Mobile Visual Analytics for Data Center Power and Cooling Management

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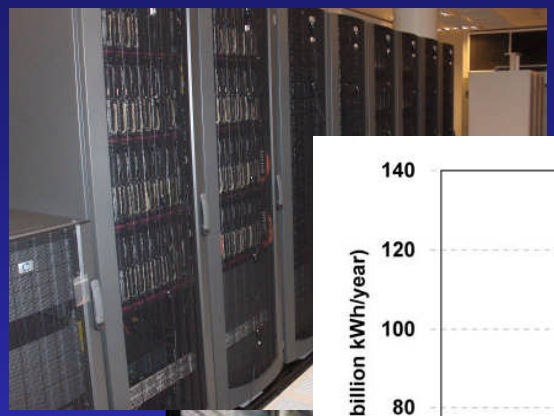
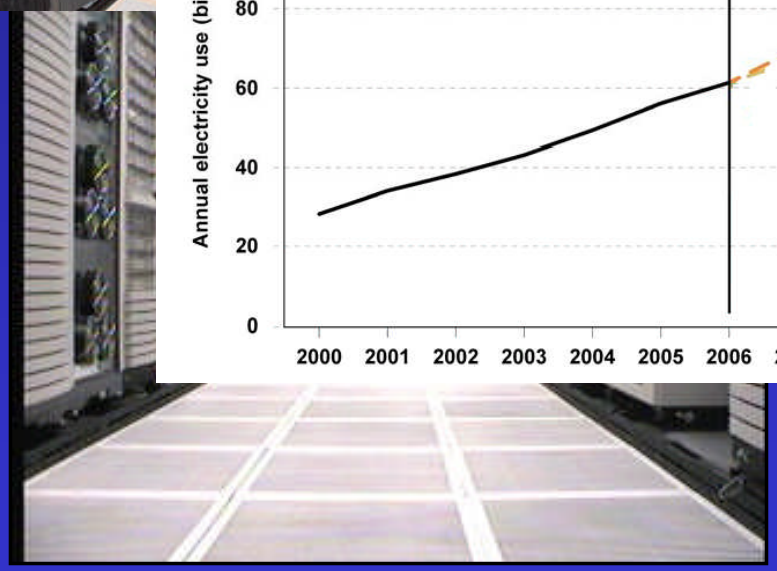
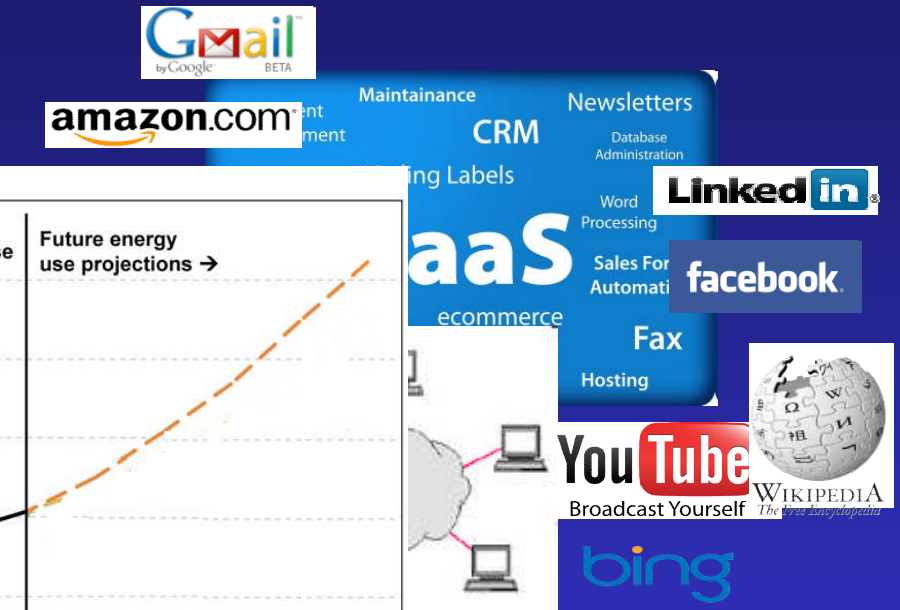
Data Centers





(Source US EPA)



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Outline

1. Introduction
2. Architecture
3. Case Studies
    a. Thermal State Detection
    b. Infrastructure Utilization
    c. Energy Consumption
4. Metrics / Analytisc
5. Conclusions
6. Future Work

