Empowering Developers to Estimate App Energy Consumption

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MobiCom, 25 Aug 2012

Microsoft Research

Angry Birds & Battery Life

Just curious - I recently downloaded Angry B... s (... s off about 10% for every 25-30 minutes I ... FYI: Wifi/Bluetooth/Push/Notifi...

21.5" iMac 3.06Gh... ...Pad 2
32GB White...

Experiencing battery drain issues? The cause could be free apps

Posted on Mon, 19 Mar 2012 4:50 pm EDT by Rich Edmonds
Filed under: News

Abhinav Pathak, a computer scientist at Purdue... have concluded that free smartph... battery being drained...

Shutterstock

“One app could drain your battery in around 90 minutes, according to the research.” Tweet This Quote

They say the miser pays twice. I've seen it countless times... reality with physical products -- cheap mice falling apart,... Meow Co. power supply failing, etc -- but it looks like no... ...n download an ad-supported copy of Bejeweled w... ...ass by this old truism. According to a s... ...Microsoft and Purdue Unive...

TODAY @ PCWORLD

iPhone 4S Battery Woes: Where is the Outrage?

By Jared Newman, PCWorld Nov 1, 2011 9:02 AM

...the latest example of a ... some

APRIL 23, 2012

These Android apps can drain your battery, wallet and your patience

Like Facebook 0 Tweet 0 +1 0 Email Share 0

Not all Android apps are created equal. Some require too much data access, gorging on your smartphone's battery life. Others barrage the notification bar with ads, or require paid updates. PCWorld named some of the worst offenders, including the popular new Instagram, Netflix and Angry Birds.

Battery draining after FB app update

Last week I updated the Facebook app ... and I had to uninstall it and then goto the play ... is draining like crazy. I've had to charge it twice today ... whole day on 1 charge. What and how could the update be caus...

Energy Efficient Apps

Developer wants to download and display an image.

Which one will consume less energy?

Image1 – 18kB
Communication cost – 2J
Display power – 600mW

Image2 – 1MB
Communication cost – 10J
Display Power – 350mW

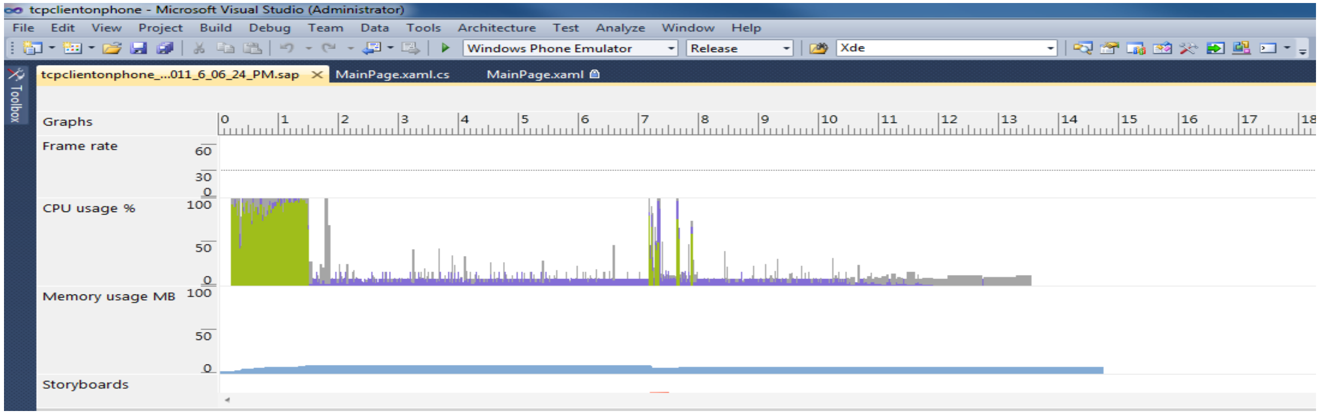
What tools do developer have to make the right decision?

Tools to Estimate App Energy

	Ease of use & set-up costs	Component energy break-up	Runs in emulator	Repeatability	What-if analysis
Measurement using Power Meter [Flinn et al]	✗	✗	✗	✗	✗
Software/Event Profiling based power modeling tools [Pathak et al, Dong et al]	✓	✓	✗	✗	✗

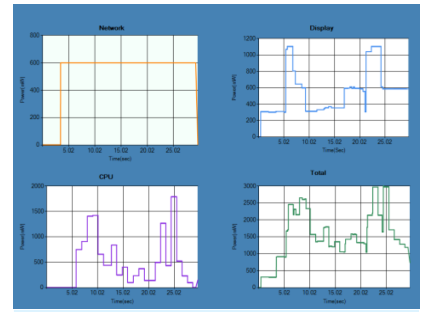
Our Approach: WattsOn

- Enables app developers to estimate energy consumed by *different components* of phone, while debugging on *emulator*



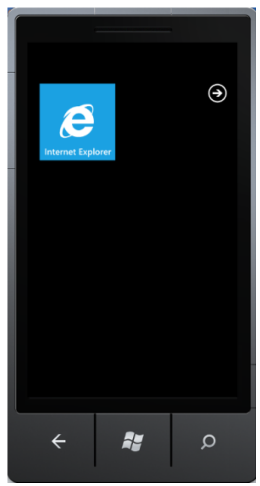
- Allows what-if analysis

Basic Structure of WattsOn



Energy Breakdown

App Developer's Code



Debugging on emulator (WattsOn runs in the background)

Exploration of varying parameters like-

- network quality
- signal strength
- screen brightness
- mobile operator
- handset

Tools to Estimate App Energy

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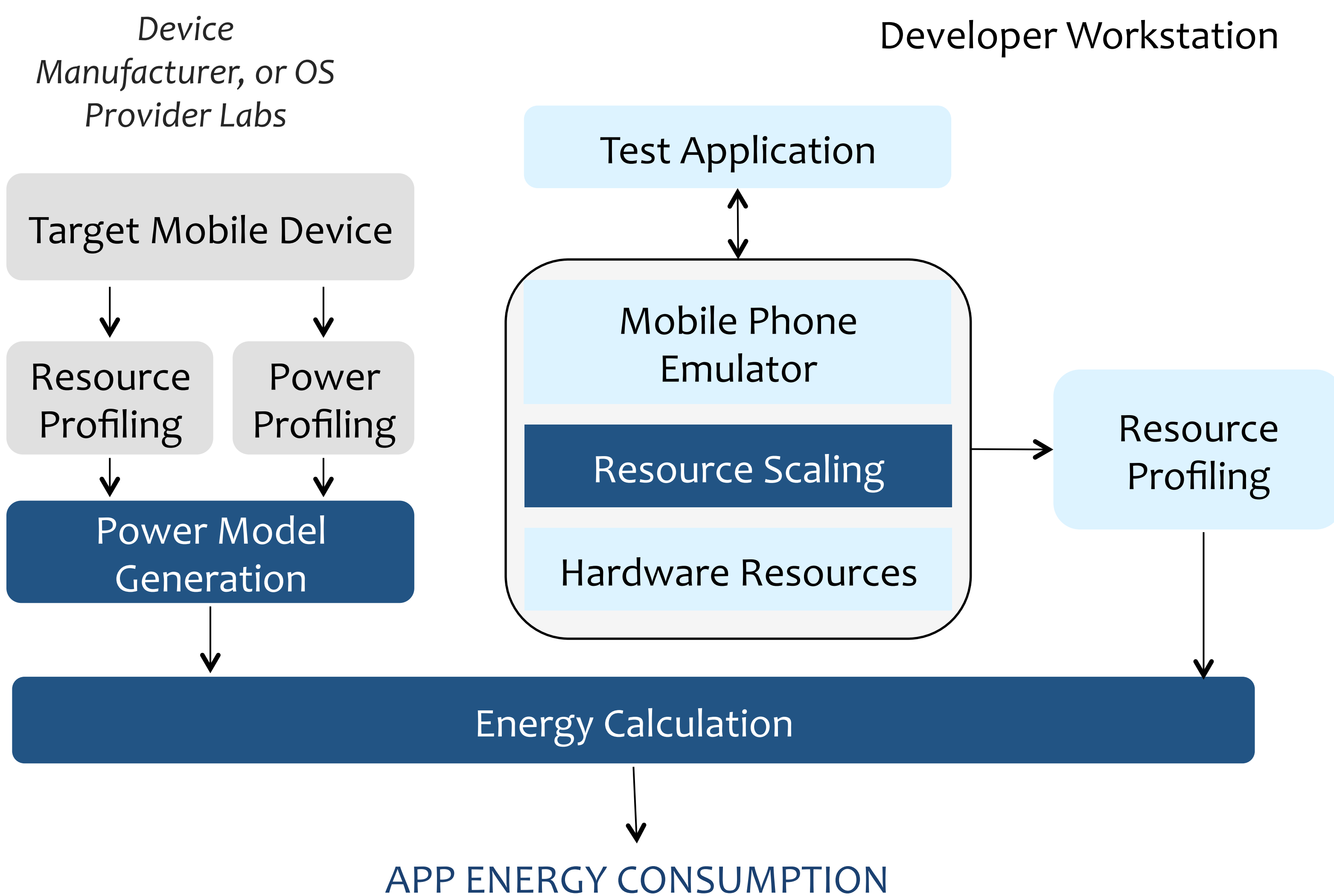
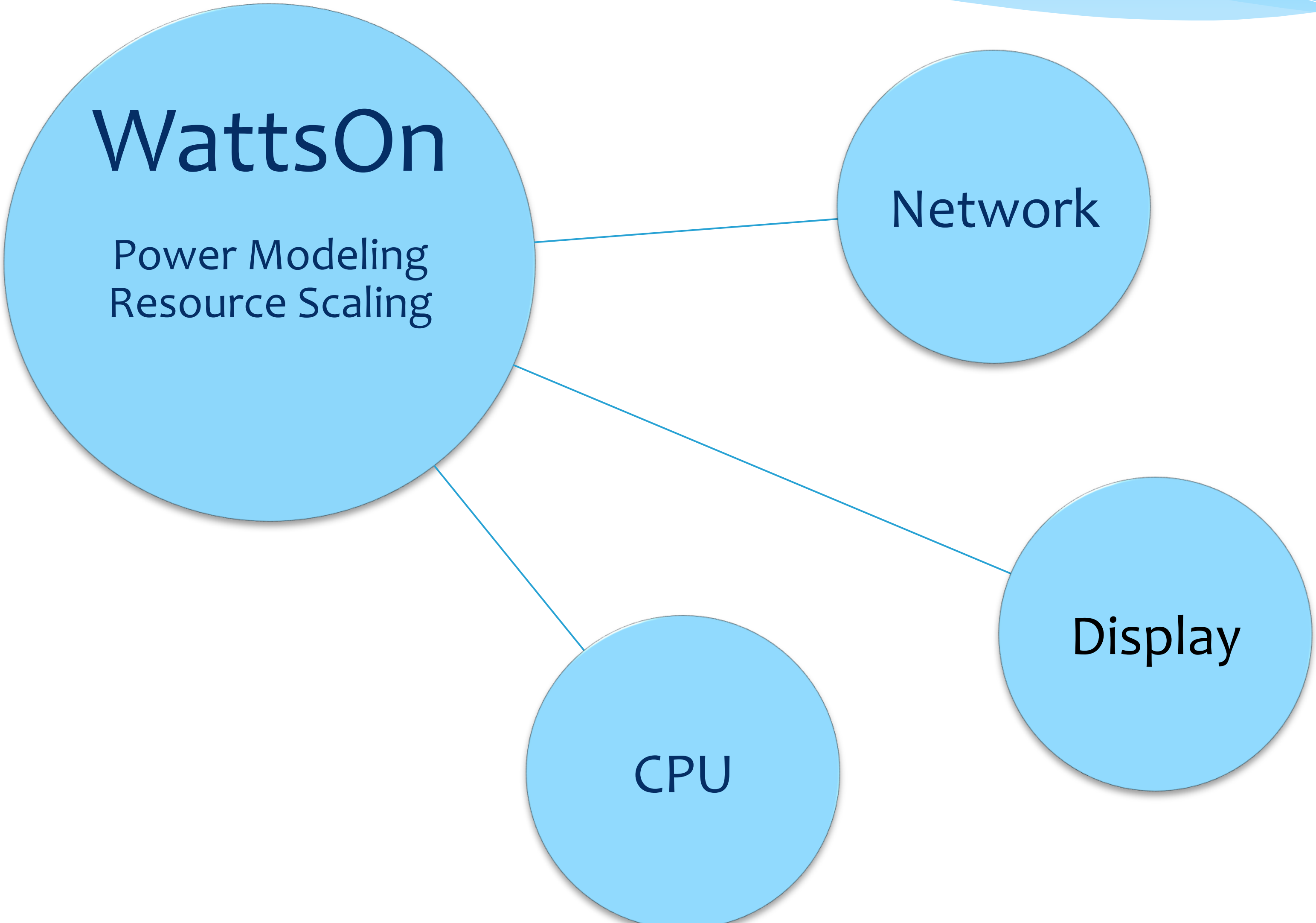
WattsOn	✓	✓	✓	✓	✓

