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ASIA PACIFIC UNIVERSITY
OF TECHNOLOGY & INNOVATION

Intake Code :

Module : Data Centre Infrastructure CT109-3-2

Title : Panadox Data Centre Design

Date Assigned :

Submission Date :

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Contents

1.0 Data Center

1.1 Introduction to Data Center

A data center is a physical facility that is used to house the business-critical applications and information of the enterprises to maintain their reliability and security. Data centers consists of several technical elements such as routers, switches, security devices, storage systems, servers and more. These elements are used to store and manage the critical systems that are vital for the continuous operating of the company.

Moreover, a data center also requires a significant amount of facilities infrastructure to keep the hardware and software up and running. The facilities include power subsystems, uninterruptable power supplies (UPS), ventilation and cooling systems, backup generators and cabling to connect to external network operators (Kerravala, 2017).

1.2 Data Center Requirements

Proper planning and design allow to construct a secure, defendable and cost-effective data center. Some of the key elements that needs to be considered for building a secure data center are as follows:

- **Site selection**

  The place where the data center will be located should be chosen carefully to get the best mix of ideal features. The site should be in a safe area that is not subject to any natural environmental dangers such as flood or landslides. Earthquakes are possible in most every part of the country so make sure the structure is hardened accordingly (Nye, 2002).

- **Facility Security/ Monitoring**

  The data center should be equipped with multiple security systems. Coming in and out of the facility should be controlled by card or biometric access systems. All security systems should be monitored 24/7, motion sensors and CCTV systems monitoring both the interior and exterior should be equipped to handle low light conditions. The staff should only have access to areas that are required by their duties. The security monitoring equipment and staff should be in a highly secure area separate from the

main computer equipment and the critical screens cannot be viewed by passers-by or through windows (Nye, 2002).

- **Power Systems**

  The power should automatically switch over to generators during an outage. The critical systems would then be attached to dual Uninterruptible Power Supplies (UPS) systems to ensure that they are unaffected during the generator start-up period (Nye, 2002).

- **Reliability**

  Data Center infrastructure must have depth, standby power supplies to take over when commercial electricity fails, and redundant network stations to handle the communication needs if a networking device malfunction. The infrastructure must be configured so there is no single component or feature that makes it vulnerable. It does little good to have multiple standby power systems if they are all wired through a single circuit, or to have redundant data connections if their cable runs all enter the building at one location. In both examples, a malfunction at a single point can bring the entire Data Center offline (Kuruvikulam, 2019).

- **Flexibility**

  The infrastructure systems of a Data Center should be built using components that are easily changed or moved as routers, switches, servers, and data storage devices will advance and change in the coming years. Inflexible infrastructure leads to more expense down the road. Data Center's flexibility also comes from whether it has enough infrastructure to handle an increased need in the future (Kuruvikulam, 2019).

- **Modularity**

  The room should be designed in interchangeable segments. Stock server cabinet locations with identical infrastructure and then arrange those locations in identical rows. Modularity keeps the Data Center infrastructure simple and scalable. It also provides redundancy on a smaller scale. If a component fails in one section of the Data Center, users can simply plug in to the same infrastructure in another area and immediately be operational again (Kuruvikulam, 2019).

2.0 Data Centre Technology and Physical Design Overview

2.1 IT Hardware

One of the Information Technology (IT) Hardware consultant from ZiPro Company has prepared an effective data center design solution for Panadox Health Care organization to construct a data center. In this section, the consultant has designed and recommended the most suitable **server type**, **storage system, data center standard** and **network architecture design** for Panadox.

2.1.1 Data Center Standards

Before deciding to construct any data center, a data center must be construct based on some standard requirements that required to comply with **Uptime Institute**'s benchmark standards. The importance of achieving data center standard that defined by Uptime Institute is to evaluate the quality and reliability of a data center's server hosting facility [CITATION Col19 \l 1033].

Data Center Standard Tiers Justifications

Typically, when it comes to larger business operation, either **Tier 3** or **Tier 4** is highly recommended for a data center. Since Panadox can be considered as a large-scale business provider for their partners and customers (patients), it is important to justify and recommend the best tier design to achieve Uptime Institute qualification. Both Tier 3 and Tier 4 have different purposes and solutions when considering for data center. The justifications and recommendation for both tiers have been suggested as follows:

Tier 3 – N+1

- 99.982% Downtime Accuracy
- Single redundancy solution for power feeds, diverse network paths, multiple Uninterruptible Power Supply (UPS), backup generators and cooling system
- Single Power Source

Tier 4 – 2N+1

- 99.995% Downtime Accuracy

- Multiple redundancy for power feeds, diverse network paths, multiple Uninterruptible Power Supply (UPS), cooling system and backup generators
- Parallel Power Source (Two Electric Utilities)

Tier 4 is more efficient compared to Tier 3 especially when it comes to achieve the highest availability of 0.8 hours compared to 1.6 hours with a Tier 3 facility. Moreover, redundancy in data center is more reliable than Tier 3 redundancy such as multiple redundancy for power feeds, diverse network paths, multiple Uninterruptible Power Supply (UPS). Alternatively known as **2N+1** which means backup for all backups**.**

Recommendation for Data Center Standard based on Uptime Institute

However, the power source for Tier 4 is required parallel power source to run the data center such as 2N+1. This is due to achieve the redundancy in power source. As a recommendation, when it comes to construct data center for Panadox, Tier 3 is the recommended solution and qualified to achieve the Uptime Tier 3 certification. For example, it provides save cost and redundancy (N+1) for data center. In addition, Malaysia has only one power source utility called **Tenaga Nasional Berhad** (TNB). The requirement to achieve Tier 3 for power utility is one source, therefore Tier 3 is recommended and qualified for Panadox’s data center.

