

Unlock Data Insight with Machine Learning and Future Data

Presented by **Bertrand Lasternas,**
Center for Building Performance and Diagnostic



Background: Carnegie Mellon University

Founded in
1900 by Andrew
Carnegie

12,991
Students (6223
undergraduate)

CMU annual
energy budget
over \$20M

That's over
\$1,600 per year
per student!

Goal:

CMU to be a
leading
university in
sustainability

About 6.500 000
sqft
65 + Buildings
80 000 data
points



Challenges

- Monitor, diagnose and optimize building performance in real time
- Predict faults and system failures

Solutions

- Use advance machine learning solution for predictive analytics
- Predict / forecast / anticipate systems performance

The Intelligent Workplace

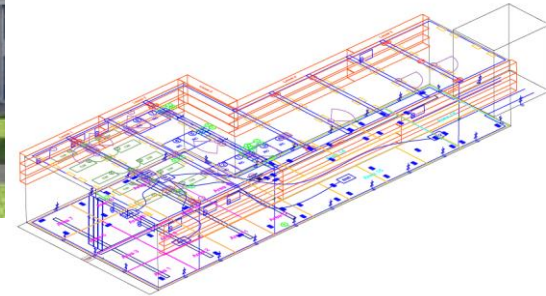
The Robert L. Preger Intelligent Workplace, built in 1997, is a 7000 square foot living laboratory of office environments and innovations located on the campus of Carnegie Mellon University.

Test and Integration of several systems:

- Heating
- Cooling
- Ventilation (mechanical and natural)
- Lighting, and day-lighting
- Electrical
- Plug load



View of the
sensors/actuators density
1500+



Why didn't we save energy?

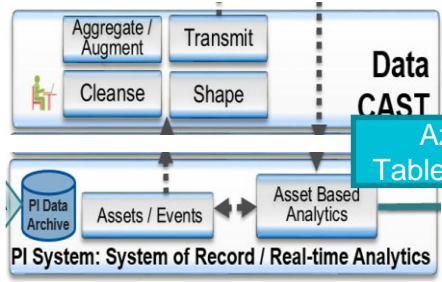
- We had no idea what we were using
- We had no idea how important it was
- There was no easy way to change outcomes
- We could not do numbers

What are the steps?

1. **Integrate all information**
2. Continuously **monitor and diagnose** building performance
3. Make information accessible to **Facility Managers and Executives**
4. Display information for **Building Occupants**
5. Display information for **the Public (Disclosure)**
6. Enable Building Occupants to **control their environment**



