Smartphone Architecture

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Smartphones

- 182 million active smartphone users in the US
  - That's 74.6% of the total population
- Apple has the largest market share
  - 41.6% of total subscribers
- Gaming
  - Worldwide mobile gaming revenues are expected to overtake console games in 2015
  - North America and Western Europe mobile gaming is growing at ~50% year after year
- Average Mobile digital media time is greater than Desktop digital media time in the US

Cellphone vs PDA vs Smartphone

Cellphone:

- Calling and texting features
- Very few other features

PDAs (Personal Digital Assistants):

- Web browsing, personal organizer
- Traditionally did not include calling / faxing / emails

Smartphones:

- Combined the PDA and Cellphone functionality

Many Similar Devices:

- Pocket PC, Tablet, “smartphone” vs. “Smartphone”

Challenges for Mobile Devices

Power Consumption:

- Battery life and device efficiency must be optimized
- Device must conserve power when idle or suspended

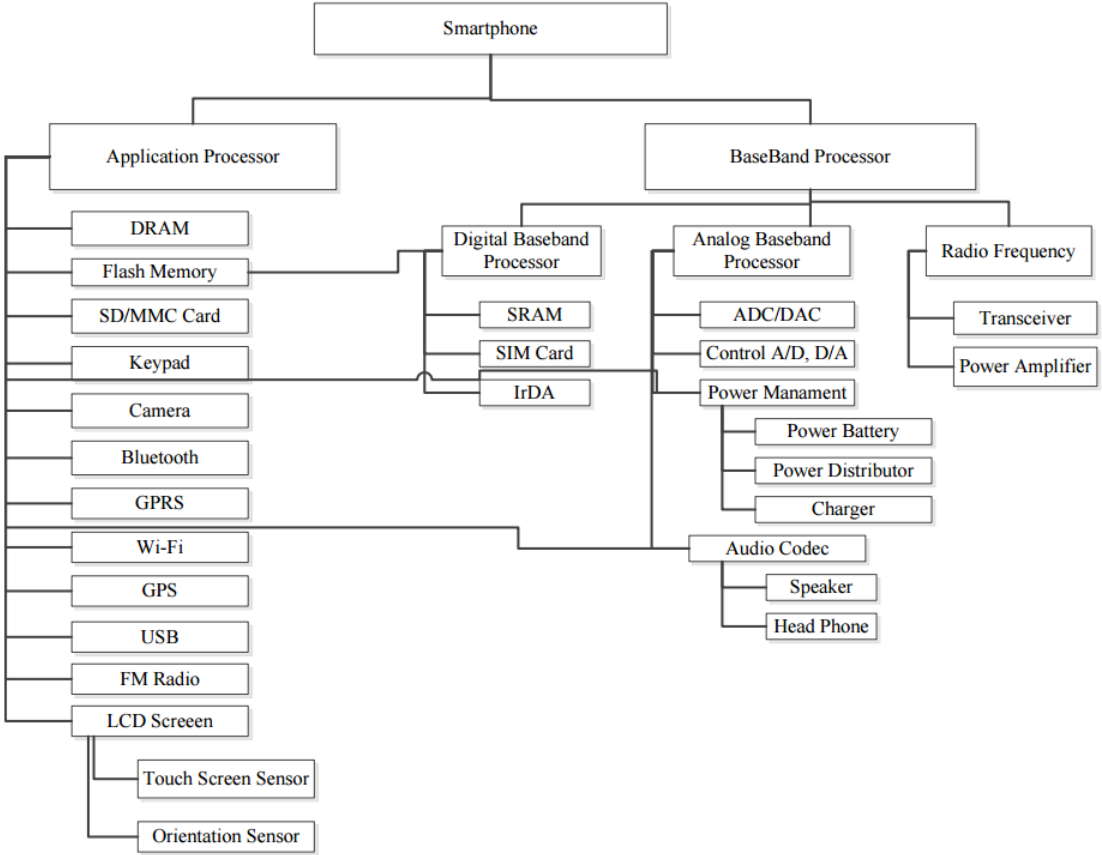
Networking:

- Most mobile devices designed for on-the-go computing
- Need to handle internet / calls / SMS reliably

Security:

- Devices can be easily lost or stolen
- Important personal information must be protected

