IceCube, HTCondor, and GPUs

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Overview

• The Basics of IceCube
• GPUs – The Motivation
• Evolution
• Summary
The IceCube Neutrino Observatory

- A kilometer scale neutrino detector
- Located at geographic South Pole
- Detects Cherenkov light from neutrino interactions
Location, Location, Location

• Why the South Pole?
• Lots of ice – a great detection medium
• The ice is very clear
• Thick ice sheet – sensors deep enough to provide significant background reduction
Propagation of Light

- A particle creates light when it interacts with the ice
- At what time did light hit a module?
- How much light hit the module?
- Shows us the track of the particle
- Provides information about the energy of the particle
- Clues as to the type of particle
Need to Model the Ice

• Given an interaction point, how does the light propagate through the ice?
• Ice scatters and absorbs light, so do a bit of math – voila!
• Actually, rather a lot of math (or a little math a lot of times)
• Early efforts (starting 15 years ago) – approximate and create lookup tables
Problems

• The ice has structure
  – Dust layers
  – Tilt
  – Each parameter adds complexity/size to the tables

• Tables introduce (large) systematic errors
Solution – Direct Propagation

• Simulate the track of each photon through the ice
• Computationally intensive
  – Even a low energy event generates a few million photons
  – Event rate is ~ 3000 events/s
• Serious efforts in this direction began in 2009
The Story So Far

- **Can we do this with CPUs?**
  - Yes! Early code written in C++ ~ 2009
  - Also assembly (1.25x-.1.37x speed-up)

- **Followed closely by GPU implementations**
  - nVidia/CUDA based
  - 150x initial speed-up vs CPU versions
Version 1

- Initial system – consumer GPUs
  - Custom-built gamer desktops
  - Proof of concept
  - No HTCondor
Version 2

- GZK-9000 cluster
- Commercial GPUs
  - 48x nVidia M2070 GPUs
  - High density, increased scale
  - Hosted at CHTC
  - HTCondor managed
Version 3

- **Consumer grade GPUs**
  - Cheaper (*much* cheaper – 4x)
  - Split pool – 32x nVidia GTX-690, 32x ATI Radeon 7970
  - SuperMicro based – integrated by re-seller
  - HTCondor managed
Cheap GPUs – What you lose

• No Free Lunch …
• … or ECC either (maybe)
• … and limited Double Precision performance
• Detailed monitoring
  – Temp & Fan speed mostly
  – No direct utilization reporting
Experiences

• Getting these stable takes time
  – For us, true for commercial & consumer alike

• Another software stack to manage
  – GPU drivers
  – SDK & execution libraries

• Consumer card market extremely variable
  – Availability
  – Many card vendors (eVGA, Asus, XFX, PNY, …)
  – AMD (ATI) is not as “into it” as nVidia
HTCondor Config

- Start with static config
- STARTD config:

```
SLOT_TYPE_3 = cpus=1, mem=2000
NUM_SLOTS_TYPE_3 = 1
SLOT3_HAS_GPU = TRUE
SLOT3_GPU_NAME = "nVidia GeForce GTX 680"
SLOT3_GPU_DEV = 1
SLOT3_STARTD_ATTRS = HAS_GPU GPU_DEV GPU_NAME

USER_JOB_WRAPPER = /etc/condor/gpu_job_wrapper.sh
```
• STARTD cont’d:
• Wrapper script:

#!/bin/bash

gpu_dev=$(awk -F ' = ' '/^GPU_DEV = /{print $2}' $_CONDOR_MACHINE_AD)

if [ -n "$gpu_dev" ]; then
    export CUDA_VISIBLE_DEVICES=$gpu_dev
    export COMPUTE=:0.$gpu_dev
    export GPU_DEVICE_ORDINAL=$gpu_dev
fi

exec "$@

HTCondor Config
Submit side

- GPU allocation is managed with Accounting Groups
- A job requests the GPU accounting group
  - +AccountingGroup="gpu.$ENV(USER)"
- CUDA jobs must require CUDA:
  - requirements = HAS_CUDA
- OpenCL jobs can run anywhere, so no special requirements
Future

• It’s hard to make predictions, especially about the future – Yogi Berra
• Upgrade HTCondor to development series (as we speak)
• Use TJ’s new detection features
Credits

• Juan Carlos Diaz-Velez, David Schultz – IceProd framework
• Dmitry Chirkin, Claudio Kopper – GPU simulation development
• Vladimir Brik – GPU wrangling
• CHTC – Hosting the GZK cluster, OSG support, HTCondor GPU efforts (TJ!)
• UW Madison – Fast networks
• NSF – IceCube M&O funding
Questions?

Roald Amundsen
December 14, 1911
“So we arrived and were able to plant our flag at the geographical South Pole.”

Elevation 9,370 ft.