Goals

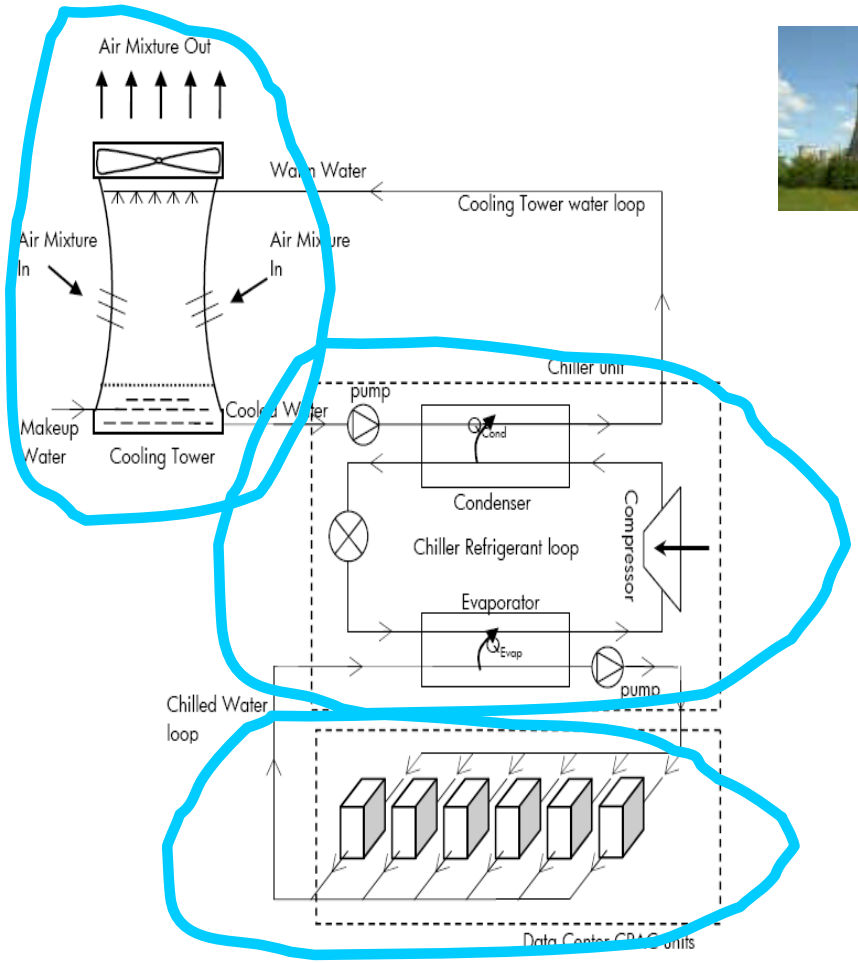
- Mobile tool to assist data center Facilities / IT administrators physically present in a data center
- Usage scenarios
  - Thermal state summary and assessment
  - Detect anomalous behavior / energy inefficiencies
  - Root cause analysis, investigate failures/outages
  - Look at utilization levels
  - Perform analytics – correlation, etc.

Data Center Infrastructure

- Computing Infrastructure
  - Servers
  - Storage
  - Network
- Power Infrastructure
  - Transformers
  - PDUs
  - UPSs
- Cooling Infrastructure
  - Chillers
  - Cooling Towers
  - CRAC units

Data Center Cooling Infrastructure

Consumes from 1/3 up to 1/2 of total power consumption



Cooling Towers

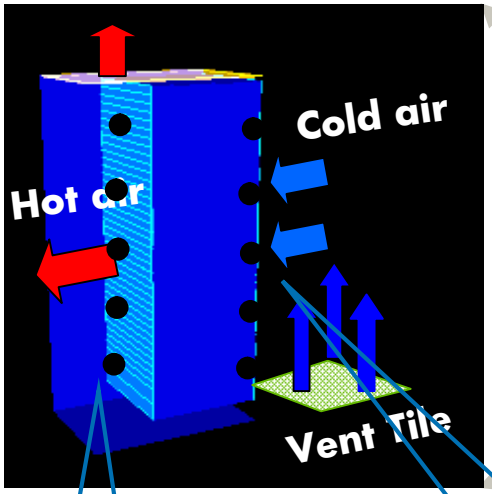
Chiller Unit

Water Return (T_{in}) →  → Water Supply (T_{out})

