GROUP ASSIGNMENT

TECHNOLOGY PARK MALAYSIA

CT109-3-2-DCI

DATA CENTER INFRASTRUCTURE

NP2F1901IT

HAND OUT DATE: 08 June 2019

HAND IN DATE: 01 December 2019

INSTRUCTIONS TO CANDIDATES:

1. **Submit your assignment at the administrative counter.**

2. **Students are advised to underpin their answers with the use of references (Cited using the Harvard Name System of referencing).**

3. **Late submissions will be awarded zero (0) unless extenuating Circumstances (EC) is upheld.**

4. **Cases of plagiarism will be penalized.**

5. **The assignment should be bound in an appropriate style (comb bound or stapled)**

6. **Where the assignment should be submitted in both hard copy and softcopy, the softcopy of the written assignment and source code (where appropriate) should be on a CD in an envelope/ CD cover and attached to the hardcopy.**

7. **You must obtain 50% overall to pass this module.**

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1. Introduction

With the increase in technology and modern devices the information and data produced is getting bigger so in order to protect the data and information data center are required. In this world of information and technology data center are highly in demand.

A data center is a facility that centralizes an organization's IT operations and equipment, as well as where it stores, manages, and disseminates its data. Data centers house a network's most critical systems and are vital to the continuity of daily operations. Consequentially, the security and reliability of data centers and their information is a top priority for organizations"[CITATION pal19 \l 1033].

Hardware infrastructure indicates physical components such as servers, storage systems, network components, power supply, cooling system, and anything needed to support data center operations. Software infrastructure, on the other hand, refers to software running on hardware infrastructure, including low-level programs (e.g. operating systems) that interact with the hardware. Software infrastructure also offers many data center features to serve a large amount of data such as data protection, backup, and virtualization. Besides, software infrastructure also provides management functionality for IT staff not only manages data but also manages hardware resource. The top level of the data center is application software which provides services to end users. Application software can vary based on usage. The applications can be a database, email service, web browsers, and enterprises applications such as ERP, billing systems"[CITATION cod19 \l 1033].

Data centers have evolved significantly in recent years, adopting technologies such as virtualization to optimize resource utilization and increase IT flexibility. As enterprise IT needs continue to evolve toward on-demand services, many organizations are moving toward cloud-based services and infrastructure. A focus has also been placed on initiatives to reduce the enormous energy consumption of data centers by incorporating more efficient technologies and practices in data center management. Data centers built to these standards have been coined green data centers"[CITATION pal19 \l 1033].

2. History of Data Center

Data center are nothing new in concepts for the people. The history of data center goes way back to 1940s. In 1940s the “Electronic Numerical Integrator and Computer (ENIAC) was built in 1946 for the U.S. Army to store artillery firing codes and was dubbed as the first general-purpose electronic digital computer. The first transistorized computer (TRADIC) was introduced in 1954 and was the first machine to use all transistors and diodes and no vacuum tubes. Serious commercial systems did not arrive until the 1960s, leading to mainframes like the IBM System series to develop a substantial jump in compute abilities”[CITATION Sil19 \l 1033].

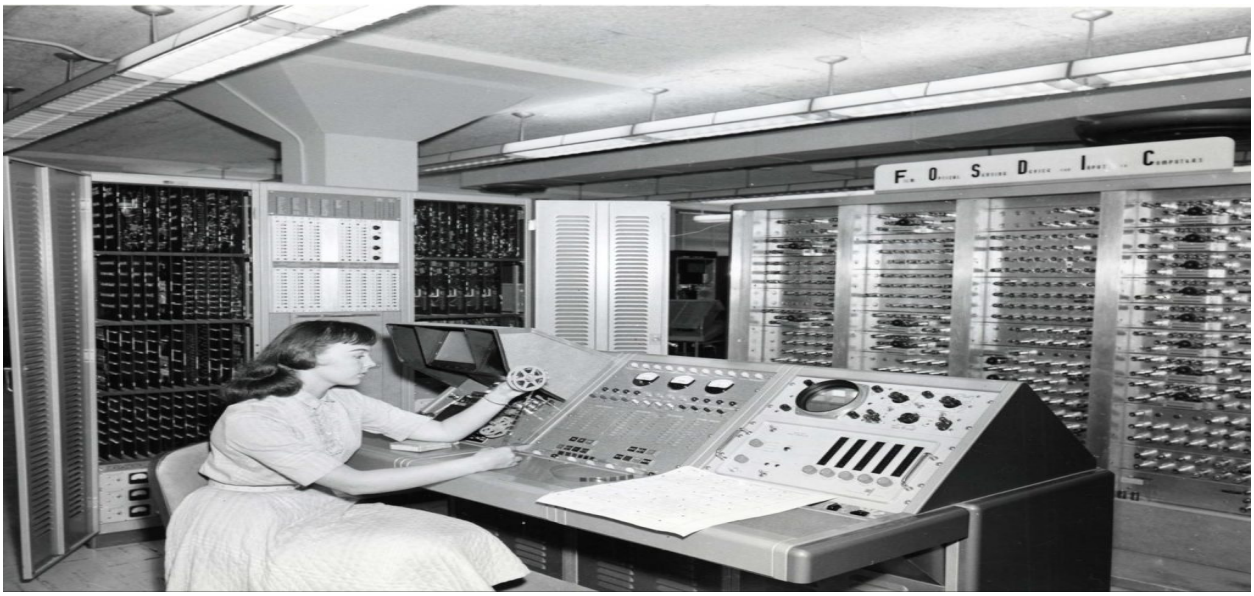

Figure 1: Data centers in the early 60s

“The release of the first commercial microprocessor by Intel in 1971 led to a significant reduction in the size of mainframe computers. Data centers in particular, gained prominence due to the growing need to have formal data recovery plans in the event of a disaster. Players in the computing industry were of the idea that if disaster struck, it wouldn’t necessarily have to disrupt business operations since computers only handled after-the-fact bookkeeping duties. Towards the end of the 1970s, huge mainframe computers were phased out gradually, and replaced by air-cooled computers that could be moved into offices [CITATION rac18 \l 1033].

Figure 2: Devices used in early stage of data center

Personal computers (PCs) were introduced in 1981, leading to a boom in the microcomputer industry. Sun Microsystems developed the network file system protocol, allowing a user on a client computer to access files over a network in a manner similar to how local storage is accessed. Computers were being installed at a rapid rate everywhere we turned, but minimal attention was being given to environmental and operating requirements[CITATION Sil19 \l 1033].

Companies were increasingly setting up server rooms within their premises due to the availability of relatively affordable networking equipment. Data centers became even more prominent during the dot.com bubble since companies needed fast Internet connection to establish a footprint on the web. Consequently, most companies started building large facilities to provide data backups [CITATION rac18 \l 1033].

Apple and VMware had contributed in creating the server area in late 90s. Moreover, Amazon web administrations began movement of suite of the cloud-based administrations in 2002. The administrations has included computation and human intelligence through “Amazon Mechanical Turk” and started giving IT foundation administrations to the trade clients within the frame of web services i.e. cloud computing. Survey was conducted within the mid-2012. Result appears that 38 % of trade were as of now expending the cloud. Afterward that year, increment of 13% was found of utilizing cloud computing within the commerce. So also, Google contributed a huge capital of $7.35 billion to improve its web frame during the year 2013. The consumption lead to the tremendous development within the global information center organize of Google

which was gotten to be as one of the greatest development within the history of information center industry.

