ASSIGNMENT 1 FRONT SHEET

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Student declaration

I certify that the assignment submission is entirely my own work and I fully understand the consequences of plagiarism. I understand that making a false declaration is a form of malpractice.

Student's signature	Hoang Cong Thanh

Grading grid

P1	P2	P3	P4	M1	M2	D1

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Contents

Task 1.

I. Overview cloud computing

Cloud computing is a paradigm for delivering computing services over the Internet on a pay-as-you-go basis. It provides access to a shared pool of computing resources, such as virtual machines, storage, networks, and applications, that can be rapidly provisioned and released with minimal management effort. Rather than relying on local servers or personal devices, users can leverage remote servers hosted in data centers operated by cloud service providers.

Cloud computing has revolutionized the way organizations and individuals consume and deliver computing resources. Its flexibility, scalability, and cost-efficiency make it an attractive option for businesses of all sizes, allowing them to focus on innovation and growth without the burden of managing complex IT infrastructure.

II. Client – server

Client-server denotes a relationship between cooperating programs in an application, composed of clients initiating requests for services and servers providing that function or service.

1. Client

Clients, also known as service requesters, are pieces of computer hardware or server software that request resources and services made available by a server. Client computing is classified as Thick, Thin, or Hybrid.

- Thick Client: a client that provides rich functionality, performs the majority of data processing itself, and relies very lightly upon the server.
- Thin Client: a thin-client server is a lightweight computer that relies heavily on the resources of the host computer -- an application server performs the majority of any required data processing.
- Hybrid Client: possessing a combination of thin client and thick client characteristics, a hybrid client relies on the server to store persistent data, but is capable of local processing.

2. Server

A server is a device or computer program that provides functionality for other devices or programs. Any computerized process that can be used or called upon by a client to share resources and distribute work is a server. Some common examples of servers include:

- Application Server: hosts web applications that users in the network can use without needing their own copy.
- Computing Server: shares an enormous amount of computer resources with networked computers that require more CPU power and RAM than is typically available for a personal computer.
- Database Server: maintains and shares databases for any computer program that ingests well-organized data, such as accounting software and spreadsheets.
- Web Server: hosts web pages and facilitates the existence of the World Wide Web.

3. Relation between Client and server

Client-server is a relationship in which one program, the client, requests a service or resource from another program, the server. The label client-server was previously used to distinguish distributed computing by PCs from the monolithic, centralized computing model used by mainframes.

III. Peer-to-peer (P2P)

A peer-to-peer network is an information technology (IT) infrastructure allowing two or more computer systems to connect and share resources without requiring a separate server or server software Workplaces may set up a P2P network by physically connecting computers into a linked system or creating a virtual network. You can also set up computers to be the clients and servers of their network.

In the P2P network, each device is considered a peer—thus “peer-to-peer”—with functions that contribute to the network. Each computer is both a client and a server and they share resources with other networked computers.

Some major features of the P2P network include:

- Each computer in a P2P network provides resources to the network and consumes resources that the network provides. Resources such as files, printers, storage, bandwidth and processing power can be shared between various computers in the network.
- A P2P network is easy to configure. Once it’s set up, access is controlled by setting sharing permissions on each computer. Stricter access can be controlled by assigning passwords to specific resources.
- Some P2P networks are formed by overlaying a virtual network on a physical network. The network uses the physical connection to transfer data while the virtual overlay allows the computers on the network to communicate with each other.

Some key advantages of using a P2P network:

- Easy file sharing: An advanced P2P network can share files quickly over large distances. Files can be accessed anytime.
- Reduced costs: There is no need to invest in a separate computer for a server when setting up a P2P network. It doesn’t require a network operating system or a full-time system administrator.
- Adaptability: P2P network extends to include new clients easily. This benefit makes these networks more flexible than client-server networks. Its scalability
- Reliability: Unlike a client-server network, which can fail if the central server malfunctions, a P2P network will remain functional even if the central server crashes. If a single computer goes down, the others continue as normal. This also prevents bottlenecking since traffic is distributed across multiple computers.
- High performance: While a client-server network performs less effectively when more clients join the network, a P2P network can improve its performance when more clients join it. This is because each client in a P2P network is also a server that contributes resources to the network.

- Efficiency: Emerging P2P networks enable collaboration between devices that have different resources that can benefit the whole network.

IV. High performance Computing

1. Definition

High performance computing (HPC) is the ability to process data and perform complex calculations at high speeds. To put it into perspective, a laptop or desktop with a 3 GHz processor can perform around 3 billion calculations per second. While that is much faster than any human can achieve, it pales in comparison to HPC solutions that can perform quadrillions of calculations per second.

One of the best-known types of HPC solutions is the supercomputer. A supercomputer contains thousands of compute nodes that work together to complete one or more tasks. This is called parallel processing. It's similar to having thousands of PCs networked together, combining compute power to complete tasks faster.

2. Why is HPC important?

Data plays a pivotal role in driving groundbreaking scientific discoveries, transformative innovations, and enhancing the lives of billions of people worldwide. High Performance Computing (HPC) serves as the fundamental backbone for advancements in science, industry, and society.

