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Advancing the Platform

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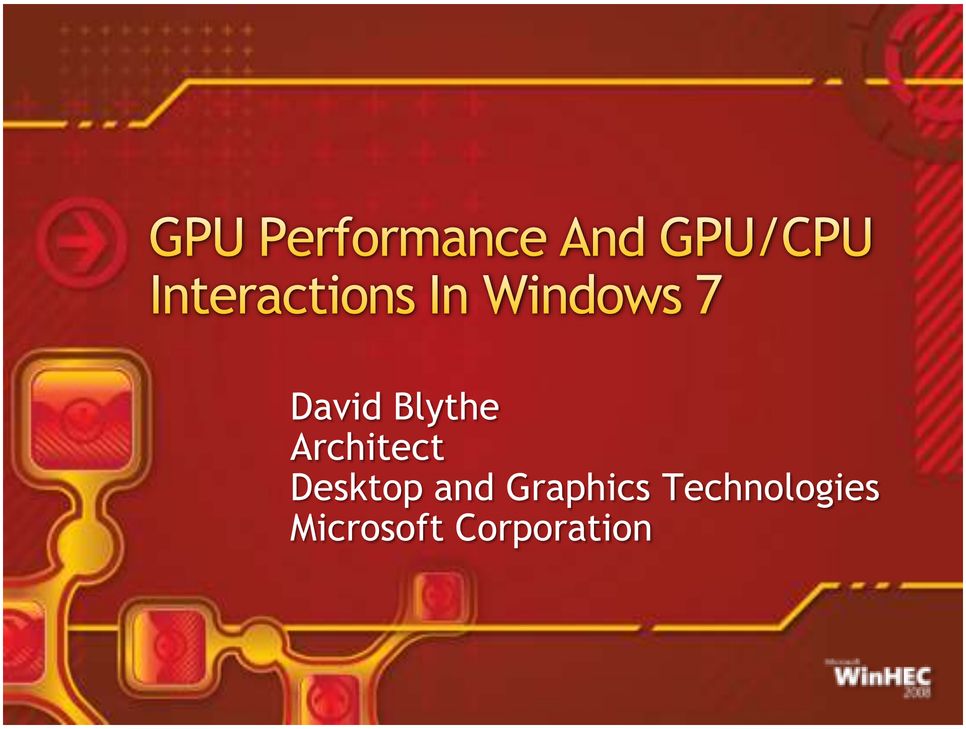

GPU Performance And GPU/CPU Interactions In Windows 7

David Blythe
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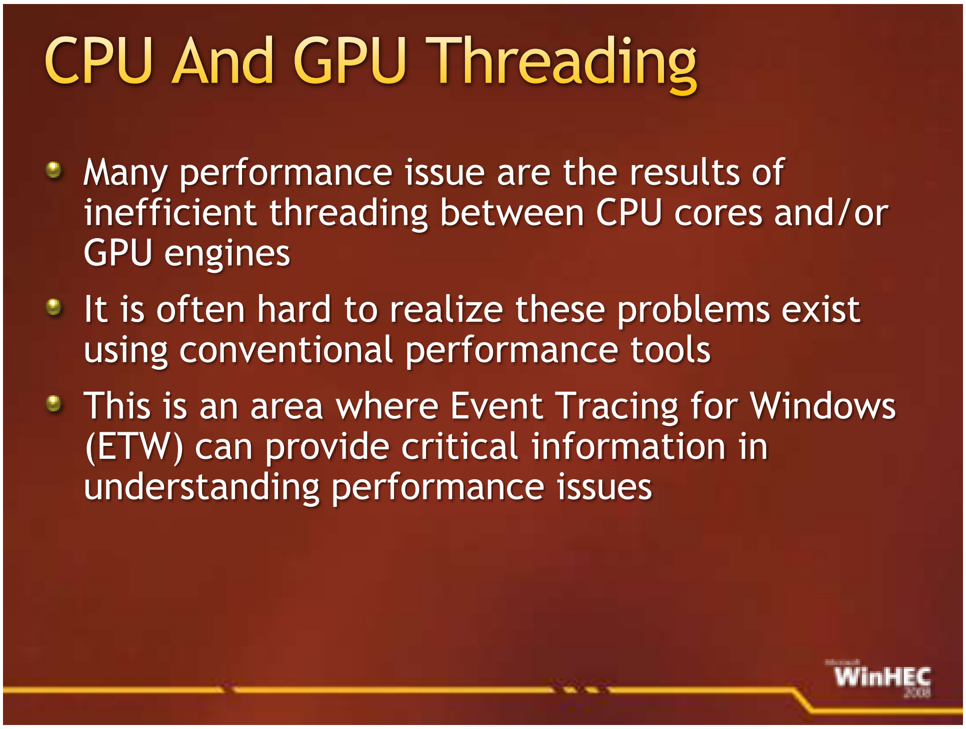
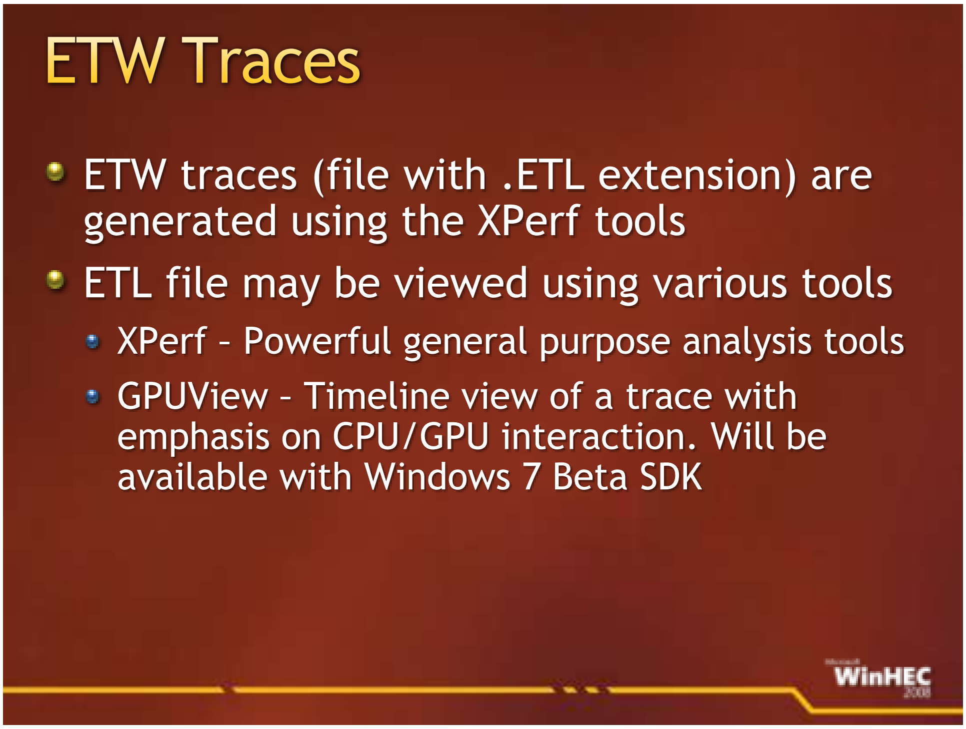


CPU And GPU Threading

- Many performance issue are the results of inefficient threading between CPU cores and/or GPU engines
- It is often hard to realize these problems exist using conventional performance tools
- This is an area where Event Tracing for Windows (ETW) can provide critical information in understanding performance issues



ETW Traces

- ETW traces (file with .ETL extension) are generated using the XPerf tools
- ETL file may be viewed using various tools
  - XPerf - Powerful general purpose analysis tools
  - GPUView - Timeline view of a trace with emphasis on CPU/GPU interaction. Will be available with Windows 7 Beta SDK

