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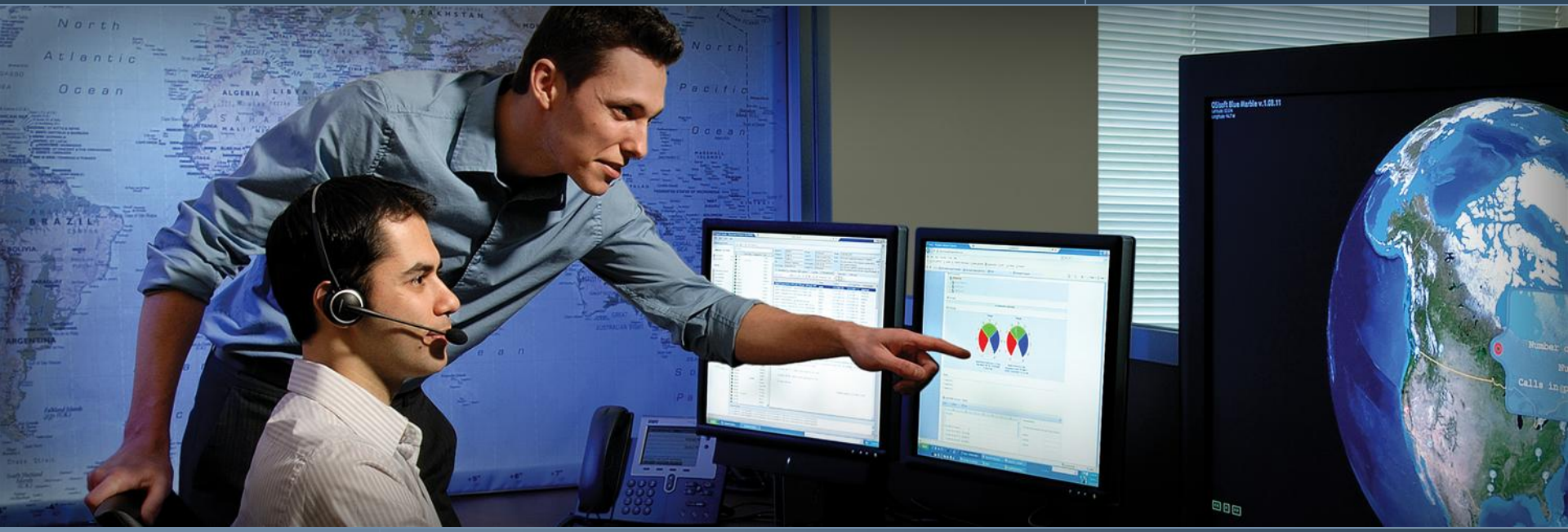


Using OSI PI to Investigate Fresh Air Cooling of Data Centers

Jon Fitch & Tom Homorodi
Enterprise Reliability Engineering
Dell

November 16, 2010

Empowering Business in Real Time.

Using OSI PI to Investigate Fresh Air Cooling of Data Centers

November 16, 2010

Jon Fitch & Tom Homorodi
Enterprise Reliability Engineering
Dell, Inc.
Round Rock, Texas

OSIsoft Regional Seminar Series
Houston TX

Thank You OSIsoft!

THANK YOU OSIsoft!

Thank you for giving us the opportunity to use PI for the term of our fresh air cooling experiment!

OSI Product Names

- **PI Server**
- **PI Data Link**
- **PI Process Book**

Agenda/Outline

- About Dell
- Abstract
- Experiment Results
- About Fresh Air Cooling
- Future Plans & Next Steps

ABOUT DELL

About Dell

- **Description & company history of Dell**
  - ✓ Michael Dell founded our company in 1984 in Austin, Texas, with an unprecedented idea — by selling computer systems directly to customers, we could deliver the most effective computing solutions to meet their needs.
  - ✓ Today the company has quarterly revenues of $15.5B and 96,000 employees world wide

ABSTRACT

Abstract

- PI was used to investigate shifts in server parametric values over time:
  - Identify pending failure modes in product operated in extended temperature & humidity operating environments
  - In an extended operating environment that approximates the use of outside air to cool the data center instead of air conditioning
  - Reason for using fresh air cooling in a data center is to save money on cooling costs

- Dell set up a high temperature high humidity data center divided evenly between a control and an experiment cell

- We found a variety of interesting findings including:
  - Memory leaks
  - Signal path issues (some evidence for prognostics)
  - Optimizing server inlet temperature to minimize overall energy consumption

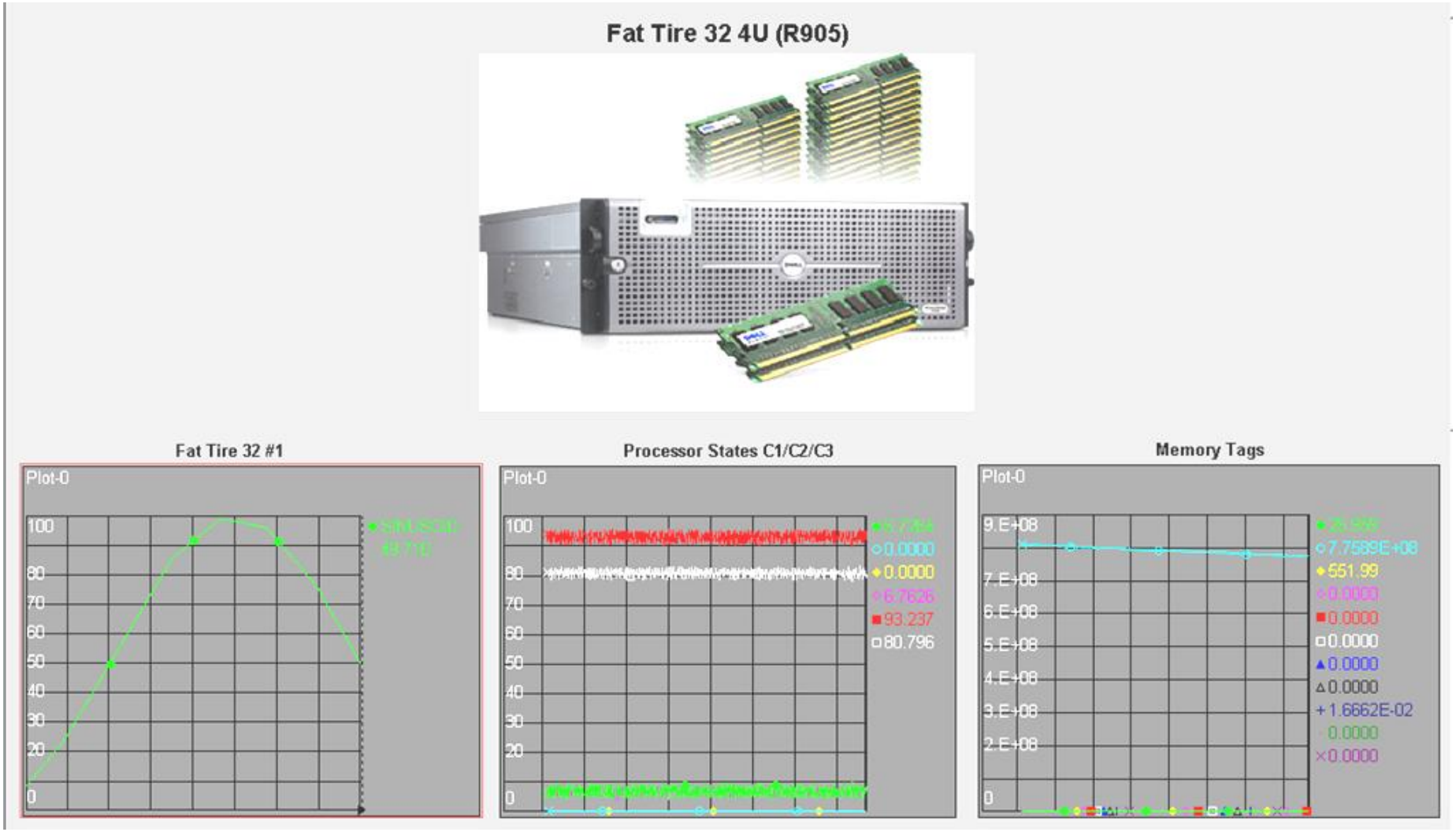
- Potential future applications for PI include:
  - Extended operating environment research
  - Data center power and cooling optimization
  - Prognostics – "health monitoring" and failure prediction

