Fast Fourier Transform with BrookGPU

CS594 GPU Programming

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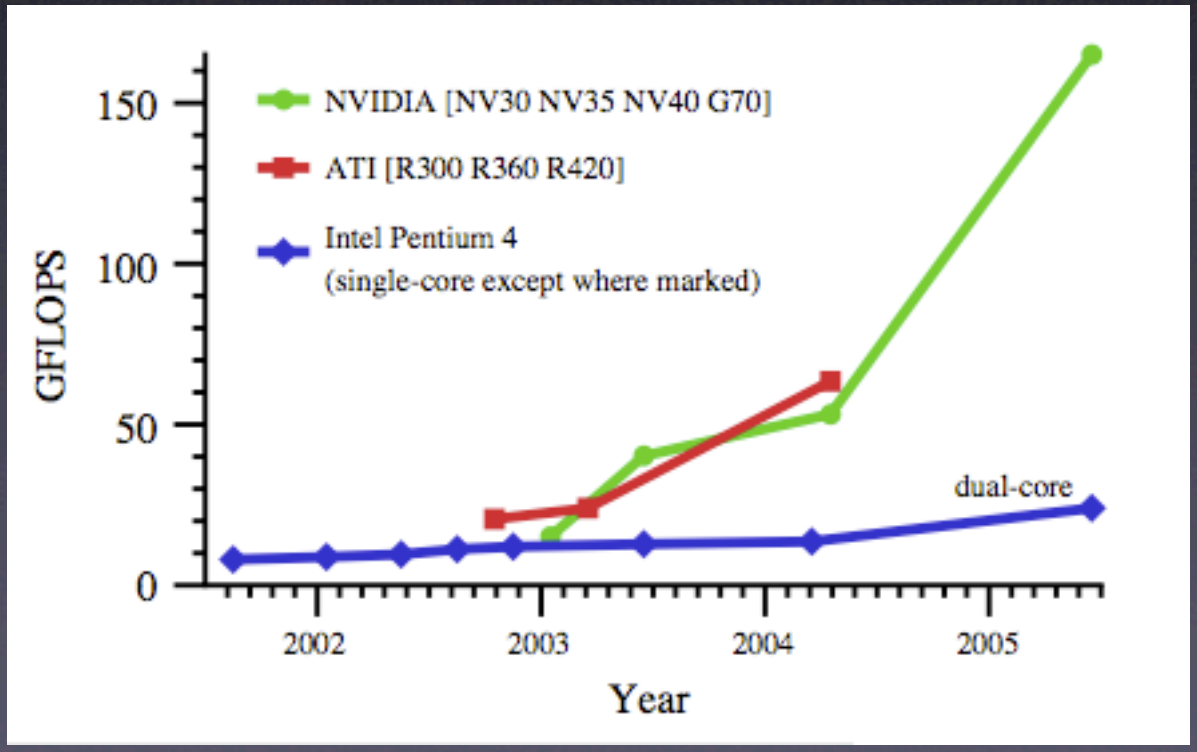
GPGPU

- Modern GPU is fast & programmable
- Out-performs CPU in some cases



Fast Fourier Transform

- Frequently used in signal processing, compression etc.
- Computation intensive
- Moreland & Angel's GPU implementation
  - Cannot have branch in frag. program
  - Need multiple frag. program switch