As technologies like the Internet of Things (IoT), artificial intelligence (AI), and 3-D imaging continue to progress, the volume and complexity of data that organizations must handle are growing exponentially. Whether it involves streaming live sporting events, tracking developing storms, conducting product testing, or analyzing stock trends, real-time data processing has become vital for numerous applications.

To stay ahead in a competitive landscape, organizations require exceptionally fast and dependable IT infrastructure to efficiently process, store, and analyze immense quantities of data.

3. How does HPC work.

HPC solutions have three main components:

- Compute
- Network
- Storage

To build a high performance computing architecture, compute servers are networked together into a cluster. Software programs and algorithms are run simultaneously on the servers in the cluster. The cluster is networked to the data storage to capture the output. Together, these components operate seamlessly to complete a diverse set of tasks.

To operate at maximum performance, each component must keep pace with the others. For example, the storage component must be able to feed and ingest data to and from the compute servers as quickly as it is processed. Likewise, the networking components must be able to support the high-speed transportation of data between compute servers and the data storage. If one component cannot keep up with the rest, the performance of the entire HPC infrastructure suffers.

4. What is an HPC Parallel?

HPC parallelism refers to the technique of breaking down a large computational task into smaller, independent sub-tasks that can be executed simultaneously. These sub-tasks are typically executed on multiple processors or cores, allowing for parallel processing and faster execution times.

There are two primary forms of HPC parallelism:

- Task Parallelism: In task parallelism, the computational task is divided into smaller, independent tasks that can be executed concurrently. Each task operates on different data sets or different portions of the input data. This form of parallelism is suitable when there are multiple instances of the same task that can be executed simultaneously. Each task runs on a separate processing unit, such as a separate core or processor.
- Data Parallelism: Data parallelism involves dividing the data set into smaller partitions and assigning each partition to a different processing unit. Each processing unit performs the same operation on its assigned data partition simultaneously. This form of parallelism is well-suited for scenarios where the same computation is applied to different parts of the data. For example, in image processing, each processing unit can work on a different portion of the image concurrently.

HPC parallelism allows for efficient utilization of computing resources and accelerates the execution of computationally intensive tasks. By distributing the workload across multiple processors or cores, parallel processing reduces the overall execution time, enabling faster and more efficient computation. However, exploiting parallelism requires careful design and programming to ensure proper synchronization, data sharing, and load balancing among the parallel tasks or data partitions.

5. What is an HPC cluster?

An HPC cluster refers to a collection of interconnected computers or servers that work together as a unified system to provide high-performance computing capabilities. These clusters are specifically designed to handle complex and computationally intensive tasks by leveraging parallel processing techniques.

Key components of an HPC cluster include:

- Compute Nodes: These are individual computers or servers within the cluster that perform the computational tasks. Each compute node typically consists of multiple processors or cores, enabling parallel processing.
- Interconnect: The interconnect refers to the high-speed network that connects the compute nodes within the cluster. It allows for fast and efficient communication between nodes, facilitating data exchange and coordination among parallel tasks.

- Storage: HPC clusters often have dedicated storage systems to accommodate large data sets and provide high-speed access to the data required for computations. This may include shared file systems, parallel file systems, or distributed storage solutions.
- Cluster Management Software: To manage and coordinate the resources within the HPC cluster, specialized software is used. This software handles job scheduling, resource allocation, monitoring, and system management tasks, ensuring efficient utilization of the cluster's computing power.

Benefits of HPC Clusters:

- Enhanced Performance: HPC clusters enable parallel processing across multiple nodes, resulting in significantly improved computational performance compared to single machines. This allows for faster completion of complex tasks and large-scale simulations.
- Scalability: HPC clusters are highly scalable, meaning that additional compute nodes can be added to the cluster to increase computational power as needed. This scalability allows organizations to handle larger workloads and accommodate growing computational requirements.
- Resource Sharing: HPC clusters facilitate resource sharing among users or research groups. Multiple users can access the cluster simultaneously and allocate computing resources based on their needs, maximizing the utilization of available resources.
- Flexibility: HPC clusters offer flexibility in terms of software and application support. Users can install and run a wide range of specialized software and tools tailored to their specific computational requirements.

HPC clusters find applications in various fields, including scientific research, engineering simulations, data analytics, machine learning, weather forecasting, and molecular modeling. They provide the computational power necessary to tackle complex problems and process vast amounts of data efficiently.

6. Distributed.

In the context of High Performance Computing (HPC), "distributed" refers to the concept of spreading computational tasks across multiple computing nodes or systems that are interconnected to form a distributed computing environment. Distributed computing in HPC involves dividing the workload and data across multiple nodes, allowing for parallel processing and efficient utilization of resources.

Here are some key aspects of distributed computing in HPC:

- Distributed Computing Architecture: In a distributed HPC system, multiple computing nodes or clusters are interconnected via a high-speed network. Each node typically consists of multiple processors or cores, and they work together as a unified system to execute computational tasks.
- Task Distribution: The workload is divided into smaller tasks, and these tasks are distributed across the available computing nodes. Each node performs its assigned tasks concurrently, enabling parallel processing. This division of tasks and distribution of workload can be done using various techniques, such as task parallelism or data parallelism.