3. Importance of Data Centers

In the modern world data center has been an important factor to run and mobilize the advancing IT world. Data center has evolved with the evolving technology. Huge investment is required to modify hardware and software resulting in development in information technology infrastructure. Such development has provided a competitive advantage over generations. So some of the importance of data center are as follows:

- No Infrastructure cost
- Security
- Bandwidth
- Uninterrupted Power Supply

3.1 No infrastructure Cost

When the data center are availed of there is no need for the investment in the infrastructure of the data center. The data center service provides charges client for services rendered. Additional software and hardware can be added later on request and can be customized within short interval of time. Saving funds on hardware can certainly be a major cost saving factor for most small and even major corporations if infrastructure costs increase disproportionately when compared to total spending.

3.2 Security

Security is one of the important things to be considered when it comes to data center. Each step to get into the data center is video logged and surveillance is kept in place and the identities can be controlled via bio-metrics. Entry to the compound is restricted and client is provided with its own dedicated space and security level according to their wishes.

3.3 Bandwidth

With the steady increment in online business, the rate for prerequisite of data transfer capacity increments fundamentally. Electronic requesting, item enrollment, online showcasing, video promotions, sound conferencing, video and sound joint effort are on the whole transmission

capacity thorough applications. Dealing with every one of these administrations constantly, we can say data center are helpful and well-prepared system service.

3.3 Uninterrupted Power Supply

Basically, no interruption in control supply implies higher server uptime. The Data centers are built in such a way that the control supply system never goes down. By and large, in case of a common control blackout, a battery bank will give control till the fuel generators are started up.

4. Services offered by ZiPro

ZiPro is a service provider that provides companies and networks with deployment and technical support services. It provides support to multinational companies for small and medium-sized enterprises. It also helps the facility to store data according to the client's requirement to the respective data center. It maintains security, proper bandwidth, and continuous power, etc.

5. Problem Statement

The main problem in the organization is that it is being unable to install the data center and not being able to find the best solution for the implementation of the data center. This will affect the customer and the organization itself. It causing a great deal in the area of data storage. If the problem in the location of the data center will be solved then it will definitely be able to improve the services provided by the Panadox to its 10 million customer.

It is necessary to find the electrical system in a secure mechanical room. It must be equipped with HVAC systems to back up the heat stack and adjust the stickiness levels to maintain each unit for a qualified professional. The extended assurance of the production line could and must be supportable. A trained production line measurement specialist must maintain a control panel. It has to be found in a safe place. UPS system in the Information Center must be measured to meet current and future needs, with sufficient battery reinforcements to allow a controlled shutdown of critical servers. It must be prepared, installed and managed in a secure area by licensed electricians and professionals. UPS systems follow the prescribed support plan of the manufacturer.

6. Basic Concept

6.1 Aim

The main aim of the project is to proposing a data center infrastructure suitable for Panadox Company.

6.2 Objective

The current aim of the project is to produce a Data Center Design Plan for Panadox with necessary data center infrastructure components.

6.3 Mission

The main mission of making a data center is to create a dependable and productive benefit for facilitating and delivering basic data resources and other information to its clients.

6.4 Vision

Data centers and servers are at the heart of modern digital universe. ZiPro wants to be the most important provider of computing cloud, servers rental and the connected services which provide the customers with unlimited access to the most up-to-date technologies in the field of data processing and storage, without the need for own investment in the area.

ZiPro wants to be present with its services in all the data centers important for Panadox and its more than 10 million patients for building a data center which provides a Customer Relationship Management (CRM) platform for hospitals, allowing practitioners to manage communications in one inbox, streamlining physician relationships, drive collaboration between partners, and engage patients – all integrated with a medical practice’s existing electronic health record (EHR).

7. DCI Architecture

The data center is home to computer control, ability, and applications that are essential to support a business. The base of the data center is fundamental to the IT technology from which all material originates or passes. Appropriate design of the information center development plan is important, and careful consideration must be given to implementation, stability, and adaptability.

Another important point of view in the development of the data center is adaptability in fast transmission and support of unused resources. A critical competitive advantage can result from planning a flexible design that has the ability to support unused applications in a short time outline. Such a plan requires strong start-up planning and thoughtful thinking within port thickness ranges, access layer uplink capacity transmission, genuine server capacity, and over-subscription, etc.

Within the services provided by the Information Center, Panadox can have faith to be able to provide its products to its customers. Panadox's availability goal could be a reliability of 99.995 percent. The data center will be evaluated in accordance with the hierarchy of the information center level. The hierarchy of the information center tier could be a guideline for awarding a level score to each information center based on the criteria for uptime. The hierarchy criteria of the data center tier are shown in the table below:

Tier requirements	TIER I	TIER II	TIER III	TIER IV
Distribution paths power and cooling	1	1	1 active / 1 alternate	2 active
Redundancy active components	N	N+1	N+1	2 (N+1)
Redundancy backbone	no	no	yes	yes
Redundancy horizontal cabling	no	no	no	optional
Raised floors	12"	18"	30"-36"	30"-36"
UPS / generator	optional	yes	yes	dual
Concurrently maintainable	no	no	yes	yes
Fault tolerant	no	no	no	yes
Availability	**99.671%**	**99.749%**	**99.982%**	**99.995%**

Figure 3: The hierarchy criteria of the data center tier

Tier 1 Architecture

A Tier 1 data center can be a kind of information center that has one database source, organizes connections, and other components. It is one of the best data center level shapes and requires some data center system components and operating resources excess or backup supply. A data center at level 1 is also known as a data center at level 1. The basic-intermediate tier of data center rates is a Tier 1 data center. Presented by the Uptime Organized, it is used in terms of accessibility to provide impartial identification of data centers. A tier1 data center only has basic components or information center foundation and isn't suited for venture or mission basic data center, because it needs any excess source of servers, network/Internet links, capacity, control and cooling resources.

Tier 2 Architecture

A data center tier 2 can be an environment with various database sources, coordinating connections and other components of the information center. It might be a center with excess parts, but as if it were one path / source or partial redundancy in the control and cooling services of the information center. In contrast, a Tier 2 Information Center is known as a Tier 2 data and Tier 1 information center highlights, but with components of excess capacity or infrastructure. A control module or hardware can be substituted or expelled in a Tier 2 data center without interrupting the control transmission to the components of the network.

Tier 3 Architecture

An area with surplus and dual-powered servers, storage, network connections and other IT resources could be a Tier 3 data center. It is one of the most frequently used data center rates, where IT components are operated by various, dynamic and autonomous control and cooling resources. A data center of tier 3 is also known as a data center of tier 3. A Tier 3 data center blends and meets the highlights and capabilities of Level 1 and Tier 2 information centers but with elements of the base of the excess capacity and information center. Like a data center tier2, IT modules can be replaced or withdrawn without interfering with activities in the information center schedule.

Tier 4 Architecture

A Tier 4 data center is an enterprise level data center lesson with excess and dual-powered database, storage, network connections, and cooling hardware control occurrences. It is the most

advanced category of data center tier, where redundancy is linked across the computing and non-computing infrastructure of the entire information center. A Tier 4 information center blends and meets the highlights and strengths of everything coming before layers of the information center. This provides end-to-end resistance to blame by sending and duplicating the entire infrastructure of the information center.

We are going to use tire 4 architecture to build the data center. The software of Tire 4 is also known as the system of fault tolerance. Tire 4 architecture's fundamental requirements should have a fault tolerance and multiple that provides redundant capacity components, while the active distributed path serves the critical environment simultaneously. All IT hardware is dual power with the unit's internal fault-tolerant power layout and properly installed to be compliant with the architecture topology. In sensitive conditions that do not follow requirements, the change point must be integrated. The distributed path must be physically separated from each other to prevent any single event from impacting all systems or distributed paths concurrently. Continuous cooling is also required, providing a stable environment for all critical spaces. Cooling cycle should be that it provides cooling until at the maximum ambient condition the mechanical system provides level cooling.

