Data Center Trends and Design

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Data Center Trends & Design

Agenda

- IT Trends
- Cooling Design Trends
- Power Design Trends
IT Trends

- Virtualization
- Density
- Density vs Reliability Profile
- Chip Cooling
Virtualization and Density

- For every 18°F rise in temperature hardware reliability decreased by 50%
- Footprint reduction = 30% per year
- Since 2000, power consumption for chips doubled
- 17% annual increase in load density in past 10 years
Chip Cooling

Chip Manufacturers are Investigating:

- New Sink Architectures
- Water Cooled Sinks
- Large Cooling Fans (up to 70 cfm per server)
Density vs. Reliability Profile

TIER

IV

ENTERPRISE

III

WEB HOSTING
COLO

II

OLD MAINFRAME

I

W/SF

50 100 150 200 250 300

Design Criteria

IT Trends
Total Cost of Ownership

- **Capital Expenditure**
  - Cost
  - Design

- **System Reliability**
  - Design Configuration
  - Reliability costs

- **Operating Costs**
  - Lifecycle Costs
  - Operating Risks
  - Resilience Costs

- **Total Cost Ownership**
  - Higher Reliability
  - Efficiency

IT Trends
Best Practices – Data Center Planning/Design

- Don’t lose the forest for the Tiers
- kW/cabinet is more insightful than average W/sq ft
- Nail the program, budget and schedule early on
- Design in modularity and scalability
- Optimization through planning, design and commissioning
Cooling Design Trends

Fighting Density and Increasing Energy Efficiency

- In the Data Center
- For the Data Center
  - System Selection Process
  - Economization Alternatives
In The Data Center

Fan Powered Cabinet Example

Cabinet Fans

Hot Air Plenum

Hot Air
is discharged out of the top via ductwork

Conditioned Air
is drawn through the front of the cabinet

Raised Floor

Cooling Trends
In The Data Center

Water Cooled Cabinet Example

High Pressure
flex hose and quick-connect fittings to chilled water mains

Fan Coil
on rear door cools servers

Conditioned Air
is drawn through the front of the cabinet

Supply Return Piping

Discharge Air

Cabinet Fans

Raised Floor

Cooling Coil

Piping

In The Data Center

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Piping

Cooling Trends
In The Data Center

Hot Aisle Cold Aisle Configuration

Conditioned Air is drawn through the front of the cabinet
Hot Air is discharged out of the back of the cabinet
Conditioned Air is drawn through the front of the cabinet

Cooling Trends
For The Data Center

System Alternatives

- Chiller/Cooling Tower
- Air Cooled Chiller
- Adiabatic Cooling/Swamp Cooler (Roof, Ground, CRAH)
- Outside Air
- Air to Air (Munthers, Schneider, Hunt Aire, Kyoto)
- Water Side Economizer
  - (Heat Exchanger)
- DX Backup/Full-Partial
- Drycoolers
For The Data Center

System Selection Process

Cooling Trends
## System Selection Process

### San Antonio
Supply Air Temp - 80°F

<table>
<thead>
<tr>
<th>ASHRAE Class - Recommended</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Evaporative</td>
<td>96%</td>
<td>99%</td>
<td>89%</td>
<td>52%</td>
<td>43%</td>
<td>23%</td>
<td>40%</td>
<td>25%</td>
<td>37%</td>
<td>75%</td>
<td>86%</td>
<td>97%</td>
</tr>
<tr>
<td>Indirect Evaporative</td>
<td>96%</td>
<td>97%</td>
<td>92%</td>
<td>80%</td>
<td>75%</td>
<td>68%</td>
<td>67%</td>
<td>67%</td>
<td>75%</td>
<td>85%</td>
<td>95%</td>
<td>96%</td>
</tr>
<tr>
<td>Direct Outdoor Air</td>
<td>88%</td>
<td>98%</td>
<td>74%</td>
<td>32%</td>
<td>22%</td>
<td>8%</td>
<td>6%</td>
<td>10%</td>
<td>19%</td>
<td>59%</td>
<td>75%</td>
<td>93%</td>
</tr>
<tr>
<td>Indirect Outdoor Air</td>
<td>97%</td>
<td>98%</td>
<td>93%</td>
<td>79%</td>
<td>73%</td>
<td>63%</td>
<td>50%</td>
<td>61%</td>
<td>75%</td>
<td>87%</td>
<td>97%</td>
<td>97%</td>
</tr>
<tr>
<td>Water Economizer Water-Cooled Chiller</td>
<td>88%</td>
<td>96%</td>
<td>81%</td>
<td>64%</td>
<td>60%</td>
<td>57%</td>
<td>57%</td>
<td>57%</td>
<td>59%</td>
<td>72%</td>
<td>84%</td>
<td>92%</td>
</tr>
</tbody>
</table>

### Cooling Trends
For The Data Center

System Alternatives

**Direct Air Economizer System**
- Outside air does not enter the data center

**Indirect Air Economizer System**
- Outside air does enter the data center

Cooling Trends
For The Data Center

System Alternatives

Direct Evaporative Air Economizer

Indirect Evaporative Air Economizer

“Swamp” cooler with outside air entering the data center

“Swamp” cooler without outside air entering the data center

Cooling Trends
For The Data Center

System Alternatives

KYOTO WHEEL
Indirect Air-side Economizer

Cooling Trends
Power Design Trends

- Reliability / Availability
- UPS Technology
- Concurrent Maintainability
- Example One Line
Reliability / Availability

