Assignment - 2

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Designing a Self-Sustained Cloud Computing Data Center for Hajee Mohammad Danesh Science and Technology University (HSTU)

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Table of content:

1. Introduction

A data center or computer center (also datacenter) is a facility used to house computer systems and associated components, such as telecommunications and storage systems. It generally includes redundant or backup power supplies, redundant data communications connections, environmental controls (e.g., air conditioning, fire suppression) and security devices. Large data centers are industrial scale operations using as much electricity as a small town.

2. History

Data centers have their roots in the huge computer rooms of the early ages of the computing industry. Early computer systems were complex to operate and maintain, and required a special environment in which to operate. Many cables were necessary to connect all the components and methods to accommodate and organize these were devised, such as standard racks to mount equipment, elevated floors, and cable trays (installed overhead or under the elevated floor). Also, a single mainframe required a great deal of power, and had to be cooled to avoid overheating. Security was important - computers were expensive, and were often used for military purposes. Basic design guidelines for controlling access to the computer room were therefore devised.

3. Requirement Analysis

The Planning, Design and Implementation Services for Data center transformation combine the people, processes and technology, with the program and project management necessary to transform a client's existing data centers into ones that provide business agility at a lower cost, a wide range of services for discovery, analysis, optimization, virtualization and migration of data centers that can complement client efforts and fill gaps in client skills and capacities.

Various aspects of the data centers include:

- Facilities: layout, power/cooling, physical security;
- System infrastructure: servers, networking, storage and security;
- Applications, infrastructure mapping & dependencies;

- Service management and operations considerations;

To design data center we have to select some select some sub area of the university. The areas are given below:

i. Departments: Finding out all of the academic and administrative departments under the university.
ii. Faculty: List the number of teachers, their research requirements, and collaboration needs.
iii. Students: Estimate the number of students and their data needs for research, projects, and learning.
iv. Administrative Staff: Determine the needs of administrative functions.
v. Special Requirements: Identify any specialized requirements such as GPU-based servers for Machine Learning (ML) workloads.
vi. Departments: 10 Teachers: 500 Students: 10,000 Staff: 500 Sections: 100

4. Data Centre Storage

Analyze current data storage and processing requirements. Project future needs for the next 5-10 years based on growth trends and new initiatives. Categorize data into tiers (hot, warm, cold) based on access frequency.

Compute: 1000 cores Storage: 100 TB Memory: 1 TB

Projected Data Needs for Next 5-10 Years

Compute: 10,000 cores Storage: 1 PB Memory: 10 TB

5. Physical Infrastructure Design:

Data center virtualization includes storage, desktop, and server virtualization, reduces overall IT equipment electrical load through consolidation of systems. The resulting energy savings can be further maximized if IT or facilities managers adjust the power and cooling infrastructure to accommodate the reduced loads. Planning for this cycle of initial reduced load followed by load growth with IT equipment running at much higher overall utilization levels can result in the capture of a signification supplemental energy savings entitlement.

Design consideration for data center:

Network Infrastructure

Communications in data centers today are most often based on networks running the IP protocol suite. Data centers contain a set of routers and switches that transport traffic between the servers and to the outside world. Redundancy of the Internet's connection is often provided by using two or more upstream service providers

The network topology for the data center will be a leaf-spine topology. This topology is highly scalable and resilient, making it ideal for cloud computing environments. The leaf-spine topology will consist of two layers of switches: leaf switches and spine switches. The leaf switches will be connected to the servers and other devices in the data center. The spine switches will be connected to the leaf switches and to each other. The spine switches will provide a redundant path for traffic between the leaf switches.

Server Racks

The server racks in the data center will be a mix of hot aisle/cold aisle and front-in/front-out racks. The hot aisle/cold aisle racks will be used for servers that generate a lot of heat. The front-in/front-out racks will be used for servers that generate less heat. The server racks will be arranged in rows and aisles. The hot aisle/cold aisle racks will be arranged with the hot aisles facing each other and the cold aisles facing each other. The front-in/front-out racks will be arranged with the front sides facing each other.

