Using the Work Queue Executor

coffea users meeting August 2021

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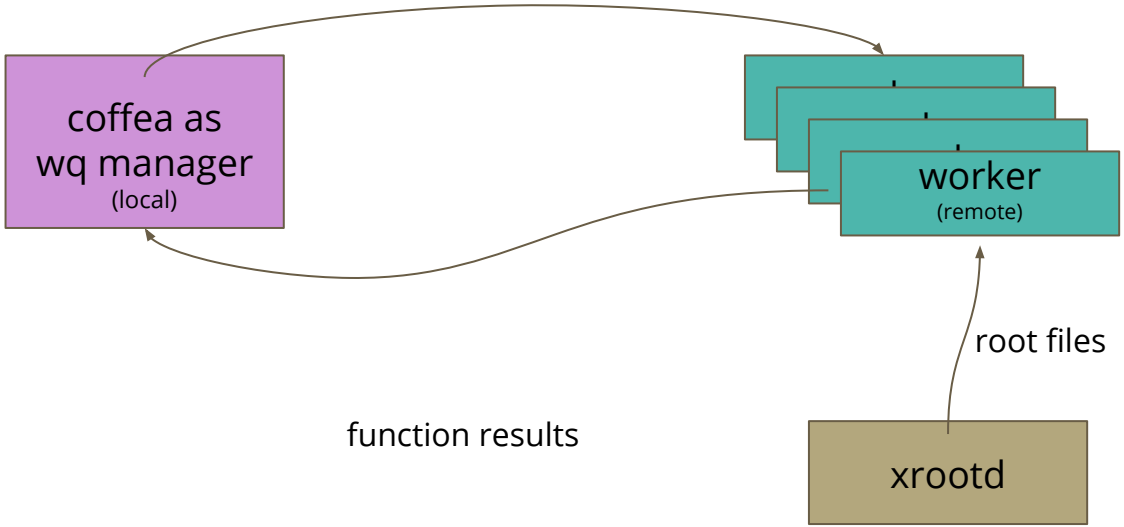
Work Queue Executor Overview

item descriptions
process functions
    or accumulator function with results to accumulate
python environment (once per worker)



Work Queue Executor User Responsibilities

- Setup coffea as Work Queue manager: **executor args**
- Construct a tarball with the python environment: **conda recipe**
- Launch desired number of workers in batch system: **manually or with wq factory**

- Optional, but highly recommended:
  - Activate automatic resource management: **wq figures out cores, mem, disk per function.**
  - Activate all log types.

Minimal Work Queue Executor arguments

```
from processor import run_uproot_job, work_queue_executor
exec_args = {
    # give the manager a name so workers can automatically find it:
    'master_name': '{}-wq-coffea'.format(os.environ['USER']),

    # find a port to run work queue in this range (above 1024):
    'port': [9123,9130],

    # if not given, assume environment already setup at execution site
    'environment_file': "my-coffea-env.tar.gz",

    # only if different from /tmp/x509up_u...
    # 'x509_proxy': 'myproxy.pem'

    # almost all coffea functions use one core
    'cores': 1}

out = run_uproot_job(..., executor=work_queue_executor, executor_args=exec_args)
```

Constructing the Environment (if not setup at execution site)

```
# First install miniconda if you don't yet have conda or anaconda.
$ curl https://repo.anaconda.com/miniconda/Miniconda3-latest-Linux-x86_64.sh > conda-install.sh
$ bash conda-install.sh
$ ...follow conda instructions...


# Create the environment:
$ unset PYTHONPATH
$ conda create --name my-coffea-env python=3.??

# Install needed modules
$ conda activate my-coffea-env
$ conda install -c conda-forge coffea xrootd ndcctools dill conda-pack
$ ...pip (not editable) or conda install other packages you need...

# Create the portable environment (everytime app or coffea is updated)
$ conda activate  my-coffea-env
$ conda-pack --output my-coffea-env.tar.gz
```

