Day 9: Introduction to CHTC

Suggested reading: Condor 7.7 Manual:

http://www.cs.wisc.edu/condor/manual/v7.7/

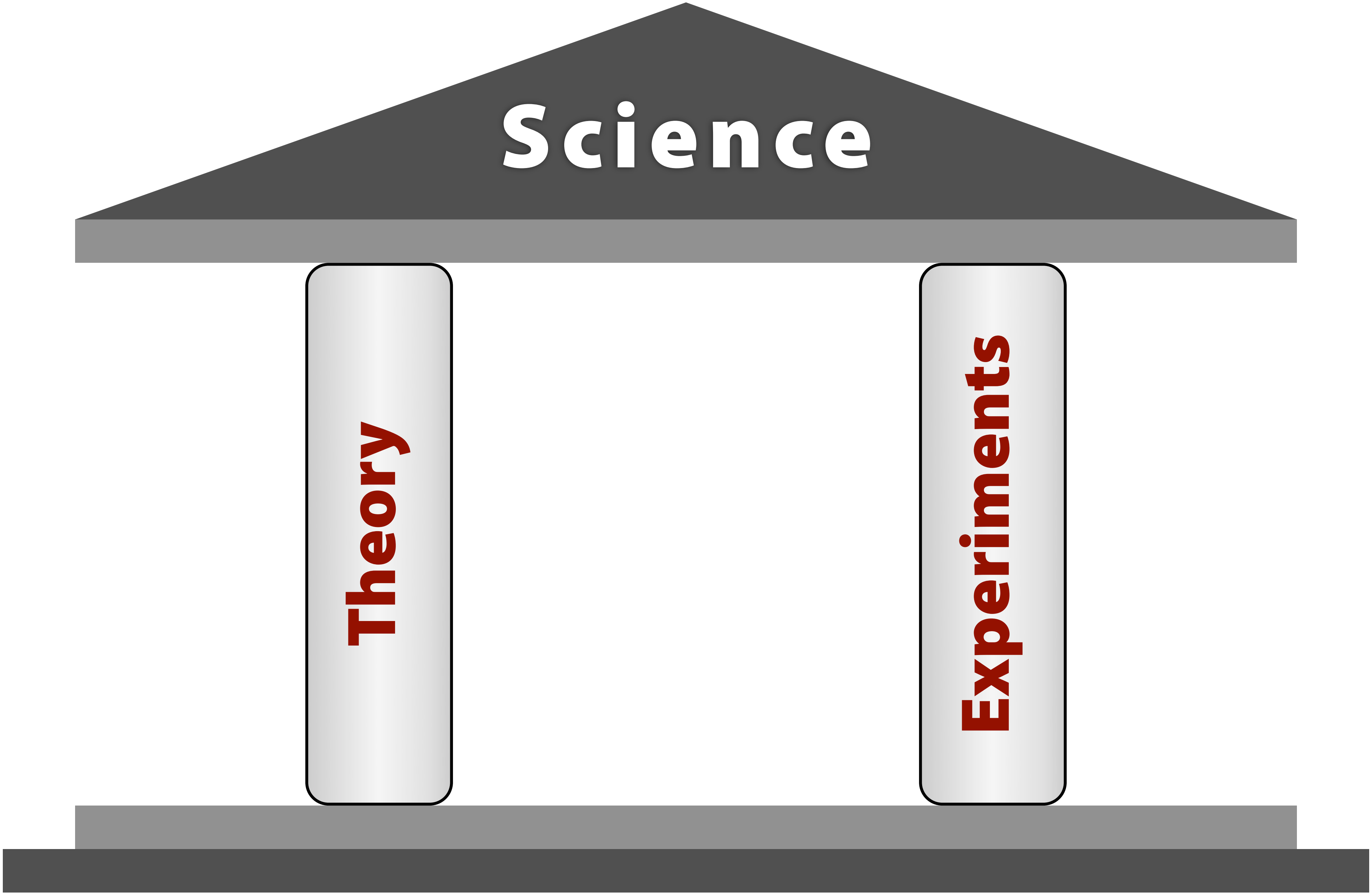
Chapter 1: Overview
Chapter 2: Users' Manual (at most, 2.1–2.7)