$$F(k) = \sum_{n=0}^{N-1} f(n) W_N^{kn},$$

$$W_N^{kn} = e^{-j\frac{2\pi kn}{N}}; \; f(n), \; n = 0, \ldots, N-1,$$

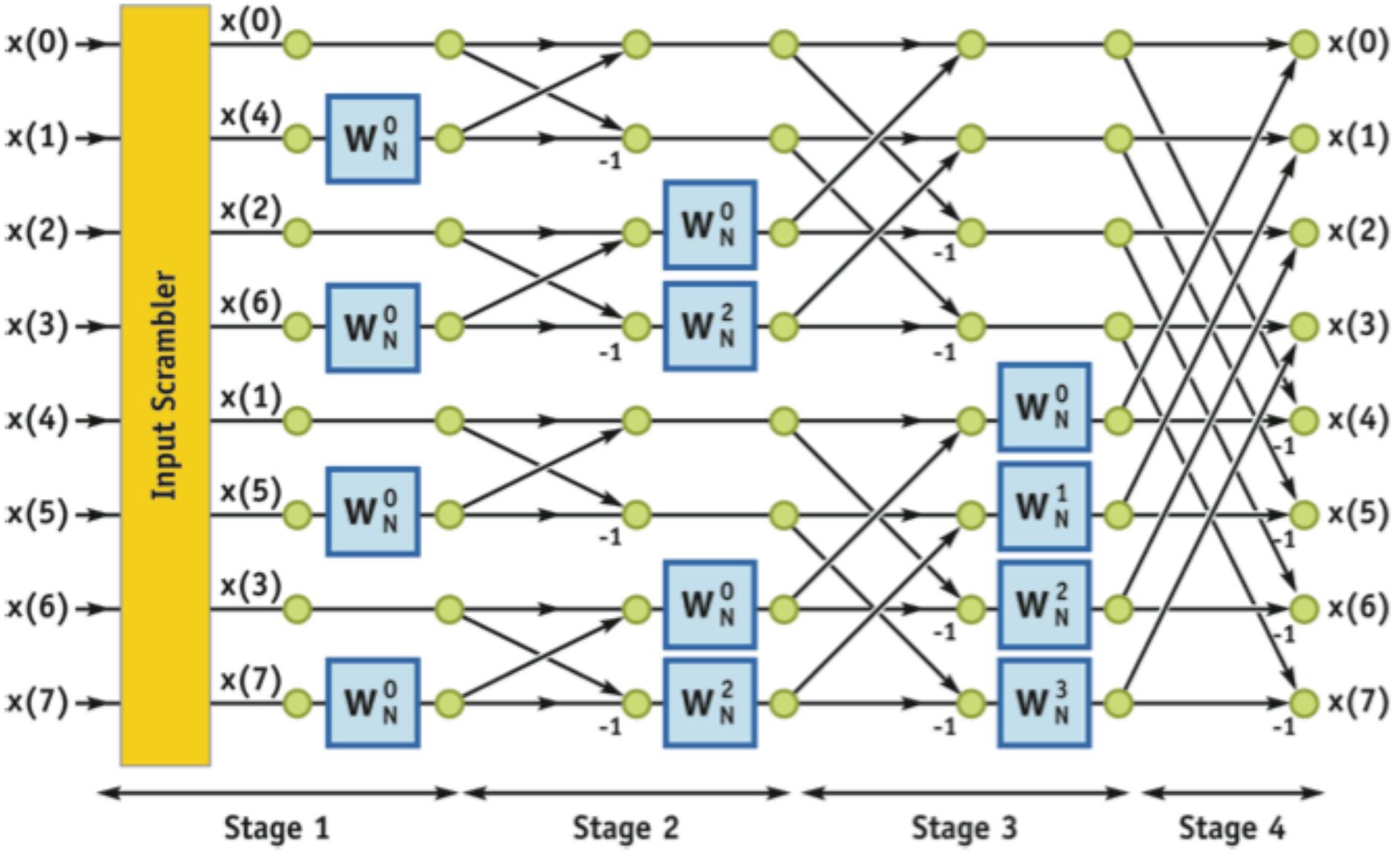


Figure 48-1. The Decimation-in-Time Butterfly Algorithm
Used for computing the DFT of a discrete digital signal of eight samples.

