Coordinating the Use of GPU and CPU for Improving Performance of Compute Intensive Applications

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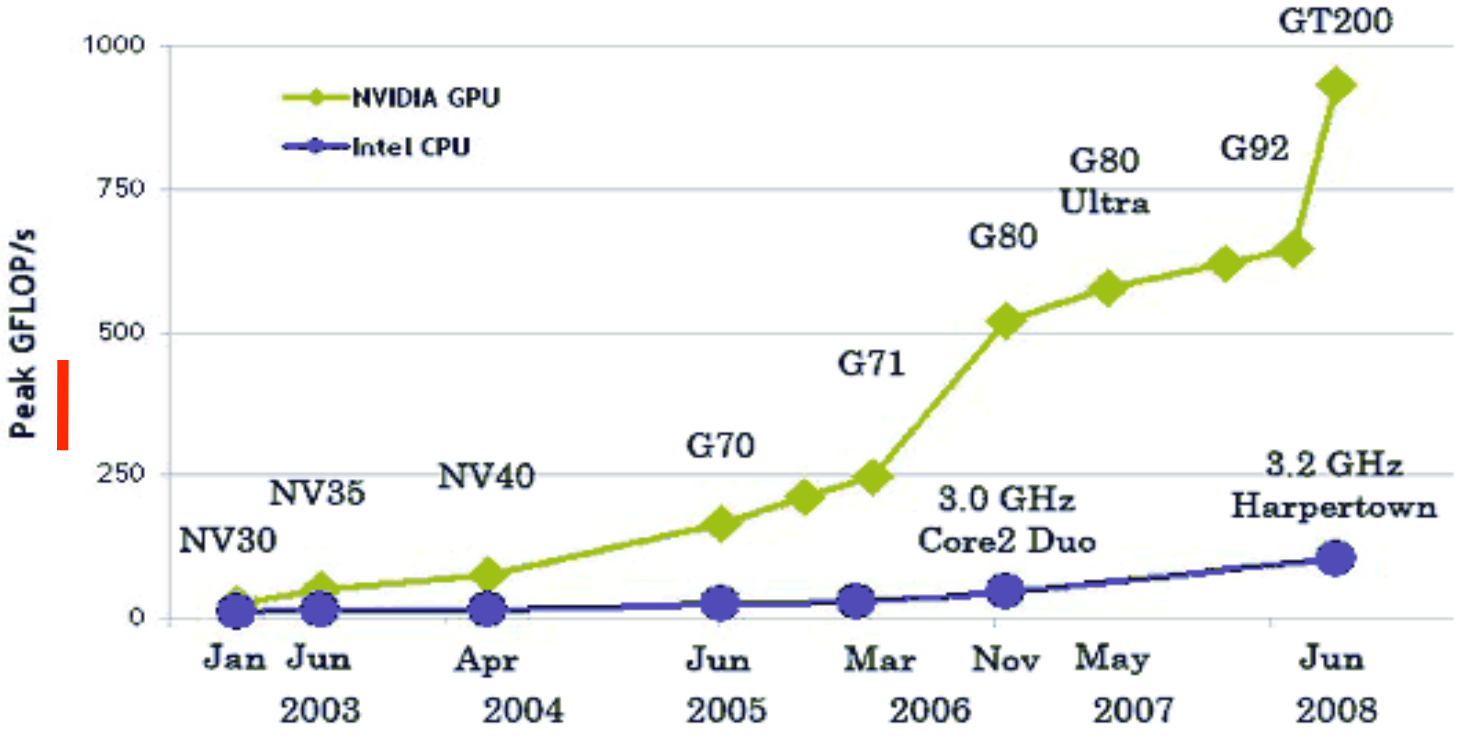
Motivation

- High performance computing
  - Large cluster of-the-shelf components
  - Multi-core/Many-core
  - GPGPU
    - Massively parallel
    - High speedups compared to the CPU

Motivation



- But... GPU is not so fast in all scenarios...
- Current frameworks
  - Assume exclusive use of GPU or CPU

