MODULE 3

CLOUD COMPUTING

- Informative computing paradigm that delivering application and services over the internet
- Delivery of computing is the delivery of computing service-including servers, storage databases, networking, software, analytics and intelligence over the internet to offer faster innovation, flexible resources and economics of scale
- “pay as you go” You can pay only for cloud services you use,helping you lower your operating costs,run your infrastructure more efficiently & scale as your business needs change.

Characteristics of cloud computing

1. On demand self-service:-

   The cloud services do not require any human administrators, the user themselves are able to provision & manage computing resources as needed.

2. Resource pooling: -
   The IT resources (computer,applications,networking, databases etc.) are shared across multiple applications
3. Broad networking access:-
   The computing services are generally provided over standard network and heterogenous devices.
4. Rapid elasticity:-
   The computing services should have IT resources that are able to scale out quickly & on a needed basis
5. Measured service:-
   The resources utilization is tracked and monitored for each application and occupant.

Benefits of cloud computing

- Highly scalable:-
  You can scale up/scale down your operation and storage.
- More flexible:-
  If your need extra bandwidth then a cloud -based services can meetup your requirement instantly
- Reduced infrastructure cost:-
  Can reduce the cost of managing and maintaining your IT systems
- Higher security:-
  Cloud provide strong incentive to enhance security best practices and complete in security for cloud provider
- High availability:-
  System designed to avoid loss of service by reducing or managing failures and minimizing planned downtime.
- Disaster recovery:-
  Cloud provide quick data recovery for all kind of emergency scenarios,from natural disasters.
- Fault tolerance:-
  System designed to avoid loss of services by reducing and managing failures
- No location constraints:-
  We can access cloud from anywhere

Cloud deployment model

1**.public cloud:**

• Public clouds are owned &operated by 3rd party cloud service provider,which deliver computing resources like servers &storage over the internet.

• Microsoft azure is an example

• In public cloud all hardware,software & supporting infrastructure is owned and managed by cloud service provider.

2.private cloud:

• Cloud computing resources used exclusively by a single business or organization.

• A private cloud can be physically located on the company's onsite datacenter

• A private cloud in which the services & infrastructure are maintained on private network

3.hybrid cloud:

•Combine public and private cloud

• Bound together by technology that allows data and application to shared between them.

• By allowing data and application to move hardware private and public cloud.

Cloud services

IaaS:-

• Infrastructure as a service

• It offers ability to provision computing and storage resources

• These resources are provided to the users as virtual mechine (vm)instances and virtual storage.

• Users can start,stop,configure and manage the VM instances on the virtual storage

Characteristics of IaaS

1.Resources are available as a service

2.Services are highly scalable

3.Dynamic and flexible

4.GUI and API-based access

5.Automated administrative tasks

PaaS:-

• Platform as a service

• Ability to develop and deploy application in the cloud using deployment tool application programming intrfaces API,software libraries and services provided by cloud service provider

• Cloud service provider can manage cloud servers,networks,os and storage

Characteristics of PaaS

1.Accessible to various users via the same development application.

2.Integrates with web services and databases.

3.Builds on virtualization technology, so resources can easily be scaled up or down as per the organization's need.

4.Support multiple languages and frameworks.

5.Provides an ability to "Auto-scale".

SaaS:-

•software as a service

• Provide the user to a complete software application of the user interface

• SaaS Applications are accessed from various client smartphone running different operating system

Characteristics of SaaS

1.Managed from a central location

2.Hosted on a remote server

3.Accessible over the internet

4.Users are not responsible for hardware and software updates. Updates are applied automatically.

5.The services are purchased on the pay-as-per-use basis

Challenges of cloud with IoT

1. Data security:

   There is a possibility of hackers getting access not only to your data ,but to all other subscriber's information.

2. Internet connectivity:

   Your need internet connectivity to access the cloud.if there is an internet outage you will not be able to access your data.

3. Migration:

   When you are migrating from one cloud provider to another,transferring huge amount of data can be time consuming & may need human error.

4. Cost:

   Initial cost of an iot cloud storage base can be costly.

5. Environment concern:

   Like cooling cost,flood,rising sea temperature etc

Some popular cloud service providers

- Amazone web services(AWS)
- Microsoft Azure
- Google cloud platform
- IBM cloud
- Oracle cloud

criteria for selecting cloud service provider for iot

1. Certifications & Standards
2. Technologies & Service Roadmap
3. Data Security, Data Governance and Business policies
4. Service Dependencies & Partnerships
5. Contracts, Commercials & SLAs
6. Reliability & Performance
7. Migration Support, Vendor Lock in & Exit Planning
8. Business health & Company profile

FOG COMPUTING

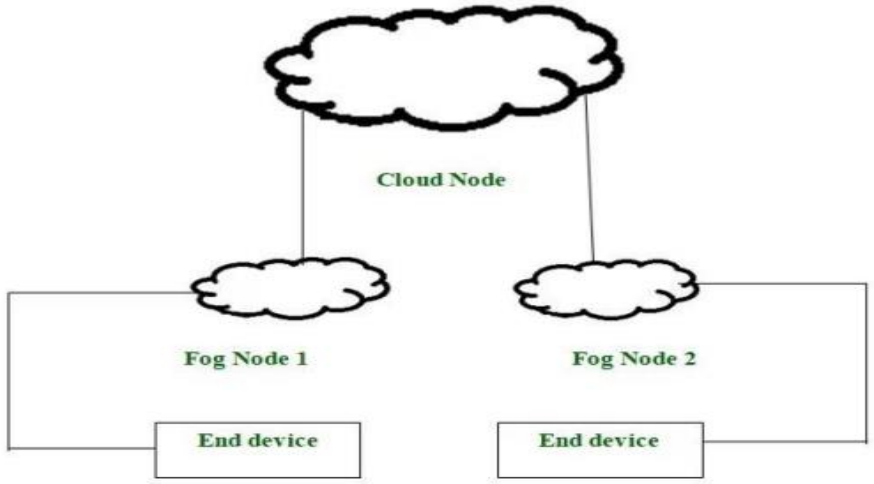
• Fog Computing is the term coined by Cisco that refers to extending cloud computing to an edge of the enterprise's network. Thus, it is also known as Edge Computing or Fogging.

