Data Center Trends and Power Management

Roger Schmidt
IBM Chief Thermal Architect

Sept 12, 2006
Contents

• Power Trends/Impacts on Data Center
• IBM’s Product Innovation
• Industry Actions
• Final thoughts
What Customers are Asking

• I am out of power in my data center, so what can be done?
• How do I handle the hot spots in my data center resulting from high server powers?
• How do I get real time information from servers on temperature and power so I can run my data center more energy efficiently?
Facility/Network Concerns

- Excessive heat: 30%
- Insufficient power: 25%
- Insufficient raised floor: 15%
- Excessive facility cost: 10%
- Poor location: 5%
- None of the above: 0%

“Power and cooling will be a top 3 issue with all CIO’s in the next 6-12 months”

Michael Bell – Gartner Group
Everyone Has A “Computer Room”

Branch Office

Client/Web Hosting Site
IT Equipment is HOT...And HEAVY

P – Series 595
31”W x 66”D x 80”H
23 kW
3014 Lbs

Toyota Camry
3276 Lbs

P-Series 690
62” W x 50” D x 80”H
32 kW
4233 Lbs
New Datacom Equipment Power Density Chart
Rack Level Heat Load Trend

Rack Level Heat Loads Rising at an Exponential Rate

Year of Announcement

[Year values from 1994 to 2006]

Rack Level Heat Load (kW)

[Graph showing exponential trend from 1994 to 2006]
System Power Comparison
System Power Varies as a Function of Configuration and Workload
It is NOT Just the Processor
- Perforated tiles do not support high flowrates required by high density servers
- Underfloor obstructions from chilled water pipes and cables
Air Blockages beneath Raised Floor

Chilled Water Pipes

Cables
The Problem in Data Centers

Chilled air does not reach top of racks
CFD Model of a Raised Floor Data Center

Highly complex flow patterns and localized rack inlet air heating focus of many studies by R. Schmidt and Co-workers (1997-2004)

Computational Fluid Dynamics

Data Center 12kW Perpendicular

Temperature (deg C)

> 41.746
36.309
30.873
25.436
< 20
The New Economics of IT; A Paradigm Shift

- Power and cooling spend will exceed new server spending (Gartner 2006)

2000 – Raw processing “horsepower” is the primary goal, while the infrastructure to support it is assumed ready.

2006 – Raw processing “horsepower” is a given, but the infrastructure to support deployment is a limiting factor.

Three Cooling Challenges
1. The System
2. The Rack
3. The Datacenter
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IBM delivers business value with innovation at all levels

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<th>Information on Demand</th>
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**Product Families**

- **Mainframe**
- **Storage**
- **Blades**

**Technology & Packaging**

- **z/OS**
- **AIX**
- **i5/OS**
- **IBM z/Architecture™**
- **Power Architecture™**
- **Cell Broadband Engine™**
- **X-Architecture™**
IBM POWER Architecture

• Track Record of Consistent Predictable Delivery
Power 6 will provide leadership for years to come…

Innovations in all areas of system design

- System Energy Management
- RAS
- Performance
- Flexibility
- Features and function
- Technology
- Current development Status

*Increased performance with increased energy efficiency*
The Datacenter

• IBM's focus on power efficiency allows our systems to run with less power than our competitors
  – For some customers this level of efficiency is still inadequate
    • Older data center floors were not designed to handle the heat load that today's servers place on it
    • Many customers run out of power and cooling before running out of rack space

  For these customers, IBM has developed a suite of additional tools to employ;
  – IBM Cool Blue rack based heat exchanger
  – “Smart Tools”
    • Power Calculator, Power Executive
    • Virtualization
Understanding Where Costs are Critical

- IBM’s Cool Blue Rear Door Heat eXchanger can remove over 50% of a rack’s heat output
  - No new fans or electricity needed.
  - Attaches to back of rack (adds 5”)
  - No rearrangement of datacenter
  - Cost effective; 1KW cooling = $286

- The Cool Blue Heat eXchanger adds cooling capacity at ~1/4 the cost of traditional methods
Comparison – with and without Cool Blue
Typical Data Center Power Distribution and Energy Savings with Water

**Example:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Electricity Consumption(kW) with Air Cooled Servers</th>
<th>Electricity Consumption(kW) with Water Cooled Servers</th>
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<tbody>
<tr>
<td>Other</td>
<td>402</td>
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<tr>
<td>Lighting</td>
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<td>Office Space Conditioning</td>
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<td>Electrical Room Cooling</td>
<td>118</td>
<td>118</td>
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<tr>
<td>Cooling Tower Plant</td>
<td>114</td>
<td>114</td>
</tr>
<tr>
<td>Data Center Cooling</td>
<td>1000</td>
<td>418</td>
</tr>
<tr>
<td>Server Load</td>
<td>1500</td>
<td>1500</td>
</tr>
<tr>
<td>Total Load</td>
<td>3248</td>
<td>2666</td>
</tr>
</tbody>
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Savings of $\frac{1}{2}$ million dollars/year at $0.10 / \text{kw-hr}$
Livermore Data Center – 3rd Fastest Supercomputer

High Power Rack Clusters within 10,000 sq ft can require 10 MW including supporting power and cooling

Annual Energy Cost for 10 MW at $0.10/kW-hr = $8.8 M

New Building Cost for 10,000 sq ft = $15 M
Energy Cost Around the World (US cents/kw-hr)
IBM Site and Facilities Services
- Providing Data Center Solutions