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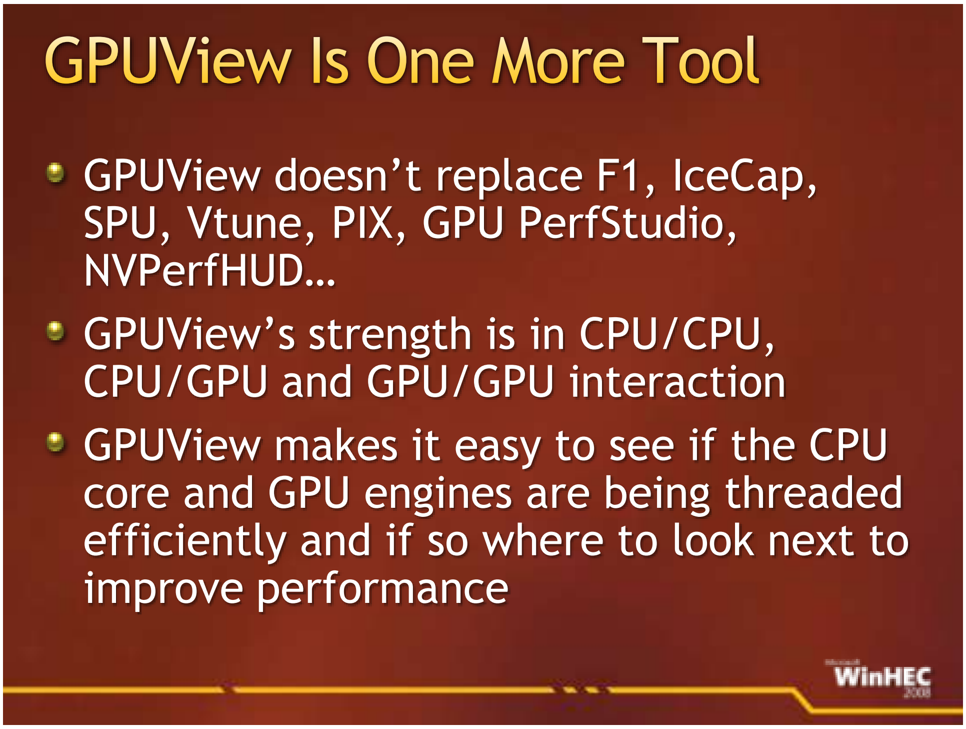
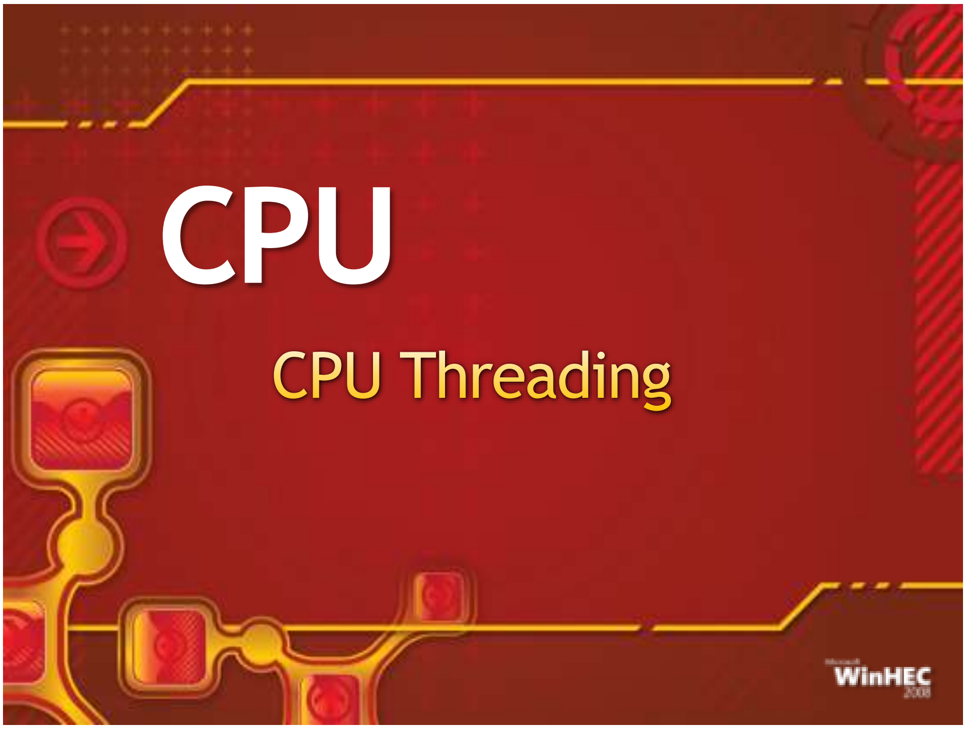


GPUView Is One More Tool

- GPUView doesn’t replace F1, IceCap, SPU, Vtune, PIX, GPU PerfStudio, NVPerfHUD…
- GPUView’s strength is in CPU/CPU, CPU/GPU and GPU/GPU interaction
- GPUView makes it easy to see if the CPU core and GPU engines are being threaded efficiently and if so where to look next to improve performance



CPU

CPU Threading

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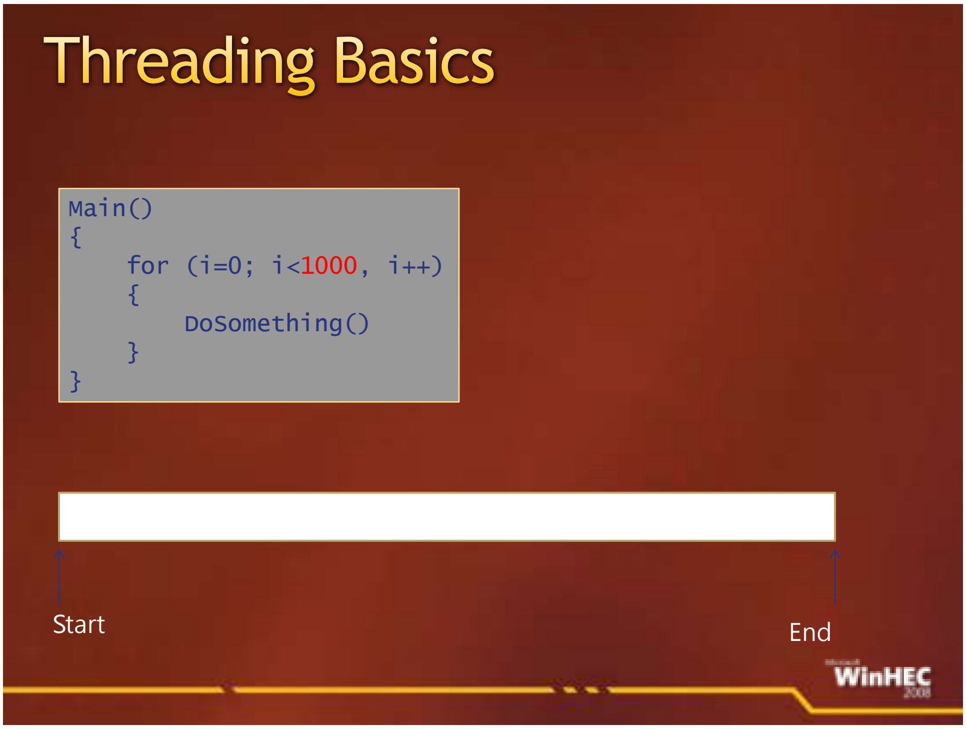
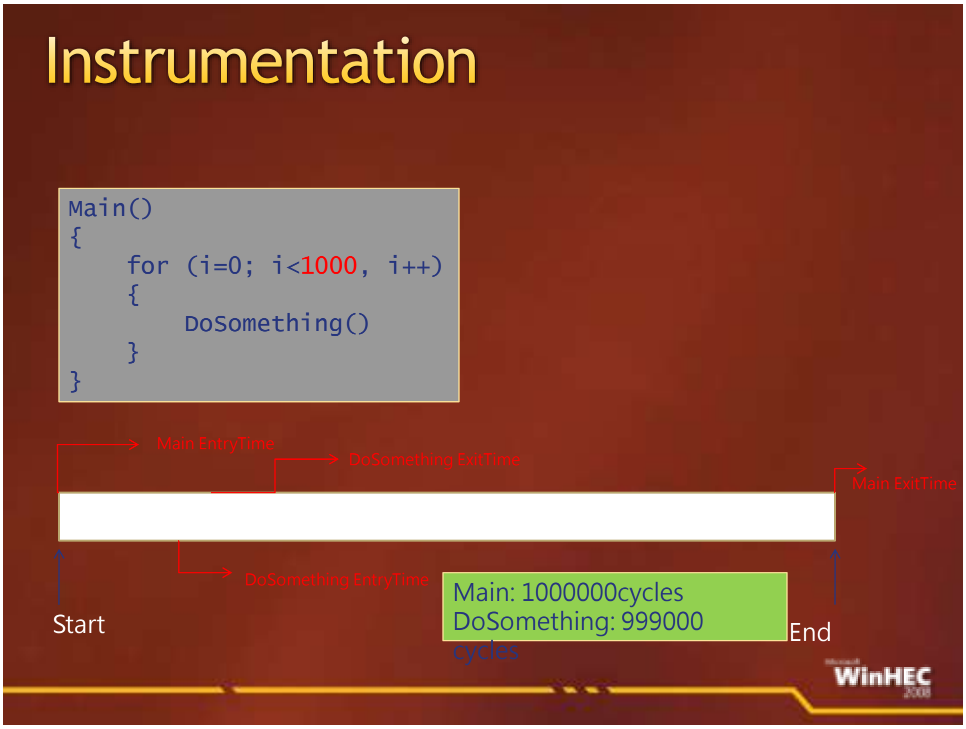


