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Boost PC Health and Performance with Sustained, Automated Processes

Proactive problem management helped us reduce blue screen errors by 60 percent, unexpected shutdowns by 40 percent, and application hangs by 75 percent.

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Executive Overview

Managing PC health in any organization takes sustained focus and a well-defined process. At Intel, we have experienced fatal errors, such as the Blue Screen of Death (BSOD), due to driver and other hardware issues. In 2009, we developed a proactive problem-management process to address these issues and improve the user experience, as well as decrease the cost of PC downtime. By collecting information, classifying and prioritizing problems, and conducting gap analyses, we were able to better manage problems and decrease errors.

Like most organizations, Intel IT contends with multiple new and competing priorities, which can jeopardize the consistency of PC health. We recently updated our proactive problem-management process to include clearly defined roles that bring domain knowledge, a multidisciplinary team, more robust data collection, and updated software and code to analyze the data and improve the process. By setting clear goals with achievable results, we have successfully improved the user experience, lowered our total cost of ownership (TCO), and reduced the number of common PC problems in our environment. The lessons we have learned on this journey include:

- Sustaining and growing the process is as important as identifying and mitigating new issues.
- Data is the foundation to better predicting problems and understanding their impact.
- Clearly defined roles with domain knowledge help us quickly resolve issues.

With our revised proactive problem-management process, we have reduced BSOD errors by 60 percent over the baseline, reduced unexpected shutdowns by 40 percent, and reduced application hangs by 75 percent, while also creating a foundation for our future transition to more advanced data analytics and predictive maintenance.[1]

[1] Based on internal testing results.

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Acronyms

BSOD	Blue Screen of Death
ITIL	Information Technology Infrastructure Library
TCO	total cost of ownership

Background

Intel's worldwide computing environment includes more than 120,000 enterprise PC clients. This complex environment includes multiple client platforms and builds, and thousands of applications. Maximizing client stability is extremely important. Users rely on their PCs, so when system and application crashes occur, they can substantially impact productivity and consume IT support resources.

In 2007, Intel IT recognized the need to proactively manage the health of our PCs. A high number of fatal errors—like the Blue Screen of Death (BSOD)—due to hardware and driver issues, as well as other problems, were negatively impacting employee productivity and the overall performance of their PCs. By 2009, we had implemented a new approach to mitigate these issues. Our early goals were to reduce the number of common PC problems in the environment, more consistently monitor PC health, and reduce IT support costs. The process helped us transition from mostly reactive problem management to a more sustainable proactive problem-management model.

While reactive problem management is an unavoidable fact in IT, our proactive method helped us reduce the number of reactive issues and improve the overall health of client PCs. Our original proactive problem-management process included the following (see Figure 1):

- **Information gathering.** We collected information from software agents installed on PCs, and user surveys and escalations to identify problems in the environment and gain a complete picture of the issues.
- **Classifying and prioritizing problems.** We logged, categorized, and prioritized each problem to determine where to focus IT resources. By analyzing the problem's impact, the resources needed to resolve it, and the business value of solving it, we created a list of priority problems to focus on.
- **Managing problems.** We developed a five-step problem-management cycle to gather information, analyze the problem, find a solution, deploy the solution, and measure the results before closing the problem.

