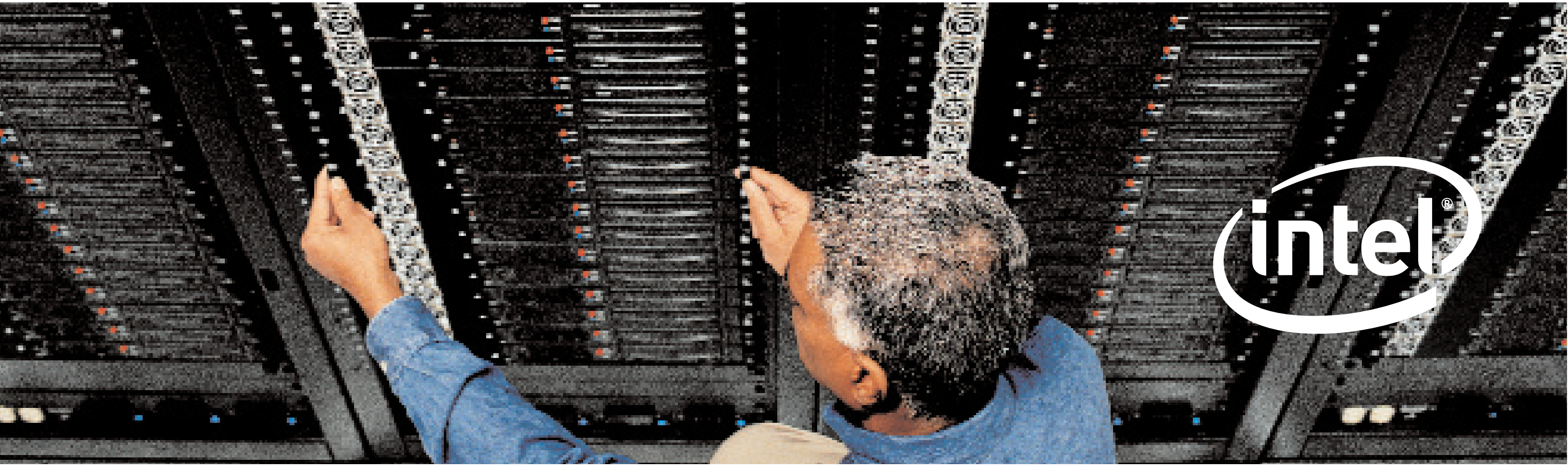

Case Study

Data Center

Power/Thermal Management

Intel® Virtualization Technology

Taking Power Management to the Limit—and Beyond

Intel maximizes power and thermal management in an aging data center to add needed servers—without expensive new infrastructure

Challenges

- **Free up power capacity** in an aging data center that is operating near its server limit.
- **Ensure there is enough power** to support 300 new servers needed for an upcoming SAP* re-platforming exercise.
- **Do it all with minimal capital investment**, since the data center is scheduled to be decommissioned within the next five years.

Solutions

- **Analysis.** Conduct a detailed power and thermal capability report on the current data center environment to help show where the power is going.
- **Alternatives.** Come up with a set of alternative solutions to improve existing capability, along with a set of IT construction specifications and a risk/benefit/cost analysis for each prospective solution.
- **Model.** Build and interpret CFD models for each alternative solution and the current environment with supporting thermal images.

Intel's 20-year-old FM1 data center in Folsom, California, was almost maxed out: Even though it had just been through a power upgrade, it already had just about as many servers as its aging infrastructure could support. But Intel IT Global Facilities Services, which operates the FM1 data center, needed to add 300 new servers to support an upcoming SAP* re-platforming—without exceeding the equipment's thermal operating limits. Another wrinkle: Intel expects to decommission the FM1 facility within the next five years, so it was essential to find a way to free up capacity for the new servers without a major capital investment.

To formulate a strategy for making best use of the data center's existing infrastructure, Intel IT Global Facilities Services carried out a detailed analysis that predicted the effect of adding new servers and compared it to the data center's potential thermal limits. Consultants also investigated ways to improve the data center's overall efficiency using the available electrical power under the current infrastructure. Finally, a risk/benefit/cost analysis and detailed computational fluid dynamics (CFD) physics model of the current environment helped to identify the best solutions.

