**Green Edge Networks**
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**Introduction: edge networks**
Emerging Internet Architecture
- More wireless
- More mobile
- Always “on”

Problem Description: dynamic, coordinated and feedback-driven energy management
- Dynamic: Things that are dynamic: workload, communication bandwidth, etc.
- Coordinated: Power-management decisions cannot be made in isolation.
- Feedback-driven: Variability in traffic load, power consumption across devices, and ambient conditions.

Proposed Solution: energy monitoring and adaptive resource management
Energy Monitoring Architecture
- Hardware Based
- Software Based
- Energy Matrix
- Current Approach
  - Accurate
  - Fine grained detailed energy map
- Approximate
- Not all components monitored
- Additional hardware
- Non intrusive
e.g. Fuel-gauge chip, EMAP2 ASIC in Leap2
- Additional hardware
- Not intrusive
e.g. Android Battery use application

Towards Adaptive Resource Management
- Experiments on LEAP2
  - LEAP2 Hardware
    - MCU: PXA270
    - Memory: SRAM/SDRAM
    - Storage: NOR/NAND flash
    - Network: CF WiFi
  - Energy Accounting Capability
    - Contained energy consumption (Tx + Rx) — Unloaded

The Network Pipe Intuition
- Pipeline analogy
- \( f(\text{state, goals}) \rightarrow \text{state_config} \)
- State = \(<A, B, C>\)
  - A, B: workload, battery, etc
  - C: data rate, loss rate
- Goals
  - Max battery life, throughput
  - Min delay, energy*delay
  - Can be combined optimization. E.g. min energy consumption for A + B

Experiments on Android
- Internet
  - User and kernel CPU time for a process
  - Bytes transferred over wireless and corresponding radio used
  - Sensor states (e.g. GPS)
  - Brightness setting for screen
  - DSP usage for Audio and Video

Towards an accurate energy monitor
- Battery power consumption depends on current battery voltage
- Attributing memory and storage read/write to correct application is not straight forward
- Aging battery stores less energy