Testing GPU/ML Framework Compatibility

Justin Hiemstra
HTCondor Week
May 24, 2022

Introduction

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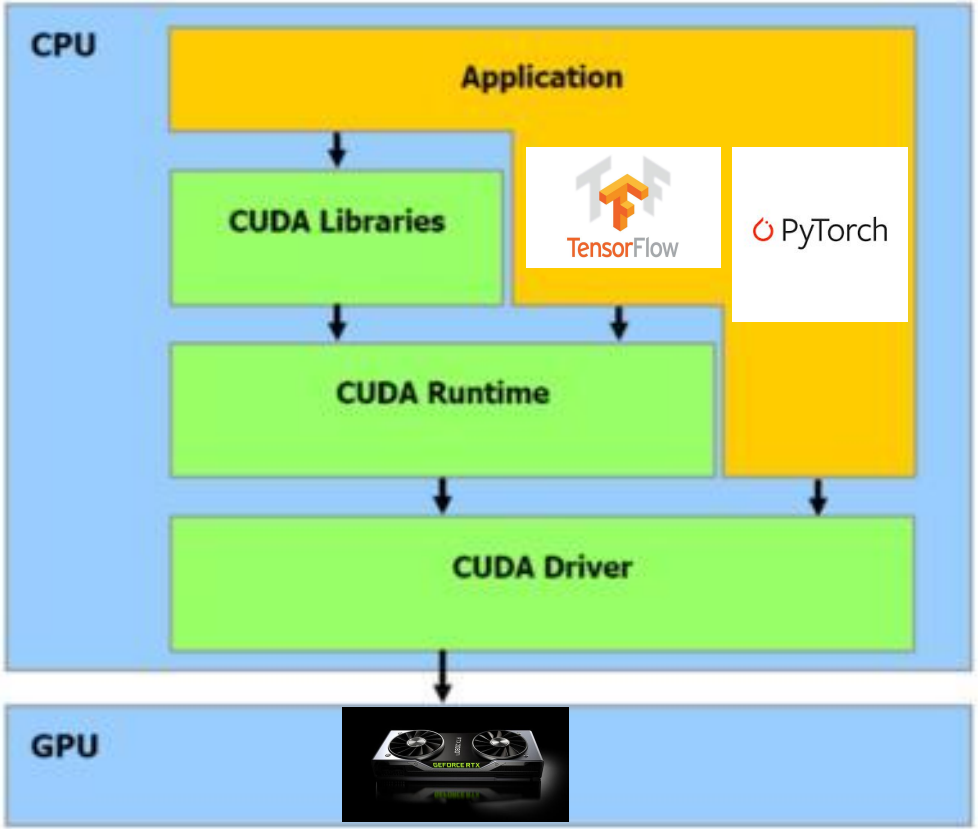

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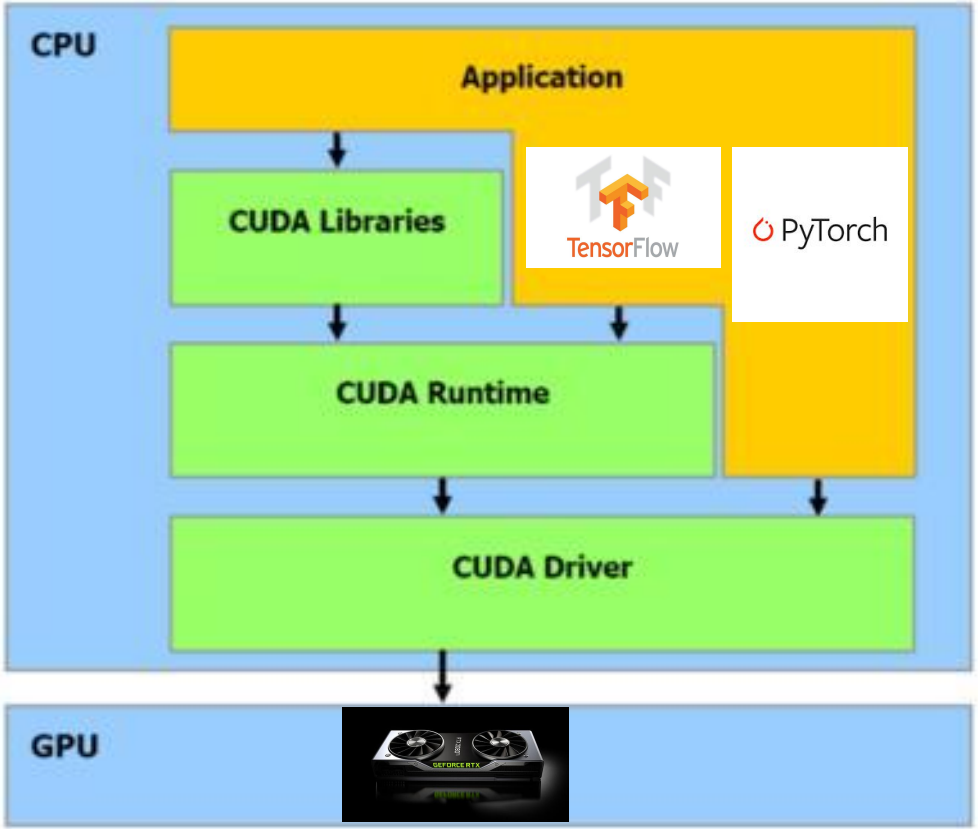