• Deep Global Expertise
  • Dedicated team since 1986
  • Mechanical & Electrical Engineers, Space planners and PM’s on staff
    • Most with over 20 years experience
    • A team of 450 people globally
  • Designed and built over 30 million SF of raise floor from Boulder and Brussels to Bangalore

• We have learned what works … because we use it
  • Built and run over 400 of our own datacenters, with 6M sq ft currently in operation
  • Built over 120 of our own disaster recovery facilities that support our clients
  • Built and reside in 4 of top 10 green buildings in Japan
  • Built state of the art clean rooms for our own leading processor technology manufacturing

• Clear understanding of current technologies and a vision of future with tight linkage to product development and research teams

• Well established partnerships with key providers ensuring best choices to fill your requirements including: APC, Liebert, etc.
IBM and the Energy Efficient Data Center

- IBM servers provide leadership energy efficiency today
  - Power5 efficiency continuing to Power6
  - Server power management features - PowerExecutive

- IBM is delivering leadership energy management technology
  - Enable customers to maximize datacenter computational efficiency
  - Enable customers to minimize datacenter operating costs

- IBM has the skill and resources to assist our customers in planning and deploying data center solutions
  - IBM’s long term commitment to providing solutions for our customers

Source: Brad McCredie, Analyst meeting, July 20, 2006
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Worldwide Focus on Climate/Energy

- Energy Usage becoming a critical global issue
  - Climate Change
  - Energy Security and Availability
  - Energy Cost
- Attracting the attention of regulators, legislators, and customers
- Carbon caps
- Energy Efficiency
  - Energy Saving Law – Japan
  - Energy Star
  - EPA researching server farm energy usage
- Green grid
  - Best practices in a data center
- Benchmarks on power/performance
IBM Providing Industry Leadership - ASHRAE TC9.9 Committee

Chair of committee: Roger Schmidt
IBM Chief Thermal Architect

Other Books being developed
- Contamination in datacom equipment center
- High density data centers - case studies and other considerations
- Seismic considerations in datacom equipment centers
- Current practices in Datacom Facility TCO analysis and Energy Efficiency

Source: Roger Schmidt
People from these firms participated:
ANCIS, APC, Ceyba, Cisco, CRS, Cray, DataAire, Dell, DLB, Echelon, EMC, Engineered Refrigeration Sys, Flomercs Inc, Fujitsu, Hellmer Medved Engineers, Hitachi, HP, IBM, Innovative Research, Intel, LBNL Labs, Liebert, Lucent, Mallory & Evans, Motorola, NCR, Sun, Telecordia, Unisys, Uptime Institute
Power Trend Book - Overview

Chapter 1 – Introduction
Chapter 2 – Background
Chapter 3 – Load Trends & their Applications
Chapter 4 – Air Cooling of Computer Equipment
Chapter 5 – Liquid Cooling of Computer Equipment
Appendix A – Collection of Terms
Appendix B – Additional Trend Chart Information / Data
Appendix C – Electronics, Semiconductors, Microprocessors, ITRS
Appendix D – Micro Macro Overview of Datacom Equipment Packaging

People from these firms participated: Alcatel, ANCIS, ATI, Cisco, Cray, DataAire, Dell, DOD, DLB, EMC, EYP, Fanniemae, Freescale, Fujitsu, Hellmer Medved Engineers, HP, IBM, Intel, LBNL Labs, Liebert, Mallory & Evans, Motorola, Nortel, Sun, Syska & Hennesey, Taylor Engineering, Uptime Institute
Data Center Considerations - Overview

Part 1 Datacom Facility Basics

Chapter 1 Introduction;  Chapter 2 Design Criteria;  Chapter 3 HVAC Load Considerations;  Chapter 4 Computer Room Cooling Overview;  Chapter 5 Air Distribution;  Chapter 6 Liquid Cooling

Part 2 Other Considerations

Chapter 7 Ancillary Spaces;  Chapter 8 Contamination;  Chapter 9 Acoustical Noise Emissions;  Chapter 10 Structural & Seismic;  Chapter 11 Fire Detection & Suppression;  Chapter 12 Commissioning;  Chapter 13 Availability & Redundancy;  Chapter 14 Energy Efficiency

People from these firms participated
ANCIS, APC, Bell South, Citigroup, Data Aire, Dell, DOD, DLB, EDS, EYP, Fannie Mae, Fluent, Fujitsu, Heapy Engineering, HP, IBM, Intel, LBNL, Liebert, Mallory & Evans, Nelson Acoustical, Nortel, Rice University, Stulz, Sun, Syska & Hennessy, Tier 4 Consulting, Wright Line
Liquid Cooling Book – Overview

Chapter 1 – Introduction

Chapter 2 – Cooling Services for Equipment Cooling Systems

Chapter 3 – Facility Piping Architecture

Chapter 4 – Liquid Cooling Implementation for Datacom Equipment

Chapter 5 – Liquid Cooling Infrastructure Requirements for Chilled Water Systems

Chapter 6 – Liquid Cooling Infrastructure Requirements for Chilled Water Systems and Datacom Equipment Cooling Systems

People from these firms participated:
APC, Aavid, Cray, DataAire, Dell, DLB, EYP, Hellmer Medved Engineers, HP, IBM, Intel, Liebert, Lytron, Mallory and Evans, NCR, NSA, Panduit, Rittal, Sanmina, SGI, Spraycool, Sun, Trane
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Final Thoughts

- Thermal issues will become ever more severe over time, and fundamental innovations are required to provide a route forward.

- Power efficient products as revealed today resolve customer challenges already limiting their ability to leverage existing assets.

- This is not going to get any easier.