

IT@Intel: Intel® Data Center Manager: A Powerful Tool for Data Center Efficiency, Management, and Sustainability

Intel IT is leveraging Intel® Data Center Manager (Intel® DCM) to bring transparency to how our data centers operate. Intel DCM helped us scale up to manage over 250,000 servers, improve efficiency, increase energy savings, and lower carbon emissions.

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Executive Summary

As Intel’s business grows, increased demands on the data center have required greater innovation and new strategies and technologies that support not just lowering costs and improving efficiency, but also meeting environmental responsibility goals.

Today’s environmental and climate-change challenges make managing data centers in a sustainable way – part of our new normal. [Intel’s RISE \(Responsible, Inclusive, and Sustainable to Enable\) strategy](#) and goals include achieving net-zero greenhouse gas emissions in global operations by 2040. This goal is requiring Intel to apply breakthrough solutions and processes throughout the organization, including data centers.

These solutions are helping to manage growing demands on the data center which are seeing a steady growth of 30-40% annually (across compute, storage and networking). Intel® Data Center Manager (Intel® DCM) allows us to address these demands while providing a complete picture of all the equipment in the room. It’s part of a solution that is helping us achieve an overall savings of USD 5.9 billion. We achieved this while improving quality-of-service (QoS) levels and reducing the total cost of ownership (TCO) for business applications. This has allowed us to improve IT operational efficiency and environmental responsibility.

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Acronyms

KPIs key performance indicators

LAN local area network

MPIs meaningful indicators of performance

PUE power usage effectiveness

QoS quality of service

ROI return on investment

TCO total cost of ownership

ESG Environment, Social, and Governance standards for company behavior

DCIM Data Center Infrastructure Management

DCM Data Center Manager

Background

Intel's data centers are critical to operating its business. Intel IT operates 54 data center modules at 15 data center sites. These sites have a total capacity of 104 megawatts and house over 385,000 servers that support the computing needs of Intel's large workforce — over 121,000 employees in total. In an effort to support the critical needs of business functions and operate data centers as efficiently as possible, Intel IT has been exploring data center infrastructure management (DCIM) for Intel's data centers since 2012. During that time, we have been experimenting with DCIM solutions in the Intel data centers.

The goal of the early proof of concept work was to find out if Intel could achieve cost savings and increase operational efficiency through remote management of critical data center infrastructure. The proof of concepts eventually proved successful, and Intel IT has new capabilities to eliminate manual asset auditing, detect "zombie" servers, identify underutilized servers for consolidation, uncover hot spots, conduct thermal and power monitoring, and more.

Through these efforts, Intel IT has enabled us to meet sustainability goals — which are increasingly important because of government initiatives such as those in Europe, India, and China that require a specific power usage effectiveness (PUE) level — and encourage the use of renewable energy.

Business Challenges

Managing the operations of dozens of diverse data centers that support the business goals of a large corporation such as Intel comes with many challenges. DCIM solutions can help improve efficiency, but only if it overcomes important hurdles. A few areas that Intel IT worked to improve include asset management, heat and energy monitoring, and supporting environmental, social, and corporate governance (ESG) initiatives.

Intel® Data Center Manager

Intel® DCM is a vendor-agnostic out-of-band solution that uses industry-standard monitoring protocol to track highly diverse types of equipment and increase visibility. It complements rather than competes with vendor-specific tools to enhance transparency and performance. Intel DCM provides real-time equipment health monitoring and alerting, allowing data center managers to react and address issues quickly and mitigate potential challenges. The solution provides benefits to both IT and facility administrators, enabling these groups to collaborate and reduce the data center energy footprint.

For more information about Intel Data Center Manager, visit intel.com/dcm.

Asset Management

Intel IT wanted to evolve capabilities around asset audits. Thousands of different types of devices need to be identified and tracked, and data from those devices reviewed and audited more seamlessly. Discrepancies often exist between asset tracking systems, and identifying these issues isn't always a quick process. Manual audit and physical asset management were not only slow but became increasingly complex with physical tags. We wanted to leverage data to conduct a continuous, live validation while auditing assets, and essentially have a DCIM tool be our system of record. However, the high overhead and cost of managing radio-frequency identification (RFID) tags and achieving 100% asset tracking was a challenge.

