q1. Listout the features of python.

Answer : Model Paper-III, Q1(e)

The features of python are as follows,

1. Object-oriented Programming Paradigm
2. Easy to Learn
3. Easily Readable
4. Easily Maintainable
5. Uses High-level Data Structure
6. Extensibility
7. Portability
8. Robust
9. Possesses the Rights of a Memory Manager
10. Interpreted and (Byte) Compiled Language
11. Scalability
12. Effective Rapid Prototyping Tool.

Q2. What are Identifiers?

Answer : Model Paper-I, Q1(e)

Python define its identifier using letters, digits and a underscore. But, the first character of a name should never be a digit.

If several names have to be binded different to the same value, it can be done in single statement as follows,

>>>$S_1 = S_2 = S_3$ = "Hello world"

Here, S_1, S_2 and S_3 are binded to Hello world string.

>>>print S_1

>>>print S_2

>>>print S_3

The output of these three statements is same i.e., Hello world as all three names binded to same string.

Q3. List out the arithmetic or numeric operators in Python.

Answer :

The numeric type arithmetic operators that are supported by python are listed below,

(i) Division (/, //)

(ii) Modulus (%)

(iii) Exponentiation (**)

(iv) Addition (binary (+) operator)

(v) Subtraction (binary (–) operator)

(vi) No change (Unary(+) operator)

(vii) Negation (Unary (–) operator).

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Q4. List out the comparison operators in python.

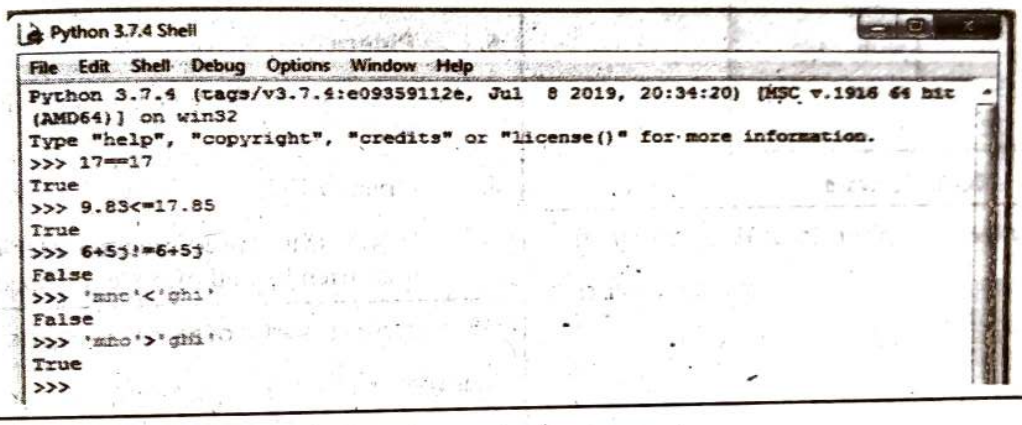
Answer : Model Paper-II, Q1(e)

Comparison operators compare only the data values of the participating objects. The comparisons performed are based on the sign and magnitude for numeric values, whereas a lexicography (i.e.,) alphabetical order is followed, in writing dictionaries for strings. The comparisons result in either Boolean True or False values.

The list of standard type value comparison operators in highest-to-lowest precedence order is given below,

Operator	Syntax	Determines
<	exp1 < exp2	exp1 is less than exp2
>	exp1 > exp2	exp1 is greater than exp2
<=	exp1< = exp2	exp1 is less than or equal to exp2
>=	exp1 > = exp2	exp1 is greater than or equal to exp2
= =	exp1 = = exp2	exp1 is equal to exp2
! =	exp1! = exp2	exp1 is not equal to exp2

Examples



Q5. List out the keywords used in python.

Answer : Model Paper-III, Q1(f)

Keywords are reserved words which forms a construct of the language. Use of these keywords for any other purpose results syntax error.

Table depicts keywords used in Python.

S.No.	Keyword
1	and
2	as
3	assert
4	break
5	class
6	continue
7	def
8	del
9	elif
10	else
11	except
12	exec

13	finally
14	for
15	from
16	global
17	if
18	import
19	in
20	is
21	lambda
22	not
23	or
24	pass
25	print
26	raise
27	return
28	try
29	while
30	with
31	none
32	yield

Table: Keywords

Q6. List out any five peripherals of Raspberry Pi.

Answer : **Model Paper-II, Q1(f)**

Some peripherals of Raspberry Pi are as follows,

1. **Power Input**

The power input to Raspberry Pi is provided through a micro USB connector.

2. **USB Ports**

There are two USB ports on Raspberry Pi that can provide power upto 100mA. However, an external power hub is needed to connect devices that require more power.

3. **Ethernet Ports**

There is RJ45 Ethernet port on board which is used to connect to Internet.

4. **Processor and RAM**

The processor of Raspberry Pi is ARM where ARM117672-F can support 700 MHz power. The RAM used for this processor is about 512 MB.

5. **GPIO Pins**

There are four types of general purpose input/output pins on Raspberry board such as SPI interface pins, true GPIO pins, RX and TX pins and I2G interface pins.

Q7. What are the flavors/versions of Linux?

Answer :

Some of the flavours/versions of Linux are as follows,

1. **Raspbian**

It is a Linux based Debian Wheezy port that is particularly used for Raspberry Pi.

2. **RaspBMC**

It is a type of XBMC media-center distribution.

3. **Arch**

It is a type of Arch Linux port developed for AMD devices.

4. **RISC OS**

It a compressed form of operating system with good speed.

5. **Pidora**

It is a type of Fedora Linux particularly developed for Raspberry Pi.

6. **OpenELEC**

It is XBMC based media-center distribution which is used friendly and offers good speed.

Q8. Write short notes on Raspberry Pi interfaces.

Answer : **Model Paper-I, Q1(f)**

Raspberry Pi Interfaces

There are three types of Raspberry Pi interfaces that support data transfer. They are I2C, Serial and SPI.

1. **I2C**

I2C interface is used to provide interconnection between hardware modules using SOA (data line) and SCL (clock line) pins. Using these pins, it supports synchronous data transfer.

2. **Serial**

The serial interface allows data transfer among serial peripherals using receive (Rx) and transmit (Tx) pins.

3. **SPI (Serial Peripheral Interface)**

SPI is a type of serial data protocol that offers synchronous data transfer among peripheral devices using the following five pins.

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PART-B ESSAY QUESTIONS WITH SOLUTIONS

3.1 INTRODUCTION TO PYTHON PROGRAMMING

Q9. What is Python? Explain the features of Python language.

Model Paper-III, Q6(a)

Answer :

Python

It is a simple, interactive, interpreted object oriented programming language. When compared to other programming languages, it is a very robust, elegant and a powerful language.

Features of Python

1. **Object-oriented Programming Paradigm**

   Python is an object-oriented programming language, as it separates data from logic. Moreover, Python is not only object-oriented, but also a proper combination of multiple programming paradigms.

2. **Easy to Learn**

   Python consists of very few keywords, simple structure and well defined syntaxes which makes it easy to learn.

3. **Easily Readable**

   Unlike other programming languages, it does not make use of symbols like ($), semicolon (;), tildes (~) for accessing variables, defining code blocks and pattern matching. Rather, it defines a simple and clear code, which is easier for the programmer to read. Python language has been designed in a way, that the code written by one programmer can be easily understood by the other.

4. **Easily Maintainable**

   Since, Python is simple unlike other programming languages, it does not require much difficulty for maintenance. For example, for the existence of its code, it does not depend on the presence of the programmer at a company. The most important advantage of Python is that, at the time of reviewing a script written very long time ago, the programmer does not require much guidance from a reference book.

5. **Uses High-level Data Structure**

   Python has been designed in a way, that the programmer does not need to look after the low level details such as, memory management. It supports high level data structures such as, realizable arrays (lists in Python), hash tables (dictionary in Python). As these building blocks are defined in the core language, they are extensively used. This reduces the development time, as well as the size of the code. Thereby, making the code more simpler to read.

6. **Extensibility**

   Python allows the programmer to code some part of the program in different languages like, C, C++, java and utilize them through Python code.

7. **Portability**

   Since Python is written in C, it can work on different platforms i.e., the Python applications built on one system, can run on any other system, with little or no modification. Any platform that contains ANSI C compiler supports Python. Python is also independent of the type of architecture.

8. **Robust**

   Python is more powerful in determining as well as handling error conditions, through software handlers. It guides the programmer, by providing full details of errors, in case of program crashing due to errors. For example, the location where the error has occurred in the code, by specifying the filename, line number and function. It also allows the programmer to take an action for the elimination of the error.

   The exception handlers in Python are capable of reducing debugging process, by simplifying the problem, redirecting the program flow, performing cleanup or maintenance measure, closing the application elegantly or just ignoring it. In case, if the errors could not be handled properly, Python generates a stack that displays the type and location of the error, in addition to the location of module that contains the erroneous code.

9. Possesses the Rights of a Memory Manager

One of the main advantages of Python programming language is that, it itself handles all the functionalities related to memory management. Thereby, reducing the programmers burden. This in turn reduces the overall development time and includes fewer bugs. It handles memory management through the use of interpreter.

10. Interpreted and (Byte) Compiled Language

Just like Java, Python is also an interpreted and a byte-compiled language. That is, it allows the programmer to run the program directly from the source code without performing the compilation process. The process followed by Python is,

(i) It just transforms the source code into an intermediate form known as, 'byte code'.

(ii) Then translates the byte code into a machine code (0's and 1's)

(iii) And then run it.

The programmer need not have to worry about the program compilation, proper linkage and loading of libraries etc.

11. Scalability

The term 'scalability' here, refers to the capability of the programming language, to accept and handle the additional performance required, upon the addition of new hardware to the system. Unlike other programming languages, Python can expand the code size, by adding new or existing Python elements and reusing the code when required. This is possible because, Python has a pluggable and modular architecture.

12. Effective Rapid Prototyping Tool

Python provides several interfaces to other systems, which makes it powerful and robust enough to prototype the entire systems within it, in a very less time.

Q10. Explain the syntax of Python language.

Answer :

Python language defines a very simple syntax. Its simplicity lies in design choice. There are several ways to represent a single program but this leads to difficulty in learning and using the language. The philosophy of Pythons states that "There is one and one way to do it".

Since, Python is a non-functional language we mostly use assignment statement. The syntax is as follows,

Syntax

name = expression

Here, the name is binded to the value of the expression.

In other programming languages the above line will assign the expression value to name.

Thus, python uses assignment operator to bind a name to data value generated by the expression. If a reference value is taken in place of expression then the name will be binded to the existing value.

Unlike, other programming language name is not bound to particular data type and no type checking is needed to bind the name to the value.

Identifiers in Python

Python define its identifier using letters, digits and a underscore. But, the first character of a name should never be a digit.

If several names have to be binded different to the same value, it can be done in single statement as follows,

>>>$S_1 = S_2 = S_3$ = "Hello world"

Here, S_1, S_2 and S_3 are binded to Hello world string.

>>>print S_1

>>>print S_2

>>>print S_3

The output of these three statements is same i.e., Hello world as all three names binded to same string.

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Q11. Write steps to install Python on windows.

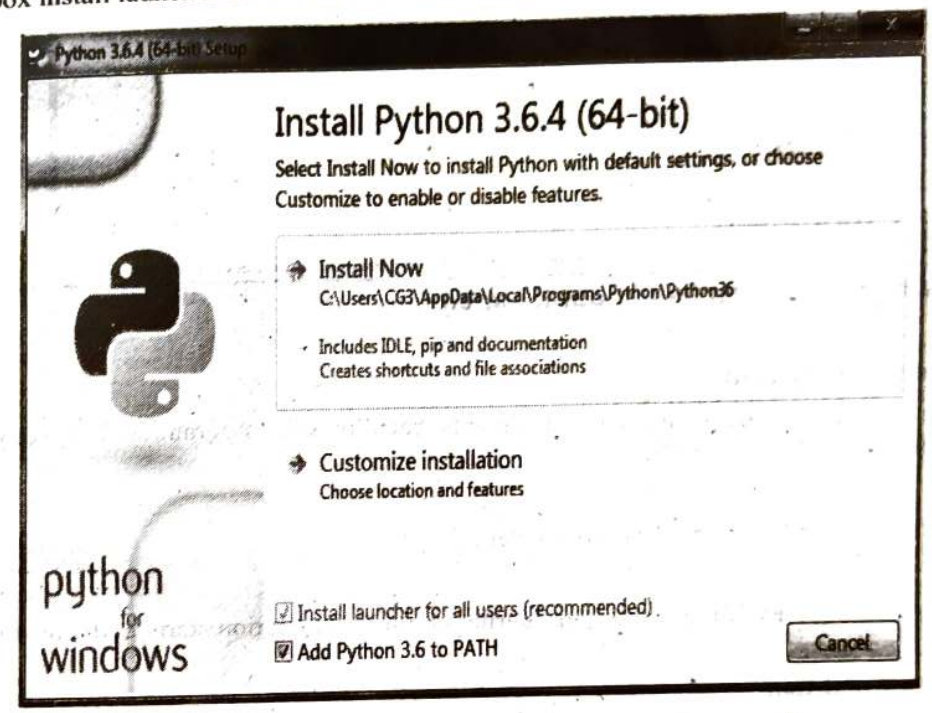
Model Paper-I, Q6(a)

Answer :

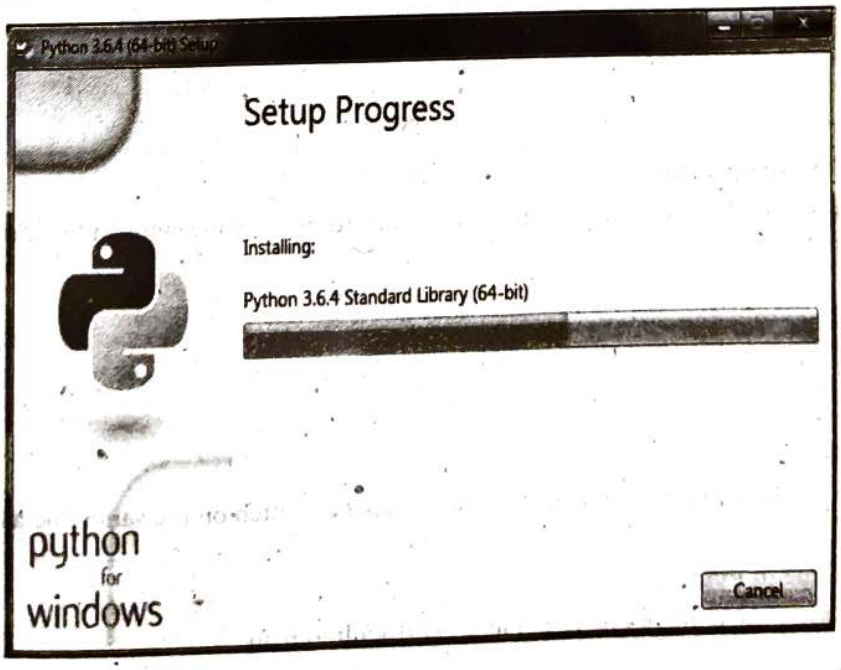
Any software has two versions 32-bit and 64-bit. The respective version based on the operating system can be downloaded and installed from the below link.

https://www.python.org/downloads/release/python-364

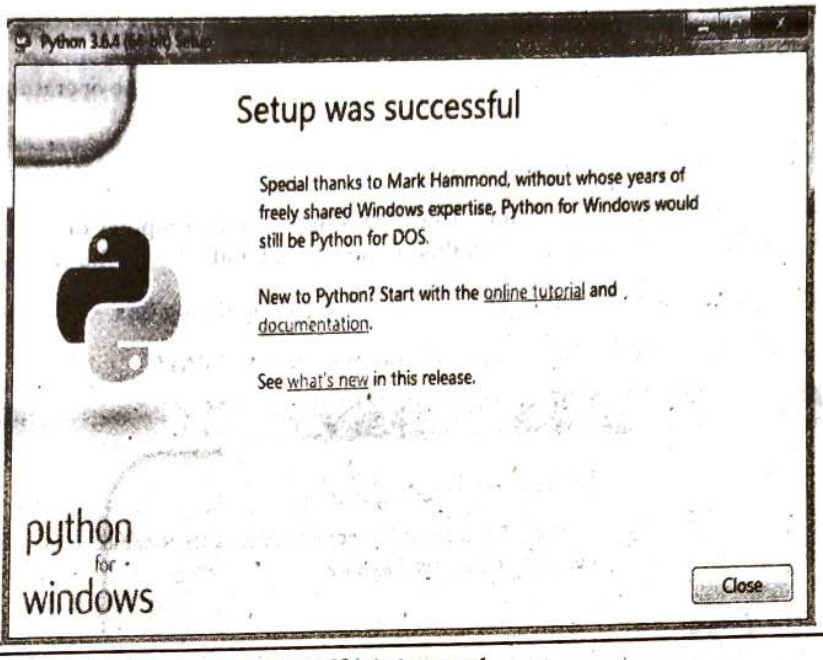
1. Select 'windows x 86-64 executable installer' for 64 bit operating system computer or select 'windows x86 executable installer' for 32-bit operating system computer with this 'python-3.6.4 and 64-exe' file will be downloaded.
2. Double click on 'python-3.6.4-and 64.exe' file. This will display a setup dialog box.
3. Click the checkbox install launcher for all the users and add python 3.6 to PATH.



4. Click on Install Now. This will show a setup program window.



5. Once the installation completes a dialog box appears showing the message 'setup was successful'. Finally, click on close button.



Q12. Define control statements. Discuss about if statement.

Model Paper-II, Q6(a)

Answer :

Decision Structures / Control Statements

Decision structures or Control statements are the statements that allows the programmer to specify the next statement that must be executed depending on some conditions.

if Statement

The *if* statement contains the following three components,

(i) **The Keyword 'if'**

The *'if'* clause is executed, only if the expression is true otherwise, execution starts at the next statement following the code.

(ii) **An Expression or a Condition**

An expression is tested for its truth value. If the expression evaluates to non-zero or Boolean true then the code is executed.

Syntax

if expression:

Statement1

Statement2

Multiple Conditional Expressions

To provide multiple conditional expressions, or to perform negation of expressions in the *if* statement, Boolean operators ***and***, ***or*** and ***not*** are used.

Example

if not valid ***or*** (count < 0):

print "Invalid input"

(iii) **The Code**

Single Statement Code

If the code of *if* clause contains only a single statement, it may be written on the same line as the header statement.

Example

if i = = 1 : print "Welcome to Python"

Although it is easy to write the code in one line, but it is difficult to read.

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Example

```
days = int(input("How many days does leap year contain?: "))
if days == 366:
print("You are right!!")
```

Output

```
Python 3.8.5 Shell
File Edit Shell Debug Options Window Help
==== RESTART: C:/Users/ref-b/AppData/Local/Programs/Python/Python38-32/ifExample.py ===
How many days does leap year contain?: 366
You are right!!
>>>
Ln: 188 Col: 4
```

Q13. Discuss about if-else statement.

Answer :

if...else Statement

If else statement is used to execute a set of statements if the condition is true otherwise it executes another set of statements. The syntax of if...else is as follows,

```
if condition :
    # statements
else :
    # statements
```

The if is succeeded by a condition and a set of statements. If the condition is true the statements following if condition will be executed.

If the condition is false the statements following else will be executed.

Example

```
a = int(input("Enter a number: "))
if a%2 == 0:
print("The given number is an even number")
else:
print("The given number is an odd number")
```

Output

```
Python 3.8.5 Shell
File Edit Shell Debug Options Window Help
== RESTART: C:/Users/ref-b/AppData/Local/Programs/Python/Python38-32/ifelseExample.py =
Enter a number: 15
The given number is an odd number
>>>
Ln: 192 Col: 4
```

In the above example initially the input is accepted from user into a. The value of 'a' is divided by 2 using % operator. This operator generates remainder of division operator. If the remainder is 0 then the statement following if condition is executed. If the remainder is non zero then the statement following else will be executed.