8. Infrastructure Challenges and Issue

Most of DCIM's emerging technologies have many doors, approaches, and confusing market definitions proliferation. Panadox is a large company, and with time, the sites will become larger and the methods of work will become more complicated. Helping facility managers make informed decisions about acquisitions, transfers, consolidations and relocations will become counterproductive. For about 10 million customers in Panadox, the data will be big, which at the beginning will be a challenge to answer questions like these on its own.

- How many servers am I going to need? Where am I going to find them?
- How will the power line and network patch board be physically connected?
- What power will I need and what impact will my power chain have?
- Do I have the power and connectivity to the network?
- Can these servers be installed on these racks?

9: Room Layout

Data center layout is used in data center design and construction to the plan out the best possible housing of the physical hardware and resources in the data center[CITATION www1938 \l 1033]. Implementing room layout in data center helps the data center designer to understand and evaluate the space consumed in data center. Data center has two components room layout that is structure layout and the equipment layout. The structure layout also known as the empty room where as equipment layout refers what will go in the room.

Structural layout

The design of the space involves the location of walls, doors, columns of support, screens, windows, and main connections to the utility. If the space has an elevated floor, it also includes the height of the elevated floor and the location of access ramps or lifts. If the space has an elevated floor or a suspended ceiling, the floor or ceiling grid index points are important variables for design and must also be included in the structural layout.

Equipment Layout

The configuration of the facilities illustrates the footprint of IT equipment and the power and cooling equipment layout. Typically, IT equipment can be identified as rack locations regardless of specific devices in the cabinets. Therefore, the airflow direction of the IT equipment in the design must be defined. The airflow is front-to-back for standard IT racks, but some systems have other airflow patterns like front-to-top. Power and cooling equipment must also be included in the configuration of the equipment

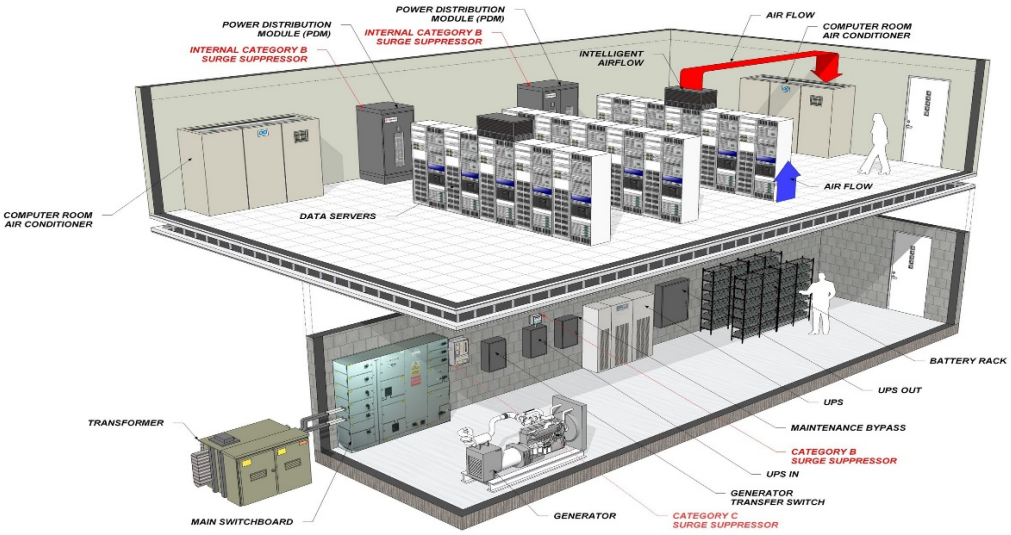

Figure 4: Room Layout

10. Logical Design

Multi-Tier Design Model is currently being used by Panadox data center. It is the company's most common model. The kernel, aggregation and access layer are the basic layers of the layout of the logical data center. The Multi-Tier Model is made up of three layers listed below:

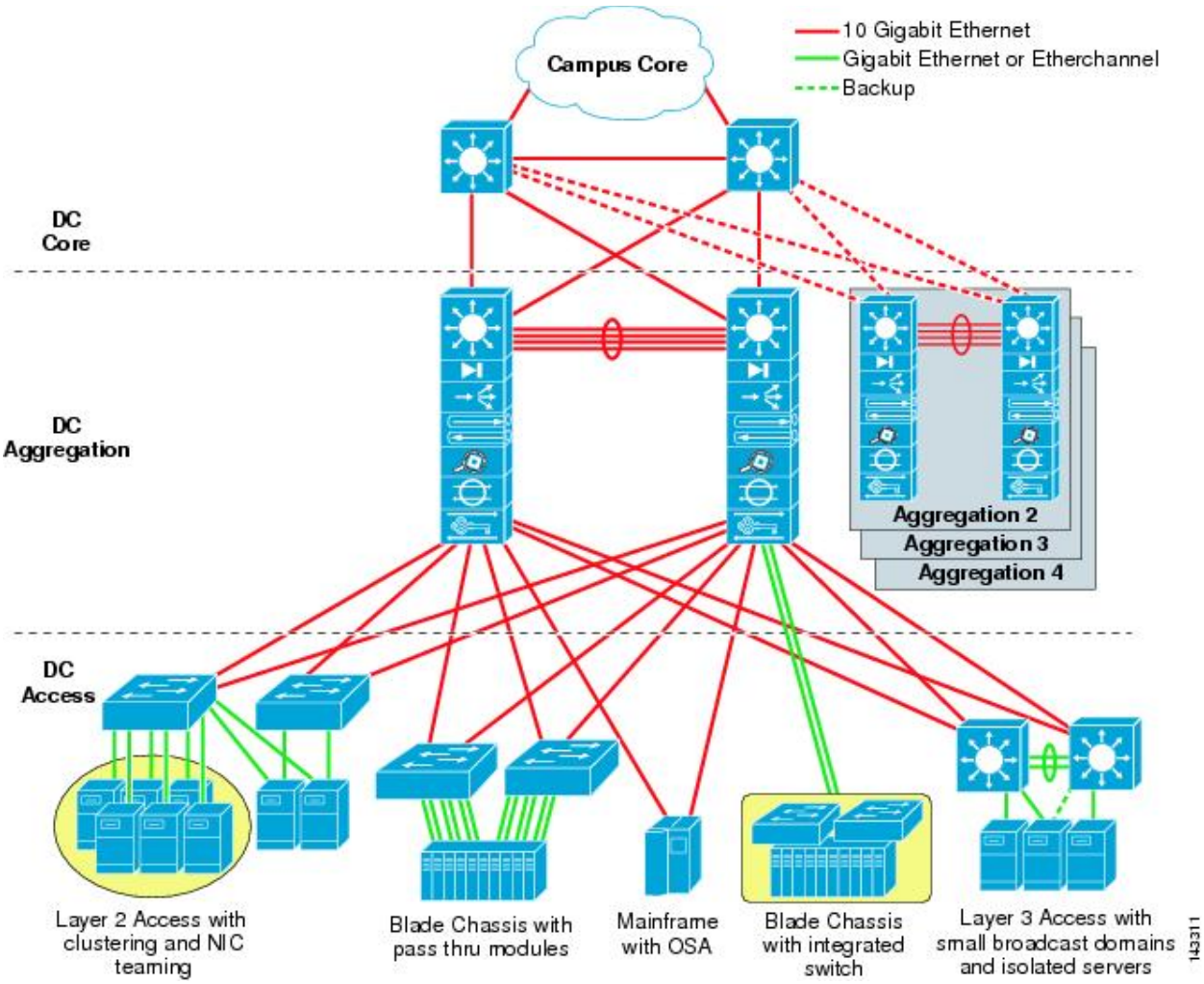

Figure 5: Logical design of the data center with all its layer

10.1 Core Layer

The core layer provides the backplane for high-speed packet switching for all data center flows. The core layer offers access to multiple aggregation modules and has no single point of failure for a robust Layer 3 routed fabric. The core layer uses Cisco Express Forwarding (CEF)-based hashing algorithms to run an internal routing protocol, such as OSPF or EIGRP, and load balances traffic between the core of the campus and aggregation layers[CITATION cis19 \l 1033].