Goal

- Target heterogeneous environments
  - Multiple CPU-cores/GPUs
  - Distributed environments
- Efficient coordination of the devices
  - Scheduling tasks according to their specificities
- High level programming abstraction

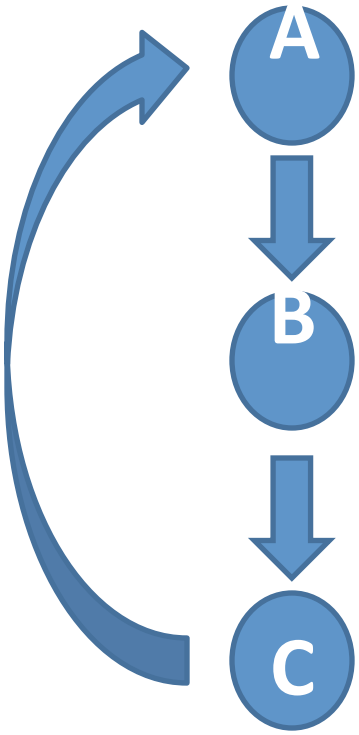
Outline

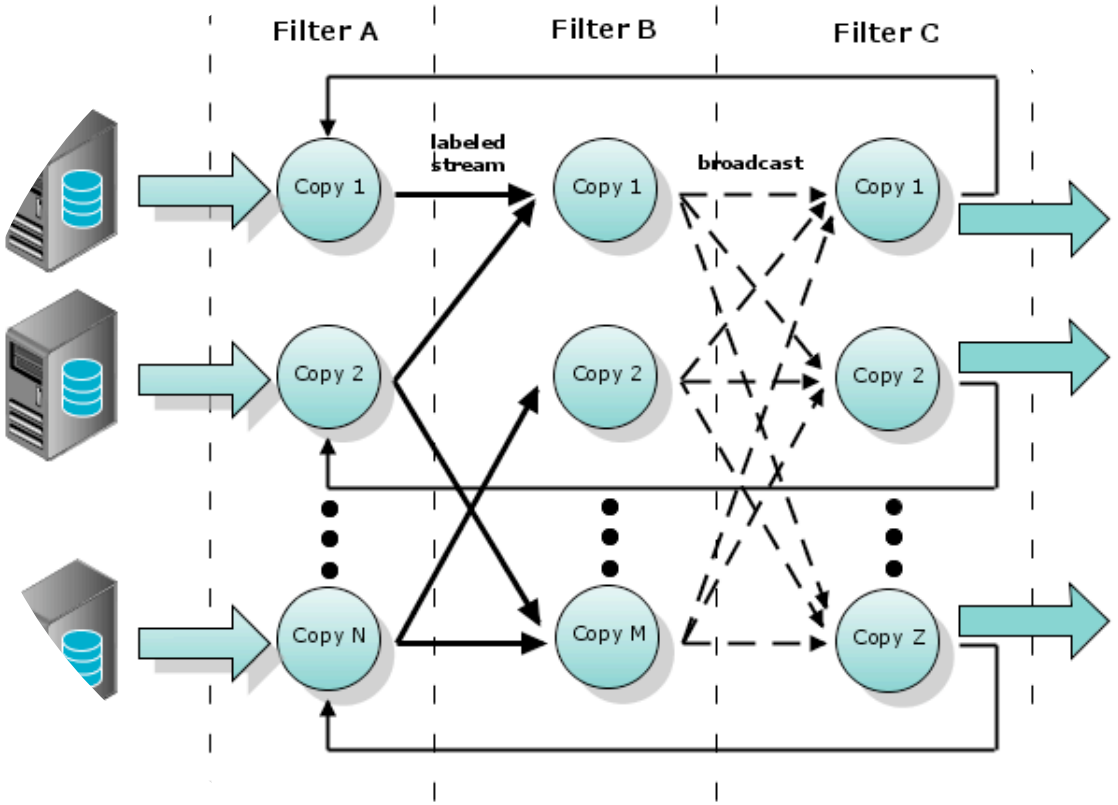
- Anthill
- Supporting heterogeneous environments
- Experimental evaluation
- Conclusions

