

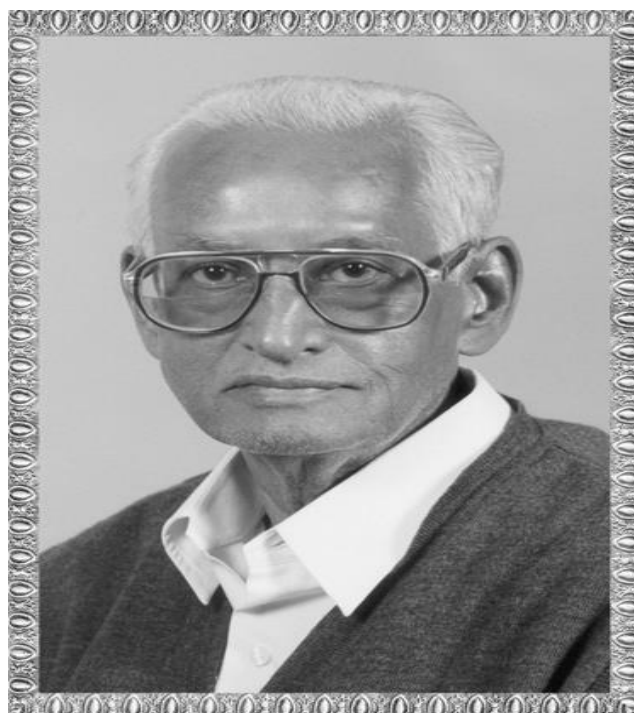
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B.Sc.IT-SEMESTER-6

SUB :- IOT

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Q-1) When was IOT found?

Ans:-

- The term 'Internet of Things' was coined in **1999** by the computer scientist Kevin Ashton.

Q-2)What is IOT?

Ans:-

- The Internet of Things (IoT) describes the network of physical objects—“things”—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet.

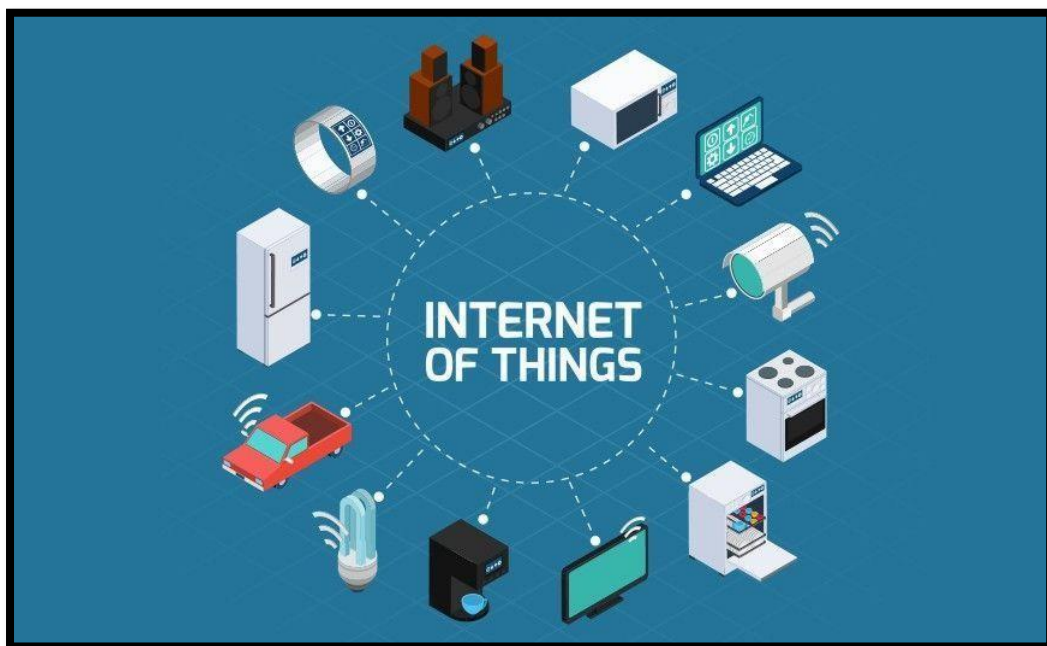


Fig:- example of iot

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Q-3) Explain Benefit of IOT.(2m)

ANS:

Here are the benefits, which come with this technology.

1. IoT promotes efficient resource utilization.
2. It minimizes human efforts in many life aspects.
3. Enabling IoT will reduce the cost of production and maximizing the returns.
4. It makes analytics decisions faster and accurately.
5. It boosts the real-time marketing of products.
6. Provide a better client experience.
7. It guarantees high-quality data and secured processing.

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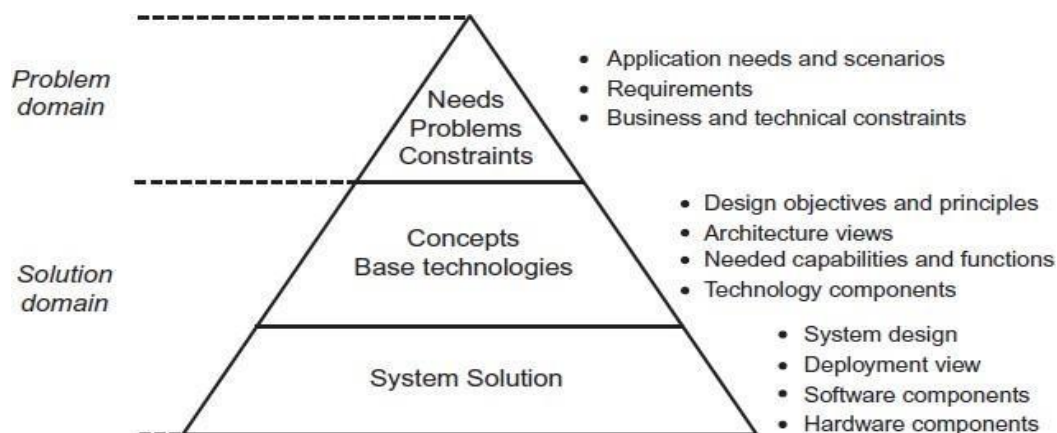
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Q-4) Explain main design principles and needed capabilities in iot.

ANS:-

- ✓ The architecture relies that it provide more better and good system to world compare to old system.
- ✓ That's help real world to more easy way.
- ✓ SENSEI further relies on an open-ended constellation of providers and users.(SENSEI Means teacher it provide end to end enterprise grade, iot solution that combine state of the art analytics ,multi platform interface and always on hardware enabling the tracing , monitoring and analysis of multiple assets in real time without need of human interaction.)
- ✓ It also provides a reference model for different business roles.
- ✓ A number of design principles and guidelines are identified, and so is a set of requirements.
- ✓ Finally, the architecture itself contains a set of key functional capabilities.
- ✓ IoT-A refers to as the Architectural Reference Model (ARM).
- ✓ The vision of IoT-A is, via the ARM.
- ✓ As per the diagram,
- Logical partitioning required two different domains partitioning such as,
 - 1)Problem Domain
 - 8. 2)Solution Domain



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1. Problem Domain: In this Owner must identify the business and technical constraints and based on constraints they design requirements and needs of application.
2. Solution Domain: As per the requirements they design objectives and Principles and create functional views of projects.
Before starting system design technical components (hardware and software components) and deployment views prepared for system solution.
 - IoT-A provides a set of different architectural views, establishes a proposed terminology and a set of Unified Requirements to create solution of problem domain and develop solutions.
1. The overall design objective of IoT architecture shall be to target a horizontal system of real-world services that are open, service-oriented, secure, and offer trust.
2. Design for reuse of deployed IoT resources.
3. Design for a set of support services .
4. Design for different security levels.
5. Design for sensing on different roles of providing and using services across different business domains.
6. Design for ensuring trust, security, and privacy.
7. Design for simplicity of management.
8. Design for different service delivery models.
9. Design for lifecycle support.

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Q-5) EXPLAIN STANDARD CONSIDERATIONS IN DETAIL.

ANS:

- ❖ There are number of standardization organizations and bodies, both proper standards development organizations (SDO) as well as special interest groups and alliances that develop standards specifications.
- ❖ There are mainly 3 types of standards considerations.
 - **Standard Considerations 1:**
 - ✓ Different national and international bodies ratify standards by SDOs, whereas standard specifications developed by special interest groups and alliances are normally agreed upon and adopted by market actors such as technology. Manufacturers.
 - ✓ **EXAMPLE:**
 - ITU- International Telecommunication Union.
 - ISO- International Organization for Standardization.
 - ETSI-European Telecommunication Standard Institute.
 - CENELEC-The European Committee for Electro technical Standardization.
 - **Standard Considerations 2:**
 - ✓ It is responsible for defining entire system or partial system also defines standards for the development of specific pieces of technologies.
Such as, develop standards for the specific protocols using IETF.
 - ✓ **EXAMPLE:**
 - 3GPP- 3rd GENERATION PARTNERSHIP PROJECT for 3G mobile Communications.
 - NIST- NATIONAL INSTITUTE OF STANDARD AND TECHNOLOGY for the development of standard

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grid of process.

➤ **Standard Considerations 3:**

- ✓ This is the final consideration in which it is responsible for standards for the technology selection part on regulatory or Legislative processes.
- ✓ Standards are emerging as a result of collaborative research involving both Academic and Industry.

EXAMPLE:-

- EU:- European Commission Within the European Union, EU is responsible for the selection of standard technologies and its related activities.

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Q-6) EXPLAIN BUILDING IOT ARCHITECTURE IN DETAIL.

ANS:

- ✓ “Architecture the term” has many interpretations.
- ✓ Main point is that How we use the term “architecture”,
- ✓ and secondly, how it relates to problems, Applications of interest, and actual M2M/IOT solutions.(M2M MACHINE TO MACHINE)

- ✓ Architecture refers to the description of the main **conceptual elements**, & **the actual Elements** of a target system,

- ✓ how they relate to each other, and principles for the Design of the architecture.

- ✓ **Conceptual element** refers to an intended function, a piece of data, or a service.

- ✓ **An actual element**, meanwhile, refers to a technology building block or a protocol.

- ✓ The term “reference architecture” relates to a generalized model that contains the richest set of elements and relations that are of relevance to the domain “Internet of Things.”

- ✓ When looking at solving a particular problem or designing a target application,

- ✓ the Reference architecture is to be used to help to design applied architecture.

- ✓ The applied architecture is then the blueprint used to develop the actual system Solution (Figure).

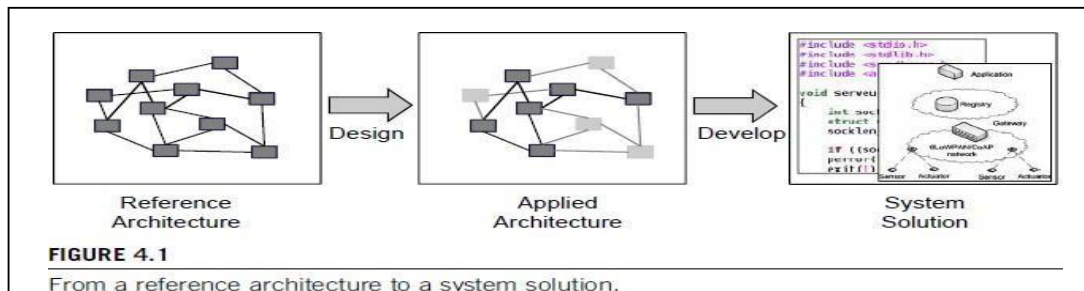
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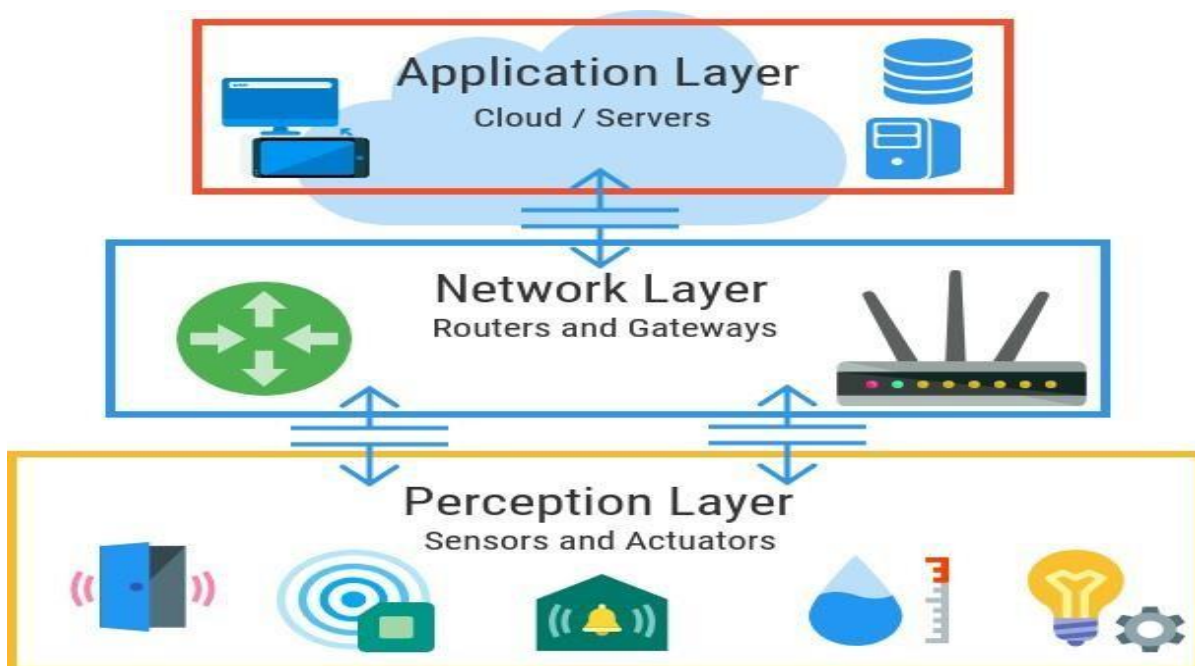


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- ✓ When creating a model for the reference architecture,
- ✓ one needs to establish Overall objectives for the architecture as well as design principles that come form understanding some of the describe major feature of the resulting system solution.



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✓ In Above diagram, there are main 3 layers to built design architecture of an IOT Project.

- **Layer 1-Perception Layer:**

- In this layer base level IOT device are active.
- This layer is responsible for data collection & actions .
- For example: Sensors and Actuators.

- **Layer 2- Network Layer:**

- This layer is responsible for data storage and sharing.
- For example: Routers, Gateways using various networking protocols

- **Layer 3- Application Layer:**

- This layer is the final layer in which data properly analyzed and results hasBeen Generated.
- For Example: Cloud data/ Server.