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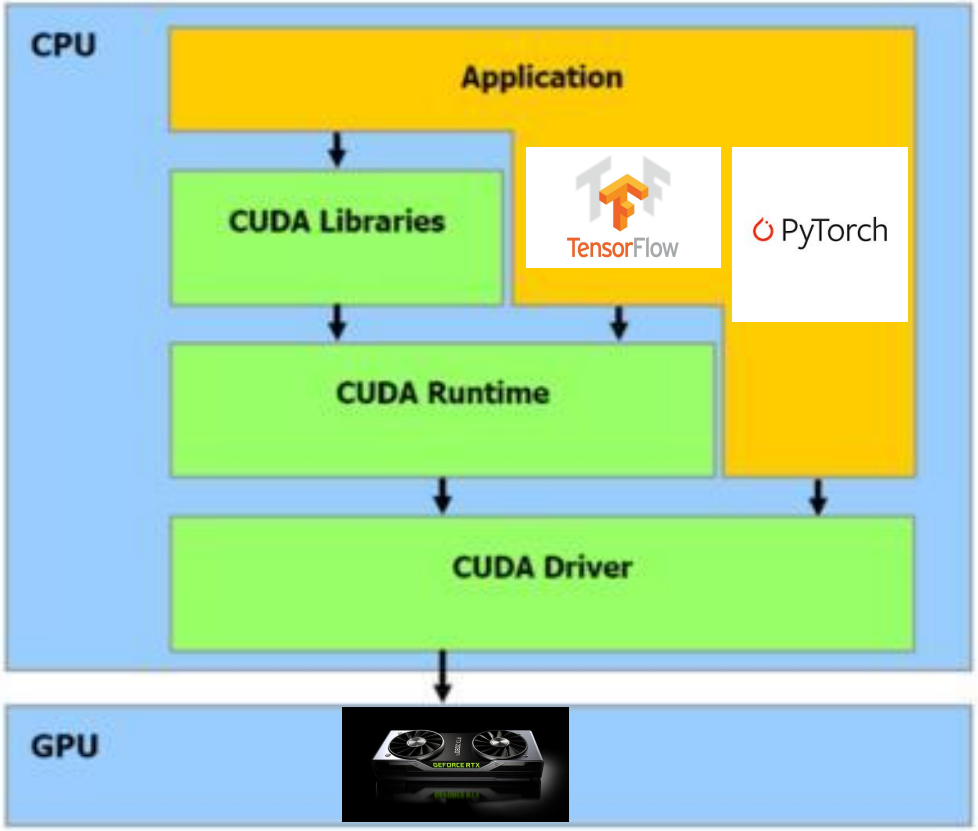
  b. GPU selection – in HTCondor, this is defined using a CUDA Compute capability



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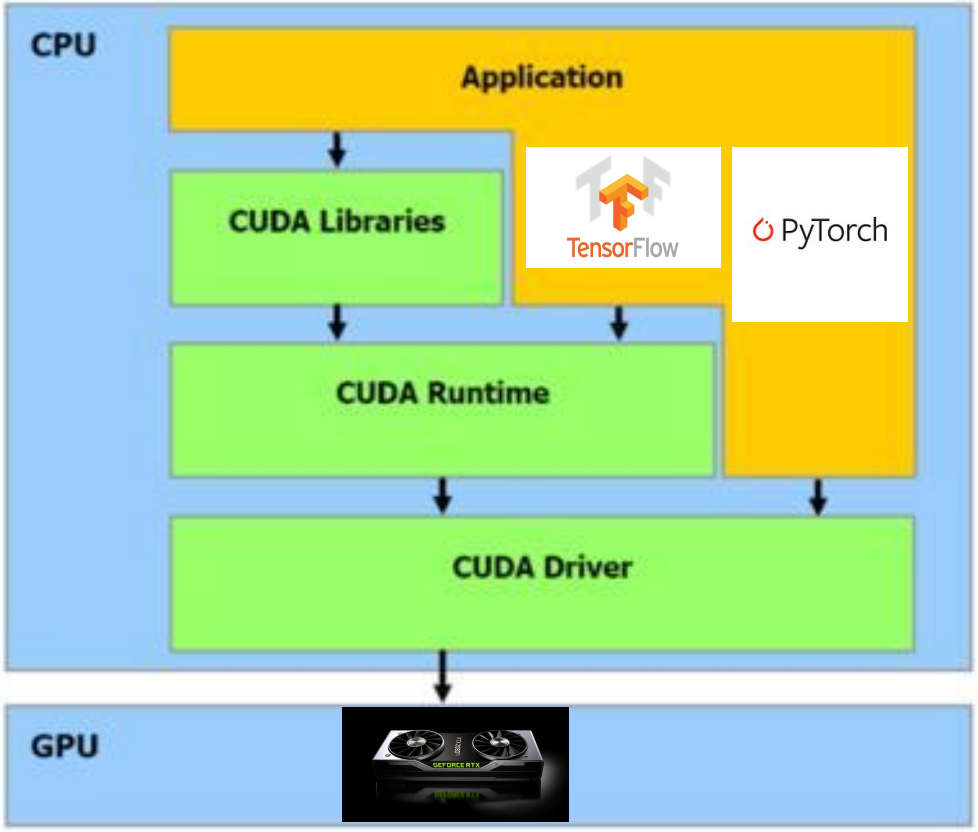
  b. GPU selection – in HTCondor, this is defined using a CUDA Compute capability
  c. An instance of some CUDA runtime library – this handles communication between the GPU and the computer by providing drivers.



