SBS IF Developer's Conference '98

Smart Battery Implementations

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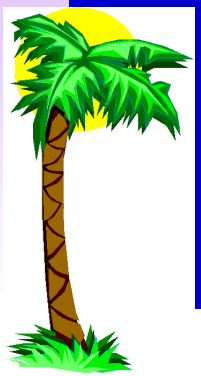
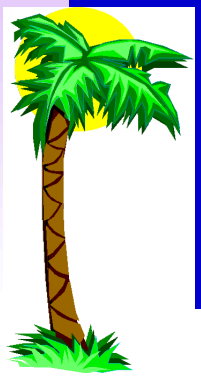
Intel Corporation
Feb 2, 1998



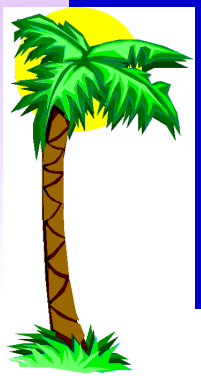
Agenda

- Background
- Battery data more important to the OS
- Smart Battery Building Blocks
- Minimum Smart Battery Requirements
- Achieving the desired Accuracy
- Implications of Standard Size Batteries
- Wrap-up



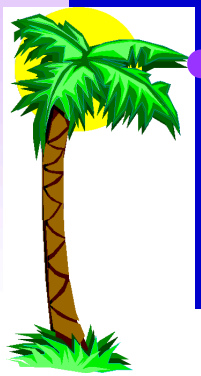
In the beginning (almost) ...

- APM was the original power management interface to OS
- Battery intelligence ranged from none to very good
- APM did have battery system interface
  - Data limited (fuel gauge, AC)
  - Not used by all systems (e.g. unreliable)



Before SB
OEMs had to build battery

- Evaluate and select cells
- Design the battery & system
  - Electronics
    - Capacity algorithms
    - Charging circuits
  - Packaging
  - Battery to host communications
  - Create firmware and drivers for the OSs
- Large recurring engineering costs



After the SB Introduction

- OEMs have off the shelf solutions at different levels of integration
  - Combine commercial SB components with cells to create own Smart Battery
  - Standard sized Battery Packs
- OEMs expect to get reliable and accurate battery readings
- OS gets good and consistent battery data
- Smart Battery package is judged as a combination of Cells and Electronics

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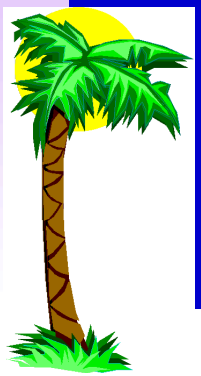
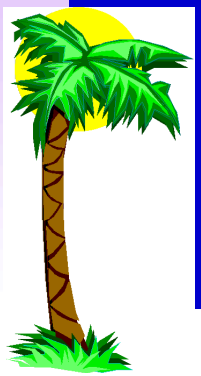
System Power Management Before ACPI (APM)

- Power Management “tuned” to the platform
  - Power management policy in platform firmware
  - Customized for every hardware/system
  - Comprehends characteristics of devices
- OS played very small role in power policy
  - OS tells platform when it is idle
  - OS accepts/rejects power events (e.g. suspend)



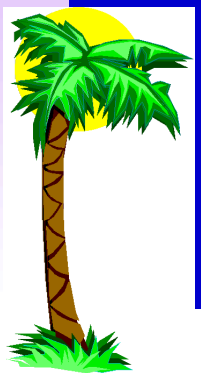
System Power Management After ACPI

- OS directed Power Management (OSPM)
- PM same for all platforms
  - No longer “tuned” for best performance on a particular platform
- OS needs data for use in formulating power policy
  - Accurate battery data
  - Device reported data (e.g.USB devices report power & latency)

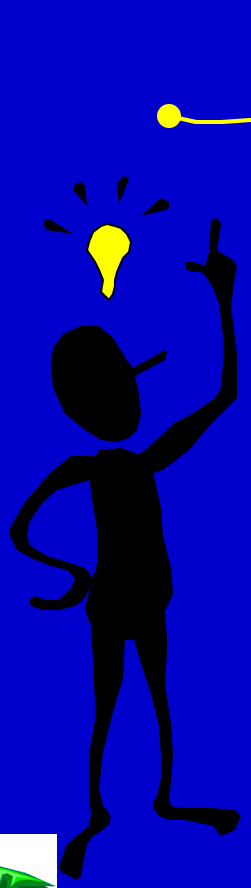


The Critical Role of SB in ACPI OS System Power Management

- Smart Battery
  - Provides power data that the OS can track
  - Correctly converts power into run time
  - Sends alarms to system (e.g. low battery etc.)
- Battery data can help OS make policy decisions
  - Power use allows OS to adapt policy for a device, set of devices or platform



