Project Topic Areas
Economics of Smart Phones
Cost Models for Mobile Design

Overview
- Die area, number of dies, and packaging considerations impose economic constraints on processor design

Why is this an important topic?
- Rapid growth rate of mobile processors
- Increasing capabilities in mobile and power constraints in PCs → redefinition of niches

Research Directions
- Where are the sweet spots for mobile application processor SoCs in terms of area (expense) vs performance and feature sets?
- How will near term advances in 3D stacking and memory technologies change these tradeoffs?
Mobile Hardware
Baseband Processing

Overview

• Handles a significant portion of communications with the outside world
• Typically has its own RAM and firmware, and is loosely coupled to the applications processor.
• Often DSP/VLIW designs running firmware
• Real-time constraints in handling protocols

Why is this an important topic?

• Managing the wireless communications in a smartphone can be a significant contributor to energy
• Optimizing the baseband processor, its usage, and its interactions with the rest of the system can lead to improved battery life for the entire phone

Research Directions

• Specialization approaches for baseband processing
Memory Systems

Overview
• Unlike desktop systems, most smartphones contain the entirety of system memory on package, or on stacked dies.
• To conserve energy and reduce power, they use different memory components and configurations than non-mobile designs.

Why is this an important topic?
• Due to memory constraints, the memory profiles of Android applications are likely distinct from those of traditional desktop applications.
• As 3D die stacking techniques improve, more bandwidth and greater quantities of memory will become available to smartphone systems.

Research Directions
• Design space exploration of future memory systems.
• Exploiting future memory technologies for mobile computing.
GPU for Mobile: Present and Future

Overview
• Use of mobile devices as a primary computing platform → increasing importance of graphical performance
• New devices must be capable of efficiently displaying interactive applications and high definition media content while remaining within both power and energy budgets

Why is this an important topic?
• Desktop GPU designs are not optimized for a low-power environment
• Providing desktop-like performance within a mobile power envelope provides a significant challenge to mobile GPU designers

Research Directions
• GPU workload characterization for mobile apps
• GPGPU on mobile / GPU assistance for compute intensive mobile apps
Battery-powered Design

Overview

• Traditionally, we think of phones as energy limited
• However, given a temporal usage model, this is also a power limitation

Why is this an important topic?

• The end of Denard scaling and rise of dark silicon also affects mobile designs
• Strict power/energy constraints → more specialized designs

Research Directions

• Dark silicon techniques beyond the processor:
  – Baseband
  – GPU
  – Memory
Power Gating

Overview
• All or part of a cell phone is often idle waiting for events
• To save energy during these periods, components are voltage-isolated

Why is this an important topic?
• Circuit design effects both performance and area as well as leakage
• Power-management policies directly impact the responsiveness of the system

Research Directions
• Study of power management policies for different possible smartphone architectures
• Comparisons against alternatives, complementary techniques
Near/Sub-threshold Computing

Overview
• Energy per operation reduces significantly at lower voltages
• However, so does performance (~10x for NTC, 50-100x for STC)

Why is this an important topic?
• For delay tolerant applications, NTC can improve J/op by 10x
• For delay insensitive applications, STC can improve J/op by 20x

Research Directions
• What portions of the mobile computing workload are necessary, but time insensitive?
Measurement and Characterization
**Workload Replay**

**Overview**
- Android applications, unlike server, or even desktop applications, tend to be highly interactive in nature
- A self-contained, repeatable Android workload must encapsulate the GUI interactions

**Why is this an important topic?**
- Manual measurement not scalable
- Repeatability is necessary for meaningful workload analysis

**Research Directions**
- I/O encapsulation for Android workloads
- Development of Android Benchmark Suites
Power Measurement

Overview
• Battery life alone is too coarse a metric – mobile platforms have many components
• Even at SoC level, we would want to know each chip’s contribution

Why is this an important topic?
• Need to be able to identify the power-hungry components
• Insight into correlation between computation type an power usage

Research Directions
• Develop an analytical model that provides a better proxy for power than execution time and/or instruction count
Execution Hot Spot Analysis

Overview

• While there are > 100,000 Android applications, < 100 dominate execution
  – The web browser alone accounts for 30% of all application time
• Even within these applications, there are smaller regions of hot code

Why is this an important topic?

• Examining these regions, gives insight into what techniques will be the most profitable to apply to an Android workload, esp. for HW specialization

Research Directions

• Workload characterization studies:
  ➢ How much code is JIT vs. Native vs. Library
  ➢ Code shared among applications/threads/modules
  ➢ Coverage encompassed by inner loops vs. outer loops vs. functions
  ➢ Time/Energy for memory bound vs. compute bound regions
  ➢ Working set size analysis
  ➢ Call graph properties: frequency, duration of hot vs. cold functions/loops
  ➢ User vs. Kernel vs. I/O and other communication in terms of time/power
  ➢ Static code size vs. dynamic coverage
The Mobile Software Ecosystem
Software Evolution

Overview
• Phone manufacturers provide support for two releases of Android
• Limited set of versions of applications and Android components

Why is this an important topic?
• Opportunity to study changes in user/Android code over a well-defined software and phone lifetime
• Deep implications for hardware specialization

Research Directions
• Analysis of changes, at source code level, in terms of:
  – LOC
  – Coverage
  – Types of changes
• Analysis of changes, at compiled-code (or byte-code) level, in terms of:
  – Static instruction count
  – Coverage
Virtual Machine Evolution

Overview
• User applications are written in high level languages that use JITs and VMs

Why is this an important topic?
• More applications, more unique, JIT–compiled code
• JIT and accelerator compatibility

Research Directions
• Analysis of changes, at JIT source level, in terms of:
  – LOC
  – Coverage
  – Types of changes
• Analysis of changes, at code-compiled-by-JIT level level, in terms of:
  – Coverage
  – Performance
  – Power
• JIT compilation targeting accelerators
Role of Threading in Android

Overview
• Smart phones are moving to multi-core
• Original Android development not TLP oriented
• Not clear whether Android apps will be heavily multi-threaded

Why is this an important topic?
• TLP is a key limitation for desktop CMPs
• This is likely to be at least as constraining for mobile applications

Research Directions
• Multi-core scalability of smartphones/workloads