Energy Cost Reduction

We needed greater real-time visibility into the data center, from server, storage, and network operations to facilities management. Without a live view of data, issues could go unnoticed for long periods of time and potentially be missed altogether. Access to real-time data allowed us to quickly spot energy waste that could have otherwise gone unnoticed. For example, improving visibility around hot-spot identification helps to avoid costly issues, such as equipment damage or downtime. Reducing potential waste supports lower costs and improves efforts to "right-size" the data center through changes to rack power provisioning.

Carbon Emissions Reduction

Intel developed the [RISE \(Responsible, Inclusive, and Sustainable to Enable\)](#) strategy and goals to help create a more responsible, inclusive, and sustainable world enabled through technology and collective actions. As part of this initiative, we're committed to achieving net-zero greenhouse gas emissions in our global operations by 2040. An area of opportunity to meet those goals is improving efficiency in the data center, since these centers typically create high emissions. One study found that U.S. data centers consumed enough electricity to power all the households in New York City twice over.¹ Studies also show that data center workloads

have steadily increased over the past several years, growing as much as 30% annually.² Our challenge was to improve efficiency, reduce energy consumption, and ultimately lower carbon output to align us with Intel's RISE strategy and goals.

Meeting the Challenges of the Data Center

Achieving awareness of data center equipment health issues is a challenge because tens of thousands of different kinds of devices are running simultaneously. Intel® Data Center Manager (Intel® DCM) provides real-time equipment health monitoring and alerting, allowing data center managers to react and address issues quickly and mitigate potential challenges, such as power failures. The following sections explain how the solution works and the benefits it provides to our data center and internal customers.

Data Center Management

Maintaining proper temperatures in the data center is essential to improving efficiency and sustainability. Intel DCM improves visibility by displaying thermal gradients, as shown in Figure 1. It allows us to easily pinpoint locations that are overcooling or undercooling to more effectively understand if too much energy is being pulled from any given room or if a room is becoming too hot (see Figure 2). For example, temperature information is gathered at the management interface so that data center administrators can set air-conditioning systems to optimize power consumption and find areas that may be overcooled (see Figure 3). This level of visibility can assist with rack provisioning so that energy use is right-sized based on capacity and real-time demands.

Device Management

Intel DCM enables real-time data collection without reliance on additional software that needs to be installed on devices to be managed. Data gathering leverages an “agentless device management” approach to streamline operations and enable out-of-band operations. As a result, we can readily access real-world device power consumption details, which allows us to lower energy use and decrease carbon output from a variety of equipment.

Access to utilization reports helps identify “zombie” servers (which use energy but do not perform useful work) along with underutilized servers that can be consolidated. With this data in hand, we can gather information to improve sustainability, spurring actions such as shutting down a specific zombie server and targeting servers for consolidation.

Additionally, Intel DCM enables data managers to identify device firmware versions and look for outliers, which helps in identifying inconsistent firmware versions and upgrading firmware to fix bugs and increase the performance of devices. The solution also provides asset management capabilities, including pulling serial numbers for efficient asset tracking, and MAC address tracking to easily find and correct duplicate MAC address problems. Figure 4 shows firmware tracking as well as the identification of problematic components in individual devices.

Intel DCM eased our asset management challenges as it allowed us to move away from technologies such as RFID, tagging, and others to instead create a book-to-floor audit capability. This enabled us to leverage two systems, including our financial record-keeping system (our book) versus what we find through Intel DCM (our floor). We can now complete a 100% audit “book-to-floor” and “floor-to-book”, and very quickly identify any discrepancies for follow up and resolution.



Figure 1. Dashboard view of thermal gradient.

