White Paper

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Wireless sensor networks for data centre monitoring

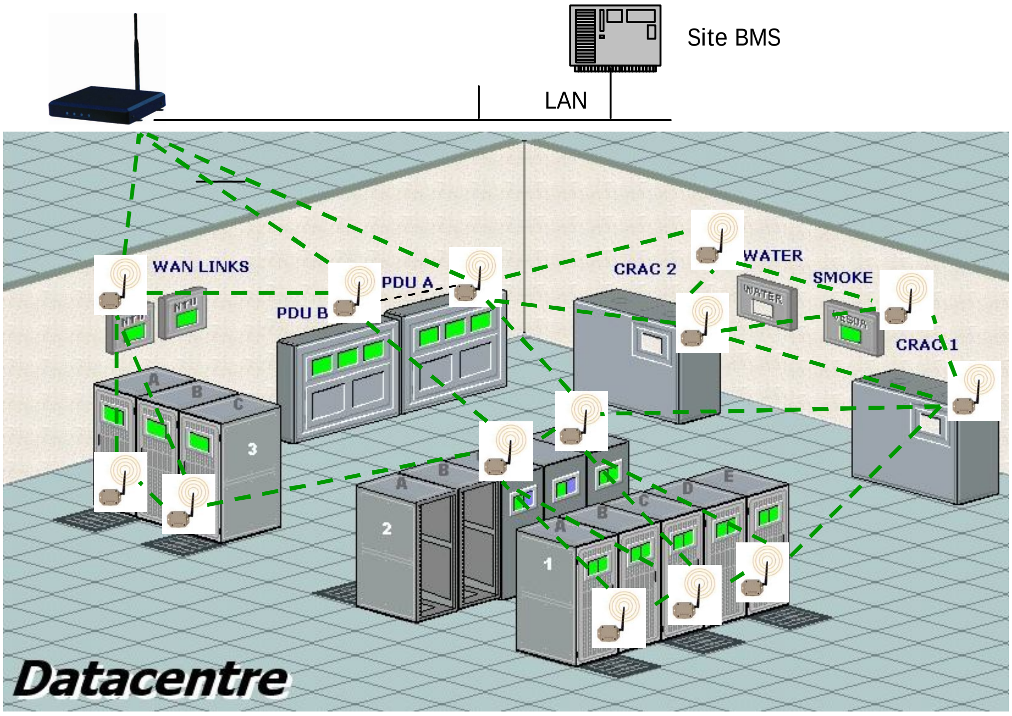
With IT energy use projected to double by 2011 reducing data centre consumption is a pressing issue for the entire IT industry. In this paper we demonstrate how wireless real-time environmental monitoring systems can improve the energy efficiency of IT facilities.

Wireless sensor networks (WSN) are ideally suited for the real time monitoring task needed to control thermal conditions and help reduce energy consumption.

This paper discusses the following issues :

- Limitations of existing monitoring solutions
- How a wireless sensor network solution solves many of those limitations
- Benefits resulting from using a wireless monitoring system

Battery powered wireless sensors require no additional network and facility infrastructure in an already complicated data centre IT environment and can provide the essential data required to optimise the growing issues of heating, cooling and energy usage control.



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Background

Only a fraction of the electricity consumed by a data centre actually powers IT equipment such as servers and networking devices. The rest is used by various environmental & control systems such as Computer Room Air Conditioning (CRAC), water chillers, and (de-)humidifiers, or simply lost during the power delivery and conversion process. The data centre Power Usage Effectiveness (PUE), defined as the ratio of the total facility power consumption divided by the power used by the IT equipment, is a metric used by The Green Grid to measure a data centre's "overhead." A higher figure indicates greater energy "overhead" while a lower figure indicates a more efficient facility.

Conventional wisdom dictates that IT equipment needs excessive cooling to operate reliably, so the air conditioning systems in many data centres use very low set points and very high fan speed, to reduce the danger of creating any potential hot spots. With limited visibility into environmental conditions operators will inevitably run the facility at lower cooling temperatures to provide a safety margin even if this results in increased energy consumption.

Whilst air side economisers and dynamic server provisioning are useful ways to reduce energy consumption they can produce variations in cooling distribution which can lead to thermal instability (hot spots) and possible premature equipment failure.

Data centre cooling

Most professional data centres use a cold-aisle-hot-aisle cooling design. Server racks are installed on a raised floor in aisles. Cool air is blown by the CRAC system into the sub-floor and vented back up to the servers through perforated floor tiles. The aisles with these vents are called cold aisles.

Typically, servers in the racks draw cool air from the front, and blow hot exhaust air to the back in hot aisles. To effectively use the cool air, servers are arranged face-to-face in cold aisles. Cool and hot air eventually mixes near the ceiling and is drawn back into the CRAC.

