Beyond 5G Mobile Terminals – Evolution or Revolution?

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Outline

- Evolution of mobile phones
- What is the bottleneck?
- A proposition

Mobile Phones through the Ages

The Motorola DynaTAC 8000X

First commercially available handheld cellular mobile phone.

1984

2000

Nokia 3310

Camera: None
Weight: 133g
Storage: None

2008

Apple iPhone 3G

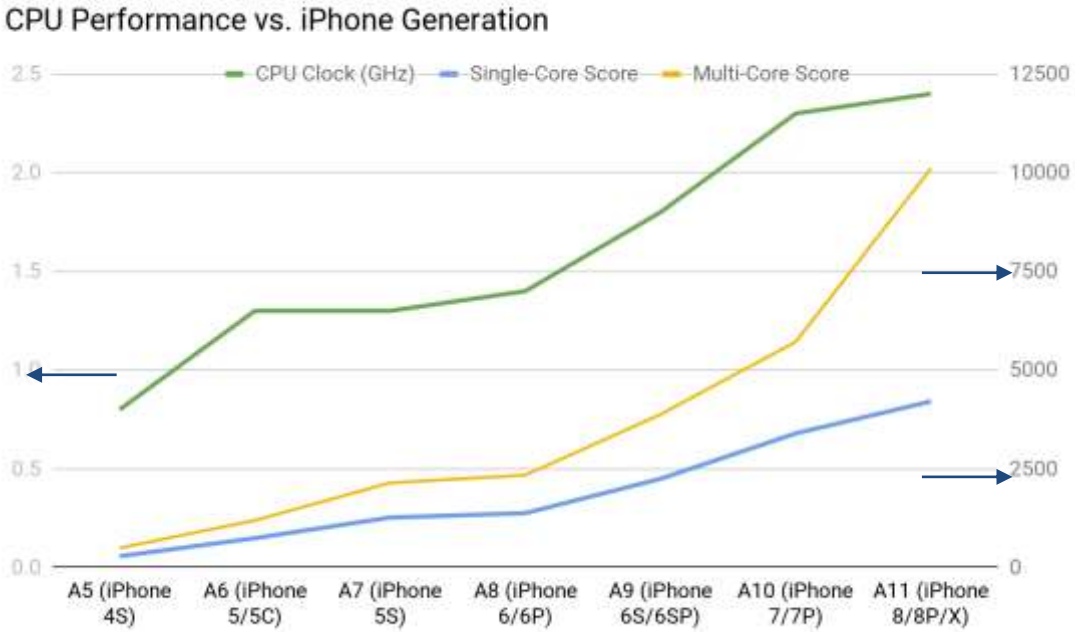
Camera: 2MP
Weight: 133g
Storage: 8/16G

