Ready, Set, Go: Coalesced Offloading from Mobile Devices to the Cloud

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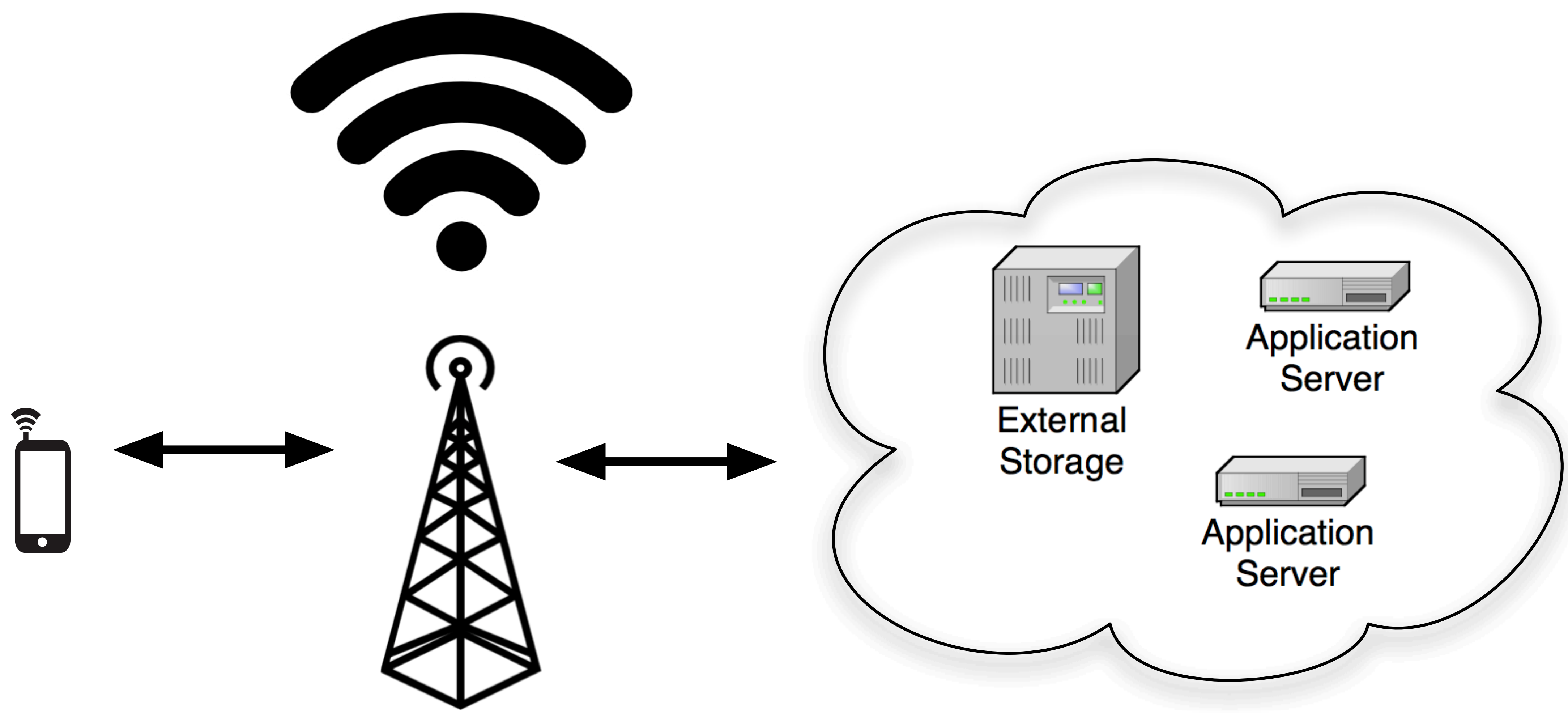
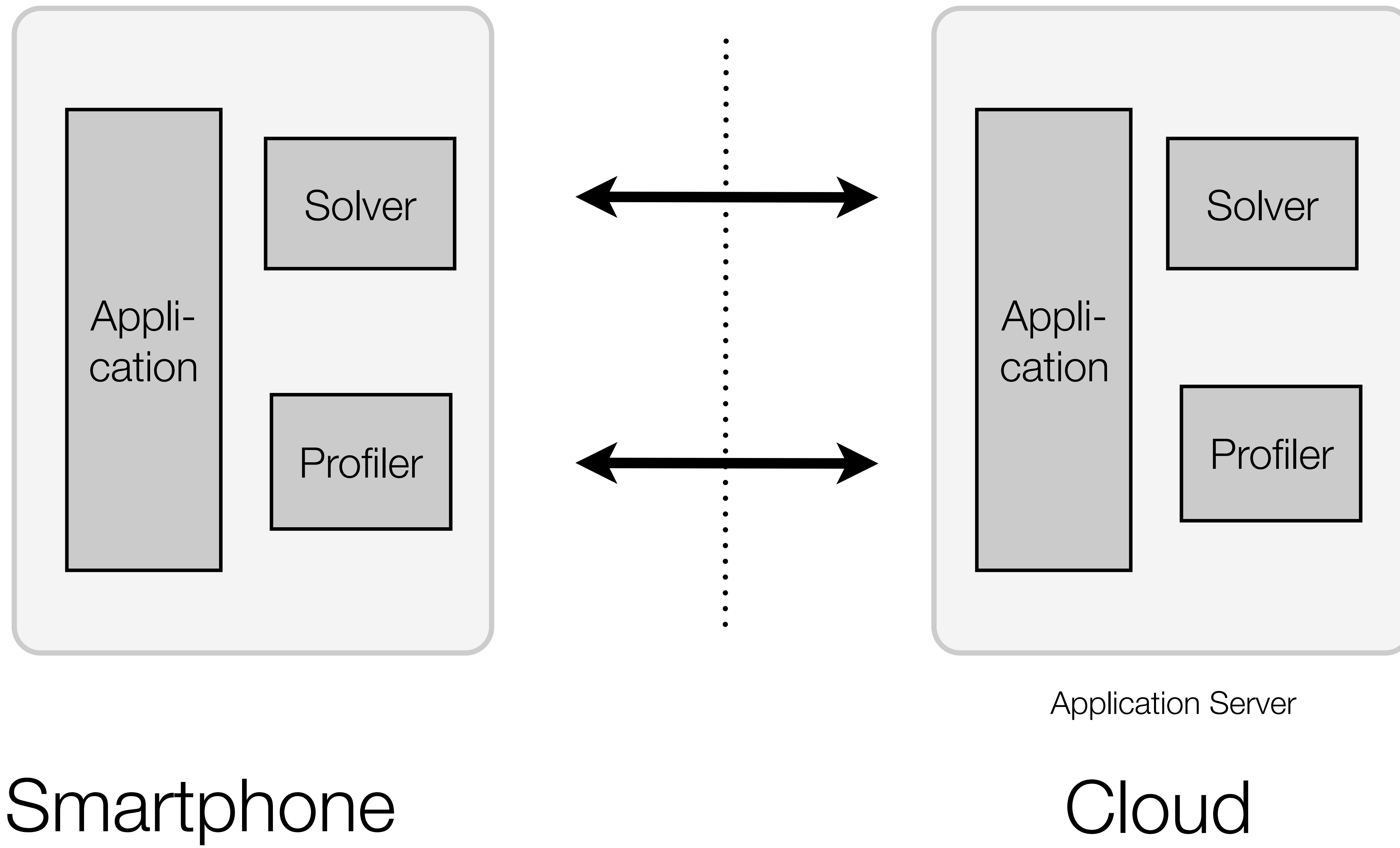
Remote execution



