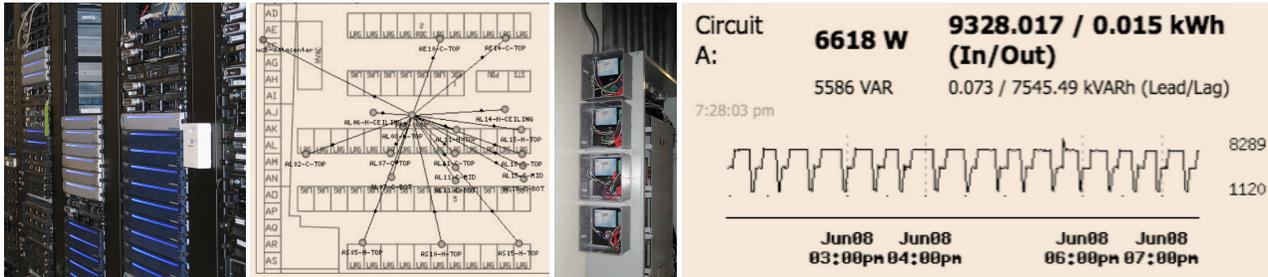# Arch Rock Energy Optimizer™ in Action

Data Center

Business Perspective

Recent trends in Information Technology such as dense blade computing, server and storage virtualization, and "cloud" computing have raised the priority for energy and thermal efficiency in data center design. Operating 24 hours a day, data center energy consumption in the U.S. has been estimated [EPA] in 2006 to be 1.5 percent of total U.S. electricity consumption and could potentially double by 2011.

For many Data Center owners or operators, what is at stake in this trend is clearly the cost implication of energy

U.S. Data Center energy consumption [EPA]
In 2006
• 61 billion kilowatt-hours (kWh)
• $4.5 billion annual electricity cost
In 2011
• +100 billion kilowatt-hours (kWh)
• $7.4 billion annual electricity cost

consumption, but often the viability of a site -- if energy cannot be supplied to it keeping pace with the growth in the demand. The challenges created by these trends for energy production, transport and cost illustrate the importance of conservation and efficiency efforts. Conservation starts with measurement, to establish a baseline of industry metrics such as Power Usage Effectiveness (PUE) and Data Center infrastructure Efficiency (DCiE), two metrics promoted by the Green Grid organization [GGRID], and continues with on-going tracking of these metrics.

To improve the data center operations, reduce energy consumption, and reap associated costs savings, an open monitoring, reporting and alerting framework is key to help the facility and IT managers improve their data center environmental efficiency. A key requirement for wide-scale acceptance of such a framework is the ease with which it can be introduced and managed, without the prohibitively costly and disruptive impacts that have been characteristic of wired instrumentation systems so far. A monitoring framework must have zero negative impact on the operation of servers and network and storage equipment, in addition to being easy to introduce and be based on open IT paradigms such as IP networking and Web Services interfaces.

Operational Challenges

A Data Center operational budget for energy is split between powering IT equipment such as servers, storage, and network devices; cooling and conditioning systems such as chillers, CRACs (Computer Room Air Conditioners) or CRAHs (Computer Room Air Handlers), humidifiers, and pumps; power systems such as batteries, generators, PDUs (Power Distribution Units), and UPSs (Uninterruptible

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Power Supplies); and miscellaneous items such as lighting, and security and safety and alarm systems. "Gartner Research[1] estimates that up to 60% of the energy consumed in a data center goes to cooling in wasteful ways." The direct relationship between power consumption and cooling infrastructure reinforces the need for gaining visibility into rack-level energy consumption, thermal gradients, humidity levels, under floor airflow, and CRAH efficiency. This is even more crucial since recent design rules recommend raising the set points in cold aisle air temperatures and chiller water temperatures in an effort to save a huge amount on power and cooling.

Here are some common operational challenges faced by the Data Center manager today.

