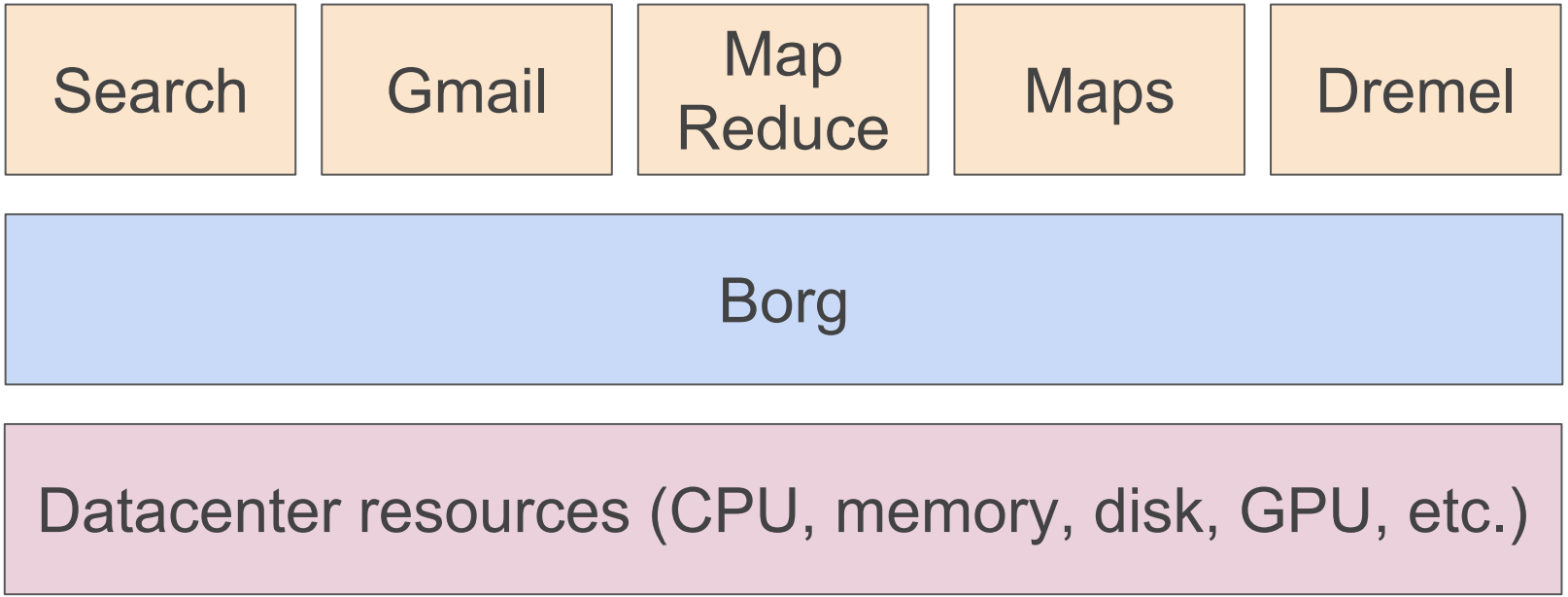
Borg

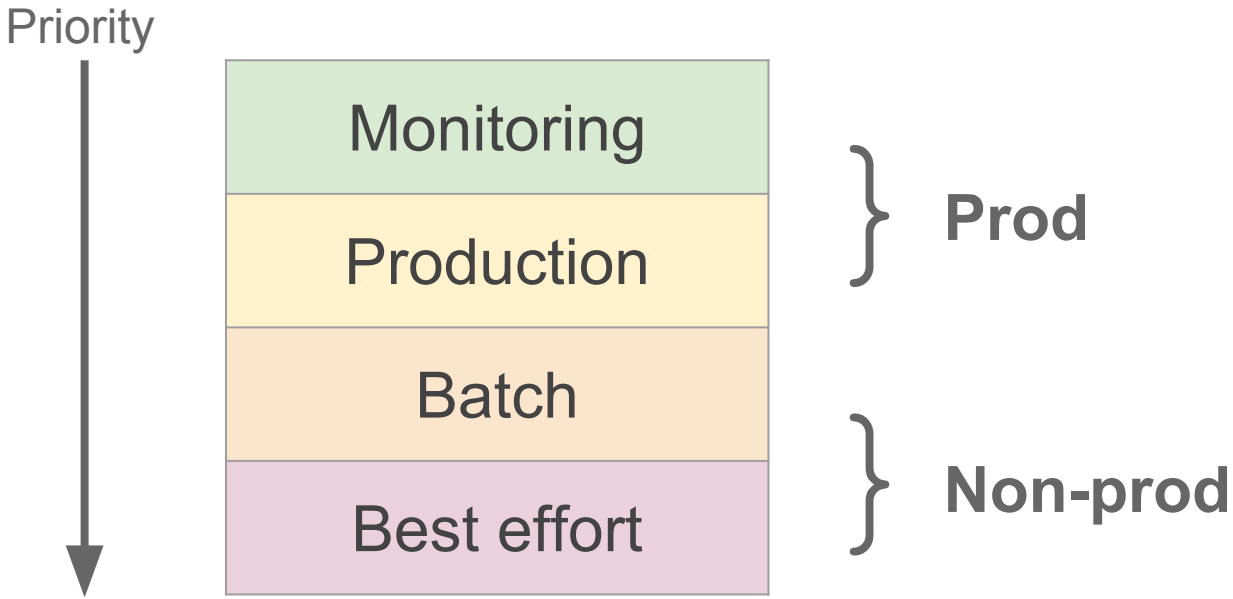
Abhishek Verma, Luis Pedrosa, Madhukar R. Korupolu, David Oppenheimer, Eric Tune, John Wilkes