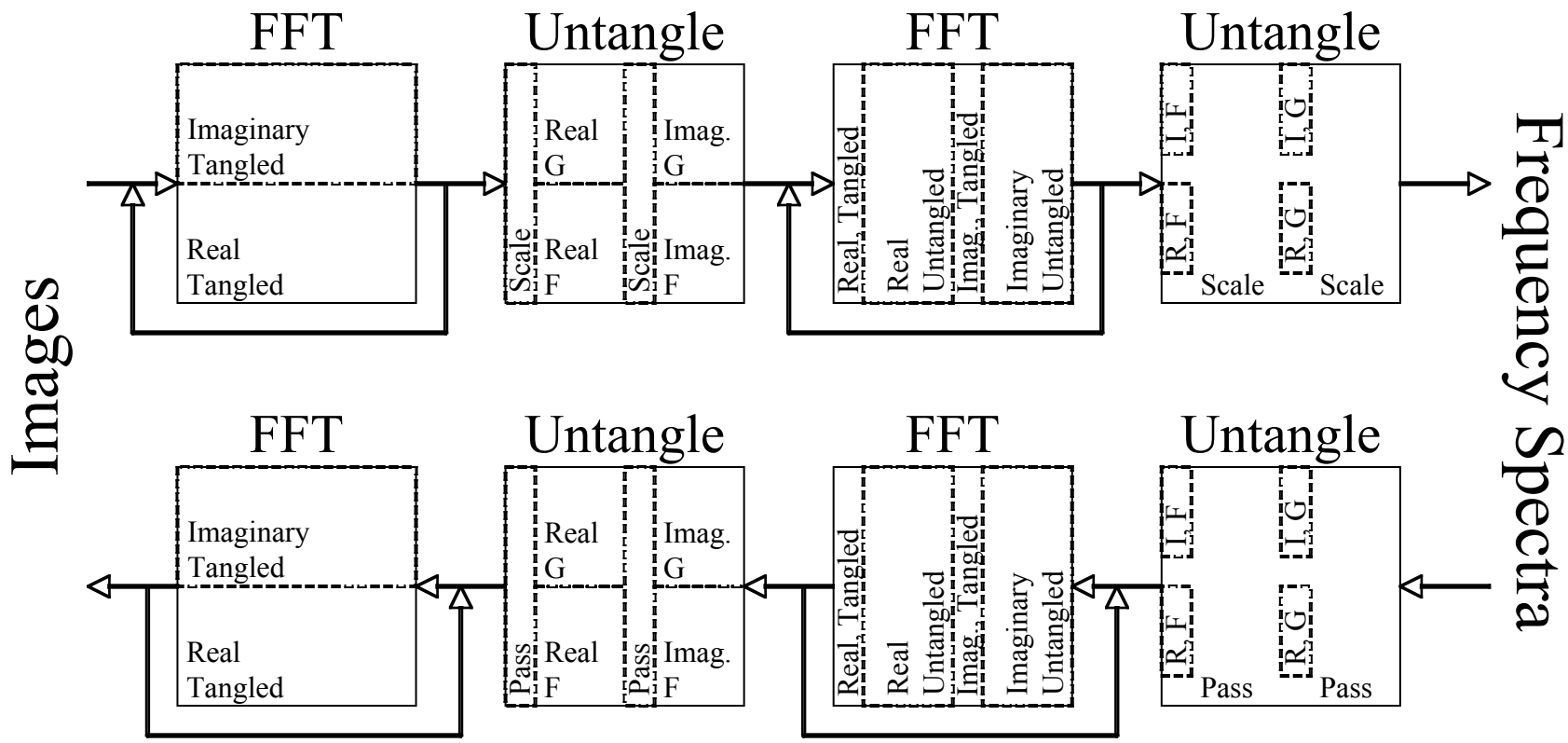
Tangle+Untangle

- Perform FFT on h(x) = f(x) + j g(x)
- FFT is linear: H(u) = F(u) + j G(u)

$$F(u)_R = \frac{1}{2}\left(H(u)_R + H(N-u)_R\right)$$
$$F(u)_I = \frac{1}{2}\left(H(u)_I - H(N-u)_I\right)$$
$$G(u)_R = \frac{1}{2}\left(H(u)_I + H(N-u)_I\right)$$
$$G(u)_I = -\frac{1}{2}\left(H(u)_R - H(N-u)_R\right)$$

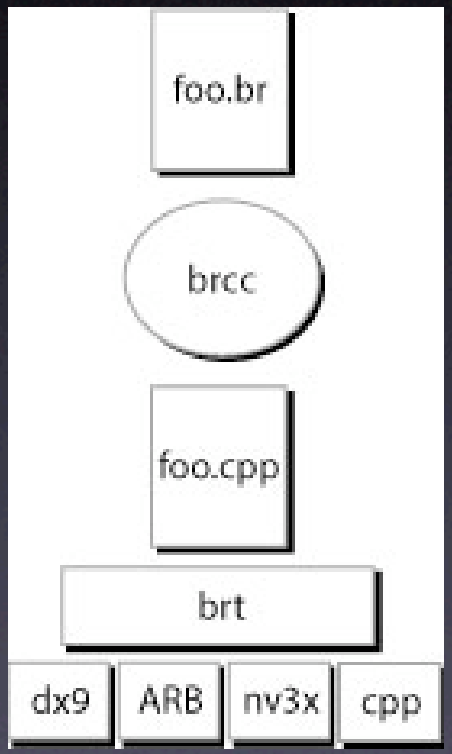
FFT

Implementation



BrookGPU

- From Stanford Univ.
- Compiler & runtime of Brook stream programming language
- Ease GPGPU programming
- Research program, still beta



BrookGPU

- stream function: kernel
- stream datatype: float2, float4
- can do something like: streamSwap(s, s_out);
- Translate to embedded Cg program
- Rendering to offscreen pbuffer
  - Nice to have in cluster environment

