White Paper
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IT@Intel: More Accurately Benchmarking the End-User PC Experience

Intel IT has deployed a new set of tools and processes to get specific data about PC power consumption and applications' effect on battery life, enabling a better understanding of the end-user laptop experience

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Executive Summary

"Why doesn't my corporate laptop battery last as long as my laptop at home?" Intel IT staff hear this question nearly every day. We know employees want to be as productive as possible, and battery life is crucial to Intel's highly mobile workforce. On the other hand, our IT build includes several components that help keep Intel's data and intellectual property safe. Necessarily, these additional software components consume their fair share of power. To fully understand what users are experiencing with their laptops—as well as how the Intel IT build introduces power consumption overhead—we rigorously benchmark the corporate PC experience.

In collaboration with Intel's Client Computing group, we recently overhauled our PC experience benchmarking methodology and toolset. We adopted new benchmarking tools that more accurately represent the applications that Intel employees use. We also now use the Intel® Battery Life Diagnostic Tool (Intel® BLDT) to identify specific background processes and applications that are responsible for excessive power consumption.

We use these tools to reduce power consumption rates on users' PCs and help the Client Computing group drive improvements to client devices and meet customers' expectations. By sharing our benchmarking approach and results, we hope to encourage other IT departments to take a similar approach.

Intel IT Contributor

Jennifer Delgado, Industry Engagement Manager

Acronyms

AC	alternating current
DC	direct current
Intel® BLDT	Intel® Battery Life Diagnostic Tool
mW	milliwatts
mW/h	milliwatts per hour

Background

Intel's employees are highly mobile. Some are road warriors who work from airports around the globe. On-site employees travel from conference room to conference room, while contingent workers often have temporary working spaces. In recent years, Intel's workforce has become increasingly hybrid, with workdays split between home and on-site offices.

To support these mobile employees, Intel IT manages 121,000 laptops. The new laptops that we procure deliver out-of-the-box battery life performance. However, when we add the IT build to a laptop, it can affect the battery life. For example, cybersecurity or networking software running in the background can consume battery power. Our job is to evaluate the users' PC experience and improve it when possible, to enhance employee productivity and job satisfaction.

Battery life varies based on commercial usage. Some employees may run several "busy" applications at once (and therefore more quickly consume battery power), while other employees' PCs may spend more time in idle mode. Users often don't understand why their corporate laptops don't have the same battery life as their consumer PCs—it's one of the most common questions we receive from users. PC experience benchmarking helps us evaluate how the Intel IT build affects PC power consumption and battery life in various scenarios; it also enables us to investigate and mitigate potential problems revealed by the benchmarking.

We have identified several PC experience benchmarking use cases:

- Out-of-the-box OEM build power consumption versus the IT build.
- Different OEM builds and a new generation of the OS versus the previous generation.
- IT build before and after making a change on the platform to quantify the impact of a change.
- IT build with and without an application to quantify the product's overall impact on the platform.

Intel IT isn't the only entity at Intel that wants to know more about the PC experience. Intel's Client Computing group is also interested in such benchmarks. For example, this group can use benchmarking for the following:

- Identifying the expected battery life for a laptop equipped with a new Intel® PC processor, which enables the group to assess what end customers will see on an enterprise PC.
- Determining if there are performance gaps that have not been addressed.
- Qualifying systems so they meet customer expectations and provide a positive user experience.

PC experience benchmarking isn't new at Intel IT, but our traditional tool for benchmarking the PC experience used OpenOffice workloads, which did not provide a realistic measurement for our users, who use Microsoft Office 365. Therefore, we needed a new benchmarking toolset that could provide accurate, reliable PC experience benchmarking.

Solution

We collaborated with the Client Computing group to develop a new approach to PC experience benchmarking. We adopted Procyon O365 as the main benchmarking tool, both for Intel IT and the Client Computing group. This new tool provides more accurate benchmarking than our previous tool because it uses the actual Microsoft Office applications installed on employees' PCs to benchmark performance.

We use a variety of other benchmarking tools that complement Procyon O365 (see Table 1). These include browser workloads, a utility to measure CPU and GPU power consumption, and an "idle" workload. We also use the Intel® Battery Life Diagnostic Tool (Intel® BLDT) to help look even deeper into how applications affect PC battery life.