- Load Density (The Major Issue)
- 99.9999% Availability (“Six Sigma”)
- 2(N+1), 2N, N+2 Redundancy Common
- N or (N+1) Systems Not Good Enough
- Full Concurrent Maintenance
- Fault Tolerant Configurations – Eliminate SPOF’s
UPS Technology

- UPS with transformer or transformer free
  - Efficiency
  - Ground current issues
- UPS Modules with internal redundancy
  - Internal redundancy but same single input/output
- UPS System Static Switch
  - module level
  - system level
- UPS Technology
  - Double Conversion
  - Offline
  - Line interactive
  - Delta Conversion
  - Rotary
  - etc.
UPS Technology

- Eco Mode
  - Good - Efficiency
  - Bad – UPS Offline
- ITIC Curve/CBEMA Curve
- UPS Distribution Voltage
  - 600, 575, 480V, 415V, 120/208V
- 3 Phase 3 Wire, 3 Phase 4 Wire
- DC systems and voltage – 380VDC
UPS Technology

Typical UPS Configurations
- Single Module Systems
- Isolated Redundant
- Parallel Redundant
- Distributed Redundant
- Block Redundant
Reliability / Availability

Parallel Redundant

Power Design Trends
Reliability / Availability

Distributed Redundant

Power Design Trends
Reliability / Availability

Block Redundant

Power Design Trends
Cost, Availability and Design Topology

Pushing the Limits of Complexity = Bad Capital Investment

![Graph showing the relationship between Availability and Cost. The graph starts with a steep increase in Availability as Cost increases, then levels off.]
## Data Center Electrical Infrastructure

### Topologies – Reliability Table

<table>
<thead>
<tr>
<th>Description of RBD</th>
<th>MTBF (Hours)</th>
<th>Inherent Availability ($A_i$)</th>
<th>Probability of Failure in 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>N + 1 UPS system - dual cord loads</td>
<td>32,509</td>
<td>0.99981626</td>
<td>58.16%</td>
</tr>
<tr>
<td>Distributed Redundant (2-3) UPS system - dual cord loads</td>
<td>161,646</td>
<td>0.99997994</td>
<td>7.43%</td>
</tr>
<tr>
<td>2N UPS system - dual cord loads</td>
<td>214,182</td>
<td>0.99998723</td>
<td>6.56%</td>
</tr>
<tr>
<td>2(N + 1) UPS system - dual cord loads</td>
<td>305,251</td>
<td>0.9999868</td>
<td>6.49%</td>
</tr>
<tr>
<td>Utility and N + 1 UPS system, ASTSs - dual cord loads</td>
<td>65,056</td>
<td>0.99999821</td>
<td>8.02%</td>
</tr>
<tr>
<td>Redundant Reserve (2-3) UPS System, ASTSs - dual cord loads</td>
<td>257,459</td>
<td>0.99999058</td>
<td>2.58%</td>
</tr>
<tr>
<td>Distributed Redundant (2-3) UPS system, ASTSs - dual cord loads</td>
<td>256,674</td>
<td>0.99999046</td>
<td>2.72%</td>
</tr>
<tr>
<td>2N UPS system, ASTSs - dual cord loads</td>
<td>445,691</td>
<td>0.99999845</td>
<td>1.12%</td>
</tr>
<tr>
<td>2(N + 1) UPS system, ASTSs - dual cord loads</td>
<td>989,960</td>
<td>0.99999839</td>
<td>0.88%</td>
</tr>
</tbody>
</table>
Electrical Trends

575V Distribution
Traditional voltage distribution to the PDU primary is 480V, consider use of 575V

Benefits:
- Reduces cable and bus sizes by 20%
- Allows systems to operate more efficiently
- Allows more capacity out of the equivalent 480V infrastructure
- Maintains the use of standard equipment sizes
- Can be utilized with UPS, motor and all other major equipment within the building
- Overall reduces initial installation cost and long term maintenance and operating costs
Electrical Trends

415V Distribution and Eliminate Transformers

- Transformers are traditionally used to step down the voltage to 208V for use at the server rack.
- Because the vast majority of modern servers are designed for the global market including the IEC low voltage standard 415/240V, the implementation of a 415/240V UPS system with a 3 phase, four wire distribution can be used.
- Distribution at 415/240V eliminates the transformation requirements and aligns critical loads directly with the UPS

Benefits:
- Still maintains the use of standard equipment, electrically and servers
- Reduces one level of transformation, increasing overall electrical efficiency by ~2%.
- Reduces HVAC requirements by 6 tons/MW.
- Reduces the amount of equipment needed to support the load, reducing initial costs.
- Increases reliability and availability, and reduces maintenance costs
Electrical Trends – Eco Mode
Concurrent Maintainability

Goals

- “Change Tires, Transmission and Engine at 60mph…and Don’t Lose Speed.”
- No IT Downtime for Preventative and Corrective Maintenance
- Scalability
Concurrent Maintainability

The Solution

- Dual/Diverse Utility Services
- Dual Active Distribution Paths
- N+2 Generator Plant
- “Self-Healing” Automation and Control
- Physical Separation/Compartmentalization
- 2N Static UPS or Similar
- Dual Electrical Cords to IT Cabinets
Medium Voltage Distribution

Utility Bypass/Gen Control Maintenance

Red-Normal ‘A’
Green-Normal ‘B’
Yellow-Generator
UPS – Normal Operation

- Red-Normal ‘A’
- Green-Normal ‘B’
- Blue-UPS ‘A’
- Pink-UPS ‘B’

Power Design Trends
UPS to RPP Normal Operation

Blue-UPS ‘A’
Pink-UPS’ B’
QUESTIONS?

Thank you and please feel free to contact me

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