# Managing infrastructure on EC2 Spot

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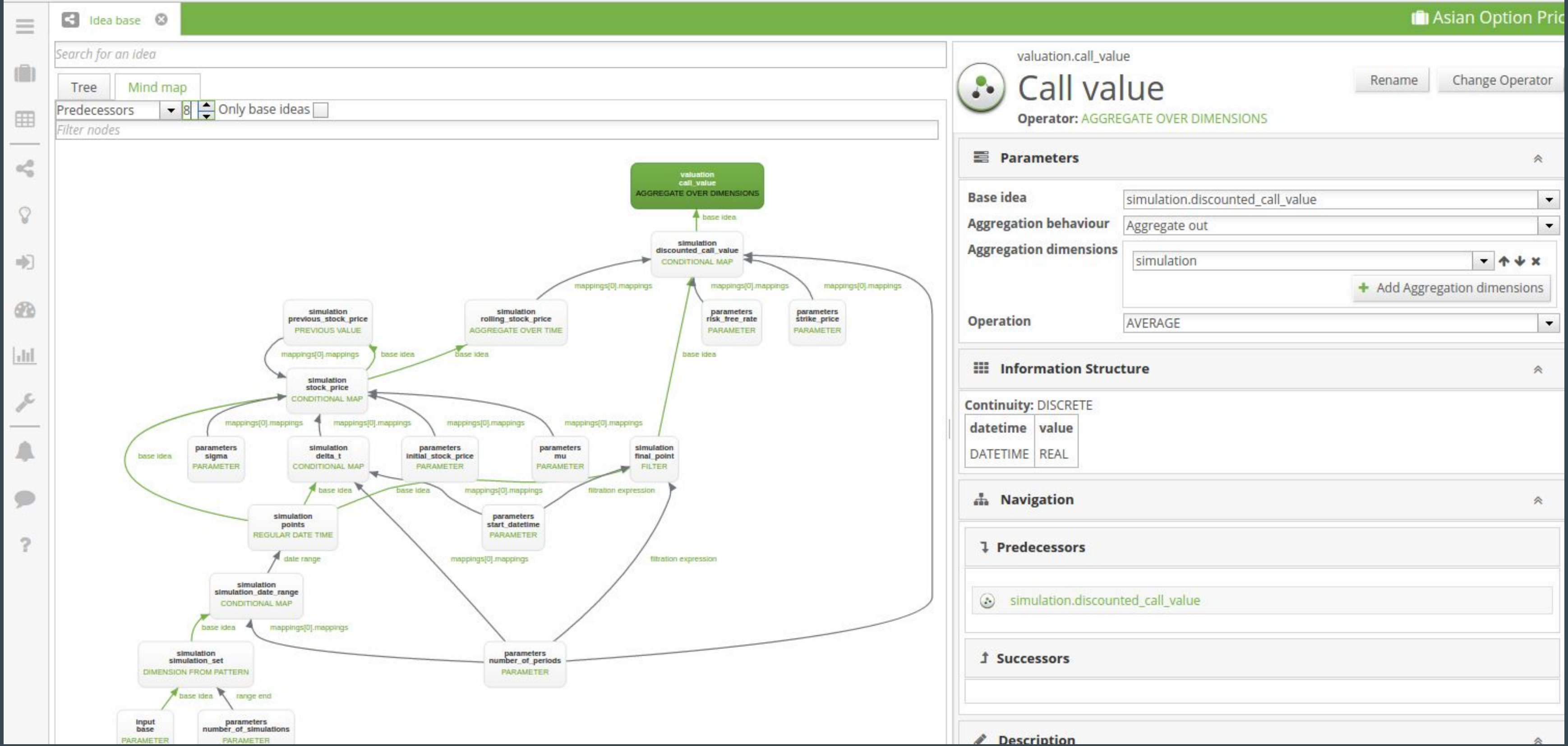
# What we do

- Modelling Platform for various forms of data:
- Financial / Insurance / Logistical / Medical/ Marketing
- Compute, Simulation, Machine Learning and Data Visualization
- Modelling has a visual component