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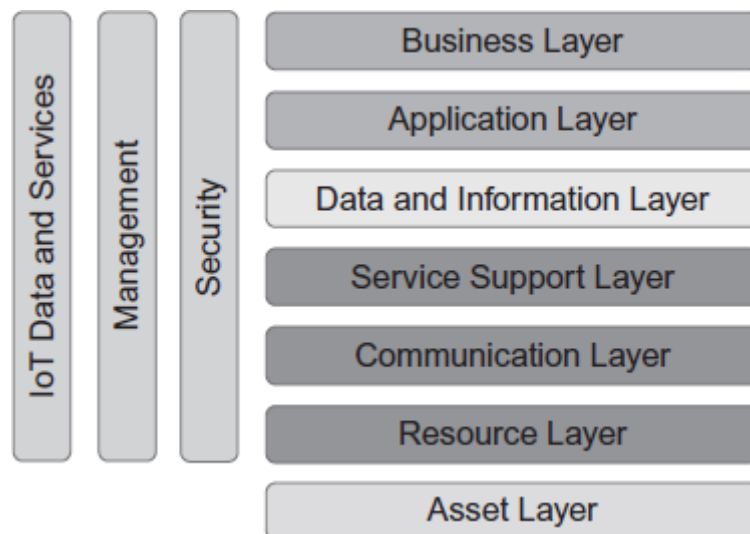
Q-6) EXPLAIN IOT ARCHITECTURE OUTLINE

OR

FUNCTIONAL ARCHITECTURAL LAYER.N DETAIL.

Ans:-

- IOT architectural outline is a concept that describes functional layers capabilities for IOT solutions.
- This architecture outline supports two different approach like software approach and network approach that are more focused to describe functional architecture in detail.
- The concept of functional architecture outline has 7 different layers. (Seediagram)



7. Asset Layer:

- At the lowest level is the Asset Layer. This layer is, strictly not providing any functionality within a target solution, but represents the reason way for any IoT Application.
- The assets of interest are the real world objects and entities that are subject to
- Being monitored and controlled, as well as having digital

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representations and identities.

- For example: Vehicles, Home, Humans, and Buildings.etc.

6. Resource Layer:

- The resource layer provides the main functional capabilities of sensing, actuation and embedded identities.
- Sensors and Actuators in various devices considered as a resource layer devices.
- For example: Smart phones, wireless Sensor actuators Network (WSANs), Smart Measuring meters RFIDS, Bar codes, Quick Response Code etc.

5. Communication Layer:

- The purpose of the communication layer is to provide the means of connectivity between the resources on one end & other hand executive service supported Devices with application logic support.
- There are different types of layers that support the communication layer & its Functionalities.
- **For example:**
 1. LAN: local area networks
 2. MAN: Metropolitan area networks
 3. WPAN: Wireless Personal Area networks.
 4. HAN & BAN: Home area network & Building area network for automation And its control.
 5. NAN: Neighbor Area Network for the distribution of smart electricity grid.
 6. V2V: Vehicles to vehicle network communication for the avoidance of Collision.

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7. Zigbee: It's a protocol stack for communication using http for the exchangingService.

4. Service support layer:

- IoT applications benefit from simplification by relying on support services that Perform common and routine tasks.
- These support services are provided by the Service Support Layer and are typically Executing in data centers or server farms inside organizations or in a cloud Environment.

3. Data and information layer:

- Main purposes of this layer is to capture knowledge and provide advancedControl logic support.
- Key concepts here include data and information models and knowledge Representation in general and the focus is on the information of the Organization.

2. Application Layer:

- The Application Layer in turn provides the specific IoT applications. There isan Open-ended array of different applications.
- For Example: smart metering in the Smart Grid, vehicle tracking, buildingAutomation.

1. Business Layer:

- The final layer in our architecture outline is the Business Layer, whichfocuses on Supporting the core business or operations of any enterprise, organization, or Individual that is interested in IoT applications.

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- For example: Customer Relationship Management (CRM), Enterprise Resource Planning (ERP) or other Business Support Systems (BSS).
- In addition to the functional layers, three functional groups cross the different Layers, namely Management, Security, and IoT Data and Services.
 - **Management:**
 - Management, as the name implies, deals with management of various parts of the system solution related to its operation, maintenance, administration, And provisioning.
 - **Security:**
 - Security is about protection of the system, its information and services, from external threats or any other harm.
 - **IOT data and services:**
 - Data and Service processing can provide very easy way to collect any difficult data and give provide real world solution and service.
 - More advanced processing is, for instance, data mining and data analytics that can be done in near real-time.
 - Different technologies are used to support the different levels of knowledge extraction, processing, reasoning, and decision-making.
 - Well-known technologies here include stream processing, analytics, machine learning and reasoning.

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Q-8) Explain types of different devices in detail. 2M/3M

ANS:

❖ BASIC DEVICES :

These devices are mostly used for a single purpose.

- For example:
 - 1- Measuring air pressure or closing a valve.
 - 2- Monitoring of humidity, Temperature and light level.
- In basic devices requirements on hardware are low.
- Both in the terms of processing power and memory.
- Main Focus:
 - The main focus is on keeping the bill of materials (BOM) as low as possible by using inexpensive devices.
- In basic devices following inexpensive components are used with single chip.
 - 1- Microcontroller
 - 2- Storage memory
 - 3- Tiny SOC(Integrated circuit)
 - 4- Low power battery as a power source.

❖ ADVANCED DEVICES:

- These devices are often intended for large multipurpose operations.
- For example:
 - 1- CCTV monitoring for traffic management.
 - 2- In Medical Instruments for different purpose of operations.
- In advance devices requirements on hardware are high.
- Both in the terms of processing power and memory.

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- Main Focus:
- The main focus is to manage monitor and control large database for future actions and decisions.
- In Advance devices following components are used with complex chipsets.
- 1- Powerful Microcontroller
- 2- Enough Storage memory for large datasets
- 3- Integrated multiple circuits
- 4- High power electricity options as a power source
- 5- Powerful User interface.
- 6- High bandwidth opera table network devices.

Q-9)What is M2M technology.

Ans:-

- **Machine to Machine communications.**
- The termed M2M/IoT is going to be the next generation of Internet revolution connecting more and more devices on Internet.
- M2M communications refer to automated applications which involve machines or devices communicating through a network without human intervention.
- Example :- **fleet tracking for a company,atm.**

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Q-10)What is data management? Explain different data formats and its characteristics. (5M)

ANS:

Data Management:-

- Traditional **data management** systems handle the storage, retrieval, and update of primary **data** items, records and files.
- In the context of **IoT, data management** systems must summarize **data** online while providing storage, logging, and auditing facilities for offline analysis.
- Data management is the practice of collecting, organizing, protecting, and storing an organization's data so it can be analyzed for business decisions.
- IoT data management enables businesses to discover new and useful patterns.
- In other words – it helps create the best connected products possible.
- Some of the key characteristics of M2M data include:
 1. BIG DATA
 2. HETEROGENEOUS DATA
 3. REAL WORLD DATA
 4. REAL TIME DATA
 5. TEMPORAL DATA
 6. SPATIAL DATA
 8. SECURITY AND PRIVATE DATA

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Big Data:

- Huge amounts of data are generated, capturing detailed point of the processes where devices are involved.

● Heterogeneous Data:

- The data is produced by a huge variety of devices and is itself highly heterogeneous, different on sampling rate, quality of captured values, etc.

Real-World Data:

- The majority of the M2M data relates to real-world processes and is dependent on the environment they interact with it .

Real-Time Data:

- M2M data is generated in real-time and it can be communicated also in a very timely manner.

Temporal Data:

- The majority of M2M data is of temporal nature.
- It collect information or data temporary .

Spatial Data:

- Spatial data is any type of data that directly or indirectly references a specific geographical area or location.

Security and Privacy:

- Due to the detailed capturing of interactions by M2M, analysis of the obtained data has a high risk of leaking private information and usage patterns, as well as compromising security.

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Q-11) What is data management? Explain Stages/layers of M2M data managements in detail.(5M)

Ans:-

Data Management:-

- Traditional **data management** systems handle the storage, retrieval, and update of primary **data** items, records and files.
- In the context of **IoT, data management** systems must summarize **data** online while providing storage, logging, and auditing facilities for offline analysis.

■ **MANAGEMENT OF M2M DATA:**

- M2M TECHNOLOGY IS ABLE TO MANAGE VARIOUS DATA USING FOLLOWING 7 STEPS:
- THESE 7 STEPS ARE RESPONSIBLE FOR COMPLETE MANAGEMENT, MONITERING AND CONTROLLING OF DATA DURING THE IOT PROJECT IMPLEMENTATION.
- The data flow from the moment it is sensed. (e.g. by a wireless sensor node)
- Dealing with M2M data may be break down into several stages, which not all of the stages are necessary in every solution, and may be used in case to case.
- Additionally, the degree of focus in each stage heavily depends on the actual use of requirements put upon the data as well as the infrastructure.
- 7 steps/stages of M2M data management:
 - 1. Data generation
 - 2. Data acquisition
 - 3. Data validation
 - 4. Data storage

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- 5. Data processing
- 6. Data retrieval
- 7. Data analysis

1. Data generation:

- Data generation is the first stage within which data is generated actively or passively from the device, system, or as a result of its interactions.
- The sampling of data generation depends on the device and its capabilities as well as potentially the application needs.

2. Data acquisition(achievement):

- Data acquisition deals with the collection of data (actively or passively) from the device, system, or as a result of its interactions
- The data acquisition systems usually communicate with distributed devices over wired or wireless links to acquire the needed data, and need to respect security, protocol, and application requirements.

3. Data validation:

- Data acquired must be checked for correctness and meaningfulness within the specific operating context.
- As real-world processes depend on valid data to draw business-relevant decisions, this is a key stage, which sometimes does not receive as much attention.

4. Data Storage:

- Machines generate an incredible amount of information that is captured and needs to be stored for further processing.
- As this is proving challenging due to the size of information, A balance between its business usage vs. storage needs to be considered.
- Due to the massive amounts of M2M data, as well as their envisioned processing (e.g. searching) specialized technologies such as massively parallel

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Processing DBs, distributed file systems, cloud computing platforms, etc. are Needed.

5. Data processing:

- This stage data is processing and work start.
- Data processing enables working with the data that is either at rest (already stored) or is in-motion (e.g. stream data).
- The scope of this processing is to operate on the data at a low level and enlarge them for future needs.

6. Data Retrieval:

- M2M data may declare critical business vision, and hence their lifecycle management should include not only the achievement and use, but also the end-of-life of data.
- If the data is erased or removed, residues may still remain in electronic media, and May be easily recovered by third parties often referred to as data retrieval.

7. Data Analysis:

- In this stage all requirement and points are study and then analysis the data.
- The analysis of data at this stage heavily depends on the domain and the context of the data.
- For instance, business intelligence tools process the data with a focus on the aggregation and key performance indicator assessment.
- This stage is the basis for any sophisticated applications that take advantage of the information hidden directly or indirectly on the data, and can be used. Where we focus on data science and knowledge management.

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Q-12)What is iot business process? (1M)

Answer:

- A **business process** is a collection of related events, activities and decisions.
- It involves a number of factors and resources, which provides valuable outcome for the organization and the customer.

Q-13)Write a note on Business processes and objective of business process in IoT. 3M/5M.

Introduction:

- A business process refers to a series of activities, often a collection of interrelated processes in a logical sequence, within an enterprise (Company or Organization), and leading to a specific result.
- There are many types of business processes like 1) management, 2) operational, and 3) supporting.
- all of which aim at achieving a best solution for any task in business.
- Several methods and techniques have been developed for their modeling, such as the Business Process Model and Notation (BPMN), which graphically represents business processes in a business process model.

➤ Objective Of Business Processes in IOT:

- To improve **business operations**, companies need to learn how to identify **Business processes using IOT technology**.
- Global industries are learning and experimenting with the IoT.
- They can utilize IoT technologies more effectively when they understand the technology and the business processes structured around it.
- It is important for businesses to understand how they can use the

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IoT to collect sensor data intelligently from various users and process this data in the cloud architecture.

- Businesses have to consider the IoT as a disruptive technology.
- This disruption is at various stages in various businesses. The speed at which companies like Google, Samsung, NXP, ARM, Intel and Apple are investing billions of dollars to create innovative applications around the IoT, there is no going back to old, non-smart technologies.
- Rockwell automation, Honeywell, Microsoft, SAP, BOSCH, IBM, INFOR and XMPRO are the leading organization for IOT business processes.

- Businesses processes using IOT gives automation offered by machines embedded in Technologies

- The decreasing cost of information exchange between the real-world and enterprise systems with the advancement of M2M.

- Ex.: Initially all these interactions were human-based (e.g. via a keyboard) or human-assisted (e.g. via a barcode scanner); however, with the prevalence of RFID, WSNs, and advanced networked embedded devices, all information exchange between the real-world and enterprise systems can be done automatically without any human intervention and at blazing speeds.

- (easy way last point- in any business all the process and interaction were human based but if business put iot technology so all the process and operation done automatically without human help).

- Objective of business process in iot is
 - (i) profit earning
 - (ii) market share/creation of customer.
 - (iii)innovation and utilization of resource.
 - (iv)increase productivity.

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Q-14) what is BPMN ?

ANS:-

- Bpmn is used to define information exchange during an iot implementation.
- We should describe how bpmn workflow engine will collect data.
- Also detail how data will be process and what type of decision automation is require.
- It is flow chart method to describe step by step process in business.
- It is software.
- Business process design with powerful bpmn software.

Q-15) Write note on XAAS.(3/5M)

Ans:-

Objective:

- To reduce local management of hardware, cost of hardware and storage as well as capacity.

Definition of Cloud Computing:

- Cloud computing is the delivery of computing service.
- Include server, storage, data base, networking , software analysis, and intelligence over internet to offer fast innovation ,flexible resource , and economies scale.

Main Things of Cloud Computing:

*** Cloud computing has main 4 things:**

1. Compute: It requires collecting basic data from the various sources.
2. Storage: It is always perform when data is available in server for the storage.
3. Data Processing: It is important thing that was performed after data storage.
4. Distribution Services: It is final thing in cloud to distribute meaningful data to various

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Number of sources.

Usefulness of Cloud Computing Service as a XAAS:

1. Any thing as a service(xaas)
2. Some common type of xaas include like saas , paas, iaas and many more.
3. It provides on demand self service for various IOT based business platforms.
4. It provides broad network access in global network area to fulfill all your needs.
5. It supports almost all types of resource pulling from various M2M devices.
6. It provides rapid stability in data management/sharing.
7. It's a pure measured service so you can get definite results based on your data.

Deployment models:

❖ There are 4 main deployment models of Cloud computing.

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

1. Private Cloud:

- The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g. business units). It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may Exist on or off premises.

2. Community Cloud:

- The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns

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(e.g. mission, security requirements, policy, and compliance considerations).