Running with one local worker

```
$ conda activate my-coffea-env
$ voms-proxy-init2   # only if you need certs to access data
$ python my-coffea-env-application

Listening for work queue workers on port 9124...
warning: this work queue manager is visible to the public.
warning: you should set a password with the --password option.
submitted preprocessing task 1
submitted preprocessing task 2
submitted preprocessing task 3
...
# In another terminal, four tasks per worker
$ conda activate  my-coffea-env
$ work_queue_worker --cores 4 --memory 8000 --disk 4000 -M ${USER}-wq-coffea

work_queue_worker: creating workspace /tmp/worker-196886-2912809
work_queue_worker: using 4 cores, 8000 MB memory, 4000 MB disk, 0 gpus
connected to manager 10.32.77.18:9124 via local address 10.32.77.18:39084
```

Running workers on batch system, manually

```
# a hundred workers in a campus cluster, 400 concurrent tasks
$ conda activate  my-coffea-env
$ condor_submit_workers --cores 4 --memory 8000 --disk 4000 -M ${USER}-wq-coffea 100
```

```
# one worker on stampede2, 68 concurrent tasks
# explicitly specify coffea wq manager host xxx.xxx... and port yyyy
# specify slurm parameters, normal queue, 60 minutes

$ conda activate  my-coffea-env
$ slurm_submit_workers -s $SCRATCH/workers -p '-p normal -t 60' xxx.xxx... yyyy 1
```

Using the Work Queue Factory (python)

```
import work_queue

exec_args = {
    'master_name': '{}-wq-coffea'.format(os.environ['USER']),
    ...
}

# available: local, condor, sge, slurm
workers = work_queue.Factory("condor", exec_args["master_name"])
workers.cores  = 4
workers.memory = 16000
workers.disk   = 20000
workers.max_workers = 20
workers.min_workers =  1

with workers:
    output = processor.run_uproot_job(
        ...
        executor=processor.work_queue_executor,
        executor_args=exec_args,
        ...
```

Using the Work Queue factory (external)

```
# wq factory creates workers as needed.
$ conda activate  my-coffea-env
$ work_queue_factory -Tcondor -C my-conf.json
```

my-conf.json: (re-read when changed, useful to manipulate max and min workers.)

```
{
    "manager-name": "btovar-wq-coffea",
    "max-workers": 200,
    "min-workers": 1,
    "workers-per-cycle": 20,
    "cores": 4,
    "memory": 16000,
    "disk": 20000,
    "timeout": 900,
}
```

Automatic resource allocations

```
exec_args = {
    'master_name': '{}-wq-coffea'.format(os.environ['USER']),
    'port': [9123,9130],
    'environment_file': "my-coffea-env.tar.gz",

    # no task can use more than these maximum values:
    'cores': 2,
    'memory': 8000,
    'disk': 8000,

    # adjust size of resources allocated to tasks as they are measured
    # use maximum resources seen, retry on maximum values if exhausted.
    'resource_monitor': True,
    'resources_mode': 'auto',
}
```

Example of resource allocation

```
TASK 1333 RUNNING 10.32.86.105:58248  FIRST_RESOURCES {"memory":[750,"MB"],"disk":[500,"MB"],"gpus":[0,"gpus"],"cores":[1,"cores"]}
...
TASK 1333 RETRIEVED RESOURCE_EXHAUSTION  143 {"memory":[750,"MB"]} {...
...
TASK 1333 RUNNING 10.32.86.105:58248  MAX_RESOURCES {"memory":[8000,"MB"],"disk":[8000,"MB"],"gpus":[0,"gpus"],"cores":[2,"cores"]}
```

```
processing task id 1333 item 8026473b with 127000 events completed on d12chas555.crc.nd.edu. return code 0
    allocated cores: 2.0, memory: 8000.0 MB, disk: 8000.0 MB, gpus: 0.0
    measured cores: 0.368, memory: 1191.0 MB, disk 305.0 MB, gpus: 0.0, runtime 329.988136
```

```
processing task id 1756 item fa13269a with 117845 events completed on d12chas580.crc.nd.edu. return code 0
    allocated cores: 1.0, memory: 4250.0 MB, disk: 500.0 MB, gpus: 0.0
    measured cores: 0.353, memory: 4000.0 MB, disk 310.0 MB, gpus: 0.0, runtime 310.851779
```

