Manage Data Center Power Consumption with Appropriate Intelligent Rack PDUs

A report revealed by the NY Times on 2012-09-22 astonished the industry. Titled “Power, Pollution and the Internet” and based on a survey by the newspaper for more than one year, the report indicates that around 90% of the power consumed by large scale data centers is wasted. Another analysis by the prominent consulting firm McKinsey & Company contacted by the NY Times concluded that only 6%~12% of data center power goes to running servers. Data centers around the world consume some 30 billion watts of power annually, which is equal to the output of around 30 nuclear power plants. Around 1/4 to 1/3 of this is consumed by data centers in the USA. One anonymous senior data center operator interviewed in the survey admitted that this wasteful power consumption is a dirty secret hidden by the industry and not many were brave enough to acknowledge this. If this occurred in the ever improving manufacturing industry, it would have been eliminated a long time ago.

As power wastage is so severe in most advanced US data centers, attention to power efficiency of data centers in Asia is catching up with its western counterparts.

You have to manage data center's power consumption before you can talk about its power efficiency. This, in turn, means to take good power consumption measurement, as you cannot manage anything without it being measured and quantified first. The very first job in improving a data center's power efficiency is to take good measurements of the power consumed.

The intelligent rack PDU (IRP) is by far the most accurate tool in measuring power consumed by information equipment. Located within an individual cabinet, the rack

PDU is the last device distributing power to information equipment, and so is the best point for taking their power consumption measurements let alone the remote on/off and ambient parameter measurement function possessed by some high end IRPs. Limited by early IRP's price tag, many data centers adopted the less expensive current transformer (CT) instead. A CT is added in the distribution panel, and collects and records power consumption data at the central monitoring server for later analysis.

Yet the IRP outperforms the CT in many dimensions. Take an overload trip pre-alarm. The rack PDU adopted by early data centers features one circuit, as power density required by equipment contained in each rack was not too high in most cases. (You can check the number of circuits by counting circuit breakers adopted by the PDU excluding backup circuit.) If there is only one circuit current data measured by the CT it is adequate for the administrator to learn the remaining capacity before tripping. For a rack PDU with more than 12 or even 16 sockets, it may feature 2 circuits, while a 3 phase PDU may equip at least 3 or even 6 circuits. Despite the number of circuits in the PDU, the CT measures only the total current consumed. This leaves the data center's administrator no measure to prevent an individual circuit trip in advance.
With ever increasing power consumption density required by information equipment contained in racks (e.g. blade servers) and fast dropping price of the IRP from improved technology, more and more data centers opt to construct their power measurement system with IRPs.

Data centers may select different types of IRPs based on servers serviced by them now and in the future as well as on their configuration planning. The following selection criteria can be used by data center administrator in choosing suitable IRPs:

1. IPRS Installation type:
   IRPs may be installed horizontally, vertically, and separately.
   - *Horizontal installation:*

   This offers the best flexibility and constrained the least by rack format. It fits any standard rack as it is installed at the front end of the rack. Limited by width of 19" a standard rack offers at most 8 serial for the 1U model. In case more ports are needed, each port costs more than that of the vertical one, yet the whole IRP costs less than its vertical counterpart. For a data center with relative few servers planned for each rack or with servers to be installed according to growth, the horizontal IRP would be a good choice.
   - *Vertical installation:*

   Vertical installation is limited by length (42U) rather than the width of a 19" rack.

Common vertical installation offers 16 or 24 ports while 40 ports IRPs are provided by some suppliers recently. For racks with relatively more servers, the vertical installation is good for its low average port costs.

- *Split installation:*

Despite the vertical IRP's benefits in more ports available, it is criticized by many data center administrators for its bulky size and interference to wiring and cooling with certain smaller racks.

More ports come with their drawbacks, as many data center administrators worry that all devices connected to the IRP have to be turned off before the IRP can be replaced for failed measurement or transmission module.

Some suppliers are offering split IRPs in addressing disadvantages revealed by both vertical and horizontal IRPs. The split IRP separates its measurement and communication function into standalone display box that can be installed at the front or back of a rack. The remaining vertical PDU now has a dimension similar to that of conventional non-intelligent one. For a data center keen on PDU volume the split IRP looks good.

