How Intelligent Data Centre Infrastructures Help Manage Resources, Services and Costs.
Who is Raritan?
A global leader in data center management solutions

- Founded in 1985 in Somerset, NJ USA (HQ)
- Acquired by Legrand in Sept 2015
- Offices in Australia, Canada, China, France, Germany, India, Japan, Netherlands, Singapore, Taiwan, UK
- Products sold and supported in over 76 countries and installed in over 50,000 critical data centers
Our solutions help IT professionals gain more insight into data center operations and manage smarter in more than one way.

We help maximize uptime, optimize efficiency and allow for strategic decision-making based on reliable data points.

Raritan is always looking to push technology further and innovation is at our core. With 47 patents granted and 30 more applications pending, we make sure you always have the latest and future-proof technology.
“Last Mile” Example Issues:
LEGRAND GROUP: The last mile

- Dry transformers
- Capacitor banks
- Switch boards
- UPS
- Cable management
- Structured cabling
- Busbar systems
- Aisle containment
- Patch & server racks
- Co-Location cabinets
- Row based cooling
- Power distribution
- KVM / Serial
- Monitoring
Today’s Agenda

“Last Mile” Example Issues:

**PDU:**
1/ Circuit Breaker Trip Coordination
2/ Sufficient Circuit Breaker Trip Detection and Alarming Overlooked in Design
3/ Improper Feed Sizing for Blade Servers and Chassis-Based Networking Gear
4/ Residual Current Monitoring
5/ Outlet malfunction - trip Analyzation
6/ Human error minimization
7/ Equipment failure & redundancy
8/ Outlet switching benefit and risk

**ATS:**
9/ Application
10/ Technologies
11/ Insufficient Switching Time
Summary learnings & best practices

UPDATE!
Connectivity considerations
Plug basics
## Power Rating

- **C19**
- **Schuko**

<table>
<thead>
<tr>
<th>Connectivity</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>10A 1ph</td>
<td>Schuko/ C13/ BS1363</td>
</tr>
<tr>
<td>16A 1ph</td>
<td>Schuko / C19/ Blue IEC60309</td>
</tr>
<tr>
<td>32A 1ph</td>
<td>Blue IEC60309</td>
</tr>
<tr>
<td>16A &amp; 32A 3ph</td>
<td>Red IEC60309</td>
</tr>
</tbody>
</table>
IP44 / IP65

- Water-cooled CRAC/ CRAH
- Below sea level
- Seismic areas
Locking
Temperature rating

- C13
  - 70°C

- C19
  - 70°C
Temperature rating

- C13 70°C
- C15 120°C
- C19 70°C
- C21 120°C
Temperature rating

- C15
- C21

Cisco MDS9500

HP Procurve
Temperature rating

XBOX 360

Cisco MDS9500

HP Procurve
Outlet flexibility and density

- Customized solutions
- Modular
- Hybrid plug options
Power Cabling

Type:
- PVC
- Rubber
- LS0H, Low Smoke Zero Halogen
  - EN 60332-1 (fire retardant requirements)
  - EN 61034-1 (low smoke requirements)
  - EN 50267/EN60754 (zero halogen)
  - 5G2.5 Cable Non Shielded
Power Cabling

Considerations:
- Cable length
- Hard wiring benefits
- Shipping cost, weight and dimensions
- On average US$1000 savings / rack
Safety considerations
The “Buckaroo Effect”

Avoid inefficiencies based on fear & uncertainty

Avoid over/under capacity with accurate data!
Ghost servers

- Mergers
- Personnel change
- Excel management
- Legacy application server left after transition/upgrade
- 0W to 5W consumption eating away power capacity!
Reasons for metering

- Billing
- Enterprise DC as a service
- Divide kWh per department, create awareness
- Make informed decisions
- Am I at risk of blowing a fuse or tripping a breaker in case power source A fails?
- What is the power consumption in evenings and at weekends?
  Can we shut down equipment (Cisco labs)
- Is there a correlation between temperature and power consumption?
- How many racks do I have left in terms of capacity before I have to change/grow my facility?
- Identify power hungry devices, potentially replace
Capacity Planning

HP Proliant DL380G5
Name plate 700 Watt

Source: http://www.spec.org/power_ssj2008/

HP Proliant DL380G6
Name plate 500 Watt
Circuit Breaker Trip Coordination
Breaker Coordination Must Extend into the Rack

EXAMPLE 1
Common scope of breaker coordination protects against cascading failure...
As IT loads become more sophisticated...

