How IBM Optimizes Energy Consumption Across Its Datacenter Space with Tivoli Energy Management

Energy Management in Data Centers from 500 ft^2 to 150000 ft^2

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Reduce, Re-Use, Recycle

How IBM Optimizes Energy Consumption Across 150,000 sqft of Datacenter Space with Tivoli Energy Management

- Introduction
- Goals of Energy Management
- Datacenter Characteristics
- Deployments
  - Austin DEMO Central Datacenter
  - Green Innovation Datacenter
  - Raleigh Leadership Datacenter
  - Poughkeepsie Datacenters
- Wrap Up
- Questions

Goals of Energy Management

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Common Goals Across IBM Data Centers

- ***Thermal Monitoring***
  - Maximize Cooling
  - Predict Capacity
  - Detect Hot Spots
- ***Power Monitoring***
  - Capacity
  - Detect Faults and Overloads
  - Usage/Capacity
- ***IT Monitoring***
  - Fault monitoring
  - Capacity
  - Optimizing
- ***Asset Management***
  - Space Planning
  - IT & Facility assets
  - Location / Area Tracking
  - Maintenance Scheduling

- **400+ data centers**
- **8+ million square feet of space**
- **1,200+ Mainframes**
- **1,100,000+ MIPS**
- **11,000+ Terabytes**
- **200,000+ Mid Range Servers**
- **3,700,000+ equipped user seats**
- **5 million square feet work area**

	IBM			Client	
	Sites	Sq Ft (m)	mW	Sites	Sq Ft (m
LDC (Raleigh)	1	.06	6		
Americas	90	2.0	42.2	107	2.8
Asia Pacific	42	1.2	10.8	85	.8
Europe	85	.6	27.4	53	.6
TOTAL	217	3.8	80.4	245	4.2

Data Center Characteristics

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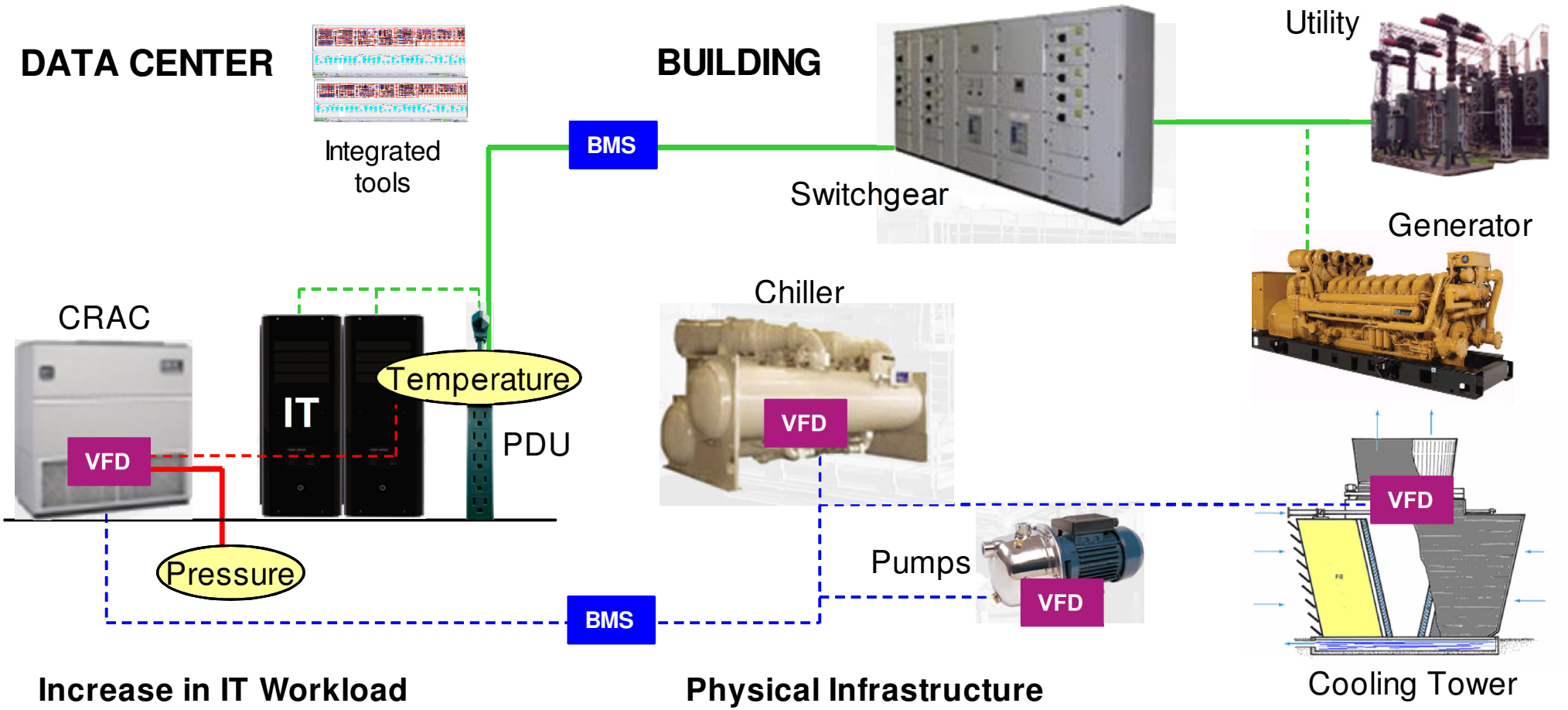
IBM Data Centers - Physical Characteristics & Comparison

Metric	Leder	eigh
DCiE	52%	62-71%
Max total U	41	7.5
Reliability	2	2
UPS Catch	No	No
LEED certi		Entry
Max rack r	4	19.2
Standard U	No	No
Support fo	No	No
Circuit lev	No	No
IT and Fac	No	No
Viewing or	No	Yes
Elevated t	No	No
High effici	No	Yes
Water side		Yes
Variable s	No	Yes
In row coo	No	Some
Direct wat	No	Yes
VESDA or	No	Yes

RTP solution: DCiE 62%-71% (PUE 1.4)

- Water side economizer for free cooling
- Variable speed CRAC and chillers
- High efficiency equipment especially UPS systems with static double-conversion
- Elevated temperature and humidity criteria
- Hot/cold aisle configuration as standard operational practice
- Software management tools to integrates IT data center Infrastructure with sophisticated control systems
- Establish server utilization and virtualization metrics
- Provisioned for potential water cooling
- Piping system sized for max capacity
- Modular UPS design
- Modular chiller plant design
- Electrical switchgear sized to grow
- Electrical dist. scaleable per module

Instrumentation & connectivity allows dynamic adjustment of physical infrastructure to changes in IT workload



Increase in IT Workload

- Integrated tools enable optimal placement of additional IT workload in the data center.
- Temperature sensors provide visibility to changes due to increased IT workload.
- Interconnectivity between IT and physical infrastructure communicates need for additional cooling.

Physical Infrastructure

- Design of facilities infrastructure equipment with variable speed drives provides “on demand” cooling.
- Use of variable speed drives in chiller plant automatically responds to the increased cooling requirement with just the right amount of additional capacity.