Results & Issues

- export BRT_RUNTIME=[ogl|cpu]
- Brook's CPU backend is way slow!
  - 0.5 sec vs. 1 min 3.7 sec on 512x512 input
  - Should compared to state-of-art CPU FFT implementation: http://www.fftw.org/
- Program complains when input size larger than 1024x1024: cannot allocate pbuffer

GPU vs. CPU

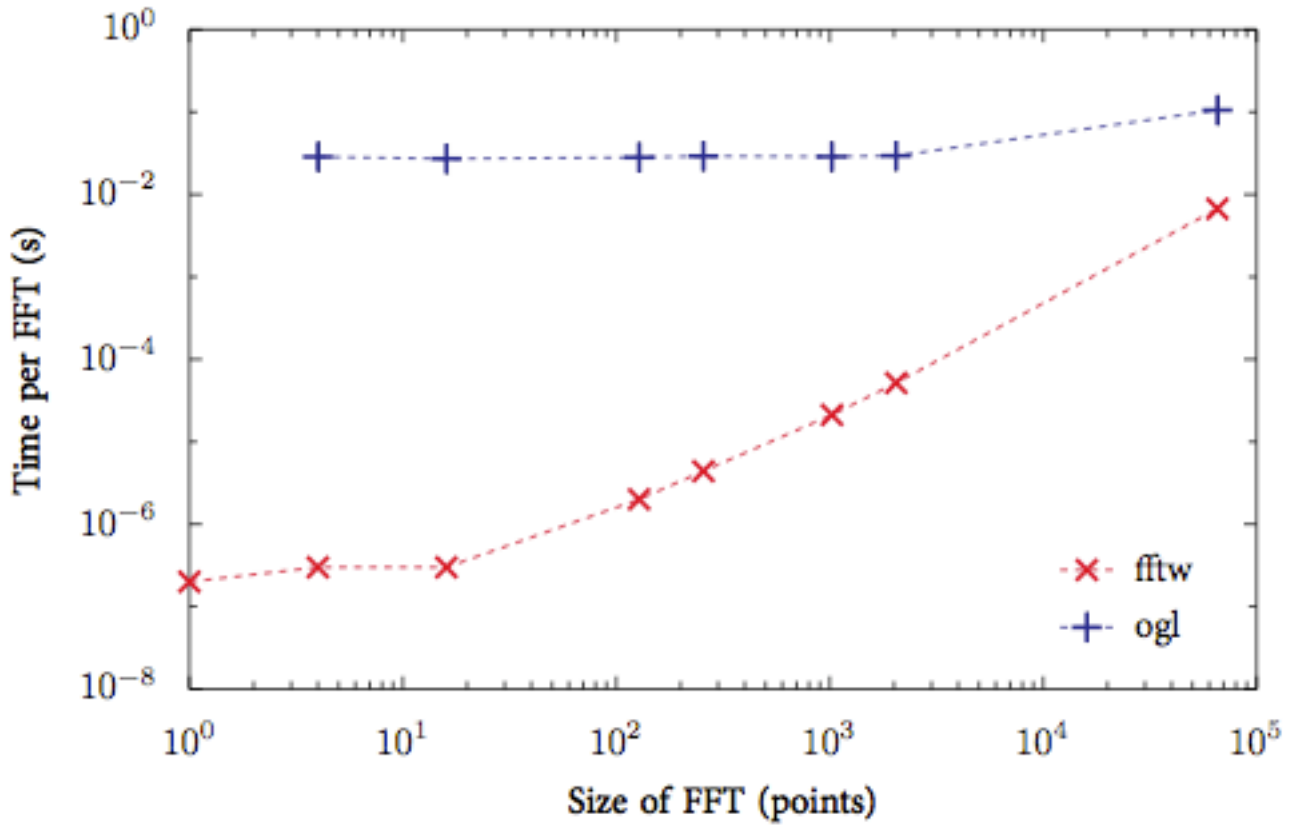
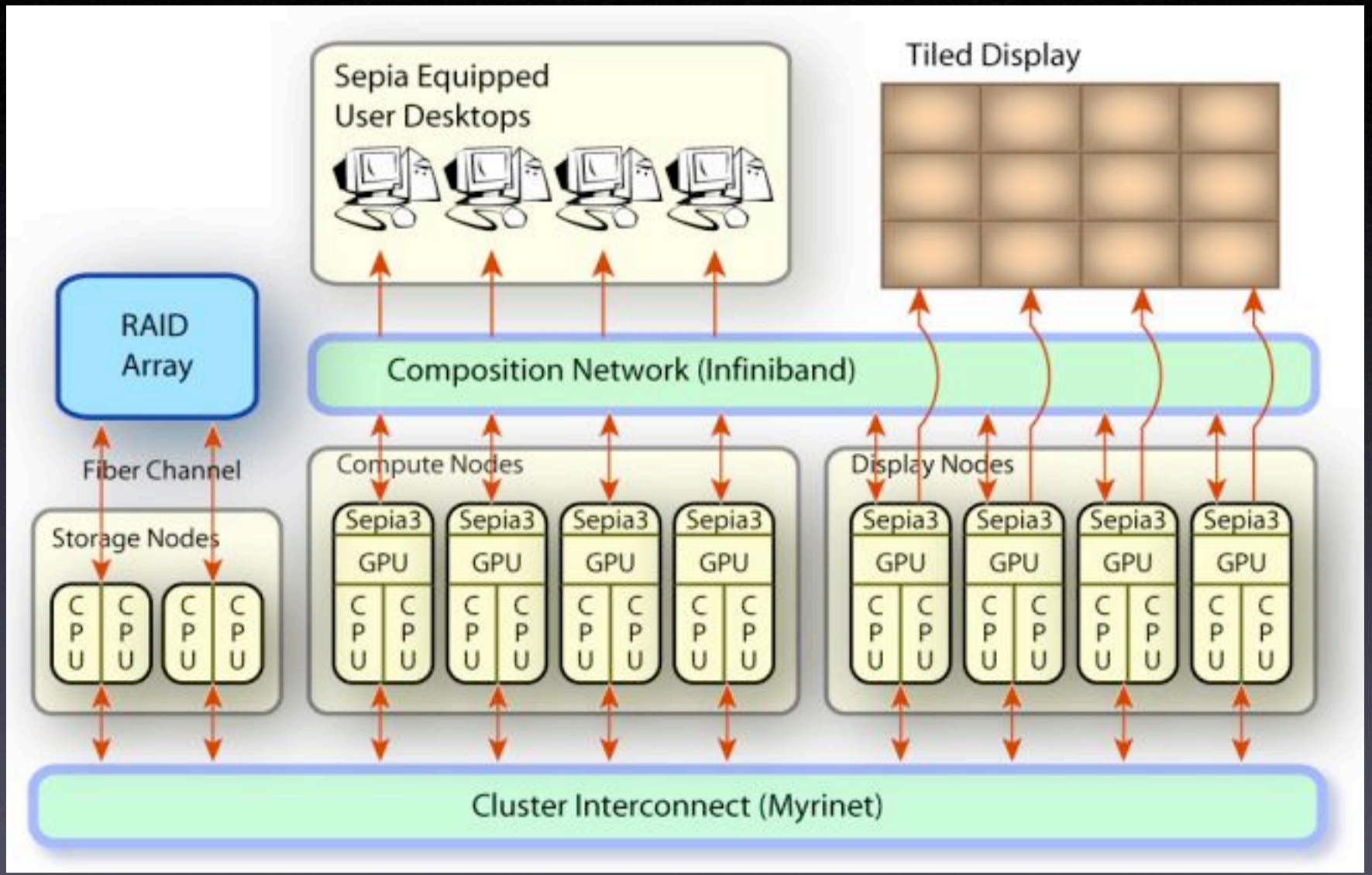
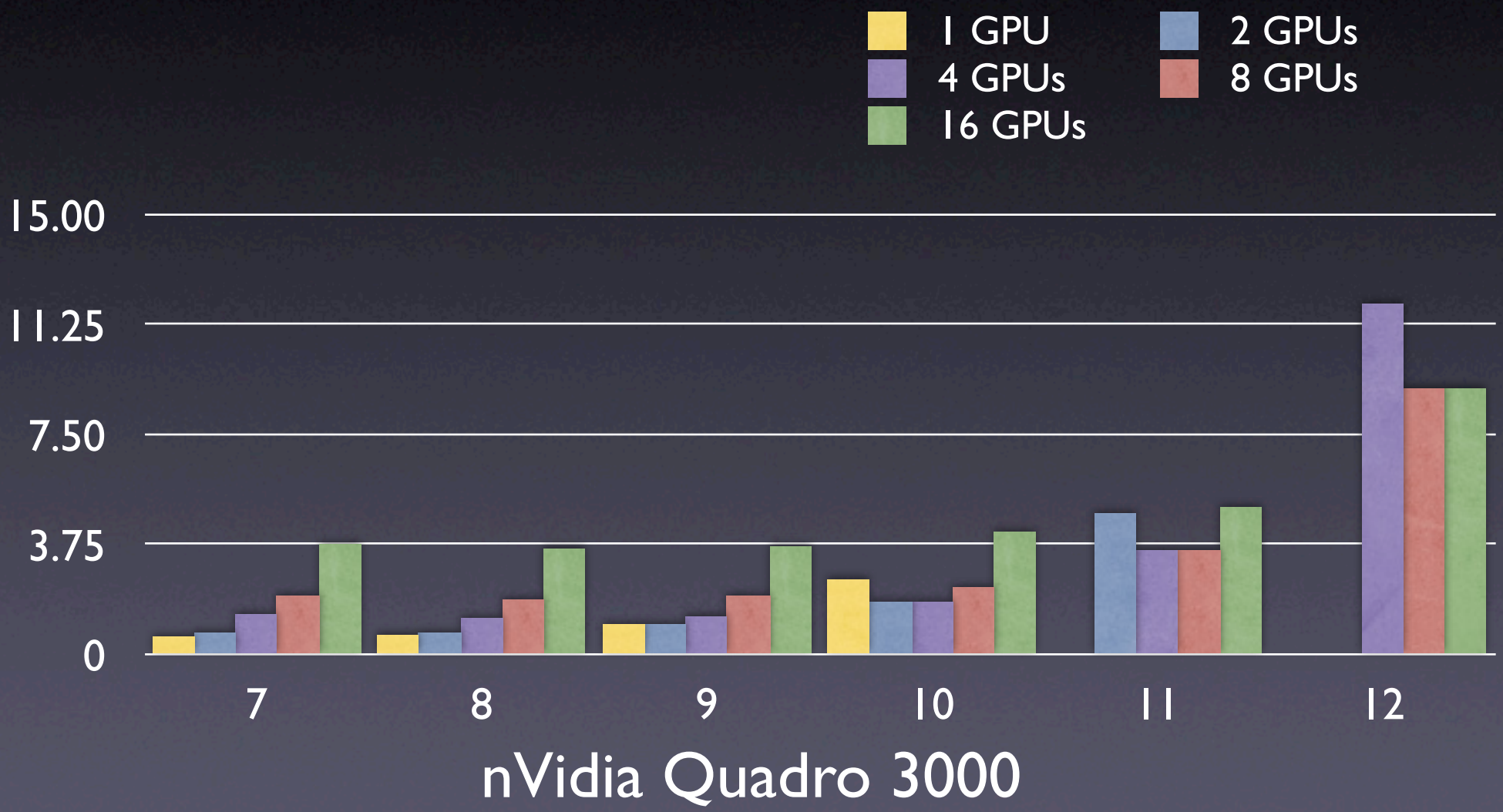


