Measurement and Management Technologies (MMT)

Data Center Solutions for a Smarter Planet
What is MMT?

Data Center Measurement and Management Technologies

- Real-time and High resolution Measurements
  - Measurement-based Modeling
  - Management and Control

High resolution measurements are made using IBM’s Mobile Measurement Technology
## Measurement and Management Technologies

<table>
<thead>
<tr>
<th>Measurement Survey and Analysis (MMT 1.0)</th>
<th>Dynamic Monitoring and Management (MMT 1.5)</th>
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</thead>
<tbody>
<tr>
<td>- 3D dimensional mapping tools for detailed environmental measurements&lt;br&gt;- Adapters to existing data sources (BMS, asset db)</td>
<td>- Permanent sensors enable analytics and alerts&lt;br&gt;- Wired and wireless solutions&lt;br&gt;- External and internal (via AEM, ITMfEM)&lt;br&gt;- Temperature, humidity, pressure and flow sensors supported on the same network&lt;br&gt;- Corrosion, power, and acoustic capabilities are being developed.</td>
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</table>

**MMT provides high time & spatial resolution combining:**
- High resolution measurements / assessments for base model generation, sensor placement etc.
- Real-time sensing for feeding dynamic models
<table>
<thead>
<tr>
<th>Wireless sensors</th>
<th>Wired sensors</th>
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</thead>
<tbody>
<tr>
<td>▪ Using IBM Low-Power Mote Technology</td>
<td>▪ Sensor grid solution with 1-wire protocol</td>
</tr>
<tr>
<td>▪ Long battery life</td>
<td>▪ Access points every 2-4' for temperature, flow, pressure,</td>
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<tr>
<td></td>
<td>and relative humidity (all with the same network)</td>
</tr>
<tr>
<td><img src="image1.png" alt="Diagram of wireless sensors" /></td>
<td><img src="image2.png" alt="Diagram of wired sensors" /></td>
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<tr>
<td>▪ Install strategy allows maximum flexibility for sensors to be moved, removed,</td>
<td><img src="image1.png" alt="Diagram of wireless sensors" /></td>
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<tr>
<td>and added to web client</td>
<td><img src="image2.png" alt="Diagram of wired sensors" /></td>
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<tr>
<td>▪ Sensors are bar-coded and location / ID is tracked on MMT</td>
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<tr>
<td>▪ Temperature, humidity, pressure, and flow sensors are supported on the same</td>
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<td>network</td>
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MMT Measurement and Survey Analysis

Solution Approach – *Three Steps*

1. **Measure**
   - Capture *high resolution temperature data, air flow data, infrastructure & layout data*

2. **Analyze / Model**
   - To identify improvement opportunities
   - *model the data center* and use optimization algorithms (*“best practices rules”*)

3. **Implementation of “Best Practices”**
   - Realize air transport energy savings
   - Realize thermodynamic energy savings
   - Achieve reduced energy consumption
   - Potential for deferring new investments
Sample Measurement and Survey Analysis - Summary

- **Surveyed 50,000 square feet of raised floor**
  - One-half million thermal, humidity and flow measurements
  - 1000 rack inlet temperatures with ~ 5000 servers were measured
  - measured air flow from all perforated tiles (total of >1600 flow measurements)
  - inspected all 54 / 54 (active) ACUs*
  - measured / estimated all relevant DC power levels

- **Energy saving opportunities of up to 3.3 MWh (~17% of IT)**
  - improve ACU utilization level from 59% to 75% (turn 14 ACUs off)
  - higher ACU utilization will reduce plenum temperature by 3 F
  - reduce hotspots by 7 F in key areas using air flow management techniques
  - increase chiller set point to increase chiller coefficient of performance
  - leverage plate heat exchanger to bypass chiller and increase free cooling durations

<table>
<thead>
<tr>
<th></th>
<th>$0.06 / kWhour (actual)</th>
<th>$0.14 / kWhour NY,NJ,CA (estimated)</th>
<th>$0.09 / kWhour National Avg (estimated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual potential energy reduction of 3.3 MWh</td>
<td>$201,000</td>
<td>$468,000</td>
<td>$301,000</td>
</tr>
<tr>
<td>Potential 3 yr savings</td>
<td>$603,000</td>
<td>$1,404,000</td>
<td>$903,000</td>
</tr>
<tr>
<td>Energy Savings/sf per year</td>
<td>$3.94</td>
<td>$9.18</td>
<td>$5.90</td>
</tr>
<tr>
<td>Energy Savings/sf for 3 years</td>
<td>$11.84</td>
<td>$27.54</td>
<td>$17.70</td>
</tr>
</tbody>
</table>

6-month payback, 100% ROI on energy alone at $0.06 / kWhour
MMT Dynamic Monitoring and Management

Development of a real-time Measurement and Management Technology (MMT 1.5)

- Data centers are dynamic
- MMT 1.0 is sparse in time but dense in space
- Real-time sensors are sparse in space but dense in time
- MMT 1.5 provides high time & spatial resolution
- Combining MMT 1.0 for base model, sensor placement, etc. and real-time sensors for creating dynamic models
**MMT Dynamic Monitoring and Management**

**MMT Client provides**
- detailed ways to manage DC by an MMT layout editor
- real-time, 3D temperature distributions with cross-sections, inspections etc..
- alarm/threshold services
- efficiencies in real-time and corresponding cooling zones
- reports and efficiency summaries
Dynamic Monitoring and Management - Benefits