The project was so successful that the research team was able to find ways to free up enough power capacity for the initial 300-server requirement and then some—enabling the current infrastructure host even more servers in the future.

Assessing the Situation

In today's typical data center, several factors can contribute to inefficiency, higher-than-necessary power use, and spiraling costs—most notably, ineffective use of the cooling infrastructure, poor management of cool airflow, and underutilized IT equipment. Fortunately, there are some fairly simple—and inexpensive—ways to change these factors and immediately reduce energy consumption and increase data center compute capacity without the high cost of new infrastructure.

In the FM1 data center, Intel identified four key problems that were preventing the facility from optimizing its power load and efficiency:

- **Inefficient** data center layout
- **Poor management** of cold air supply distribution and pressure
- **Isolation** of cold and hot air
- **Ineffective** removal of hot air

Because the FM1 data center's lifetime was limited, it wasn't practical to evaluate the most expensive solutions to prevent air mixing—installing isolation chambers in hot or cold aisles. Instead, Intel focused on quick and inexpensive fixes such as relocating perforated tiles, reducing tile leakage, and turning around server cabinets to form well-defined hot and cold aisles.

Changing the location of perforated tiles is harder than it looks because of the counter-intuitive behaviors of fluids. Therefore, the team developed a computational fluid dynamics model (CFD) to optimize perforated tile placements using first principles of physics. A solution using tables or heuristics instead of physical simulation would not have been able to maximize potential cost savings.

The consultants took a methodical approach to gathering data, modeling and analyzing problems, and identifying solutions. First, they collected data and modeled the FM1 data center into their CFD tools. Then they validated the results to ensure the modeling output was accurate.

The process measured several parts of the data center including:

- Temperature readings at the racks
- Cubic feet per minute measurements of all perforated tiles
- Survey of server cable blockages
- Percent full of each cabinet
- Survey of blanking panels
- Under-floor obstructions
- Power distribution systems impact on airflow
- Cable distribution systems impact on airflow
- Tile cutouts and their location in the room
- Server room layout validation at the time of measurements
- Raised floor height

"The procedures developed at Intel, combined with quantitative, numerical simulation techniques, allow us to address targeted, system-level questions for our customers."

Enrique Castro-Leon, Ph.D.
Technical Architect
Intel

The CFD tool also helped validate the size and location of every piece of equipment and perforated tile in the room. Consultants used the tool to take physical measurements, build a model of the current environment, and then compare the results of the model to actual measurements.

The physical modeling enabled the consultants to consider a number of solution alternatives, ranging from "do nothing" (the status quo) to a sophisticated air management design that would allow expanding the thermal limits for landing servers under the current infrastructure.

While the model for the FM1 data center was not the largest ever built by Intel (which was 60,000 square feet), it was one of most complex, since the data center:

- **Used a common** under-floor air supply plenum
- **Divided the floor plan** into several small rooms sharing the plenum
- **Had several different kinds of rooms** including fully closed rooms surrounded by under-floor obstructions, closed rooms with their own computer room air conditioners (CRAC) and perforated tiles, and rooms communicating with other rooms through louvered walls.

Delivering the Solution

Air flow management is an important way to ease data center power and thermal problems very quickly. An air flow management solution can have several components:

- **Data center air flow and thermal efficiency:** Delivers the right amount of cooling air to servers and removes hot air with minimal mixing of cold and hot air or shorting (cold air returning to a CRAC without doing any work cooling a server).
- **Reduced heat generation:** Reducing the intensity and number of heat sources leads to a corresponding reduced need for cooling. This can require an upgrade to more power-efficient platforms.
- **Consolidation:** Moving two or more applications to a server, increasing the loading factor and reducing the total number of servers needed in a data center.
- **Virtualization:** Can be considered a step up from consolidation where physical servers host one or more virtual machines in a highly automated environment.

Intel found inefficiencies in the use of the cold air supply. The net effect was:

"We can run a whole series of what-if scenarios without disturbing a data center in operation."