Q14. Give a brief introduction about repetition structure.

Answer : Model Paper-III, Q7

The programmers sometimes need to write the code that performs the same task repeatedly. For example, consider a program to calculate 10 percent sales commission for several sales people. One best approach is to write the code to calculate the sales person commission and then repeat the same code for every sales person.

```
Sales = float (input ('Enter sales amount:'))
      = float (input ('Enter commission rate'))
Com = Sales * rate
print = ('Commission $', format(commission, ', .2f', sep ' '))
```

If the above code is repeated for every person then there is duplication of same code. Writing of long sequence of statements will be time consuming. If the duplicated code need to be corrected then corrections has to be done several times. The best way to repeatedly perform an operation is to write the code the once and then place the code in a structure which makes the computer to repeat required number of times. This is possible with a repetition structure more commonly called as loop. There are two types of loops namely, condition-controlled loop and count-controlled loop. A condition controlled loop uses true/false condition to control number of times it repeats. The count controlled loop repeats for specific number of times. In python, while statement is used to write a condition controlled loop and for statement is used to write the count controlled loop.

1. Condition Controlled Loop: The while Loop

'*while*' is the first conditional looping statement in python. In '*if*' statement, the code is executed if the condition is true, whereas, in *while* the code is executed in a loop until the condition becomes false.

Syntax

while *condition*

Code to be executed.

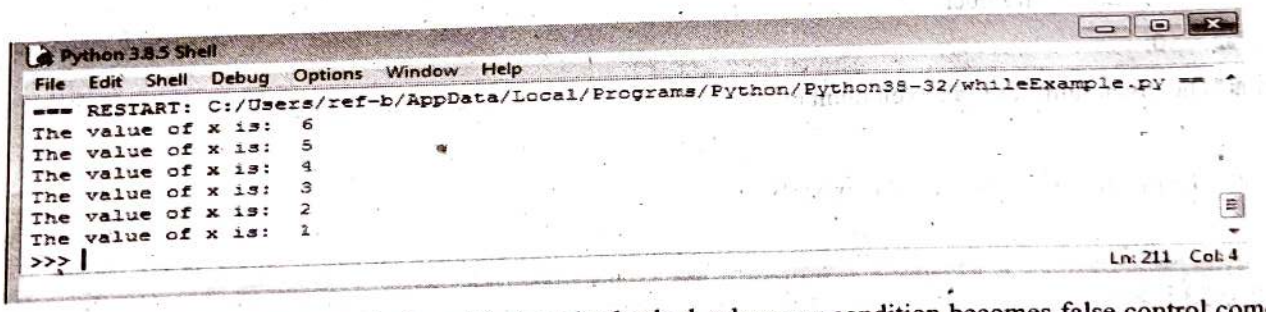
The code in the ***while*** loop, gets executed repeated number of times, until the expression (condition) becomes false (Boolean value false).

Whenever a user does know the number of times a loop need to execute, it is better to use the '*while*' statement.

Example

```
x = 6
while (x>=1):
    print("The value of x is: ",x)
    x = x-1
```

Output



With each iteration, the condition in the while loop is checked, whenever condition becomes false control comes out of the loop.

2. Count Controlled Loop: The for Loop

The *for* statement is a powerful looping construction in Python. The looping mechanism in *for* statement is applied, over the sequence members. *for* statement calls the *next()* method of an iterator and ends when *StopIteration* exception is raised. List comprehensions and generator expressions also uses '*for* statement'.

Syntax

for var *in* <object> :

<statements>

To repeat the code in the *for* loop, each time the iteration variable is set to the current element of the object.

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Uses of for Loops

(i) **Used with Sequence Types**

Basic Usage

```
for spam in 'student':
    print('Current letter:', spam)
```

Output

```
Python 3.8.5 Shell
File Edit Shell Debug Options Window Help
=== RESTART: C:/Users/ref-b/AppData/Local/Programs/Python/Python38-32/for-basic.py ===
Current letter: s
Current letter: t
Current letter: u
Current letter: d
Current letter: e
Current letter: n
Current letter: t
>>>
Ln: 19 Col: 4
```

The iteration variable 'spam', always contains only a single character when iterating over a string. This construct is useful in debugging of sequences in the *for* loop.

(ii) **Iterating by Sequence Item**

Example

```
chocolates = ['Snickers','Cadbury', 'Lacto']
for x in chocolates:
    print(x, "chocolate")
```

Output

```
Python 3.8.5 Shell
File Edit Shell Debug Options Window Help
== RESTART: C:/Users/ref-b/AppData/Local/Programs/Python/Python38-32/for-sequence.py =
Snickers chocolate
Cadbury chocolate
Lacto chocolate
>>>
Ln: 25 Col: 4
```

For each iteration in the above example, the list is iterated and the variable 'x' contains the list elements.

(iii) **Iterating by Sequence Index**

Example

```
arrayelements = ['table', 'chair', 'pen', 'pencil']
for x in range(len(arrayelements)):
    print(arrayelements[x])
```

Output

```
Python 3.8.5 Shell
File Edit Shell Debug Options Window Help
=== RESTART: C:/Users/ref-b/AppData/Local/Programs/Python/Python38-32/for-index.py ===
table
chair
pen
pencil
>>>
Ln: 31 Col: 4
```

Here, *len*( ) and *range*( ) are the built-in functions

len( ) gives the total number of elements in the tuple and *range*( ), provides the actual sequence to iterate over tuple elements.

```
>>> len(array elements)
4
>>> range (len(arrayelements))
[0, 1, 2, 3]
```

Q15. Write the basic style guidelines.

Answer :

The basic style guidelines for python are as follows,

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

1. Comments

Comments should be used in programs to provide information about the function that a program is going to perform i.e., the logic used and the process adopted. Comments should be clear, short and convey meaningful messages. They increase program readability and save time of others who use the programs.

2. Indentation

The spaces left while starting a new paragraph is called indentation. Four to six spaces are ideal for indentation while less than three are bad and more than seven spaces are wastage of resources. Tabs can also be used for indentation but spaces should be preferred.

3. Documentation

In python, documentation strings can be retrieved dynamically using a variable named _doc_. The attribute obj_obj._doc_ is used to access first unassigned string in a class or function declaration. Here, obj refers to module, class or function name.

4. Selecting Identifier Names

Selection of identifier names must be short in length and meaningful. Modern computing storage does not hinder length of the name however, short names are preferred.

Q16. Explain how to write and execute a program in python.

Answer :

A python program can be executed in three different ways, they are,

(a) Using python's command line window

(b) Using python's IDLE graphics window

(c) From system prompt.

(a) Using Python's Command Line Window

This is an interactive mode where a program can be typed in one line at a time. PVM will execute it.

- Open the python's command line.
- Type the desired program beside >>> symbol (python prompt).
- Result will be displayed when the user type the last line of program and clicks Enter button.

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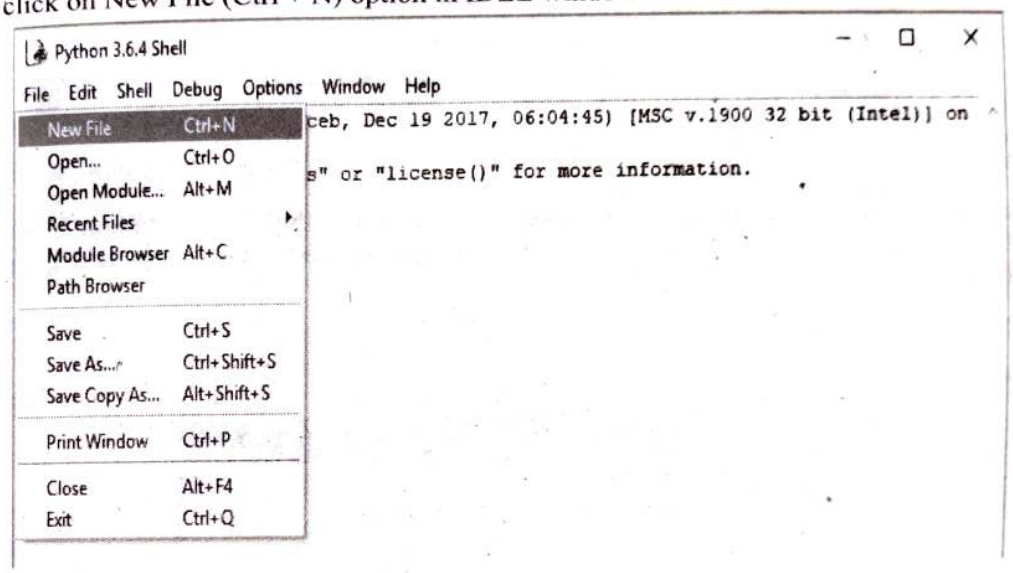
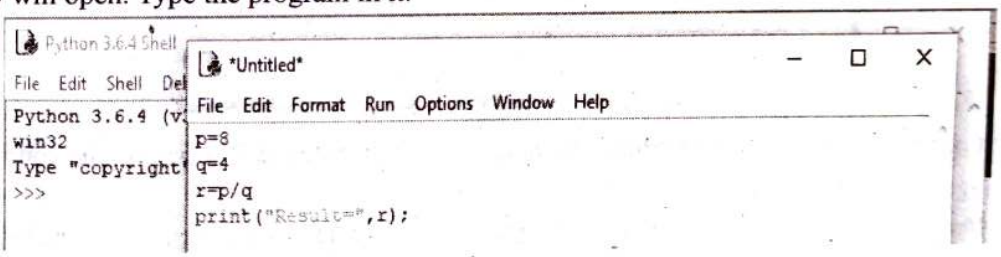
```
Python 3.6 (32-bit)
Python 3.6.4 (v3.6.4:d48eceb, Dec 19 2017, 06:04:45) [MSC v.1900 32 bit (Intel)] on win32
Type "help", "copyright", "credits" or "license" for more information.
>>> p=8
>>> q=4
>>> r=p/q
>>> print("Result=",r)
Result= 2.0
>>>
```

(b) **Using Python's IDLE Graphics Window**

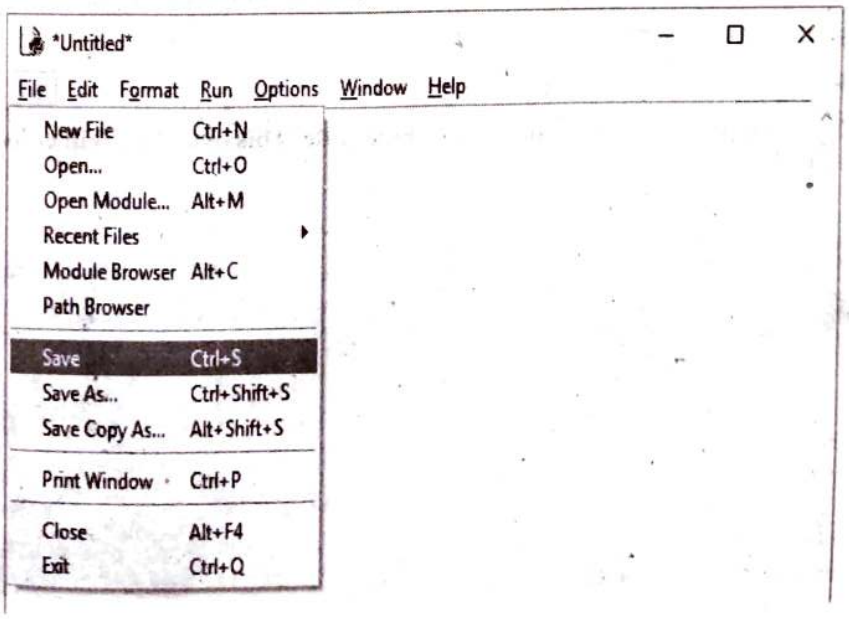
1. Click on Python's IDLE icon
2. Go to file and click on New File (Ctrl + N) option in IDLE window



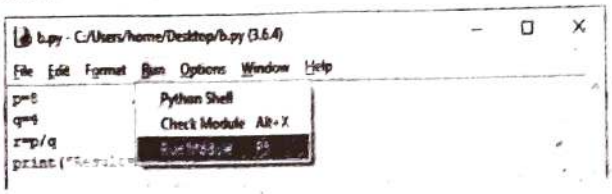
3. A new window will open. Type the program in it.



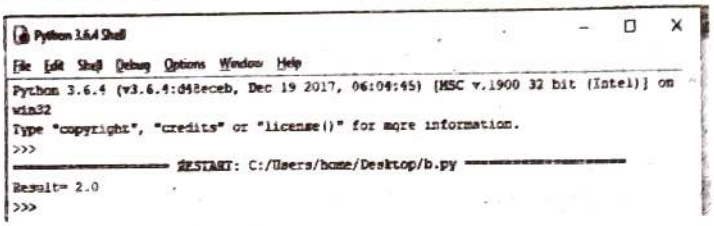
4. Save the file.



5. Go to Run and select Run Module.



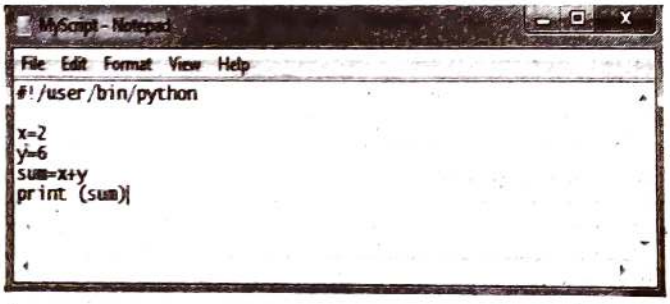
6. Result will be displayed in a new window.



(c) From System Prompt

Writing and executing the python scripts is an easy process. Initially type "Python" or "Python 3" at the command prompt to access python. With this even python REPL (Read-Eval-Print-Loop) gets opened. To exit from REPL type Ctrl-D. Follow the below steps to write and run a python script.

1. Create a new file with name MyScript.py.
2. Type the below code in it

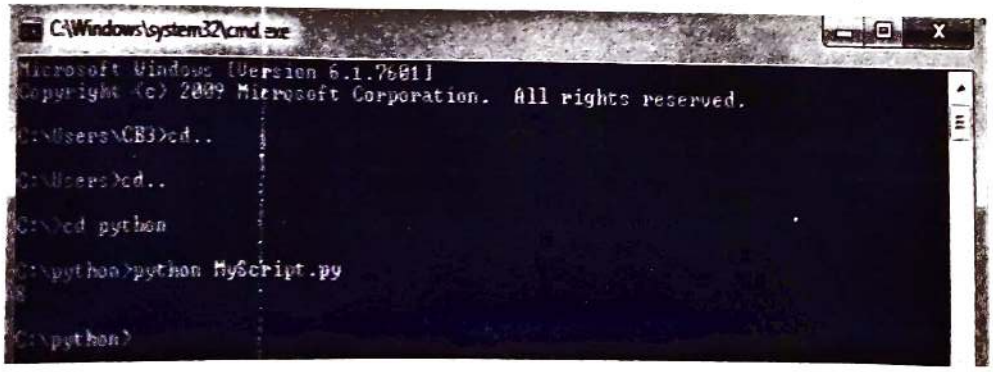


3. Save the file with .py extension. Even text editors such as notepad or notepad ++ to write the code and press ctrl + x to exit.
4. Without making the file executable it can be run by navigating the location of the script and then by typing MyScript.py.
5. MyScript.py can be made executable by typing chmod +x MyScript.py at command prompt.
6. To run the script type at command prompt.

   C:\>python MyScript.py

This command will call the compiler to convert the file into byte code. This byte code will converted to machine code and the processor will execute this machine code.

Output



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Q17. Define operator. Describe different types of operators supported by Python with an example for each.

Model Paper-I, Q7

Answer :

Operator

An operator can be defined as a symbol which perform specific operations such as mathematical, logical and other manipulations using one or more operands. Python supports, large number of operators.

Types of Operators

There are three main different types of operators supported by Python. They are listed below,

I. Arithmetic or numeric operators

II. Comparison/Relational operators

III. Logical operators.

I. Arithmetic or Numeric Operators

The numeric type arithmetic operators that are supported by python are listed below:

1. Division (/, //)
2. Modulus (%)
3. Exponentiation (**)
4. Addition (binary (+) operator)
5. Subtraction (binary (–) operator)
6. No change (Unary(+) operator)
7. Negation (Unary (–) operator).

1. Division(/, //)

There are three different types of division operations,

(i) Classic division

(ii) True division (/)

(iii) Floor division (//).

(i) Classic Division

In the Classic Division Operation, the quotient or result obtained will have the same type as that of the operand involved. That is, if integer type operands are involved, then the classic division operation returns an integer type by truncating the fraction. Similarly, for floating point operands, it returns the actual floating point quotient.

Example

```
>>> 25/2
12
>>> 25.0/2.0
12.5
```

(ii) True Division (/)

In the True Division Operation, the quotient or result obtained will be the actual value, irrespective of the operand types. This type of division operation can be performed, only when the 'from–future–import division' directive is defined.

Example

```
>>> from–future–import division
>>> 25/2
12.5
>>> 25.0/2.0
12.5
```

(iii) Floor Division (//)

In the floor division operation, the fractions obtained in the quotient are always truncated and rounded to the smallest whole number which is on its immediate left on the number line.

Example

```
>>> 25//2
12
>>> 25.0//2.0
12.0
```

2. Modulus(%)

The computation of modulus is different for different numeric types.

- The modulo of two integer numbers is the remainder of their integer division.

  Example

  17 % 3 = 2

- The modulo of two floating point numbers is obtained using the following formula.

$$\left[\text{dividend} - \left(\text{math.floor}\left(\frac{\text{dividend}}{\text{divisor}}\right) * \text{divisor}\right)\right]$$

- The modulo of two complex numbers is obtained using the following formula.

$$\left[\text{dividend} - \left(\text{math.floor}\left(\left(\frac{\text{dividend}}{\text{divisor}}\right).\text{real}\right) * \text{divisor}\right)\right]$$

3. Exponentiation (**)

The exponentiation operation, determines the power of a numeric type. The binding between the exponentiation operator and its left operand is more tighter than that with unary operators (+, –). Whereas, the binding between the exponentiation operator and its right operand is less tighter than that with unary operators (+, –).

Examples

```
>>>2**5                    # 2 power 5
32
>>>>–2++5                  # left binding with '**' is tighter than with '–'
–32
>>>(–2)**5                 # Makes left binding with '–' more tighter
–32
>>>2.0 ** – 5.0            # Right binding with '–' is tighter than with '**'.
>>>2**–5                   # Integers cannot be raised to negative powers
Traceback(innermost last);
File"<stdin>", line1 \n?
ValueError:integer to the negative power
```

The list of all numeric arithmetic operators in the highest-to-lowest order of precedence is given below.

S.No.	Operator	Syntax	Function
1.	**	exp1 ** exp2	exp1 power exp2 (tighter binding to its left)
2.	+ (unary)	+exp	Keep sign of exp, unchanged
3.	– (unary)	–exp	Negation of exp (or) change sign of exp to '–'
4.	**	exp1 ** exp2	exp1 power exp2 (tighter binding to its right)
5.	*	exp1 * exp2	Multiply exp1 and exp2
6.	/	exp1/exp2	Divide exp1 by exp2. This division can either be a classic or a true division
7.	//	exp1 // exp2	Divide exp1 by exp2. This division can be only a floor division
8.	%	exp1 % exp2	Module of exp1 divided by exp2
9.	+ (unary)	exp1 + exp2	Add exp1 and exp2
10.	– (unary)	exp1 – exp2	Subtract exp1 and exp2

4. **Addition (Binary(+) Operator)**

The addition operator is used to add two operands and generate sum of them as the result.

