

## **Abstract**

SPIC Malaysia is one of the world's leading providers of Data Center Consulting, custom software, mobile application development, as well as building many data centers across the world. For one of their clients, we were assigned the task of implementing a new data center that can offer full security and compliance features. In order to design a relevant data center infrastructure, several aspects must be thoughtfully planned, such as performance, resilience and flexibility for fast deployment and support of new services. We studied constituent elements such as selection of appropriate data tier, technical goals, hardware, softwares and power distributions, so that the designed data center encounters no major issues while functioning. Furthermore, we also compared and resolved implementation of cooling systems, fire suppression systems along with securities such as EMS and BMS for the data center.

## **Acknowledgement**

The encouragement and positive motivation we were given throughout the completion of this project is gigantic. First of all, we manifest our heartfelt appreciation to our subject teacher **Mr. Yuvraj Sharma** sir, who guided us to the triumph of project from the very first day. Without his assistance, we might not be able to complete the project with detailed understanding and lucidity.

Likewise, we also convey thankfulness to all our colleagues who helped us during project. Your visualization and perception about the project aided us to learn new ideologies and functionalities and to consider them in the data center designing task. Winding up, we would like to make use of this opportunity to express our deepest gratefulness to our parents and the college who are facilitating us to learn professorial technical courses.

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## 1. Introduction to Data Center

SPIC MALAYSIA is renowned company for their top notch consulting services to their clients. Company also provides services such as customized software and developing application those are smart phones compatible. SPIC also connects international and domestic business together with their network. SPIC has also a lot of various size data center across the Malaysia. SPIC as they don't like to take chance. So, they has deputed us to plan and design a proposal a data center for Columbia hospital.

### 1.1. Data Center Explained

Data center is the high value property for everyone in this word. Every person in this world has a connection with data center for every reason they can imagine. We record business related data, personal information, educational and entertainment, family videos etc. In order to store all the data in their devices can be problematic which can result in device processing ability painfully slow or corrupted data. Data seems to be increasing everyday so it is hard for any small business to store and maintain data in their storage.

## 2. Technical Goals of Data Center



Figure 01 : Technical Goals of Data Center

The requirement of the data center is only determined by the amount of service expected to be conducted by the data center. In our scenario, the data center is intended for Customer Relationship Management (CRM) system. Data center requirements of the Columbia hospital are as listed below :

## **2.1. Security**

Security is a very crucial part of the data center as there are highly confidential data and high value storage equipment's are kept. Data center will be processing data recorded by the CRM which is highly important to treat their patient correctly or in some case to save patients life. In order to keep data secure Columbia hospital's data center security system will have both physical security along with cyber security.

## **2.2. Scalability**

Columbia hospital has expended a lot as they added more services to the hospital and its inevitable that the hospital will expand its services. In order to co-op with the future data load data center must be scalable. Scalability of the data center can be considered by making extra space for equipment, higher redundant energy distribution planning, higher capacity and top end storage and network devices etc.

## **2.3. Manageability**

With big data center comes bigger responsibility and that is to keep it up and running 24/7. Over the time pipes, cables, devices, floor, wall and ceiling etc. gets old and deteriorate. Pipes starts to leak, cable gets ripped, floors fall apart and a lot of problems that comes over time and to be able to repair and solve the problem, every things has to be placed according to the safety standards and replaceable space between the equipment's.

## **2.4. Cost**

Building and maintaining a data center can be very costly. The performance of the data center can depend on the cost of the equipment such as cooling, electric, routing devices and employees etc.

## 2.5. Availability

Columbia hospital may need to fetch data any given time, due to which the availability of the data from data center is crucial. The availability for the Columbia hospital is 99.982%.

Data center are categorized according to the tier system. Tier system helps understand the availability and redundancy of the designed data center.

## 3. Data Center Tiers

Data centers are ranked with specific tiers, based on their reliability and facilities. They are provided with international ranking from an independent organization : Uptime Institute. There are a total of four tiers where tier 1 is considered as the inferior and tier 4 is considered the best.