2.1.2 Tier 3 Network Architecture Design for Panadox Data Center

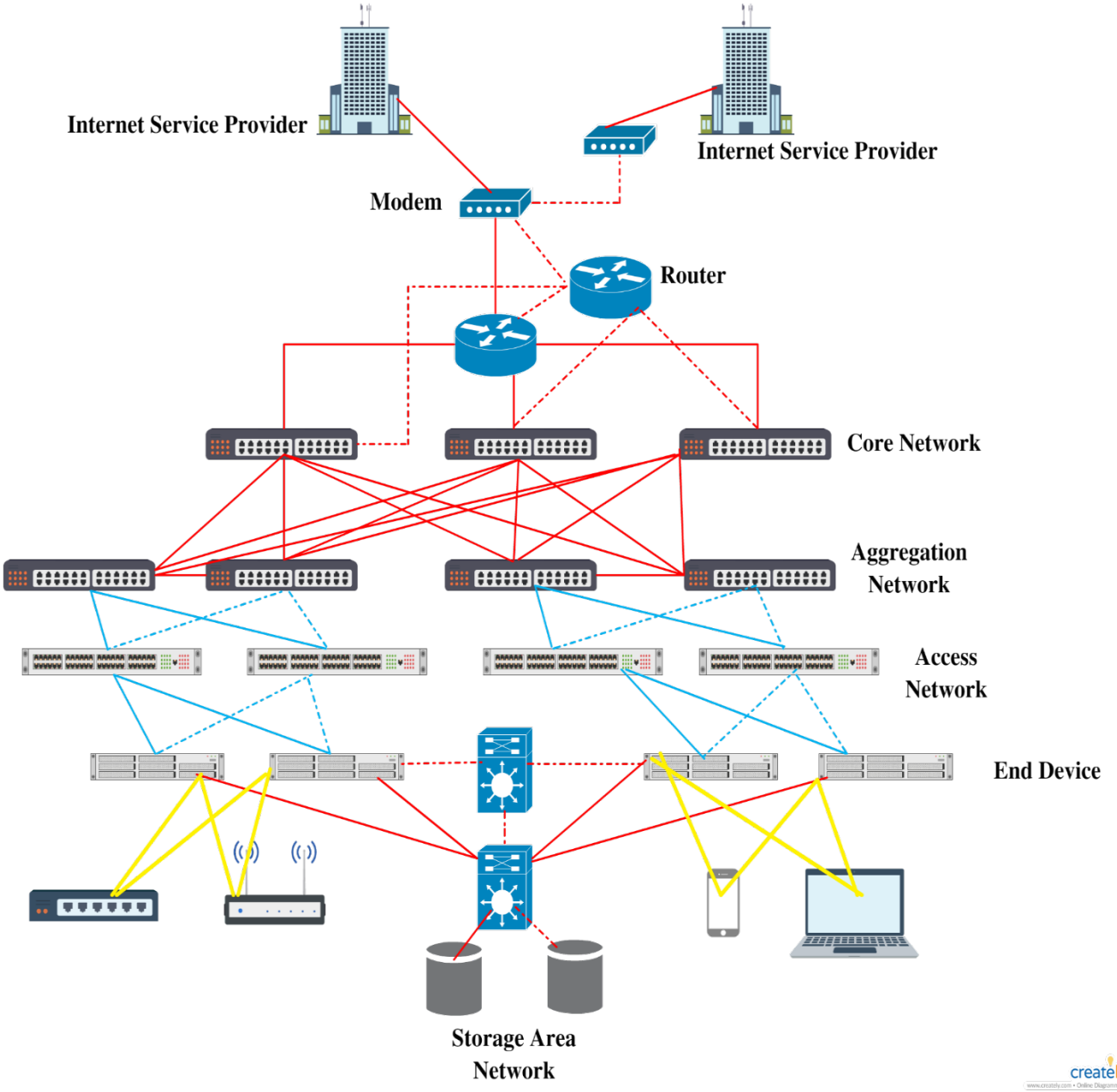


Figure 1 : Tier 3 Uptime Data Center Design for Panadox

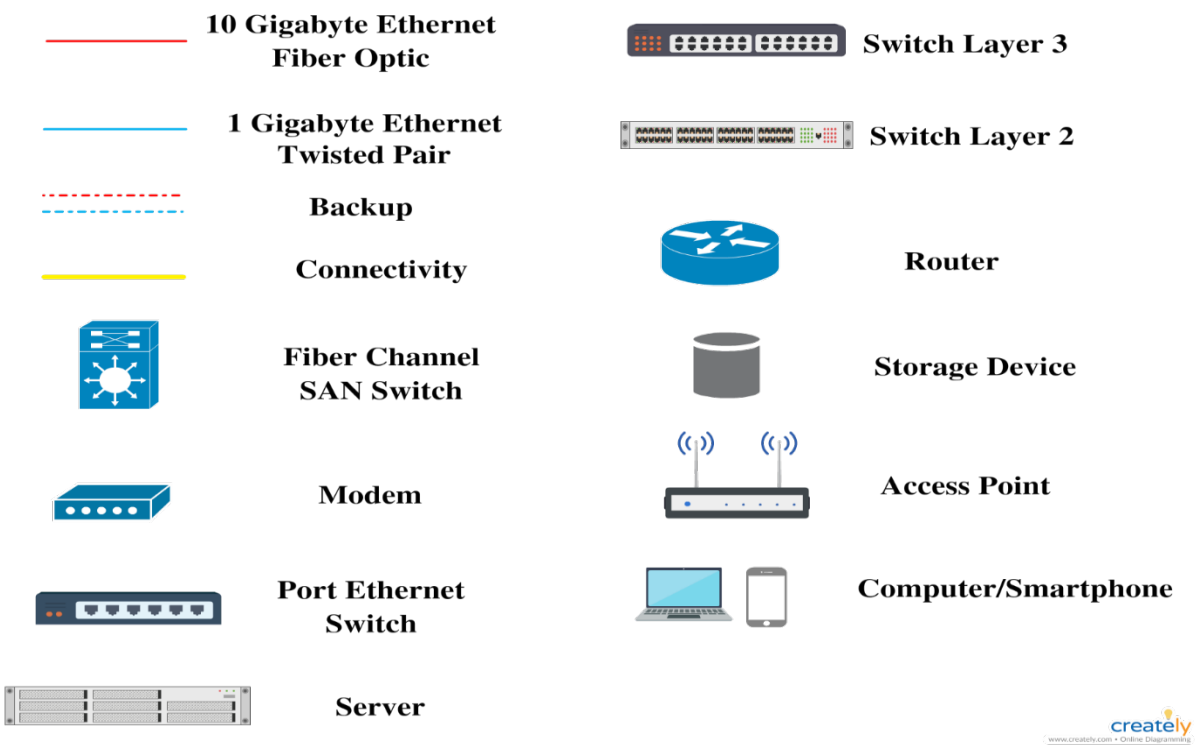


Figure 1: Legend for Tier 3 Design Components

2.1.3 Data Center Storage System for Panadox

Storage system is required especially when it comes to large scale enterprise that required to store their application storage to access internally or externally of an organization. Sometimes storage system recommended for some enterprise to back up their data or manage their data for third-party. There are three types of storage networking technologies that enable to run storage system for organization such as Direct Attached Storage (DAS), Network Attached Storage and Storage Area Network (SAN). To recommend the most suitable storage system technology for Panadox Health Care, a comparison between these three technologies have been made in the following Table.

Purpose	DAS	NAS	SAN
Cost Effective	Cheaper than NAS and SAN.	Expensive than DAS.	Most expensive solution compared to DAS and NAS.
Data Sharing Capability	Only shareable within the server that DAS directly attached to such as “ad-hoc” services	Resources can be shared through network since it’s connected directly to a network switch (Ethernet network) rather than directly connect to server [CITATION CT1 \p 17 \t \l 1033].	Shareable resource through a large network or multiple virtual servers.
Scalability	Not scalable due to limited in size such as storage capacity. Connectivity into server is limited and rely on expansion slots [CITATION Chr09 \l 1033].	NAS is scalable in terms of capacity and performance such as RAID and swappable drives [CITATION Chr09 \l 1033].	SAN is scalable due to virtualization [CITATION Chr09 \l 1033].
Performance	Slow due to technology it uses such as cooper as transmission.	Slow due to throughput affects such as “bottlenecks” [CITATION Chr09 \l 1033].	The performance for SAN is rapid due to fiber optic transmission in a network [CITATION CT1 \p 18 \l 1033].
Advanced Features	Not suitable for data virtualization [CITATION Chr09 \l 1033].	Allows snapshots for virtualization [CITATION Chr09 \l 1033].	Disaster recovery strategy such as data will keep on synchronous [CITATION Chr09 \l 1033].
Best Use Case Scenario	For small business that has non-growth budget [CITATION Joh18 \l 1033].	Small business which required a minimal-maintenance [CITATION Joh18 \l 1033].	SAN is best for block-level data sharing of mission- critical files or applications at data centers or large-scale enterprise[CITATION Joh18 \l 1033].

Table 2: Comparison of DAS, NAS and SAN

Justification and Recommendation for Chosen Storage System

Based on the analysis made from Table 2, SAN technology is strongly recommended for Panadox’ Data Center. For example, data can be shared widely using virtual large network or

virtual server and this will be useful because ZiPro Company's aim is to provide a cloud computing technology for their customers' data center designs. SAN is faster in data processing because it uses fiber optic as transmission media at access point layer. This is important when it comes to monitor or manage patients' records in a rapid way. Apart from that, SAN is scalable due to virtualization capability. Since Panadox Health Care maintaining more than 10 million records, the probabilities of their business growth is significantly higher. Therefore, SAN can provide virtualization to extend the storage capabilities at any time. In the meantime, Panadox maintaining patients' records from different hospitals, this is crucial to have some backup plan for their data. SAN provides data recovery if any of the data lost due to any disaster. Since, SAN is recognized for a large-scale enterprise, SAN is recommended for Panadox Data Center.

2.1.4 Server Type for Panadox Data Center

Choosing the best server for a data center is important for hosting data to for customers around the globe. There are many servers available in marketplace. However not every server suitable for every type of enterprise/business. Servers can be varied from serving in different purposes. There are three types of well-known servers are available such as Tower Server, Rack Server and Blade Server. Usually, tower server is only recommended for operating small business scale. Hence, tower server is not qualified for large enterprise such as Panadox Health Care. Tower server is ideal for small businesses that have a limited number of clients [CITATION Suk17 \l 1033]. Rack server and blade are preferable for data centers which capable to support complex information. However, as for this purpose, consultant only will recommend one type of server for Panadox based on the comparison between rack server and blade server. Table 1 shows the features of each individual purposes of these three servers.

Features	Rack Server	Blade Server
Spatial Density	Required greater space	Required low space
Energy Consumption (Power Usage)	Low power density	High power density
Cabling Structure	Required comprehensive cables to connect with nodes	Centralized cable management system to connect with different nodes
Server Flexibility	Easier for upgrading process. Supports	Weaker in terms of flexibility.

Features	Rack Server	Blade Server
	Redundant Array of Inexpensive Disks (RAID) for storage virtualization. Can stack more servers within a chassis.	Doesn't support virtualization technology. Can only supports limited stack of "blades" in blade chassis.
Maintenance	Complexity in maintenance	Easier in maintenance.

Table 3: Rack Server vs Blade Server

According to Table 1, Rack server is more suitable for Panadox Data Center. For example, the main objectives of ZiPro is taking aims at cloud computing data centers using advanced environmentally friendly and energy-efficient technologies. Since, rack server is considered as energy saving equipment amongst blade servers which have a high-power density. Rack server is recommended and suitable server for Panadox. Moreover, server flexibility in rack sever can be extended in terms of hard disk storage and supports RAID technology for storage virtualization especially when it comes cloud services and redundant data backup in RAID. Although rack server type has some cons but overall, it's aligned with objectives of ZiPro's aims to construct data centers based on cloud technology and environmentally friendly.

