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
Agenda of today’s Seminar

“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
Circuit Breaker Trip Coordination
Why metering?

The “Buckaroo Effect”

Avoid inefficiencies based on fear & uncertainty

Avoid over/under capacity with accurate data!
Capacity Planning

HP Proliant DL380G5
Name plate 700 Watt

HP Proliant DL380G6
Name plate 500 Watt

Source: http://www.spec.org/power_ssj2008/
Breaker Coordination Must Extend into the Rack

EXAMPLE 1
Common scope of breaker coordination protects against cascading failure...
Critical Facility Design Scope: End-to-End

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!
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**

- 5kAIC typical;

**Fuse Melt Curve**

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

- IEC 60950-1 Safety Standard requires use overcurrent protectors (OCP)
  - Thermal-Magnetic Breakers
  - Magnetic-Hydraulic 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 our 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.
Circuit Breaker Trip Delays

Thermal magnetic delays are standardized: A, B, C, or D. For data centers, type D is used.

Hydraulic magnetic trip delays are not standardized. Type 62 are used by most vendors.

Thermal Magnetic Delay

Sensata Type 62 Delay

At 600% delay is 0.02 to 2 seconds.
Circuit Breaker Trip Coordination

When short occurs, only 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

EXAMPLE 2

- Most modern data centre 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

EXAMPLE 2
Very important to differentiate between zero amperes and zero volts!
Proper Feed Sizing for High Density Blade Chassis

Example 3

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

EXAMPLE 3

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

EXAMPLE 3

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

EXAMPLE 3

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

EXAMPLE 3

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

**EXAMPLE 3**

- “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);
Metering Accuracy
Metering Accuracy

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

- Outlet Metering
- Circuit Breaker Status Monitoring
- Inlet level Metering
- Residual Current Monitoring
Metering Accuracy - Squelch
Metering Accuracy – Phase shift

IEC 62053
1% - Class 1
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
Residual Current Metering
Residual Current Monitoring (RCM)
Residual Current Device (RCD)

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.
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.
Risks of current leakage: avoid downtime

- Proactive detection of a leakage current in high-availability facility.
- Regulatory testing required by law in some regions Germany, Austria, UK moving towards EN 50600
- Permanent monitoring, automated saves cost
Residual Current: causes?

- Old or damaged cable isolation
- Leaking capacitors
- Failing power supplies
- IEC-60950-1 compliance
Residual Current: Sensor options

RCM Type A

Detects AC leakage and is sensitive down to 6mA leakage.

RCM Type B

Detects AC and DC leakage and is sensitive down to 30mA.

Neutral Monitoring

UL/IEC 60950-1 + IEC 62020 standard Compliance tolerates leakage up to 3mA (Type A) and 30mA (Type B)
Residual Current: Testing

Avoid false positive/negative readings, ignore current measured under 3mA

- Useful for testing the alerting system
- Ensures Sensor Readings reliability
Minimize Human Error
### Human Error: Data

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

<table>
<thead>
<tr>
<th>Cause</th>
<th>2010</th>
<th>2013</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPS system failure</td>
<td>25%</td>
<td>24%</td>
<td>29%</td>
</tr>
<tr>
<td>Cyber crime (DDoS)</td>
<td>2%</td>
<td>18%</td>
<td>22%</td>
</tr>
<tr>
<td>Accidental/human error</td>
<td>22%</td>
<td>22%</td>
<td>24%</td>
</tr>
<tr>
<td>Water, heat or CRAC failure</td>
<td>11%</td>
<td>12%</td>
<td>15%</td>
</tr>
<tr>
<td>Weather related</td>
<td>10%</td>
<td>12%</td>
<td>12%</td>
</tr>
<tr>
<td>Generator failure</td>
<td>6%</td>
<td>7%</td>
<td>10%</td>
</tr>
<tr>
<td>IT equipment failure</td>
<td>4%</td>
<td>4%</td>
<td>5%</td>
</tr>
</tbody>
</table>

- 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)
Human Error: Locking

Outlet locking
- PDU side
- Server side
Equipment failure and redundancy
PDU redundancy

Additional features

- Temperature sensors
- Smoke detection
- Door-lock solutions
- USB webcam security
- Cascading/ Daisy chain
- Modem/ SMS notification
PDU redundancy: Power Sharing

In case of a feed outage, your PX controller stays powered and sends alerts.
Regular Cascading
Regular Cascading With Power Sharing
Regular Cascading With Power Sharing
Networking Cascading

Eliminate daisy-chains single points of failure

Protocols / Options
- Modbus daisy chain
- Modbus ring
- Master / Slave setup
- SNMP
PDU redundancy: 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
Relays: (near) Zero-Crossing

Synchronize relay switching > Cheap components

![Graph showing voltage over time with a zero-crossing point marked.]
Automatic Transfer Switch (ATS)
When do you need an ATS

- Single power supply units
Switching times

- 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;
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
Technical considerations

Power Quality

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
QUESTIONS?
THANK YOU
Shukran Jazilan
شكراً جزيلاً
Backup: Environmental

- “Goal Posts are Moving”
- Demand for Increased Capacity
- Governed by the ASHRAE Standards
- Q = Consider Operating Temp, back of rack?

<table>
<thead>
<tr>
<th>@ Equipment Intake</th>
<th>Recommended</th>
<th>Allowable</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Centers ASHRAE</td>
<td>18-27 °C</td>
<td>15-32 °C</td>
</tr>
<tr>
<td><strong>Humidity (RH)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Centers ASHRAE</td>
<td>40% RH</td>
<td>60% RH</td>
</tr>
<tr>
<td></td>
<td>5.5 °C DP</td>
<td>15 °C</td>
</tr>
</tbody>
</table>