VOLTTRON ™

Cloud Analytics & App Platform

CORAS Cloud

Proprietary and Confidential

Introduction to CORASCloud

CORASCloud products allow customers to visually design, build and share applications that connect to any information source.

- **Founded in 2003**
- **Over 175 customers worldwide**
- **3 Core Products**
  - **CORASManage** – integrated suite of business and work management apps.
  - **CORASWorks** – app platform that allows customers to visually build and share applications in Microsoft Sharepoint.
  - **CORASNow** – Platform as a service (PaaS) that delivers Software as a Service (SaaS) apps in any cloud (AWS, Azure, etc.) or behind the firewall.

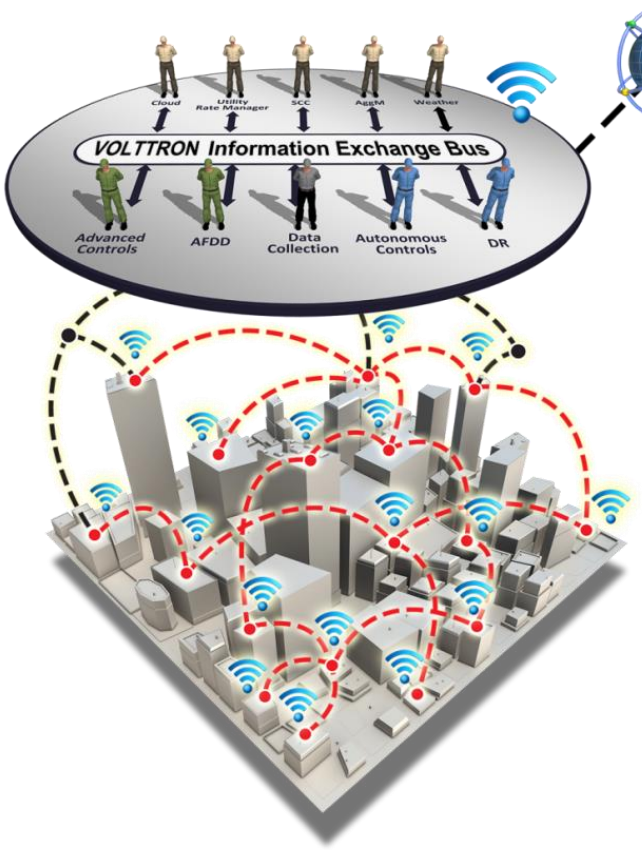
focus of today's presentation

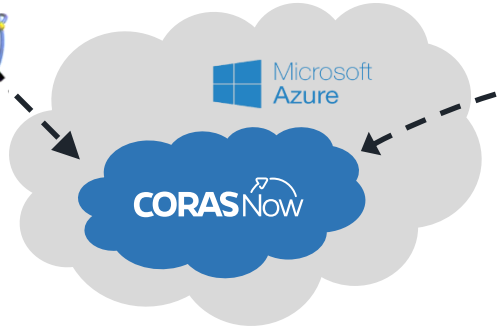
Snapshot of Customers

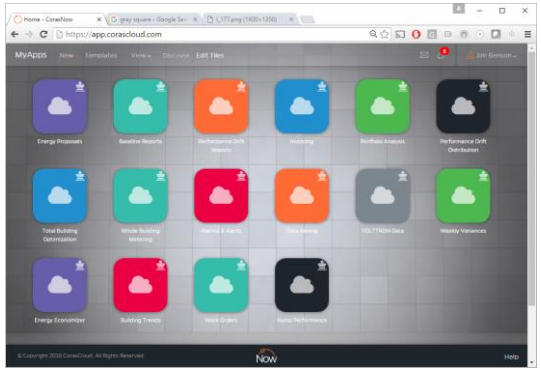
How we got here …

- **In May 2016, we were approached by PNNL about piloting CORASNow with VOLTTRON ™. Specifically,**
  - establish a secure cloud platform that captures VOLTTRON ™ information.
  - build three (3) cloud-based applications that integrate VOLTTRON ™ information.
  - integrate and apply select OpenEIS algorithms into applications.
  - document our findings, challenges and recommendations for how to fully operationalize this at a broader scale.
- **Today …**
  - VOLTTRON ™ information is being securely sent to CORASNow within Microsoft Azure's public cloud.
  - We are receiving ~ 3m VOLTTRON ™ records a day (every minute) from 11 buildings and 2,700+ points.
  - Pilot SaaS applications have been created which are using / analyzing VOLTTRON ™ information.