Enrique Castro-Leon, Ph.D.
Technical Architect
Intel

Key Technologies

- **Virtualization**, an advanced form of consolidation that can reduce both the number of servers the data center needs and power/thermal load requirements. Intel® Virtualization Technology (Intel® VT) is a set of processor enhancements that improve traditional software-based virtualization solutions.
- **Improved** data center layout
- **Better management** of hot and cold air supply distribution and pressure

Replacing the old design with a more efficient one helped increase service levels while reducing operating expenses.

- More cold air was needed for the given server load.
- Limited cold air supply that put an artificial ceiling on the number of servers that could be deployed.
- A need for more electricity to generate the extra cold air, adding to operating costs.

The team suggested several options to help improve the data center's overall efficiency and allow for additional capacity, dividing its recommendations into short- and long-term improvements.

In the short term, the data center needed to:

- **Add blanking panels.** This option was not feasible for all racks, but was still highly recommended to keep hot and cold air as isolated as possible. Investing in the panels will pay for itself—both in terms of reduced cold air requirements and ability to increase electrical loads of cabinets by adding additional compute capacity.
- **Eliminate unnecessary supply plenum leakage.** The FM1 data center had numerous perforated tiles located in hot aisles or where there was no equipment. This reduces supply plenum pressure and the load each room can support. It also adds to operating costs because more cold air is needed to maintain the existing equipment load.
- **Implement 25 percent flow perforated tiles.** All perforated tiles in use were 7.5 percent tiles. The model predicted that hot spots would form at higher loadings due to insufficient air flow. The team recommended introducing 25 percent flow perforated tiles in specified areas to make it possible to maintain higher equipment loads.
- Replace unused cut-out tiles not in use with solid tiles. A number of cut-out tiles were found to have no cables running through them, with some grouped together as an apparent way of building a resource pool. These tiles release substantial cold air from the supply plenum without cooling the equipment.
- Install air leakage barriers for all cut-out tiles. This would significantly help curtail air leakage.

In the longer term, the team recommended:

- **Installing a hot air return plenum.** This would improve overall airflow design and allow for more efficient removal of hot air and additional load capacity and reduce the cost of cooling per kilowatt of load.
- **Removing inner-room walls.** This would create a single large data center floor to help balance the cooling capacity across rooms.
- **Aligning racks to tile edges.** This would reduce the efficiency of the cold air delivery, particularly where two rows of racks are sharing the same cold aisle. The team recommended adopting a standard to align the fronts of racks to the edge of the perforated tiles.

After implementing all these recommendations, would the FM1 data center have the capacity to add the 300 new servers it needed? The answer was yes—and then some. To make an even greater improvement in the data center's performance, the Intel Solution Services team recommended virtualization, a more advanced form of consolidation that could reduce both the number of servers the data center needed and the power/thermal load requirements.

A virtualization solution would include Intel® Virtualization Technology (Intel® VT), a set of processor enhancements that improve traditional software-based virtualization solutions. These integrated features give virtualization software the ability to offload workload to the system hardware, enabling more streamlined virtualization software stacks and "near native" performance characteristics.

Virtualization solutions enhanced by Intel VT allow a platform to run multiple operating systems and applications as independent virtual machines. Using virtualization capabilities, one computer system can function as multiple "virtual" systems.

Virtualization has emerged as a compelling technology for server platforms, enabling data center managers to consolidate multiple workloads on one physical server system. Server consolidation offers lower hardware acquisition costs as well as improved data center performance efficiency.

Client platforms are using virtualization technology to enable secure partitions for system back and security features.

Building a Foundation for the Future

By coordinating application components, Intel was able to inject new life into a 20-year-old data center without an expensive infrastructure overhaul. Not only was the data center able to add the 300 new servers it needed to meet the goals of the SAP re-platforming project, it had the capacity to add even more servers in the future.

Replacing the FM1 data center's old, inefficient design with a newer and more efficient one let the data center substantially increase its service levels while reducing operating expenses. Reducing heat also can also extend the life of the facility infrastructure—and potentially the data center itself.

Find a business solution that is right for your company. Contact your Intel representative or visit the Reference Room at www.intel.com/references.

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