The joys of beekeeping

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Software pipeline (Q)

- ***What makes a software pipeline different from a script/program?*** (assuming top-down approach)

Software pipeline (A)

- Usually a computation that doesn't need interaction
- Availability of multiple computers (cluster/farm/grid) to perform the computation
- Availability of convenient tools/languages to automate running of this computation

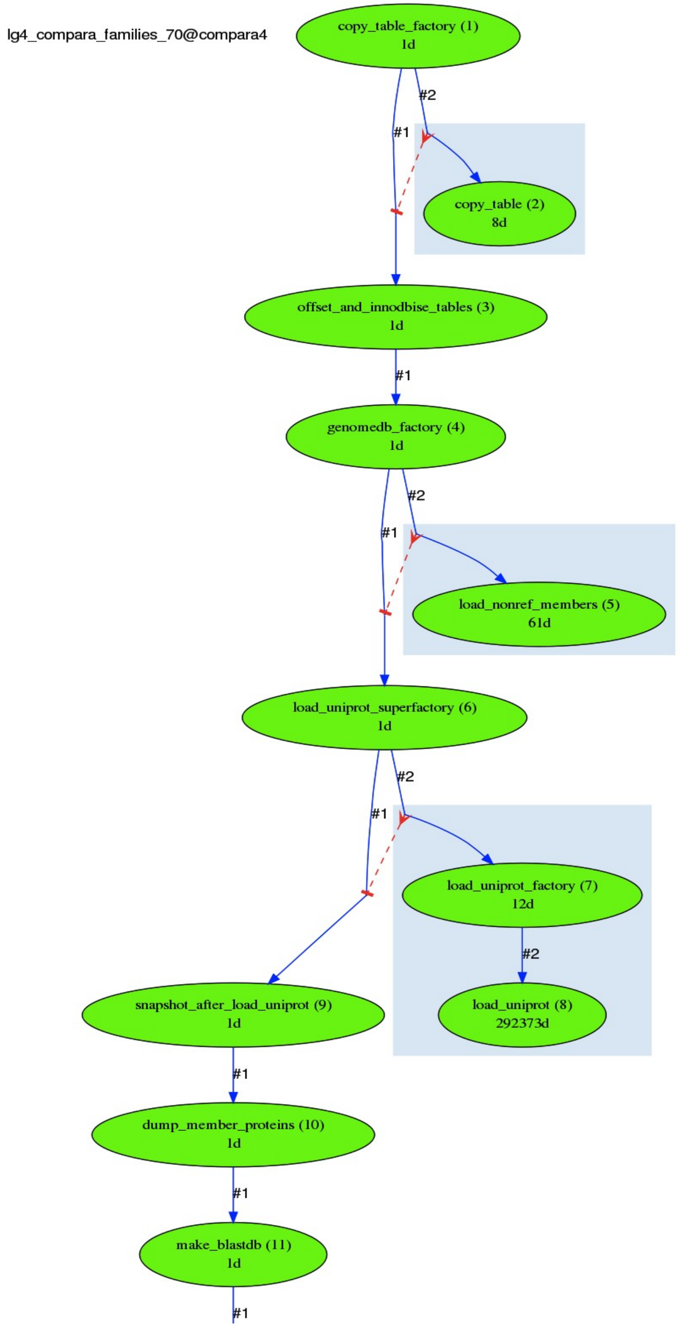
Software pipeline (requirements)

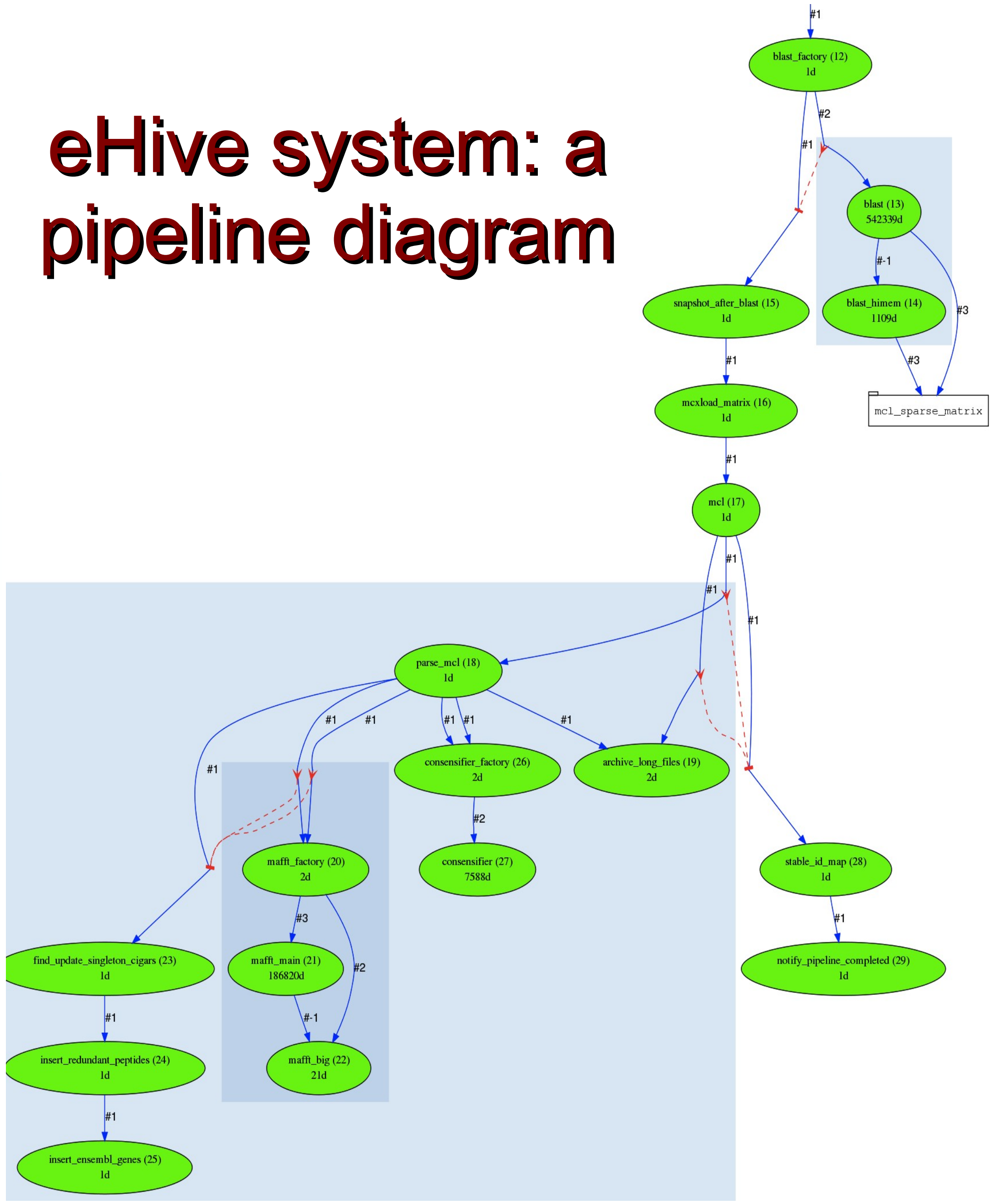
- Some code may take too long to compute sequentially
  - Transform independent loop iterations into individual “jobs”
    - rotate time into space
- Some code may crash eventually
  - Use checkpointing, restarting only individual jobs that crashed
    - rather than restarting the whole computation
  - Checkpointing in a non-sequential process means complex states
- Some code may be resource-greedy
  - Jobs can be given different (estimated) resources - memory, execution time, disk/temp storage space
  - Feedback collected on the actual usage of resources