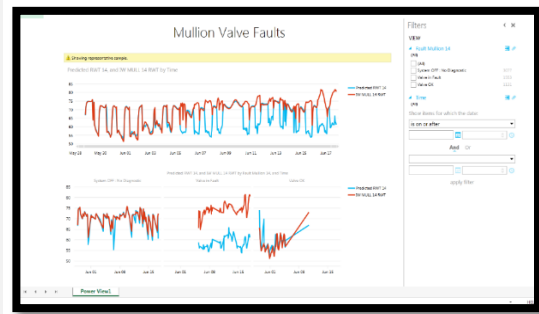
CMU Intelligent Workspace



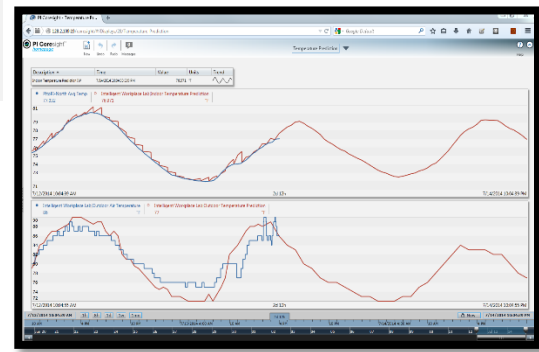
Azure Tables/Blobs

ML Studio

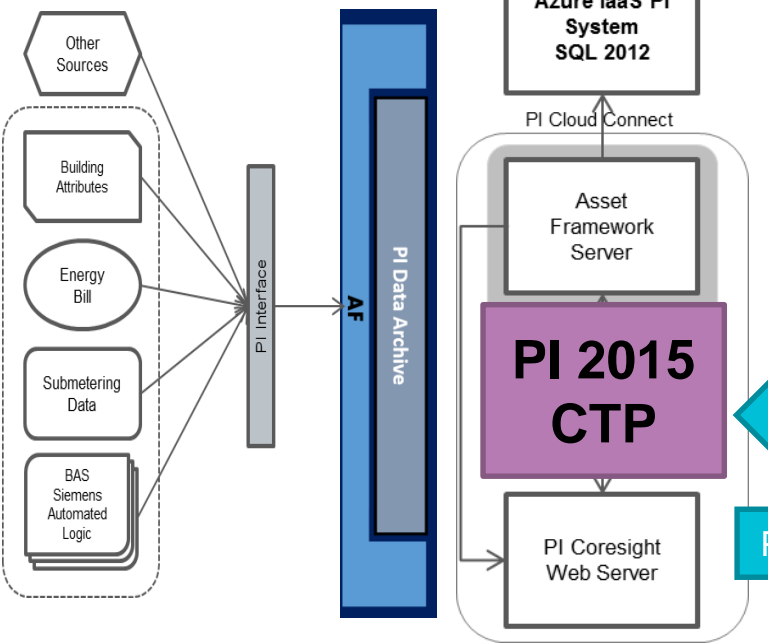
C# Code, Python Script, R, AzureML API



Office 365
Power BI for Office 365
Self-service analytics for all your data



PI Coresight



Future Data / Predictions

Plotting Real-time and Future Data

Fault Detection and Diagnostic (Predictive Maintenance)

