Enhancing the Visual Experience on the Mobile Computing and Communications Platforms

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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.

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Outline

- Mobile computing: recent trends
- Consumer focus: key requirements
- Video & display technologies for mobile platforms: advances, challenges and opportunities
Personal Computing & the Internet are going mobile...
Personal Computing is Going Mobile!

Worldwide PC Shipments

- **Mobile**
- **Desk-based**

Source: Intel Estimates
Internet to Pass All Other Media

Consumer Spending by Media

- Internet Access
- All TV
- Books
- Newspapers
- Film
- Recorded Music
- Magazines
- Video Games
- Radio

Source: Pricewaterhouse Coopers
Mobility and Growth

The Mobile Era In Phones
Worldwide Phone Lines

1876: Invention of Telephone
1973: Mobile Phone

Mobility Will Have As Profound Effect On The Internet and Computer As It Did On The Phone!

Source: CTIA, RHK
Intel is Building on a Tradition of Notebook Platforms

Napa 2006
- Intel® Core™ Duo Processor
- Intel® Wireless WiFi Link 4965AGN

Santa Rosa 2007
- Refresh
- Intel® Core™ 2 Duo Processor
- Penryn (with Intel 45nm Hi-k metal gate silicon technology)

Montevina 2008
- Refresh
Santa Rosa Platform Launched May 2007
Building for 2008: Montevina Platform
Intel Technology Spans the Mobile Computing Spectrum

MID, UMPC

Notebooks

CPU

Graphics & Chipset

Wi-Fi / WiMax
Consumers Driving Mobility; Even in Emerging Markets

Notebook as % of Consumer PC Market Segment

Source: Intel estimates
Key Consumer Trends

• Web video growing in importance in Mainstream Consumer experience
  - The average consumer watches 151 minutes of video over the Internet a month¹
  - User-generated content sites (YouTube, etc), TV networks, and movie studios are providing compelling content

Growth in Worldwide Broadband Penetration is Enabling the Video Revolution

Video complexity is on the rise...
“The Fast and the Furious: Tokyo Drift”

1920x1080 HD Primary Video
Advanced Graphics Layer
Secondary video
Menus

• Courtesy to Andre Espinoza, Universal Studios Home Entertainment, for providing the HD DVD movie image
• HD DVD Logo is a Trademark of DVD Format/Logo Licensing Corporation.
Pervasive Media Usage: Intel Vision

Consumers Enjoying Entertainment
(Movies, Music, Photos, Games)
Anytime... on Any Device

In the Home
On the Go

Enjoy Media & Games
Stream Content to Connected Devices
Synch Content to Media Players
Take Media with You
Burn-N-Go
Key Requirements for the Video & Display Subsystem

- Low-power to enable long battery life
- “CE-like” visual experience
  - High-quality video decode and post-processing architecture and algorithms
  - Display with high brightness, high contrast & color gamut, fast response time & blur-free motion performance
- Display with form-factor and attributes for mobile usages
  - Thin & light
  - Viewable in both dark and bright ambient
  - Wide viewing angle
- New consumer usages (e.g. low-power high-quality faster-than-real-time encoding/transcoding, etc.)
Notebook Video & Display Subsystem: Platform View

- **Graphics Controller**
  - Display Controller
  - GPU & Media Accel. Engines

- **Memory**
  - Data, Buffers

- **LCD Panel**
  - RX/TCON
  - Drivers
  - Display Controller
  - LCD
  - Backlight

- **Opportunity for system-level optimization…**

- Major elements
  - Video & Display processor in Graphics Controller
  - LCD module: LCD panel, drive electronics, backlight
  - Display interface
LCD as the Mobile Computer Display

First, The Good: LCD Made “Mobility” Possible
Issues with LCD:
1. LCD optical stack has very poor efficiency

Consumes almost half of platform average power at full brightness
2. LCD exhibits severe motion blur due to
   a. Slow LC response time
   b. Sample-and-Hold characteristics

Blurred Video
Mobility’s Nemesis: Battery Life

Display is the largest consumer of notebook average power!

BAPCo® MobileMark® 2005 Workload Average Power
System: Thin & Light segment Notebook, 2.26 GHz Intel® Centrino® processor technology, Intel® 915GM chipset, 14.1” XGA display, 60 GB Hard Disk, 512 MB DDRII-533 memory, CD/DVD Drive, Microsoft® Windows® XP SP2 Operating System
Note: The subsystem percentages noted in the chart are representative figures; they may vary from platform to platform.
Strong Market Demand for Battery Life

- User research study to better understand laptop purchase process, usage and satisfaction
- New buyers: Top three factors in laptop purchases
  - #1: High Performance or Speed
  - #2: Long battery life
  - #3: Wireless Capability
- Existing users: Desired improvements with current laptop
  - Battery life ranked #1

Long battery life: a high priority end-user requirement

*Intel research Dec 2005, US, Japan, Europe, China*
System-Level Display Optimization for Mobile Platforms

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<tr>
<th>Traditional Approach</th>
<th>Intel® Centrino® Platforms</th>
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<td><strong>LCD Backlighting</strong></td>
<td>Dynamic backlight level and image adjustment</td>
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<td>Static settings independent of content</td>
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<td>and ambient lighting</td>
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<td><strong>LCD Driving</strong></td>
<td>Dynamic and seamless refresh rate management</td>
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<td>Refresh rate change associated with</td>
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<td>glitch on display</td>
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Frame Buffer

Image Analysis

Processing

Image Adaptation

LCD Panel

Backlight

Backlight Controller

User & Platform Policy

Frame Buffer

Image Analysis

Processing

Image Adaptation

LCD Panel

Backlight

Backlight Controller

User & Platform Policy
Intel® Display Power Saving Technology (DPST)

- DPST digitally enhances the graphics and video images prior to transmission to display, simultaneously adjusts the backlight.
- ~25% backlight power saved: >1W at full panel brightness.
- Most major OEMs have adopted DPST on laptops.
Intel® Automatic Display Brightness

- Ambient Light Sensor detects ambient light conditions
- Automatic Display Brightness feature uses this information to adjust backlight brightness as appropriate for current environment
  - In a dark environment, decreases backlight brightness to account for increased sensitivity of human eye as pupil dilates
  - In a bright environment, increases backlight to adjust for decreased human eye sensitivity

Usability benefit, and in some environments, power savings benefits
Intel® Display Refresh Rate Switching

Higher Motion
Increased Power

Example Refresh Rates

60Hz
50Hz
40Hz
...