WattsOn Design

Overview


Device Manufacturer, or OS Provider Labs
Developer Workstation
Test Application
Target Mobile Device
Mobile Phone Emulator
Resource Profiling
Power Profiling
Resource Scaling
Resource Profiling
Power Model Generation
Hardware Resources
Energy Calculation
APP ENERGY CONSUMPTION


WattsOn
Power Modeling
Resource Scaling
Network
Display
CPU

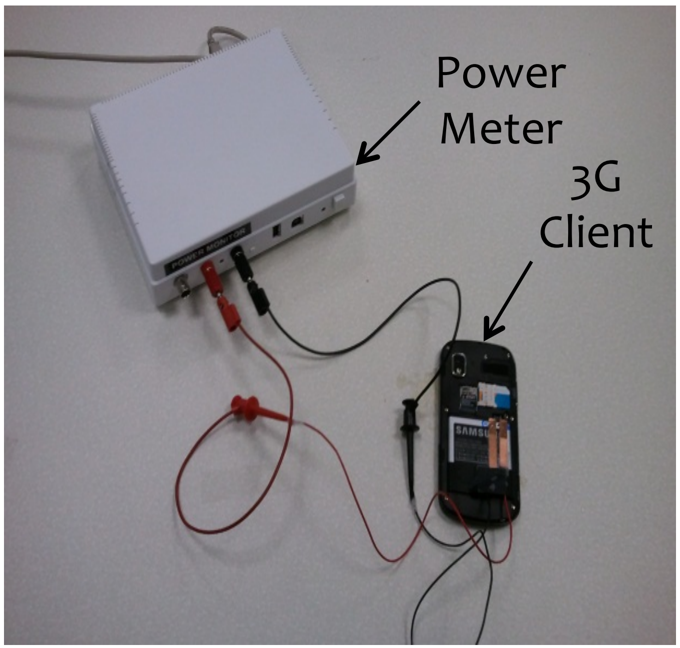
Challenges

- Emulator runs on PC over Broadband Internet
- Phone uses **cellular network (3G,4G…)**

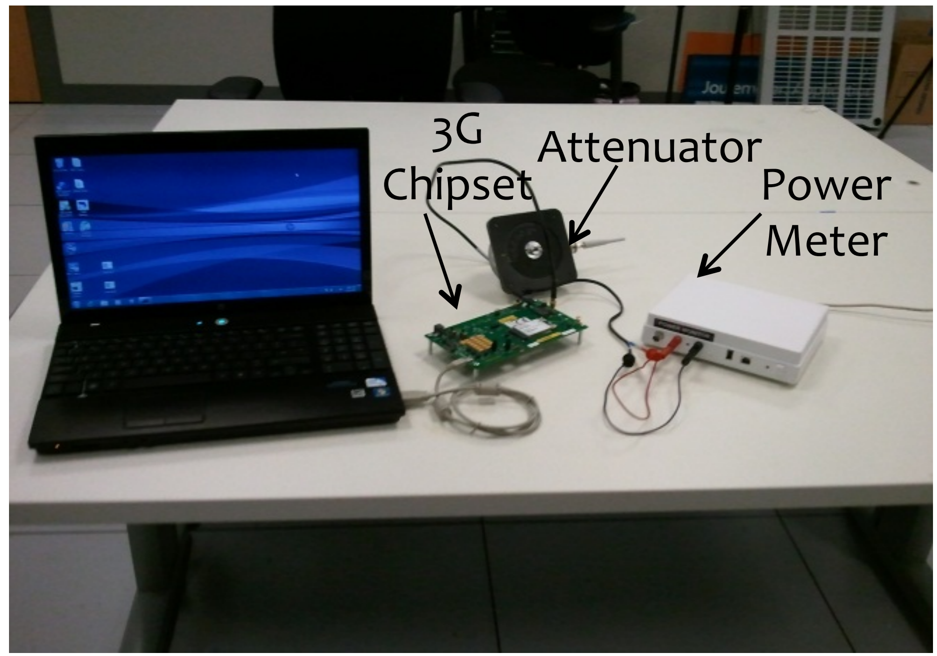
- Cellular energy consumption varies with
  - Signal Strength
  - Network Quality
  - Mobile Operator
  - 3G chipset

Power Modeling

TCP server was setup with Packet Sniffer running on it to capture the packets transmitted to/from a 3G device (phone, chipset dev. board)



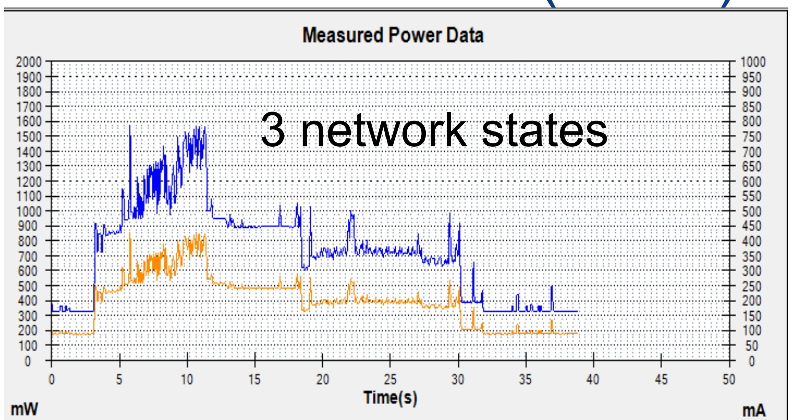
Windows Phone client containing Qualcomm 3G chipset



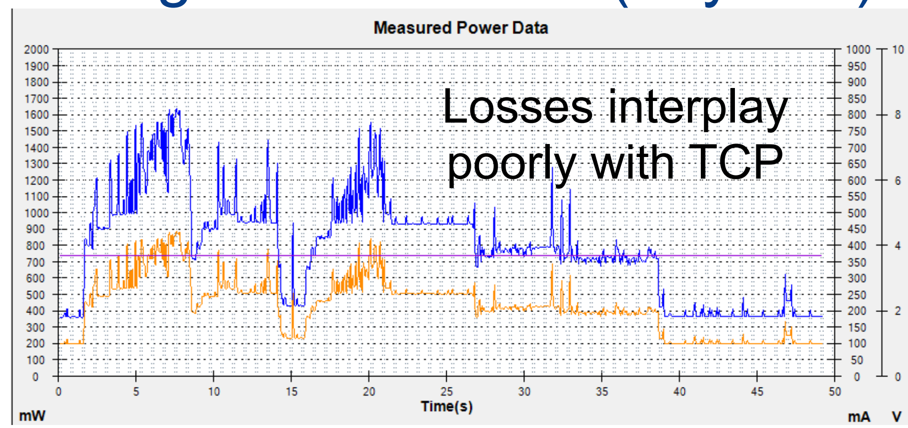
Computer client connected to an Ericsson 3G chipset and attenuator

Observations

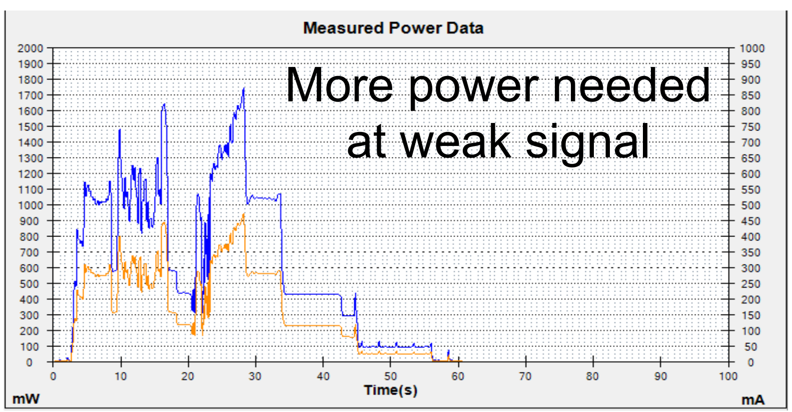
Normal conditions (AT&T)