Anthill

- Based on the filter-stream model (DataCutter)
  - Application decomposed into a set of filters
  - Communication using streams
  - Transparent instance copy
  - Data flow
  - Multiple dimensions of parallelism
    - Task parallelism
    - Data parallelism

Anthill


A
B
C


Filter A
Filter B
Filter C
labeled stream
broadcast
Copy 1
Copy 1
Copy 1
Copy 2
Copy 2
Copy 2
Copy N
Copy M
Copy Z

Filter programming abstraction

- Event driven interface
  - Aligned with the data flow model
- User provide data processing functions to be invoked upon availability of data
- System controls invocation of user function
  - Dependency analysis
  - Parallelism

Event handlers

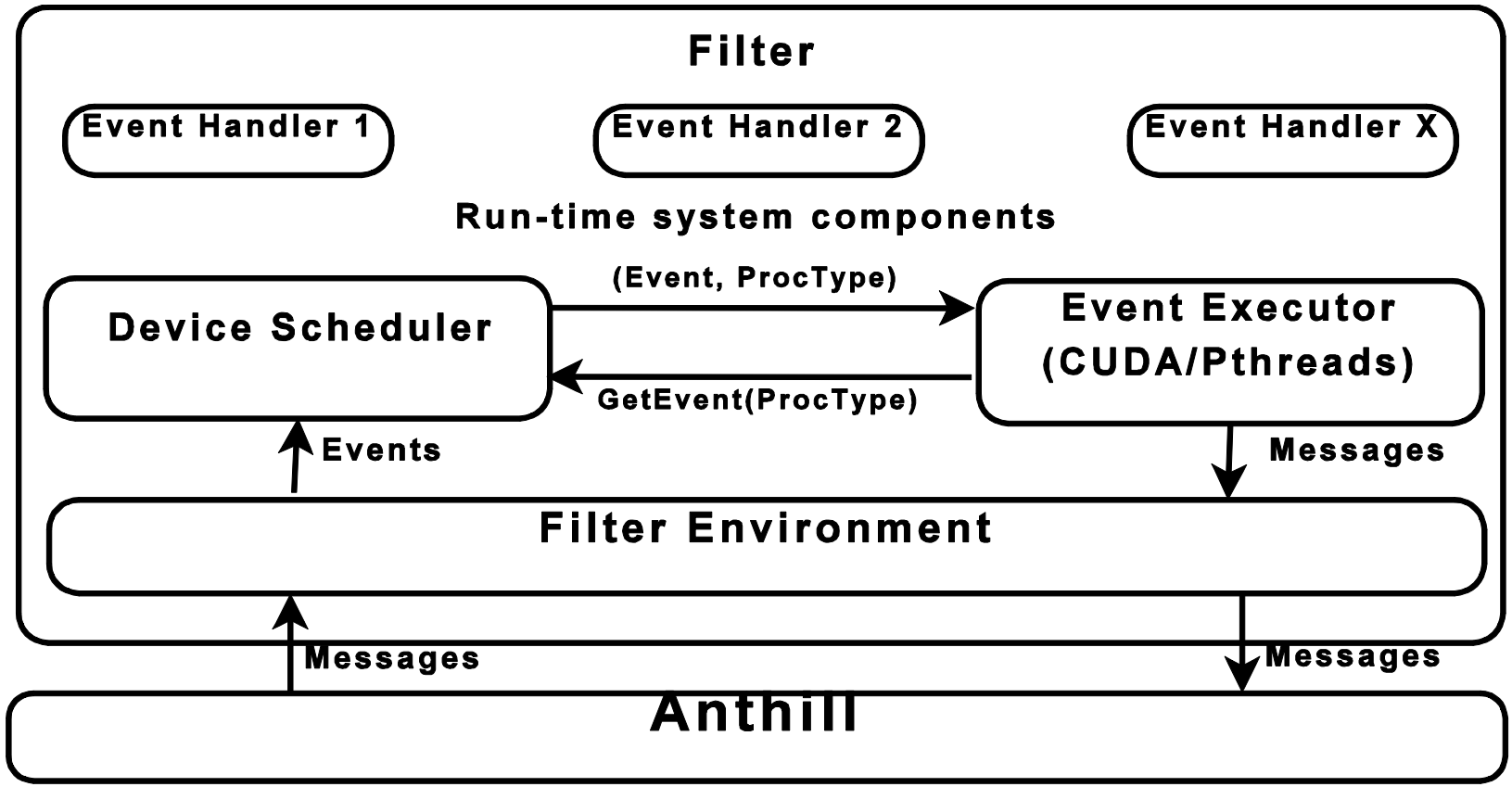
- User provided functions
- Operate on data objects
  - Updates filter state (global)
  - May trigger communication
  - Returns after processing the data element
- Gets invoked automatically when data is available
  - And dependencies are met