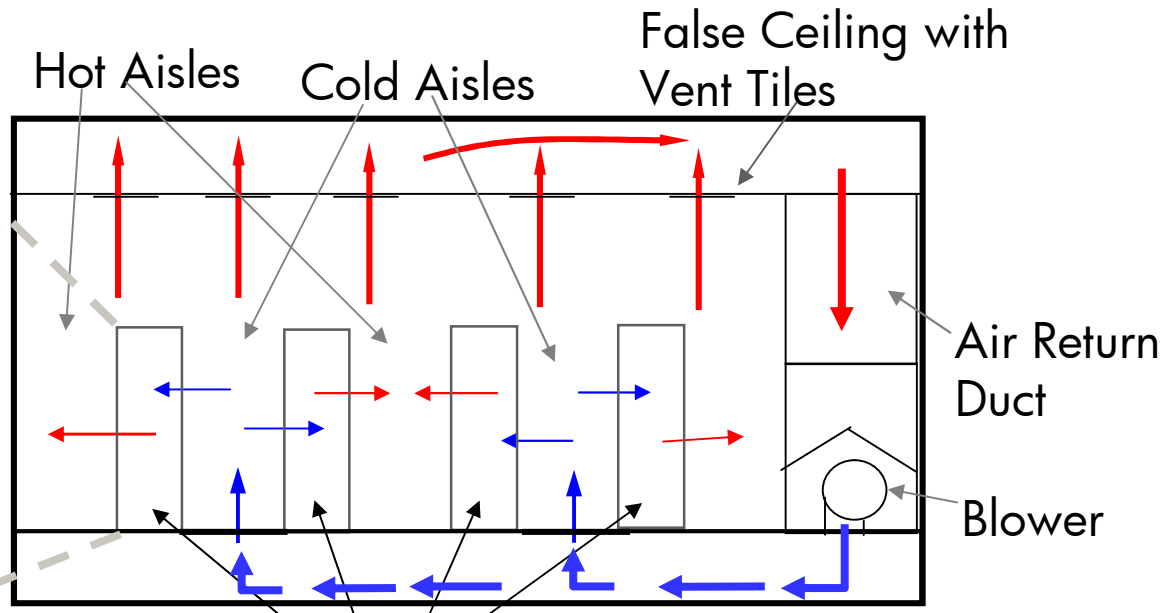
Computer room air-conditioner (CRAC)

