

Schoolcraft College

Data Center Concepts

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Vice President and CIO

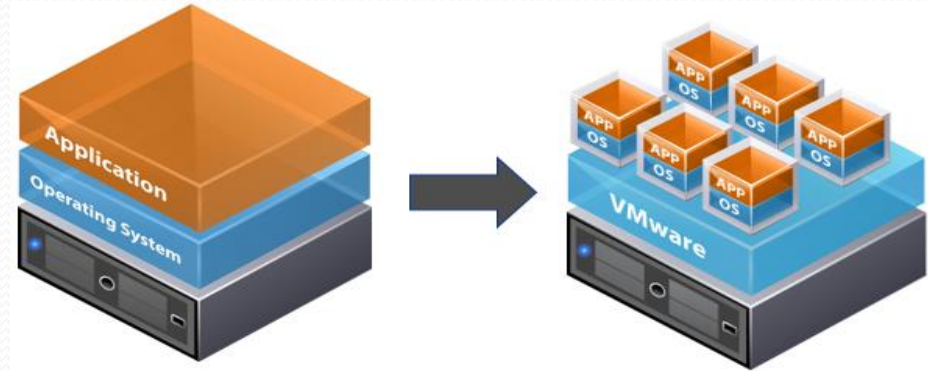
Goal of Seminar

- Introduce the Data Center Design and Operations Classes
- Fill the void between IT and Facilities POV.
- Stay more practical vs. theoretical
- Prepare you to work with DC designers and architects



Overview

- A Data Center can be a physical or virtual infrastructure used by companies to house compute, storage, and networking systems. These components can be used for multiple companies or for a singular company's information technology needs.
- Redundancy is a must have for a data center in the areas of power, cooling, networking, and security.
- The top features typically overlooked that are a must for a successful data center are **REDUNDANCY**, **MAINTENANCE**, and **MONITORING!**



Traditional Architecture

Virtual Architecture

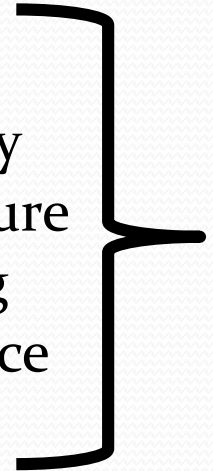
Functional Musts

- Provide a secure environment that meets the power and cooling requirements to sustain a critical load
 - Calculating the power to “sustain” critical load is typically “max capacity power x 0.80(safety factor)”
- Provide a level of redundancy and reliability that is consistent with the companies risk tolerance sensitivity
 - **RPO – Recovery Point Objective** – time since last full backup - how much data can you afford to lose due to a catastrophic system failure
 - **RTO – Recovery Time Objective** – time from outage to fully back online and in production - typically 1hr to several days

The Turner CRIMMP[©] Data Center Design Model

CRIMMP – represents key strategies to be applied to the major resources and services provided by a data center. When fully considered and implemented, assures a robust, resilient, and available data center system that can meet the required RPO and RTO.

- **C** – Capacity
- **R** – Redundancy
- **I** – Infrastructure
- **M** – Monitoring
- **M** – Maintenance
- **P** – Policy



- Power
- Cooling
- Network
- Security
- Building/Floor Plan

Fun Facts:

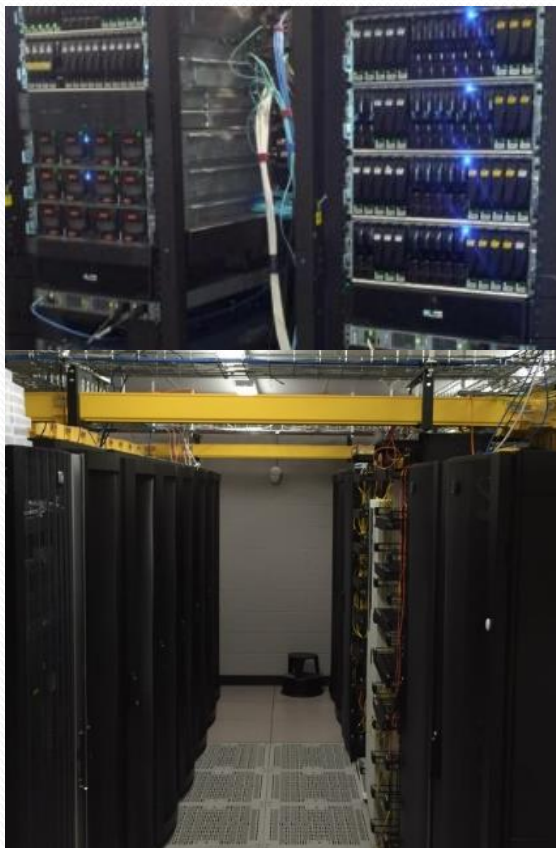
CRI... mostly relates to Data Center Design

...MMP mostly relates to Data Center Operations

Crimp – press together – squeeze together – to secure in place – to join firmly – to bond – to press or draw together, as the ends of something

Infrastructure

- IT
 - Networking
 - Compute
 - Storage (IOPS)
 - Security
 - Disaster recovery
 - Business continuity



- Physical
 - Size of data center
 - Power
 - Cooling
 - Fire detection
 - Monitoring
 - Security

Building Selection & Design Criteria

- Utility power availability in sufficient capacity
- Cooling is largest “non-IT” power usage (1W IT = 1W Cooling)
- Truck access for equipment delivery
- Location outside flood plains
- Consider commute for major end users (no longer than an hour)
- Local authorities amenable to building use
- Building should be non-descript
- Single point of entry, elevation from road level, and sufficient setback of building for perimeter security



Uptime Institute Tier Rating

- Tier I- Basic Capacity
 - Tier I – Infrastructure that includes a dedicated space for IT systems; an uninterruptible power supply (UPS); dedicated cooling equipment; and an engine generator
- Tier II – Redundant Capacity Components
 - Tier II -The redundant components include power and cooling equipment such as UPS modules, chillers or pumps, and engine generators
- Tier III – Concurrently Maintainable
 - Tier III – Does not require shutdown for maintenance or equipment replacement - Has same features as Tier II along with **redundant distribution paths** for power, network, etc.
- Tier IV – Fault Tolerance
 - Tier IV – Builds on Tier III.... **Active-Active**

High Availability – High Density

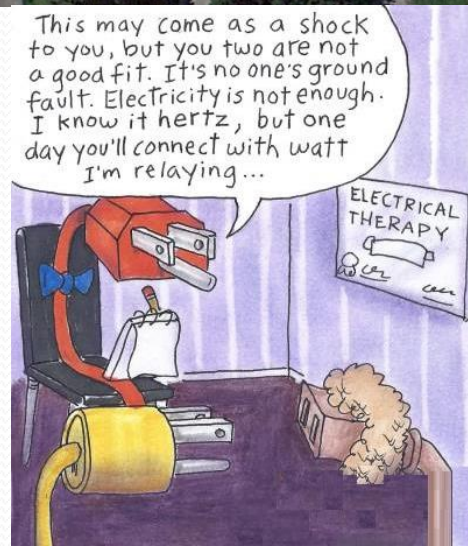
- High Availability (HA) is the elimination of any one single point of failure
- HA is achieved through:
 - Multiple capacity components
 - Multiple independent distribution paths
- 24/7/365 Monitoring
- N + 1 redundancy on all systems
- Dual powered IT equipment
- (HD) - Increasing amounts of power, cooling, etc. in a smaller footprint
- Highly utilized servers
 - Blade server enclosures
 - High capacity rack mounted servers
 - SAN storage
- Incremental KW per rack
- Power per square foot
- Specialized cooling system configurations
- Virtualization