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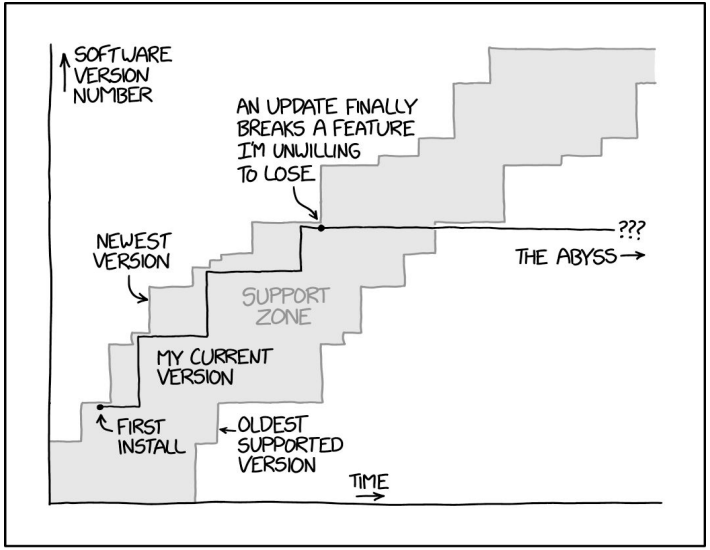
So why is this a difficult problem?

- Lack of documentation



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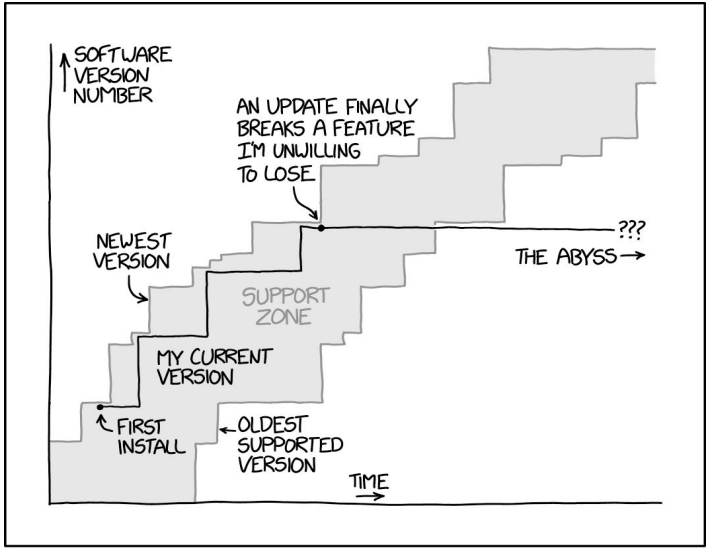
- Lack of documentation
- Dropped support for obsolete frameworks/compute capabilities
    - e.g. support for compute capability 2.x (Fermi architecture) dropped starting at CUDA runtime version 9.0



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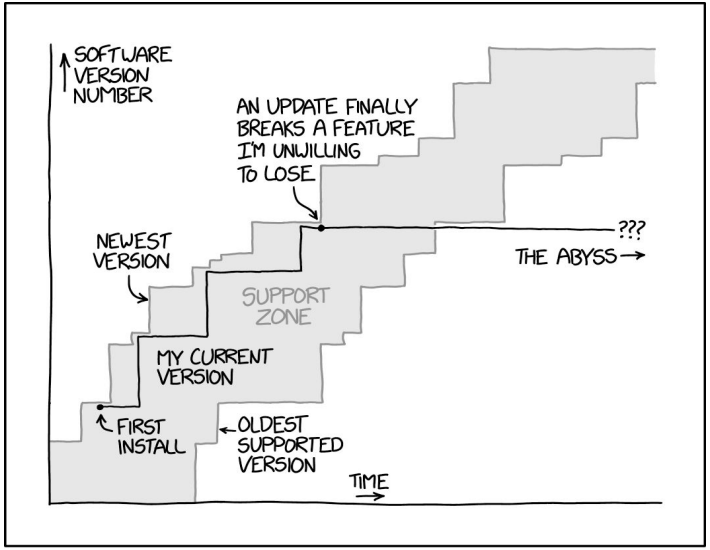
- Non-heterogeneous server configuration

Different servers with different max CUDA library versions

```
gzk-1.chtc.wisc.edu 8 NVIDIA GeForce GTX 1080 6.1 11.6
gitter0000.chtc.wisc.edu 4 NVIDIA GeForce GTX 1080 Ti 6.1 11.7
gitter2000.chtc.wisc.edu 4 Tesla K40m 3.5 11.4
```



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Testing a single tuple of versions

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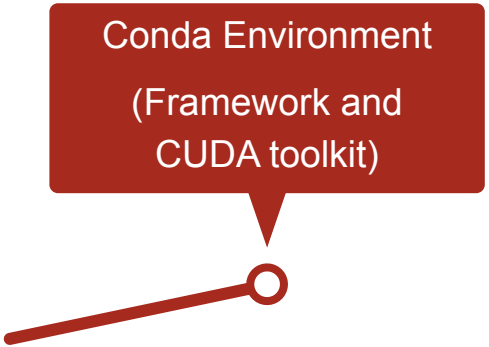

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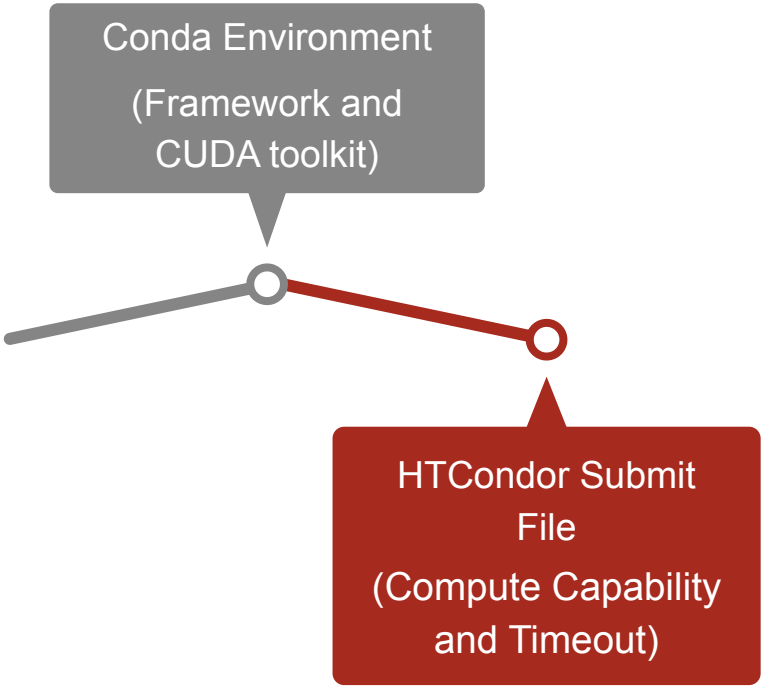