- It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises.

3. Public Cloud:

- The cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination thereof. It exists on the premises of the cloud provider.

4. Hybrid Cloud:

- The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability.

Q-16) Explain Knowledge management in detail.5M

Or

Write a note on knowledge management architecture.5M

Or

Explain Data, Information and Knowledge concepts in detail.5M

ANS:

- Knowledge management is the process of creating, sharing, using and managing the knowledge and information of an organization.

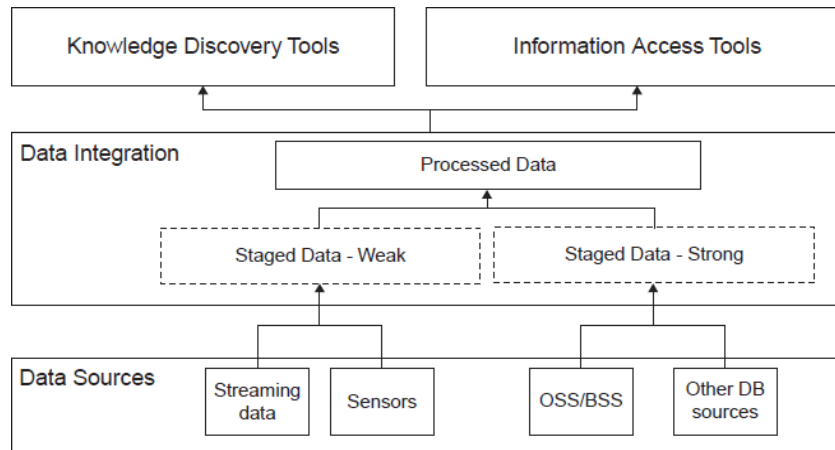
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- Figure outlines a high-level knowledge management reference architecture that illustrates how data sources from M2M and IoT may be combined with other types of data.
- Knowledge management reference architecture:
- 3 layer architecture, IT has 3 layers :-
 - (1) Data sources,
 - (2) Data integration,
 - (3) Knowledge discovery and information access.

1. Data Sources:-

- Data sources refer to the broad variety of sources that may now be available to build enterprise solutions.
- There are several types of such data like big data, Polymorphic data, heterogeneous data, Temporal data, real time data etc.

2. Data Integration:-

- The data integration layer allows data from different formats to be put together in a manner that can be used by the information access and knowledge discovery tools.
- Staged Data: Staged data is data that has been abstracted to manage the rate at which it is received by the analysis platform.

- ❖ There are two main types of data: Strong data and weak data.

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➤ **Strong Type Data:**

- Strong type data refers to data that is stored in traditional database formats, i.e. it can be extracted into tabular format and can be subjected to traditional database analysis techniques.

➤ **Weak Type Data:**

- Weak type data is data that is not well structured according to traditional database techniques.
- Examples are streaming data or data from sensors. Often, this sort of data has a different analysis technique compared to strong type data.

Processed data:-

- Processed data is combined data from both strong and weak typed data that has been combined within an IoT context to create maximum value for clear decision making process.

Information access tools:-

- Information access relates to more traditional access techniques involving the creation of standardized reports from the collation of strong and weak typed data.
- Information access essentially involves displaying the data in a form that is easily understandable and readable by end users.

3. Knowledge Discovery:-

- Knowledge Discovery, meanwhile, involves the more detailed use of ICT (Information and Communication Technology) in order to create knowledge, rather than just information, from the data..

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Q-17) Explain M2M and IOT analytics in detail. 5M

ANS.

- IOT analytics is the application of data analytics tools and procedure to realize value from the huge volume of data generated by connected IOT devices.
- IOT analytics refer to analyzing and examining the data obtain from the device and sensor.
- IOT data can be considered as a subset of big data. Big data is characterized by 3V's Model...
 - (I) Volume :- Amount of data.
 - (II) Variety :- The number of different types of data and devices.
 - (III) Velocity :- The speed of data processing

Types of Data Analytic

1) Streaming Analytics :-

- Real time data streaming are analyzed in this process to detect urgent situations and immediate action.
- IoT applications based on...
- Ex. – Financial Transactions, Traffic analysis etc. Can benefit from this method.

2) Spatial Analytics :-

- This is the data analytics method that is used to analyze geographic patterns to determine the spatial relationship between the physical objects.
- Ex:- Location based IoT applications, such as smart parking applications can benefit from this form of data analytics.

3) Time Series Analytics :-

- As the name suggests, this form of data analytics is based upon the time based data which is analyzed to reveal associated trends and patterns.
- Ex:- IoT applications, such as weather forecasting applications and health monitoring system can benefit from this form of data analytics method.

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UNIT-2 REFERENCE ARCHITECTURE.

Q-1) Introduction of reference architecture.

Ans:-

- Here provide a detailed conceptual overview of an M2M/IoT reference architecture.
- The term “Architecture Reference Model” (ARM) is borrowed from the IoT Architecture (IoT-A).
- Here also describe a combination of a reference model and a reference architecture.
- **A reference model is a model** that describes the main conceptual entities and how they are related to each other.
- **the reference architecture** aims at describing the main functional components of a system as well as how the system works, how the system is deployed, what information the system processes, etc.
- An ARM is useful as a tool that establishes a common language across all the possible stakeholders of an M2M or IoT system.

Q-2) Explain state of art . or explain state of art in reference architecture.(2m)

Ans:-

- State-of-the-art refers to the highest level of general development, as of a device, technique, or scientific field achieved at a particular time.
- **Four most popular Reference Architectures and Models exist for M2M and IoT systems:**
 - 1) European Telecommunications Standards Institute(ETSI) M2M/oneM2M
 - 2. International Telecommunication Union –Telecommunication (ITU-T) sector view
 - 3. Internet Engineering Task Force(IETF) architecture fragments
 - 4. Open Geospatial Consortium(OGC) architecture

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Explain European Telecommunications Standards Institute architecture in detail.3M/5M(etsi in detail)

One M2M/M2M

- The oneM2M is global organization which creates technical specifications to ensure that Machine-to-Machine Communication works efficiently.
- The goal of organization is to create a global technical standard for security , more real world application, and environmental solution for machine to machine and iot technologies based on requirements.
- One m2m enable an eco system to support a wide range of application and services such as smart cities grid, connected car , home automation, public safety and health.

Etsi:-(etsi m2m)

- The European Telecommunications Standards Institute is an independent, not-for-profit, standardization organization in the field of information and communications.
- ETSI supports the development and testing of global technical standards for ICT(information and communications technology)-enabled systems, applications and services.
- Headquarters: Sophia Antipolis, France
- Founded: 1988.
- It is the initial promoter of the oneM2M action(leadership) .
- The ETSI M2M specifications are based on specifications from ETSI as well as other standardization bodies such as the IETF (Internet Engineering Task Force), 3GPP (3rd Generation Partnership Project), OMA (Open Mobile Alliance), and BBF (Broadband Forum).

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- ETSI M2M produced the first release of the M2M standards in early 2012, while in the middle of 2012 seven of the leading Information and Communications Technology (ICT) standards organizations (ARIB, TTC, ATIS, TIA, CCSA, ETSI, TTA) formed a global organization called oneM2M Partnership Project (oneM2M) in order to develop M2M specifications, promote the M2M business, and ensure the global functionality of M2M systems.

■ ETSI M2M High-Level Architecture

- This high-level architecture is a combination of both a functional and topological view showing some functional groups (FG) clearly associated with pieces of physical infrastructure (e.g. M2M Devices, Gateways).
- There are two main domains in high level architecture, 1) network domain and 2) device and gateway domain.

device and gateway domain

M2M Device:

- This is the device of interest for an M2M scenario, for example, a device with a temperature sensor.
- An M2M Device contains M2M Applications and M2M Service Capabilities.
- An M2M device connects to the Network Domain either directly or through an M2M Gateway:

****M2M Area Network:**

- LAN or PAN(Bluetooth, Zigbee)and provides connectivity between M2M Devices and M2M Gateways.

****M2M Gateway:**

- Gateway acts as a proxy between M2M device and the Network Domain. Gateway runs M2M application using M2M service capabilities.

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2) Network Domain:-

- **Access Network:** Access Network Technologies are fixed wired (xDSL, HFC) and wireless (Satellite, UTRAN, E-UTRAN W-LAN, WiMAX).

M2M Service Capabilities:

- Service efficiency Provide M2M functions that are to be shared by different applications.

M2M Applications:

- utilize the M2M Service Capabilitie

Network Management Functions:

- Manage the Access and Core Network (ex .Fault Management, supervision).

M2M Management Functions:

- security identity(security icard) .
(i)M2M Service Bootstrap Function (MSBF)
ii. M2M Authentication Server (MAS).

Q.4 Explain International Telecommunication Union _Telecommunication sector view architecture in detail. Or (4-Layer Architecture of IoT) (5M)

■ ITU:-

- ❖ The international telecommunication union is an agency of the us(united states).
 - ❖ Whose purpose is to co ordinate telecommunication operation and services throughout the world.
 - ❖ Found:- 17 may 1865
 - ❖ Hq:- Geneva (Switzerland)
 - ❖ ITU-T is subsidiary of itu.
 - ❖ It is global standard of iot.
- there are four layer in itu-t like
 - i. application layer
 - ii. service and application support layer

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- iii. network layer
- iv. device layer

- now we can explain each of above layer in detail.

1) Application Layer:

- IoT Application(mobile app) to access IoT System.

2) Service & Application Support Layer:

- I. **Generic service capabilities** : Data processing and Data storage
- II. **Specific service capabilities**: specific application domains like e-health.

3) Network Layer:-

-- Networking capabilities like Mobility Management, Authentication, Authorization, and Accounting (AAA), and Transport Capabilities such as connectivity for IoT service data.

4) device layer:-

--**Device Capabilities**: direct interaction with the communication network(sensors, actuators).

-- Gateway Capabilities:

- indirect interaction with the communication network.
- multiple protocol support and protocol conversion in order to bridge the Network Layer capabilities and the device communication capabilities.

■ Management Capabilities:

- FCAPS model (Fault, Configuration, Accounting, Performance, Security), Device management, software updates, activation/deactivation, network topology management and traffic management.

■ Security Capabilities:

- Authentication, Authorization, and Accounting (AAA), key exchange,

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message confidentiality support. specific application, e.g. mobile payment.

Q-5) Internet Engineering Task Force (IETF) architecture fragments.

Ans :- **IETF:**

- It is body that define standard operating internet protocol such as tcp/ip.
- It is responsible for the management and development of the internet protocol concept.
- Which include tcp and ip.

- IETF has defined three working groups for M2M and IoT:
 - 1) 6LoWPAN (IPv6 over Low-power WPAN) (wpan wireless personal area network)
 - 2) CoRE (Constrained RESTful Environments)
 - 3) ROLL (Routing Over Low power and Lossy networks)

**** it is use 2 layer :-like 1)adaption layer (2) application support layer.**

1) **Adaptation Layer:**

- It is position between the Physical/Data Link and the Network Layer.

2) **Application Support Layer:**

- It is IETF Constrained Application Protocol (CoAP), which provides reliability and Restful operation support to applications

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Q-6) Open Geospatial Consortium(OGC) architecture.

Ans:-

- The Open Geospatial Consortium (OGC 2013) is an international industry consortium of a few hundred companies, government agencies, and universities that develops publicly available standards that provide geographical information support to the Web, and wireless and location-based services.
- Hq:- Rockville.(Usa)
- Founded:- 1994.
- OGC includes the Sensor Web Enablement (SWE) (OGC SWE 2013) domain working group, which develops standards for sensors:
- Discovery of sensor systems and observations that meet an application's criteria.
- Discovery of a sensor's capabilities and quality of measurements.
- Retrieval of real-time observations.
- Subscription / publishing of alerts to be issued by sensors.

OGC functional architecture and interactions:-

1) Sensor Observation Service (SOS) :

- This is a service for requesting, filtering, and retrieving observations and sensor system information.

2) Sensor Planning Service (SPS) :

- It define interface for queries that provide information about the capability of sensor and how to task the sensor.

3) Observations and Measurements (O&M) :

- which is a model and an XML schema for describing the observations and measurements for a sensor.

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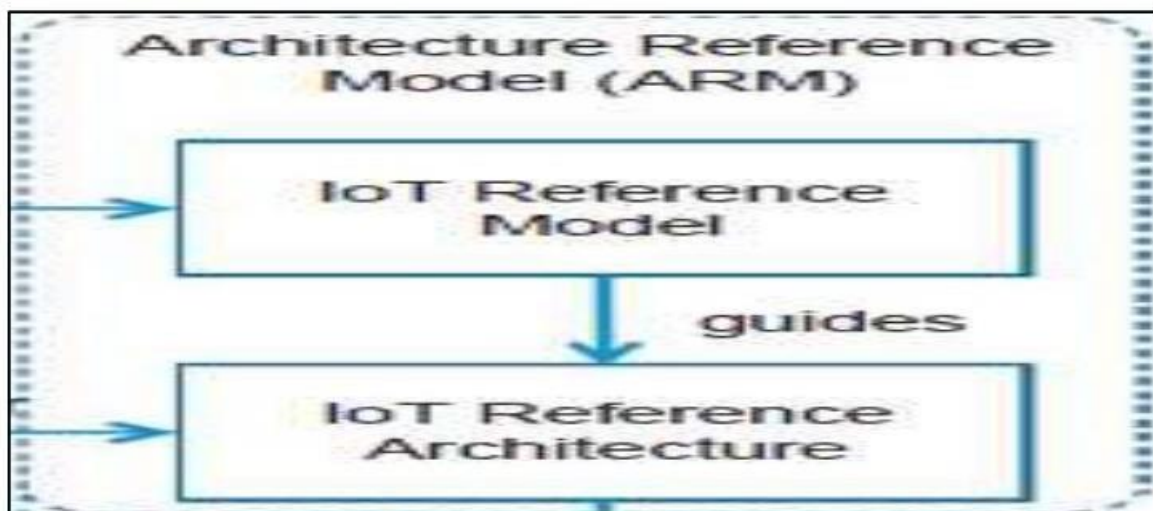
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Q-7) Explain ARM(Architecture reference model).

Ans:-

- The term “Architecture Reference Model” (ARM) is borrowed from the IoT Architecture (IoT-A).
- ARM consists of two main parts :
- **1. IoT Reference Model:** This Model describes the main conceptual entities and how they are related to each other.
- **2. IoT Reference Architecture:** It describes the main functional components of a system as well as how the system works, how the system is deployed, what information the system processes etc.