- Communication and Coordination: Communication between distributed nodes is critical in distributed HPC systems. Efficient data exchange and coordination are essential to ensure proper synchronization and sharing of data among the distributed nodes. The high-speed network interconnect facilitates fast and low-latency communication, enabling effective collaboration between nodes.
- Load Balancing: Load balancing is an important consideration in distributed HPC systems. It involves distributing the workload evenly across the available computing nodes to ensure optimal resource utilization and minimize idle time. Load balancing techniques aim to evenly distribute tasks and data among the nodes, avoiding overloading or underutilization of specific resources.
- Fault Tolerance and Resilience: Distributed HPC systems often incorporate mechanisms for fault tolerance and resilience. Since failures in individual nodes or network components can occur, fault-tolerant techniques are employed to ensure uninterrupted operation. These techniques may involve redundancy, checkpointing, and fault detection and recovery mechanisms to mitigate the impact of failures.

Distributed computing in HPC allows for the effective utilization of resources, improved performance, and scalability. By distributing tasks and data across multiple nodes, organizations can tackle larger computational problems, process large datasets, and achieve faster execution times. However, designing and managing distributed HPC systems require careful consideration of communication, load balancing, fault tolerance, and coordination to achieve optimal performance and reliability.

V. Deployment models

An exclusive class of cloud environment known as a cloud deployment model is defined primarily by ownership, scale, and access.

There are four typical models for cloud deployment:

- Public cloud.
- Community cloud.
- Private cloud.
- Hybrid cloud.

a) Public cloud

The public cloud makes it possible for anybody to access systems and services. The public cloud may be less secure as it is open to everyone. The public cloud is one in which cloud infrastructure services are provided over the internet to the general people or major industry groups. The infrastructure in this cloud model is owned by the entity that delivers the cloud services, not by the consumer. It is a type of cloud hosting that allows customers and users to easily access systems and services. This form of cloud computing is an excellent example of cloud hosting, in which service providers supply services to a variety of customers. In this arrangement, storage backup and retrieval services are given for free, as a subscription, or on a per-user basis.

Advantages of the Public Cloud Model:

- Minimal Investment: Because it is a pay-per-use service, there is no substantial upfront fee, making it excellent for enterprises that require immediate access to resources.
- No setup cost: The entire infrastructure is fully subsidized by the cloud service providers, thus there is no need to set up any hardware.
- Infrastructure Management is not required: Using the public cloud does not necessitate infrastructure management.
- No maintenance: The maintenance work is done by the service provider (not users).
- Dynamic Scalability: To fulfill your company's needs, on-demand resources are accessible.

Disadvantages of the Public Cloud Model:

- Less secure: Public cloud is less secure as resources are public so there is no guarantee of high-level security.
- Low customization: It is accessed by many public so it can't be customized according to personal requirements.

b) Private cloud

The private cloud deployment model is the exact opposite of the public cloud deployment model. It's a one-on-one environment for a single user (customer). There is no need to share your hardware with anyone else. The distinction between private and public clouds is in how you handle all of the hardware. It is also called the "internal cloud" & it refers to the ability to access systems and services within a given border or organization. The cloud platform is implemented in a cloud-based secure environment that is protected by powerful firewalls and under the supervision of an organization's IT department. The private cloud gives greater flexibility of control over cloud resources.

Advantages of the Private Cloud Model:

- Better Control: You are the sole owner of the property. You gain complete command over service integration, IT operations, policies, and user behavior.
- Data Security and Privacy: It's suitable for storing corporate information to which only authorized staff have access. By segmenting resources within the same infrastructure, improved access and security can be achieved.
- Supports Legacy Systems: This approach is designed to work with legacy systems that are unable to access the public cloud.
- Customization: Unlike a public cloud deployment, a private cloud allows a company to tailor its solution to meet its specific needs.

Disadvantages of the Private Cloud Model:

- Less scalable: Private clouds are scaled within a certain range as there is less number of clients.
- Costly: Private clouds are more costly as they provide personalized facilities.

c) Hybrid Cloud

By bridging the public and private worlds with a layer of proprietary software, hybrid cloud computing gives the best of both worlds. With a hybrid solution, you may host the app in a safe environment while taking advantage of the public cloud's cost savings. Organizations can move data and applications between different clouds using a combination of two or more cloud deployment methods, depending on their needs.

Advantages of the Hybrid Cloud Model:

- Flexibility and control: Businesses with more flexibility can design personalized solutions that meet their particular needs.
- Cost: Because public clouds provide scalability, you'll only be responsible for paying for the extra capacity if you require it.
- Security: Because data is properly separated, the chances of data theft by attackers are considerably reduced.