Table 1. Summary of Our PC Experience Benchmarking Tools

Tool	Description	Purpose	CPU Activity	GPU Activity
Procyon O365	Enterprise and general-purpose tasks like productivity, application launch, browsing, and conferencing	Performance Measure the impact of office productivity applications on battery life and the performance of the PC	Bursty	Bursty
Browser Testing	Web-based workload using HTML5 and JavaScript	Performance Measure the browser's performance experience	Bursty	Bursty
Browser Testing	Web-based workload using Cascading Style Sheets (CSS), JavaScript, and Document Object Model (DOM)	Performance Measure the browser's performance experience	Sustained	Idle
CPU/GPU	Utility to measure CPU and GPU activity	Performance Measure different workloads that tax the CPU and GPU to understand PC performance and impact on battery life	Bursty and Sustained	Bursty
Idle (3-Hour)	Background activity during idle time	Power Consumption Measure power consumption while the PC is idle	Idle	Idle

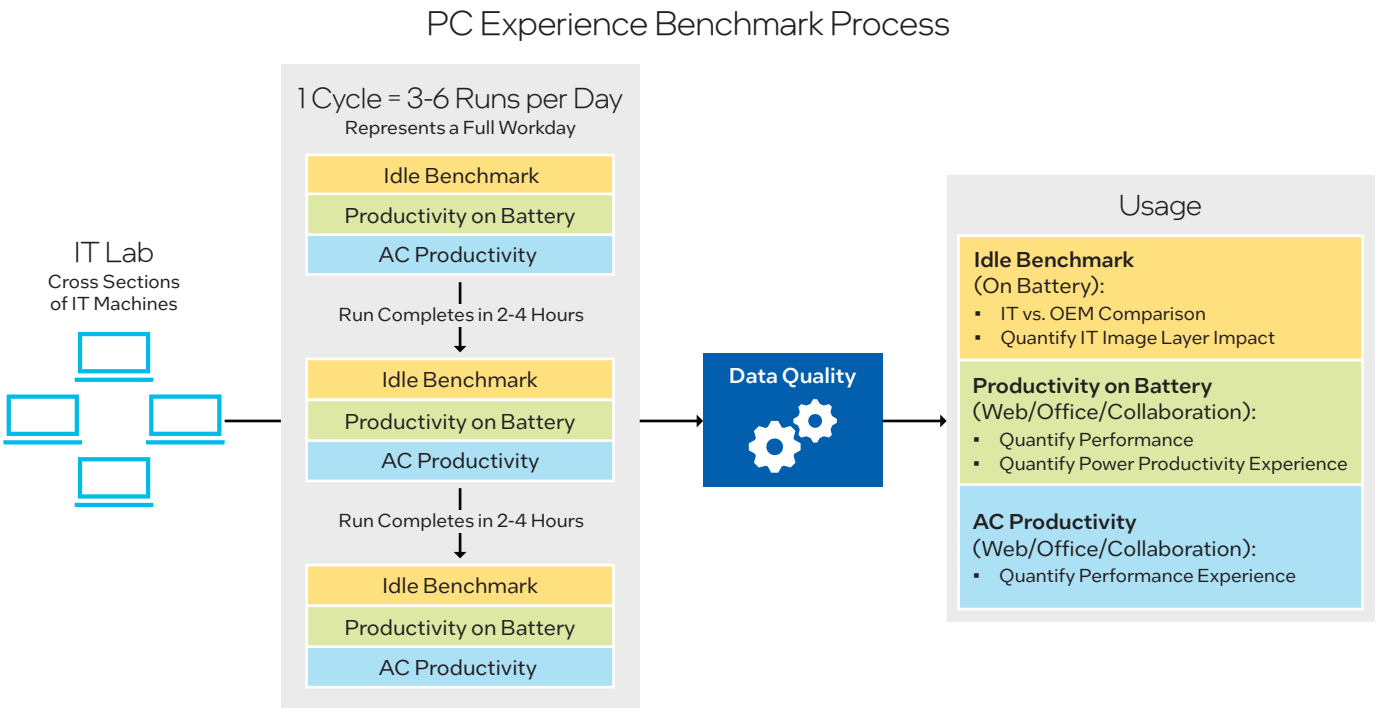

Figure 1. We test laptops' power consumption at idle, on battery, and while connected to power.

Power Consumption Benchmarking Methodology

Figure 1 depicts our benchmarking methodology. We choose PCs that represent a cross-section of the laptops in use across Intel. For instance, we run the benchmarks on three generations of Intel® Core™ processors (such as 12th, 13th, and 14th Gen). This helps identify areas that may need optimization. For those PCs, we compare OEM build power consumption—measured in milliwatts (mW) to IT build power consumption—over three phases:

- **Idle testing:** We let the device run for three hours with no active applications or benchmarking tools. Knowing the total power consumption during the idle phase helps us understand the IT overhead on the platform, such as the power consumption attributed to cybersecurity and manageability software.

