Energy Delay Tradeoffs in Smartphone Applications

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Introduction:

Pervasive Urban Documentation System

- **VCAPS** is a system to capture, archive and navigate through a video corpus. (http://tomography.usc.edu)
- It provides automatic video transfer, and is usable by non-experts
- High quality video, together with audio, adds rich detail.
- Deployed at
  - Major transportation hub, in Los Angeles.
  - Research project at Ohio State documenting Mississippi Gulf Coast reconstruction.
  - May others...

Energy Delay Tradeoffs

- Nominal data rates differ significantly
  - From hundreds of Kbps for GPRS, to a few Mbps for 3G, to ten or more Mbps for WiFi.
- WiFi is more energy-efficient in terms of energy/bit
  - On cellphones, instantaneous energy consumption may be similar, but the energy usage for transmitting a fixed amount of data can differ an order of magnitude or more.
- Availability characteristics of networks can vary significantly.
  - Cellular networks availability is much higher than WiFi availability.

Link Selection Problem

- Time-varying access point availability and quality.
- Should the system transmit now or later? If it decides to transmit, which interface should we use?

Example Scenario

- Greedy approaches such as min-delay and min-energy might waste significant amount of energy, or incur high delay.
- It is possible to achieve significant energy savings with only a slightly increase in delay.

Proposed Solution: SALSA – Stable and Adaptive Link Selection Algorithm

Algorithm Design (SALSA)

- Principled approach - Lyapunov Optimization framework
  - Can design stable algorithm in the queueing system with a certain penalty or reward.
  - If the system is in the capacity region, the theory guarantees the system’s stability.
- How to choose the appropriate network interface?
  \[ \hat{I}[t] = \arg \max_{I \in L} \{ (U[I] \times X [\mu[I] | L_{SP}[I], P_{T}[I]]) - V \times P_{T}[I] \} \]

Reference Algorithms

- Intended to achieve minimum delay (Min-Delay)
  - Simplest approach to achieve minimum delay.
  - Greedily choose the best available access point at every decision slot.
- Intended to consume minimum energy (WiFi-only)
- Static balancing algorithm (Static-Delay)
  - Try to balance between energy and delay in a static way.
  - Combine Min-delay and Min-energy algorithm with fixed amount of time parameter T.
  - May be hard to decide the optimal parameter T.
- Omniscient algorithm (Know-WiFi)
  - Assumes that we already know future WiFi availability and do the best.

Trace-driven Simulation

- Adaptation across parameter \( \alpha \).
- Comparison to simple strategies.
- Comparison to balanced strategies.

Experiments using Nokia N95