Conclusion to IT Hardware

To conclude the recommendations on IT hardware for Panadox data center that have been mentioned previously, the consultant can be certified as Tier 3 Design that accredited by Uptime Institute. Tier 3 always ensures the redundant of achieving N+1 for every single IT components in Panadox Data Center to avoid data loss such as Figure 1 showing the redundancy for each component except for end devices. Moreover, the chosen rack server may give more efficiency in terms of data processing for Panadox Health Care and able to run Electronic Health Record (EHR) applications globally. Besides, SAN network can provide best virtualization when Panadox decide to extend their data/services or planning for storage backups. As for future enhancement, Blade server is recommended if Panadox Data Center decided to upgrade their server storage. For example, upgrading Rack server required more chassis. Therefore, it will consume more space in the facility of rack server. Blade server technology can help in overcome this problem. Furthermore, blade server is easier in maintenance and provide large data processing storage.

2.2 IT Space

Designing the physical space of the data center is a very essential part of the overall construction of the data center. To design the physical space certain standards must be maintained to ensure the designed has been built according to globally accepted standards and still able to be flexible according to the business requirements. ANSI/TIA 942 is the standard used to design the physical infrastructure including but not limited to site location, architectural, electrical, mechanical, fire safely, telecommunication, security and other requirements. Telecommunications Industry Association (TIA) accredited by American National Standard Institute (ANSI) provides the standard, ANSI/TIA-942 which is provides a standard by a non-profit organization. There are no certifications provided which makes the requirements and the constraints very transparent and aids whomever wants to build a reliable and efficient data center. Below in figure 3 shows a standard physical arrangement of a data center (Tia-942.org, 2014).

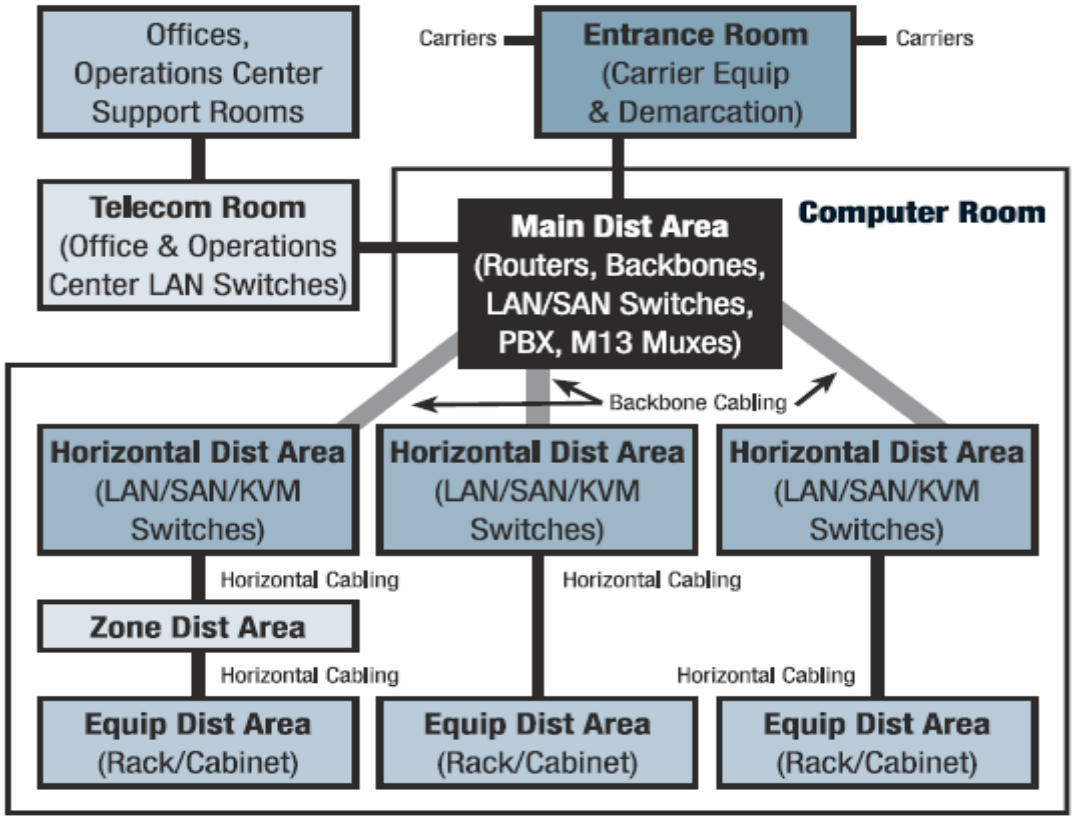


Figure 2: Data center space architecture & cabling

https://www.fiberoptics4sale.com/blogs/archive-posts/95042182-ansi-tia-eia-942-data-center-design-guidelines-and-structured-cabling-standards

2.2.1 Types of cabling

- Horizontal cabling

  This type of cabling extends from user work station in equipment distribution area to either the horizontal distribution area or the main distribution area.

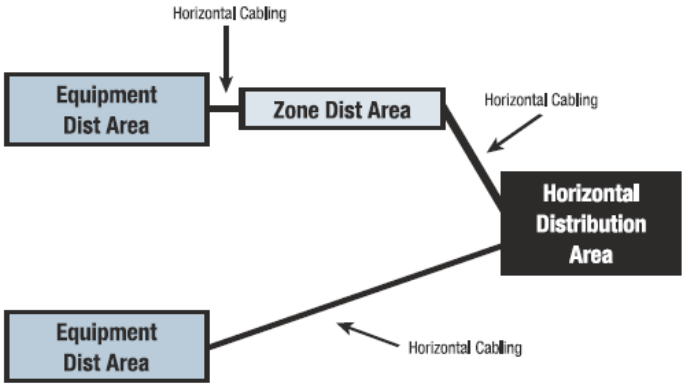


Figure 3

- Backbone cabling

  This type of cabling is mainly used to interconnect

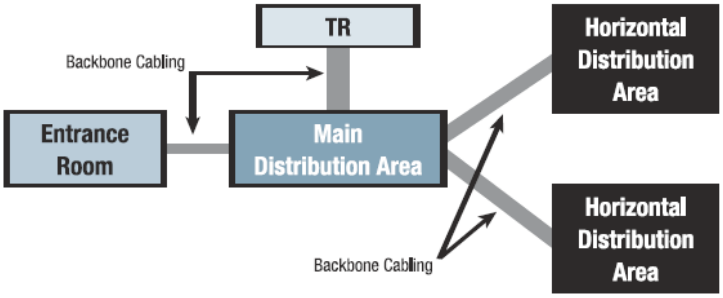


Figure 4

2.2.2 Space distribution

Entrance room

Main Distribution Area (MDA)

Horizontal Distribution Areas (HDAs)

Zone Distribution Area (ZDA), and

Equipment Distribution Area (EDA)

2.3 Power

Nowadays, Data centers have engineered a comprehensive and advanced power distribution system, conversion and backup devices to maintain a reliable and high-efficiency electrical energy supply for the I.T equipment's or other electronic components.[CITATION Xue14 \l 1033]. Panadox Data center will be having A 380V DC power Distribution System which will deliver reliable, high transmission efficiency power supply to the data center**.** DC power distribution has been chosen as it provides higher efficiency as it has high-efficiency centralized power conversion equipment**.** The DC power distribution will provide supply to transformer.