RESULTS

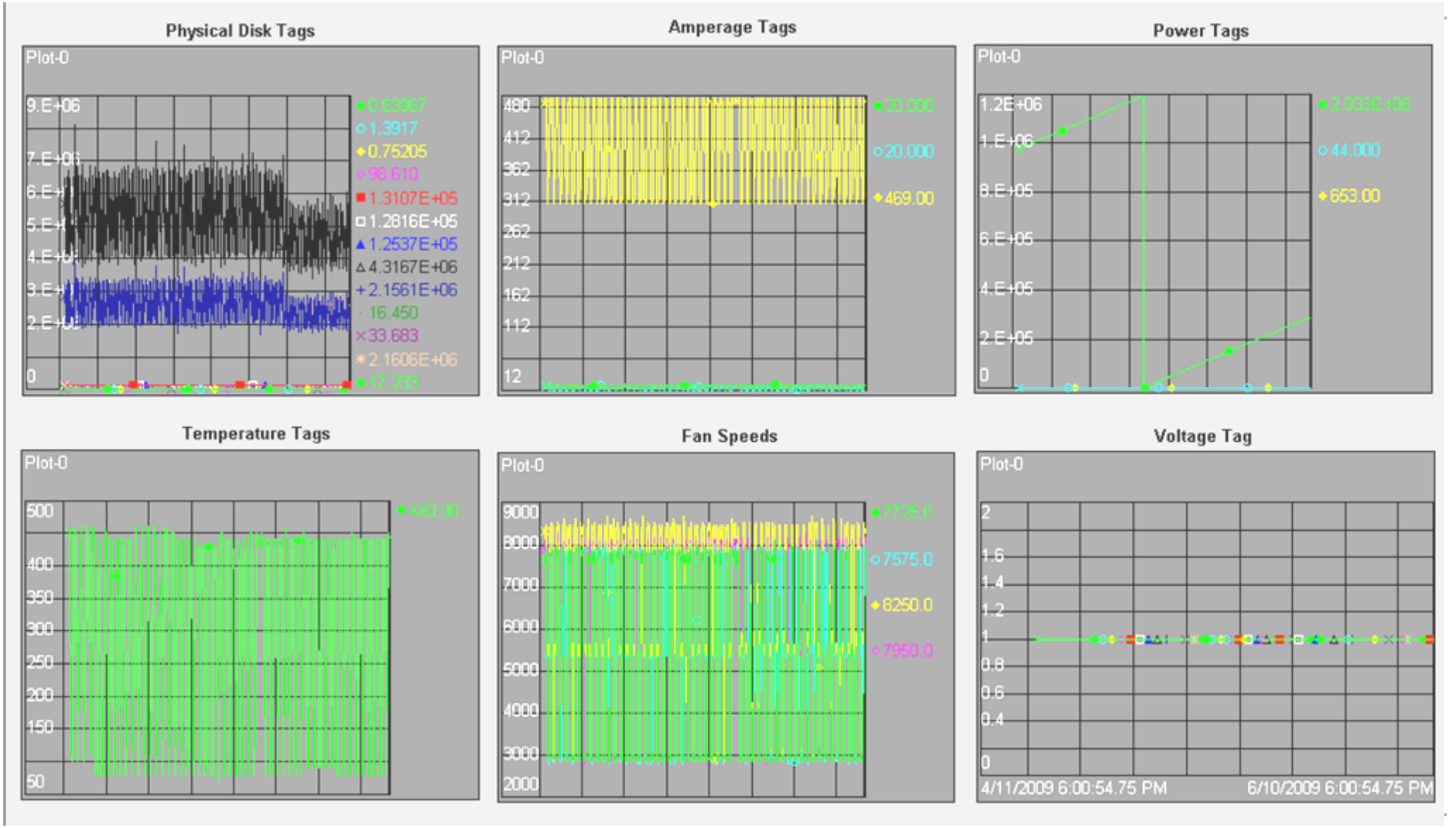
Application of PI to Parametric Monitoring

- Set up PI to collect parametric data in 1 minute intervals from the WMI, Perfmon and SNMP interfaces from all servers both exp and control
- Objective was to determine whether long term exposure to fresh air cooling environmental conditions caused any performance changes in the hardware
  - Wider temperature ranges
  - Wider humidity ranges
  - Daily temperature and humidity cycles
- Every server had its own GUI (see example below and on next page)
- Building the GUIs was as easy as using Powerpoint!
- Before PI, most server data was captured by taking a single “snapshot” in time.
- PI gave us the ability to look at trends over extended periods of time in a way we had never been able to do before.