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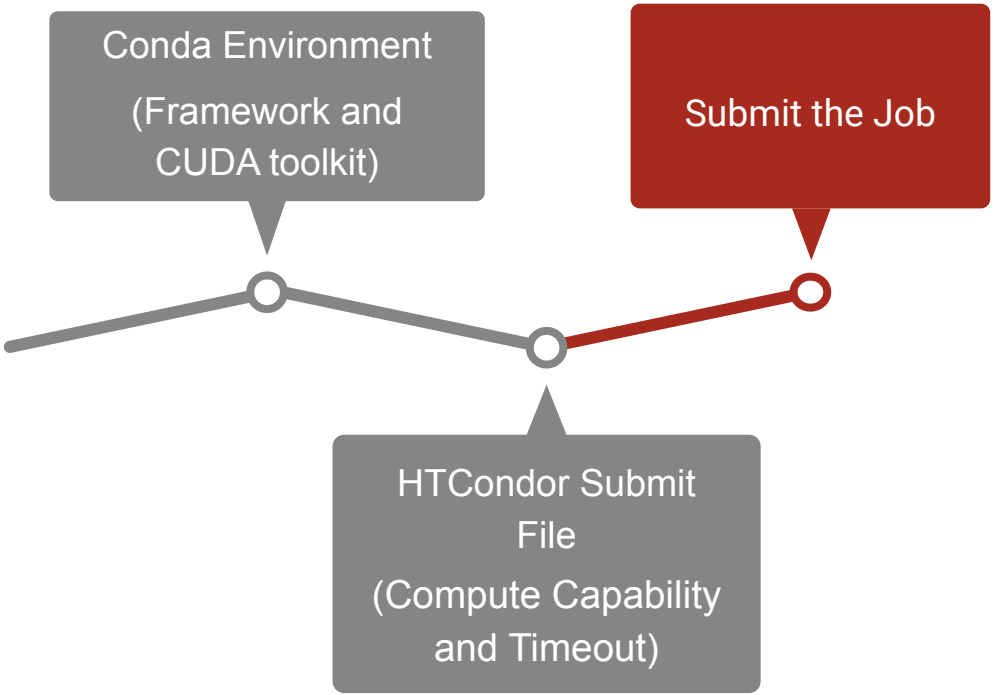

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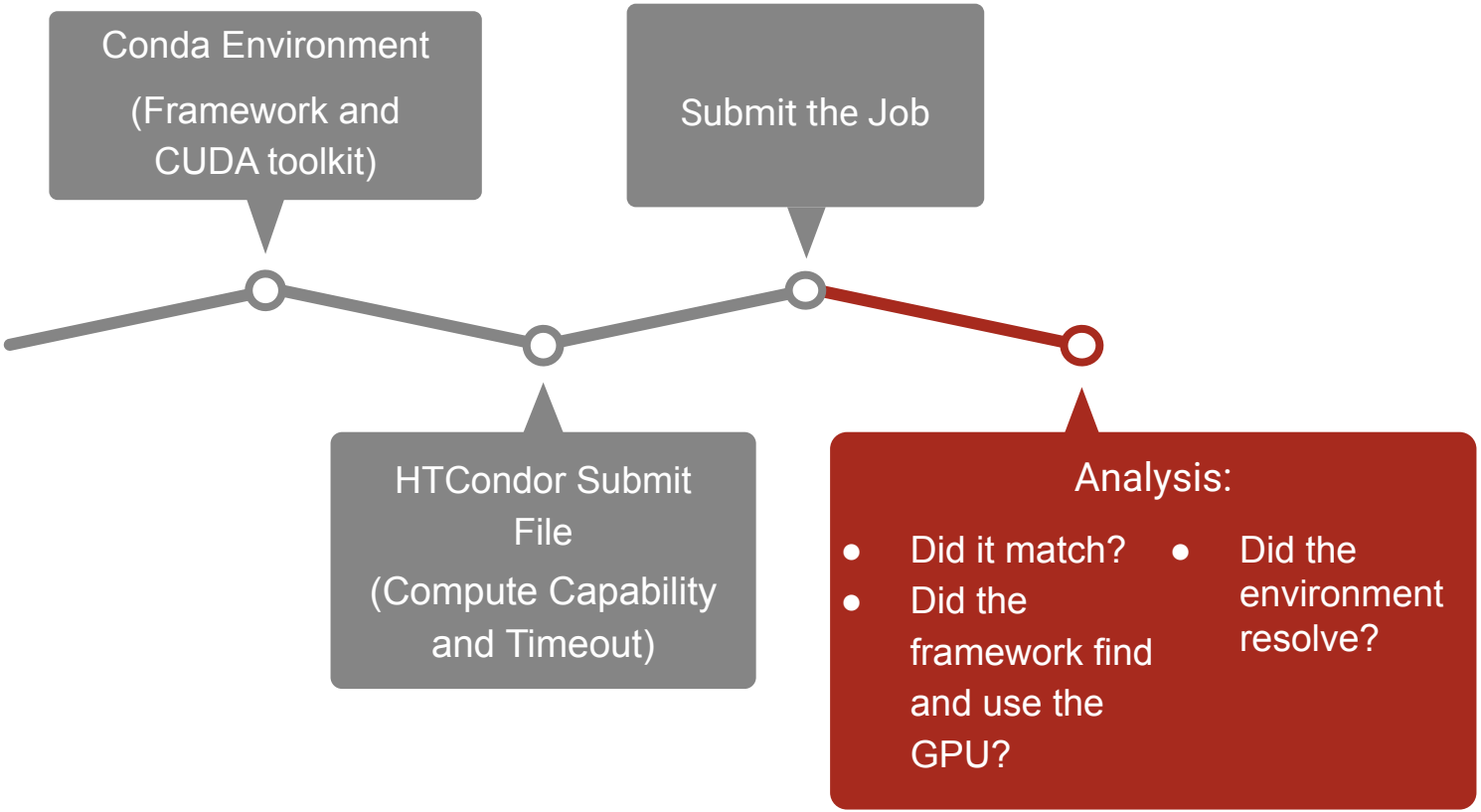
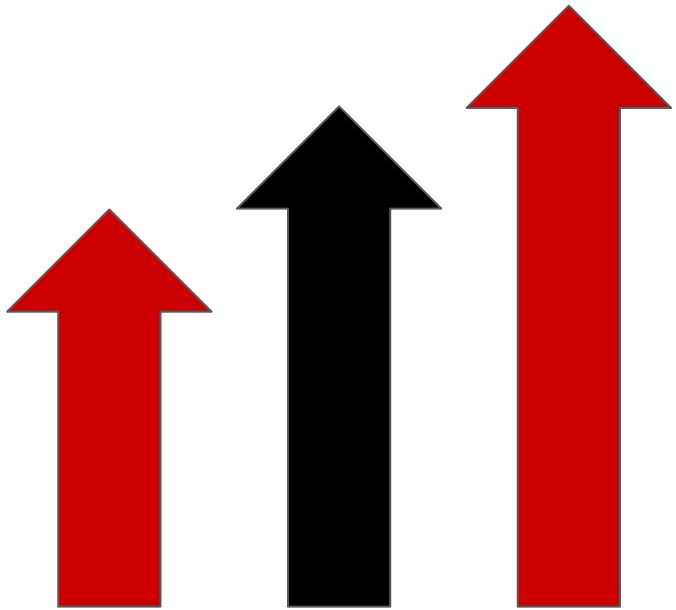