... the “last mile” of the power chain: from the distribution board, to the cabinet, to the equipment...

... pose new challenges for clients
Breaker Coordination Must Extend into the Rack

EXAMPLE 1

... but must consider cabinet components to be fully effective!

Derating 16A vs 20A
Breaker Coordination Must Extend into the Rack

EXAMPLE 1
Most common trip event = faulty server power supply.
Breaker Coordination Must Extend into the Rack

**EXAMPLE 1**

- **MCCB Trip Curve**
  - DELAY 62

- **Fuse Melt Curve**

  - 5kAIC typical;
  - Finger-safe cylindrical fuse holder; Typical 20kAIC+
Circuit Breakers types

- IEC 60950-1 Safety Standard requires use overcurrent protectors (OCP)
  - Thermal-Magnetic Breakers
  - Hydraulic-Magnetic Breakers
  - Fast-blow fuses per branch or per outlet

**Standardized trip delay curves:** Type B (fastest), C or D (slowest).

Recommended are Type D

to manage inrush current and because of temperature derating / harsh environment

2 Pole for UL Models and 1 Pole Breakers (For EU / VDE)
Regulatory Approved OCP

Approved Circuit Breakers
- UL-489 (USA)
- CSA C22.2 #5 (Canada)
- EN 60934 VDE 0642 (Europe/International)

Approved Fuses
- UL-248 (USA)
- CSA C22.2 #248 (Canada)
- IEC 60127-1 (International)

NOT Approved Devices
- UL-1077
  (“supplemental” button breakers found on multi-outlet tap boxes)
- UL-489A
  (DC rated for communication circuits)
Circuit Breaker Mechanism Types

**Thermal Magnetic**
- Most common type. Used in all commercial/residential panelboards.
- Standardized trip delay curves.
- Thermal element (bimetallic strip) handles time delayed trips (currents <=600% breaker rating).
- Magnetic element (iron core coil) handles instantaneous trip short circuits.
- Must be derated if used at high ambient temperature (i.e. rack PDU)

**Hydraulic Magnetic**
- Used where high ambient temperature is concern (rack PDU)
- Non-standardized vendor specific trip delay curves.
- Variable magnetic element. An air coil core containing a movable, viscous damped spring loaded iron slug.
- No derating at high ambient temperature.
- Slower to trip compared to thermal magnetic for short circuits.
Derating of Thermal Magnetic Breakers

• All thermal magnetic breakers must be derated when operated at high (>40°C) temperatures.

• Graph shows in a Moeller thermal magnetic breaker must be derated to 95% at 50°C (20A breaker = 19A @ 50°C) and cannot be used in a 60°C rated PDU.
For data centers, type D is used.

Hydraulic magnetic trip delays are not standardized. Type 62 are used by most vendors.
Circuit Breaker Trip Coordination

When a short occurs, only the closest up-stream breaker should trip. Short in rack should trip PDU breaker - not panel breaker protecting the PDU.

- Panel main & branch CB manufacturer/type.
- PDU and panel breakers are different manufacturer & type. Current ratings are close (PDU 16A, panel 32A). PDU hydraulic-magnetic are slower than panel thermal-magnetic.
- Some customers test and complain panel trips before PDU breaker. Highly dependent on panel breaker manufacturer and current capacity of circuit.
Insufficient Trip Breaker Alerting in Power Chain

- Most modern data center builds equipped with branch circuit monitoring per pole;
- For same reasons as in previous example, granularity is insufficient;
- Clients often do not realize until too late;
Insufficient Trip Breaker Alerting in Power Chain
Very important to differentiate between zero amperes and zero volts!
Proper Feed Sizing for High Density Blade Chassis

- Prevalence of blade servers increasing every year;
- Increased confusion regarding power interconnects required to maintain true 2N;
- Issue compounded when clients solely consider power capacity guidelines of RPP / distribution panel feed;