valuation.call_value

Call value

**Operator:** AGGREGATE OVER DIMENSIONS

**Base idea:** simulation.discounted_call_value

**Aggregation behaviour:** Aggregate out

**Aggregation dimensions:** simulation

**Operation:** AVERAGE

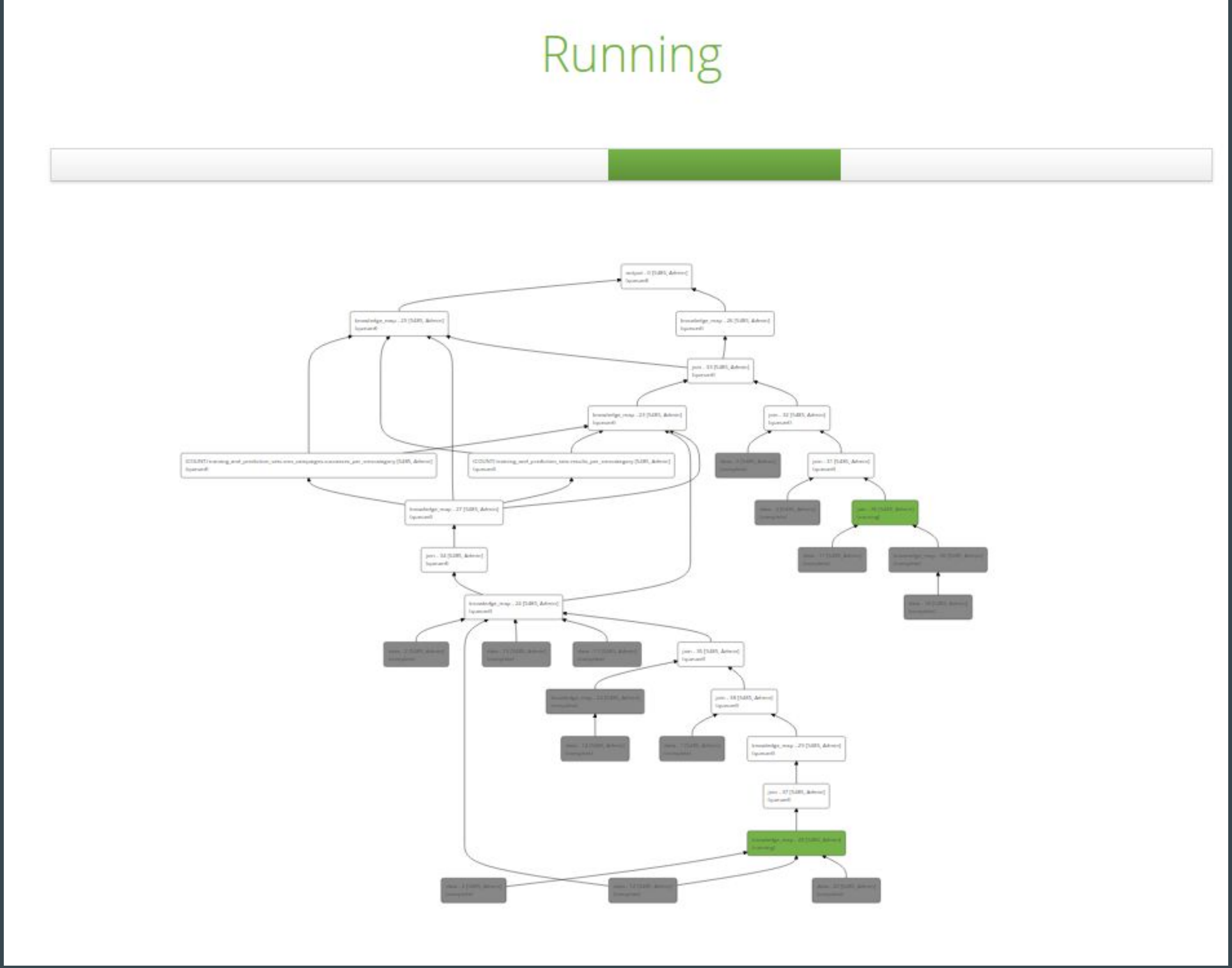
**Continuity:** DISCRETE

| datetime | value |
|---|---|
| DATETIME | REAL |

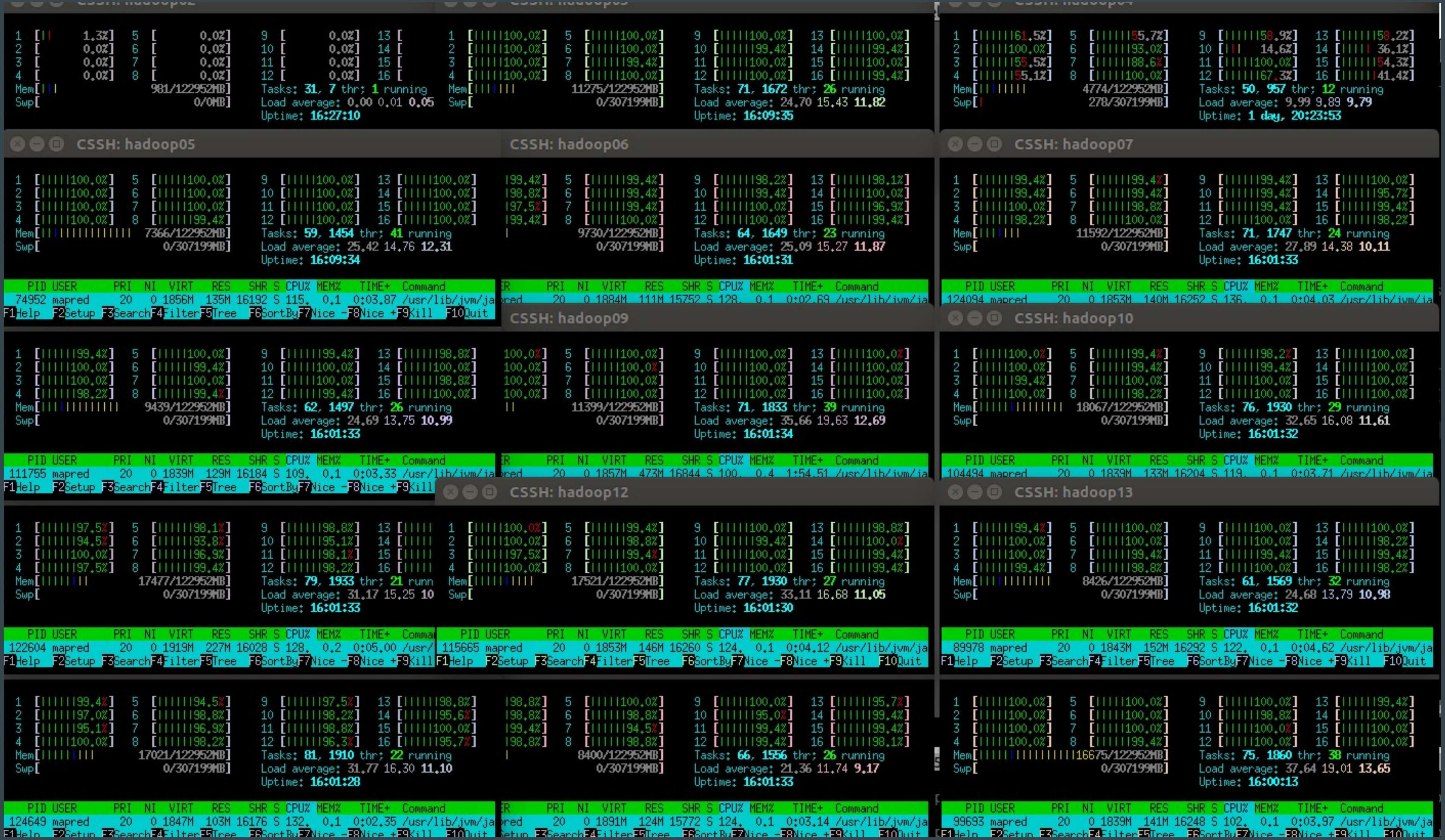
Predecessors: simulation.discounted_call_value