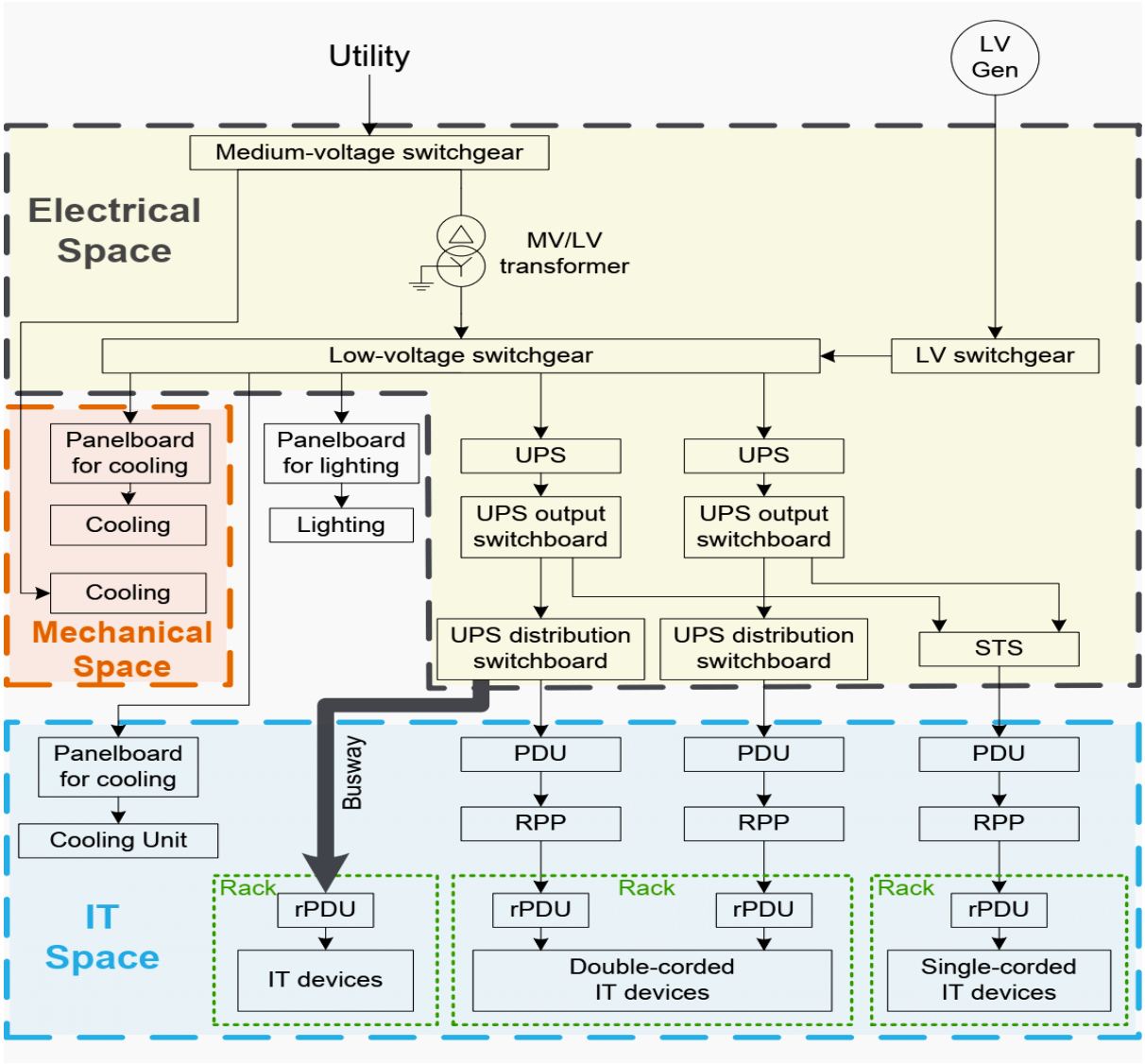


Figure 5: electrical distribution system in a data center

2.3.1 Transformer

In a modern data centers having an advanced data distribution system transformer are must for the transmission and distribution of electricity. It basically transforms the primary voltage into a less secondary voltage. Transformers are basically sized in Kva. The size of transformer is directly related to the amount of power available in the data center. [CITATION EDI17 \l 1033]. In Panadox data center Transformer will be used in order to increase and decrease an electrical voltage to the switchgear and provide a reliable and high-efficiency electrical energy supply.

Figure 6: Transformer

2.3.2 Automatic Transfer Switch

Automatic transfer switch(ATS) is a device that automatically transfers a power supply from its primary source to a backup source when it senses a failure or outage in the primary source. After sensing failure or outrage in power supply it automatically switches it to a back-up circuit. It is considered as the critical component in case of any failure or outrage of power which can provide fast and reliable load transfer I.e. with 5-10 minutes. This will be used in Panadox Data center power supply system which will provide power to UPS.[CITATION Mar182 \l 1033]

Figure 7: Automatic Transfer Switch

2.3.3 Uninterruptible Power Supply (UPS):

It is a back-up power system used to ensure uninterrupted power for various electronic devices. It gives emergency power supply Whenever the power is cut as it has its own rechargeable batteries. The main objective of UPS is to give emergency power supply

whenever the power is cut which helps in preventing transmission faults and data loss. In order to avoid possible, negative consequences of short power failure UPS provides enough battery power for the files to be saved and for the whole system to be shut down in an orderly manner. In Panadox Data center it will give power supply to Power Distribution Unit (PDU). The size of UPS depends on the energy consumption sites. Modern data centers have a UPS for each I.T equipment. The two types of UPS system are:

- Static UPS System
- Rotating(dynamic) UPS system

Figure 8: UPS

2.3.4 Power Distribution Unit

A power distribution unit (PDU) is a type of electrical and power distribution system that manages to supply AC power to multiple I.T equipment devices I.e. computers, servers and networking devices that are available within the rack system. A power distribution unit has the ability to manage and distribute large amount of electricity and is directly installed in the rack.[CITATION Tec183 \l 1033] .Power distribution unit provides steady and uninterruptible power to multiple servers in a rack environment**.** The rackmount PDUs are

designed to be installed in a vertical (0U) or horizontal (1U or more) server rack position. This device is essentially an industrial-grade power strip.[CITATION 42U18 \l 1033].

Figure 9: Power Distribution Unit

As discussed above Panadox is a modular high-density data center and power distribution system in Panadox is according to the standard and need of the modern data center. A modular PDU has been chosen as it much more convenient than traditional data center. Moreover, most of the things can be added to the Power distribution Unit overtime as to meet the challenge with the latest technology I.e. Transformer less PDU, power capacity management software etc.[CITATION Nei09 \l 1033]. Power Distribution Unit (PDU) has multiple sources of integrated power outputs and each output sockets are connected directly to I.T equipment's present in the rack system. There are mainly two types of PDUs named as Floor mounted PDU and Rack mounted PDU. The main reason of choosing a modular PDU was that power conversion happens in PDU where AC input is transferred to multiple I.T equipment's which is in low voltage DC server power. Distribute power simply with a basic power strip with no internal intelligence or boost it up with a more advanced model including outlet level power monitoring to remotely monitor, control, and report the status of every outlet within the unit[CITATION Xue141 \l 1033].

2.4 Fire Suppression

Fire Suppression Systems are for the most part utilized in situations with substantial power hardware (apexfire, 2018). Fire suppression system for data centers is essential. On the off chance that the data center encounters any sort of fiasco it generally conveys at downtime. In this way, data center must have a legitimate fire concealment measure to limit the danger of harm and downtime. Fire suppression must be a piece of any data center calamity recuperation plan, it's fundamental to think about what sort of fire the data center danger of, and the measure of the data center additionally plays a move to decide the appropriate fire suppression for debacle recuperation plan (titanpower,2017) .There are two types of data centre fire suppression agents that you may consider using, water fire suppression systems, and clean agent fire suppression systems.

2.4.1 Water Fire Suppression System

The essential goal of water sprinkler is not fire extinguishment but fire control, meaning that preventing the fire from spreading. Sprinkler system utilize water, average flow rate of 25 galloon per minute. Main issue with sprinkler is that it can cause major damage to the equipment. Once if it gets activated it will continue to expel water until it’s been shut off. Sometimes water sprinklers can accidentally become activated and cause unnecessary damage. In the event of activation, water damage to the facility and equipment can be significant, and the clean-up, which required after activation of sprinkler system can be extensive (Robin, 2019). Sprinkler standards such as NFPA 13 usually need a 30-minute supply of water. Sprinkler heads will get activated by thermally sensitive frangible bulb or fusible link, which releases water only after the head gets a certain minimum temperature. By that time fire will get increased, causing more smoke, and water related damage might occur (Robin, 2015). With the aim of outstanding operational and increasing uptime while preventing fire, dramatic water damage could still lead to downtime (titanpower2019).

Water systems used to mitigate fires, there are also a few different fire mitigation systems that rely on water as opposed to gases. The most common of these water systems is a sprinkler system, which can vary depending upon the type of head and how the water is stored within the pipes. Of the sprinkler systems, there are a unit two kinds of pipes: wet pipes, that store water within the pipe to dump overhead once a fire is detected; and dry pipes, within which water is control back by a secondary or pre-action sprinkler valve till a heat and/or smoke

signal causes it to release. Pre-action pipes are the IT industry standard because of they keep dry, and thus cannot collect condensation to drip on its equipment. The tow commonest action pipe systems are single interlocked systems and double interlocked systems (Tsohost2018).

1. Single Interlocked System
2. Double Interlocked System

- **Advantages and disadvantages of water fire suppression systems;**

Advantages:

- **Simple and reliable system**
- **Minimal maintenance costs**
- **Easily modified for renovations**
- **Short-term downtime following a fire**

Disadvantages

- **Water damage costs**
- **Unsuitable for subfreezing environments**
- **Not suitable for grease fires**

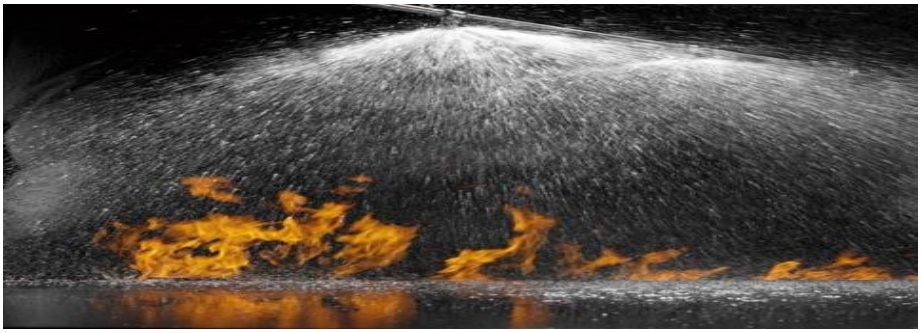


Figure 10: water fire suppression

2.4.2 Clean Agent systems

Clean Agent systems are gaseous systems that deprive a fire of heat or oxygen in order to suppress it. All systems can use gases that are much safer for the environment and humans, these types of systems do not leave chemical residue on the equipment, and by their configuration but they utilize different ways of suppressing a fire (Fireline, 2018).

a) **FM-200 System.**

FM-200 systems suppress fire by removing heat from the room. They can be used with people in the room with few adverse effects. FM-200 systems are quicker than Intergern

systems to reach full fire suppression levels. FM-200 has better potential for having a global warming effect than the other two systems (Fireline2018).

b) Novec 1230, System.