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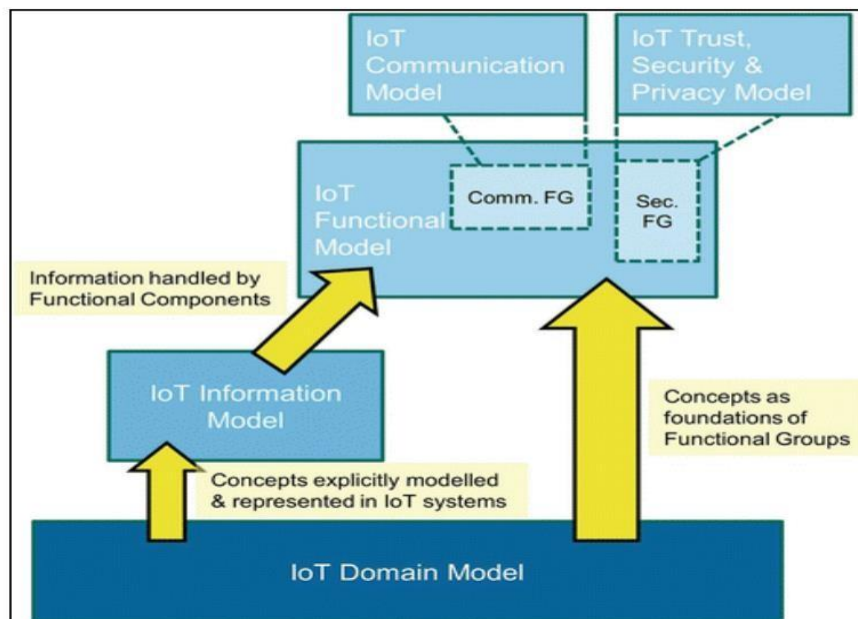


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Q-8) Explain IOT reference model in detail.

❖ **IoT Reference Model [shortcut : DIFCS]**



- Reference Model consists:
 1. Domain Model
 2. Information Model
 3. Functional Model
 4. Communication Model
 5. Trust, Security and Privacy Model

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1) Domain model:-

- Primary and the key model
- Domain Model describes definition of the main concepts, their responsibilities and their relationships of a particular area of interest.
- It also helps in exchange of data between domains easily.
- It includes a set of physical devices that connect directly or through gateway devices to a communication network that allows them to exchange information with other devices, services, and applications.
- The main purpose is to generate a common understanding of the target domain in question.
- It helps us structuring an application scenario.
- As communication with the physical world through remotely (software) is the key for the IoT.

Augmented Entity: (boost/develop/expand)

1. Physical Entity
2. Virtual Entity

1) Physical entity :-

- Fundamental interaction is between a human/application with the physical world object or place.
- User (application is also a User) and a Physical Entity (car, AC, TV, cloth, animals etc) are two concepts that belong to the domain model.

2) Virtual entity:-

- A Physical Entity is represented in the digital world as a Virtual Entity.
- A Virtual Entity represents current state of Physical Entity(e.g. the parking spot availability, bulb on/off).
- A Virtual Entity can be 3D models, database entries.

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Digital Artifact:

- Passive Digital Artifact (PDA): a database entry
- Active Digital Artifact (ADA): application software.

Devices:

- Three types of devices:
 - 1) Sensor
 - 2) Actuators
 - 3) Tag.

1) Sensor :-

- It provides data about the Physical Entity they monitor.
- It converts physical parameters like temperature, distance, images into electrical signals.
- Information from sensors can be recorded and stored for processing.

2) Actuators:

- converts electrical signals to a force (e.g. turn on/off a switch)

3) Tag:

- A tag as a Physical Entity is a paper-printed immutable barcode or Quick Response (QR) code contains a unique identification.
- The reader Device operating on a tag is typically a sensor.(RFID tag)

2)information model:-

- Information Model defines the structure (e.g. relations, attributes, services) of all the information for Virtual Entities
- The IoT Information Model is a model that provides a structure for the information being handled by IoT Systems.
- It deals with the representation, gathering, processing, storage and retrieval of information and as such is used as a basis for defining the functional interfaces of the IoT system.

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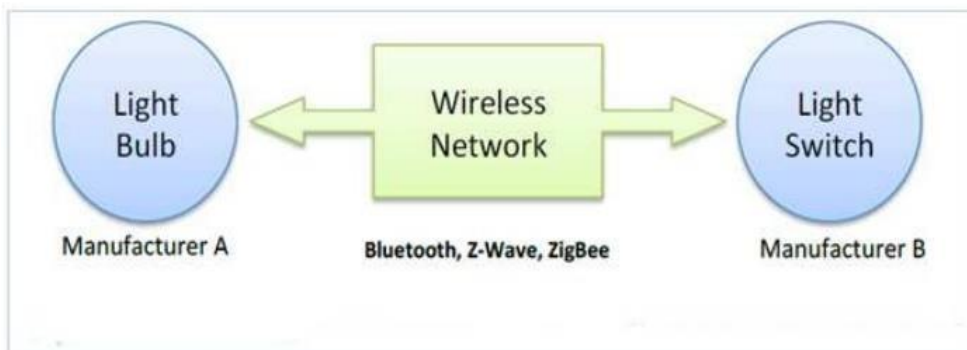
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3) Functional Model:-

- The Functional Model contains both the Functionality Groups (FGs) and the interaction between parts.
- From the main abstractions identified in the Domain Model the FGs are derived.
- Various types of fg are available like
 - (i) Device function model
 - (ii) Communication function group
 - (iii) Service functional group
 - (iv) Virtual entity functional group.
 - (v) Management functional group
 - (vi) Security group.

4) Communication model:-

a) Device to device communication.



Example of device-to-device Communication model

- Device to device communication model represent two or more device that directly connect & communication between each other instead of server.
- b) Device to cloud communication
- In a device-to-cloud communication model, the IoT device connects directly to an Internet cloud service like an application service provider to exchange data and control message traffic.

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c) Device to gateway communication:-

- There is application software operating on a local gate way device, which act as an intermediary between the device and cloud service and provide security and protocol translation.

5) Safety, privacy, trust, security model

- Safety comes first , because in iot system actuator that could harm object.
- Designer add safety in the interaction between users , services , resources , and device.
- Authentication is a function process of verifying who you are?

Q-9 Explain IOT reference architecture.(FIDO).

Ans:-

- The Reference Architecture is a starting point for generating concrete architectures and actual systems.
- It does not contain details about the environment where the actual system is deployed.
- The Reference Architecture as a set of architectural views:
 1. **Functional View:** Description of what the system does, and its main functions.
 2. **Information View:** Description of the data and information that the system handles.
 3. **Deployment and Operational View:** Description of the main real world components of the system such as devices, network routers, servers, etc.
 4. **Other relevant architecture view.**

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1) Functional view:-

- It consists of the Functional Groups (FGs), each of which includes a set of Functional Components (FCs).

- (i) Device and Application functional group
- (ii) Application functional group
- (iii) Communication functional group.

- It is also use network communication like
- 1) End-to-End Communication
- 2) Network Communication
- 3) Hop-by-Hop communication.

2) Information view:-

- The information view consists of
- (a) Information description
- (b) Information lifecycle and flow (how information is created, processed, and deleted).

a) Information description :-

- Virtual Entity context information(Ex. the attributes)
- Associations between Virtual Entities and related IoT Services.
- IoT Service Descriptions
- Resource Descriptions,
- Device Descriptions
- IoT Business Process Model
- Security information
- Management information

(b) Information flow and lifecycle:-

- (i) from the device
- (ii) from the application.

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- It is use four(4) message exchange patterns.

(i) push- pattern :-

- it is one-way communication.
- A server sends data to a client that receives the data
- The server knows the address of the client and the client is constantly awaiting messages from the server.

(ii) Request/Response-pattern:-

- A client sends a request to a server.
- The server will receive the request and will send a response back to the client.

(iii) Subscribe/Notify

- It allows an asynchronous way of communication between two parties without the client waiting for the server response.

(iv) Publish/Subscribe:-

- It allows a loose coupling between communication partners.
- There are services offering information and advertise those offers on a broker component.

3) Deployment and Operational View:

- It depends on the specific actual use and requirements\
- It is important to address how devices can communicate using different technologies and operate in proper way.
- It is set of guidelines to choose best model from different designs.
- After complete analysis of all the technological possibilities, Domain Model found three main element groups: Devices, Resources and Services.

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→ **Viewpoints** used in the Deployment and Operation view:

- (i) Domain Model diagram : UML diagram
- (ii) Functional Model : Functional group
- (iii) Network connectivity Diagram
- (iv) Device Descriptions & resource requirements.

→ **Technologies:**

- I. Sensor & Actuator Networks
- II. RFIDs and smart tags
- III. WiFi
- IV. Cellular network.

Sensors possibility:

- (i) Cabled sensor
- (ii) Wireless sensor.
- (iii) Low power wifi sensor.

→ **Requirements:**

- **Life time :-** all the installed devices must operate unassisted for more than 2 years.

→ **Data Storage:**

- (i) **Local only:** Data is stored on the device, it may get lost.
- II). **Web only:** No local copy is maintained by devices. Data is sent to the cloud.
- III) **Local with web cache:** A hierarchical structure for storing data is maintained from devices up to database servers.

→ **where to deploy the software :**

- (i) on smart object
- (ii) on gateway.

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4.Other relevant architecture view.

-- **Two most important views:**

- I. Physical Entity View
- II. Context View

■ **Physical Entity View:**

- Physical Entity View describes the Physical Entities from the IoT Domain Model in terms of physical properties
- It describes the relationship between Physical Entities.

■ **Context view:-**

- Describes the relationships, dependencies, and interactions between the system and its environment.(people, systems, external entities)

Q-10.Explain real world design constraints- introduction.(2)

Ans:-

- Outlines the technical design when developing and implementing M2M and IoT system in the real world.
- Devices are Connected and designed in such a way that they capture and utilize every bit of data.
- The system designer has selected the appropriate communications technologies to bridge the device and application domains :

- **The device (hardware)**
- **Representation (data and visualization)**
- **Interaction (local or remote control).**

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Q-11. Explain technical design constraints- hardware is popular again.

Ans: -

- It is include
 - a. device and network
 - b. functional requirement.
 - c. Sensing and communication field.
 - d. Programming and embedded intelligence
 - e. Power
 - f. Gateway
 - g. Non functional requirements
 - h. Financial cost

a. Device and network:-

- Devices makes network, they must have
- Energy source (batteries)
- Computational capability (MCU-multipoint control unit)
- Communications interface (Radio Frequency Integrated Circuit- RFIC, NIC-Network interface card)
- Memory (program and data)
- Sensing and Actuation capability.
- These must be integrated in such a way that the functional requirements can be satisfied.

b. functional requirement:-

- Sensing and actuating capabilities are basic functional requirements.
- The device must be capable of sensing data from the environment.
- Sensors are difficult to perform proper work.
- The sensors may directly measure the changes (e.g. temperature) or may be used to derive data.
- Sensing may be expensive or unjustifiable at scale. For Ex. Air and water quality monitoring systems.

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c. Sensing and communication field:-

- The sensing field is importance either data is local or distributed
- The distance between sensing points and Gateway matters.
- It also depends on the communications technologies selected.
- Devices must be placed in close enough to communicate.
- If the distance is too great, routing devices are necessary.

d. Programming and embedded intelligence:-

- There are various computational architectures like signal conditioning, communications media, peripheral components (sensors, actuators, buttons, screens, LEDs), etc.
- Devices in the IoT are fundamentally different or sometimes same.
- An application programmer must consider the hardware design and its capabilities.
- Application-level logic performs the local processing on sensor readings.
- Careful implementation of the embedded software is required to ensure that the device operates as Desired.
- The embedded software may be changed device by device.
- It is difficult to combine different functionalities of devices with logical design (software)

e. Power:-

- Power is main point for any IoT device.
- Depending on the application, power may be provided by the mains, batteries or any other sources.
- In prior development of IoT device, the power requirements are measured.
- This helps designer to estimate the cost of maintenance over time.
- limited power supply is used (like a battery), application has short future.

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f. Gateway:-

- Depending on the application, power considerations Gateway devices are selected.
- Gateway works as a mediator between Devices and cloud storage.
- Gateway also works as data filtering, processing and managing.

g. Nonfunctional requirement:-

- Ease of use
- Easy to installation
- Easy to maintenance
- Easy to accessibility
- Easy to configuration of IoT applications.
- What kind of power supply can I use?
- alternative storage?
- Are there physical size limitations on the device?
- Can the additional electronics be easily integrated into the existing system?

h. Financial cost:-

→ Component Selection:

- The energy, sensors, actuators, memory, power, connectivity, physical, and other functional and nonfunctional requirements are considered.

→ Integrated Device Design:

- Printed Circuit Board (PCB) and Integrated Circuit (IC) are designed on the basis of functional and non-functional requirements.

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Q-12. Explain data representation and visualization.

Ans:-

- Connecting devices and generating data alone are not achievements.
- All the big data generated from different IoT devices are not useful until you can not analyze them and translate them into a pattern that is easy to understand, process and present on visual language.
- For this reason, Data Visualization is becoming an integral part of IoT.
- Data visualization is the presentation of data in a graphical format.
- It is possible with Data Visualization Tools. Data Visualization will help us to have strong analytics.
- Visualizing and analyzing data will:
 - A. Realize your business and discover hidden patterns and trends in your IoT data
 - B. Improve decision making
 - C. Getting right messages to the right customers
 - D. Growth and Updating in new Product.

Q-13. Explain interaction and remote control.

Ans :-

- Authentication and availability challenges, different software architectures in operating systems, running on different devices and control through remotely continuously are difficult task.
- The main thing is to deliver end-to-end quality of service
- (QoS) to customers.
- **Device Management** (specifically reprogramming and reconfiguration) for embedded devices deployed in inaccessible locations.
- **Service Agreements (SA) or Service Level Agreements (SLA)** should to be defined.

End-to-end latency, security, reliability, availability, times between failure and repair, responsibility are all likely to feature in such agreements.

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Unit-3

IOT data link layer & network protocol

Q-1:- what is PHY/MAC Layer ? (1 mark)

Ans :-

→ PHY Layer :-

- The phy layer means physical layer.
- It define physical and electrical characteristics of the network.
- It is responsible for managing the hardware that modulate and demodulates the rf bits.(rf Bit:-it means radio frequency wirelesstransmission using in iot)

→ Mac Layer:-

- Media access control
- it is responsible for sending and receiving rf frames.

Q-2. Explain PHY/MAC LAYER in detail (5m)

Ans:-

- in phy/mac layer we can discuss 3 main point likes

- (I) IEEE 802.15.4
- (II) IEEE 802.11(WIFI)
- (III) 3GPP MTC.

1) IEEE 802.15.4:-

- Institute of Electrical and Electronics Engineers (IEEE)
- It specifies the Physical layer and Media access control (MAC) layer
- IEEE 802.15.4 is a technical standard which defines the operation of low-rate wireless personal area networks (LR-WPANs)
- It focuses on low-cost, low-speed communication.