Disadvantages of the Hybrid Cloud Model:

- Difficult to manage: Hybrid clouds are difficult to manage as it is a combination of both public and private cloud. So, it is complex.
- Slow data transmission: Data transmission in the hybrid cloud takes place through the public cloud so latency occurs.

d) Community cloud

It allows systems and services to be accessible by a group of organizations. It is a distributed system that is created by integrating the services of different clouds to address the specific needs of a community, industry, or business. The infrastructure of the community could be shared between the organization which has shared concerns or tasks. It is generally managed by a third party or by the combination of one or more organizations in the community.

Advantages of the Community Cloud Model:

- Cost Effective: It is cost-effective because the cloud is shared by multiple organizations or communities.
- Security: Community cloud provides better security.
- Shared resources: It allows you to share resources, infrastructure, etc. with multiple organizations.
- Collaboration and data sharing: It is suitable for both collaboration and data sharing.

Disadvantages of the Community Cloud Model:

- Limited Scalability: Community cloud is relatively less scalable as many organizations share the same resources according to their collaborative interests.
- Rigid in customization: As the data and resources are shared among different organizations according to their mutual interests if an organization wants some changes according to their needs they cannot do so because it will have an impact on other organizations.

VI. Cloud service models

1. Infrastructure as a Service

a) definition

Infrastructure as a Service (IaaS) is a cloud computing service where enterprises rent or lease servers for compute and storage in the cloud. Users can run any operating system or applications on the rented servers without the maintenance and operating costs of those servers. Other advantages of Infrastructure as a Service include giving customers access to servers in geographic locations close to their end users. IaaS automatically scales, both up and down, depending on demand and provides guaranteed service-level agreement (SLA) both in terms of uptime and performance. It eliminates the need to manually provision and manage physical servers in data centers.

b) The benefits of IaaS

Infrastructure as a Service (IaaS) can be more efficient for an enterprise than owning and managing its own infrastructure. New applications can be tested with an IaaS provider instead of acquiring the infrastructure for the test.

Other advantages of infrastructure-as-a-service include:

- Continuity and disaster recover – Cloud service in different locations allows access to applications and data during a disaster or outage.
- Faster scaling – Quickly scale up and down resources according to application demand in all categories of cloud computing.
- Core focus – IaaS allows enterprises to focus more on core business activities instead of IT infrastructure and computing resources.

c) How Does Infrastructure as a Service Work?

IaaS started in the cloud as one of the service layers including Platform as a Service (PaaS) and Software as a Service (SaaS). Customers use dashboards and APIs to directly access their servers and storage. With IaaS, there is higher scalability. IaaS users enjoy many advantages of Infrastructure as a service, such as accessing the same infrastructure technology services of a traditional data center without having to invest as many resources as possible. It is a flexible cloud computing model that allows for automated deployment of servers, processing power, storage, and networking.

2. Platform as a Service

a) Definition

Platform as a Service (PaaS) is a complete cloud environment that includes everything developers need to build, run, and manage applications—from servers and operating systems to all the networking, storage, middleware, tools, and more.

b) How does PaaS work?

Unlike IaaS or SaaS service models, PaaS solutions are specific to application and software development and typically include:

- Cloud infrastructure: Data centers, storage, network equipment, and servers.
- Middleware software: Operating systems, frameworks, development kits (SDK), libraries, and more
- User interface: A graphical user interface (GUI), a command line interface (CLI), an API interface, and in some cases, all three

Platform as a Service is typically delivered as a secure online platform that developers can access over the internet, allowing them to work on projects from anywhere and collaborate freely with other members of their team. Applications are built directly on the PaaS system and can be immediately deployed once they are completed.

c) Benefits of PaaS

The most common benefits of PaaS compared to running and maintaining your own environment include:

- **Faster time to market.** No heavy lifts required. Developers have instant access to a complete application development platform that they don't have to build or manage, freeing up time to develop and deploy.
- **Low maintenance.** In-house application stacks come with headaches, especially when it comes to upgrades. With PaaS, the provider is responsible for keeping everything up-to-date—and none of the maintenance pain is yours.
- **Cost-effective pricing.** PaaS resources are on-demand, so you only pay for what you actually use. A PaaS also provides access to advanced development tools and capabilities that might be too expensive to purchase outright.
- **Easy scalability.** No more worrying about capacity. PaaS lets you scale down for low-traffic periods or scale up immediately to meet unexpected surges in demand.
- **Flexible access.** Development and DevOps teams can access shared PaaS services and tools from anywhere and on any device over an internet connection.
- **Shared security.** With PaaS, the provider is responsible for securing the infrastructure. Most major PaaS service providers also offer guidelines and best practices for building on their platforms.

3. Software as a Service

a) definition

SaaS modifies how clients are given access to software. Software distributed as a license-based product must be installed in the end user device according to the conventional software delivery paradigm. SaaS is an on-demand service, therefore Software installation on the end user's device is not necessary when using an Internet-based service. Depending on the needs of the end user, SaaS services can be connected or withdrawn at any moment. Any lightweight web browser on any device, including a laptop, tablet, and smartphone, can access SaaS services. Some SaaS services can be accessed using a thin client, although they have less storage capacity and processing power than a conventional desktop PC.

b) Advantages of SaaS

SaaS offers a variety of advantages over traditional software licensing models. Because the software does not live on the licensing company's servers, there is less demand for the company to invest in new hardware. It is easy to implement, easy to update and debug, and can be less expensive than purchasing multiple software licenses for multiple computers.

