Energy Efficient Wi-Fi Management for Smart Devices

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Introduction and Motivation

Motivation

- Existing Wi-Fi energy management scheme only analyzing the network layer communication patterns
- Impossible to perform application-specific energy management
- Combine the existing energy management scheme with application layer management!

Research Goals

- Propose an application-aware Wi-Fi energy management solution
- Only require device side deployment
- Should be realizable for many mobile devices

Related Work

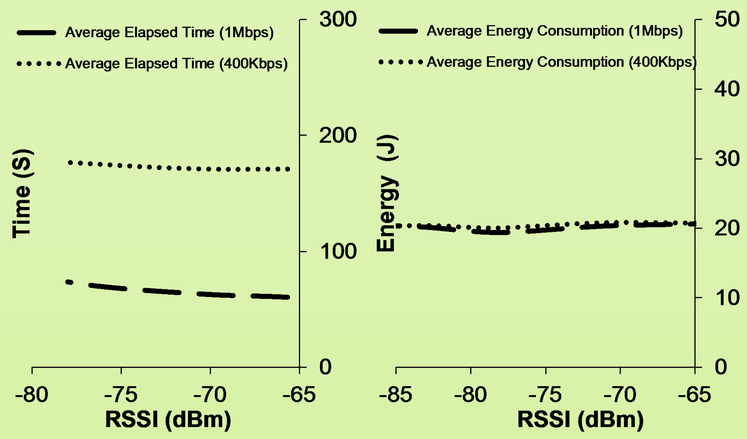
Related Work

- **Resource scheduling:** scheduling the major hardware component such as CPU, LCD and Wi-Fi comm. module to perform energy saving. Protocol level modification is required, and not application-aware
- **Resource offloading:** offloading resource intensive task to high performance computer to perform energy saving. Additional effort is required for developer to support resource offloading

Analysis of Wi-Fi Energy Consumption

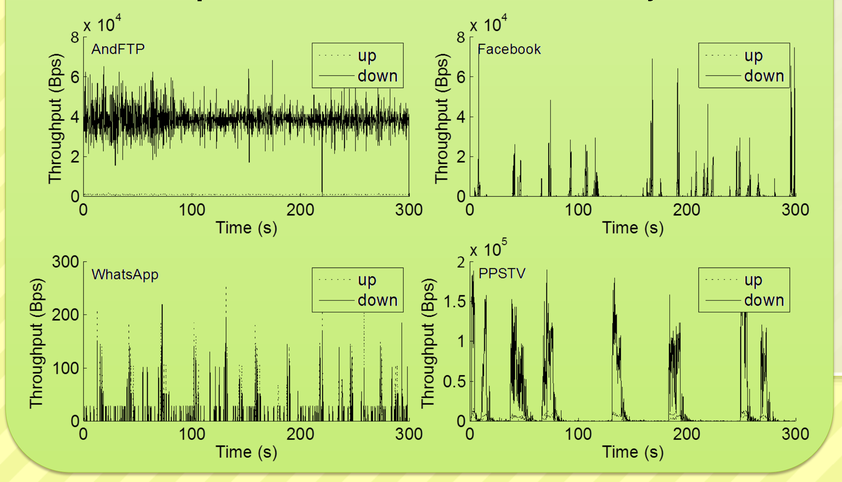
Relation of Energy, Time & Data Rate

- Energy expenditure is decided by data transmit time
- Beneficial to maximize the data rate to gain more energy efficiency



Application Characteristics

- **Delay sensitivity:** categorize applications into Delay Sensitive Application & Delay Tolerant Application
- **Expected throughput:** better schedule application transmission
- **Burst cycle:** better determine expected throughput
- **Session preservation:** determine the delayable time



Dynamic Wi-Fi on-off Control

Concept of Proposed Method

- Turn off Wi-Fi communication when available throughput cannot support application requirement

