GOOGLE’S TEN COMMANDMENTS FOR MOBILE COMPUTING: AS OUR WORLD GOES MOBILE, TECH GIANT CALLS FOR BETTER RESEARCH. AT STAKE IS YOUR FUTURE SMARTPHONE.

Work done during sabbatical @ Google in the Mobile SoC Team*

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Infrastructure and Methodology for SoC Performance & Power Modeling

*The thoughts expressed here are the views, thoughts, and opinions expressed in the text belong solely to the author, and not necessarily to the author’s employer, organization, committee or other group or individual.
“Why does Google care?”
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How much time do people spend on their mobile phones in 2017?

*The simple answer is "over 4 hours a day."*
Smartphone Growth Prevails
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- The number of smartphone subscribers continues to grow.
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- Provide an integrated solution that can provide a unique quality of experience.
A New Beginning - The Pixel Visual Core from Google
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- HDR+ produces beautiful images, and they evolved the algorithm that powers it to use the Pixel 2’s processor efficiently, and enable you to take multiple pictures in sequence by intelligently processing HDR+ in the background.

- HDR+ will be the first application to run on Pixel Visual Core. Notably, because Pixel Visual Core is programmable, and they are preparing the next set of applications. The great thing is that as they port more machine learning and imaging applications to use Pixel Visual Core, Pixel 2 will continuously improve. So keep an eye out!
Why Google Cares?

The Mobile Device Virtuous (Vicious) Cycle

- End Users
- Applications
- Architecture
- Mobile Device

Features and Capabilities
Power/Energy and Thermal Budgets

Satisfaction
Performance
Power Consumption
Thinking of the Mobile Hardware Ecosystem at Large
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• Driven the ability to adopt ARM ISA easily and integrate to create custom chipsets.
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- Driven the ability to adopt ARM ISA easily and integrate to create custom chipsets.

- Lead to the widespread diversification of the chipset market for the mobile processor community.
The Dearth of Mobile Computer Architecture Research
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- Mobile computer architecture is severely lagging behind in the community
- Mobile systems are highly advanced and consist of many processing engines
The Ten Commandments of Mobile Computer Architecture

I. Thou shalt have no other gods before Me.

II. Thou shalt not make unto thee any graven image.

III. Thou shalt not take the name of the Lord thy God in vain.

IV. Remember the sabbath day to keep it holy.

V. Honor thy father and thy mother.

VI. Thou shalt not kill.

VII. Thou shalt not commit adultery.

VIII. Thou shalt not steal.

IX. Thou shalt not bear false witness against thy neighbor.

X. Thou shalt not covet.
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⇐ Need a more representative solution to benchmarking mobile systems.
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It is important for hardware vendors and architects to keep pace with which applications are “hot” and keep the mobile benchmarking application suite updated.
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Mobile processor architects must include the browser in the creation of a benchmark suite and any sort of hardware or software optimization analysis. It is akin to GNU gcc.
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We need to design a system that can provide a sustainable throughput with no dropped frames, rather than build a system that has a high frame rate (such as 120 FPS) but drops frames even occasionally.
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➤ It is important to understand the relationship between microarchitectural enhancements and the actual user impact.
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<thead>
<tr>
<th></th>
<th>50th Latency</th>
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<td>One random leaf finishes</td>
<td>1ms</td>
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<td>10ms</td>
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Single Request Completion time (Source: The Tail at Scale)
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➤ It is important to report the distribution or assume the worst case and report results and conduct analysis accordingly.
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☛ Given the heterogeneity in mobile hardware, one needs to understand that the same application can be hard-coded differently on different devices to perform differently.
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Therefore, architects are strongly encouraged to consider the role of the various IP blocks in the process of evaluating a mobile system, as there are numerous opportunities for research and development of novel solutions to enhance mobile processor performance.
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Measuring the power peaks and energy consumption of new ideas is necessary given that battery and heat dissipation are first-order constraints for mobile systems.
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Look beyond today’s mobile computing systems (i.e., smartphones) and embrace the future (e.g., AR headsets that add to phones).
Two Billion Devices and Counting

An Industry Perspective on the State of Mobile Computer Architecture

Mobile computing has grown drastically over the past decade. Despite the rapid pace of advancements, mobile device understanding, benchmarking, and evaluation are still in their infancies, both in industry and academia. This article presents an industry perspective on the challenges facing mobile computer architecture, specifically involving mobile workloads, benchmarking, and experimental methodology, with the hope of fostering new research within the community to address pending problems. These challenges pose a threat to the systematic development of future mobile systems, which, if addressed, can elevate the entire mobile ecosystem to the next level.

Mobile devices have come a long way from the first portable cellular phone developed by Motorola in 1973. Most modern smartphones are good enough to replace desktop computers. A smartphone today has enough computing power to be on par with the fastest supercomputers from the 1990s. For instance, the Qualcomm Adreno 540 GPU found in the latest smartphones has a peak compute capability of more than 500 GFlops, putting it in competition with supercomputers that were on the TOP500 list in the early to mid-1990s.

Mobile computing has experienced an unparalleled level of growth over the past decade. At the time of this writing, there are more than 2 billion mobile devices in the world. But perhaps even more importantly, mobile phones are showing no signs of slowing in uptake. In fact, smartphone adoption rates are on the rise. The number of devices is rising as mobile device penetration increases in markets like India and China. It is anticipated that the number of mobile subscribers will grow past 6 billion in the coming years. As Figure 1 shows, while the Western European and North American markets are reaching saturation, the vast majority of growth is coming from countries in Asia. Given that only 35 percent of the world’s population has thus far adopted mobile technology, there is still significant room for growth and innovation.