Anatomy of a smartphone



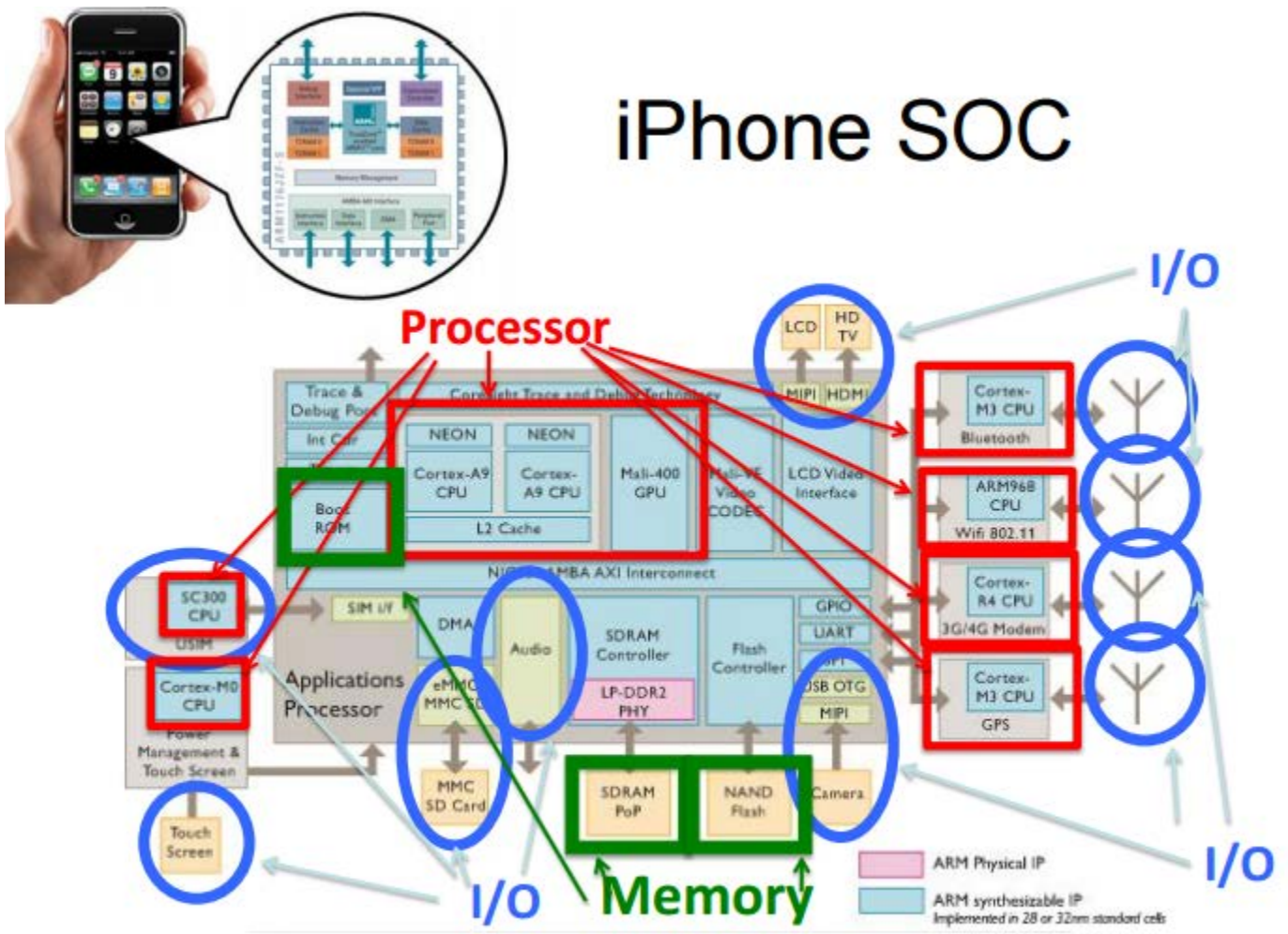
System on Chip (SOC)

- Single chip solution for application processor
  - Processors (CPUs and GPUs)
  - On-chip memory
  - Accelerating function hardware
  - All analog components
- Coordinated software and hardware
- Smartphones use SoC instead of connecting separate chips on a PCB because:
- Reduces cost, power, and size
- Increases performance