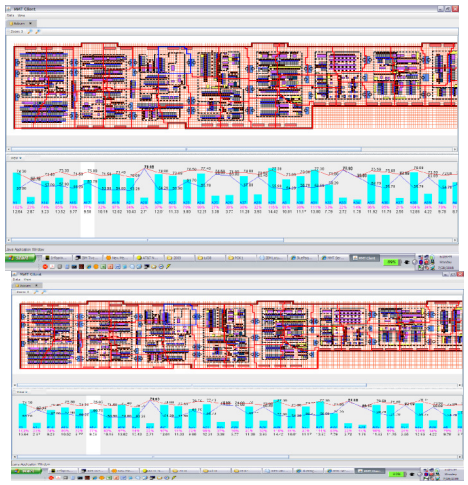
Integration allows for improved asset purchase and placement decisions to help meet service level objectives throughout lifecycle

Do I have the capacity to install new servers?

IT & Facilities Dashboard

- Real-time data for visibility to how much system capacity is available at all times.
- Improve visibility to power and cooling utilization for planning of new equipment.
- Include data center and facility assets in the service model.

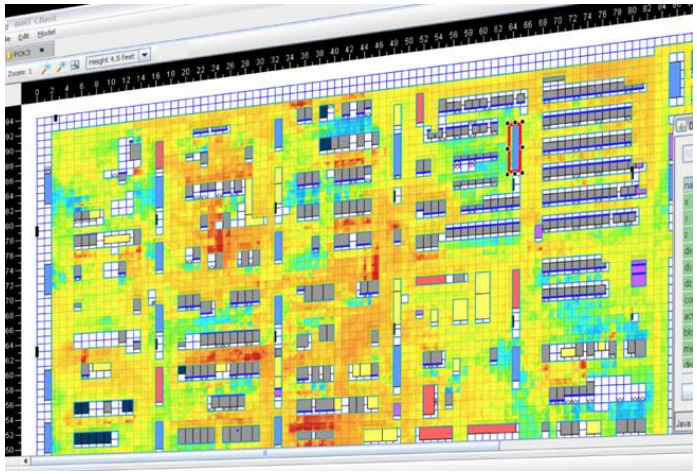
Where can I locate the new servers?



Asset Planning Information

- Collection and integration of assets and metered data with CAD layout to select optimal location in the service model.
- Reduced time and cost to deploy new IT equipment.
- Continuous feedback on utilization of critical systems.

How to run at higher ASHRAE standards yet avoid hot spots?



Thermal Analysis for Placement

- Analyze “what if” scenarios with Measurement and Management Technology (MMT) CFD modeling.
- Operate at higher ASHRAE temperatures (72-80° F); reduce energy costs & maintain availability.
- Use IBM asset management to keep model content up to date.

Deployments:
Austin DEMOCentral Datacenter

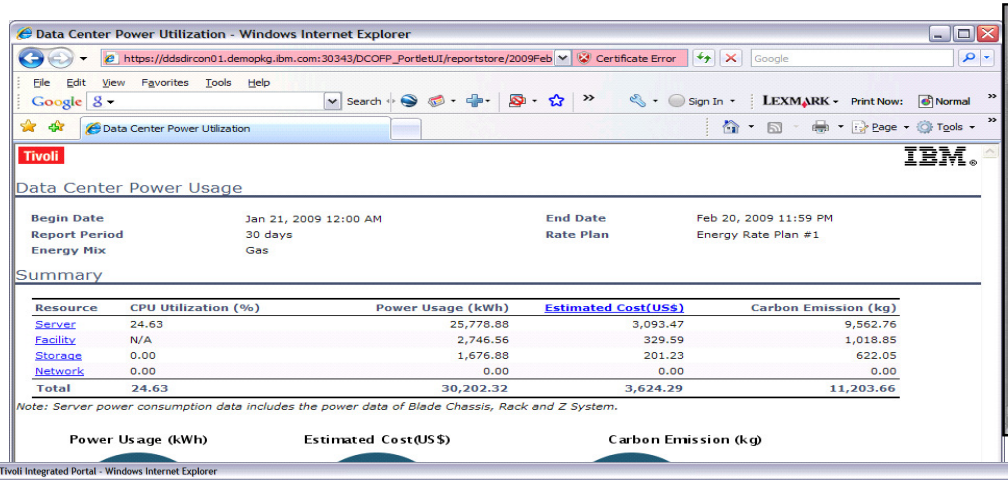
Austin DEMOCentral - Backgroud

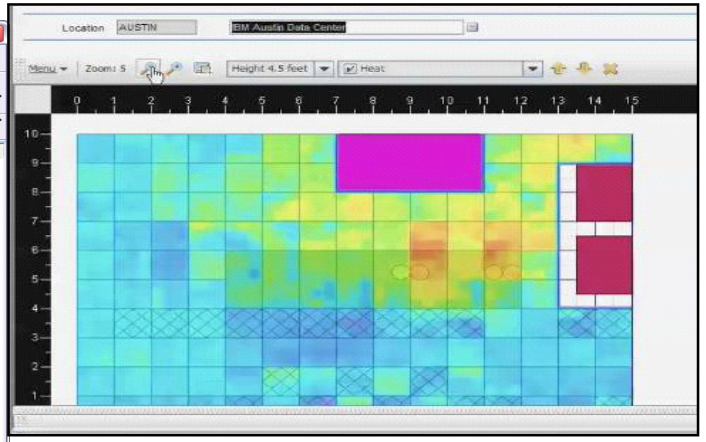
- Motivation
  - The original Data Center ran out of power, which prevented new equipment from being deployed and eventually necessitated a costly move to a new location.
- Goals
  - Reduce Energy Usage
  - Predict Power Capacity
  - Optimize cooling
  - Monitor IT Performance and Availability
- Characteristics
  - Mission: Run Demos for the Worldwide IBM Sales Force, delivers 3000+ demos per day, 24x7
  - Small: 4000sqft, 130kW, with room for growth to 300kW
  - Legacy Space with <12” raised floor, Legacy “Dumb” Facilities Equipment, New Instrumented IT Equipment
  - Full Control of Systems and Software
  - Some cooperation with Facilities

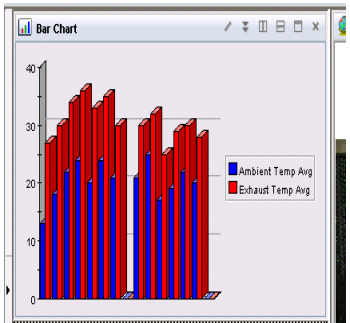
Austin DEMO Central – The Solution

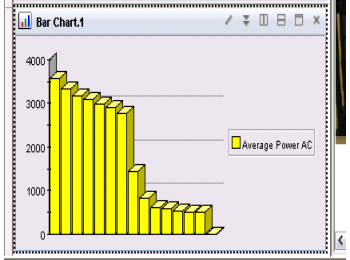
- Hardware and Facilities
  - Instrument legacy UPS (15 years old) with new SNMP management card to provide total lab power and UPS fault
  - Integrate to Building Management System to get Lab Temp and Chilled Water Temp at the Chiller Plant
  - Integrate to Rack Mount UPS to provide facilities alerts
  - Pull input, output and core temperature and power utilization from IBM server
  - Deploy Active RFID Sensors to measure temp, humidity, and occupancy
- Software:
  - IBM Tivoli Monitoring and IBM Tivoli Composite Application Monitoring for OS, Hypervisor and Application Monitoring
  - ITM for Energy Management, with Systems Director Active Energy Manager, for monitoring Energy Usage through the UPS, BMS and IT Systems
  - Tivoli Common Reporting, using ITM for EM out of the box reports, to calculate energy usage and carbon footprint
  - Maximo for Energy Optimization to visualize hot spots in the datacenter
  - Tivoli Business Services Manager to put the Energy information in context of the business.
- Work in Progress
  - Retrofitting legacy Air Handlers for temp and motor voltage/current