Supporting heterogeneous resources

- Event handler implemented to multiple devices
  - Each filter may be implemented targeting the appropriate device
- Multiple devices used in parallel

- Anthill run-time chooses the device for each event

Heterogeneous support overview



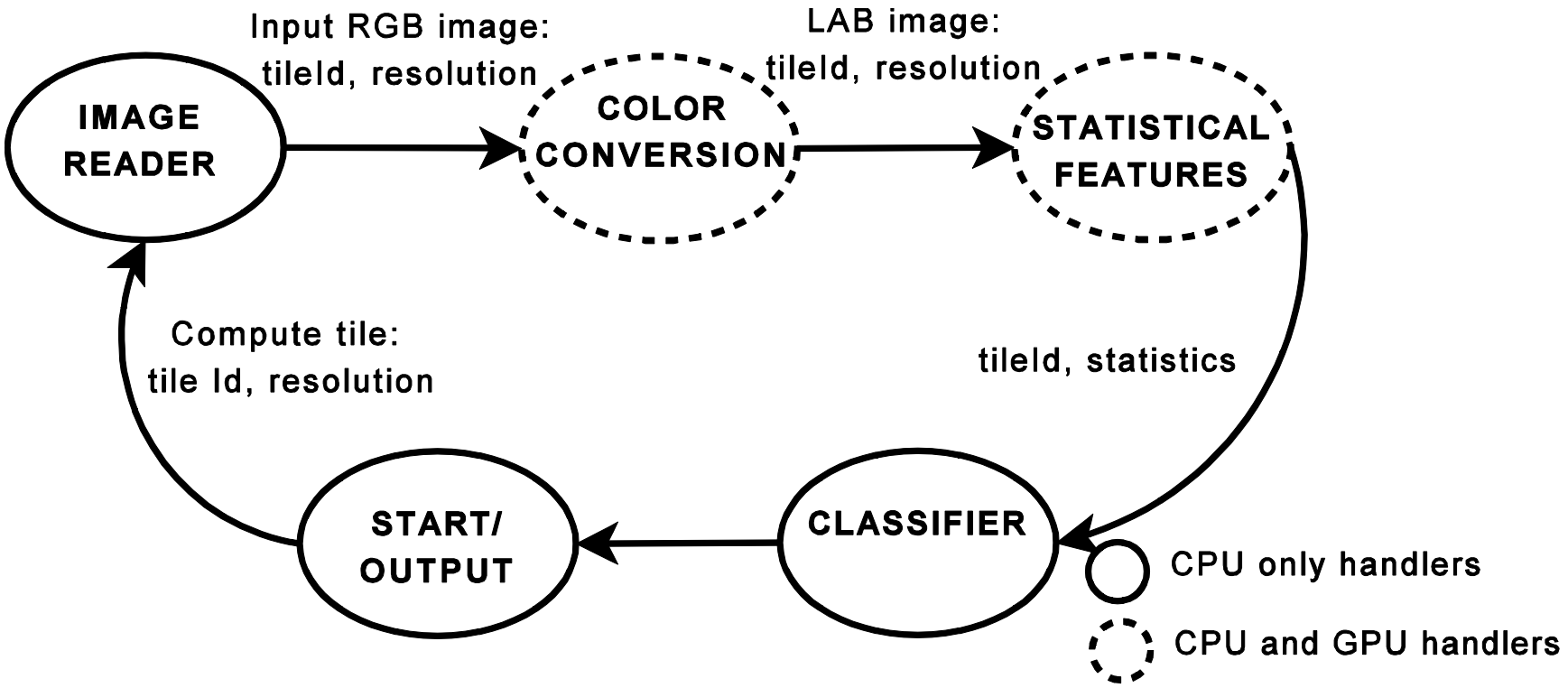
Device scheduler

- Assumes
  - Events are independent
  - Out-of-order execution
- Scheduling policies
  - FCFS – first -come, first-served
  - DWDR – dynamic weighted round robin
    - Orders events according to its performance to each device
    - Selects the event with the highest speedup
    - User given function

Neuroblastoma Image Analysis System

- Classify tissues in different subtypes of prognostic significance
- Very high resolution slides
  - Divided in smaller tiles
- Multi-resolution image analysis
  - Mimics the way pathologists examine them