Example of PI Graphical User Interface

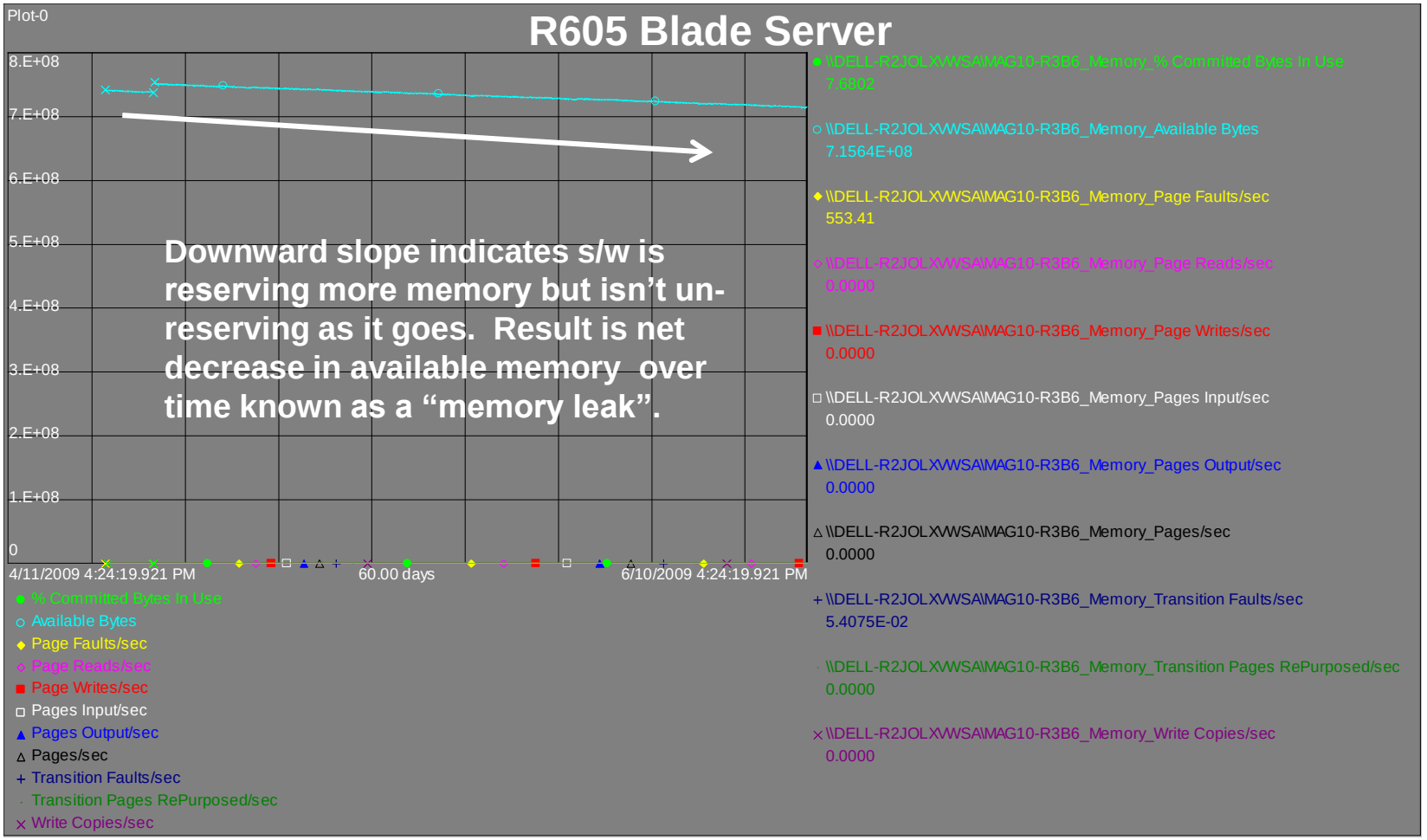


Example of PI Graphical User Interface – Cont'd.