SaaS has numerous applications, including email services, auditing functions, automating sign-up for products and services, managing documents, and Customer relationship management (CRM) systems, a database of client and prospect information. SaaS-based CRMs can be used to hold company contact information, business activity, product purchase history, and sales leads.

The SaaS model works well for enterprise-level services, such as human resources. These types of tasks are often collaborative, requiring employees from various departments to share, edit, and publish material while not in the same office.

- Accessible from anywhere
- Cost effective.
- Easy to implement, update, and debug.
- Easy to scale.

c) Disadvantages of SaaS

Drawbacks to the adoption of SaaS center around data security and speed of delivery. Because data is stored on external servers, companies must ensure it is safe and cannot be accessed by unauthorized parties. Slow Internet connections can reduce performance, especially if the cloud servers are accessed from far distances. Internal networks tend to be faster than Internet connections. Due to its remote nature, SaaS solutions also suffer from a loss of control and a lack of customization.

- Increased security risks
- Slower speed
- Loss of control
- Lack of customization

VII. Characteristics of Cloud.

- **On-demand self-services:** The Cloud computing services does not require any human administrators, user themselves are able to provision, monitor and manage computing resources as needed.
- **Broad network access:** The Computing services are generally provided over standard networks and heterogeneous devices.
- **Rapid elasticity:** The Computing services should have IT resources that are able to scale out and in quickly and on as needed basis. Whenever the user require services it is provided to him and it is scale out as soon as its requirement gets over.
- **Resource pooling:** The IT resource (e.g., networks, servers, storage, applications, and services) present are shared across multiple applications and occupant in an uncommitted manner. Multiple clients are provided service from a same physical resource.
- **Measured service:** The resource utilization is tracked for each application and occupant, it will provide both the user and the resource provider with an account of what has been used. This is done for various reasons like monitoring billing and effective use of resource.
- **Multi-tenancy:** Cloud computing providers can support multiple tenants (users or organizations) on a single set of shared resources.
- **Resilient computing:** Cloud computing services are typically designed with redundancy and fault tolerance in mind, which ensures high availability and reliability.
- **Flexible pricing models:** Cloud providers offer a variety of pricing models, including pay-per-use, subscription-based, and spot pricing, allowing users to choose the option that best suits their needs.
- **Security:** Cloud providers invest heavily in security measures to protect their users' data and ensure the privacy of sensitive information.
- **Automation:** Cloud computing services are often highly automated, allowing users to deploy and manage resources with minimal manual intervention.
- **Sustainability:** Cloud providers are increasingly focused on sustainable practices, such as energy-efficient data centers and the use of renewable energy sources, to reduce their environmental impact.

VIII. Virtualization and Multicore

1. Virtualization.

a) Definition

Virtualization is the "creation of a virtual (rather than actual) version of something, such as a server, a desktop, a storage device, an operating system or network resources". In other words, Virtualization is a technique, which allows to share a single physical instance of a resource or an application among multiple customers and organizations. It does by assigning a logical name to a physical storage and providing a pointer to that physical resource when demanded.

b) Types of virtualizations

1) Hardware Virtualization

When the virtual machine software or virtual machine manager (VMM) is directly installed on the hardware system is known as hardware virtualization. The main job of hypervisor is to control and monitoring the processor, memory and other hardware resources. After virtualization of hardware system we can install different operating system on it and run different applications on those OS.

Usage: Hardware virtualization is mainly done for the server platforms, because controlling virtual machines is much easier than controlling a physical server.

2) Operating system virtualization

When the virtual machine software or virtual machine manager (VMM) is installed on the Host operating system instead of directly on the hardware system is known as operating system virtualization.

Usage: Operating System Virtualization is mainly used for testing the applications on different platforms of OS.

3) Server Virtualization

When the virtual machine software or virtual machine manager (VMM) is directly installed on the Server system is known as server virtualization.

Usage: Server virtualization is done because a single physical server can be divided into multiple servers on the demand basis and for balancing the load.

4) Storage Virtualization

Storage virtualization is the process of grouping the physical storage from multiple network storage devices so that it looks like a single storage device.

Usage: Storage virtualization is mainly done for back-up and recovery purposes.

c) How does virtualization work in cloud computing?

Virtualization plays a very important role in the cloud computing technology, normally in the cloud computing, users share the data present in the clouds like application etc, but actually with the help of virtualization users shares the infrastructure.

The main usage of Virtualization Technology is to provide the applications with the standard versions to their cloud users, suppose if the next version of that application is released, then cloud provider has to provide the latest version to their cloud users and practically it is possible because it is more expensive.

To overcome this problem we use basically virtualization technology, By using virtualization, all severs and the software application which are required by other cloud providers are maintained by the third party people, and the cloud providers has to pay the money on monthly or annual basis.