The iPhone

- Design features
  - One of the first phones with a GPU
  - Accelerometer (automatically rotates screen)
  - 2 megapixel camera
  - Proximity sensor (dims screen during calls)
  - Ambient light sensor to automatically change brightness
- Problems:
  - exclusive to AT&T
  - low battery life (due to GPU and new sensors)
  - No removable battery or SD card…did not please power-users
- Resulted in more “Average” users entering smartphone market

iPhone SOC



Source: UC Berkeley

SoC design challenges

- Very complex designs
- Much more expensive than alternatives
- Performance requirements: (must do well for all)
  - Size limitations
  - Power usage (affects battery life)
  - Heat dissipation is more difficult
  - Performance with images, sound, video of all varieties
  - Performance with networks of all varieties (Wifi, cellular, etc.)
- Smartphone sales can drop if even one aspect is sub-par

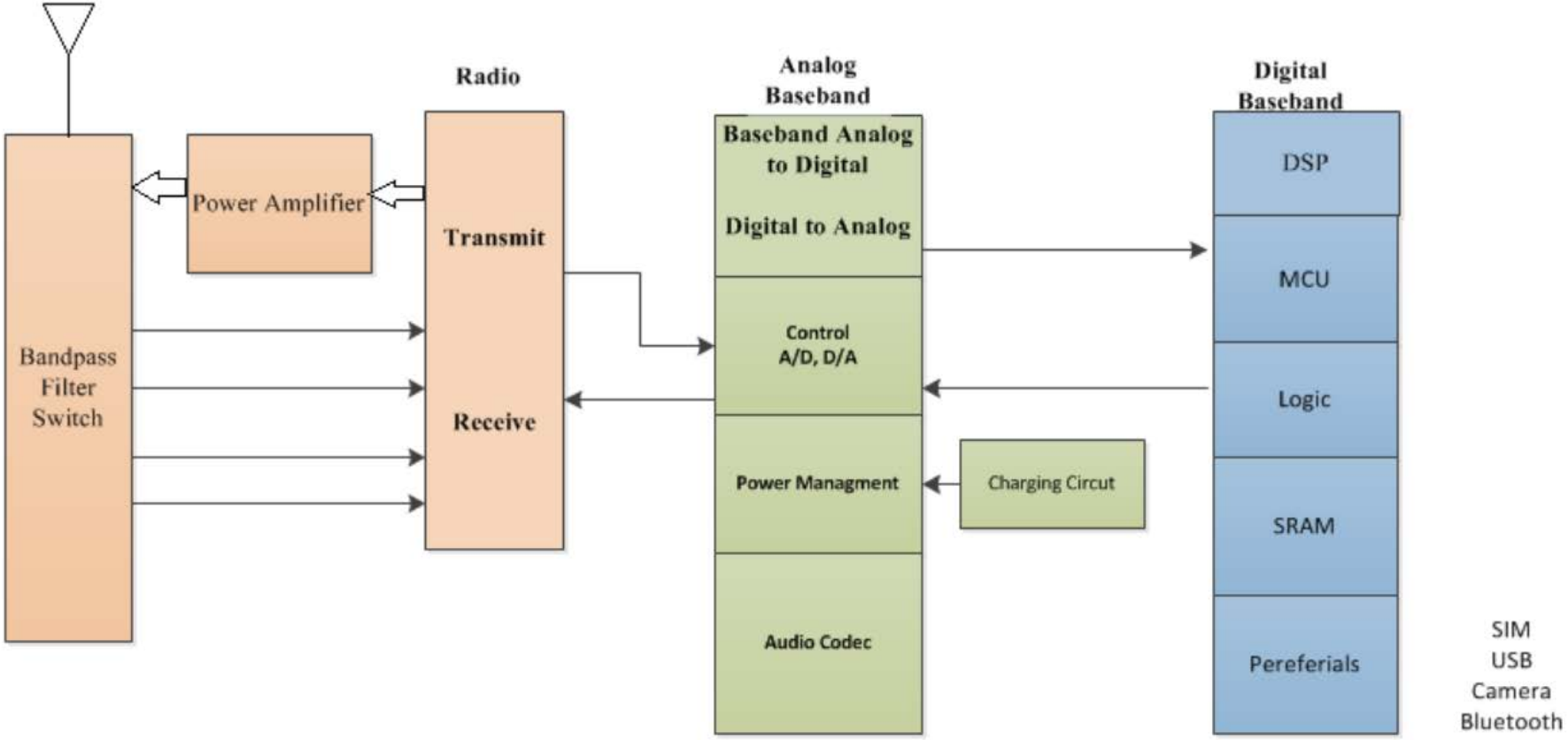
Solutions to SoC problems

- Multi-core processing and Hyperthreading
  - Run task in parallel for more speed
  - Rotate between cores for temperature management (sort of like minigun)
  - Non-linear increase in performance when adding cores
- Rely more upon GPUs