Power

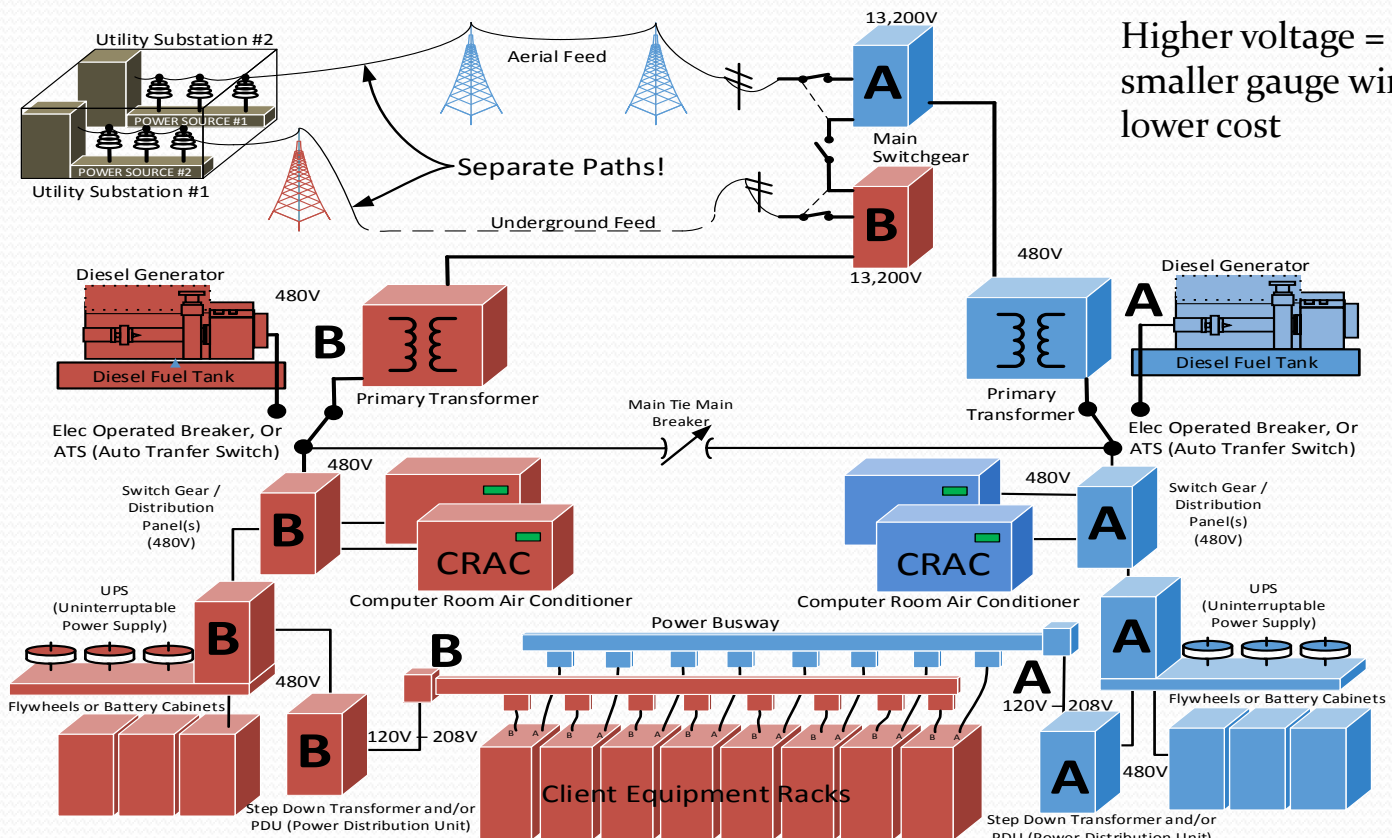
- Power is the highest cost element in a data center – designing for efficiency becomes a priority
- There is a need to understand load capacity / draw of each piece of equipment (rack load calculators)
- Description of power path: Sub station, switchgear, primary transformer, UPS, PDU, busway, client rack
- Split phase, phase balancing, A-B balancing
- Finally, a common “project-delaying” mistake is ordering PDUs, busplugs, or servers with incompatible plug types



Hager Sub Station



Power Distribution



Higher voltage =
smaller gauge wire =
lower cost

Power Connectivity

- Conduit & receptacles
- Breaker panel
- Busway – In row power
- More flexible alternative



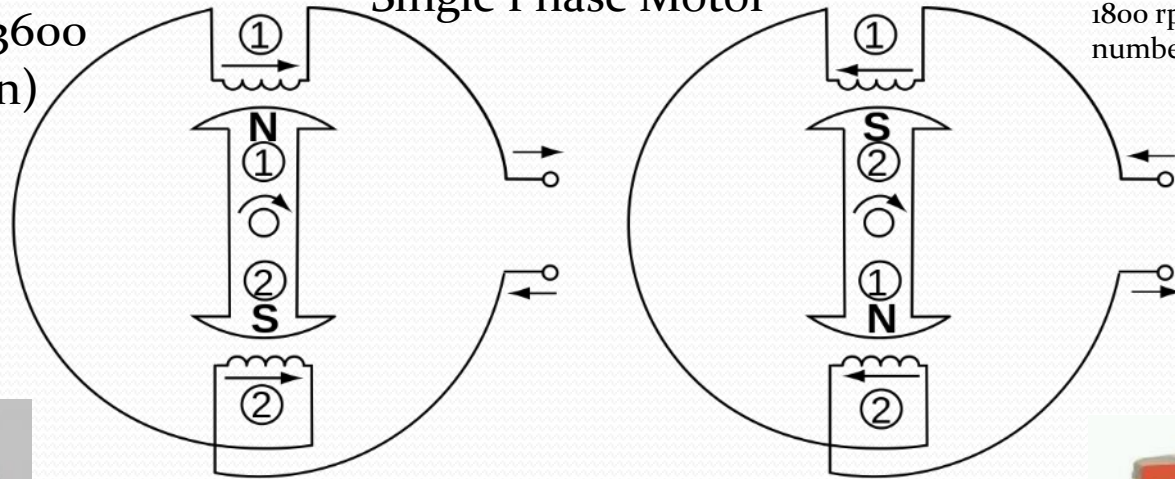
- Incompatible plug type is a very common error for both

Understanding 3 Phase Power

How rotary motion creates alternating current power

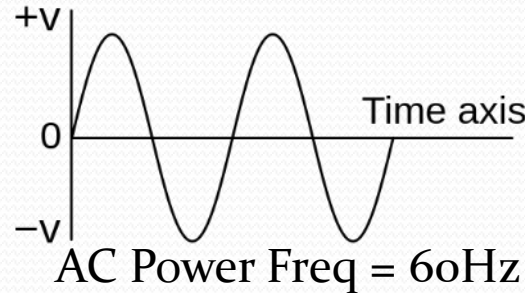
Typical Speed = $(3600 \text{ RPM}) / (60 \text{ sec/min})$
= 60 RPS
= 60 Hz

