Open Science Grid

Submitting Many Jobs at Once

Monday, Lecture 2

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Questions so far?

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Goals for this Session

- Logs, job states, and resource utilization
- Testing and troubleshooting as part of scaling up.
- Best ways to submit multiple jobs (what we're here for, right?)

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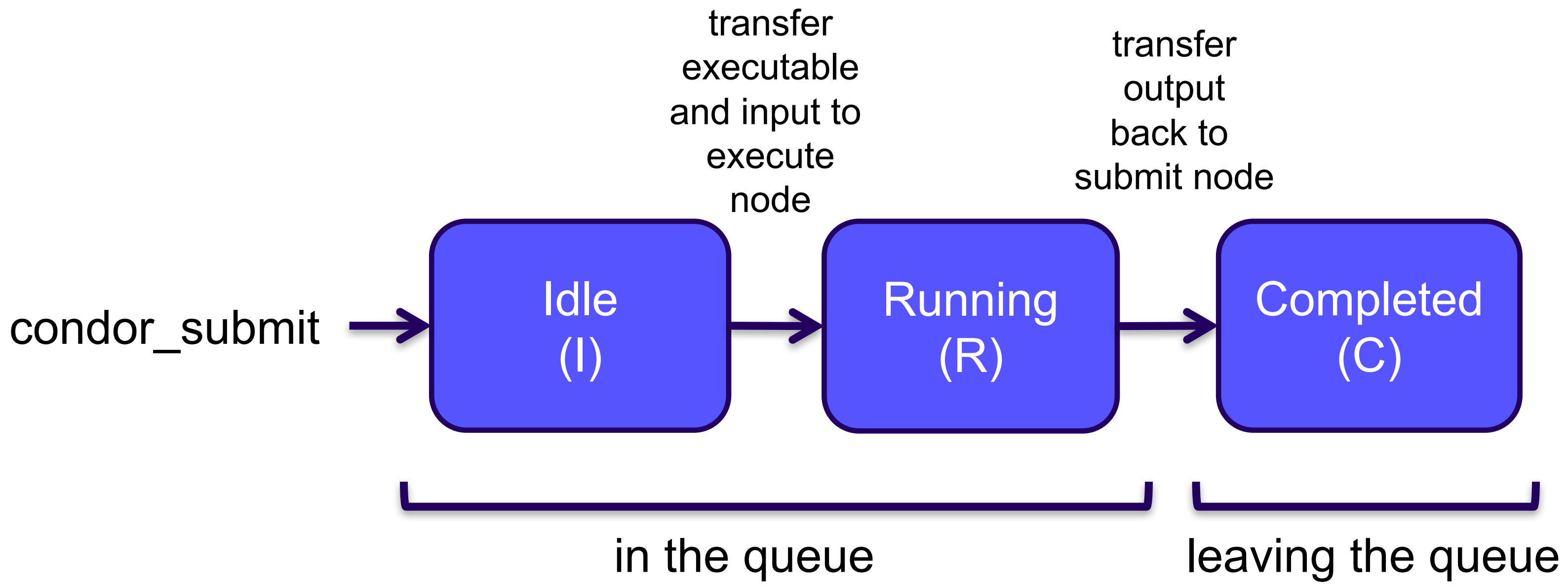
Log File

```
000 (128.000.000) 05/09 11:09:08 Job submitted from host: <128.104.101.92&sock=6423_b881_3>
...
001 (128.000.000) 05/09 11:10:46 Job executing on host: <128.104.101.128:9618&sock=5053_3126_3>
...
006 (128.000.000) 05/09 11:10:54 Image size of job updated: 220
        1   -  MemoryUsage of job (MB)
        220   -  ResidentSetSize of job (KB)
...
005 (128.000.000) 05/09 11:12:48 Job terminated.
        (1) Normal termination (return value 0)
                Usr 0 00:00:00, Sys 0 00:00:00  -  Run Remote Usage
                Usr 0 00:00:00, Sys 0 00:00:00  -  Run Local Usage
                Usr 0 00:00:00, Sys 0 00:00:00  -  Total Remote Usage
                Usr 0 00:00:00, Sys 0 00:00:00  -  Total Local Usage
        0   -  Run Bytes Sent By Job
        33   -  Run Bytes Received By Job
        0   -  Total Bytes Sent By Job
        33   -  Total Bytes Received By Job
        Partitionable Resources :    Usage  Request Allocated
           Cpus                 :                 1         1
           Disk (KB)            :       14    20480  17203728
           Memory (MB)          :        1       20        20
```