# Graph based compute engine (C++)

Compile these graphs into dependent Hadoop Map-Reduce jobs



# Calculations can get pretty big



```
CSSH: hadoop02
1  [||      1.3%]   5  [        0.0%]    9  [        0.0%]   13 [
2  [        0.0%]   6  [        0.0%]    10 [        0.0%]   14 [
3  [        0.0%]   7  [        0.0%]    11 [        0.0%]   15 [
4  [        0.0%]   8  [        0.0%]    12 [        0.0%]   16 [
Mem[|||             981/122952MB]    Tasks: 31, 7 thr; 1 running
Swp[                      0/0MB]    Load average: 0.00 0.01 0.05
                                    Uptime: 16:27:10
```

```
CSSH: hadoop03
1  [|||||100.0%]   5  [|||||100.0%]    9  [|||||100.0%]   13 [|||||100.0%]
2  [|||||100.0%]   6  [|||||100.0%]    10 [||||||99.4%]   14 [||||||99.4%]
3  [|||||100.0%]   7  [||||||99.4%]    11 [|||||100.0%]   15 [|||||100.0%]
4  [|||||100.0%]   8  [|||||100.0%]    12 [|||||100.0%]   16 [||||||99.4%]
Mem[|||||||         11275/122952MB]    Tasks: 71, 1672 thr; 26 running
Swp[                    0/307199MB]    Load average: 24.70 15.43 11.82
                                       Uptime: 16:09:35
```

```
CSSH: hadoop04
1  [||||||61.5%]   5  [||||||55.7%]    9  [||||||58.9%]   13 [||||||58.2%]
2  [|||||100.0%]   6  [||||||93.0%]    10 [|||    14.6%]   14 [|||||  36.1%]
3  [||||||55.5%]   7  [||||||88.6%]    11 [|||||100.0%]   15 [||||||54.3%]
4  [||||||55.1%]   8  [|||||100.0%]    12 [||||||67.3%]   16 [||||||41.4%]
Mem[||||||||         4774/122952MB]    Tasks: 50, 957 thr; 12 running
Swp[|                 278/307199MB]    Load average: 9.99 9.89 9.79
                                       Uptime: 1 day, 20:23:53
```

```
CSSH: hadoop05
1  [|||||100.0%]   5  [|||||100.0%]    9  [|||||100.0%]   13 [|||||100.0%]
2  [|||||100.0%]   6  [|||||100.0%]    10 [|||||100.0%]   14 [|||||100.0%]
3  [|||||100.0%]   7  [|||||100.0%]    11 [|||||100.0%]   15 [|||||100.0%]
4  [|||||100.0%]   8  [||||||99.4%]    12 [|||||100.0%]   16 [|||||100.0%]
Mem[|||||||||||||    7366/122952MB]    Tasks: 59, 1454 thr; 41 running
Swp[                    0/307199MB]    Load average: 25.42 14.76 12.31
                                       Uptime: 16:09:34

  PID USER      PRI  NI  VIRT   RES   SHR S CPU% MEM%   TIME+  Command
74952 mapred     20   0 1856M  135M 16192 S 115.  0.1  0:03.87 /usr/lib/jvm/ja
F1Help  F2Setup F3SearchF4FilterF5Tree  F6SortByF7Nice -F8Nice +F9Kill  F10Quit
```

```
CSSH: hadoop06
|99.4%]   5  [||||||99.4%]    9  [||||||98.2%]   13 [||||||98.1%]
|98.8%]   6  [||||||99.4%]    10 [||||||99.4%]   14 [|||||100.0%]
|97.5%]   7  [||||||99.4%]    11 [|||||100.0%]   15 [||||||96.9%]
|99.4%]   8  [|||||100.0%]    12 [|||||100.0%]   16 [||||||99.4%]
|                9730/122952MB]    Tasks: 64, 1649 thr; 23 running
                   0/307199MB]    Load average: 25.09 15.27 11.87
                                  Uptime: 16:01:31

ER      PRI  NI  VIRT   RES   SHR S CPU% MEM%   TIME+  Command
red      20   0 1884M  111M 15752 S 128.  0.1  0:02.69 /usr/lib/jvm/ja
```

```
CSSH: hadoop07
1  [||||||99.4%]   5  [||||||99.4%]    9  [||||||99.4%]   13 [|||||100.0%]
2  [||||||99.4%]   6  [||||||99.4%]    10 [||||||99.4%]   14 [||||||95.7%]
3  [|||||100.0%]   7  [||||||98.8%]    11 [||||||99.4%]   15 [||||||99.4%]
4  [||||||98.2%]   8  [|||||100.0%]    12 [|||||100.0%]   16 [||||||98.2%]
Mem[||||||          11592/122952MB]    Tasks: 71, 1747 thr; 24 running
Swp[                    0/307199MB]    Load average: 27.89 14.38 10.11
                                       Uptime: 16:01:33

   PID USER      PRI  NI  VIRT   RES   SHR S CPU% MEM%   TIME+  Command
124094 mapred     20   0 1853M  140M 16252 S 136.  0.1  0:04.03 /usr/lib/jvm/ja
```

```
1  [||||||99.4%]   5  [|||||100.0%]    9  [||||||99.4%]   13 [||||||98.8%]
2  [|||||100.0%]   6  [||||||99.4%]    10 [|||||100.0%]   14 [|||||100.0%]
3  [|||||100.0%]   7  [|||||100.0%]    11 [|||||100.0%]   15 [||||||98.8%]
4  [||||||98.2%]   8  [||||||99.4%]    12 [||||||99.4%]   16 [|||||100.0%]
Mem[|||||||||||      9439/122952MB]    Tasks: 62, 1497 thr; 26 running
Swp[                    0/307199MB]    Load average: 24.69 13.75 10.99
                                       Uptime: 16:01:33

   PID USER      PRI  NI  VIRT   RES   SHR S CPU% MEM%   TIME+  Command
111755 mapred     20   0 1839M  129M 16184 S 109.  0.1  0:03.33 /usr/lib/jvm/ja
F1Help  F2Setup F3SearchF4FilterF5Tree  F6SortByF7Nice -F8Nice +F9Kill
```

```
CSSH: hadoop09
100.0%]   5  [|||||100.0%]    9  [|||||100.0%]   13 [|||||100.0%]
100.0%]   6  [|||||100.0%]    10 [|||||100.0%]   14 [|||||100.0%]
100.0%]   7  [|||||100.0%]    11 [|||||100.0%]   15 [|||||100.0%]
100.0%]   8  [|||||100.0%]    12 [|||||100.0%]   16 [|||||100.0%]
||              11399/122952MB]    Tasks: 71, 1833 thr; 39 running
                    0/307199MB]    Load average: 35.66 19.63 12.69
                                   Uptime: 16:01:34

ER      PRI  NI  VIRT   RES   SHR S CPU% MEM%   TIME+  Command
red      20   0 1857M  473M 16844 S 100.  0.4  1:54.51 /usr/lib/jvm/ja
```

```
CSSH: hadoop10
1  [|||||100.0%]   5  [||||||99.4%]    9  [||||||98.2%]   13 [|||||100.0%]
2  [|||||100.0%]   6  [||||||99.4%]    10 [||||||99.4%]   14 [|||||100.0%]
3  [||||||99.4%]   7  [|||||100.0%]    11 [|||||100.0%]   15 [|||||100.0%]
4  [|||||100.0%]   8  [||||||98.2%]    12 [|||||100.0%]   16 [|||||100.0%]
Mem[|||||||||||||   18067/122952MB]    Tasks: 76, 1930 thr; 29 running
Swp[                    0/307199MB]    Load average: 32.65 16.08 11.61
                                       Uptime: 16:01:32

   PID USER      PRI  NI  VIRT   RES   SHR S CPU% MEM%   TIME+  Command
104494 mapred     20   0 1839M  133M 16204 S 119.  0.1  0:03.71 /usr/lib/jvm/ja
```

```
1  [||||||97.5%]   5  [||||||98.1%]    9  [||||||98.8%]   13 [|||||
2  [||||||94.5%]   6  [||||||93.8%]    10 [||||||95.1%]   14 [|||||
3  [|||||100.0%]   7  [||||||96.9%]    11 [||||||98.1%]   15 [|||||
4  [||||||97.5%]   8  [||||||99.4%]    12 [||||||98.2%]   16 [|||||
Mem[||||||||        17477/122952MB]    Tasks: 79, 1933 thr; 21 runn
Swp[                    0/307199MB]    Load average: 31.17 15.25 10
                                       Uptime: 16:01:33

   PID USER      PRI  NI  VIRT   RES   SHR S CPU% MEM%   TIME+  Comma
122604 mapred     20   0 1919M  227M 16028 S 128.  0.2  0:05.00 /usr/
F1Help  F2Setup F3SearchF4FilterF5Tree  F6SortByF7Nice -F8Nice +F9Kill
```

```
CSSH: hadoop12
1  [|||||100.0%]   5  [||||||99.4%]    9  [|||||100.0%]   13 [||||||98.8%]
2  [|||||100.0%]   6  [||||||98.8%]    10 [||||||99.4%]   14 [|||||100.0%]
3  [||||||97.5%]   7  [||||||99.4%]    11 [|||||100.0%]   15 [||||||99.4%]
4  [|||||100.0%]   8  [|||||100.0%]    12 [|||||100.0%]   16 [||||||99.4%]
Mem[||||||||||      17521/122952MB]    Tasks: 77, 1930 thr; 27 running
Swp[                    0/307199MB]    Load average: 33.11 16.68 11.05
                                       Uptime: 16:01:30

   PID USER      PRI  NI  VIRT   RES   SHR S CPU% MEM%   TIME+  Command
115665 mapred     20   0 1853M  146M 16260 S 124.  0.1  0:04.12 /usr/lib/jvm/ja
F1Help  F2Setup F3SearchF4FilterF5Tree  F6SortByF7Nice -F8Nice +F9Kill  F10Quit
```

```
CSSH: hadoop13
1  [||||||99.4%]   5  [|||||100.0%]    9  [|||||100.0%]   13 [|||||100.0%]
2  [|||||100.0%]   6  [|||||100.0%]    10 [|||||100.0%]   14 [||||||98.2%]
3  [|||||100.0%]   7  [||||||99.4%]    11 [||||||99.4%]   15 [||||||99.4%]
4  [||||||99.4%]   8  [||||||98.8%]    12 [|||||100.0%]   16 [||||||98.2%]
Mem[|||||||||||      8426/122952MB]    Tasks: 61, 1569 thr; 32 running
Swp[                    0/307199MB]    Load average: 24.68 13.79 10.98
                                       Uptime: 16:01:32

  PID USER      PRI  NI  VIRT   RES   SHR S CPU% MEM%   TIME+  Command
89978 mapred     20   0 1843M  152M 16292 S 122.  0.1  0:04.62 /usr/lib/jvm/ja
F1Help  F2Setup F3SearchF4FilterF5Tree  F6SortByF7Nice -F8Nice +F9Kill  F10Quit
```

```
1  [||||||99.4%]   5  [||||||94.5%]    9  [||||||97.5%]   13 [||||||98.8%]
2  [||||||97.0%]   6  [||||||98.8%]    10 [||||||98.2%]   14 [||||||95.6%]
3  [||||||95.1%]   7  [||||||96.9%]    11 [||||||98.8%]   15 [|||||100.0%]
4  [|||||100.0%]   8  [||||||98.2%]    12 [||||||96.3%]   16 [||||||95.7%]
Mem[|||||||||       17021/122952MB]    Tasks: 81, 1910 thr; 22 running
Swp[                    0/307199MB]    Load average: 31.77 16.30 11.10
                                       Uptime: 16:01:28

   PID USER      PRI  NI  VIRT   RES   SHR S CPU% MEM%   TIME+  Command
124649 mapred     20   0 1847M  103M 16176 S 132.  0.1  0:02.35 /usr/lib/jvm/ja
F1Help  F2Setup F3SearchF4FilterF5Tree  F6SortByF7Nice -F8Nice +F9Kill  F10Quit
```

```
|98.8%]   5  [|||||100.0%]    9  [|||||100.0%]   13 [||||||95.7%]
|98.8%]   6  [||||||98.8%]    10 [||||||95.0%]   14 [||||||99.4%]
|99.4%]   7  [||||||94.5%]    11 [||||||99.4%]   15 [||||||99.4%]
|98.8%]   8  [||||||98.8%]    12 [||||||99.4%]   16 [||||||98.1%]
|                8400/122952MB]    Tasks: 66, 1556 thr; 26 running
                   0/307199MB]    Load average: 21.36 11.74 9.17
                                  Uptime: 16:01:33

ER      PRI  NI  VIRT   RES   SHR S CPU% MEM%   TIME+  Command
red      20   0 1891M  124M 15772 S 124.  0.1  0:03.14 /usr/lib/jvm/ja
etup F3SearchF4FilterF5Tree  F6SortByF7Nice -F8Nice +F9Kill  F10Quit
```

```
1  [|||||100.0%]   5  [|||||100.0%]    9  [|||||100.0%]   13 [||||||99.4%]
2  [|||||100.0%]   6  [|||||100.0%]    10 [||||||98.8%]   14 [|||||100.0%]
3  [|||||100.0%]   7  [|||||100.0%]    11 [|||||100.0%]   15 [|||||100.0%]
4  [|||||100.0%]   8  [||||||99.4%]    12 [|||||100.0%]   16 [|||||100.0%]
Mem[|||||||||||||||||16675/122952MB]    Tasks: 75, 1860 thr; 38 running
Swp[                    0/307199MB]    Load average: 37.64 19.01 13.65
                                       Uptime: 16:00:13

  PID USER      PRI  NI  VIRT   RES   SHR S CPU% MEM%   TIME+  Command
99693 mapred     20   0 1839M  141M 16248 S 102.  0.1  0:03.97 /usr/lib/jvm/ja
F1Help  F2Setup F3SearchF4FilterF5Tree  F6SortByF7Nice -F8Nice +F9Kill  F10Quit
```