Air Flow within Data center

Rack Air flow



Data Center Air flow

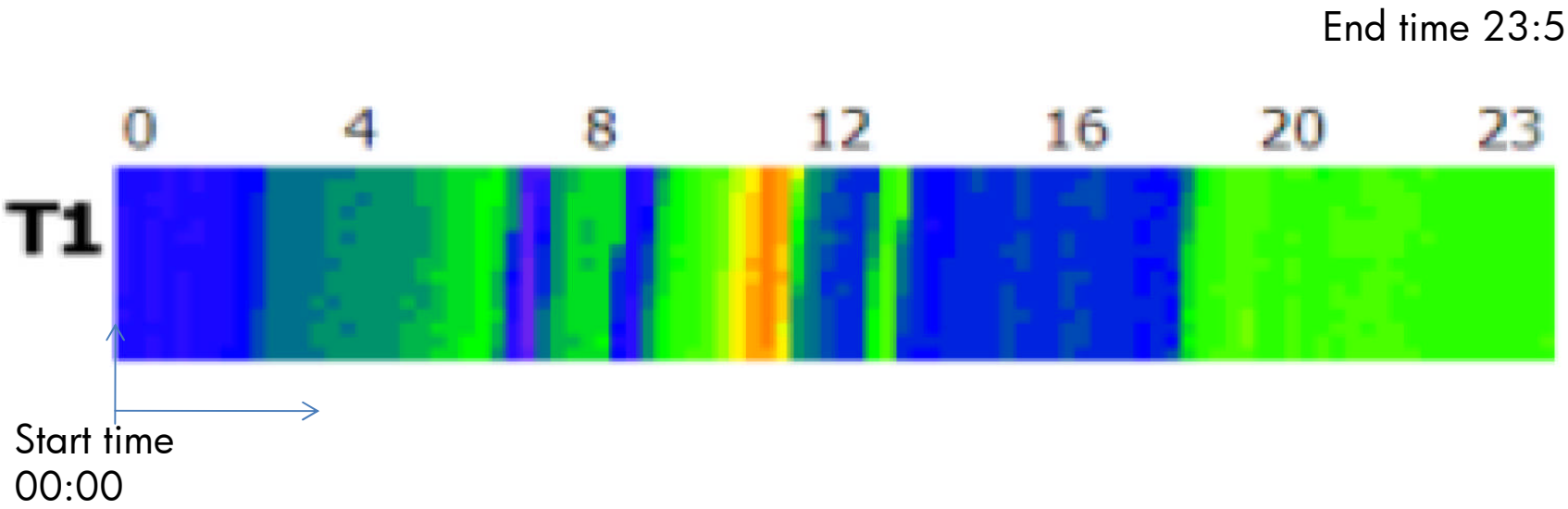


Cold Air
Hot Air

Inlet sensors

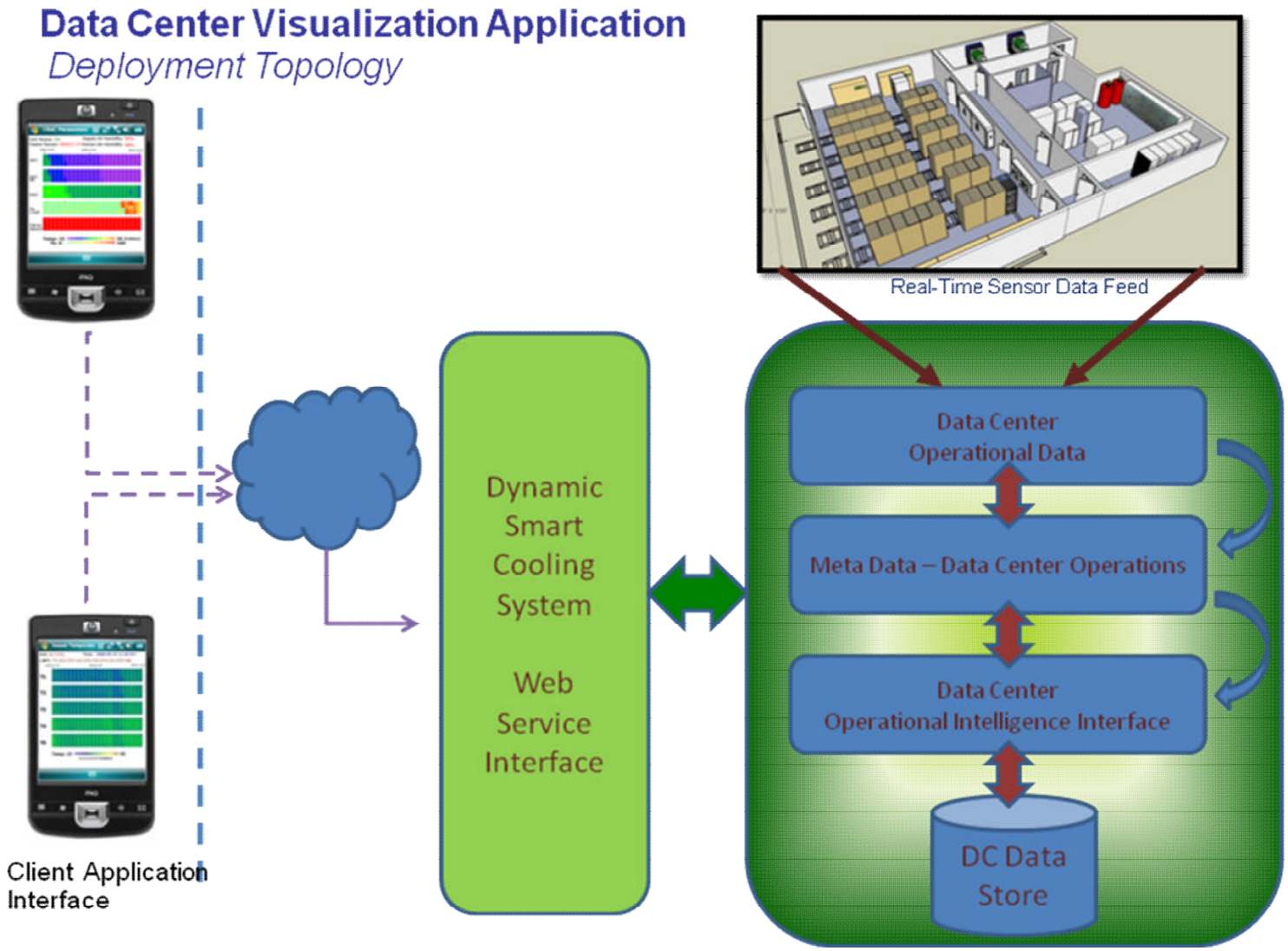
Outlet sensors

Pixel-Bar Charts

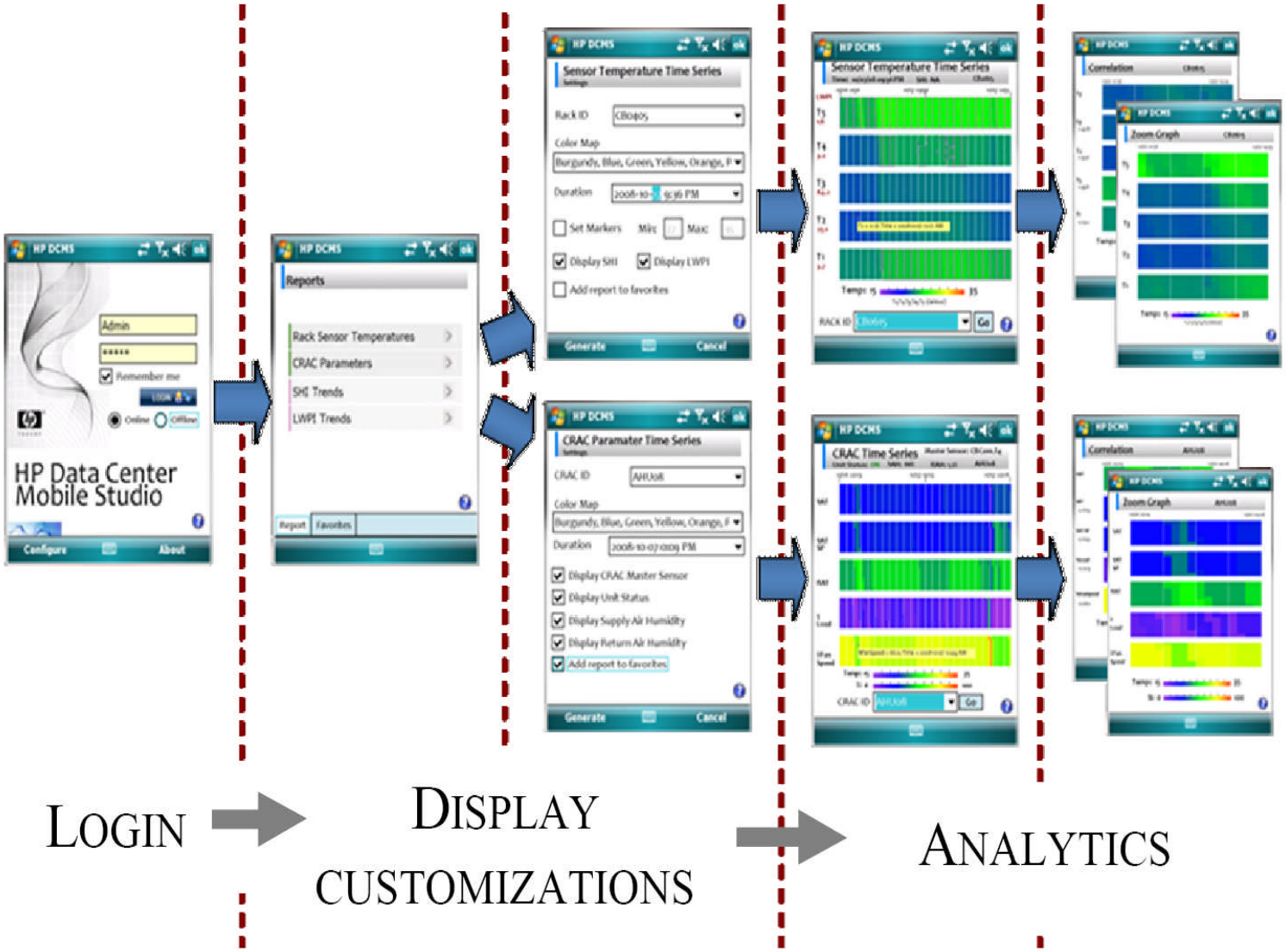


- Each cell corresponds to one sample in the time series
- Time increases bottom to top and left to right
- Size of cells automatically scales down as more cells are displayed
- Color of a cell reflects property displayed. E.g. for temperature Red and Yellow are hotter. Green and Blue are cooler