The ACPI PM Ingredients



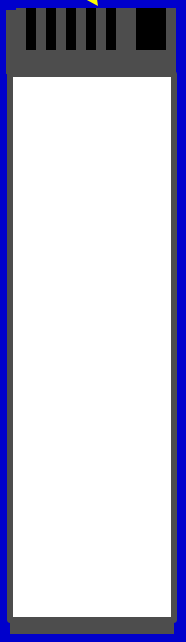
The End User

Power Management Aware Applications

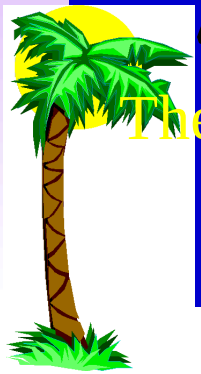
OS Directs Power Management

Power Management Aware Drivers

Power Manageable Devices/Hardware



The Smart Battery



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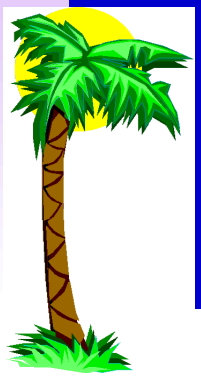
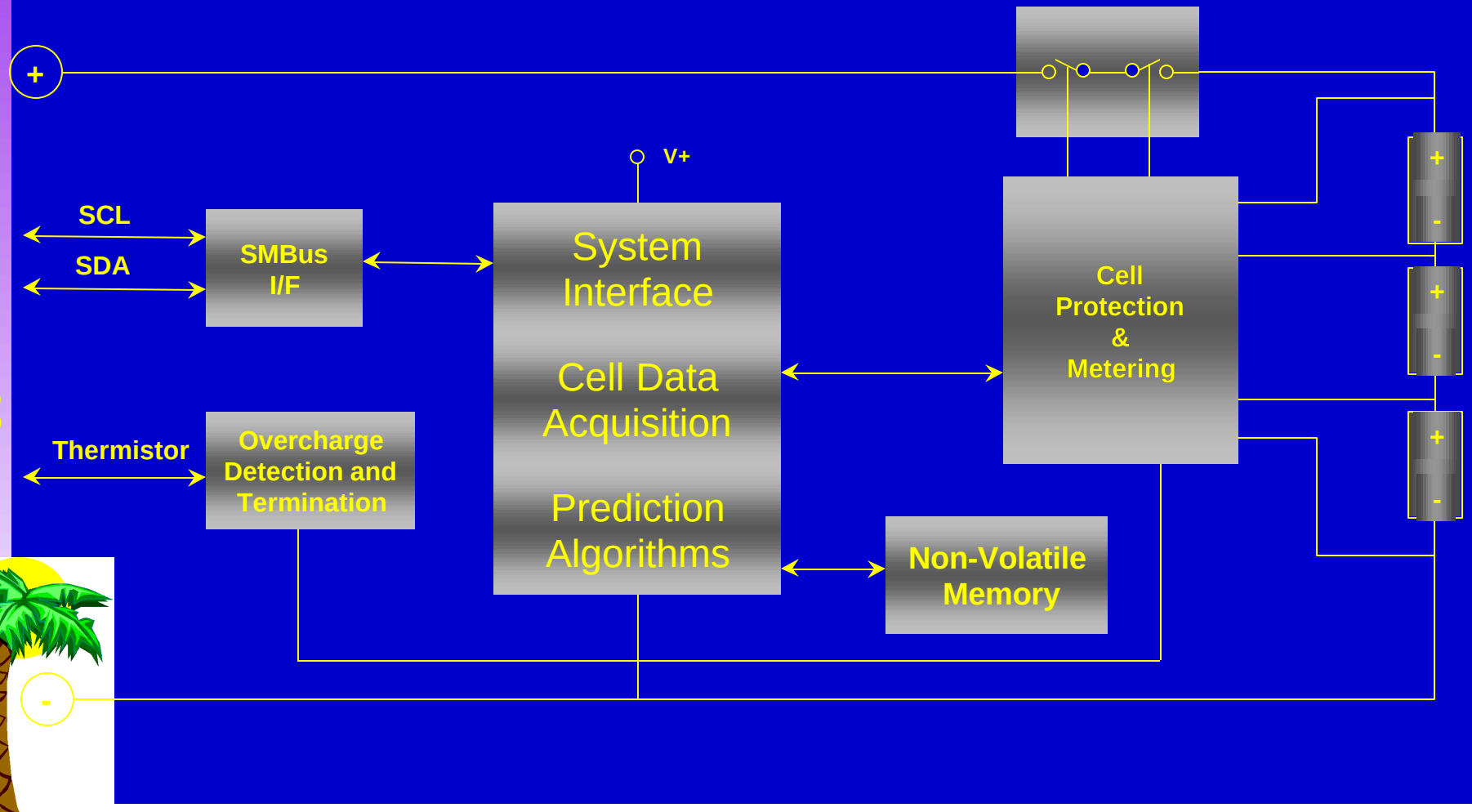
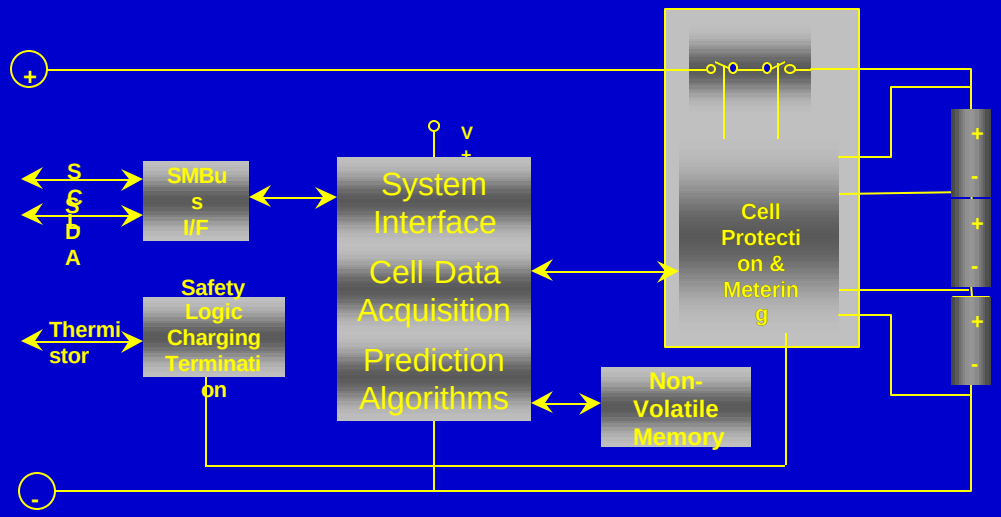


