Operating Systems must support GPU abstractions

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Lots of GPUs
Must they be so hard to use?
We need dataflow...
GPU Haiku (apropos 10 min talks)

Lots of GPUs
Must they be so hard to use?
We need dataflow...

...support in the OS
Motivation and Agenda

- There are lots of GPUs!
  - ~ more powerful than CPUs
  - Great for Halo <X> and HPC, but little else
  - Underutilized

- GPUs are difficult to program
  - SIMD execution model
  - Cannot access main memory
  - Treated as I/O device by OS
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A. These two things are related
B. We need OS abstractions (dataflow)
Traditional OS-Level abstractions

- Hardware interface
- OS-level abstractions
- programmer-visible interface
The programmer gets to work with great abstractions…

Why is this a problem?
We expect traditional OS guarantees:
- Fairness
- Isolation

No user-space runtime can provide these!

No kernel-facing interface
- The OS cannot use the GPU
- OS cannot manage the GPU

Lost optimization opportunities
- Suboptimal data movement
- Poor composability
CPU-bound processes hurt GPUs

CPU scheduler and GPU scheduler not integrated!
GPU-bound processes hurt CPUs

Flatter lines are better

- Windows 7 x64 8GB RAM
- Intel Core 2 Quad 2.66GHz
- nVidia GeForce GT230
Composability: Gestural Interface

> capture | filter | detect | hidinput &

- Data crossing u/k boundary
- Double-buffering between camera drivers and GPU drivers

Pipes between filter and detect move data to and from GPU even when it’s already there
Meaningful GPGPU implies GPUs should be managed like CPUs

- Process API analogues
- IPC API analogues
- Scheduler hint analogues
- Abstractions that enable:
  - Composition
  - Data movement optimization
  - Easier programming
OS abstractions: dataflow!

- **ptask** (parallel task)
  - Have *priority* for fairness
  - Analogous to a process for GPU execution
  - List of input/output resources (*e.g.* stdin, stdout...)

- **ports**
  - Can be mapped to ptask input/outputs
  - A data source or sink (*e.g.* buffer in GPU memory)

- **channels**
  - Similar to pipes
  - Connect arbitrary ports
  - Specialize to eliminate double-buffering
Gestural interface revisited

Computation expressed as a graph
- *Synthesis* [Masselin 89] (streams, pumps)
- Dryad [Isard 07]
- SteamIt [Thies 02]
- Offcodes [Weinsberg 08]
- others…
Eliminate unnecessary communication…
Gestural interface revisited

- Eliminates unnecessary communication
- Eliminates u/k crossings, computation

**Diagram:**
- **process:** capture
- **usbsrc**
- **rawimg**
- **ptask:** filter
- **cloud**
- **det_inp**
- **ptask:** detect
- **hands**
- **hid_in**

**Legend:**
- = process
- = ptask
- = port
- = channel

**Notes:**
New data triggers new computation
Conclusions

- OS must get involved in GPU support
- Current approaches:
  - Require wasteful data movement
  - Inhibit modularity/reuse
  - Cannot guarantee fairness, isolation
- OS-level abstractions are required

Questions?