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Smartphone Battery Life and SoC Power Benchmarking

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Battery life is a key aspect of user experience of battery-operated and handheld/mobile devices, and even more so with smartphones given their widespread use and compact form factors. This is also an area of significant challenge as devices get thinner, batteries get slimmer, screens get bigger (consuming more power) and chips get faster. This has triggered widespread interest in understanding battery life within the media and smartphone user community. In the past year, there has been a significant surge in the number of blog posts and articles that aspire to quantify battery life and compare power consumption differences between different phones and underlying chipsets (also commonly referred to as Systems on a Chip, or SoCs) that form the brains of these mobile devices.

Several approaches have been developed to quantify power consumption/battery life. In this article, we intend to take a ground up approach to help understand smartphone battery life and power consumption aspects at smartphone and SoC levels along with examine popular approaches to quantifying power, and discuss key aspects that need to be considered in the process.

What is battery life?

Battery life is the amount of time a phone can run on a single charge for a given "usage pattern." The usage pattern is key since this can have a huge impact on battery life. The usage pattern can sometimes be comprised of a single use case, such as video playback or web browsing, which somewhat corresponds to the specifications advertised with smartphones (e.g., 10 hours of video playback), or a complex set of use cases that try to mirror a certain type of usage profile.

What is the relationship between battery life and power consumption?

- Battery life = [Battery Capacity (Watt-hour)] / [Power consumption (Watt)]
- Power consumption (Watt) = [Voltage(Volt)] * [Current (Ampere)]

The important aspect to note here is that both voltage and current need to be factored in when calculating power consumption. This becomes even more important while comparing power consumption between multiple devices—often current consumption (mA) is compared. Current consumption comparisons are valid only as long as all the devices compared were tested at the same (battery) voltage. If the voltages were different, the comparison is not accurate. To be safe, it's always better to compare power than current.

What are the different approaches to measure battery life?

There are two popular approaches:

1. Run a use case continuously on a phone starting with a completely charged battery and wait until the phone turns off due to low battery

For example, run a video back to back until the phone turns off due to low battery. The amount of time the video runs is the approximate battery life for that use case.

This is easy to use but limited in its application—usually suitable for measuring power consumption for a single use case in a loop. It is also subject to variation due to the age and part-to-part variation of the battery, and to errors if the battery is not really fully charged at the beginning of the exercise.

2. Measure power consumption using a power measurement tool

A power measurement tool provides a more flexible, fast and accurate method to measure consumption and estimate battery life.

Power consumption for individual use cases can be measured and compared or individual use cases can be combined in "time-weighted ratios" to estimate battery life for a certain usage profile (e.g., business user) that has set of use cases, to mimic real world use.

The phone needs to be instrumented to use this method, such that the power is drawn from an external supply (usually part of the measurement equipment itself) instead of the phone battery.

Commercially available measurement tools can be used for this purpose.

What factors need to be considered during power measurements and analysis?

- *Smartphone-level vs. SoC-level measurements*

Power measured at the phone battery reflects overall consumption at the "smartphone" level—which includes power consumed by individual mobile SoC components (modem, CPU, GPU, etc.), display, sensors and other components on the PCB that are turned ON for a given use case. *Therefore, battery level comparisons between different phones that are valid at an "overall phone level" may not directly reflect power consumption of the underlying SoC.* These factors also help explain why two different phone models based on the same SoC can have different power profiles at an "overall phone" level. Software components used (OS, UI customizations, driver optimizations) can also have significant impact on power consumption of a specific smartphone. In summary, "smartphone-battery-level" power comparisons are not directly reflective of "SoC-level" power and more effort/experimentation is required to derive the SoC-level picture.

To get reasonable SoC/system-level power consumption estimates, the effect of the display (a dominant contributor) and other power consuming components external to the SoC needs to be estimated and isolated, which needs careful analysis and can be a complex process.

Also, it would be very useful to profile multiple smartphone models/designs that use a particular SoC to get a view of which OEM design makes best use of the power features supported by the SoC.

- *Impact of display power*

For many use cases that have display ON (e.g., streaming, UI interactions, browsing, gaming) the display can be a major contributor to overall battery level power. Typically, different phone manufacturers use displays that have very different specs (which result in different power consumption). In many cases, especially with larger displays, the power consumed by the display can overshadow the power consumed by the remaining components. Therefore, it is key to make sure the impact of display is carefull
eliminated (where necessary) to get fair power comparisons.

For "smartphone-level" comparisons, it should be ensured that the display bri
standard/usable level (e.g., 200 nits) on all devices in the comparison. Not doi

results in inaccurate comparisons. Each screen has a different achievable max brightness. On several instances, we have seen power measurements made by setting the display brightness in the phone settings to a fixed percentage, like 50%. While the software settings are equal, the actual, absolute screen brightness may be different and noticeable to the naked eye.

For “SoC-level” comparisons, the display power should be carefully isolated from overall battery power. Given the magnitude of display power consumption, minor inaccuracies in estimating display power can have considerable impact on the accuracy of “SoC- level” comparisons.

- *Power measurements at equivalent performance/quality of experience*

Making sure power consumption is compared in the context of delivering equivalent performance or quality of experience is important for the comparisons to be fair. If the workload/quality is not same on both, reasonable “performance/power” normalizations can be made only where meaningful.

Examples:

Video record/camcorder power comparisons at a SoC level should address questions such as whether the power measurements were done with the same camera sensor or a sensor with comparable power consumption, whether the recording was at the same resolution & frame rate and if the final recorded video was of equivalent quality on both devices. If the quality of the video recording was very different between phones, power consumption comparison alone—without putting performance/quality into context—will not be meaningful.

While measuring power during gaming, making sure that the frame rate and quality of rendering is equivalent is key.

- *Comprehensive view of power*

It is important to cover all key smartphone technology areas and use cases to get a realistic assessment of power. This needs to include modem (voice, data), multimedia (audio, video, graphics), browsing, streaming and other real world cases than just focus on one or two aspects such as measuring power while running a specific CPU or GPU synthetic benchmark. This assumes even more importance given the trend of mobile chipset architectures becoming more heterogeneous and making increased use of offloading the processing to the appropriate (i.e., most efficient for the job) blocks. At the SoC level, this translates to taking a holistic view of all the components of the SoC over just focusing on one block or processing component.

- *Understanding and minimizing causes of variation*

There can be considerable amount of variation from device to device (component variation) and operating devices at different temperatures (thermal variation). Therefore, measurements done on multiple devices at similar temperature levels would help obtain more meaningful comparisons.

Stay tuned for our next post about how Snapdragon processors are engineered to meet new smartphone design trends.

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