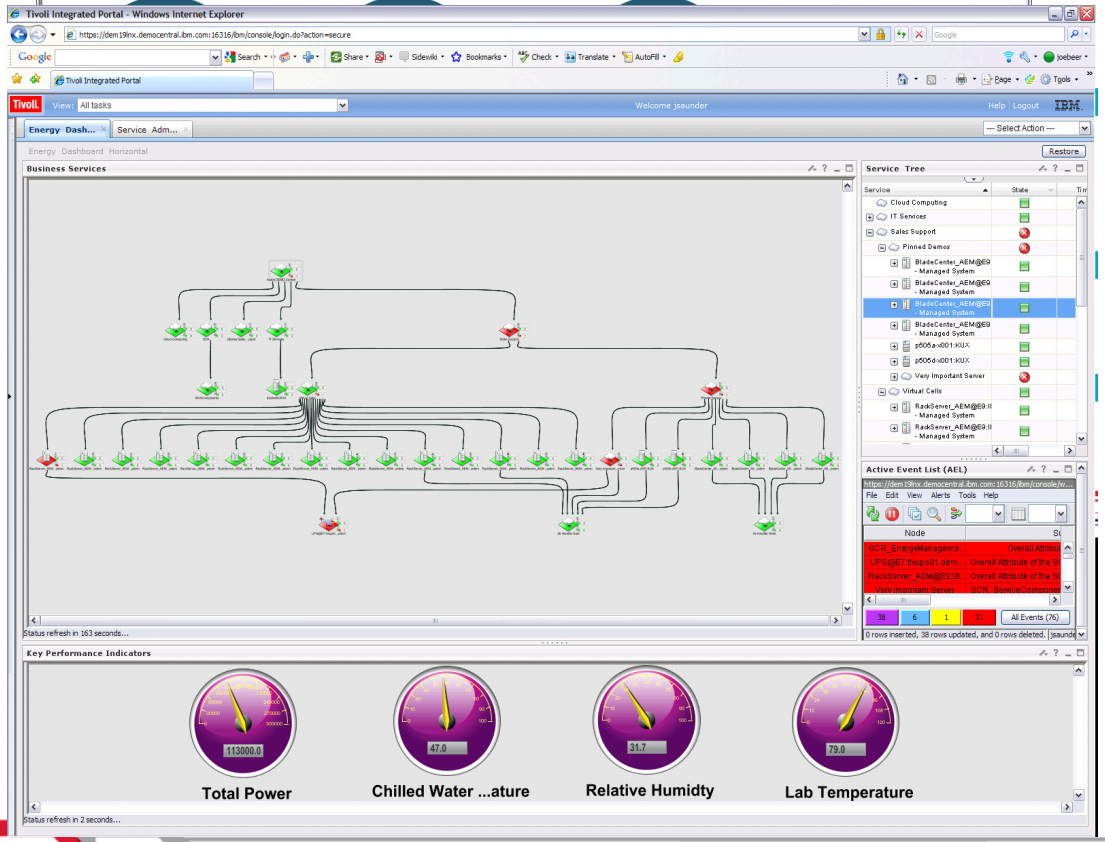
Austin DEMO Central – Screen Shots

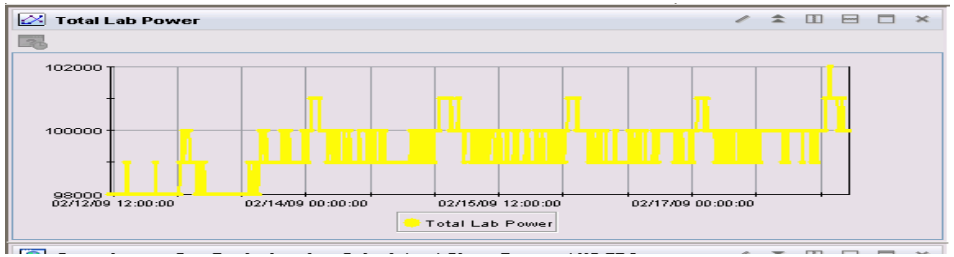


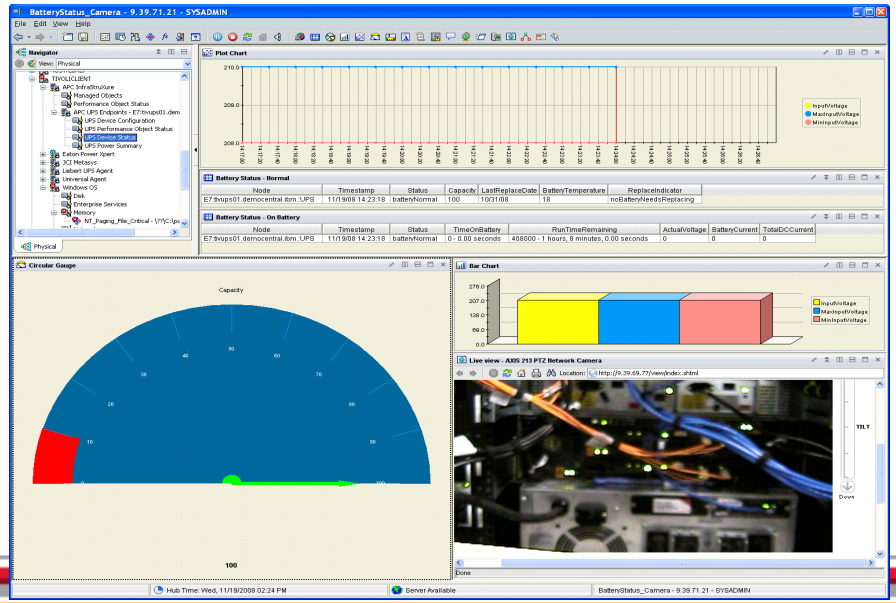












Austin DEMOCental – The Results

- Results
  - Energy Use in the lab has dropped by 20% while processing capacity has increased by 50% and storage capacity has increased by 200%
    - Energy Monitoring indicated the need for and provided the justification for projects to virtualize workloads, consolidate servers and replace inefficient hardware
  - Lab Temperature was raised to the point where humans were no longer comfortable
    - Perfect knowledge of input temperatures on all machines allowed the temperature to be raised
  - Facilities Alerts are placed in context of the business services allowing lab admins to respond to events more quickly
- Lessons Learned
  - The full path from the BMS to the Monitoring system must be on battery back-up. Since BMS components exist outside the data center, they may not be hardened against power outages
  - Tivoli Application and Discovery Manager Level 1 scan was useful for determining energy monitoring coverage

Deployments:
Green Innovation Datacenter

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Green Innovation Data Center - Background

Motivation

- By 2006 the data center had reached the limits of its
- power and cooling capacity and resources were spread
- across four locations
- Significant growth in innovation within IBM created a large demand for innovation IT resources

Goals

- Initiated project in 2007 to improve and optimize our:
  - facilities resources (power and cooling)
  - infrastructure utilization (virtualization)
  - system administrator resources (optimization)
- Create an operational sandbox environment for testing and showcasing IBM's green technologies

Data Centers' Before Characteristics

- Four separate data center locations
- Inefficient infrastructure deployment
- Facilities expenses too high and not efficiently utilized
- Administrator resources were stressed managing multiple installations