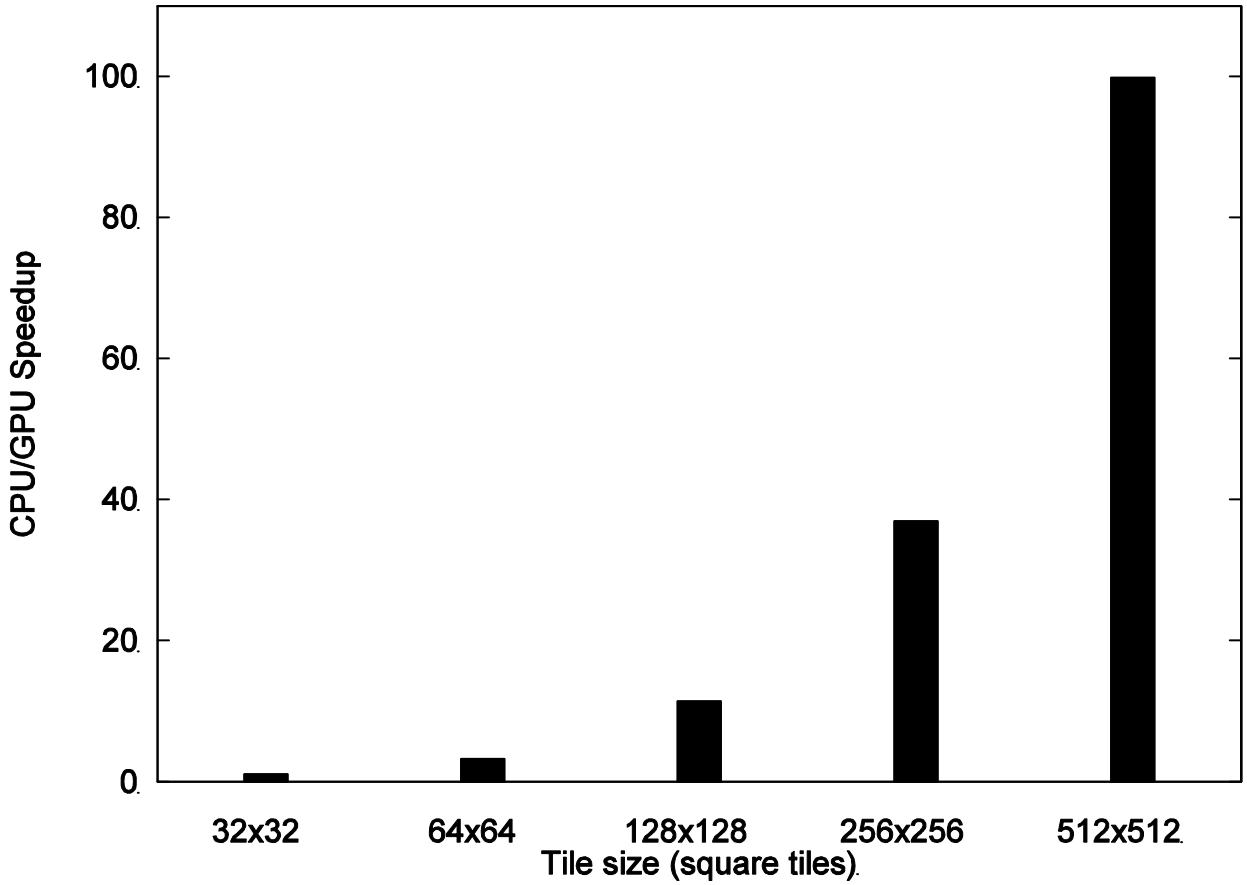
Anthill implementation



Experimental results

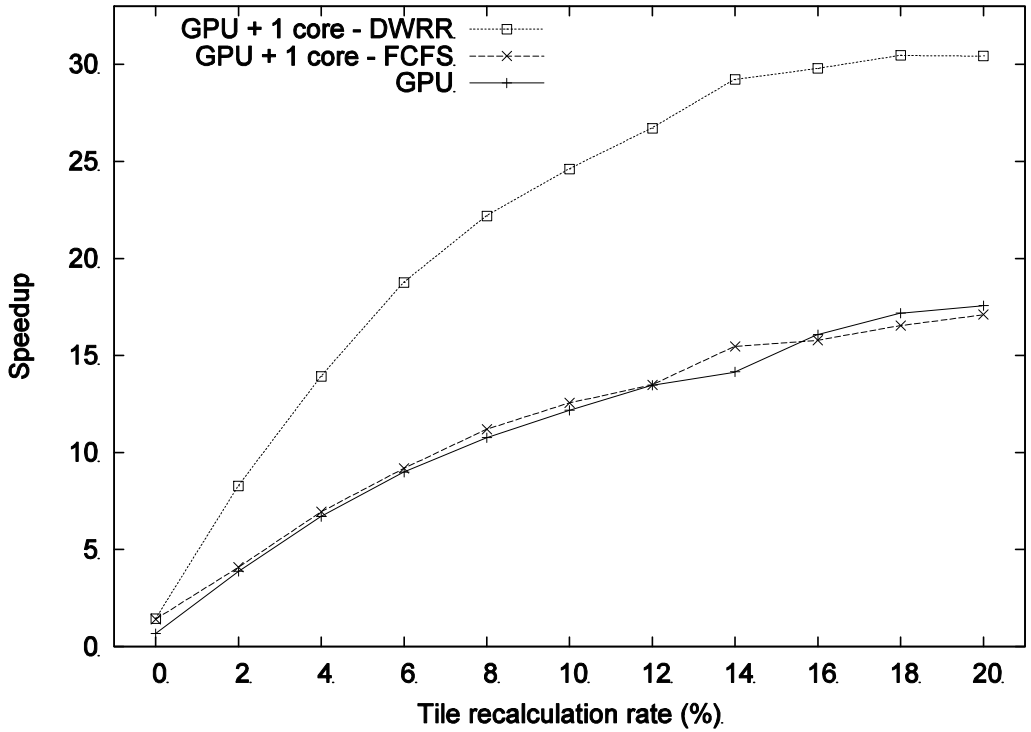
- Setup
  - 10 PCs with an Intel Core 2 Duo CPU 2.13GHz / NVIDIA GeForce 8800GT GPU
  - 4 PCs with a dual quad-core AMD Opteron 2.00GHz processor/ NVIDIA GeForce GTX 260
  - Input data: images of 26,742 tiles using two resolution levels: 32x32 and 512x512