Smart Battery Building Blocks



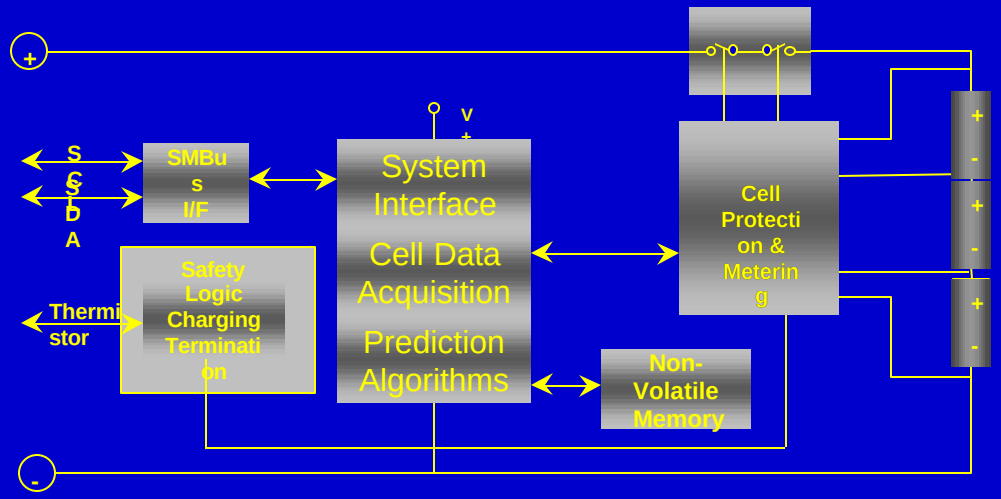
Independent Circuits

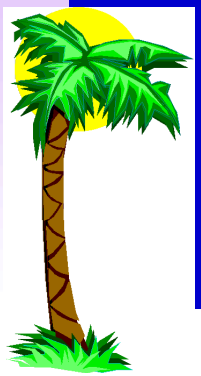
- Using independent circuitry for cell protection from the rest of the SB functions increases the SB safety through fault tolerance



Independent Circuits

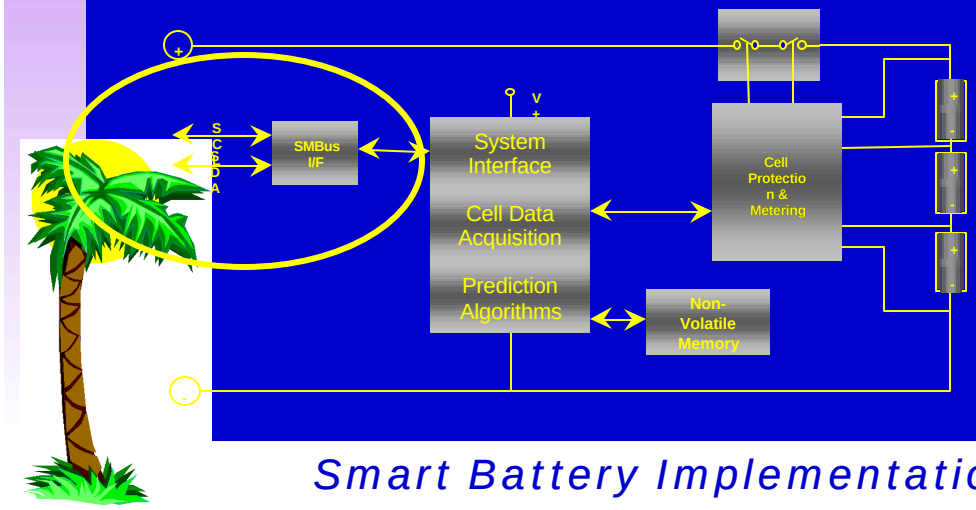
- Out-of-band signaling to terminate charging increases safety
  - Thermistor for NiMH
  - Over voltage detection for liION