Application Architecture

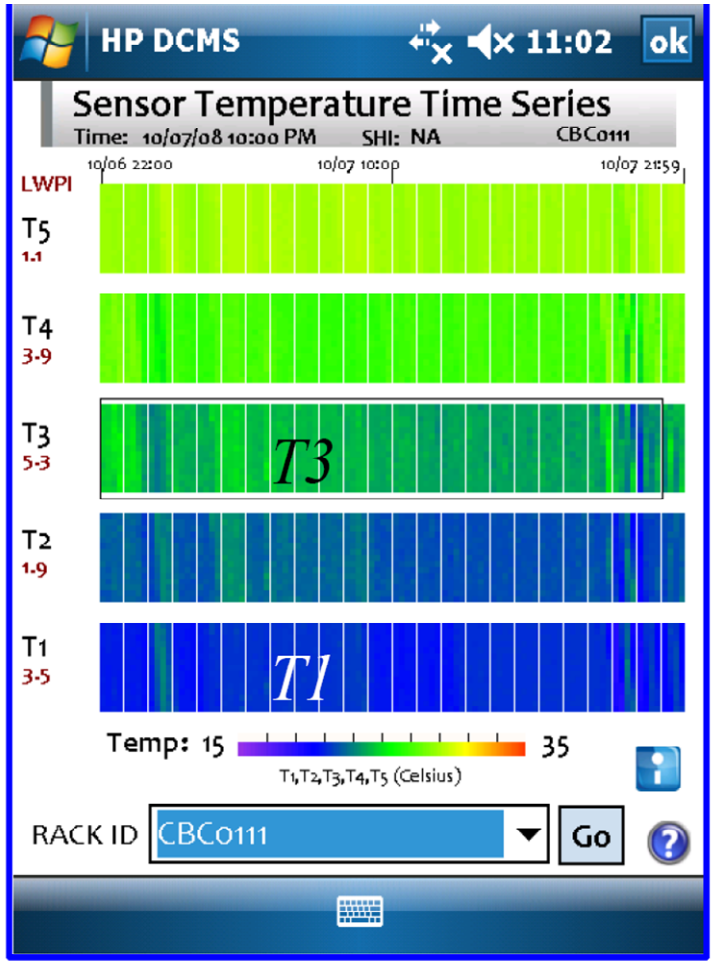


Datacenter mobile studio application pipeline

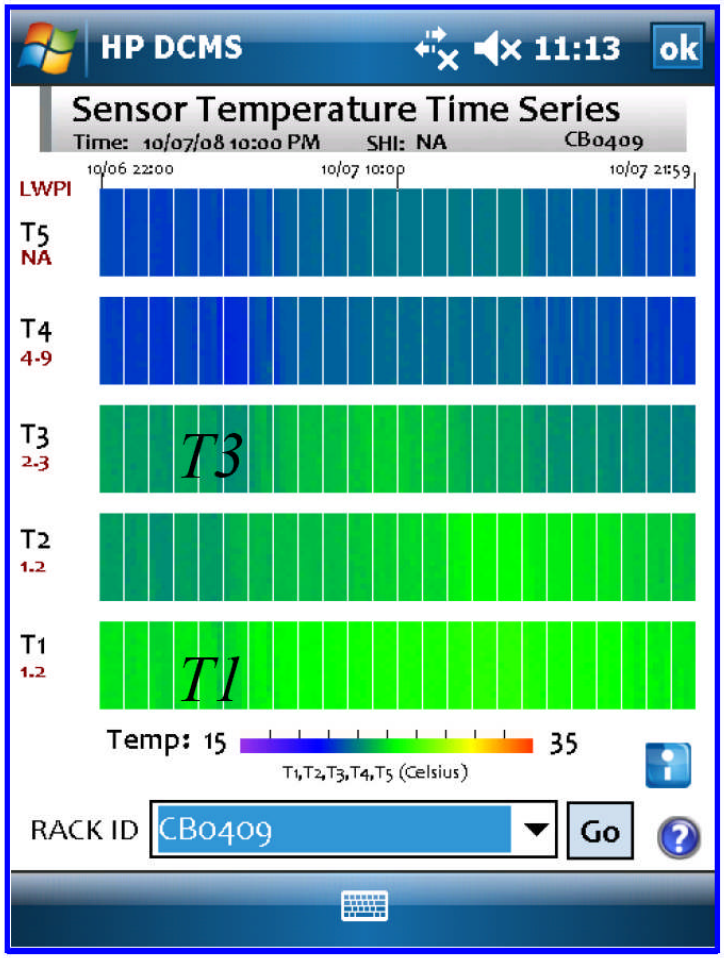


Thermal State Detection

Not out of sequence: (T5>T4>T3>T2>T1)