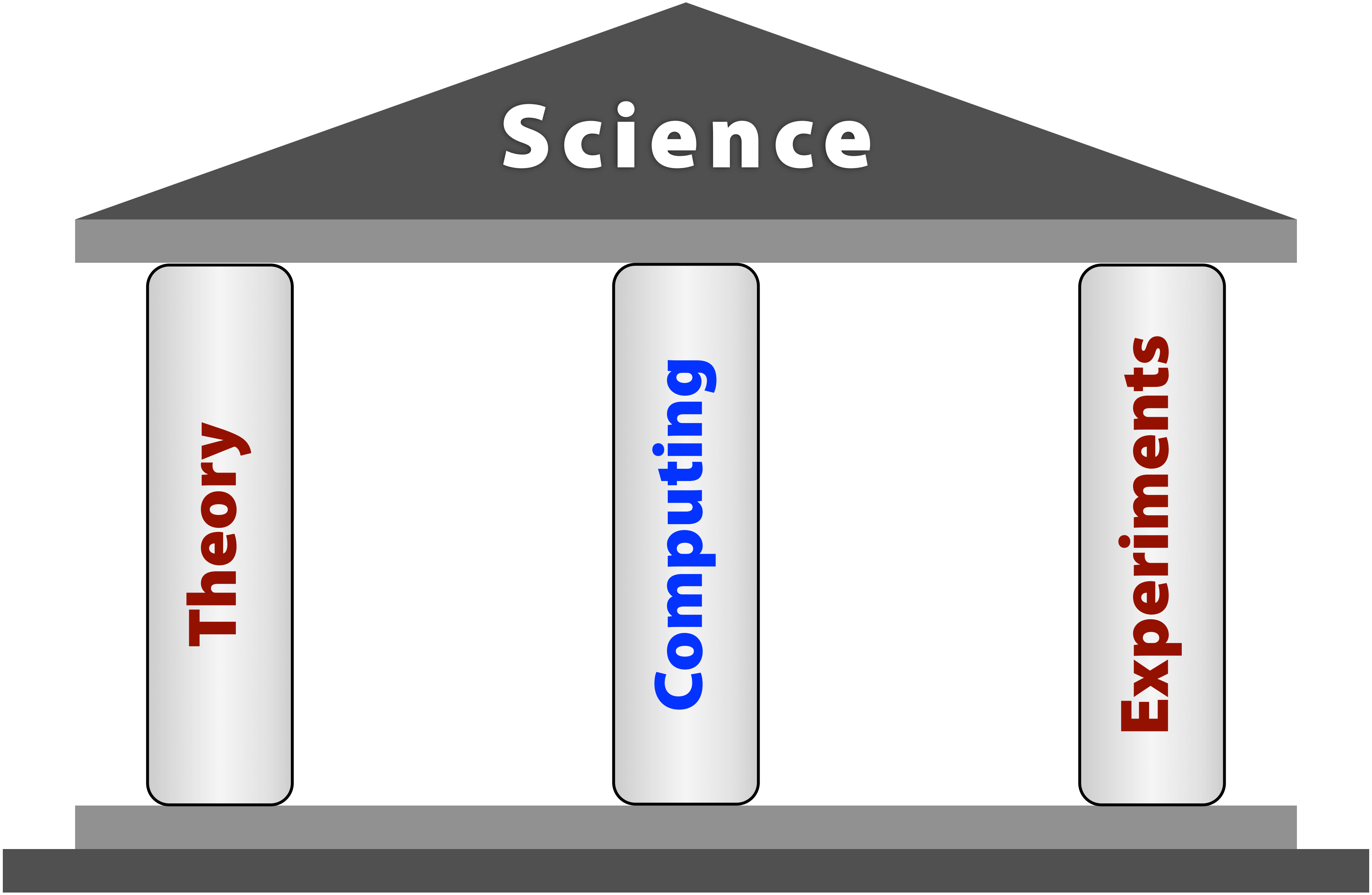
Turn In Homework

Homework Review

CHTC

Center for High Throughput Computing


Science
Theory
Experiments


Science
Theory
Computing
Experiments

CENTER FOR
HIGH THROUGHPUT
COMPUTING

- Computing resources for researchers
- Right here on campus
- **Free** for UW–Madison researchers
- Funded by UW, NSF, Dept. of Energy, NIH, …
- Last year: **15 million** CPU hours *delivered*