2017

Samsung Galaxy S8/S8+

Camera:
12MP(Front)/8MP(Rear)
Weight: 155g(S8)/173g(S8+)
Storage: 64/128GB

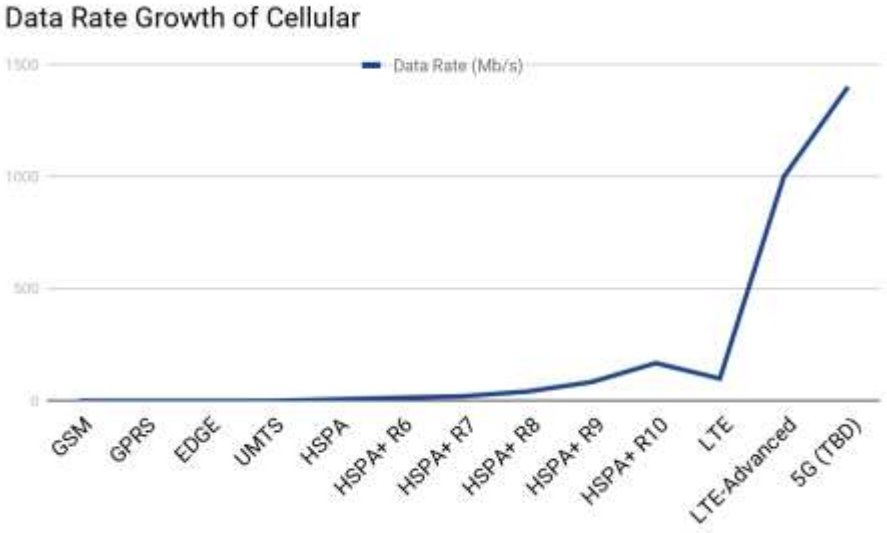
Growth in Computation Performance ☺

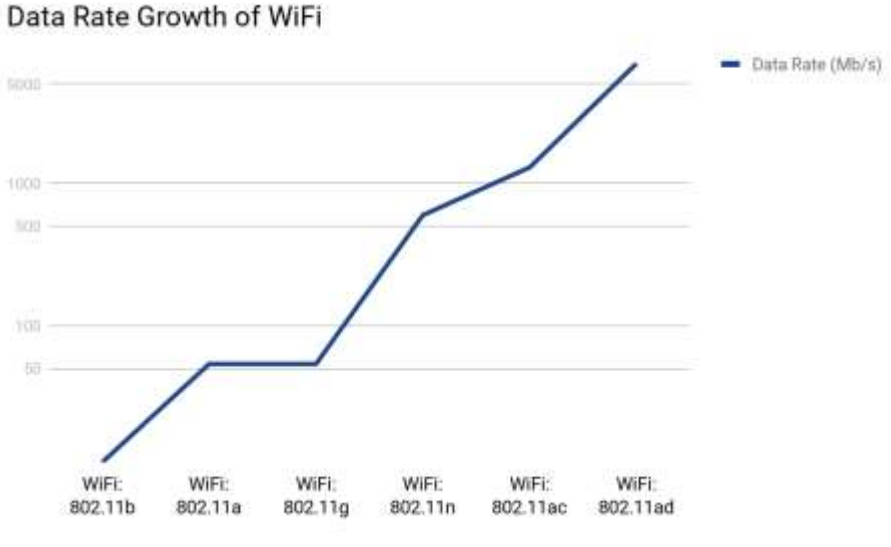


CPU scores are based on Geekbench benchmark database, https://browser.geekbench.com/ios-benchmarks

Growth in Communications Performance ☺

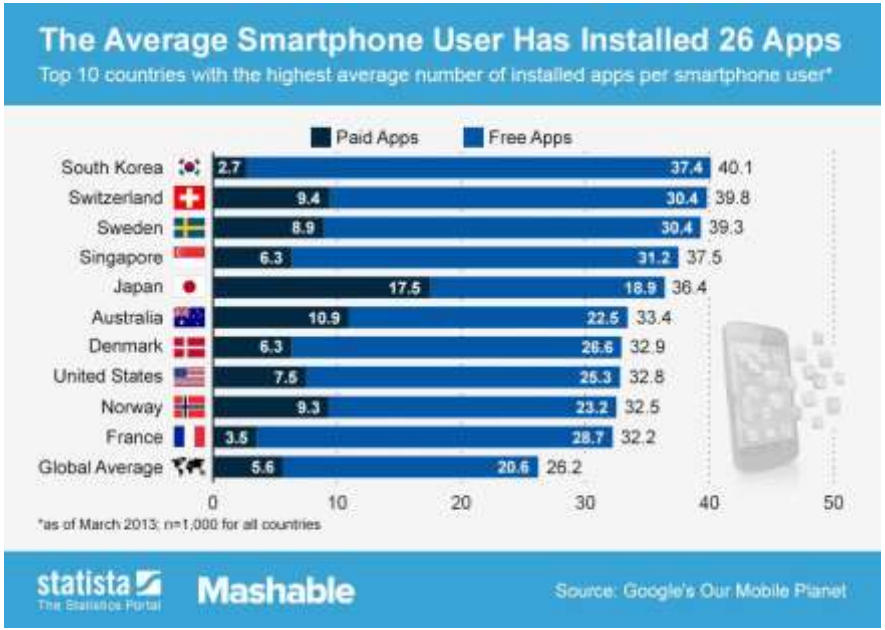
Data rate of contemporary wireless data networks can exceed 1Gbps.