- Raising set points. Studies [SETPT] indicate that raising the operating temperature of data centers does not significantly reduce the reliability of the equipment, while delivering significant savings in cooling costs. But raising the temperature without first eliminating existing hot spots creates localized areas of vulnerability.
- Using outside air for cooling. HVAC Economizers have been demonstrated to save money. But once again, lack of fine-grained visibility of the temperature at the rack intake level prevents many Data Center managers from implementing or using Economizers.
- Installing aisle separations. Simply walking around in the aisles tells you that there may be hot air contaminating the cold aisle from the top or sides. But before you spend the time and money to install the physical separations between aisles, you'd like to confirm the problem and baseline the temperatures, so that the ROI of the separations can be demonstrated and quantified.
- Pushing the capacity limits on power. Where will you land your new blade server? Which racks and circuits have the capacity? Not knowing the exact rack power usage at all times during the day or the week, the natural tendency is to over-provision the power to all racks or under-utilize the available rack space and power.

AREO Solution

Arch Rock Energy Optimizer™ (AREO) is a suite of wireless environmental sensors, wireless sub-meters, IP routers, and web-based applications -- all dedicated to Data Center energy optimization. By using AREO, Data Center IT and facility managers can quickly benefit from a real-time networked energy measurement and environmental monitoring solution that is easy to integrate and manage within their existing IT infrastructure while delivering better visibility into thermal profiles and power consumption profiles of their Data Centers.

AREO offers the Data Center manager the ability to:

- Closely track the thermal environment in time and space, enabling an increase of the global Data Center air temperature to save cooling costs while avoiding hot spots.
- Utilize HVAC Economizers with confidence gained by fine-grained temperature visibility.
- Optimize the use of existing power capacity and defer expensive Data Center upgrade by reporting in real time the detailed power usage at the circuit and rack level.
- Deploy new server capacity with confidence, knowing the exact load on the circuit and rack PDUs at all times.

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[1] *Gartner Inc. Press Release, November 28, 2006*

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- Verify the efficiency of the Data Center cooling system and properly match plant load to rack cooling load as well as identify operational issues through Data Center thermal monitoring at any desired granularity in time and space.

Adoption of Arch Rock Energy Optimizer as a framework for energy and environmental monitoring offers tremendous benefits in the context of a Data Center alone or more broadly for an overall campus or building [Building]. This paper focuses on the benefits of AREO in a Data Center deployment.
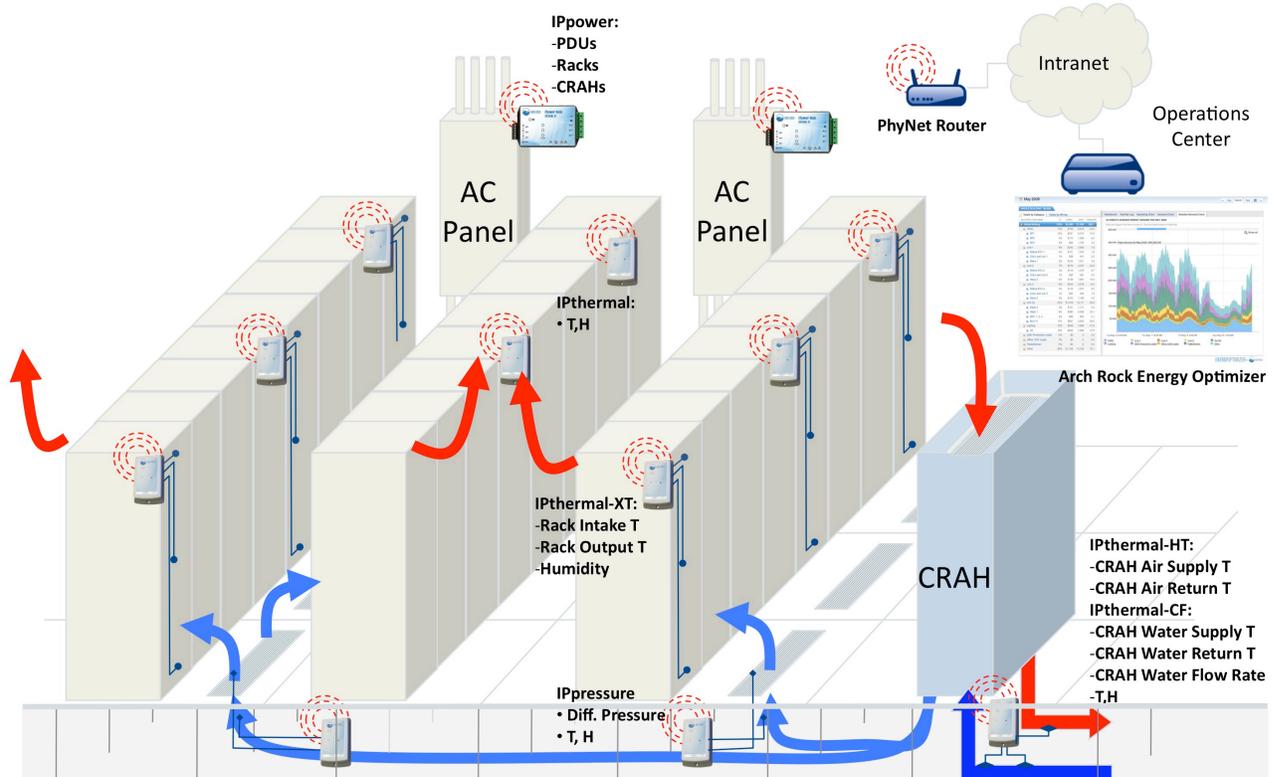