**e.g. Cisco UCS 5108**
- 6U height;
- ~1800W typical; ~2300W peak;
- 4x Power Supplies, up to 2500W each;

**e.g. 415V, 3phase WYE; 32a Supply**
- 23,000VA / ~22,400 Watts;
- In theory, should support up to \( \frac{22400}{2300} = 9 \) chassis;

Let’s try seven (48U rack)…
Proper Feed Sizing for High Density Blade Chassis

First Connect
Six Chassis
(14.2kVA)

Peak = 4.9A per connection;

Peak (Failure Mode) = 9.8A on one plug
Proper Feed Sizing for High Density Blade Chassis

Even with B-side down, each circuit breaker at 61% load. Very safe.
Proper Feed Sizing for High Density Blade Chassis

Failure Mode:
B-Side power down and some A-side power supplies fail. Still safe.
Proper Feed Sizing for High Density Blade Chassis

Add 7th Chassis. Need to share breakers.
Proper Feed Sizing for High Density Blade Chassis

Still safe so far. Two breakers load to 14.7A if B-side power down.
Proper Feed Sizing for High Density Blade Chassis

Not truly redundant!

One bad power supply (during B-side maintenance) can shut down 3 chassis
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Violates best practice concept of isolated failure domains.
Proper Feed Sizing for High Density Blade Chassis

- “This cabinet provides two redundant 23kVA power feeds.”
- Does not necessarily translate into, “Can implement 23kVA of load.”
- 7 chassis @ ~16.5kVA did not work!
- Apparent maximum = 6 chassis @ 36U (14.1kVA);
  - Wastes 40% of power capacity;
  - Wastes 25% of rack space (assuming 48U cabinet);
Residual Current Monitoring
Residual current is the difference between the outer conductor (L1 or L1-L3) and the neutral conductor (N) flowing stream. This is known as current leakage and resulting an alarm to identify the presence of residual current.
Residual Current: causes?

- Old or damaged cable isolation
- Leaking capacitors
- Failing power supplies
- IEC-60950-1 compliance
Detecting and Protecting against Residual Current

**RCDs**
- Residual Current Devices
- **Will Disconnect** Power above a certain threshold ($I_\Delta > 30\text{mA}$) of Residual Current
- Used in Household or similar applications, when operated by unskilled personal.
- Not Suitable for Data Center application because of Power Disconnect
- Standard: IEC 60755 General requirements for residual current operated protective devices

**RCMs**
- Residual Current Monitoring
- Monitoring of Residual Current only, **No disconnect**
- Ideal to detect insulation errors at an early stage
- Constantly monitor the state of leakage current from the IT equipment
- In Data Centers, it is usage to observe 0.2 to 0.3% of leakage current (ex: 20A (4.6kW) * 0.2% = 40mA)
- Standard: IEC/EN 62020-AMD2Ed1 – Residual current monitoring devices for household and similar uses

Both RCDs and RCMs require periodic and repetitive examination on unpowered equipment = Downtime (DIN-VDE-0701/0702)
Basic electric theory says sum of currents in a closed loop = zero.
Basic electric theory says sum of currents in a closed loop = zero.

When leakage occurs sum of currents does not equal 0.
Basic electric theory says sum of currents in a closed loop = zero.

When leakage occurs sum of currents does not equal 0.

Sensor is a current transformer with inlet phase & neutral wires passing through it.
Operational reliability

- DGUV requires that “electrical systems and fixed operating equipment” are tested every 4 years

- Prevent against electrical shock caused by residual current
- Reduce the risk of fire caused by leakage and fault current by alerting in time
- Facilitate Preventative maintenance and detect insulation errors
- Increase Overall performance of the Data Center
Biere, Germany  Data Centers

Advanced Predicative analysis from Correct Power Institute

Tracking RCM Type B evolution and behavior to identify failing server PS
Operational reliability

Important criteria for an RCM solution:
- EN62020 (VDE 0663)
- Configurable threshold and configurable alert system
- Test the residual-current sensors (self-test)
- Avoid overload or overheating of the neutral wire
  (EN 50600: 8.2.1): neutral-wire current monitoring
- Residual current type A or B
Residual Current: options