2. Multicore

When using multi-core technology, a single chip houses two or more CPUs. In this architecture, the essential logic of two or more processors is housed on a single physical processor. Each of these microprocessors is contained within an integrated circuit (IC). Die refers to this particular IC. Multiple molds bundled together are another example of multicore technology. The system can now handle more jobs with greater system-wide efficiency thanks to this technology. Additionally, it uses less energy and works more effectively by managing several activities at once. Desktops, mobile personal computers (PCs), servers, and workstations can all utilize multi-core technology.

Processing is sped up in a multi-object cloud environment using this multi-core technology. Recently, multi-core design has gained popularity for high-performance processors, and the outcomes of various theories and case studies show that multi-core architectures scale as the number of cores increases. Two varieties of multi-core exist:

- Scalability of multi-core processors and virtual machines
- Parallelism in the cloud and multi-factor technologies

Task 2.

I. Explain why ATN should use cloud?

ATN, or Air Traffic Network, could benefit from using cloud services for several reasons. Here are some key advantages:

- Scalability: Cloud services offer the ability to scale resources up or down based on demand. Air traffic can vary significantly depending on factors like time of day, weather conditions, and special events. With cloud computing, ATN can easily scale its infrastructure to accommodate peak traffic periods without the need to invest in and maintain expensive hardware and infrastructure.
- Cost Efficiency: Using cloud services can be more cost-effective compared to maintaining an on-premises infrastructure. Cloud providers operate at a large scale, which allows them to provide resources at a lower cost. ATN can avoid upfront hardware costs, reduce maintenance expenses, and pay only for the resources they use, resulting in significant cost savings.
- High Availability: Cloud services typically offer high availability and reliability. Cloud providers have data centers distributed across multiple geographic regions, ensuring redundancy and fault tolerance. This means that even in the event of hardware failures or natural disasters, ATN's critical services can continue operating without significant disruptions.
- Flexibility and Agility: Cloud computing enables ATN to rapidly deploy and update applications and services. This agility allows for faster development and innovation, enabling ATN to adapt to

changing air traffic management needs quickly. New features, upgrades, and patches can be deployed seamlessly without disrupting ongoing operations.

- Data Storage and Analysis: Air traffic generates vast amounts of data that can be utilized for various purposes, such as improving safety, optimizing routes, and enhancing operational efficiency. Cloud services provide ample storage capacity and powerful analytical tools that can process and analyze this data, deriving valuable insights to enhance decision-making processes.
- Collaboration and Integration: Cloud computing facilitates collaboration and information sharing among different stakeholders in the aviation industry. Air traffic controllers, airports, airlines, and other relevant entities can securely exchange data and collaborate in real-time through cloud-based platforms, improving communication and coordination.
- Security and Compliance: Cloud providers invest heavily in security measures to protect their infrastructure and customer data. They typically employ advanced security protocols, encryption, and access controls to safeguard against unauthorized access and data breaches. Additionally, cloud services can help ATN comply with industry-specific regulations and data protection requirements more efficiently.

By leveraging cloud services, ATN can enhance its operational efficiency, improve scalability, reduce costs, and take advantage of the latest technological advancements, ultimately leading to safer and more effective air traffic management.

II. Which deployment model should be used and why?

I would choose public cloud deployment model for reasons below:

- Cost Efficiency: Public cloud services typically follow a pay-as-you-go model, allowing organizations to pay only for the resources they use. This eliminates the need for upfront investments in hardware, infrastructure, and maintenance costs. By leveraging the economies of scale provided by cloud providers, ATN can reduce costs significantly.
- Scalability and Flexibility: Public cloud services offer high scalability, allowing organizations to easily adjust their resources based on demand. This is particularly beneficial for ATN, as air traffic can fluctuate throughout the day, week, or year. During peak periods, additional computing power can be quickly provisioned to handle increased traffic, while resources can be scaled down during periods of lower demand.
- Global Availability: Public cloud providers have data centers located in multiple regions worldwide. This global presence ensures that ATN can access cloud resources and services from various locations, enabling efficient and reliable access regardless of geographical boundaries. It also allows ATN to deploy services closer to the regions where they are needed, reducing latency and improving user experience.
- Reliability and High Availability: Public cloud providers have robust infrastructure and redundancy measures in place to ensure high availability and uptime. They utilize advanced data center technologies, such as failover mechanisms, data replication, and backup systems, to

minimize the risk of service disruptions. ATN can benefit from the reliability of public cloud services to maintain uninterrupted operations.

- Security and Compliance: Public cloud providers invest heavily in security measures and compliance certifications. They implement advanced security protocols, encryption mechanisms, and access controls to protect data and infrastructure. By leveraging the expertise of cloud providers, ATN can benefit from enterprise-grade security practices and ensure compliance with industry-specific regulations.
- Rapid Deployment and Innovation: Public cloud services enable organizations to rapidly deploy and iterate on applications and services. This agility allows ATN to experiment with new technologies, quickly roll out updates, and innovate in air traffic management. It reduces the time-to-market for new features and capabilities, enabling ATN to stay ahead of evolving industry requirements.
- Access to Advanced Technologies: Public cloud providers offer a wide range of advanced technologies and services, such as machine learning, big data analytics, and Internet of Things (IoT) platforms. ATN can leverage these services to analyze large volumes of air traffic data, improve operational efficiency, and gain valuable insights for decision-making.

