Who Tripped the Circuit?

The clear-cut case for branch circuit monitoring in data centers

Imran Ahmad, product manager
Eaton Data Center Solutions

The large Internet service provider had spent millions of dollars on reliability measures for its state-of-the-art data center. After all, its data center was its life blood. No downtime was acceptable.

So the infrastructure was bolstered with redundant UPS systems, redundant cooling, redundant generators and redundant power feeds into the AC servers.

However, in spite of all these protections, the ISP experienced a lot of unplanned downtime—at the worst times, when Internet activity was at its highest. The trigger was embarrassingly simple: branch circuit breakers were tripping.

For this ISP, so much money and focus had been directed at ways to ensure high uptime, but a key aspect had been overlooked: ensuring appropriate loading at the branch circuit level. Variable power consumption patterns caused circuits that were normally loaded at less than 50 percent to jump beyond 100 percent, and trip a breaker. To compound the problem, maintenance staff had a hard time locating the tripped breaker, so there would be unnecessary and costly delays before power was restored.

This is just one example, but it's not unusual. In fact, scenarios like this are surprisingly common. Ironically, as data centers become more sophisticated and technology-rich, the risks actually tend to worsen.

Why Are Branch Circuits Getting Overloaded?

There are several reasons...

Data Centers are More Power-Hungry Than Ever.

Traditionally, data center managers could plan for about 60 to 100 watts of power consumption per U of rack space. With today's blade servers that figure has escalated to more than 600 to 1,000 watts per U and growing. Power consumption can easily double or triple during peak periods and frequently fluctuates. Adding a 1U or 2U server used to mean drawing 300 to 500 more watts from the branch circuit; now a new blade server consumes 10 times as much current.

IT Equipment Has More Variable Power Consumption Than Before.

Traditionally, computer equipment required pretty much the same amount of power, no matter how much processing was taking place. Trouble was, computers consumed too much power overall, relative to the work they were doing. This was particularly true for laptops, because precious power was being drained from batteries even when the unit was fairly idle.

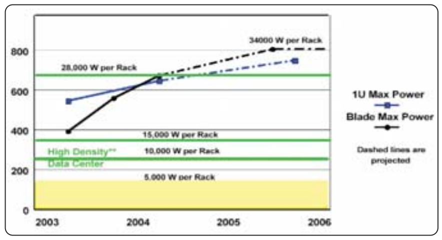

Figure 1. Blade servers have dramatically increased power consumption in a rack.

In the last decade the trend has been toward designs that consume power at a rate that matches the computing load, less when the PC isn't working very hard, more when needed. Power management technologies such as voltage and frequency scaling, low-power disks, and low-power power supplies have managed to reduce power utilization by more than 80 percent during periods of low computational burden. Not surprisingly, server manufacturers started adopting these technologies to reduce power consumption and heat output in high-density data centers and network rooms.

These more efficient technologies mean that server power consumption now varies dramatically as the workload varies, often more than doubling. Imagine the impact of seasonal peaks in retail sales for an online retailer, such as Amazon, or card vendors such as Visa and MasterCard. Christmas season volumes could stress circuits beyond their thresholds, bringing systems down at the worst possible time.

As new server-class processors are developed, consuming even more power to deliver higher performance, the problem will worsen. Six years ago, a typical server consumed 100 watts per U space. Today's blade servers consume more than 10 times that amount, more than 1 kilowatt. A 10 percent variation in power consumption today means more than a 50 percent variation in old servers.

Blade servers also use very few disk drives, which means processor power represents a larger percentage of overall power consumption—and variations due to changing computational loads become much bigger factors.

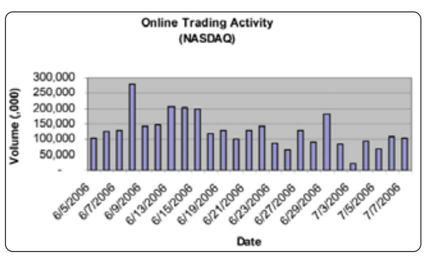

Figure 2. Transaction volume can vary 200 to 500 percent in some enterprises, with big implications for data center power consumption.

Circuits Get Loaded for Day-to-Day Averages, Rather Than Potential Maximums

Server consolidation efforts have increased server utilization, but still the average server operates at 5 to 30 percent of processing capacity, typically less than 15 percent. That means most servers spend much of their time operating at light computational loads, drawing far less power than they potentially could.

Under normal operating conditions, data center managers could mistakenly assume there's plenty of capacity on a branch breaker or panel board. After all, day-to-day power consumption seems well within limits. But there's always the potential for one or more servers to increase computational load, draw more power to match the workload, and cause a branch breaker to trip. With today's denser, space-saving equipment, the risk of overloading a branch breaker is higher than ever.