Threading Basics

```
Main()
{
    for (i=0; i<1000, i++)
    {
        DoSomething()
    }
}
```

Start

End



Instrumentation

```
Main()
{
    for (i=0; i<1000, i++)
    {
        DoSomething()
    }
}
```

Main EntryTime

DoSomething ExitTime

Main ExitTime

DoSomething EntryTime

Start

Main: 1000000cycles
DoSomething: 999000 cycles

End

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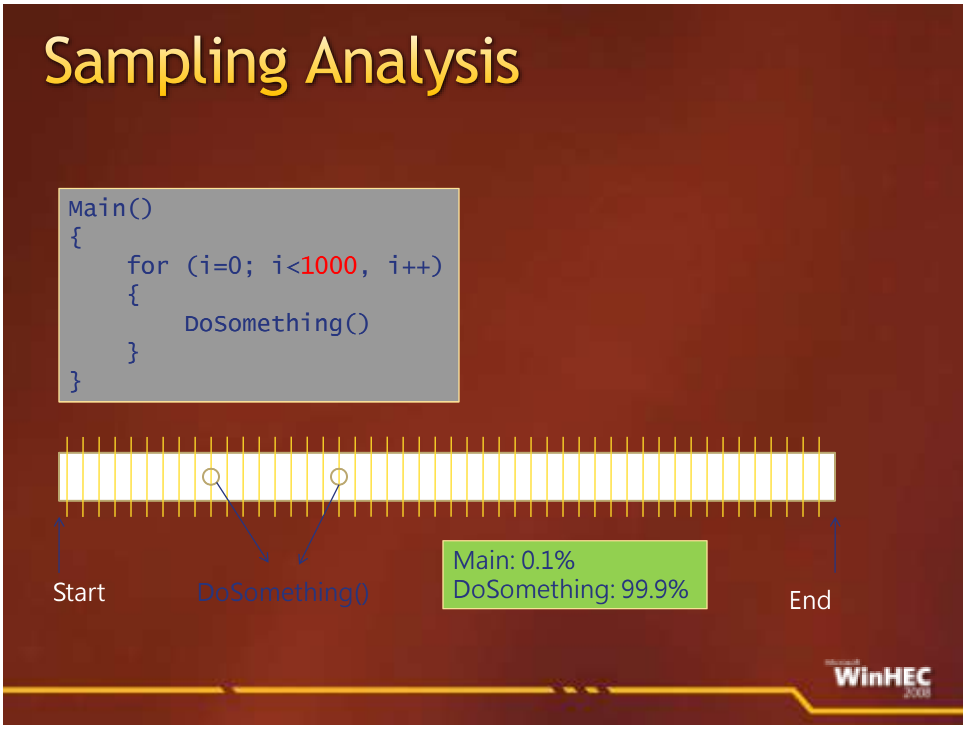


Sampling Analysis

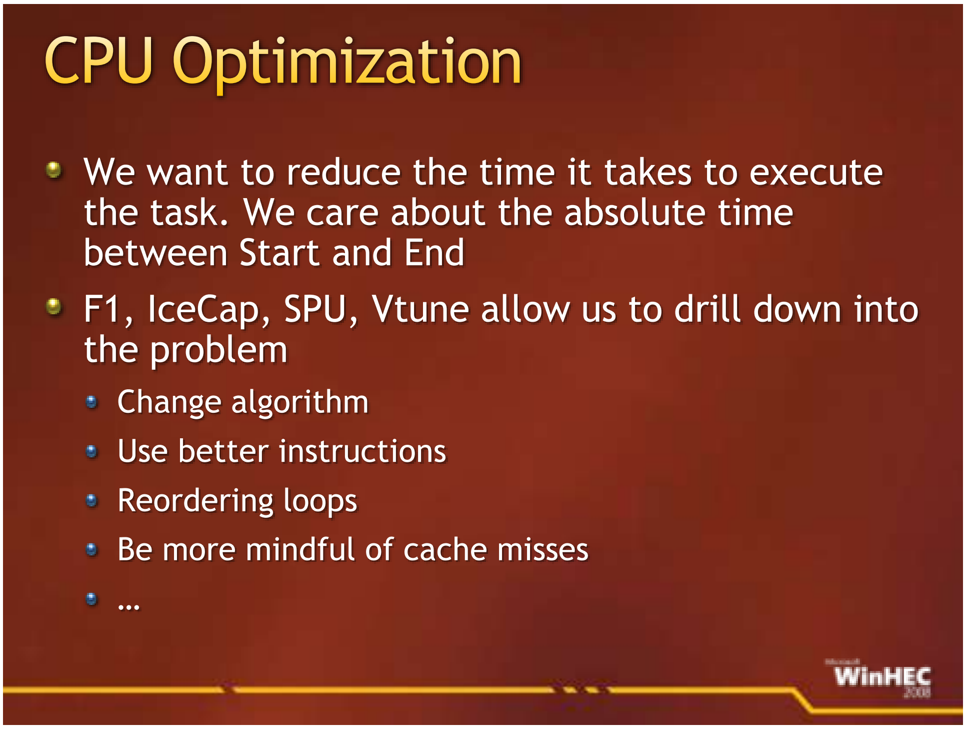
```
Main()
{
    for (i=0; i<1000, i++)
    {
        DoSomething()
    }
}
```

Start

DoSomething()

Main: 0.1%
DoSomething: 99.9%

End



CPU Optimization

- We want to reduce the time it takes to execute the task. We care about the absolute time between Start and End
- F1, IceCap, SPU, Vtune allow us to drill down into the problem
  - Change algorithm
  - Use better instructions
  - Reordering loops
  - Be more mindful of cache misses
  - …

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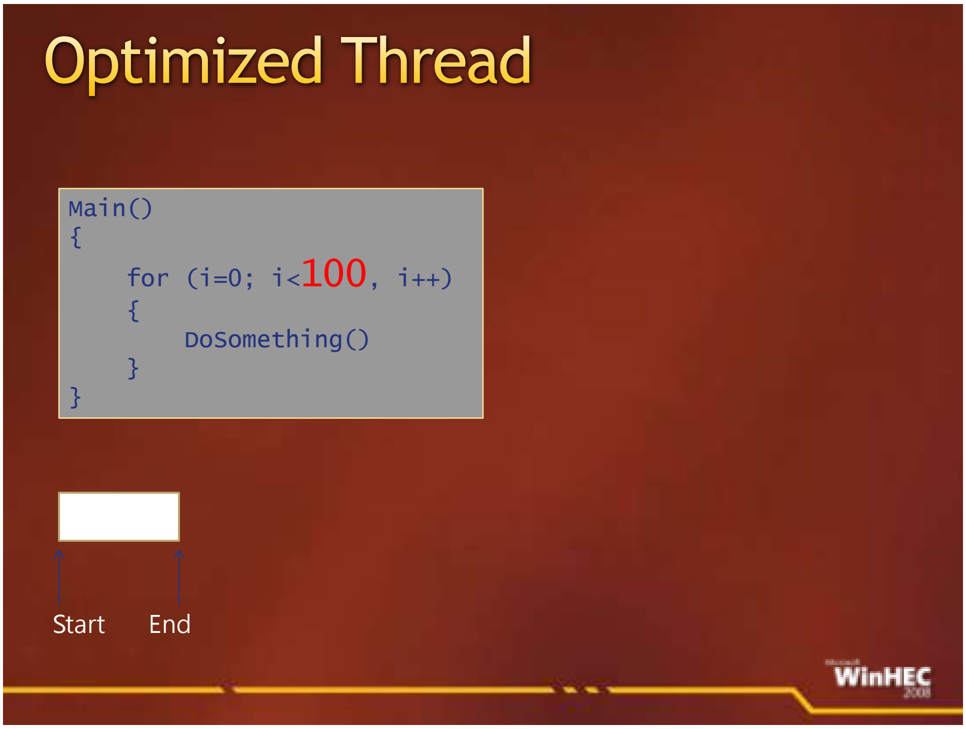

Optimized Thread

```
Main()
{
    for (i=0; i<100, i++)
    {
        DoSomething()
    }
}
```