eHive system: analyses, jobs, rules

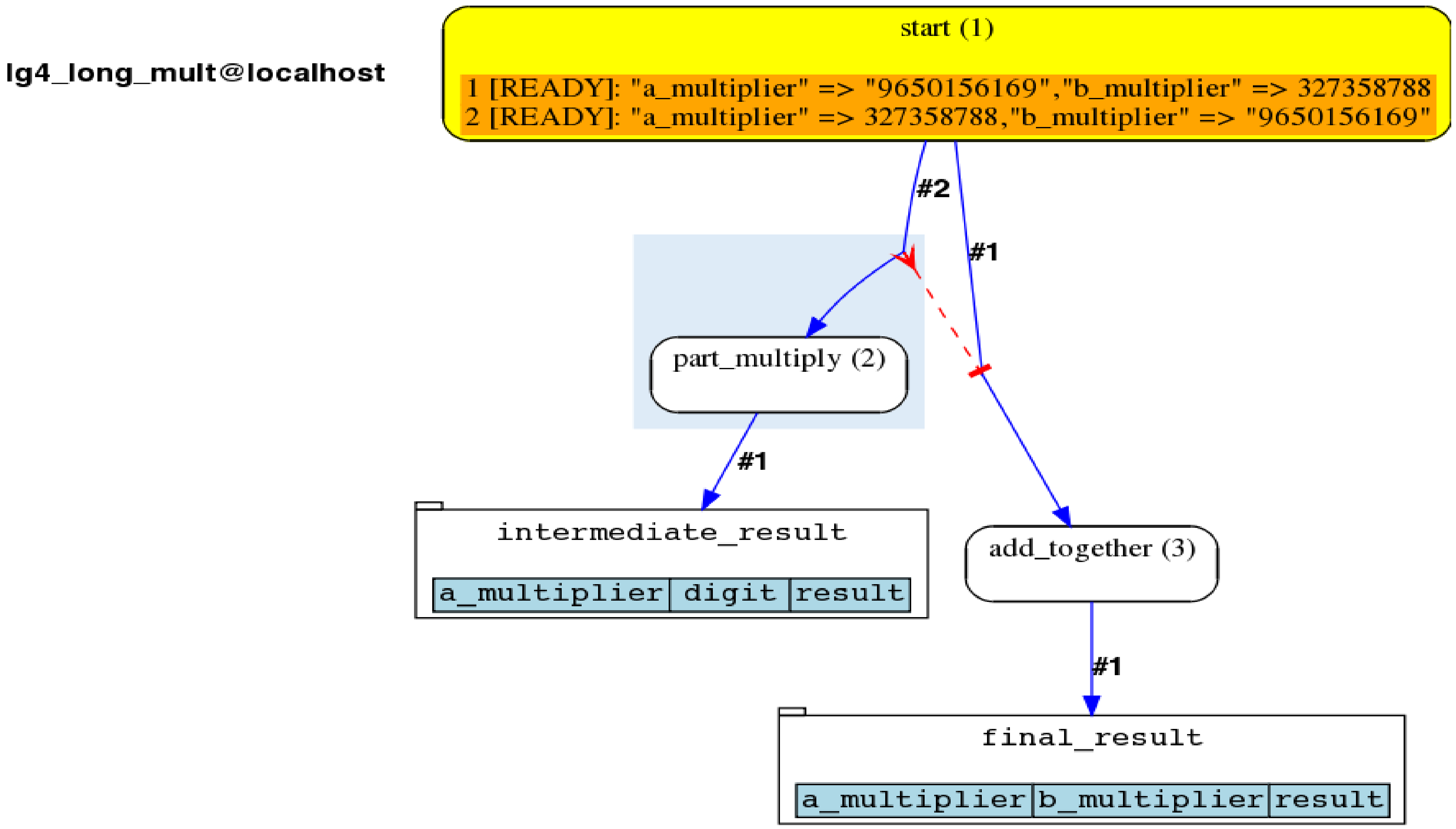
- Database-centric
- Individual pipeline instances created from config files and become “pipeline databases” with eHive schema
  - possibly extended with pipeline-specific tables
- Pipeline database contains a flow diagram with “*analyses*” as its nodes and “*rules*” as its edges.
- *Analyses* are abstract classes, *jobs* are specific instances, units of computation.
- *Jobs* can create other jobs (*dataflow rules*), block other jobs (*semaphores*) or whole analyses (*control rules*)