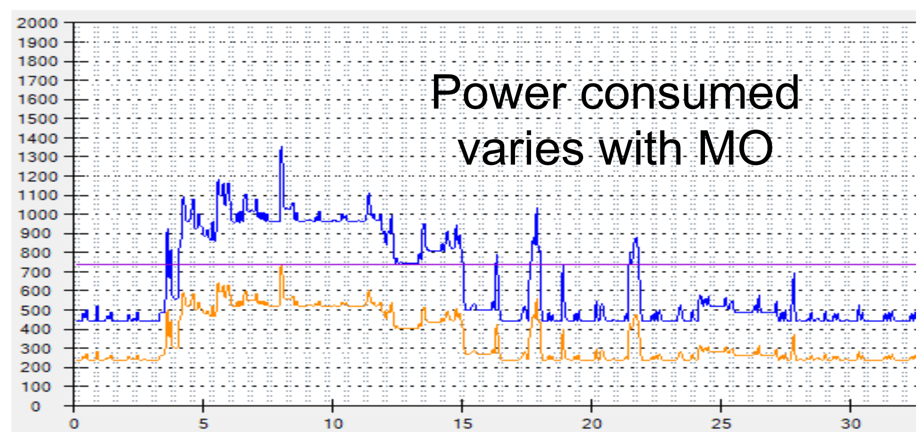
Congested network (daytime)



Weak signal (1-bar)



Another MO (T-Mobile)

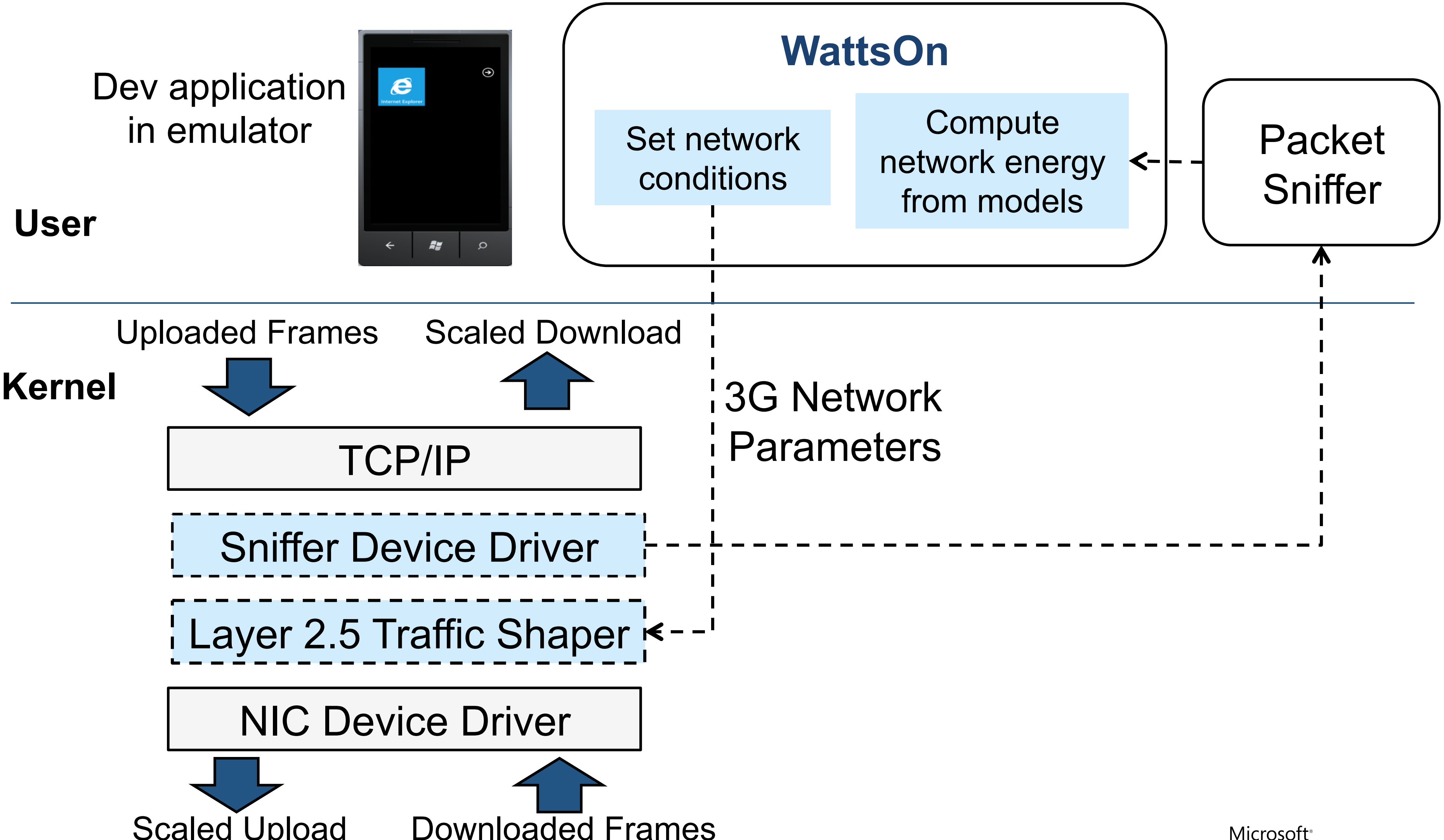


Resource Scaling

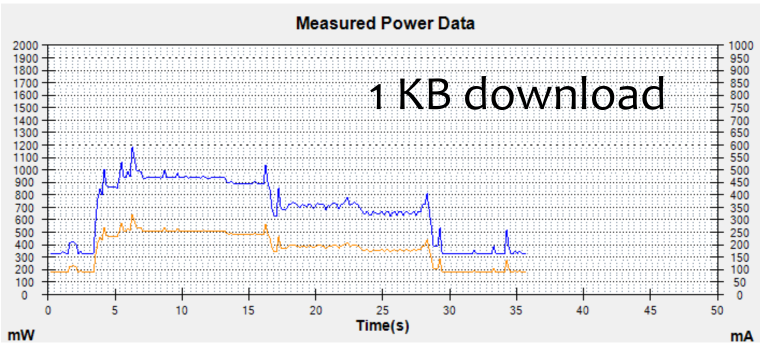
- **Trace Stretching** –
  - Inconsistency with other resource utilizations which depend on network activities
  - Effect on other parameters of network flow not captured

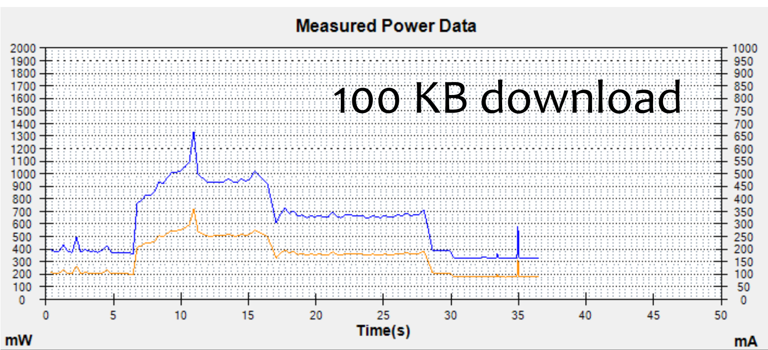
We perform **link shaping** – NEWT, Linux Traffic Shaper…