<table>
<thead>
<tr>
<th>RCD type</th>
<th>Symbols</th>
<th>Sensitivity to residual current</th>
<th>Properties</th>
<th>Standards</th>
</tr>
</thead>
</table>
| AC       | ![AC symbol] | Alternating                       | Sinusoidal AC with rated frequency | IEC / EN 61008
| A        | ![AC symbol] | Alternating and pulsating direct current | Sinusoidal AC and pulsating DC up to 6 mA | IEC / EN 61008
| F        | ![AC symbol] | Alternating and pulsating direct current | Sinusoidal AC and pulsating DC up to 10 mA | IEC / EN 61009
| B        | ![AC symbol] | Alternating and pulsating direct current and flat direct current | All kinds of current up to 1 kHz | IEC / TR 60755

RCM types A and Type B Supported by Raritan
Residual Current: options
Surge protection
The case for considering Surge Protection

Over-voltages caused by lightning are responsible for 25% to 40% of all damage to equipment.

If the transient over-voltages caused by other phenomena are added to this, close to 60% of all electrical damage could be avoided by installing surge protective devices (SPDs)*.
SPDS... NOT JUST PROTECTION AGAINST THE EFFECTS OF LIGHTNING

The operation of distribution networks, installations and equipment can cause very harmful transient over voltages. As well as providing protection against the effects of lightning, installing SPDs also protects sensitive equipment against this type of disturbance.
How does a SPD Work?

The 1P+N and 3P+N SPDs with dedicated protection of the neutral pole discharge the common and differential mode over voltages that may occur in installations with TT and TNS systems, when there is a lightning strike.
Different classes of SPDs in the data center:
SPD Deployment

• Choice Number 1: Deployment inside the Tap-off Box:

  - Requires Electrician to Install (150$ to 300$ in average)
  - Requires Electrician intervention to replace cartridge in the case of a surge or overvoltage
  - Need Electrician during periodic inspections
  - Price of the SPD itself (standard 60$ to 90$ depending on the power configuration)
  - Lack of monitoring capabilities
  - SPD not accessible (height concern)
  - One time use

Not Optimal
SPD Deployment

• Choice Number 2: Deployment inside the Panel Board or floor RPP:
  - Class III specs might be too small
  - Requires Electrician to Install (150$ to 300$ in average)
  - Requires Electrician intervention to replace cartridge in the case of a surge or overvoltage (one time use)
  - Need Electrician during periodic inspections
  - Price of the SPD itself (standard 60$ to 90$ depending on the power configuration)
  - Lack of monitoring capabilities
  - SPD not accessible (Closed Panels)

Not Optimal
SPD Deployment

• Choice Number 3: Deployment inside the rack PDU:

- Perfect for Class III specs
- No Electrician required to instal, inspect, or maintain the SPDs
- Price of the SPD itself integrated to PDU (150$ to 250$ depending on Power Configuration)
- Full monitoring capabilities + Alerting in case of surges
- SPD is accessible directly inside the Rack

Best Solution
Embedded Class3 SPD

- Resettable
- No-break
- HD/ IEC 60364

metal-oxide varistor
Metering Accuracy
Metering Accuracy

ISO/IEC 62053-21 = +/-1%

for billing purposes: Class 0,2 (±0,2 %) of EN60044-1:1999;
for non-billing purposes: Class 1 (±1 %) of EN60044-1:1999.

MID?
Metering Accuracy - Squelch
IEC 62053
1% - Class 1

Metering Accuracy – Phase shift
EN 50600:
Include energy efficiency performance as a high priority criterion when choosing new ICT equipment. The power consumption of the device in normal operating circumstances should be considered in addition to peak performance per Watt.