eHive system: a pipeline diagram

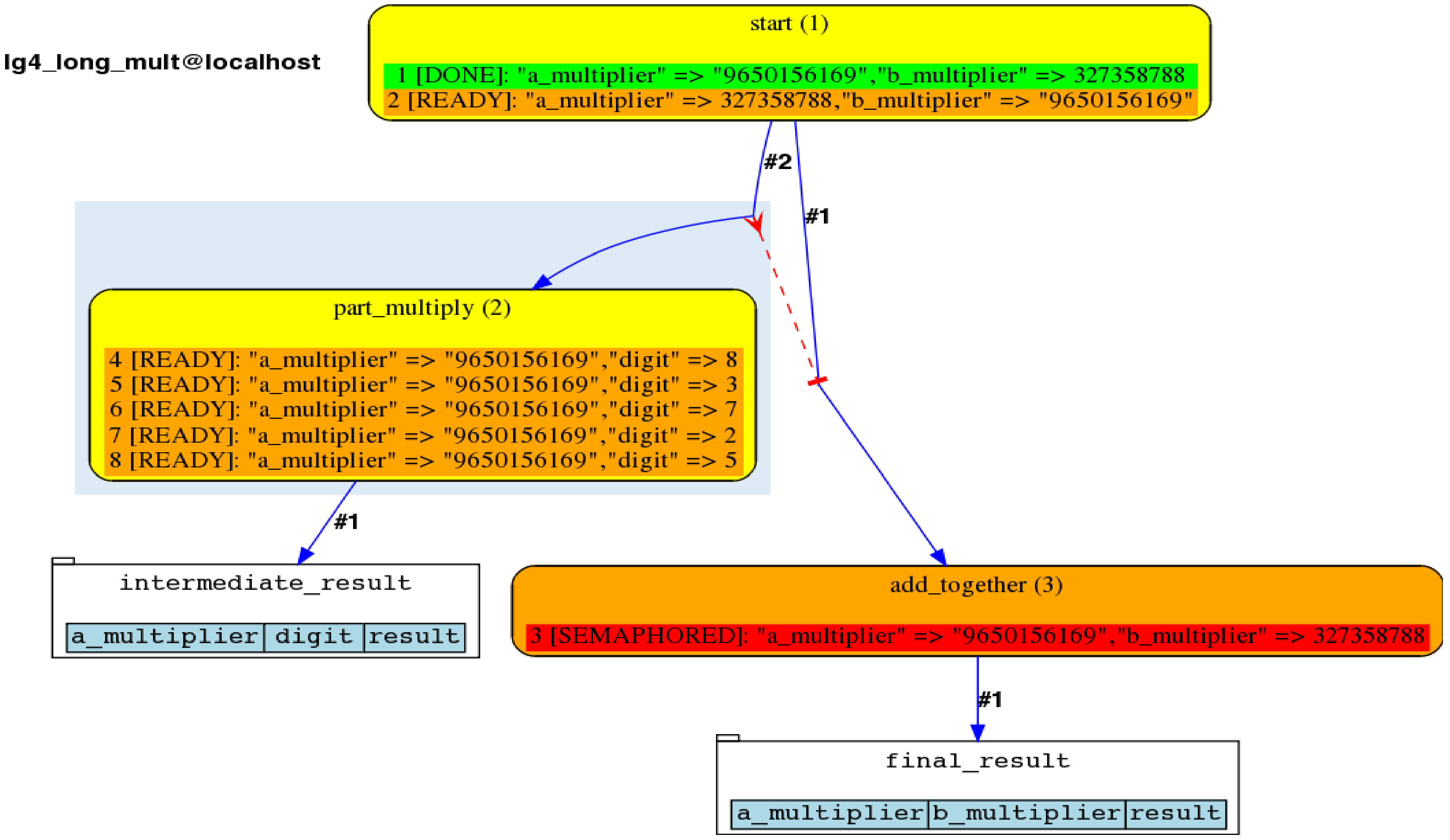

lg4_compara_families_70@compara4
copy_table_factory (1) 1d
#1
#2
copy_table (2) 8d
offset_and_innodbise_tables (3) 1d
#1
genomedb_factory (4) 1d
#1
#2
load_nonref_members (5) 61d
load_uniprot_superfactory (6) 1d
#1
#2
load_uniprot_factory (7) 12d
#2
load_uniprot (8) 292373d
snapshot_after_load_uniprot (9) 1d
#1
dump_member_proteins (10) 1d
#1
make_blastdb (11) 1d
#1



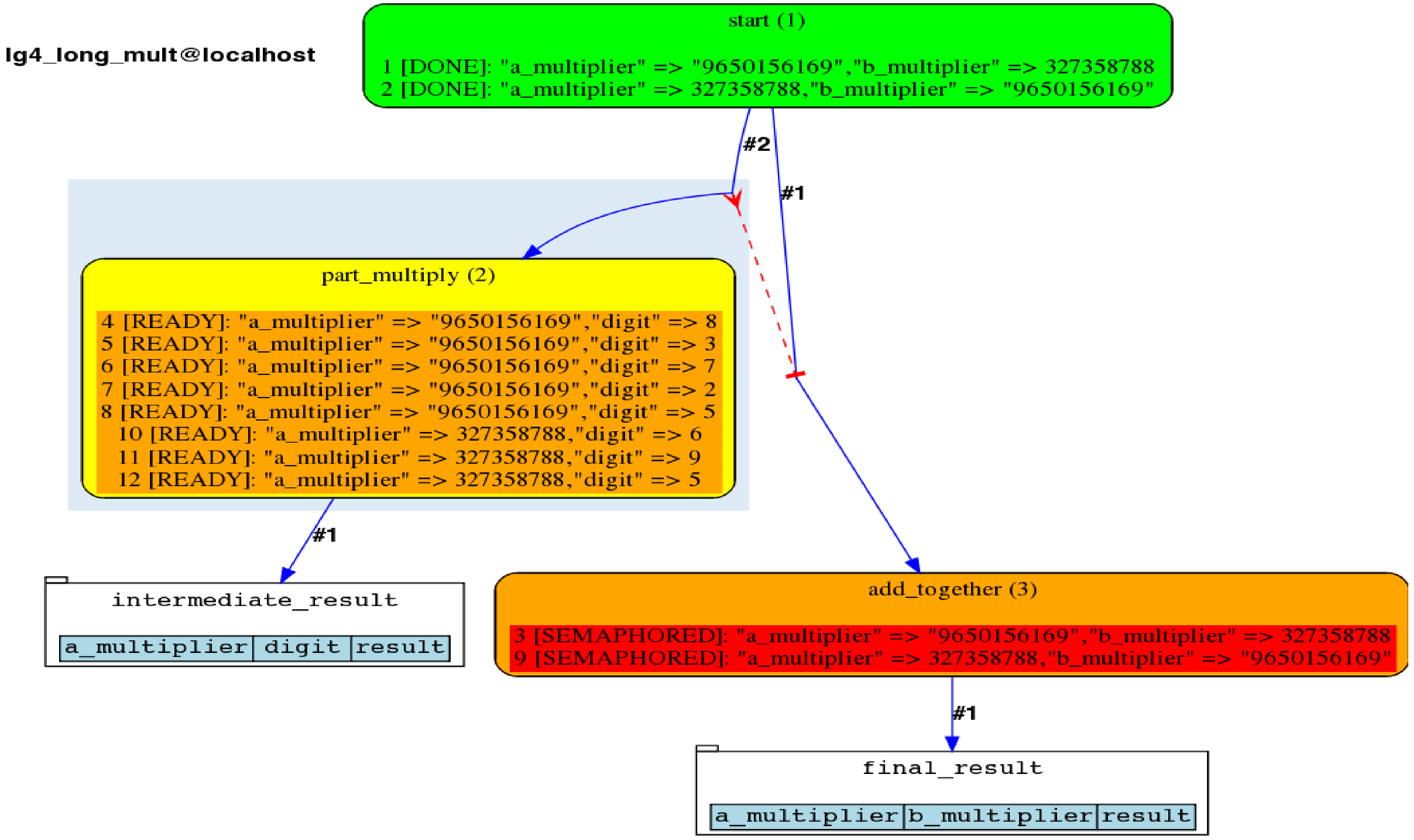
LongMultiplication example pipeline (1)