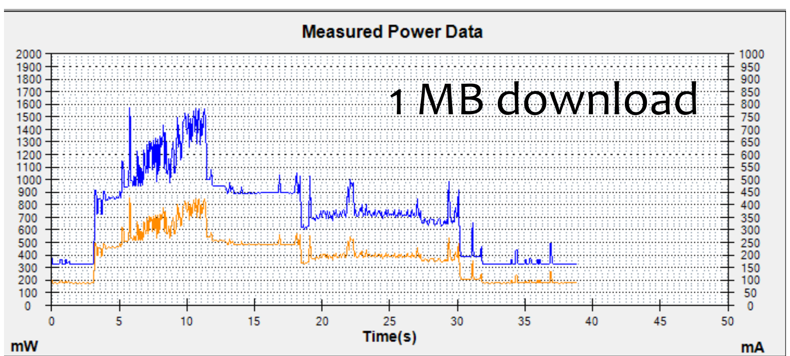
Network Emulation

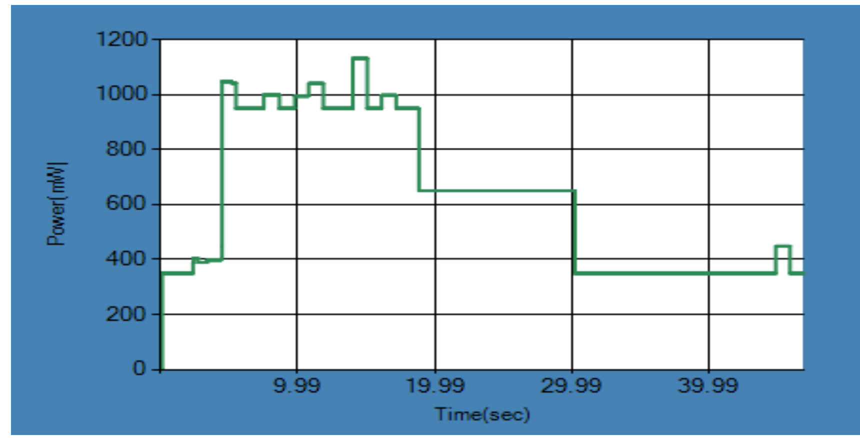


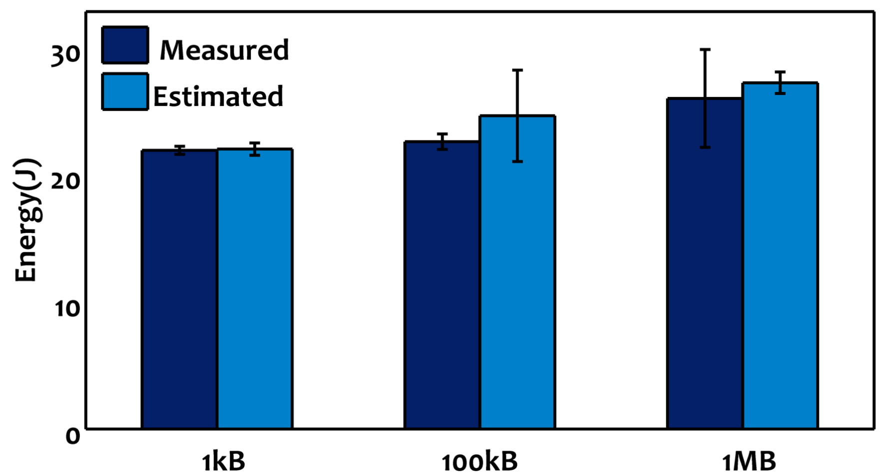
Network Accuracy Testing



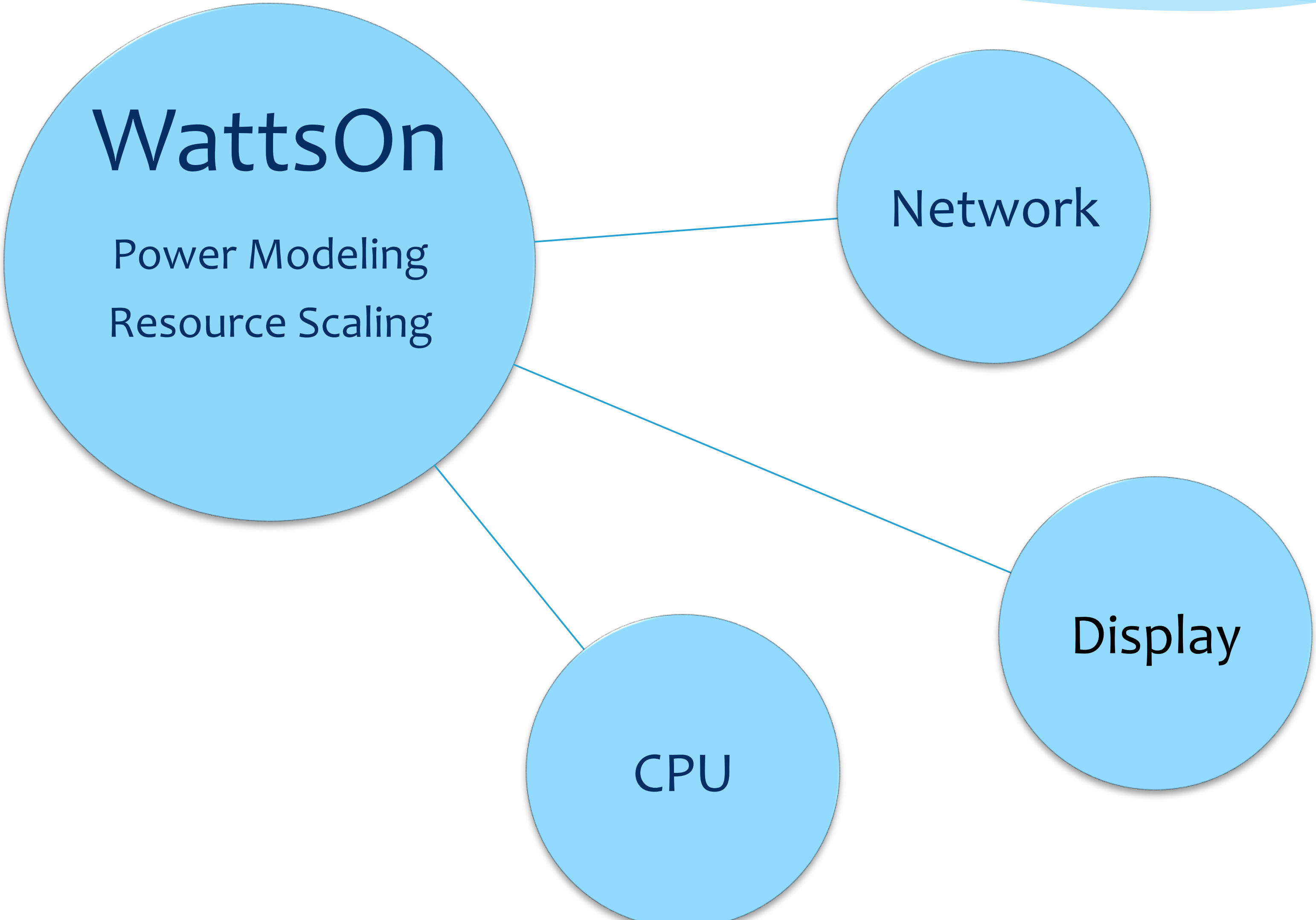








Average Error - 4.73% across all tests



WattsOn
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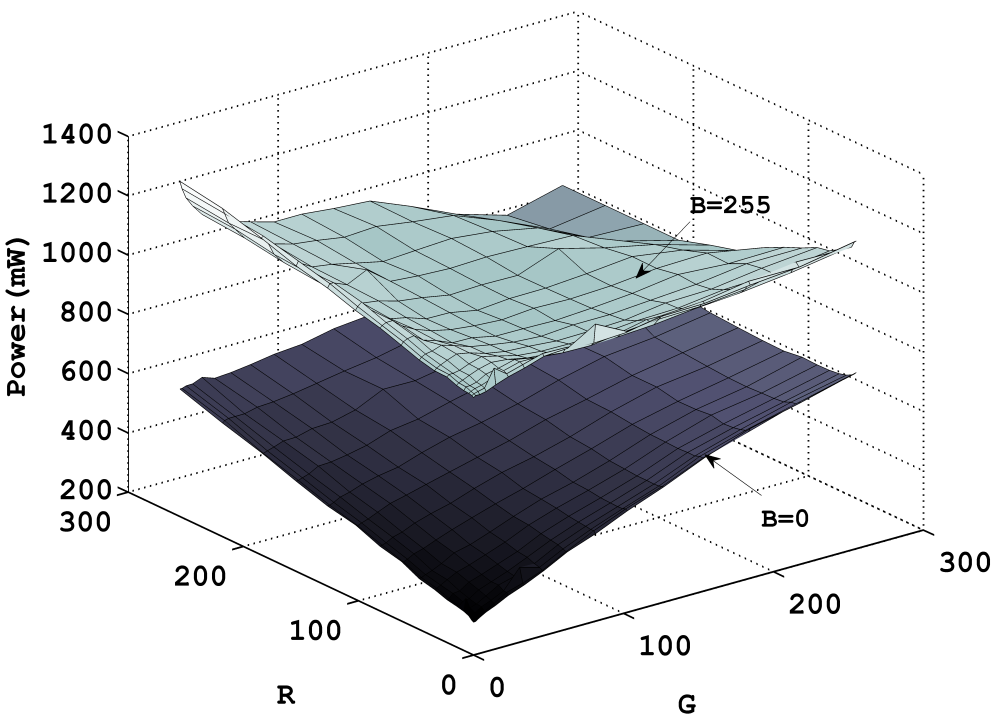
Challenges

- LCD and OLED power models show linear and additive properties

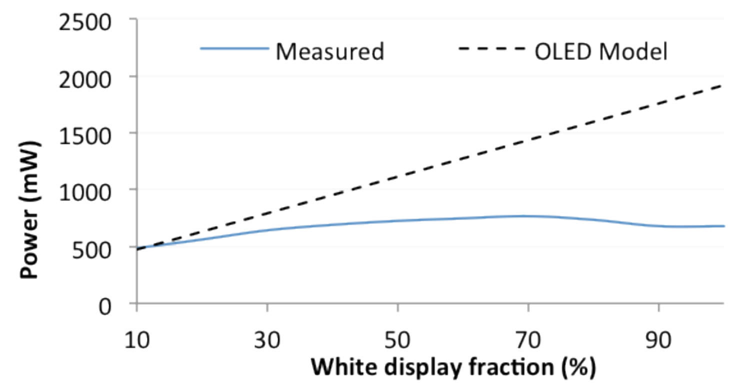
- Most mobile devices today use Active Matrix OLED
  - optimizes power by adjusting screen brightness based on the scene displayed
  - additive and linear properties no longer applicable