High Level Architecture





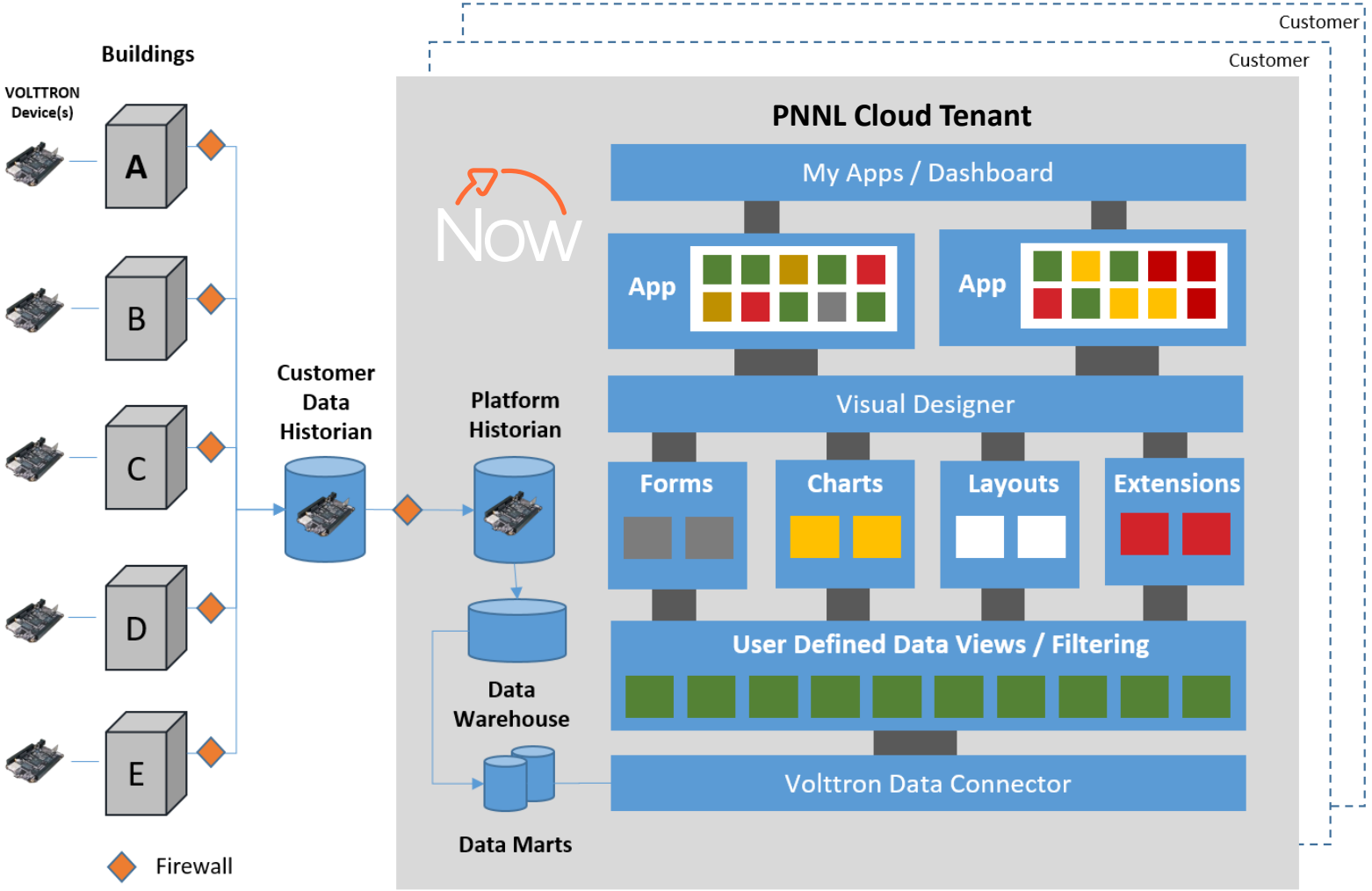


1 VOLTTRON ™ information is securely captured from buildings and points and transmitted to CORASNow.

2 CORASNow receives VOLTTRON ™ information and stores and structures it within a highly scalable database and data marts.