Single Phase Motor



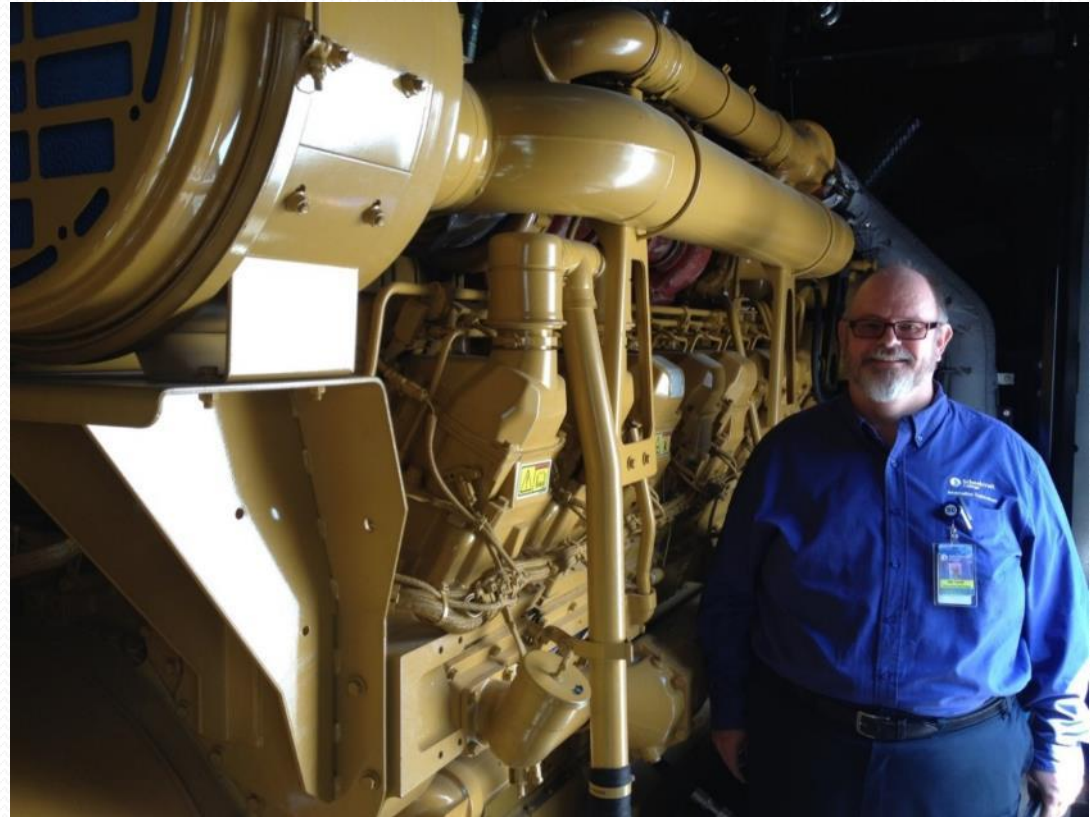
Large generators will run at 1800 rpm but have twice the number of coils.

As the armature pole passes the outer field coil the voltage rises and falls as shown in the graph below.



I Like Generators

- Generator (Two if required for back up redundancy, i.e., no dual utility – $N+1$, $2N$, or $2N+1$)
 - Required for extended outages
- Dual generators (dual starters)
 - Separate control circuitry power (typically a battery)
 - Charging system monitoring (major failure mode)



Power Redundancy

- Dual UPS – Uninterruptible Power Supply (N+1, 2N, 2N+1)
 - With battery or flywheel energy storage systems
- Dual step down transformers (from 480V 3Φ to 208V 3Φ)

Fun Fact: The closer step down transformers are to racks, the smaller copper wire runs are, which means lower wire cost. Can mean higher cooling costs.

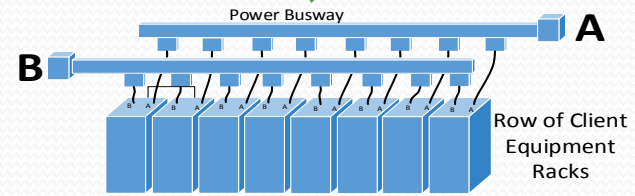
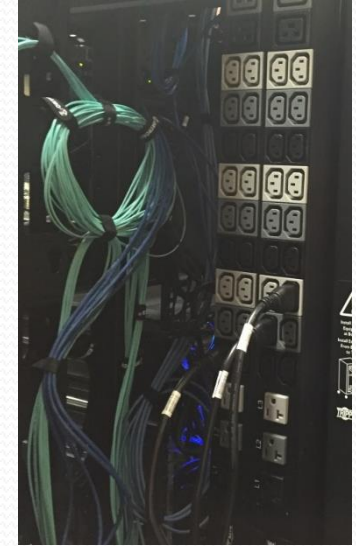
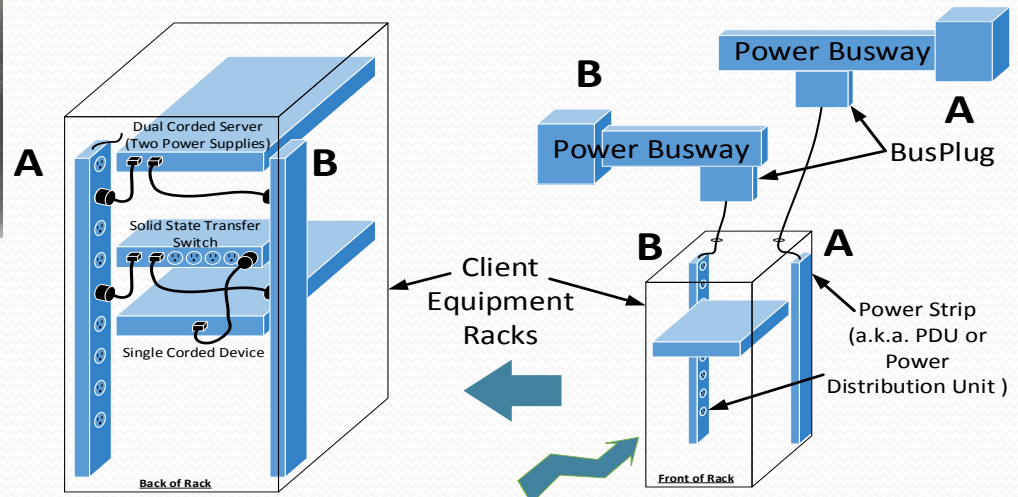