- Maintain high saving rates
- Implement new ASHRAE guidelines
- Provides additional means to increase ACU utilization
  - Currently average ACU utilization levels are still below 50% (2x over capacity)
  - 1% improvement of ACU utilization can save 0.5 % of power
- Manages change in data center
  - Equipment placement
  - Dynamic cooling capacity to match cooling to IT power
- Provides unique visibility and control into the DC space
  - Dashboard / summary views developed
- Global IBM Systems Lab Services and Training support & Tivoli Maximo SW support
- MMT 1.5 is an open/integrated system with ongoing IBM Research development
Dynamic Monitoring and Management – Active Data-Center Management (Client example A)

Four types of Savings
- Energy Savings
- Delay of capital investments
- Increased reliability (cost avoidance)
- Lost revenue avoidance

Customer Example:
- DC power changes all the time
- without active management, ACU utilization followed power density (blue curve)
- customer started to use MMT 1.5 to actively manage ACUs to maintain constant 75% utilization level
• rapid ROI can be accomplished by active management to a prior ACU utilization level
• after ~ 30 weeks more than $1 / sqf of hard savings (@ $0.12 per kW hour)
• another 20% more energy savings are possible if managed to design point
• operation at 85% of ACU utilization allows also increasing the power density from 77 to 93 W/sq ft, which can save an additional ~ $25 / sqf per year * in capital cost avoidance

* @ ~ $1000/sqf construction cost and 5% COC over 25 years
Dynamic Monitoring and Management
- Hard Savings (Client example B)

- MMT provided energy savings without compromising inlet temperatures (reliability of IT equipment)
  - hotspot mitigation was very effective driving down average inlet temperatures
  - specific actions reduced significant hotspots locally
    - in one example, MMT alerted the client to adjust “sub-optimum” ACU settings, which had caused significant hotspots
    - the BMS did not detect problems with the ACU settings
  - decommissioning of ACUs reduced inlet temperatures even more
    (low-utilized ACUs discharge warm air into the plenum)
  - combination of turning off ACUs and hotspot mitigation allowed safely increasing set points
**Dynamic Monitoring and Management - Process**

- use MMT 1.0 service to derive specific recommendations and create MMT **base model**
- installed (real-time) sensor network (thermal, flow, humidity, pressure)
- create MMT base model and divide DC into cooling zones
- compute local efficiency changes in real time
- provide updated real-time dynamic models & weekly energy efficiency reports
- update base models to provide real-time temperature distributions

* order can be switched
Wireless Sensors
- IBM Low-Power Mote Technology
- Long battery life

Temperature
12 feet (total)

Pressure / Flow
10 feet

Temperature
4 feet

Humidity
12 feet

Pressure / Flow

Temperature

Humidity
Dynamic Monitoring and Management – Deployment of Wired Sensors

- Sensor access points are installed every ~ 2-4 feet (T-boxes)
- Sensors are bar-coded and location / ID is tracked on MMT web client
- Install strategy allows maximum flexibility for sensors to be moved, removed and added
- Temperature, humidity, pressure and flow sensors are supported on the same network
Dynamic Monitoring and Management – Architecture
Dynamic Monitoring and Management - Deployment Example

- 922 thermal sensors
- 62 pressure sensors
- 72 flow sensors
- 42 humidity sensors
- 87 in plenum
- 72 discharge + 72 return
- 492 @ inlet (class #1)
- 283 @ network (other classes or in room)
Dynamic Monitoring and Management - Implementation

- Detailed ways to manage the data center using an MMT layout editor
- Real-time, 3D temperature, humidity, pressure distributions with cross-sections etc.
- Alarm / threshold services
- Efficiencies in real-time and corresponding cooling zones
- Reports and energy efficiency summaries
- Available in Maximo for Energy optimization (MEO) as a product and as a service
Dynamic Monitoring and Management - Cooling Zones and Utilization Levels

Zone is 72% efficient

Bar heights indicate efficiency of respective zones

ACU

Zone boundary
Dynamic Monitoring and Management - Alarms

- User-specified thresholds
- E-mail alarm alerts
IBM Internal Deployment

Measurement and Survey Analysis successfully deployed and implemented in more than 1M sq. ft. of internal DC space

- More than 20% cooling energy savings
- Almost 8M kWhour of savings today
- Over 25 IBM strategic data centers assessed

Dynamic Monitoring and Management successfully deployed at large-scale production DC

- To actively manage large-scale dynamic DC
- Additional installations underway
- Wider rollout in NA and in EMEA

Dynamic Monitoring and Management is part of the RTP Leadership Data Center design and architecture

- Full deployment in this new Leadership DC
- Integrated into ITD data models & asset management systems, Maximo and Tivoli

LDC Architecture Framework

Asset Data: AutoCAD, Stickups, Systems, Data ORG, SC, Power Cooling, Power, Power, TEP, TEP, TEP

Metered Data: DC BMS, Siemens, Systems, DC Cooling, IBM, MMT, DC Power, DC Power, IT Devices, IT Devices

Join ID: TEP, TEP, TEP, TEP, TEP

ITM: ITM, ITM, ITM, ITM, ITM

Tivoli: Tivoli, Tivoli, Tivoli, Tivoli, Tivoli

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MMT Integration – Active Energy Manager, ITMfEM, Maximo

Delivering key energy management metrics through an integrated solution

Graphical view with key energy & thermal metrics

Role-based energy dashboard

IBM Maximo Asset Manager for Energy Optimization

IBM Tivoli Business Service Manager (optional)

IBM Systems Director Active Energy Manager

IBM Tivoli Monitoring for Energy Management

INFORMATION TECHNOLOGY

FACILITIES & PROPERTY

ASSETS
Summary

• MMT Measurement and Survey Analysis has repeatedly shown energy efficiency improvement opportunities equivalent to, on average, more than 10% of IT power costs and 20% of cooling power costs
• MMT Dynamic Monitoring and Management has been extended to provide a real-time energy and thermal monitoring and management solution
• MMT Dynamic Monitoring and Management, and beyond, is being integrated into IBM’s Software stack
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