The split IRP comes with one additional benefit. Since its measurement and communication functions are contained in a separate box, it can be replaced without interruption to its power supply operation and in turn, server operation. Split installation looks like a balanced and perhaps the best choice for its port abundance, better space utilization, and reliability.

2. Measurement function

- *Circuit specific measurement:*

This is basic to any PDU with measurement capacity. Its original purpose is to ensure power usage status of the current PDU before any new servers are added to avoid overload trip afterwards. As overload trips may lead to power outages for every device connected to the circuit, no data center can bear this kind of disaster. With the introduction of IRP, the data center administrator is now able to identify racks or PDUs with available power capacity through monitoring screens provided by the IRP's remote control software.

As data center's power efficiency is getting more and more attention, and power usage information can be collected with central control servers through the IRP, the features of circuit specific measurement capacity have been accepted as the most appropriate tool for measuring data center power efficiency (PUE).

- *Port specific measurement:*

This is originally for collocation in measuring power consumption by different clients' equipment. Now it has been adopted by many enterprises to measure

consumption by individual units for operational cost allocation. This is more practical and accurate than the conventional allocation by number of servers.

3. Remote control function

   - *With a remote switch:*

   Along with remote access to measurement data, IRPs are added with remote power on and off functions for unmanned data centers. IRPs with a remote switch should be equipped together with KVM for real and fully unmanned remote control.

   - *Without a remote switch:*

   The PDU with a remote switch are usually banned from large scale data centers as any invalid power off operation may lead to a huge loss. Commonly adopted data center standards TIA942 explicitly recommends PDUs without a power switch.

   - *Critical load function:*

   Despite large scale data centers' ban on PDUs with auto ON/OFF function, some of them desire to have IRP with scheduled on/off function to power off certain non-critical information equipments during off hours to save energy and cut increasing power bills. How to tackle the dilemma of keeping auto scheduling on/off function while complying with the TIA942 recommendation of PRDs without an on/off switch?

   One answer to this question may come from some suppliers' newly launched IRPs featuring critical load function. These remote or scheduling on/off switch featured IRPs reserves specific number of key load ports without switch. Critical servers that cannot afford to be turned off incorrectly can be connected to these special ports and so are free from any invalid power off.

4. Protection mechanism

   The overload trip mentioned above has been a nightmare to any data center. Scores of solutions are provided by IRP suppliers. One is to add one low capacity fuse at every port which fails to be adopted by high power-density servers, like the blade ones, as current at any port is limited. After the fuse is broken, a proper replacement may be hard to get while the use of invalid fuses may cause even greater damage to the data center.

   Some IRP suppliers have now come up with a proactive overload protection by taking advantage of IRP's measurement and on/off switch capability. The theory goes like this. The IRP detects the last port where a server is turned on. If the IRP found that the last power on of a server may lead to overload trip, with its accurate measurement and fast computation, it turns off the last one automatically to

protect those already in operation from any loss caused by power interruption. The last server being turned on is powered off without any data loss as it is just started or has even not started yet.

5. Anti-disconnection function

   Power line disconnection has been threatening data centers for a long time. Power line disconnection may come in two types: Manual interruption caused by rack wiring operation which is common among during data center installation work. The other is wire loosening. This is commonly experienced by the C19, big current plug for blade servers. Many measures are adopted by IRP suppliers against this line disconnection issue. One of the frequently accepted solutions is to equip the PRD with latches for wire securing. The problem with it is that you have to replace the server including power lines with a special one made by PRD suppliers.

   An optional Lok-U-Plug design revealed by some IRP suppliers tries to deal with it in simpler way. It employs the IRP with a reserved special slot and a simple Lok-U-Plug tie to fasten server power lines to the IRP.

6. Software function

   Software for monitoring IRPs has been the worst issue faced by many data center administrators. IRPs without fully functioning software cannot make the most of its "intelligence" whilst a full-functioning one costs a fortune. Some foreign brands even charge for its software by the number of "nodes" which leads to even more severe headaches as you have to pay more when using more IRPs.

   Fully functioning software bundled with IRPs now offered by some suppliers may ease the burden to certain degree. Just buy the IRP and enjoy its full "intelligence" without having to pay another large sum of money.

   Software that makes the most of IRP's "intelligence" must have the following features:

   - Graphical display of racks in the data center for easy control by data center administrators.

   - Instant data display to enable data center administrators' direct control at their office or control center.