Dual UPS



Step Down Transformers 480v to 208v/120v

Power Redundancy – Rack Level



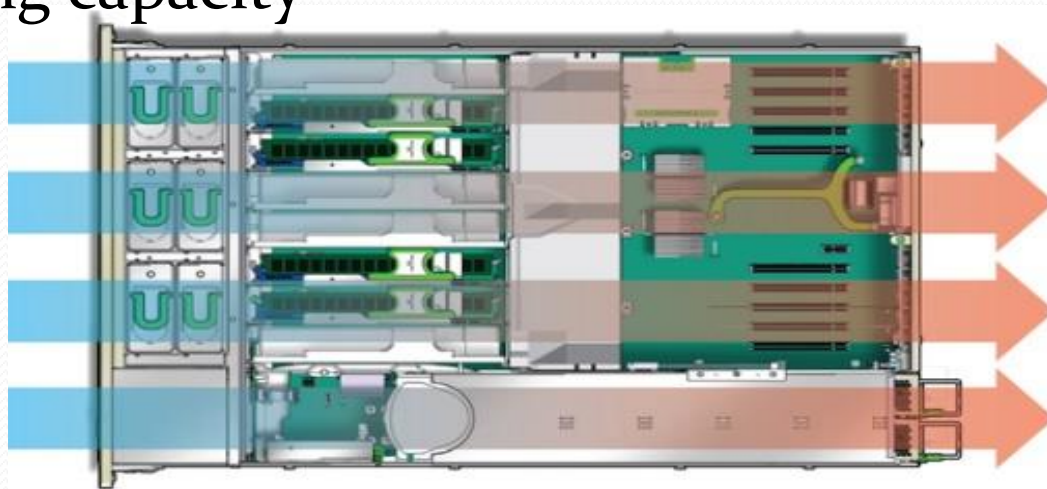
Power Utilization Efficiency

$$PUE = \frac{\text{Total D.C. Power}}{\text{Power to Racks}}$$

Last Modified 3-16-2014 PRT

HVAC

- Cooling 101 – Get cold air to the front of the device allowing internal fans to pull air through the device
- **Hot & cold air mixing is the #1 cooling efficiency problem seen in data centers**
- N+1 cooling capacity