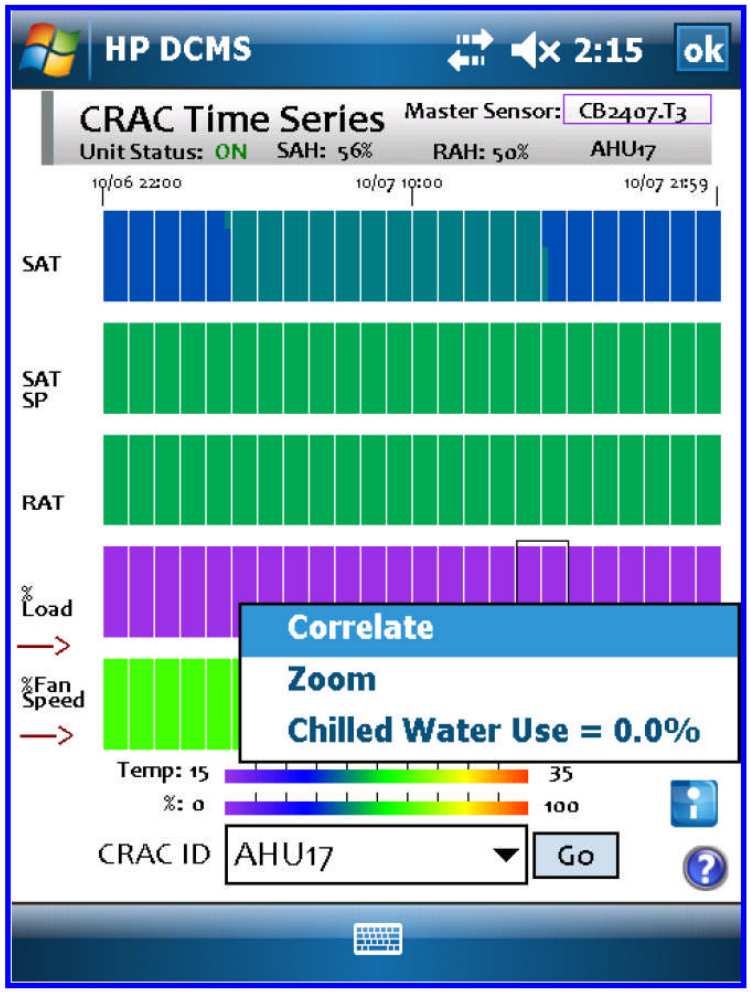


Out of sequence: (T5<T4<T3<T2<T1)