10.2 Aggression Layer

This layer provides significant capabilities, such as incorporating administration module, layer 2 space definitions, traversing tree handling, and excess default input. Multi-level server to server traffic courses through the overall layer and can use administration to streamline and verify applications, such as firewall and server load adjustment. Within the accumulation layer switch, the littler symbols speak to the coordinated management modules. For example, these modules give administration, content exchange, firewall, SSL offload, discovery of interruption, organize investigation, and from there the sky is the limit.

10.3 Access Layer

This is the lowest of the three layers of architecture, where all servers are attached to the network. At the access layer, connectivity of SAN must be considered and the storage path could either use Ethernet or Fibre channel (FC) interfaces. Access layer devices include center points, units and switches are accessed via multi-station. The foundation of the access layer network consists of secluded switches, 1 or 2RU fixed setup switches, and basically blade server switches. Switches give both Layer 2 and Layer 3 topologies, satisfying the different servers broadcast space or regulatory requirements.

11. Hardware Components

There are many types of hardware components used in the data center for its proper functioning and usability. Some of the types of hardware components used in the data center are as follows:

1) Server rack
2) Blade Server
3) Router
4) Switch
5) Cabling

11.1 Server Rack

A server is a computer designed to handle requests and deliver data over the internet or a local network to another computer. A properly selected server rack for the data center should fit the equipment dimensions. While racks of 19 inches are always the same nominal size, they differ in height and length. The so-called rack unit (U), defined as 1.75 inches, is a widely used measure of a rack's height. Usually, rack width and depth are determined in standard units. Standard data center racks are the most common have a width of 19 inches and a height of 42U (73.5 inches high). Enough usable space should be left in the cabinet after the device is being installed and fitted with wheels in case of movement. All the weights should be considered while choosing server rack like PDU, cables, switches and overhead cable. The cooling efficiency of the racks should also be considered while installing the server.[CITATION com16 \l 1033]

Figure 6: Server Racks in use in data center

11.2 Blade Server

A blade server, also referred to as a high-density database, is a portable device with a computer that is used to handle and transmit data in a machine and service collection called a network. Its function is to serve as a conduit between computers, applications, programs and systems. Blade servers are classified by category based on different features, including different CPUs, amount of RAM and cache memory or connections. Various central processing units such as Intel, Advanced Micro Devices (AMD), Motorola and Sun Microsystems can be fitted with blade servers. The CPU performs the computation and programming of the system as a whole, and the more efficient the central processing unit, the more tasks the computer system can perform at a given time.[CITATION sea19 \l 1033] FireWire is a type of port that is often used to connect digital cameras, external hard drives, computers, tablets and devices that require high transfer rates to be used. A link to FireWire will accommodate connection speeds of up to 480 Mbps.

Figure 7: Blade Server

11.3 Router

Essentially, routers are quite simple devices. They effectively direct data traffic over a computer network, read information about incoming data packets about the network address, and "path" it to the appropriate destination. There are many different types of routers that can be used in a particular situation, depending on the nature of that information and the scope of the networks involved. Core routers and edge routers are the two most essential for the use of edge data centers. Core routers are in charge of managing data traffic within a network. These are designed to transfer traffic through the network as quickly as possible with high-speed interfaces. Core routers can be optimized for high bandwidth and speed because they handle data packets that are already supposed to be within the network and can only go to so many destinations.[CITATION vxc19 \l 1033]

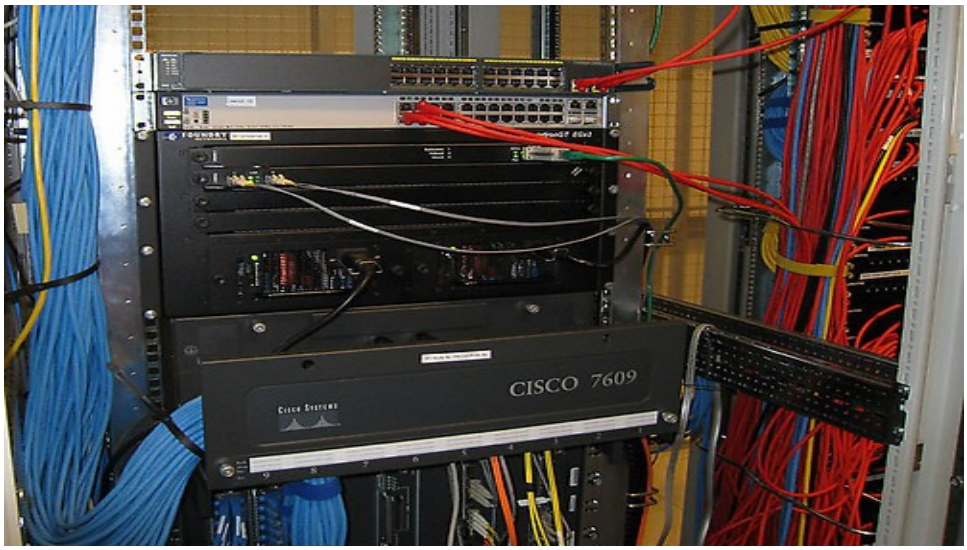

Figure 8: Core Router

11.4 Switch

The incoming TCP / IP data packets / frames containing destination information are read by a switch in an Ethernet-based LAN as they pass through one or more ports. The packet destination information is used to decide that output ports are to be used to send the data to their intended destination. Switches are hubs-like, only smarter. A hub basically links all the nodes on the network— interaction is inherently haphazard with any computer at any time trying to communicate, leading to many collisions. On the other side, a switch produces a virtual tunnel for a split second between origin and destination ports that no other traffic will reach. This leads to communication without collision.[CITATION tec193 \l 1033]

Figure 9: Switch

11.5 Cabling

The main types of network cabling used in data centers are AC / DC power, ground, copper and fiber optics. “The software available on the computer used in the data center is the primary means to decide what cabling type should be used. The network data cabling may also be selected based upon the bandwidth requirements of the equipment being used in the data center. Cabling can be either organized or unstructured within a data center. Structured cabling is based on predefined standards with predefined connection points and pathways. In a structured wiring design, the cabling used is specified by the system's bandwidth requirements and is tested to ensure proper performance. The cables used will be well organized in a structured wiring system. While a structured cabling system may take longer to install and have a higher initial cost, the operating cost will eventually be lower and the system's life cycle will be longer compared to an unstructured system”[CITATION cab19 \l 1033].

Figure 10: Cabling in data center

12. Cooling System

The server used in the data center and computer equipment along with the racks gets heated pretty quickly so without the help of a cooling system the temperature in the server racks and equipment cannot be controlled. Cooling system helps to maintain the temperature in the room and around the racks. There are two types of cooling system that we are going to suggest for the Panadox data center and they are:

1) Hot Aisle Containment System

2) Cold Aisle Containment System

12.1 Hot Aisle Containment System

With a Hot-Aisle Containment system, your data center's hot aisle is enclosed within a physical barrier. “This allows the discharge air from your facility's IT equipment to be returned directly to the cooling equipment through a ceiling plenum or ductwork, while the cooled air is introduced directly into the data center through a raised floor, directly into the room through the AC units, or through ductwork. By containing the hot air, you can improve the cooling efficiency of your data center's equipment by 30% or more, control energy costs by allowing for lower AC fan speeds, and improve the overall comfort of technicians working within the data center itsel”[CITATION web19 \l 1033].