It is also called Sapphire. Novec 1320 systems suppress fires by removing heat from the room. Novec 1320 is a synthetic fire suppression agent that is stored as a liquid but is used to suppress a fire by converting to a gas form. It does not require as much pressure to store as Intergern does, and has a much simpler piping system (Fireline2018).

c) Intergern System.

Uses inert gases- nitrogen, argon, and carbon dioxide- to reduce the oxygen level and suppress the fire. Once the Intergern concentration is discharged, it returns to the atmosphere in its natural state. Intergern is a breathable gas comprised of 52% Nitrogen, 40%Argon and 8% Carbon Dioxide. The release time for Intergern is 60 seconds, which is the longest release time of these three options. Intergern systems require more intricate pipe systems that also require more pressure to be maintained within the system (Tsohost, 2018).

- **A comparison of the three most common fire suppression clean agents – Inert, Novec 1230, and FM-200.**

-

	Inert gases	**Novec 1230**	**Fm-200**
Type of Compound	A mixture of the inert gases: nitrogen, argon, and carbon dioxide (CO_2)	A fluorinated ketone containing carbon, fluorine, and oxygen	A hydrofluorocarbon (HFC) compound containing hydrogen, fluorine, and carbon
Storage	Stored as a gas	Stored as a liquid.	Stored as a liquefied compressed gas.
Discharge Time	**60 seconds**	10 seconds	10 second
Clean Up	**None**	**None**	**None**

Table 4

Advantages and disadvantages of clean agent systems;

Advantages

- Environment-friendly
- Quick Fire Deployment
- Clean and Effective
- Save to use around people
- Space saving

Disadvantages

- High agent cost
- Requires “tight “enclosure
- Need to increase concentration if generator cannot be deenergized

Figure 11: Clean Agent systems

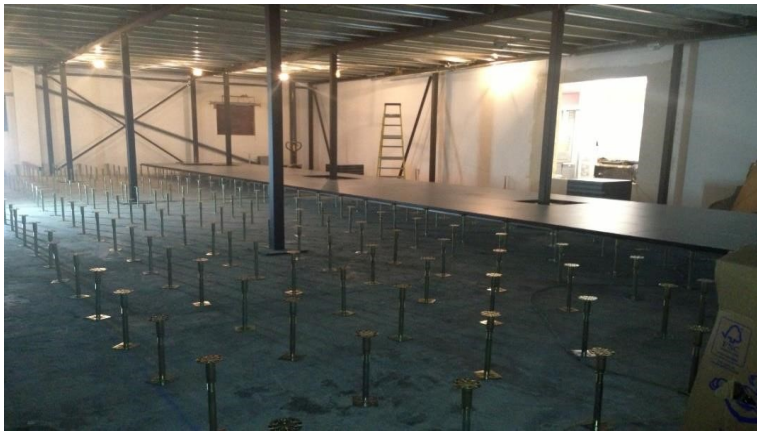


Figure 12: Clean Agent systems

Recommendation for Fire Suppression System:

To choose the best fire suppressions comparison between the types and how they work and operate as well which one is the most needed is done. Both clean agent systems and water systems have their advantages and disadvantages. Clean agent systems prevent water from entering the server room. However, they cost much more than sprinkler systems and take up much more floor space, as sprinkler systems are installed overhead. On the other hand, clean agent systems leave water out of the server room. They leave no chemical residue on equipment and pose no electrical hazard. Which is the better fire mitigation solution come down to the individual data centre.

The recommendation for the data centre is the clean agent system. The clean agent system can help protect a specific room or area in the building, as well as the subfloor in a data centre and the electrical and mechanical rooms. The clean agent is released from nozzles in the ceiling, allowing the suppression product to "flood" the room. Because clean agents are discharged as gaseous materials, they penetrate equipment, floors, and obstructions to extinguish the fire. They also work extremely quickly; clean agents can reach extinguishing levels in 10 seconds or less after deployment, helping to minimize the fire's damage to the data centre. Additionally, the solution does not affect hardware operations or damage the information stored in hard drives or servers. Finally, a clean agent will not leave any residue to clean up after it is deployed. At every stage, a clean agent system operates efficiently and effectively to help protect the data centre.

1) Fire Detection System

To ensure reliable, early detection of fire, it is important to be familiar with the different fire phenomena, fire propagation and possible deceptive phenomena.

Data centres should even have fire detection systems that may recognize the difference between a gas leak and smoke from a fire. Air-sampling smoke detection systems are an excellent choice, as they these systems will notice fire in its earliest stages, alerting personnel and avoiding overpriced suppression system discharges. There are basically three types of fire detecting mechanisms: smoke detection, fire detection, and flame detection. For obvious reasons, data centres opt for smoke detectors. There are two types of smoke detectors: Optical fire detectors, and ionization fire detectors. By increasing the sensitivity of fire detector, they can be made to detect fire in its initial stages.

2) Emergency Power Off

In a room full of electronics, it’s crucial to have an emergency power button to shut down all devices quickly. Also, within the unlikely event of a warning by the suppression system, it’s important to possess an emergency suppression system cancel-switch to show off the system safely. data centre groups United Nations agency do install associate EPO button should clearly mark the button's presence, and install it under a clear, lift-cover box, preferably with associate integrated alarm, to avoid the danger of someone touching it accidentally, and inflicting unintentional period. This has historically been a major cause of data centre outages, usually when the button was mistaken for a door release. (SearchDataCenter2018)

3) Fire Alarm and Emergency Lights

The purpose of a fire alarm is to warn people about the presence of a fire within the premises.

In a data centre context these people may be divided into 3 target groups:

- Selected members of staff
- Staff working in the building (in general) or visitors
- The municipal fire services
- General alarms

- Staged alarms

. (Downloadssiemens2018)

4)Fire Prevention and Protection Services

The primary goal is to minimize any operational interruptions even in case of a fire and to protect people and property effectively. Fire safety is therefore a long-term investment that must be carefully planned to ensure the business continuity of a data centre. If a damaging fire can no longer be prevented, the effects of the fire must be limited as efficiently as possible. Typical protection objectives are:

- No business interruptions.
- Keep data safe at all times.
- Personal injury must be prevented.
- Asset damage must be kept to an absolute minimum.
- Environmental damage, for example due to extinguishing water must be avoided

(SearchDataCenter2018)

2.5 Cooling

Introduction

Data center cooling is one of the main components in a data center which has a major role when comes to build a data center. Cooling is an integral part of data centres ecosystem. Devices in data centres works continuously with a very high rates that gets extremely hot (Isberto, 2018). For our case, serving more than 10 million patients which their data is stored in servers which reflects a huge load on servers which can overheat. So, cooling must be there to avoid any overheating and to ensure that the data center is environmentally friendly. Cooling system is different among years and there are many methods and options based on the requirements of each case (Isberto, 2018).

Figure 13:Data center cooling (Isberto, 2018)

Purpose of cooling

According to cisco, the power that is consumed by the IT equipment and severs in the data center is converted to heat. Though power is reported in units of watts (W) and heat is reported in units of British Thermal Units (BTUs) per hour (BTU/hr). thus, the conversion from watts to BTU/hr is 1W = 3.412 BTU/hr (Cisco.com, 2017). For instance, a server that consumes 100W produces approximately 341.2 BTU/hr of heat energy which produces a huge amount of heat that needs to be optimized. As a result, cooling technologies needed to optimize the heat generated by the devices (Cisco.com, 2017). In figure 2 below, it shows how the heat generated is optimized by cooling as the heat and hot air is exchanged by cold air.

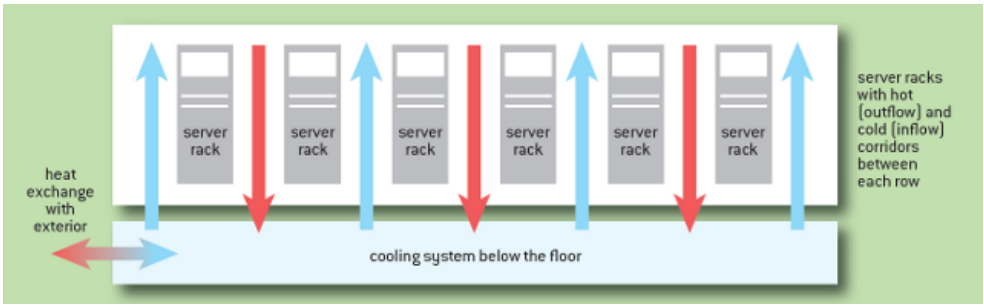


Figure 14: purpose of cooling

Cooling methods

There are two main methods for data center cooling which are air-based cooling and liquid based cooling. The air-based cooling is the cold Aisle/Hot aisle system which simply separates cold air from the hot air (Green Revolution Cooling, 2018). While the liquid-based

cooling is reducing the heat of the data center devices through exploiting properties of liquids (Rouse, 2014).