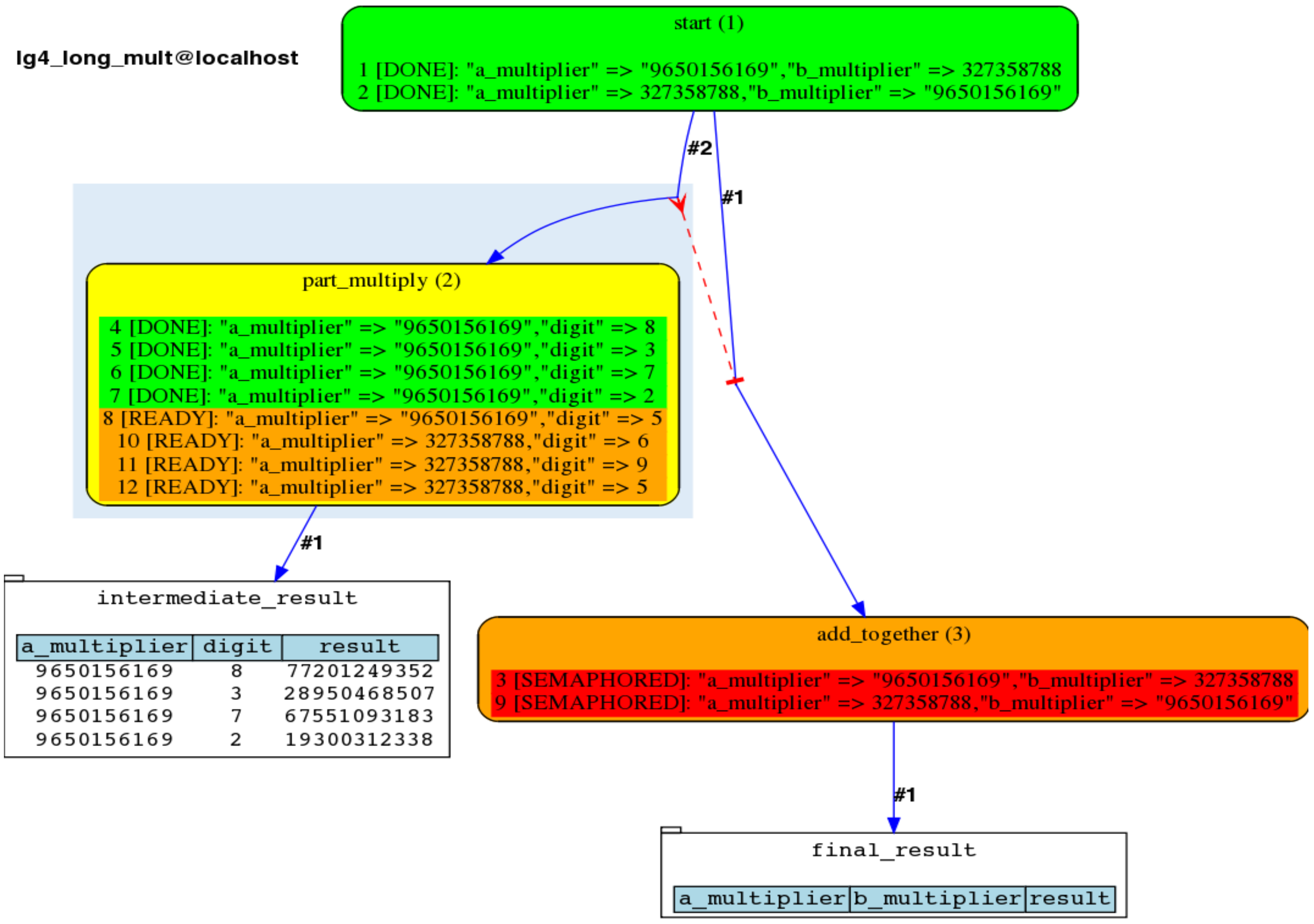
LongMultiplication example pipeline (2)


lg4_long_mult@localhost
start (1)
1 [DONE]: "a_multiplier" => "9650156169","b_multiplier" => 327358788
2 [READY]: "a_multiplier" => 327358788,"b_multiplier" => "9650156169"
#2
#1
part_multiply (2)
4 [READY]: "a_multiplier" => "9650156169","digit" => 8
5 [READY]: "a_multiplier" => "9650156169","digit" => 3
6 [READY]: "a_multiplier" => "9650156169","digit" => 7
7 [READY]: "a_multiplier" => "9650156169","digit" => 2
8 [READY]: "a_multiplier" => "9650156169","digit" => 5
#1
intermediate_result
a_multiplier | digit | result
add_together (3)
3 [SEMAPHORED]: "a_multiplier" => "9650156169","b_multiplier" => 327358788
#1
final_result
a_multiplier | b_multiplier | result

LongMultiplication example pipeline (3)


lg4_long_mult@localhost
start (1)
1 [DONE]: "a_multiplier" => "9650156169","b_multiplier" => 327358788
2 [DONE]: "a_multiplier" => 327358788,"b_multiplier" => "9650156169"
#2
#1
part_multiply (2)
4 [READY]: "a_multiplier" => "9650156169","digit" => 8
5 [READY]: "a_multiplier" => "9650156169","digit" => 3
6 [READY]: "a_multiplier" => "9650156169","digit" => 7
7 [READY]: "a_multiplier" => "9650156169","digit" => 2
8 [READY]: "a_multiplier" => "9650156169","digit" => 5
10 [READY]: "a_multiplier" => 327358788,"digit" => 6
11 [READY]: "a_multiplier" => 327358788,"digit" => 9
12 [READY]: "a_multiplier" => 327358788,"digit" => 5
#1
intermediate_result
a_multiplier
digit
result
add_together (3)
3 [SEMAPHORED]: "a_multiplier" => "9650156169","b_multiplier" => 327358788
9 [SEMAPHORED]: "a_multiplier" => 327358788,"b_multiplier" => "9650156169"
#1
final_result
a_multiplier
b_multiplier
result

LongMultiplication example pipeline (4)



lg4_long_mult@localhost
start (1)
1 [DONE]: "a_multiplier" => "9650156169","b_multiplier" => 327358788
2 [DONE]: "a_multiplier" => 327358788,"b_multiplier" => "9650156169"
#2
#1
part_multiply (2)
4 [DONE]: "a_multiplier" => "9650156169","digit" => 8
5 [DONE]: "a_multiplier" => "9650156169","digit" => 3
6 [DONE]: "a_multiplier" => "9650156169","digit" => 7
7 [DONE]: "a_multiplier" => "9650156169","digit" => 2
8 [READY]: "a_multiplier" => "9650156169","digit" => 5
10 [READY]: "a_multiplier" => 327358788,"digit" => 6
11 [READY]: "a_multiplier" => 327358788,"digit" => 9
12 [READY]: "a_multiplier" => 327358788,"digit" => 5
#1
add_together (3)
3 [SEMAPHORED]: "a_multiplier" => "9650156169","b_multiplier" => 327358788
9 [SEMAPHORED]: "a_multiplier" => 327358788,"b_multiplier" => "9650156169"
#1