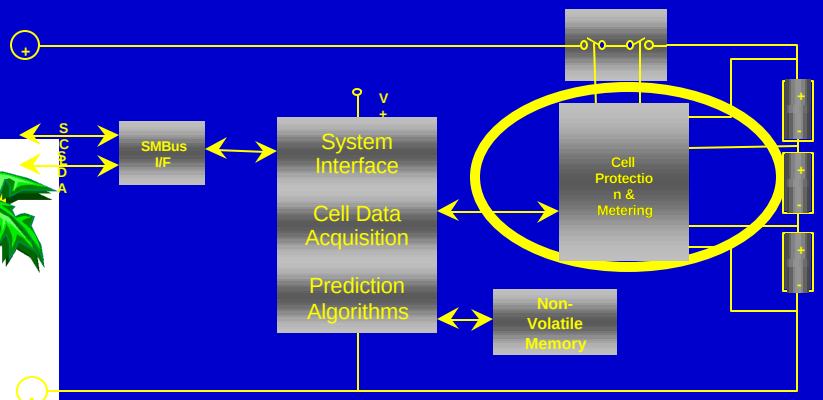
The SMBus Interface

- Ensures seamless integration ACPI Operating System
- Should demonstrate interoperability at SBS-IF PlugFests
- Should pass the SBS-IF published compatibility self-check lists
- Should be 100% compatible with the SBS specs
- Ensures all SMBus devices inter-operate flawlessly



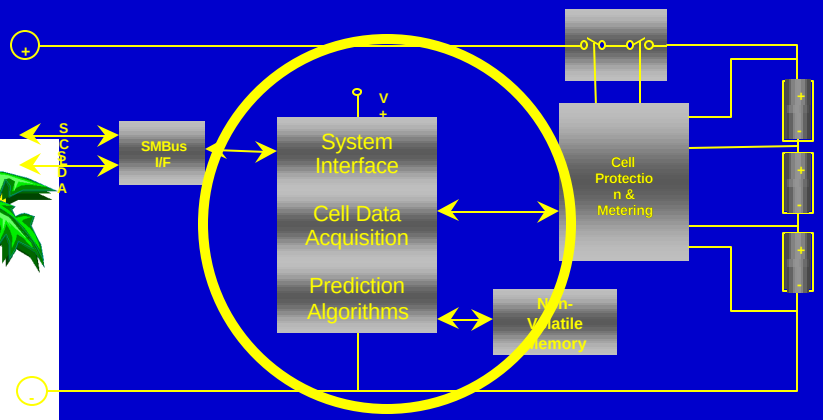
Cell Protection & Monitoring

- Monitoring increases the safety of LiIon batteries
- Prevents individual cell overcharge or voltage reversal



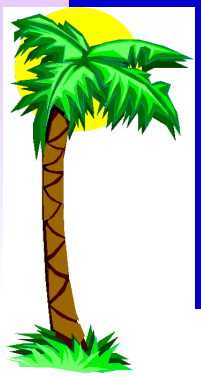
The Core

- Microcontrollers offer more flexibility and sophistication than ASICs at additional cost ($$ & power)
- Programmable memory is essential for maintaining battery historical data



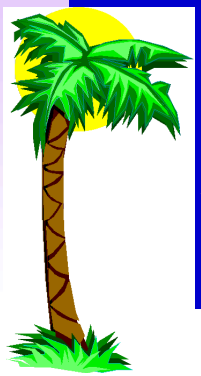
Firmware/State Machine

- Implements the SBS command protocol
- Measures
  - Voltage for each individual cell
  - Temperature
  - Discharge/recharge current
  - Time
- Performs the prediction algorithms
- Maintains pack accounting (self-discharge, charge cycles etc.)



