Mobile Platform Idle Power Optimization – Methodologies and Tools

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Session ID: EBLS003
Agenda

- Mobile platform energy efficiency goals
- Hardware considerations
- Software considerations
- Tools for idle power analysis
Mobile Platform Energy Efficiency Goals

Minimize power consumption while idle

- Mobile client systems are idle (low CPU utilization) most of the time
  
  Example: Office PC loaded with many IT applications

- Even with moderately busy workloads, there are a lot of low CPU utilization sections

Source: Intel Corporation
Platform Power Saving Features

• Today’s mobile platform implements many power saving features
• But, many systems are not taking full advantage of them
  – Not properly configured
  – Bad component selection
  – Bad software activities
• One bad component can cause significant impact
Agenda

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CPU Power Saving

- CPU is a well power managed component
  - Dynamic power supply voltage
    Lower voltage when CPU utilization is low
  - Power gating
    Turn off power when CPU is idle to minimize leakage
  - CPU can adjust performance/power to the workload
- But, burns energy at each idle/active transition
Software Impact to Platform Power

- Resource utilization (CPU cycle count) isn’t the only factor
- Periodicity of the activity makes big impact
- Optimization needs to address both
- Details will be discussed in the software section
PCI Express* / SATA Power Saving

- Serial buses implement Link Power Management
  - L0s and L1 (ASPM) states for PCI Express* links
  - Partial and Slumber states for SATA links
- Maximize residency in the lower power states
- But, just setting enable bits isn’t enough
  Actual residency determined by many factors
  - Traffic on the bus
  - Device and driver policy

Recommendations

- Select devices with adequate policy*
- Verify LPM state residency in the shipping configuration
- Configure driver policy if necessary
  Intel® Rapid Storage Technology (RST) has registry settings for SATA policy*

Please see the following white papers for details:
- Designing Energy Efficient SATA Devices (SATA devices)
- Energy-efficient platform devices (PCI Express* devices)
USB Device Power Saving

• USB operates on periodic polling and keeps large part of platform in active state

• USB device should implement Selective Suspend and stay in that state as long as possible

Please see the following white papers for details:
• Energy-efficient platform devices
• Making USB a more energy efficient interconnect

PCIe = PCI Express* Technology
USB Device Power Saving (Cont.)

- Periodic device polling diminishes the benefit of selective suspend

Recommendations:
- Choose devices with selective suspend support
- Minimize access to the devices
- Place the device closer to host controller if periodic access is necessary
Interrupt Sharing

- Interrupt sharing increases platform activity
  - ISRs (Interrupt Service Routines) for multiple devices are executed to determine the source of interrupt
  - Each ISR accesses its hardware and wakes bus from low power state

Recommendations
- Make sure device and driver support MSI
- If not, assign dedicated line for devices with frequent interrupts

PCLe = PCI Express Technology
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Optimize Application Behavior

- Two major factors that determine platform power
  - Resource Utilization
    - (e.g. CPU utilization)
  - Resource Usage Pattern
    - Fragmented activities cause more power impact

- Focus on idle
Application Design Principles

- Optimize Resource Usage
- Coalesce Timers
- Reduce Periodic Activity

Respect System Idle
Respect System Idle

• Idle dominates usage scenarios for client systems
  – Reducing idle power is essential for extending battery life
  – Windows* 7 made vast improvements

Source: Microsoft Corporation
Optimize Resource Usage

- Performance improvement = power improvement
- Architect event driven designs instead of polling or spinning
  - `WaitForSingleObjectEx()` or `SleepEx()`

```c
void EatBatteryLife()
{
    HANDLE sharedResource = NULL;

    //your process waits for a file to be created via:
    while (sharedResource == NULL)
    {
        waitTime++;
        sleep(1);
    }
}
```
WaitForSingleObjectEx() API Usage

//process 1's code
void UpdateSharedResource()
{
    //set sharedResource
    sharedResource = UpdateResource();

    // Set sharedResourceIsReadyEvent to // signaled
    SetEvent(sharedResourceIsReadyEvent);
}