  - Better performance for specialized tasks
- Move analog functionality do digital domain
  - Analog tech growth rate doesn't follow Moore's law
- Use ARM processors (over 95% of market share)

Baseband Processors

- Secondary processors functioning as modems
- Originally used in cellphone networks
  - Have since evolved to handle Digital, 3G, LTE, etc.
- Most employ an ARM design for very low power usage
- Processors contain their own micro OS and memory
  - Allows the processor to function on its own
  - Increases reliability by isolating functions from main system
- Handles device functions when device is idle

Baseband Processor Design



Power Usage - Idle vs Suspended

A device is considered IDLE when:

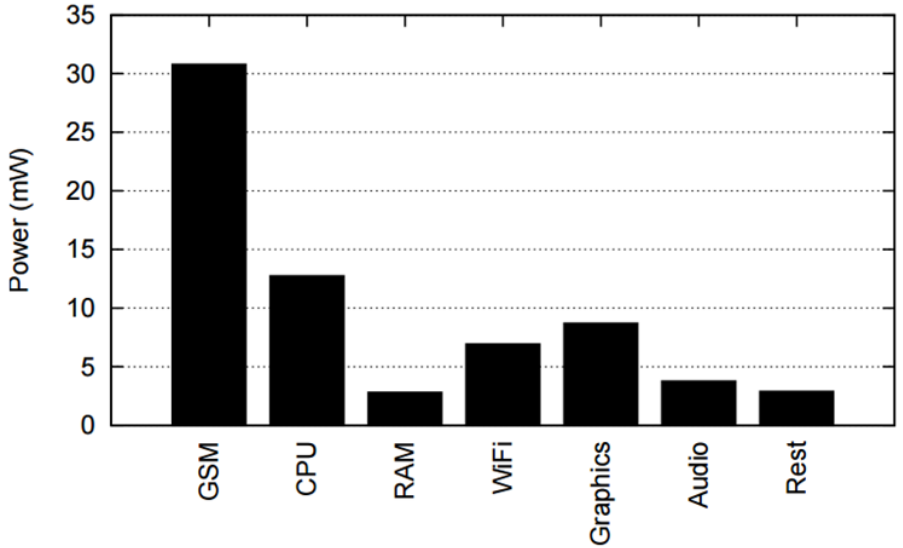
- The device is fully awake, with the SoC running
- SoC is powered but not performing tasks
- Power consumption is fairly stable and can be benchmarked

A device is considered SUSPENDED when:

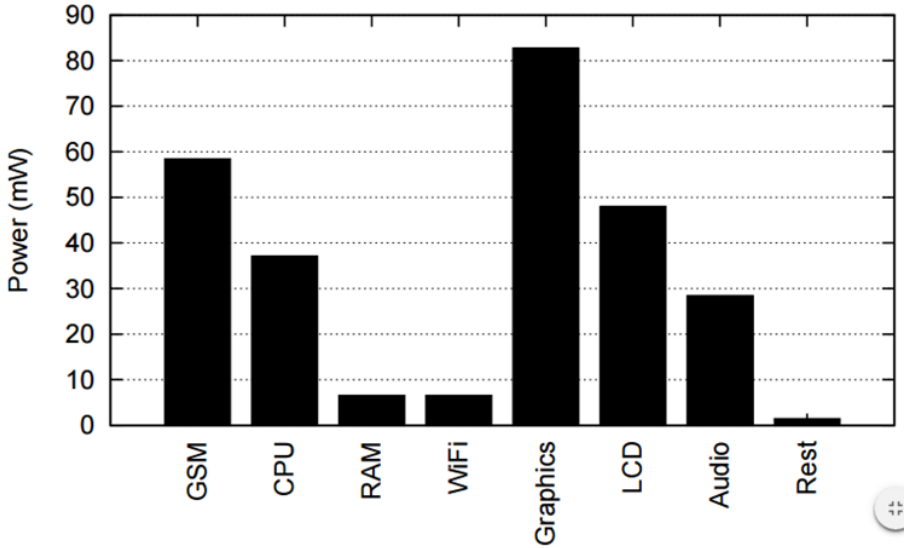
- The SoC of the device is in low-power mode
  - Android devices power off main SoC by saving current state to RAM
- Only the low power baseband processor is active
- Most of a device's time is spent in the suspended state