Since average server utilization tends to be light, the risky situation can go undetected for a long time. The breaker then trips and shuts down power to critical systems at the most damaging time, when the equipment is handling the highest transaction volumes.

Many IT Components are Served by Two Power Supplies

The equipment has two independent yet paralleled power supplies and accepts two separate power feeds. Either power supply is sufficient to take over if the other fails.

On the surface, that doesn't seem like a problem, does it? When power requirements are distributed among two sources, you gain redundancy and fault tolerance for greater system availability. If a power supply or power source fails, the other can take over and the equipment keeps running. However, consider that scenario from the branch circuit perspective. The power supply inside the IT equipment may be sized to handle the full power draw, but does the circuit have the capacity? Often not.

Each breaker in a dual power path must be loaded at less than 50 percent of trip rating during normal conditions. That way, a failure of one path won't overload the alternate path and cause breakers to trip. However, if you've loaded each circuit conservatively at less than 50 percent, a failure condition can go unnoticed for a long time, because the alternate power path has picked up the slack and servers are running normally.

What if the alternate path, now the sole power path, fails? It trips the breaker and brings the system down, possibly producing a cascading effect that jeopardizes upstream power feeds and puts the entire system at risk.

Moves, Adds and Changes are Constant

In a typical data center, flux is continuous. Managers of large data centers reported that moves, adds and changes take place several times a week. Even in the smallest computer rooms, changes take place at least once a month (see chart below).

Study - July 2006 (474 IT/Data Center Managers)			
Frequency of M.A.C. in a Data Center	Small Computer Rooms <20 Racks	Medium Data Centers 20-100 Racks	Large Data Centers 100+ Racks
Several times a week	11.3%	29.5%	42.0%
Once a week	15.7%	26.4%	18.0%
Once a month	40.7%	28.7%	38.0%
Once a year	28.8%	10.1%	20.0%
Never	3.6%	5.4%	-

Changes in data center configuration can put a lot of pressure on branch breakers. In constantly changing environments, it's easy to create misbalanced loads. Because you don't have current or historic data on the current draw per breaker, you might overload one breaker while under-loading another.

The risks are intensified by the more power-hungry nature of new servers. Breaker loads are often optimized based on the average power consumption of servers when the data center was designed. But new servers consume a far greater percentage of the power available on a breaker, increasing the likelihood that adding new equipment to a branch circuit will result in overload.

Is Branch-Level Power Distribution a Weak Link?

With the increase in and varying nature of power consumption, branch circuits are at risk. It is easy to overload a circuit, trip a breaker, and cause costly, unplanned downtime. The problem has grown significantly in the last few years and is reaching a point where it cannot be ignored.

Seems improbable? Even the architecture of the typical panelboard represents a point of vulnerability. Consider that a standard panelboard generally has a main breaker rated at 225 amps with 42 branch circuits. Based on a derating factor of 80 percent for all breakers, 42 single-pole, 20-amp breakers can potentially draw up to 672 amps—nearly four times as much as the main breaker. Without proper coordination and monitoring, a branch breaker could trip and actually cause the panelboard main breaker to trip as well.

Many organizations rely on so-called "lights out" or "dim" data centers that are not staffed. Some form of automated monitoring must be implemented to replace the human presence.

Why Traditional Approaches Have Fallen Short

Clearly, changing conditions and new IT equipment predispose today's data centers to the costly and damaging effects of tripped circuit breakers. At the branch circuit level you might not be able to see trouble coming until the breaker trips, and that's too late. Systems go down. Valuable data is lost, and business comes to a standstill. It can take hours to recover. Avoid such an undesirable situation: monitor the power consumption of each branch breaker.

Some organizations periodically check current loads with hand-held meters; a risky procedure considering that that this method can easily miss problem conditions, which can appear and disappear in microseconds. The sampling might also take place during lightly loaded periods, producing unreliable data. And of course, it would be cost-prohibitive to have a permanently installed meter on every branch circuit.

Another common approach is to monitor power at the rack power strip level. However, a single branch circuit may support multiple rack power strips or racks. Conditions could be fine at the power strip level but approaching overload at the branch circuit level.

Furthermore, not all equipment in a typical data center is powered from power strips. Storage devices, mainframes and other large elements are usually powered directly from a branch circuit. Strip-level monitoring would miss these systems altogether. Finally, monitoring at the power strip level requires the organization to reserve a lot of IP addresses and connections, which complicates the management environment.

The only dependable way to monitor appropriate loading for each breaker is by installing monitoring devices that measure the current draw 24/7. However, branch circuit monitoring systems that have been on the market until now were seen as too expensive and did not provide enough data points or features to ensure complete information. Facility managers needed a better way to ensure reliable, continuous power at the branch circuit level.