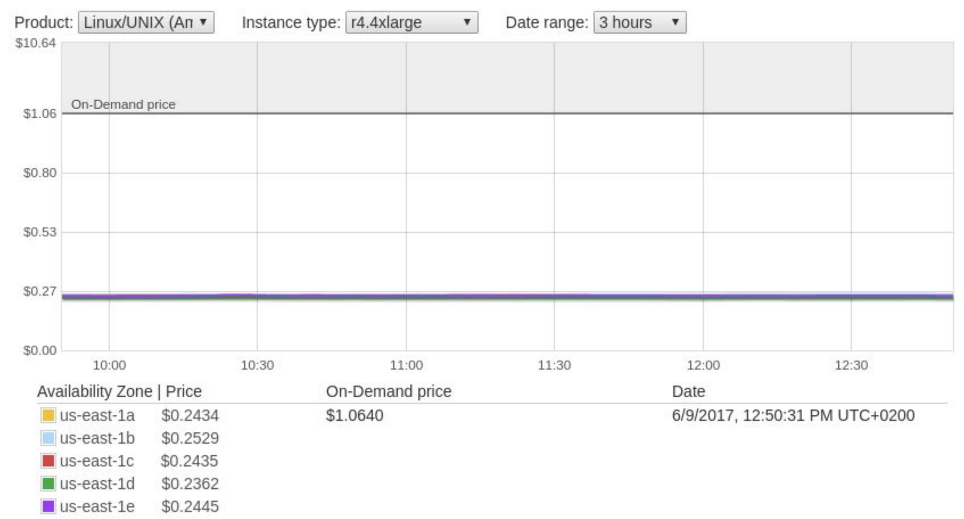
# Motivations for using EC2 Spot

- Big calculations require many instances
- Much cheaper ~ $0.24 spot vs $1.06 on demand for r4.4xlarge per hour (4.4 times cheaper) - when not surging
- Can handle losing some machines

# How Spot Pricing Works

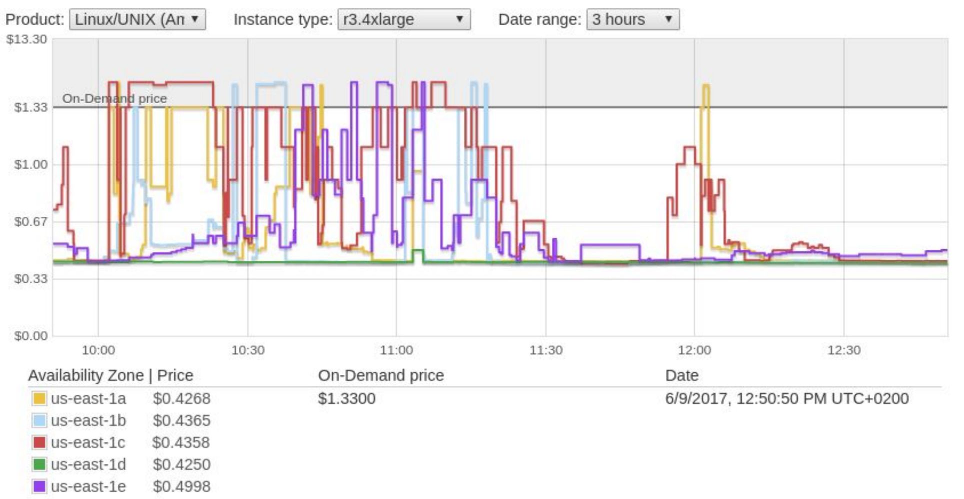
- Quasi market
- Set a bid, pay the market price
- If market price goes above your bid => your instance gets terminated
- Spot price can go 10X above the on demand price
- Different prices for different instance types

# Different volatility for different instance types



Product: Linux/UNIX (An ▾ Instance type: r4.4xlarge ▾ Date range: 3 hours ▾

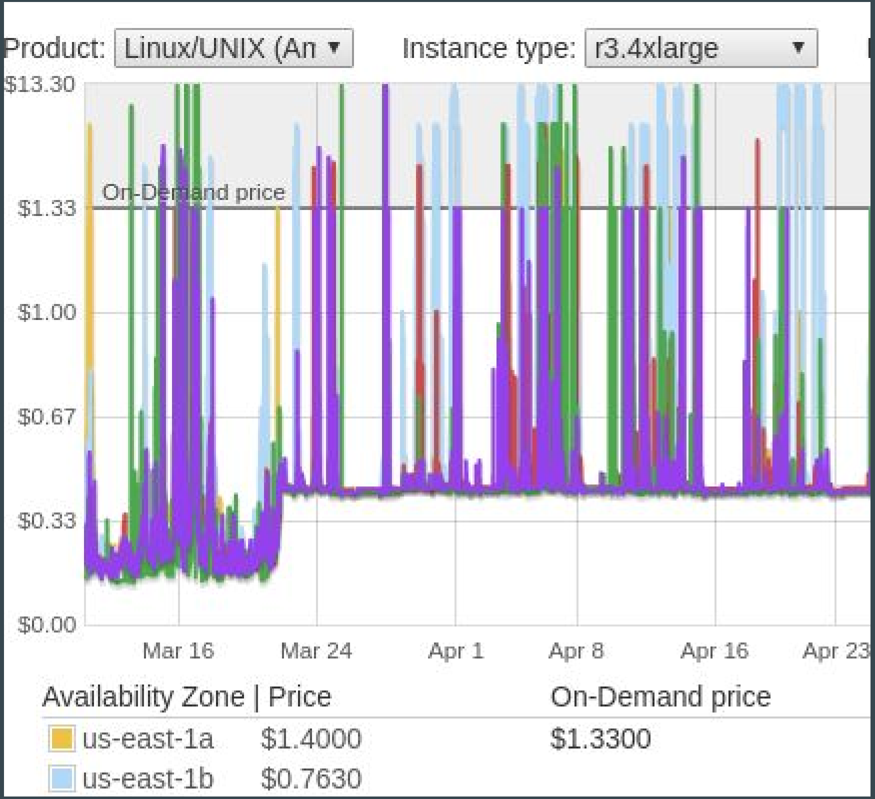
| Availability Zone \| Price | | On-Demand price | Date |
|---|---|---|---|
| 🟨 us-east-1a | $0.2434 | $1.0640 | 6/9/2017, 12:50:31 PM UTC+0200 |
| 🟦 us-east-1b | $0.2529 | | |
| 🟥 us-east-1c | $0.2435 | | |
| 🟩 us-east-1d | $0.2362 | | |
| 🟪 us-east-1e | $0.2445 | | |



Product: Linux/UNIX (An ▾ Instance type: r3.4xlarge ▾ Date range: 3 hours ▾

| Availability Zone \| Price | | On-Demand price | Date |
|---|---|---|---|
| 🟨 us-east-1a | $0.4268 | $1.3300 | 6/9/2017, 12:50:50 PM UTC+0200 |
| 🟦 us-east-1b | $0.4365 | | |
| 🟥 us-east-1c | $0.4358 | | |
| 🟩 us-east-1d | $0.4250 | | |
| 🟪 us-east-1e | $0.4998 | | |

# Jumps in market price



Product: Linux/UNIX (An ▾ Instance type: r3.4xlarge ▾

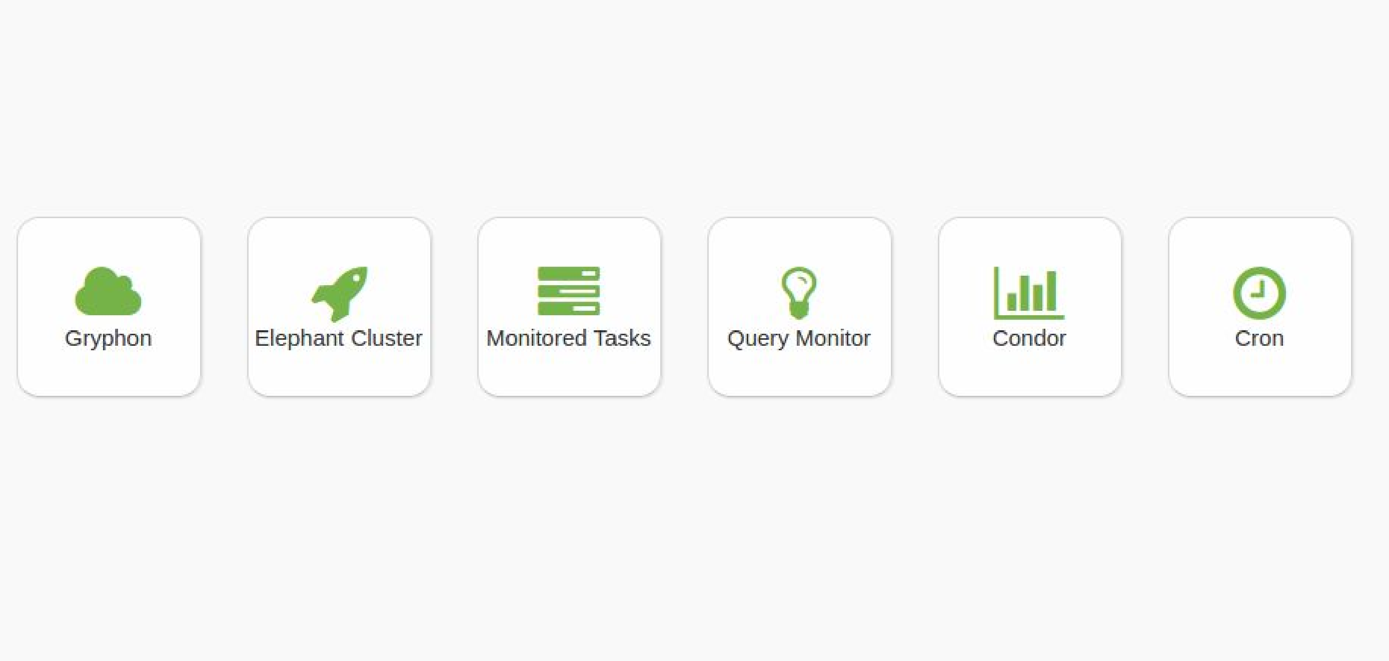
| Availability Zone \| Price | | On-Demand price |
|---|---|---|
| 🟨 us-east-1a | $1.4000 | $1.3300 |
| 🟦 us-east-1b | $0.7630 | |