Start
End
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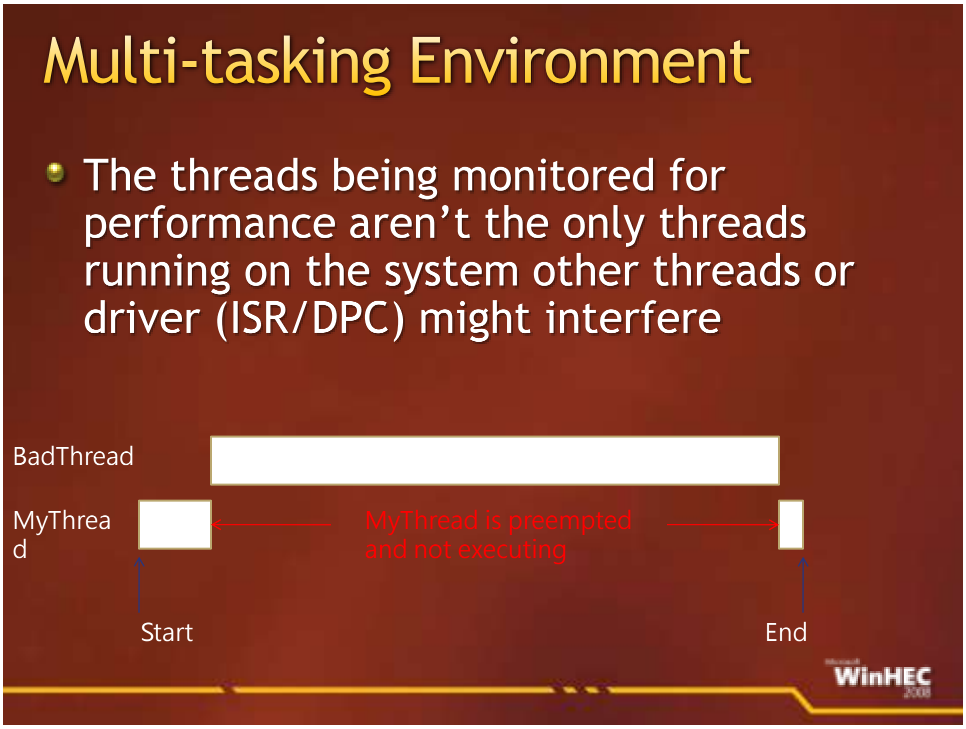

Multi-tasking Environment

- The threads being monitored for performance aren’t the only threads running on the system other threads or driver (ISR/DPC) might interfere

BadThread
MyThread
MyThread is preempted and not executing
Start
End
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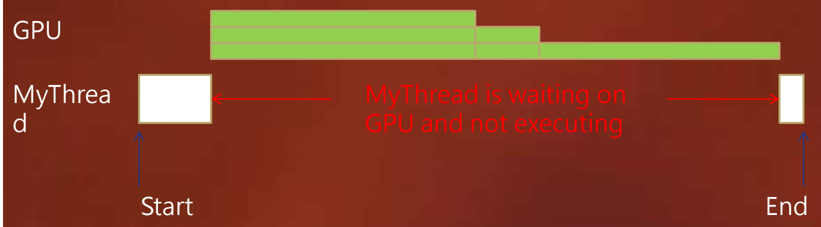
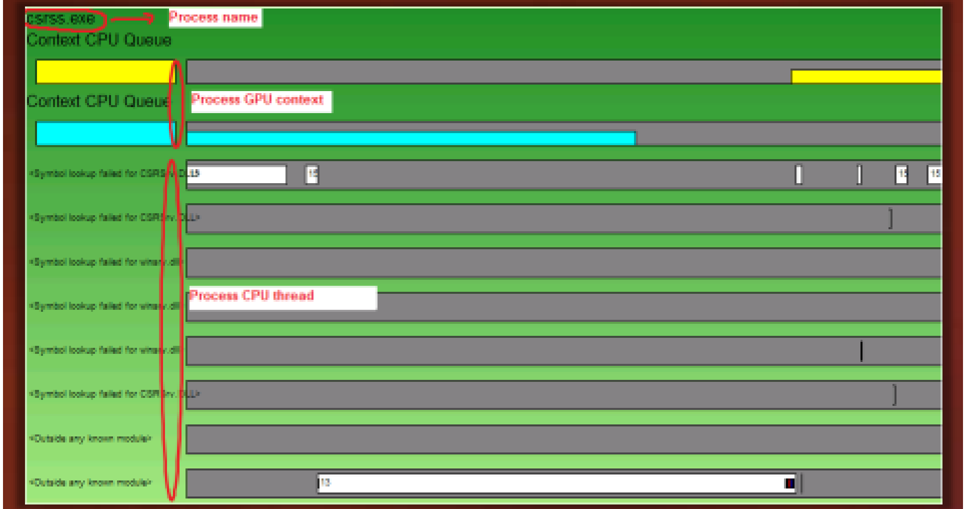
Device Interaction

- A thread might interact with other threads or with a device and may be put into a wait state waiting for something to happen on another thread or device



GPUView Process View


csrss.exe
Process name
Context CPU Queue
Context CPU Queue
Process GPU context
<Symbol lookup failed for CSRSrv.DLL>
<Symbol lookup failed for CSRSrv.DLL>
<Symbol lookup failed for winsrv.dll>
Process CPU thread
<Symbol lookup failed for winsrv.dll>
<Symbol lookup failed for winsrv.dll>
<Symbol lookup failed for CSRSrv.DLL>
<Outside any known module>
<Outside any known module>

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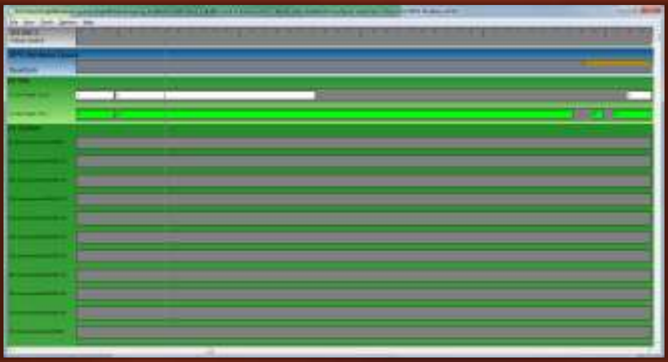
Idle Thread

- Every CPU core executes a particular thread at any given time; When Idle, a core executes the idle thread



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CPU Core

- Every CPU core gets assigned a color, threads are colored from the core they are executing on

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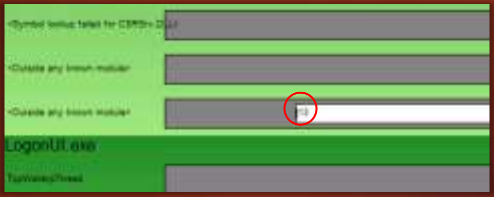
Thread Priority

- The priority at which a thread segment is executing is displayed in the left portion of that segment; If the segment isn't large enough, zoom in



<Symbol lookup failed for CSRSS> [illegible]
<Outside any known module>
<Outside any known module>
LogonUI.exe
TpWaiterThread

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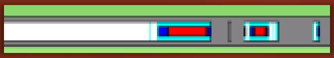
Thread Execution

- Thread segments are colored to help identified what the thread is currently doing
  - Light blue: Thread in kernel mode
    (only if syscall events were enabled as tracing option, not available on MP system)
  - Dark blue: Thread in dxgkrnl
  - Red: Thread in KMD



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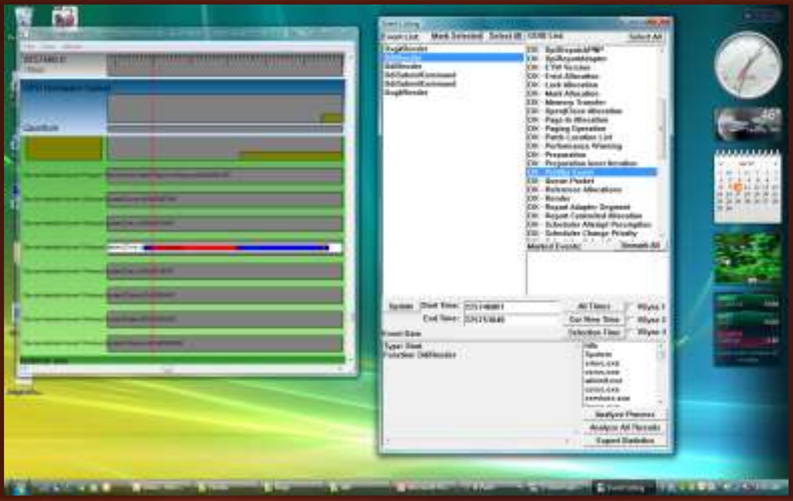
Thread Profiler Events