Using the public cloud provides ATN with cost savings, scalability, global availability, enhanced security, and access to cutting-edge technologies. However, it's important to carefully consider factors like data sensitivity, regulatory compliance, and any specific requirements unique to ATN's operations before choosing the public cloud as the deployment model.

III. Which service model should be used and why?

I would choose the Software as a Service (SaaS) for reasons below:

- Accessibility and Ease of Use: SaaS applications are accessible over the internet, which means users can access them from anywhere, anytime, using a web browser or a dedicated client application. This accessibility promotes collaboration and allows users to work remotely or across different locations seamlessly. SaaS applications typically have intuitive user interfaces, making them easy to use and reducing the need for extensive training.
- Lower Maintenance and Support Efforts: SaaS providers are responsible for maintaining and supporting the software applications they offer. This includes tasks such as updates, patches, security enhancements, and infrastructure maintenance. By leveraging SaaS, ATN can offload these responsibilities to the provider, reducing the burden on their IT staff and allowing them to focus on more strategic initiatives.
- Rapid Deployment and Time-to-Value: SaaS applications are pre-configured and ready to use, eliminating the need for time-consuming software installation, configuration, and compatibility checks. This allows ATN to quickly deploy and start using the applications, resulting in faster time-to-value and improved productivity. SaaS providers also handle scalability, ensuring that the applications can accommodate growing user bases or increased demands without disruption.

- Cost Efficiency and Predictability: SaaS follows a subscription-based pricing model, where organizations pay a regular fee based on usage or the number of users. This eliminates the need for upfront capital investments and reduces the total cost of ownership. SaaS providers also handle infrastructure costs, including hardware, storage, and network infrastructure, further reducing ATN's expenses. Additionally, the predictable pricing structure allows for better budget planning and cost control.
- Continuous Updates and Innovation: SaaS providers are responsible for keeping the applications up to date with the latest features, enhancements, and security measures. This ensures that ATN always has access to the most recent software versions without the need for manual updates or migrations. SaaS providers often prioritize innovation and invest in research and development, allowing ATN to benefit from new capabilities and advancements in air traffic management.
- Scalability and Flexibility: SaaS applications are designed to be highly scalable, allowing ATN to easily accommodate changing user demands and scale the usage up or down as needed. SaaS providers have the infrastructure in place to handle fluctuations in user loads, ensuring smooth and reliable performance even during peak usage periods. This scalability enables ATN to align their software usage and costs with their specific requirements.

By leveraging the SaaS service model, ATN can focus on their core air traffic management activities while benefiting from readily available, well-maintained software applications. It enables them to reduce maintenance efforts, quickly deploy applications, control costs, and take advantage of continuous updates and innovations, ultimately enhancing operational efficiency and user experience.

IV. Which programming language should be used? (In this case NodeJS)

Node.js is a popular programming language that is well-suited for certain use cases. Here are some reasons why Node.js may be a good choice for ATN:

- Asynchronous and Non-Blocking: Node.js is built on an event-driven, non-blocking I/O model. This allows ATN to handle concurrent requests efficiently, making it suitable for applications that require high scalability and responsiveness. In the context of air traffic management, where real-time data processing and communication are critical, Node.js can handle a large number of concurrent connections and perform well under heavy loads.
- JavaScript Ecosystem: Node.js is based on JavaScript, which is one of the most widely used programming languages in the world. This provides ATN with a large and active developer community, extensive libraries, frameworks, and tools. The JavaScript ecosystem offers numerous modules and packages that can accelerate development, improve productivity, and simplify integration with other systems and APIs.
- Full-Stack JavaScript: Node.js allows for full-stack JavaScript development, where the same programming language can be used for both the frontend and backend. This can streamline the development process, enable code reuse, and enhance the collaboration between frontend and backend developers. ATN can leverage this advantage to build end-to-end applications using a unified language and development approach.

- Microservices Architecture: Node.js is well-suited for implementing microservices architectures. Microservices promote modularity, scalability, and maintainability by breaking down applications into smaller, loosely coupled services. Node.js' lightweight and fast performance, along with its support for event-driven and non-blocking I/O, make it a good choice for building microservices-based systems that can handle individual air traffic management functions independently.
- NPM (Node Package Manager): Node.js has a powerful package manager called NPM, which provides access to a vast repository of open-source packages. NPM makes it easy to manage dependencies, reuse code, and integrate third-party libraries into ATN's applications. The availability of numerous pre-built modules can accelerate development and provide ATN with a wide range of functionality to enhance their air traffic management systems.

It's important to note that the choice of programming language ultimately depends on the specific requirements, expertise, and preferences of ATN's development team. While Node.js offers several advantages, other programming languages may also be suitable for different use cases within ATN's infrastructure. It's recommended to evaluate the requirements, performance characteristics, and available resources before finalizing the choice of programming language.