Layout

Either hot or aisle way needs to be arranged on hot/cold aisle layout. Simply, position racks to face each other's which is resting on a raised floor on a series of rows which every rack face the other. Refer to the below figure to see the hot aisle/cold aisle layout (42U, 2009).

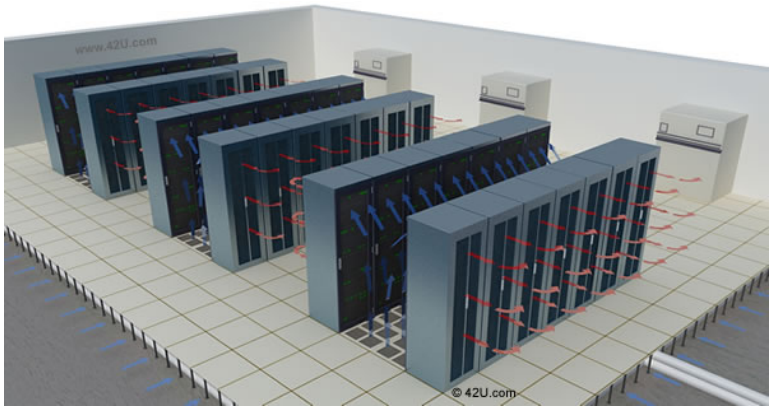


Figure 15:Hot/cold aisle layout

Hot and cold Aisle

The two methods provide a huge savings regarding energy and power. Also, they are both can be used for data center, but it varies on the usage and requirements. Briefly, will discuss the methods and choose the best that fits our specific scenario.

Cold Aisle

Horizontal panels form a flat roof across the cold aisle to block out the cold air in elevated floor surroundings, where cooling is provided throughout the floor. The cold isle is extended by vertical panels to the ceiling for use with cooling duct systems (Peterson, 2015).

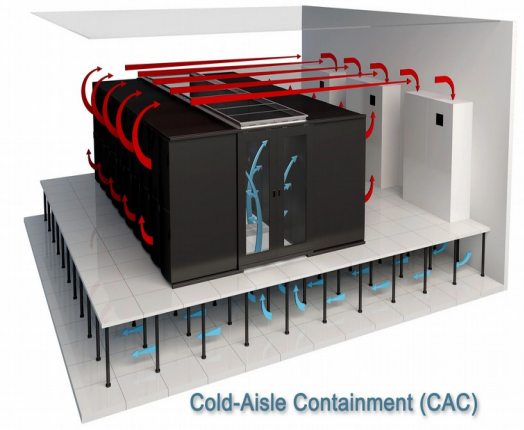


Figure 16:Cold-Aisle Containment (Peterson, 2015)

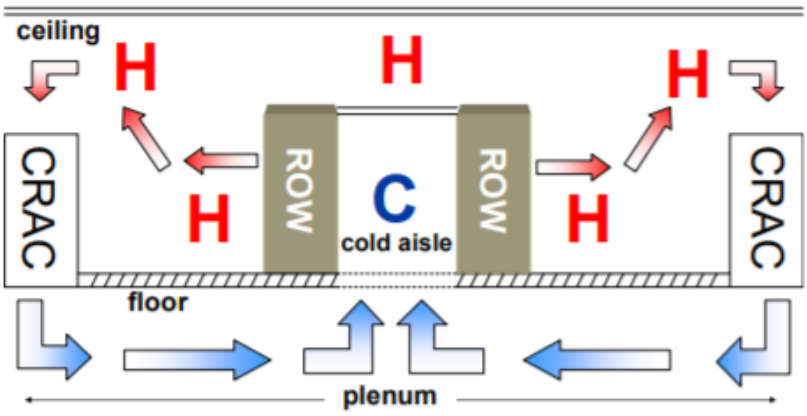


Figure 17:Cold Aisle System

In figure 18, the cold aisle will be going inside through the raised floor after separated by the CRAC while the hot air will be outside and will increase the average temperature of the room which is non-recommended.

Pros and cons of cold aisle

Pros	Cons
Doesn't require additional parts for returning or exhausting Air which makes it easier than hot aisle.	Creates a hot spot in the room which is not human friendly.
Doesn't require much in case of space which Only requires doors and a partition at the end.	*Increases the mix of air which lowers the difference of the temperature.*
Cheaper	Inefficient which leakage from floors can occur
In case of failure, enables cold sink area.	An obstacle for fire detection systems in the data center space

Figure 18:Pros and cons of cold aisle (Ahdoot and Ahdoot, 2014)

Hot aisle

In HAC, there is a physical barrier and heated exhaust air from the back of the hot aisle of the cabinets. The result is horizontal panels forming a flat ceiling over the warm aisle or vertical panels extending over the hot aisle to the ceiling. In combination with in-row cooling systems horizontal panels are usually used to maintain the cool environment outside the contained area. The main purpose of vertically-mounted panels is to direct the hot return air to the full overhead reverse air with a perimeter CRAC units. Also, the Hot Aisle follows the TIA-942

standard which makes the average temperature varies between 21-24 degrees (Peterson,2015).

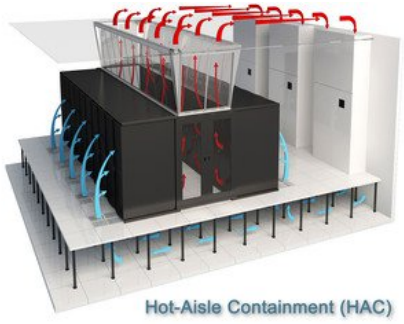


Figure 19:Hot Aisle Containment (Peterson,2015)

Pros and cons of Hot aisle

Pros	Cons
Creates a cold environment in the room which is human friendly and let the room in the normal temperature.	Upfront costs
Cold space receives the leakage of AC	expensive
Much more effective	Not comfortable to IT technicians
Used in the most data centres and let the standard fire detection system works normally.	Requires contained path for the air flow from AC.

Figure 20:Pros and cons of Hot aisle (Ahdoot and Ahdoot, 2014)

Chosen system and Justification

After comparing both containment systems, Hot Aisle containment system is the chosen system for panadox data center. Hot aisle was chosen for many different reasons which gives the advantage over the cold aisle. Maintaining the temperature in the data centre is one of the main aspects to consider for panadox data center as to be following the standard data center temperature which varies between 21-24 degrees. Thus, the chosen aisle containment system will achieve a cold environment across the room which will be human friendly. In contrast, the cold aisle containment system will create a hot spot across the room which will be so difficult for humans by time to stay on it and this will be not human friendly. In addition, it won't follow the standard of TIA-942 which the temperature will exceeds the norm temperature. Hot aisle containment system is used in most of the modern data centres which is more efficient and reliable. Moreover, this will increase the delta T which is the differences of the temperature which will make the space extremely hot. In addition, the cold Aisle will obstruct the fire detection which will be inefficient, and it won't follow the standard. However, Hot Aisle will be following the standard fire detection systems. Regardless upfront costs, the chosen system will be more cost saving compared to the hot Aisle as the hot aisle will require too much of maintenance and won't be efficient for panadox data center. To achieve green computing on the data center heat should be reduced and even should be eliminated. For achieving green computing, the hot aisle will be used because it will reduce the heat by blocking it inside as it won't be affecting the room environment. In conclusion, the hot Aisle will be more efficient which will be eliminating heat and separating it from humans and it will achieve environmentally friendly data center. Moreover, this method will be following the TIA- 942 standard which the room temperature will be varying between 21-24 degrees. Also, it will be easy for standard fire detection system to work without any obstacles. Furthermore, after a visit to HDC data center identified that they are using this type which confirms our analysis and choice. In the figure below, the cooling system of panadox which will block the hot aisle inside, this will be more effective, cost saving, and environmentally friendly

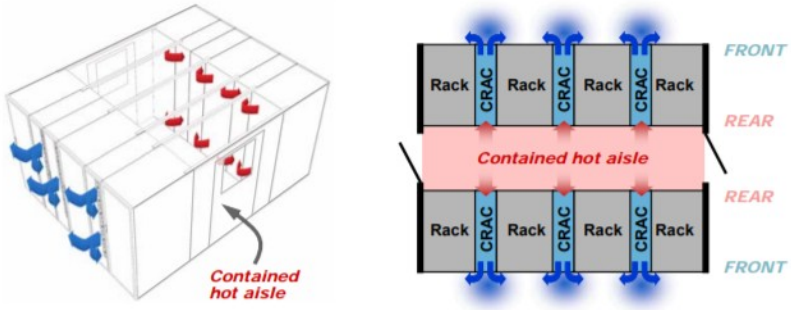


Figure 21:Hot aisle

2.6 Raised Floor

Figure 22:Data center raised floor (RFS, 2019)

Purpose

Data center raised floors are mainly installed to provide the following functionalities:

- Effective cold air distribution system for cooling IT:

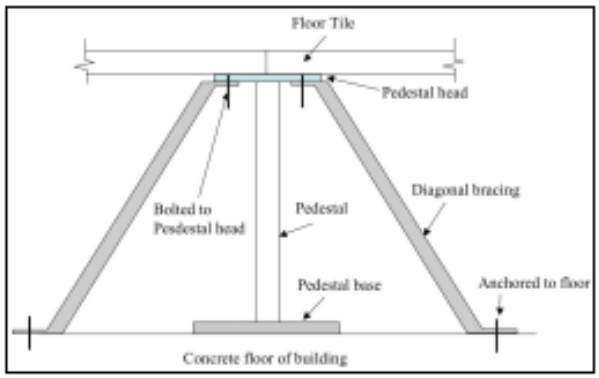
The advanced IT equipment used in data centers today require effective cooling as to the massive workload being processed and thus the high temperatures. The use of raised floors allows for better use of space and well-defined airflows, leading to a higher equipment density and energy efficiency.