   - Historical data analysis and power usage in given time span in line or bar chart.

   - Ambient situation and benchmarking analysis: Usually this means measuring temperature and humidity. Yet the health of data centers' air-conditioning relies not on temperature but on the rack cooling index (RCI) of weighted temperature

according to the U.S. Department of Energy and the American Association of Refrigeration and Air Conditioning. The existence of hot spots in data center can be determined by the RCI in advance. Many green data centers adopt isolated hot and cool air passages which improves air-conditioning efficiency at the expense of fast temperature rise during condensing unit failure. In worst cases, this may cause a fire. The RCI also helps data center administrator to identify fast temperature rise in any area at the very beginning.

Increasing power density mandated by servers outpaces the cooling capacity featured by most data centers original design. Servers' life span shortens sharply when working in a high temperature environment for long time. The RCI is an effective tool to pinpoint long time over heating issue in any data center.

7. Energy efficiency indicators

   One hot topic in the data center industry is the ISO50001 energy management standards published in June 2011. The newly unveiled directive mandates every ISO50001 unit must set its critical energy use area as its prioritized management item. The data center, for its high electricity density, is definitely a critical energy use area and so must be the top goal in ISO50001 implementation. Now the question is, which data center benchmarks need be set and managed?

   The first one is power usage effectiveness (PUE), the ratio of total data center power consumption VS. information equipment power consumption. The formula of the PUE indicates that the IRP must be the best device for measuring power consumed by information equipment. This may not be the case with total data center power consumption, as the latter can only be measured with meters featuring digital transmission capability while the measurements must be integrated with data provided by the IRPs. This operation is not only complex but also may be subject to additional costs. Certain suppliers already add spreadsheet function in its IRP's central control software. Data center administrators may post figures recorded in data center's master meter to the software manually to calculate average PUE based on information equipment power consumption recorded by the IRPs in given time span.

   Air-conditioning equipment consumes more power only second to information devices. The research report by the Energy Star Program, EPA, USA mentioned earlier pointed out that most data centers' air-conditioning equipment consumes more than 50% of its total consumption. The very first step in improving data

center's PUE is to optimize its air-conditioning power consumption where the "optimization" means applying all air-conditioning to cooling servers. The air-conditioning indicator benchmarks the optimization level of air conditioning. Commonly adopted data center' air-conditioning indicators are the RCI, which has been described above, and the Return Temperature Index (RTI). Poor power efficiency (high OUE value) at any data center almost always lies in poor air-conditioning efficiency. The American Association of Refrigeration and Air-conditioning suggests that the air-conditioning power consumption should be around 1/3 of that consumed by the information equipment. The fact that most data center's air-conditioning equipment consumes more than 50% of total power consumption indicates that the temperature of a data center is set too low as indicated by relatively low RCI. If the RCI remains normal while air-conditioning equipments' power consumption rate tops 50% then some hot air that should be removed from data center is returned into the air conditioning's cooling passage (hot return) or some cool air is directly sent to the hot passage (side air) instead to the information equipment by invalid passage separation. When cool air is cooling hot air that should have been expelled from data center, the PUE rate is doomed. Both hot return and side air problems are manifested by RTI. As a result, both RCI and RTI are key indicators for air-conditioning efficiency benchmarking.

8. Quality reliability

   One more benefit of the IRP that is hard to learn from its datasheet is its reliability. After mass IRP installation and operation for a short period of time, some may fail on account of interferences caused by a big chunk of data processing. The only way to solve this problem is to re-start the failed IRP that is a lot of trouble to any data center. The worse is once this interference occurred it comes again and again at different IRPs. This happens to the IRPs from suppliers not familiar with controlling large amount of devices through TCP/IP communication. The best way to avoid this annoying difficulty is to select suppliers with profound techniques in controlling vast TCP/IP devices contained in data centers, e.g. TCP/IP KVM supplier. Only they have the knowledge in dealing with TCP/IP signals for mass control as well as sufficient testing facilities to ensure equipment steadiness.

This article highlights ways in selecting intelligent rack power distribution units. As mentioned at the beginning, the key to data center's energy saving management endeavor is a software system together with intelligent environment protection power distribution unit for energy performance indicator measurement and appraisal. We hope this helps data center administrators in selecting appropriate data center energy

saving management system.