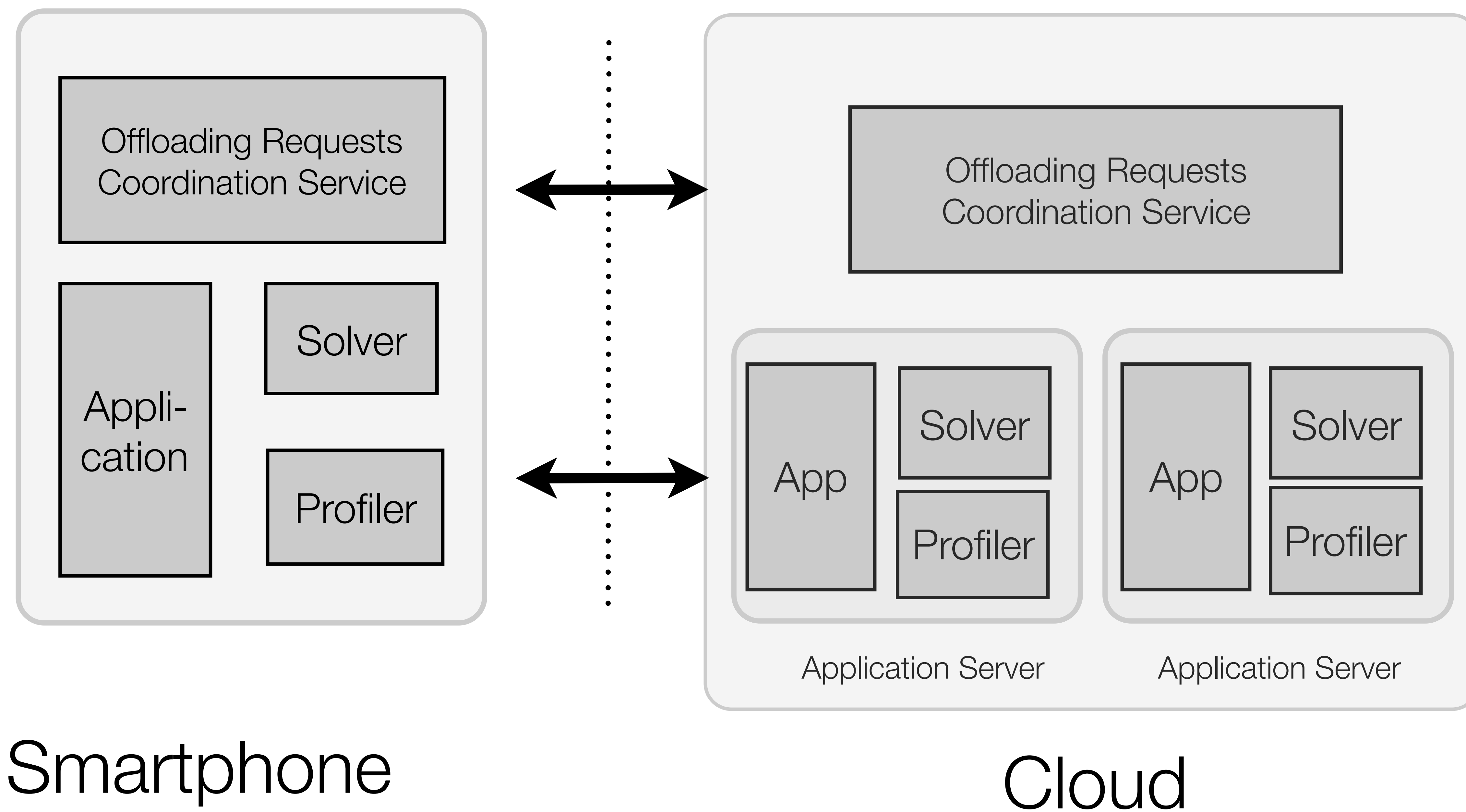
Code offloading



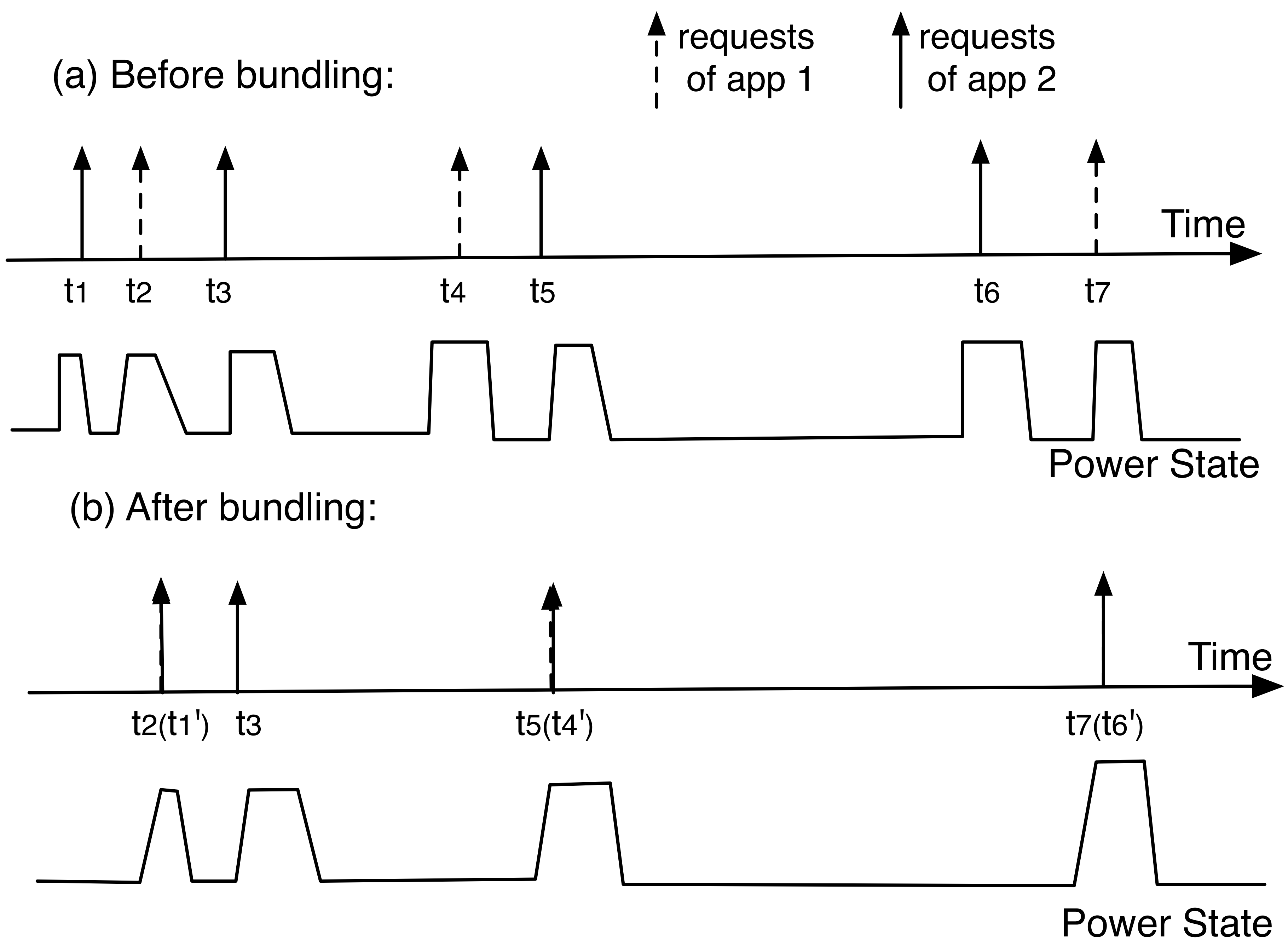
Tail time phenomenon

- When multiple applications send their offloading requests without coordination, network interface enters at high-power state at arbitrary times.