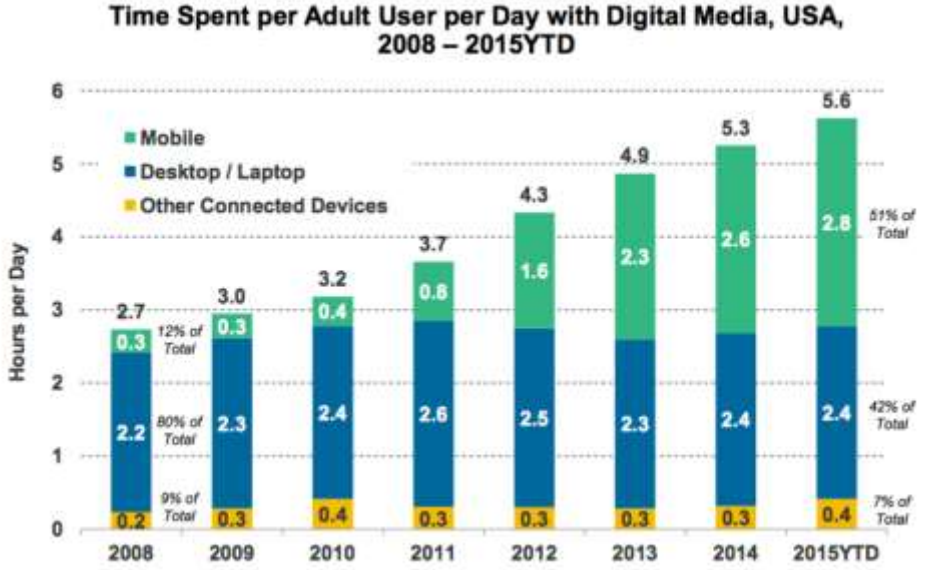


Rapid Growth of Apps and Daily Usage

More apps installed, more time spent



Statistic from statista and Google



Statistic from smartinsights.com

Growth in Battery Consumption ☹

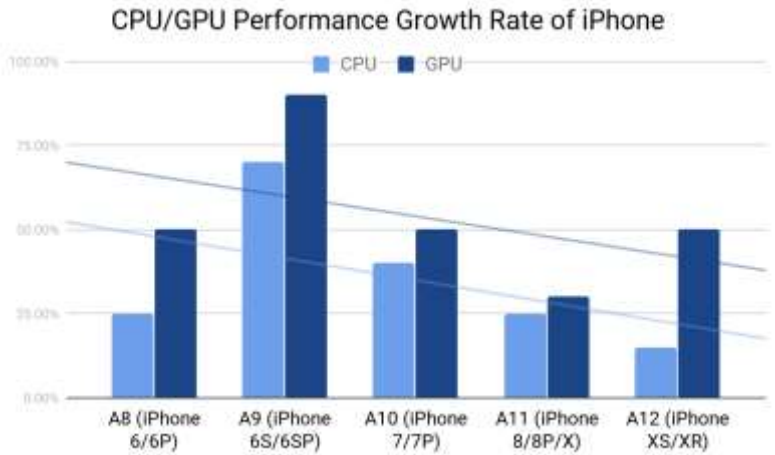
Increasingly people find that they need to charge their mobile phones every night or even carry a supplementary power bank.

The typical capacity of recent mobile phone batteries is around 3500mAh, some reaches nearly 6000mAh, but still need a **recharge every one or two days** under heavy use.