Example

```
>>>65 + 60
    95
>>>65.4 + 16.2
    81.6
```

5. **Subtraction (Binary(–) Operator)**

The subtraction operator is used to subtract two operands and generate the difference between them as the result.

Example

```
>>>32 – 10
20
>>>16.8 – 4.2
12.6
```

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6. **No Change (Unary(+) Operator)**

The no change (unary(+) operator) is used before a variable but the value of it does not change. If the value is positive it remains positive and if the value is negative it remains negative.

Example

```
>>>x = 5
>>>print (– x)
– 5
>>>x = 5
>>>print (x)
5
```

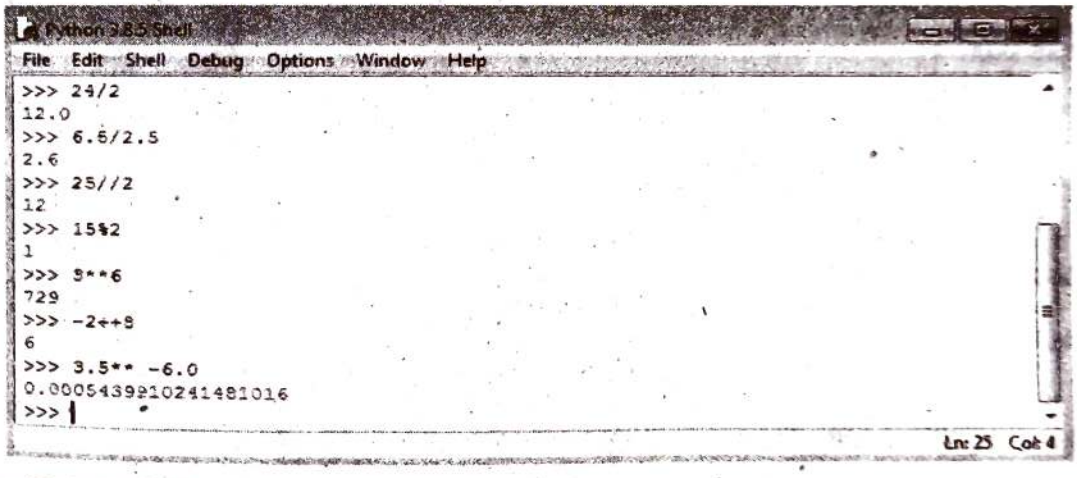
7. **Negation(Unary(–) Operator)**

Unary minus operator is represented by the symbol minus (–). It is used before a variable to make its value negated. That is the positive value of a variable will become negative and negative value will become positive when this operator is used.

Example

```
>>>x = 5
>>>print (– x)
– 5
>>>n = –5
>>>n = –n
>>>print (n)
5
```

Examples



II. **Comparison/Relational Operators**

These operators compare only the data values of the participating objects. The comparisons performed are based on the sign and magnitude for numeric values, whereas a lexicography (i.e.,) alphabetical order is followed, in writing dictionaries for strings. The comparisons result in either Boolean True or False values.

The list of standard type value comparison operators in highest-to-lowest precedence order is given below,

Operator	Syntax	Determines
<	exp1 < exp2	exp1 is less than exp2
>	exp1 > exp2	exp1 is greater than exp2
<=	exp1< = exp2	exp1 is less than or equal to exp2
>=	exp1 > = exp2	exp1 is greater than or equal to exp2
= =	exp1 = = exp2	exp1 is equal to exp2
! =	exp1! = exp2	exp1 is not equal to exp2

Examples

```
Python 3.8.5 Shell
File  Edit  Shell  Debug  Options  Window  Help
>>> 17==17
True
>>> 9.83 <= 17.85
True
>>> 6+5j != 6+5j
False
>>> 'mno' < 'ghi'
False
>>> 'mno' > 'ghi'
True
>>> |
Ln: 42  Col: 4
```

III. Logical Operator

These operators negate or link two or more expressions.

The list of standard type logical operators in highest to lowest precedence order is given below:

Operator	Syntax	Determines
not	not exp	negation or logical NOT of exp
and	exp1 and exp2	conjunction or logical AND of exp1 and exp2
or	exp1 or exp2	disjunction or logical OR of exp1 and exp2

Examples

```
Python 3.8.5 Shell
File  Edit  Shell  Debug  Options  Window  Help
>>> m,n = 5.59, 422
>>> m > 3.02
True
>>> not (m == 5.29)
True
>>> (m>3.02) or (n<300)
True
>>> (m>3.02) or (n>300)
True
>>> not (m is n)
True
>>>
Ln: 53  Col: 4
```

Q18. Explain the various datatypes in python.

Model Paper-II, Q7

Answer :

Datatypes in Python

The various data types supported/used in Python are as follows,

1. Numeric datatypes
2. String datatypes
3. List datatypes
4. Tuple datatypes
5. Dictionary datatypes.

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1. Numeric Datatypes

Numeric datatypes are the immutable datatypes in Python. It stores the numeric values. Python supports various numerical datatypes like,

(i) Integer

(ii) Floating point

(iii) Boolean

(iv) Complex.

(i) Integer

Integer datatype is used to store signed numeric values. It does not have a decimal point. Integers are usually represented as int. It ranges from –2147483648 to 2147483648.

Syntax

To declare any variable as integer, the following syntax is used,

variable_name = integer value

Example: a = 10

Here, '*a*' represent variable, '10' represents the value of type int.

(ii) Floating Point

Float datatype represents numeric values. It is similar to integer except that it has a decimal point. In general it has 15 decimal places. They are usually represented as float.

Syntax

To declare any variable as floating point, the following syntax is used,

variable_name = floating point value

Example: a = 3.14

Here, 'a' represents variable, '3.14' represents the value of type float.

(iii) Boolean

Boolean datatype is used when a specific condition need to be tested while program execution. It consists of two possible values i.e., true and false. These two values can be used for assigning the boolean values directly. The numeric equivalent of true is 1 and false is 0.

Syntax

To declare any variable as boolean, the following syntax is used,

variable_name = 'true' or 'false'

Example

```
>>> a = 10
>>> b = 15
>>> a < b
True
```

Here, the value of variable 'a' is lesser than the value of variable 'b', it returns true.

(iv) Complex

Complex datatype is used to represent complex integers. It consists of two parts that is a real part and an imaginary part. This datatype is usually represented as $a + bj$, in which 'a' is the real part (which can either be a int or float value), bj is imaginary part (where b can take either int or float value and j denotes square root of –1).

Syntax

To declare any variable as complex, the following syntax is used,

variable_name = complex(a, b)

(or)

variable_name = a + bj

Example: a = 3 + ij

Here, 'a' represents a variable, 3 + ij represents a value of type complex.

Moreover, in Python adding an integer value to another integer value results in a new integer value (i.e., 2 + 2 = 4) whereas, adding an integer value to a float value results in a new float value (i.e., 2 + 2.0 = 4.0).

```
>>> 2 + 2
4
>>> 2 + 2.0
4.0
```

2. String Datatypes

Strings are the commonly used datatypes in Python. They define sequence of characters declared within single or double quotes. In Python single quote, double quotes and three single quotes ('''') means the same.

Syntax

strings are declared as follows,

variable_name = 'string_value'

(or)

variable_name = "string_value"

(or)

variable_name = '''string_value'''

Examples

(i)
```
>>> 'Hello Python'
'Hello Python'
```

(ii)
```
>>> 'didn\'t'
"didn't"
```

(iii)
```
>>> "Author - 'Drake'"
"Author - 'Drake' "
```

(iv)
```
>>> x = "book"
>>> print(x)
book.
```

In the above example (ii), backslash '\' is used to represent a specific value. Here, usually the string consisting of single quotes will be enclosed within double quotes, else it is placed within single quotes.

A string can have more than one line. This type string consists of a backslash at the end of the line inorder to indicate that the succeeding line is its continuation.

Example

string = "Strings can have more than one line. Such things can be declared by using a backslash at the end of each line (i.e., \n) inorder to indicate the continuation".

print(string)

String can have more than one line. Such strings can be declared by using a backslash at the end of each line inorder to indicate the continuation.

3. List Datatypes

List is an organized/ordered series of items or values. It is the most flexible/versatile datatype in Python. Its values are defined within the square brackets where each value/item is separated using commas. Here, all the values within a list can be of different datatypes.

Syntax

Lists are declared as follows,

list_name = [values]

(or)

list_name = [ ]

A list can either be empty or it can consist of values or items.

Example

>>> x= ['book', 'pen', 250, 45]

Here, the list x consists of 4 items i.e., two string values and two integer values and the index value in list starts at 0 i.e., x[0] = 'book'. The items of a list can be accessed in a backward/ reverse order. This can be done by using negative index values i.e., to access the last item of list x, x[−1] is used. This returns the last value '45' from the list x.

4. Tuple Datatypes

Tuples are container, that are used to store data items. They are similar to lists because they store list of elements. They can have values of any datatype and are indexed using integers. They are immutable and they are declared using comma separated values.

Syntax

Tuples are declared as follows,

tuple_name = (values)

(or)

tuple_name = values

(or)

tuple_name = ( )

A tuple can either be empty or it can consist of values or items.

Example

>>> tuple1 = ('x', 'y', 'z')

They can also be declared without parenthesis,

>>> tuple1 = 'x', 'y', 'z'.

Here, tuple1 is the tuple name and 'x', 'y', 'z' are tuple elements.

5. Dictionary Datatypes

Dictionary in Python is an unordered set of elements. Each element in the dictionary has a key-value pair. The elements of a dictionary can be accessed through keys. The keys are of strings and the values are of any arbitrary Python object or may be of any datatype.

Dictionary is a mutable datatype. That is mutable datatype is dynamic and can be modified after declaration.

Syntax

Dictionaries are declared as follows,

dictionary_name = {key1 : value1, key2 : value 2, ..., keyn : value n}

(or)

dictionary_name = { }

A dictionary can either be empty or contain of key-value pairs.

Example

Roll_No = {"Mariya" : 21, "Seema" : 22, "Sushma": 23}

Here, Roll_No is the dictionary name, "Mariya", "Seema" and "Sushma" are keys and 21,22, 23 represents the values of their respective keys.

Q19. Discuss briefly about identifiers and keywords in python.

Answer :

Identifiers

Identifiers refers to a set of valid strings that can be used as names in a computer language. In python, the rules for naming a identifier are as follows,

1. The first character of identifier is either underscore (_) or a character.
2. The second character can be any alphanumeric character or underscore.
3. Identifiers cannot be initiated with a number or symbol except underscore(_).
4. Identifiers are case sensitive i.e., man, Man and MAN are not identical.

Keywords

Keywords are reserved words which forms a construct of the language. Use of these keywords for any other purpose results syntax error. The below table depicts keywords used in Python.

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S.No.	Keyword
1	and
2	as
3	assert
4	break
5	class
6	continue
7	def
8	del
9	elif
10	else
11	except
12	exec
13	finally
14	for
15	from
16	global
17	if
18	import
19	in
20	is
21	lambda
22	not
23	or
24	pass
25	print
26	raise
27	return
28	try
29	while
30	with
31	none
32	yield

Table: Keywords

Built-in

Built-ins are special names identifiers used by interpreter. These are not keywords but considered as reserved for system. Therefore, programmers should not use them. Built-ins are members of built-in module. Interpreter automatically imports the built-in module before the program begins or user enter the >>> prompt in the interpreter. They can also be used as global variables that can be accessed anywhere in programs.

Special Underscore Identifiers

In Python, special underscore variables are also used. These variables are both prefixed and suffixed. Some of these underscore identifiers are as follows,

- ❖ _xxx

  It requests private name that integrates within classes.

- ❖ __xxx

  It states that donot import with 'from module import *'

- ❖ __xxx__

  It is a system defined name.

Q20. What are the rules and symbols used with regard to statements in Python?

Answer :

Python statements need to follow rules and symbols such as,

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

1. Comments

Python allows programmers to comment anywhere in the program. Comments are provided using the hash (#) symbol. They are placed in the beginning of the line. The text followed by '#' symbol is ignored by the interpreter. Comments increases the readability of programs and makes the programmer to understand the logic and flow.

2. Module

A module is a python script, it exists physically on the disk in the form of files. A portion of module that becomes very lengthy can be shifted to another module.

3. Newline

Newline breaks a single python statement into multiple lines. The backslash symbol ('\') is used to denote a newline.

Example

```
if(student_age > 17) and \
    (student_GPA > 3.5) :
    admission = 1
```

However, lines can be continued on next line without using '\' in two exceptions.

- ❖ One when enclosing operators are used, such as square brackets or parenthesis.
- ❖ Another when triple quotes are used for strings.

Example

(i) '''SIA edu group pioneer in ..... today'''

(ii) SIA need (240, more....)

4. **Colon**

- In python, a set of individual statements that forms a single code block are known as "suites".
- Complex or compound statements such as (if, while, def and class) that need a suite and a header line.
- A header line starts with a keyword and ends with colon (:) and then followed by one or more lines.

5. **Semicolon**

Multiple statements are allowed in a single line using semicolon (;). However, they can be used only when none of the statements initiate a new code block.

Example

import abc; p = 'Today';

6. **Indentation**

In python, indentation is used to delimit blocks of code. All lines of a program must be indented the same number of spaces i.e., it needs exact indentation. Indentation is applied with spaces or tab. However, spaces are preferred.

3.2 INTRODUCTION TO RASPBERRY Pi, INTERFACING RASPBERRY Pi WITH BASIC PERIPHERALS

Q21. Give a brief introduction to Raspberry Pi. List out the peripherals of Raspberry Pi.

Answer :

Model Paper-I, Q6(b)

Raspberry Pi is a device that comes in the size of equal to credit/debit card works like a mini computer and has the capability of performing tasks of a desktop computer. It is a low cost device which can run on different versions of Linux. It connects sensors and actuators with the help of I/O pins. A Raspberry Pi board shown below is incorporated with several components/peripherals.

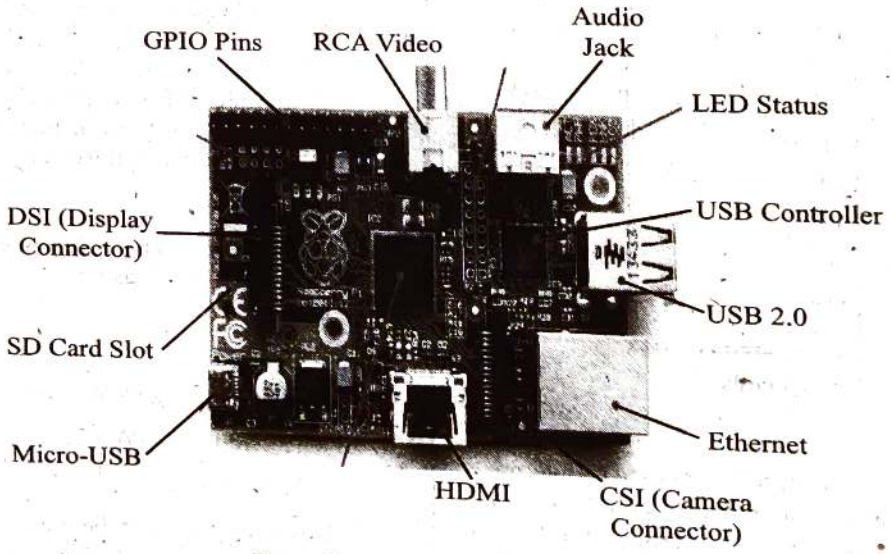

Figure: Components of Raspberry Pi

The major components or peripherals among the above components are discussed below,

1. **Power Input**

The power input to Raspberry Pi is provided through a micro USB connector.

2. **USB Ports**

There are two USB ports on Raspberry Pi that can provide power upto 100mA. However, an external power hub is needed to connect devices that require more power.

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3. **Ethernet Ports**

There is RJ45 Ethernet port on board which is used to connect to Internet.

4. **Processor and RAM**

The processor of Raspberry Pi is ARM where ARM117672-F can support 700 MHz power. The RAM used for this processor is about 512 MB.

5. **GPIO Pins**

There are four types of general purpose input/output pins on Raspberry board such as SPI interface pins, true GPIO pins, RX and TX pins and I2G interface pins.

6. **DSI (Display Serial Interface)**

It is used as an interface between LCD panel and Raspberry Pi.

7. **CSI (Camera Serial Interface)**

It is used as an interface between camera and Raspberry Pi.

8. **SD Card Slot**

It is used to insert an external SD card containing Linux image.

9. **HDMI Output**

It is used to provide Audio and video from Raspberry Pi.

10. **Audio/Video Output**

It is used to obtain audio/video output from Raspberry Pi to televisions.

Q22. What are the various flavors/versions of Linux supported by Raspberry Pi? List out the interfaces of Raspberry Pi.

Answer :

Flavors/Versions of Raspberry Pi

The different flavours/versions of Linux supported by Raspberry Pi are as follows,

1. **Raspbian**

It is a Linux based Debian Wheezy port that is particularly used for Raspberry Pi.

2. **RaspBMC**

It is a type of XBMC media-center distribution.

3. **Arch**

It is a type of Arch Linux port developed for AMD devices.

4. **RISC OS**

It a compressed form of operating system with good speed.

5. **Pidora**

It is a type of Fedora Linux particularly developed for Raspberry Pi.

6. **OpenELEC**

It is XBMC based media-center distribution which is used friendly and offers good speed.

Raspberry Pi Interfaces

There are three types of Raspberry Pi interfaces that support data transfer. They are I2C, Serial and SPI.

1. **I2C**

I2C interface is used to provide interconnection between hardware modules using SDA (data line) and SCL (clock line) pins. Using these pins, it supports synchronous data transfer.

2. **Serial**

The serial interface allows data transfer among serial peripherals using receive (Rx) and transmit (Tx) pins.

3. **SPI (Serial Peripheral Interface)**

SPI is a type of serial data protocol that offers synchronous data transfer among peripheral devices using the following five pins.

(a) **Chip Enable (CE0)**

The CE0 pin is used to enable and disable the devices.

(b) **Chip Enable 1 (CE1)**

This pin works similar to CE0.

(c) **MISO (Master In Slave Out)**

MISO is a master pin that is used to forward data to peripherals.

(d) **SCK (Serial Clock)**

SCK is a clock that supports synchronization of data transmission.

(e) **MOSI (Master Out Slave In)**

MOSI is slave pin that is used to forward data to the master i.e., MISO.

Q23. List and explain the Raspberry Pi commands.

Answer :

Some of the frequently used Raspberry Pi commands are tabulated below,

Command	Function
mv	It is used to move or rename file.
cd	It is used to change directory.
tar	It is used to extract/create archive.
df	It is used to report the usage of file system disk space.
grep	It is used to print the lines which are matching with pattern.
cat	It is used to display the file contents.
rm	It is used to remove the file.
mkdir	It is used to make or create a directory.
ls	It is used to list the folders and files.
pwd	It is used to print name of currently active directory.
lsusb	It is used to display all the USB devices.
ifconfig	It is used to configure network interface.
wget	It is a non-interactive network downloader.
netstat	It is used to print the network connections, interface statistics and routing tables.
shutdown	It is used to shutdown the device.
reboot	It is used to reboot device.
locate	It is used to search for a file.

3.3 IMPLEMENTATION OF IoT WITH RASPBERRY Pi

Q24. Describe implementation of Raspberry Pi with python.

Model Paper-II, Q6(b)

Answer :

Raspberry Pi can support both Linux and python for its implementation. It allows any python program that can be executed on any machine. To support this, it uses GPIO pins along with various types of sensors and actuators and its interfaces. It utilizes the capabilities of GPIO pins to make it useful for IOT. The input obtained from sensors can be processed tasks of further and different actions can be performed on the input such as transferring data, sending an email etc. Consider the following Raspberry Pi using python.