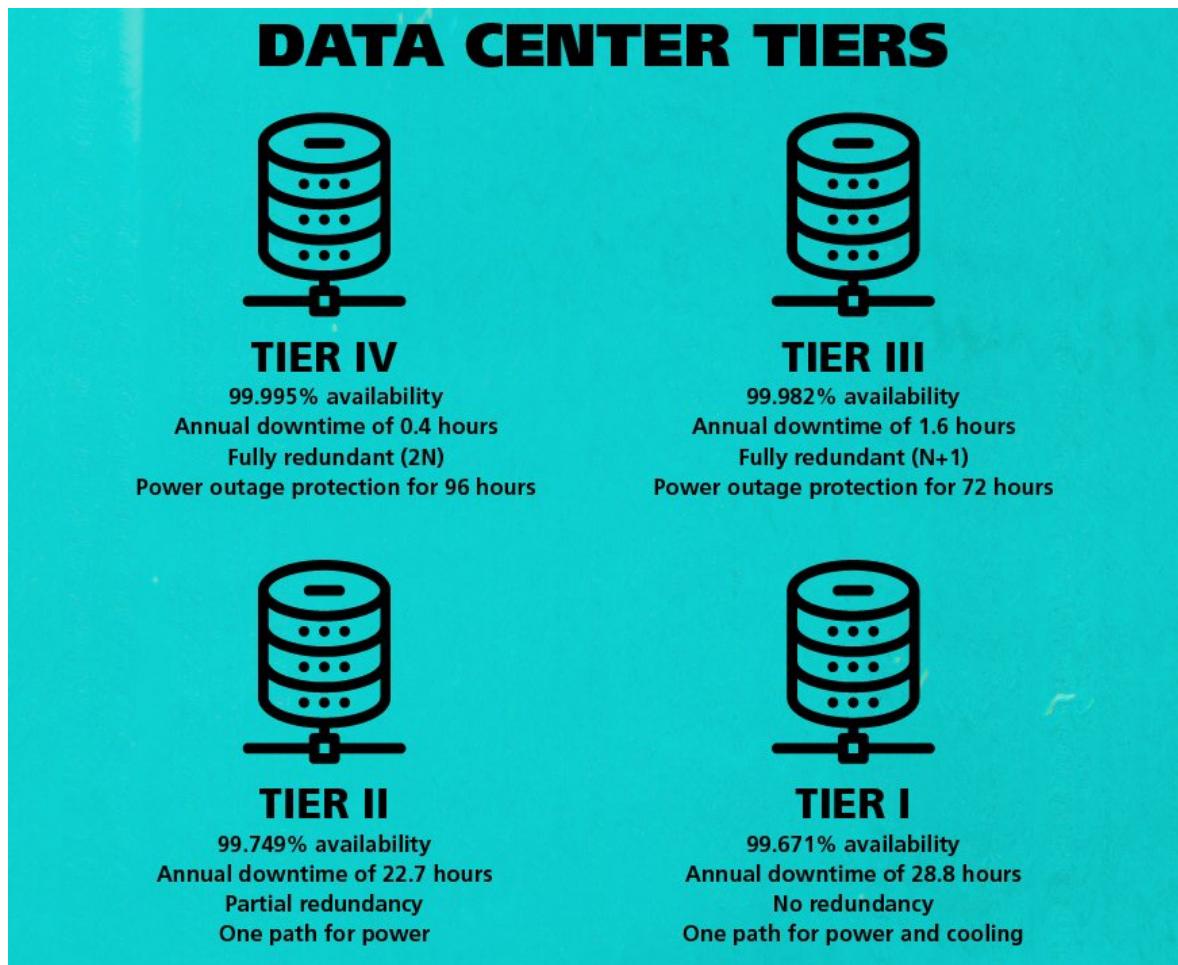


Figure 02 : Classification of Data Center Tiers (Browning, 2022)

### **3.1. Tier I**

A tier I data center is considered to be weakest data center among all tiers. Data centers falling under tier I usually have lone path for cooling and power (Velimirovic, 2021). There is no component redundancy whereas the downtime for these data centers stays under 29 hours per year.

### **3.2. Tier II**

Unlike tier I, tier II ranked data centers have some backup components for maintenance and disruption avoidance. This ties includes several components such as cooling units, fuel tanks, storage, engine generators, etc. The downtime is expected to be less than 23 hours for tier II.

### **3.3. Tier III**

Tier III data centers comprise of redundant system and multiple paths that assists in cooling. This tier is considered to be useful for growing large businesses. The downtime of tier III is less than 1.5 hours.

### **3.4. Tier IV**

Tier IV is the best possible rank among all tiers. A tier IV data center is considered to be the most reliable among all. What makes tier IV data centers distinctive is its isolated systems, which are independent and prevents massive disruptions in multiple systems.

### **3.5. Chosen Tier**

After studying all available tiers, our team has chosen ‘Tier IV’ as the most appropriate tier for Columbia Hospital. There are several reasons for choosing this specific tier. One of the main reason is data center security, which is crucial in institutions like hospitals. Moreover, the uptime of 99.99% is something remarkable as there will be less than 25 minutes of down time per year. The tier IV data center will also have fault tolerance, which prevents disruptions in IT operations during any sort of interferences.

PARAMETERS	TIER 1	TIER 2	TIER 3	TIER 4
<b>Uptime guarantee</b>	99.671%	99.741%	99.982%	99.995%
<b>Downtime per year</b>	<28.8 hours	<22 hours	<1.6 hours	<26.3 minutes
<b>Component redundancy</b>	None	Partial power and cooling redundancy (partial N+1)	Full N+1	Fault tolerant (2N or 2N+1)
<b>Concurrently maintainable</b>	No	No	Partially	Yes
<b>Price</b>	\$	\$\$	\$\$\$	\$\$\$\$
<b>Compartmentalization</b>	No	No	No	Yes
<b>Staffing</b>	None	1 shift	1+ shift	24/7/365
<b>Typical customer</b>	Small companies and start-ups with simple requirements	SMBs	Growing and large businesses	Government entities and large enterprises
<b>The main reason why companies select this tier</b>	The most affordable data center tier	A good cost-to-performance ratio	A fine line between high performance and affordability	A fault-tolerant facility ideal for consistently high levels of traffic or processing demands

*Figure 03 : Availability table of Data Center*

## 4. Data Center Design Explained

In this section the factor that are considered during planning, designing and building a data center are mentioned.

### 4.1. Location

Finding a perfect location for a data center is very crucial step. Nature is unpredictable because of environmental changes and disastrous it can be. Natural calamities such as flood tsunami, landslides, earthquake, over raining, bush fires etc. are unpredictable that can be disastrous for data center infrastructure and its equipment. Recovery after a natural calamities strike would be costly and time consuming and worst case loss of data that was collected over many years. Find a perfect location according to temperature can be very cost effective.

Therefore, building a data center in a location that has low risk of weather and natural calamities is highly recommended.

### 4.2. Network Services

Network service helps to connect clients with the data center. It is important to choose a location with a high speed network reach. Fiber optic network has less attenuation, latency, high

data capacity over long distance. High speed fiber network is highly preferred since it helps to deliver high performing internet service.



Figure 04 : Fiber Network of NTC

### 4.3. Security

Security system for a data center is very important. Data center stores a lot of confidential data that can be used against the organization by the outsiders. It is best to have both type of security Physical and cyber security. Physical security such as barbed wire fences and high brick walls, closed-circuit television (CCTV), biometric login system, face recognition system, motion sensor system are mandatory as the attackers with wrong intention can enter physically. It also means the rodent repellent system so the rodent can't enter into data center because they can chew cables increasing operational cost.

Cyber security is also a must for data center because hackers are either hired or employed to steal the confidential data from the rival company in order to track every move. Fire walls, highly skilled cyber security employees has to be deployed to stop hackers from stealing or secure the integrity of the data.

#### **4.4. Additional Considerations**

##### **4.4.1. Raised Floors and Perforated Tiles**

Raised floor is a standard for the data center that must be followed while building a data center. Data center floors are raised so the cold air can be circulated and supplied from under the floor. Raised floor helps to maximize space of the data center. Maintenance work can be easier since raised floor in a data center are over 5 foot tall. Perforated tile are widely used in data center due to its strength and functionality. Perforated tiles are used to let the cold air into the devices and with these type of tiles cold air can be directed to the specific area where it should provide cold air.



*Figure 05 : Raised floor in Data Center*

#### 4.4.2. Suspended Ceilings

It is a ceiling that is hung under the actual roof and it provides a space in between so the space could be used to run cables for electric cable, water pipes, air duct systems. Because almost every data center has overhead air condition duct pipes.

#### 4.4.3. Insulated Walls

Insulated walls for a data center is very important because of the temperature difference between inside and outside of the wall which can cause humidity issues. High humidity in the data center can moisture inside the devices such as motherboards, hard drives and connecting socket which leads to corrosion and in worse case damage for good. According to the ASHRAE's guideline, recommended humidity for datacenter is between 45% and 55%. Therefore, wall of the data center must be insulated.