- Lack of breakthrough in battery technologies
- Battery capacity limited by the the volume of device

Dealing with Battery Limitations

- Within the battery energy limit, designers try to find a balance between performance and power consumption
- This has worked for more than one decade, thanks to advances in the manufacturing process of chips (Moore's Law) and design optimizations
- Growth in chips' gate density and power efficiency is slowing down as they become more and more complex



Officially announced CPU/GPU performance growth rate of iPhone by Apple

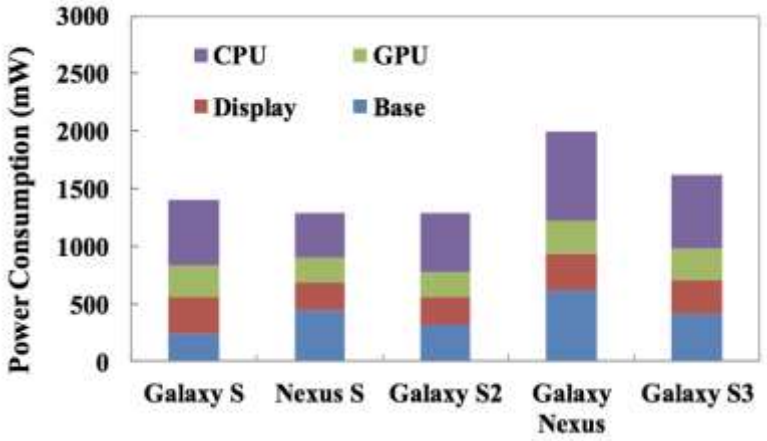
What takes the most power?

Typical power consumption of main components of a smartphone.

- An ARM A9 CPU: 500 ~ 2000 mW.
- A display: ~ 400 mW.
- Active cell radio: ~ 1000 mW.
- Accelerometer is 21 mW.
- Gyroscope is 130 mW.
- Microphone is 101 mW.
- GPS is 176 mW.

CPU & GPU can take the most power when there is a high **LOCAL** workload.

Power component breakdown example of video game [1]



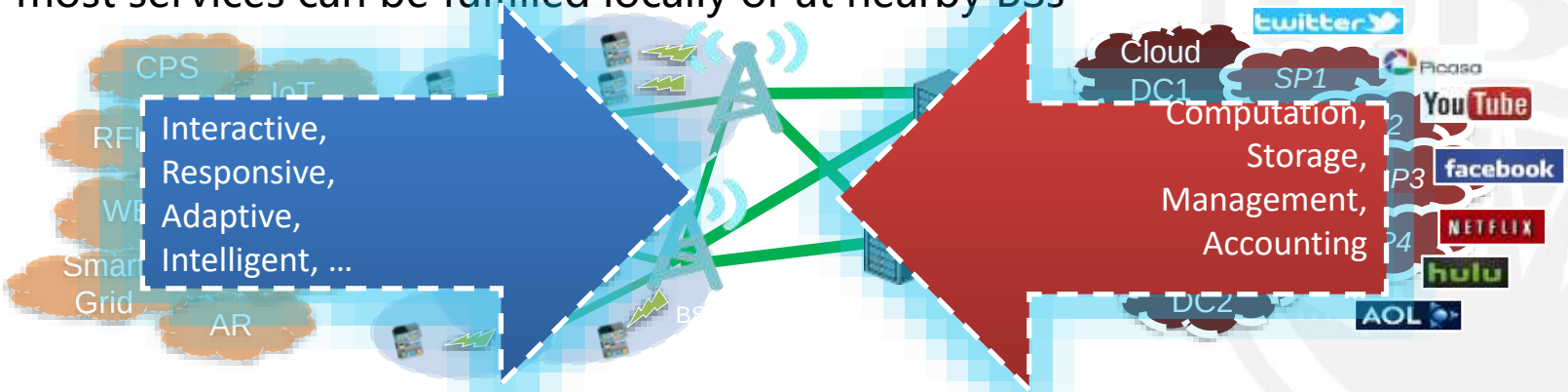
Without revolutionary in battery technology and little improvements in device technologies, we need revolutions in system architectures

[1] Chen, Xiang and Chen, Yiran and Ma, Zhan and Fernandes, Felix C. A, “How is Energy Consumed in Smartphone Display Applications?”, ACM HotMobile '13

Potentials of CCC

Convergence of Communications and Computing

- Push the frontier of computation and storage services away from centralized MNO facilities to edges of mobile networks
- Offload the services and optimize the enabling systems dynamically at edges of mobile networks
- Terminals utilize edge nodes to compute, store, and manage services so that most services can be fulfilled locally or at nearby BSs



Thank You!

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