For remaining answer refer Unit-III, Q25, Q26.

Q25. Discuss how LED is controlled with Raspberry Pi.

Answer :

The LED is connected to the Raspberry Pi board as shown in the figure below,

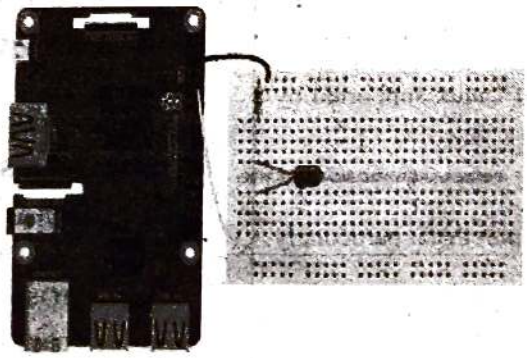

Figure: Controlling LED with Raspberry Pi

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The LED can be switched on/off from Raspberry Pi command line console in the following way,

```
$ echo 18 > /sys/class/gpio/export
$ cd/sys/class/gpio/gpio18
$ echo out > direction
$ echo 1 > value        # Switching LED on
$ echo 0 > value        # Switching LED off
```

The code to make LED (connected to Raspberry Pi) blink for every second using python is as follows,

```
import  RPi.GPIO as GPIO
import  time
GPIO.setmode (GPIO.BCM)
GPIO.setup (18, GPIO.OUT)
while Ture:
    GPIO, output (18, True)
    time.sleep(1)
    GPIO.output (18, false)
    time.sleep (1)
```

The above code makes use of RPi and GPIO for controlling the GPIO. The pin 18 is set to generate output with true and false values that switch after every second.

Q26. Explain about interfacing light sensor with Raspberry Pi.

Answer : **Model Paper-III, Q6(b)**

A Light Dependent Resistor (LDR) which is a light sensor can be interfaced with Raspberry Pi by connecting one end to 3.3v and other end to 1μF capacitor and GPIO pin. A part from this an LED is also connected to pin18 so that if can be turned on/off based on the light sensed.

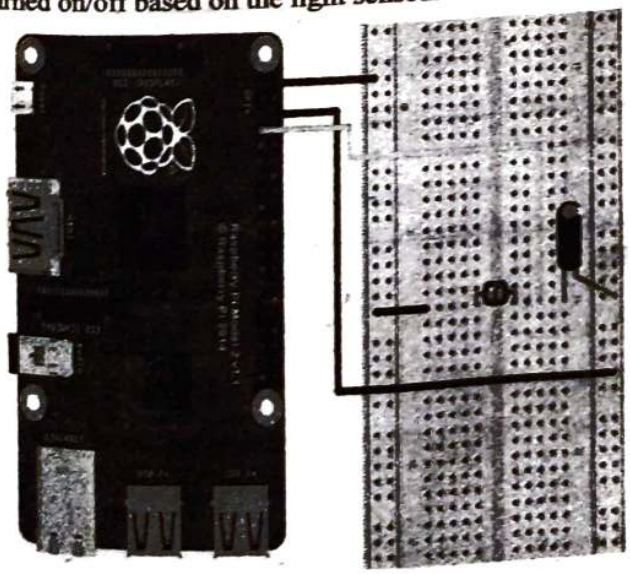

Figure: Interfacing LDR with Raspberry Pi

The python code to control LED based on light sensed using LDR is an follows,

```
import RPi.GPIO as GPIO
import time
GPIO.setmode (GPIO.BCM)
ldr_thr = 1000
LDR_PIN = 18
LIGHT_PIN = 25
define readLOR(PIN):
    read = 0
    GPIO.setup(LIGHT_PIN, GPI.OUT)
    GPIO.output(PIN, False)
    time.sleep (0.1)
    GPIO.setup(PIN, GPIO.IN)
    while (GPIO.input(PIN) = = False):
        read = read + 1
    return read
def switchOnLight (PIN):
    GPIO.setup(PIN, GPIO.OUT)
    GPIO.output(PIN, True)
def switchOffLight (PIN):
    GPIO.setup(PIN, GPIO.OUT)
    GPIO.Output (PIN, False)
while True:
    ldr_Read = readLDR (LDR_PIN)
    if ldr_read < ldr_thr:
        switchOnLight (LIGHT_PIN)
    else:
        switchOffLight (LIGHT_PIN)
    time.sleep(1)
```

In the above code, readLDR( ) function is used for returning a count proportional to light level. It carries LDR pin which is set to output and low followed by input respectively. The input will read high until capacitor gets charged via resistor. When the read value of input triggers high, the counter is stopped.

IMPORTANT QUESTIONS

SHORT QUESTIONS

Q1. List out the features of python.

Ans: For answer refer Unit-III, Q1. Important Question

Q2. List out the comparison operators in python.

Ans: For answer refer Unit-III, Q4. Important Question

Q3. List out any five peripherals of Raspberry Pi.

Ans: For answer refer Unit-III, Q6. Important Question

Q4. Write short notes on Raspberry Pi interfaces.

Ans: For answer refer Unit-III, Q8. Important Question

ESSAY QUESTIONS

Q5. What is Python? Explain the features of Python language.

Ans: For answer refer Unit-III, Q9. Important Question

Q6. Define control statements. Discuss about if statement.

Ans: For answer refer Unit-III, Q12. Important Question

Q7. Write the basic style guidelines.

Ans: For answer refer Unit-III, Q15. Important Question

Q8. Explain the various datatypes in python.

Ans: For answer refer Unit-III, Q18. Important Question

Q9. Give a brief introduction to Raspberry Pi. List out the peripherals of Raspberry Pi.

Ans: For answer refer Unit-III, Q21. Important Question

Q10. List and explain the Raspberry Pi commands.

Ans: For answer refer Unit-III, Q23. Important Question

Q11. Describe implementation of Raspberry Pi with python.

Ans: For answer refer Unit-III, Q24. Important Question

Q12. Explain about interfacing Light sensor with Raspberry Pi.

Ans: For answer refer Unit-III, Q26. Important Question

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UNIT 4

Syllabus

Implementation of IoT with Raspberry Pi, Introduction to Software Defined Network (SDN), SDN for IoT, Data Handling and Analytics.

LEARNING OBJECTIVES

- ✓ Implementation of IoT with Raspberry Pi.
- ✓ Introduction to Software Defined Network (SDN)
- ✓ SDN for IoT
- ✓ Concepts of Data Handling and Analytics.

INTRODUCTION

Software Defined Networking (SDN) is the method of separating data plane and control plane. It then assigns the separated control plane to the centralized network controller. The data plane consists of activities such as the outputs generated from data packets received from end users. Examples of it are packet transmission, duplication of packets to be used in multicasting and dividing and reuniting the data. Where as control plane consists of activities required to perform the activities related to data plane. But the activities of control plane does not contain any end user data packets. It can be actually referred as brain of the network. Examples of it are setting of policies related to packet handling and developing routing tables.

Analytics refers to decision making which is completely based on facts instead of intuition. It acts as a key factor for the success of an enterprise as it provides business intelligence. Analytics are used to design or build models by selecting the appropriate data so the data must always be available and accessible. Further these models are first tested and then used for various processes and services.

PART-A SHORT QUESTIONS WITH SOLUTIONS

Q1. Define SDN.

Answer :

Software Defined Networking (SDN) is the method of separating data plane and control plane. It then assigns the separated control plane to the centralized network controller. The data plane consists of activities such as the outputs generated from data packets received from end users. Examples of it are packet transmission, duplication of packets to be used in multicasting and dividing and reuniting the data. Where as control plane consists of activities required to perform the activities related to data plane. But the activities of control plane does not contain any end user data packets. It can be actually referred as brain of the network. Examples of it are setting of policies related to packet handling and developing routing tables.

Q2. List out various models of SDN.

Answer :

The different types of SDN models are as follows,

1. **Open SDN**

   In this model the network administrators control and manipulate the virtual and physical switches using OpenFlow protocol at data plane.

2. **SDN by API's**

   In this model, the application programming interfaces control and manipulate the flow of data on all the devices accorss the network.

3. **Hybrid SDN**

   In this model, an environment is embedded with SDN and traditional networking protocols to perform the functions related to a network. Here, the networking protocols take on the responsibility to control the flow of traffic where as SDN takes care of other traffic.

4. **SDN Overlay Model**

   In this model, the SDN develops dynamic tunnels over the virtual network which can be used by various on premise and remote data centers.

Q3. What are the key elements of SDN?

Answer : **Model Paper-II, Q1(g)**

The key elements of SDN are as follows,

1. **Programmable Open API's**

   The interfacing in between SDN application and control layers is provided by programmable open API's. This again provisions the network services like access control, routing and quality of service.

2. **Centralized Network Controller**

   The SDN network is configured with separate control and data planes along with the centralized controller. This handled by the network administrators.

3. **Standard Communication Interface (OpenFlow)**

   The standard communication interface is used in between the control layer and infrastructure layer in SDN architecture. The open flow is a SDN protocol provided for the southbound interface. It allows to access and manipulate the forwarding plane of network devices. This protocol depends upon the concept of flows that are developed either statically or dynamically.

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Q4. What is data analytics?

Model Paper-III, Q1(g)

Answer :

Analytics refers to decision making which is completely based on facts instead of intuition. It acts as a key factor for the success of an enterprise as it provides business intelligence. Analytics are used to design or build models by selecting the appropriate data so the data must always be available and accessible. Further these models are first tested and then used for various processes and services.

Q5. What is data acquisition?

Answer :

Data acquisition can be defined as a process of obtaining or acquiring data from IoT or M2M devices. An application i.e., data acquisition system interacts with several number of devices to obtain or acquire the required data. A device sends data only on demand, otherwise at certain programmed intervals. The data acquired from these devices interact through the network layer, transport layer and security layer.

Q6. What is data validation?

Model Paper-III, Q1(h)

Answer :

Data validation is a process of performing validation checks on the data acquired and this can be done by using data validation software. This software applies several rules, logics and semantic annotations on the acquired data to check its validity. An application and its services should rely upon valid data so that the predictions, prescriptions, analytics, decisions are agreeable.

Q7. What are the advantages of using blocks in HDFS?

Answer :

The concept of blocks in HDFS provides the following advantages,

(i) Blocks can be helpful in the situations where the size of the file is greater than the size of disk on individual system. As they provide transparency, they can be distributed over disks across the network.

(ii) When the unit of abstraction is represented as a block instead of a file, it makes the storage subsystem simpler. It is one of the major advantage because in distributed file system the storage subsystem carryout. Certain critical responsibilities such as making the storage management simpler, handling blocks, resolving the issues related to metadata.

(iii) They make use of replication approach so as to provide fault tolerance and high availability. This approach ensures protection against corrupted data because the data is copied on multiple systems and hence can be recovered in case of data corruption and deletion.

Q8. Explain why Namenode is considered as the most important node of Hadoop.

Model Paper-I, Q1(g)

Answer :

Namenodes manage the filesystem tree and stores the metadata for all files and directories in persistent storage. It uses two files for this purpose. They are namespace image and edit log. Namenodes have the information of data nodes which store all the blocks of information pertaining to a specific file. This information can be re-created from the nodes as soon as the system starts. Hence, the namenodes does not keep these blocks on persistent storage.

Q9. Write a brief note on MapReduce.

Model Paper-II, Q1(h)

Answer :

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

Q10. What is mapper code? What is the general format of it?

Answer :

Mapper Code

A mapper in MapReduce is responsible for providing parallelism. The TaskTracker contains the mapper and processes it. The code associated with mapper is referred to as mapper code. The logic used in the mapper code must be capable of executing independently. It should be capable of performing the parallel tasks mentioned in the algorithm. The input format resides in driver program of specific InputFormat type or the file in which the mapper is executed. The output of mapper might be mapper and value that are set in the mapper output. It is stored in an intermediate file that is specifically created in OS space path. Operations such as read, shuffle and sort are performed on this file.

General Format of Mapper Code

Org.apache.hadoop.mapreduce.Mapper < INPUT_KEY, INPUT_VALUE, OUTPUT_KEY, OUTPUT_VALUE>

This four parameters specify the type of inputs and outputs associated with the mapper function.

Q11. What are the three major operations of reducer code?

Model Paper-I, Q1(b)

Answer :

Reducer Code

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

1. Shuffle
2. Sort
3. Reduce.

1. Shuffle

It is responsible for collecting the inputs and generating the mappers in a sorted order. It uses HTTP protocol to retrieve the required partition of the output of mappers.

2. Sort

It is responsible for arranging the reducer keys in various orders typically using merge sort approach.

3. Reduce

This phase of reducer uses a method reduce(object, Iterable, context) which relates to <key, (collection of values)> associated with every input in the sorted array. It uses TaskInputOutputContext. Write(object, object) to forward the results generated from reduce( ) to RecordWriter.

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PART-B ESSAY QUESTIONS WITH SOLUTIONS

4.1 IMPLEMENTATION OF IoT WITH RASPBERRY Pi

Q12. Explain the implementation of IoT with Raspberry PI.

Answer :

For answer refer Unit-III, Q24.

4.2 INTRODUCTION TO SOFTWARE DEFINED NETWORK (SDN), SDN FOR IoT

Q13. Write in brief about Software Defined Network (SDN).

Model Paper-I, Q8(a)

Answer :

Software Defined Network (SDN)

Software Defined Networking (SDN) is the method of separating data plane and control plane. It then assigns the separated control plane to the centralized network controller. The data plane consists of activities such as the outputs generated from data packets received from end users. Examples of it are packet transmission, duplication of packets to be used in multicasting and dividing and reuniting the data. Where as control plane consists of activities required to perform the activities related to data plane. But the activities of control plane does not contain any end user data packets. It can be actually referred as brain of the network. Examples of it are setting of policies related to packet handling and developing routing tables.

SDN makes use of software based controllers or API's in order to interact with the embedded hardware infrastructure and even to guide the flow of traffic in the network. The SDN is capable of controlling a virtual network or traditional hardware through the use of any software.

Types of SDN

There are different types of SDN models, they are as follows,

1. **Open SDN**

   In this model, the network administrators control and manipulate the virtual and physical switches using OpenFlow protocol at data plane.

2. **SDN by API's**

   In this model, the application programming interfaces control and manipulate the flow of data on all the devices accorss the network.

3. **Hybrid SDN**

   In this model, an environment is embedded with SDN and traditional networking protocols to perform the functions related to a network. Here, the networking protocols take on the responsibility to control the flow of traffic where as SDN takes care of other traffic.

4. **SDN Overlay Model**

   In this model, the SDN develops dynamic tunnels over virtual network which can be used by various on premise and remote data centers.

Advantages of SDN

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

Q14. Discuss about traditional network architecture.

Answer : Model Paper-III, Q9(b)

The traditional network architecture is created by special hardware including switches, routers etc. The architecture of the traditional network is depicted as follows,

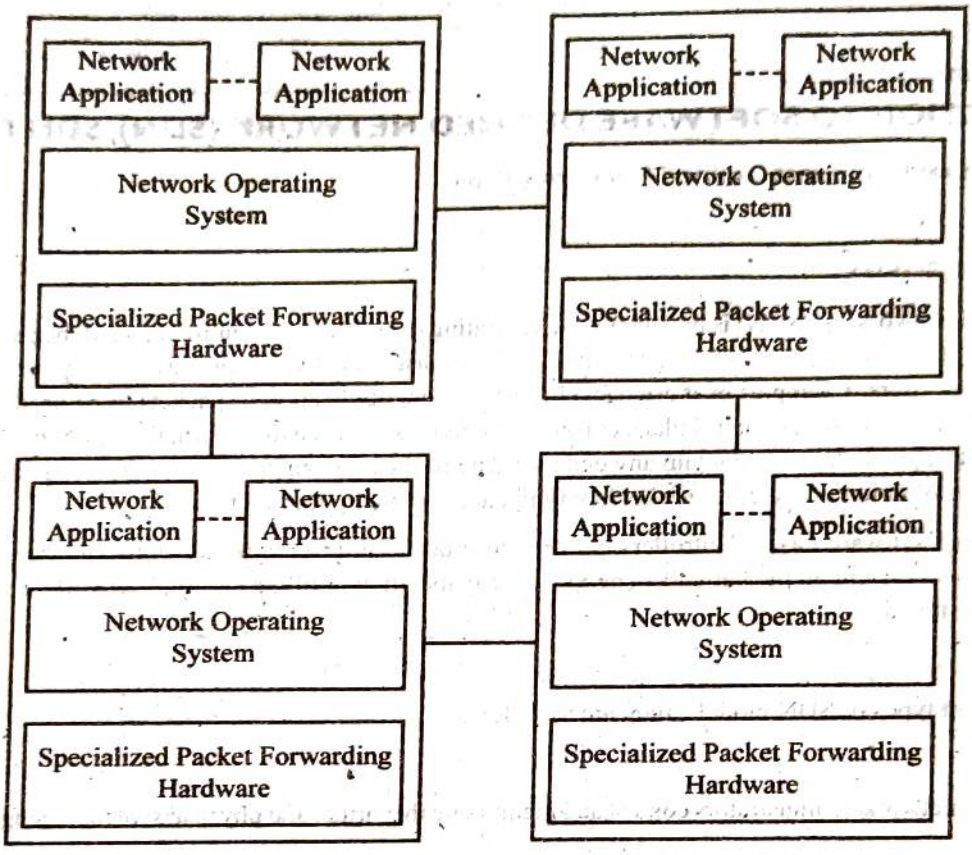

Figure: Architecture of Traditional Network

In the architecture of traditional network the network devices become complex with an increase in distributed protocols that are implemented along with the hardware and interfaces. Here, the control plane as well as data plane are combined. Signalling and flow of data traffic is handled by control plane where as flow of payload data traffic is handled by data plane. But the traditional network architecture has various limitations such as the following,

1. **Management Overload**

Management of various network devices and devices received from various vendors is difficult to be handled by the network managers. Any modifications to the network leads to alterations in configuration of the devices. With this management overhead is involved in traditional network architecture.

2. **Complex Network Devices**

The traditional network architectures becomes complex with the implementation of protocols in order to enhance speed and reliability. Even the interoperability decreases with the decrease in number of standard and open interfaces. The complexity of network devices effects the alterations in network as well.

3. **Limited Scalability**

The traditional networks provide limited scalability to the computing environments where large volumes of data exchange is done among multiple virtual machines.