## PRECAST DATA CENTER WALLS

VERSATILE. RESILIENT. EFFICIENT



-  Equipment can be stored without damage from weather extremes or physical security breaches
-  Designed for extended life without need for costly maintenance or repairs
-  Strength and durability to withstand explosions, projectiles, high winds, and tornadoes
-  Can be constructed with an aesthetically pleasing exterior or to match existing structures
-  Manufactured off site and assembled in less time with less man hours saving resources
-  Provides insulation to assist with regulation of temperatures housing sensitive equipment

Figure 06 : Wall of Data Center

## 5. IT Hardware

### 5.1. Hard Disk Drive (HDD)

HDD is known as Hard Disk Drive, it consist of magnetic components for storage, a motors that spins the disks, circuitry and sealed in a metal case to protect from dust. Because has a moving component inside, it emits heat.

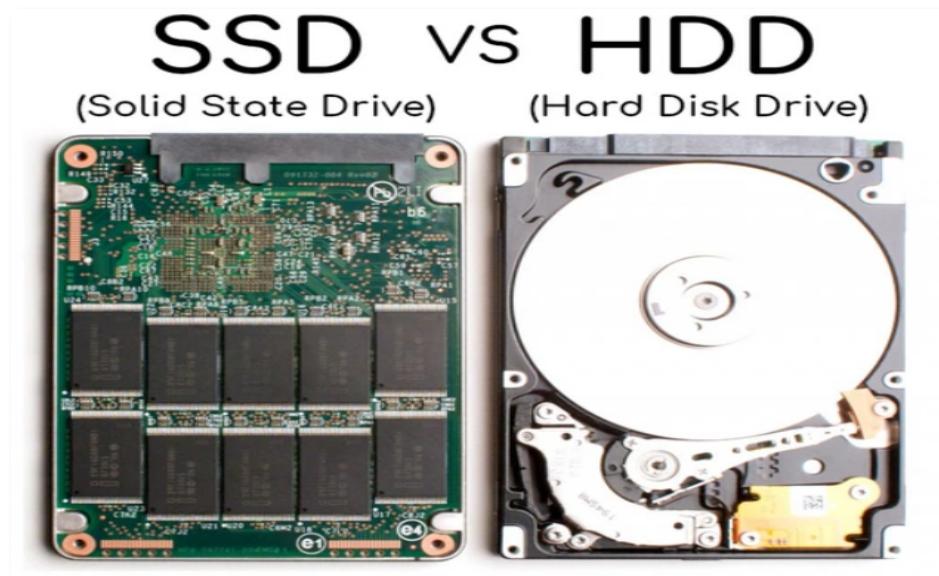


Figure 07 : SSD vs HDD (“Ssd vs hdd image - Google Search,” 2019)

### 5.2. Solid State Drive (SSD)

SSD stands for Solid State Drive, it is a storage device that has a flash memory system type that can read write and store data for long period of time. Because it has a flash memory system it does not emit heat from the device (“SSD explained - Google Zoeken,” n.d.).

### 5.3. Rack Server

Rack servers are also known as rack mounted server. It is a computer specifically used as a server for providing services to the clients, it is designed according to the rack mountable features and capabilities.



*Figure 08 : Dell PowerEdge R240 Rack Server (Amazon, n.d.)*

### 5.3.1. Rack Standards

While choosing a server rack, it has to be up to the data center standard because installing servers is not the only concern of the data center they have to clean, repair and maintain the optimal standard for servers to work perfectly. The normal standard for data center according to EIA (Electronic Industries Alliance) is 19 inch wide rack.

### 5.3.2. Rack Comparison

There are 4 different types of server racks that can be deployed according to the standard established for the data center.

Rack Name	4 post open rack	Colocation Rack Cabinets	Acoustic Quiet Soundproof Rack	Server Enclosure
Image				
Rack unit (U)	44U	43 U	44U	42U
Internal width (in)	19 (EIA Compliant)	19 (EIA Compliant)	19 (EIA Compliant)	24 (EIA Compliant)
Material	Extruded Aluminium	Solid Steel	Extruded Aluminum	Solid Steel

Door style	None	Vented Mesh	Solid/Solid	Vented Mesh
Price	\$1,095.97	\$ 1580.96	\$ 6,899	\$ 1,431
Number of Fan	None	None	6	None
Model Number	772030-L	CL43-610-2	AQ772036	SR42UB
Sound Reduction	None	None	20.7 dbA	None

*Table 01 : Comparison between Rack Servers*

### **5.3.3. Rack Recommendation**

Each rack on the comparison table are eligible to be implemented according to EIA standard. Each rack offers it's unique features that makes each one better than the other such as sound reduction, none-framed, built in fan etc. 4 post open rack is the cheapest among other which can be good option for a clean environment data center other wise it can be damaged by the dust. Colocation rack offer dual door that can be open with separate key that can help reduce the amount of dirt that can accumulate over time if it had single door. Acoustic Quiet Soundproof Rack offers built in fan system, reduces up to 20.7 dbA of noise, dissipates 3.0KW of heat. This rack stands out of all since it offers better feature and protection to the device. Cabinet enclosure offers decent features such as perforated doors for nice amount of air flow into the devices, adjustable mounting rails, easy maintenance.

Conclusion, because data takes a lot of money and time to collect and it can help someone track their health recovery or even save life. So, it shouldn't be compromised with the cost factor. Acoustic Quiet Soundproof server rack is the ideal rack to be deployed.

### **5.4. Cabling**

Cabling are considered as a transportation path for data. There are different types of cable for different types of job. Unshielded Twisted Pair (UTP) and Fiber optic cables are used in a data center. Fiber optic cables are of two types single mode and multi mode. Fiber optic cables

are consists of one or more glass core through which huge amount of data are shared with minimal loss of strength. Multi mode fiber cable are known to have less range compare to single mode fiber cable.

COMPARISON OF SINGLE-MODE AND MULTIMODE INDEX FIBRES	
Table 1 Comparison of single-mode and multimode index fibers	
Single-mode fibre	Multimode fibre
<ol style="list-style-type: none"> <li>An SMSI fibre has its core diameter smaller than an MMSI fibre.</li> <li>The range of core diameter is 4–10 <math>\mu\text{m}</math> depending on the wavelength of propagating light. Here, cladding is about 120 <math>\mu\text{m}</math>.</li> <li>Difference between the refractive indices of core and cladding is small.</li> <li>Single mode is propagated through the core.</li> <li>Small radii of single-mode fibres make it difficult to launch optical power into fibre.</li> <li>A single-mode fibre requires more sophisticated light source to launch optical power in small core. Usually, laser diodes are used.</li> <li>Single-mode fibres are more expensive.</li> <li>Single-mode fibres are free from intermodal dispersion.</li> <li>NA of single-mode fibres are small.</li> <li>Single-mode fibres have high information carrying capability.</li> <li>Single-mode fibres are used for short distance communication.</li> </ol>	<ol style="list-style-type: none"> <li>An MMSI fibre has greater diameter than an SMSI fibre.</li> <li>The range of core diameter is 25–110 <math>\mu\text{m}</math> and the cladding diameter is in the range 130 <math>\mu\text{m}</math>–510 <math>\mu\text{m}</math>.</li> <li>Difference between the refractive indices of core and cladding is comparatively large.</li> <li>Many modes are propagated.</li> <li>Due to large radii, it is easy to launch optical power into the fibre.</li> <li>A multimode fibre requires simple sources such as LED.</li> <li>Multimode fibres are cheaper.</li> <li>Multimode fibres suffer intermodal dispersion.</li> <li>NA of multimode fibres are large.</li> <li>Multimode fibres have low information carrying capability.</li> <li>Multimode fibres are used for long distance communication.</li> </ol>