If its Firmware Implementation

Critical Error
Press Ctrl-Alt-Del



State Machines cannot go stray either

- Once it starts running it may never stop
- ANY reset will require user interference and re-calibration
- You cannot afford crashes during critical functions
- Independent backup circuitry for critical charge functions is a must

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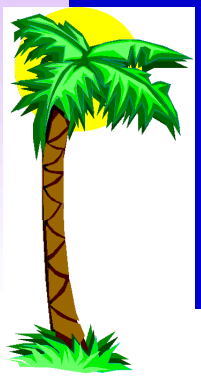
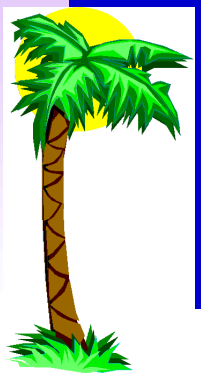


Functional Requirements

- Return complete data set
- Meet accuracy requirements
- Meet the SMBus requirements
- Watch Power Consumption
  - Total NB Suspend power goal 20-50mw
  - Battery electronics add to total



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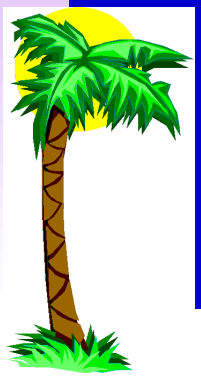
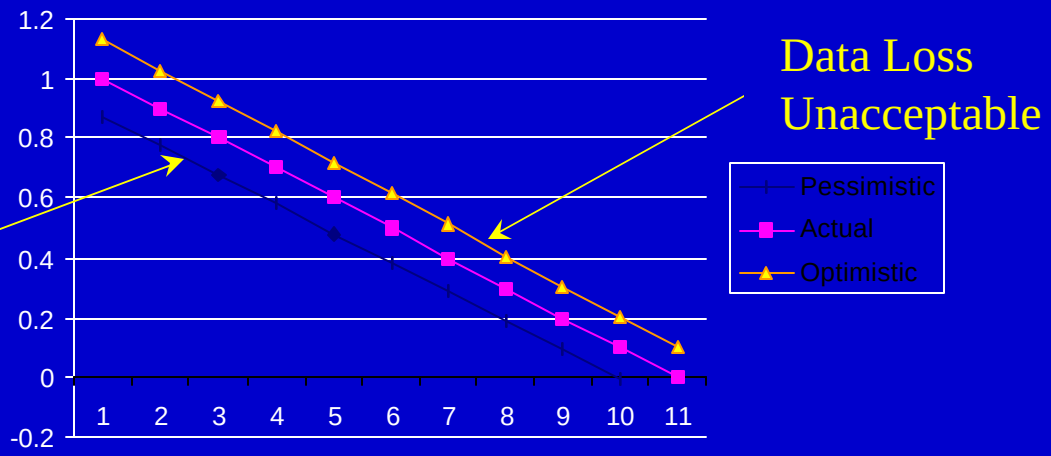


The "Effective" Capacity

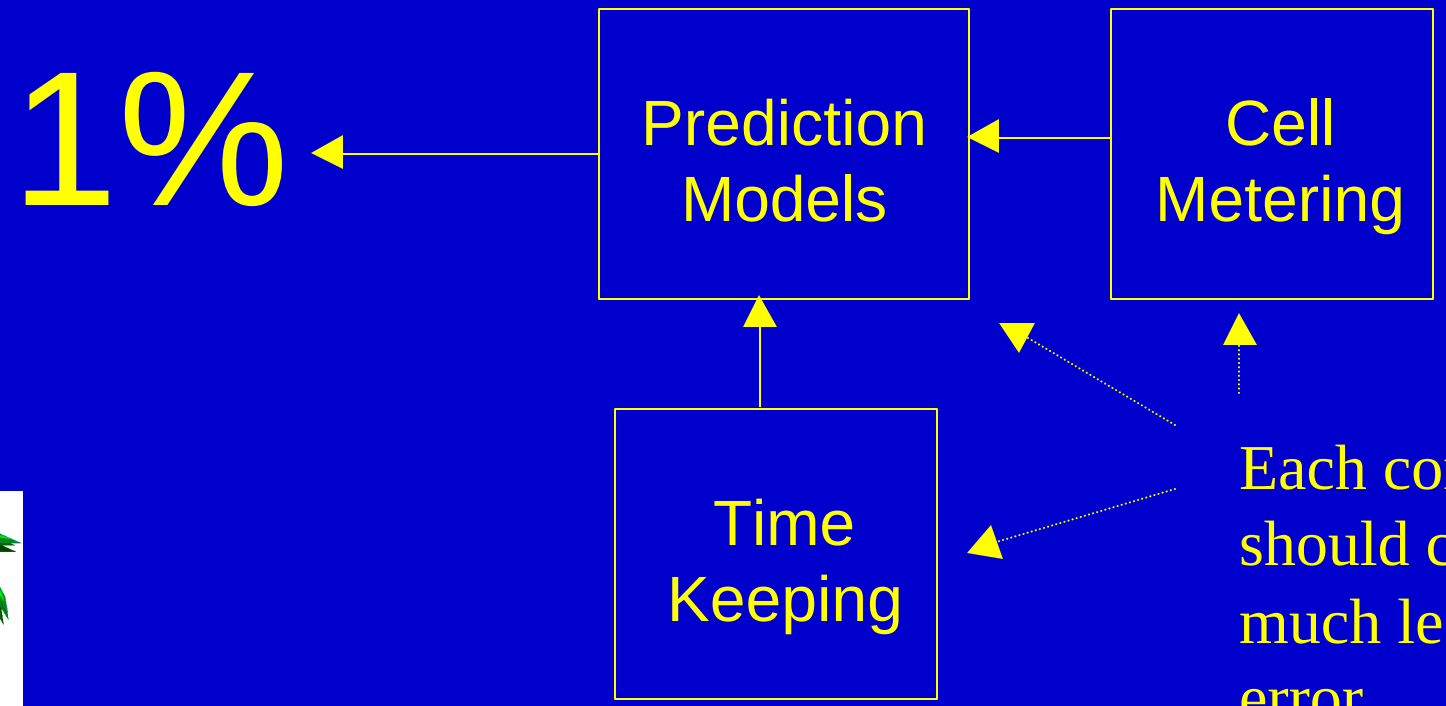
- "Effective" capacity is the capacity reported by the SB electronics at any state of charge and that's all that matters