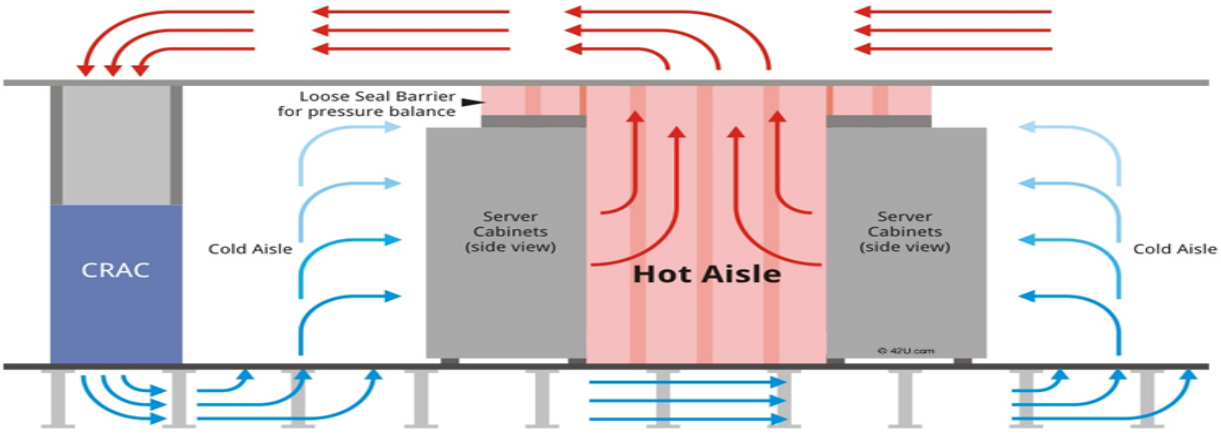

Figure 11: Hot Aisle Containment System

Hot aisle containment can greatly enhance the effectiveness of the cooling capacity of your data center. If the hot exhaust air of your data center is kept separate from the rest of the room, not only do you ensure that the air conditioning is cooled more easily, but also that the exhaust air is kept both hot and dry as it returns to the main AC coil. This return air is kept in the warmest temperature.

12.2 Cold Aisle Containment System

The approach to Cold Aisle Containment (CAC) encloses the cold aisle between adjacent racks and doors at the end of the aisle with ceiling panels above the aisle. This allows for containing and delivering the cold air from the perforated floor tiles in front of the cabinets to the air inlets of the server equipment. The CAC prevents cold air from mixing with warm air or from being blocked by the environment.[CITATION Sol19 \l 1033]

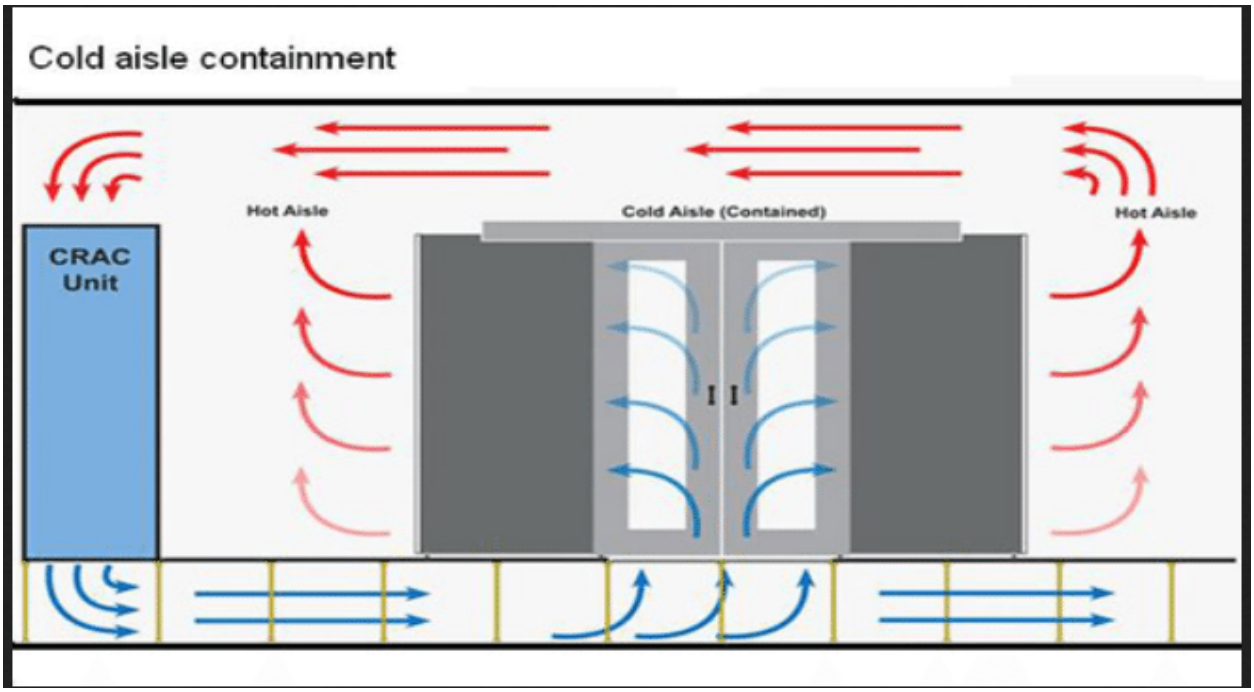

Figure 12: Cold Aisle Containment System

For elevated floor supply plenums or overhead ducted supply with no raised floor, Cold Aisle Control can be used. In the event that controls were precisely organized, it could give some fascinating emphasis on productivity by giving more vital capacity to discuss supply to promote server wind streaming. Cold Aisle Control does not require air pipes to work.

12.3 Recommendation

Comparing the both containment system the best one for the Panadox to use would be hot aisle containment system. We have considered hot aisle containment system would be better because "open area of room is cold environment and leakage from raised floor openings in the larger area of the room goes into the cold space which is generally more specific. Hot aisle containment can perform well in a slab environment by merely flooding the data center with an adequate volume of supply air and containing the exhaust air"[CITATION ups14 \l 1033].

13. Power Management

Power management is an important factor to be considered while developing a data center. The products used in the different stages for the power distribution to the server from the initial source should be of high quality and should have no point of failure. The power management product range in the data center for power distribution is based on clear plug-&-play extension

implementation – there is no need to interrupt current operations.[CITATION Sol191 \l 1033] The different stages involved in power distribution in data center are

1) Switch Gear

2) PDU

3) UPS

4) Rack Power Distribution

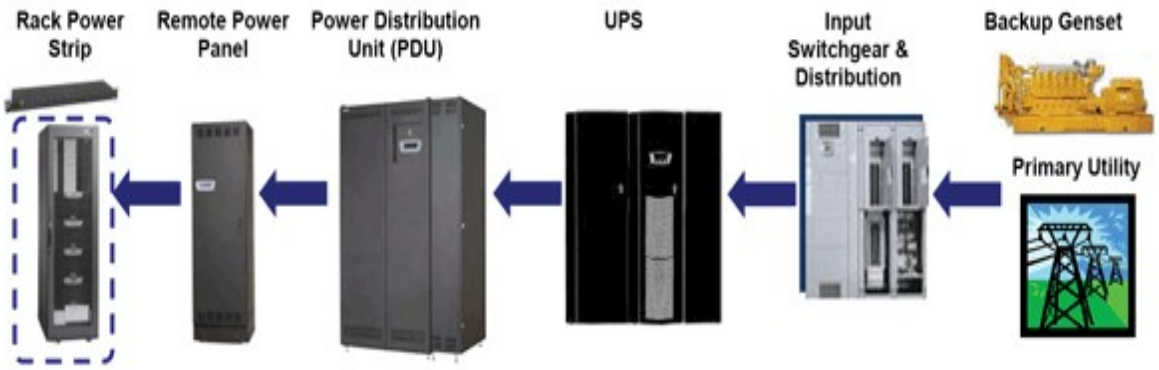

Figure 13: Power Distribution in Data Center

13.1 Switch Gear

To securely distribute from the utility to the data center floor, switchgear and distribution board are used. The switchgear includes circuit breakers and switches for monitoring medium and low voltages and they are regularly used to transfer enormous amounts of control to various areas within the data center and buildings. This handle is designed to interrupt and disengage the load from the control source in the event of strangely high current conditions that appear to harm the electrical system or create risky working conditions. Automatic transmission switches are critical

components of any emergency or standby power system required to maintain up-time. These switches automatically experience power loss and switch to a back-up circuit seamlessly. An ATS can deliver quick (load transfer from 8 to 15 MS) and reliable load transfer from one power source to another.[CITATION Sol191 \l 1033]

