Battery Life Challenges on Future Mobile Platforms

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Disclaimer

Actual measurement results may vary depending on the specific hardware and software configuration of the computer system measured, the characteristics of those computer components not under direct measurement, variation in processor manufacturing processes, the benchmark utilized, the specific ambient conditions under which the measurement is taken, and other factors.
Agenda

• Mobility Is Happening
• Battery Life
• Energy Sources
• Energy Consumers
• Summary
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Intel’s Mobility Vision

Simple Secure Wireless Connectivity

Best Performance in Form Factor

Innovative Form Factors for Your Life Style

Exceptional Battery Life
Mobility - - - > Growth

Notebook CAGR 17% ('02-'07)
Source: Gartner, Dec '03

- Strong notebook growth in 2003
- Could point to faster growth trend long term
  - >20% y-t-y growth ’02 to ’03

Mobile % of PCs

Mobility systems expected to be ~60% of volume by 2006*

*Source: Intel analysis based on Gartner Qstats Q1-Q3’03
Mobility - - - > New Lifestyles
Mobility Is Happening

Usage Model Directions

- Digital Office
- On-the-go Lifestyle
- Mobile in the Digital Home

Traditional mobile solution focus

Grow notebook usage with solutions designed for consumers and broader base of business users
Digital Office Vision

Usages and Capabilities

- Integrated Communications (VoIP, Collaboration)
- Extended Mobile Access (Always On)
- Simple Secure Wireless Connectivity
- Exciting New Form Factors (Pen Input, Camera Input)
- Location Based Computing (Location Input)
2005 Digital Office – 14-15” Concept

14-15” All-in-one performance Thin & Light
Next gen Intel® Centrino™ Mobile Technology
EMA, SNS / OBR, VoIP
Camera, Array Microphones,
Fingerprint, Smartcard

Connectivity
WLAN 802.11abg, UMTS-GPRS, Bluetooth*

All-around mobile business notebook

* Other names and brands may be claimed as the property of others
Mobile Digital Home Vision

**Usages and Capabilities**

- Integrated Communications (VoIP, Collaboration)
- Rich Digital Entertainment around the Home (TV, PVR, VoD)
- Exciting Form factors beyond clam shells (Camera Input)
2005 Mobile Digital Home 17” Concept

17” Widescreen portable
Next gen Intel® Centrino™ Mobile Technology
Computer-Media-Communication device
Media stack, BT Remote control, HD Audio
Camera, array microphones, VoIP Handset
TV display experience

Connectivity
802.11abg, Bluetooth*

Mobile Entertainment PC

* Other names and brands may be claimed as the property of others
On-The-Go Lifestyle Vision

Usages and Capabilities

- Integrated Communications (VoIP, Voice, Video, Unified Inbox)
- Extended Mobile Access (Always-On, External Displays, WWAN)
- Simplified Network Selection
- Personal entertainment on road
- Location Based Computing
2005 On-the-Go Lifestyle 12” Concept

12” Detachable tablet / laptop
Next gen Intel® Centrino™ Mobile Technology
Extended Mobile Access (EMA)
Simplified Network Selection (SNS) / One Bill Roaming (OBR)
Media Client, Camera, VoIP
Fingerprint recognition

Connectivity
WLAN 802.11abg, EDGE-GPRS, Bluetooth*

Work around the office or around the world

* Other names and brands may be claimed as the property of others
Convergence in Mobile Notebooks

- Computing: best performance
- Communications: Wireless (WLAN, WWAN, Bluetooth, WiMAX, UWB)
- Entertainment: Digital Video, TV, MP3, WMA, PVR
- Form factor: Clamshells, Tablets, New Portables
- Security: Biometrics, TPM, Smartcards, SIM, LT
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Battery Life Background

• Most Notebooks are measured with BAPCO’s* MobileMark* 2002 benchmark

• Measures Performance and Battery Life for Productivity Workload – assumes typical usage system idle 80% and active 20% of time

• For future usage we need to assume two connected scenarios:
  – Today usage: sleep (not connected), active, idle
  – Always-on – low power (connected), active, idle

*Third party brands and names are the property of their respective owners
Battery Life Innovations

• Intel® Centrino™ Mobile Technology platform improved Thin and Light platform battery life from under 3hr to > 4hrs w/6 cell battery

• Silicon innovations – Intel® Pentium® M processor, Chipsets
  – Dynamic Voltage Scaling; Aggressive Clock gating, Frequency scaling, Intel® 2D Smart Display Technology

• Platform Innovations – Displays, Power Delivery, HDD, ODD
  – Lower Power Displays, Display Power Saving Technology, Buffering Drives, More efficient Voltage Regulators

Longer battery life is desired as users want mobility
Agenda

- Digital Office Vision 2010
- Mobility Is Happening
- Battery Life – Energy Sources
- New Usage Models
- Summary
8-Hr Battery Life Challenges

Battery Life (hr) \approx \frac{\text{Input Power Capacity (Whr)}}{\text{Average Platform Power Consumption (W)}}

Battery Capacity required to meet 8-hour Computing

Conventional Battery increasing \sim 5\text{-}10\% yearly

Large Gap for conventional battery to overcome
Emerging Battery Roadmap

Emerging technologies may bridge the gap
# Battery Summary

<table>
<thead>
<tr>
<th>Battery Type</th>
<th>Volumetric Energy Density (Whr / L)</th>
<th>Gravimetric Energy Density (Whr / kg)</th>
<th>Cost ($)</th>
<th>Cycle Life (80% charge retention)</th>
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<td>400</td>
<td>170</td>
<td>Baseline</td>
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<tr>
<td>Solid State</td>
<td>800-1000</td>
<td>300</td>
<td></td>
<td>3x</td>
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</tbody>
</table>