Figure 09 : Comparison of Single and Multi Mode

Similar to fiber optic cable UTP also has its variants, all the variants with different and upgraded capacity. Figure below is the table to display comparison of different types of CAT cables.

ETHERNET CABLE PERFORMANCE SUMMARY			
CATEGORY	SHIELDING	MAX TRANSMISSION SPEED (AT 100 METERS)	MAX BANDWIDTH
Cat 3	Unshielded	10 Mbps	16 MHz
Cat 5	Unshielded	10/100 Mbps	100 MHz
Cat 5e	Unshielded	1000 Mbps / 1 Gbps	100 MHz
Cat 6	Shielded or Unshielded	1000 Mbps / 1 Gbps	>250 MHz
Cat 6a	Shielded	10000 Mbps / 10 Gbps	500 MHz
Cat 7	Shielded	10000 Mbps / 10 Gbps	600 MHz
Cat 8	Shielded	25 Gbps or 40Gbps *	2000 MHz

Figure 10 : Display of Category Cable Capacity

Table above shows the capacity of all the CAT cables. CAT cable 3 and above has transmitting distance range up to 100 meters which in some case are controversial. The comparison of the cables are made according to their category, speed, frequency and distance range is also mentioned. There are different types of shielding cable available now some of them are U/UTP unshielded twisted pair, F/UTP- foil shielded UTP, U/FTP- Unshielded cable/ foil shielded twisted pairs, S/FTP- Braided shielded cable/ foil shield twisted pairs. CAT cable follows two type of standard to the RJ45 connectors that are T568A and T568B.

PIN	T568A	T568B
1	White with green stripe	White with orange stripe
2	Green	Orange
3	White with orange stripe	White with green stripe
4	Blue	Blue
5	White with blue stripe	White with blue stripe
6	Orange	Green
7	White with brown stripe	White with brown stripe
8	Brown	Brown

*Figure 11 : Table of Rj-45 Pinout and Wiring*

Projects sites are not always of the same length and height due to which different length of cables has to be implemented. Length of the cable can cause in drop of throughput capability which can cause in poor network. It is best practice to implement cables according to the table shown above.

## 5.5. Patch Panel

It is a multiple port panel the can connect many devices with each other and organize all the cables used. Patch panel can be used to set up for various types of cables such as fiber optic cables, RJ45 cable, cat5 cables etc (“Patch panel explained - Google Zoeken,” n.d.).

## 5.6. Networking Devices

### 5.6.1. Core Router

Core Router is a router with higher speed, high load and bandwidth handling capacity used as a backbone router. It is placed right in the heart of the topology of the network providing edge to edge connection. Core routers are used in large organization that have huge volume of bandwidth requirement.



*Figure 12 : CISCO Service Provider Core Router (Indiamart, 2021)*

### 5.6.2. Edge Router

Edge router are located at the edge point/ boundary of the topology of the network which helps to connect two or more core routers. It has low speed, load and bandwidth handling capacity. Edge router does offers lots of function that can be used to maintain the quality of the service of the network. Edge routers can help internal network connect with external network.



*Figure 13 : Ubiquiti Edge Router*

### **5.6.3. Layer 2 Switch**

It is a switch that are placed in data link layer of OSI model. Layer 2 switch use mac address table to determine the path to forward the frames. There are different types of switch such as Store and forward switch, cut through switch, fragment free switch and adaptive switch. Adaptive switch can be used as all the other types because it hold the ability to work as them.

## **6. Electrical Power Distribution Design Overview**

### **6.1. Power (Electric Supply)**

These days' data centers are power efficiency technology has advanced, thanks to the engineers. Power supply and distribution system, power back up and conversion to operated and maintain a high-efficiency has been built for the smooth operation of the data center. DC power

are generated by renewable energy such as solar, wind, water, heat etc. and are considered as a clean energy. Polarity and magnitude of the dc power remains constant which makes it efficient power and that helps electronic device function well. DC power are known to have less noise, low power loss and high efficient. DC current can be stored in a battery and later used during power outage. All the new modern high tech equipment are dependent on DC power supply. Columbia hospital data center will have 380V DC power system to provide reliable high power supply. Power consumption factors in the Data Center are Chiller, Humidifier, CRAC, Switchgear, IT Equipment, PDU, UPS, Lighting, etc.