High-Throughput Computing

- "… use of many computing resources over long periods of time to accomplish a computational task" — Wikipedia (retrieved 7 Nov 2011)

- Not high-performance computing (HPC)
  - TOP500 list of supercomputers
  - FLOPS (**f**loating-**p**oint **o**perations **p**er **s**econd)

- Aims to maximize long-term throughput
  - "How many results this week/month/year?"
  - FLOP**Y** ≠ (60 × 60 × 24 × 365) FLOPS

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The Hope (& Hype) of Distributed Computing

- Do a *lot* of computing
- Always be available and reliable
- Degrade gracefully
- Spread the workload automatically
- Grow (and shrink) easily when needed
- Respond well to temporary overloads
- Adapt easily to new uses

Adapted from: Enslow, P. H., Jr. (1978). What is a “distributed” data processing system? *Computer, 11*(1), 13–21. doi:10.1109/C-M.1978.217901

Definition of Distributed Computing

Multiplicity of resources

- General purpose; not same, but same capabilities
- More replication is better

Component interconnection

- Networked, loosely coupled

Unity of control

- Not centralized control (single point of failure)
- Unified by common goal, and hence policy

System transparency

- Whole system appears as one virtual system to user

Component autonomy

- Autonomous (act locally) but cooperative (think globally)

Enslow, P. H., Jr., & Saponas, T. G. (**1981**). *Distributed and decentralized control in fully distributed processing systems: A survey of applicable models* (GIT-ICS-81/02). Georgia Institute of Technology.