Emerging battery technologies meet 8-hour computing target
Shorter Term Battery Life Solutions

- Extended Packs, Drive Bay – E.g., IBM T40 (9 cell), Samsung, Toshiba*, etc can deliver 6+Hrs today
  - Heavier, Bulkier
  - Longer Charge Time

- Use Mini Notebooks – E.g., Sony TR3A, IBM X40* can deliver >7hr battery life today with extended packs
  - Compromise on Experience
  - Heavier, Bulkier
  - Longer Charge Time

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Longer Term Battery Life Solutions

- **Fast Recharge Battery -10mins**
  - New Chemistry
  - Smaller Capacity (50-70% of Li-Ion)
  - Heavier Adapters
  - Cost

- **Fuel Cells (Hybrid Battery)**
  - Trickle charge
  - Regulatory Issues
  - Bi-products – generate heat, water
  - Miniaturization required – pumps

Both will require long qualification cycles
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Average Power Contributors 2003 Platforms

Source: Intel Corp.
Average Power Contributors 2003 Platforms

- PWR LOSS, 1.20
- ODD, 0.30
- HDD, 1.00
- LCD, 3.20
- MISC PLATFORM, 1.00
- CLOCK, 0.50
- COM, 0.30
- MEMORY, 0.61
- ICH, 0.30
- MCH, 1.56
- CPU, 0.80

Source: Intel Corp.
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Intel® Centrino™ Mobile Technology Thin & Light Platform Average Power Comparison

Power optimizations can yield >1Hr in Battery Life for same CPU/CS

Thin & Light Platforms

Source: Intel Corp.

Plenty of Opportunity to Improve Battery Life
LCD Display

- Current technology is based on Amorphous TFT, largely driven by conversions of TV LCD
  - Trending to higher power (4.5-5.5W Displays) for NB’s

- New technology – Low Temperature Poly Silicon (LTPS)
  - Reduced power (2.8-3W), Thinner, lighter (less components), Brighter (let’s more light thru – thus reduces Back light)

- Longer Term potential
  - OLED/PLED – eliminate backlight, but currently higher power
  - Flexible Displays – polymer based
Display Power Goals & Challenges

- Key Areas to focus
  - Display subsystem - let more light thru with less energy
  - Back light - reduce or eliminate back light
  - Improve power delivery

- Challenges
  - User like higher resolution (XGA, SXGA+, QXGA, UXGA)
  - Bright screens (150-200+ nits) – note MM’02 uses 60 nits, some OEMS quote battery life at 30 nits
  - Larger displays (E.g., 14.4”, 15.4”, 17”)
Other Display Power Reductions Opportunities

- Use camera or light sensor to detect ambient lighting to decrease or increase back light on Notebook
  - Can result in 0.5-1W reduction in average power

- User presence detect (UPD) – uses camera to detect user is present / absent or attention to control display or system
  - Can result significant savings >1-2W on typical usage
**Intel® Pentium® M Processor – Makes Right Hand Turn**

- Lower Thermal Design Power – Thinner & Lighter FF
- Lower Average Power - Longer Battery Life

![Graph showing the performance and power consumption of Intel processors over time](image)

*Intel® Pentium® M delivers high performance and best performance / watt*

Dynamic Voltage Scaling (DVS)

- One \( \mu \) ARCH implementation – Power and energy control

Switch on Thermal or Utilization
Dynamic Voltage Scaling (DVS)

- PLL relock at lower frequency at same Vcc
- Fast change – no user experience impact

Short time O.K with S/W
Dynamic Voltage Scaling (DVS)

- Vcc drops gradually while CPU active
- Power savings changes from linear to $F^3$

Performance drops by Function of F (Frequency)

CPU power drops by $P = C \cdot V^2 \cdot F \Rightarrow$ function of $F^3$

Power savings > time increase
Energy net savings
Dynamic Voltage Scaling (DVS)

- Vcc is ramped up increasing power
- Once stable – PLL relock at high frequency
Adaptive Energy Control

- Applications have dynamic need - require high power high performance bursts

- Trade Average power vs. performance as needed
  - Driven by User thru Operating system ACPI (Max Battery, Max Performance or Adaptive - Average power control on the fly)
Average Power management on Thin & Light NB

Source: Intel Corp.
Average Power management on Thin & Light NB

- 48% Performance, 66% Power, Efficiency 1:1.4 - Static
- 10% Performance, 43% Power, Efficiency 1:4

Source: Intel Corp.
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Trends – Straining Battery Life

• Higher performance Si (General Purpose, Media, Graphics)
  – More Logic, Bigger Caches, Higher Speed Interconnect, Com

• Proliferating Usage - Always-Connected, Media Usage

• Better Displays - Bigger, Brighter, Higher Resolution

• Shrinking Si Geometries – Leakage dominates Idle power

• New operating systems – MS Longhorn, 3D User Interface
Call to Action

- Drive System Level Approach to increasing Battery Life
  - Newer Display Technologies
  - Device Performance States (ala DVS in Peripherals)
  - Lower power platform designs
  - Turn off devices when not in use

- Drive to address leakage power on all Silicon

- Drive low average power on all Si - CPU, Chipset, Graphics

- Drive software to be power state aware (e.g., remove loops)

- Drive development of higher density energy and fast renewable sources