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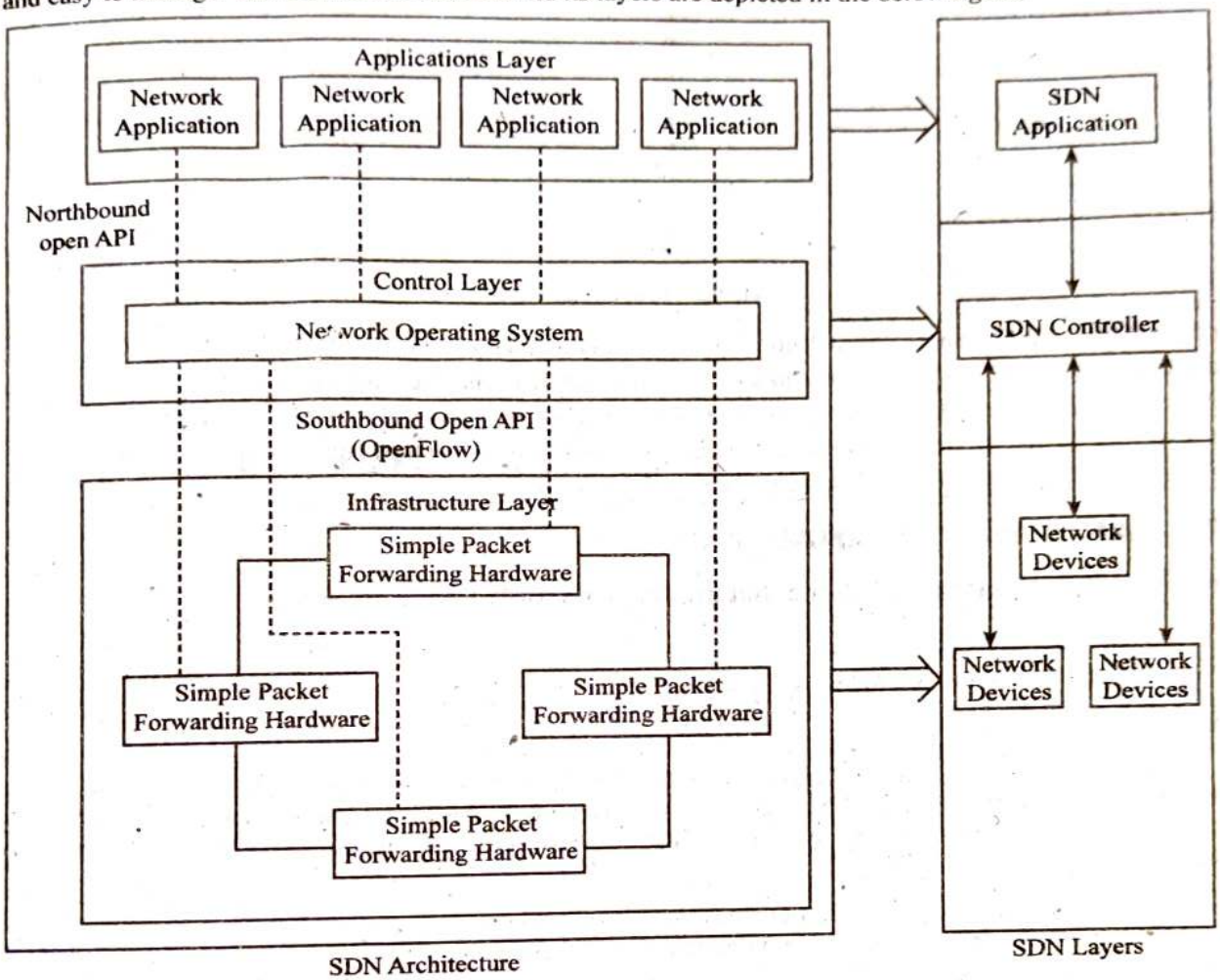
Q15. Illustrate the architecture and key elements of SDN.

Answer : Model Paper-II, Q8(a)

The architecture of SDN overcomes the limitations of traditional network architecture. It is simple, scalable, agile, cost effective and easy to manage. The architecture of SDN and its layers are depicted in the below figure.



SDN Architecture SDN Layers

In the above figure, the control and data planes are separated and a central network controller is incorporated. The configuration, management and provisioning are made simple with the unified view of network. And this maintained by the software based SDN controllers. The infrastructure of SDN makes use of packet forwarding hardware and it is not exposed to the applications. The centralized controller is responsible for instructing the network devices and flow packets. These devices are developed from standard hardware and software components because of which they become simple and cost effective. The key elements of SDN are as follows,

1. **Programmable Open API's**

   The interfacing in between SDN application and control layers is provided by programmable open API's. This again provisions the network services like access control, routing and quality of service.

2. **Centralized Network Controller**

   The SDN network is configured with separate control and data planes along with the centralized controller. This handled by the network administrators.

3. **Standard Communication Interface (OpenFlow)**

   The standard communication interface is used in between the control layer and infrastructure layer in SDN architecture. The open flow is a SDN protocol provided for the southbound interface. It allows to access and manipulate the forwarding plane of network devices. This protocol depends upon the concept of flows that are developed either statically or dynamically. The below figure depicts various components of OpenFlow switch.

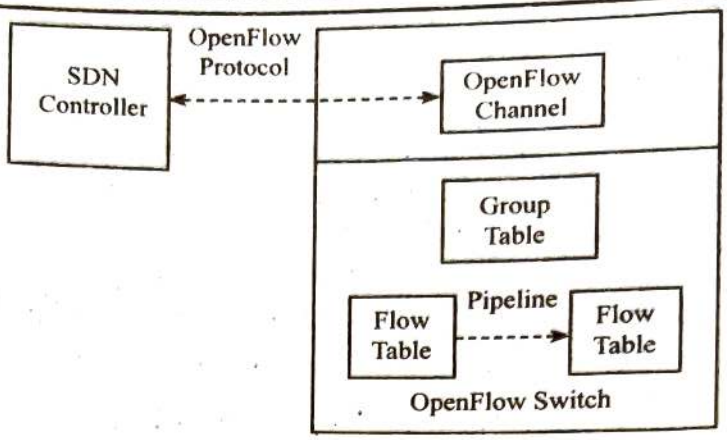


Figure: OpenFlow Switch

In the above figure, the OpenFlow switch consists of flow tables and group tables. They perform functions such as packet fetching and packet forwarding. There is a OpenFlow channel in the switch connected to the external SDN controller. The switch is controlled by the external controller through this OpenFlow switch protocol that is implemented in the either sides of interface that connects to controller and the network devices. The open flow table consists of flow entries each of which contians counters, match fields and certain instructions to be followed to match the packets.

4.3 DATA HANDLING AND ANALYTICS

Q16. Explain in detail about the functions that are required for IoT applications.

Answer :

The IoT applications requires the following functions,

(i) Data Acquiring

Data acquisition can be defined as a process of obtaining or acquiring data from IoT or M2M devices. An application i.e., data acquisition system interacts with several number of devices to obtain or acquire the required data. A device sends data only on demand, otherwise at certain programmed intervals. The data acquired from these devices interact through the network layer, transport layer and security layer.

A device can be configured by an application, to send data only at certain programmed intervals. This is possible only if the device has the ability to support the necessary configurations. All these configured devices have the capability to control the frequency of data generation.

Consider an example where a system configures an umbrella device to obtain information related to weather from an Internet weather service on every working day in a week.

Consider another example, where an Automatic Chocolate Vending Machine (ACVM) is configured to transfer the sales data every hour in the day. The ACVM system can also be configured to transfer data immediately whenever fault events occur and also when there is a necessity for "Fill service" of any particular chocolate flavour.

An application sends data only after filtering or enriching of data at the gateway which is present at data adaptation layer. This gateway exists between device and application and it provides some of the functions like transcoding, data management and device management.

The data management function provides privacy and security, data integration, compaction and fusion, where as the device management function provides device ID or address, configuration, activation, registration, deregistration, attaching and detaching.

(ii) Data Organizing

For answer refer Unit-IV, Q19.

(iii) Data Analytics

For answer refer Unit-IV, Q20.

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Q17. Write a short notes on data generation.

Model Paper-III, Q8(a)

Answer :

The data generate will be at a system or a device and it is further transferred to the Internet by using a gateway. The following are the various data generates,

(i) **Active Devices Data**

An active device possess a power source and it is connected with microcontroller, transceiver and memory. In such devices the data is generated at a system or a device, based on the consequences of communication.

Examples

Active RFID, streetlight sensor or wireless sensor nodes are some of the examples of active devices.

(ii) **Passive Devices Data**

A passive device does not possess a power source, so it requires an external power source to generate and transfer the data. In such devices the data is generated at a system or a device, based on the consequences of communication. These devices may or may not be connected with microcontroller, transceiver and memory. A contactless card and a label or barcode are their examples respectively.

Examples

RFID or an ATM debit card are the examples of passive devices.

(iii) **Event Devices Data**

The data is generated by a device, only once, for an event.

Examples

Traffic detection, dark climatic conditions,instrusion detection, security violation etc. All these above conditions indicate the event and then the action is performed i.e., data is generated for once.

(iv) **Event-driven Device Data**

In event driven devices the data is generated by a device, only once for an event.

Examples

- Suppose, if a monitor sends a command to a device, then the device receives the command and executes it by using an actuator. After the implementation of necessary actions, the device sends an acknowledgement regarding the completion of execution.
- Suppose if an application requests the device for its status, then the device status is transmitted to that application.

(v) **Real Time Device Data**

In real time device data the information is instantly transmitted to the servers by using internet.

Example

Whenever an ATM service is used, it generates information/data which is immediately sent to the server using internet. Thus in this way Online Transaction Processing (OLTP) is implemented in real time.

Q18. Write a short notes on,

(i) Data validation

(ii) Data categorization for storage

(iii) Assembly software for events.

Answer :

Model Paper-I, Q8(b)

(i) **Data Validation**

Data validation is a process of performing validation checks on the data acquired and this can be done by using data validation software. This software applies several rules, logics and semantic annotations on the acquired data to check its validity. An application and its services should rely upon valid data so that the predictions, prescriptions, analytics, decisions are agreeable. However, the data acquired from a device is not always correct, meaningful and consistent, therefore data validation is necessary.

A large extent of data is obtained from several devices like automobiles, health devices in ICUs or wireless sensor networks, machines used in industrial plants or in embedded components etc. The data validation software uses important and necessary resources. It is essential to choose a proper strategy, so the plan of action can be any of the following,

- Filtering of worthless data at a device or at a gateway.
- Regulating the frequency of data acquisition.
- Cyclic scheduling of a set of devices in an industrial system.

Thus, the data enrichment, data aggregation, data integration and data compression can be achieved at the adaptation layer even before transmitting it into the internet.

(ii) **Data Categorization for Storage**

The data that is valid, beneficial and appropriate is used in business process, services and business intelligence. So, this data can be classified into three types for storage purpose and they are as follows,

(a) **Store Data Alone**

A copy of data is only stored so that it can be processed, referred and audited any number of times in the future.

(b) **Store Data and Results of Processing**

The data and the results of processing are stored so that they can be used for referencing and auditing in the future. This is also useful for quick visualization and report generation even without processing the data again.

(c) **Store Results of Data Analytics**

The online and real time data has to be processed, so the results of processing and the results of data analytics are stored.

(d) **Store Big Data**

The data acquired from huge number of source and devices can be categorized into Big data. This data can be stored as big data onto a cloud or data warehouse on server database.

(iii) Assembly Software for Events

Assembly software can be defined as a software component in an application that can congregate the events and also attaches date time stamp to the events.

Each and every event contains a Event ID, logic value and device ID associated with it.

(a) Event ID

When a device generates an event then it is allocated with an ID called event ID.

(b) Logic Value

A logic value contains 1 or 0. It sets or results based on an event state. Logic value 1 indicates that an event is generated but the action is not yet taken. Logic value 0 indicates that an event is generated and the action is also taken or the event is still not generated.

(c) Device ID

The device that generates an event is allocated with an ID called device ID.

Examples

- A temperature sensor generates an event when the temperature rises to a adjusted value or underneath a threshold value.
- A pressure sensor which exists in a boiler generates an event when the boiler pressure surpasses a critical value which requires attention.

Q19. What are the various ways of organizing the data? Explain.

Model Paper-II, Q8(b)

Answer :

The data can be organized into various forms such as objects, files, database, relational and object oriented database etc.

1. Database

Database is defined as a collection of data which can be organized into tables. The database tables are useful for retreiving and updating. A single database table file is called as flat file database. Every record is represented in a row and they are not related to each other.

2. Relational Database

A relational database is defined as a collection of data which are organized into multiple number of tables. All these tables are related with each other by using keys. Keys are the special fields such as primary key, unique key and foreign key.

Example

MySQL,Microsoft SQL Server, Oracle database, Post GreSQL.

3. Object Oriented Database

Object oriented database is defined as a collection of objects that are used in object oriented design.

Examples

Concept Base, Cache.

4. Database Management System (DBMS)

Database management system is a software that performs the following functions,

- Define a database
- Support query language
- Generate reports
- Create data entry screens.

DBMS basically consists of set of interrelated data and set of programs for accessing those data. The primary objective of Database Management System is to provide an efficient environment that makes the retrieval and storage of database information easier.

ACID Properties

These are the properties that a transaction should posses in order to avoid failures during concurrent access of a database. ACID is an acronym which stands for Atomicity, Consistency, Isolation and Durability.

(a) Atomicity

Atomicity ensures that the transaction is either executed completely or not executed at all. Incomplete transaction consequences are not valid. Consider the example of a transaction involving crediting and debiting the account.

If there is a failure during transaction execution, then measures are taken to get back the data in a form which was in, before transaction. This is taken care of by transaction management component.

(b) Consistency

The data in the database must always be in a consistent state. A transaction that is carried on a consistent data should bring the data to another consistent state after execution. However, transaction need not maintain consistency at intermediate stages.

It is the responsibility of application program to ensure consistency.

(c) Isolation

All transactions must run in isolation from one another that is every transaction should be kept unaware of other transactions and execute independently. The intermediate results generated by the transactions should not be available to other transactions.

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(d) **Durability**

This property ensures that data remains in a consistent state even after the failure. This is ensured by loading the modified data into disk. This task is handled by recovery-management component of DBMS. It ensures that either the complete modified data is loaded into disk or the information that would be sufficient to get the modified data is loaded in disk. This enables a system to recover after a system crash.

5. **Distributed Database**

Distributed database partitions a single logical database into multiple data fragments. Later stores them on several independent computers connected through a single network.

Distributed Database Characteristics

The characteristics of a distributed database are as follows,

(a) **Logical Relation**

The distributed database is considered as a collection of several databases which have logical relationship among them.

(b) **Transparency**

Transparency exists in between databases i.e., a database user can access data from all the databases providing an illusion to the users that they were using only single database.

(c) **Location Independent**

Distributed database must be location independent i.e., the system user should not know about the location of data and also about the possibility of moving data from one location to another without any affect.

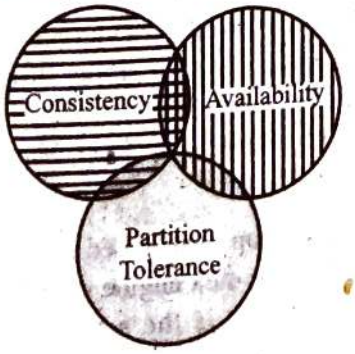
6. **CAP Theorem**

CAP theorem states that it is not possible for a distributed system to guarantee all the three features. These three features are,

(a) Consistency

(b) Availability

(c) Partition tolerance.



Consistency and availability

Consistency and partition tolerance

Availability and partition tolerance

Figure: CAP Theorem

Q20. What is Analytics? Explain about analytics phases.

Answer :

Model Paper-III, Q20(a)

Analytics

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

Phases of Analytics

The process of analytics is classified into three phases and they are as follows,

1. **Descriptive Analytics**

Descriptive analytics provides information to a query, based on the historical data or the data that is collected in the past. It groups the data find the mean value, variance value, number of occurrences of an item and aggregates or some specific properties. Moreover, Descriptive analytics provides OLAP, Data visualizations, generating spreadsheets and key performance indicators.

The Descriptive Analytics methods are as follows,

(a) **Spreadsheets and Data Visualization**

Spreadsheets provides the results of descriptive analytics in the form of a table. It contains values in its rows and columns but within a cell. Each and every value in a cell is related to another cell or a group of cells. Here, the relationship can be a formula or a statistical value or boolean relation etc. Thus, in this way spreadsheets provide user visualization of the data.

(b) **Descriptive Statistics based Reports and Data Visualization**

Descriptive analysis uses descriptive statistics which refers to computing the minima, variance, peak and probabilities etc. It uses the formulae for applying on the data sets to provide easily understandable data visualizations to the users.

(c) **Data Mining and Machine Learning**

Data mining uses algorithms to extract hidden patterns whereas machine learning designs a model to perform a specific task. The programming language is considered as an essential part of open source products and it also acts as a software environment for the statistical computing and statistical graphics.

2. Predictive Analytics

Predictive analytics is an advanced analytics where a user interprets the results which are obtained from descriptive analytics. The data visualization method displays the effects on a product that can occur in future. This enables the enterprises to take better decisions. This type of analytics use several algorithms like correlation and regression, optimization, other techniques like simulation, modelling, machine learning, neural networks etc. The several software tools in the market provides the results of predictive analytics to the user in a easily understandable manner.

Examples

It predicts the future trends, identifies patterns and clusters with same behaviour. It also performs preventive maintenance by observing the device failures that have occurred in the past. Moreover, it implements integrated marketing strategies. It also provides predictions based on the anomalous detection and anomalous characteristics.

3. Prescriptive Analytics

Prescriptive analytics considers business rules descriptive analytics inorder to provide information regarding,

(i) What will happen?

(ii) When it will happen?

(iii) Why it will happen?

It suggests predictions along with necessary actions considering a set of rules and inputs.

There are some more types of analytics, they are as follows,

1. Event Analytics

Event analytics requires event data for tracking and reporting the events. Every event consists of the following components,

(i) Category

(ii) Action

(iii) Label

(iv) Value.

2. In Memory Data Processing and Analytics

In some specific database, there exists an option for selecting row format or column format with in the memory. The two options are as follows,

(i) In Memory and on Store Row Format Option

In this format option there are few rows and many columns. Each and every row is associated with several columns. The data accessing becomes easy as the entire data in the row is brought into CPU by single memory reference. The row format is beneficial for performing OLTP operations such as inserting, updating, querying etc.

(ii) In Memory and on Store Column Format Option

In this format option there are few columns and many rows. This type of option is useful for analytics on monthly sales, yearly profits etc. In this option, the entire data in the column is brought into CPU by a single memory reference.

3. Real Time Analytics Management

Real time analytics management is useful for providing large speedups for OLAP and OLTP. It performs direct querying by using an OLTP database and it can also query an OLAP database, data warehouse on already queried results.

Q21. Explain in detail about big data analytics.

Model Paper-I, Q9(a)

Answer :

Big Data Analytics

The big data analytics like Hadoop, NoSQL and Cassandra will support the big data architectures/infrastructures. The storage of big data is the storage infrastructure which is designed to store, manage and retrieve large amount of data. It stores and formats the data in the storage such that it can be accessed, used or processed by the applications easily. The storage of big data is flexible in its scale. It allows input and output operations with huge number of data files and objects. The storage is built using the DAS (direct attached storage) pools, (NAS) scale out or clustered network attached storage or infrastructure based on the object storage format. The storage infrastructure is connected to the computing server nodes that allow to process and retrieve the large amount of data.

Most of the companies are applying the big data analytics to achieve greater intelligence from metadata. The big data storage makes use of low cost hard disk drives, even though the prices of flash permitted to use flash in servers and storage systems as the base of big data storage. The storage system will gather multiple servers connected to high capacity disk to support analytic software that is written to test the data. It depends upon the databases that are connected parallely to analyze the data that is retrieved from various sources. Because of this the big data might not have proper structure leading to complexities while processing. Various components of Big Data storage include HDFS, NoSQL, Hadoop, MapReduce, Server nodes etc.

The Apache Hadoop Distributed File System (HDFS) is one of the common big data engine combined with partial NoSQL database. Hadoop is the software coded in Java language. The HDFS advances the data analytics among various server nodes without the need of performance hit. Mapreduce component allows Hadoop to distribute the processing in the form of safeguard against catastrophic failure. Various nodes act as the data analysis platform at the end of network. The Mapreduce will execute the processing directly on storage node of data. Then it collects the results from the server and compresses to produce single cohesive response.

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One more feature of Hadoop is that it receives data in unstructured format such as audio, video and text. It does not mean that Hadoop is replacing other technologies like relational database. But it means that both the Hadoop and relational databases are added parallely. The massively parallel relational platform for example deals with the high value transactional data which is in structured format and supports the feature of receiving data requests from users and applications with performance guarantee and enterprise level security.

The Hadoop eco system is one of the technology that deals with big data other technologies used for selecting and accessing big data from databases are,

- Amazon web service for infrastructure.
- Apache HDFS for distributed file system.
- MapReduce for distributed programming model.
- Cassandra or HBase.