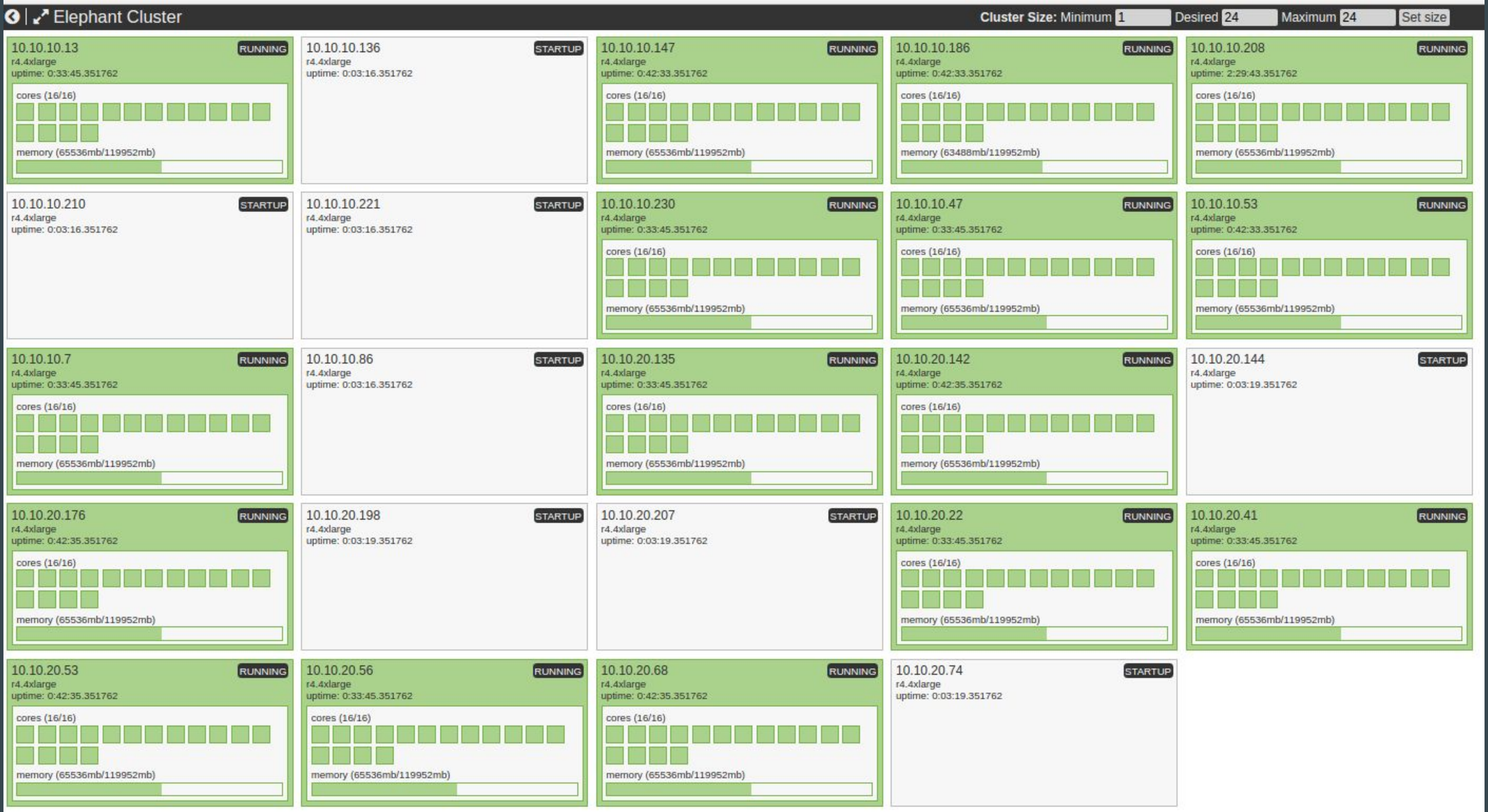
# Problems we've encountered

- What if price stays up?
- Multi-AZ - incurs interzone traffic costs
- Losing local disk can be a problem
- Some services don't handle node churn