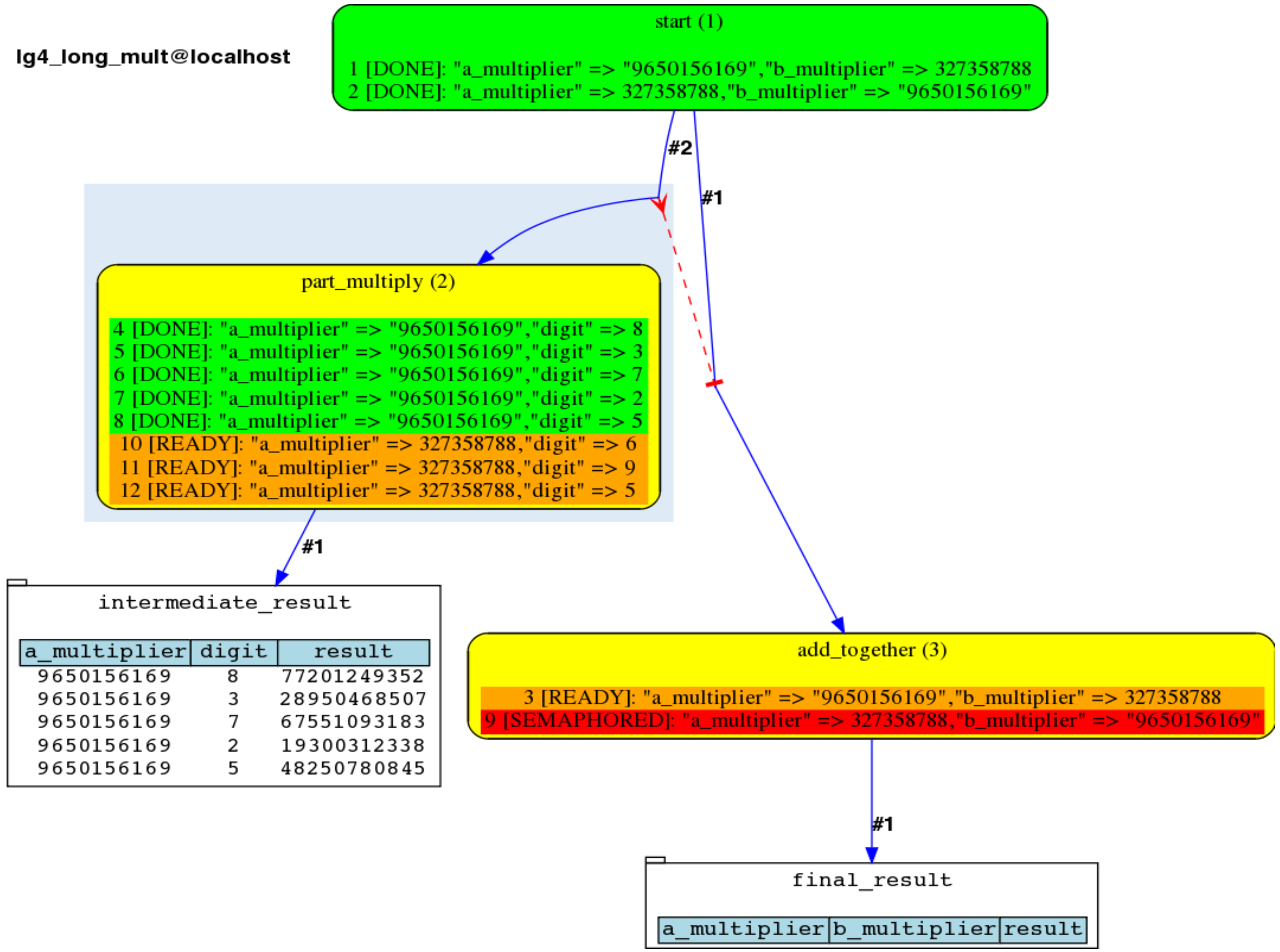
intermediate_result

a_multiplier	digit	result
9650156169	8	77201249352
9650156169	3	28950468507
9650156169	7	67551093183
9650156169	2	19300312338

final_result

a_multiplier	b_multiplier	result

LongMultiplication example pipeline (5)



start (1)

```
1 [DONE]: "a_multiplier" => "9650156169","b_multiplier" => 327358788
2 [DONE]: "a_multiplier" => 327358788,"b_multiplier" => "9650156169"
```

part_multiply (2)

```
4 [DONE]: "a_multiplier" => "9650156169","digit" => 8
5 [DONE]: "a_multiplier" => "9650156169","digit" => 3
6 [DONE]: "a_multiplier" => "9650156169","digit" => 7
7 [DONE]: "a_multiplier" => "9650156169","digit" => 2
8 [DONE]: "a_multiplier" => "9650156169","digit" => 5
10 [READY]: "a_multiplier" => 327358788,"digit" => 6
11 [READY]: "a_multiplier" => 327358788,"digit" => 9
12 [READY]: "a_multiplier" => 327358788,"digit" => 5
```

add_together (3)

```
3 [READY]: "a_multiplier" => "9650156169","b_multiplier" => 327358788
9 [SEMAPHORED]: "a_multiplier" => 327358788,"b_multiplier" => "9650156169"
```