Design of Method

- Introduce control parameters for making better on-off decision

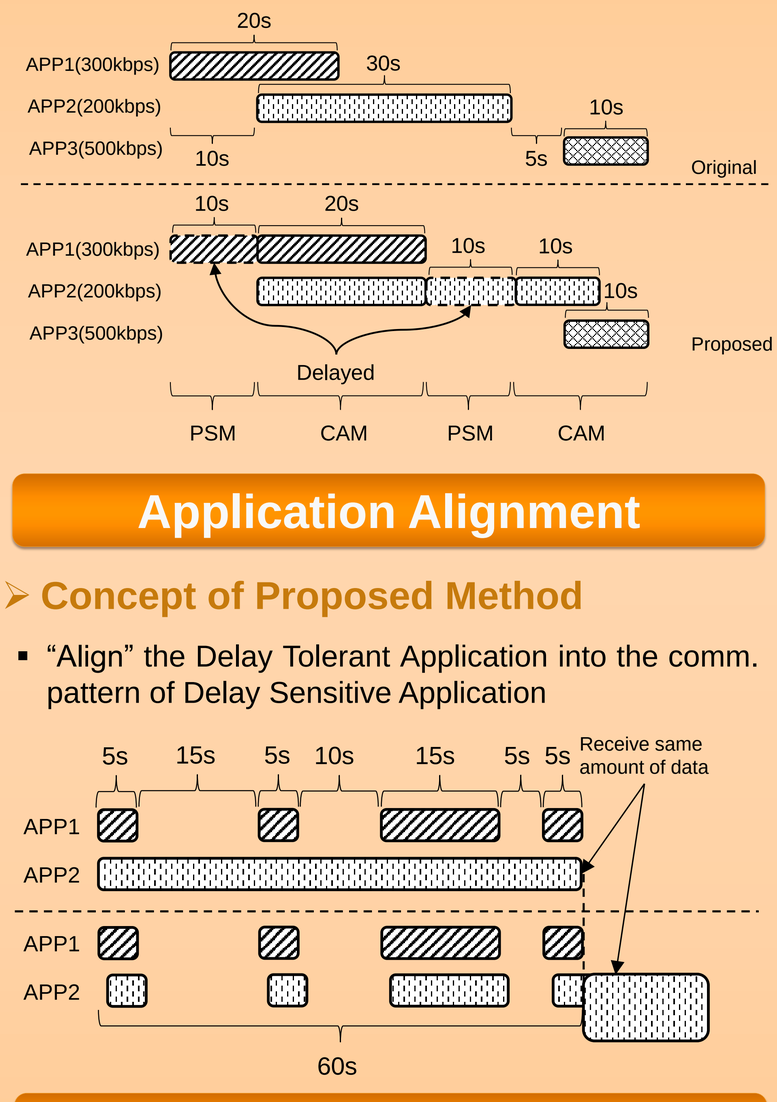
$$\alpha = \frac{Th}{E_{Th}} \qquad \beta = \frac{Th}{5 * t_{assoc} f_{dissoc} E_{Th}}$$

- Delay Sensitive Application: larger threshold
- Delay Tolerant Application: smaller threshold

Application Packing

Concept of Proposed Method

- "Pack" the Delay Tolerant Application together to maximize the utilization of the available capacity



Application Alignment

Concept of Proposed Method

- "Align" the Delay Tolerant Application into the comm. pattern of Delay Sensitive Application

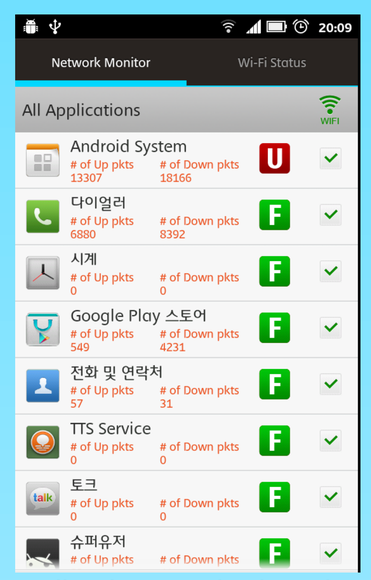
Application Comm. Mgmt.