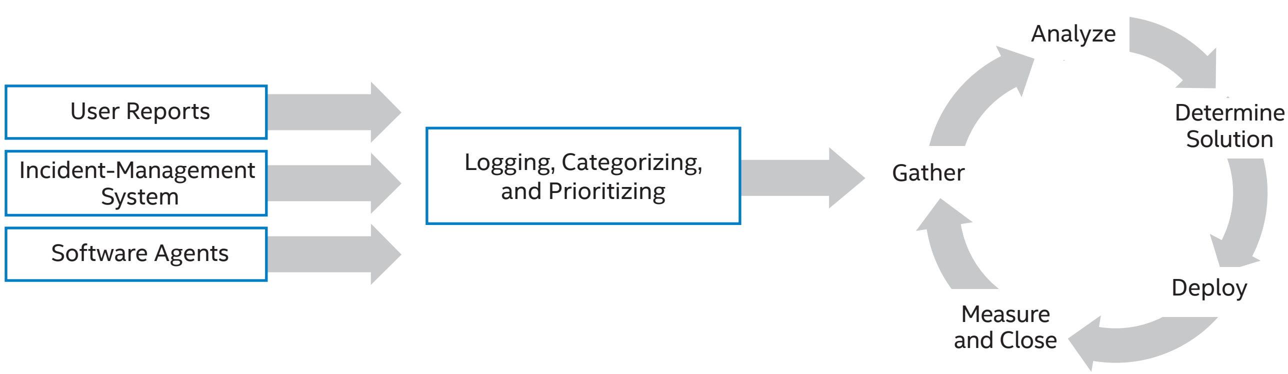

Figure 1. Our five-step problem-management process included gathering information from reports, incidents, and software agents that were logged, categorized, and prioritized. Then we analyzed the problem, found and deployed a solution, and measured the success of the solution.

- **Conducting gap analysis.** We examined several areas to determine where gaps existed, including infrastructure, reporting, analysis tools, solution-deployment capabilities, and process governance.

The results of our initial proactive problem-management process resulted in a 50 percent decrease in BSOD errors, which had peaked at 5,500 per week. BSOD errors can never be eliminated entirely, but through sustained PC health efforts, we kept the rate of incidents low. We also decreased the number of application crashes by 15 percent and isolated 65 percent of the problems to 10 commonly used applications. For example, through proactive problem management, we defined a disk-error threshold for these problems and targeted those PCs at risk. These measures put us in the position to proactively help users, even before they reported issues.

50% DECREASE IN BSOD ERRORS
as a result of our initial proactive problem-management process

Problems

Like most IT organizations, Intel IT grapples with competing priorities and new technology every day. We strive to improve the user experience, while reducing PC total cost of ownership (TCO). With the success of our proactive problem-management process in 2009, fatal errors dropped, our infrastructure was standardized, and we were able to focus on more pressing issues.

As a result, in the following years, we experienced varying levels of investment in the process. We drew a direct correlation between the level of investment and the results, and over time discovered that fatal errors and other common problems were increasing once again.[2] In addition to what we developed in 2009, new technology and more sophisticated partnerships, as well as increased complexity in technology, revealed gaps in our scope and analysis of collected data, which limited our problem detection and time to repair.

Solution

In 2015 and 2016, we recognized the need to further enhance our previous proactive problem-management process and revived our level of investment, updating the process for the modern environment. We began by focusing on analytics, but discovered we lacked data. Attempting to identify problems with limited scope of data in an environment that comprised thousands of variables did not provide enough meaningful information. We also lacked domain knowledge, as the former process was managed through different IT groups.

We decided to go back to basics, consolidating the business needs and technology under the appropriate Information Technology Infrastructure Library (ITIL)—a set of concepts and policies we now use for IT service management—with an added focus on providing domain knowledge, collecting and analyzing the right data, setting clear goals, and elevating the process to maintain success. We also decided to approach the solution through a combination of people, processes, and technology.

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[2] For more information, see the Improving Client Stability with Proactive Problem Management white paper.

People-Focused Process

Providing excellent customer service required domain knowledge to ensure the new proactive problem-management process, along with others, remained healthy and aligned with business goals. We focused the problem manager role on tracking, analyzing, and recommending action. We staffed both the events manager and problem manager roles with experienced system engineers, which brought important domain knowledge to the process. As a result, we were better able to define best practices for detecting, analyzing, remedying, and sustaining the health of our PCs based on root-cause analysis before escalating to the engineering organization (see Figure 2).