Coalesced Offloading

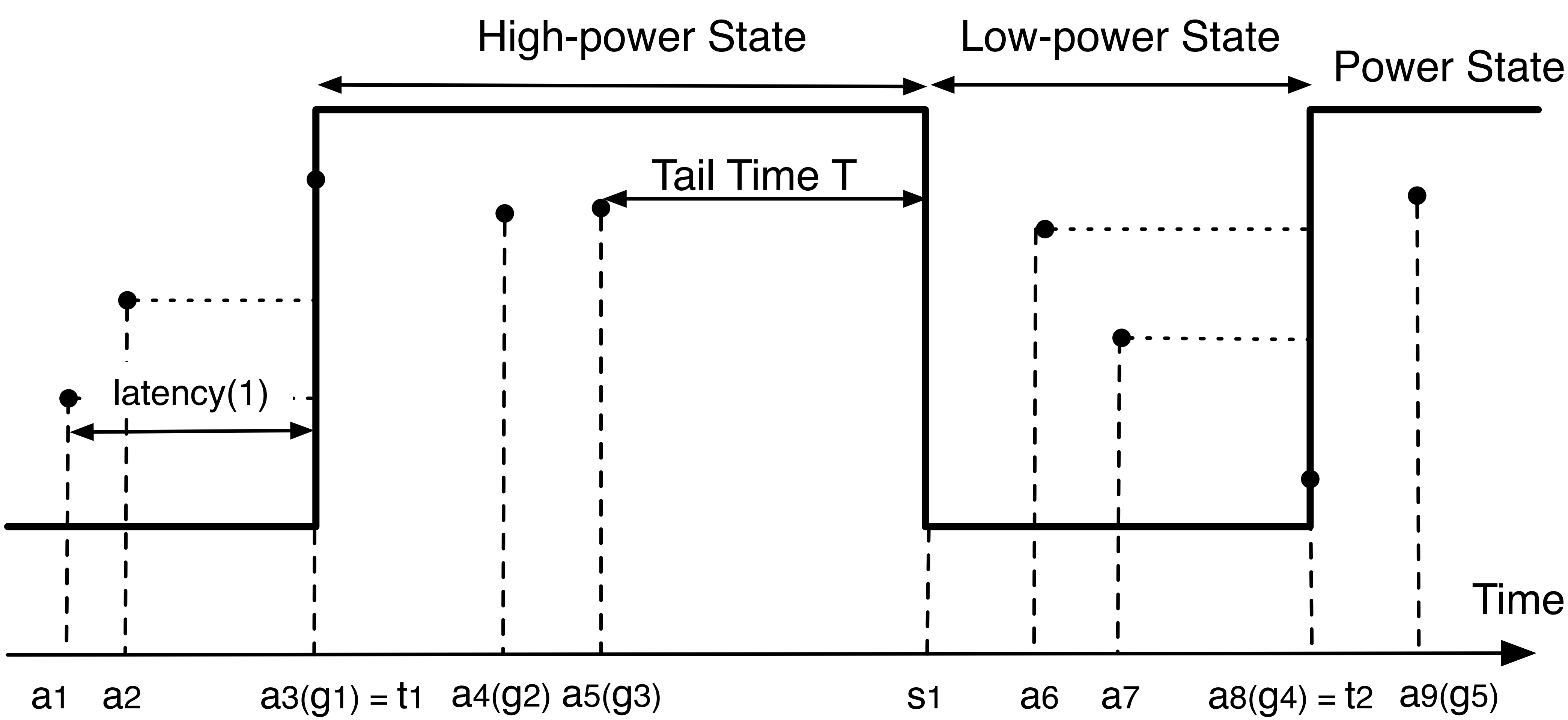


Coalesced Offloading



Problem Formulation

- Assume that M applications, generating requests at $a_1, a_2, \ldots$. The requests are granted at $g_1, g_2, \cdots$.



Problem Formulation

- Energy cost function $\simeq \sum_j \min\{g_j - g_{j-1}, T\}$
- Latency cost function $= \sum_j \sum_{\substack{a_i \ s.t. \\ g_{j-1} \leq a_i \leq g_j}} (g_j - a_i)$
- The joint optimization problem is as follows:

$$\min f_{\text{cost}} = \sum_j \min\{g_j - g_{j-1}, T\} + \alpha \sum_j \sum_{\substack{a_i \ s.t. \\ g_{j-1} \leq a_i \leq g_j}} (g_j - a_i)$$

How to solve the problem?