Enable debug logs

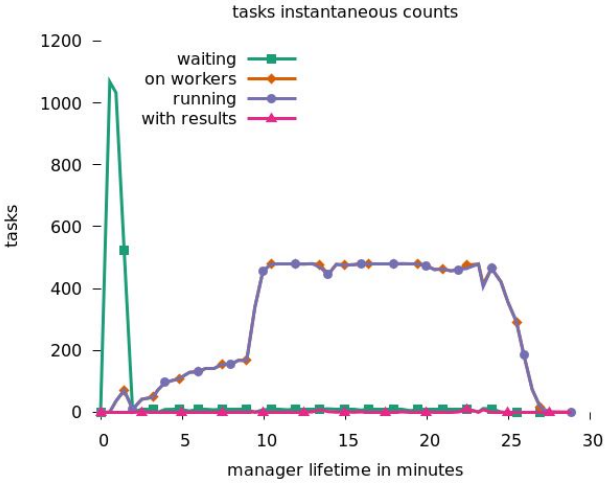
```
exec_args = {
    ...,

    # print messages when tasks are submitted, and as they return, their
    # resource allocation and usage.
    'verbose': True,

    # detailed debug messages
    'debug_log': 'debug.log',

    # lifetime of tasks, workers, and resource allocations
    'transactions_log': 'tr.log',

    # time series of manager statistics, plot with work_queue_graph_log
    'stats_log': 'stats.log',
}
```

