Protocols for Low Power

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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

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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!!!

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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

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Challenges

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

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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

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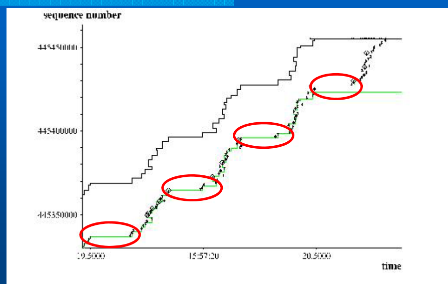
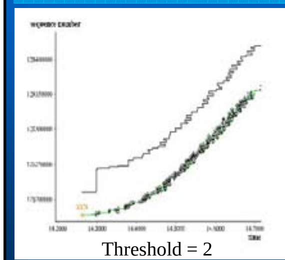
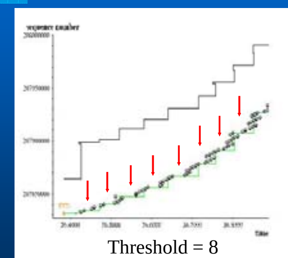
Opportunistic Sleeping



Delayed ACKs





Sleep Algorithm

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

Sleep Algorithm (Real)

- **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
- ↑ Power Savings = ↓ 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