Figure 14: Switch Gear

13.2 PDU (Power Distribution Unit)

A Power Distribution Unit (PDU) provides multiple servers in a rack environment with steady, uninterruptible power. “The rackmount PDUs are designed to be mounted in a database rack position, either vertical (0U) or horizontal (1U or more). This device is essentially a power strip of industrial quality”[CITATION Sol191 \l 1033]. A PDU's main purpose is to provide AC power in the rack network for multiple pieces of IT equipment. “Simply distribute power with a basic power strip without internal intelligence or boost it with a more advanced model including monitoring of outlet level power to monitor, control and report the status of each outlet within the unit remotely. Rack PDUs can be customized to meet the requirements of: voltage, current, number and type of connections, remote access, and monitoring functionality”[CITATION Sol191 \l 1033]. We have selected smart/monitored PDU for the data center which usually provide metered consumer feature sets in a single unit, but also have the ability to monitor the distribution unit's condition remotely (IP).

Figure 15: PDU

13.3 UPS

The uninterruptible power supply is a backup power source used in the data center to ensure power supply continuously throughout the data center in every electronic devices. It plays important role in storing the data and help to prevent any type of loss that could happen because of the power loss. The UPS has its own rechargeable source which automatically turns on when the main power supply to the source is cut thus preventing data loss. In any event the UPS will run for enough time to save all your data and shut the whole system down in orderly manner or in case of second power supply such as solar or generator then it will run till the second power supply is brought online. There are various type of UPS available in the market for the data center but the best for this data center would be Multi-Mode System. Although it may be expensive it is a good recommendation for a company looking for efficiency and protection.

Figure 16: UPS (Uninterruptible Power Supply)

13.4 Rack Power Distribution

Rack power Distribution are designed to provide electrical power and distribute power among the equipment present in the racks/cabinet. The rack PDU can be mounted vertically or

horizontally in the rack. The amount of sustained power a PDU can handle is 30A and it should be that or higher than that installed with 20A breaker to prevent the injury in case of short circuit. The input power with 3-phase service and voltage of 208/240V is better for the rack. The ideal power cord length of 10 feet should be used. In order to avoid the potential problem PDUs with local meter display is better as it helps to know when the circuits and breakers may trip[CITATION dat18 \l 1033] .

Figure 17: Rack Power Distribution

14. Service Management

Data Center Services help organizations provide, manage and resolve operational requirements to ensure continuous delivery of data center operations and management services for all mission- and business-critical applications for their customers and end users. Some of the services provided by data center are as follows:

14.1 Services (SAAS, IAAS, PAAS and Colocation)

“Software as a service, SAAS utilizes internet to deliver applications which are managed by third party vendor to its users. Most of the SaaS application run directly on web browser without requiring further download or installation on client side. SaaS eliminates the need to have IT staff install application on each individual computer and help the vendor maintain all the technical issue, servers, and storage. SaaS provides various advantage to the employee and company by saving a lot of time and money and helps to free up technical staff to spend more time on other important matter in the organization”[CITATION bmc19 \l 1033].

“Platform as a Service, PaaS delivers a framework for developers that they can build upon and use to create customized applications. All the servers, storage and networking can be managed by third party while developers can maintain management of the applications. PaaS is simple, cost effective development and deployment of apps and is highly available. PaaS builds on virtualization technology so the resources can be easily scaled up or down”[CITATION bmc19 \l 1033].

Infrastructure as a Service, IaaS provides complete self-service to access and track machines, networking, storage and other services. IaaS enables companies to purchase on-demand and as-needed services instead of directly purchasing hardware. IaaS delivers cloud computing infrastructure, servers, network and storage through virtualization technology. IaaS client have complete control over their entire infrastructure without having to manage them physically. IaaS is the most flexible cloud computing model and multiple user can do work on single piece of hardware.[CITATION bmc19 \l 1033]

Collocation (also spelled colocation) stands for a space or a room in a data center rented for the customer's own IT equipment. The term open collocation usually refers to a space shared by several customers.

14.2 SPOF (Single Point of Failure)

SPOF as known as Single Point of Failure is a small event or failure that may occur in hardware or the software that can hold entire data center operation. A data center without up to date short circuit coordination can be a cause to SPOF. The outage Associated with this problem are not long lasting but process involved in recovering this type of problem may take several hours. [CITATION SPO19 \l 1033]. SPOF is a possible risk that affects the System reliability and availability. When data is transmitted by multi-tenant through single point from multi servers there could occur a huge problem.

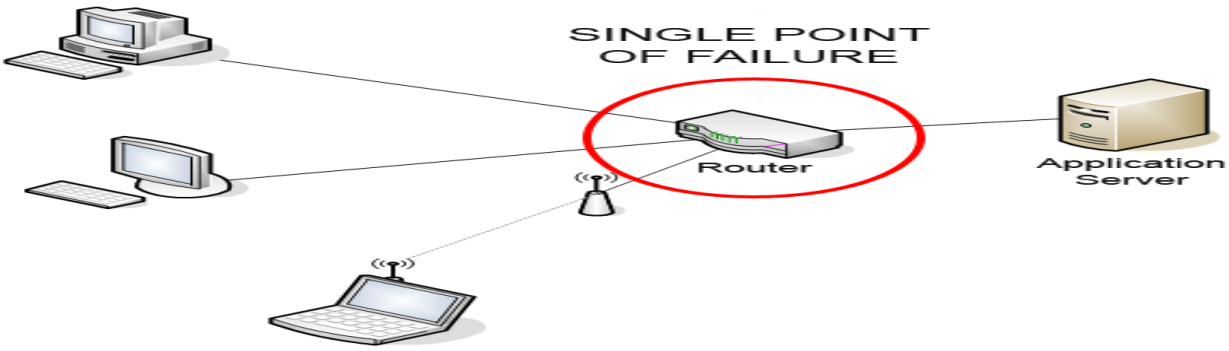

Figure 18: Single Point of Failure

In order to avoid SPOF, Redundancy and high-availability clusters are the key factor. Both physical and logical redundancy is needed to be achieved and high availability cluster minimize the outage of the system components in the cloud when a system components fails then immediately another component should take over the role of failed part such as multi switches connected to multi server. Logical redundancy can be achieved with the help of multiple application servers which will help to identify, address, isolate and prevent software flaws. Physical redundancy can be achieved with the help of high availability clusters.

14.3 MTTR (Mean Time to Recover)

“MTTR or Mean Time to Recovery is a computer term that measures the time period between a system being detected as "down" to a user-friendly state. This calculation can then be used to quantify the financial impact on the business. The first step to improve the MTTR is to measure it using Application Performance Management (APM) which will help by measuring the extent and location of production related outages. Documenting outages can be done to help the development and operations teams to understand what led to particular outage. It will help the

team to recognize the outage faster in the future reducing the MTTR”[CITATION ray18 \l 1033].