1/Collect Data
Real-Time

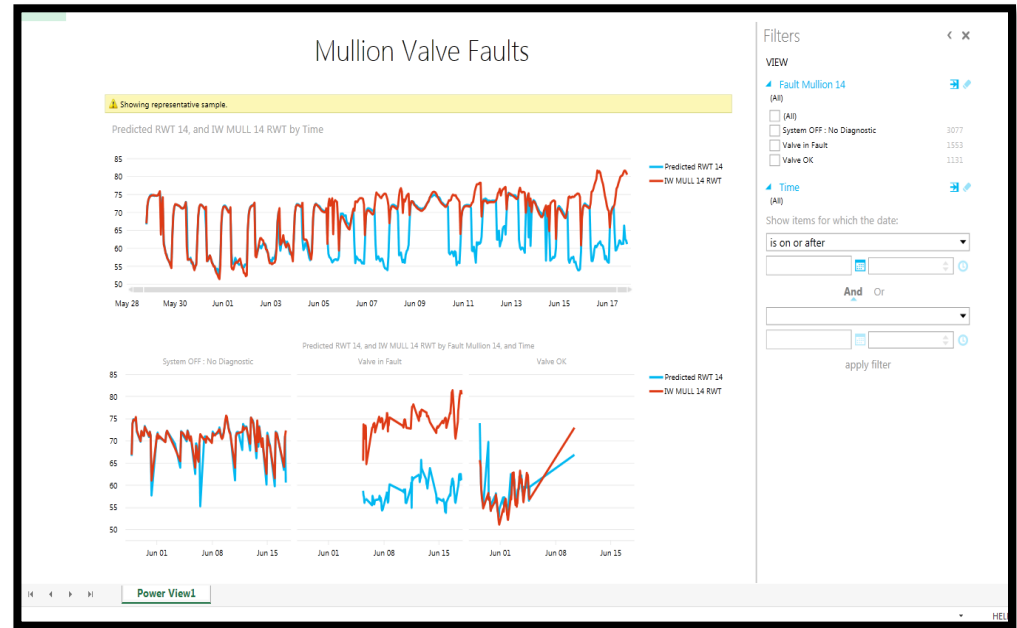
2/ Train Model
against baseline

3/ Predict (project)
baseline behavior

4/ Measure variation between
prediction and measured
behavior

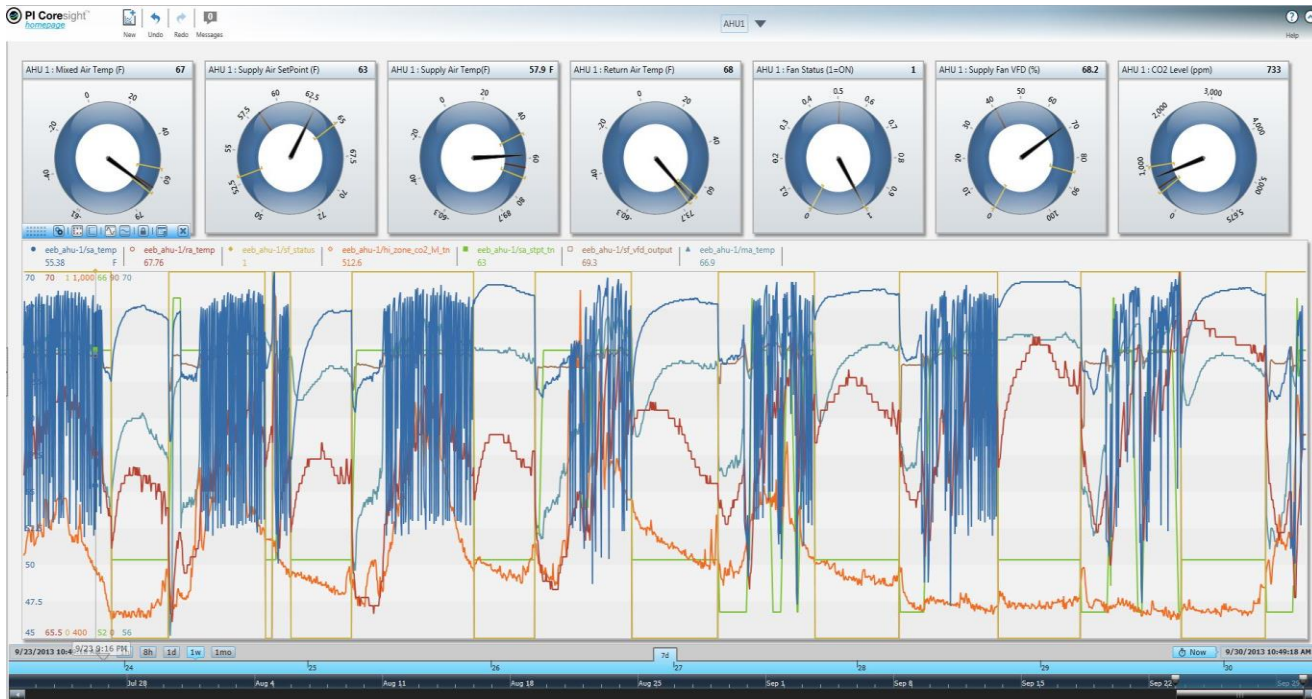
5/ Trigger notification, corrective actions