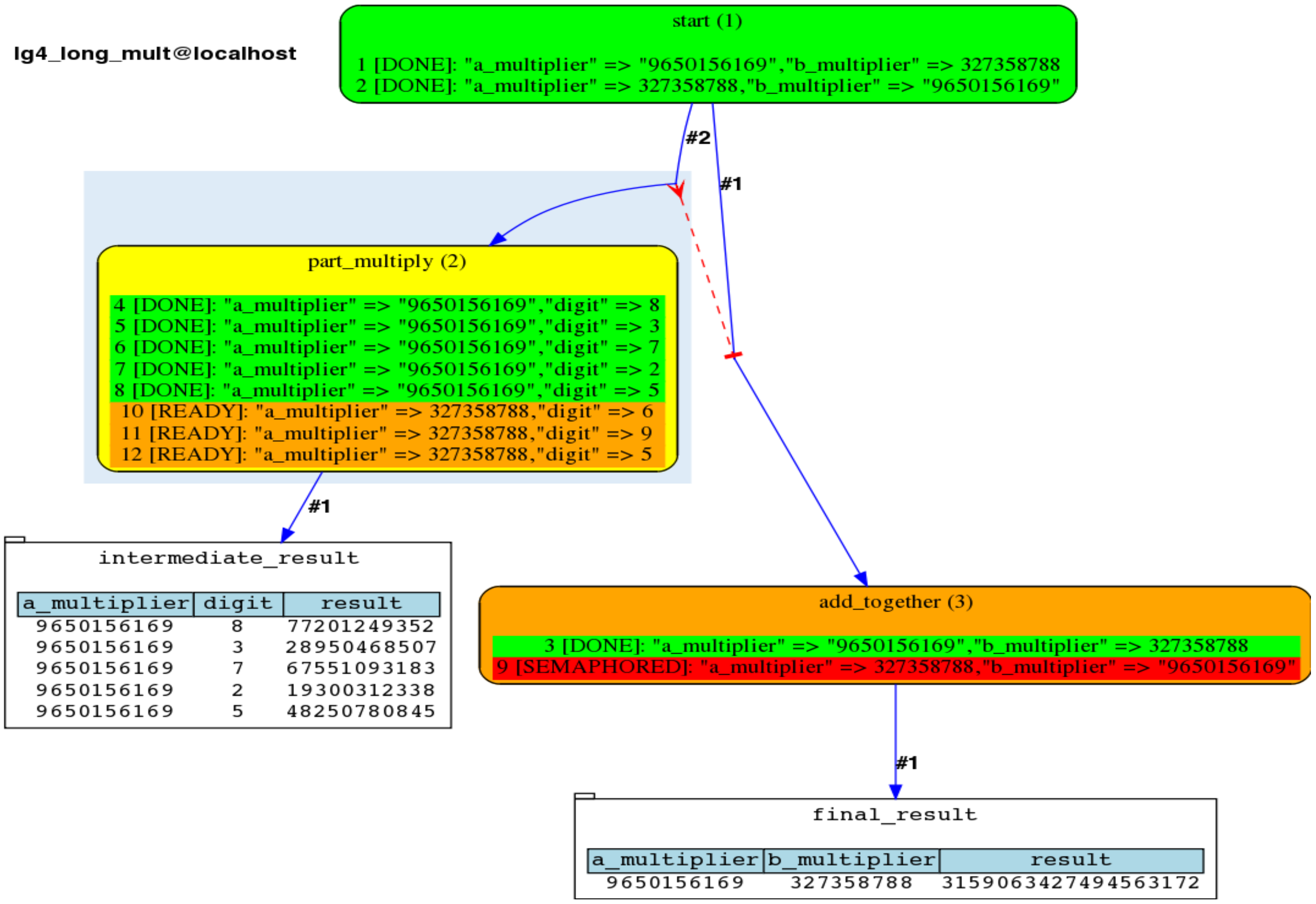
intermediate_result

a_multiplier	digit	result
9650156169	8	77201249352
9650156169	3	28950468507
9650156169	7	67551093183
9650156169	2	19300312338
9650156169	5	48250780845

final_result

a_multiplier	b_multiplier	result

LongMultiplication example pipeline (6)



start (1)

1 [DONE]: "a_multiplier" => "9650156169","b_multiplier" => 327358788
2 [DONE]: "a_multiplier" => 327358788,"b_multiplier" => "9650156169"

part_multiply (2)

4 [DONE]: "a_multiplier" => "9650156169","digit" => 8
5 [DONE]: "a_multiplier" => "9650156169","digit" => 3
6 [DONE]: "a_multiplier" => "9650156169","digit" => 7
7 [DONE]: "a_multiplier" => "9650156169","digit" => 2
8 [DONE]: "a_multiplier" => "9650156169","digit" => 5
10 [READY]: "a_multiplier" => 327358788,"digit" => 6
11 [READY]: "a_multiplier" => 327358788,"digit" => 9
12 [READY]: "a_multiplier" => 327358788,"digit" => 5

intermediate_result

a_multiplier	digit	result
9650156169	8	77201249352
9650156169	3	28950468507
9650156169	7	67551093183
9650156169	2	19300312338
9650156169	5	48250780845

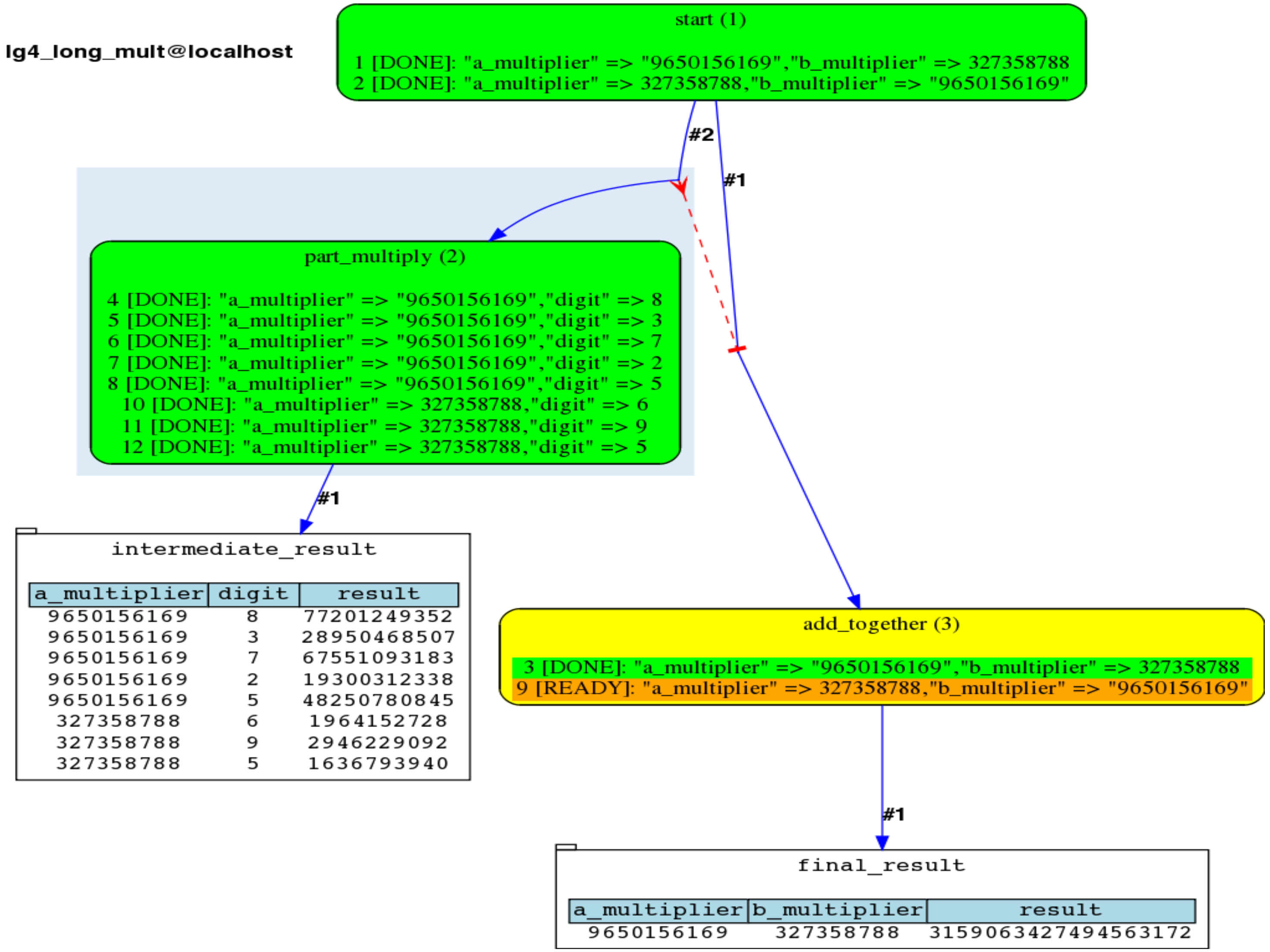
add_together (3)

