The world has changed a lot in 8 years.

Past

Present
FEATURE PHONES

CALL

TEXT

E-MAIL

GAMES
SMART DEVICES
“I want **true** desktop-level user experience on my mobile device.”
NEED A COMBINED EFFORT ACROSS THE BROAD LAYERS

MOBILE NETWORK

MOBILE HARDWARE

MOBILE SOFTWARE
MOBILE IS A (SEVERELY) BATTERY RESOURCE CONSTRAINED DEVICE

WHAT IS AN EVERYDAY MOBILE DEVICE OCCURRENCE ANNOYANCE?!
DISPLAY, RADIO, PROCESSOR ARE THE HEAVY BATTERY CONSUMERS
BATTERY DENSITY HAS NOT BEEN INCREASING WELL

LITHIUM-ION ENERGY DENSITY IMPROVES BY 5% TO 10% PER YEAR
MOBILE DEVICE POWER CONSUMPTION TRENDS

Peak Sustained Power (mW)

- Droid (2009)
- Galaxy S (2010)
- Galaxy N (2011)
- Galaxy S3 (2012)
- Galaxy S4 (2013)
Mobile Device Power Consumption Trends

- Peak Sustained Power (mW)

- Smartphone Models:
  - Droid (2009)
  - Galaxy S (2010)
  - Galaxy N (2011)
  - Galaxy S3 (2012)
  - Galaxy S4 (2013)
MOBILE DEVICE POWER CONSUMPTION TRENDS

- **Droid** (2009)
- **Galaxy S** (2010)
- **Galaxy N** (2011)
- **Galaxy S3** (2012)
- **Galaxy S4** (2013)

**Peak Sustained Power (mW)**

- Screen
- Radio

Smartphone Model:
- Droid (2009)
- Galaxy S (2010)
- Galaxy N (2011)
- Galaxy S3 (2012)
- Galaxy S4 (2013)
MOBILE DEVICE POWER CONSUMPTION TRENDS

AN ORDER OF MAGNITUDE INCREASE IN TOTAL CPU POWER CONSUMPTION
BATTERY AND VOLUME SYNERGY

Battery Capacity (mAh)

Screen Size (inches)

2006-2009
BATTERY AND VOLUME SYNERGY

Battery Capacity (mAh)

Screen Size (inches)

2006-2009
Droid (2009)

2010-2011
Galaxy S (2010)

2012-2013
Galaxy N (2011)
Galaxy S3 (2012)
Galaxy S4 (2013)
THE MOBILE DEVICE YING-YANG

COMPUTE CAPABILITY

ENERGY EFFICIENCY
TRADITIONAL APPROACHES TO ADDRESS THE PROBLEM

HARDWARE OPTIMIZATION

DEVICE FABRICATION

CIRCUIT TECHNIQUES

COMPUTER ARCHITECTURE

SOFTWARE OPTIMIZATION

POWER

PERFORMANCE
NEW APPROACHES TO ADDRESS THE PROBLEM

MOTION  TEMPERATURE  CONTEXT  LIGHT

Cold side of the TEG module is attached to a hot side connecting to the heat source
THE WORLD HAS CHANGED A LOT IN 8 YEARS

(FIX ENERGY-EFFICIENCY)

FUTURE