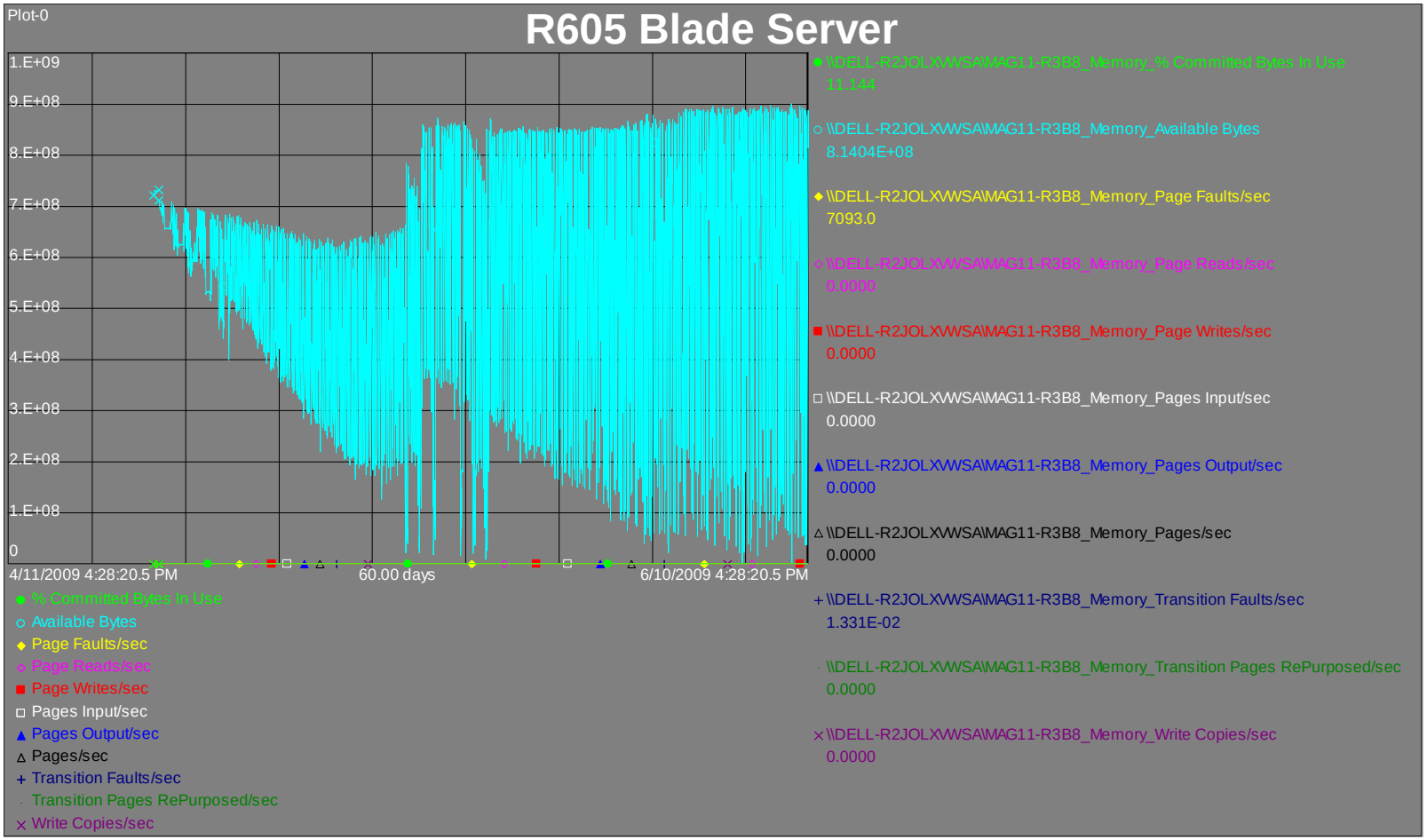


Note how the fan speed and amperage tags track the temperature cycling

Interesting Findings – Memory Leak ?

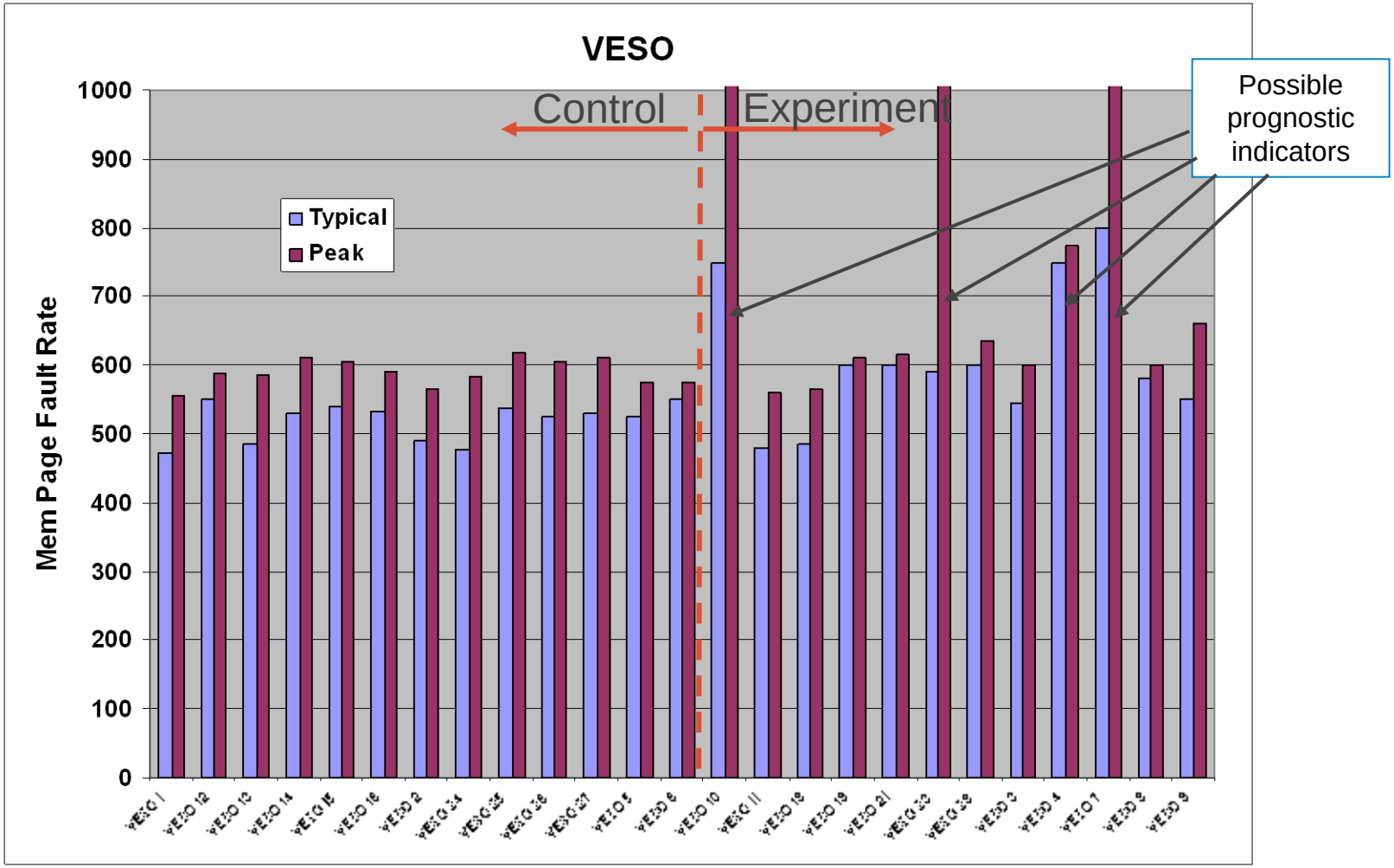


Interesting Findings – Signal Path Issue?



Large oscillations in the total amount of system memory available may have been indicative of a signal path issue.

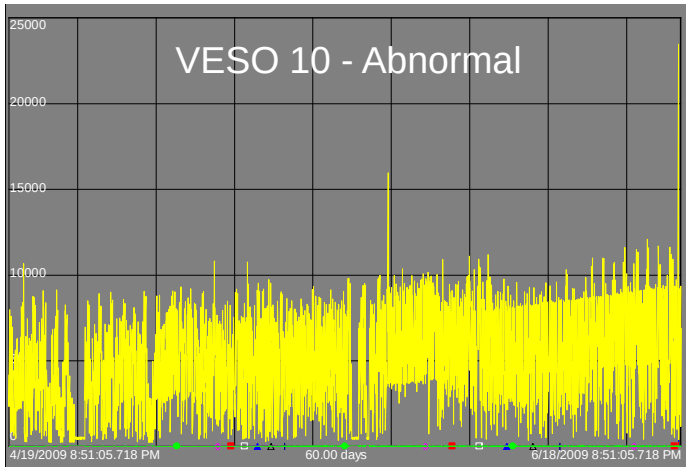
Possible Prognostic Indicators of Failure