Scaling up

- Brute-force analysis of the entire version space poses challenges:
  - Very large search space will gobble up resources
  - Need some type of automation for collecting valid test parameters
  - How to manage all the jobs



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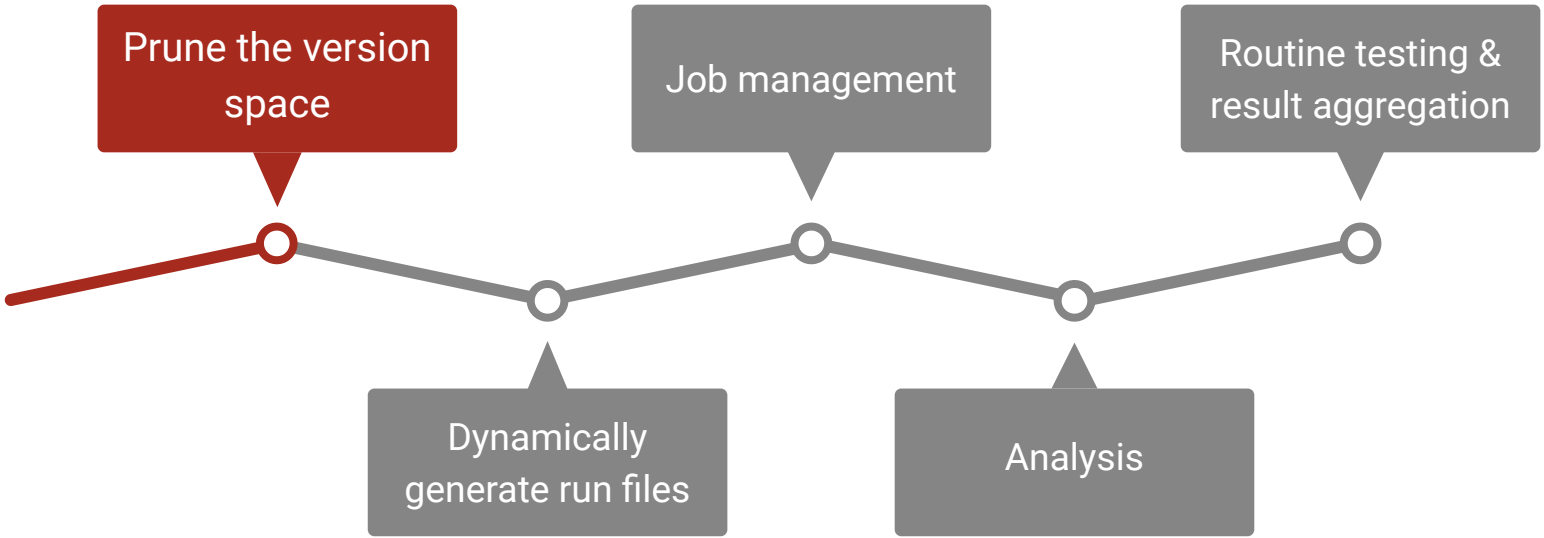
Prune the version space
Job management
Routine testing & result aggregation
Dynamically generate run files
Analysis

Version space pruning

- Only certain compute capabilities may be available
  - Query the system:

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conda search tensorflow-gpu -c conda-forge | grep -E -o \
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- Consider testing only the most recent versions of each framework/CUDA runtime