HVAC DX CRAC Hardware

**TWO
COMPRESSORS**



**CONDENSER
FANS & COILS**

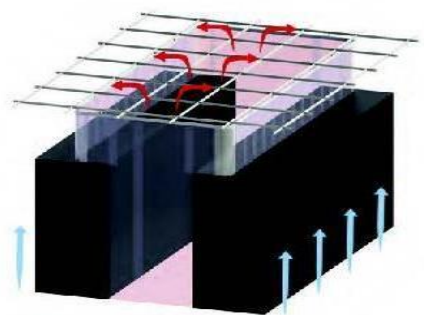


**TWO
EVAPORATOR
COILS**

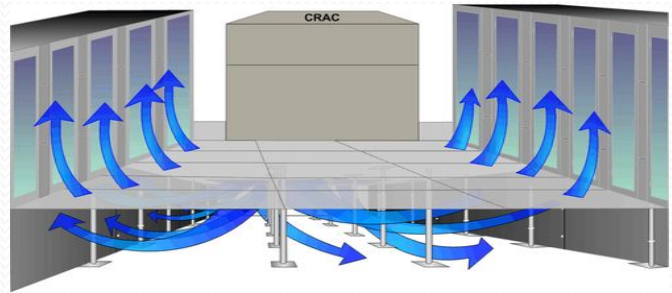
**BLOWER
FAN**

HVAC Strategies

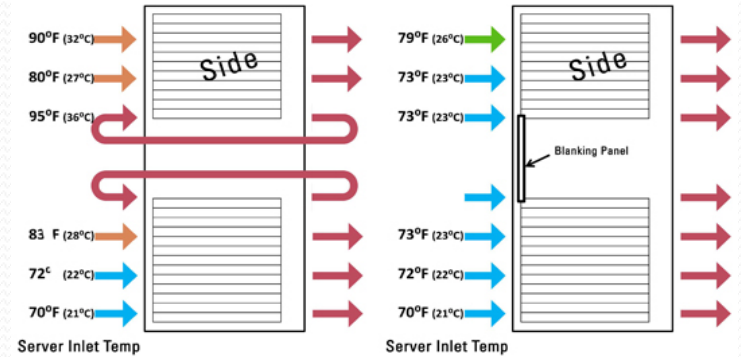
Hot Aisle Containment



Raised Floor



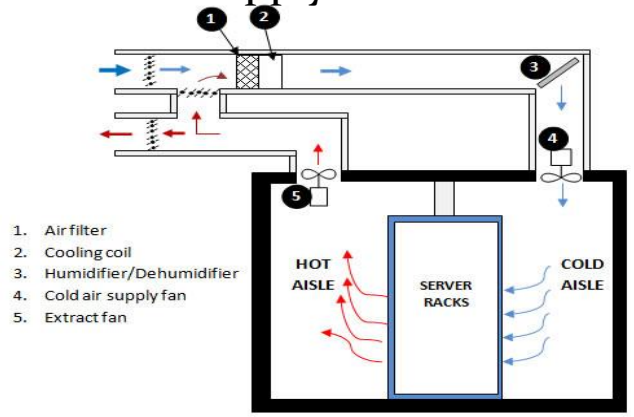
In-Rack Air Leakage



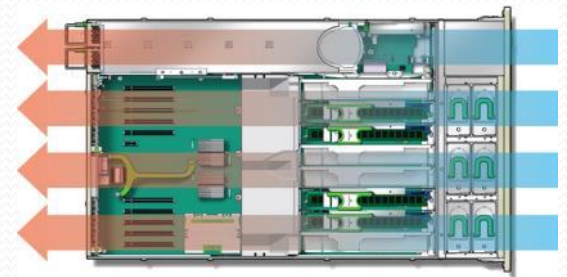
In Row



Ducted Supply & Return



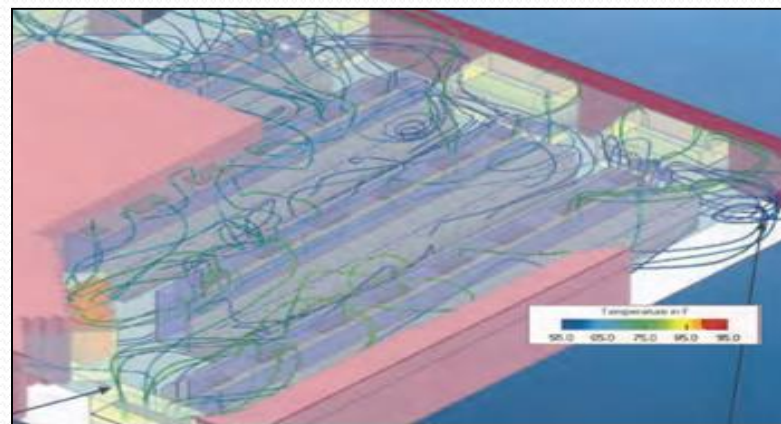
Cooling 101 – Main Mode



Air through via device Fans 19

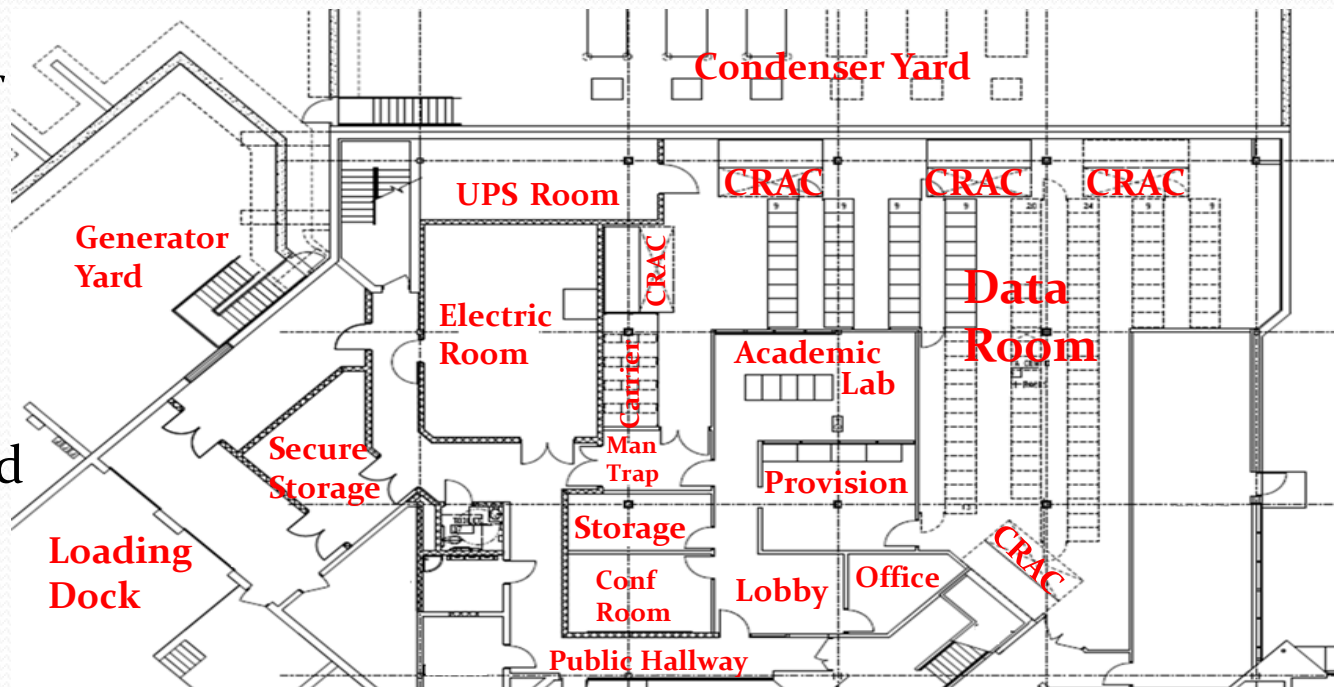
Floor Plan

- Compare a data center to an oven inside a refrigerator
- Floor plan layout effects power density and cooling efficiency and effectiveness
- Amount of cooling required
- Air flow can be non-intuitive: CFD



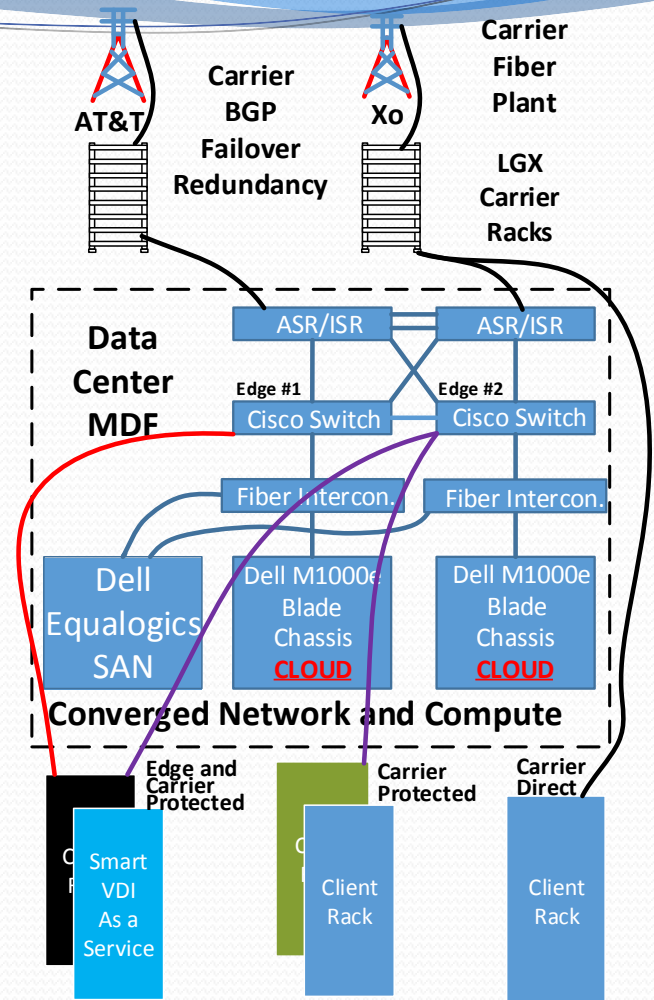
Floor Plan

- Floor plan layout –
 - Structural (shape of room – # of racks possible)
 - Equipment (footprint of IT equipment)
- Air flow/cooling efficiency are impacted by rack layout, air plenum/duct layout, and blanking plates
- Electrical grounding – Perimeter and rack level



Network Design

- Multiple carriers with failover redundancy
- Multiple entry points - diverse entry
- Multiple carrier paths - diverse path
- Dual connection per carrier
- Entry pathways owned
- Redundant carrier routers
- Redundant customer facing routers



Physical Security

- Physical

- Social training
- Set-backs and barriers
- Low key appearance
- Limited entry points
- Cameras - overlap
- Man trap
- Dual authentication door access (prox card, biometrics)
 - What you have: prox card or key
 - What you know: pin number or pw
 - Who you are: fingerprint or retina scan
- Badge ID
- Permanent security staff is a plus
- Security should be in layers
- Non-clients / vendors 100% escorted



Security Video
Motion Recorded



Emergency Power Off

- The EPO button allows fire fighters to rapidly disconnect power in the event of a fire
- An EPO button can also create great risk for uptime and security



Disconnection Means (Emergency Power Off) Section 645.10 of the 2008 *NEC* requires that there be disconnecting means for each zone in the IT room. Section 645.10 of the 2011 *NEC* has two alternatives for the disconnecting means, (A) covers remote disconnect controls with requirements the same as the 2008 *NEC* and (B) covers critical operations data systems. Critical operations data systems (defined in 645.2) are permitted to have alternate disconnecting means provided that five additional conditions are met:

- (1) An approved shut down procedure has been established
- (2) Qualified personnel are continuously available 24/7
- (3) Smoke sensors are in place.
- (4) A fire suppression system is in place.
- (5) Plenum cables are used for signaling



Fire Suppression

- Clean agent fire suppression systems - non-conductive, non-corrosive, specific application, residue free, targeted fire protection
 - **From NFPA 2001, 2008 ed. (1.4.1.1)** - The fire extinguishing agents addressed in this standard shall be electrically non-conducting and leave no residue upon evaporation
 - Types: Halocarbon agents (aka chemical agents), Inert Gas agent
- Dry pipe sprinkler systems - preventing water from entering sensitive areas unless an uncontrolled fire situation exists (last resort extinguishment)