3 Users visually create VOLTTRON ™ enabled apps, dashboards and reports that use and analyze VOLTTRON ™ information. No coding required.

Functional Architecture



Some of the information being captured …

HVAC / AHU

- Zone Temperature / Discharge Temperature
- Outdoor / Indoor / Set Temperatures
- Exhaust / Supply Fan Speeds

Hot Water Heater

- Supply / Return Temperature
- Boiler Temperature
- Natural Gas Flow

Electric

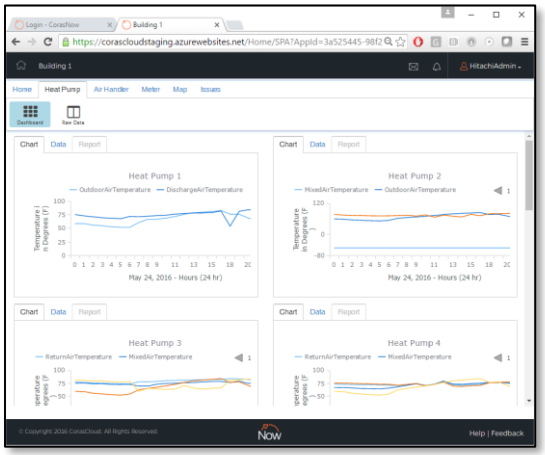
- Whole Building Power / Demand
- Whole Building Apparent Power
- Reactive Power / Demand

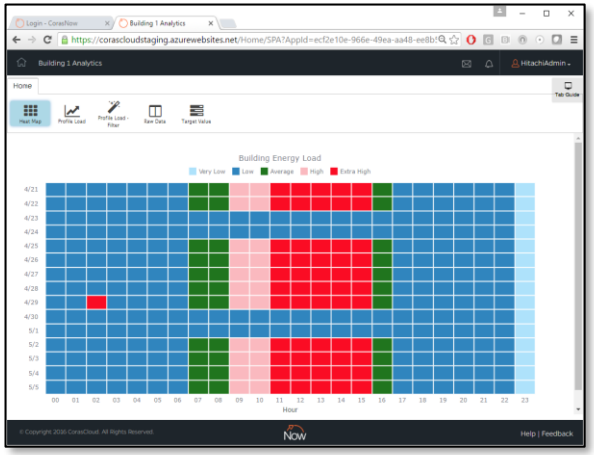
Lighting

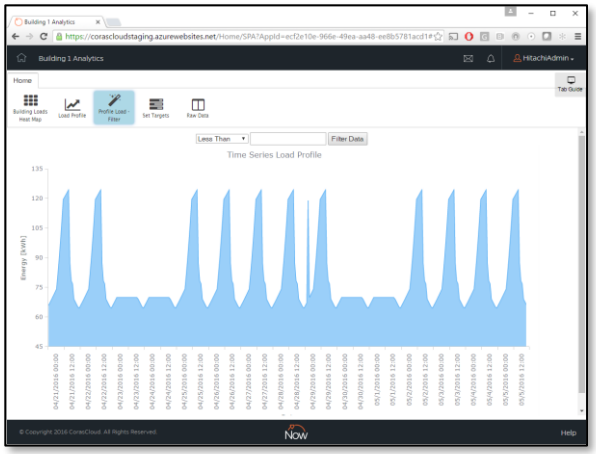
- Active Loads (exterior, corridors, by room, etc.)
- Dimming Output Levels
- Occupancy Status'