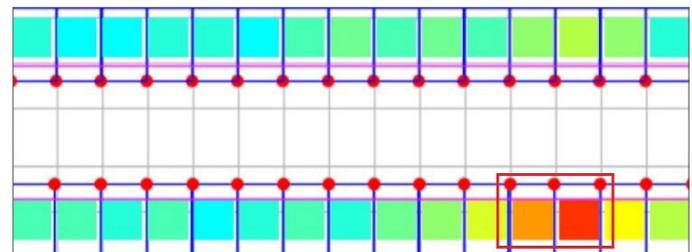


Figure 2. Top view of hot spots from the layout.

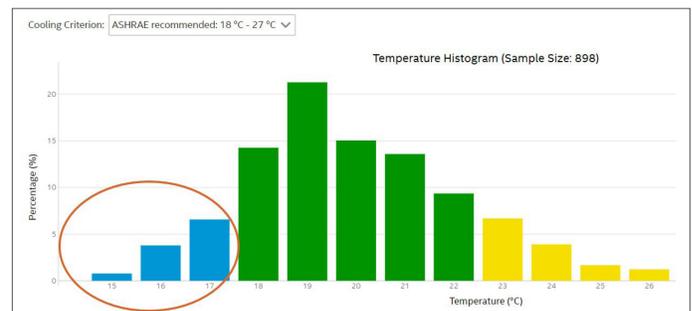


Figure 3. Overcooling view from the dashboard.

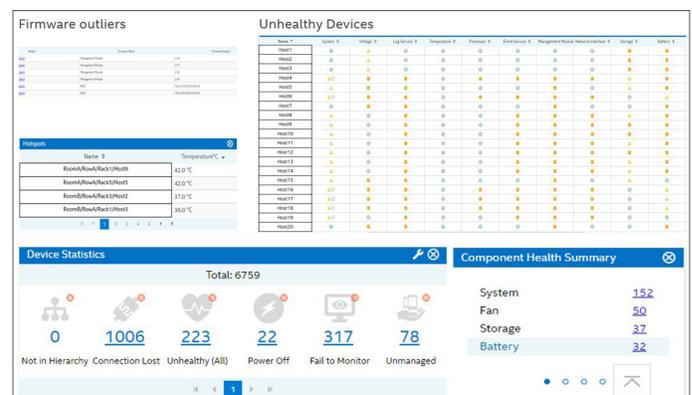


Figure 4. Dashboard enables viewing of unhealthy devices and firmware outliers.

Vendor-Agnostic Solution

Intel DCM is a vendor-agnostic solution that uses industry-standard monitoring protocols to track highly diverse types of equipment to increase visibility. It doesn't require the installation of additional software or agents, and it easily collects and displays granular systems data, including power, thermal, health, asset info, inventory, and carbon emissions. This data helps our team uncover insights about how to improve data center efficiency and reduce the total cost of ownership (TCO). Out-of-band collection capabilities offer a high level of granularity for device monitoring as compared to what is typically offered by other DCIM tools.

Intel DCM also integrates well with other tools that we use in the data center. For example, we're using APIs to report room temperatures in a centralized dashboard. Additionally, we have created safeguards to generate events when a given threshold is crossed. We're also integrating Intel DCM with our centralized global monitoring using APIs to connect with other OEM software solutions. A vendor-agnostic solution fits well with Intel's overall "stacking" approach, which favors integration over a "walled garden" strategy. Our approach does not preclude use of vendor-specific tools, and in many cases, we use both Intel DCM and software tools tailored to specific vendors.

Analytics and Sustainability

Intel DCM allows us to leverage analytics capabilities to understand carbon output more effectively. The technology leverages telemetry and aggregation to measure and forecast potential carbon emissions based on preset time frames, such as daily, weekly, monthly, or annually. We show examples for trending (Figure 5) and on a daily scale (Figure 6). We leverage these capabilities to meet expectations for power consumption and stay on target with power-capping goals, thus avoiding the issue of unknowingly exceeding those limits.