NBIA tasks analysis – performance variation



Dual quad-core AMD Opteron 2.00GHz/NVIDIA GeForce GTX260

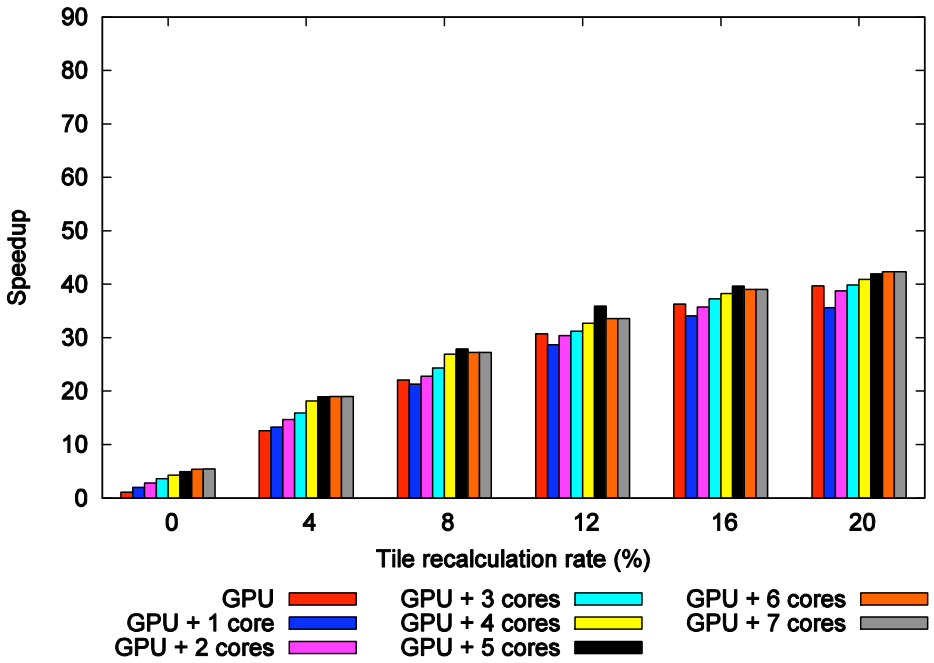
Heterogeneous scheduling analysis



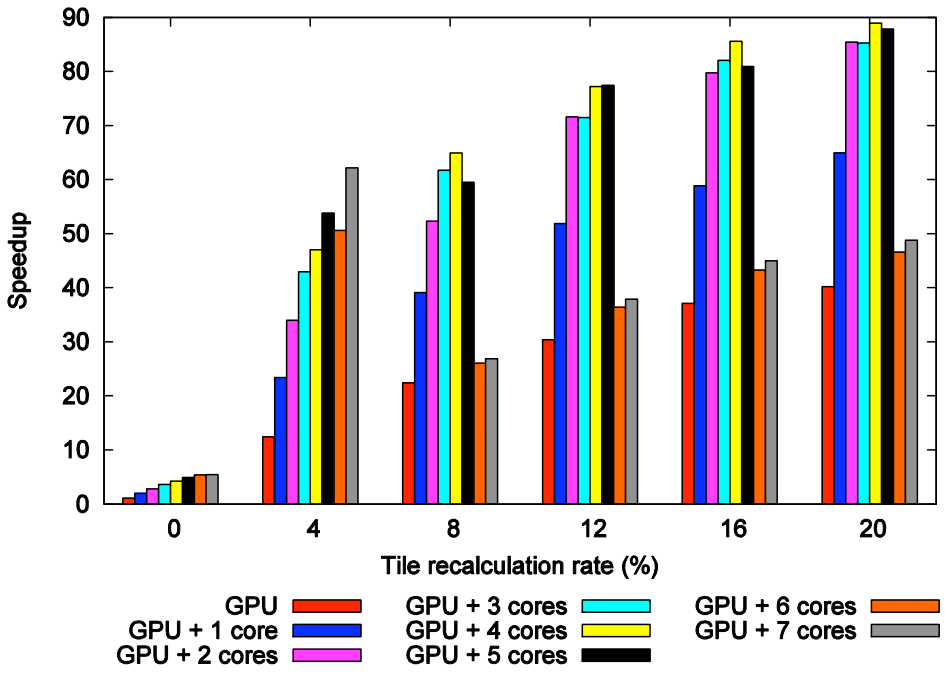
16 + 1 = 30 ??