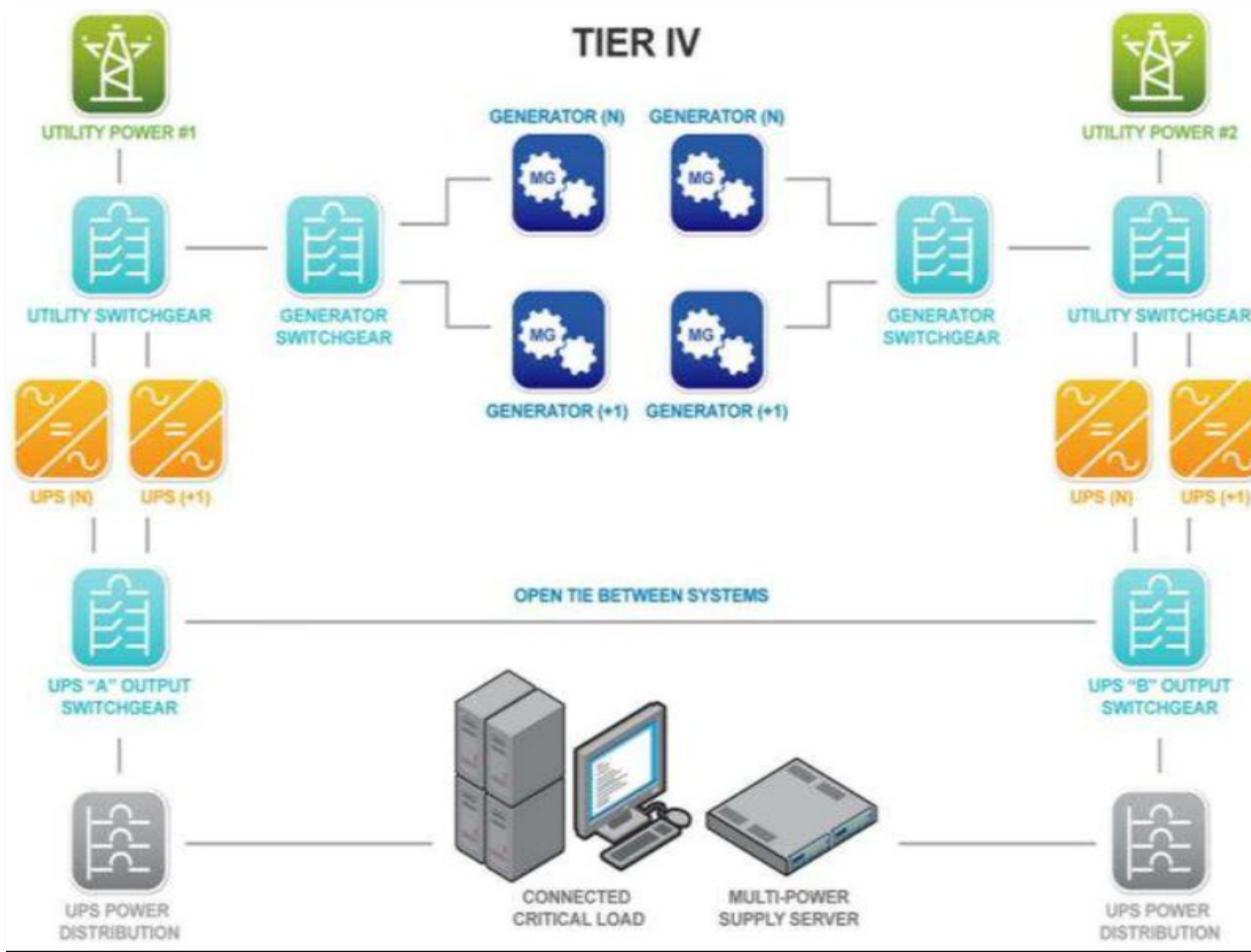


Figure 14 : Tier 4 electronic distribution system

## 6.2. Transformer

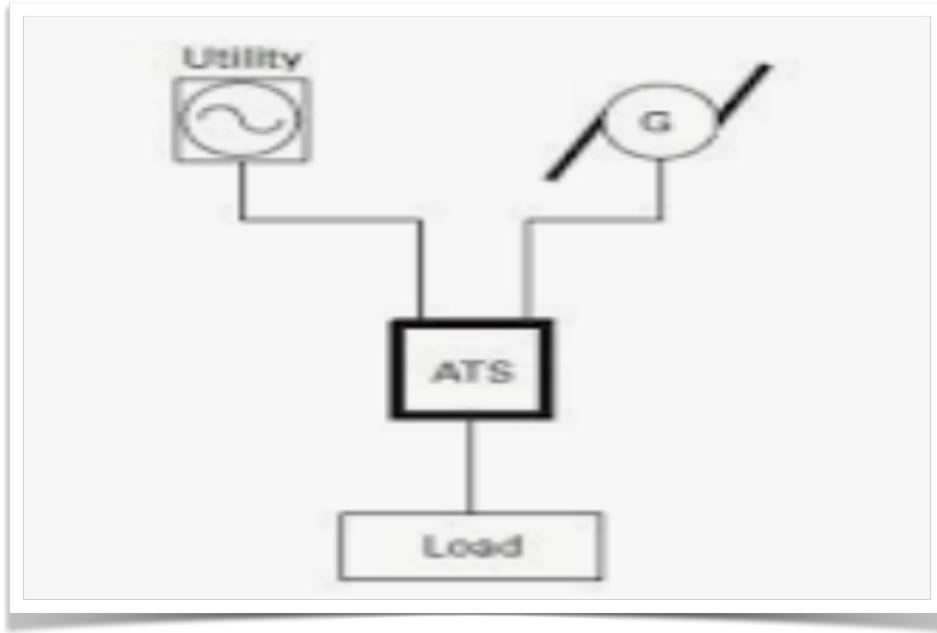
Data center are with all the power supply system has to have a transformer for transmission and distribution of the power all over the load. Transformer are used to either increase or decrease the voltage of the electricity. So, the devices low voltage can operate according to the device capacity. Transformer are connected to switchgear for the distribution of the power to the devices.



*Figure 15 : Transformer for Data Center*

## 6.3. Automatic Transfer Switch

Automatic Transfer Switch (ATS) is a advance self-acting system that switches power to devices with the help of dedicated intelligent control logic. During the power failure ATS automatically switch gear to the backup power source and when the main power source is back on the service ATS switches the power supply back to normal power supply.



*Figure 16 : Automatic Transfer Switch*

#### **6.4. Uninterruptible Power Supply (UPS)**

It is a device that provides emergency electric supply during the absence of the main power supply. It provides power instantly from its battery when the normal power source is cut off. The soul purpose of this device is to save data, injuries, protect IT devices during the sudden power disruption. There are three types of UPS such as On-line UPS, Line-interactive UPS and standby UPS (Wikipedia contributors, 2022).

Standby also known as offline ups are cheap to buy and it is preferred by small office. It is also known as standalone device because it consists of built in battery. It is considered only 55% effective. Line-interactive ups are preferred in a situation where power are in constant fluctuation and frequent power outage. It is considered 85% effective for situation such as light sag, surges etc. Online ups provide very reliable power protection, power conditioning and back up. Switch over time doesn't exist here which is good news for the users. Unlike line-interactive and offline ups, online ups regenerate output power. Online ups can be monitored by remote device which helps users to stay alert all the time. It is considered to be 100% efficient. This device is best for intensive care units in emergency room, data center etc.



*Figure 17 : Online UPS*

## **6.5. Power Distribution Unit (PDU)**

Power distribution unit helps to distribute AC power to all the IT devices such as switch, router, servers etc. mounted in a rack. It has a capability of managing and distributing high volume of electricity. It is directly mounted in a rack. It supplies uninterruptible power to many servers in a cluster because it consists of many outputs.



*Figure 18 : Power Distribution Unit*

## **6.6. IT Space Requirements and Distribution Space**

### **6.6.1. Entrance Room (ER)**

The room that connects the data center structured cabling system with inter-building cabling owned by access providers and from customers is known as entrance room. In addition to improving security, the entrance room might be outside the computer room so that access provider technicians would not have to enter the computer room.