Source: Principled Technologies Test Report
Calculators: HP Power Advisor & Cisco UCS Power Calculator

<table>
<thead>
<tr>
<th></th>
<th>Peak power usage in watts</th>
<th>Calculated peak power usage</th>
<th>Actual peak power usage</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1U servers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cisco UCS C200 M2 SFF</td>
<td>451</td>
<td>362.7</td>
<td>-24.3%</td>
<td></td>
</tr>
<tr>
<td>HP ProLiant DL360 G7</td>
<td>334</td>
<td>377.2</td>
<td>11.5%</td>
<td></td>
</tr>
<tr>
<td><strong>2U servers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cisco UCS C210 M2</td>
<td>451</td>
<td>355.4</td>
<td>-26.9%</td>
<td></td>
</tr>
<tr>
<td>HP ProLiant DL380 G7</td>
<td>306</td>
<td>368.2</td>
<td>16.9%</td>
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</table>
Power Usage Effectiveness

EN 50600:
Report periodically, as a minimum (via written or automated means), the following:

• Energy consumption;

• Power Usage Effectiveness (PUE) in accordance with EN 50600–4–2 or Data Centre Infrastructure Efficiency (DCIE)

PUE =  \[
\frac{\text{Total Facility Energy}}{\text{IT Equipment Energy}}
\]
Why 3 Phase at the rack?
When to consider – 3Phase

- Reduced Costs on Installation
- Increased Phase balancing
- Higher Operating Capacity
- Future Proofing
- 3 x The Power
- Speed of Deployment
- 50% increase Cost of Unit
Redundancy requirements
Example of Implementation

400V, 3Φ Wye, 22.2kVA, 32A
6 X 16A rated MCBs

400/1.732=230V
per circuit

230X16A=
3.7kVA/Branch

3.7 X 6 = 22.2kVA

Load Max recomended per breaker:
16A X 40%= 6.4A

IEC60309 32A
When to consider – 3Phase

- Raritan’s best seller 32A 1ph
- IHS average load <5kW
- 40% load recommendation
- 3 Phase cheaper at high density
- Allows for load disaggregation and convenience outlet circuits (120V in NA)
- 3 Phase allows 73.2% more power than single phase with the same footprint.
## Savings Calculation – 3 Phase Option

<table>
<thead>
<tr>
<th>Single Phase</th>
<th>Three Phase</th>
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<tbody>
<tr>
<td>16 Amp</td>
<td>16Amp</td>
</tr>
<tr>
<td>3.2 Kw</td>
<td>11 Kw</td>
</tr>
<tr>
<td>$359</td>
<td>$615</td>
</tr>
<tr>
<td>12.8 Kw</td>
<td>21.6 Kw</td>
</tr>
<tr>
<td>$1436</td>
<td>$1434</td>
</tr>
</tbody>
</table>

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>32 Amp</td>
<td>32 Amp</td>
</tr>
<tr>
<td>7.2 Kw</td>
<td>23 Kw</td>
</tr>
<tr>
<td>$478</td>
<td>$956</td>
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</tbody>
</table>

**Savings**

<table>
<thead>
<tr>
<th>Single Phase</th>
<th>Three Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Savings</td>
</tr>
<tr>
<td>$1436</td>
<td>$821</td>
</tr>
</tbody>
</table>

ASHRAE: “Server lifetime varies widely: 3 to 8 years”

“Rack PDU & Rack ATS Typical Usage Lifetime: 8-12 years”.

“The life of a typical data center is 15 to 20 years”
7360VA is the Apparent Power, this value is ALWAYS the same (230 Volt x 32 Amps = 7360 VA).

**Scenario 1, connecting purely resistive circuit:**
In this case the Power Factor = 1
The power factor is defined as: Power Factor = P(Real Power) / S(Apparent Power) = cos(φ)
In this case the Real Power is the same as the Apparent Power:
( Apparent Power 7360VA ) x ( Power Factor 1 ) = Real Power 7360 Watt

**Scenario 2, connecting a capacitive or inductive load:**
In this case the Power Factor is lower than 1 (e.g. Power Factor = 0.5)
In this case the Real Power is NOT the same as the Apparent Power:
( Apparent Power 7360VA ) x ( Power Factor 0.5 ) = Real Power 3680 Watt
Minimize Human Error
Human Error: Data

Bar Chart 9: Root causes of unplanned outages
Comparison of 2010, 2013 and 2016 results