RSG Solutions

- Optimal offline algorithm:
  - With the arrival time sequence $a_1, a_2, \ldots, a_n$ known *a priori*.
- Online algorithms.
  - Without *a priori* knowledge of the arrival time sequence.

RSG Offline Solution

- For request a_i,

$$f_{\text{cost}}^{i} = \begin{cases} \min\{a_i - g_{\text{prev}}, T\}, & \text{if granted,} \\ \alpha(g_{\text{next}} - a_i), & \text{if delayed.} \end{cases}$$

- For 2^n Combinations of binary transmission sequence, we should:

$$\min f_{\text{cost}} = \sum_{i=1}^{n} f_{\text{cost}}^{i}$$

- The problem is transformed from continuous-time to discrete-time formulation.

What if we don't know the entire input sequence?

Our Results

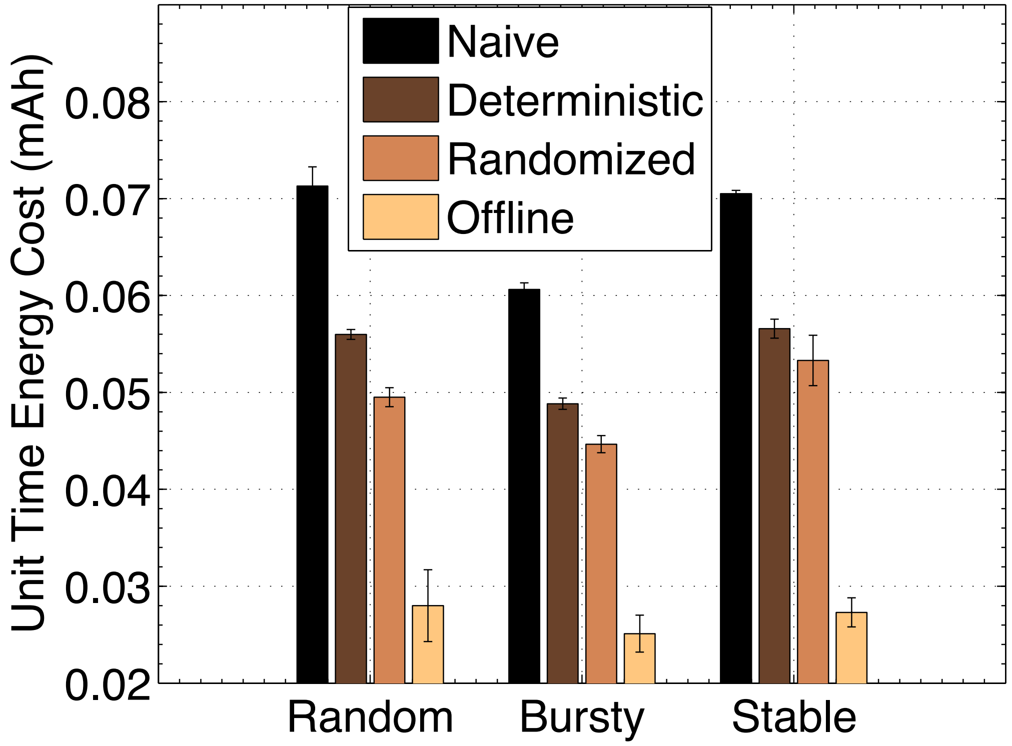
- Algorithm A_1 is *2-competitive*.
- The competitive ratio between the expected cost incurred by A and the optimal cost is $e/(e-1)$.
- RSG Online Algorithm have the optimal competitive ratio.