Fire Alarms


- Completely separate from the fire suppression system except, the two systems may share detectors in the data room space only
- Office zones are separate from the data room zones
- Fire alarm panel is also separate
- Key pads and enunciators near exterior doors for alarm acknowledgement and resetting
- Alarm sound is more of a siren (wa-wa) and fire suppression is pulsing buzzing type sound (rate changes with stage of agent discharge timer status)
- Fire alarm will not fire the EPO system



Fire Extinguishers







- Halon in data / electrical rooms
- Halon is okay in small amounts
- Type B & C in office areas
- Inspected once per year



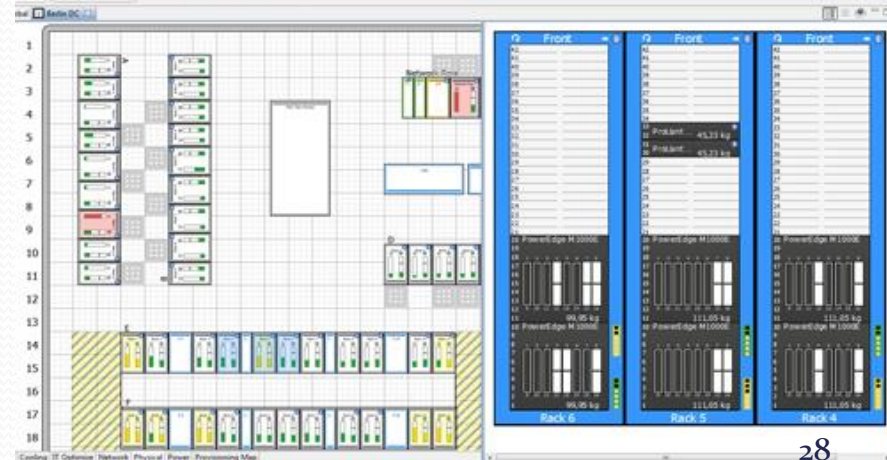
Class C Fire Extinguishers
 contain carbon dioxide for use against electrical fires.

Fire Extinguisher Chart

Extinguisher		Type of Fire				
Colour	Type	Solids (wood, paper, cloth, etc)	Flammable Liquids	Flammable Gasses	Electrical Equipment	Cooking Oils & Fats
	Water	✓ Yes	✗ No	✗ No	✗ No	✗ No
	Foam	✓ Yes	✓ Yes	✗ No	✗ No	✓ Yes
	Dry Powder	✓ Yes	✓ Yes	✓ Yes	✓ Yes	✗ No
	Carbon Dioxide (CO2)	✗ No	✓ Yes	✗ No	✓ Yes	✓ Yes

DCIM – Data Center Infrastructure Mgmt.

- Is an information management and monitoring system
- Major troubleshooting advantage – go directly to the circuit breaker panel, row, rack where a problem is occurring
- Products of many different flavors and focuses on the market
- Major functions include:
 - Asset Management
 - Client/Customer Management
 - Monitoring

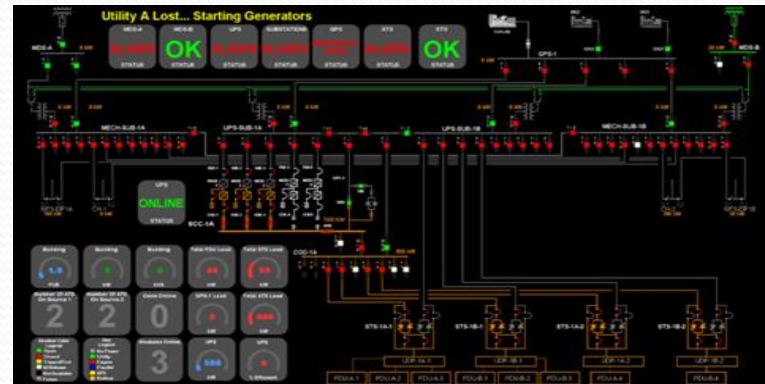
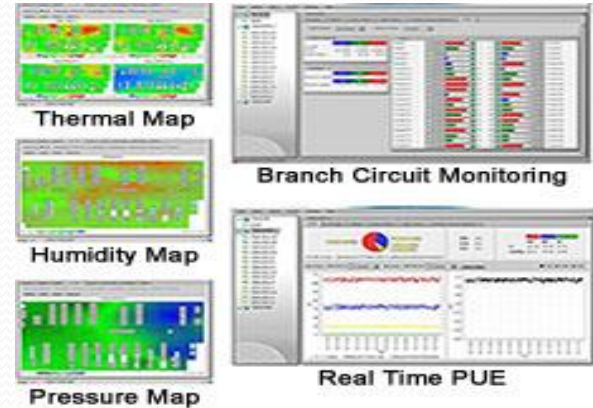


Monitoring

- Monitoring

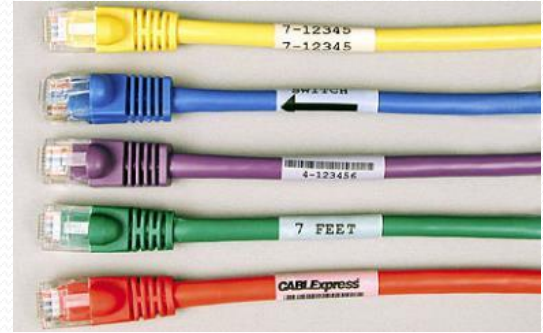
$$PUE = \frac{\text{Power to Racks}}{\text{Total D.C. Power}}$$

- Initial expense with major equipment vs add on
- Preventative vs reactive
- Granular view vs summary alarms
- Multiple methods & protocols
- Outside-In connectivity
- Alerts
- Response policies



Cable Management

- Label cables at both ends (aids in trouble shooting)
- Add port labels in switch configurations (maintenance upkeep is substantial)
- Pull out dead cables (label with length, coil and store for reuse)



Cable Management

- Cable straight up and down from cable tray
- Use innerduct tubing or 2" or 4" fiber tray for running fiber cross connects
- Use cable of proper length to avoid coils (creates connector strain problems) and cooling obstructions



Audit Compliance Control Points

- A management strategy which targets audit compliance
- Policy compliance – SSAE16 SOC2, HIPAA, PCI, etc.
- Quality control repository for audit artifacts
- Operations guide containing control policies
- Risk analysis & mitigation plan
- Disaster recovery plan – first responder guide
- Employee handbook
- DCIM & asset management
- Client deployment, incident management, & ticketing system
- Maintenance



Compliance

- Why is audit compliance required
- Being in compliance can increase business potential – provide objective comparison – create best practices
- Audit readiness/preparedness – There are two ways to get ready for your first audit
 1. Get a reputable auditor’s “pre-audit questionnaire” and create real answers (controls or policies)/artifacts for every question (i.e., Operations Guide and artifact repository)
 2. Hire a consultant familiar with the Control Points/Processes required by the audit spec and engage in a project to create the Control Points and Tests
 3. Don’t just talk the talk, but walk the walk as well (visitor sign in)
- Documentation – Operations Guide & a list of artifacts from a successful audit

Operations Manual

- Mission, strategy, philosophy
- Policies and procedures
 - Document business flow
- Business guidelines
 - Mission of the enterprise
- Documented standards and tests
 - Schedules
- Emergency contact list
- Org chart with separation of duties
- Job descriptions