HBase stores data in column format. It grants read or write access permissions to the users on several database tables that are distributed in HDFS. It provides random access with quick look-ups and less access latency.

Q22. Illustrate the architecture of data analytics.

Answer : **Model Paper-II, Q9(b)**

Data Analytics Architecture

The data analytics architecture consists of four layers given as follows,

(i) Data sources layer.

(ii) Data storage and data processing layer.

(iii) Data accessing and query processing layer.

(iv) Data services and advanced analytics layer.

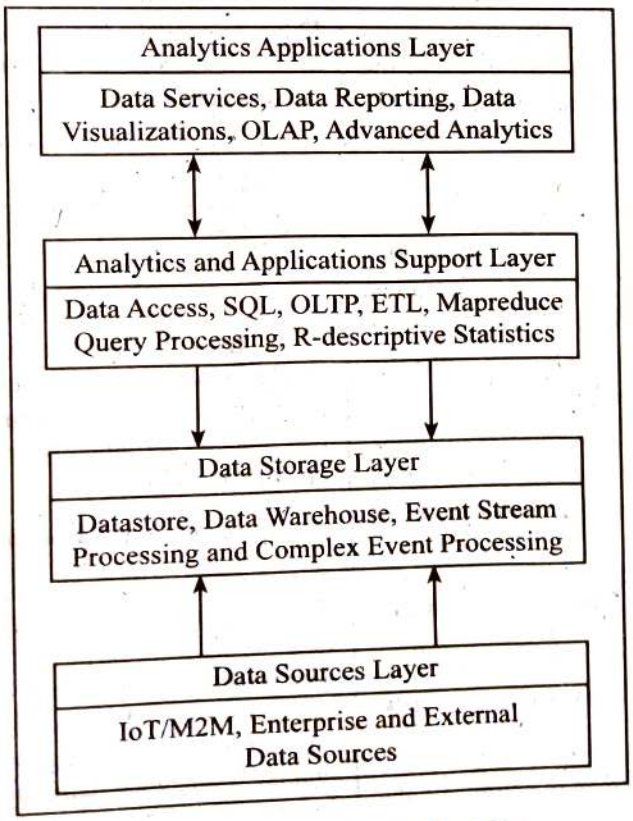

Figure: Architecture of Data Analytics

Q23. Discuss about the design of Hadoop Distributed File System (HDFS).

Answer : **Model Paper-II, Q9(a)**

A file system that manages huge storage across various networks is referred to as distributed file system. The distributed file system associated with Hadoop is typically referred to as HDFS (Hadoop Distributed File System). HDFS has been designed or storing massive amount like mega bytes, gigabytes or terabytes of data which support streaming data access pattern and so on. Moreover, it ensures availability of copies of the data to the end user by saving its copy on different remote location. Thereby providing parallel processing.

The HDFS provides supports the following,

1. Storing files of larger size
2. Streaming data access
3. Commodity hardware.

1. Storing Files of Larger Size

Files of larger size refers to the files that are capable of storing Terra Bytes (TB) of data.

2. Streaming Data Access

The data stored on HDFS follows "writing once and reading several times data processing pattern. Here a data set is simply copy from the source location and analyzed. While performing data analysis, the major focus should be made on reading most (or) all of the data rather than providing high latency with respect to the first record.

3. Commodity Hardware

HDFS is designed in such a way that it can be run on commodity hardware that can be easily found everywhere. It also supports hardware components of different vendors to be easily integrated thereby making it highly reliable and cost-effective. However, this feature makes the HDFS more prone to node failure. Moreover, it does not provide any notification to the user about failures and continue to work accordingly.

Q24. Discuss in detail about the building blocks of Hadoop.

Model Paper-III, Q9(a)

Answer :

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

The building blocks (or) daemons of Hadoop are,

1. Namenode
2. Datanode
3. Secondary Namenode
4. JobTracker
5. TaskTracker.

1. Namenode

Namenodes manage the filesystem tree and stores the metadata for all files and directories in persistent storage. It uses two files for this purpose. They are namespace image and edit log. Namenodes have the information of data nodes which store all the blocks of information pertaining to a specific file. This information can be re-created from the nodes as soon as the system starts. Hence, the namenodes does not keep these blocks on persistent storage.

2. Datanode

Datanodes store and retrieve the blocks of information upon request. They also generate reports to the namenode whenever they store blocks of information. This node is responsible for carrying out the operation allocated to it by master node. They typically perform read and write operations between HDFS blocks and local filesystem. These operation involve splitting of files into blocks distributed over different data node according to the instructions provided by the NameNode. After this, the client will be able to connect with their respective DataNodes to carryout their functionalities. These DataNodes perform inter-node communication to carryout data replication on atleast 3 datanodes.

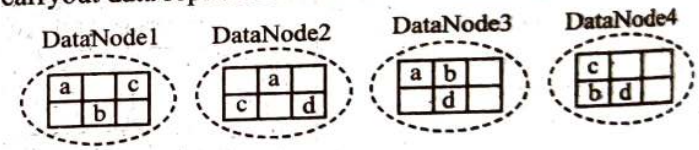

Figure: DataNodes

By using replication, it is possible to make the system available even if some blocks gets corrupted (or) deleted. The information regarding information contained within a DataNode gets updated periodically on the NameNode to carryout further operations correctly.

3. Secondary Namenode

A Secondary NameNode (SNN) is used for merging the namespace images with the edit log. This integration is done so as to prevent the edit log from increasing its size. The secondary NameNode basically run on seperate physical machine. This is because merge operation require significant amount of CPU and huge memory space. Beside this, a secondary NameNode maintain a copy of the merged namespace images. This images can later be reused in the events when nameNode failure occur.

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4. **JobTracker**

JobTracker is another daemon of Hadoop. It is responsible for providing communication between Hadoop and end-user application. It is a master which manages the entire execution of MapReduce job. It's responsibility is to create an execution plan for executing the code provided by the user to the cluster. This plan is created by performing the following tasks,

(a) Capturing the files that are needed to be included in the process.

(b) Allocating the tasks associated with the process to various nodes.

(c) Tracking the execution of these tasks.

When a task fails the JobTracker automatically reaches it on different nodes. In a Hadoop cluster there exist only a single JobTracker which typically runs as master nodes of the cluster on a server.

5. **TaskTracker**

TaskTracker is responsible for managing the execution of tasks that are allocated to individual slave nodes. The basic responsibility of each TaskTracker is to execute all the task assigned by JobTracker. A single TaskTracker has the ability to shown more than one Java Virtual Machines (JVM). This helps in carrying out multiple MapReduce tasks concurrently.

The TaskTracker even communicate with JobTracker so as to provide updated information about its state. If the TaskTracker does not provides this information, then the JobTracker considers it as dead and takes backs all the responsibilities given to that particular TaskTracker. These responsibilities are then handed over to some other node in the cluster.

This process is illustrated in the figure below,

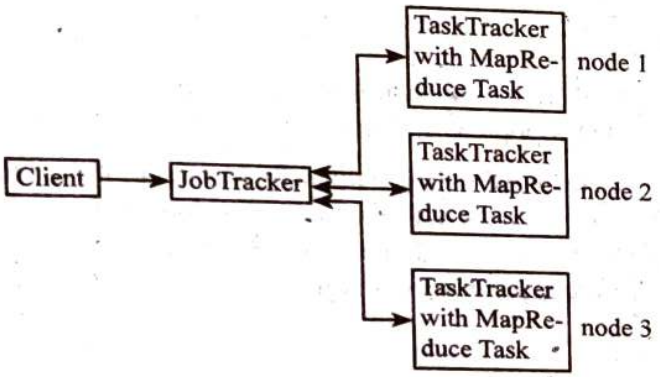


Figure: Communiction Process between JobTracker and TaskTracker

From the figure, it can be observed that the code submitted by client gets received by JobTracker which inturn divides the code into different MapReduce tasks. These tasks are distributed over different nodes that carry their own TaskTracker. Once the tasks gets completed, the results are returned to the JobTracker. During the time period of carryingout these tasks on TaskTracker, it regularly provide updates regarding its current state to the JobTracker.

Figure below depicts the topology of Hadoop cluster

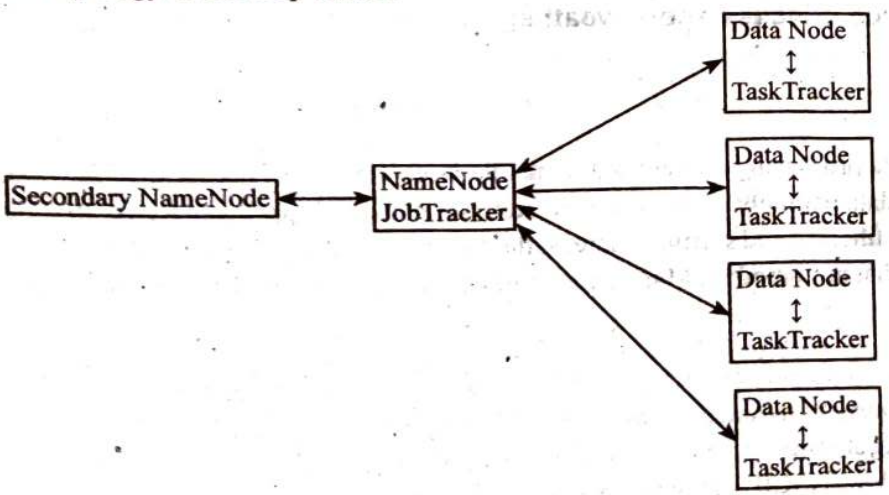


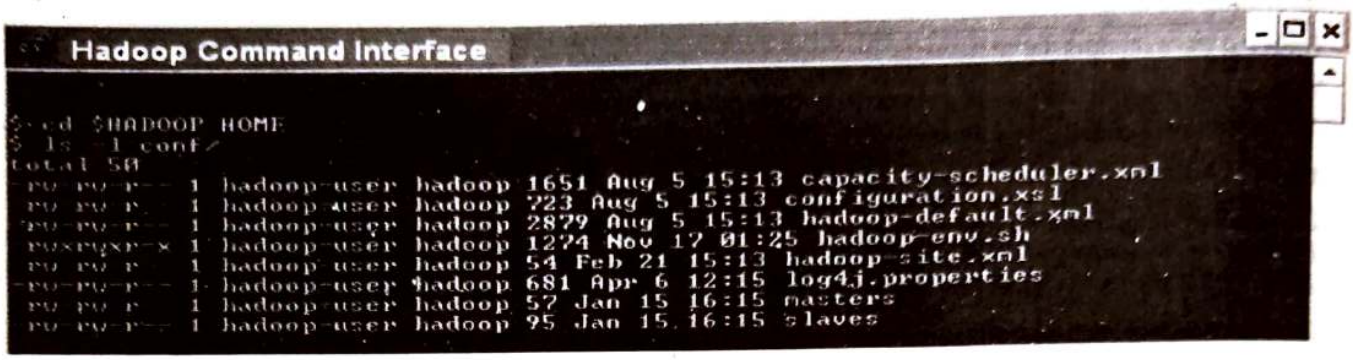
Figure: Hadoop Cluster

The above figure illustrates the topology of Hadoop cluster. It can be inferred from above figure that the masterNode runs on NameNode and JobTracker daemons. If failure occur, the standalone node with secondary NameNode is used. If the cluster is small, the secondary NameNode reside on one single slave Node. Whereas on large clusters the NameNode and JobTracker lie on two machines. The slave machines uses DataNodes and TaskTrackers so as to run the tasks on the node where data is stored.

Q25. What are the things that need to be configured before running Hadoop?

Answer : Model Paper-I, Q9(b)

Hadoop comes up with a set of configuration files that reside in a configuration directory and are needed to be configured effectively for the successful execution of Hadoop. The list of configuration files can be generated using 'ls' command of UNIX as follow;



Configuring these files requires providing the location of Java on all nodes and master. And then define JAVA_HOME environment variable in hadoop-env.sh inorder to indicate the java installation directory. This mapping is carried out using the following formula,

export JAVA_HOME = /user/share/jdk

All the variables except JAVA_HOME are included in the file, named hadoop-env.sh. All these variables are used in the creation of Hadoop environment. The file hadoop-env.sh can also be changed according to the requirements of the system.

As it can be seen from the list generated using 'ls' command that most of the configuration reside in the XML files. In the earlier versions of Hadoop, there existed only two XML files which are hadoop-default.xml and hadoop-site.xml. Hadoop-default carries all the default configurations which can be modified accordingly over hadoop-site.xml. However in the later versions, some additional files are included which are expanded form of hadoop-site.xml.

- core-site.xml
- hdfs-site.xml
- mapred-site.xml.

Use of these files made the configuration more appropriate which is far more better than the configurations that reside on hadoop-site.xml.

All these configurations are necessary to be carried out before running Hadoop.

Q26. Define MapReduce. Discuss about weather dataset.

Answer :

MapReduce

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

Weather Dataset

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

23759	23062015	0530	+ 47213	+ 23121	+ 523	470	3	S	750	
1	S	15000	1	N	12	1	–14	1	12139	1

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Each field in this record can be defined as follows,

Field	Description
23759	Identifier to represent weather station
23062015	Date
0530	Time
+ 47213	× 1000 degrees latitude
+ 23121	× 1000 degrees longitude
+ 523	Elevation in meters
470	Direction of wind in degrees
3	Quality code
S	Southern direction
750	Sky ceiling height
1	Quality code
S	South
15000	Visibility distance
1	Quality code
N	Towards north
12	Temperature of air in Celsius
1	Quality code
– 14	Temperature of dew point in Celsius
1	Quality code
12139	Atmospheric pressure in hectopascals
1	Quality code

It can be observed from the original record that the fields included in it are written continuously without any delimiters between them. The table describes the terms used in the record. Typically, the records are arranged in terms of date and the weather station where these records are placed in its respective directory. The directories are created in an year-wise manner which carries files of weather data associated with each weather station. The directory is composed of several small files because there exist many weather stations. The process of handling small number of large files is simpler and efficient.

Q27. Explain with an example, the mapper code in Hadoop.

Answer :

MapperCode

A mapper in MapReduce is responsible for providing parallelism. The TaskTracker contains the mapper and processes it. The code associated with mapper is referred to as mapper code. The logic used in the mapper code must be capable of executing independently. It should be capable of performing the parallel tasks mentioned in the algorithm. The input format resides in driver program of specific InputFormat type or the file in which the mapper is executed. The output of mapper might be mapper and value that are set in the mapper output. It is stored in an intermediate file that is specifically created in OS space path. Operations such as read, shuffle and sort are performed on this file.

The general format of a mapper class is as follows,

Org.apache.hadoop.mapreduce.Mapper < INPUT_KEY, INPUT_VALUE, OUTPUT_KEY, OUTPUT_VALUE>

This four parameters specify the type of inputs and outputs associated with the mapper function.

Example

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

```
import java.io.IOException;
import java.util.StringTokenizer;
import org.apache.hadoop.io.IntWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapreduce.Mapper;
public class WordCountMapper extends Mapper < Object, Text; Text, InWritable>
{
private static final IntWritable iw = new IntWritable (1);
private Text w= new Text( );
public void map(Object key, Text value, Context cnt) throws IOException, Interrupted Exception
{
StringTokenizer t = new
StringTokenizer(value, toString(1));
while(t.hasMoreTokens( ))
{
word.set(t.nextToken( ))
context.write(w, iw);
}
}
}
```

Q28. Write short notes on reducer code.

Answer :

Reducer Code

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

1. Shuffle
2. Sort
3. Reduce.

1. Shuffle

It is responsible for collecting the inputs and generating the mappers in a sorted order. It uses HTTP protocol to retrieve the required partition of the output of mappers.

2. Sort

It is responsible for arranging the reducer keys in various orders typically using merge sort approach.

3. Reduce

This phase of reducer uses a method reduce(object, Iterable, context) which relates to <key, (collection of values)> associated with every input in the sorted array. It uses TaskInputOutputContext. Write(object, object) to forward the results generated from reduce( ) to RecordWriter.

The general format of reducer code can be written as,

org.apache.hadoop.mapreduce.Reducer<INPUT_KEY, INPUT_VALUE, OUTPUT_KEY, OUTPUT_VALUE>.

It can be observed that it also uses four parameters similar to mapper code.

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Example

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

```
import java.io.IOException;
import java.util.StringTokenizer;
import org.apache.hadoop.io;
import org.apache.hadoop.io. IntWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapReduce.Reducer;
protected void reduce(KEYIN key, Iterable <VALUEIN> values, org.apache.hadoop.,mapreduce. Reducer. Context context
throws IOException, InterruptedException
public class WordCountReducer extends Reducer < Text, IntWritable, Text, IntWritable >
{
IntWritable cnt = new IntWritable( );
public void reduce(Text key, Iterable < IntWritable > values, Context con) throws IOException, InterruptedException
{
int total = 0;
for(IntWritable value : values)
{
total + = value.get( );
}
cnt.set(total);
con.write(key, cnt);
}
}
```

In the above example, the four parameters are Text, IntWritable, Text and IntWritable in which, the first two are input types and the remaining are output types. Here, an iterator is used to move across all the words and counting each of the words i.e., the total result is provided as output.

IMPORTANT QUESTIONS

SHORT QUESTIONS

Q1. Define SDN.

Important Question

Ans: For answer refer Unit-IV, Q1.

Q2. What are the key elements of SDN?

Important Question

Ans: For answer refer Unit-IV, Q3.

Q3. What is data validation?

Important Question

Ans: For answer refer Unit-IV, Q6.

Q4. What is mapper code? What is the general format of it?

Important Question

Ans: For answer refer Unit-IV, Q10.

ESSAY QUESTIONS

Q5. Write in brief about Software Defined Network (SDN).

Important Question

Ans: For answer refer Unit-IV, Q13.

Q6. Explain in detail about the functions that are required for IoT applications.

Important Question

Ans: For answer refer Unit-IV, Q16.

Q7. Write a short notes on,

(i) Data validation

(ii) Data categorization for storage

(iii) Assembly software for events.

Important Question

Ans: For answer refer Unit-IV, Q18.

Q8. Illustrate the architecture of data analytics.

Important Question

Ans: For answer refer Unit-IV, Q22.

Q9. Discuss in detail about the building blocks of Hadoop.

Important Question

Ans: For answer refer Unit-IV, Q24.

Q10. Define MapReduce. Discuss about weather dataset.

Important Question

Ans: For answer refer Unit-IV, Q26.

Q11. Write short notes on reducer code.

Important Question

Ans: For answer refer Unit-IV, Q28.

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UNIT 5

Syllabus

Cloud Computing, Sensor-Cloud, Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring.

LEARNING OBJECTIVES

- ✓ Basic Concepts of Cloud Computing
- ✓ Definition and Applications of Sensor-cloud
- ✓ Usage of IoT in Smart Cities and Smart Homes
- ✓ Usage of Connected Vehicles Approach
- ✓ Smart Grid
- ✓ Industrial IoT with its Advantages
- ✓ Case Studies on Agriculture, Health Care and Activity Monitoring.

INTRODUCTION

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

Sensor cloud is a unique platform that supports visualization, remote management and sensor data storage over cloud computing technologies. Use of these technologies offers rapid visualization, data scalability and user programmable analysis. It is completely based on integration of cloud services with IoT. Some other applications of IoT include Smart Cities, Smart Homes, Connected Vehicles and Smart Grids. Moreover, IoT is also getting adopted in fields like agriculture, health care and activity monitoring.

PART-A SHORT QUESTIONS WITH SOLUTIONS

Q1. What is cloud computing?

Answer :

Model Paper-I, Q1(i)

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

Q2. List any four features offered by Nimbits PaaS services.

