Power Management: A Battery's Perspective

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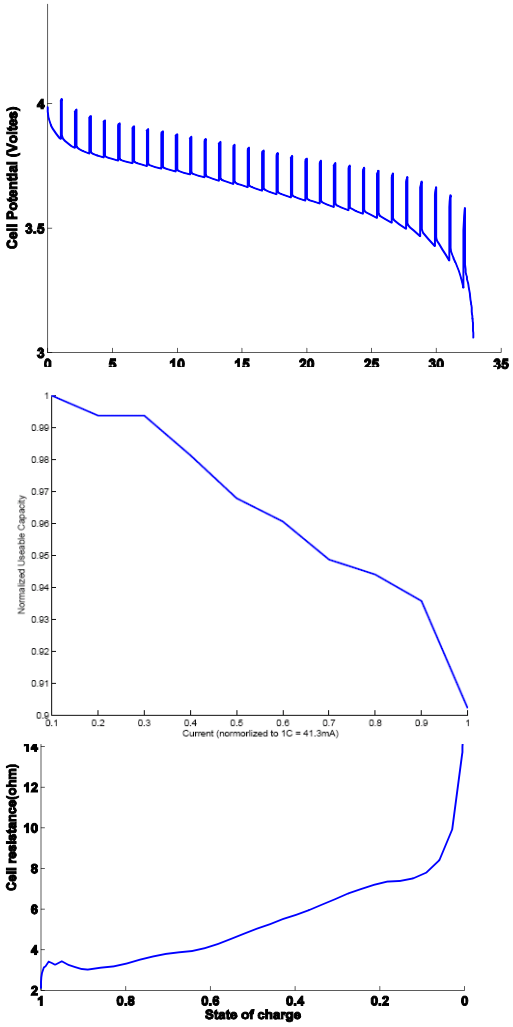
Motivation

- Status Quo
  - Current research on power management focuses on power-aware hardware/software design and development
  - However, in most cases, a battery is regarded as a passive two-terminal analog device, even for battery-aware computing
  - Most batteries being used nowadays are multi-cell battery
- Reality is
  - Battery is dynamic and complex
  - Battery operating time and life time depends on how it is used
  - Battery may be the least understood element of a battery-powered computing system, especially for multi-cell battery



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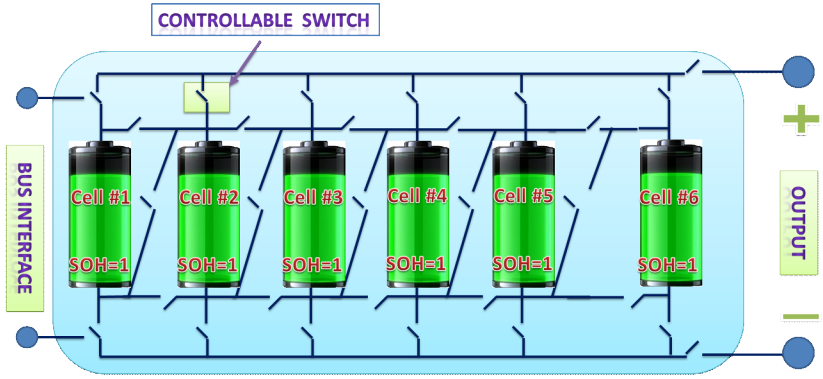
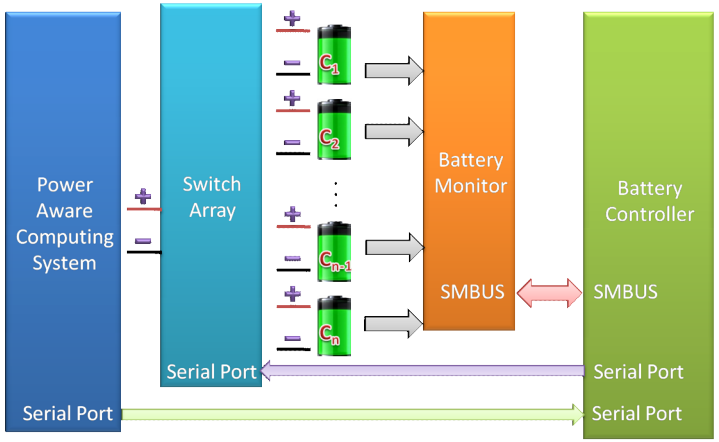
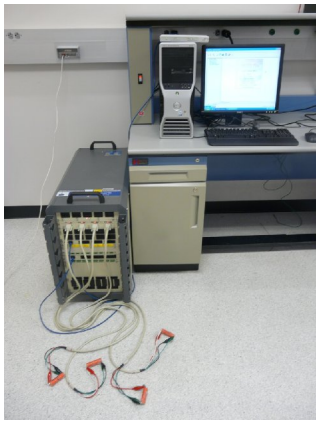
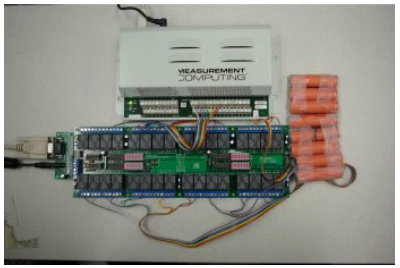
Our Approach: Bring Intelligence into Multi-Cell Battery