Lower Motion
Decreased Power

Power conservation by dynamically switching between multiple display refresh rates depending on content and power policy.

Reduced power consumption in panel electronics, display controller, display link, and memory.
Dynamic Display Power Optimization* using Multi-Field Drive Technology

High motion content

60Hz
Progressive

Dynamic seamless switching based on motion detection

Static / low-motion content

60Hz
Interlace

Progressive: \( n \)th “frame”
60 “frames” per second

Interlace: \( n \)th “field”
60 “fields” per second

\((n+1)\)th “field”

Reduced power consumption in panel electronics, display controller, display link, and memory

* Jointly developed by Intel and Toshiba Matsushita Display Technology Co., Ltd.
LED is Emerging as LCD Backlight

Chart and data from Toshiba Matsushita Display Technology Company Ltd.
Intel® Graphics Media Accelerator

- Array of Cores
  - Multi core
  - Multi-thread per core
  - Advanced SIMD ISA

- Fixed Functions
  - Sampler: texture engine
  - Math: transcendental
  - ITC: Inter thread communication
  - CC: Color Calculator
  - 3D: 3D fixed function pipe
  - Media: Media fixed function pipe

Advanced graphics media architecture balancing programmable and fixed function acceleration
### Processing Pipeline in Intel® Clear Video Technology

<table>
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<th>Video Processing Pipeline</th>
<th>Description</th>
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<td>Temporal/Spatial Adaptive Noise Reduction</td>
<td>• Remove video sensor, analog and digital noise</td>
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</table>
| Film Mode Detection | • Convert Interlaced video to Progressive Scan video.  
| Advanced Deinterlacing | • Includes 24 to 30 frame rate conversion and Film mode detection. |
| Adaptive Detail Enhancement | • Sharpness and detail enhancement |
| Scaling |  
| Color Enhancement | • Change size to match display size/type  
|  | • Enhance picture contrast and color |
Hollywood Quality Video (HQV*)

What is it?

- Current “De Facto” benchmark intended to evaluate video quality in the consumer electronics industry
  - Created and published by Silicon Optix*

- Subjectively scored
  - Each test contains brief visual descriptions of potential video artifacts and scoring guidelines for the resulting image

- 10 different test patterns designed to test variety of scenarios
  - De-interlacing
  - Detail Enhancement
  - Noise reduction
  - Film cadence detection

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Improving Video Quality

- Significant video quality enhancement from last generation chipsets
- Performance scalability provided through flexible graphics architecture

* Please see demos in the Mobility Zone
Advanced De-interlacing

Intel® GM945 without Intel® Clear Video Technology

Intel® GM965 with Intel® Clear Video Technology

* Images obtained from Silicon Optix HQV benchmark
Film-Mode Detection & Reconstruction

- Detects when progressive “film-mode” content is encoded as interlaced
- Intelligently combines fields to recreate original progressive frames
- Support for large number of cadences:
  - 3:2, 2:2, 2:2:2:4, 2:3:3:2, 3:2:3:2:2, 5:5, 6:4, 8:7

Without Intel® Clear Video Technology

With Intel® Clear Video Technology

* Images obtained from Silicon Optix HQV benchmark
Detail Enhancement

- Detects and sharpens edges of image increasing visibility of scene detail
- Reduces perceived image softness
- Adaptive technology to sharpen image w/o emphasize noise

* Images obtained from Silicon Optix HQV benchmark
Example Comparison (Out-of-Box)

Comp A

Comp B

GM965

* Images obtained from Silicon Optix HQV benchmark
Example Comparison (Custom Player)

Comp A

Comp B

GM965

* Images obtained from Silicon Optix HQV benchmark
Transition from SD to HD...

- **6X Resolution:**
  - from SD (720x480) to HD (1920x1080)

- **>5X Codec complexity:**
  - From 1-stream MPEG2 to 2-stream MPEG2/AVC/VC1

- **>4X Usage complexity:**
  - From 2-plane non-interactive to multi-plane interactive

Graphics/Media Processor with Media Hardware Assist

Video Codec Pipe

Future Graphics Generations

Intel will continue innovation to bring power efficient, high quality, HD media experience to mobile platforms.
Compensating for LCD Slow Response Time

- **Frame Interval**
- **Gray Level**
- **Luminance Response**
  - Deficit at End of Frame Interval
  - Compensation: Over-Drive to overcome deficit
  - Compensation: Under-Drive to overcome deficit

### Graphs
- **Slow gray-to-gray response time of mainstream laptop**
  - w/o overdrive
- **Improved with Overdrive**
  - w/ overdrive

**Intel**
Summary

- Rapid growth continues in the mobile computing market, aided by exploding internet usage and technology advancements.
- Intel is leading the mobility wave with power-performance optimized platforms.
- Significant challenges and opportunities for the video & display technologies to continue enhancing the visual experience for the consumer.
- We look forward to collaborative R&D with innovators in the academia.