# Having insights is important

# Build internal monitoring tools





Elephant Cluster

**Cluster Size:** Minimum 1 Desired 24 Maximum 24 Set size

10.10.10.13 RUNNING
r4.4xlarge
uptime: 0:33:45.351762
cores (16/16)
memory (65536mb/119952mb)

10.10.10.136 STARTUP
r4.4xlarge
uptime: 0:03:16.351762

10.10.10.147 RUNNING
r4.4xlarge
uptime: 0:42:33.351762
cores (16/16)
memory (65536mb/119952mb)

10.10.10.186 RUNNING
r4.4xlarge
uptime: 0:42:33.351762
cores (16/16)
memory (63488mb/119952mb)

10.10.10.208 RUNNING
r4.4xlarge
uptime: 2:29:43.351762
cores (16/16)
memory (65536mb/119952mb)

10.10.10.210 STARTUP
r4.4xlarge
uptime: 0:03:16.351762

10.10.10.221 STARTUP
r4.4xlarge
uptime: 0:03:16.351762

10.10.10.230 RUNNING
r4.4xlarge
uptime: 0:33:45.351762
cores (16/16)
memory (65536mb/119952mb)

10.10.10.47 RUNNING
r4.4xlarge
uptime: 0:33:45.351762
cores (16/16)
memory (65536mb/119952mb)

10.10.10.53 RUNNING
r4.4xlarge
uptime: 0:42:33.351762
cores (16/16)
memory (65536mb/119952mb)

10.10.10.7 RUNNING
r4.4xlarge
uptime: 0:33:45.351762
cores (16/16)
memory (65536mb/119952mb)

10.10.10.86 STARTUP
r4.4xlarge
uptime: 0:03:16.351762

10.10.20.135 RUNNING
r4.4xlarge
uptime: 0:33:45.351762
cores (16/16)
memory (65536mb/119952mb)

10.10.20.142 RUNNING
r4.4xlarge
uptime: 0:42:35.351762
cores (16/16)
memory (65536mb/119952mb)

10.10.20.144 STARTUP
r4.4xlarge
uptime: 0:03:19.351762

10.10.20.176 RUNNING
r4.4xlarge
uptime: 0:42:35.351762
cores (16/16)
memory (65536mb/119952mb)

10.10.20.198 STARTUP
r4.4xlarge
uptime: 0:03:19.351762

10.10.20.207 STARTUP
r4.4xlarge
uptime: 0:03:19.351762

10.10.20.22 RUNNING
r4.4xlarge
uptime: 0:33:45.351762
cores (16/16)
memory (65536mb/119952mb)

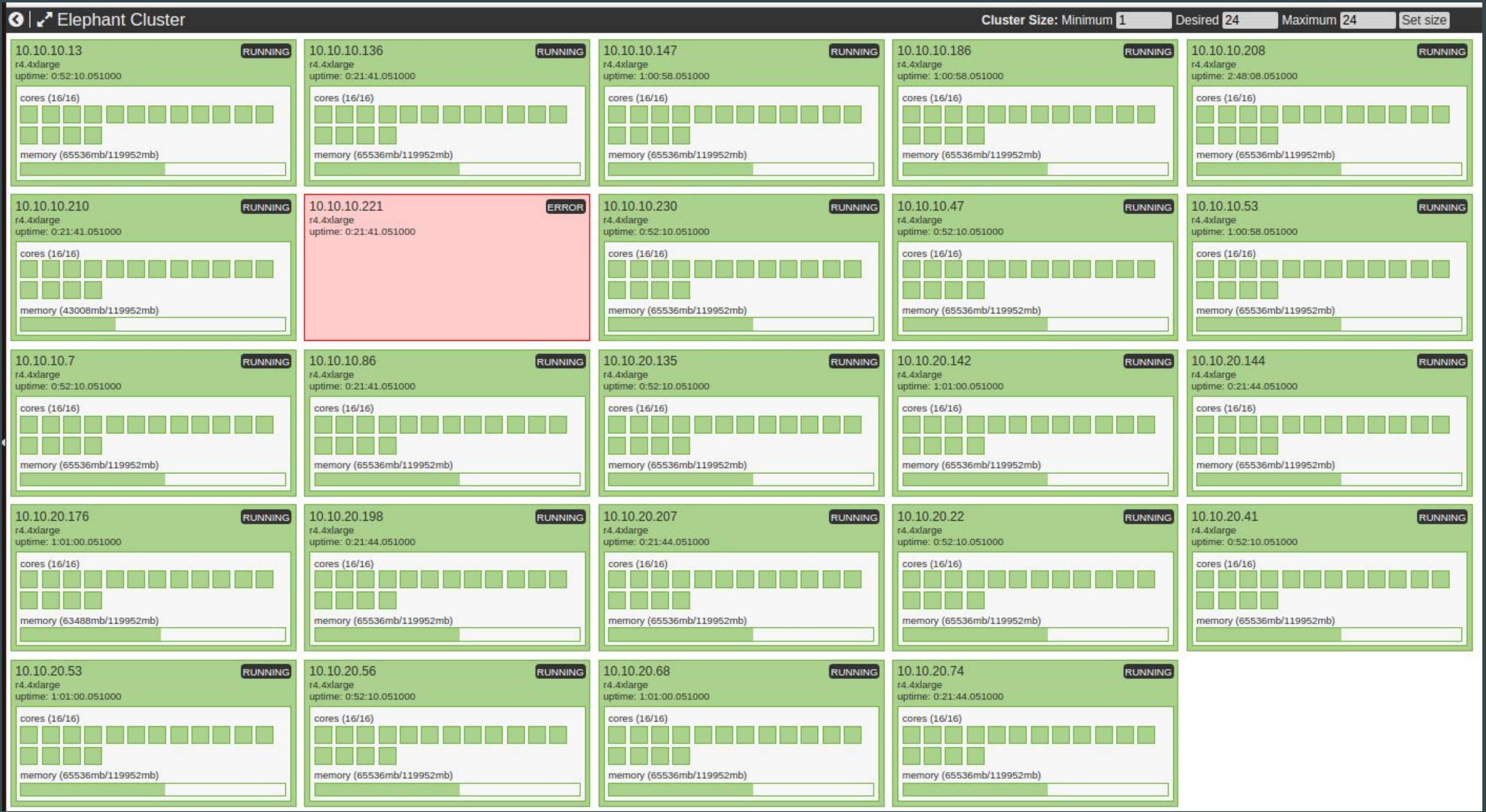
10.10.20.41 RUNNING
r4.4xlarge
uptime: 0:33:45.351762
cores (16/16)
memory (65536mb/119952mb)

10.10.20.53 RUNNING
r4.4xlarge
uptime: 0:42:35.351762
cores (16/16)
memory (65536mb/119952mb)

10.10.20.56 RUNNING
r4.4xlarge
uptime: 0:33:45.351762
cores (16/16)
memory (65536mb/119952mb)

10.10.20.68 RUNNING
r4.4xlarge
uptime: 0:42:35.351762
cores (16/16)
memory (65536mb/119952mb)

10.10.20.74 STARTUP
r4.4xlarge
uptime: 0:03:19.351762



Elephant Cluster

**Cluster Size:** Minimum 1 Desired 24 Maximum 24 Set size

10.10.10.13 RUNNING
r4.4xlarge
uptime: 0:52:10.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.10.136 RUNNING
r4.4xlarge
uptime: 0:21:41.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.10.147 RUNNING
r4.4xlarge
uptime: 1:00:58.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.10.186 RUNNING
r4.4xlarge
uptime: 1:00:58.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.10.208 RUNNING
r4.4xlarge
uptime: 2:48:08.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.10.210 RUNNING
r4.4xlarge
uptime: 0:21:41.051000
cores (16/16)
memory (43008mb/119952mb)

10.10.10.221 ERROR
r4.4xlarge
uptime: 0:21:41.051000

10.10.10.230 RUNNING
r4.4xlarge
uptime: 0:52:10.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.10.47 RUNNING
r4.4xlarge
uptime: 0:52:10.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.10.53 RUNNING
r4.4xlarge
uptime: 1:00:58.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.10.7 RUNNING
r4.4xlarge
uptime: 0:52:10.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.10.86 RUNNING
r4.4xlarge
uptime: 0:21:41.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.20.135 RUNNING
r4.4xlarge
uptime: 0:52:10.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.20.142 RUNNING
r4.4xlarge
uptime: 1:01:00.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.20.144 RUNNING
r4.4xlarge
uptime: 0:21:44.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.20.176 RUNNING
r4.4xlarge
uptime: 1:01:00.051000
cores (16/16)
memory (63488mb/119952mb)

10.10.20.198 RUNNING
r4.4xlarge
uptime: 0:21:44.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.20.207 RUNNING
r4.4xlarge
uptime: 0:21:44.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.20.22 RUNNING
r4.4xlarge
uptime: 0:52:10.051000
cores (16/16)
memory (65536mb/119952mb)

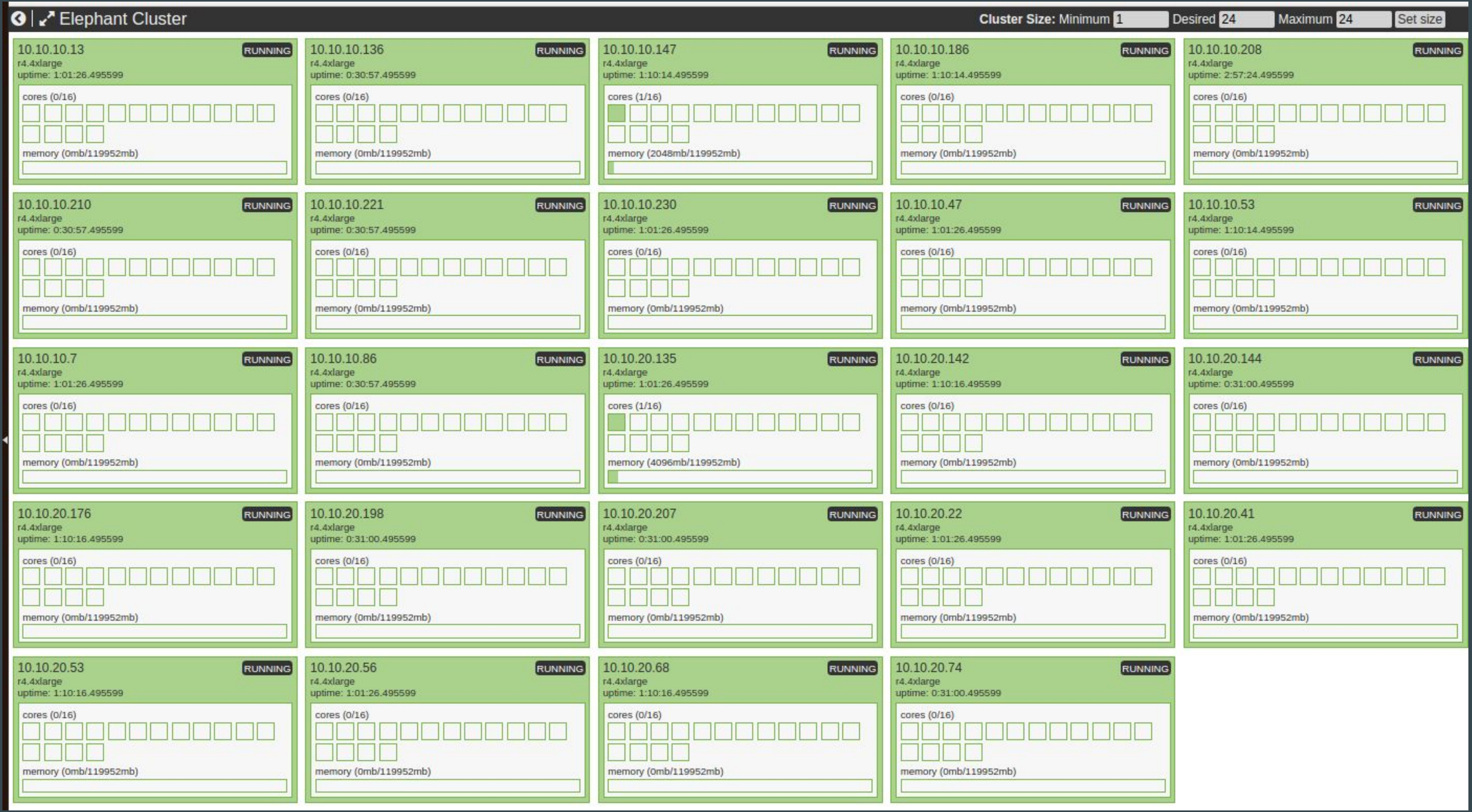
10.10.20.41 RUNNING
r4.4xlarge
uptime: 0:52:10.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.20.53 RUNNING
r4.4xlarge
uptime: 1:01:00.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.20.56 RUNNING
r4.4xlarge
uptime: 0:52:10.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.20.68 RUNNING
r4.4xlarge
uptime: 1:01:00.051000
cores (16/16)
memory (65536mb/119952mb)