• It facilitates the operation of computing, storage, and networking services between end devices and computing data centers.

• In fog computing, all the storage capabilities, computation capabilities, data along with the applications are placed between the cloud and the physical host.

• All these functionalities are placed more towards the host. This makes processing faster as it is done almost at the place where data is created.

• It improves the efficiency of the system and is also used to ensure increased security.



Fog Computing Architecture

When to use fog computing?

• It is used when only selected data is required to send to the cloud. This selected data is chosen for long-term storage and is less frequently accessed by the host.

• It is used when the data should be analyzed within a fraction of seconds i.e Latency should be low. • It is used whenever a large number of services need to be provided over a large area at different geographical locations.

• Devices that are subjected to rigorous computations and processings must use fog computing.

• Real-world examples where fog computing is used are in IoT devices (eg. Car-to-Car Consortium, Europe), Devices with Sensors, Cameras (IIoT-Industrial Internet of Things), etc.

Advantages of fog computing

• This approach reduces the amount of data that needs to be sent to the cloud.

• Since the distance to be traveled by the data is reduced, it results in saving network bandwidth.

• Reduces the response time of the system.

• It improves the overall security of the system as the data resides close to the host.

• It provides better privacy as industries can perform analysis on their data locally.

Disadvantages of fog computing

• Congestion may occur between the host and the fog node due to increased traffic (heavy data flow).

• Power consumption increases when another layer is placed between the host and the cloud.

• Scheduling tasks between host and fog nodes along with fog nodes and the cloud is difficult.

• Data management becomes tedious as along with the data stored and computed, the transmission of data involves encryption-decryption too which in turn release data.

Applications of fog computing

• It can be used to monitor and analyze the patients' condition. In case of emergency, doctors can be alerted.

• It can be used for real-time rail monitoring as for high-speed trains we want as little latency as possible.

• It can be used for gas and oils pipeline optimization. It generates a huge amount of data and it is inefficient to store all data into the cloud for analysis.

EDGE COMPUTING

- Edge computing is a game changer for the IoT.
- It allows IoT devices to be more independent, storing, processing, and analyzing data locally instead of just sending it to a centralized server.
- This can improve the effectiveness of existing IoT devices, and make new devices and deployment topologies possible.
- Internet of Things applications often work as monitoring systems that collect and analyze data to trigger informed actions.
- IoT apps might process data daily, hourly, or in respond to external triggers.
- Edge computing benefits IoT by moving computing processes closer to the device, reducing network traffic and latency to enable real-time insights.
- IoT devices often send small data packets back to a central management platform for analysis. This system works well for some applications, but the expected growth of IoT means that future networks will be overburdened with devices.
- Edge computing optimizes bandwidth and only sends long-term storage data to the central platform, not all data.
- Managing security is another major challenge for organizations with large numbers of IoT devices.

- Edge computing does not automatically provide more security than private clouds, but the localized approach makes it easier to manage security.

3 Edge Computing Architectures

Here are three common options for edge computing architecture:

- **Pure edge**—deploying all compute resources on-premises. This is suitable for organizations with security or compliance requirements that do not allow sending data to the cloud. This requires a larger initial investment.
- **Thick edge + cloud**—deploying an on-prem data center, cloud-based resources, and edge computing devices. This lets an organization leverage existing investments in on-premise data centers, but use the cloud for aggregating, analyzing, and storing some of the data.
- **Thin edge + cloud**—this approach connects edge resources directly to the public cloud, with no on-premise data center. This is the most lightweight and flexible approach, which also has the lowest upfront costs. But it provides less control over the operating environment and might raise security issues.

EDGE COMPUTING	FOG COMPUTING
Less scalable than fog computing.	Highly scalable when compared to edge computing.
Billions of nodes are present.	Millions of nodes are present.
Nodes are installed far away from the cloud.	Nodes in this computing are installed closer to the cloud(remote database where data is stored).
Edge computing is a subdivision of fog computing.	Fog computing is a subdivision of cloud computing.
The bandwidth requirement is very low. Because data comes from the edge nodes themselves.	The bandwidth requirement is high. Data originating from edge nodes is transferred to the cloud.
Operational cost is higher.	Operational cost is comparatively lower.
High privacy. Attacks on data are very low.	The probability of data attacks is higher.
Edge devices are the inclusion of the IoT devices or client's network.	Fog is an extended layer of cloud.
The power consumption of nodes is low.	The power consumption of nodes filter important information from the massive amount of data collected from the device and saves it in the filter high.
Edge computing helps devices to get faster results by processing the data simultaneously received from the devices.	Fog computing helps in filtering important information from the massive amount of data collected from the device and saves it in the cloud by sending the filtered data.