LEVERAGING BIG DATA AT UNIVERSITY OF NEBRASKA-LINCOLN

Chris Walsh, Director, Building Systems Maintenance, University of Nebraska - Lincoln
Lalit Agarwal, Director, Facilities Systems, University of Nebraska - Lincoln
PRESENTATION OBJECTIVES

- How Big Data can be used to improve the operational efficiency of assets to reduce energy and maintenance costs and improve occupant comfort
- How to develop data collected by Building Automation Systems (BAS) into actionable knowledge
- How to prepare and implement a system to leverage Big Data
OUTLINE OF PRESENTATION

- Big Data and Strategic Goals
- Big Data and the Maintenance Maturity Continuum
- Harnessing Big Data using Fault Detection and Diagnostics (FDD)
- FDD Implementation and Results at UNL
- Wrap up:
  - Lessons Learned
  - Conclusions
  - Questions
Big Data and Strategic Goals
WHAT IS BIG DATA?

- Big data is a term for data sets that are so large or complex that traditional data processing applications are inadequate

  – Wikipedia
If the Digital Universe were represented by the memory in a stack of iPads:

- In 2013 the stack would have reached 2/3 of the way to the moon
- In 2020, the stack is projected to reach the moon 6.6 times

\[ 1 \text{ ZB} = 1 \text{ trillion GB} \]
BIG DATA AT UNL FACILITIES

- 60,500 connected sensors and control devices
- 7.4 million new records collected every day
- Total volume of 7.2 billion records
- Most data is purged without ever being used

A clear picture of our facilities’ performance is obscured by the sheer volume of records
WHY IS BIG DATA IMPORTANT?

- Big Data can be utilized to address Operations & Maintenance (O&M) costs
  - Typically the 2\textsuperscript{nd} largest cost category in an institutional budget (after people costs)
- Big Data can be used to support the strategic goals of the institution
Asset Degradation is the Key

- The performance of campus assets (building equipment and infrastructure) will degrade over time.

- As performance degrades, assets will typically:
  - Experience reduced useful life and may suffer catastrophic failure
  - Use more energy
  - Provide less reliable facility conditions

- Assets connected to the Building Automation System (BAS) can signal a change in condition and the need for a maintenance response.
FOCUS ON ASSET PERFORMANCE FOR COST SAVINGS

- Reduce Energy Consumption
- Avoid catastrophic breakdowns
- Resolve issues before occupant awareness

Degradation Curve
MAINTENANCE MATURITY CONTINUUM AT UNL
MAINTENANCE MATURITY CONTINUUM

- Reactive (RM)
- Corrective (CM)
- Preventive (PM)
- Predictive (PDM)
- Reliability-Centered (RCM)
**Timeline of Maintenance Maturity at UNL**

- Moved from centralized to zone-based shops
- Added sensors to collect equipment data
- Implemented calendar-based PM program
- Implemented Computerized Maintenance Management System (CMMS)
- Integrated CMMS and BAS
Data-Driven PM Drives Cost Savings

- Semi-annual Fan, Pump, and Motor PMs
- Average frequency reduced from 6 to 10.5 months
- 30% cost savings versus calendar-based PMs
Data-Driven Filter PDM Drives Cost Savings

- 55% reduction in labor hours
- 50% fewer filters
- Reduced energy consumption
- Reduced environmental impact
- Improved Indoor Air Quality (IAQ)
Hamilton Hall Chemistry Lab Filter Savings

- Energy Savings: $8,700/year
- Labor Savings: $2,200/year
- Material Savings: $2,900/year

Filter Savings

- Energy Conservation
- Occupant Satisfaction
- Operations & Maintenance Savings

Before           After
APPROACHING RCM

- Reduced energy costs and consumption
- Operational improvements
- Improved environmental footprint
- Improved occupant comfort

*However... we’re not yet *leveraging* Big Data*
FAULT DETECTION AND DIAGNOSTICS (FDD)
FDD Leverages Big Data

- FDD aligns specialized algorithms and Big Data
  - Identifies asset degradation
  - Prioritizes maintenance response
  - Records the asset’s performance over time

*FDD provides real-time actionable knowledge*
BUILDING AUTOMATION AND FDD

Fault Detection and Diagnostics
Detect current problems and changes in performance

Historian
(long-term patterns)

Prioritized Maintenance Response

BAS System (Vendor A)

BAS System (Vendor B)