→ Limitations:

- Reliability and scalability issues
- Unbounded latency
- No guaranteed bandwidth.

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- It defines a frame format, headers including source and destination addresses, and how nodes can communicate with each other.
- IEEE802.15.4e was created to extend IEEE802.15.4 and support low power communication.

→ Features:-

1) Slotframe Structure:

- IEEE 802.15.4e frame structure is designed for scheduling and telling each node what to do.
- A node can sleep, send, or receive information.
- in the sleep mode, the node turns off its radio to save power and stores all messages that it needs to send at the next transmission opportunity.
- When transmitting, it sends its data and waits for an acknowledgment.
- When receiving, the node turns on its radio before the scheduled receiving time, receives the data, sends an acknowledgement, turn off its radio, delivers the data to the upper layers and goes back to sleep.

2) Scheduling:-

- Building the schedule, informing others about the schedule and other nodes will just follow the schedule.

3) Synchronization:

- **Acknowledgment-based mode:** nodes are already in communication and they send acknowledgment.
- **Frame-based mode:** nodes are not communicating and send an empty frame at pre-specified intervals (about 30 second typically).

4) Channel Hopping:

- Channel hopping for time slotted access to the wireless medium
- This introduces frequency diversity and reduces the effect of interference and multi-path fading.

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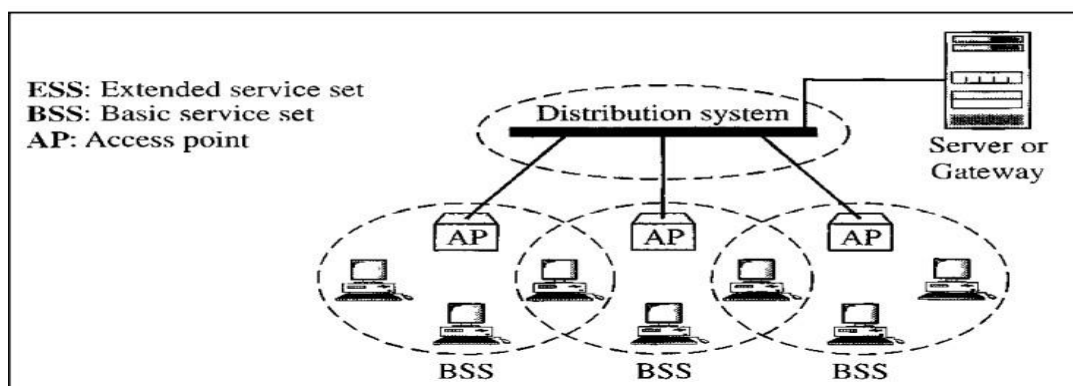
5) Network formation:

- It include network topology
- it include network layer.

2) IEEE 802.11(WIFI):-

- IEEE 802.11 is part of the IEEE 802 set of LAN protocols.
- It Is World's most widely used wireless computer networking standard.
- MAC and Physical layer protocols for implementing wireless local area network (WLAN).
- IEEE 802.11 standards also known as Wi-Fi, are the most commonly used wireless standards.
- WiFi or WLAN uses high-frequency radio waves instead of cables for connecting the digital devices including laptops, mobiles, tablets, and digital TVs in home and office networks.
- Public Wi-Fi access is everywhere - in cafes, hotels, airports etc.
- It is very easy for hackers to gain access and see exactly what you are sending: user names, passwords, credit card etc.
- 802.11a, 802.11b, 802.11g, 802.11n, and 802.11ac, 802.11ah, others all are family of IEEE 802.11.
- 802.11b and 802.11g use the 2.4 GHz radio frequency, while 802.11a uses 5 GHz.

IEEE 802.11 Architecture



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- Extended Service Set (ESS) – It is a set of all connected BSS
- Basic service set(BSS) – It is a set of AP.
- Distribution System (DS) – It connects access points in ESS.

→ 802.11ah

- Original WiFi standards are not suitable for IoT applications due to their frame overhead and power consumption.
- 802.11ah task group was developed to develop a standard that supports low overhead, power friendly communication.
- 802.11 ah published in year 2017.
- It is wireless networking protocol.
- It is also called wi-fi Halow.(HEY-Low).

• Features of 802.11 ah:-

1) Synchronization Frame:

- Frame means data unit to transfer into network.
- Frame synchronization is a method of finding valid data in a transmission that consists of data frames.
- The transmitter inserts a fixed data pattern at the start of each data frame.

2) Efficient Bidirectional Packet Exchange:

- This feature allows the sensor device to save more power by allowing both uplink and downlink communication between the access point and the sensor and allowing it to go to sleep as soon as it finishes the communication.

3) Short Mac Frame:

- The normal IEEE 802.11 frame is about 30 bytes, which is too large for IoT applications.
- IEEE 802.11ah use about 12 bytes.

4) Increase Sleep Time:

- 802.11ah is designed for low-power sensors and, hence, it allows a long sleep period of time and waking up infrequently to exchange data only

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3) **3GPP MTC:-**

- 3GPP MTC stands for 3rd Generation Partnership Project Machine Type Communication.
- 3GPP is a collaboration between groups of telecommunications standards associations.
- The 3GPP support team (also known as the "Mobile Competence Centre") is located at the ETSI.
- It is the standard body behind UMTS (Universal Mobile Telecommunications System), which is the 3G upgrade of GSM.
- 3GPP systems including the GERAN, the UTRAN, and the E-UTRAN support Machine Type Communication (MTC), which is also known as M2M.
- The 3GPP system provides services which are used for end-to-end communications between the MTC applications on the external network.
- The MTC has service-specific features:
 1. low mobility
 2. time controlled & time tolerant
 3. small data transmission.
 4. mobile originated
 5. MTC monitoring
 6. secure connection and priority alarm.
- 3GPP specifications also cover W-CDMA (Wideband Code Division Multiple Access), LTE (3GPP Long Term Evolution), LTE-Advanced, Europe's UMTS and Japan's FOMA (Freedom of Mobile Multimedia Access) networks.
- The project covers cellular telecommunications network technologies, including radio access, the core transport network, and service capabilities - including work on codes, security, quality of service.
- There are four Technical Specifications Groups (TSG) under 3GPP
 1. TSG GERAN for GSM EDGE radio access networks,

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2. TSG RAN for the UTRA/E-UTRA radio access networks in its two modes (FDD and TDD)
3. TSG SA for Service and Systems Aspects
4. TSG CT for Core Network and Terminals.

O-3. Explain WirelessHART in detail.

Ans:

- WirelessHART is a wireless sensor networking technology based on the **Highway Addressable Remote Transducer Protocol (HART)**.
- WirelessHART is a **DataLink Protocol** that operates on the top of IEEE 802.15.4 PHY and adopts **Time Division Multiple Access (TDMA)** in its MAC.
- WirelessHART uses a **2.4 GHz band**
- It is a secure and reliable MAC protocol that **uses advanced encryption** to encrypt the messages and offers **reliability (safely)**.
 - It consists of a network manager, a security manager, a gateway to connect the wireless network to the wireless devices.
 - The standard offer end to end security mechanism.
 - End to end security mechanism enforce security from source to destination.

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Q-4. Explain Z-wave.

Ans :-

- Z-Wave is a low-power MAC protocol IoT communication
- It covers about 30
- Data rate is upto 100kbps.
- Z-Wave protocol was developed by Zensys in 1999.
- It is suitable for small messages in IoT applications like light control, energy control, healthcare control, locks, swimming pools and garage door openers.
- less expensive, lower power
- alternative option of Zigbee.
- Zigbee and Z-Wave are wireless protocols that focus on connectivity within the smart home.
- Z-Wave operates on the 800-900MHz radio frequency range, while Zigbee operates on 2.4GHz.
- Unlike Wi-Fi, where devices have to connect to a central hub, Z-Wave devices all link up together to form a mesh network.

Q-5. Explain BLUETOOTH LOW ENERGY.

Ans :-

- Bluetooth low energy (Bluetooth LE) or Bluetooth smart or BLE is a short range communication protocol with PHY and MAC layer.
- Used for applications in the healthcare, fitness, security, and home entertainment industries, vehicle networking.
- Its low energy can reach ten times less than the classic Bluetooth.
- Used to transfer small amounts of data between nearby devices.
- All Mobile OS supports Bluetooth LE.
- Small size and low cost, long battery life and ease of deployment.
- It follows master/slave architecture.
- Master/slave is a model of communication for hardware devices where one device (Master) has a unidirectional control over one or more

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devices(Slaves).

- Android 4.3 introduces built-in platform support for Bluetooth Low Energy (BLE) in the central role and provides APIs that apps can use to discover devices, query for services, and transmit information.

→ BLE's M2M/IoT Applications:

- Blood pressure monitors
- Industrial monitoring sensors
- location-based information
- Public transportation apps



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O-6. EXPLAIN ZIGBEE SMART ENERGY.

ANS:-

- Zigbee communication is specially built to control sensor networks on IEEE 802.15.4 standard for wireless personal area networks (WPANs), and it is the product from Zigbee alliance.
- This communication standard defines physical and Media Access Control (MAC) layers.
- ZigBee smart energy is designed for a large range of IoT applications including smart homes, remote controls and medical device data collection systems
- Zigbee is a low-power, low data rate, low cost.
- Range of zigbee is 10 to 100 meter.’
- It was found in 1998.
- Less expensive than other wireless personal area networks (WPANs), such as Bluetooth , Wi-Fi.
- It supports a wide range of network topologies including star, peer-to-peer or tree.
- ZigBee standard defines two stack profiles: ZigBee and ZigBee Pro.
- These stack profiles support full mesh networking and work with low memory and processing power.

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Q-7. EXPLAIN DASH7.

ANS:-

- DASH7 Alliance Protocol (D7A) is an open source bi-directional wireless communication protocol
- for Wireless Sensor and Actuator Network.
- DASH7 is a wireless communication protocol. it operates in globally available Industrial Scientific Medical (ISM) band and is suitable for IoT requirements.
- DASH7 is developed by DASH7 Alliance.
- Found in year 2009.
- It is European ngo.
- It is mainly designed for scalable, long range outdoor coverage with higher data rate compared to traditional ZigBee.
- It is a low-cost solution that supports encryption and IPv6 addressing.
- Data transfer rate is up to 167 kbps.
- Use in Star or tree network topology (no mesh).
- DASH7 provides multi-year battery life, range of up to 2 km, low latency.

Q-8. Explain network layer.

Ans:-

- The network layer is divided into two sublayers
- 1. **Routing layer** which handles the transfer of packets from source to destination
- 2. **Encapsulation layer** that forms the packets.

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Q-9. Explain IP Address.

Ans :-

- IP Address is an identifier (unique address) for a computer or device in network.
- There are two types of IP addresses:
 - (i) IPv4
 - (ii) IPv6

Q-10. Explain IPv4.

Ans:-

- IPv4 Stands for Internet Protocol Version 4.
- It was the first version of internet protocol to be widely used in today's internet traffic.
- It is the underline technology that makes it possible for us to connect the devices to web
- Whenever device access internet it assigns a unique numerical IP address such as 192.168.1.1.
- To send a data from one computer to another through a web a data packet must be transferred across the network containing IP address of both the devices.
- IPv4 uses 32 bit (4 bytes) address which limits the address space to 2^{32} (4294967296 address).
- IPv4 is connectionless protocol used in packet switched layer network such as Ethernet.
- It provides the logical connection between network devices by providing identification of each device..
- There are many ways to configure IPv4 with all kind of devices including manual and automatic configuration depending on the network type.
- IPv4 address is divided into two parts:
 - (i) Network ID
 - (ii) Host ID.
- IPv4 uses 32 bit address for Ethernet communication named: A, B, C, D

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and E.

Class	Theoretical Address Range	Binary Start	Used for
A	0.0.0.0 to 127.255.255.255	0	Very large networks
B	128.0.0.0 to 191.255.255.255	10	Medium networks
C	192.0.0.0 to 223.255.255.255	110	Small networks
D	224.0.0.0 to 239.255.255.255	1110	Multicast
E	240.0.0.0 to 247.255.255.255	1111	Experimental

→ Class structure:-

- There are five class structure in IPv4 like
 - 1) Class a
 - 2) Class b
 - 3) Class c
 - 4) Class d
 - 5) Class e

1) Class A:-

- The first octets(octal ,byte) of class A IP address is a value from 1 to 127.
- First bit is always 0

2) Class B:-

- The first octets(octal ,byte) of class B IP address is a value from 128 to 191.
- First bit is always 10.

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3) Class C:-

- The first octets of class C IP address is a value from 192 to 223.
- The first three bits of first octet is always set to 110

4) Class D:-

- The first octets of class D IP address is a value from 224 to 239.
- The first four bits of first octet is always set to 1110.

5) Class E:-

- Range is 240 to 255.
- The first four bits of first octet is always set to 1111.

Q-11. Explain IPv6.

Ans:-

- IPv6 (Internet Protocol version 6) is the latest version of the Internet Protocol, the primary communications protocol.
- IPv6 was developed by the Internet Engineering Task Force (IETF)
- IPv4 is use 32 bits.
- IPv6 uses a 128-bits.
- IPv6 provides larger addressing space.
- IPv6 addresses, as commonly displayed to users, consist of eight groups of four hexadecimal digits separated by colons,
2001 : 0db8 : 85a3 : 0042 : 0000 : 8a2e : 0370 : 7334
- An IPv6 address is made of 128 bits divided into eight block.

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O-12. Explain 6LoWPAN

Ans :-

- 6LoWPAN stands for IPv6 over Low power Wireless Personal Area Network.
- 6LoWPAN is an open standard defined by the Internet Engineering Task Force (IETF).
- The 6LoWPAN technology utilise IEEE 802.15.4 to provide the lower layers for this low power wireless network system.
- It is necessary to have a method of converting the packet data into a format that can be handled by the IEEE 802.15.4 lower layer system.
- It was found in 2007.
- IPv6 requires the maximum transmission unit (MTU) to be at least 1280 octets. In contrast, IEEE 802.15.4's standard packet size is 127 octets.(1 octet = 8 bits).
- The specification supports different topologies including star or mesh, power consumption, low cost, scalable networks and long sleep time.
- Used in Home automation, smart meters, Industrial monitoring etc.

O-13. Explain 6TiSCH

Ans :-

- 6TiSCH stands for IPv6 over the TSCH(Time-Slotted Channel Hopping) mode of IEEE 802.15.4e.
- It is designed for low-power and lossy networks (LLNs).

→ History:-

- TSCH is the standard for industrial automation
- The TSCH mode was introduced in 2012 as in MAC portion of the IEEE 802.15.4 standard.
- 6TiSCH used for industrial standards and the convert of Operational Technology (OT) with Information Technology (IT).
- Time Slotted Channel Hopping or Time Synchronized Channel Hopping (TSCH) is a channel access method for shared medium networks.