  For example, suppose that an OEM states that a battery has a capacity of 55,000 mW/hour (mW/h), and our benchmarking tests confirm that the out-of-the-box model delivers 20 hours of idle time. This translates to a mean power consumption of 2,750 mW/h. If the mean power consumption is 5,000 mW/h during three hours of idle time on the IT build, that translates to only 11 hours of idle time available. The delta between 2,750 mW and 5,000 mW is the IT overhead. Figure 2 shows a sample output from our power consumption benchmarking. In this figure, the IT build power consumption increases sharply in the second week—this would trigger our investigation to determine what caused the increase, such as a new version of an application or some other root cause.

- **Direct current (DC) performance testing:** Next, we use the Procyon O365 benchmark tool and other benchmarks on the laptops while they are running on battery (OEM versus IT build).

- **Alternating current (AC) performance testing:** Finally, we conduct the same tests on the laptops while they are connected to power.

The results, an example of which is shown in Figure 2, indicate the power consumption of the IT build versus the OEM build when running the same benchmark, whether on AC or DC.

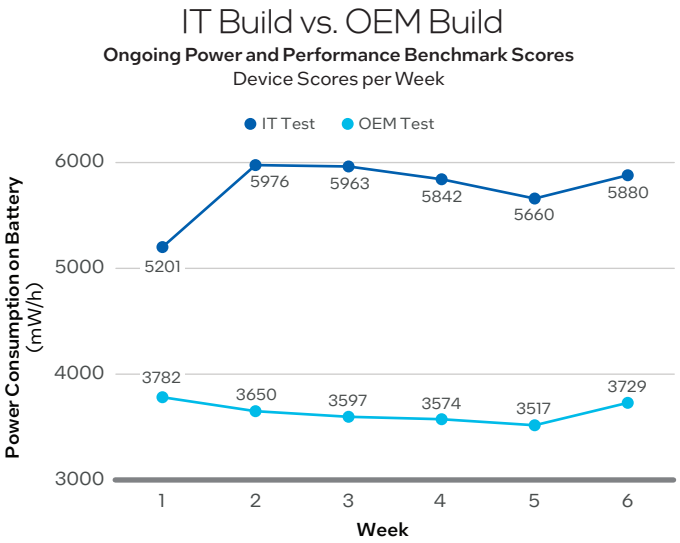

Figure 2. The data point trends here show the differences in power consumption between the IT build and OEM build in milliwatts per hour (mW/h) when running the same benchmark.

Benchmarking Considerations

We use custom scripts to automate switching between AC and DC, running the tests, and charging the PCs. We aggregate the data from the tests and upload it into a database. We also conduct data quality operations on the data, such as excluding outliers based on certain thresholds, which helps provide more accurate and reliable data. It's important to use the same device models and hardware/software configurations for both IT and OEM build tests and to keep the devices updated with the latest patches from Microsoft.

Intel BLDT Benchmarking Methodology

The power consumption benchmarking results can show power consumption and its effect on battery life, but do not explain WHY the experience degrades. The Client Computing group developed the Intel BLDT to pinpoint the specific application that is causing high power consumption. The tool provides insight into individual background processes that can affect battery life. For example, if an application constantly wakes up the CPU, the CPU will rarely achieve a low power state and, therefore, consume more power from the battery. To enable longer battery life, the goal for any software application is to use the CPU only for short periods and keep the CPU sleeping for longer periods.

When we notice a large delta between the OEM and IT build power consumption (such as in week 3 in Figure 2), we use Intel BLDT to run a diagnostic. We run the tool on DC for 30 minutes, then examine the report and perform root-cause analysis to determine which process or application is consuming more than its share of battery power.

Results

We used our new PC experience benchmarking toolset to discover three commercial software products that significantly impacted battery life. As one example, a PDF viewer application ran an update service in the background to constantly check the network for updates. However, because we use our manageability tools to update our applications, this service was irrelevant. The Intel BLDT identified it as a major contributor to battery drain. When we disabled the service, we saved 25 mW/h. Although this represents only a few minutes of additional battery life, it shows that we can improve battery performance with minimal effort.

For the other two commercial software products, we are now working with the software vendors to optimize the software.

Conclusion

Benchmarking the PC experience is a significant aspect of our overall efforts to deliver the best possible user experience while safeguarding Intel's data and intellectual property.

Our IT build components, such as cybersecurity and networking software, introduce necessary power consumption overhead. However, by conducting continuous benchmarking and root cause analysis, we can keep that overhead to a minimum.

Our PC experience benchmarking methodology and toolset help us make decisions about operating systems, devices, and software. We will continue to fine-tune our data collection and optimize our IT build as well as collaborate with the Client Computing group to drive product improvement. By reducing the IT overhead on the platform, we can make the IT build battery experience as similar as possible to the OEM build battery experience.

We hope by sharing our benchmarking method and results, we can inspire other IT departments to take a similar approach. We encourage readers to download and test the Intel BLDT, in pursuit of the same benefits we have achieved. Feel free to engage with the IT@Intel program to get more information about using this tool.

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