Coordination across roles was critical in creating a virtuous service cycle. With a stronger focus, the entire team was able to work in concert with the process for better decision making and prioritization. However, information was needed to fully utilize these roles. We already knew about many of the issues—users were reporting them—but we needed added visibility to better prioritize and address them.

To set the right goals, we needed to know what we could do now, what we wanted to do in the future, and how to achieve it. Using the collected and analyzed data, we set the following measurable goals for PC health in the enterprise:

- **Reduced hard crashes.** Fewer than two hard crashes per system per quarter.
- **Improved responsiveness.** Fewer than two complete system freezes in which the PCs were unresponsive for more than one minute, per system per quarter, and fewer than five reports of system slowness per system per quarter.
- **Faster boot time.** Boot time of under two minutes per system for 99.5 percent of reboots per quarter.
- **Faster wake-up.** PCs waking up from sleep and hibernation modes, on average, do not exceed 20 seconds per system for 99.5 percent of wake-ups per quarter.

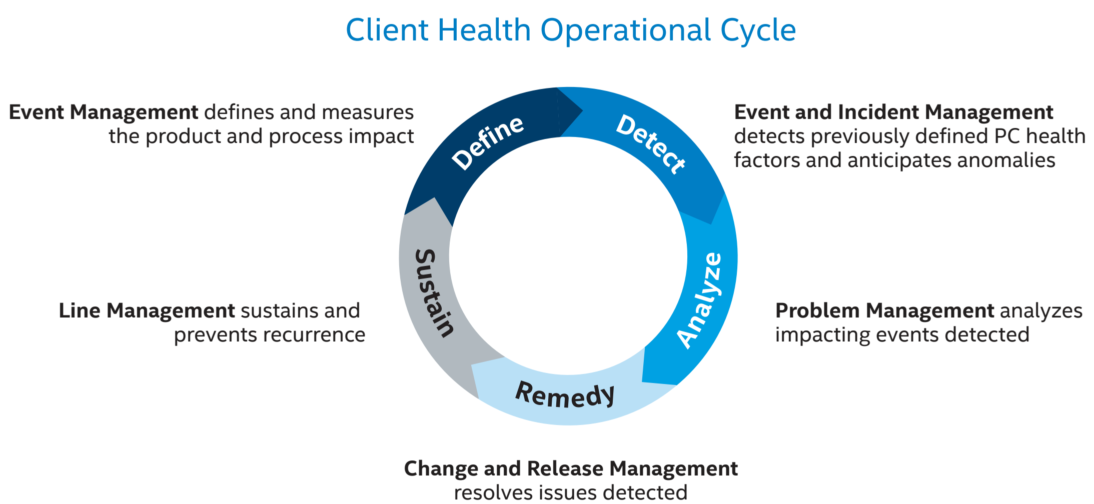

Figure 2. With clearly defined, dedicated roles that include domain knowledge, we can better detect, analyze, remedy, and sustain PC health across the organization.

Technology

We established a set of dynamic data-collection and analysis capabilities to ensure we were "data rich" and gathering the correct extent of information. Through this process, we discovered startup applications and scheduled tasks that were no longer relevant, policy and enforcement gaps, and other opportunities for improving PC performance. By defining thresholds for collected and analyzed data, now when we experience trend changes in the data, such as a rise of BSOD errors, enhanced data collection begins automatically. We also use dynamic data collection for application issues, which we can share with the solution provider to help speed resolution.

Data analysis is a structured process, and we built a set of analysis engines and parsers to automatically process the data. Once we structured the data, we gained visibility into what was causing some PCs to slow down, such as CPU or memory usage spikes. While this is not yet a production capability, we have used it to discover and resolve dozens of performance issues over the past year. This is especially useful when we introduce new changes in our environment; we can now analyze the impact of those changes before deploying them.

We use Microsoft Windows Event Forwarding* (Microsoft WEF*) to collect data. We developed capabilities to analyze the data that support performance and responsiveness measures, and we apply that to a staggered release process using ring management.