3 [DONE]: "a_multiplier" => "9650156169","b_multiplier" => 327358788
9 [SEMAPHORED]: "a_multiplier" => 327358788,"b_multiplier" => "9650156169"

final_result

a_multiplier	b_multiplier	result
9650156169	327358788	3159063427494563172

LongMultiplication example pipeline (7)



start (1)

1 [DONE]: "a_multiplier" => "9650156169","b_multiplier" => 327358788
2 [DONE]: "a_multiplier" => 327358788,"b_multiplier" => "9650156169"

part_multiply (2)

4 [DONE]: "a_multiplier" => "9650156169","digit" => 8
5 [DONE]: "a_multiplier" => "9650156169","digit" => 3
6 [DONE]: "a_multiplier" => "9650156169","digit" => 7
7 [DONE]: "a_multiplier" => "9650156169","digit" => 2
8 [DONE]: "a_multiplier" => "9650156169","digit" => 5
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11 [DONE]: "a_multiplier" => 327358788,"digit" => 9
12 [DONE]: "a_multiplier" => 327358788,"digit" => 5

intermediate_result

a_multiplier	digit	result
9650156169	8	77201249352
9650156169	3	28950468507
9650156169	7	67551093183
9650156169	2	19300312338
9650156169	5	48250780845
327358788	6	1964152728
327358788	9	2946229092
327358788	5	1636793940

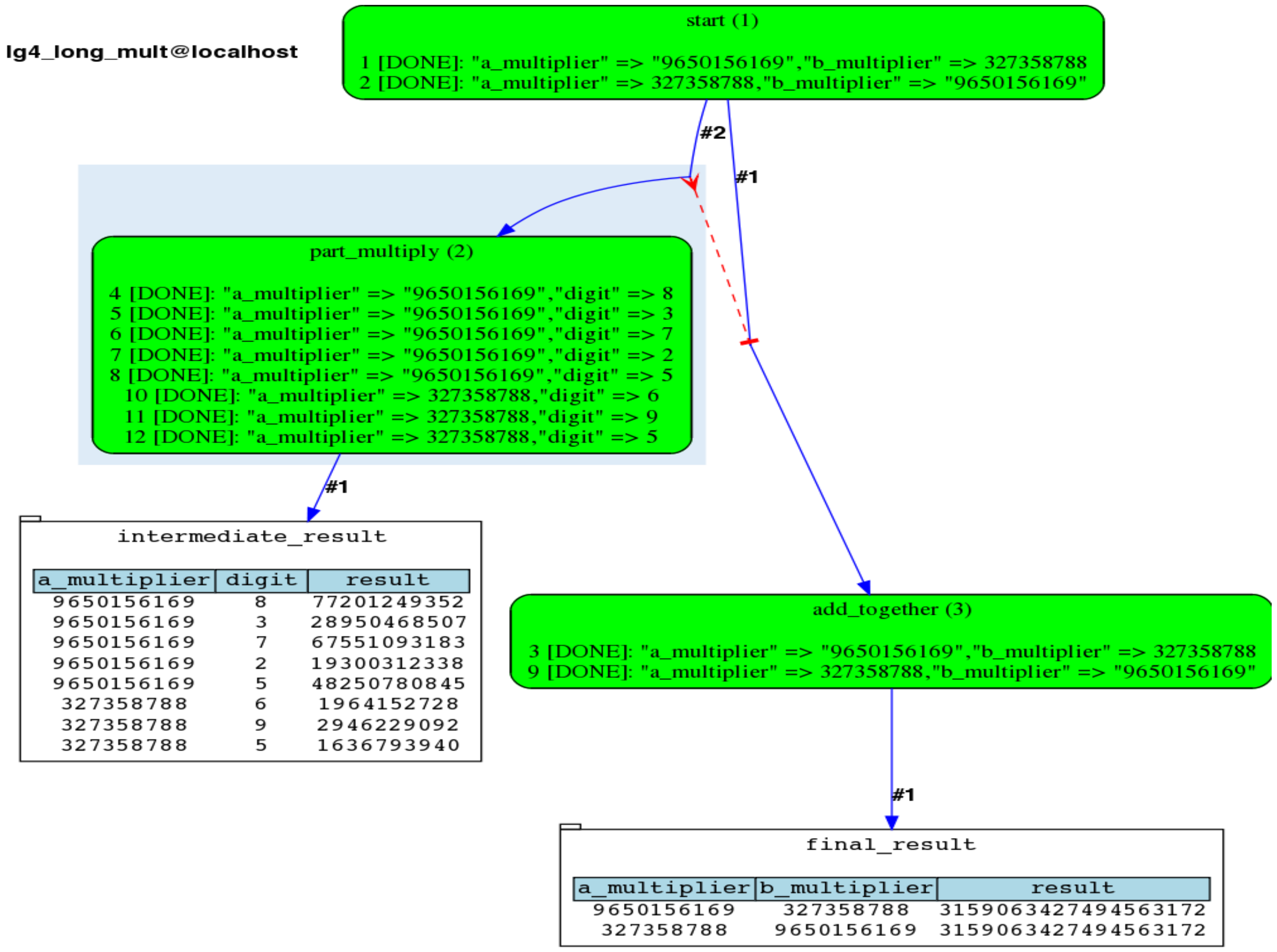
add_together (3)