15. Storage Devices

Storage of data centers is the collective term used to describe techniques, systems and processes for planning, implementing, maintaining and tracking data center storage infrastructure and resources. It is part of the data center network which comprises all IT / data center resources that play a role in data center processing directly or indirectly. The types of storage used in this proposed data center are:

1) DAS
2) NAS
3) SAN

15.1 DAS

Direct attached storage (DAS) is digital storage that is attached directly to a server. DAS can refer to a single drive or a group of drive that are connected together. Multiple system can use the DAS device as long as server has a separate connection to the storage devices. The main benefit of DAS is it cost is low. Generally all the server in the data center come along with DAS so in case of more storage all the things needed is just storage device and cable. Maintenance of DAS is also very simple[CITATION DAS19 \l 1033].

Figure 19: Direct Attached Storage

15.2 NAS

Network attached storage (NAS) device is a server that is directly connected to the network. NAS is a mid-level storage offering. Companies assign a NAS appliance with an IP address. Communication between the NAS and the server is based on TCP/IP. The storage is available at file level and NAS uses a traditional file system. It is a good choice for unstructured data and is a good replacement for aging file server. But it may not be a good option for structured data storage [CITATION sea191 \l 1033].

Figure 20: Network Attached Storage

15.3 SAN

A Storage Area Network (SAN) is a secure high-speed data transfer network providing access to centralized storage at the block level. A SAN allows multiple servers to access a network of storage devices. SAN devices appear as attached drives to servers, eliminating traditional bottlenecks in the network[CITATION tec194 \l 1033].

Figure 21: Storage Area Network

16. Monitoring

Controlling of the data center is the method of controlling, maintaining and running a data center that satisfies the functional and organizational requirements. It is the practice of using manual and automated tools and techniques to ensure a data center's best operational security. This ensures that a data center's main functions and facilities are provided without interruptions or anomalies. Data center monitoring is also known as data center management[CITATION tec195 \l 1033].

Monitoring of the data center is a broad process that focuses on monitoring the whole infrastructure of the data center. Data center monitoring is typically performed using automated tools that provide statistical insights into the performance / status of the data center. Data center administrators use this data to identify and address irregularities[CITATION tec195 \l 1033]. Data center monitoring usually include:

- Monitoring data center servers and computers for performance, security uptime and more
- Power availability and consumption

- Monitoring and managing network operations and resolving network problems as they arise
- Data center temperature, and the heating and ventilation systems
- Physical data center security to restrict unauthorized personnel from entering the premises

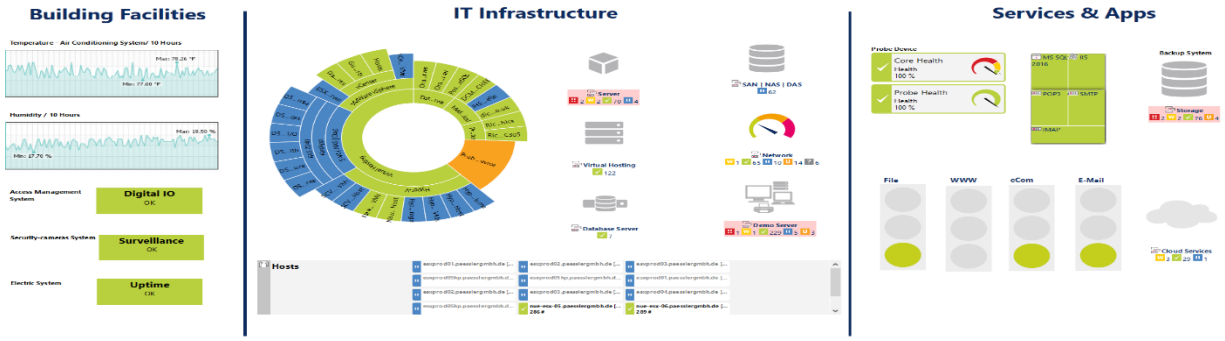

Figure 22: Example of a dashboard displaying mission critical information of a data center

We recommend to use PRTG for monitoring the data center and its facilities. It contains monitoring of switches, routers, servers, firewall, virtual environment etc. it includes all application and services in the data center such as Oracle, SQL servers, backups, security and other custom made applications. It covers all the area on the data center such as humidity, smoke, movements, access etc. in the server rack room. After starting to use no need to worry about bottleneck, bandwidth, or fluctuation in the temperature in the room.

17. Security

The protection of the data center relates to the physical activities and digital systems used to secure a data center from external threats and attacks. A data center is an IT infrastructure storage facility that consists of networked computers and storage used to manage, process and store large amounts of data. Data centers provide services including data storage, backup and retrieval, data management and networking. Because data centers contain confidential or proprietary information, such as customer data or intellectual property, sites must be protected both electronically and physically.[CITATION Cyb19 \l 1033]

17.1 Physical Security

Data center are designed as a single purpose building which does not hold any other type of business not related to the data centers. Its security characteristics are related to design and

layout of the data center. The data center is made away from the main road to avoid noise and built a buffer zone made up of a combination of landscapes and barriers. Our data center is protected by the wall along with the fences in the top of the wall and CCTV cameras in every nook and corner of the data center inside and outside of the server room. The data center is limited for only few personal. Unauthorized access to the data center is strictly prohibited. Checking points in the gates is established to check the id and finger print scanner to avoid the unauthorized access. The data center is made with no exterior window and few entry points to the server room and the data center itself.

17.2 Software Security

Hacking malware could be a big problem in a data center and threats to both company and the client in case of data loss. A security information and event management tool (SIEM) play a big role in protection of data it provides real time view of the data center and provides visibility and control into everything from access and alarms system in the perimeter. One way to secure the layer in the data center is to create secure zones in the network. Administrators can divide networks into three areas: a flexible test area, a slightly more stringent environment development area, and a production area with only approved production equipment. Before the code and application re deployed in the data center they should be checked for any problems or vulnerabilities and data flow in the system should be monitored closely.

18. Maintenance

Data center are very important for the client and the company. It is more than just an investment. There are resources in the data center that need to be maintained to keep the system working efficiently and effectively. Our data center has deployed Data Center Infrastructure Management (DCIM), maintenance to ensure the availability of the system. Effective maintenance of the data center helps to reduce the down time and repairing cost, outage, and SPOF related cost. There are four types of maintenance employed in our data center. They are as follows:

1) Corrective Maintenance
2) Adaptive Maintenance
3) Preventive Maintenance
4) Perfective Maintenance

18.1 Corrective Maintenance

Corrective Maintenance are the maintenance tasks that are done in order to rectify and repair faulty systems and equipment. The main purpose of the corrective maintenance is to restore broken down system in the data center. It helps to decrease downtime. It is done when a piece of an equipment is about to be broken and can affect whole operation then it can be repaired or restored without causing any downtime”[CITATION Lea19 \l 1033].

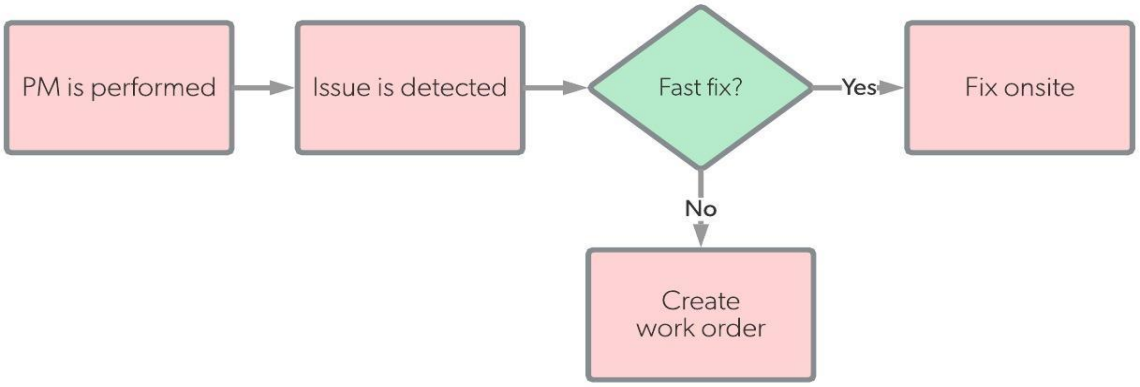

Figure 23: Workflow during Corrective Maintenance

18.2 Adaptive Maintenance

Adaptive Maintenance is the implementation of changes in a part of the system which has happened because of some other part failure in the system. Adaptive maintenance involves adapting software to environmental changes such as hardware or operating system. Adaptive maintenance often means the need for some functionalities to be changed, although the system works as planned and there is no system fault or failure in this context. This usually occurs when legal standards shift or political business users change”[CITATION Ada19 \l 1033].