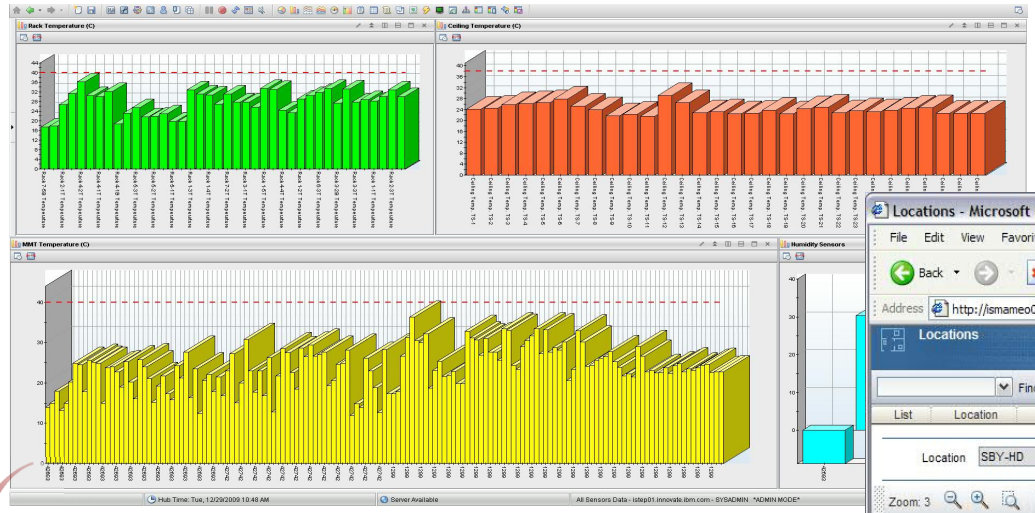
Green Innovation Data Center – The Solution

- Hardware and Facilities:
  - Variety of IBM IT platforms (Systems i, p and x)
  - Servers provide power and temperature data via systems Director / AEM
  - VFD Computer Room AC units, PDUs with branch circuit monitoring
  - 130+ temperature and pressure sensors, flow meters and probes deployed
  - Rack level cooling and data center zoning to optimize cooling efficiency

- Software Deployed:
  - IBM Tivoli Monitoring (ITM 6.2.1.0.2)
  - Tivoli Usage and Accounting Manager (TUAM)
  - Tivoli Data Warehouse (TDW DB2v9.5)
  - Tivoli Composite Application Manager (ITCAM 6.1.0.4)
  - Tivoli Provisioning Manager (TPM)
  - Tivoli Storage Manager (TSM)
  - Tivoli Identity Manager (TIM)
  - IBM Tivoli Directory Server (ITDS)
  - IBM Tivoli Monitoring for Energy Management (6.2.1)
  - BM Tivoli Monitoring for Energy Management Reporting and Optimization (6.2.1)
  - Tivoli Common Reporting (TCR 1.2.0.1)
  - Maximo Energy Optimization (MEO 7.1.0)
  - Tivoli Business System Manager (TBSM 4.2.1)
  - IBM Systems Director (Director 6.2.1.2)
  - Active Energy Manager (AEM 4.2.1)

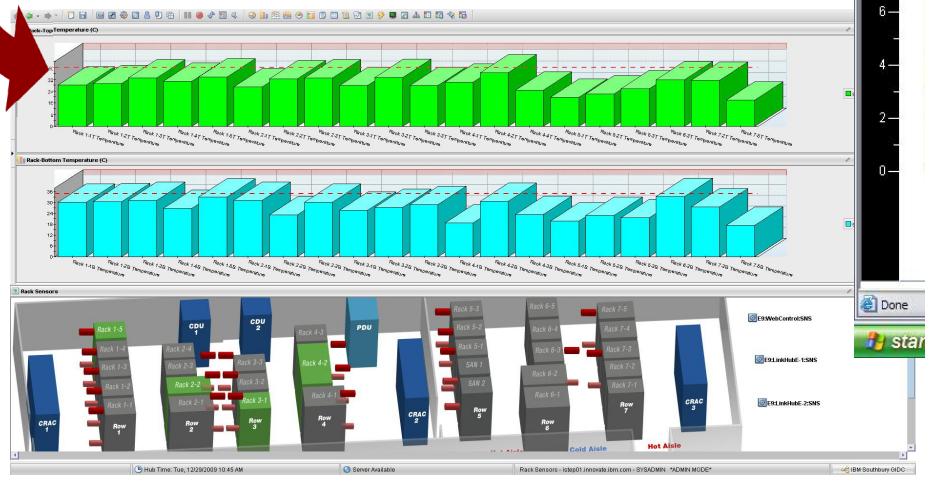
Green Innovation Data Center – Tivoli and MEO Screen Shots

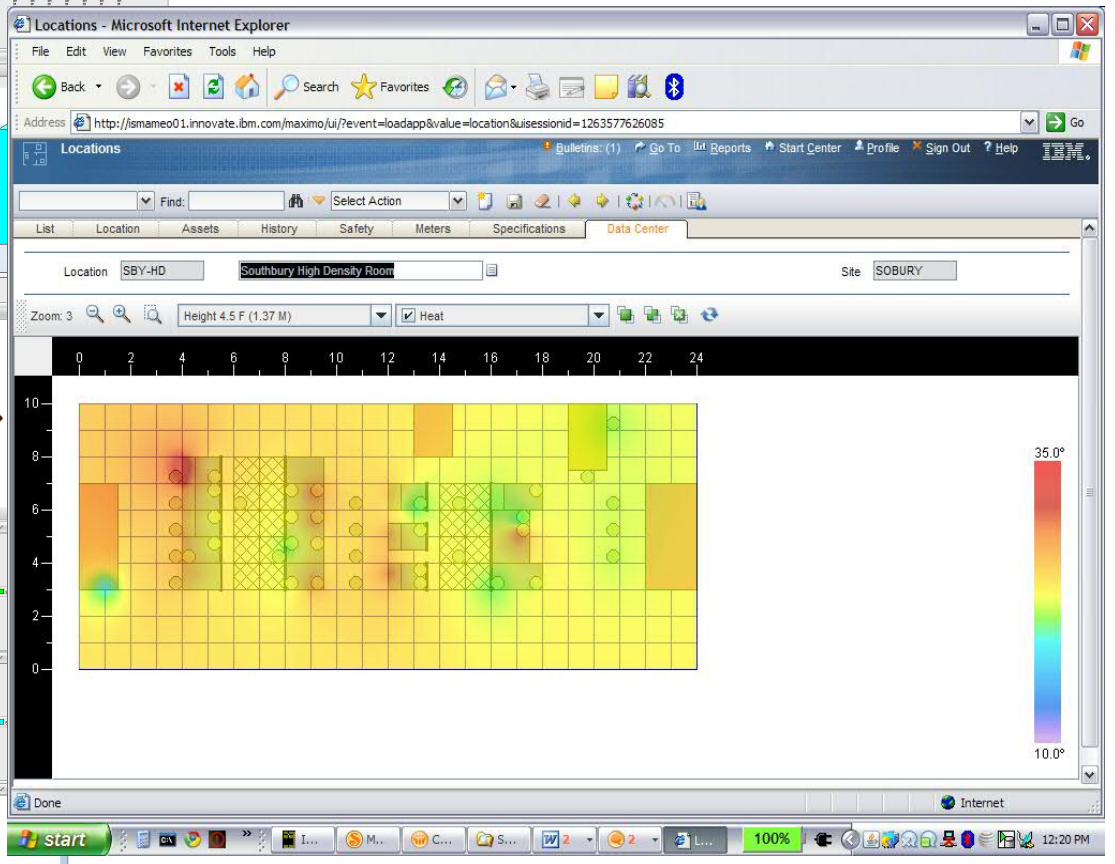
Sensor readings are visible in the TEP...