In the CRAC, the mixed exhaust air exchanges heat with chilled water, supplied by a chilled water pipe from water chillers outside of the facility. Usually, there is a temperature sensor at the CRAC's air intake. The chill water valve opening and (sometimes) CRAC fan speed are controlled to regulate that temperature to a set point.

Heat distribution depends on factors including chilled water temperature, CRAC fan speed, rack spacing, server types and server workload. Without detailed knowledge of heat distribution patterns operators are likely to be cautious and over cool the facility.

Computational fluid dynamics simulations can be used to estimate heat distributions and are particularly useful during the design stage. However CFD models can easily become obsolete and updating them is likely to be expensive and time consuming.

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Real time monitoring software completes the picture

A wireless sensor network only provides part of a complete solution for data centre thermal management. What's also required is the ability to analyse collected data and integrate with other physical and network parameters including :

Facility layout - to provide a template for data presentation

Cooling systems - which are typically monitored by a building management system

Server performance - server subsystem performance metrics are readily available using standard protocols - the trick is to integrate these with other non-IT data to build an overall performance picture.

Load variation - power consumption patterns are seen as key tools in the search to measure application performance

Environmental data - as well as temperature other critical parameters might include humidity, air flow, air pressure and chilled water flow.

Leading edge software collects both IT and non-IT data from SNMP and wireless devices in order to provide analysis and report on various factors including alarm thresholds exceeded, alarm correlation, temperature profiling, server performance and energy consumption.

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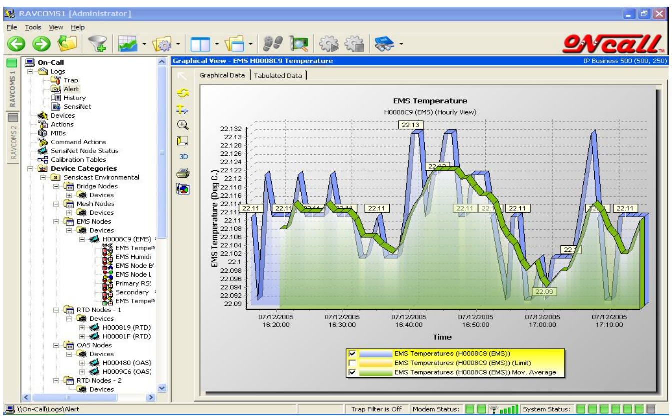
Wireless sensor network design

The main elements of a wireless sensor network are the sensor nodes which collect the environmental data, router nodes which relay the data (and can double up as sensors too in some systems) and a gateway device which is responsible for network setup and management and also acts as an interface to other elements in the data centre whether that be existing monitoring applications or a dedicated analysis package.

Wireless sensor networks are based on the industry standard IEEE 802.15.4. specification which supports a self forming, self healing mesh network. This makes for easy network set up and allows additional monitoring nodes to be added, or changes in the network layout to be made, with minimal effort.

Reliability is an issue often associated with wireless networks. Tests have shown that the nature of the mesh architecture results in data reliability of 99% over extended time periods even in high data traffic environments.

The frequency hopping nature of the wireless mesh network ensures that interference with other wireless devices is eliminated.



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Data centre environmental monitoring benefits

Using wireless sensors in data centre environments can provide a range of insights not previously available concerning thermal behaviour and the potential impact of other measures to try and curb energy consumption.

Heat distribution

Detailed heat maps generated from wireless sensor data can help determine optimum settings for cooling rather than depending on single point measurement which might not be representative of the true conditions being controlled.

Techniques such as virtualisation can effectively adjust the number of active servers based on server work load, reducing the total energy consumption during periods of low utilization. However if shutting down one server causes increased work load on an adjacent machine, but the CRAC is more sensitive to the former's condition, might lead to a reduction in cooling and put the latter machine at risk.

Thermal overload

In the event of cooling system failure some IT sub -systems, for example storage arrays, might be more prone to overheating than others which has implications when choosing locations within racks and aisles and how to make best use of other local cooling air flows.

Energy use optimisation

Increased data concerning infrastructure equipment performance, gained by employing wireless sensors, allows operators to see the impact on energy performance resulting from efforts to vary operating parameters. Such efforts could result in lower energy consumption e.g. increased chiller water temperature, where every degree higher can produce up to a 3% efficiency gain.

Conclusion

Ultimately achieving maximum reliability at minimum energy cost in data centre environments will rely on the ability to make fine grained, real time measurements for which wireless provides the best long term solution.

Only by understanding the complex interactions between the IT and facilities installations can the goal of best performance at least cost be realised.

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