Job States


transfer executable and input to execute node
transfer output back to submit node
condor_submit
Idle (I)
Running (R)
Completed (C)
in the queue
leaving the queue

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Log File

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        Partitionable Resources :    Usage  Request Allocated
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           Memory (MB)          :        1       20        20
```

Resource Request

- Jobs are nearly always using a part of a machine (a single slot), and not the whole thing
- Very important to request appropriate resources (***memory***, ***cpus***, ***disk***)
  - **requesting too little**: causes problems for your and other jobs; jobs might by ‘held’ by HTCondor
  - **requesting too much:** jobs will match to fewer “slots” than they could, and you’ll block other jobs

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Log File

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...
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                Usr 0 00:00:00, Sys 0 00:00:00  -  Total Local Usage
        0   -  Run Bytes Sent By Job
        33   -  Run Bytes Received By Job
        0   -  Total Bytes Sent By Job
        33   -  Total Bytes Received By Job
        Partitionable Resources :    Usage  Request Allocated
           Cpus                 :                 1         1
           Disk (KB)            :       14    20480  17203728
           Memory (MB)          :        1       20        20
```

TESTING AND TROUBLESHOOTING

What Can Go Wrong?

- Jobs can go wrong “internally”:
  - the executable experiences an error
- Jobs can go wrong from HTCondor’s perspective:
  - a job can’t be matched
  - a job is missing files
  - uses too much memory
  - has a badly formatted executable
  - and more...

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Reviewing Failed Jobs

- A job's log, output and error files can provide valuable information for troubleshooting

Log	Output	Error
• When jobs were submitted, started, held, or stopped • Resources used • Exit status • Where job ran • Interruption reasons	Any "print" or "display" information from your program (may contain errors from the executable).	Errors captured by the operating system while the executable ran, or reported by the executable, itself.

Reviewing Jobs

- To review a large group of jobs at once, use **condor_history**

As **condor_q** is to the present, **condor_history** is to the past

```
$ condor_history alice
 ID        OWNER     SUBMITTED    RUN_TIME     ST  COMPLETED    CMD
189.1012 alice     5/11 09:52   0+00:07:37 C   5/11 16:00 /home/alice
189.1002 alice     5/11 09:52   0+00:08:03 C   5/11 16:00 /home/alice
189.1081 alice     5/11 09:52   0+00:03:16 C   5/11 16:00 /home/alice
189.944  alice     5/11 09:52   0+00:11:15 C   5/11 16:00 /home/alice
189.659  alice     5/11 09:52   0+00:26:56 C   5/11 16:00 /home/alice
189.653  alice     5/11 09:52   0+00:27:07 C   5/11 16:00 /home/alice
189.1040 alice     5/11 09:52   0+00:05:15 C   5/11 15:59 /home/alice
189.1003 alice     5/11 09:52   0+00:07:38 C   5/11 15:59 /home/alice
189.962  alice     5/11 09:52   0+00:09:36 C   5/11 15:59 /home/alice
189.961  alice     5/11 09:52   0+00:09:43 C   5/11 15:59 /home/alice
189.898  alice     5/11 09:52   0+00:13:47 C   5/11 15:59 /home/alice
```

HTCondor Manual: condor_history

Held Jobs

- HTCondor will put your job on hold if there’s something YOU need to fix.
  - files not found for transfer, over memory, etc.
- A job that goes on hold is interrupted (all progress is lost) and kept from running again, but remains in the queue in the “H” state until removed, or (fixed and) released.

Diagnosing Holds

- If HTCondor puts a job on hold, it provides a hold reason, which can be viewed in the log file, with **`condor_q -hold <Job.ID>`**, or with:

`condor_q -hold -af HoldReason`

```
$ condor_q -hold -af HoldReason
Error from slot1_1@wid-003.chtc.wisc.edu: Job has gone over
  memory limit of 2048 megabytes.
Error from slot1_20@e098.chtc.wisc.edu: SHADOW at
  128.104.101.92 failed to send file(s) to <128.104.101.98:35110>: error
  reading from /home/alice/script.py: (errno 2) No such file or directory;
  STARTER failed to receive file(s) from <128.104.101.92:9618>
Error from slot1_11@e138.chtc.wisc.edu: STARTER
  at 128.104.101.138 failed to send file(s) to <128.104.101.92:9618>;
SHADOW at
  128.104.101.92 failed to write to file /home/alice/Test_18925319_16.err:
  (errno 122) Disk quota exceeded
```

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Common Hold Reasons

- Job has used **more memory** than requested.
- **Incorrect path to files** that need to be transferred
- **Badly formatted executable scripts** (have Windows instead of Unix line endings)
- Submit directory is **over quota**.
- **Job has run for too long**. (72 hours allowed in CHTC Pool)
- The **admin has put your job on hold**.