Save Time, Money, and Energy

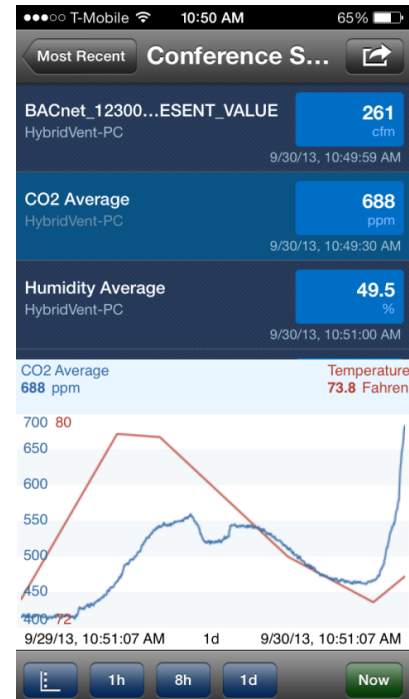


Power BI for Office365

Tablet-toting (mobile) field service



Online webpage and tablets interface



iPhone interface

Temperature and Energy Prediction

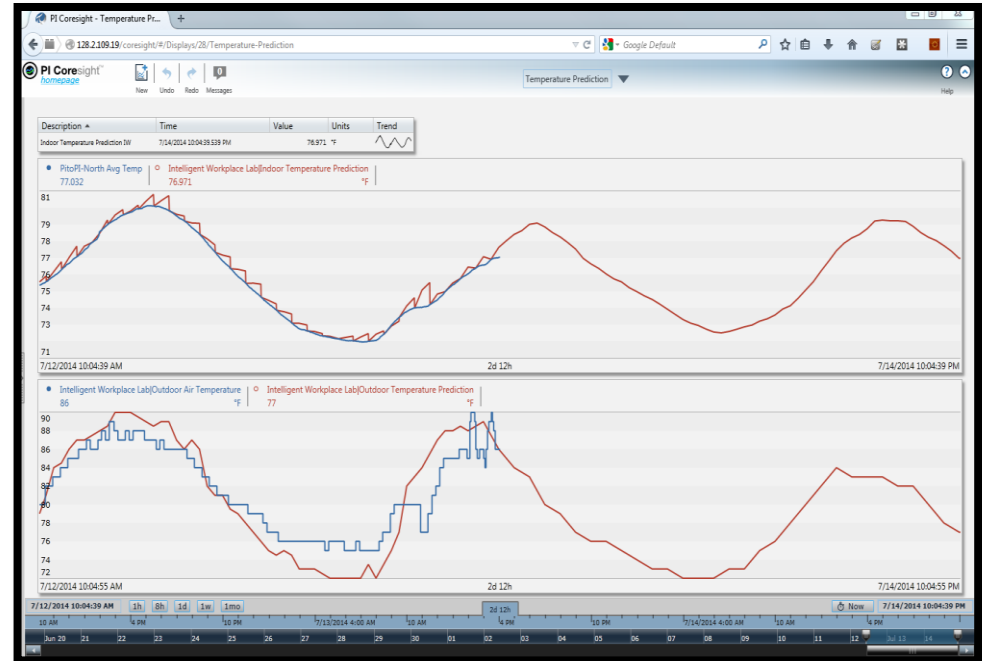
1/Collect Data
Real-Time

2/ Train Model

3/ Predict temperature and energy
at different horizons (up to 48h)

4/ Detect potential energy savings
* Over-Cooling/Heating
* Space conditioned without occupancy

5/ Corrective Actions:
* Adjust Control Logics
* Turn Off systems



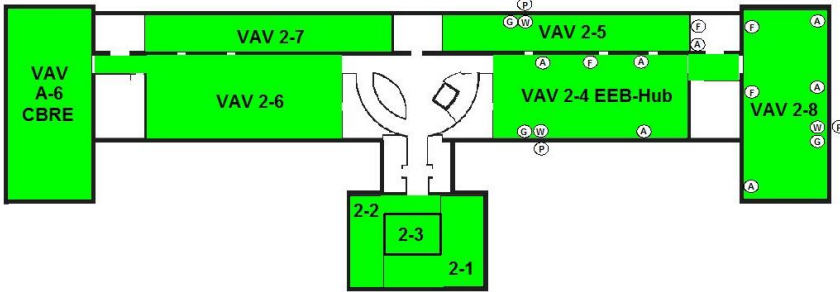
OSisoft PI Coresight

Facility Manager Dashboard

Second Floor

W Wall Sensor A Aircurity
P Pyranometer G Glazing Sensor

Outside Air Temp. 73.4 F	Zone CO2 573 ppm	Zone CO2 534 ppm	Zone CO2 486 ppm
Outside RH 48.4	Zone RH 46 %	Zone RH 46 %	Zone RH 45 %
	Zone Temp 74.9 F	Zone Temp 73.0 F	Zone Temp 72.7 F
	Discharge Air Temp. 63.5 F	Discharge Air Temp. 62.8 F	Discharge Air Temp. 62.7 F
	Air Flow Rate 1880 cfm	Air Flow Rate 1435 cfm	Air Flow Rate 1029 cfm
Exterior Condition	206_VAV_2-7	222_VAV_2-5	227_VAV_2-8