Recalc (%)	12	
Resolution	Low	High
1 CPU core- FCFS	263	215
1 CPU core – DWRR	21592	4

Heterogeneous scheduling analysis



FCFS

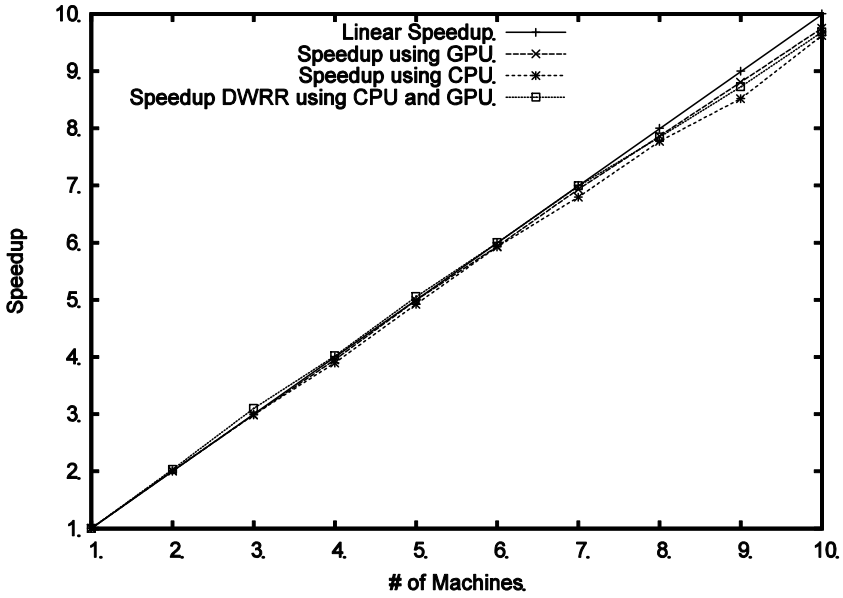


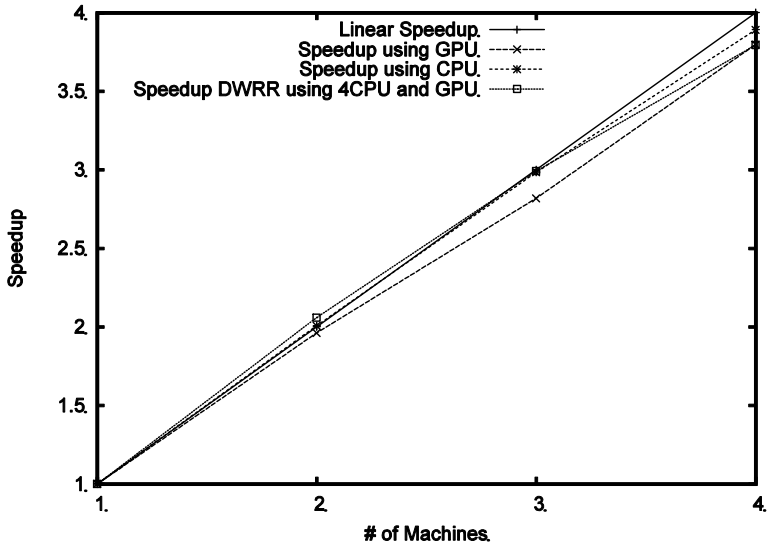
DWDR

Heterogeneous scheduling analysis

# of CPU cores	FCFS		DWRR	
	Low	High	Low	High
1	637	58	10714	1
2	117	133	15748	2
3	1925	173	18614	5
4	2090	219	18634	28
5	2872	286	20070	40
6	3819	393	20147	76
7	4726	478	20266	57

Distributed environment evaluation





Conclusions

- Relative performance between CPU/GPU is data dependent
- Adequate scheduling among heterogeneous processors doubled the performance of the application
- Neglect the CPU is a mistake
- Data-flow is an interesting model to exploit parallelism

Future work

- New scheduling techniques
- Execution in cluster with heterogeneity among the computing nodes

Questions?