Answer :

The features offered by Nimbits PaaS services are as follows,

1. It provides solution to the complexity of edge computing involved in IoT by providing a platform that is built upon embedded systems locally and then runs the rules using rule engine and pushes the data that seems to be crucial on the cloud.
2. It offers Nimbits.io, an open source Java library that allows the process of developing JAVA, web and android solutions in a simple manner.
3. It provides support for programming languages such as Arduino, Push functions subjected to Arduino cloud, Latest Arduino library, HTML and JavaScript.
4. It offers a rule engine inorder to connect not only sensors but also persons and software to the cloud and with one another. Here, rules represent email alerts, XMPP messages, push notification, statistics and any calculation.

Q3. Write in brief about sensor cloud.

Answer :

Model Paper-III, Q1(i)

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

1. It allows unlimited data to be stored offering reliability equal to redundant data stored three times.
2. It allows data of sensor data streams to be stored for longer duration.
3. It offers the feature of MathEngine that helps in development and deployment of data along with its processing and analyzation of apps which are present in the cloud.
4. It allows the viewers to navigate large volumes of data through time series visualization and graphing tool generating faster response.
5. It allows the users to generate alerts through scripting features such as flexible SMS and email alerts.

Q4. List out the applications of sensor cloud.

Answer :

Model Paper-I, Q1(j)

Applications of Sensor Cloud

Following are the applications of sensor cloud.

1. **Telematics**

Sensor clouds are used in telematics that allow data to be transferred over long distance. This transmission is carried out in a smooth way.

2. **Agriculture and Irrigation Control**

Sensor clouds are used in agriculture in order to analyze crop fields. The field servers are equipped with camera sensors to capture air, temperature, soil moisture etc. Such type of sensors can also be used for harvesting.

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3. **Google Health**

Google Health is a cloud based personal health information portal. Using this, the users can analyse the health records obtain health tips.

4. **Wildlife Monitoring**

Sensor cloud is used to track wild life sanctuaries, forests etc., for obtaining data related to various wild species.

5. **Transportation and Vehicular Traffic Applications**

Sensor cloud offers stable, sustainable and efficient traffic tracking system. It helps in tracking fuel level, location of vehicle, status of driver and total distance covered.

Q5. List out the applications in smart home.

Answer :

The connected home includes the below applications in smart home.

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

Q6. Write short notes on smart grid.

Answer : **Model Paper-II, Q1(i)**

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

Q7. Discuss in brief about industrial IoT.

Answer :

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

The connectivity among the production process parts including machines, systems, products and users of big data and cloud is provided by the IIoT. In future there will be a major role of data analytics, visualization, software based systems, service platforms. The IIoT is also considered as an important component in Industry 4.0.

Q8. List out the advantages of industrial IoT. **Model Paper-III, Q1(j)**

Answer :

The advantages of industrial IoT are as follows,

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

Q9. How agriculture can be improved?

Answer :

IoT can improve agriculture in the following ways,

1. **Improved Quality and Volumes**

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

2. **Data Gathering Through Smart Agricultural Sensors**

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

3. **Increase in Business Efficiency Through Process Automation**

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

4. **Cost Management and Waste Reduction due to Increased Control over Production**

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

5. **Better Control over Internal processes Yields to Decrease in Production Risks**

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

Q10. Define Smart Agriculture. Model Paper-II, Q1(ii)

Answer :

Smart Agriculture

Smart agriculture can be defined as an integration of various implementations of technologies in various dimensions. The inconsistent, inefficient and unreliable techniques of traditional farming are replaced by the applications with efficient, sustainable and reliable smart agriculture.

Examples

1. Contract farming
2. Context aware farming
3. Pesticide control
4. Security control
5. Remote monitoring
6. Precious agriculture
7. Environmental monitoring
8. Machine and process control.

PART-B ESSAY QUESTIONS WITH SOLUTIONS

5.1 CLOUD COMPUTING

Q11. Discuss about cloud computing. Also, list various services and usages of cloud platform.

Model Paper-II, Q10(a)

Answer :

Cloud Computing

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

In real world, the user of computing service can be compared with the user of electricity. It is not compulsory that user of electricity should be aware of source as well as hidden infrastructure of electric supply. In the same manner, it is not required for a user of computing service to be aware of the process of deploying the infrastructure as well as the information about computing environment. It is like, process of accumulating information regarding the inter processor present in a computer. The user of computing service requires only services such as data, computing and intelligence available in the cloud.

Services and Usage of Cloud Platform

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

(i) It provides infrastructure for devices storing huge amount of data, RFIDs, automobiles, industrial plant machines and device networks.

(ii) It offers capabilities of computing like IDE and analytics.

(iii) It provides collaborative computing and sharing of data store.

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

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

Internet cloud + Clients = User applications and services without boundaries and walls

The execution of an application service is carried out on a platform containing basic hardware, operating system and networks. Initially, diversified applications were designed in such a way that they can run different platforms like hardware, operating systems and networks. It is necessary for applications and services to get integrated along a common platform and running environment.

Even though, they are multiple platforms and environments are available, computing environment and cloud storage support virtualized environment, that indicating running environments are allowed to appear as one to all applications and services.

Q12. List different techniques of data collection, storage and computing in cloud computing paradigm.

Answer :

The various techniques of data collection, storage and computing are as follows,

(i) Devices or sensor networks data collection at the device web server.

(ii) Local files.

(iii) Dedicated data store at co-ordinating node.

(iv) Local node in a distributed DMBS.

(v) Internet connected data center.

(vi) Internet connected server.

(vii) Internet connected distributed DBMS nodes.

(viii) Cloud infrastructure and services.

The following figure illustrates different techniques of data collection, storage and computing.

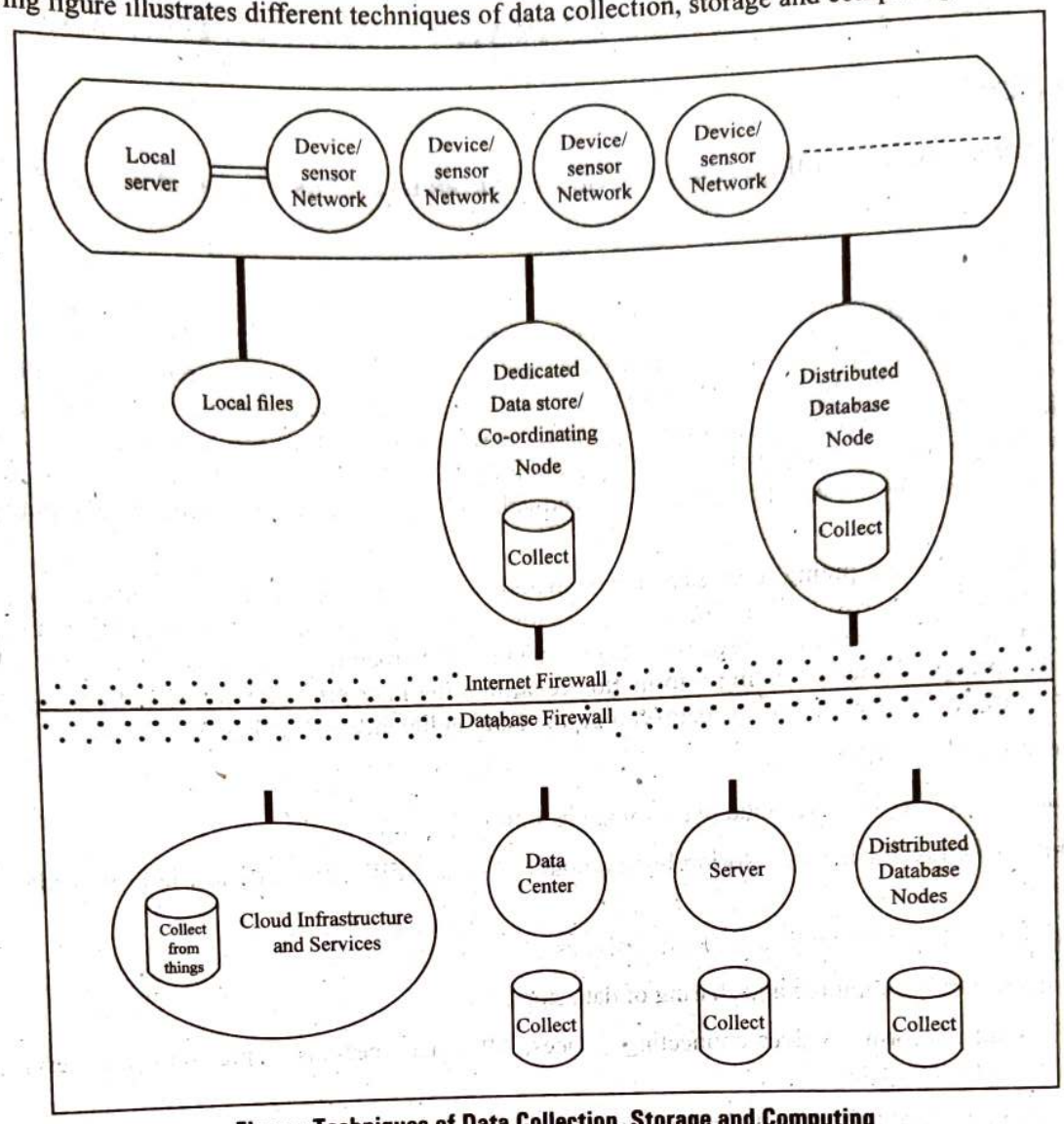

Figure: Techniques of Data Collection, Storage and Computing

Q13. What are the various concerns and key characteristics of cloud computing?

Answer :

Concerns of Cloud Computing

The various concerns of using cloud computing are as follows,

(i) It requires internet connection of constant high speed.

(ii) It uses multiple APIs and protocols at distinct clouds.

(iii) It requires high trust as well as low risk regarding the security in multitenant environment.

(iv) It has limitations or restrictions on the existing services.

(v) It has loss of users control.

(vi) It is non-delivery according to performance defined in service level agreement.

(vii) It has chances of data loss.

Characteristics of Cloud Computing

The key characteristics of cloud computing are as follows,

1. It offers services to specific consumers and small business because these services helps them to minimize their capital expenditure.

2. It allows the customer to access the cloud computing services regardless of their locations or devices.

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

Q14. List the advantages of cloud computing.

Answer :

Model Paper-III, Q10(a)

Advantages of Cloud Computing

The following are the advantages of the cloud computing.

1. **Cost Effective**

Cloud computing is considered to be cost effective method because most of the cloud services are available at low prices when compared to traditional desktop software this completely reduces the IT company's expenses. The company can follow any of the services which includes one-time payment, pay-as-you-go.

2. **Storage Capacity**

The cloud offers limitless storage capacity, there by providing provision for storing millions of gigabytes virtually. This means that a user can store anywhere in the cloud and need not worry about running out of storage space, increasing its desktop or PC storage space issues.

3. **Enhanced Performance**

The cloud computing executes less number of programs and loads less processes into the memory. This allows the system to boot quickly and run fastly, thereby increasing the over all performance of the system.

4. **Flexibility**

The clouds provide quick access to its services and resources making it very flexible and fast. It can also extend it services on client demand.

5. **Security**

The cloud computing provide secured data storage than desktop component. The data is not lost even if the computer crashes because the clouds automatically duplicates the stored data. So, whatever the data is stored into the clouds always stays safe in the clouds. And also, it does not require any back-up.

6. **Convenience**

The cloud computing offers the facility to access the user data anywhere at any time just by connecting to the internet via., internet-enabling services. The user need not have to carry the business computer or be in office to access the data.

7. **Data Backup and Recovery**

With cloud computing the user can easily restore the data in case of any system crashes. This is because the process of taking backups and restoration is much easier than traditional method of restoration or backup. Besides this, the clouds are very efficient in handling recovery of information.

8. **Ease of Group Collaboration**

The cloud computing has the ability to allow one or many users to collaborate on documents and projects.

Q15. Discuss various cloud service models.

Answer :

Model Paper-I, Q10(a)

The various types of cloud service models includes the following,

1. Software-as-a-Service (SaaS)
2. Platform-as-a-Service (PaaS)
3. Infrastructure-as-a-Service (IaaS)
4. Data-as-a-Service (DaaS).

A simple equation describing the cloud computing is as follows,

Cloud computing = SaaS + PaaS + IaaS + DaaS

1. Software-as-a-Service (SaaS)

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

2. Platform-as-a-Service (PaaS)

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

Example

Google APP engine is a reliable service, that is capable of creating applications which easily executes large amount of data. Now a days, these applications are executed using python programming languages.

3. Infrastructure-as-a-Service (IaaS)

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

(a) Dividing the very large physical infrastructure resource into smaller virtual resource, or

(b) By providing the complete virtual machine as at is, along with an operating system so that the consumer can access it.

The major objective of Iaas is to deliver IT in the form of service to customers. It does this by providing significant technology services as well as data center investments. In relative to other traditional outsourcing service, Iaas is capable of providing a predefined standard infrastructure as it focuses mostly on a model of service delivery.

4. Data-as-a-Service (DaaS)

Application user or developer can access the data residing at data center on demand. In Data-as-a-Service model, the data warehouse or data store can be accessed by means of internet on demand there by paying rent to an enterprise based on the usage. The service provider of data center is responsible for data center management, control, scaleup, 24 × 7 power, maintenance, physical security, data replicating and mirror nodes and systems.

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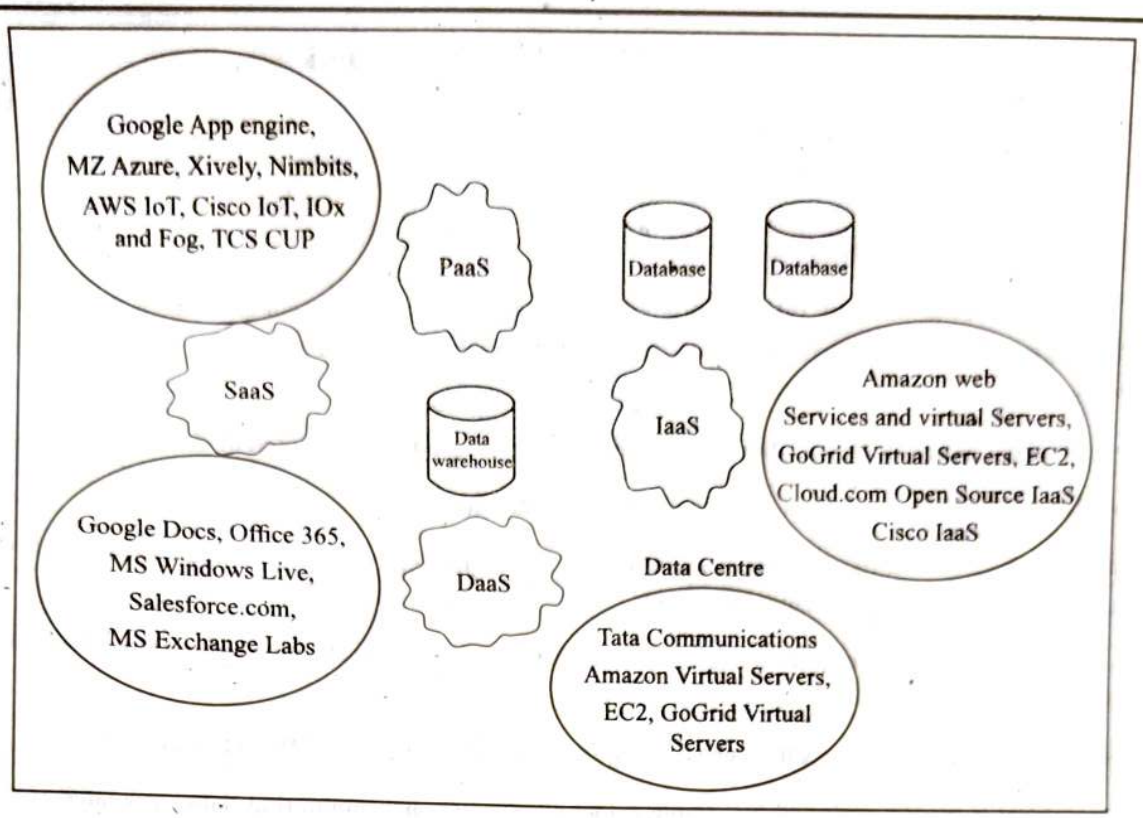

Figure: PaaS, SaaS, IaaS and DaaS Cloud Service Models

Q16. Explain different types of cloud deployment models.

Answer :

Model Paper-III, Q10(b)

The different types of cloud deployment models includes the following,

(i) Public cloud

(ii) Private cloud

(iii) Hybrid cloud

(iv) Community cloud.

(i) Public Cloud

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

(ii) Private Cloud

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

(iii) Hybrid Cloud

Hybrid cloud is the combination of both public and private cloud. This type of cloud is preferred whenever there is heavy workload or any hardware facts. Private cloud provide services by combining their systems with third party provide of public cloud services. This cloud allows the organization to keep the data secured with firewalls (i.e., private cloud) and less secured data on the public cloud.

(iv) Community Cloud

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

5.2 SENSOR-CLOUD, SMART CITIES AND SMART HOMES

Q17. Write short notes on sensor-cloud.

Answer : Model Paper-I, Q10(b)

Sensor-cloud

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

1. It allows unlimited data to be stored offering reliability equal to redundant data stored three times.
2. It allows data of sensor data streams to be stored for longer duration.
3. It offers the feature of MathEngine that helps in development and deployment of data along with its processing and analyzation of apps which are present in the cloud.
4. It allows the viewers to navigate large volumes of data through time series visualization and graphing tool generating faster response.
5. It allows the users to generate alerts through scripting features such as flexible SMS and email alerts.

The sensor cloud is usually preferred for remote gathering, viewing and monitoring data associated with applications belonging large networks.

It utilizes the features of various cloud computing technologies to simplify management of large volumes of data.

It makes use of graphing functions to accelerate graphing related queries generated by the users including parallel computing and client side caching. The sensor cloud is available on initial web based sensor data aggregation platform to serve as a flexible online analytics tool for apps developed by users. Users belonging to the fields like prognosis and health care are allowed to upload their own code or develop apps ranging from simple scripts to advanced online algorithms.

It actually helps the teams to collaborate event responses with flexible alerts. It even enables teams to work collaboratively for the development of code. It also helps in transforming the abilities of cloud into tools that are used in gathering customer data and visualize and extract large volumes of sensor data.

Applications of Sensor Cloud

Following are the applications of sensor cloud.

1. **Telematics**

   Sensor clouds are used in telematics that allow data to be transferred over long distance. This transmission is carried out in a smooth way.

2. **Agriculture and Irrigation Control**

   Sensor clouds are used in agriculture in order to analyze crop fields. The field servers are equipped with camera sensors to capture air, temperature, soil moisture etc. Such type of sensors can also be used for harvesting.

3. **Google Health**

   Google Health is a cloud based personal health information portal. Using this, the users can analyse the health records obtain health tips.

4. **Wildlife Monitoring**

   Sensor cloud is used to track wild life sanctuaries, forests etc., for obtaining data related to various wild species.

5. **Transportation and Vehicular Traffic Applications**

   Sensor cloud offers stable, sustainable and efficient traffic tracking system. It helps in tracking fuel level, location of vehicle, status of driver and total distance covered.

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Q18. Discuss in brief about smart cities.