18.3 Preventive Maintenance

Preventive Maintenance is the regular and routine maintenance to help keep the equipment up and running and preventing any downtime and cost loss from equipment failure. The maintenance includes cleaning. Repairs, parts placements and lubrication. There are various type of preventive maintenance such as calendar based maintenance and usage based maintenance.

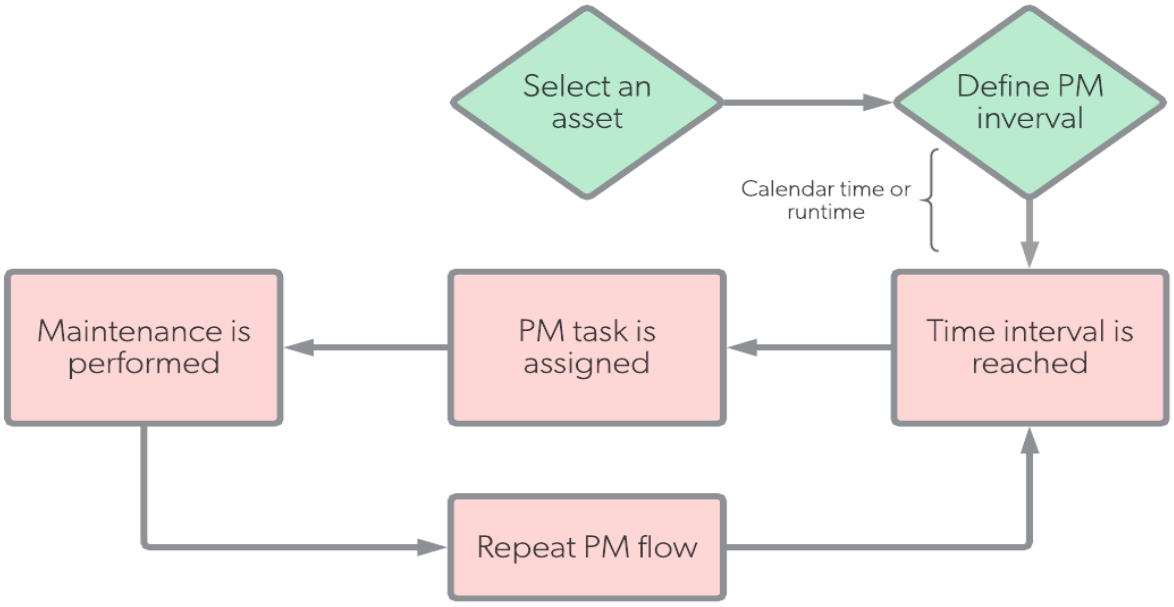

Figure 24: Preventive Maintenance Workflow

18.4 Perfective Maintenance

Proper maintenance is largely about implementing new or modified application specifications. Perfect maintenance involves making functional improvements to the system in addition to enhancing the performance of the system even if the changes were not suggested by faults. This includes enhancing the code's functionality and efficiency as well as changing the system's functionality according to the changing needs of the users.

19. Conclusion

Our team has worked hard to propose the system, as we had to put forward the datacenter infrastructure, necessary equipment and systems, and other operational requirements for Panadox. In fact, much of our theoretical knowledge was used to complete the assignment. Next, we have also explained how to design the datacenter infrastructure, major factors to consider, and what components were required while designing the data center. A secured data center having a high level of security has thus been designed which can be easily accessed by the client. The proposed system also has a cost-efficient colocation. We have also focused on the

issues and challenges concerned with the infrastructure in data center design, and our team has discussed about cooling capability, energy efficiency, along with technologies and techniques that promote green computing in the data center.

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Workload matrix

S.N.	Name of Student	Work %	Signature
1	Gunjan Adhikari	34%	
2	Madan Babu Ghale	33%	
3	Sonam Rinzing Tamang	33%	

Marking Scheme (based on SLT)

Marks	0	1-8	9-14	15-10	
Analysis (20%)	Poor analysis/examination of Data Centre Components that are required to construct Panadox Data centre. Also, poor consideration of ethical principles in analyzing the data.	Limited analysis/examination of Data Centre Components that are required to construct Panadox Data centre. Also, limited consideration of ethical principles in analyzing the data.	Satisfactory analysis/examination of Data Centre Components that are required to construct Panadox Data centre. Also, good consideration of ethical principles in analyzing the data**.**	Good analysis/examination of Data Centre Components that are required to construct Panadox Data centre. Also, consideration of ethical principles in analyzing the data is excellent.	
Marks Awarded					/20
Marks	0	1-9	10-16	17-20	
Synthesis and Evaluation (20%)	Poor composition of Data Center components and no sensitivity towards panadox requirements. Also, the decision made to choose the component without weighing the significance of each component is poor	Limited combination of Data Center components with little sensitivity towards panadox requirements. Also, the process of weighing the significance of choosing a component needs improvement	Satisfactory composition of Data Center components with the clear sign of sensitivity towards panadox requirements. Also, the process of weighing the significance of choosing a component is appropriate	Good composition of Data Center components for building panadox Data Centre and the decision made to choose the component by weighing the significance of each component is excellent	
Marks Awarded					/20
Marks	0	1-9	10-16	17-20	
Data Center Design (20%)	Poor thought process of proposing Panadox Data Center design solution from	Able to propose Panadox Data Center design solution from several alternatives	Good thought process of selecting a Panadox Data Center design solution from	Excellent thought process of selecting a Panadox Data Center design solution from	

	several alternatives which fails to achieve group's objectives	which achieves group's objectives	several alternatives which achieves or constructing Panadox Data Center.	several alternatives for constructing Panadox Data Center.	
Marks Awarded					/20
Marks	0	1-8	9-14	15-20	
Social Responsibility (20%)	Not concern about Green policy and no consideration towards the implementation of Green Data Center.	Little concern and considerate towards the implementation of Green Data Centre and Green Policy.	Satisfactory concern and considerate towards the implementation of Green Data Centre and Green Policy	Excellent and strong concern and considerate towards the implementation of Green Data Centre and Green Policy.	
Marks Awarded					/20
Marks	0	1-4	5-7	8-10	
Presentation (10%)	Not able to present the work together effectively with other group members towards goal achievement	Little effort in presenting the work together effectively with other group members towards goal achievement with and require major improvements	Able to present the work together effectively with other group members towards goal achievement with and require minor improvements	Excellent coordination and effective presentation of work with other group members towards goal achievement	
Marks Awarded					/10
Marks	0	1-4	5-7	8-10	
Documentation (10%)	No clear evidence of working together effectively with other group members towards goal achievement. Also, not able to	Evidence of working together effectively with other group members towards goal achievement but with limited	Satisfactory evidence of working together effectively with other group members towards goal achievement	Good evidence of working together effectively with other group members towards goal achievement. Also, able to write	

	write ideas clearly.	effort and require major improvements. Also, able to write ideas with limited clarity and require further requirements.	but with some effort and require minor improvements. Also, able to write ideas clearly.	ideas with good clarity.	
Marks Awarded					/10
Total Marks [100]					/ 100