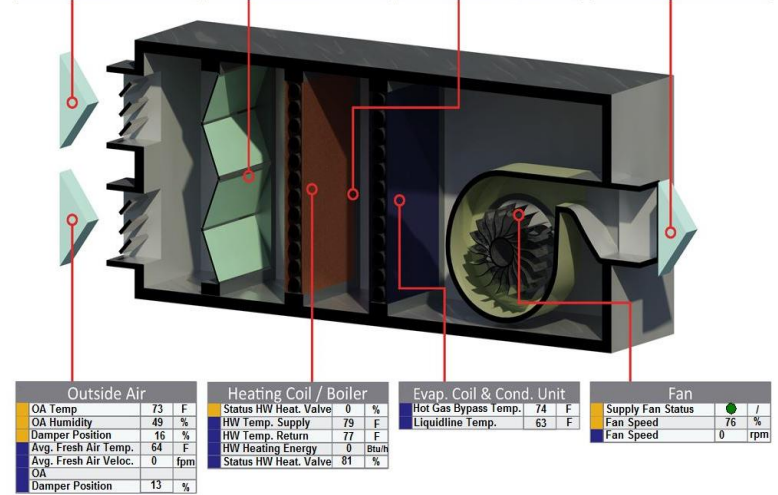


Zone CO2 587 ppm	Zone CO2 543 ppm	Zone CO2 516 ppm	Zone CO2 530 ppm
Zone RH 47 %	Zone RH 45 %	Zone RH 49 %	Zone RH 43 %
Zone Temp 73.9 F	Zone Temp 74.8 F	Zone Temp 72.5 F	Zone Temp 74.8 F
Discharge Air Temp. 63.7 F	Discharge Air Temp. 63.5 F	Discharge Air Temp. 72.0 F	Discharge Air Temp. 62.4 F
Air Flow Rate 3135 cfm	Air Flow Rate 2216 cfm	Air Flow Rate 588 cfm	Air Flow Rate 1463 cfm
201_VAV_A-6	205_VAV_2-6	214_VAV_2-1	223_VAV_2-4
Zone CO2 544 ppm	Zone CO2 519 ppm	Zone CO2 519 ppm	Zone CO2 519 ppm
Zone RH 46 %	Zone RH 44 %	Zone RH 44 %	Zone RH 44 %
Zone Temp 74.8 F	Zone Temp 75.3 F	Zone Temp 75.3 F	Zone Temp 75.3 F
Discharge Air Temp. 72.9 F	Discharge Air Temp. 72.9 F	Discharge Air Temp. 72.9 F	Discharge Air Temp. 72.9 F
Air Flow Rate 245 cfm	Air Flow Rate 90 cfm	Air Flow Rate 90 cfm	Air Flow Rate 90 cfm
212_VAV_2-2	213_VAV_2-3		

