Large-scale debugging with graphs

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How do we get a useful debugging experience at large scales?

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What is a useful experience?

- Debugger works at the same scales as application
- Interactivity; rapid turn-around
- Intuitive input
- Command output and program state should be understandable and informative

What is a useful experience?

- Focus: Command output and program state should be understandable and informative

- … And some scalability

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Stack traces

- We know how to do this for stack traces
  - PGDB can merge similar stack traces
  - STAT has “3D trace/space/time” analysis
  - Etc.

PGDB: Dryden, Nikoli. “PGDB: A Debugger for MPI Applications.” *XSEDE14*. ACM, 2014.
STAT: Arnold, Dorian C., et al. "Stack trace analysis for large scale debugging.” IPDPS 2007. IEEE International. IEEE, 2007.

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Outline

- Merging output
- Adding a notion of “time”: in general
- … And in specific
- Current status

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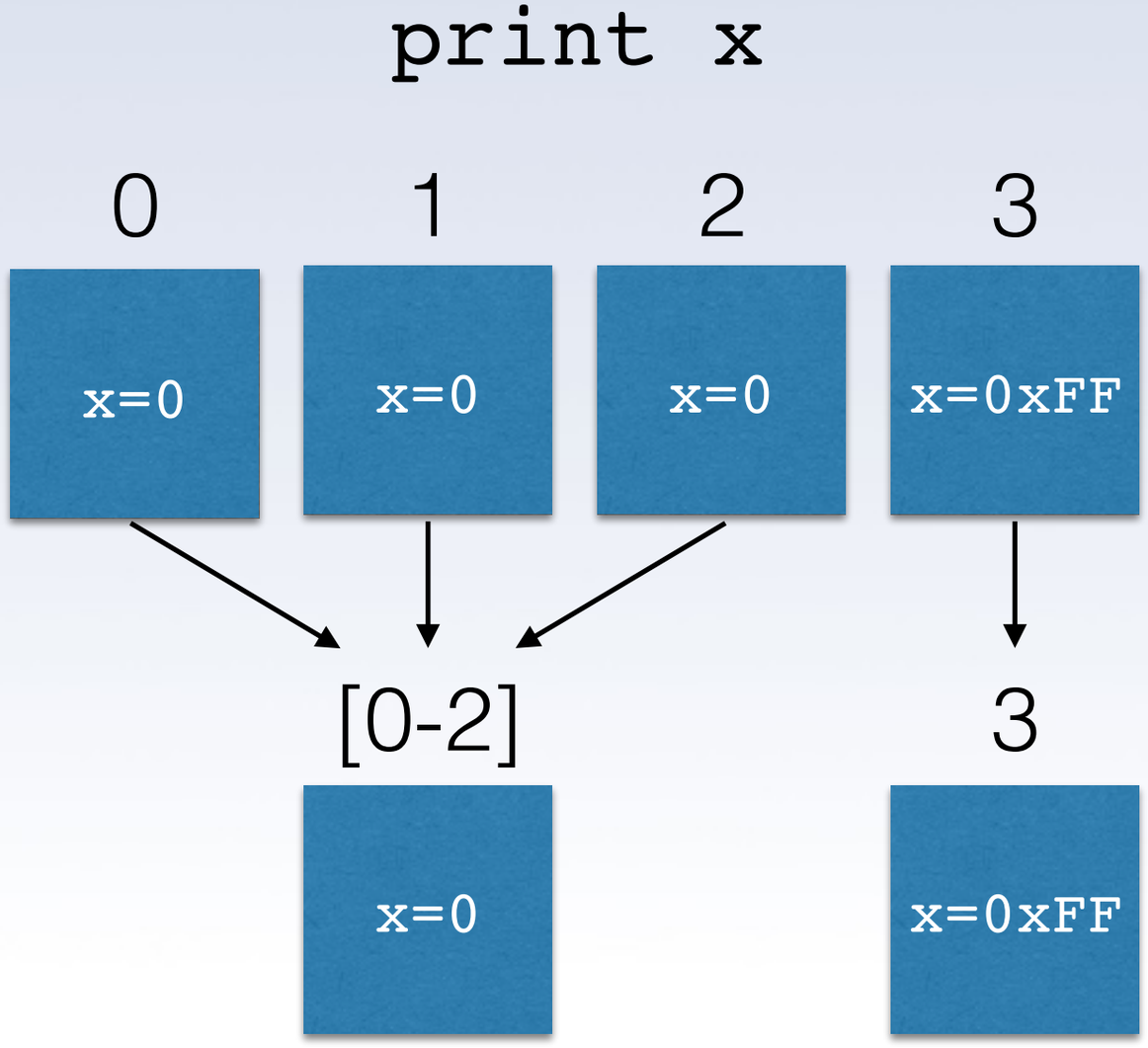
Merging output

- Most ranks in application will be in (approximately) the same state
- Define equivalence classes for different types of output
- Merge output based on these and present overview