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Fixing Holds

- Job attributes can be edited while jobs are in the queue using:

condor_qedit [U/C/J] Attribute Value

```
$ condor_qedit 128.0 RequestMemory 3072
Set attribute ”RequestMemory".
```

- If a job has been fixed and can run again, release it with:

condor_release [U/C/J]

```
$ condor_release 128.0
Job 18933774.0 released
```

HTCondor Manual: condor_qedit
HTCondor Manual: condor_release

Holding or Removing Jobs

- If you know your job has a problem and it hasn't yet completed, you can:
  - Place it on hold yourself, with **`condor_hold [U/C/J]`**

```
$ condor_hold bob
All jobs of user "bob" have been held
```

```
$ condor_hold 128
All jobs in cluster 128 have been held
```

```
$ condor_hold 128.0
Job 128.0 held
```

  - Remove it from the queue, using **`condor_rm [U/C/J]`**

[HTCondor Manual: condor_hold]()
[HTCondor Manual: condor_rm]()

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SUBMITTING MULTIPLE JOBS

Many Jobs, One Submit File

- HTCondor has built-in ways to submit multiple independent jobs with one submit file

Advantages

- Run many independent jobs...
    - analyze multiple data files
    - test parameter or input combinations
    - scale up by breaking up!
    - *we're learning HTC, right?*
- ...without having to:
    - create separate submit files for each job
    - submit and monitor each job, individually

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From one job …

job.submit

```
executable = analyze.exe
arguments = file.in file.out
transfer_input_files = file.in

log = job.log
output = job.out
error = job.err

queue
```

(submit_dir)/

```
analyze.exe
file0.in
file1.in
file2.in

job.submit
```

- Goal: create 3 jobs that each analyze a different input file.

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Multiple numbered input files

job.submit

```
executable = analyze.exe
arguments = file.in file.out
transfer_input_files = file.in

log = job.log
output = job.out
error = job.err

queue 3
```

(submit_dir)/

```
analyze.exe
file0.in
file1.in
file2.in

job.submit
```

- Generates 3 jobs, but doesn't change inputs and will overwrite the outputs
- So how can we specify different values to each job?

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One submit file per job (not recommended!)

job0.submit

```
executable = analyze.exe

arguments = file0.in file0.out
transfer_input_files = file0.in
output = job0.out
error = job0.err
queue 1
```

job1.submit

```
executable = analyze.exe

arguments = file0.in file0.out
transfer_input_files = file0.in
output = job0.out
error = job0.err
queue 1
```

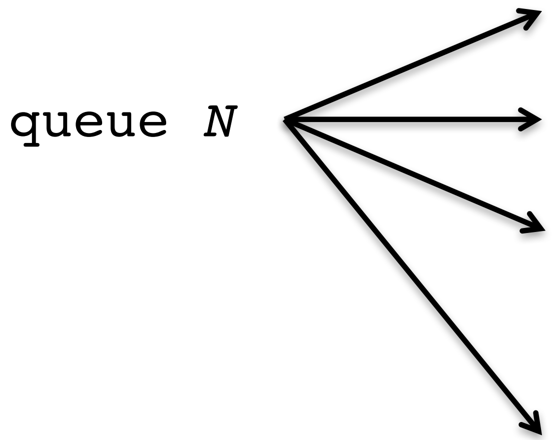
(etc…)

(submit_dir)/

```
analyze.exe
file0.in
file1.in
file2.in
(etc.)

job0.submit
job1.submit
job2.submit
(etc.)
```

Automatic Variables



ClusterId	ProcId
128	0
128	1
128	2
…	…
128	*N-1*

Each job's **ClusterId** and **ProcId** numbers are autogenerated and saved as job attributes.

The user can reference them inside the submit file using:*

- **`$(Cluster)`**
- **`$(Process)`**

* $(ClusterId) and $(ProcId) are also okay

Using $(Process) for Numbered Files

job.submit

```
executable = analyze.exe
arguments = file$(Process).in file$(Process).out
transfer_input_files = file$(Process).in

log = job_$(Cluster).log
output = job_$(Process).out
error = job_$(Process).err

queue 3
```

(submit_dir)/

```
analyze.exe
file0.in
file1.in
file2.in

job.submit
```

- $(Process) and $(Cluster) allow us to provide unique values to each job and submission!