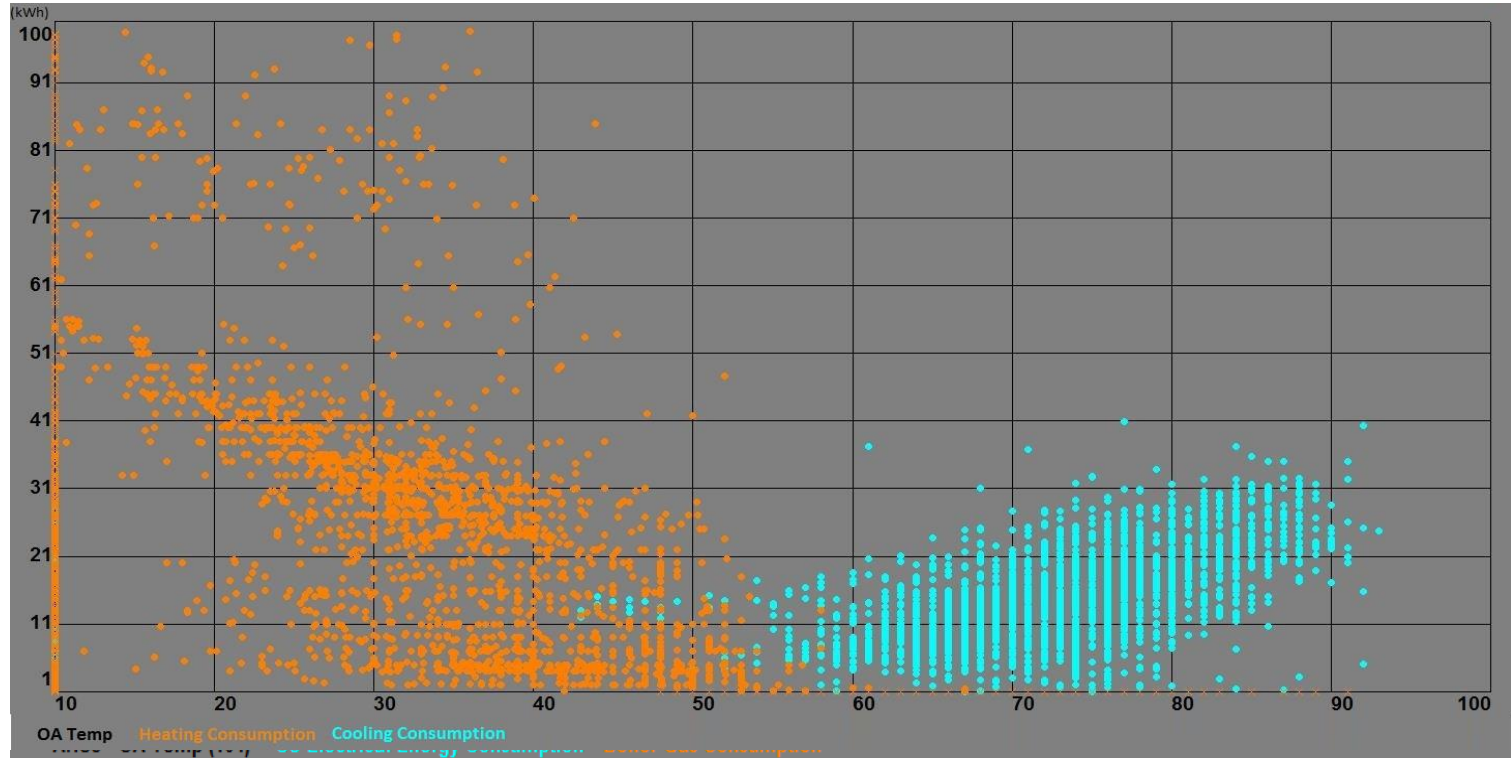
Alarm Cold Comfortable Hot Alarm

AHU1 Building Automation System 9/30/2013 10:25:00 AM
Hub Scientific Database 9/29/2013 12:01:00 AM

Return Air Temp. 68.0 F	Mixed Air Temp. 67.0 F	Return Air Flow (calc) -0.07 in	External Pressure 1.12 in
Damper Position 84 %	Mixed Air Static Pres. 1.15 in	OA Air Flow 1.6 cfm	External Pressure Stpt. 1.13 in
Return Air Temp. 74.2 F	Mixed Air Temp. 74.2 F	Supply Air Flow 0 cfm	Temperature 57.9 F
Return St. Pressure -0.07 in	After Filter St. Pres. -0.07 in		Temperature Stpt. 63.0 F
Return Air Humidity 42.2 %	Mixed Air Humidity 42.1 %		Avg. Supply Velocity 0 fpm
Return Air CO2 467 ppm			Avg. Supply Temp. 75.5 F
			Supply Air Temp. 75.6 F
			Supply Air St. Pressure -0.07 in
			Supply Air RH 40.4 %
			Supply Air CO2 522 ppm



(ID-F) Data Analytics



Real-time measured data for meaningful diagnostics

Demo

Benefits

- Expected energy savings of about 20% for predictive building control and Automation (currently tested in the Intelligent Workplace)
- Substantial Potential Energy Savings at a Campus scale
- **Tablet-toting field service technicians will use the predictive analytics using PI Coresight to check and update remote equipment before it fails**

Smart Buildings/ Smart Campus

Demonstrate real-time, analytic and visualization capabilities to integrate, monitor and diagnose building performance indices.