Microsoft WEF

Intel IT has used Microsoft WEF for years, and as we revived our problem-management process in 2015 and 2016, we found that the existing infrastructure was unable to scale to our new scope. To enhance its capability, we further distributed the infrastructure, built a scalable, high-availability WEF collector on the backend, and added new administrative options and load balancing.

Using the new analysis and reporting system, we can correlate errors, such as unexpected shutdowns, boot-time degradation, and application malfunctions, with their causes and resolve them. With this data, we now support dozens of application and services owners.

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To help solution providers resolve issues more quickly, we introduced a new ad-hoc capability to the collected verbose debug-level data through a selective application crash-analysis architecture, which includes an app dump parser, boot tracing, and live kernel reports. These automatic collections of verbose data provide faster automatic root-cause detection.

Performance and Responsiveness Measures

In addition to reducing BSOD errors, matching hard-crash data with boot data, and adding Microsoft WEF capabilities, we needed to understand when users experienced slowness and freezes. We used our routine common-performance troubleshooting process and built an automatic performance analyzer to reveal when PCs were slow or frozen.

Our analysis traced high-level performance thresholds, which can be translated into full, verbose performance analysis that identifies the cause of poor performance.

Blue-Screen Parsers

The original problem-management system consisted of a single-node infrastructure that was unable to process the total BSOD data in the environment. To gain new insights, we distributed the solution to several hosts worldwide operating on multiple nodes with updated code.

Over the course of a year, we reduced and maintained BSOD errors to less than four percent by addressing the most common causes. Because BSOD errors are caused by system code bugs, to further decrease the number of incidents we needed to work with our suppliers to decrease the escalation time. To achieve this, we introduced verbose blue-screen parsing—a complementary capability.

Verbose Blue-Screen Parsing

By combining verbose blue-screen parsing with a ring-management system, we dynamically targeted BSOD errors, such as the top 10 crashes of a specific type. We grouped machines with high crash levels into a ring to automatically configure them to generated full dumps from these systems, which were analyzed and prepared for escalation (see Figure 3). This enhanced process further decreased the number of BSOD errors to two percent, which we have sustained through constant changes in operating systems, adapters, and platforms.

To help suppliers resolve issues more quickly, like we did with BSOD errors, we obtained verbose debug data through a selective application crash-analysis architecture. We continue to provide data to our suppliers, helping them to correct and further reduce system code bugs.