What CHTC Offers

What CHTC Offers

Computing

What CHTC Offers

What CHTC Offers

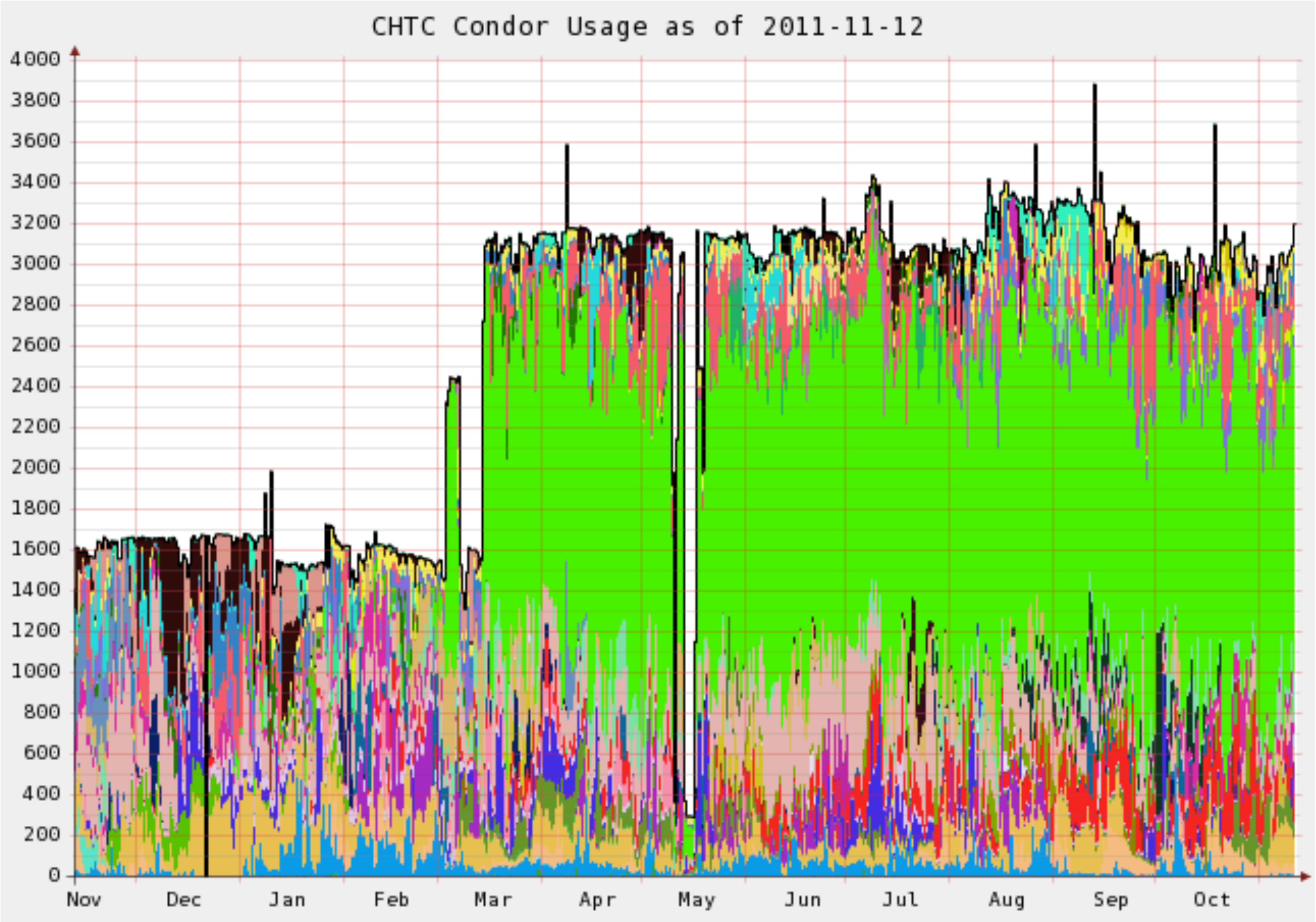
Computing

People

CHTC Machines

- **Hardware**
  - ~170 8–12-core 2.6–2.8 GHz Intel 64-bit, 1U servers
  - Typical machine: 12–24 GB memory, ~350 GB disk
  - 1 Gbit Ethernet (good for file transfer, not MPI)
- **Software**
  - Scientific Linux 5 (var. of RHEL 5); some RHEL 6
  - Languages: ***Python***, C/C++, Java, Perl, Fortran, …
  - Extra software (no licenses): R, MATLAB, Octave
- **Location:** Mostly in CompSci B240, some in WID