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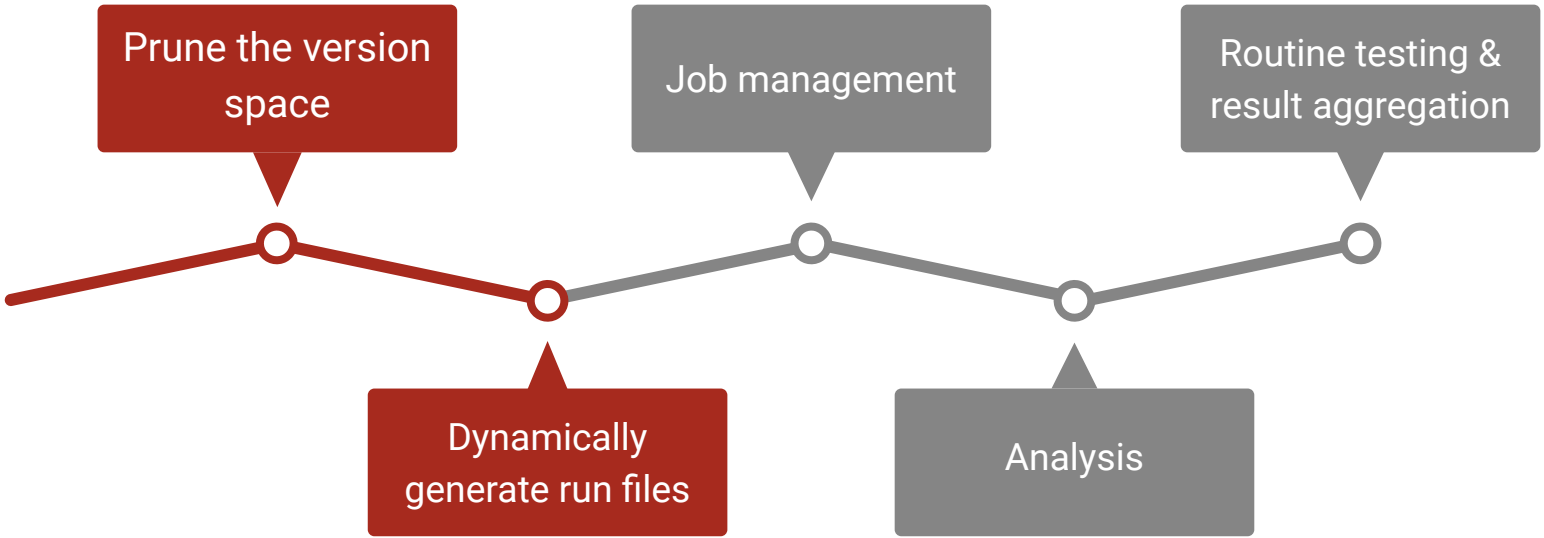
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Dynamic file generation

- Each job needs needs several files:
  - Portable Conda installer
  - Conda environment file (ML framework version and CUDA runtime version)
  - HTCondor submit file (Compute capability and timeout)
  - Script to configure environment on execute node

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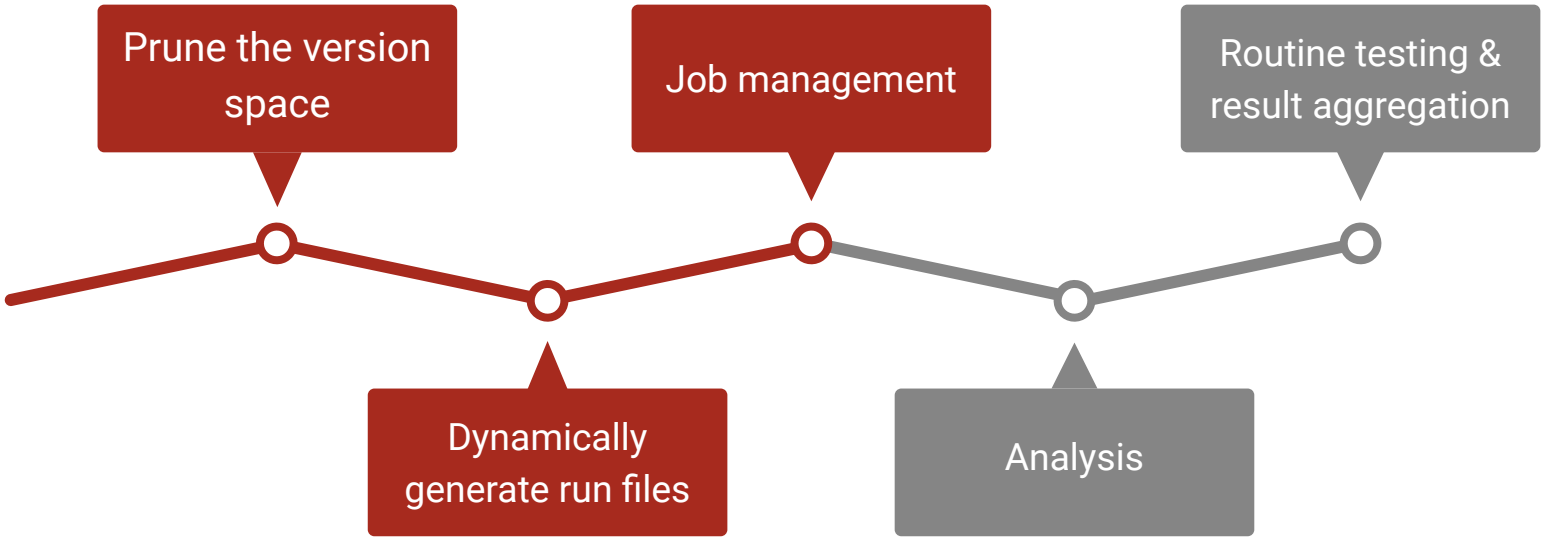
  - Script to configure environment on execute node
- For each job, use Python String format() method to build files

```
env_yml = """channels:
- conda-forge
- defaults
dependencies:
- tensorflow-gpu={}
-cudatoolkit={}"""\
.format(tf_version,cuda_lib_version)
```