//process 2's code
void ConsumeSharedResource()
{
    DWORD dwWaitResult;

    dwWaitResult = WaitForSingleObjectEx(
        sharedResourceIsReadyEvent,
        INFINITE,
        FALSE);  // indefinite wait

    switch (dwWaitResult)
    {
        case WAIT_OBJECT_0:
            // TODO: use sharedResource
            //
            break;
        default:
            return 0;
            //
    }
}
Optimize Resource Usage (2)

• Repainting GUI cascades work to graphics controller
  – 1 pixel change causes 10 VBI
  – Avoid animation icons in the system tray area

• Don’t use WMI where Win32 APIs or .NET classes will suffice
  – Example: Repeated Win32_Directory enumeration vs. FileSystemWatcher class

• Choose event-driven APIs
  – Example: EvtSubscribe() instead of EventLogQuery()
Optimize Resource Usage (3)

• Assume all devices have power states
• Reduce device activity to enable low power states
  – Disk spin-down
  – Periodic, low-priority disk activity from applications should be on order of several hours
  – Batch I/Os where possible
  – Use volatile registry keys for transient information

Example HDD Power

Source: Microsoft Corporation
Reduce Periodic Activity

• Avoid changing timer resolution from the default setting
  – Avoid reducing by using larger buffers
  – If you want more granular timestamps, use QueryPerformanceCounter()

• Media playback should use 10ms (or larger)
  – Limit request to as little codepath as possible

• Audio playback code should use event-driven, shared-mode WASAPI*

* Please see Windows* 7 SDK sample code at C:\Program Files\Microsoft SDKs\Windows\v7.0\Samples\multimedia\audio\n
Source: Microsoft Corporation
Reduce Periodic Activity (2)

• Thread ping-pong effects
  – Avoid extremely short duration ‘work & signal’ patterns
    – Use of RPC/COM can cause this
  – Battery Life Analyzer tool provides insight into thread behavior
Coalesce Timers

• Kernel mode and user mode timers should coalesce with other work on the system for minimum power impact
  – Need to engineer for timing tolerance
• New coalescing APIs in Windows* 7
SetWaitableTimerEx() API

- Replace calls to SetWaitableTimer() with this API
  - More efficient than a purely periodic timer
  - Tolerance parameter should scale with the timer period

```c
BOOL WINAPI SetWaitableTimerEx(
    __in     HANDLE hTimer,
    __in     const LARGE_INTEGER *lpDueTime,
    __in     LONG lPeriod,
    __in_opt PTIMERAPCROUTINE pfnCompletionRoutine,
    __in_opt LPVOID lpArgToCompletionRoutine,
    __in_opt PREASON_CONTEXT WakeContext,
    __in     ULONG TolerableDelay
);
```
SetWaitableTimerEx() API Usage

```c
void CreateAndSetPeriodicTimer()
{
    myTimer = CreateWaitableTimerEx(NULL,
        TimerName, //string with chosen timer name
        NULL,
        TIMER_MODIFY_STATE); //required security attribute to call
        //SetWaitableTimerEx

    bError = SetWaitableTimerEx(myTimer,
        DueTime, //UTC due time
        10000, //periodic timer duration is ten seconds
        CompletionRoutinePointer, //APC completion routine
        ArgsToCompletionRoutine, //completion routine arguments
        WakeContext, //only if waking the machine
        1000); //tolerable delay is one second

    //DO WORK

    bError = CancelWaitableTimer(myTimer); //be sure to cancel periodic timers!
}
```
Bonus: Optimize for System State

- System state holds optimization potential for applications
  - Firewall application should do very little when the PC is not connected to network
- Register for power state change notifications
  - Use the callback to trigger behavioral changes