IPpower:
-PDUs
-Racks
-CRAHs

Intranet

PhyNet Router

Operations Center

AC Panel

AC Panel

IPthermal:
• T,H

Arch Rock Energy Optimizer

IPthermal-XT:
-Rack Intake T
-Rack Output T
-Humidity

CRAH

IPthermal-HT:
-CRAH Air Supply T
-CRAH Air Return T
IPthermal-CF:
-CRAH Water Supply T
-CRAH Water Return T
-CRAH Water Flow Rate
-T,H

IPpressure
• Diff. Pressure
• T, H

Figure 1 AREO in Action

Sensing Nodes

Arch Rock's suite of wireless sensing nodes installed in a data center ranges from wireless nodes with integrated sensors (energy monitoring, temperature, humidity, pressure, chiller flow rate, etc.) to wireless expandable nodes capable of incorporating additional off-the-shelf external sensors, offering the flexibility to enhance the service capabilities as new sensor types become available. A typical deployment in the data center consists of Arch Rock PhyNet™ Nodes with 802.15.4/6LoWPAN low-power radio, IP-based mesh networking and embedded web services, such as:

AREO Components

- **IPpower Node** – power sub-metering at the rack or circuit level
- **IPthermal Node** – thermal and humidity monitoring; chiller water temperature and flow rate monitoring
- **IPpressure Node** – Differential air pressure monitoring
- **IPsensor Node** – Versatile analog and digital sensor node
- **IPrelay Node** – Wireless network range extender
- **PhyNet router** – IP WSN router
- **PhyNet server** – Data aggregation, export and IP WSN management
- **Energy Portal** – Energy data analysis and presentation, and KPIs (e.g. DCiE and PUE)

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- IPpower Nodes with appropriately sized current transformers installed on individual circuits either at the electrical panels or in-line at the power ingress points of individual racks. It can monitor up to 3 circuits or phases and report kW, kWh, VAr, VArh, Amp, Volts, power factor and frequency. The Rack IPpower Node is a key element for the optimization of existing power capacity.
- IPthermal Node Series is a family of temperature, humidity and flow rate monitoring nodes in the Arch Rock PhyNet™ wireless sensor network product line. All models are available with built-in and external sensing devices for measuring one or more ambient temperature and humidity points enabling fine grained monitoring when raising the Data Center temperature set points or enabling HVAC Economizers. IPthermal Nodes come in various models:
  - IPthermal-HT provides up to four temperature and humidity measurement points using one integrated (humidity and temperature) sensor and up to three external (humidity and temperature) sensor probes. Combined temperature and humidity probes are well suited for sensing CRAH supply and return conditions.
  - IPthermal-XT provides up to seven temperature measurements using one integrated temperature (and humidity) sensor and up to six external thermal sensors. It is well suited for sensing rack inlet/outlet air temperatures.
  - IPthermal-CF provides for non-intrusive monitoring of the chiller water supply of air conditioning units. The node supports up to two chiller pipe surface temperature probes and one external ultrasonic flow meter input.
- IPpressure Node can measure the differential pressure at up to three sets of points, for example below and above cold aisle's raised floor. In addition, it also measures ambient air temperature and humidity with a built-in sensor. IPpressure and IPthermal-CF nodes are the ideal companion nodes when monitoring the efficiency of the Data Center cooling system and identifying issues.