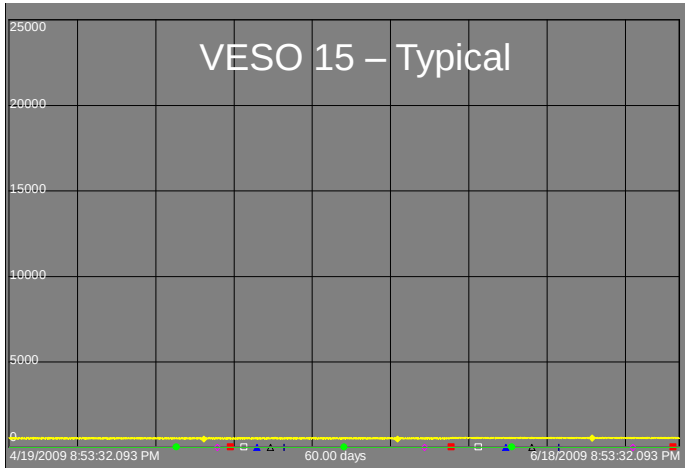


- Overall Page Fault Rate of experiment is slightly higher
- High peak values in experiment are possible prognostic indicators of future failures

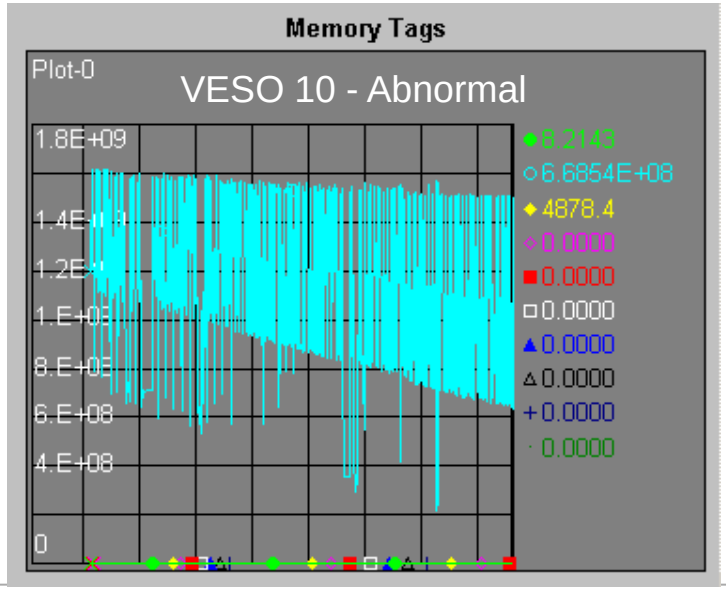
Interesting Findings

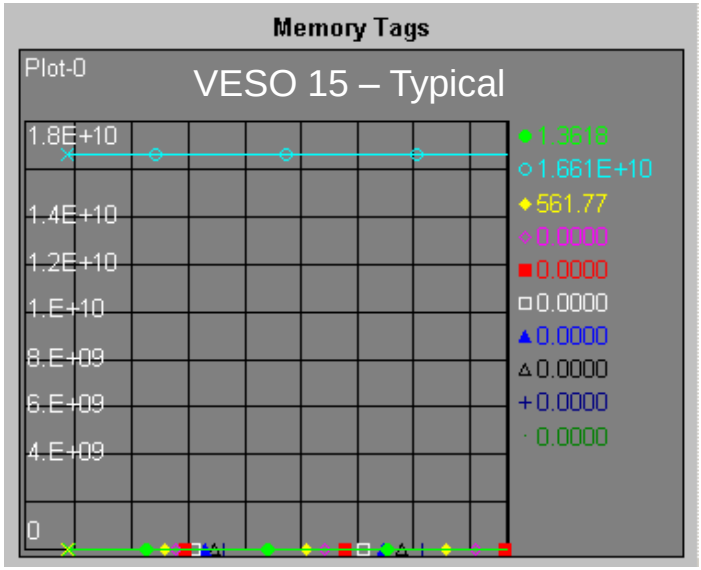
Page Fault Rate



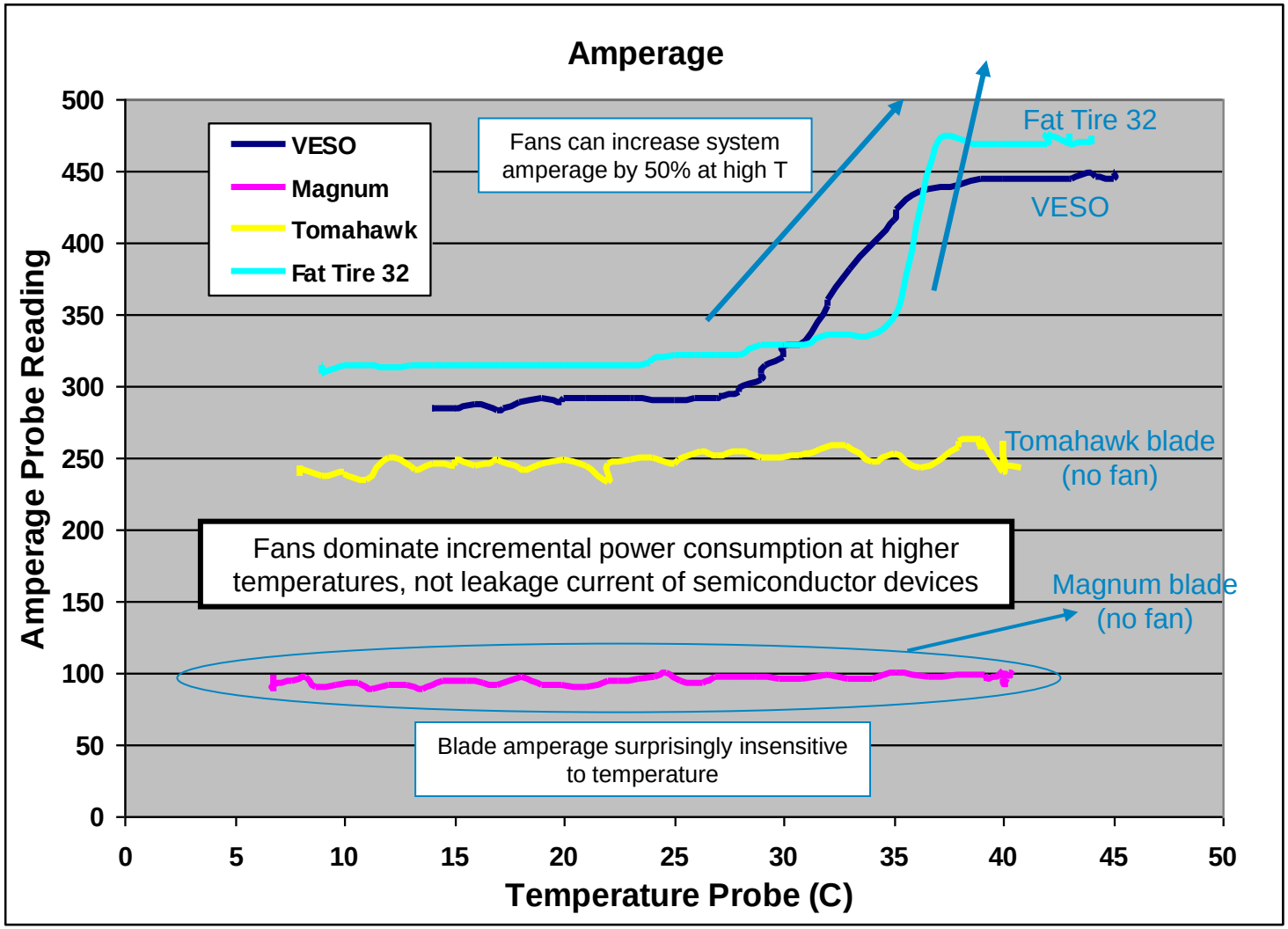


Total Available Memory





Interesting Findings – Fans Dominate Power
Combined multiple PI data streams



ABOUT
FRESH AIR COOLING

What is Fresh Air Cooling?

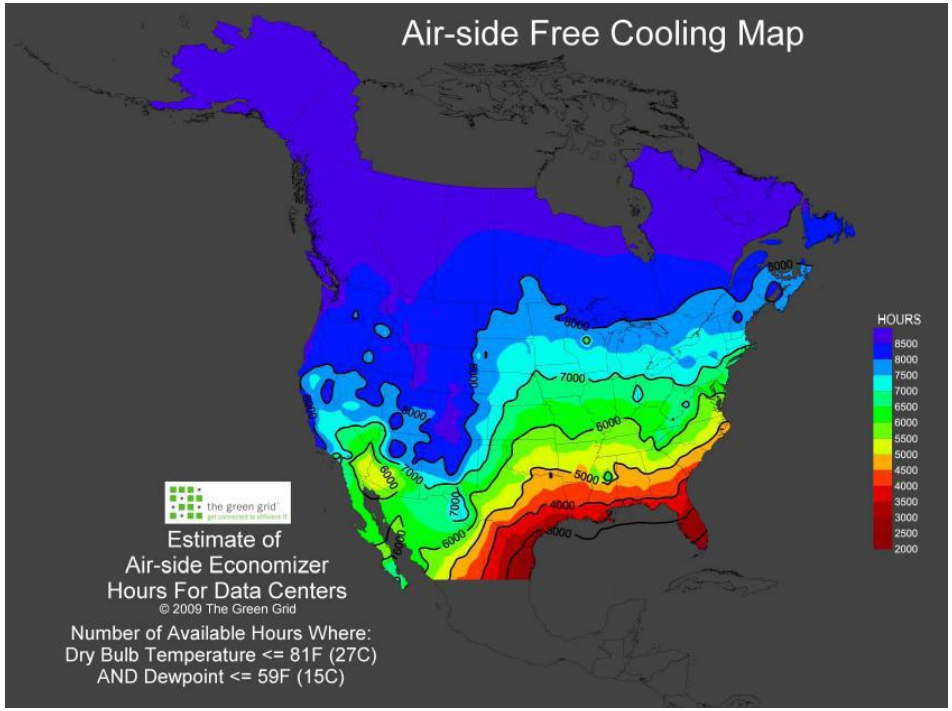
Fresh air cooling is the use of outside air to cool a data center without air conditioning or humidification ***to reduce power & cooling costs***

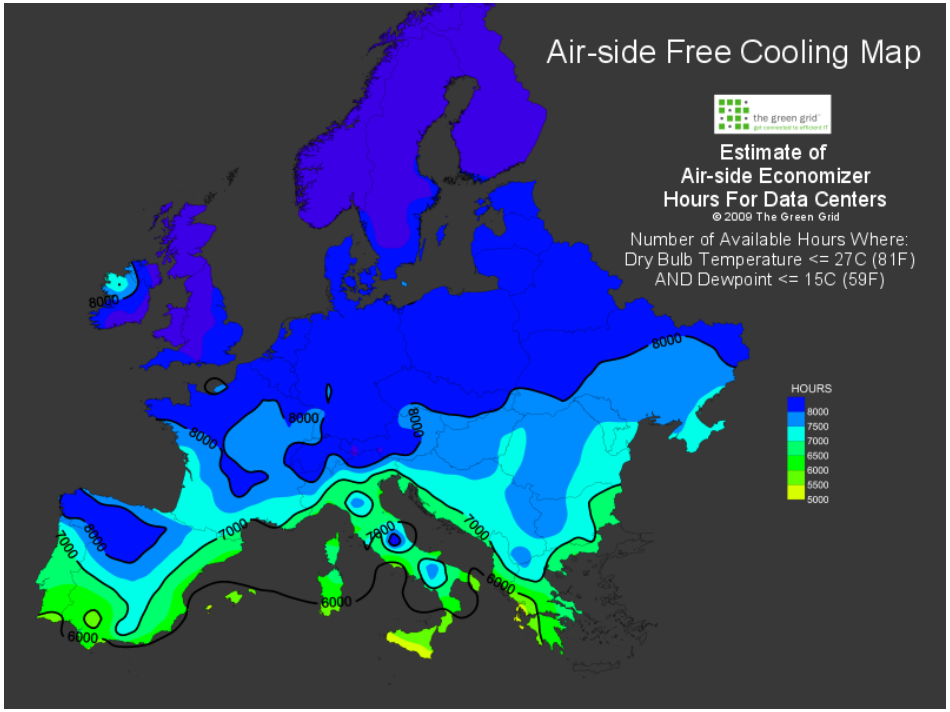
Background

- **Data centers consume 1-3% of the world's total electric power generation capacity**
- **Cost of power over lifetime of a server is comparable to the purchase price of the server hardware**
- **A significant percentage of data center power consumption is used for cooling**
- **Telecommunications companies have been doing fresh air cooling successfully for many years**
  - Un-manned telephone switching offices
  - Telephone equipment in remote or rural areas
  - Equipment that resides on top of telephone poles
- **EU telecom companies - "If fresh air cooling works for our telecom equipment, why can't it work for our data centers?"**
- **Telecom equipment is designed for a wider range of temperature and humidity than data center hardware**

The Goal: Energy Efficiency and Reduce Waste

Would you run your home air conditioner when it is cold outside?

