Leveraging Ubiquitous Sensors to Predict Failures and Discover Data Center Flaws

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Purpose and Motivation

The Possibilities:
• Decreased cost of deployment
• More information to correlate with and predict failures
• Help find datacenter cooling inefficiencies

The Roadblocks:
• Insulation of sensors
• More work involved to use collected data
• Limited only to sensors which are built into devices
Presentation Overview

- What are some of the ways sensors are generally used in a datacenter?

- How can we use onboard sensors as stand-ins for external sensors?

- How can we learn to leverage this sensor data more effectively?
Available Sensors

- Water leak detector
- Humidity
Available Sensors

• Motion Detector

• Smoke Detector
Available Sensors

- Power Availability
- Switches
Available Sensors

- Airflow
- Accelerometers
Available sensors: Temperature

Air conditioning
Available sensors: Temperature

Room
Available sensors: Temperature

Rack
Onboard Sensors

• CPU thermal sensors

• Hard Disk and Solid-State Drive thermal sensors

• Chassis internal temperature sensors
Other Available Information

• Fan speed
• Power use
• IO and device load stats
Candidates for Replacement?

- Water Leak Detector
- Humidity Sensor
- Motion Detector
- Smoke Detector
- Power Use/ Availability
- Airflow Sensor
- Accelerometer
- Temperature
## Candidates for Replacement?

- Water Leak Detector: NO
- Humidity Sensor: NO
- Motion Detector: NO
- Smoke Detector: NO
- Power Use/Availability: YES
- Airflow Sensor: YES
- Accelerometer: NO
- Temperature: YES
Candidates for Replacement

Power Use/Availability

- Metrics are available
- Best to use dedicated device
Candidates for Replacement

Airflow Sensors

• No outside-rack information available inside the rack

• Fan speeds indicate target airflow rate

• Limited usefulness
Candidates for Replacement

Temperature Sensors

• Most available sensor

• Most direct readings

• Problems with sensor insulation
Problems using internal sensors

- Physical insulation
- Sensitive to individual device failure
- Device locations must be known
• Higher CPU loads, disk activity, will cause temperatures to increase if unchecked

• Higher core/memory voltages and clock speeds contribute to increased temperatures

• Fan speeds increase in an effort to bring temperatures down
External Influences to Temperature

- Other local devices
- Intake temperature
- Airflow obstructions
Model for Normalizing Temperatures

\[(\text{CPU}^i + \text{HDD}^j - \text{Fans}^k) = \text{Thermal Contribution (T)}\]

\[(\text{Intake Temperature}) + (T) = (\text{Measured Temperatures})\]

\[(\text{Measured Temperatures}) - (T) = (\text{Intake Temperature})\]
More Data Matters

- Polling frequency and device load
- Know your history
- More data results in a better model
What Sensor Interpolation Provides

- Intake/exhaust temperatures
- Hot/cold aisle estimates
- Limited air flow information
Using Internal Sensors

Air conditioning and room focused

- Temperature rises over entire datacenter
- Temperatures are in a gradient
- Multiple racks with heat issues
- Average temperatures at specific heights/regions
Using Internal Sensors

Rack and Machine focused

- Temperature rises only in a specific rack
- Temperatures gradient inside the rack
- Match best practices for rack sensors
- Relationship between neighbor machines
Findings

- Temperature variations by height
- Device internal temperature variations
- Rack temperature accuracy
- Variations in temperature by device type
Taking It To The Limit

- Throttling and overclocking
- Load balancing
- Active zone management (air management)
The Future

- Data indicates support for the hypothesis
- More data collection! (also stuff we can't get yet)
- Datacenter and device heat visualizations
- Obtain negative test data(blck vents)
Questions?