### **6.6.2. Main Distribution Areas (MDA):**

In a data center, the main distribution area is the main distribution point for structured cabling and may also include horizontal cross-connects (HC) when equipment areas are served directly from the main distribution area. In the main distribution area, which is also the hub of cabling infrastructure for the data center, core routers, core LAN switches, core SAN switches, and PBXs are often located.

### **6.6.3. Horizontal Distribution Areas (HDAs):**

When the HC is not located in the main distribution area, the horizontal distribution area is used to serve equipment areas. Thus, when used, horizontal distribution areas will include the HC, which is the point at which the cables are directed to the equipment distribution areas.

### **6.6.4. Zone Distribution Area (ZDA):**

The horizontal cabling may have an optional interconnection point known as zone distribution area. In order to enhance flexibility and frequent reconfiguration of this area, it is located between the HDA and the EDA.

### **6.6.5. Equipment Distribution Area (EDA):**

Equipment distribution areas (EDA) are designated for end equipment, including computer systems and telecommunications equipment. It is not acceptable for these areas to serve as entry rooms, main distribution areas, or horizontal distribution areas.

## **Conclusion:**

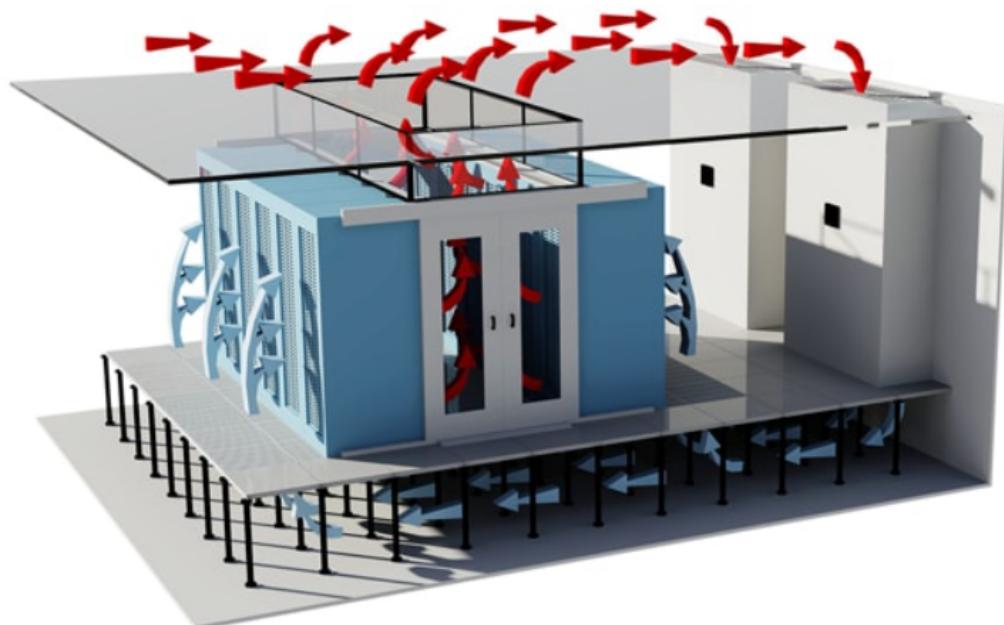
Columbia hospital has to have a fully redundant power supply because hospital are very sensitive place where patients health monitoring system that are connected to data center for storing continuously. We have decided to implement tier 4 redundant power supply to the data center.

## **7. Cooling Solution**

Data center cooling system is mainly designed to keep the IT devices temperature cool and maintain operable temperature all the time. Hot aisle containment and cold aisle containment are the two types of cooling system used in data center.

### **7.1. Hot Aisle Contamination System**

In this system of hot aisle which is back side of the devices is contained/ encases and isolated. So, the cold air don't get mixed up and only hot air is extracted out of the overhead exhaust fan. In this technique all the racks of the IT devices are placed according to the hot aisle adjustment standards.



*Figure 19: Hot Aisle Containment*

Hot aisle containment system keeps the general space of the data center chilled, helping the whole building stay under controlled temperature which also helps employees to work in a suitable environment. However, Hot aisle containment is implemented creating a suspended ceiling duct pile which is expensive to maintain and the temperature in a containment tunnel can raise and over heat the device and tunnel damaging other cables and devices in its path.

## 7.2. Cold Aisle Contamination System

Cold aisle containment is the system which contains/ encases cold aisle. Cold air is then supplied from the perforated tiles inside the cold aisle containment. It helps the cold air flow into the device keeping IT devices clean and cool throughout its operation. Hot air are sucked inside the plenum then processed again. This process helps to isolate the hot and cold air path. Cold Aisle containment is implemented with the raised floor or with the over head supply through a ducted channel of cold air. It is a cost effective method of keeping IT devices chilled during operation. It can be best solution in a space where ceiling is already low and duct pipe channel can't be implemented. Conversely, cold aisle containment system can be disastrous because this system the hot air is released in a open space which can raise the temperature of the data center, making a very uncomfortable place to work for employees.

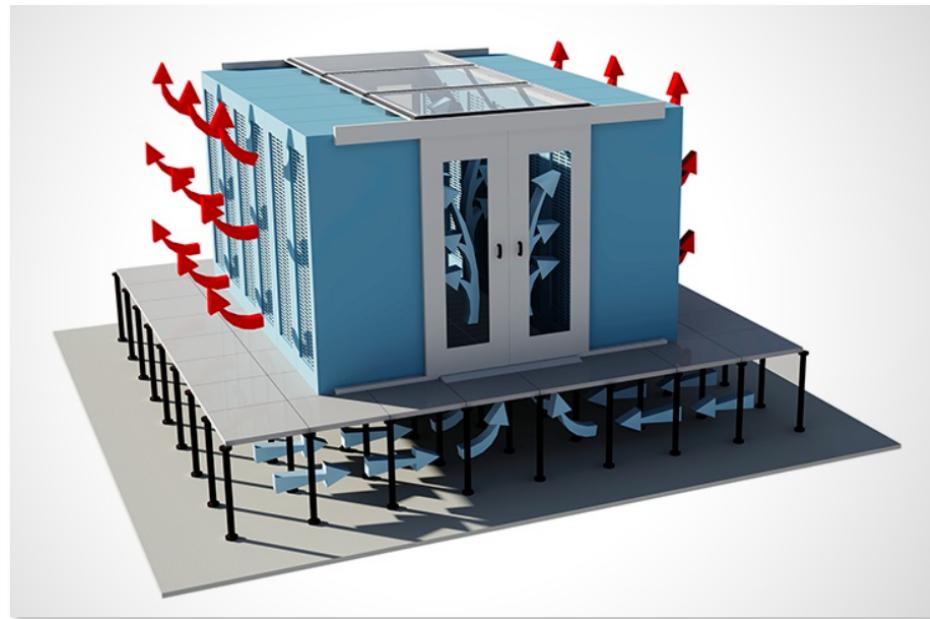


Figure 20 : Cold Aisle Contamination

### **7.3. Recommendation**

After all the information gathered from the available resources, Hot aisle containment system has higher efficiency and effective technology that can be highly beneficial for the Columbia hospital. Due to the high temperature in working environment and risk of infrastructure and devices damage. Cold aisle containment system can also be more expensive to operate and maintain the system of the data center. Hot aisle system provides suitable temperature environment which helps to make employees more productive and enjoy at their work place.