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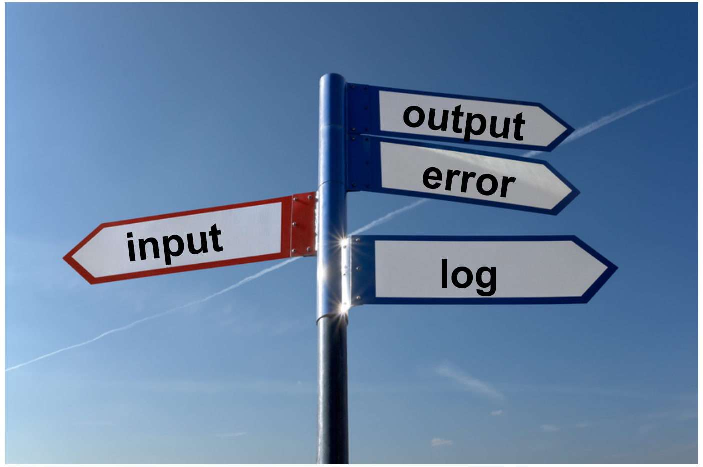
Organizing Files in Sub-Directories

- Create sub-directories* and use paths in the submit file to separate various input, error, log, and output files.



* must be created before the job is submitted

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Shared Files

- HTCondor can transfer an entire directory or all the contents of a directory
  - transfer whole directory

```
transfer_input_files = shared
```

  - transfer contents only

```
transfer_input_files = shared/
```

- Useful for jobs with many shared files; transfer a directory of files instead of listing files individually

```
(submit_dir)/

job.submit
shared/
    reference.db
    parse.py
    analyze.py
    cleanup.py
    links.config
```

Use Paths for File Type

(submit_dir)/

```
job.submit     file0.out     input/         log/          err/
analyze.exe    file1.out       file0.in       job0.log      job0.err
               file2.out       file1.in       job1.log      job1.err
                               file2.in       job2.log      job2.err
```

job.submit

```
executable = analyze.exe
arguments = file$(Process).in file$(Process).out
transfer_input_files = input/file$(Process).in

log = log/job$(Process).log
error = err/job$(Process).err

queue 3
```

Separating Files by Job with InitialDir

- `Initialdir` sets the initial location for each job's files, allowing each job to "live" in separate directories on the submit server
- Allows same filenames for input/output files across jobs
- Also useful for jobs with lots of output files

job0
job1
job2
job3
job4

Separating jobs with initialdir

(submit_dir)/

```
job.submit        job0/          job1/          job2/
analyze.exe         file.in        file.in        file.in
                    job.log        job.log        job.log
                    job.err        job.err        job.err
                    file.out       file.out       file.out
```

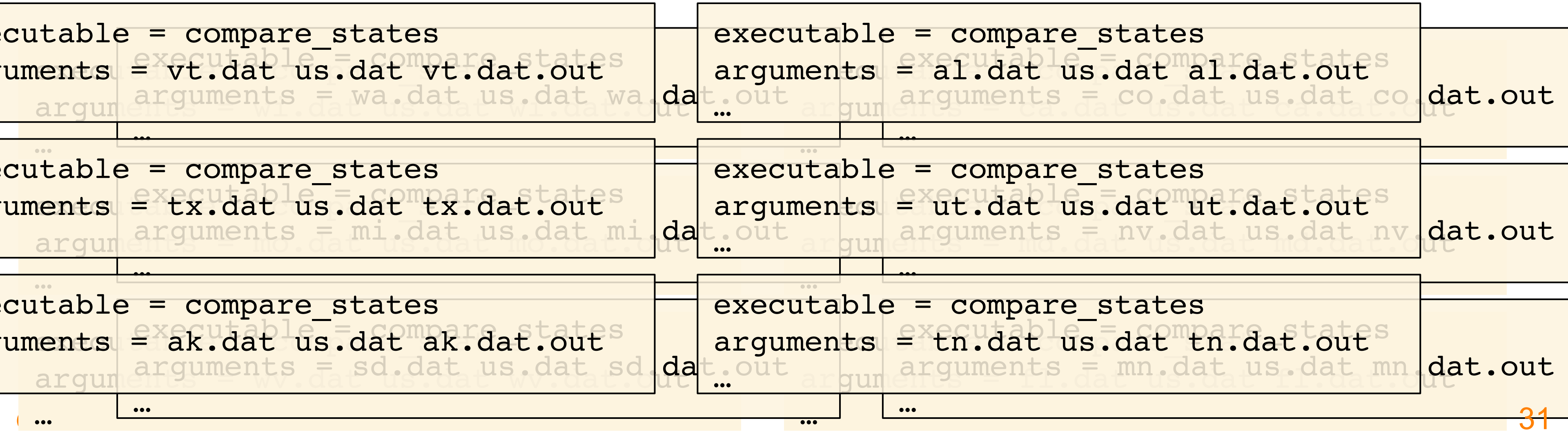
job.submit

```
executable = analyze.exe
initialdir = job$(Process)
arguments = file.in file.out
transfer_input_files = file.in

log = job.log
error = job.err

queue 3
```

executable must be relative to the submission directory, and *not* in the InitialDir.