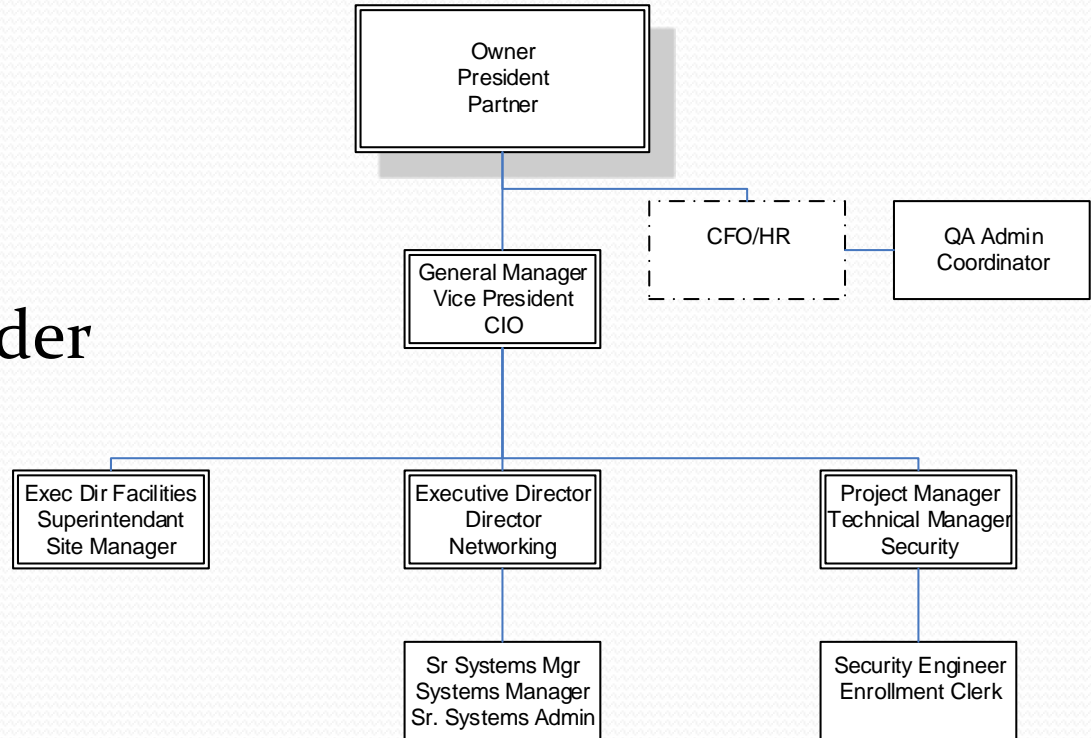
Operations Control Manual

Version 0.1

June 4, 2015

Sample Org Chart

- Separation of duties required
- Authority to enforce controls/policies under their control
- Many titles for a given role/position



Risk Mitigation

- System Failure – It’s not “**if**” a system will fail, it’s “**when**” it will fail and “**what**” mitigation plan is in place
- Risk mitigation is key to sustaining a successful data center operation and for audit compliance – have a “what if” plan
- Not realistic to have a mitigation plan for everything – just high risk
- Having the proper protocol in place to prevent service interruption is imperative - a data center is only as good as its reputation
- 100% uptime is no longer a goal, it’s a requirement
- A risk mitigation process is as simple as two tools:
 - Risk analysis questionnaire with likelihood and impact scoring
 - Risk mitigation plan based on analysis results



Client Orientation - Deployment

- Orientation process
- Badging and IDs
 - Photo ID, Prox Card and Fingerprinting
- Equipment Policy
- Monitoring
- Ticketing System AUP (Acceptable Use Policies)
- Policies
 - Security
 - Accessibility
- Procedures
- SLA (Service Level Agreement)



Acceptable Use Policy

SCHOOLCRAFT COLLEGE's Acceptable Use Policy ("AUP") is designed to help protect SCHOOLCRAFT COLLEGE's customers and the Internet community from irresponsible or illegal activities and to provide a high quality of service to SCHOOLCRAFT COLLEGE's customers. SCHOOLCRAFT COLLEGE reserves the right to modify this AUP at any time. By purchasing the Services provided by SCHOOLCRAFT COLLEGE, Customer agrees to abide by this AUP as modified

Service Order Form - Exhibit A DC&SC
 [Date] 18600 Haggerty, Livonia, MI 48152

Bill to:

[Company] _____
 [Street Address] _____
 [City, State Zip] _____
 Attn: [Contact Name] _____

Schoolcraft College Services and Charges	Quantity	Rate	Amount
[Service Type] Services			
[Service]			
[Service]			
[Service]			
[Service]			
[Service Type] Services			
[Service]			
[Service]			
[Service]			
[Service]			
			Total
Additional Services			
[Service]			
[Service]			
[Service]			
[Service]			
[Service]			
[Service]			
[Service]			
Notes			
36 Month Service Term			
*Bandwidth measured at the 95th percentile			
This order is subject to Terms and Conditions of the Master Terms and Conditions Agreement			

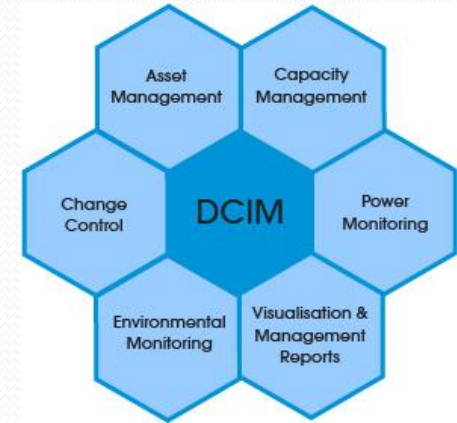


of SCHOOLCRAFT COLLEGE, one or more of the Services and Services. SCHOOLCRAFT COLLEGE reserves the right to suspend and/or terminate the Services and Services, including but not limited to, gambling, or other activities that are prohibited by the Acceptable Use Policy.

DCIM – Data Center Infrastructure

Management

- Documents where things are, how they relate, change, and are controlled
- One of the most confusing areas of Data Center Tools
- Some main categories of DCIM:
 - Asset Management
 - Change Control
 - Customer Management
 - Monitoring and Control
- Typically labor intensive to configure or requires professional services