MEO provides a SMART Thermal Mapping of high density zone assets

... and can be visualized against limits and their orientation in the data center.





Green Innovation Data Center – The Results

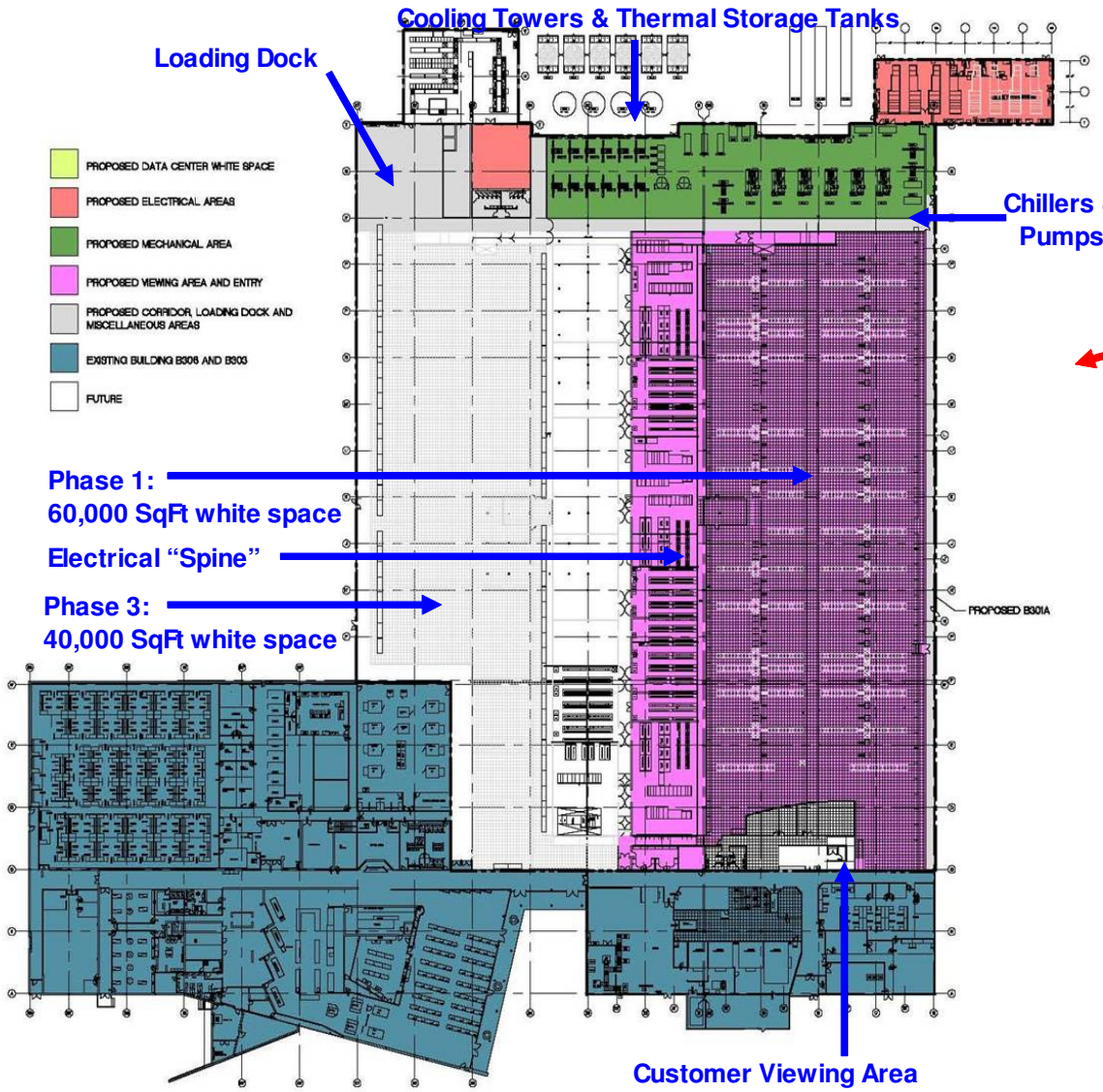
- Results - Green Innovation Data Center Characteristics
  - Consolidated all Innovation IT Infrastructure into one location
  - Reduced number of servers to 1/8th original number
  - Virtualized almost 100% of the data centers workload
  - Reduced overall power and cooling requirements
  - Decreased annual data center operating expenses
  - Increased visibility of virtual machines, guests, and server performance
  - Increased awareness of energy use and thermal trends

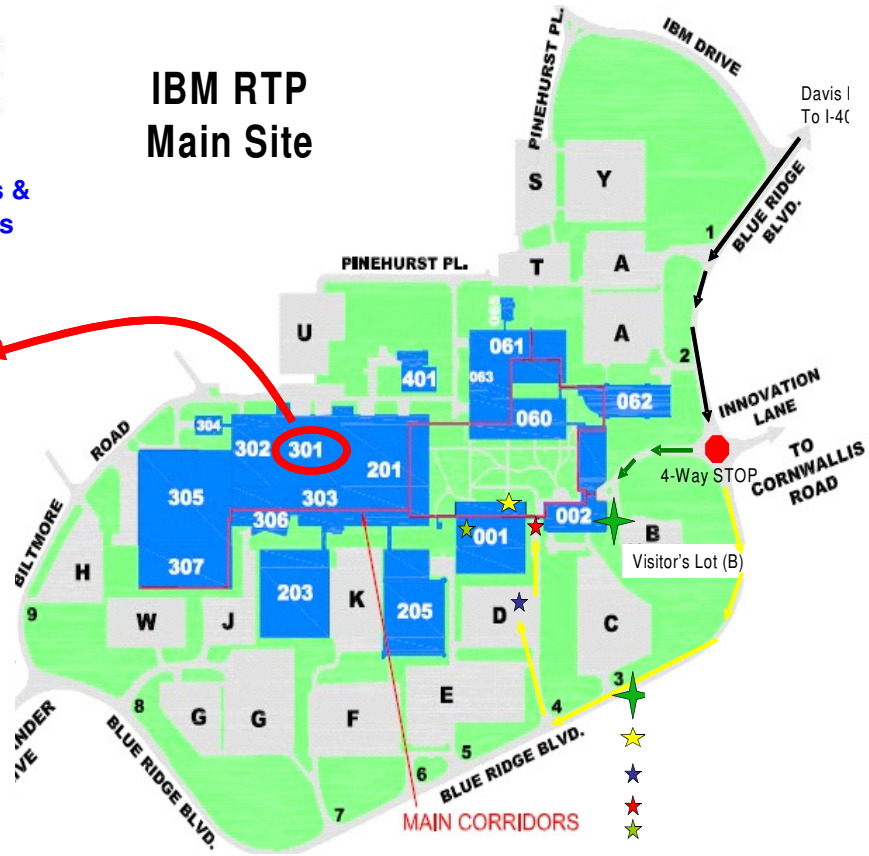
- Lessons Learned
  - You cannot correct what you cannot measure
  - Integrated data and dashboards can provide a powerful set of tools to infrastructure / operations team
  - Awareness of energy use can foster an atmosphere where people want to save energy
  - Linkages between data center thermals, energy use and system performance can help troubleshoot issues
  - MEOs combined asset management and thermal capability is powerful