AMOLED Observations

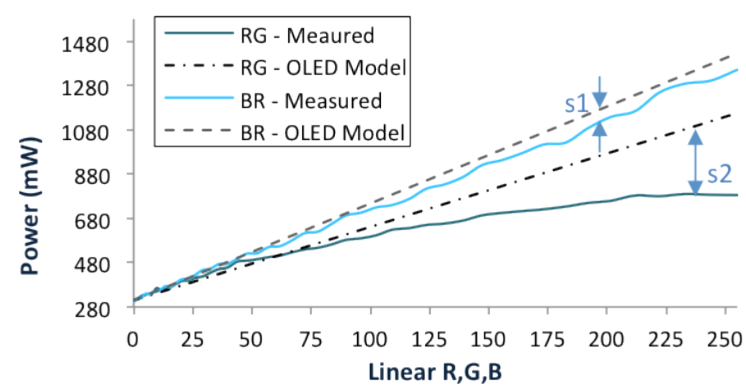
Non-linearity at high magnitudes



Dependency on other pixels



Dependency on color



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Power Model

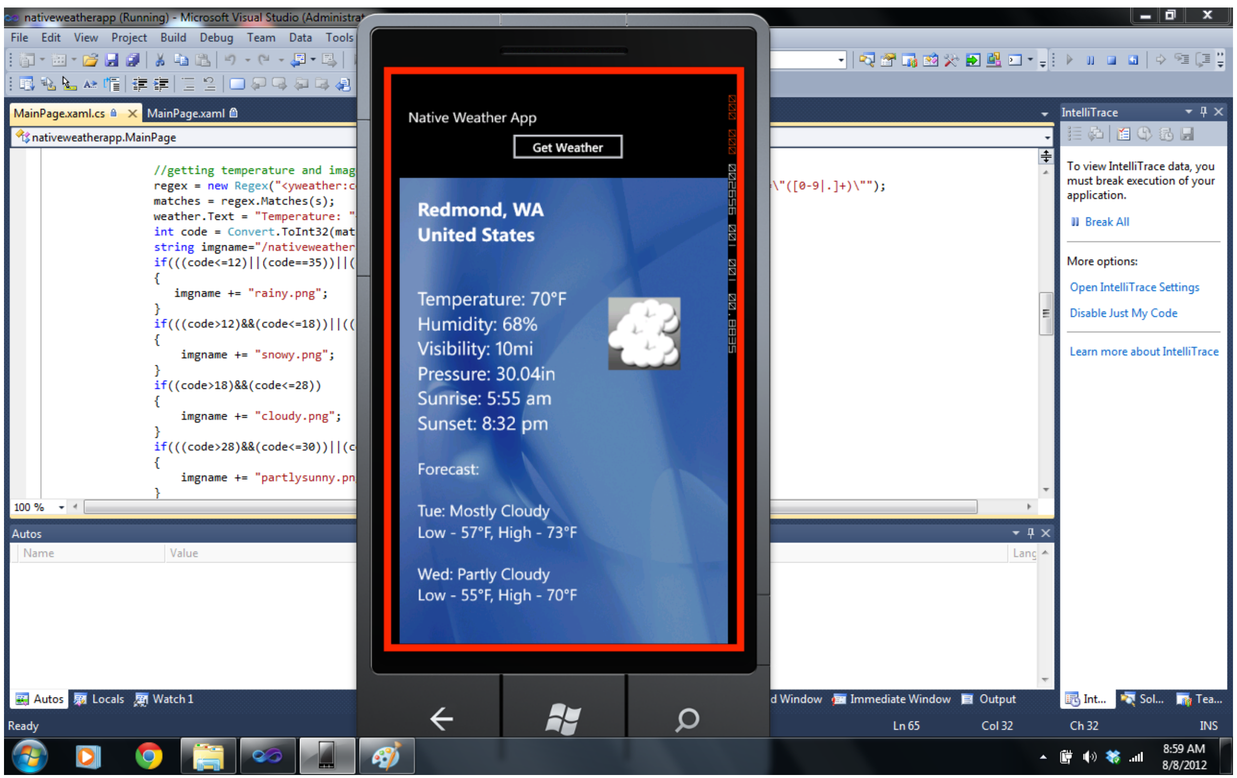
- Basic linear model from OLED
- Power optimizations modeled using a look-up table
  - 16×16×16 entries (each of R, G, B discretized to 16 levels)
    - Measurement done when color occupies entire screen

$$P_{display} = \underbrace{\beta(s)\,.\,L(s)}_{\text{Optimized power from Lookup table}} + \underbrace{(1-\beta(s))\,.\,O(s)}_{\text{From linear OLED model}}$$

- $\beta(s)$ - controls the fraction of screen area for which power optimizations matter (based on color thresholds)
- **s** represents the screenshot displayed

Resource Scaling

- Display model depends on pixel power
  - Number of pixels in emulator screen may vary



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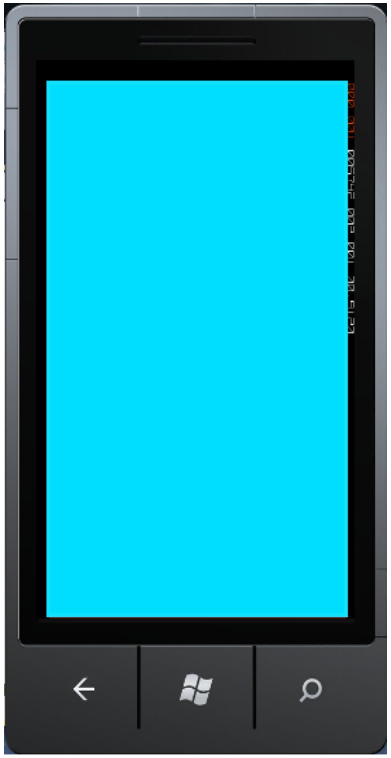
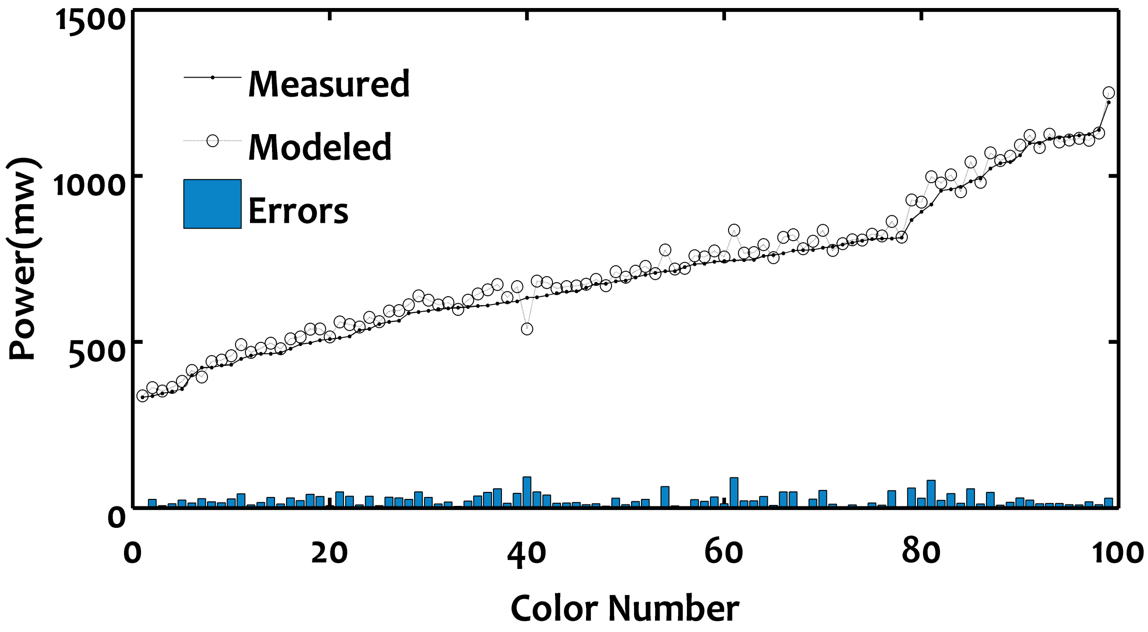
Display Accuracy Testing