Source: Microsoft Corporation
RegisterPowerSettingNotification() API

- Allows you to register for change notifications on power settings
- Callback is a notification to change application behavior
  - Includes new power setting value

```cpp
void MyApp::OnInit()
{
    hACDCSource = RegisterPowerSettingNotification(m_hWnd,
        &GUID_ACDC_POWER_SOURCE,
        DEVICE_NOTIFY_WINDOW_HANDLE);
}
void MyApp::OnDestroy()
{
    if (hACDCSource != 0)
        UnregisterPowerSettingNotification(hACDCSource);
}
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Choose the Right Tool

- **Microsoft* Windows* “PowerCfg /energy”**
  - OS Built-in command
  - Easy to use, suitable for identifying some common issues

- **Microsoft* Windows* Performance Toolkit (xperf)**
  - Built on ETW (Event Tracing for Windows) Technology
  - Good tool for deep performance / power analysis

- **Battery Life Analyzer**
  - New tool from Intel
  - Easy to use, suitable for identifying bad components
  - More detailed information on Intel mobile platforms
  - Built on ETW Technology
Battery Life Analyzer - Outline

• High level tool to identify battery life issues
  – Simple GUI application
  – In most cases, it takes only few mouse clicks

• Quantifies the impact of the issues
  – Where possible, power impact is estimated
Battery Life Analyzer - Features

- **Hardware Analysis**
  - CPU C-state residency
  - PCI Express*, SATA Link Power Management
  - USB selective suspend

- **Software Analysis**
  - Fine-grained CPU utilization information
  - Periodicity of the activity
  - Concurrency of multi-core activity
  - Graphics activity
  - Identify process causing HDD spin-ups
Battery Life Analyzer – CPU C-State

CPU C-State Example:
• High residency in the deepest C-state
• All software behaving well
Battery Life Analyzer – SATA LPM

SATA Link Power Management

• Bad Example
  – DVD drive not entering Slumber state

• Good Example
  – Same drive enters Slumber state after enabling host initiated Slumber in the registry
Battery Life Analyzer – HDD Spin-up

Disk Activity Analysis

Identify which process/routine is causing HDD spin-up
Summary

• Your product has a direct impact to the battery life of mobile platforms
• One bad product can ruin the customer experience
• Start looking at the impact to idle power
• Tools and more information are available from Intel and Microsoft
Call to Action

• Get tools
  – “PowerCfg /energy”
    Windows* 7 built in command
  – Microsoft* Windows* Performance Toolkit (xperf)
    Now included in Windows 7 SDK
  – Battery Life Analyzer
    Send e-mail to: BatteryLifeAnalyzer@intel.com

• Analyze your product and identify the issue
• Improve power efficiency of your product
Additional sources of information on this topic:

- **Other Sessions**
  - EBLS001: Interconnect Bus Extensions for Energy-Efficient Platforms
  - EBLS002: Impact of “Idle” Software on Battery Life

- **White papers**
    - Designing Energy Efficient SATA Devices
    - Making USB a More Energy-Efficient Interconnect
    - Energy-Efficient Platforms – Considerations for Application Software and Service
    - Mobile Battery Life Solutions Guide for Windows 7
    - Developing Efficient Background Processes for Windows
    - Using PowerCfg to Evaluate System Energy Efficiency
    - Windows Timer Coalescing
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Backup Slides
PowerSetRequest() API

• Replaces setthreadexecutionstate()
• Allows you to issue availability requests for monitor & system
• Allows you to create a custom, localized reason string
• Does not prevent user-initiated sleep transitions
void KeepSystemAwake()
{
    // This example uses a simple, non-localized availability request diagnostic string
    POWER_REQUEST_CONTEXT SimpleRqContext;
    SimpleRqContext.Version = POWER_REQUEST_CONTEXT_VERSION;
    SimpleRqContext.Flags = POWER_REQUEST_CONTEXT_SIMPLE_STRING;
    SimpleRqContext.Reason.SimpleReasonString = L"System needed to burn a CD."
;
    HANDLE SimplePowerRequest = PowerCreateRequest(&SimpleRqContext);

    // Set a system request to prevent automatic sleep
    PowerSetRequest(SimplePowerRequest,PowerRequestSystemRequired);

    //
    // Do work here...
    //

    // Clear the request
    PowerClearRequest(SimplePowerRequest,PowerRequestSystemRequired);
}