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- TSCH can be seen as a combination of Time division multiple access and Frequency-division multiple access mechanism.
- 6TiSCH group will reuse existing protocols such as (ND), (6LoWPAN), and RPL.

Q-14. Explain ND.

Ans :-

- ND stands for Neighbor Discovery Protocol (NDP or ND).
- ND is used with Internet Protocol Version 6 (IPv6).
- ND replaces ARP, ICMP redirect messages, ICMP router discovery in IPv6.
- It was found in 1996.
- Neighbor discovery is a protocol that allows different nodes on the same link to advertise their existence to their neighbors, and to learn about the existence of their neighbors.

Q-15. Explain DHCP.

Ans :-

- DHCP stands for Dynamic Host Configuration Protocol.
- DHCP is created by IETF.
- It runs over UDP.
- It uses client-server model.
- It utilises 67(connection to server) and 68(connection to client) port numbers.
- DHCP server dynamically assigns an IP address and other network configuration to each device on a network so they can communicate with other IP networks.
- In most homes and small businesses, the router acts as the DHCP server. In large networks, a single computer might act as the DHCP server.
- The DHCP protocol requires no authentication so any client can join a network quickly. Because of this, it increases security risks.
- DHCP server's methods of allocating IP addresses:
 1. Automatic allocation
 2. Manual allocation.

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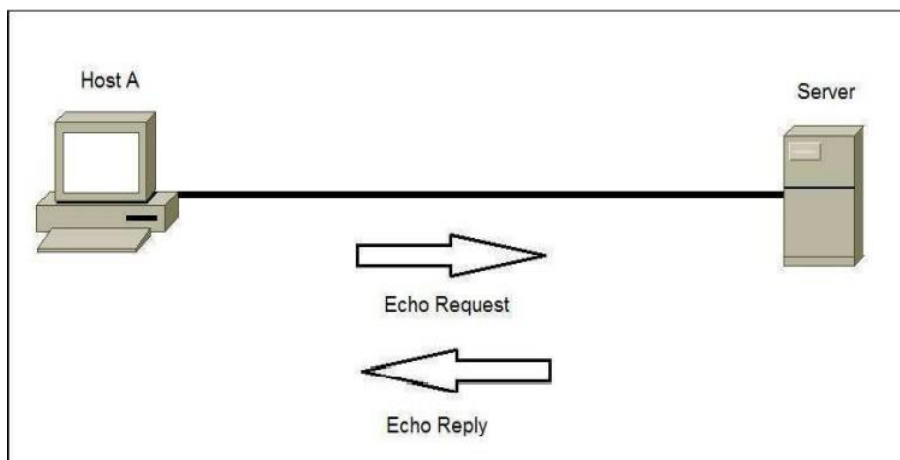
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Q-15. Explain ICMP.

Ans :-

- ICMP stands for Internet Control Message Protocol.
- ICMP is used for reporting errors and management queries.
- It is a supporting protocol and used by networks devices like routers for sending the error messages and operations information. e.g. the requested service is not available or that a host / router could not be reached.
- It was found in 1981.
- Any IP network device has the capability to send, receive or process ICMP messages.



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Q-16. Explain RPL.

Ans :-

- RPL stands for Routing Protocol for Low-Power and Lossy Networks.
- A low power and lossy network (LLN) is a network of embedded devices with limited power, memory and processing resources.
- Also chances of packet loss in transmission.
- RPL is a modified version of 6LoWPAN.
- RPL protocol works on Network Layer.

Q-17. Explain CORPL.

Ans :-

- An extension of RPL is CORPL, term as cognitive RPL.
- CORPL protocol works on Network Layer.
- CORPL is designed for cognitive networks
- Cognitive network is Advanced analytics, Autonomous, Predictive intelligence tools, big data with machine learning, maximize network resources.

Q-18. Explain CARP.

Ans :-

- CARP stands for Channel-Aware Routing Protocol.
- CARP is a distributed routing protocol designed for underwater communication.
- It can be used for IoT due to its lightweight packets.
- It perform two different functionality like network initialization and data forwarding.

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UNIT -4 TRANSPORT & SESSION LAYER PROTOCOLS.

→ Transport layer:-

Q-1) Explain TCP.

Ans:-

- TCP stands for Transmission Control Protocol.
- Together, TCP and IP define the basic rules for the Internet.
- TCP is defined by the Internet Engineering Task Force (IETF).
- Transmission Control Protocol / Internet Protocol (TCP/IP) the communication suite used to transmit data on the internet.
- TCP is a connection-oriented protocol, which means a connection is established and maintained until the application programs at each end have finished exchanging messages.

■ Features:

- Performs sequencing and segmentation of data.
- Reliable protocol
- TCP provides error and flow control.
- Determines how to break application data into packets that networks can deliver, sends packets to and accepts packets from the network layer.
- Handles acknowledgement of sent data.
- Handles retransmission of dropped or garbled packets.
- Supports host-to-host communication.

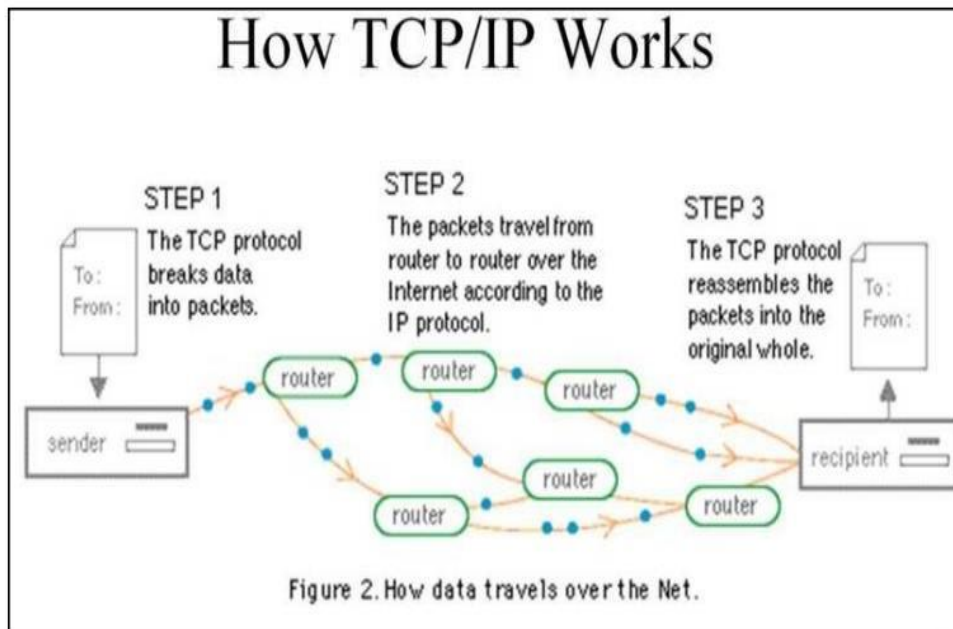
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- When a Web server sends an HTML file to a client, it uses the HTTP protocol to do so.
- The HTTP program layer asks the TCP layer to set up the connection and send the file.
- The TCP stack divides the file into packets, numbers them and then forwards them individually to the IP layer for delivery.
- Although each packet in the transmission will have the same source and destination IP addresses, packets may be sent along multiple routes.
- The TCP program in the client computer waits until all of the packets have arrived, then acknowledges those it receives and asks for the retransmission for lost packets, then assembles and arranges in sequence them(packets) into a file and delivers the file to the receiving application.

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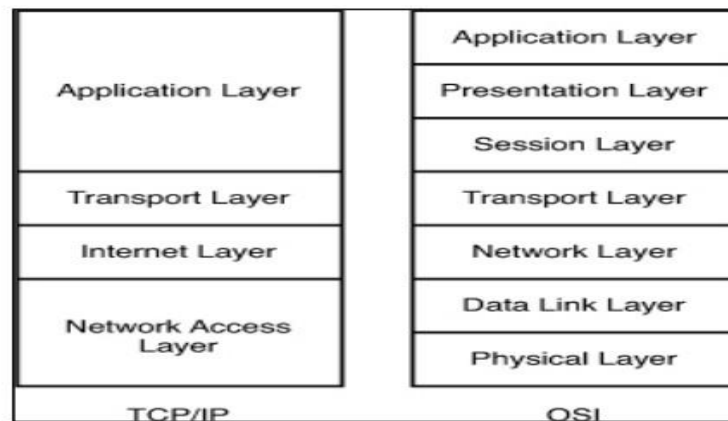
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TCP/IP Model V/s OSI Model



Q-2 EXPLAIN UDP.

Ans:-

- UDP stands for User Datagram Protocol.
- UDP is an alternative communications protocol to TCP.
- Both UDP and TCP run on top of the Internet Protocol (IP) and are sometimes referred to as UDP/IP or TCP/IP.
- UDP is mainly used for establishing low-latency connections between applications on the internet.
- UDP is unreliable and connectionless protocol.
- UDP sends messages, called datagram.
- UDP enables process-to-process communication.
- No Error control and flow control mechanism, so it saves bandwidth.
- It allows packets to be dropped and received in a different sequence than they were transmitted.
- No guarantee of: Data delivery and Data sequence.

→ Use:-

- UDP is used where speed and efficiency are more important than the

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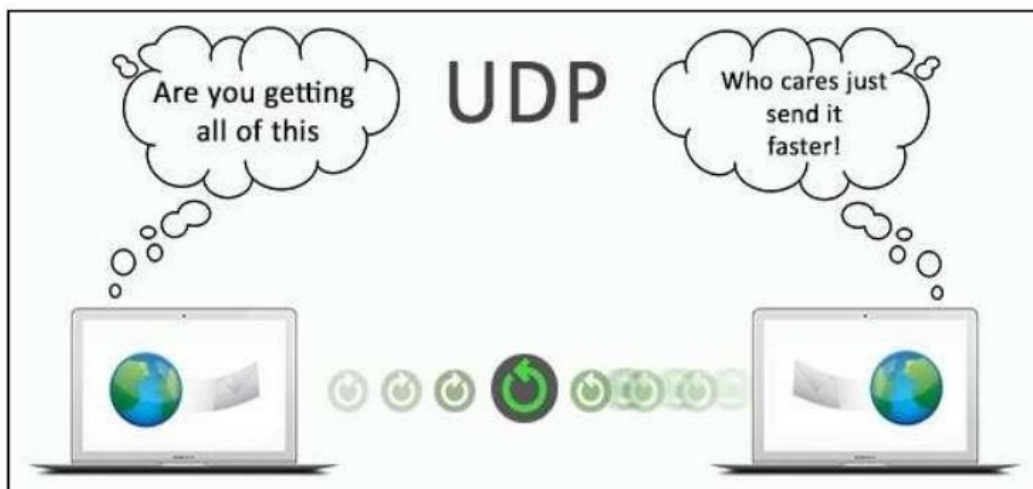
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reliability.

- UDP is light weight protocol.
- The data is sent without establishing or waiting for a connection.
- This means that a bit or segment of data can get lost during transportation.

→**UDP application:**

- Domain Name Services
- Simple Network Management Protocol
- File Transfer Protocol
- Routing Information Protocol.



Q-3.Explain MPTCP

Ans:-

- MPTCP Stand for multipath transmission control protocol.
- It is allow a tcp connection to use multiple path to maximize resource usage.
- It is as extension to existing tcp protocol at transport layer.
- MPTCP will be used in point to point or point to multi point connection

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environment.

→ Disadvantage of TCP

- Traditional TCP protocol cannot use all available network interfaces simultaneously.
- It can use any one network interface of system at a time.

Q-4) EXPLAIN DCCP.

ANS:-

- DCCP stands for Datagram Congestion Control Protocol.
- DDCP is message-oriented transport layer protocol.
- DCCP is useful for applications with timing constraints on the delivery of data.

→ USE :-

- Contains acknowledgment traffic and data traffic.
- Mainly used in applications like streaming (radio, TV) media, multiplayer, online games.

→ TWO MAIN FUNCTION:-

- The establishment, maintenance packets.
- Traffic control of datagram (message).

Q-5) EXPLAIN SCTP.

ANS:-

- SCTP stands for Stream Control Transmission Protocol.
- SCTP also referred as "next generation TCP".
- It is a connection- oriented protocol.
- SCTP is transport layer protocol.
- SCTP is an IETF standard developed by the Transport Area Working Group
- SCTP provides end-to-end Internet communications.
- SCTP does have a 12-byte header.
- SCTP makes it easier to support telephonic conversation on Internet.
- SCTP provides some of the features of both UDP and TCP:
 1. It is message-oriented like UDP.

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2. Ensures reliable, in-sequence transport of messages with congestion control like TCP.

→ Comparisons of SCTP and TCP:

- SCTP can handle multiple simultaneous streams and multiplexed streams where TCP can handle only a single stream of data per connection.

→ Characteristics :-

- Message-based multi-streaming.
- Reliable Transmission (Error control):
- Multi-homing:
- Full- duplex connection-

Q-6.EXPLAIN TLS.

ANS:-

- TLS stands for Transport Layer Security.
- TLS is used for Web browsers and other applications that require data to be securely exchanged over a network.
- TLS provides privacy and data integrity (data accuracy and consistency) between two communicating applications.
- Data must not be changed and data cannot be altered by an unauthorized person.
- TLS evolved from Netscape's Secure Sockets Layer (SSL) protocol and SSL/TLS provides security at TCP layer.
- SSL/TLS runs over TCP, using TCP to provide reliable, end-to-end transport.
- TLS is a more secure and efficient protocol for message authentication.
- TLS is composed of two layers:
 1. TLS Record Protocol : provides connection security.
 2. TLS Handshake protocol enable the client and server to authenticate each other and exchange security keys before any data is transmitted.

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Q-7. EXPLAIN DTLS.

ANS:-

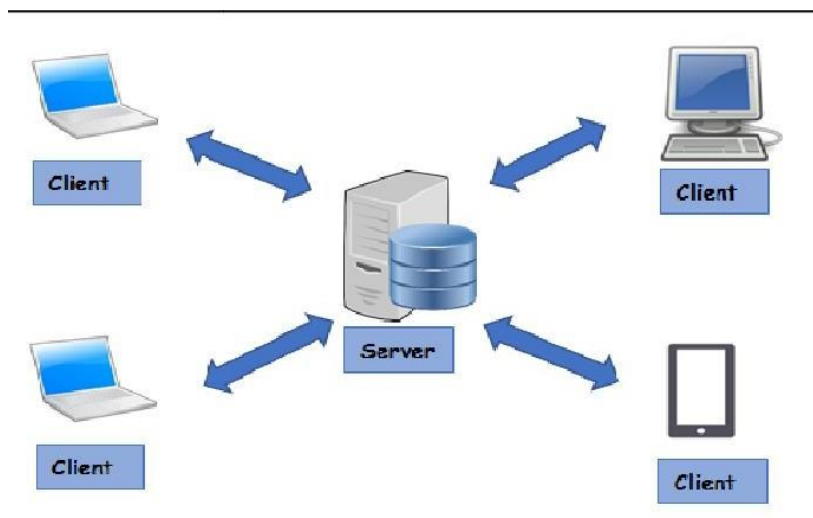
- DTLS stand for Datagram Transport Layer Security.
- It is based off the Transport Layer Security (TLS) protocol ,which is a protocol that provide security to computer based communication network.
- Datagrams are common in streaming media, such as gaming or secured video conferencing.
- The main difference between DTSL and TLS is that DTLS uses UDP and TLS uses TCP.