We can also generate an energy report for the various system models in any given room. Analytics are conducted to understand how much power a system uses and if it's an outlier. Finding and fixing rogue systems can help reduce power utilization (Figure 7). Data from the report shows if a system is ideal, has zero utilization, or is in another category, providing actionable insights that contribute to reducing consumption.

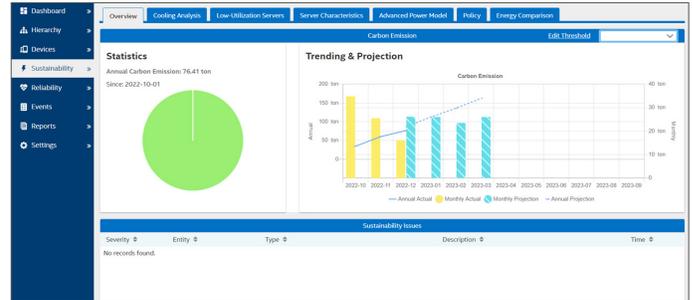


Figure 5. Intel® Data Center Manager (Intel® DCM) can display yearly carbon emission trending.

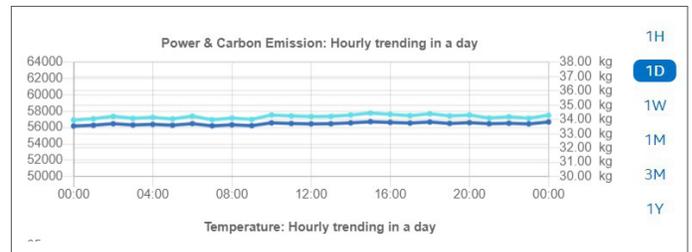


Figure 6. Intel® Data Center Manager (Intel® DCM) can also display carbon emission trending down to the hour.

Intel IT Data Center Dashboard and Sustainability

Intel IT built and deployed an integrated Intel IT Data Center Dashboard, which helps us monitor key performance indicators (KPIs) by understanding the current state of opportunities and optimizations. We can achieve and track improvements that align with our data center strategy goals, such as energy reduction and improved sustainability. The dashboard can report on effective utilization of a variety of data center resources, like electronic design automation capacity and utilization as a meaningful indicator of performance per system; raw and utilized storage capability; and space, power, and cooling. This data can be used to compare KPIs across several data centers, helping optimize energy consumption, reduce risk, and improve sustainability.

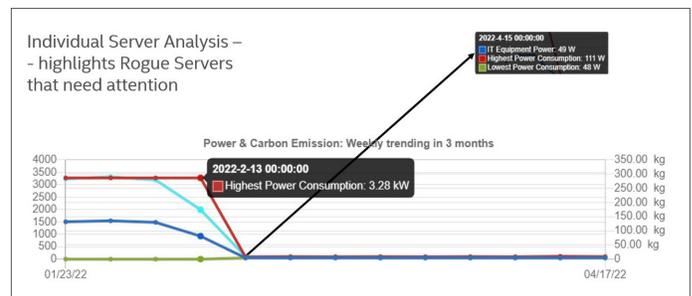


Figure 7. Intel® Data Center Manager (Intel® DCM) can help fix rogue server power consumption through firmware updates.

Results

In large data centers, it's not uncommon for equipment health issues to go undetected for long periods of time. Intel DCM allows us to leverage real-time equipment health monitoring and alerting, enabling data center managers to react and address issues faster. Other results included:

- **Visibility into capacity management to help reduce energy consumption.** Intel DCM enables us to better understand power consumption trends for any given rack. We can evaluate individual rooms, power usage, base utilization, and more. This helped us transition from making reasonable guesses to making data-enabled decisions to best optimize the data center.
- **Ease of spotting discrepancies between asset management systems.** Intel DCM allows us to collect data from many different devices simultaneously. We can use this information to conduct continuous, live asset data validation during auditing. This capability allows Intel DCM to become our system of record. We can easily spot discrepancies between systems and leverage book-to-floor audit capabilities.
- **Capability to oversubscribe rack power capacity.** Collecting real-time power consumption data helps with rack provisioning and right-sizing racks to improve capacity management. Live data helps discover potential challenges, allowing us to resolve them to minimize waste and improve sustainability. It also enables us to move workloads in order to utilize capacity in a rack despite oversubscription.
- **Ability to detect zombie servers and potential energy waste.** Access to live data helps us identify zombie servers as well as rogue servers (servers with high utilization that use a lot of energy but are producing results) more easily. We can also uncover potential energy savings by viewing a report that helps us understand how much CO₂ these servers are expected to release.
- **Identification of data center hot spots and overcooled sections.** Intel DCM provides live temperature visibility to enable faster hot-spot detection. Areas of undercooling and overcooling are identified in real time, and early alerts help reduce the risk of unexpected outages. The use of agentless devices enables us to collect the required data without the use of any special tools or applications.
- **Identification of divergence from firmware software standards.** Improved visibility at the device level assists with identifying different firmware versions, uncovering outliers, and fixing any firmware- or hardware-related issues. For example, we might have a system model that contains many different firmware versions; we always want the most current version running, and improved visibility helps us identify where improvements are required.
- **Identifying rogue servers.** Intel® DCM helped us to identify a few systems where the power consumption was an outlier in the model so we could proactively fix those issues.

Implementation Challenges

Intel DCM assists with improving manageability, lowering costs, and supporting those who rely on Intel data centers. Arriving at these results, however, was not without implementation challenges. A few of those challenges include:

- The remote protocol wasn't initially set up or enabled for all systems. We needed to enable this to take advantage of real-time monitoring capabilities.
- Many of our systems were not configured with remote management accounts. We needed to set up the appropriate credentialing to enable access.
- Limitations existed regarding how many devices could be added to a given Intel DCM instance. One of our major data centers had over 100,000 servers, and adding them to a single instance wasn't possible. We had to roll out multiple instances to manage that room. Our IT team is working with the DCM product team to improve scalability and support a higher number of devices in the future.
- Rigorous testing of all combinations of deployed hardware in controlled environments was required prior to deployment in the production data center. This process is repeated every time we patch or upgrade to a newer Intel DCM release. The testing process is also required for the introduction of new hardware to the data center environment.

Overcoming these challenges helped us successfully leverage real-time health, power, and thermals of a variety of devices in the data center, offering the clarity required to improve reliability, efficiency, cost, and sustainability.

Machine Learning and Artificial Intelligence: A Glimpse of Future Possibilities

Machine learning and artificial intelligence will play an important role in the future of Intel® DCM. We plan to use machine learning and artificial intelligence for innovations in sustainability, "what-if" analysis, and predictions of equipment health and potential cooling issues. For example, orchestration engines like Kubernetes could use the DCM API to pull data and conduct carbon-minimizing scheduling or minimize utility costs and power consumption.