Deployments:
Raleigh Leadership Data Center

Optimizing the Power / Thermal Environment

RTP (Research Triangle Park) LDC Site / Floor Plan





B/301 Data Center Layout

Raleigh Leadership Data Center

Objectives

- ***What are the Leadership Data Center Objectives?***
  - *develop innovative strategy to maximize DC resiliency, efficiency & flexibility*
    - *integrate IT and facilities infrastructure*
    - *infuse state-of-the-art hardware and software technologies*
  - *drive proactive versus reactive data center operations management*
  - *establish sustainable processes & tools to facilitate lifecycle management*
  - *optimize economic & environmentally responsible designs and operations*
  - *provide foundation for Cloud, NEDC, and Dynamic Infrastructure initiatives*
  - *Develop a template for deployment to ITD's other 60+ strategic data centers*

Resiliency *- proactive designs, processes, compliance, monitoring, and controls*
Efficiency *- operational best practices; optimally balanced use of power & thermal resources*
Flexibility *- modular deployment of facility systems; pre-installed power density infrastructure*

Raleigh Leadership Data Center

Background

- **What is unique about the Green Data Center?**
  - *LDC is the initial pilot for IBM's 60 strategic worldwide data centers*
  - *Accommodates nearly 800 virtually autonomous commercial accounts*
  - *Contains massively heterogeneous IT equipment & facility HW/SW infrastructure*
  - *Scope requirements exceed scalability of many traditional management systems*
  - *Size, proximity, & organizational complexity requires formalized lifecycle processes*
  - *Volume necessitates selection of most cost effective solutions (e.g. BCM vs IPDUs)*
  - *Lifecycle processes & applications must encompass current & forecasted demands*

Facility *- state-of-the-art infrastructure*
- extensive, modular growth capability
- low cost energy region and 1.4 PUE

Tools *- synchronized asset inventory*
- IMAC lifecycle placement model
- scalable power / thermal management

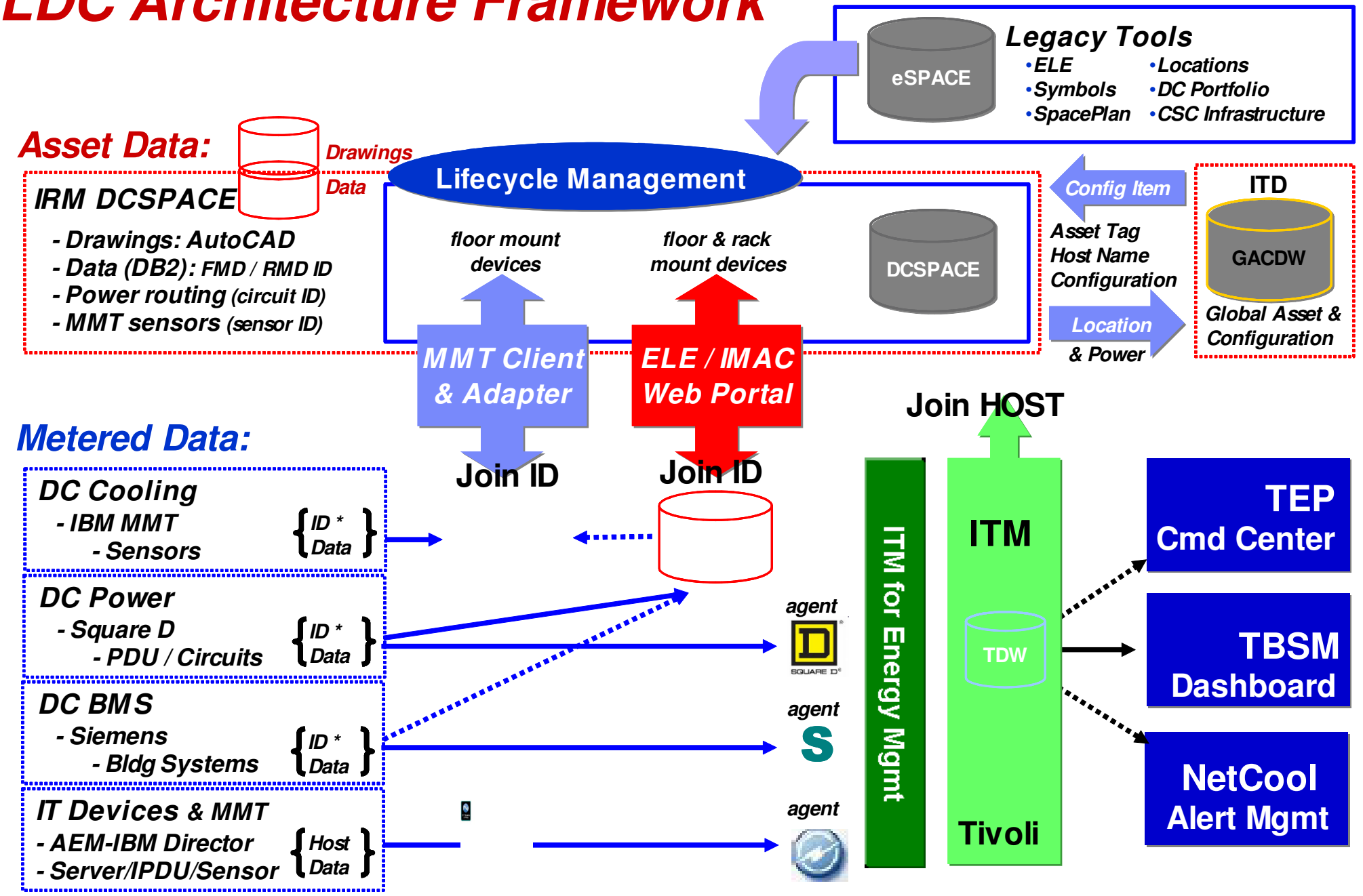
Raleigh Leadership Data Center

Solution – Phase 1

– processes & tools for facility operations, asset inventory, & lifecycle

- ***Facility management (Siemens, SquareD PowerLogic, CSC)***
  - *enterprise hosted BMS (building management system) for US strategic sites*
  - *alerts and event handling for all major infrastructure managed by RESO facility engineering*
- ***Space management (AutoCAD / DCSPACE, DB2)***
  - *graphical floor layouts & rack / cabinet / chassis elevation data*
  - *calculated areas and pinpointed locations, synchronized with all DC applications*
- ***Power management (PanelsPLUS, OSIsoft Pi Server)***
  - *circuit traceability to ensure dual feeds to equipment & isolate rack utilization metrics*
  - *capacity versus utilization metrics at PDUs, panels, and branch circuits, linked to racks*
- ***Thermal management (MMT Client, AutoCAD / DCSPACE, DB2)***
  - *operational environmental monitoring & guidance to optimize CRAC & chiller utilization*
  - *alerts, event handling, and eventual autonomic control of CRAC VFD units*
- ***Asset Management (DB2, SpacePlan, ELE, IMAC Portal, MMT Adapter, GACDW)***
  - *service management & change management integrated with official ITD governance*
  - *IMAC (install, move, add, change) processes & tooling to support placement & registration*
  - *real-time CFD modeling via MMT Adapter synchronization with AutoCAD / DCSPACE, DB2*
  - *compliance checks via ITD GACDW (global asset & configuration), and eventually RFID*