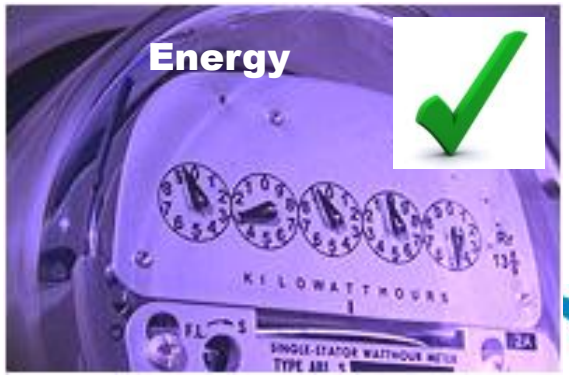




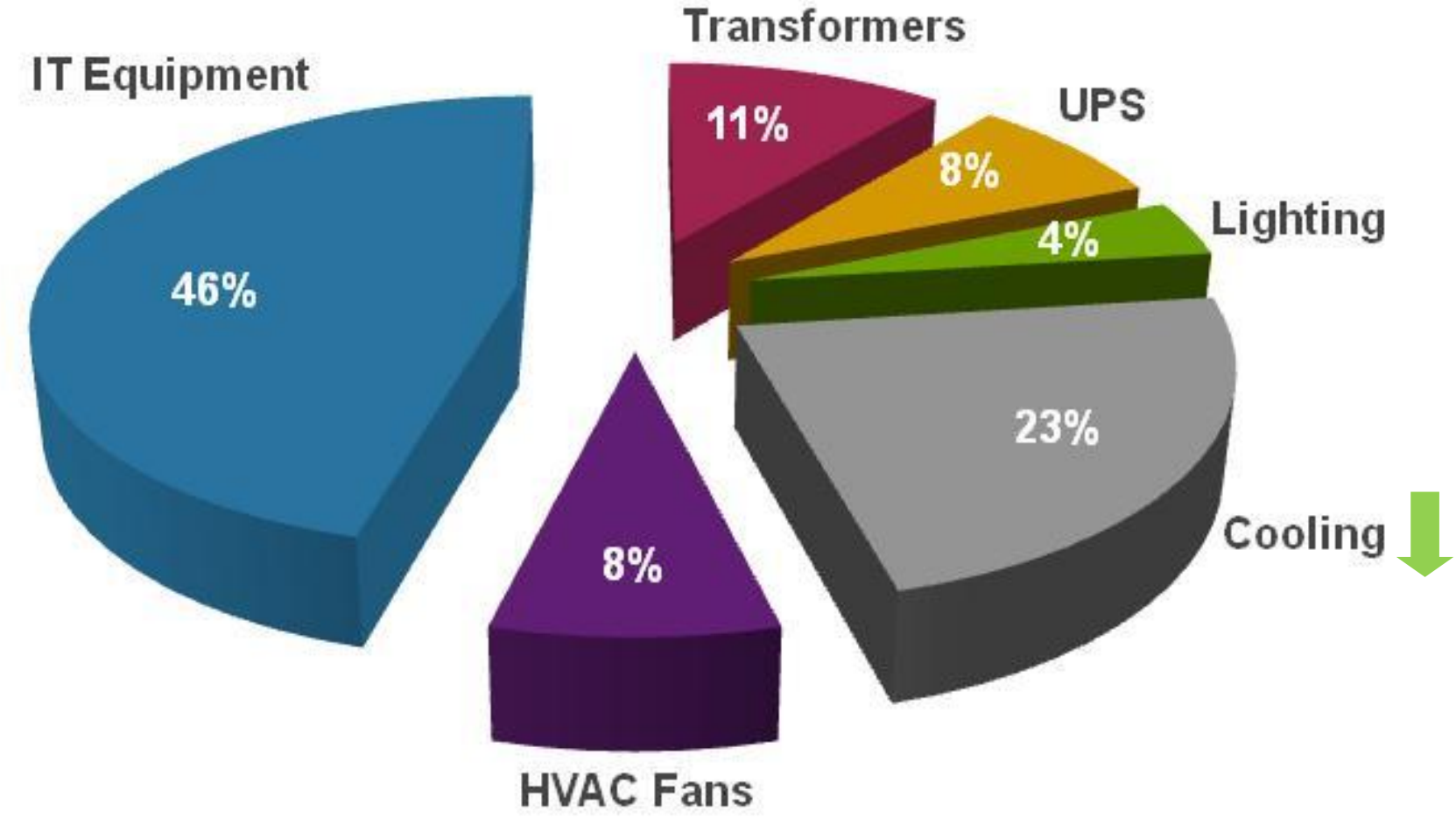
Historically, this is what data centers have been doing
However, fresh air cooling is gaining momentum

Minimize Total Cost of IT

- Fresh air cooling (air side economization) reduces data center energy costs as well as the facility capital cost of new data center construction
- New paradigm: minimize total IT cost per unit of compute delivered



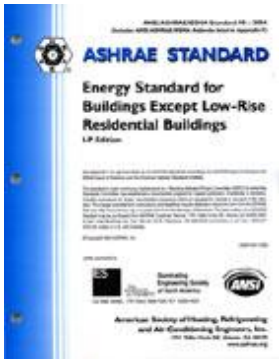
Breakout of Data Center Power Consumption



Source: ASHRAE/DOE "Save Energy Now", 2009

Important Regulatory Changes . . .

- **ASHRAE 90.1 (US)** – pending revision in 2011 will remove data center exemption and mandate economization for new data centers. ASHRAE 90.1 is often incorporated into state and local regulations.
- **High Temperature Excursion Tolerant Servers (EU)** – The EU is considering legislation for 2012 that would require data center hardware to be temperature excursion tolerant up to 45C
- **EU Code of Conduct (EU)** – Though voluntary, this document is a blueprint for future EU legislation. Fresh air cooling is one of its primary recommendations
- **Carbon Credit Legislation (EU & US)** – Several European countries already have carbon credit legislation in place