### **7.4. Cooling Component**

#### **7.4.1. CRAC**

It stands for Computer Room Air Condition and it is used for cooling in a data center. It provides precision cooling in a data center for devices such as servers, storage, networking and communication system. The CRAC system can be customized to according to the need of the organization.



*Figure 21 : Computer Room Air Condition in Data Center*

The trend of power consumption in a modern data center is as follows.

1. Networking devices, server and storage consumes 50% of the power in a organization.
2. The other 50% of the power is consumed by auxiliary equipment required to run the IT system.

#### **7.4.2. Precision Air Cooling (PAC)**

Precision air cooling system are designed to temperature and humidity up to precise level which is not possible in comfort air conditioning. They provide high reliability for year-round operation, with the ease of service, system flexibility and redundancy necessary to keep the system running. It helps to maintain humidity as well which is not possible with comfort cooling system.



*Figure 22 : Precision Air Cooling (Indiamart, 2021)*

### **Types of PAC :**

- i. DX type of PAC Unit
- ii. Chilled water type PAC
- iii. Dual fluid type PAC

### **Recommendation :**

Dual fluid type because it provides redundancy along with cold air

#### **7.4.3. Crash Cart**

It is a cart that is equipped with a high performance laptop. It is called crash cart because it can be moved to desired location to directly connect to the crashed server that need to be configured or troubleshoot during operation (“What is a Crash Cart?,” 2019).

## **8. Fire Suppression System**

Fire suppression system to protect the data center from the fire that can be caused due to device overheating, short-circuit, or any other cause. Fire alarm system in build can detect potential fire hazard, sends alert message to the system controller. Gas release panels are used instead of water panel since water can cause collateral/ equipment damage. Such as Inert gas system is the most environmental friendly since it uses nitrogen, argon and CO<sub>2</sub> which are already present in the atmosphere.

### **8.1. Clean Agent System (Inert Gas)**

In a data center, there are gaseous systems using clean agent gas or mostly inert gas. This is one of the keys to avoid any sort of fire accidents. Systems using inert gas comprise of nitrogen and argon gases which automatically reduces oxygen level and hence prevents fire possibilities.

## **8.2. Water Sprinkler System**

The water sprinkler system releases water automatically in case of any fire or smoke. This can prevent data centers from huge fire disruptions as water is sprinkled from pipes to extinguish fire. Sprinkle pipes in this system are filled with water and instantly release water during fire.

## **8.4. Recommendation**

To make up mind on which fire protection system to choose depends on the comparison between their functionality and effectiveness. There will always be advantage and disadvantage of using either water sprinkler system or clean agent system. Water sprinkler system are takes less space where as clean agent system more space and can cost way more to install. Water sprinkler system may cost less to install but can be very expensive to clean up after discharge and device will most likely won't be re-usable due to the damage caused by water.

Clean agent system are very effective and efficient to use. Clean agent system are free of corrosion, non-conductive and no residue is left behind, it helps to keep the cost low as much as possible by not damaging devices and no need of cleaning after discharge. Clean agents are discharged in a form gas which performs very effectively by entering inside the devices. Clean agents are faster to extinguish fire compared to water sprinkler system. After comparison of both system, Columbia hospital data center will be implemented with clean agent system.

## **9. Building Management System**

Building Management System (BMS) is a must have system in a data center that helps to monitor and control lights, water, ups, backup generator, fire alarm system, fire extinguisher system, surveillance system, access control, environment protection such as water and waste, temperature, internal and external wind speed, sound level, vibration and biological factors etc. It uses both hardware and software to monitor and control the entire system. It uses microprocessor based controller some examples are compact or modular DDC (Direct Digital Controller). There are different types of DDC available such as BACnet Controller, Advance Application Specific

Controller (AASC), Building Controller. It helps to make a data center environment friendly by monitoring and controlling use of resources.

## **10. Physical Security**

Physical security of the data center is a very serious matter. Data center are known as a high risk industry because outsider may try to access the confidential with the wrong intention. Data center has to be categorized in a layer system in order to make it easily understandable and quicker analyze during the time of trespassing (Shailaja, 2020). The four layers of the physical security are perimeter security, facility controls, computer room control and cabinet control.

### **10.1. Physical Safety**

It is the first layer of security that are guarded with the security personal to discourage, detect and delay of unauthorized entry of the people into the premises.

### **10.2. Facility Controls**

It is the second layer of security that is equipped with the face recognition, thumb print and card swapping system to allow the only authorized personal to get access inside the area.

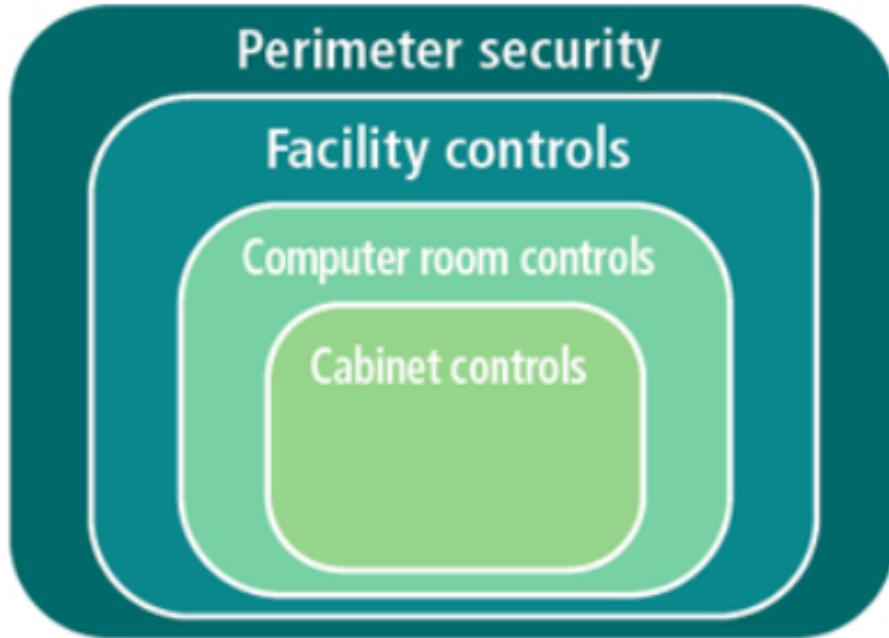
### **10.3. Computer Room Control**

It is a third layer of security where the restriction of the access is even more stricter such as restricted areas are constantly monitored, turnstile restriction for entry are deployed, biometric access control such as finger print and eye scan are implemented and many more.