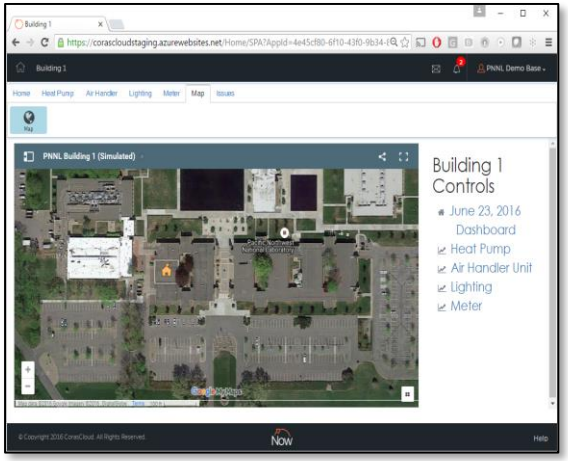
Hundreds of other points are also being collected but do not change often (i.e., set points, valve positions, damper signals, occupancy modes, etc.)

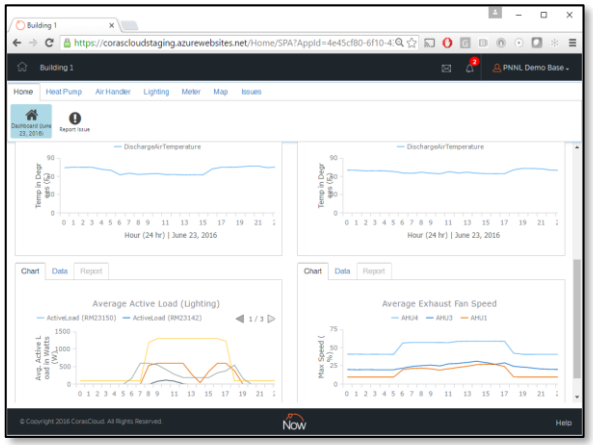
App dashboards, reports and analytics



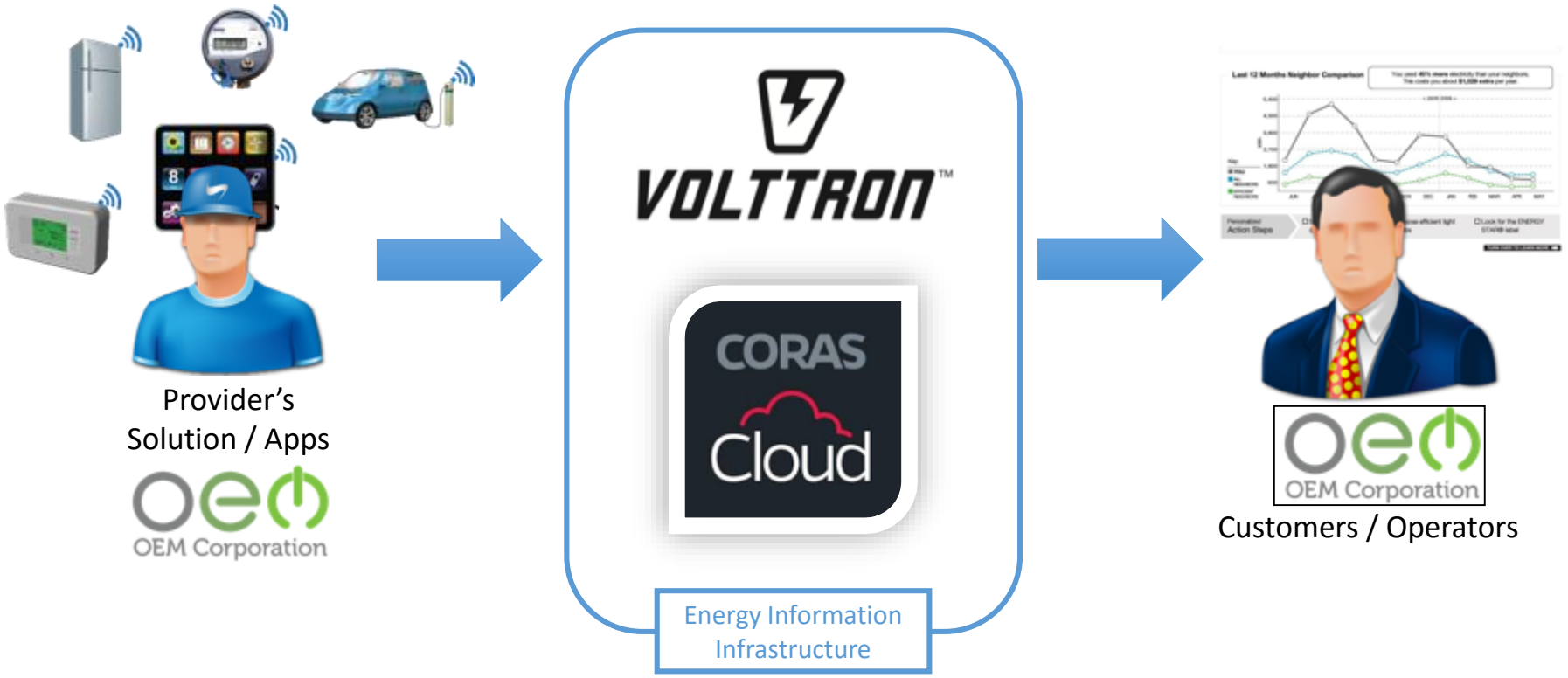








Emerging business models …



From DATA to DECISIONS

A cloud base energy information infrastructure service to securely integrate with your enterprise and power your customers' business intelligence.

Why is this important?

Managing and monitoring energy performance is complex

- thousands of controls and systems, dozens of vendors, proprietary interfaces, legacy and modern devices, no consistent standards.
- expensive management and monitoring systems, high installation and sustainment costs, proprietary hardware sets

Capturing and analyzing energy information is exhaustive

- lack of data availability, expensive data acquisition and maintenance costs, complex data integration and harmonization routines, lack of security
- proprietary taxonomies, lack of standards, expensive hardware and software costs, limited real-time analytics and reporting
- applications are expensive, outdated, rigid and typically proprietary

Companies are demanding faster, cheaper and better ways to capture and analyze energy information to support and inform critical business functions.

Today's market challenges (and opportunities)

Market Sector	Key Challenges	Example Companies
Equipment System Companies	Need cost effective ways and platforms to collect and analyze information from multiple devices to support energy management portfolio, contracts and cost savings / quality commitments	Johnson Controls, Honeywell, HITACHI, SIEMENS
Energy Service Companies	Responsible for the performance of energy buildings, portfolios and contracts. Need information from devices to analyze energy performance, make recommendations on improvements, and monitor equipment and trends.	GE, Lockheed Martin, leidos, ENERNOC, AMERESCO, Honeywell
