Avoiding the Rush Hours: WiFi Energy Management via Traffic Isolation

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• Energy management is a relevant problem.
  ▫ *Always-connected* usage model of smartphone
  ▫ *Background* application running push-based alert services, location based notifications, and periodic sensor updates

• WiFi network communication is a predominate source of energy consumption.
Existing WiFi Management

- **Power Save Mode (PSM)**
  - One of the early protocols that attempts to turn off the device whenever beneficial
  - Focus on a single device and a single AP

- **Scenario**
  - Client periodically wakes up to listen to advertisements from the AP
  - Waking up the radio incurs a high energy cost
  - Clients are made to wake up less frequently permitting multiple packets to queue up at the AP.

- **NAPman protocol (MobiSys’10)**
  - Presented at MobiSys’10
  - Focus on multiple devices and a single AP

- **Scenario**
  - Multiple clients wake up after an AP advertisement
  - Every client must remain awake for a longer duration to receive its packets
    - AP transmit one packet at a time in a round-robin manner
  - Key idea: each client believe that it is a associated to a different virtualized AP
In reality...

- **Multiple APs** are within the wireless vicinity
- This strongly impacts the energy consumption of individual clients.

  - For example,
    - In homes or dense office areas, it is usual to overhear 5 to 10 other APs
    - APs are likely to share the channel fairly between them
    - A client remains awake almost 5 times longer
      - than it would if there was no contention with other APs
• APs monitor ongoing wireless traffic from nearby APs
  ▫ APs are always powered on

• Each AP tracks the periodicity of other APs and dynamically re-schedules its own period to minimally overlap with others
Energy Profiling

Transition from deep-sleep to High Power state

Beginning of receiving a burst of data packets

Overhearing packets from other Aps/clients:
Drop packets at the radio

Receiving an advertisement message

Anticipation of efficiently waking up for subsequent bursts
Impact of Network Contention on Energy

Under bulk data transfer with varying contention
• **Traffic monitoring**
  - Listen for ongoing beacons
  - Identify which other APs are within its collision domain

• Traffic migration

• Traffic preemption
• Traffic monitoring

• **Traffic migration**
  ▫ Fair share: at least $1 / (n + 1)$
    • $n$: number of other contending APs
  ▫ Actual share: the time from its beacon to the immediate next
  ▫ Unsatisfied: $\text{actual share} < \text{faire share} \&\& \text{traffic saturation}$
  ▫ If unsatisfied,
    • Find the largest inter-beacon interval (not including its own beacon)
    • If the interval $\geq 2 \times$ fair share, AP moves to the mid-point of this interval
    • Otherwise, AP migrates its beacon to a time $T$, such that $T_{\text{end}} - T = 1 / (n+1)$

• Traffic preemption
• Traffic monitoring

• Traffic migration

• Traffic preemption
  ▫ A client wakes up at the PSM beacon time and downloads packets until AP turns off the MORE_DATA flag
  ▫ Continuous downloads at different APs include continuous contention

  ▫ A simple preemptive mechanism
    • When AP\textsubscript{i} observes that its traffic is likely to “spill” into AP\textsubscript{j}'s, turn off the MORE_DATA flag
    • AP\textsubscript{j}'s client wakes up at the next PSM beacon
      • Loose form of TDMA
      • I.e., avoid “rush hour”
• Assumption & Solution
  ▫ Saturated traffic
    • ➔ Introduce and consider *needed* channel share and *available* channel share
  ▫ Single client
    • ➔ Buy NAPman’s idea
  ▫ No legacy Aps
    • ➔ Treat legacy APs identically for the purpose of beacon placement
Evaluation

- How 2 clients adjust their beacons and preempt traffic to converge on non-overlapping traffic bursts
Overall energy gain
Performance gap from the case of zero-contention