Power Consumption: SPEC2000 Benchmarks

- Performed on an Openmoko Neo Freerunner with Android (2008)
  - Similar to the Google Nexus One (2010) and HTC Dream (2008)

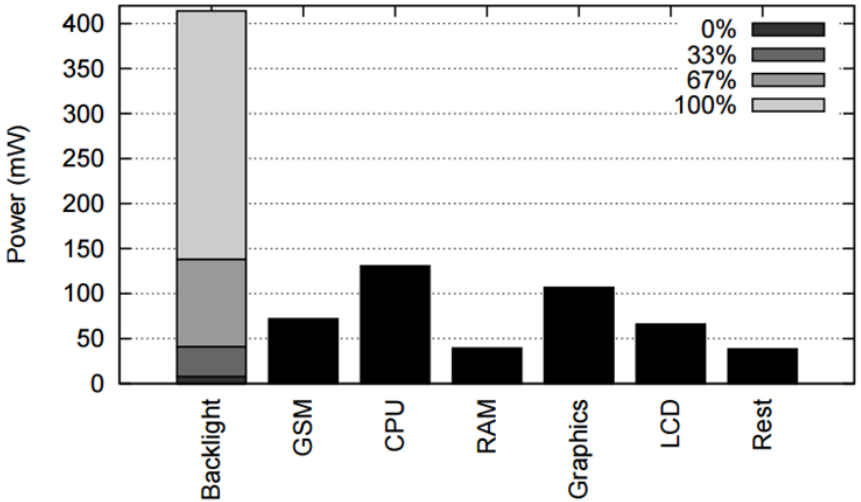


Power consumption in Suspended State

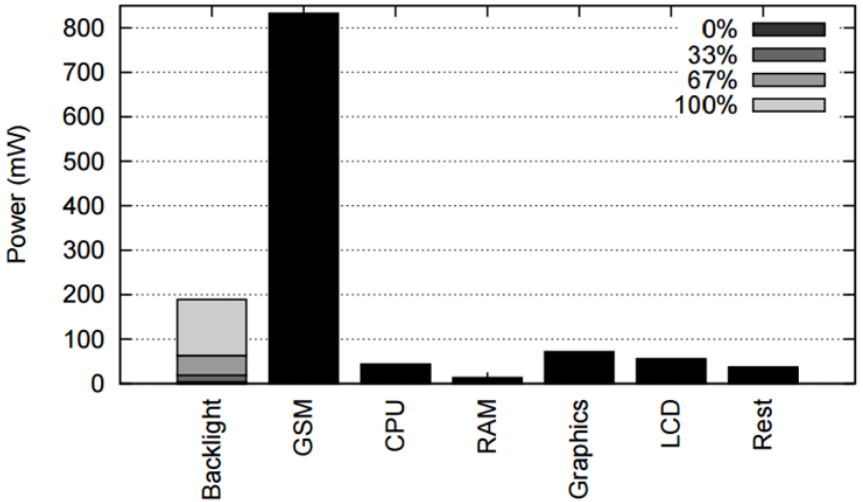


Power consumption in Idle State

Power Consumption: SPEC2000 Benchmarks



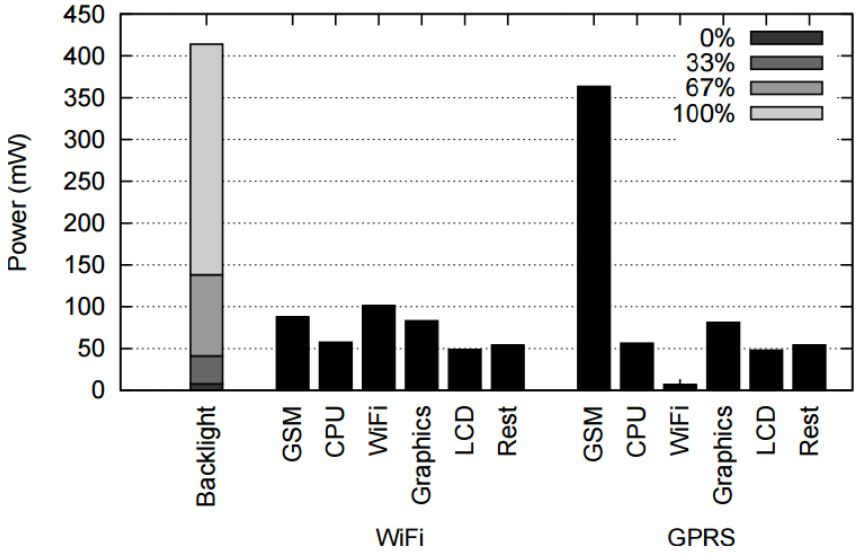
Power consumption playing a 5 minute video with no sound



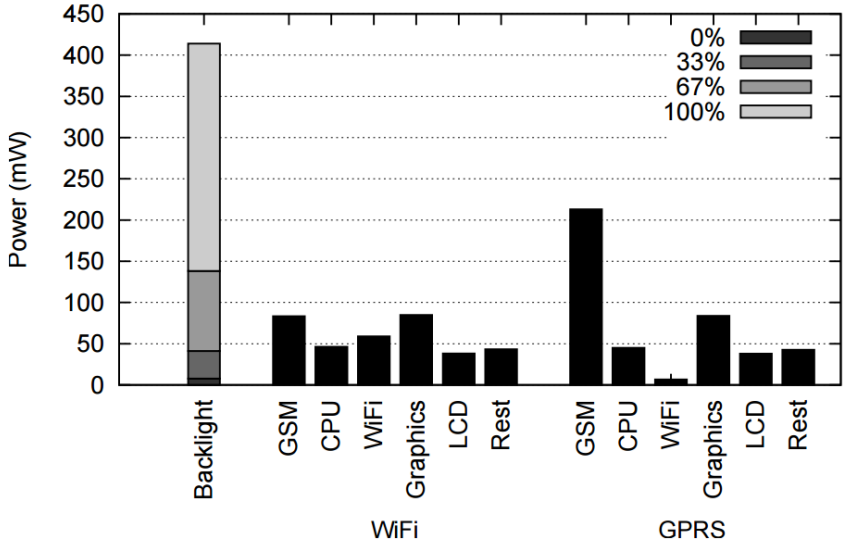
Power consumption during a 77 second phone call

- Notice the power consumption bottleneck

Power Consumption: SPEC2000 Benchmarks



Power consumption handling emails with wifi and GPRS (2G and "old" 3G)



Power consumption handling web browsing with wifi and GPRS

Future Challenges

- Users desire ever-increased computing power
  - Results in higher power consumption
  - Will require a more aggressive power conservation method
- Baseband Processor Designs
  - Very closed source hardware
  - Unknown security risks
  - Power consumption bottleneck during device suspension
- Battery technology
  - Not advancing fast enough to relieve power consumption issues
  - Consistent increase in smartphone costs until major battery tech breakthrough

Links

Baseband and SIM Card Secondary Processors on smartphones:
http://www.androidauthority.com/galaxy-s4-att-update-317818/
http://www.bapress.ca/ccc/ccc2013-1/3_13052701_Final%20Draft.pdf

Network Challenges and Architecture for Smartphones (look at pages 9+):
http://onlinelibrary.wiley.com/doi/10.1002/wcm.1203/epdf

Smartphone Power Usage Analysis (performed on Openmoko Freerunner):
https://www.usenix.org/legacy/event/usenix10/tech/full_papers/Carroll.pdf

Mobile game revenues set to overtake console games in 2015
http://fortune.com/2015/01/15/mobile-console-game-revenues-2015/

Mobile Marketing Statistics 2015
http://www.smartinsights.com/mobile-marketing/mobile-marketing-analytics/mobile-marketing-statistics/

System on chip (SoC) for mobile phones
http://www.slideshare.net/Funk98/system-on-chip-soc-for-mobile-phones

iPhone original
http://www.imore.com/history-iphone-original