Answer : Model Paper-II, Q10(b)

Smart Cities

The concept of IoT is applied on Internet of everything inorder to develop smartcities. An architectural frame work with four layers for a city is as follows,

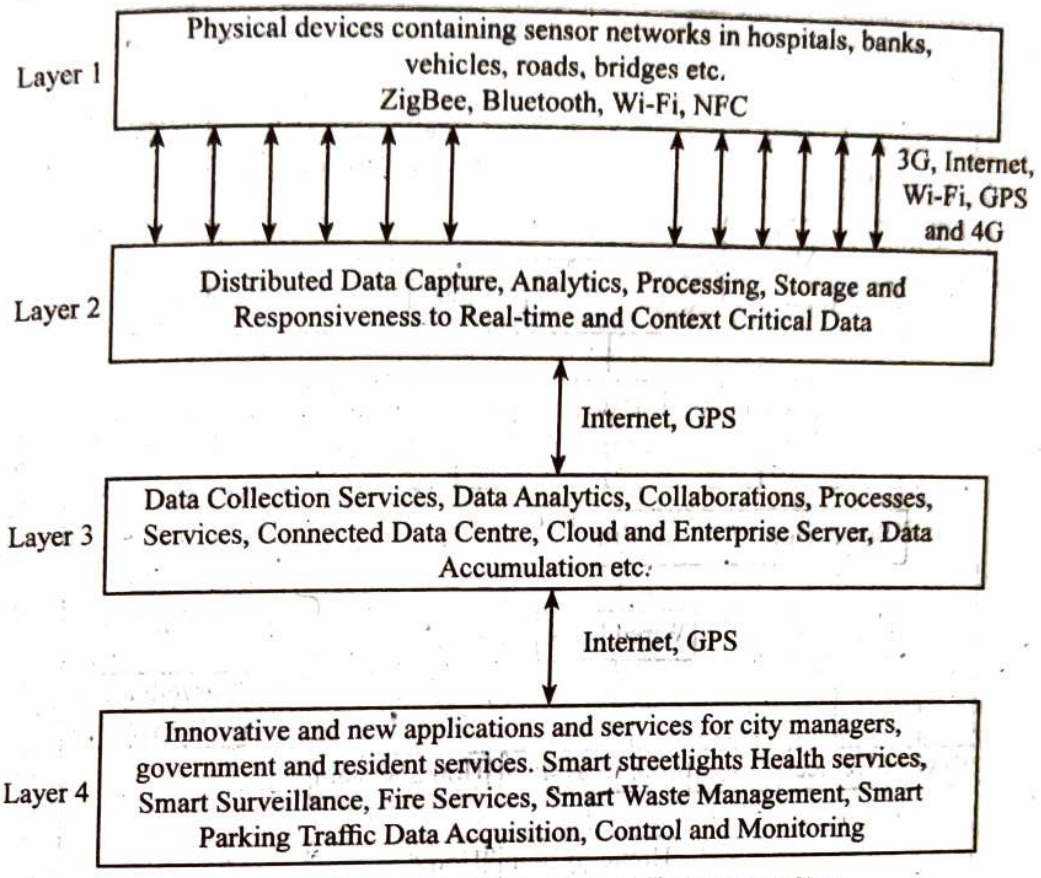

Figure: Architectural Four Layer Framework for Smart City

Q19. Explain in brief about smart homes.

Answer : Model Paper-I, Q11(a)

Smart Home

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

The connected home includes the below applications in smart home.

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

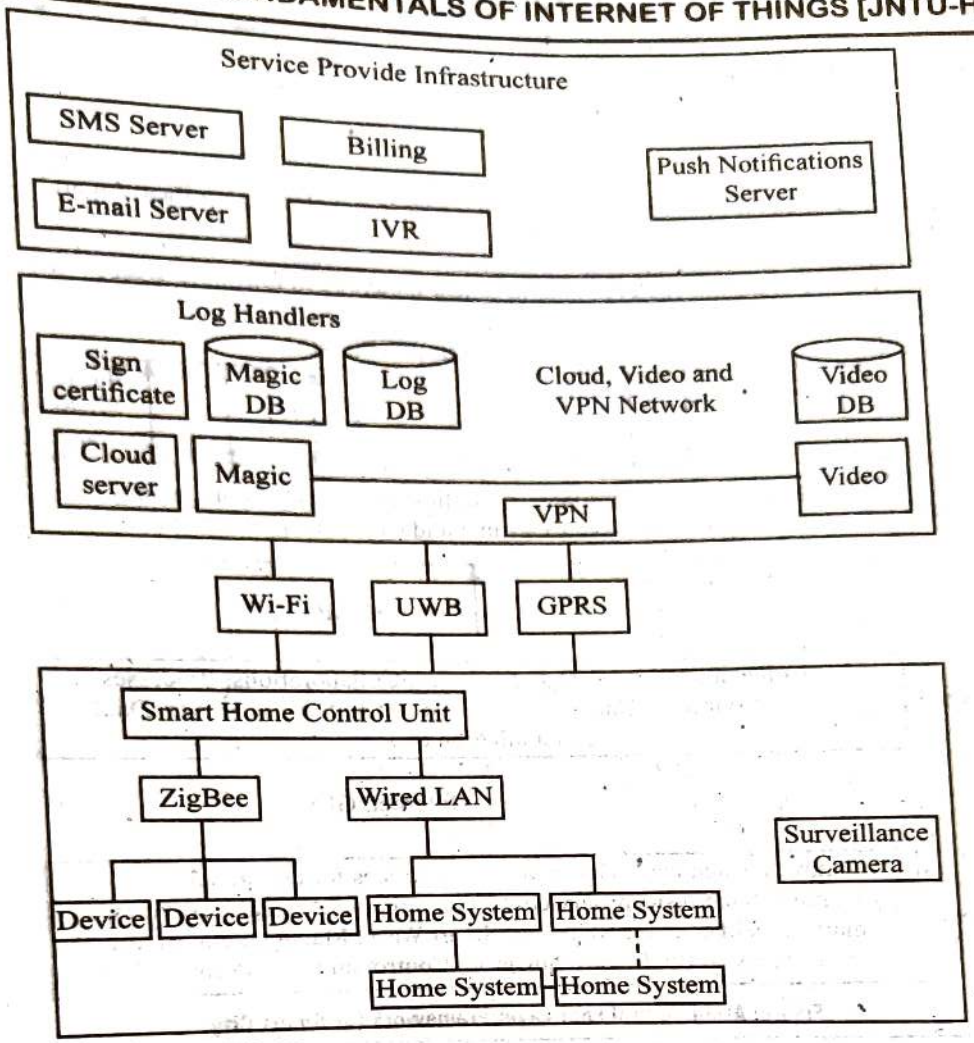

Figure: Architectural View of Cloud Based IoT Platform for Smart Home

Q20. Which of the devices are used to connect IoT devices to a home network?

Answer :

The devices that are used to connect IoT devices to a home network are as follows,

1. Cloud server
2. Home gateway.

1. Cloud Server

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

2. Home Gateway

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

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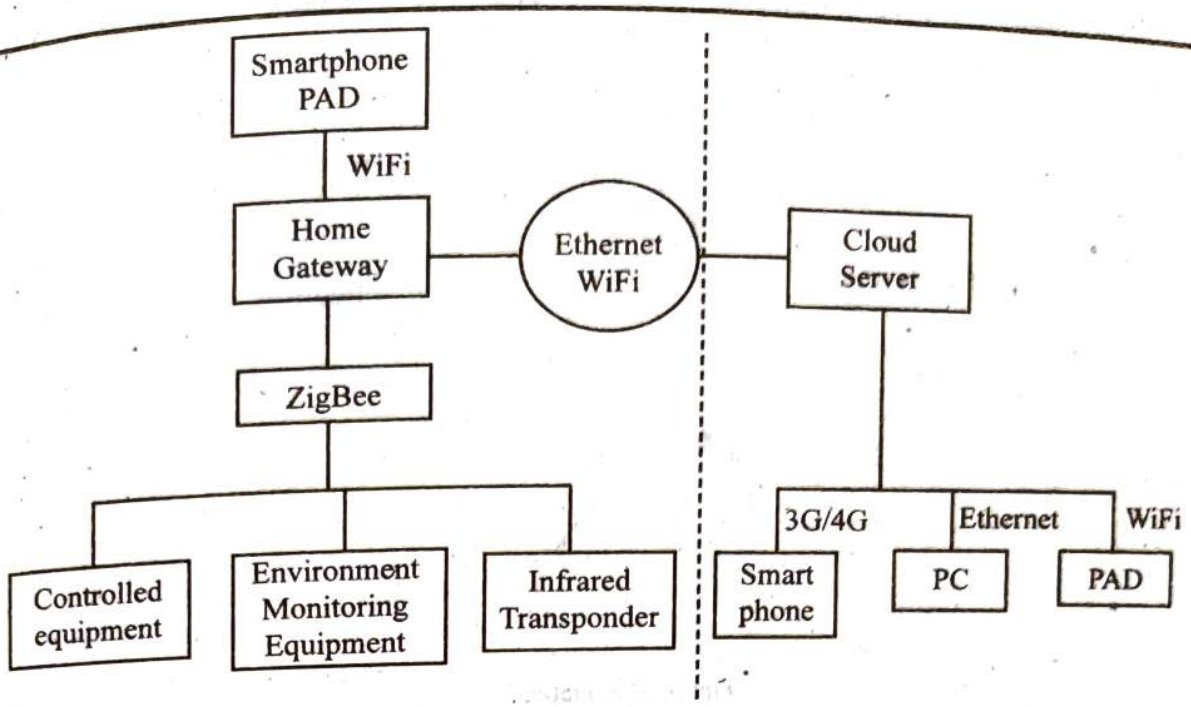

Figure: Design Diagram of Smart Home System

5.3 CONNECTED VEHICLES

Q21. Explain about connected vehicles.

Model Paper-II, Q11(a)

Answer :

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

The sensors and GPS system are used in generating accurate data to gain knowledge about surroundings of vehicles. The main purpose of connected vehicles is to provide a means of communication among vehicles running on road.

There are different types of platforms which provide numerous applications. Sprint velocity connect is one such platform that offer the following features,

1. **Rental Car Features**

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

2. **Dealership Sales**

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

3. **Fleet Management**

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

The Airbiquity choreo service delivery platform is another cloud platform which is preferred for auto manufactures, third party app developers and wireless carriers. This platform provides connected services to the customers. It also provide services such as electric vehicle optimization, fleet management, embedded connectivity and mobile integration.

The drivers can download and install the applications in their smart phones and connect to vehicles through Bluetooth or USB using Airbiquity platform.

Consider an example of vehicles connected to exchange data with various devices over Internet. The transmitter/receiver in vehicle or smartphone provides internet connection to vehicle.

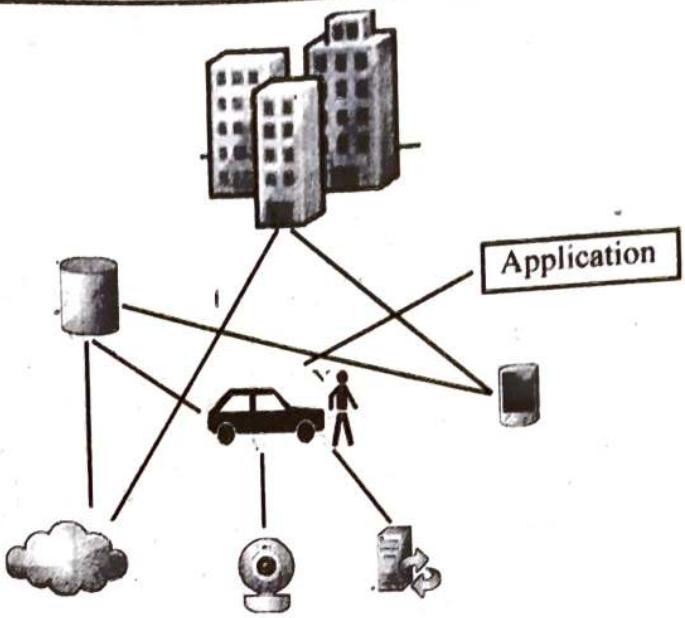

Figure: Connected Car

The drivers for connected cars are depicted below,

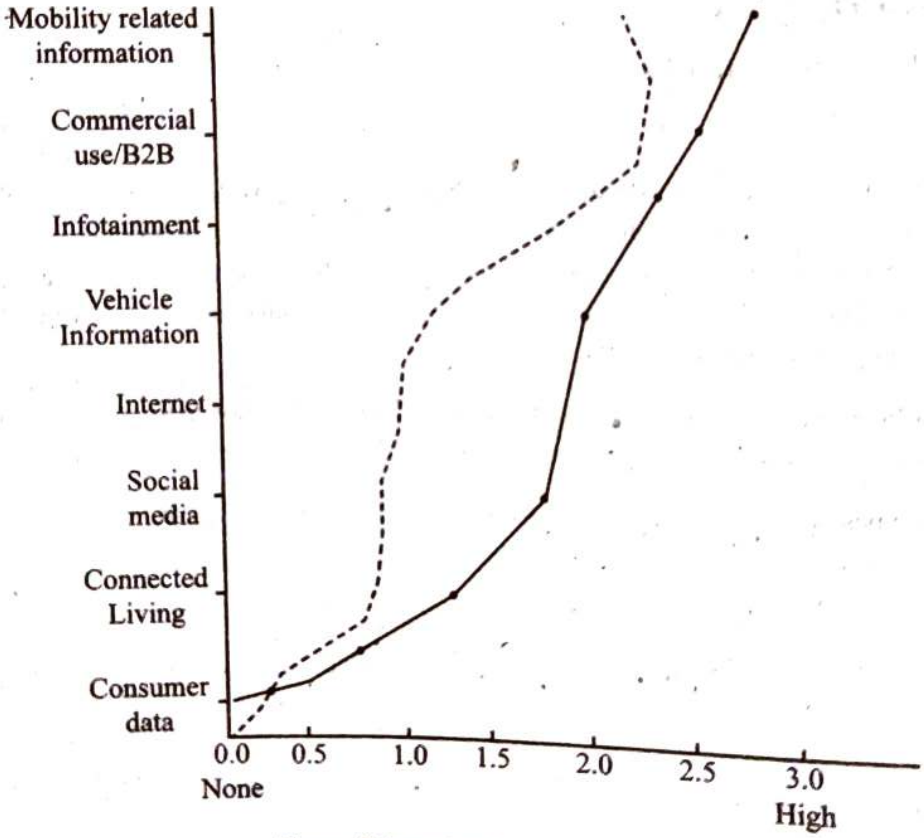

Figure: Drivers for Connected Cars

The features of connected cars are listed below,

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

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5.4 SMART GRID

Q22. Discuss about smart grid.

Model Paper-III, Q11(a)

Answer :

Smart Grid

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

There are three types of components such as the following,

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

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

5.5 INDUSTRIAL IoT

Q23. Explain about Industrial Internet of Things (IoT).

Model Paper-I, Q11(b)

Answer :

Industrial IoT

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

The connectivity among the production process parts including machines, systems, products and users of big data and cloud is provided by the IIoT. In future there will be a major role of data analytics, visualization, software based systems, service platforms. The IIoT is also considered as an important component in Industry 4.0.

Advantages of Industrial IoT

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

5.6 CASE STUDY : AGRICULTURE, HEALTHCARE, ACTIVITY MONITORING

Q24. Write about agriculture in IoT.

Model Paper-II, Q11(b)

Answer :

Agriculture in IoT

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

1. **Improved Quality and Volumes**

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

2. **Data Gathering Through Smart Agricultural Sensors**

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

3. **Increase in Business Efficiency Through Process Automation**

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

4. **Cost Management and Waste Reduction due to Increased Control over Production**

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

5. **Better Control over Internal processes Yields to Decrease in Production Risks**

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

Usecases of IoT in Agriculture

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

1. **Green House Automation**

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

2. **Crop Management**

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

3. **Agricultural Drones**

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

4. **Monitoring Climate Conditions**

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

Q25. Explain about Healthcare in IoT.

Answer :

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

The dimensions of using IoT in healthcare are as follows,

(i) Clinical Care

Some of the ill patients need to be observed constantly. Such type of patients are kept in Intensive Care Units (ICU's). This type of monitoring is possible by IoT driven non-invasive monitoring technology through sensors to extract physiological data related to different organs of patients. This data is forwarded to the care takers through gateways and wireless networks.

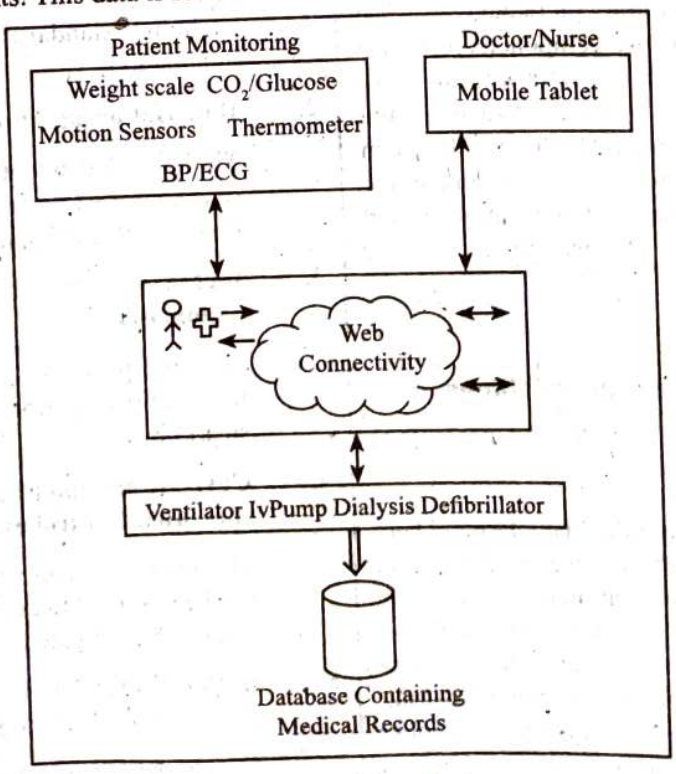

Figure: Clinical Care System

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(ii) **Remote Monitoring**

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

Types of Monitoring Devices

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

1. Safety Monitors

- Personal safety and tracking devices
- Fall detection device

2. Activity Monitors

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

3. Vital Sign Monitors

- Blood pressure measuring device
- Heart rates measuring device
- Weight measuring device
- ECG
- Pulse oximeters
- Blood glucose measuring device

4. Medication Monitors

- Smart pill dispenser
- Medical adherence systems

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

Q26. Write short notes on activity monitoring. **Model Paper-III, Q11(b)**

Answer :

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

1. **Body Temperature Sensors**

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

2. **Blood Pressure Sensors**

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

3. **Pulse Sensors**

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

4. **Respiratory Rate Sensors**

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

5. **Pulse Oximetry Sensors**

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

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

IMPORTANT QUESTIONS

SHORT QUESTIONS

Q1. List any four features offered by Nimbits PaaS services.

Important Question

Ans: For answer refer Unit-V, Q2.

Q2. List out the applications in smart home.

Important Question

Ans: For answer refer Unit-V, Q5.

Q3. Discuss in brief about industrial IoT.

Important Question

Ans: For answer refer Unit-V, Q7.

Q4. Define Smart Agriculture.

Important Question

Ans: For answer refer Unit-V, Q10.

ESSAY QUESTIONS

Q5. Discuss about cloud computing. Also, list various services and usages of cloud platform.

Important Question

Ans: For answer refer Unit-V, Q11.

Q6. List the advantages of cloud computing.

Important Question

Ans: For answer refer Unit-V, Q14.

Q7. Discuss various cloud service models.

Important Question

Ans: For answer refer Unit-V, Q15.

Q8. Write short notes on sensor-cloud.

Important Question

Ans: For answer refer Unit-V, Q17.

Q9. Explain about connected vehicles.

Important Question

Ans: For answer refer Unit-V, Q21.

Q10. Discuss about smart grid.

Important Question

Ans: For answer refer Unit-V, Q22.

Q11. Explain about Industrial Internet of Things (IoT).

Important Question

Ans: For answer refer Unit-V, Q23.

Q12. Write about agriculture in IoT.

Important Question

Ans: For answer refer Unit-V, Q24.

Q13. Write short notes on activity monitoring.

Important Question

Ans: For answer refer Unit-V, Q26.