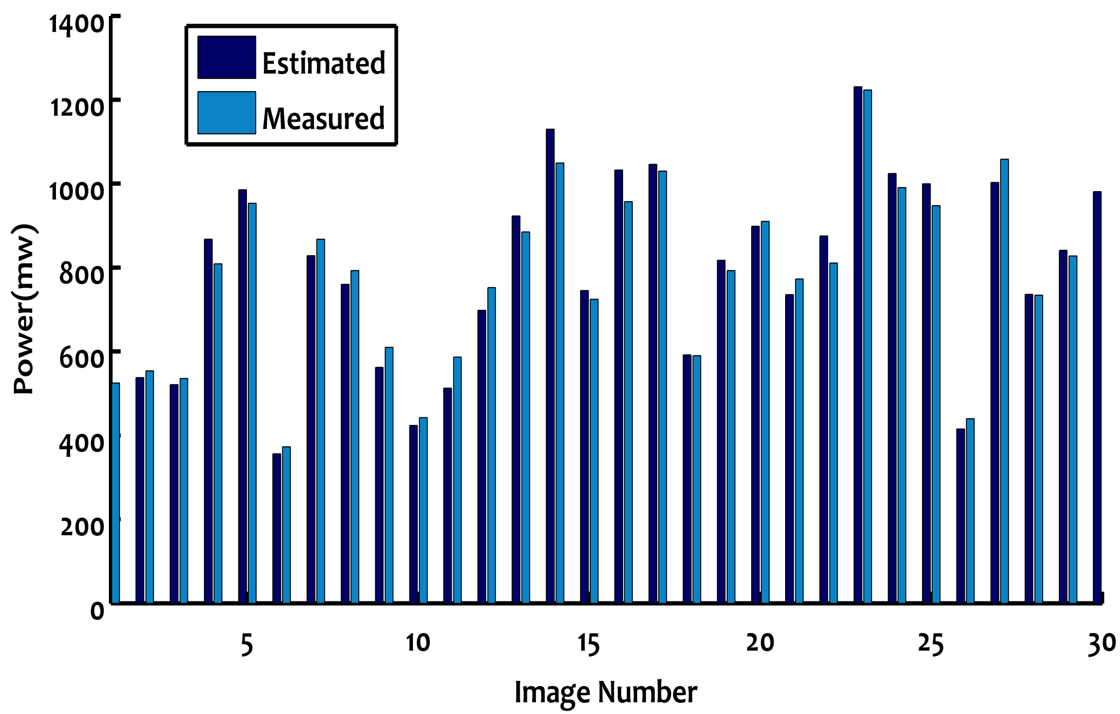
Testing accuracy with simple colors





Display Accuracy Testing

Testing with 30 images



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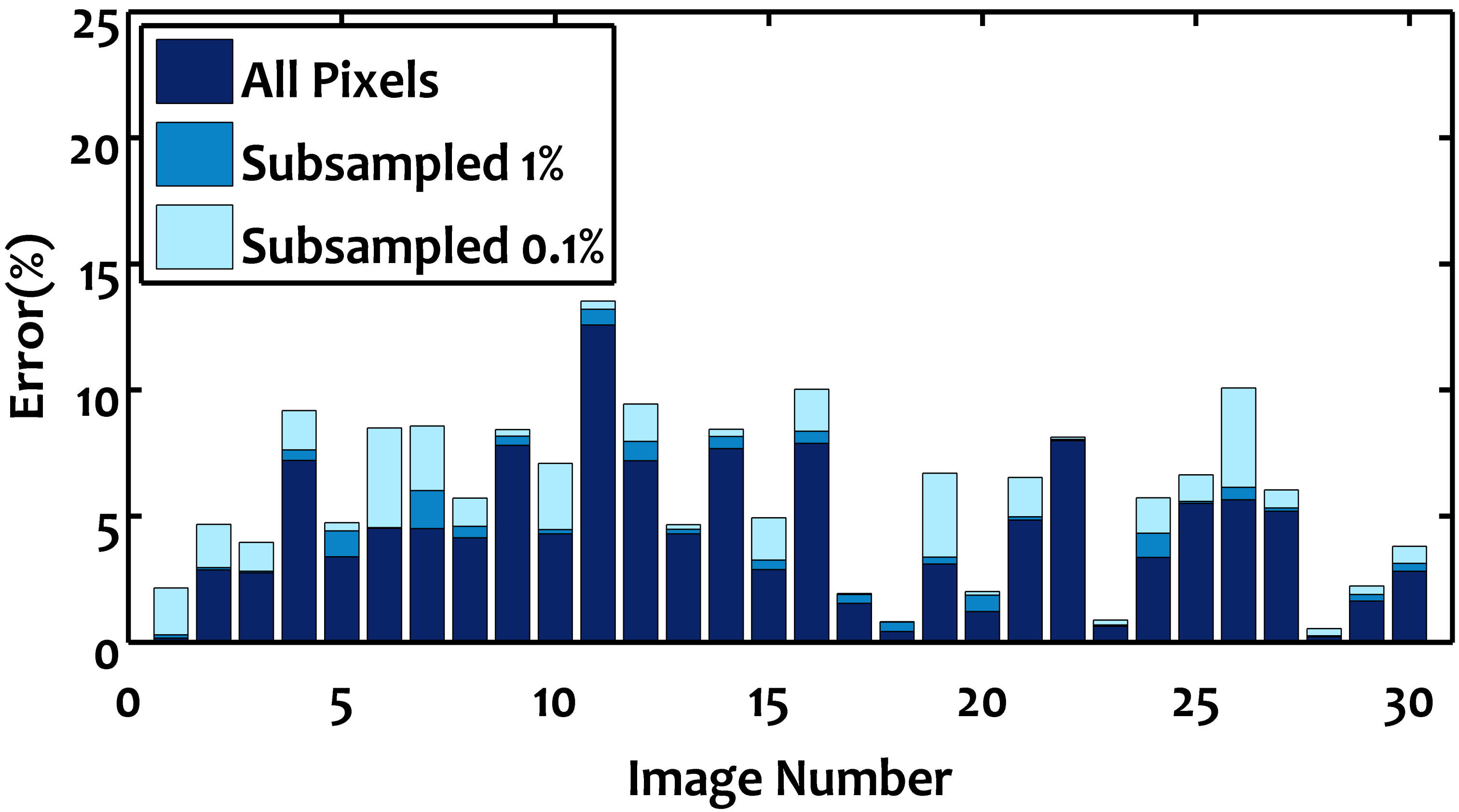
Display Accuracy Testing

Testing sub-sampling of pixels for optimization



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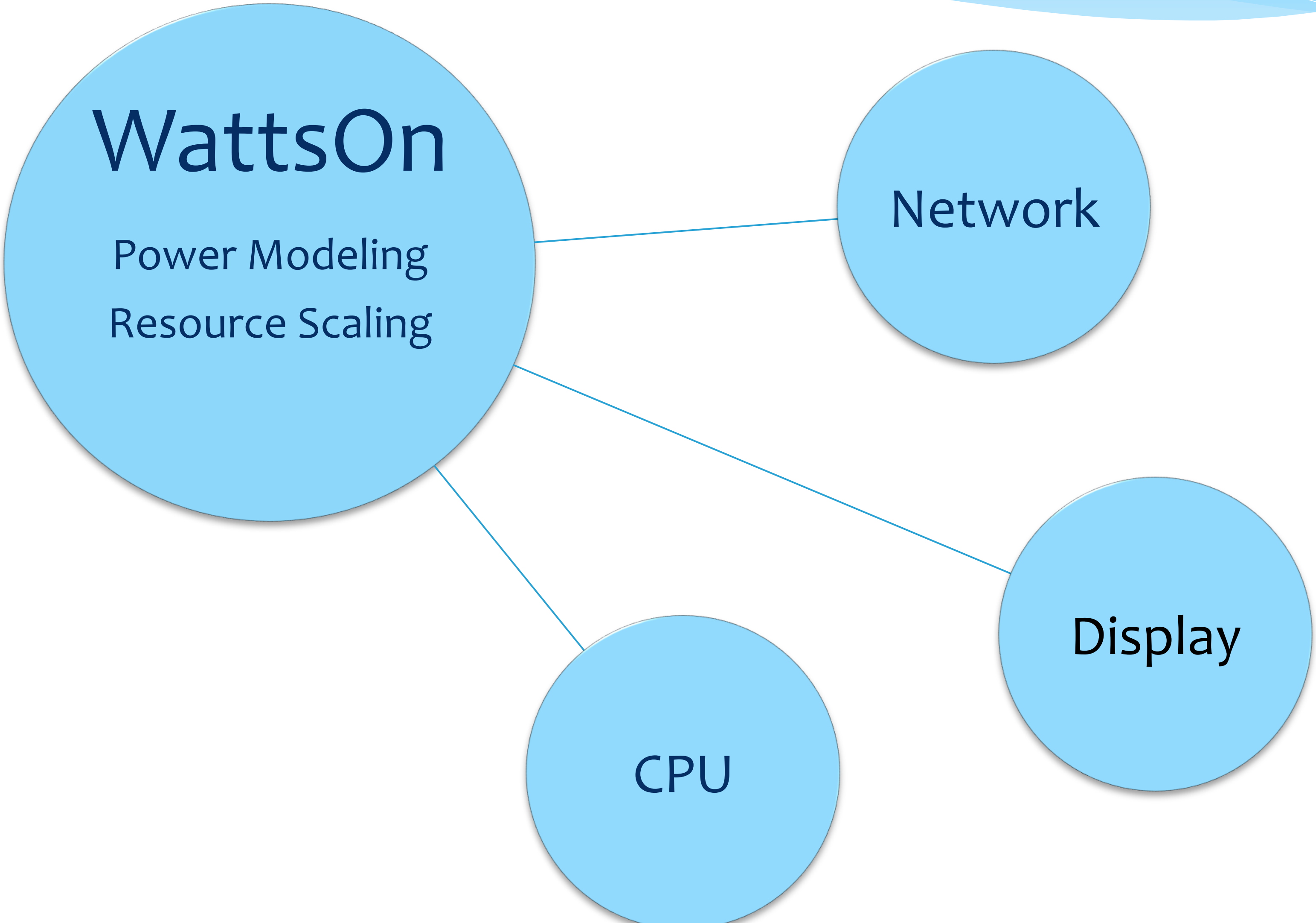
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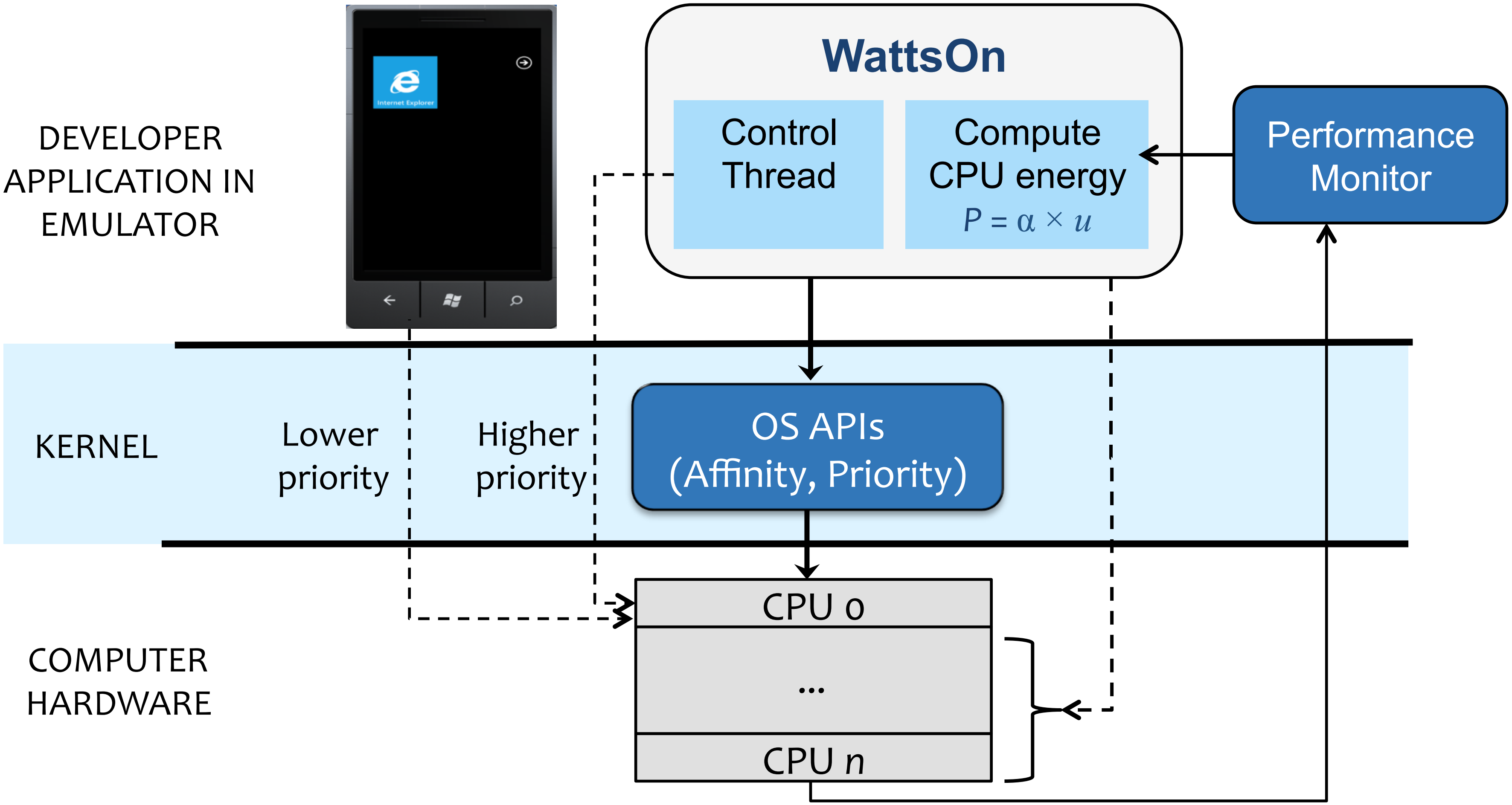
Challenges