Infrastructure Devices

One of the key benefits of the AREO solution is its seamless integration with any IT infrastructure through the "no wire" 6LoWPAN wireless technology which is now part of the open and standard based IP protocol suite that extends to all sensing nods in the solution. The wireless sensor network gets linked to the Data Center IP infrastructure through:

- PhyNet Router that links the IEEE 802.15.4/6LoWPAN sub-network to the rest of the IP network. In a sample Data Center configuration, two or more PhyNet Routers are connected to Ethernet switches servicing the Data Center, depending on scaling and redundancy requirements.
- IPrelay Node that helps extend the low-power meshed infrastructure by relaying data between wireless sensing nodes and PhyNet Routers when the distance or path properties over which to propagate the radio signal requires relaying or when redundant paths are desired for robustness and spatial diversity of the radio propagation paths. In an AREO deployment, IPrelay Nodes can be added at any time for improving the robustness and diversity of paths over which wireless network meshing can take place with high levels of data reliability.

AREO Applications

The Arch Rock Energy Optimizer solution includes turnkey, enterprise-level energy monitoring, analysis and savings applications. As an enterprise-wide Web2.0 portal, it provides dashboards and visualization/analytics tools to the enterprise customers' energy data, environmental data and other

energy-related data. This set of applications is offered either as an Arch Rock hosted service or a self-hosted application at the customer's premise on an Arch Rock supplied appliance.
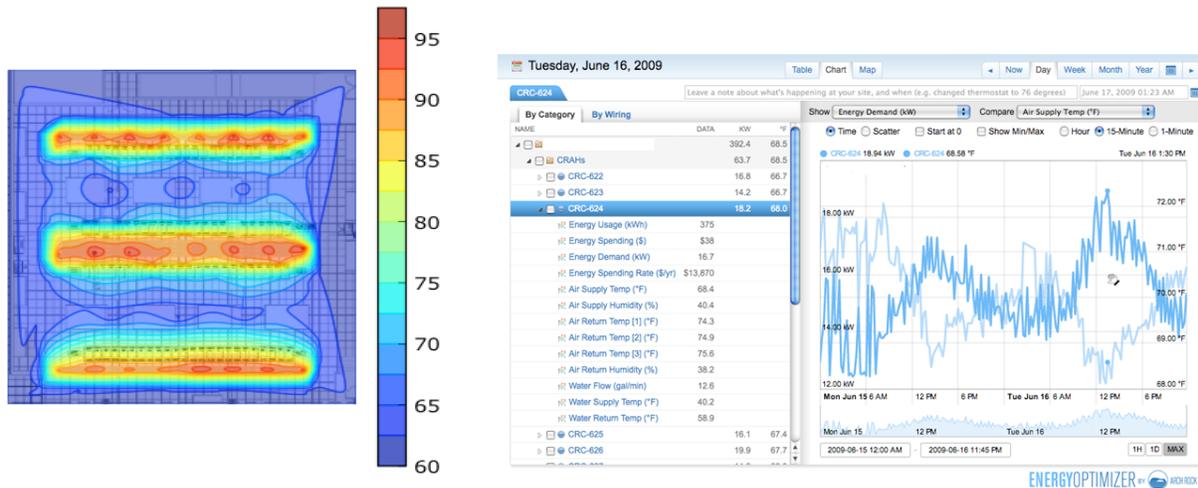

Figure 2 AREO Thermal Monitoring Examples

Key AREO features are:

- Configure and display the electricity load hierarchy of mains, UPSs, PDUs, server racks, chillers and CRAHs
- Display electricity usage by categories over varying time intervals
- Display thermal data from CRAH, server's racks and chillers
- Display air flow and water flow data from sensing nodes listed over time
- Spatially display electricity usage and sensor readings on a static image and refresh at some rate with live readings
- Temperature contour maps over a floor plan
- Export all energy data and sensor data as CSV files
- Report alerts on data threshold set by the end-user
- Import data from an external relational database in a well-defined format
- Enterprise-wide dashboard of key performance indicators (KPI) such as PUE for multiple sites and tracking them against a target.
- Ability to drill down from an enterprise level to specific data centers and racks, where applicable.
- Sensor data repository (PhyNet Server) from which applications such as Arch Rock Energy Optimizer or third-party applications are built. All the data can be accessed via standard Web Service interfaces (REST or SOAP) or exported as CSV or XML files.
- Management server for the IP wireless network and associated devices providing a rich set of web-based user interfaces for managing the routers and nodes, analyzing network health statistics as well as diagnosing and remedying network problems.