3 [DONE]: "a_multiplier" => "9650156169","b_multiplier" => 327358788
9 [READY]: "a_multiplier" => 327358788,"b_multiplier" => "9650156169"

final_result

a_multiplier	b_multiplier	result
9650156169	327358788	3159063427494563172

LongMultiplication example pipeline (8)



```
start (1)

1 [DONE]: "a_multiplier" => "9650156169","b_multiplier" => 327358788
2 [DONE]: "a_multiplier" => 327358788,"b_multiplier" => "9650156169"
```

```
part_multiply (2)

4 [DONE]: "a_multiplier" => "9650156169","digit" => 8
5 [DONE]: "a_multiplier" => "9650156169","digit" => 3
6 [DONE]: "a_multiplier" => "9650156169","digit" => 7
7 [DONE]: "a_multiplier" => "9650156169","digit" => 2
8 [DONE]: "a_multiplier" => "9650156169","digit" => 5
10 [DONE]: "a_multiplier" => 327358788,"digit" => 6
11 [DONE]: "a_multiplier" => 327358788,"digit" => 9
12 [DONE]: "a_multiplier" => 327358788,"digit" => 5
```

```
add_together (3)

3 [DONE]: "a_multiplier" => "9650156169","b_multiplier" => 327358788
9 [DONE]: "a_multiplier" => 327358788,"b_multiplier" => "9650156169"
```

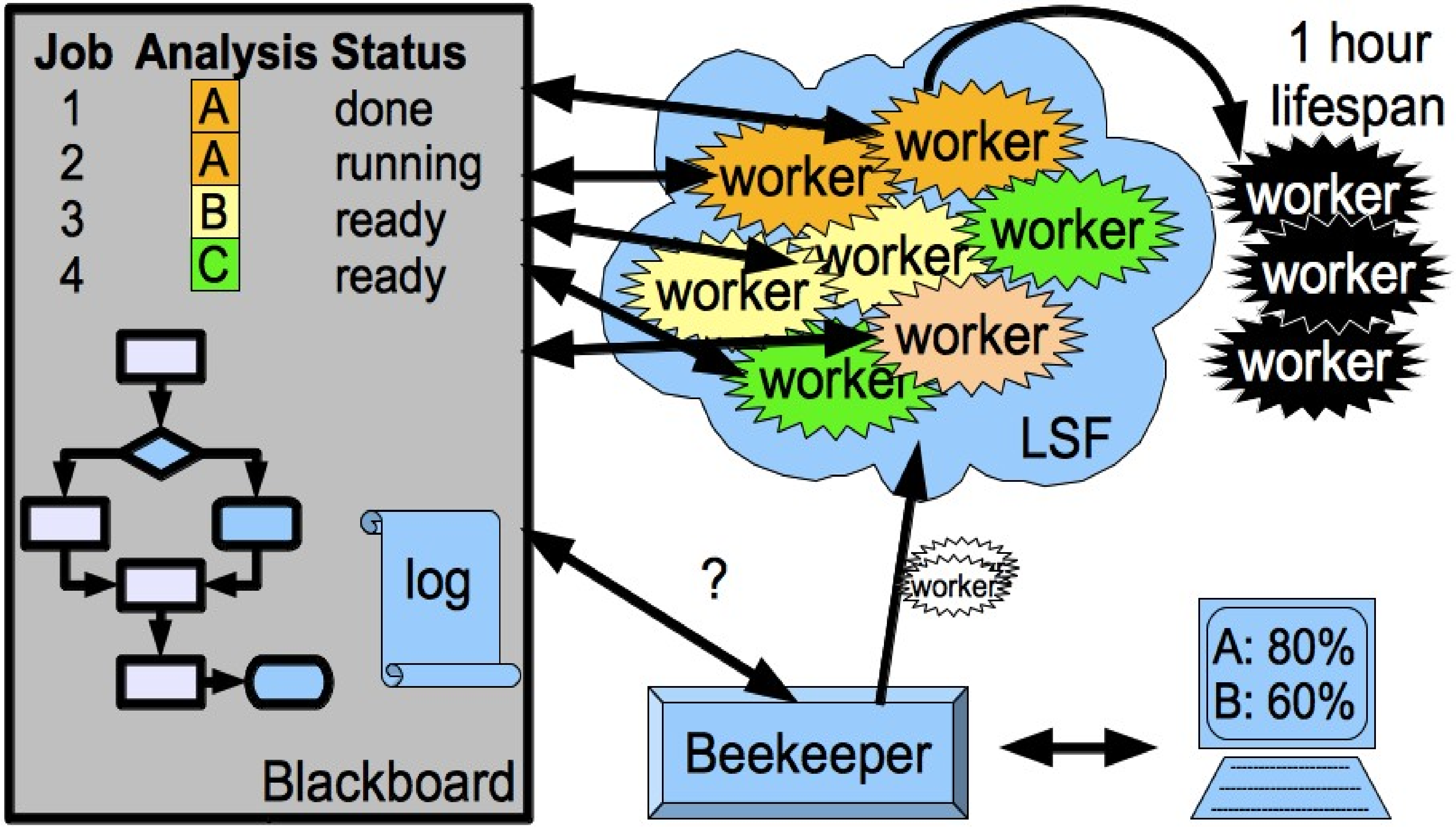
intermediate_result

a_multiplier	digit	result
9650156169	8	77201249352
9650156169	3	28950468507
9650156169	7	67551093183
9650156169	2	19300312338
9650156169	5	48250780845
327358788	6	1964152728
327358788	9	2946229092
327358788	5	1636793940

final_result

a_multiplier	b_multiplier	result
9650156169	327358788	3159063427494563172
327358788	9650156169	3159063427494563172

Workers, beekeeper, [re]specialization



Multi-meadow scheduling

- The same beekeeper can now submit both farm Workers and local Workers (busy farms, lots of light “linking code” between farm-needing processes)
- This preference (as well as desired resources) can be set for each Analysis
- Helps to save compute time, esp. combined with re-specialization of Workers

Using Git for development

- Development is done in Git (locally)

- Regularly pushed to the internal Git server visible to Sanger network users

- Less frequent (once per release?) exports to the externally-visible CVS server

- Fancy to try?

```
git clone git.internal:/repos/git/ensembl/compara/ensembl-hive.git
```

- eHive mailing list:

  ehive-users@ebi.ac.uk

Acknowledgements

Current and previous members of Compara team

All users of eHive system for testing, feedback and ideas

Paul Flicek, Steve Searle and the entire Ensembl Team

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wellcome trust

EMBL

National Human Genome Research Institute

BBSRC bioscience for the future

European Commission Framework Programme 7

SEVENTH FRAMEWORK PROGRAMME

Quantomics

From Sequence to Consequence : Tools for the Exploitation of Livestock Genomes

GEN2PHEN

BLUEPRINT epigenome