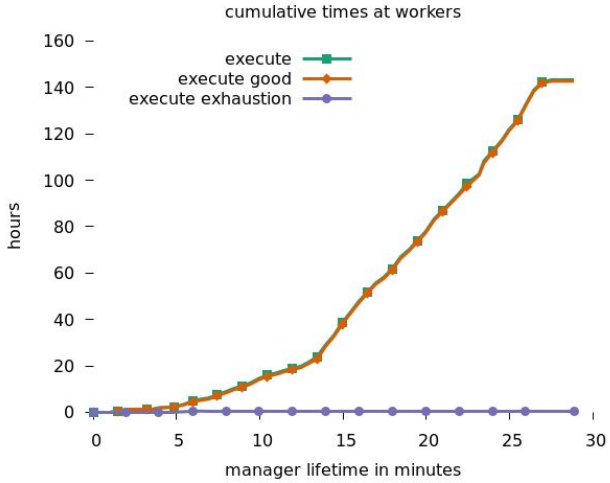
'verbose': True

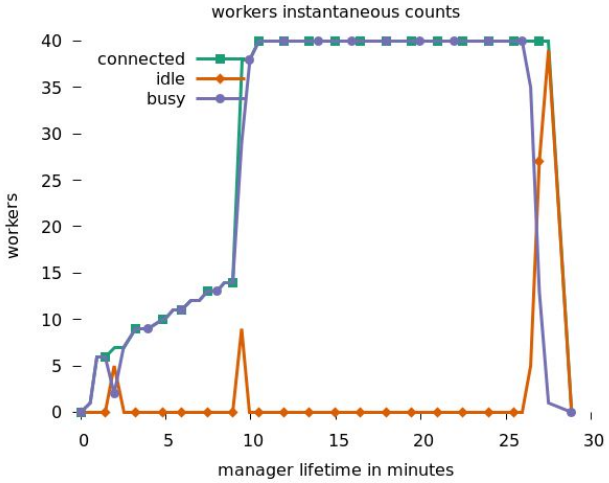
```
code 0
    allocated cores: 1.0, memory: 2750.0 MB, disk: 500.0 MB, gpus: 0.0
    measured cores: 0.379, memory: 1593.0 MB, disk 300.0 MB, gpus: 0.0, runtime 200.515746
submitted processing task id 2095 item 974bfe68, with 123500 events
processing task id 1396 item dc66182a with 127750 events completed on d12chas583.crc.nd.edu. return
code 0
    allocated cores: 1.0, memory: 2500.0 MB, disk: 500.0 MB, gpus: 0.0
    measured cores: 0.4, memory: 1357.0 MB, disk 291.0 MB, gpus: 0.0, runtime 239.530528
submitted processing task id 2096 item 0894bedf, with 117000 events
processing task id 1549 item 19e56faf with 116357 events completed on d12chas547.crc.nd.edu. return
code 0
    allocated cores: 1.0, memory: 2750.0 MB, disk: 500.0 MB, gpus: 0.0
    measured cores: 0.363, memory: 1206.0 MB, disk 300.0 MB, gpus: 0.0, runtime 215.822369
submitted processing task id 2097 item f303c8d5, with 117000 events
processing task id 1601 item f91400b4 with 111359 events completed on d12chas575.crc.nd.edu. return
code 0
    allocated cores: 1.0, memory: 2750.0 MB, disk: 500.0 MB, gpus: 0.0
    measured cores: 0.368, memory: 1080.0 MB, disk 300.0 MB, gpus: 0.0, runtime 209.20616
submitted processing task id 2098 item c1da1e8d, with 127500 events
processing task id 1406 item fd51ce29 with 123000 events completed on d12chas560.crc.nd.edu. return
code 0
    allocated cores: 1.0, memory: 2500.0 MB, disk: 500.0 MB, gpus: 0.0
    measured cores: 0.384, memory: 2431.0 MB, disk 291.0 MB, gpus: 0.0, runtime 242.325009
submitted processing task id 2099 item 7f66cfa1, with 127500 events
Submitted      53%|                                | 126436654/237149394 [06:30<19:32, 94461.19event/s]
Processing     13%|                                | 31814581/237149394 [06:30<35:37, 96052.40event/s]
Accumulated    13%|                                | 10/75 [06:30<23:50, 22.01s/tasks]
```

Plot stats.log

```
$ conda activate my-coffea-env
$ work_queue_graph_log -Tpng stats.log
```

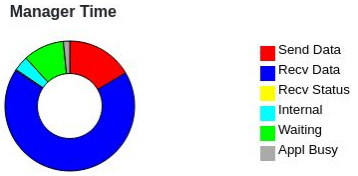


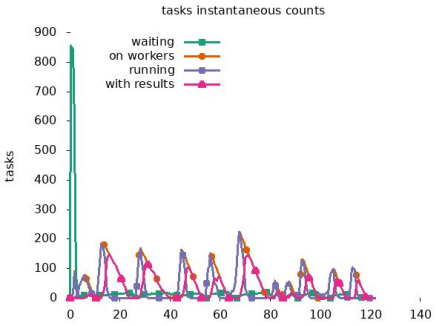




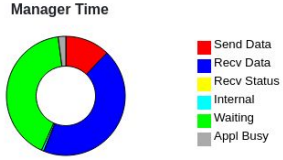
Other exec args: 'compression': 9 (default)

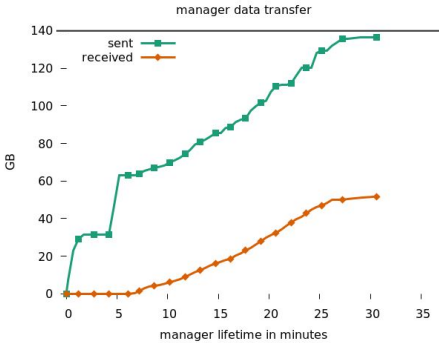
compression: None



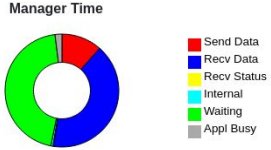


compression: 0 (min)