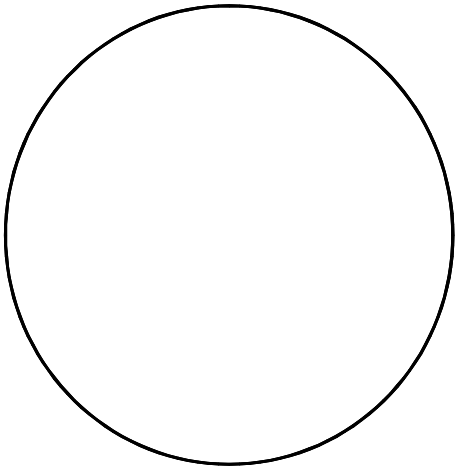
LDC Architecture Framework



IMAC (install, move, add, change) Lifecycle Portal

Initialize IMAC Plan

- Downloads Excel to SpacePlan
- Updates SpacePlan kW forecast
- Imports Excel worksheet to DB2
- Synchronizes ELE / CAD Symbols



IMAC ELE Device (Baseline)

- Manages baseline adjustments
- Tracks all devices & quantities
  - Base, Qty, In Plan, Deployed
  - Standalone & Rack Mounted
- Links via SpacePlan Reference #
- Secures by Blue Group & Contact roles
- Queues equipment for subsequent panels
- Notifies Space/HW Planning of changes

FMD- Standalone Panel

- Select devices for current plan
- Associate data center location
- Enter AssetTag information as prereq to register installation

FMD- Rack / RMD Panel

- Build existing / virtual rack
- Position selected devices (RU)
- Enter AssetTag; register installs

Chassis / Shelf Pop-up

- Denote devices / quantities
- Build chassis / shelf plans
- Pass results back to RMD panel

Workflow (notification)

- Acct Plan → HW Planner

AutoCAD (location)

- Add FMD to floor
- Accept / override kW
- Proceed with MMT v1.5

MMT (validation)

- Analyze Thermal Data
- Validate Floor Location
- Proceed with IMAC FMD

IMAC FMD Portals

- Register Floor Location

Workflow (notification)

- HW Planner → Installer

IMAC FMD /RMD Portals

- Enter AssetTag information

Workflow (notification)

- Installer → Space/HW Planner

Data Management

- GACDW validation
- IMAC Baseline update
- DCSPACE synchronization

Raleigh Leadership Data Center

Solution – Phase 2

- facility & IT environmental data to Tivoli

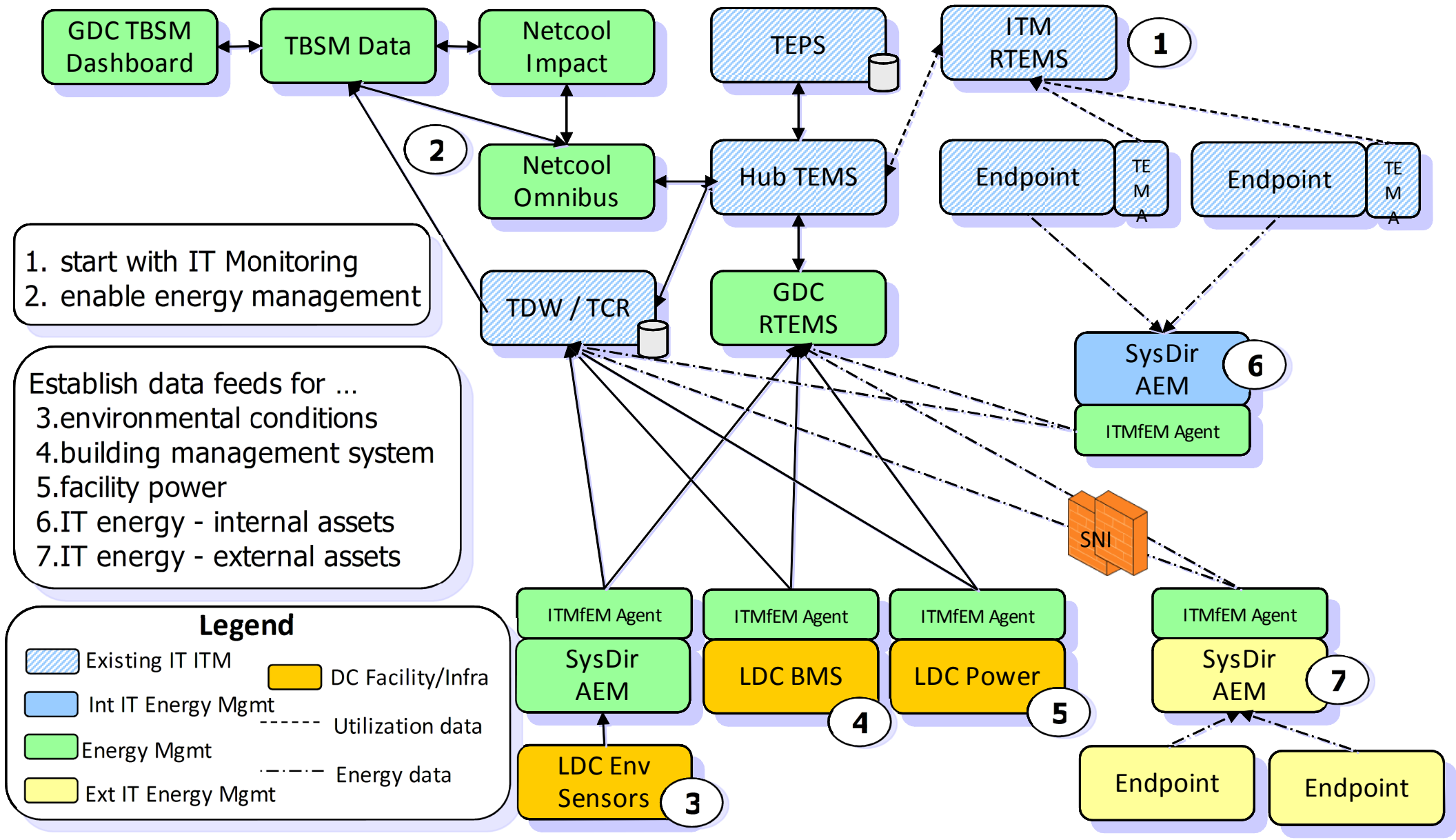
- extended capability for lifecycle compliance tools

- ***Data acquisition***
  - *establish API interface to RESO's BMS (bldg mgmt system) for site power / thermal data*
    - *Initial interface will leverage Siemens as a single interface*
    - *Power metrics will be collected for PDU systems and above*
  - *channel MMT thermal data through Systems Director, AEM, ITMfEM, TDW, NetCool*
  - *enable collection of component (IT / IPDU) environmental data via same path as MMT*
- ***Data reporting / visualization***
  - *collected data will support reports & visualization via TBSM, TCR, and TEP*
- ***Alert & event management systms***
  - *NetCool Impact & Omnibus provides for alerts & event handling by defined roles / thresholds*

Expanded capability for Phase 1 deliverables

- *asset management – RFID; MMT rack / tile level analytics; SpacePlan to WebSphere / DB2*
- *alerts & event handling - Transpara consolidation / mobile output, MMT autonomic controls*

LDC Tivoli Architecture Configuration (Production)



Raleigh Leadership Data Center

Solution – Phase 3

- integrated & autonomic controls; highly leveraged Tivoli products

- ***Rules-based Event Handling***
  - *Autonomic adaptation to environmental conditions (CRAC / VFD control)*
  - *Spans scope from device level to data center level*
  - *Preemptive response to potential problem situations (CRAC failures)*
- ***Workload Balancing***
  - *Servers*
  - *Storage*
- ***Cloud Management / Dynamic Infrastructure***
- ***IT Optimization***
  - *Metrics for Capacity vs Utilization*
  - *Managed Virtualization / Consolidation*
- ***Consumption-based Management***
  - *Chargeback methodology (initially using ITD allocation methods; later potential for ITUAM)*
  - *Behavior Modification / Incentives*

RTP Leadership Data Center - Lessons learned

Align goals for consistency across organizations

- Technical and management team buy-in is critical when you need to deploy end-to-end processes and applications
- Establish cross-organizational governance, accountability, prioritization, and support to ensure mission success.
- Deliver world-class offerings via consultation and collaboration across in-house product, service, research and delivery organizations.