Current Data

Alarm

Response

Operator Managing Control Systems

Buildings

Buildings
Fault Detection versus Alarm Management

Air Handler Unit (30,000 CFM)

Monetizing Fault Savings

<table>
<thead>
<tr>
<th></th>
<th>Heating Energy Cost /year:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal</td>
<td>2,130 $/year</td>
</tr>
<tr>
<td>Alarm Status</td>
<td>30,300 $/year</td>
</tr>
<tr>
<td>Fault Detected</td>
<td>4,880 $/year</td>
</tr>
<tr>
<td>Fault Savings</td>
<td>25,420 $/year</td>
</tr>
<tr>
<td>Fault vs Alarm</td>
<td>84%</td>
</tr>
</tbody>
</table>

Degradation Curve
PERIODIC RECOMMISSIONING (RCx)
CONTINUOUS COMMISSIONING WITH FDD

- Automates visibility of ALL assets!
- FDD Solution Enabled Optimization
- Efficiency Loss with Recommissioning

Building Efficiency (%)

5 years
10 years
15 years
20 years

Time

Periodic Recommissioning

FDD solution
FDD at Microsoft Campus Redmond, Washington

- FDD saved 10% of annual energy costs
- 45% of faults fixed within 30 seconds
- ROI in less than 24 months

- In four years, this solution saved Microsoft $4.5M
- Microsoft projects $100M global savings in ten years
ROI Analysis for UNL

- Projected payback in 10 years based on energy savings alone
- Anticipated 5% annual energy savings
- O&M savings will accelerate our payback
  - Reduced labor hours
  - Reduced material cost
FDD IMPLEMENTATION AND RESULTS AT UNL
FDD IMPLEMENTATION – FY16

- Align BAS assets and integrate with ICONICS software
- Establish recommissioning program
  - Six buildings each year
  - Concurrent FDD development
- Develop fault prioritization algorithms
  - Cost
  - Criticality
FAULT RESPONSE

- Dashboards prioritize faults
- Control Center triage
  - Identify root cause using BAS
  - Resolve issues remotely if possible
  - Dispatch field technician when necessary
Ross Van Brunt Visitors Center
RCx Energy Savings

- Energy Use Index (EUI) decreased by 15.5%
- Identified additional energy conservation projects
INTL. QUILT MUSEUM
RCx ENERGY SAVINGS

- Original Building
  - 37,851 GSF
  - 10,615 MMBtu/year

- With Addition
  - 51,551 GSF (36% increase)
  - 7,294 MMBtu/year (31% reduction)

- EUI decreased by 45.1%
CUMULATIVE RCx ENERGY SAVINGS

- 11.8% reduction in EUI for buildings with at least 6 months of data
- Not every building will realize energy savings
FY17 FDD
DETECTED FAULT COSTS

- 19 Buildings currently being monitored by FDD
- 259 unique faults reported in first 2 months of FY17
  - If left uncorrected for a year, these equate to $50,000 in wasted energy
- Many faults are resolved remotely at no/low cost
OCCUPANT SATISFACTION

- Improved temperature control
- Reduced air handler noise
- Mitigated safety concerns

“We have noticed the noise in the air handler is gone! The offices in the south wing have been much more comfortable – they have been cooler. The Great Hall has been cooler as well.”
LESSONS LEARNED, CONCLUSIONS AND QUESTIONS
LESSONS LEARNED

- Select a good business partner
- Use FDD to help target recommissioning efforts
- Seek feedback from building occupants and maintenance staff to direct recommissioning efforts
- Leverage FDD for warranty oversight of construction and renovation projects
FUTURE ENHANCEMENTS TO UNL’S FDD PROGRAM

- Extend FDD enrollment to
  - Approximately 100 campus buildings
  - Five campus utility plants
  - All new buildings
- Integrate FDD with Computerized Maintenance Management System (CMMS) to automatically generate work orders for specific fault types
- Implement mobile notification for field and on-call personnel
CONCLUSIONS

- Big Data can be used to improve asset performance, reduce energy and maintenance costs, and improve occupant comfort
- FDD translates Big Data into actionable information that can help institutions meet strategic goals and move toward RCM
- Alignment of a Recommissioning program with an FDD program will enhance the benefits of both programs
QUESTIONS?

- Chris Walsh – cwalsh2@unl.edu
- Lalit Agarwal – lagarwal2@unl.edu