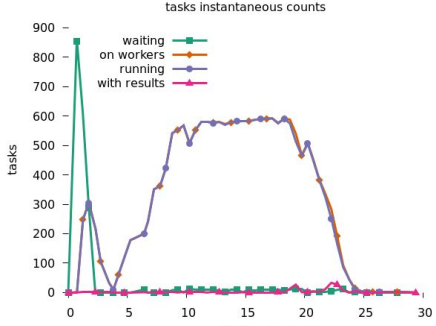


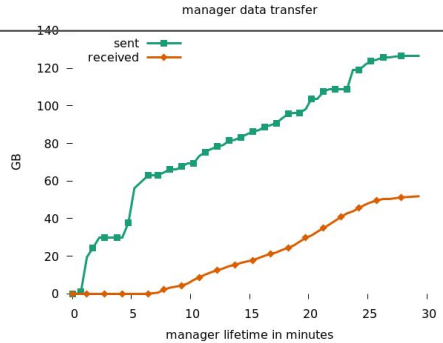


compression: 9 (mid)



compression: 16 (max)





Size of accumulation tasks

```
# these are the default values

exec_args = {
    ...,
    # use mid-range compression for chunks results. 9 is the default for work
    # queue in coffea. Valid values are 0 (minimum compression, less memory
    # usage) to 16 (maximum compression, more memory usage).
    'compression': 9,

    # control the size of accumulation tasks. Results are
    # accumulated in groups of size chunks_per_accum, keeping at
    # most chunks_per_accum at the same time in memory per task.
    'chunks_per_accum': 10,
    'chunks_accum_in_mem': 2,
}
```

In development

- Automatic chunksize with target memory usage per task.
  - Currently can be used with run_uproot_job(...,dynamic_chunksize=True)
  - chunksize adapted so that tasks run for about 1 minute by default
- Automatic construction of python environment when changes are detected.
  - Currently topcoffea (a coffea application) uses an automatic construction.
  - Picks up local changes in pip editable packages, useful for development.
  - We are working on generalizing it for coffea.

```
WARNING:Found unstaged changes in '.../src/topcoffea'
INFO:Looking for base environment env/base_env_a97aafa0.tar.gz...
INFO:Creating environment /tmp/tmpn53zo2eo
INFO:Installing python=3.8.10,conda into /tmp/tmpn53zo2eo via conda
INFO:Installing conda-pack,dill,xrootd into /tmp/tmpn53zo2eo via conda
INFO:Installing reqs of .../src/coffea into /tmp/tmpn53zo2eo via pip
INFO:Installing reqs of .../src/topcoffea into /tmp/tmpn53zo2eo via pip
...
```

topcoffea exec args

```
executor_args = {
    'master_name': '{}-workqueue-coffea'.format(os.environ['USER']),
    'port': [9123,9130],

    'debug_log': 'debug.log',
    'transactions_log': 'tr.log',
    'stats_log': 'stats.log',

    'environment_file': topeftenv.get_environment(),
    'extra_input_files': ["topeft.py"],

    'schema': NanoAODSchema,
    'skipbadfiles': False,

    'resource_monitor': True,
    'resources_mode': 'auto',

    'cores': 1,
    'disk': 8000,   #MB
    'memory': 8000, #MB

    'fast_terminate_workers': 5,     # terminate workers which seem slower than the rest (avg * 5)

    'chunks_per_accum': 25,

    'verbose': True,
}
```

Quick comparison with parsl and dask executors

wq:

- Easier to develop when no shared filesystem is available, opportunistic resources.
- Tarball with python environment is important (conda-pack).
- Automatic resource management, and dynamic chunksize.
- Dynamic accumulation as results are computed.

parsl:

- wq is also available as a parsl provider.
- 'workers' declared in code to configure the provider.
- Parsl executor assumes you already setup the environment at the execution site.

dask:

- As wq, workers can be declared in python, or outside the coffea code.
- Dask executor assumes you already setup the environment at the execution site.

More information

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work queue documentation:

https://cctools.readthedocs.io/en/latest/work_queue