- UPS system failure
  - 2016: 25%
  - 2013: 24%
  - 2010: 29%

- Cyber crime (DDoS)
  - 2016: 2%
  - 2013: 18%
  - 2010: 22%

- Accidental/human error
  - 2016: 22%
  - 2013: 22%
  - 2010: 24%

- Water, heat or CRAC failure
  - 2016: 11%
  - 2013: 12%
  - 2010: 15%

- Weather related
  - 2016: 10%
  - 2013: 12%
  - 2010: 12%

- Generator failure
  - 2016: 6%
  - 2013: 7%
  - 2010: 10%

- IT equipment failure
  - 2016: 4%
  - 2013: 5%
  - 2010: 4%

- CNET 22%
- Uptime Institute 70%
Human Error: Color

- Easily Identify Power Feeds
- Critical and non-critical Feeds
- Corporate identity
- Phase Marking
- Alternating Load Balancing Circuits (L1/L2, L2/L3, L3/L1)

BICSI: “Class F2 or above, Equipment color coded Recommended”
Colored cabling/ units

- Alternating Load Balancing Circuits
  - L1/ L2
  - L2/ L3
  - L3/ L1

UPS Battery time+
Colored cabling/ units

- Alternating Load Balancing Circuits
  - L1/ L2
  - L2/ L3
  - L3/ L1

UPS Battery time+
Alternating Phase in the Rack

- Simplifies load balancing
- Speeds up deployment
- Shorter cable runs
- Improves air flow
Colored cabling/ units

- Alternating Load Balancing Circuits
Equipment failure and redundancy
@Marketing
Add a picture highlighting that the PDU is not just a powerstrip, but a gateway for multiple facets. Ie. environmental gateway, doorlock, cctv etc.
PDU redundancy: Power Sharing

In case of a feed outage, your PX controller stays powered and sends alerts.

Feed A

Feed B

Power Share
Networking Cascading

Eliminate daisy-chains single points of failure

Protocols / Options
- Modbus daisy chain
- Modbus ring
- Master / Slave setup
- SNMP
Integration to the enterprise network

- Network standard: 1000 Mbit / 100 Mbit
- Two network connections (different subsections, users, safety levels)
- Costs: switch port and IP address (CapEx+OpEx)
- Colocation

BICSI: “-Modbus, gateway devices should be used to isolate the protocol between the equipment and gateway on a separate and isolated network (e.g., VLAN, physical links) even if these protocols are running on TCP/IP.
Replaceable controllers
Outlet switching benefit and risk
Why outlet switching

- Remote reboot / Lights out
- Outlet sequencing
- Load Shedding, UPS
- Security
- In-rush current
- Graceful shutdown
Outlet switching: Relays

- **Non-latching**
  - 0.5W – 1.0W ON status
  - Default state generally ON
  - Non configurable power-on
- **Latching**
  - 0.0W ON status, only consumes when changing state
  - User configurable power-on relay: pre-outage state or power cycle
Metering Accuracy icw. Circuit Breakers

- Detect the Root-cause of unplanned outages per branch
- Gain time on device testing in case of circuit breaker trip event
- Leverage instant alerting to limit business impact and improve MTTR

CB Peak current sensor ➔ Flags the outlet responsible for tripping the breaker

“suspected-Trip-CauseOutlet Xx”
Relays: (near) Zero-Crossing

Synchronize relay switching > Cheap components
Automatic Transfer Switch (ATS)
When do you need an ATS

- Single power supply units
Switching power supplies (SMPS) frequently cited with 15ms+ holdup time (one cycle at 50Hz);

Example: HP DL360 G9 Power Supply

**But reality is not deterministic.**

- Can depend on load, capacitance, ambient heat, AC power curve, etc.;
- Real-world experience: switchover for ~12ms – non-zero probability of server reboot;

ASHRAE: “ATS will seamlessly switch – within ½ of an AC Cycle” = 10ms
Cost of outage

Avg. cost of downtime:
2010: $5.617
2016: $8.851 (+57%)

Avg. downtime:
84 minutes
Transfer Switch
Technical considerations

Switch Technology

Switch point

Power Quality
Technical considerations

ATS (Automatic Transfer Switch)