Choosing a Branch Circuit Monitoring System

When searching for a branch circuit monitoring system, first assess your needs and the system's monitoring capacity. Determine how many panelboards you will need to support in addition to the main input/output paramaters of the distribution equipment, such as a power distribution unit (PDU) or remote power panel (RPP).

Now, search for a system that continuously measures and stores the history of the current on branch circuits and warns you of impending trouble, so you can take proactive action. Armed with these insights, data center and facilities managers can more effectively manage energy consumption to prevent overload conditions and optimize power distribution. Some other key features to consider when looking for a system include the ability to have both local and remote access to power monitoring data, monitoring of environmental conditions.

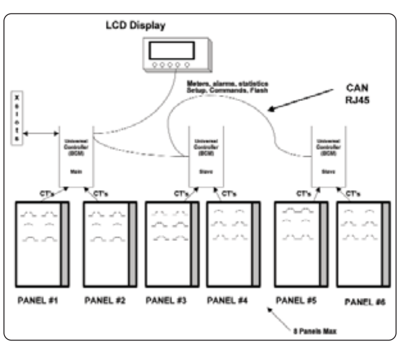

Figure 3. An example of a branch circuit monitoring system that sends data from many sources to a single display.

Detailed Insights into Circuit-Level Power Conditions

Choose a branch circuit monitoring system that assesses circuit activity 24/7 and provides time-stamped information for each branch circuit.

For example, look for a system that shows detailed information about current, voltage and frequency power quality metrics, time-stamped event records and more. If this information is shown for individual circuits and summarized for each panelboard and at the equipment level, you get visibility at all levels within one unit.

With this information, you always know how close a circuit is to exceeding its overall rating, and whether or not a device can be added to a branch circuit or panelboard. This enables you to operate at maximum efficiency, using data center assets, energy and space wisely.

Early Warning of Problem Conditions.

Choose a system that allows for a user-defined threshold of power consumption, at which point the system sends a warning alarm to the local display and the defined communications network, alerting the data center or facility manager to the specific circuit and the condition before the current approaches the breaker's trip point.

Local and Remote Access to Power Monitoring Data

Another feature to consider is how the system displays information. Is a display included in the base system or is it a separate purchase?

Some systems allow information to be accessible and communicable remotely. This can be especially helpful for managing large data centers with hundreds of panels and thousands of branch breakers.

Monitoring Environmental Conditions

Generally, most of the electrical power consumed by computing equipment is dissipated as heat. When the power consumption varies (as it does), so does heat output, potentially creating undesirable hot spots.

Some branch circuit monitoring systems also monitor key environmental conditions, such as temperature and humidity of the distribution equipment. These capabilities enable data center managers and facility managers to identify trouble conditions and then design and monitor layouts that avoid adverse hot spots.

Trending and Load Profiling for More Accurate Management and Planning

It is important to be able to assess the historical power consumption of a branch circuit or panelboard, to consider past trends before adding new loads.

Look for a branch circuit monitoring system with the ability to archive data and perform load profiling across many months. This data provides valuable insight for managing power consumption and diagnosing issues. In turn, this will extend the life of existing infrastructure and delay the need for new investment.

Summary

Branch circuit monitoring technology has been field-proven for years, and recent advances in technology and design have made the solution more affordable than ever. It definitely provides cost-effective insurance against tripped circuits and unplanned shutdowns.

The cost of downtime is difficult to quantify, but substantial. Besides the obvious out-of-pocket losses, there are hidden costs, such as loss of customers, reputation and image. The average cost of downtime ranges from approximately $90,000 per hour in the transportation industry (airline reservations) to $6.5 million for large financial brokerages (according to Contingency Planning Research, 2001). Without a branch circuit monitoring system, it can take more than an hour to discover and rectify the problems created by a single trip.

When comparing features and technical specifications of different systems, data center managers must first assess their current needs and future concerns. Then choose a system that provides detailed insights into circuit-level power conditions, gives early warning of problem conditions, provides local and remote access to power monitoring data, monitors environmental conditions and provides trending and load profiling, all enabling more accurate power management and planning.

Today's data center environment demands a power quality and power management solution that is both flexible and adaptable, without compromising the reliability of your power chain.

That's why Eaton has a driving focus on power quality solutions for enterprise and business IT systems, from network closets to large data centers. Eaton manufactures, sells and supports unified data center solutions incorporating Powerware UPS products, enclosures, power distribution, advanced power management and reliability techniques, and world-class services.

Eaton is your one-stop resource for IT power protection and distribution needs, for small businesses to large enterprises. IT managers can simplify their operations and reduce total cost of ownership by relying on Eaton for adaptive infrastructure solutions that thoroughly address critical power issues. For more information please visit www.powerware.com/datacentersolutions.