Specify server types based on workload:

- Various Cisco routers
    - Cisco CRS Router (carrier routing system)
    - Cisco ASR 9000 Series Aggregation Services Routers
    - Cisco XR 12000 Series Router
- General-purpose servers for administrative tasks.
- GPU-equipped servers for ML workloads.
- Storage servers for data repositories.

Types of Servers

The types of servers that will be used in the data center will include:

- Compute servers: These servers will be used for general-purpose computing workloads, such as web hosting, email, and database servers.
- Storage servers: These servers will be used for storing data, such as files, databases, and backups.
- GPU-based servers: These servers will be used for machine learning and artificial intelligence workloads.

Network switch

A network switch is a computer networking device that links network segments or network devices. The term commonly refers to a multi-port network bridge that processes and routs data at the data link layer (layer 2) of the OSI model. Switches that additionally process data at the network layer (layer 3) and above are often layer-3 switches or multilayer switches.

Various Cisco switched

- Cisco catalyst 4500-X series Switches
- Cisco Nexus 7000 Series Switches
- Cisco Nexus 5000 Series Switches
- Cisco Nexus 3000 Series Switches

Storage Solutions

The storage solutions that will be used in the data center will include:

- Network attached storage (NAS): NAS will be used for storing large amounts of unstructured data, such as files and backups.
- Storage area networks (SAN): SAN will be used for storing high-performance data, such as databases and virtual machines.
- Object storage: Object storage will be used for storing large amounts of data that needs to be accessed frequently, such as images and videos.

Choose appropriate storage technologies:

- SSDs for high-speed, low-latency storage.
- HDDs for cost-effective, high-capacity storage.
- Network Attached Storage (NAS) or Storage Area Network (SAN) for shared storage.
- Implement redundancy and scalability.

Cooling Solutions

The cooling solutions that will be used in the data center will include:

- Air cooling: Air cooling is the most common type of cooling used in data centers. It is a relatively inexpensive and easy-to-maintain solution.
- Water cooling: Water cooling is more efficient than air cooling, but it is also more expensive and complex to maintain.
- Liquid cooling: Liquid cooling is the most efficient type of cooling, but it is also the most expensive and complex to maintain.
- Use energy-efficient cooling techniques like hot/cold aisle containment.
- Implement temperature and humidity monitoring systems.
- Consider free cooling options where applicable.

Backup and Disaster Recovery Strategy

The backup and disaster recovery strategy for the data center will include:

- Daily backups of all data to a remote location.
- Weekly backups of all data to a tape library.
- Monthly off-site backups of all data.
- A disaster recovery plan that includes the ability to restore all systems and data from the backups.
- Use energy-efficient cooling techniques like hot/cold aisle containment.
- Implement temperature and humidity monitoring systems.
- Consider free cooling options where applicable.

6. Security and Compliance

The security and compliance measures that will be implemented in the data center will include:

- Firewalls: Firewalls will be used to protect the data center from unauthorized access.
- Intrusion detection systems (IDS): IDS will be used to detect and respond to malicious activity on the network.
- Data encryption: All data will be encrypted at rest and in transit to protect it from unauthorized access.
- Identity and access management (IAM): IAM will be used to control who has access to the data center and its resources.

a. Security Protocols:

- Define security policies and access controls.
- Implement role-based access control (RBAC) for data and resources.
- Conduct regular security audits and vulnerability assessments.

b. Network Security:

- Use firewalls and intrusion detection/prevention systems (IDS/IPS).
- Implement Virtual LANs (VLANs) for network segmentation.
- Employ encryption for data in transit.

c. Data Encryption:

- Encrypt data at rest using industry-standard encryption methods.
- Implement secure key management.
- Enable encryption for data in transit (SSL/TLS).

d. Identity and Access Management:

- Implement Single Sign-On (SSO) for user convenience.
- Use two-factor authentication (2FA) for enhanced security.

- Regularly review and update access permissions.