– Electromechanical Relay

– Advantage:
  • Power loss free transfers

– Disadvantage
  • Risk of Arc Welding
  • Slow
Technical considerations

STS (Static Transfer Switch)

- Thyristor / SCR

- Advantage
  - Very Fast switching
- Disadvantage
  - Energy consuming transfer
Technical considerations

HTS (Hybrid Transfer Switch)

- Thyristor / SCR + Relay
- Advantage: Fast Switching
Technical considerations

Switch Point

– Make-before-Break
  Closed transition

– Break-before-Make
  Open transition
Technical considerations

Power Quality

EN50600: Power Quality according to EN50160

- Voltage tolerance +/-10%
- Frequency tolerance +/-0.5Hz
- Unbalance
  - Voltage
  - Phase
- Harmonic Distorsion
Causes of downtime

1% < U < 90%
- Short downtime (1ms – 1min)

Lightning, failing breakers, Arc flashes
- Black Out – planned or unplanned
  - Voltage drop
  - Longterm failure >3 minutes
- Brown Out
  - Ie. Overload
  - Rare in the region due to UPS/ Gen.set
Environmental considerations
Demanding
TIA-942 – Telecommunications Industry Association

Rack server $\Delta T$: 6-8°C
Blade server $\Delta T$: 10-12°C

<table>
<thead>
<tr>
<th>2011 Class Range</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended</td>
<td>18°C</td>
<td>27°C</td>
</tr>
</tbody>
</table>
ASHRAE: “-HVAC failures – when they do, a temperature rise in the cold aisle air temperature of 30°C in as little as 5 minutes is not uncommon”.
### 2011 Class Range

<table>
<thead>
<tr>
<th>Class</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended</td>
<td>18 °C</td>
<td>27 °C</td>
</tr>
<tr>
<td>Allowable A1</td>
<td>15 °C</td>
<td>32 °C</td>
</tr>
<tr>
<td>Allowable A2</td>
<td>10 °C</td>
<td>35 °C</td>
</tr>
<tr>
<td>Allowable A3</td>
<td>5 °C</td>
<td>40 °C</td>
</tr>
<tr>
<td>Allowable A4</td>
<td>5 °C</td>
<td>45 °C</td>
</tr>
</tbody>
</table>
ASHRAE: “Most rack PDUs are passively cooled –* have to be designed for much higher temperature operation than the IT equipment that connects them”

ASHRAE: “Recommends all new rack PDU products be designed to at least 60°C”
High temperature ratings importance

ASHRAE: “The original ASHRAE air temperature recommended envelop for datacenters (2004) 20-25°C. This was a conservative statement…”

ASHRAE: “Rack PDU & Rack ATS Typical Usage Lifetime: 8-12 years”.

ASHRAE: “Higher temperatures can impact equipment reliability. Exposure to warmer temperatures, coupled with the fact that usable life cycle of power equipment is typically longer than IT equipment, increases the importance of this topic”

ASHRAE: “As the inlet air temperature rises to 35°C and 45°C, most servers reach a maximum exhaust air temperature somewhere between 58 and 60°C”

ASHRAE: “Recommends all new rack PDU products be designed to at least 60°C”
ASHRAE & TIA-942

Demands metering at 3 levels in the front of the cabinet. 3x Temperature & 1 Humidity

BICSI:  “Class F2 and above required - One sensor in cold- and one in hot aisles”

“Class F3 and above Required in open aisle configuration - Two sensors in cold and two in hot aisles at different heights”
ASHRAE:

“Temperatures above 50°C will adversely affect the service life of a battery”.

“Tape products require a stable and more restrictive environment – rate of change of temperature is less than 5°C/hour.”
Humidity sensor decay

- Cooling = Taking away water
- High humidity leads to condensation/corrosion
- Low humidity leads to Electrostatic Discharge (ESD)
- Rule of thumb, replace Humidity sensors every 2 years!

ASHRAE: 30 – 60% RH
Field replaceable sensor heads

- Facilitate MTTR in case of failed probes
- Eliminate standard fixed cords
- Cheaper deployment and elegant cable management
QUESTIONS?
THANK YOU