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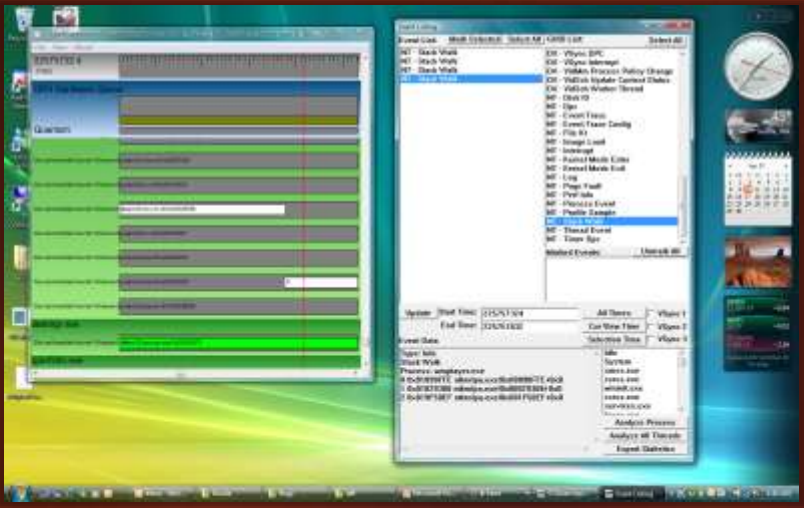
Context Switch Stack



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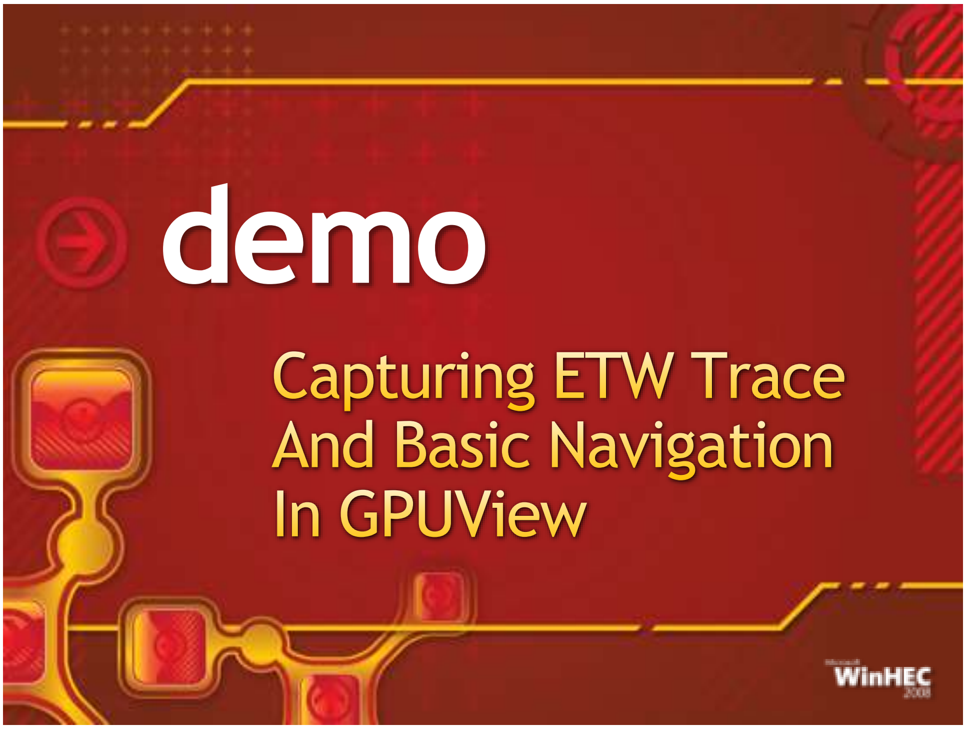
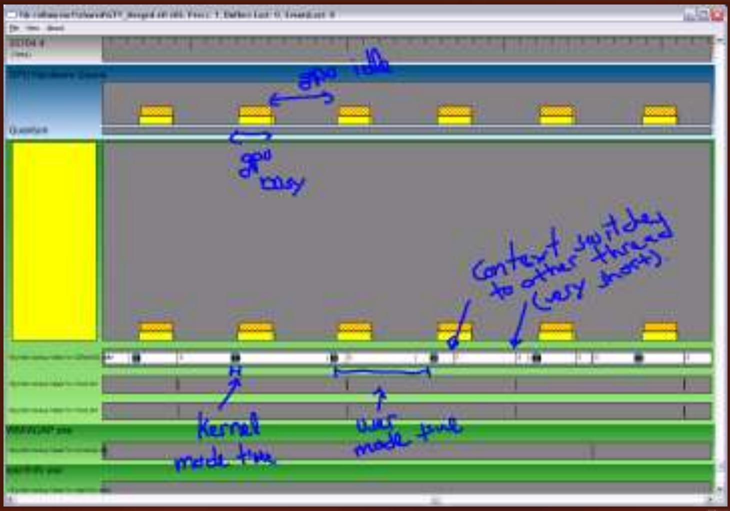


demo

Capturing ETW Trace And Basic Navigation In GPUView

Example: CPU Bound Game



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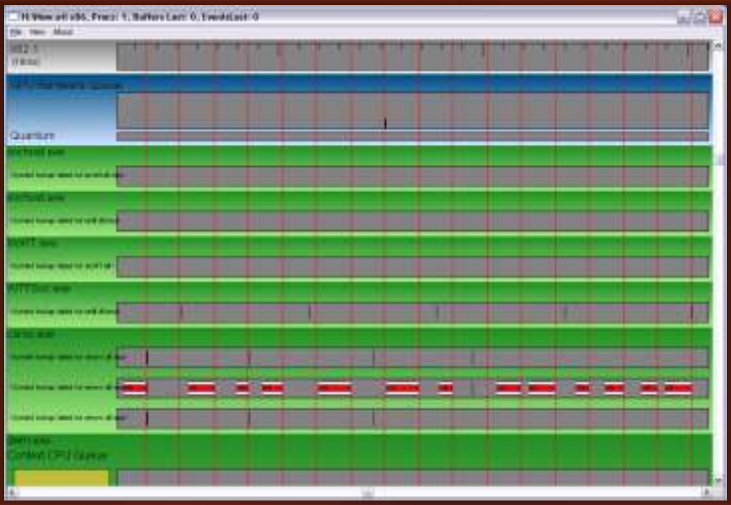
Example: Interference



GPU

GPU Threading

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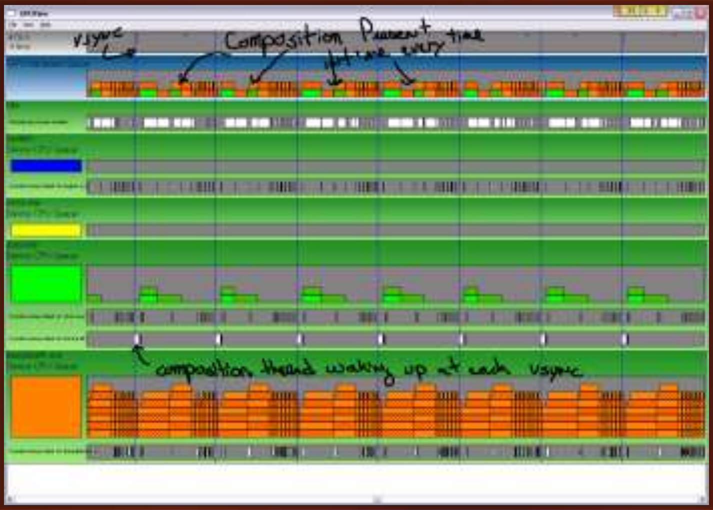
GPU Context And Engine Queue



Context Queue

- The device queue (also referred to as the software queue or QueuePacket queue) represents the accumulation of work submitted by a process to a particular GPU Context
- A process can have multiple GPU contexts (ex: Multi D3D Device, LDA, Video…)

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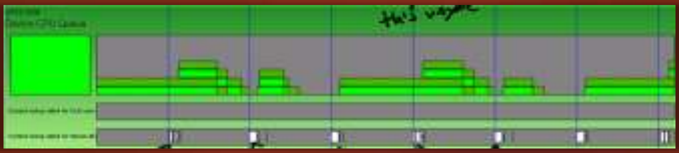
Context Queue

- Queue is represented through time as a histogram
- On submission of work by the UMD the histogram grows up, on completion of work by the GPU the histogram goes down



Queue Packet

- Various type of packet may be queued
  - Orange: MMIO flip
  - Diag-Cross Hatch: Present through DMA
  - Cross Hatch: Deferred Command
  - Light Pink: WaitForSynchronizationObject
  - Dark Pink: SignalSynchronizationObject

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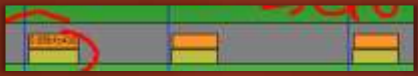
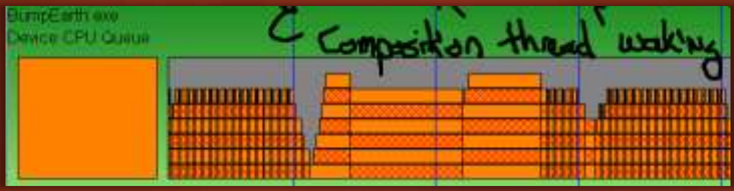
MMIO Flip