Arch Rock PhyNet™ Technology

Arch Rock Energy Optimizer leverages the IP-based wireless sensor networking and open IT data access paradigms pioneered by Arch Rock. By adopting open standards of the IP architecture, AREO brings the benefits of a layered framework to energy and environmental monitoring such as:

- IEEE 802.15.4/IETF 6LoWPAN Low Power Radio technology – enables the deployment of an out-of-band environmental infrastructure with no impact on existing installation. Low installation labor costs (no wires), easy re-configuration through the evolution of the Data Center and integration of new featuring nodes make it perfect for environmental monitoring.
- End-to-end IETF IP standards – bring its set of capabilities including Ease of Configuration, network Management, Security, Provisioning and Automatic and Adaptive Mesh Networking. The strengths of open IP features make high availability and Data Reliability as part of the AREO solution.
- Open Web Services (REST/SOAP) and Data Formats (CSV/XML) – offers the Ability to pull energy and thermal data into broader enterprise activity contexts or outside weather contexts for data presentation or export. It is used by AREO real-time visibility, benchmarking, goal setting and tracking, anticipation of failure and visibility into hot spots

Business Benefits

By analyzing AREO energy consumption and thermal monitoring data, IT data center operations can become more efficient in several ways.

- Benchmarking the data center to evaluate its energy efficiency may be one of the first business benefits of Arch Rock Energy Optimizer solution. To measure industry metrics such as PUE and DCiE will require collecting the amount of power entering the Data Center as well as the power used to run the computer infrastructure within it. AREO delivers the capacity to establish those metrics on a real-time basis and at different times of the day, week, month and year.
- Data center server consolidation and virtualization holds the promise of energy savings through its server consolidation. By running AREO, IT managers can visualize the energy savings during the transition of their data centers towards consolidation and virtualization.
- AREO solution offers an opportunity to stop "over–sizing" the power and cooling equipment in data centers which represents a considerable waste of energy as reported by Gartner Research. By collecting data through AREO, IT operators can realize the impacts of such changes on the efficiency of the physical data center infrastructure.
- Arch Rock Energy Optimizer real-time monitoring and alerting capabilities allow IT operations to adopt the recent recommendations of raising the temperature in data center. For example, rather than maintaining 16 degrees Centigrade (61 Fahrenheit) at the cold aisle rack air inlet, the data center temperature can be increased to 24 degrees Centigrade (75 Fahrenheit), saving on power and cooling and leading to reduced operating cost. AREO monitoring allows verifying that no hot spot gets created, whereby sections of the data centers may be served air at significantly higher temperatures than the desired 24 degrees Centigrade (75 degrees Fahrenheit). Real-time alerts enable IT operators to quickly get informed and react ahead of when failures occur. Energy monitoring will help benchmark the potential savings.
- By leveraging Arch Rock PhyNet wireless mesh networking capabilities, Arch Rock Energy Optimizer provides an out-of-band monitoring network crucial for production data centers when re-configuration downtime is not an option. The flexibility of Arch Rock wireless sensing nodes enables easy initial deployment of sensing points where needed and subsequent re-deployment of sense points where and when needed in the data center, something that would be prohibitive to the point of dissuasion with wired alternatives.
- Arch Rock Energy Optimizer is based on open IP standards, which greatly facilitates its integration and management by IT operators. The deployment draws on all IT familiar Internet

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services such as Routing, Security and Manageability generally available from the data center infrastructure, enabling data to be monitored from anywhere in the world by authorized users.

- Arch Rock Energy Optimizer open data formats and ease of data export allows the users to pull the environmental data into a broader enterprise data context. It becomes now possible to achieve complex correlations such as outside weather conditions and indoor temperature and cooling, computing loads like factory shipping levels, financial closing activities, stock trading activity levels, final phases of R&D project completion, universities student exams, etc versus energy consumption.

For more information

To find out more about Arch Rock Energy Optimizer, please visit: http://www.archrock.com

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