Identify needs versus capabilities to be successful

- Identify affected organizations, locations, workforce and assets.
- Persistently pursue resource needs to secure headcount and funding
- Be flexible – balance internal and partner capabilities
- Assess process and product maturity to support mission requirements, determining pre-requisite infrastructure, data, and integration needs.

Drive project management discipline

- Follow PM discipline, including sponsorship, charter, initiation & plans. Clearly define responsibility for escalation points, resource allocations.
- Ensure comprehensive processes are formally owned and enforced.
- Manage transition to steady-state operations, including IT support and adequately staffed, skilled, trained, and willing workforce.

Deployments:
Poughkeepsie Datacenter

Poughkeepsie Data Center

"A Holistic Approach to solve a problem"

Execute

Plan

Analysis

History

10 year old RF

Evolved by adding 8 other groups **new workload** and **hardware** with no regard to the holistic impact

No instrumentation for thermals, power, or utilization

Changes made did not take into account the impact to the facilities

High temperature alarms started going off in 2Q/08

Mobile Measurement Tool analysis showed the whole floor was hot

No best practices observed in terms of creating **Hot/Cold aisles**, open holes in racks, no control of air flow, poor cable management

Any changes had to be done with **no impact to workloads,** and improve flexibility

We introduced **Rear Door Heat Exchangers** using water to remove heat, applied best practices for RF layout, and rack organization, increasing density and proper cable management

Instrumentation was added to allow for monitoring and we integrated all the data into a holistic dashboard view

A **Computational Fluid Dynamics** model was used to achieve an optimal layout before making any physical changes

A Transformational model was used rather then a big bang approach to minimize any impact to the workload running

We took advantage of **free cooling** (Air, River) with site chilled water creating a **water cooled zone** and an **air cooled zone**

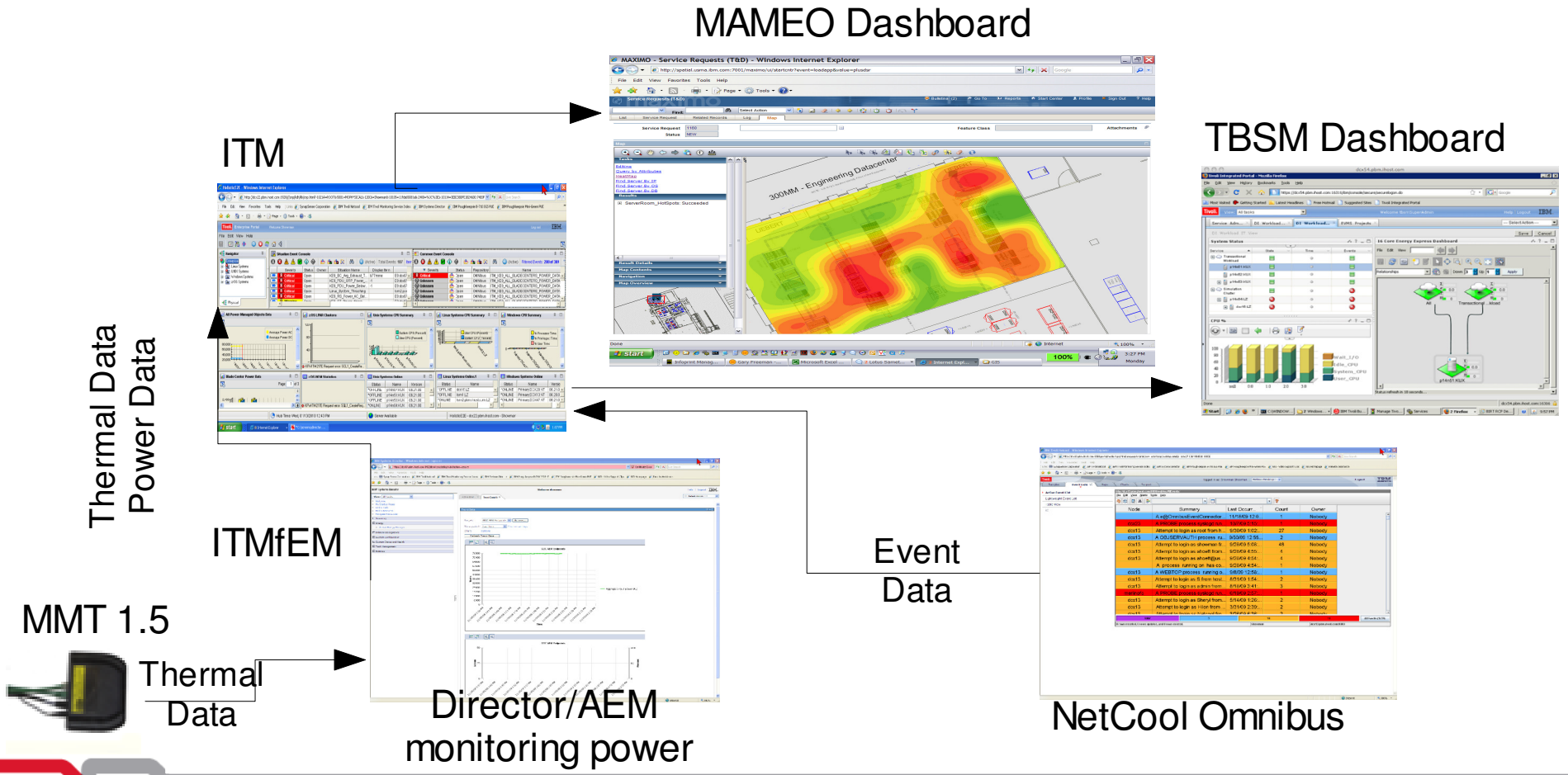
We increased server density and virtualization

We installed **thermal sensors, PDU+'s for Power, software probes and agents**

Poughkeepsie Green Data Center

The new layout and technology introduced not only fixed the cooling problem, but freed up 660sqft. of RF for additional HW, reduced cost of cooling, giving us a ROI of 10 months. In addition the PUE (Power Usage Effectiveness) for the RF is 1.2.

The instrumentation, monitoring and management solution included a holistic approach that covered thermal monitoring all the way up to event management.



Wrap Up

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Conclusions

- Different datacenters present unique challenges which will require slightly different approaches to the problem
- However, common goals and common tools emerge in each case
- Tivoli provides the building blocks to put together an Energy Management solution that brings Energy into the context of the business.
- The Tivoli building blocks have proven valuable in a variety of internal deployments ranging from 500sqft to 150000sqft

Questions?

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