What about non-numbered jobs?

- Back to our compare_states example…
- What if we had data for each state? We could do 50 submit files (or 50 "`queue 1`" statements) ...



```
cutable = compare_states
uments = vt.dat us.dat vt.dat.out
```

```
executable = compare_states
arguments = wa.dat us.dat wa.dat.out
…
```

```
argum ents = wi.dat us.dat wi.dat.out
…
```

```
executable = compare_states
arguments = al.dat us.dat al.dat.out
```

```
executable = compare_states
arguments = co.dat us.dat co.dat.out
…
```

```
argum ents = ca.dat us.dat ca.dat.out
…
```

```
cutable = compare_states
uments = tx.dat us.dat tx.dat.out
```

```
executable = compare_states
arguments = mi.dat us.dat mi.dat.out
…
```

```
argum ents = mo.dat us.dat mo.dat.out
…
```

```
executable = compare_states
arguments = ut.dat us.dat ut.dat.out
```

```
executable = compare_states
arguments = nv.dat us.dat nv.dat.out
…
```

```
argum ents = md.dat us.dat md.dat.out
…
```

```
cutable = compare_states
uments = ak.dat us.dat ak.dat.out
```

```
executable = compare_states
arguments = sd.dat us.dat sd.dat.out
…
```

```
argum ents = wv.dat us.dat wv.dat.out
…
```

```
executable = compare_states
arguments = tn.dat us.dat tn.dat.out
```

```
executable = compare_states
arguments = mn.dat us.dat mn.dat.out
…
```

```
argum ents = fl.dat us.dat fl.dat.out
…
```

What about non-numbered jobs?

- We could rename (map) our data to fit the $(Process) or approach …

- Or we could use HTCondor’s powerful **`queue`** language to submit jobs using our own variables!

Submitting Multiple Jobs – Queue Statements

multiple submit files	Not Recommended
var matching *pattern*	`queue state matching *.dat`
var in (i ii iii …)	`queue state in (wi.dat ca.dat co.dat)`

var1,var2 from *csv_file*	`queue state from` **`state_list.txt`**
	`state_list.txt:` `wi.dat`
	`ca.dat`
	`mo.dat`
	`...`

Using Multiple Variables

- Both the "`from`" and "`in`" syntax support multiple variables from a list.

job.submit

```
executable = compare_states
arguments = -y $(year) -i $(infile)

transfer_input_files = $(infile)

queue infile,year from job_list.txt
```

job_list.txt

```
wi.dat, 2010
wi.dat, 2015
ca.dat, 2010
ca.dat, 2015
mo.dat, 2010
mo.dat, 2015
```

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Multiple Job Use Cases – Queue Statements

multiple submit files	**Not recommended.** Though, can be useful for separating job *batches*, conceptually, for yourself.
var matching *pattern*	Natural nested looping, minimal programming, can use "files" or "dirs" keywords to narrow possible matches. Requires good naming conventions, less reproducible.
var in (i,ii,iii,…)	All information contained in the submit file: reproducible. Harder to automate submit file creation.
var1,var2 from *csv_file*	Supports multiple variables, highly modular (easy to use one submit file for many job batches that have different *var* lists), reproducible. Additional file needed, but can be automated.

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Other Features

- Match only files or directories:

```
queue input matching files *.dat
```

```
queue directory matching dirs job*
```

- Submit multiple jobs with same input data

```
queue 10 input matching files *.dat
```

  – Use other automatic variables: `$(Step)`

```
arguments = -i $(input) -rep $(Step)
queue 10 input matching files *.dat
```

- Combine with InitialDir:

```
InitialDir = $(directory)
queue directory matching dirs job*
```

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YOUR TURN!

Exercises!

- Ask questions!
- Lots of instructors around

- Coming up:
  - Now-12:15 Hands-on Exercises
  - 12:15 – 1:15 Lunch
  - 1:15 – 5:00 Afternoon sessions