- Efficient tracking and support for data cabling:

Access to change cables is a common requirement. Raised floors allows for efficient support of data center cabling and ease of tracking.

- Convenient location for power cabling

Apart from IT equipment cabling, raised floors allow for a well-suited power distribution across the data center's varying IT equipment.



- Grounding of equipment

Grounding of equipment remains essential for safety & efficiency. Grounding the data center equipment allows for efficient cooling & distribution of air, effective support of equipment and power cabling. (Rasmussen, 2015)

Specifications

Figure 23:floor structure

Raised floors are supported by gridded metal framework of adjustable-height lifting the floor's removable floor panels. According to TIA-942, The panels are typically 60x60 cm in size. The height of the gridded metal frameworks is dependent on the volume of the cables going underneath. The height of the floor is at least six inches and would typically range between 24 and 48 inches. The raised floor of the data center provides support to equipment with less than 300 kg of weight (Tang and Schiff, 2014).

Types of Raised floor

Low profile raised floor:

A low-profile floor has a height of less than six "with the objective of organizing cables, wires and pipes. Because of the low board height, air flow under the floor is not an option. This type of raised floor can't be used on our case because it doesn't allow air follow which is necessary for panadox.

Standard raised floor:

Standard access floors are usually 12 "or higher with some floors up to 6 feet or higher. These floors allow both cable control and airflow under floor management. This type of raised floor is used in most of the data centres.

Chosen raised floor and justification

After comparing between both access floors and doing a complete comparison between them to choose the best one that fits for panadox data center. Standard access floor is the most suitable one for our case for many several reasons. This type of raised floor can weight up till 300 kg which will be very strong and can hold as many servers as want. Moreover, this one is used in most of the data centres and it's recommended by them. One of the main reasons that this type will be used for panadox is that it allows the cable management and air flow which is required for cooling and to let the air flows through the raised floor.
The cooling is set up by arranging under the appliance perforated floor tiles. Equipment is des igned to take cool air down and warm blow to the ceiling. Moreover, this type will be following TIA-942 standard. Therefore, the chosen type will be very suitable for panadox as it will allow airflow and cable management.in contrast, low profile raised floors don't allow airflow which won't be suitable for panadox. Furthermore, after a visit to HDC data center identified that they are using this type which confirms our analysis and choice. Finally, the chosen type will be standard raised floor which will be more effective and efficient for panadox data center.

Figure 24:standard raised floor

2.7 Energy Management System and Green Computing

- Control costs & heat with natural climate control

  Data centres invest a lot of money into temperature control and ensuring the data centre is running at an optimum temperature because climate and the environment in and around the data centre is essential. It is important because if the server and devices are in an area with poor temperature control, it can end up damaging those devices as too hot or too cold temperatures can affect the operation of the devices, damaging their structural integrity, operational integrity and eventually destroying them. Cooling systems are very expensive and power consuming. When a cooling system in trying to cool an area, which is in a warmer location, the cooling systems will work more exhaustively to control the temperature. The temperature and climate of the geographic location can aid in this issue by making it easier for the cooling systems to control the temperature as the initial temperature is closer to the optimal temperature therefore efficiently cutting the use of too much power. (Stanganelli, 2017)

- Consolidate servers, storage, and data centres

  Blade servers are expensive but provides significant power efficiency which makes it an important strategy to go green. Blade servers are built into a single chassis that contains multiple servers which all share the power supply, fans, network & storage devices, this not only helps to reduce space but also the multiplication of power sources compared to unconsolidated structure such as rack servers. Blade servers also help with drive consolidation by providing higher density computing for power used as essential devices are built in and share the same power source. (Citilindia.com, 2019)

- Virtualize servers and storage

  When an application is deployed, the stakeholders for various security and other reasons choose to the use of dedicated servers and storage for each application. So, when the application is running, all the power is used for the individual application to run on the dedicated devices no matter how small the task. Virtualization allows the

connection of servers and storage devices to share a platform with strict separations among operating systems, applications, data and users. This enable the applications to run on separate virtual machines that are sharing hardware with other applications behind the scene. This essentially reduces the load on power making it more efficient and reduces the use of unnecessary hardware like servers and storage devices**.** (Jin et al., 2013)

- Turn off idle IT equipment (EMS)

  IT equipment in a data centre are not used all the time and rigorously, only at a mere 5-15%, computers at 10-20%, directly attacked storage devices at 20-40% and network storage devices at 60-80%. The stats mentioned before shows that the devices are not running all the time. The devices even though are not running but at idle still utilizes power. A typical x86 server consumes about 30-40% of maximum power when its only at idle. With a power management software or the built-in feature of server processors the issue of power usage at idle state can power usage or stop the device from consuming power in idle state. (Carroll, 2019)

- Use IT devices and equipment with certified energy efficiency (Energy Star)

  Energy star is a program that is run by the U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE). To earn the star devices must meet strict energy efficiency criteria set by EPA or DOE. The difference between energy star devices compared to standard devices is that energy stared devices use much less energy resulting in lower impact on the environment. Energy stared devices can be up to 25% more efficient than a standard device which in turn means lesser use of energy and lesser cost impact and essentially lowering the negative effects on the environment so by strictly choosing energy stared devices where applicable can help approach towards a more effective green computing initiative. (Bosscontrols.com, 2019)

3.0 Data Center – A Complete Picture

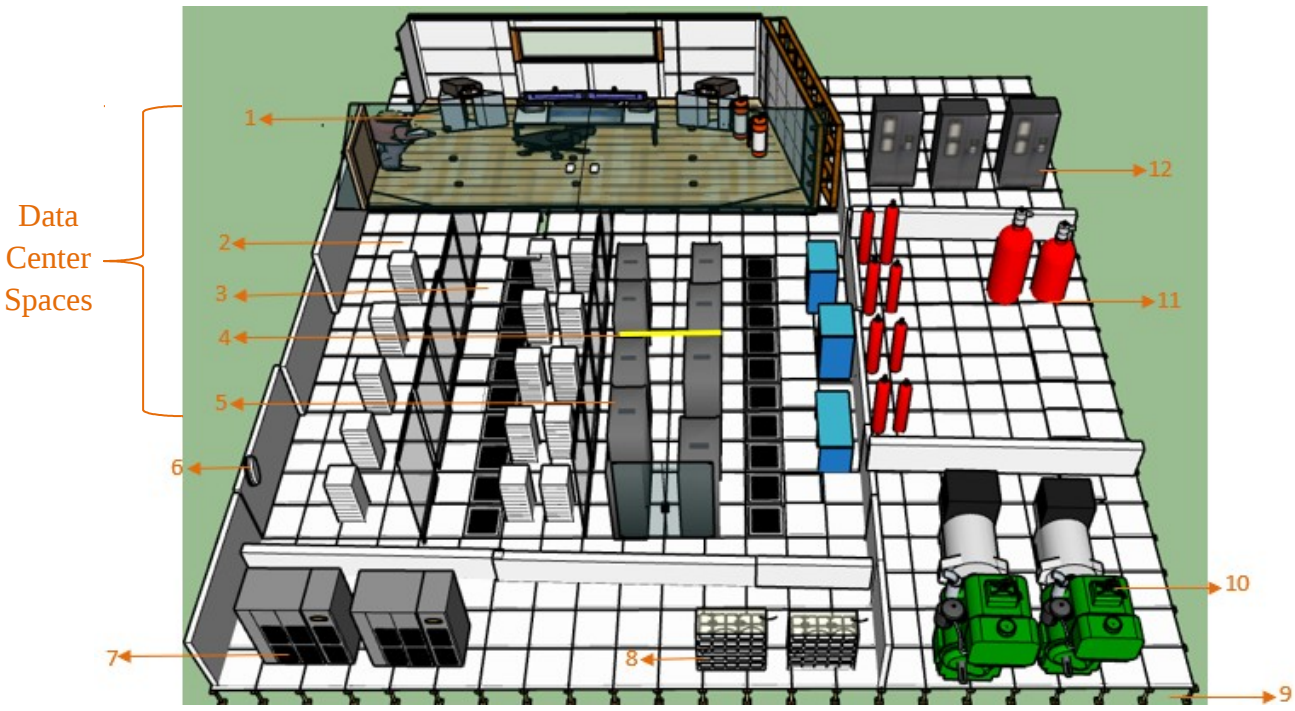


Figure 25: Proposed Data Center Design for Panadox

Justification

The data center design proposed for Panadox is following the TIA-942 standard as mentioned in section 2.2 of this report. It has five basic data center spaces such as Entrance Room, Main Distribution Area, Horizontal Distribution Area, Zone Distribution Area and Equipment Distribution Area. Following is a brief explanation of each of the component of the data center as shown in Figure 26.