- Completion of the packet indicate the flip was pushed to the flip queue
- Flips are dequeued from the flip queue:
  - At VSYNC for synchronized flip
  - Immediately for immediate flip
- The content of the flip queue isn't currently displayed by GPUView
- Packet contain two pieces of information
  - VidPnSource : PrimaryAllocationHandle



Present Through DMA

- Three types of present through DMA
  - DWM Redirection
  - Blit to back buffer
  - Immediate flip (through DMA)



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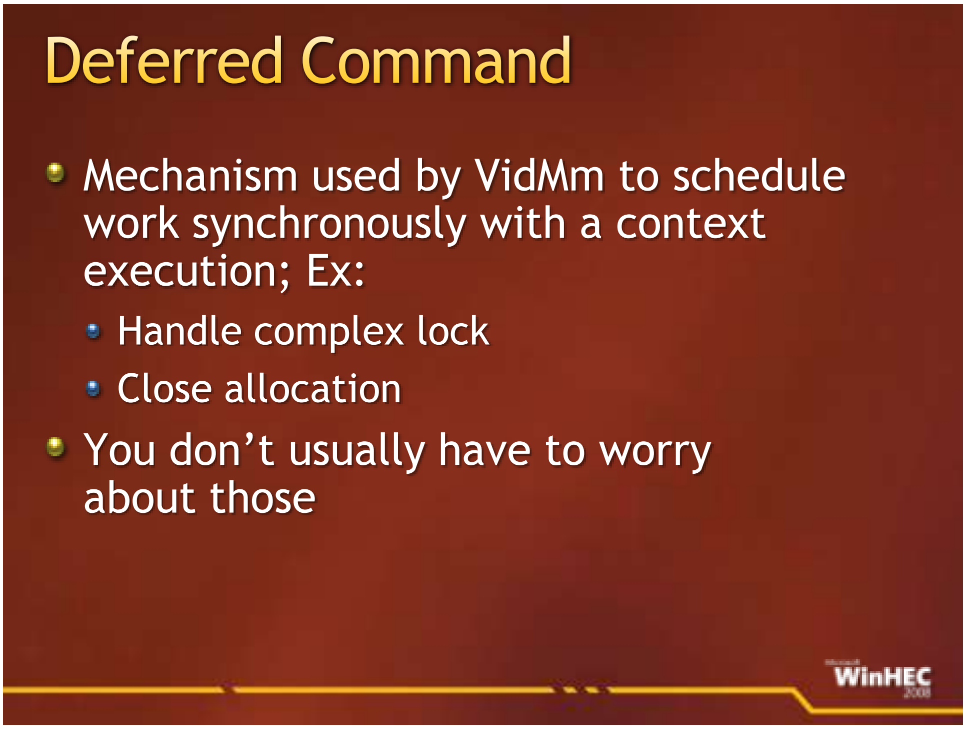
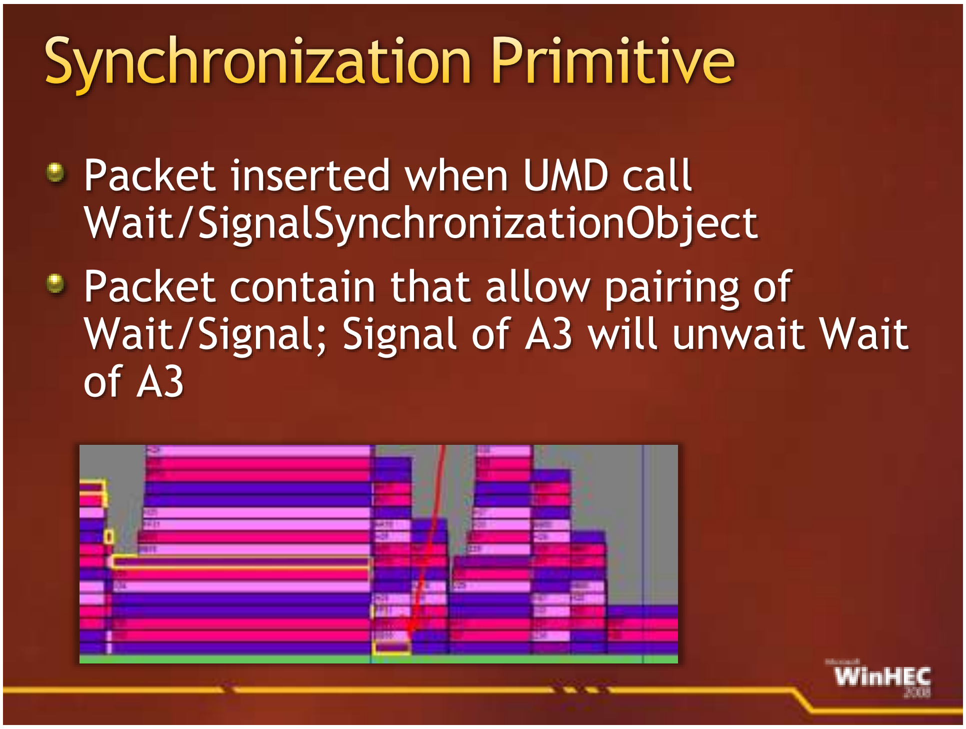


Deferred Command

- Mechanism used by VidMm to schedule work synchronously with a context execution; Ex:
  - Handle complex lock
  - Close allocation
- You don’t usually have to worry about those



Synchronization Primitive

- Packet inserted when UMD call Wait/SignalSynchronizationObject
- Packet contain that allow pairing of Wait/Signal; Signal of A3 will unwait Wait of A3

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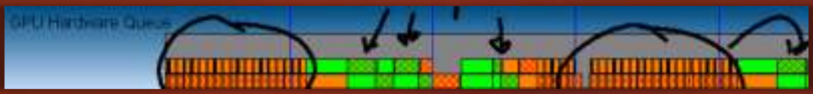
GPU Engine Queue

- Also referred as hardware queue or DMAPacket queue
- Represent work (DMA Buffer) submitted to a particular GPU engine for execution
- Each exposed engine has exactly ONE engine queue



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DMA Packet

- Various type of DMA packet may be submitted to the GPU
  - Red: Paging
  - Black: Preemption
  - Diag-cross hatch: Present (through DMA)
  - Other: DMA payload from QueuePacket

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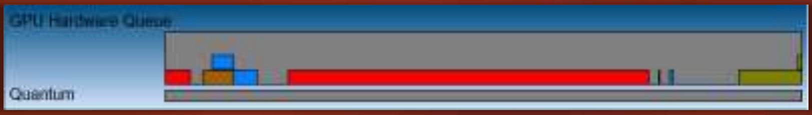
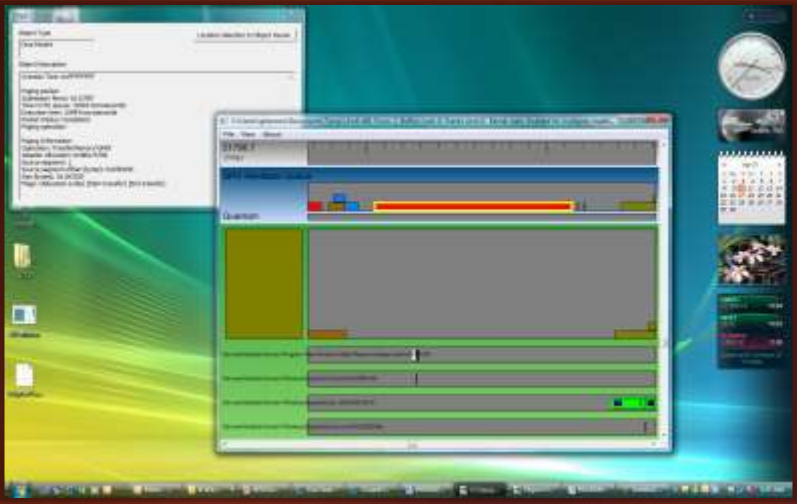
Paging Buffer

- Submitted as a result of a paging operation
- Cause of paging operation is usually the preparation of a DMA buffer; Look at the DMA packet following the paging operation
- Some exception
  - Pinning allocation
  - Evict allocation as a result of a DxLock
  - …