→ Session layer:-

Explain http.

Ans:-

- HTTP stands for Hypertext Transfer Protocol
- Development of HTTP was initiated by
- HTTP follows Client/Server architecture



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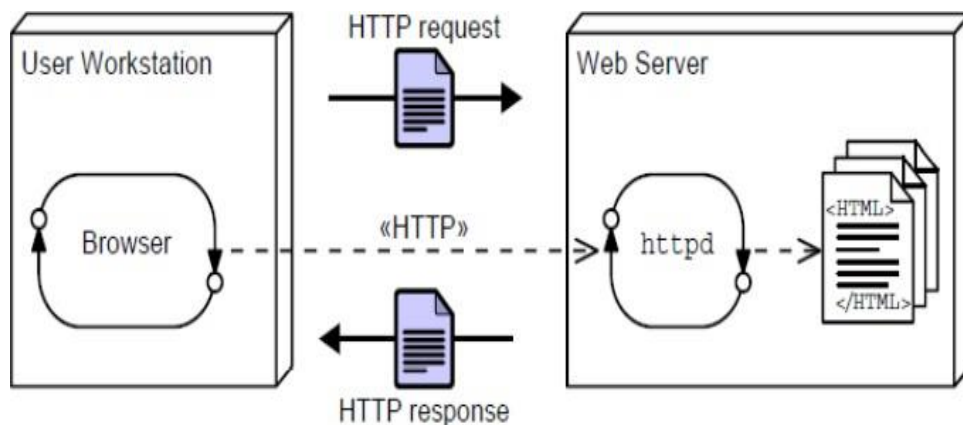
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- HTTP is the foundation of data communication for the world wide Web.
- HTTP provides standard rules for web browsers & servers to communicate.
- HTTP is a TCP/IP based communication protocol that is used to deliver data.
- It is also known as "stateless protocol" as each command is executed separately, without using reference of previous run command.
- HTTP is a request/response protocol where clients request information from a server and the server responds to these requests accordingly.



- Both GET and POST method is used to transfer data from client to server in HTTP.
- The PUT and DELETE methods allow clients to upload and remove content from the server.
- HTTP by default operates on port 80 whereas HTTPS by default operates on port 443.

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→ Advantages of http:-

- HTTP can be implemented with other protocol on the Internet.
- HTTP pages are stored on computer and internet caches, so it is quickly accessible
- Platform independence .
- Does not need any Runtime support.

→ Disadvantages of http:-

- Distributing small packets of data in huge volumes
- Pushing information over unreliable networks
- Power consumption (battery-powered devices)
- There is no privacy as anyone can see content

EXPLAIN HTTPS.

ANS:-

- Hypertext Transfer Protocol Secure (HTTPS) is an extension of HTTP.
- It is used for secure communication over a computer network In HTTPS, the communication protocol is encrypted using Transport Layer Security (TLS) that is referred as HTTP over TLS or Secure Sockets Layer (SSL) that is referred as HTTP over SSL.
- HTTPS connections were primarily used for payment transactions on the World Wide Web, e-mail and for sensitive transaction.

EXPLAIN COAP.

ANS:-

- CoAP stands for Constrained Application Protocol.
- CoAP is created by the IETF Constrained RESTful Environments (CoRE) working group.
- It is a M2M protocol and web transfer protocol.
- It uses request/response model.
- This protocol specially design for iot system based on http protocol.
- CoAP is an Internet application protocol for constrained device.

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→ Constrained devices:

- Small devices with limited CPU, limited bandwidth, memory, and power resources, so called as "constrained devices" (Ex. sensors/actuators).

→ Uses :-

- It is used within mobiles and social network based applications.
- It is used http get ,post, delete and put method.
- These applications range from smart home application, smart energy, smart grid, building control, intelligent lighting control, industrial control systems, asset tracking, to environment monitoring.

→ Features:-

- CoAP is a UDP based protocol, HTTP is TCP based protocol.
- It makes use of the UDP protocol for lightweight implementation.
- Respect to HTTP protocol, COAP is lightweight with smaller packets.
- It can support one to many (multicast) requirements and is faster than other TCP based protocols like HTTP.
- It is a better choice for continuous conditioning monitoring scenario in a constrained environment.
- It is faster which makes it a better option for M2M/ device to device (D2D) / device to gateway (D2G) communication.

→ Why coap?

- HTTP is based on TCP protocol using point to point (p2p) communication model that not suitable for constrained devices, HTTP is too complex.

→ DTLS for CoAP Security:-

- Security is important to protect the communication between devices. DTLS can achieve all integrity, authentication and confidentiality security elements.
- DTLS solves two problems: reordering and packet lost.

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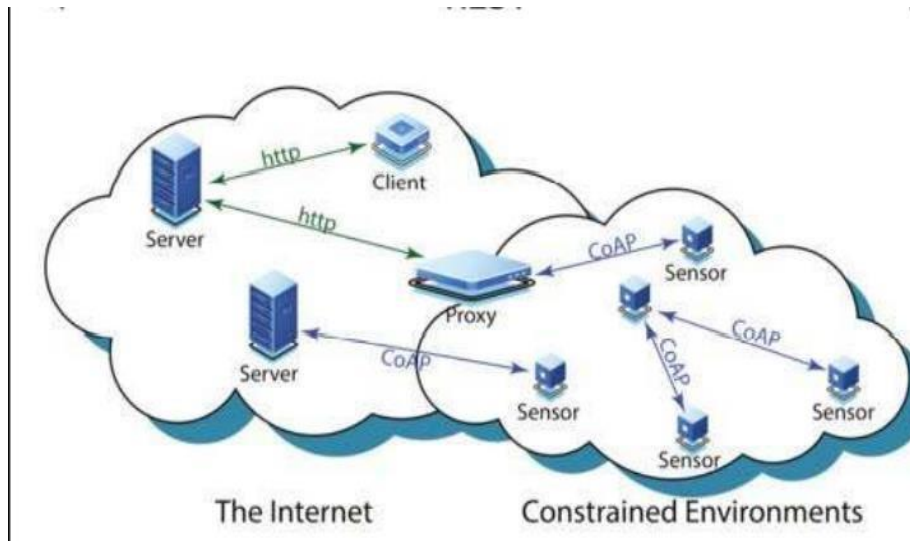
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Coap architecture.



Explain XMPP.

Ans:-

- XMPP stands for Extensible Messaging and Presence Protocol.
- XMPP protocol is sometimes called "Jabber".

→ X — eXtensible:-

- It has been designed to grow and accommodate changes.
- using the power of XML, anyone can build custom functionality
- Defined in an open standard and using an open systems approach to develop application.

→ M — Messaging:-

- The Instant Message (IM) sent between clients.
- XMPP has been designed to send all messages in real-time using a very efficient push mechanism.

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→ P — Presence:-

- It determines whether you are online/offline/busy. It indicates the state

→ P-Protocol

- Set of standards that allows systems to communicate with each other.

→ Key Factor:-

- Extensible
- Open standard (publicly available, no single definition)
- Flexible
- Secure

→ Features:-

- **Open:-** the XMPP protocols are free, open, public, and easily understandable.
- **Decentralised** – XMPP is based on client-server architecture, i.e. clients don't communicate directly, they do it with the help of server as intermediary.
- XMPP uses XML messages.
- The XMPP-IoT is designed specifically for IoT environment.
- XMPP enables users to send real-time messages and handles the user presence (Online, Offline, Busy).
- As an extensible protocol, XMPP is an ideal backbone protocol to provide universal connectivity among different endpoint protocols.

Explain AMQP.

Ans:-

- AMQP stands for Advanced Message Queue Protocol
- It is maintained by OASIS.(ORGANIZATION FOR THE ADVANCEMENT OF STRUCTURED INFORMATION STANDARDS)
- AMQP is an open standard to exchange business messages between applications (M2M).
- AMQP enables encrypted and interoperable messaging between

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organizations and applications.

- The protocol is used in client/server messaging and in IoT device management.
 - It is a message-oriented protocol that provides features like routing and queuing.
- ➔ The key factors of AMQP are:
- Open source - open source refers to any program whose source code is made available for use or modification as users or other developers see fit.
 - interoperable
 - secure
 - Portable
 - Monitoring and sharing updates
 - Ensuring quick response of the server to requests
 - Distribute messages to multiple recipients
 - Connection offline clients for further data retrieval
 - Reliability of message delivery

Explain MQTT.

Ans:-

- MQTT stands for Message Queue Telemetry Transport
- MQTT is a lightweight messaging protocol for industrial and mobile applications.
- It is best suited for application where network bandwidth and power usage are limited.
- for example, small sensor, remote location applications, machine to machine communication.
- MQTT communicates with a server over TC

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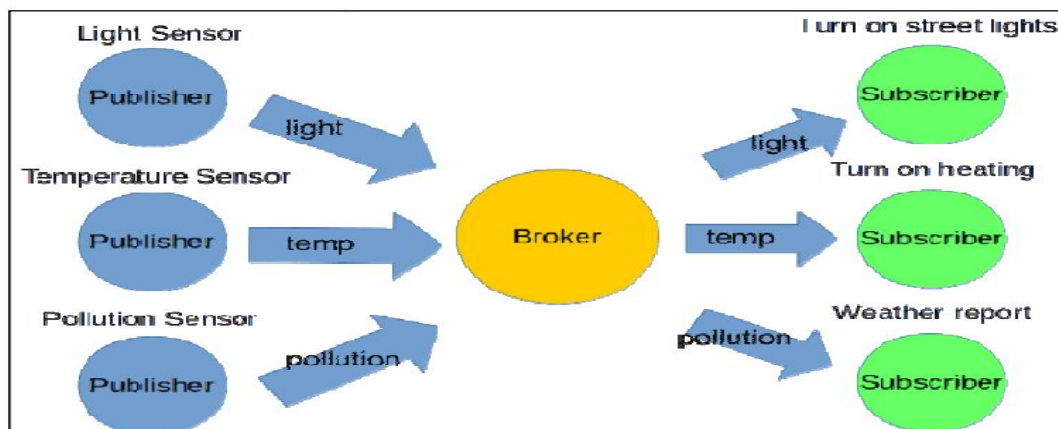
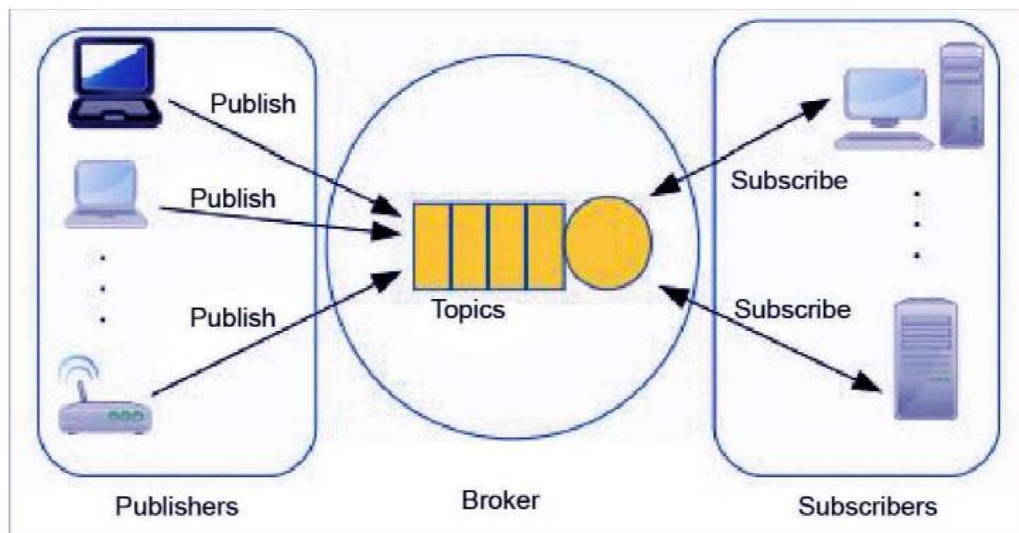


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→ MOTT ARCHITECTURE:-

- MQTT works on publish / subscriber model.
- MQTT Protocol consists of three main components: subscriber, publisher and broker.
- The publisher generates the data and transmits the information to subscribers through the broker.
- The broker ensures security by cross-checking the authorisation of publishers and subscribers.



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UNIT-5

SERVICE LAYER PROTOCOLS & SECURITY

→ SERVICE LAYER:-

Q-1 WHAT IS M2M?

ANS:-

- Machine-To-Machine (M2M) technologies enable devices to communicate, collect and share data through wired and wireless networks without human interaction.
- It is also the foundation for the internet of things (IoT).
- The main components of an M2M system include sensors, RFID, Wi-Fi or cellular communications link, and autonomic computing software programmed to help a network device interpret data and make decisions.
- IoT needs M2M, but M2M does not need IoT.
- M2M systems use point-to-point communications between machines, sensors and hardware over cellular or wired networks, while IoT systems Depend on IP-based networks to send data collected from IoT-connected devices to gateways, the cloud or middleware platforms.
- Five basic capabilities for M2M PLATFORMS:
 - Connectivity
 - Device Management
 - Application Management
 - Data Processing }
 - Security.

European Telecommunications Standards Institute(ETSI) M2M.ANS:-

- M2M reference architecture is proposed by standard organization ETSI.
- ETSI M2M is the initial promoter of the oneM2M initiative.
- ETSI defines M2M communication as “the communication between two or more entities (devices) that do not necessarily need any direct human intervention”.