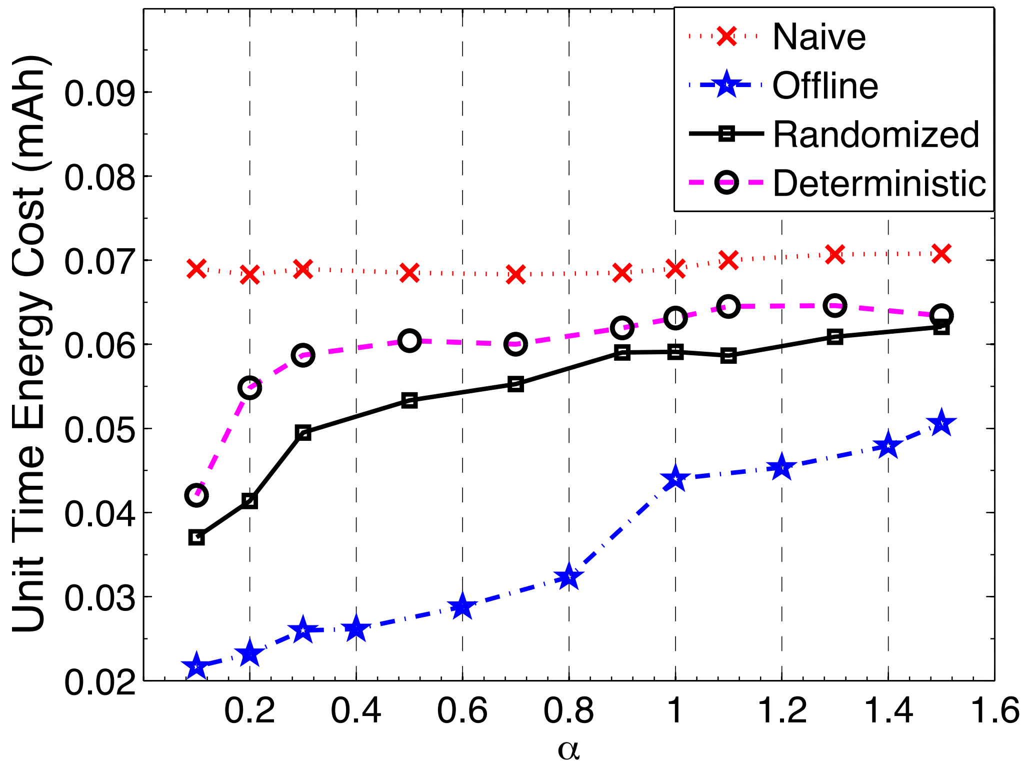
Performance Evaluation

- Measuring the Tail Time (on iPhone 3GS, Bell Mobility 3G network)
  - Transmitting successive packets of equal size with constant transmission intervals.
- Model-driven Simulations
  - Simulating the timing of multiple offloading requests from several simultaneously running applications.
- Real-world Experiments