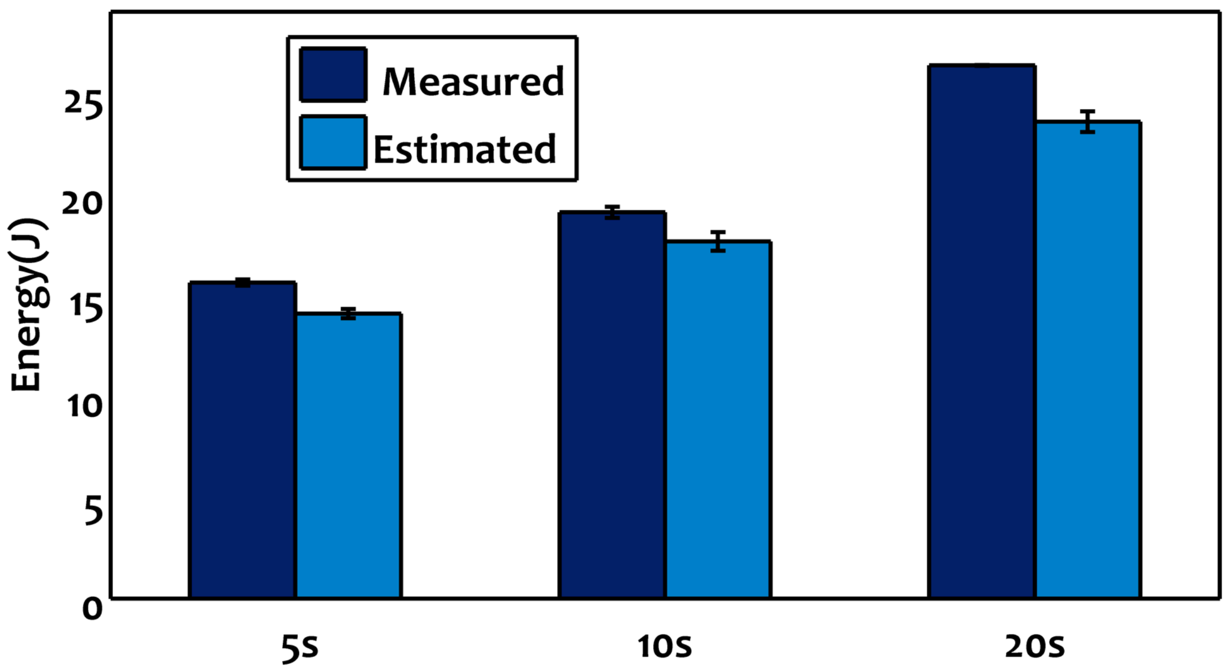
- Emulator PC has much faster CPU than phone:
  - For e.g. 100% utilization on phone with 1GHz CPU maps to 13.8% utilization 2.7 GHz Intel Core-2 Quad-Core processor
  - Other differences like cache size, front side bus speed, …
- Scaling cannot be done after capturing data:
  - CPU speed affects activities of other components
  - May lead to imbalance in readings.

CPU Emulation

Restrict the number of processor cycles available to the emulator



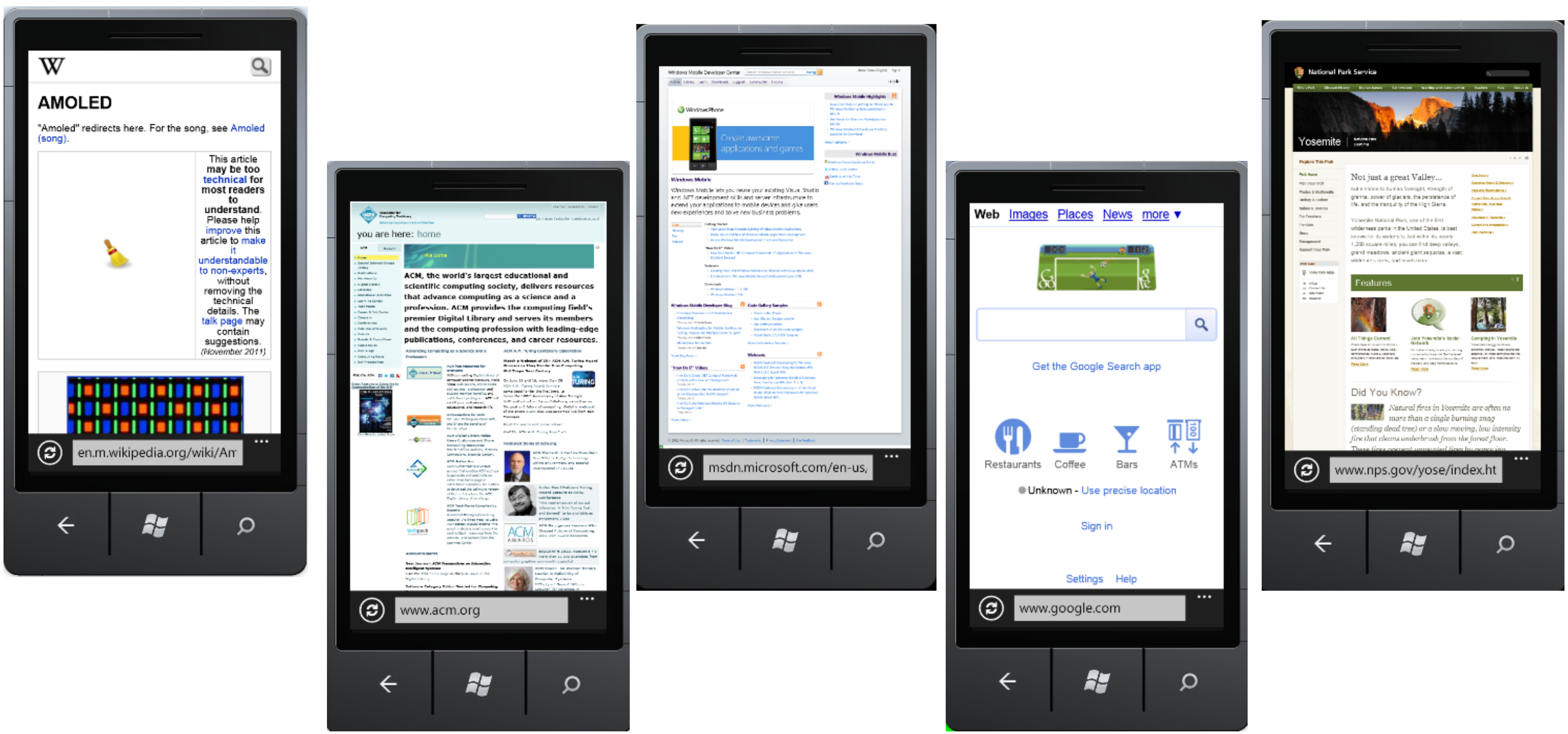
CPU Accuracy Testing



Average Error - 9.73% across all tests

Evaluation of WattsOn

Browser App


AMOLED
"Amoled" redirects here. For the song, see Amoled (song).
This article may be too technical for most readers to understand. Please help improve this article to make it understandable to non-experts, without removing the technical details. The talk page may contain suggestions. (November 2011)
en.m.wikipedia.org/wiki/Am
you are here: home
ACM, the world's largest educational and scientific computing society, delivers resources that advance computing as a science and a profession. ACM provides the computing field's premier Digital Library and serves its members and the computing profession with leading-edge publications, conferences, and career resources.
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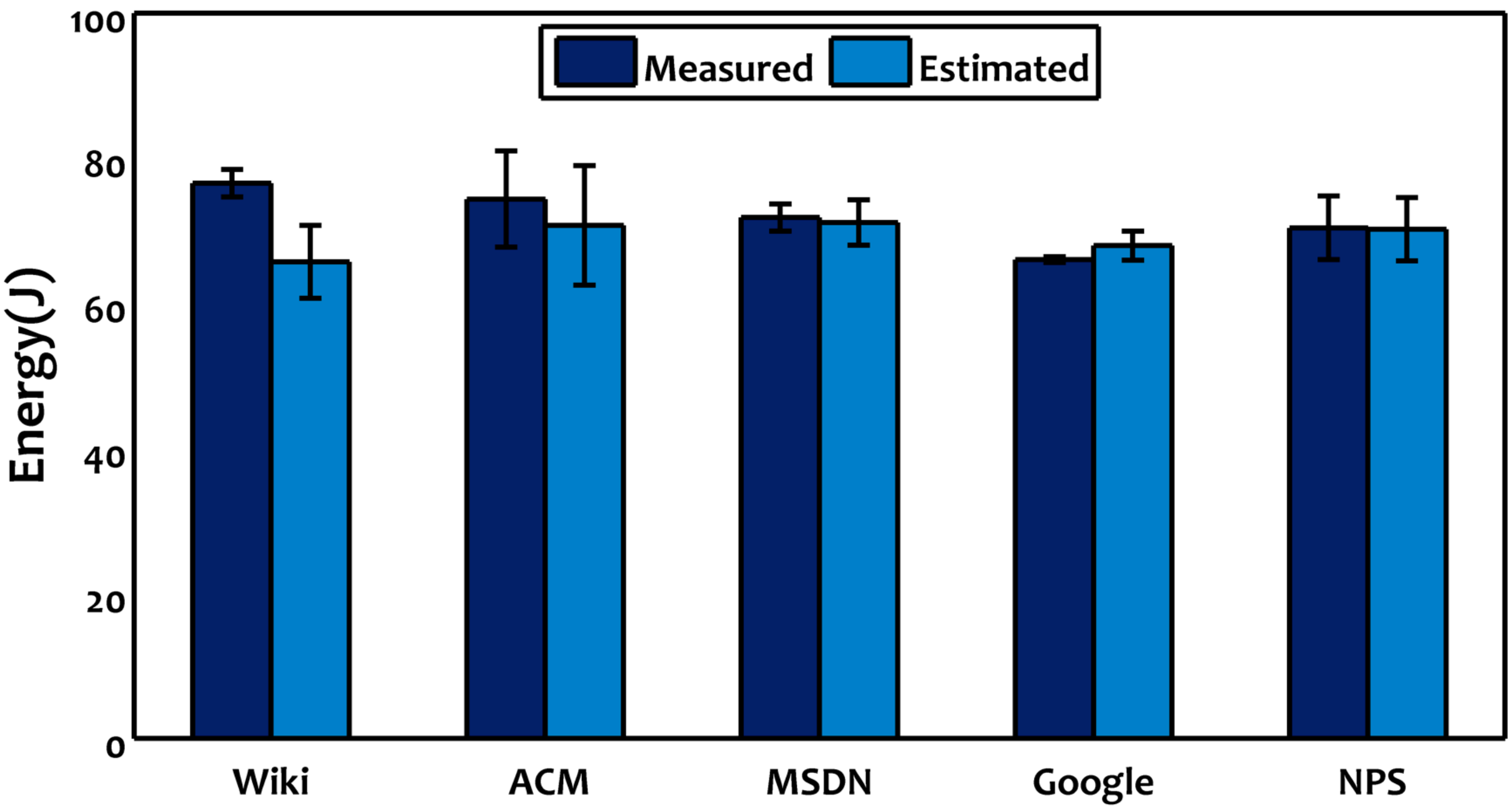
Unknown - Use precise location
Sign in
Settings Help
www.google.com
Yosemite
Not just a great Valley...
Features
Did You Know?
www.nps.gov/yose/index.ht