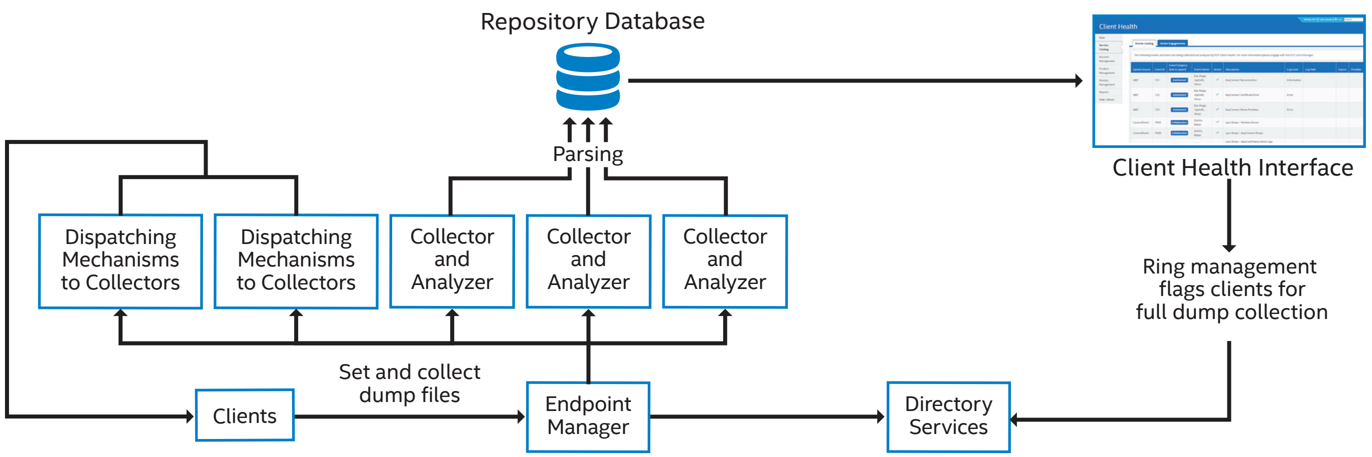

Figure 3. Using blue-screen parsers, verbose blue-screen parsing, and the ring-management system, we have reduced Blue Screen of Death errors to two percent.

Ring-Management System

The ring-management system stages our development across the testing population, beginning with a small group to control the impact of new releases and to solve problems faster. It essentially allows us to orchestrate changes during the pilot or proof-of-concept phases, and enables us to understand the impact. The ring model is dynamic, yet our common methodology divides the early-adoption population into three groups: small, medium, and large. In the small testing group, we collect data, often at a higher volume per system, and debug, then either deploy the improved configuration to the medium ring or reconfigure and start over in the small ring. The same process is repeated in the medium ring before we deploy the configuration to the large ring. At any point, if we discover quality issues, we can delay deployment to the subsequent ring until the configuration is stable. The ring model allows us to collect both shallow data across the entire PC fleet, as well as deeper data acquisition for specific audiences based on changes or triggers from that general collection.

Log Parser

The log parser is designed to specifically parse data that does not reside as configured or standard event logs. The solution requires specific logical parsing rules per log type, but still allows data streams from various inputs not hosted in the common data streams.

Client Data Warehouse

The client data warehouse stores the data from the ring-management system, as well as the various data collectors and parsers. This big-data repository enables better decision making by performing basic correlations across all of the data feeds. It is accessed and made available through reporting applications that can produce summary and detailed reports of specific issues.

Data Analytics and Predictive Maintenance

Intel IT's long-term goal is to significantly reduce impact on our customers, and data analytics and predictive maintenance can help us achieve that. Collecting and analyzing data is an evolutionary process. Defining what data to collect, developing automated processes to collect that data when specific thresholds are met, and understanding how to interpret the information all lay the foundation for big-data analytics and machine learning.

We have found that obtaining the data is the first critical component to developing a sustainable model. Since 2015, we have successfully implemented the building blocks for advanced analytics. With refurbished data streams that provide more relevant information, a data scheme, and big-data storage in place, we are focusing on the core elements of advanced analysis, which include:

- **Unsupervised learning**. Mass data from a small, but representative sample of the environment will provide information on unknowns—or things we should investigate.
- **Persistent, supervised learning.** We can perform automated root-cause analysis and predict issues on known data through persistent, supervised learning.

Moving forward, we will develop the foundation for feature-selection exploration and algorithm tests. As our data-centric process matures, we are well positioned to make the transition to data analytics. With predictive maintenance, we can further improve the user experience by addressing some issues before they are reported, maximizing the health of our PC fleet and avoiding unexpected downtime for users.

In the second half of 2017, we conducted a very successful proof of concept (PoC) demonstrating that we are on the right path, and expect to gain excellent value through advanced analytics.

Results

The original 2009 proactive problem-management process has matured with our recent changes. It is not enough to simply find and fix a problem, we must also sustain the health of the PC and address issues that resurface. Tools alone are not enough; sustained PC health requires a strong, clearly defined process, as well as continuous improvement. Through process maturity, we have achieved a 60 percent reduction in BSOD errors (see Figure 4), a 40 percent reduction in unexpected shutdowns (see Figure 5), and a 75 percent reduction in application hangs (see Figure 6).

With a sustainable process to collect and standardize data from a variety of sources, we can begin a transition to data analytics. In 2018, our focus will be on automated data predictive analytics.