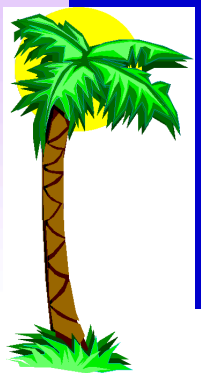
Early shut-down
No data loss, but
less battery usage



Data Loss
Unacceptable

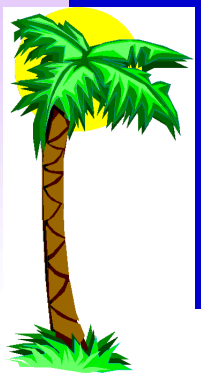
Accuracy Components



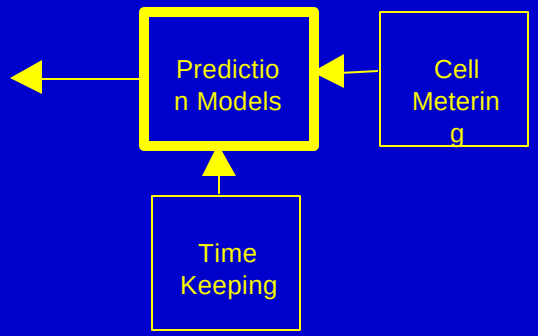


Prediction Models

- The most important error contributor
  - Modeling Errors
  - Calculation Errors
  - Systematic prediction errors originating from the utilized battery models accumulate over time

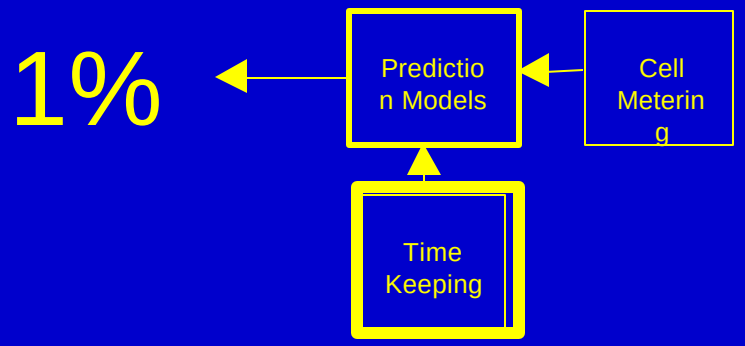


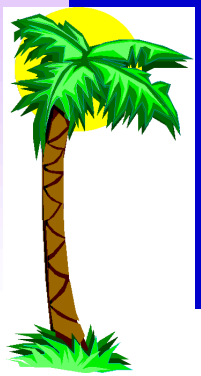
1%



Time Keeping

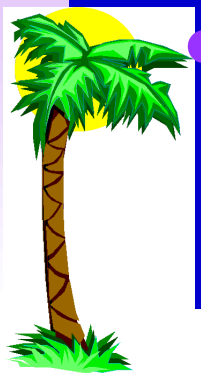
- Clock should be accurate over the whole range of battery voltages and temperatures