Browser App



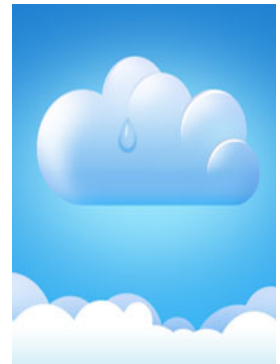
Average Error: 4.64%

Case Study

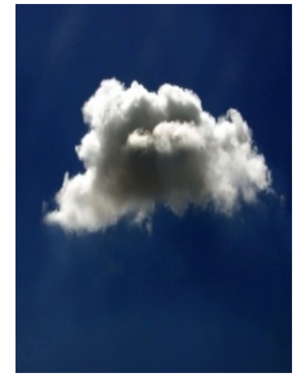
App Design Decisions

What's the energy overhead for desirable app features:

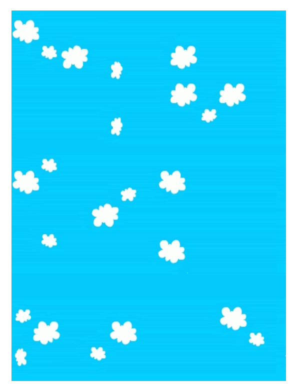
- **Portability** – Hybrid (HTML5) app or Native?
- **Rich Graphics** vs. simplistic icons
- **Animation**



Simple icon
18KB

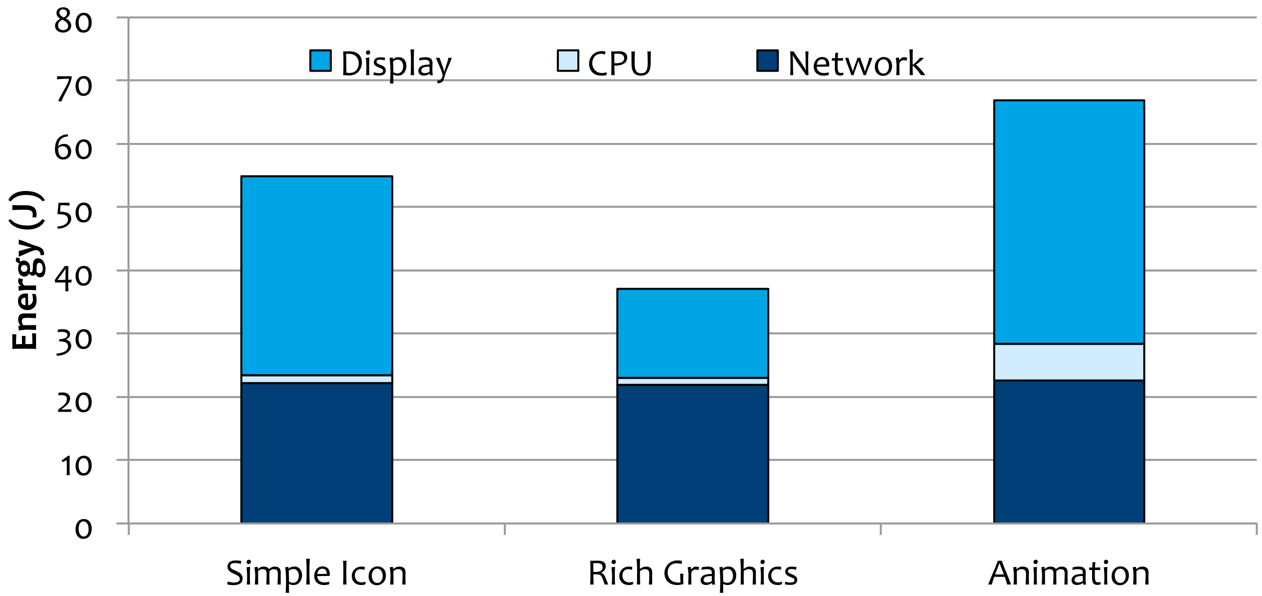


Rich graphics
138KB



Animation
(90kB)

App Design Decisions



Portability and rich graphics has negligible energy overhead

- network energy consumption dominated by tail state

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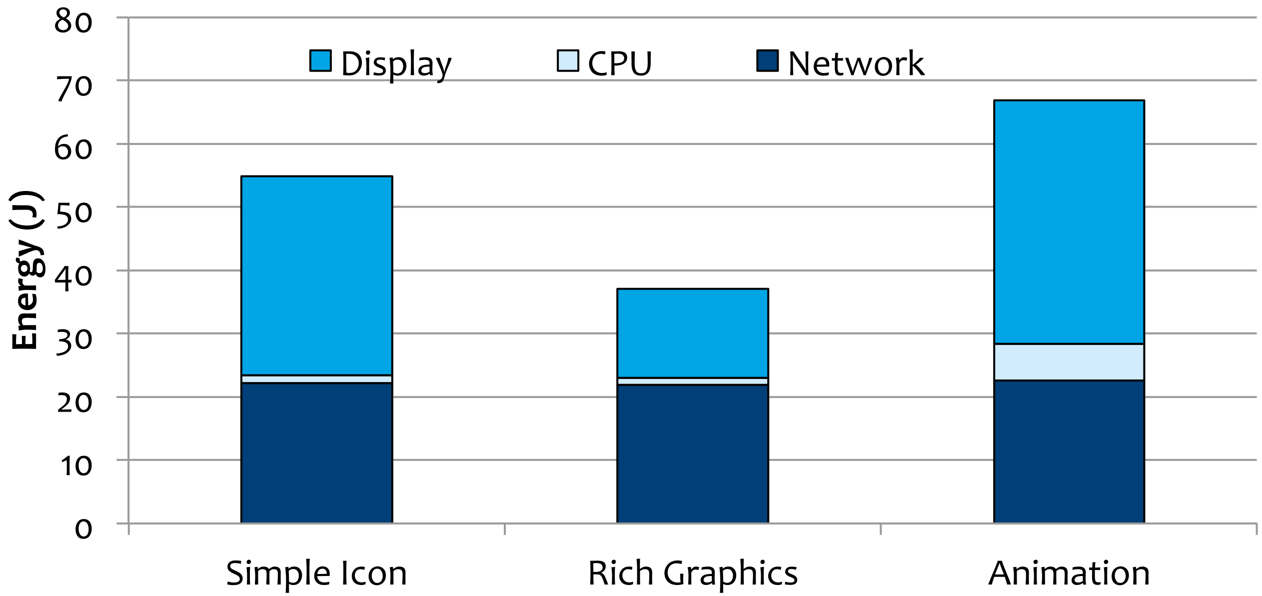
App Design Decisions



Display consumes major fraction of energy usage

- avoiding brighter images leads to significant energy savings

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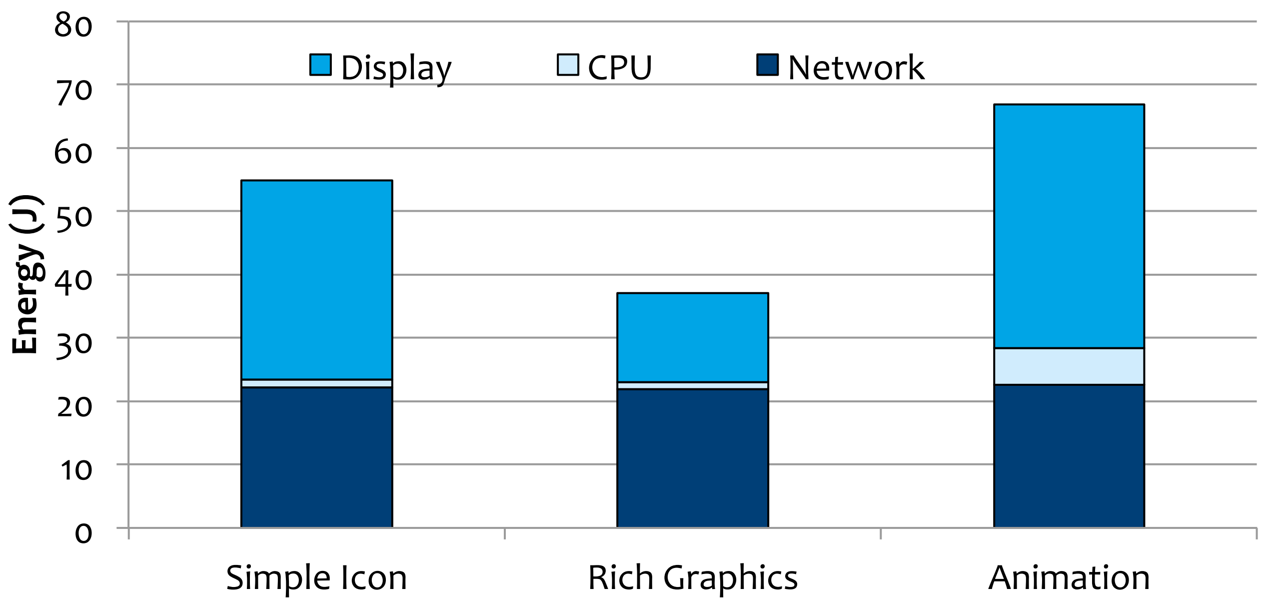
App Design Decisions



Including animation leads to higher CPU energy consumption.

Conclusion

- WattsOn – lightweight emulation time tool for developers
  - Not biased by network conditions or device configuration
  - Enables what-if analysis
  - Average Energy Error: 4% - 9%
- Future Work
  - Power model for sensors e.g. GPS, accelerometers
  - Energy debugging by linking spikes to code snippets

Thank you!!