1. Entrance Room: It is a location for access provider equipment and demarcation points.
2. Main Distribution Area (MDA): It consists of the core routers and switches for LAN and SAN infrastructures.
3. Horizontal Distribution Area (HDA): It serves as a distribution point for horizontal cabling for distributing cable to the equipment distribution area and it consists of LAN, SAN and KVM switches.
4. Zone Distribution Area (ZDA): It is an optional interconnection point in the horizontal cabling between HDA and EDA. It can house equipment like mainframes and servers.

5. Equipment Distribution Area (EDA): It consists of racks and cabinets, installed in an alternating pattern to create hot and cold aisles that will dissipate heat (Accu-tech.com, n.d.).

The connection between Entrance Room, MDA and HDA is provided by backbone cabling whereas the connection between HDA, ZDA and EDA is provided by horizontal cabling as mentioned in section 2.2.1 of the report.

6. Smoke detector: It is necessary to deploy in a data center as it reduces fire related business interruption and property damage. It notifies the authorized personnel early of a potential situation (Mazzurco, 2013).
7. Uninterruptable power supply (UPS): It is a critical component of data center backup power. The purpose of UPS is to maintain the infrastructure until consistent power returns, or the generator turns on (1547 Realty, 2015). It will be used in the data center as mention in section 2.3.3 of this report.
8. UPS Battery: A UPS battery turns on after the system senses a loss of power (1547 Realty, 2015).
9. Raised floor: It is intended to provide enough space to place quantity of communications cable and power necessary for the data center to work. The floor is also necessary to convey cool air especially to all the cabinets (Tier 3 Data Center Indonesia, 2017). The raised floor specifications are based on the section 2.6 of this report.
10. Generators: The power will automatically switch over to generators during an outage (Nye, 2002).
11. CO2 Fire Extinguishers: As suggested in section 2.4 that clean agent system will be used in the data center. Therefore, CO2 fire extinguishers is an option for use on electrical fires involving sensitive, high-value electrical equipment. It leaves no residue, is non-conductive, and is a non-contaminating gas. It suffocates the fire, removing oxygen from the area and thus disrupting and extinguishing it. This type of extinguisher is will be safe to be used in Panadox data center as it is a safe option for electric equipment (WHAT IS THE RIGHT FIRE EXTINGUISHER TO USE AROUND COMPUTERS & SERVERS?, 2018).
12. Power distribution unit: It is there to supply power to the Panadox data center connected from the main electric poles.

The data center would be redundant as all the equipment in the data center has a backup, so if one fails the other takes over.

4.0 Conclusion

In conclusion, our team has proposed a data centre design plan for Panadox that ensures to create a secure and efficient data center. The proposed data center is following the Tier 3 data center standard. The recommended storage system for the Panadox data center is SAN as SAN can provide virtualization to extend the storage capabilities at any time. Rack servers are recommended for the Panadox Data Center, however for future enhancement blade servers can be implemented. The Panadox Data Design is following the TIA-942 design standard and it is divided in five spaces such as Entrance room, Main Distribution Area (MDA), Horizontal Distribution Areas (HDA), Zone Distribution Area (ZDA), and Equipment Distribution Area (EDA). Clean agent system will be used in the data center for fire prevention. For the cooling, hot aisle containment system is preferred. The data center will have a raised floor as it provides enough space to place quantity of communications cable and power necessary for the data center to work and it is necessary to convey cool air. The Panadox Data Center is a Green Data Center as all the necessary measures are taken that are required for a Green Data Center. The Panadox Data Center is a secure Data Center as it has all the necessary security measures such as biometric access systems, all the security systems will be monitored 24/7. Motion sensors and CCTV systems monitoring will be equipped to handle low light conditions. The staff will only have access to areas that are required by their duties. The visitor’s appointments will be verified before allowing escorted access only to the necessary location.

5.0 Work break down structure

Name	TP Number	Tasks
Utaya Surian	TP053183	• Data Center Standard • Tier 3 Network Architecture Design • Data Center Storage System • Server Type
Ahmed Yasser Ahmed EL Gabry	TP047468	• Cooling System • Raised Floor
Abdullah Mohd Belayat Pahlwan	TP028958	• IT Space • EMS and Green Computing
Rameesha Shehzad	TP051416	• Introduction • Data Center Requirements • Data Center – A complete picture • Conclusion
Abdullah Saleh Basaad	TP043014	• Fire Suppression System • Power Distribution Unit

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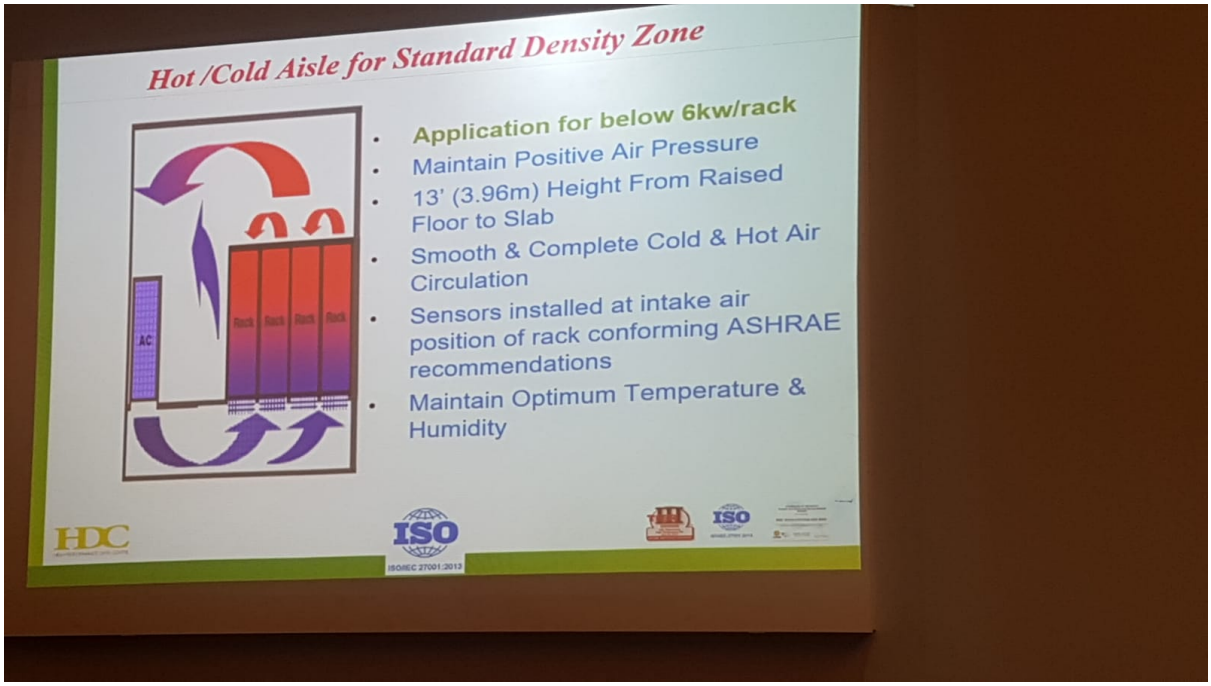
Appendix

Consultants from ZiPro had made an analysis before proposing for Panadox Data Center. The visit to **HDC Data Center** was on 24th April, 2019. From there, the analysis have been made based on data center standard (Uptime Institute), required IT hardware, cooling system & raised floor, power system, green computing and IT space.

HDC Data Center is certified as Tier 3 Uptime standard design. They have provided sufficient redundancy for every IT components except for power utility. Although the power utility in tier 3 is only allocated for one utility, however the HDC data center using a different utility sources from same power industry known as **TNB** such as two power grids to support their entire data center facility. Therefore, Panadox Data Center can apply the similar concept such as use dual power grids for distribute power system into its data center in order to achieve redundancy as **N+1**.

Rack server in HDC Data Center to achieve the energy savings along with EMS and BMS to monitor each servers performance and temperature. The cabling structure were designed more structured because of easy maintenance .



HDC Data Center's cooling system based on hot aisle designed for dedicated servers such as rack servers and blade servers along with Computer Room Air Conditioning (CRAC) units. They have provided containments to keep the exhaust air and release from the chambers. Moreover, EMS also helps in monitoring the cooling system in facility. Hot aisle allows to maintain the optimum temperature and humidity in a way to achieve the environmental friendly. Therefore, for Panadox Data Center, the consultant will design hot aisle cooling system for the IT facility.