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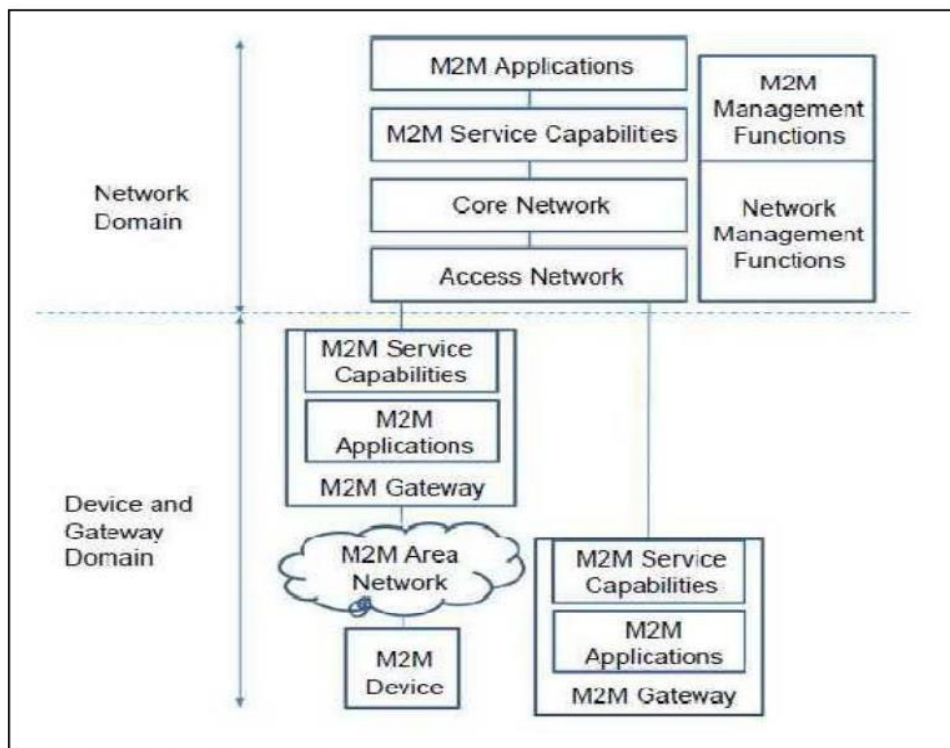
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- ETSI M2M work defines a middleware Service Capability Layer (SCL) that interact with M2M nodes.



ETSI M2M High-Level Architecture

→ M2M Device:

- M2M device connects to the Network Domain through:
 - Direct connection
 - Through one or more M2M Gateway.

→ M2M Area Network:

- LAN or PAN and provides connectivity between M2M Devices and M2M Gateways.

→ M2M Gateway:

- The device that provides connectivity for M2M Devices and M2M Area Network towards the Network Domain.

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→ Access Network:

- Access Network Technologies are fixed (xDSL, HFC) and wireless (Satellite, UTRAN, E-UTRAN W-LAN, WiMAX).

→ Core Network:

- Examples of Core Networks are 3GPP Core Network Functions:
 - IP connectivity
 - Service and Network control.
 - Interconnection with other networks.
 - Roaming

→ M2M Service Capabilities:

- Service efficiency

→ M2M Applications:

- utilize the M2M Service Capabilitie

→ Network Management Functions:

- Manage the Access and Core Network (ex .Fault Management).

→ M2M Management Functions:

- i. M2M Service Bootstrap Function (MSBF)
- ii. M2M Authentication Server (MAS)

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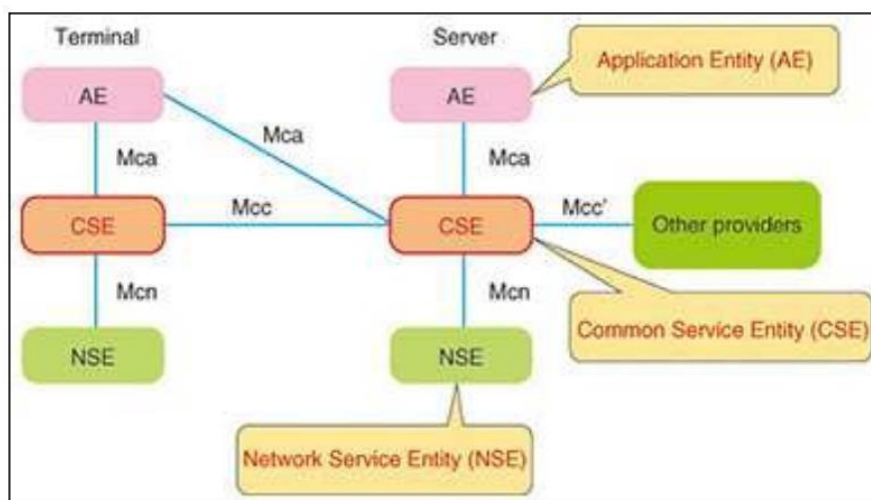
EXPLAIN ONE M2M

ANS:-

- The oneM2M is global organization which creates technical specifications to ensure that Machine-to-Machine Communication works efficiently.
- oneM2M is a global organization that creates requirements, architecture, API specifications, security solutions and interoperability for Machine-to-Machine and IoT technologies.
- ETSI M2M produced the first release of the M2M standards in 2012, seven of the leading Information and Communications Technology (ICT) standards organizations [ARIB (Japan), ATIS (United States), CCSA (China), ETSI (Europe), TTA (USA), TSDSI (India), TTA (Korea) and TTC (Japan)] formed a global organization called oneM2M in order to develop M2M specifications.
- oneM2M specifications support a wide range of applications and services such as smart cities, connected car, home automation, public safety, and health.

Unit-5: SERVICE LAYER PROTOCOLS & SECURITY

oneM2M architecture Model



→ oneM2M functional architecture has three types of entities:

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- 1) AE (Application Entity): The AE is responsible of providing end-to-end M2M logic solution.
 - 2) CSE (Common Services Entity) : set of Common Service Function
 - A. IN-CSE (Infrastructure Node CSE) is hosted in the cloud by the oneM2M Service Provider.
 - B. MN-CSE (Middle Node CSE) is hosted on the Home Gateway.
 - 3) Network Services Entity (NSE): The NSE provides services to the CSEs, such as device management, location services.
- oneM2M has four type of nodes:
- 1) the Application Service Node (ASN)
 - 2) the Application Dedicated Node (ADN)
 - 3) the Middle Node (MN)
 - 4) the Infrastructure Node (IN)

EXPLAIN OMA(OPEN MOBILE ALLIANCE)

ANS:-

- The Open Mobile Alliance (OMA) is a standards which develops open standards for the mobile phone industry.
- The functional areas for these interfaces are the following:
 - **Data Configuration and Management:** Responsible for creating, reading, updating and deleting data of XML or non-XML type. It also provides a subscribe/notify mechanism for the managed data.
 - **Call Control and Configuration:** Offers methods for Call setup, handling and event notifications. Also call conferencing control is supported.
 - **Multimedia List Handling:** Management of Lists of media identifiers (e.g. URIs), being used by a streaming functionality.
 - **Service Registration and Discovery:** Is a service dictionary, which supports registration of services and allows to lookup services.
 - OMA SpecWorks defines common set of standards for managing light weight and low capability devices on a variety of networks.

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→ Key OMA SpecWorks enablers for IoT devices and services include:

- OMA Device Management (DM) Objects }
- OMA DM Gateway Management Object }
- OMA M2M Device Classification }
- OMA LightweightM2M (LwM2M) protocol }
- OMA Open Connection Manager API.

→ OMA LIGHTWEIGHT M2M:-

- It is protocol from the oma for m2m or iot device management.
- It define the application layer communication protocol between lwm2m server and lwm2m client.
- It make use of light and compact protocol as well as efficient resource data model.
- It is frequently used with coap.

GIVE THE FULL FORM OF BBF

ANS:-

- BROADBAND FORUM.

EXPLAIN APPLICATION LAYER.

ANS:-

- In iot architecture, application layer lies above the service layer.
- It is highest layer in the architecture extending from the client ends.
- It is the interface between the end devices and the network
- Like for a computer, application layer is implemented by the browser.
- This layer is responsible for data formatting and presentation.
- Ex. File transfer, email ,remote login etc.
- The application layer in the Internet is typically based on HTTP protocol
- However, HTTP is not suitable in resource constrained environment.
- because it is extremely heavyweight and a large parsing overhead
- So, there are many alternate protocols that have been developed for IOT

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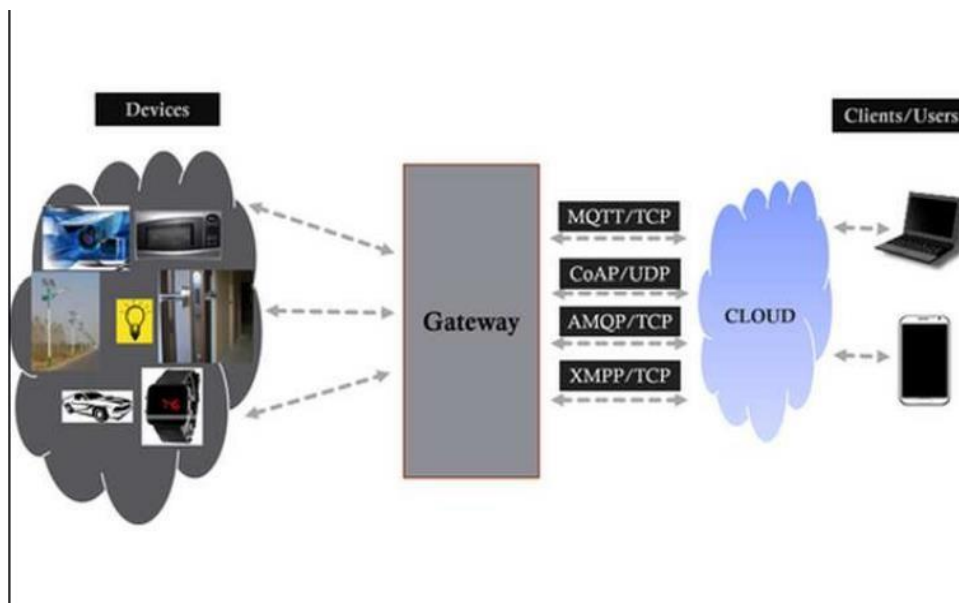
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environments.

→ **In an IoT project, there are three communication challenges faced and they are listed below :**

- Communication between devices on a local network.
- Communication between devices through the internet and communication between devices and servers that store data.
- Communication between servers that store data.



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Note:-

Protocols of Application Layer in IoT:

1. HTTPS
2. MQTT
3. AMQP
4. XMPP
5. CoAP

(૩૩૩ ૩૩ ૩૩૩૩ protocol chapter-૩ ૩૩૩૩૩ ૩૩૩૩૩૩.)

→ SECURITY PROTOCOLS.

EXPLAIN RPL

ANS:-

- Remote initial program load.
- It is a protocol for starting a computer and load its operating system from server.
- Ibm develop rpl.
- Security in IoT is supported by RPL, 6LoWPAN to minimize the impact of attacks.
- RPL works on basis of Destination-Oriented Directed Acyclic Graph (DODAG) in the network.

→ To build DODAG four important control messages are used:

- 1. DODAG Information Solicitation (DIS)
- 2. DODAG Information Object (DIO)
- 3. Destination Advertisement Object (DAO)
- 4. DODAG Advertisement Object Acknowledgement (DAO-ACK).
- Each control message is necessary for the construction of DODAG to perform routing in RPL.

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→ Challenges of RPL

- RPL routing is performed with certain Objective Function (OF) that is selected for routing a packet between nodes.
- To achieve better results of RPL routing, a best objective function is selected, which is challenging in RPL routing.
- **Load balancing** is needed while the level of traffic is too high, which is caused when thousands of nodes involve in data transmission.
- Data broadcasting and Security are challenging process in RPL.

→ Security Mechanisms

- A DODAG can operate in one of the following security modes:
 - (i) unsecured mode,
 - (ii) preinstalled mode, or authenticated mode.
- In the unsecured mode, the RPL messages are sent in the clear and without any security protection.
- In the preinstalled mode, the RPL messages are protected by cryptography-based security mechanisms, which depend on a key assumed to be already present in each node at boot time. In the authenticated mode, the RPL messages are protected as well, but the nodes receive keys after an authentication process.

→ Requirement of Security in RPL:-

1. Confidentiality
2. Integrity
3. Identity Management
4. Authentication
5. Non-refusal
6. Availability
7. Privacy

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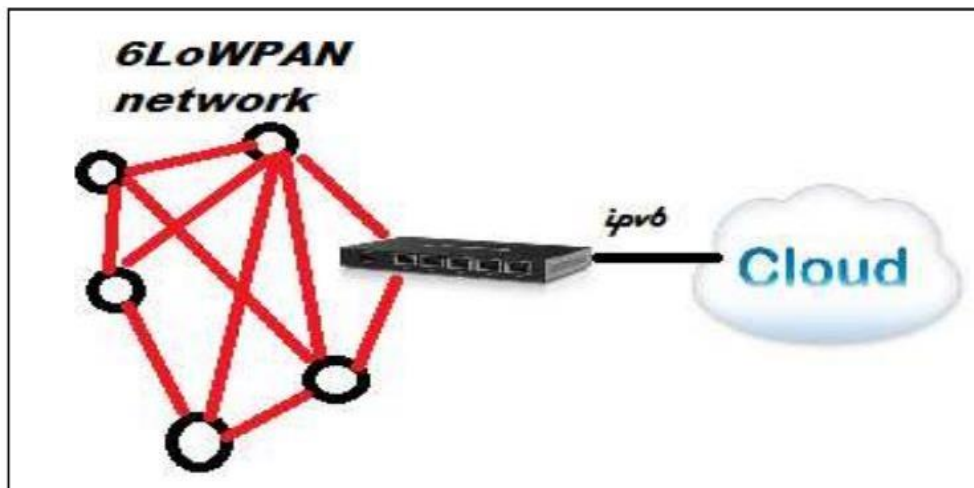
EXPLAIN 6LoWPAN.

Or

→ Challenges for wireless 6LoWPAN networks

ANS:-

- 6LoWPAN stands for IPv6 over Low power Wireless Personal Area Network.
- 6LoWPAN is an open standard defined by the Internet Engineering Task Force (IETF).
- The devices at the nodes of the typical 6LoWPAN network are characterized by low computational ability, low battery life, memory and even storage.
- Given the IPV6 transport protocol, the costs of forwarding data are higher than the costs of computation.
- The wireless IOT devices at the nodes have low processing power. As a result, it becomes difficult to implement cryptography.



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- The 6LoWPAN wireless mesh technology typically uses 128-bit AES(Advanced Encryption Standard)-128 bit encryption at the link layer defined by the IEEE 802.15.4 specification.

→ **6LoWPAN wireless IEEE 802.15.4 specification offers two basic security modes:**

- 1) Secure Mode
- 2) Non Secure Mode.

- Secure mode of the 6LoWPAN IEEE 802.15.4 specification, there are 2 options:

Access Control List Mode	Secure Mode
In the Access Control List Mode, each device at a node of the 6LoWPAN network maintains its own Access Control List (ACL). The ACL identifies all nodes that are allowed to communicate with this particular node.	The Secure Mode is the complete secure mode which includes everything from data integrity to sequencing checks.