Scaling up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- Once all files are generated, they need to be submitted and managed:
  - Each job as a timeout – if no match has occurred within this period, count as a failure
  - Wait until global timeout before processing output files

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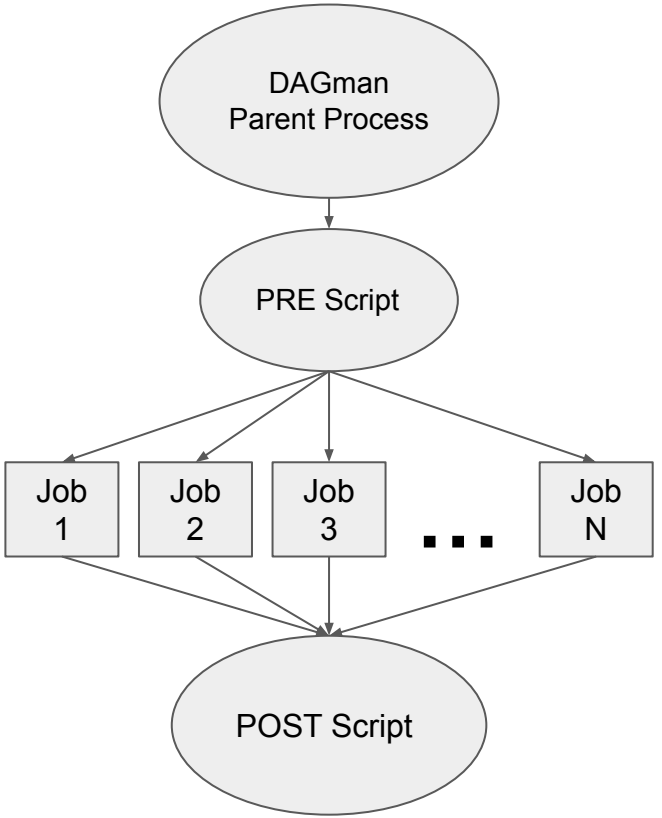
How can we automatically manage job submissions without leaving a script running on the submit node?

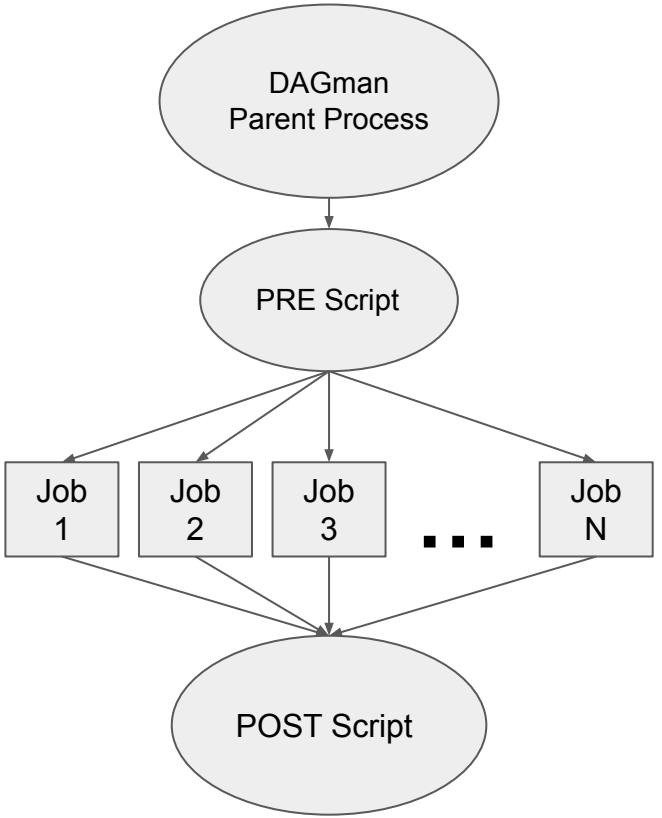
Directed Acyclic Graph Workflows (DAGs)

- HTCondor supports DAGman, a tool for DAG workflows



Directed Acyclic Graph Workflows (DAGs)

- HTCondor supports DAGman, a tool for DAG workflows
- Testing procedure using DAGman:
  - DAGman spawns a parent process
  - Parent process runs PRE Script to handle pruning and file generation
  - Parent process submits all jobs with a 24 hour timeout. Most will match but some won't
  - After 24 hours, parent process runs a POST script to interpret output of each job