V. Which database should be used? (In this case MongoDB)

MongoDB, a popular NoSQL database, can be a suitable choice for ATN based on the following considerations:

- Flexibility and Scalability: MongoDB is a flexible and scalable database that can handle large volumes of data and accommodate the dynamic nature of air traffic management. It supports horizontal scaling by distributing data across multiple servers, allowing ATN to scale their database infrastructure as their data grows and handle increasing traffic loads efficiently.
- Document-Oriented Data Model: MongoDB uses a document-oriented data model, where data is stored in flexible, self-contained documents in BSON (Binary JSON) format. This data model aligns well with the semi-structured and evolving nature of air traffic data. It allows for easy representation of complex data structures and enables efficient querying and indexing.
- Real-Time Data Processing: MongoDB's ability to handle real-time data processing makes it suitable for capturing and analyzing air traffic data in near real-time. Its support for data replication and change streams enables applications to react to data changes instantly, facilitating real-time monitoring, alerting, and decision-making in air traffic management.
- Geospatial Data Capabilities: MongoDB has robust geospatial data capabilities, making it suitable for spatial analysis and location-based queries. This is particularly relevant to ATN, as air traffic management involves tracking and managing aircraft positions, routes, and airspace. MongoDB's geospatial indexes and queries can efficiently handle spatial data, enabling ATN to perform geospatial analysis and optimization.
- High Availability and Fault Tolerance: MongoDB provides features like replica sets and automatic failover to ensure high availability and fault tolerance. Replica sets allow for data replication across multiple nodes, providing redundancy and eliminating single points of failure. In the event

of a primary node failure, MongoDB automatically elects a new primary node, ensuring uninterrupted access to data.

- Rich Querying and Aggregation Capabilities: MongoDB offers a powerful query language and aggregation framework that allows for flexible and expressive querying, filtering, and aggregation of data. This enables ATN to perform complex data analysis, generate reports, and gain valuable insights from their air traffic data.
- Developer Productivity: MongoDB's query language and APIs are intuitive and familiar to developers, making it easier to work with and reducing the learning curve. Additionally, MongoDB's community support and extensive documentation contribute to developer productivity and troubleshooting.

It's important to note that the choice of database ultimately depends on ATN's specific requirements, existing infrastructure, and expertise. While MongoDB offers several advantages, other databases (both SQL and NoSQL) may also be suitable depending on factors like data structure, transactional requirements, and integration with existing systems. ATN should carefully evaluate their needs and consult with database experts before finalizing the choice of database.

VI. Which cloud platform should be used? (GitHub in this case)

GitHub is primarily a version control and collaboration platform for software development, rather than a traditional cloud platform for hosting applications. However, GitHub does provide some cloud-based services and features that can be beneficial for ATN's software development and collaboration needs. Here are some reasons why GitHub as a collaboration platform can be advantageous:

- Version Control: GitHub offers robust version control capabilities through Git, allowing developers to track changes, manage different branches, and collaborate on code seamlessly. Git provides a distributed model, making it easy for teams to work on code locally and synchronize their changes with the central repository. Version control is crucial for managing codebase integrity and enabling collaboration among developers working on different aspects of ATN's software.
- Collaboration and Code Review: GitHub provides features like pull requests, code review tools, and issue tracking, enabling effective collaboration among developers. Pull requests allow team members to propose changes, discuss code, and review each other's work before merging it into the main codebase. This promotes code quality, knowledge sharing, and better teamwork.
- Continuous Integration and Deployment (CI/CD): GitHub integrates with various continuous integration and deployment tools, allowing for automated build, testing, and deployment pipelines. Services like GitHub Actions provide a built-in CI/CD workflow, enabling teams to automate the testing and deployment processes for their applications. This facilitates rapid and reliable delivery of updates to ATN's software systems.
- Community and Open Source Collaboration: GitHub has a large and active community of developers and open-source projects. By leveraging GitHub, ATN can tap into this community and collaborate with external developers, contribute to open-source projects, and showcase their own

projects. This fosters knowledge sharing, innovation, and the potential for partnerships with other organizations in the air traffic management space.

- Documentation and Wikis: GitHub provides features for creating and maintaining documentation, wikis, and project wikis. This allows ATN to document their software development processes, APIs, and other project-related information. Well-maintained documentation ensures that the development team and other stakeholders have access to up-to-date information, facilitating smoother collaboration and knowledge transfer.

While GitHub offers these collaboration and code management features, it may not be the ideal platform for hosting and deploying the actual ATN application. For hosting and deploying applications, it's recommended to explore traditional cloud platforms like Amazon Web Services (AWS), Microsoft Azure, or Google Cloud Platform (GCP), which provide a broader set of infrastructure and service offerings to meet the hosting and deployment needs of ATN applications.

Conclusion

Trends in cloud computing are spreading across the globe. Although there are many distinct cloud computing models, all of them aim to engage and advance each company plan in line with the rapidly changing state of technology. The paper I just presented provides an overview of cloud computing and its concept, but rather the features, exceptional services, and advantages that cloud computing offers to businesses and society. We have developed a strategy, a case, and justifications for choosing cloud computing over conventional methods of data management based on the circumstance.