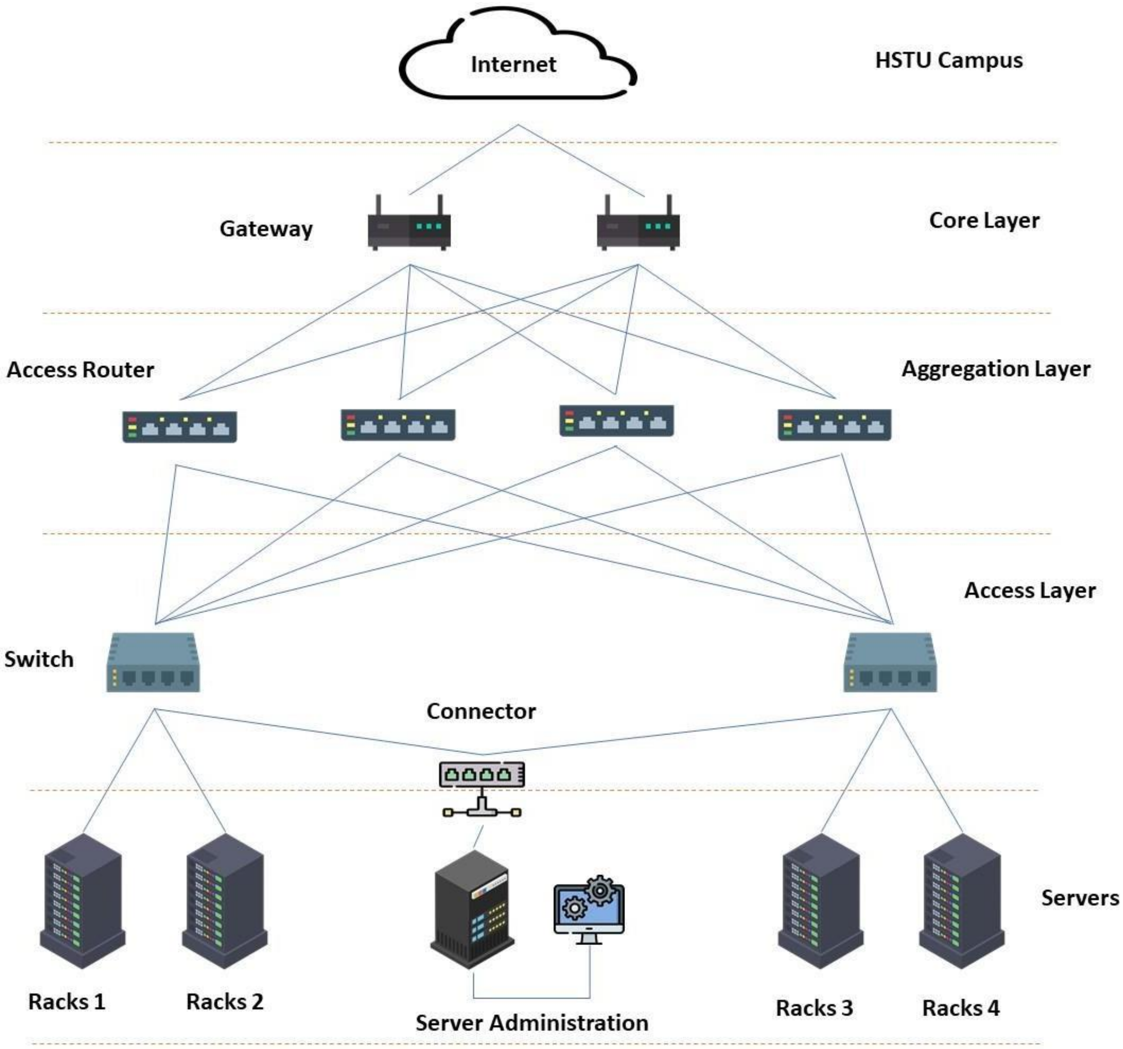

Figure 1: Designing a Data Center for Cloud Computing at HSTU

7. Mechnical Engineering Infrastructure Design

Mechanical engineering infrastructure design addresses Mechnical systems involved in maintaining the interior environment of a data center, such as heating, ventilation and air conditioning (HVAC); humidification and dehumidification equipment; pressurization; and so on. This stage of the design process should be aimed at saving space and costs, while ensuring business and reliability objectives are met as well as achieving PUE and greed requirements. Modern designs include modularizing and scaling IT loads, and making sure capital spending on the building construction is optimized.