10.10.20.74 RUNNING
r4.4xlarge
uptime: 0:21:44.051000
cores (16/16)
memory (65536mb/119952mb)



Elephant Cluster

Cluster Size: Minimum 1 Desired 24 Maximum 24 Set size

10.10.10.13 RUNNING
r4.4xlarge
uptime: 1:01:26.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.10.136 RUNNING
r4.4xlarge
uptime: 0:30:57.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.10.147 RUNNING
r4.4xlarge
uptime: 1:10:14.495599
cores (1/16)
■□□□□□□□□□□□
□□□□
memory (2048mb/119952mb)

10.10.10.186 RUNNING
r4.4xlarge
uptime: 1:10:14.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.10.208 RUNNING
r4.4xlarge
uptime: 2:57:24.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.10.210 RUNNING
r4.4xlarge
uptime: 0:30:57.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.10.221 RUNNING
r4.4xlarge
uptime: 0:30:57.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.10.230 RUNNING
r4.4xlarge
uptime: 1:01:26.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.10.47 RUNNING
r4.4xlarge
uptime: 1:01:26.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.10.53 RUNNING
r4.4xlarge
uptime: 1:10:14.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.10.7 RUNNING
r4.4xlarge
uptime: 1:01:26.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.10.86 RUNNING
r4.4xlarge
uptime: 0:30:57.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.20.135 RUNNING
r4.4xlarge
uptime: 1:01:26.495599
cores (1/16)
■□□□□□□□□□□□
□□□□
memory (4096mb/119952mb)

10.10.20.142 RUNNING
r4.4xlarge
uptime: 1:10:16.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.20.144 RUNNING
r4.4xlarge
uptime: 0:31:00.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.20.176 RUNNING
r4.4xlarge
uptime: 1:10:16.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.20.198 RUNNING
r4.4xlarge
uptime: 0:31:00.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.20.207 RUNNING
r4.4xlarge
uptime: 0:31:00.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.20.22 RUNNING
r4.4xlarge
uptime: 1:01:26.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

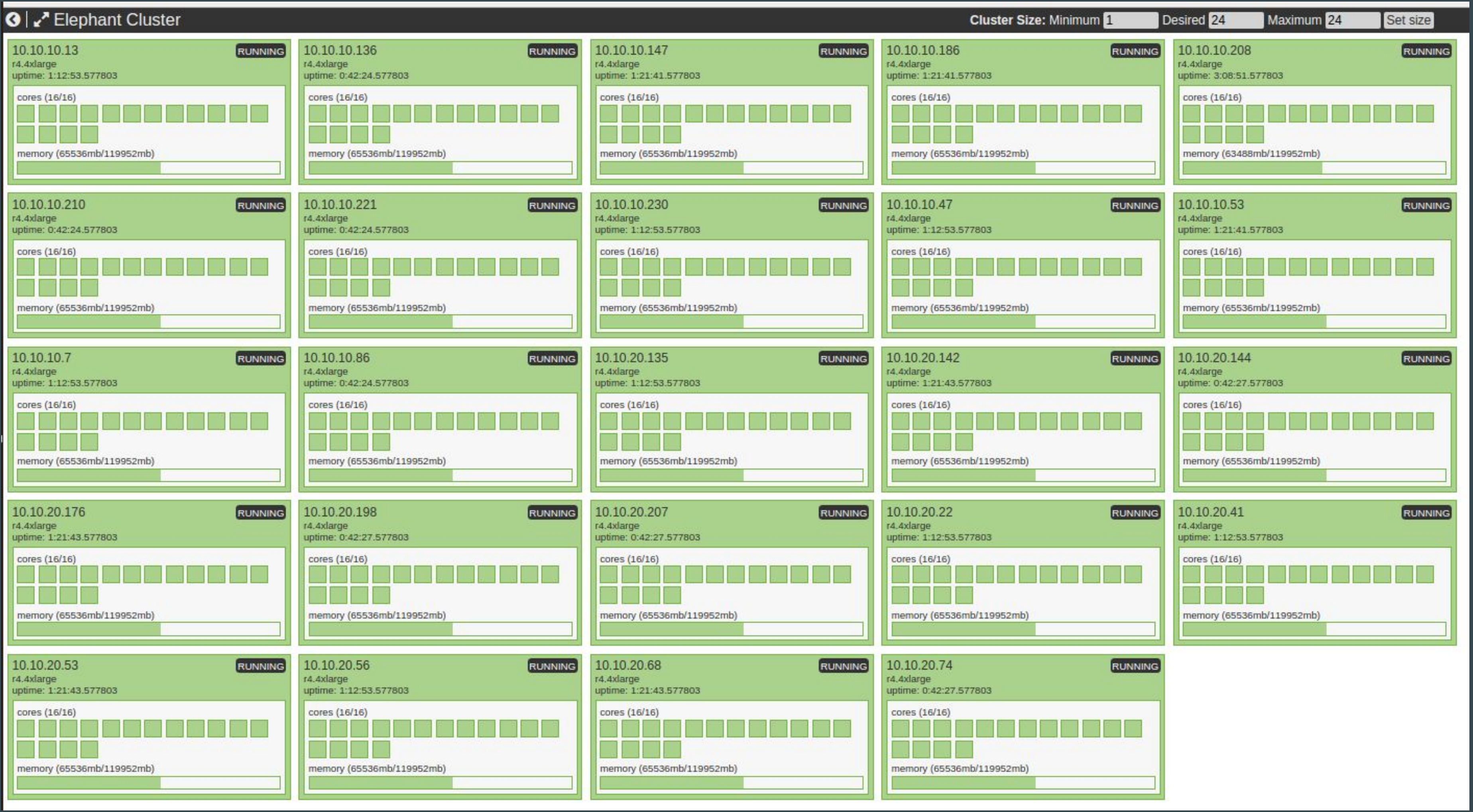
10.10.20.41 RUNNING
r4.4xlarge
uptime: 1:01:26.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.20.53 RUNNING
r4.4xlarge
uptime: 1:10:16.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.20.56 RUNNING
r4.4xlarge
uptime: 1:01:26.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.20.68 RUNNING
r4.4xlarge
uptime: 1:10:16.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)

10.10.20.74 RUNNING
r4.4xlarge
uptime: 0:31:00.495599
cores (0/16)
□□□□□□□□□□□□
□□□□
memory (0mb/119952mb)



10.10.10.13 RUNNING
r4.4xlarge
uptime: 1:12:53.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.10.136 RUNNING
r4.4xlarge
uptime: 0:42:24.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.10.147 RUNNING
r4.4xlarge
uptime: 1:21:41.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.10.186 RUNNING
r4.4xlarge
uptime: 1:21:41.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.10.208 RUNNING
r4.4xlarge
uptime: 3:08:51.577803
cores (16/16)
memory (63488mb/119952mb)

10.10.10.210 RUNNING
r4.4xlarge
uptime: 0:42:24.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.10.221 RUNNING
r4.4xlarge
uptime: 0:42:24.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.10.230 RUNNING
r4.4xlarge
uptime: 1:12:53.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.10.47 RUNNING
r4.4xlarge
uptime: 1:12:53.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.10.53 RUNNING
r4.4xlarge
uptime: 1:21:41.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.10.7 RUNNING
r4.4xlarge
uptime: 1:12:53.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.10.86 RUNNING
r4.4xlarge
uptime: 0:42:24.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.20.135 RUNNING
r4.4xlarge
uptime: 1:12:53.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.20.142 RUNNING
r4.4xlarge
uptime: 1:21:43.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.20.144 RUNNING
r4.4xlarge
uptime: 0:42:27.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.20.176 RUNNING
r4.4xlarge
uptime: 1:21:43.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.20.198 RUNNING
r4.4xlarge
uptime: 0:42:27.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.20.207 RUNNING
r4.4xlarge
uptime: 0:42:27.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.20.22 RUNNING
r4.4xlarge
uptime: 1:12:53.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.20.41 RUNNING
r4.4xlarge
uptime: 1:12:53.577803
cores (16/16)
memory (65536mb/119952mb)