CHTC Usage Statistics



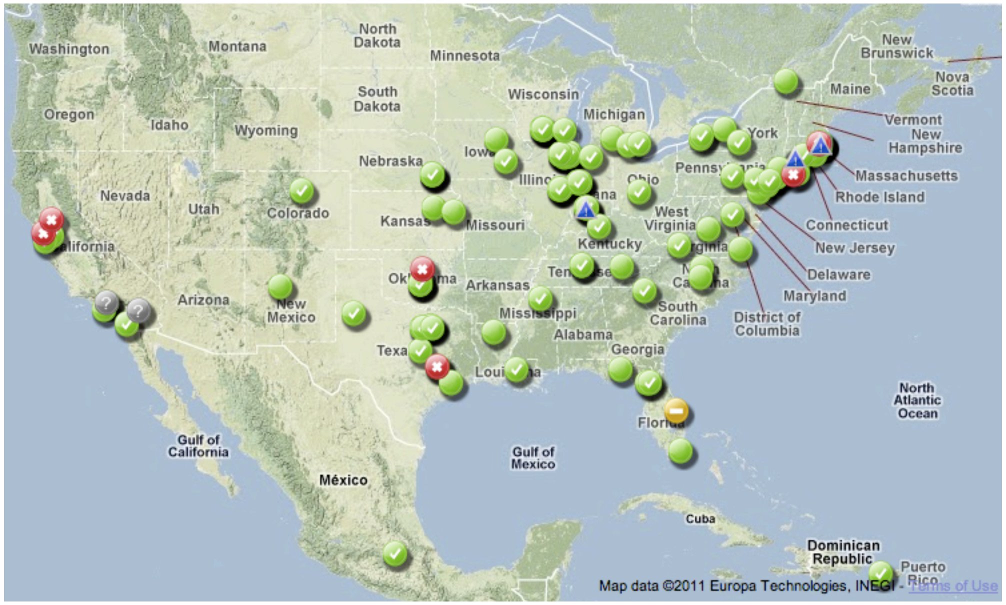
~35,000 hours per day

~1,000,000 hours per month

~15,000,000 hours per year

Open Science Grid

- HTC scaled ***way*** up
  - Over 100 sites
  - Mostly in U.S., plus others
  - Past year:
    - ✦ ~200,000,000 jobs
    - ✦ ~514,000,000 CPU hours
    - ✦ ~280,000 TB transferred



- Can submit jobs to CHTC, move to OSG
- http://www.opensciencegrid.org/

Anyone want a tour?

Condor

History and Status

- **History**
  - Started in 1988 as a “cycle scavenger”
  - Protected interests of users ***and*** machine owners
- **Today**
  - Expanded to become CHTC team: 20+ full-time staff
  - Current production release: Condor 7.6.6
  - Condor software alone: ~700,000 lines of C/C++ code
- **Miron Livny**
  - Professor, UW–Madison CompSci
  - Director, CHTC
  - Dir. of Core Comp. Tech., WID/MIR
  - Tech. Director & PI, OSG

What Does Condor Do?

- **Users**
  - Define jobs, their requirements, and preferences
  - Submit and cancel jobs
  - Check on the state of a job
  - Check on the state of the machines
- **Administrators**
  - Configure and control the Condor system
  - Declare policies on machine use, pool use, etc.
- **Internally**
  - Match jobs to machines (enforcing all policies)
  - Track and manage machines
  - Track and run jobs

Jobs

- **= Computer programs**
- **Not *interactive*** (e.g., Word, Firefox, email)
- ***Batch processing***: Run without human intervention
  - Input: command-line arguments, files, downloads?
  - Run: do stuff
  - Output: standard output & error, files, DB update?
- **Scheduling**
  - Reserved: Person gets time slot, computer runs then
  - Opportunistic:
    Person submits job, computer decides schedule

Machines

- Terminology
  - A ***machine*** is a physical computer (typically)
  - May have multiple ***processors*** (computer chips)
  - These days, each may have multiple ***cores*** (CPUs)
- **Condor: *Slot***
  - One assignable unit of a computing resource
  - Most often, corresponds to one core
  - Thus, typical machines today have 4–40 slots
- Advanced Condor feature: Can request multiple cores for a single slot (that uses parallel computing)

Matchmaking

- Two-way process of matching jobs and machines
- **Job**
  - Requirements, e.g.: OS, architecture, memory, disk
  - Preferences, e.g.: owner, speed, memory, disk, load
- **Machine**
  - Requirements, e.g.: submitter, time of day, usage
  - Preferences, e.g.: submitter, memory, disk, load
- **Administrator**
  - Preferences, e.g.: prior usage, priority, various limits
- Thus: Not as simple as waiting in a line!