We have to consider some concepts to design this:

- Heating
- Ventilation
- Air conditioning
- Fire Protection
- Site selection

8. Software and Platform Choices

The cloud platform/software that will be used in the data center will be OpenStack. OpenStack is an open-source cloud computing platform that is well-suited for academic environments. It is scalable, reliable, and secure.

Scalability and Future Growth

The design of the data center will support easy scaling without major architectural changes. The network topology, server racks, and storage solutions are all scalable. The cloud platform/software is also scalable.

a. Cloud Platform/Software:

- Choose a cloud management platform like OpenStack or VMWare suitable for academic environments.
- Ensure compatibility with existing software and tools.

9. Scalability and Future Growth:

a. Scalability:

- Design for horizontal scalability with the ability to add more servers and storage without major disruptions.
- Implement load balancing for resource allocation.

10. Cost Analysis

The budget for the data center will include the following costs:

- Infrastructure costs: This will include the cost of the servers, storage, networking equipment, and cooling equipment.
- Software license costs: This will include the cost of the cloud platform/software license and any other software licenses that are required.
- Ongoing maintenance costs: This will include the cost of paying staff to maintain

Prepare a detailed budget including:

- Infrastructure costs (servers, storage, and networking).
- Software license costs.
- Ongoing maintenance costs (power, cooling, staffing).

- Projected energy costs based on server and cooling requirements.

Table 1: Infrastructure Costs:

Servers (General-purpose)	*10,000,000 BDT*
Specialized Servers (GPU, etc.)	*2,000,000 BDT*
Storage Systems	*8,000,000 BDT*
Networking Equipment	*1,500,000 BDT*
Racks and Cabinets	*1,000,000 BDT*
Power and Cooling Infrastructure	*3,000,000 BDT*
Other Hardware and Accessories	*500,000 BDT*
Total Infrastructure Costs	*26,000,000 BDT*

Table 2: Software and Licensing Costs:

Cloud Management Software	*2,000,000 BDT*
Security Software and Licenses	*1,000,000 BDT*
Backup and Disaster Recovery Software	*1,500,000 BDT*
Other Software (if applicable)	*500,000 BDT*
Total Software Costs	*5,000,000 BDT*

Table 3: Ongoing Operational Costs (Per Year):

Category	Estimated Cost (BDT)
Power and Cooling	**2,500,000 BDT**
Maintenance and Support	**1,500,000 BDT**
Staffing and Salaries (if applicable)	**3,000,000 BDT**
Energy Costs (Electricity)	**1,000,000 BDT**
Total Operational Costs	8,000,000 BDT

Table 4: Total Projected Costs (Initial + 5-10 Years of Operations):

Category	Estimated Cost (BDT)
Infrastructure Costs (Initial)	**26,000,000 BDT**
Software and Licensing Costs (Initial)	**5,000,000 BDT**
Ongoing Operational Costs (5-10 years)	**40,000,000 BDT**
Total Projected Costs	71,000,000 BDT

7. Deliverables:

Provide a comprehensive report and design blueprint that includes:

- Detailed diagrams of the proposed infrastructure.
- Justifications for each design choice based on HSTU's requirements.
- Projected cost analysis with a breakdown of expenses.

Ensure that your design aligns with HSTU's objectives of creating a self-sustained cloud environment that promotes innovation, supports research, meets administrative needs, and provides a learning platform for students. Regularly update and adapt the design to keep up with evolving technology and institutional needs.

8. Overall Summary

The total cost of designing, implementing, and operating a data center for cloud computing at HSTU is estimated to be total Infrastructure Costs 26,000,000 BDT and Total Software Costs 5,000,000 BDT and Total Operational Costs 8,000,000 BDT and Total Projected Costs 71,000,000 BDT.The infrastructure costs, software license costs, and ongoing maintenance costs are the most significant cost items.

HSTU can reduce the cost of the data center by using open-source software, such as OpenStack, and by negotiating favorable pricing with vendors. HSTU can also save money on energy costs by designing the data center to be energy efficient and by using renewable energy sources, such as solar power.

The cost of the data center is justified by the benefits that it will provide to HSTU. The data center will enable HSTU to support its increasing need for cloud resources, which will promote innovation, support large-scale research, meet administrative needs, and offer a learning platform for students.