Paging Details



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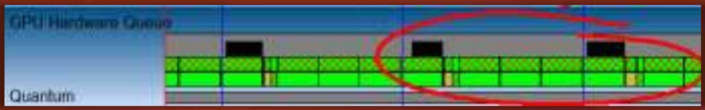
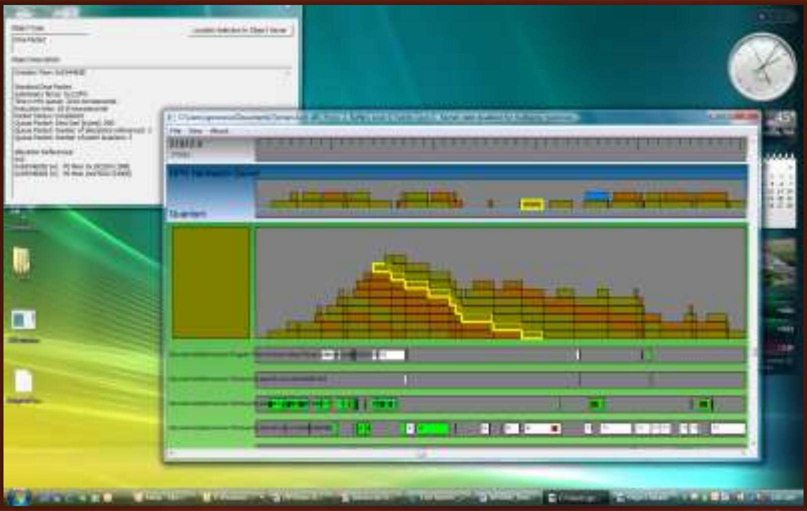
Preemption

- Represent request by the schedule to preempt the DMA packet currently in the engine queue
- Preemption request don’t have actual payload; Their completion indicate GPU acknowledgement of the preemption request



QueuePacket With DMA Payload



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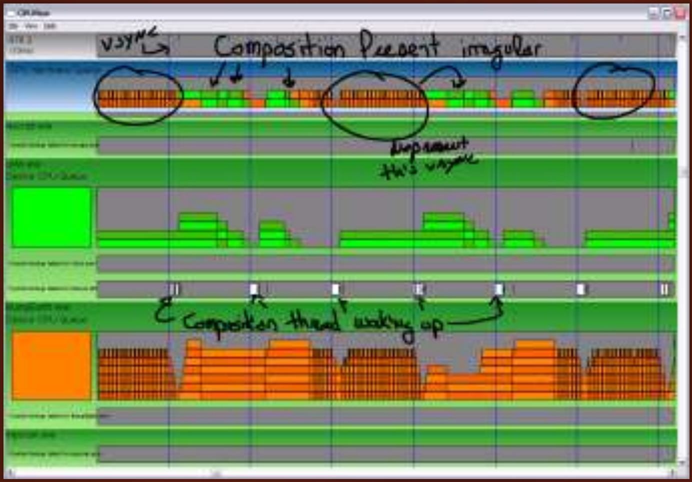
demo

GPU Usage In GPUView

Ex: DWM Regular GPU Priority



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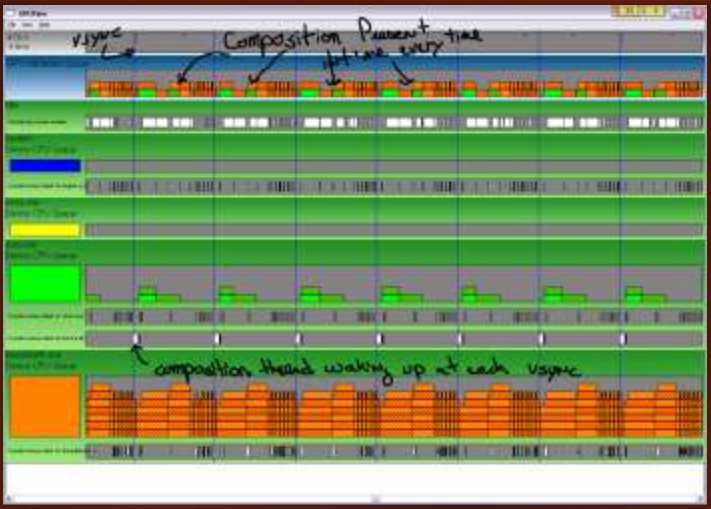
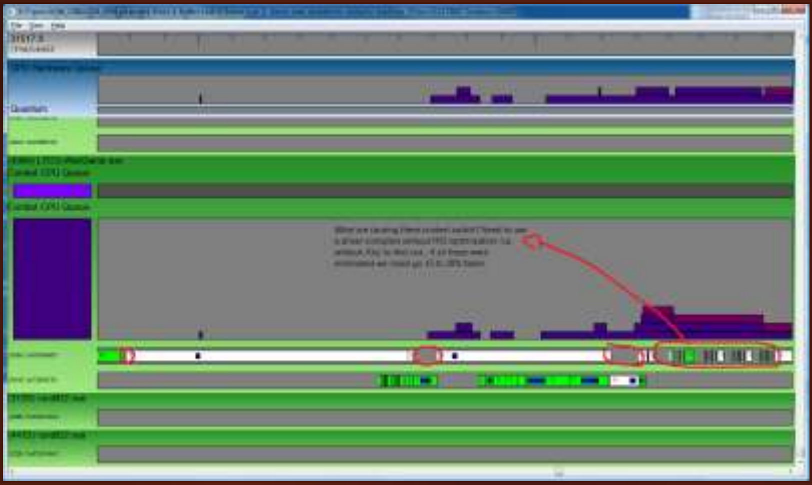
Ex: DWM High GPU Priority


vsync
Composition
Present picture every time
composition thread waking up at each vsync

Ex: Available Resources



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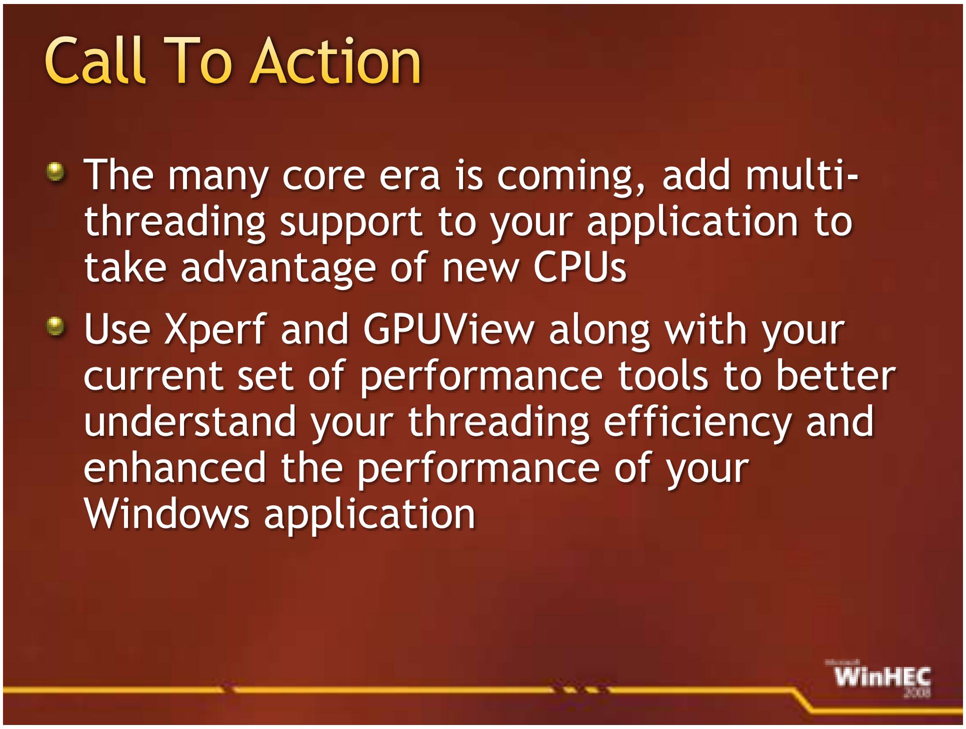
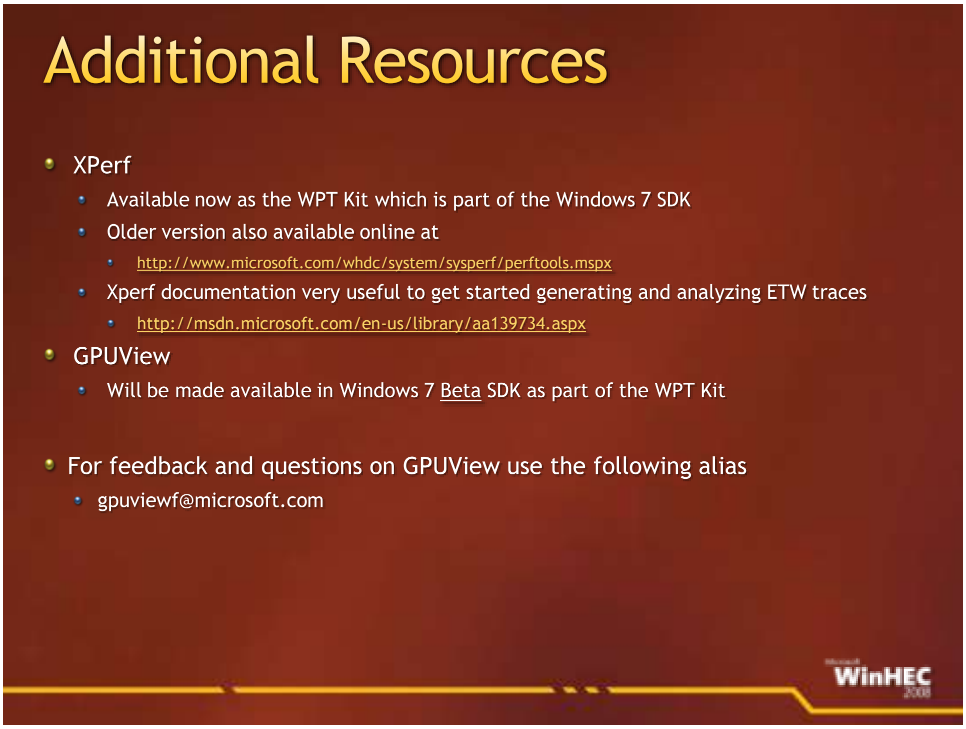