ASHRAE 90.1

Carbon Credit Legislation

EU Code of Conduct
ETSI Excursion Tolerant

Industry Trends & Competitor Announcements

Updated

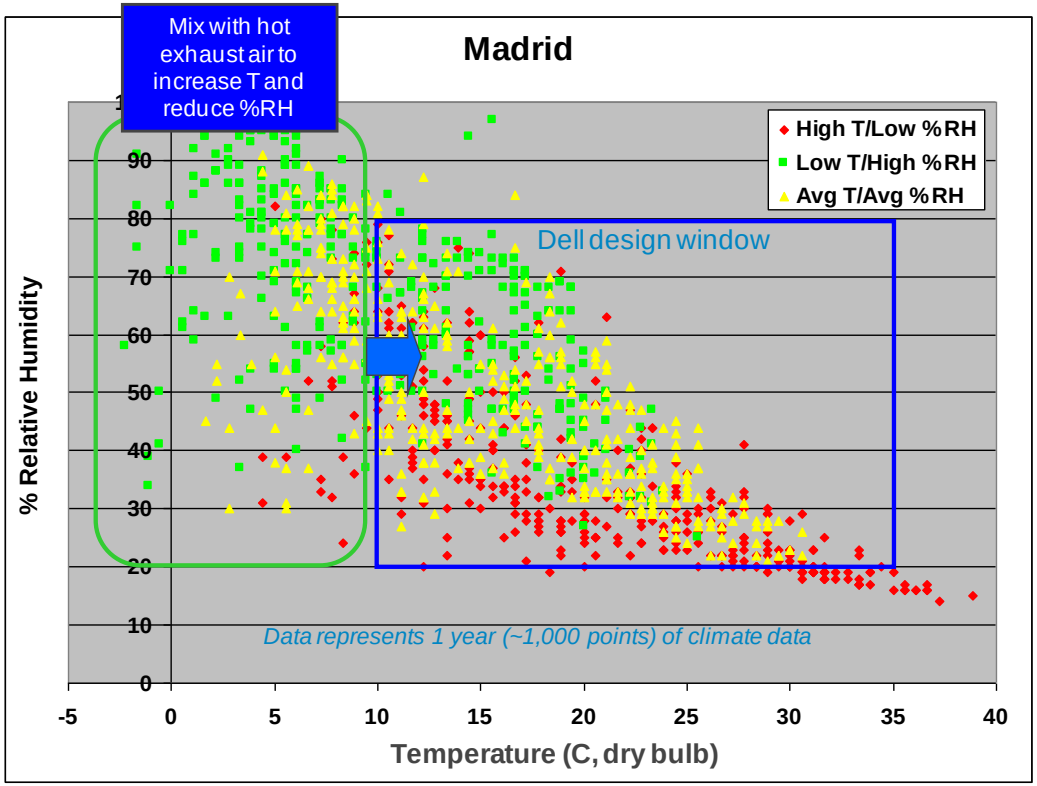
DELL	**November 2, 2010 – Dell buys land in Quincy WA for future data center. Quincy is already home to Sabey, Intuit, and Microsoft DCs because the climate is very conducive to fresh air cooling**	Dell buys land for future DC
OPERA software	**November 1, 2010 – Opera Software announces new containerized fresh air cooled data center located in Iceland**	Opera Containerized DC
CISCO	**October 23, 2010 – Cisco announced it has raised the temperature of all of its world wide data center to 27C, which is the upper limit of ASHRAE recommended range**	Cisco Raises All DC Temps to 27C
CISCO	**October 19, 2010 – Cisco announced plans to build data center north of Dallas that will rely on fresh air cooling for 50% of its cooling needs.**	Cisco Fresh Air DC North of Dallas
verizon	**October 13, 2010 – Verizon in discussions to build 900,000 sq.ft. fresh air cooled data center in New York near Yahoo Lockport DC.**	Verizon Fresh Air DC in NY
YAHOO!	**October 8, 2010 – Yahoo announces new fresh air cooled data center in Switzerland based on same novel "coop computing" building design as DC in Lockport NY.**	Coop Design DC in Switzerland
YAHOO!	**October 5, 2010 – Yahoo announces it has eliminated the use of chillers and humidity control in all of its data centers**	Eliminates Chillers & Humidity Control
Bay Area Internet Solutions	**September 29, 2010 – Bay Area Internet Solutions (BAIS) fresh air cooled 83,000 sq.ft. data center in Santa Clara, wins Silicon Valley Power Energy Innovator Award**	Bay Area Internet Solutions
YAHOO!	**September 20, 2010 – Yahoo announces 155,000 sq.ft. fresh air "computing coop" data center with PUE = 1.08 in Lockport NY.**	Yahoo Computing Coop Data Center
DELL	**September 9, 2010 – Dell announces modular DC with outside air or evaporative cooling options**	Dell Modular DC

Significant amount of customer fresh air cooled data center activity just in the last 3 months.

Caveat: the above announcements were what we were able to find through Google search. Other public announcements may have been made that aren't captured here.

Challenge/Problem Details

- **Design and run an experiment to validate that Dell enterprise hardware can operate under fresh air conditions typical of a northern climate for an extended period of time (e.g. 7 years)**



Continuous Operation: 10-35C at 10-80% RH
10% time: 5 - 40C, 5-85% RH
1% time: -5 - 45C, 5-90% RH

Fresh Air Cooling Experiment

Control racks (2)

Experiment racks (2)

- Product divided 50/50 between Fresh Air and ASHRAE conditions. Sample size will resolve differences to 90% confidence
  - Racks, cabling, and CMAs emulate data center configuration
  - Control racks sit in lab air, i.e. ~ASHRAE data center conditions
  - Experiment rack will see 40C, 85%RH both steady state and thermal cycling (5 to 40C) = 7 years of fresh air cooling in worst case EU climate

- Hardware is comprised of 1U, 2U, 4U, and blade form factors as well as AMD and Intel based platforms plus Dell storage platforms

FUTURE PLANS & NEXT STEPS

Future PI opportunities

- **Future industry applications of PI: data center level power and cooling optimizations**
  - ✓ PI can be used to collect time based data from facility and hardware sensors to optimize facility power and cooling
  - ✓ Making the data available in a time-based format is key for enabling data center power and cooling savings
  - ✓ Power & cooling budgets for data centers are many millions of dollars annually

- **Future industry applications of PI: Prognostics "health monitoring"**
  - ✓ Prognostics is a way of predicting hardware failures in advance of when they happen
  - ✓ University of Maryland CALCE has reported successful application of prognostics to several automotive applications
  - ✓ If you had enough advance warning of a hardware failure, you could schedule maintenance or repair to prevent it
  - ✓ Our experimental results hinted that prognostics may be possible for compute hardware, however, more sensitive forms of parametric measurement may be needed
  - ✓ Prognostics requires a foundation of historical time based data that captures failures – PI would be an ideal tool for collecting the data you need to "teach" a prognostic system what an impending failure looks like.

Dell's Future Plans/Next Steps

- PI helped Dell identify several key opportunities we need to evaluate in order to consider expanding operating environment specs of our Enterprise products
- Research proves we employ a high level of design rigor already
- Opportunities for continued improvement are under review
  - Even more robust product offerings
  - Improved quality and reliability
  - Improved customer Satisfaction and Customer Experience
  - Warranty cost reductions
- We are closely following important industry developments affecting data center operation such as:
  - Regulatory changes (EU Code of Conduct, ASHRAE 90.1)
  - Customer data center usage trends

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THANK YOU!