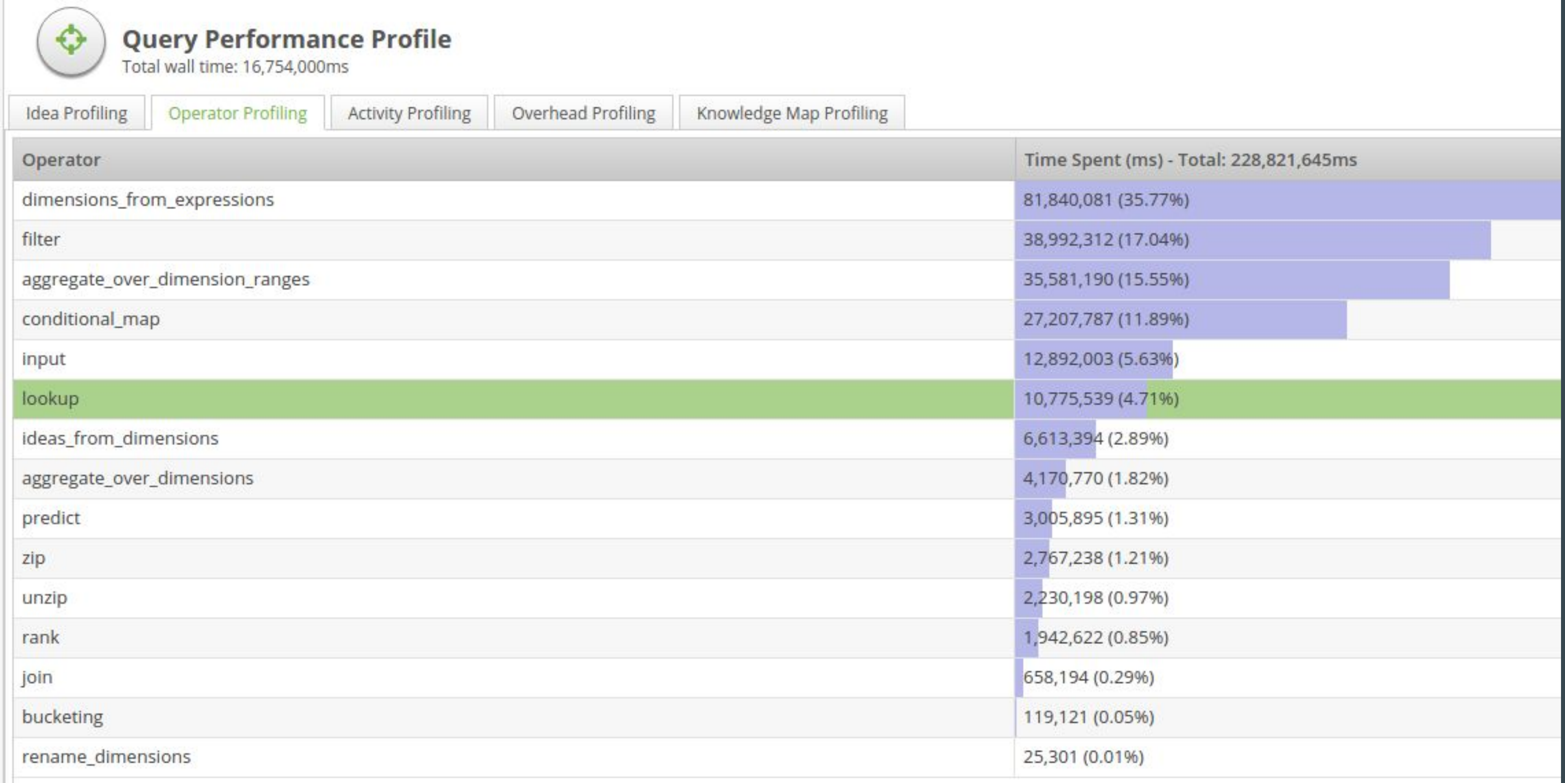
10.10.20.53 RUNNING
r4.4xlarge
uptime: 1:21:43.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.20.56 RUNNING
r4.4xlarge
uptime: 1:12:53.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.20.68 RUNNING
r4.4xlarge
uptime: 1:21:43.577803
cores (16/16)
memory (65536mb/119952mb)

10.10.20.74 RUNNING
r4.4xlarge
uptime: 0:42:27.577803
cores (16/16)
memory (65536mb/119952mb)

# Profile the code



**Query Performance Profile**

Total wall time: 16,754,000ms

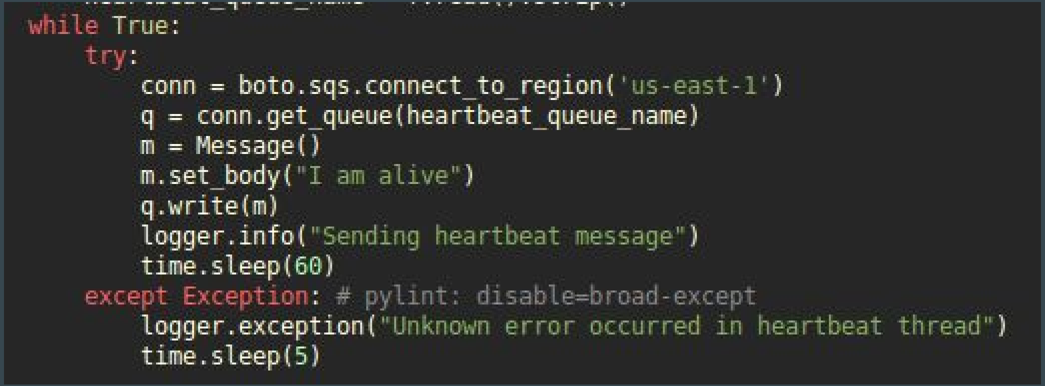
| Operator | Time Spent (ms) - Total: 228,821,645ms |
|---|---|
| dimensions_from_expressions | 81,840,081 (35.77%) |
| filter | 38,992,312 (17.04%) |
| aggregate_over_dimension_ranges | 35,581,190 (15.55%) |
| conditional_map | 27,207,787 (11.89%) |
| input | 12,892,003 (5.63%) |
| lookup | 10,775,539 (4.71%) |
| ideas_from_dimensions | 6,613,394 (2.89%) |
| aggregate_over_dimensions | 4,170,770 (1.82%) |
| predict | 3,005,895 (1.31%) |
| zip | 2,767,238 (1.21%) |
| unzip | 2,230,198 (0.97%) |
| rank | 1,942,622 (0.85%) |
| join | 658,194 (0.29%) |
| bucketing | 119,121 (0.05%) |
| rename_dimensions | 25,301 (0.01%) |

# Insights

- Monitoring can makes your life easier
- Compute coming up faster saves $$$ (docker vs puppet): image download vs package install
- Match cluster size to resource requirements
- Having the right autoscaling conf matters

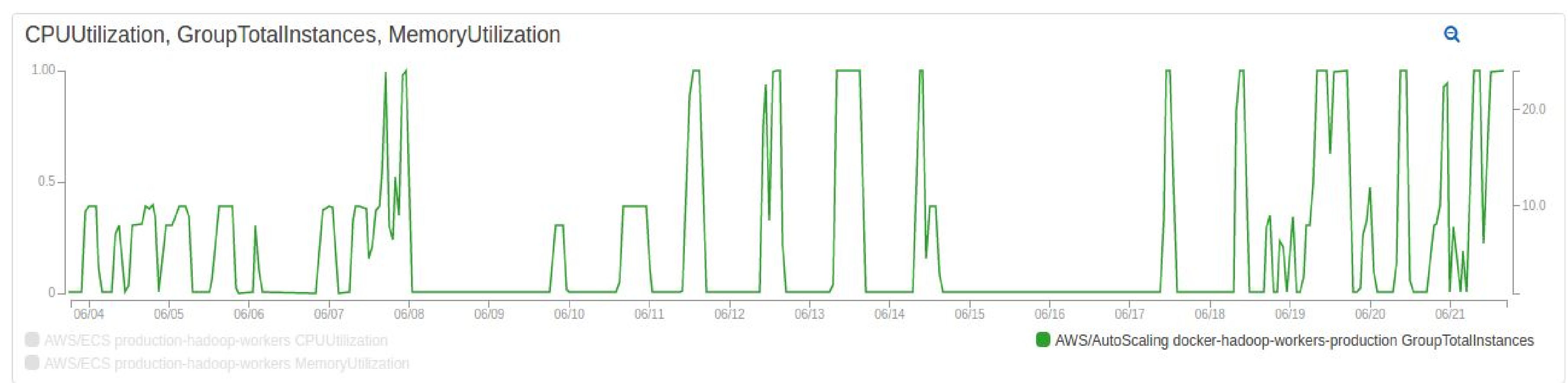
# Autoscaling issues

- Don’t flip on and off
  - Two Causes for us:
    - new job => scale up => complete => scale down => new job (within an instance hour)
    - Scale up too high too quickly => low resource utilization => scale down => (repeat)
- Scale up on load metrics (high cpu), gate scaledown on # messages in alive queue



```
while True:
    try:
        conn = boto.sqs.connect_to_region('us-east-1')
        q = conn.get_queue(heartbeat_queue_name)
        m = Message()
        m.set_body("I am alive")
        q.write(m)
        logger.info("Sending heartbeat message")
        time.sleep(60)
    except Exception: # pylint: disable=broad-except
        logger.exception("Unknown error occurred in heartbeat thread")
        time.sleep(5)
```

# Some recent spot autoscaling usage



# Questions