Energy Finance and Insurance	Need information (beyond utility bills) to understand energy usage to effectively price risk of energy investments. Also, to capture energy variances to ensure investments are performing well.	HSBC, Paramount Equity, Bank of America, Wells Fargo, SunWest Mortgage Company, Inc.
Product Manufacturers	Seeking low cost devices and monitoring platform that can be installed on existing controls / IoT to monitor and hedge against control failure and performance. It's cheaper to replace before it fails.	SAMSUNG, LG, CISCO, TOSHIBA
Utilities	Seeking new ways to complement existing revenue channels / product offerings (i.e., curtailment programs, transactional grid, energy reduction, etc.).	AVISTA, New York Power Authority, DUKE ENERGY, PG&E Pacific Gas and Electric Company

Risk Management / Monetization of Value Streams

Challenges and lessons learned …

- **Data. Be careful what you ask for.**
  - We went from 0 – 3million records overnight. Now, extrapolate that for 3 months! Measure and monitor what your business needs and when they need it, avoid collecting points you don't need. More data means more cost and latency in analytics and apps.
  - SQL (relational) vs. NoSQL (non-relational) or both?
  - Data Processing. Create data cubes / marts to simplify analytics and reporting.
  - Some networks are within your control, others are not. Plan that all networks are not reliable and build in controls that let you know when you're not receiving VOLTTRON ™ data.
  - Balance server side analytics versus client side. Browsers only have so much memory and when plotting 1,000 points you can quickly run out of resources.
- **Real-time versus Offline analysis.**
- **Platforms are cool, but <u>apps and algorithms</u> show the value of VOLTTRON ™**

Questions …

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