- Basic idea: dynamically reconfigure the cell topology of a multi-cell battery based on the load requirements imposed by system and application









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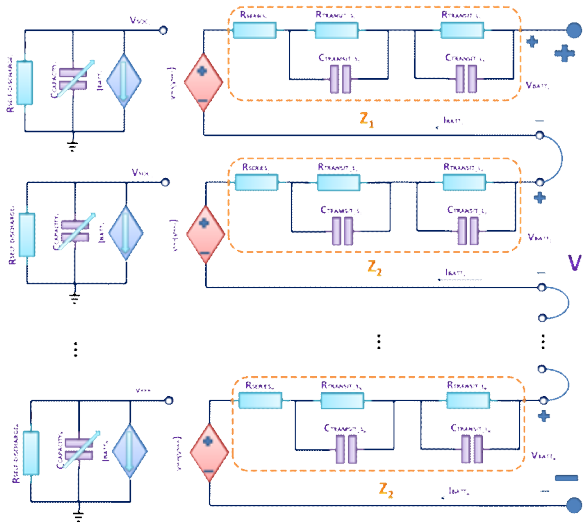
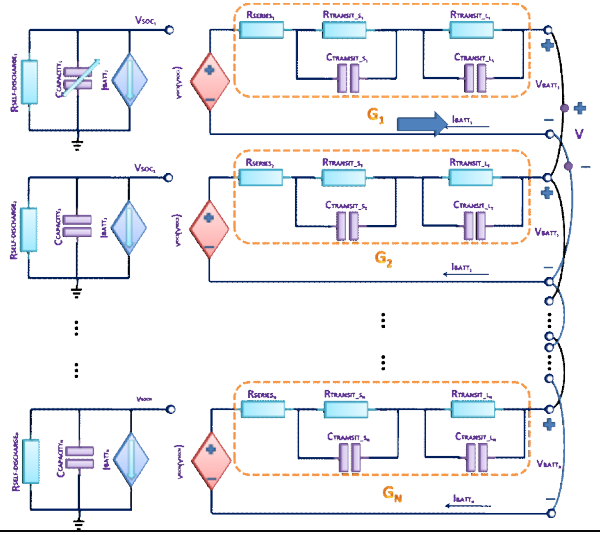
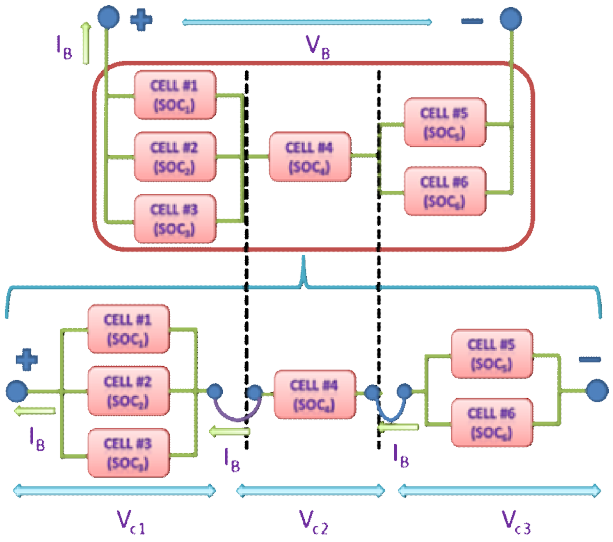
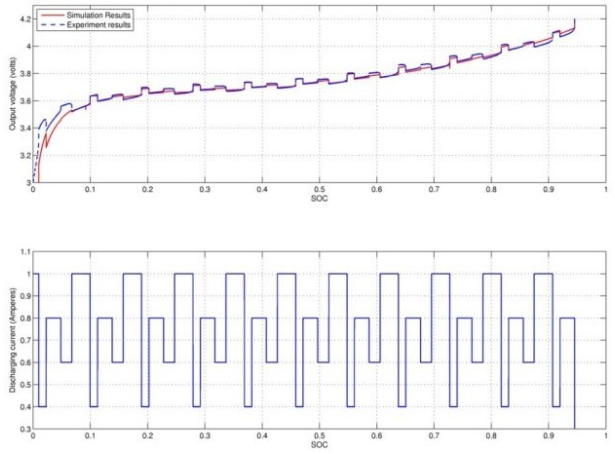
Key Issue: Modeling Adaptive Multi-Cell Battery