Merging output



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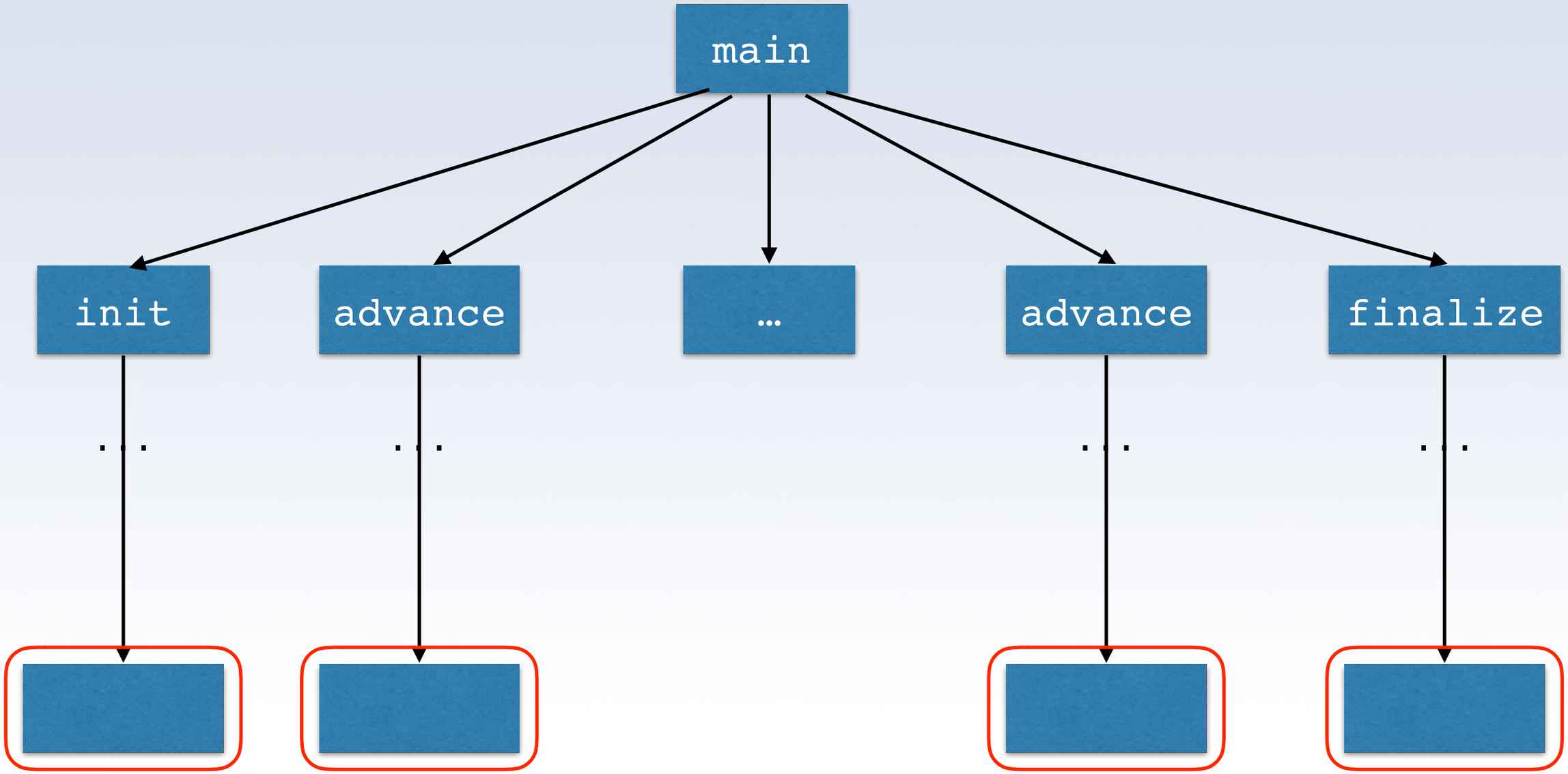
Merging output

- Tree-based reduction implements merging naturally
- Scalable and reduces data volume

Graph cuts

- Think of the graph of program execution (call tree)
- Each rank is somewhere in this when you get debugger output
- Regularly cutting the graph can provide context
- Merging now additionally considers which cut the output came from

Graph cuts



Collectives

- Some applications proceed in phases delineated by collective operations
- Simple choice for the cut point
- But not suitable for every application

PGDB

- Existing open-source parallel debugger for MPI
  https://github.com/ndryden/PGDB

- Basis for work

See also: Dryden, Nikoli. “PGDB: A Debugger for MPI Applications.” *XSEDE14*. ACM, 2014.

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Current status

- Initial proof-of-concept implemented at small scale in PGDB
- Merging using MRNet filters
- But PGDB is currently text-based (not as pretty)
- Code available soon

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Quick example

```
backtrace
...
[0|1] #7 in PMPI_Reduce (...) at src/mpi/coll/reduce.c:
1216
[0|1] #8 in advance (rank=0) at mpideadlock.c:14
[0|1] #9 in main (...) at mpideadlock.c:26
...
[1-2,4-15|2] #7 in PMPI_Reduce (...) at src/mpi/coll/
reduce.c:1216
[1-2,4-15|2] #8 in advance (...) at mpideadlock.c:14
[1-2,4-15|2] #9 in main (...) at mpideadlock.c:26
...
[3|1] #2 in pthread_mutex_lock() from /lib64/
libpthread.so.0
[3|1] #3 in advance(...) at mpideadlock.c:9
[3|1] #4 in main(...) at mpideadlock.c:26
```

Future work

- Other notions for when to cut
- Handle MPI communicators better
- Further testing and scalability work
- Exploration: How well can we apply this to (lightweight) threads, etc.?

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Thanks!

- Questions?

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