Figure 3: *Time to compute one FFT (latency), as a function of the size of the FFT. Toward the bottom of the graph is faster. "fftw" is the CPU-based FFTW; "ogl" is the GPU-based Brook OpenGL back end to libgpufft.*


Sepia Equipped
User Desktops
Tiled Display
RAID
Array
Composition Network (Infiniband)
Fiber Channel
Compute Nodes
Display Nodes
Storage Nodes
Sepia3
GPU
CPU
Cluster Interconnect (Myrinet)

Results


1 GPU
2 GPUs
4 GPUs
8 GPUs
16 GPUs
15.00
11.25
7.50
3.75
0
7
8
9
10
11
12
nVidia Quadro 3000

Multiple GPUs?

- MPI + BrookGPU
- Can do bigger problem size
- Significant speedup?
- Meaningful for using GPUs?

Some thoughts

- Use nVidia cards + Cg!
- Beneficial under certain situations
- Graphics clusters
- Graphics resource monitoring
  - Available pbuffer size?

Issues

- GPU today: Single-precision floating-point
  - Need IEEE-compliant, double, even 64-bit?
  - Exceptions: eg.divide-by-zero
- Size limitation
- Programming model

References

- http://www.gpgpu.org/
- http://graphics.stanford.edu/projects/brookgpu/
- http://www.cs.unm.edu/~kmorel/documents/fftgpu/
- http://www.umiacs.umd.edu/research/GPU/
- http://libgpufft.sourceforge.net/
- http://graphics.stanford.edu/projects/gpubench/