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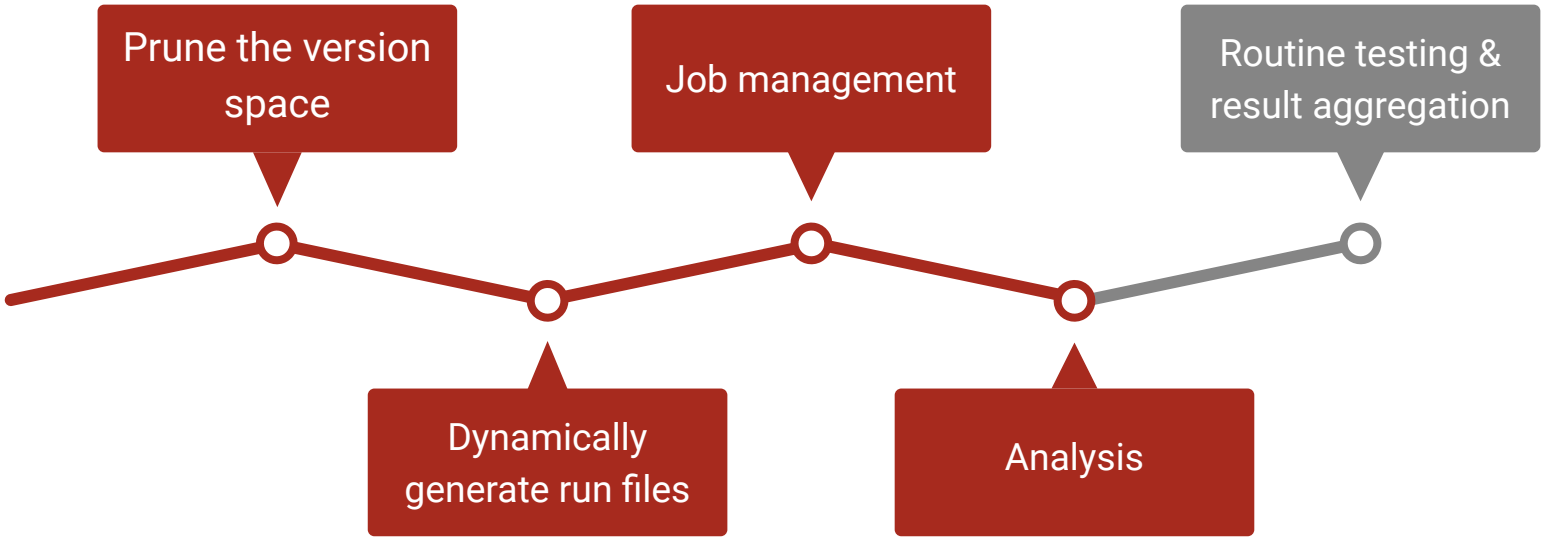
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- Conditions for "success:"
  - The job matched
  - The environment resolved
  - ML framework can see GPU and run a basic operation
- For each job:
  - Scan the output and error file
  - Look for keywords that indicate status of each condition
- A failure in any step constitutes a total failure
  - Record which step failed to better understand the system

Sample Output

Valid Combinations

Framework	Framework Version	Compute Capability	CUDA Runtime Version
TF	2.6	7.5	11.1-11.5
TF	2.7	7.5	11.1-11.5
TF	2.6	8.0	11.1-11.5
TF	2.7	8.0	11.1-11.5
PT	1.10	7.5	11.1-11.5
PT	1.11	7.5	11.1-11.5
PT	1.10	8.0	11.1-11.5
PT	1.11	8.0	11.1-11.5

Invalid Combinations

Framework	Framework Version	Compute Capability	CUDA Runtime Version	Failure Reason
TF	2.4	8.0	11.4	Environment Resolution Failure
TF	2.6	8.0	11.6	Failure to Match
PT	1.11	8.0	11.1	Environment Resolution Failure
PT	1.11	8.0	11.6	Failure to Match

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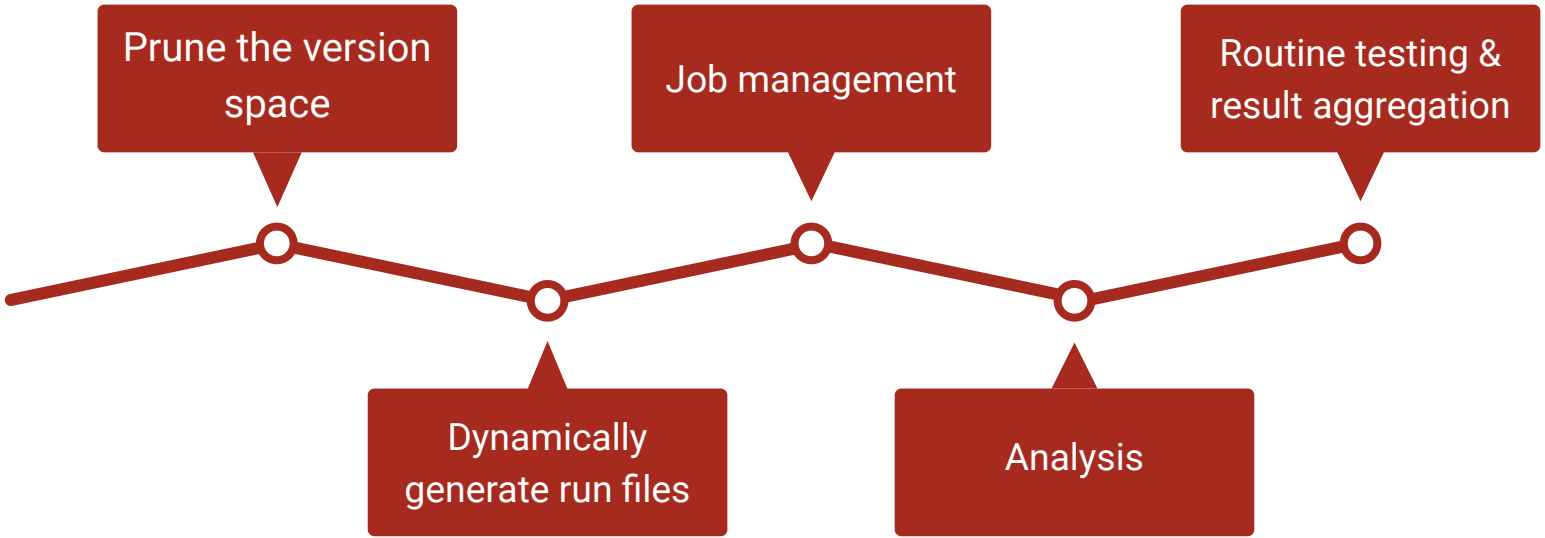
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Routine testing and result aggregation

- Run quarterly, view tables, look for anything unexpected
- Use the stored valid and invalid combinations to help during facilitation meetings, quickly diagnose reasons for failure
- Researcher could use this code and DAG to explore how these version combinations affect runtime or deep learning model performance

Questions?

GitHub Repo:
https://github.com/CHTC/gpu-compatibility-testing

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