Running Jobs

Our Submit Machine

- **Access**
  - Hostname (ssh): **`submit-368.chtc.wisc.edu`**
  - If enrolled, get account info from me
- **Rules**
  - Full access to all CHTC resources (i.e., machines)
  - All UW Information Technology policies apply
    `http://www.cio.wisc.edu/policies.aspx`
  - OK for research ***and training***
  - Usage is monitored
- **Notes**
  - No backups! Keep original files elsewhere
  - Accounts will be disabled 1 June 2012, unless…

Viewing Slots

```
condor_status
```

- With no arguments, lists *all* slots currently in pool
- Summary info at end
- For more options: **-h**, Condor Manual, next class

```
slot6@opt-a001.cht LINUX      X86_64 Claimed   Busy     1.000  1024  0+19:09:32
slot7@opt-a001.cht LINUX      X86_64 Claimed   Busy     1.000  1024  0+19:09:31
slot8@opt-a001.cht LINUX      X86_64 Unclaimed Idle     1.000  1024  0+17:37:54
slot9@opt-a001.cht LINUX      X86_64 Claimed   Busy     1.000  1024  0+19:09:32
slot10@opt-a002.ch LINUX      X86_64 Unclaimed Idle     0.000  1024  0+17:55:15
slot11@opt-a002.ch LINUX      X86_64 Unclaimed Idle     0.000  1024  0+17:55:16
```

```
                     Total Owner Claimed Unclaimed Matched Preempting Backfill

       INTEL/WINNT51     2     0       0         2       0          0        0
       INTEL/WINNT61    52     2       0        50       0          0        0
        X86_64/LINUX  2086   544    1258       284       0          0        0

               Total  2140   546    1258       336       0          0        0
```

Viewing Jobs

```
condor_q
```

- With no args, lists *all* jobs waiting or running here
- For more options: **-h**, Condor Manual, next class

```
-- Submitter: submit-368.chtc.wisc.edu : <...> : ...
 ID      OWNER            SUBMITTED     RUN_TIME ST PRI SIZE CMD
   6.0   cat            11/12 09:30   0+00:00:00 I  0   0.0  explore.py
   6.1   cat            11/12 09:30   0+00:00:00 I  0   0.0  explore.py
   6.2   cat            11/12 09:30   0+00:00:00 I  0   0.0  explore.py
   6.3   cat            11/12 09:30   0+00:00:00 I  0   0.0  explore.py
   6.4   cat            11/12 09:30   0+00:00:00 I  0   0.0  explore.py

5 jobs; 5 idle, 0 running, 0 held
```

```
condor_q owner
```

- Just one owner’s jobs (e.g., your own)

Basic Submit File

```
executable = word_freq.py
universe = vanilla
arguments = "words.txt 1000"

output = word_freq.out
error = word_freq.err
log = word_freq.log

should_transfer_files = YES
when_to_transfer_output = ON_EXIT
transfer_input_files = words.txt

queue
```

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```

Program to run.
Must be runnable
from command line.
Path is relative to
current directory
when submitted

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Command-line arguments to pass to executable when run; surround with double quotes *[opt]*

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Local files that will receive the contents of standard output and error from the run *[opt]*

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queue
```

Condor's log file from running the job; very helpful, do not omit!

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```

Comma-separated list of input files to transfer to machine *[opt]*

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error = word_freq.err
log = word_freq.log

should_transfer_files = YES
when_to_transfer_output = ON_EXIT
transfer_input_files = words.txt

queue
```

Must have this to run job!

Submit a Job

```
condor_submit submit-file
```

- Submits job to local submit machine
- Use **condor_q** to track

```
Submitting job(s).
1 job(s) submitted to cluster NNN.
```

- One **condor_submit** yields one ***cluster*** (in queue)
- Each **queue** statement yields one ***process***
- **condor_q**: **ID** is ***cluster*.*process*** (e.g., **8.0**)
- We will see how to set up multiple jobs next time

Remove a Job

```
condor_rm cluster [...]
condor_rm cluster.process [...]
```

- Removes one or more jobs from the queue
- Identify each removal by whole cluster or single ID
- Only you *(or admin: me)* can remove your own jobs

```
Cluster NNN has been marked for removal.
```

Homework

Homework

- Run a job… or several!
  - I supply a Python script — a bit like homework #1
  - How many of your past homeworks can you run?
  - Do you have any other jobs to run?
- Turn in submit file + resulting log, out, and err files
- Watch for errors and hung jobs!!!
  - Be sure your script runs from command line
  - Monitor log file
  - Remove hung jobs (see homework)