Service Interruptions

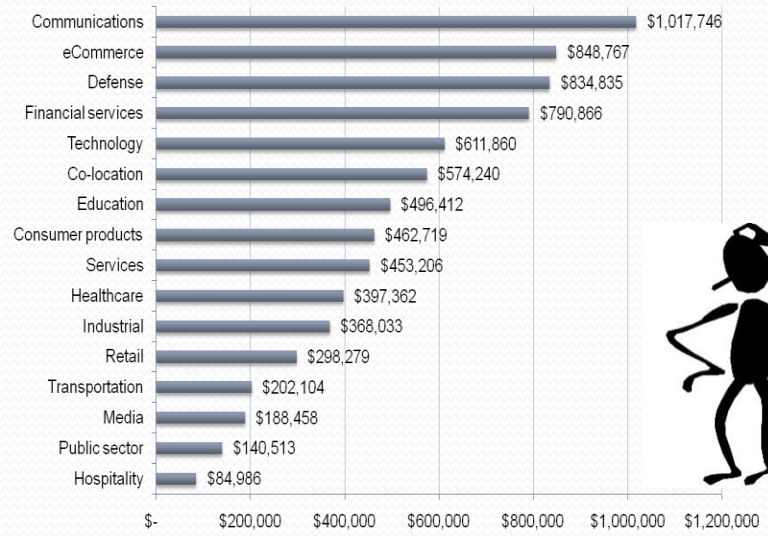
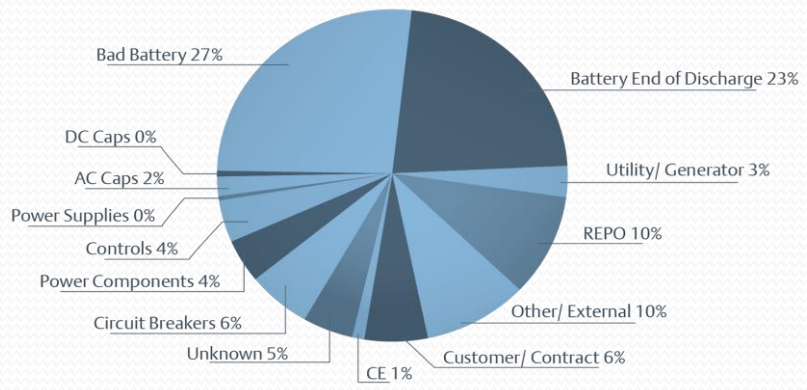
- Planned
 - Client communication – Data center clients must be made aware 2 to 3 weeks
 - Should be rare if ever and never involve all data center services at once - 100% uptime goal
- Unplanned
 - Client communication – Data Center Clients need to be made aware immediately of an outage effecting their systems
 - Standards (response policy) – aware 5-15 minutes, diagnose 15 min to 1 hr., resolution immediate to 4 hrs., max 24 hrs.



Cost of Data Center Outage

- Reputation
- Customer loss
- Loss of revenue
- Data loss

Causes of an outage



Cost of an outage

Disaster Recovery

- A set of processes and systems used to take over if your facility or part of it becomes un-usable for a set period
- Business continuity planning
 - How an organization guards against loss of productivity, loss of systems, or future disasters
 - Depends on “risk tolerance” and “down time sensitivity”
 - Policy statement
 - Recovery strategies
 - Plan development
- First responder guide – who are the first people to swing into action



Maintenance Practices and Protocols

- Preventative
- Maintenance agreements are in place
- Scheduled maintenance
 - CRACs and condensers
 - Primary transformers
 - Generator and switchgear
 - UPS
 - Breakers
 - Fire suppression and EPO
 - Transfer switch and control logic
- Customer is given advance notification of any maintenance

Generators

Manufacturer	
Model #	
Serial #	
(kW rating) Size	
Load Bank Testing	
ATS Manufacturer	
ATS Model	
Number of PM's	

HVAC

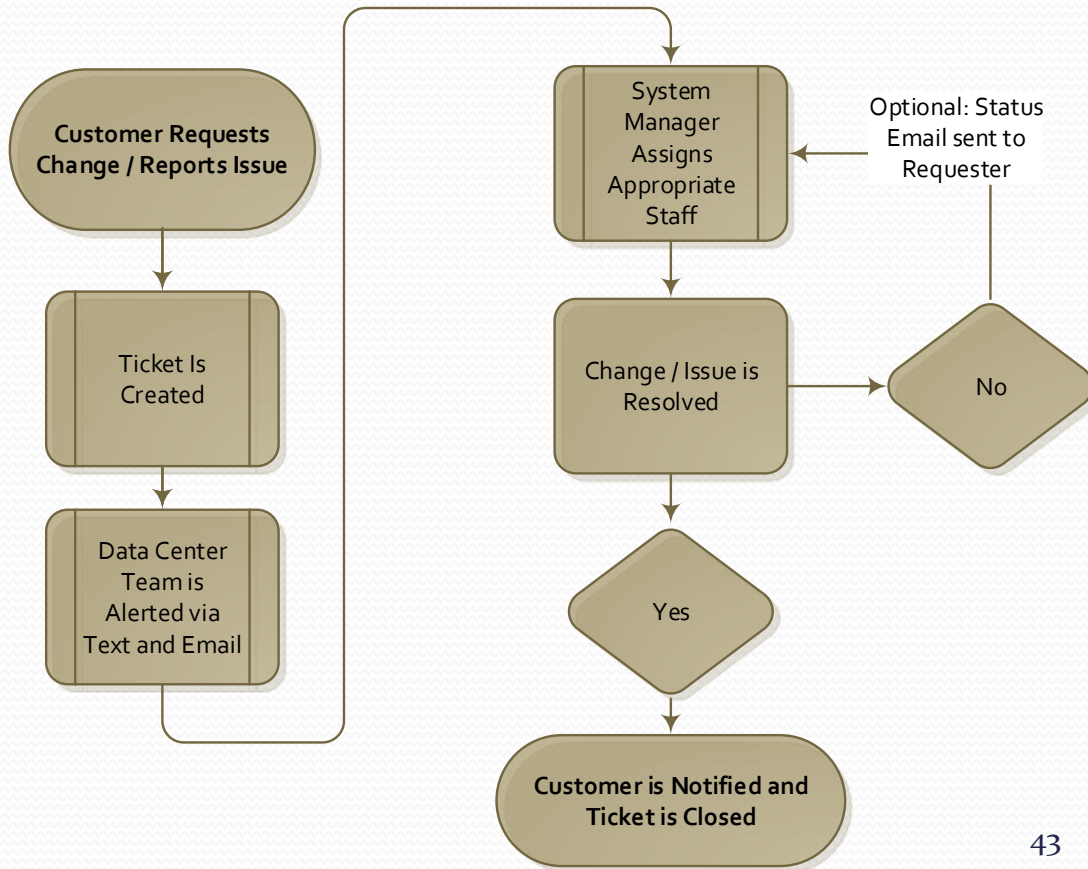
Manufacturer	
Model #	
Serial #	
Size	
Number of PM's	

UPS

Manufacturer	
Model #	
Serial #	
KVA size rating	
#of Strings	
#of Batteries per string	
Battery model	
Battery date	
Service level	
Annual load bank testing	
External load bank testing requirements	

Incident Ticketing System

- Tracking
- Documentation
- Resolution
- Notification
- Workflow



Addressing Client Needs

- Customer service is a huge differentiator in the Colocation Data Center community
- Clients are looking for problem solvers not order takers
- Don't nickel and dime clients - Have extra rack screws, power cords, plug adapters, velcro, minor tools, crash cart(s), equipment cart, pallet jack, remote hands, etc.
- Be present for deliveries, questions, be able to recommend services, equipment, or solutions to common install problems



Non – IT Items

- Lights consume a very small portion of energy in a data center, but still need to be considered when determining how much power a data center will consume
- Office space within the data center becomes a valuable asset for clients, for brief visits, provisioning activities, meetings, disaster recovery activities, etc.



Questions