Motivation

- Many more devices using the Internet are small devices.
- They are power constrained (maybe computationally and bandwidth constrained)
- Current network protocols do not take these factors into consideration

Why is Power Being Lost?

- Wireless LAN network cards are very power hungry
- Consumes 1400 mW of power just while idle!! (Wavelan)
- Sleep modes of these card consume much less power (80mW)
  ⇒ Big Power Savings!!

Goals of the project

- Design mechanisms which reduce the power usage of TCP
- Implement these mechanisms and verify their effectiveness
- Develop a generic framework for multi-modal protocols

Challenges

- Identifying operating mode
  - Who does what?
- Negotiation & Verification
- Feedback
- Metrics
  - Different metrics bias towards different resources

How do we save Power?

- Transferring Functionality
  - Timers, State etc.
- Proxy Support
  - Can buffer packets allowing us to sleep
- Modified Data Transfers
  - E.g., Compress the data
- Opportunistic Sleeping
Opportunistic Sleeping

- We sleep
- We wake up
- Repeat until battery is dead

Threshold = 2
Threshold = 8

Sleep Algorithm

- Stay awake for \( \delta \) after a packet was received
- Sleep for a fraction \( f \) of the estimated RTT (starting from the first packet in the burst)
- \( \delta \) and \( f \) need to be carefully tuned

Simulation Results (Single Flow)

- Window Constrained
  - Sleep time increases with delayed ACK threshold
  - Throughput does not change much
  - Energy per packet goes down (~ 40%)
  - \( \Delta \) and \( f \) can be set aggressively
- Bandwidth Constrained
  - Can sleep only in slow start
  - Marginal gains (at most 5%)

Simulation Results (Cross Traffic)

- Cannot sleep as aggressively
  - Interference with cross traffic spaces packets apart randomly
- Throughput doesn’t change much
- Power savings are smaller (~ 20%)
  - Sleep time is reduced
  - \( \Delta \) and \( f \) must be set conservatively
Tradeoffs

- Sleeping produces packet loss
- Moving from sleep to idle mode uses power and takes time
  - 300 ms transition time
- \( \uparrow \) Power Savings = \( \downarrow \) Throughput
- Increasing delack threshold reduces throughput
  - Increased bursty nature of traffic
  - TCP stacks which don't have ACK byte counting

Future Work

- Metrics
- Negotiation Infrastructure
  - Implementation
  - Testing
- Feedback / logging mechanism

Conclusions

- Power savings can be achieved through various techniques
- More potential for power saving during slowstart
- Multi-modal network modes are useful to have