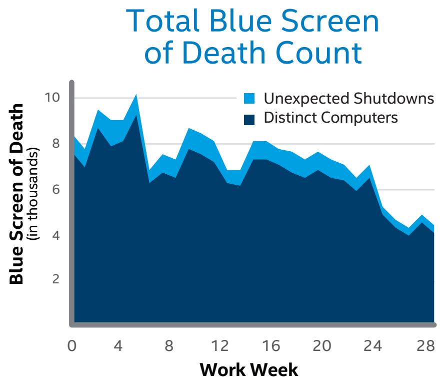

Figure 4. The matured problem-management process decreased Blue Screen of Death errors by 60 percent over a 28-week period.

Lessons Learned

One of the most important lessons we have learned is that it is easy to let processes slip when problems have been resolved. But over time, without maintaining those processes, new and existing problems resurface in the organization. PC health requires sustained investment and dedicated resources. A large part of the success of our revised process includes these lessons:

- **Sustained, focused process.** Driver and software releases, new OS versions, and changes in the environment continuously introduce new issues. Sustaining and growing the process is as important as identifying and mitigating new issues. With data, we can predict problems better and understand their impact, which allows us to prioritize critical or widespread issues. With multiple competing issues, prioritization based on data allows us to stay focused on the most important ones.
- **Clearly define roles.** Analyzing problems with applications and drivers requires domain knowledge. Incorporating subject matter experts with specific roles helps us identify and prioritize issues before they negatively impact users and to quickly resolve issues.
- **Collect the right data.** Data allows us to predict problems and identify the need for future capabilities, such as data analytics and predictive maintenance. By analyzing the right data, we can work more closely with solution providers to help them resolve issues faster, and meet the business goals.

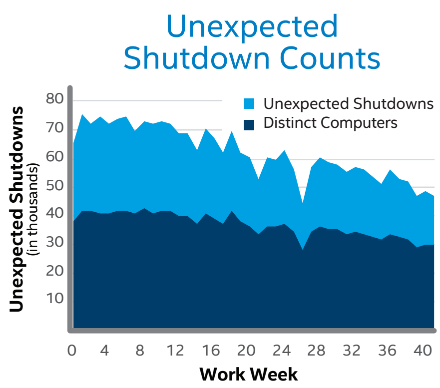

Figure 5. We have decreased unexpected shutdowns by 40 percent over a 40-week period.

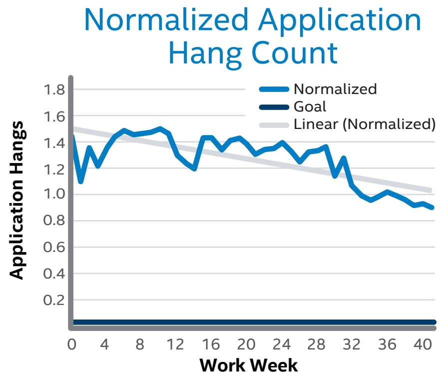

Figure 6. We have experienced a 75 percent decrease in application hangs over a 40-week period.

Conclusion

At Intel, we experienced a high number of BSOD errors that negatively impacted employee productivity. In 2009, we developed a proactive problem-management process to address these issues, as well as improve overall PC health monitoring and sustainability. Over the years, the growing complexity of the environment and our focus on other challenges resulted in a resurgence of user interruptions due to platform instability. We recently resurrected and updated the original process, and created new foundational capabilities in data collection and analysis, allowing us to focus on predictive maintenance.

By clearly defining roles, setting achievable goals, working with a multidisciplinary team, and updating methods for collecting and analyzing data, we have achieved a 60 percent reduction in BSOD errors, a 40 percent reduction in unexpected shutdowns, and a 75 percent reduction in application hangs. Through our lessons learned, we have developed a sustained focus on the process and its ongoing improvement.

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