### **10.4. Cabinet Control**

It is a fourth and last layer of control and this is a system of cabinet locking mechanisms which applied when the insider threat is addressed. Server cabinet are equipped with a electronic locking mechanism to make sure only authorized personal to access the devices and also smart cabinet card are issued to authorized personal for the access of the device.

Columbia hospital is a huge hospital with high number of people visit every day. So, this is the physical security measure that will be implement



*Figure 23 : Layers of Security*

## 11. Green Computing

Since data centers devour extensive amount of energy, it requires huge amount of fuel usage which eventually consequence in massive carbon emission. Therefore, a concept of ‘Green Data Center’ is brought into consideration. A green data center is a computing provision which is constructed and operated on the basis of green computing principles. The main aim of green data center is to follow environmental friendly methodologies and minimize the use of non-renewable energy (Techopedia, 2013). In case of Columbia Hospital, we are planning to install lowest carbon footprint and recyclable wastages that follows green computing principles. Furthermore, the team plans in implementing natural cooling methods which significantly reduces energy price. The chosen environment for our data center has stubby humidity and quality airflow, which is optimal.

## 12. Environmental Monitoring System (EMS)

The EMS will play an indispensable role in monitoring reprobating factors such as humidity, fire, temperature and leakages within a data center. The system alerts the management team with a notification, either by warning sign or via email.

The chosen EMS for Columbia Hospital's Data Center is 'Avtech' based on the quality of product and its price. It analyze several components like fire, entrance, air flow and, leakages as well as temperature.

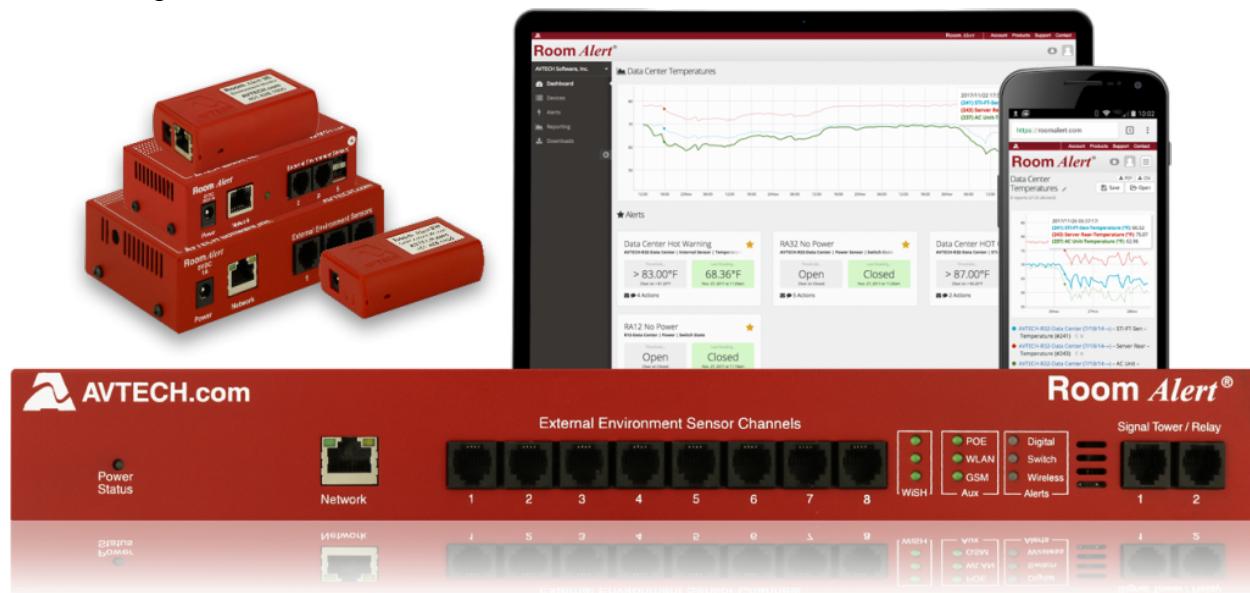


Figure 24 : Avtech EMS for Data Center (Avtech, n.d.)

## 13. Conclusion

This world will never be the same since information technology is making rapid progress every day of the week. Information Technology has changed the way we work, play, and lifestyle. The ideas and equipment those decided to be implement for the Columbia hospital are thoroughly considered. Data center will be able to store huge amount of data that can be later used to treat patient and research purpose. So, further study and research can be conducted for development of effective cure for the patient.

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## Gantt Chart

ID	Task Name	Start	Finish	Duration	Dec 2021			Jan 2022				Feb 2022		
					12/12	12/19	12/26	1/2	1/9	1/16	1/23	1/30	2/6	2/13
1	<b>1.0 Project Planning</b>	12/16/2021	12/25/2021	10d										
2	<b>2.0 Documentation</b>	12/26/2021	2/10/2022	47d										
3	2.1 Technical goals	12/26/2021	12/28/2021	3d										
4	2.2 Data center standard tiers	12/29/2021	1/1/2022	4d										
5	2.3 Floor Selection	1/2/2022	1/5/2022	4d										
6	2.4 IT Hardware Requirements	1/6/2022	1/12/2022	7d										
7	2.5 IT Space Requirements	1/13/2022	1/19/2022	7d										
8	2.6 Electrical Components	1/20/2022	1/23/2022	4d										
9	2.7 Fire Protection	1/24/2022	1/28/2022	5d										
10	2.8 Cooling System	1/29/2022	2/1/2022	4d										
11	2.9 Green Computing	2/2/2022	2/5/2022	4d										
12	2.10 Energy management system	2/7/2022	2/10/2022	4d										
13	<b>3.0 Implementation</b>	2/11/2022	2/16/2022	6d										

Avtivite  
Go to Start

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## **Workload Matrix**

<b>Student's Name</b>	<b>Student ID</b>	<b>Workload Distribution (in %)</b>
Sandesh Subedi (A)	NPI000040	33.33%
Sagun Shrestha	NPI000037	33.33%
Mahesh Bhandari	NPI000031	33.33%

Sandesh Subedi 'A' - NPI000040

Sagun Shrestha - NPI000037

Mahesh Bhandari - NPI000031

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