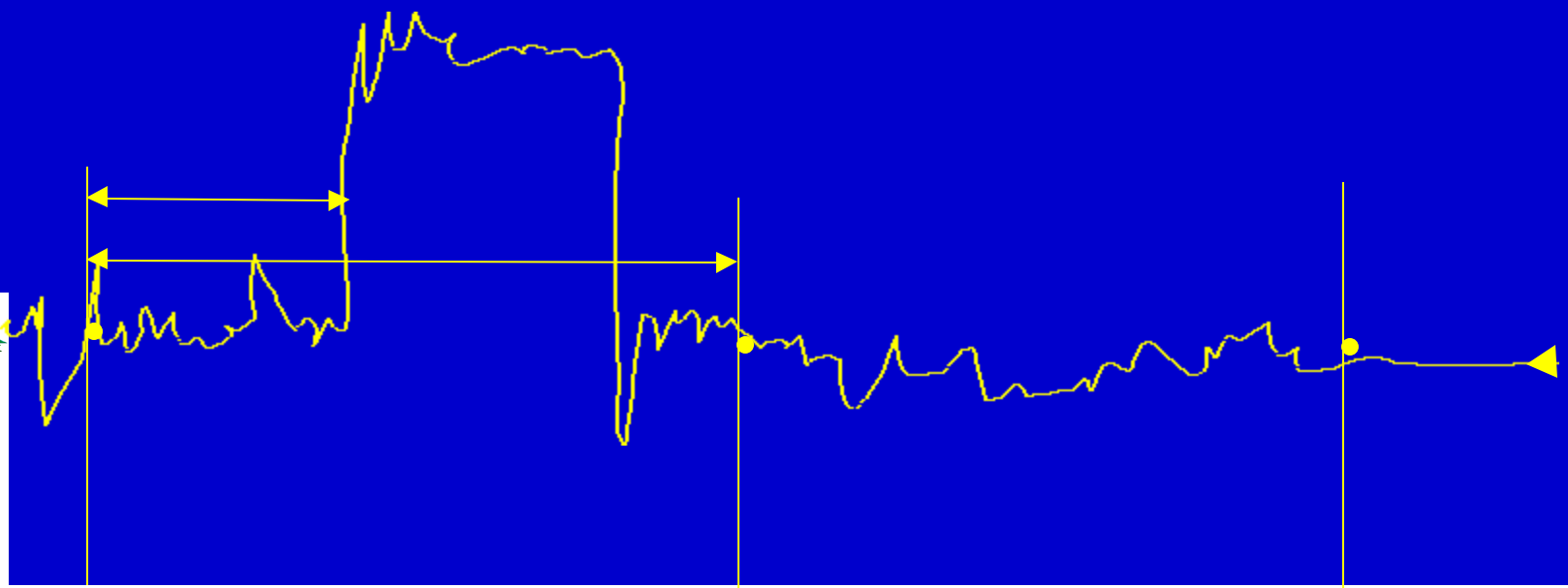
Cell Metering

- Appropriate sampling technique
  - Sampling Rate
  - Input
    - Integrating, Flash, Track and Hold
    - S&H Accuracy
- Adequate Dynamic Range
- Overall accuracy