Call To Action

- The many core era is coming, add multi-threading support to your application to take advantage of new CPUs
- Use Xperf and GPUView along with your current set of performance tools to better understand your threading efficiency and enhanced the performance of your Windows application



Additional Resources

- XPerf
  - Available now as the WPT Kit which is part of the Windows 7 SDK
  - Older version also available online at
    - http://www.microsoft.com/whdc/system/sysperf/perftools.mspx
  - Xperf documentation very useful to get started generating and analyzing ETW traces
    - http://msdn.microsoft.com/en-us/library/aa139734.aspx
- GPUView
  - Will be made available in Windows 7 Beta SDK as part of the WPT Kit
- For feedback and questions on GPUView use the following alias
  - gpuviewf@microsoft.com

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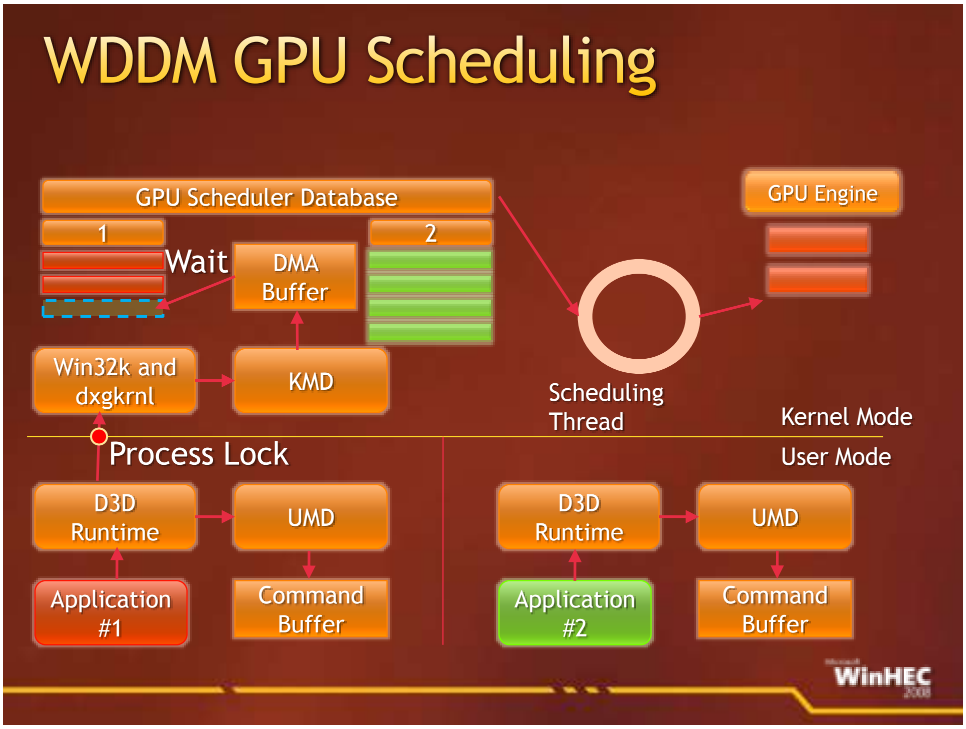
Appendix



WDDM GPU Scheduling

GPU Scheduler Database

1

2

Wait

DMA Buffer

Win32k and dxgkrnl

KMD

Scheduling Thread

GPU Engine

Kernel Mode

User Mode

Process Lock

D3D Runtime

UMD

Application #1

Command Buffer

D3D Runtime

UMD

Application #2

Command Buffer

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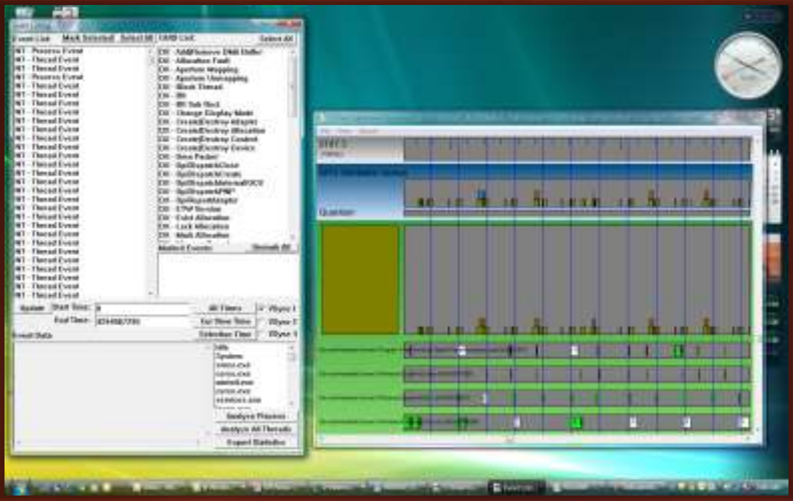
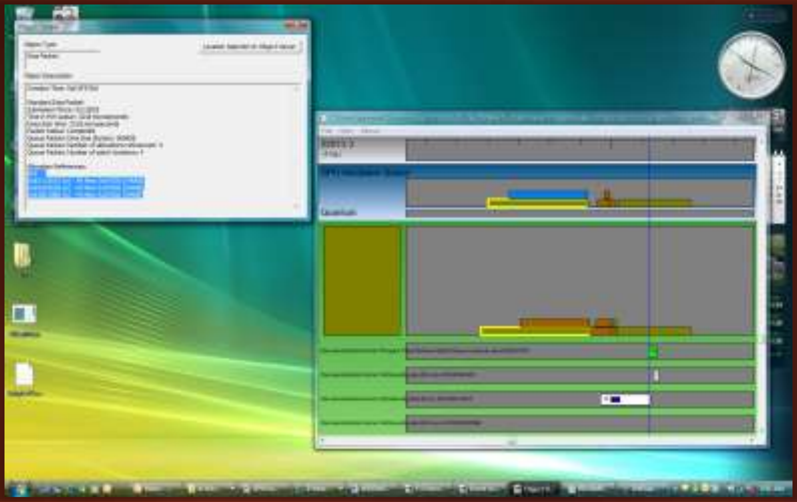
VSync



AllocationList And Placement



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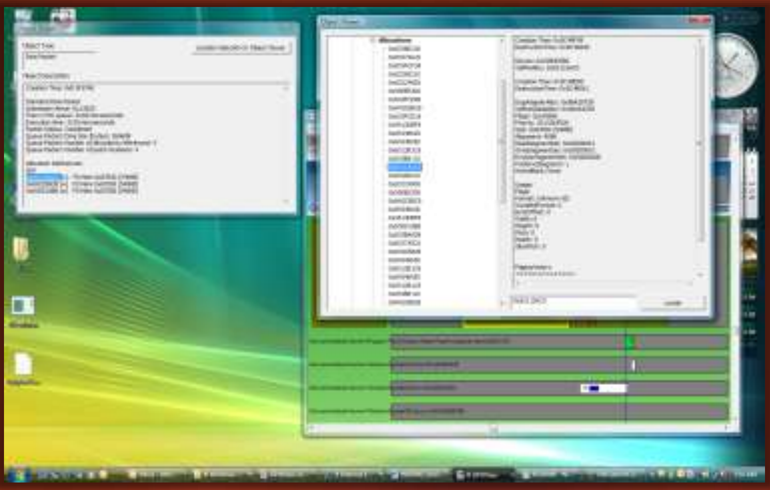
AllocationList And Placement

- 0x83115AC0 (w) P0 Mem 0x87000 (540KB)
- Handle: Global identifier for the allocation
- Operation: (w) indicate a write operation. The default is read
- Relative priority: Where the allocation was placed relative to its priority
- Mem/App: Memory segment or Aperture Segment
- Size of allocation

More Details On Allocation



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