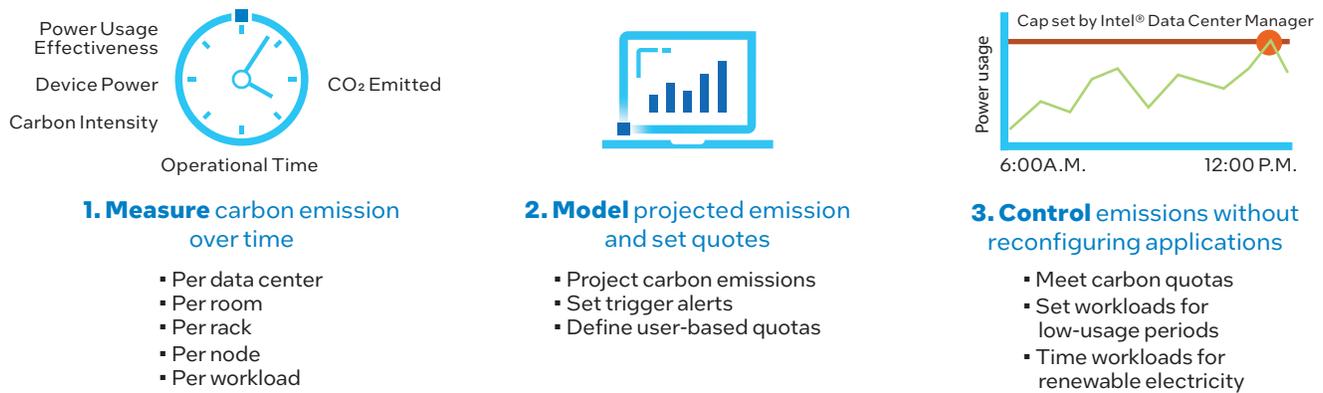


Figure 8. 3-in-1 solution for managing data center carbon footprint.

Plans for 2023 and Beyond

Intel IT is constantly striving to improve our data center strategy. We're working to close the gap between our current goals and the next best possible scenario. To that end, we're planning to enable the following tactics in the future:

- **Manual additions (required automated integration from system of record).**
- **New OEMs additions.** We will add additional device types and models to be monitored by Intel DCM.
- **Increasing facilities efficiency.** Techniques such as higher ambient temperatures for specific data center locations can leverage newer equipment specifications to further help lower cooling needs. This would be monitored and enabled by DCM.
- **Improving operational efficiency.** Increased telemetry data provides more visibility into the power, cooling, and component HealthCheck of the servers inside data center.

Intel® Data Center Manager 5.0 – Improving Sustainability

Intel Expands Its Plans and Capabilities.

In July 2022, Intel® DCM version 5.0 was rolled out with innovative features to expand what's possible in the data center. New features enable data managers and IT operators to easily calculate, report, alert, predict, and control data center carbon emissions and footprints (see Figure 8).

Measuring carbon emissions. Intel DCM collects real-time information about power consumption of servers and other IT devices in the data centers. Carbon emissions can be calculated per data center, per room, per rack, or per node.

Modeling carbon emissions. Intel DCM can project carbon emissions and trigger alerts based on user-defined quotas. It can also predict power consumption and carbon emissions of a single node.

Controlling carbon emissions. Intel DCM can identify underutilized servers so they can be consolidated to help reduce carbon emissions. It can also power cap servers and provide additional insights to support further emissions reduction.

Adjusting carbon intensity. This can be adjusted per hour and copied to other months as needed.

Reporting capabilities help identify low-utilization servers and drive informed decisions about the next best steps. A report may show that only 1% of a given server is utilized. The report may also show a server is consuming roughly 20 kWh of energy without doing anything for Intel's business. With this information in hand, we can decide to switch off the server to save roughly 90-plus pounds of carbon from the room on a monthly basis.

The capability to compare different rooms in the data center provides even greater energy consumption intelligence based on the hour, day, week, or another preset period of time. These insights can drive more informed decisions to optimize the data center. As we continue to roll out Intel DCM 5.0, we're looking forward to discovering what else is possible and further refining our results.

Conclusion

Data center operators face many complex challenges, and it's not always easy to balance those challenges with the goal of improving sustainability. As data centers work to become greener and meet fast-changing government mandates and demands, making the data center sustainable isn't optional, but essential.

Intel DCM has assisted our data center managers and IT operators in making our data centers easier and more efficient to manage while achieving sustainability objectives by monitoring, calculating, reporting, alerting, predicting, and controlling the data center carbon emissions and footprint. By collecting information about real-time power consumption, thermal, health, asset, inventory, and carbon emissions of servers and achieving real-time visibility, we can more effectively discover issues in the data center and continually work to become more efficient and sustainable.

It is our goal that by sharing our journey of bringing Intel DCM to Intel IT, we can encourage others to implement similar technologies and strategies to gain the benefits of a more efficient, coordinated, and sustainable data center; reduce their carbon footprint; and help better serve end users.

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Our goal is simple: improve efficiency throughout the organization and enhance the business value of IT investments.

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¹“Inefficiencies Cost Data Centers Time and Money.” Intel, 2022.

²“How Much Energy Do Data Centers Consume?” TechTarget, April 25, 2022.