Communication Management Methods

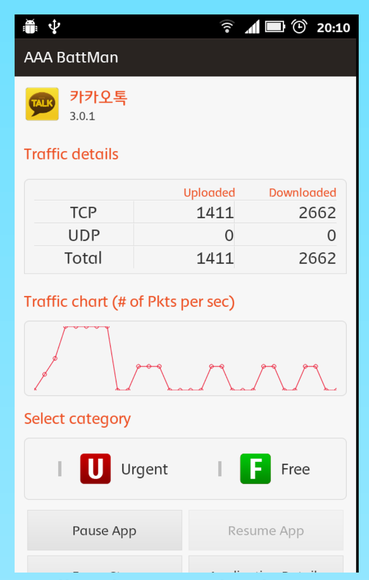
- **Process manipulation scheme:** originally designed for efficient CPU resource sharing and scheduling. Quickly recovered from suspend mode, but lack of user interactivity
- **Traffic shaping scheme:** exploit the firewall policy to control the traffic, better user interactivity, but slow recoverability from suspend mode

Process manipulation | Traffic shaping

Implementation & Deployment



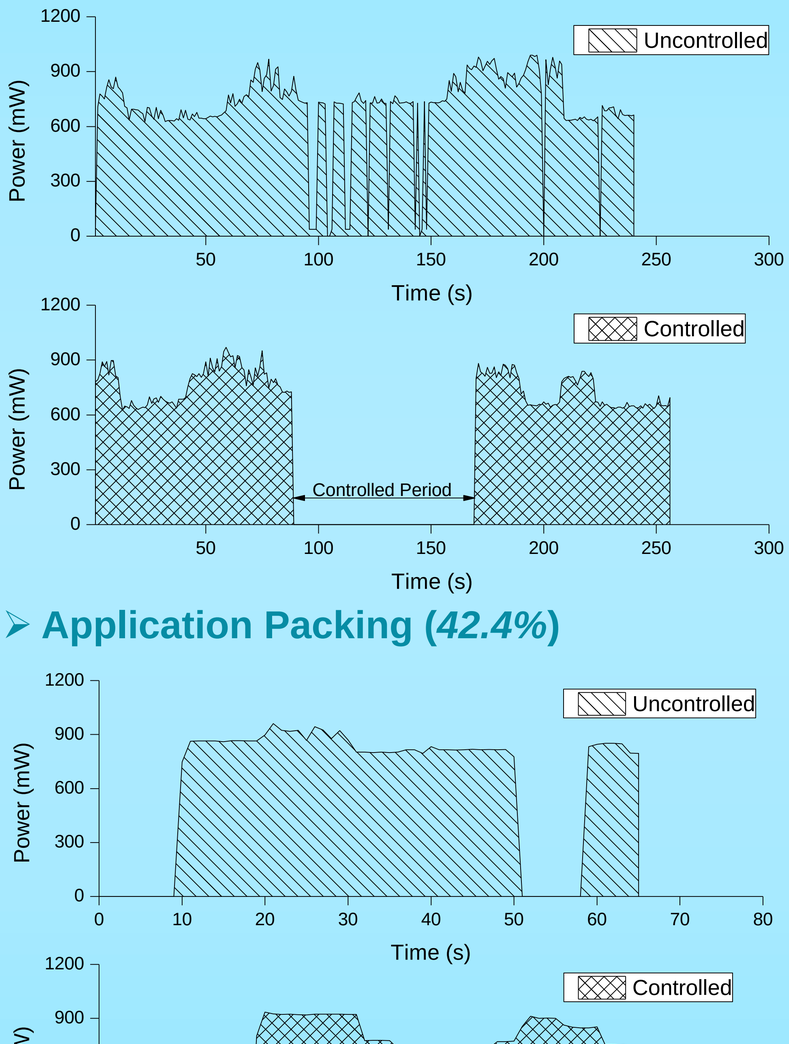
Application Monitoring List



Application Monitoring Detail

Experiment Result

Dynamic Wi-Fi on-off Control (*26.3%*)



Application Packing (*42.4%*)

Application Alignment (*23.3%*)

Conclusion & Future Work

Conclusion

- Investigated the key attributes impacting Wi-Fi energy consumption
- Proposed, implemented and validated three application-aware device-side energy mgmt. schemes

Future Work

- Production-quality implementation, field experiments
- Extend the proposed approach to 4G comm. module