Experiment Results

Energy consumption with different types of requests

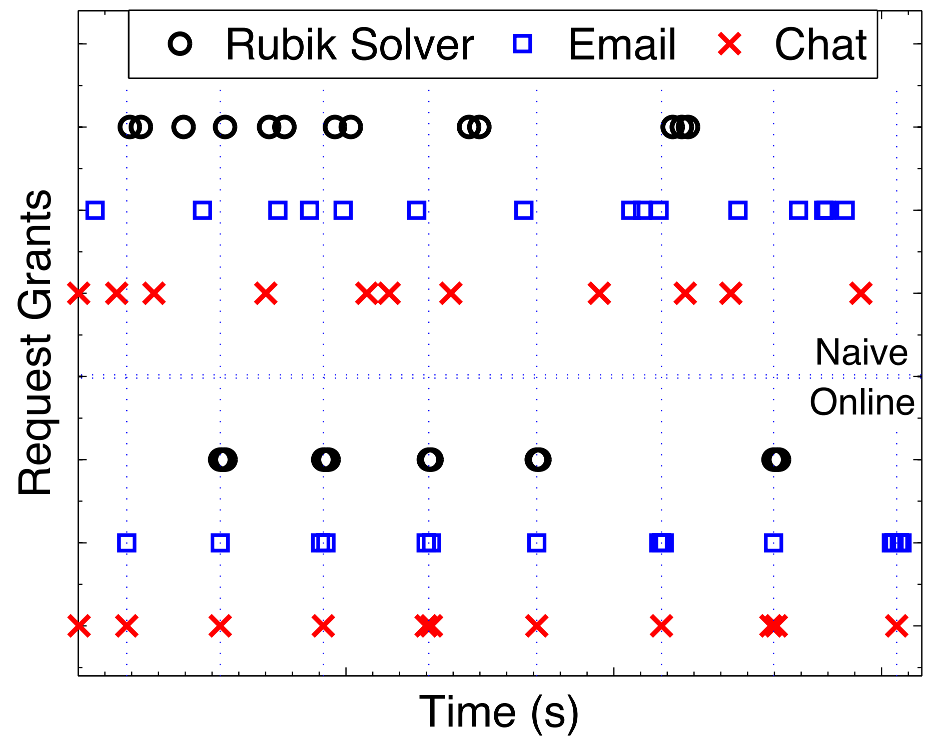


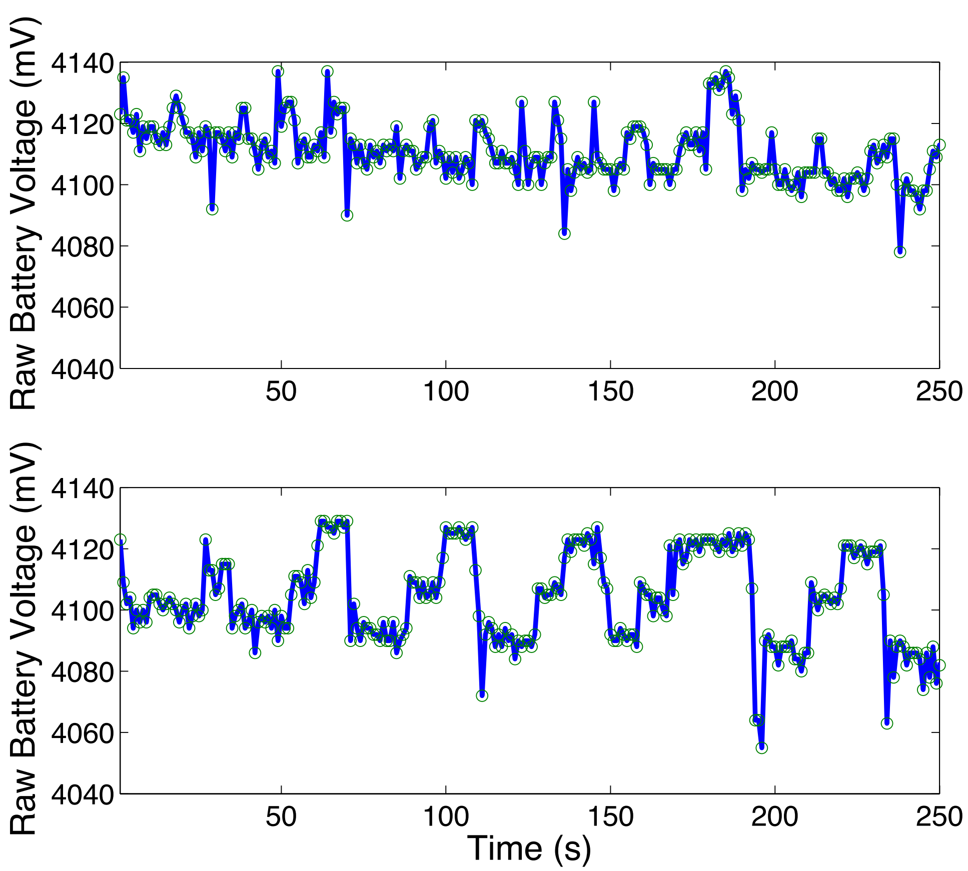


Energy consumption with varying alpha

Experiment Results

Real requests on mobile device w/o RSG solutions





Battery Voltage Change on mobile device w/o RSG solutions

Conclusions

- By bundling the offloading requests of multiple applications, we achieve greater energy savings while maintaining satisfactory performance.

- The RSG online algorithm achieves the best possible competitive ratio.

Thank you.