Generate knowledge and distribute it through the chain of decision



The Carnegie Mellon logo is displayed in white serif font on a dark red rectangular background.



Business Challenge

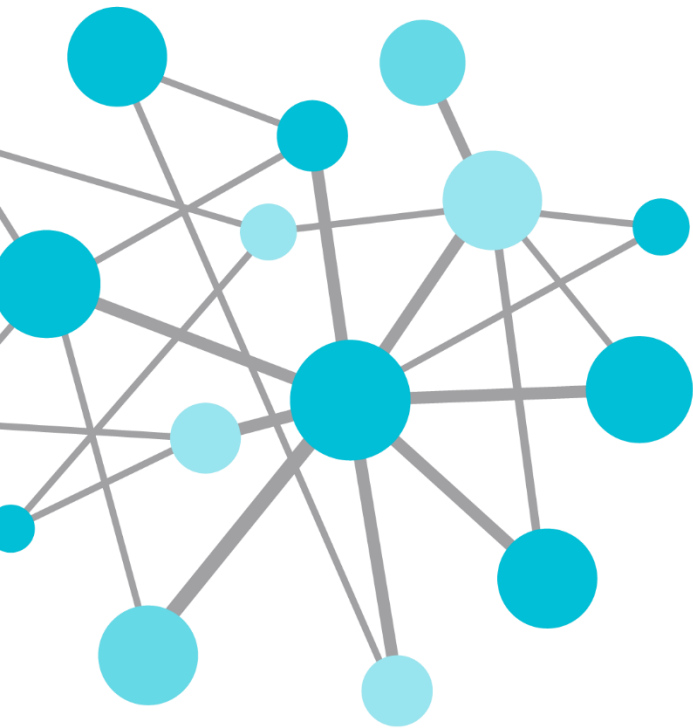
- Monitor, diagnose and optimize building performance in real time.
- Predict Fault and system Failures.

Solution

- PI CAST (Prototype), PI Data Archive 2015, PI AF 2014
- PI ProcessBook, PI Coresight 2014, PI WebServices,
- Power BI for Office 365, Azure Storage, Azure IaaS and Azure Machine Learning

Results and Benefits

- Ensure Energy Savings and Carbon footprint reduction.
- Prioritize investments and retrofit actions.
- Increase Occupants Comfort, Satisfaction and Productivity.

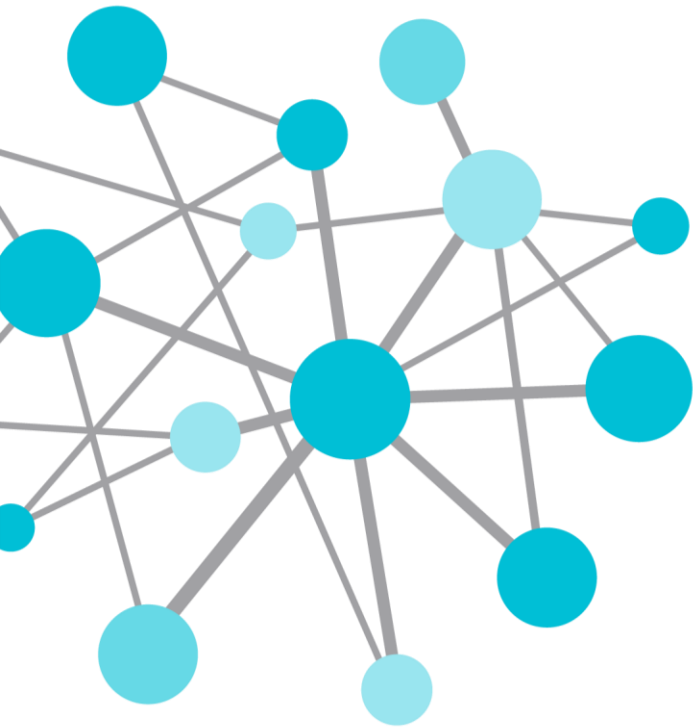


Questions

Please wait for the microphone before asking your question



Please state your name
and your company



THANK
YOU

Brought to you by  **OSIsoft.**

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Carnegie Mellon University