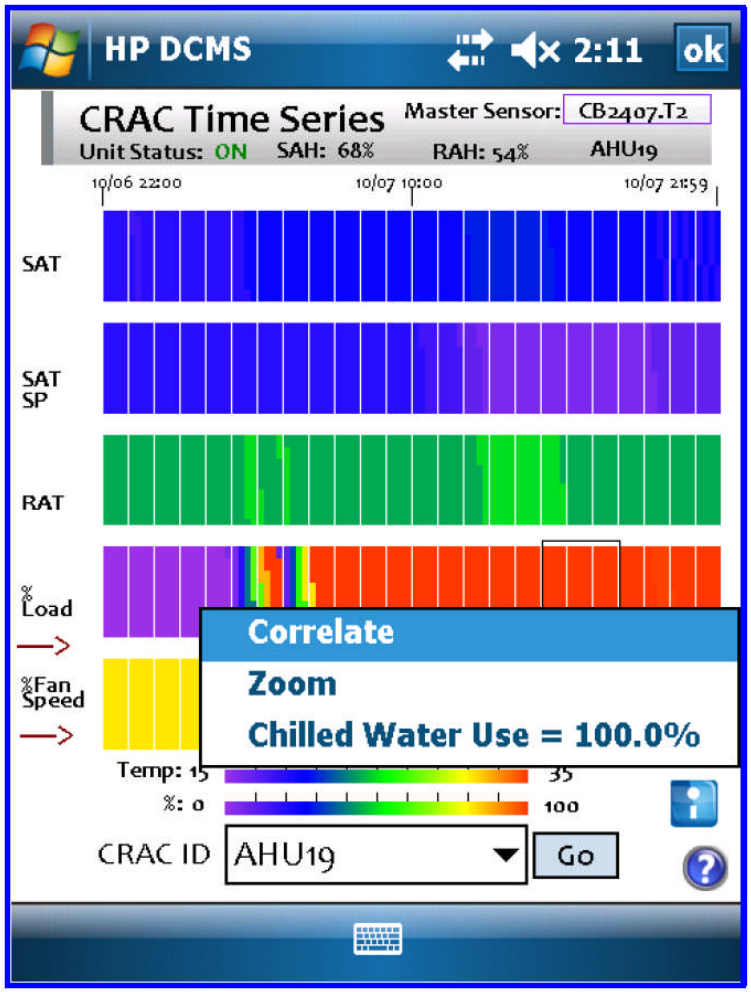


Infrastructure Utilization

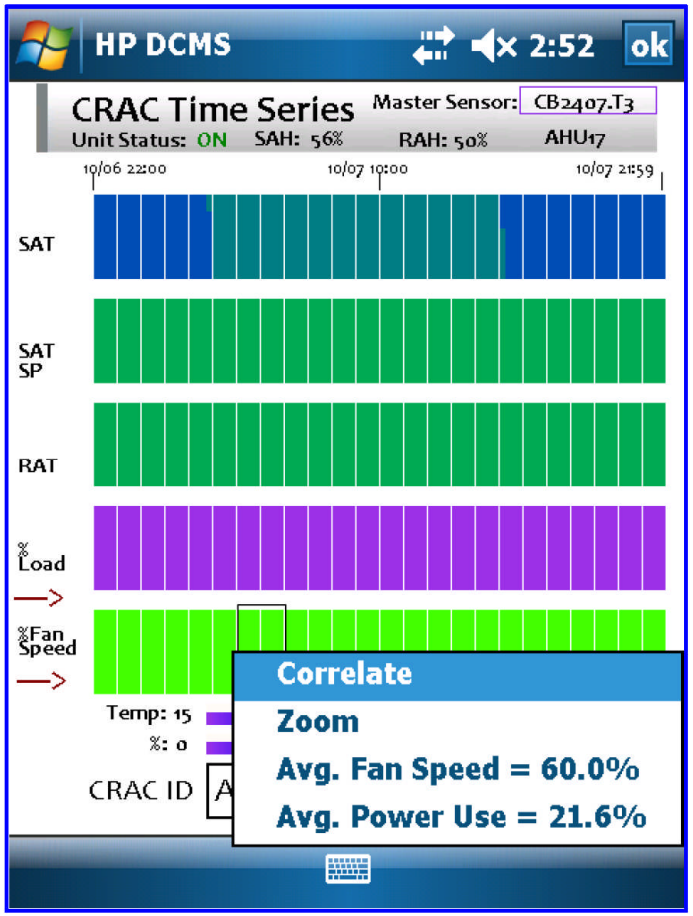
No chilled water utilization (0%)



Chilled water utilization (100%)



Energy Consumption



- Tracking energy over time provides administrator insights on demand profiles
- Variation in energy consumption can be correlated to thermal management states in the data center
- Power capping plans can be developed to manage demand during peak hours

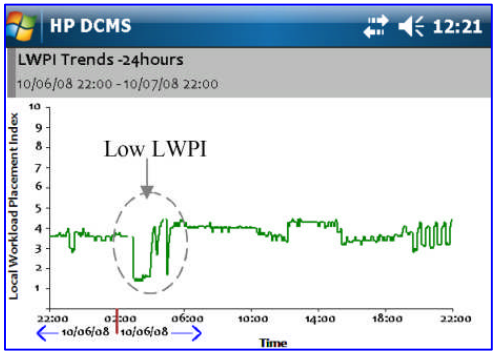
Metrics / Analytics

- Master sensor → Hot spots → Thermal redesign
- Supply heat index (SHI) → air recirculation → equipment misconfiguration

$$SHI = \frac{T_i - T_{ref}}{T_o - T_{ref}}$$

- Local workload placement index (LWPI) → cooling efficiency → workload placement

LWPI = AC Margin + Thermal Margin – Hot Air Recirculation



- Correlations → anomalies / root cause → bad sensor / vent obstructed / equipment misconfiguration

Conclusion

- We presented a mobile visual analytics application to enable IT/facilities administrators to manage data center cooling and power
- Detect anomalies, Identify inefficiencies that are hard to discover otherwise
- Useful for troubleshooting, get information on state of infrastructure, various metrics
- Leverages visual analytics for enhanced onsite data center management

Future Work

- Incorporate additional data streams – power, computing infrastructure – to draw cross-cutting inferences
- Add more data analytics, including predictive capabilities
- Enhance with more metrics, summarization
- Enhance user interface
- Add location awareness

Thank you for your attention

Questions?