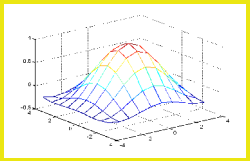
Modeling

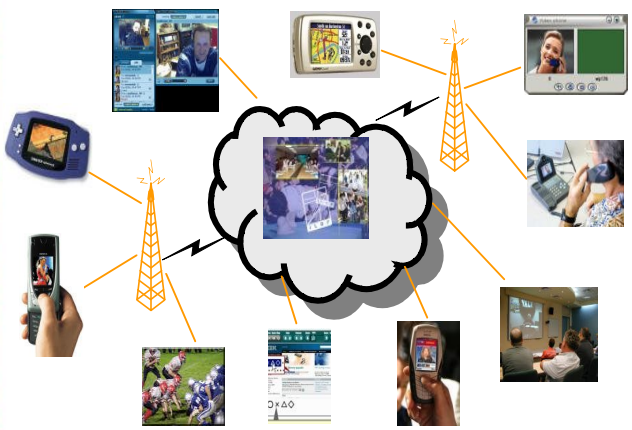
$$J(y,T) = \int_0^T F(x_1, x_2, ..., x_n, y_1, y_2, ..., y_m)dt$$

$$dx_i/dt = G_i(x, y), x_i(0) = c_i, i \in [1, n]$$

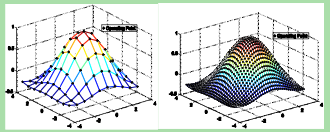
$$R_k(x, y) \le 0, k \in [1, l]$$

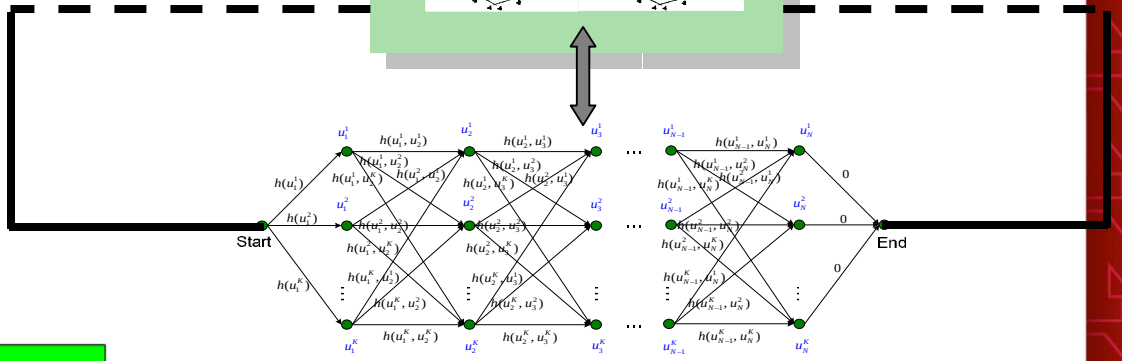
$$y^*(c,T) = \arg\max_y J(y,T)$$





Temporal-Spatial Behavior Study





Application QoS: end-to-end delay, jitter, data rate, etc.

Network QoS: TCP/TFRC, routing, MAC and PHY

E/D

E/D

User and System: display distance, size, resolution, luminance, contrast, HW/SW

E

User-Centric Capacity-Driven Cost Function

SoC-Delay-Quality (C-D-Q) optimization

Control Policy

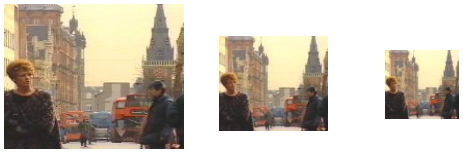
PSNR

E/D

E/D

Source Codec: quantization paramter, mode selection, motion prediction, packetization

Customization: content analysis, display cache, and error concealment methods



Scientific Challenges: A Battery's Perspective

- Understand the temporal-spatial behavior of large-scale multi-cell battery under dynamic power management
  - Large cell array: high power applications
  - Dynamic source and load: renewable energy, hybrid vehicles
- Bridge the gap between multi-cell battery dynamics and system dynamics in power management
  - Battery and HW such as DC-DC
  - Battery and SW such as battery-aware task scheduling
    - Mission-critical environment, e.g. data center and battlefield
    - Resource-limited scenarios, e.g. battery-powered embedded systems
- Build a theoretical foundation for application-centric battery-driven power management
  - Systematic modeling and holistic optimization
  - Quantify various design tradeoffs in battery-driven power management
    - Among computation , communication, task scheduling, service quality, and battery
  - Service quality should be the ultimate design goal for power management

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Thank you!

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