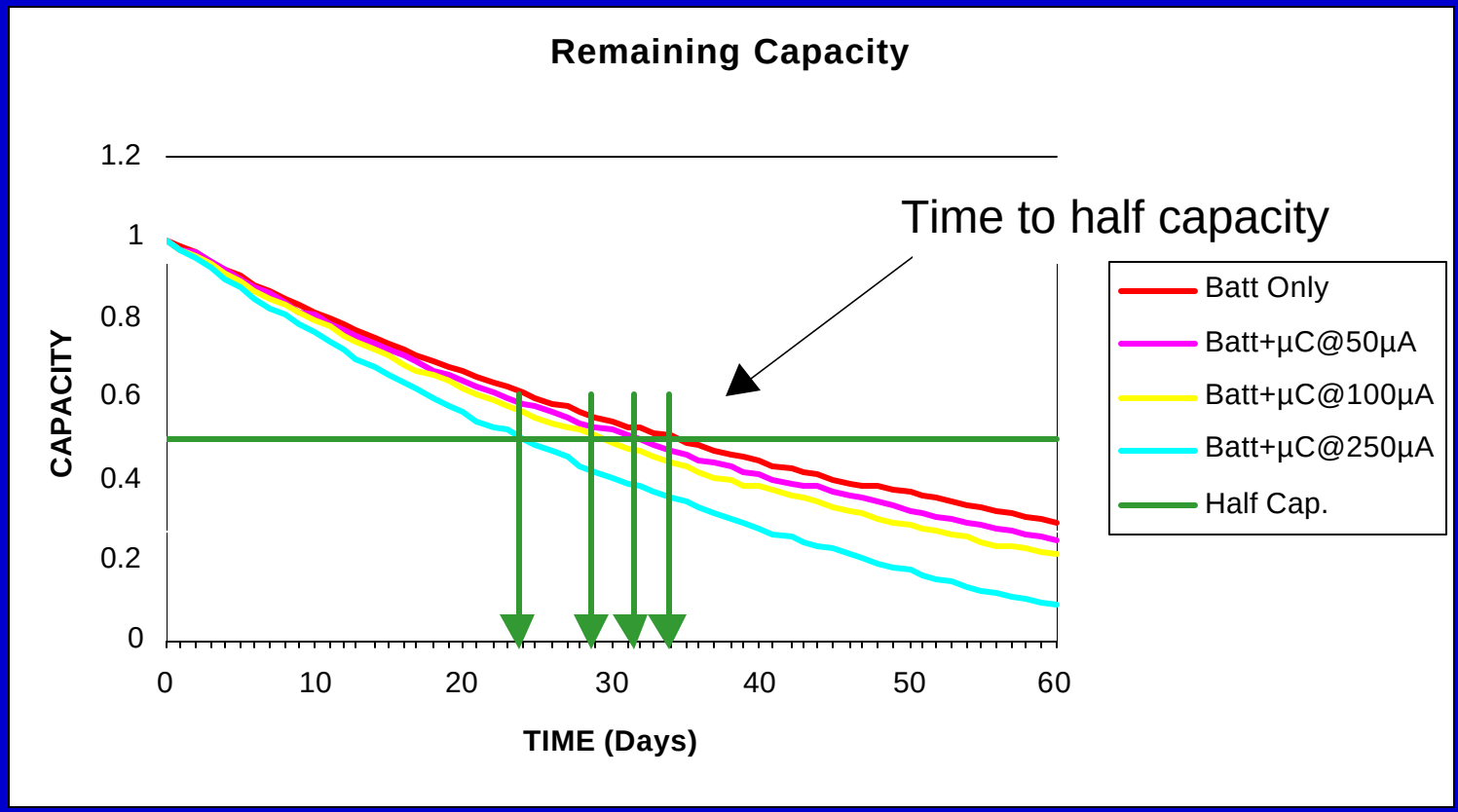
Sampling vs. Integrating

- Important in Coulomb metering
  - Depending on sampling rate transitions or part of them can be missed



Other Design Parameters

- Power consumption of battery electronics



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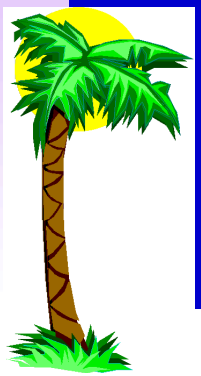
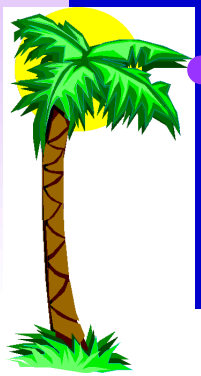


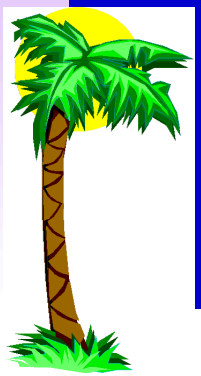
Custom or Standard Sized Packs

- OS doesn't know or care ...
- But, standardization adds hidden system requirements - packs interchangeable
  - Safety, battery life
  - Operational: Max V, operational V range, LV cutoff
  - Charging: max V, max I
  - Care required in system design
- MUST use Smart Charger



Safety Issues

- System makes charging assumptions
  - Fixed charger (e.g. NiMH)
  - Charger is non-compliant (e.g. master only and fails to poll for alarms, does not read thermistor, etc.)
- Poor or bad battery implementations
  - Battery looks like a Smart Battery, but has no or inadequate smarts (I.e. does not control charging)



Battery Life Compromised

- Improper charging
  - May reduce total delivered energy
- Charger can't supply requested charging V/I
- Low voltage cutoff set too high
  - System can't use all the energy in battery
  - Electronics does not see EOC point
- System required higher voltage than battery delivers

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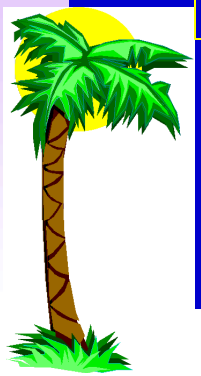
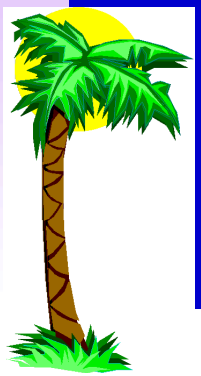


Implications of poor implementations...

- If Smart Batteries
  - Don't offer complete data
  - Are inaccurate
  - Algorithms are poor
- OS will not trust Smart Batteries
- Aggressive PM requires good data



How do we make SB the STANDARD?

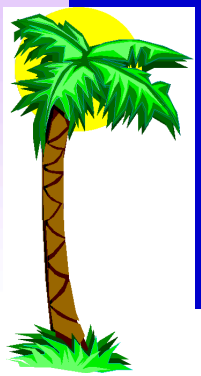
- Classic Chicken & Egg Problem
  - Microsoft needs SB ACPI systems to test SW
  - OEM times system availability to coincide with OS availability - no systems to test!
- Non-compliance data/accuracy
  - OS will not trust batteries
  - OS limited by battery data to use aggressive power policy

Compliance Testing

- Standard compliance tests allow
  - OEMs to verify batteries are compliant
  - Help MS develop confidence in SB
  - Industry reviewers to compare SB implementations
- If we don't ...
  - Ad hoc testing will create confusion
  - MS may develop WHQL tests

Call to Action

- Good SB are cost effective
- Watch the details
- Standard sizes call for extra care
- OEMs must support MS



Backup