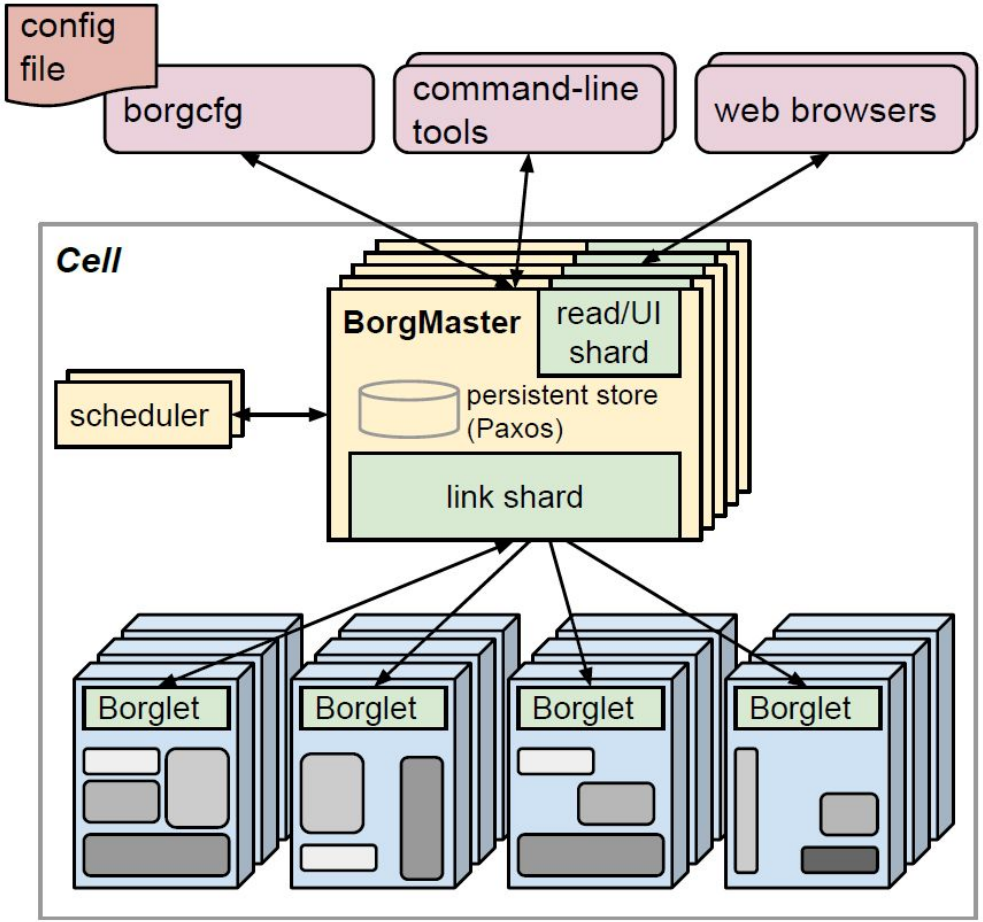
Google Inc.

What is Borg?


Search
Gmail
Map Reduce
Maps
Dremel
Borg
Datacenter resources (CPU, memory, disk, GPU, etc.)

Heterogeneous Workload

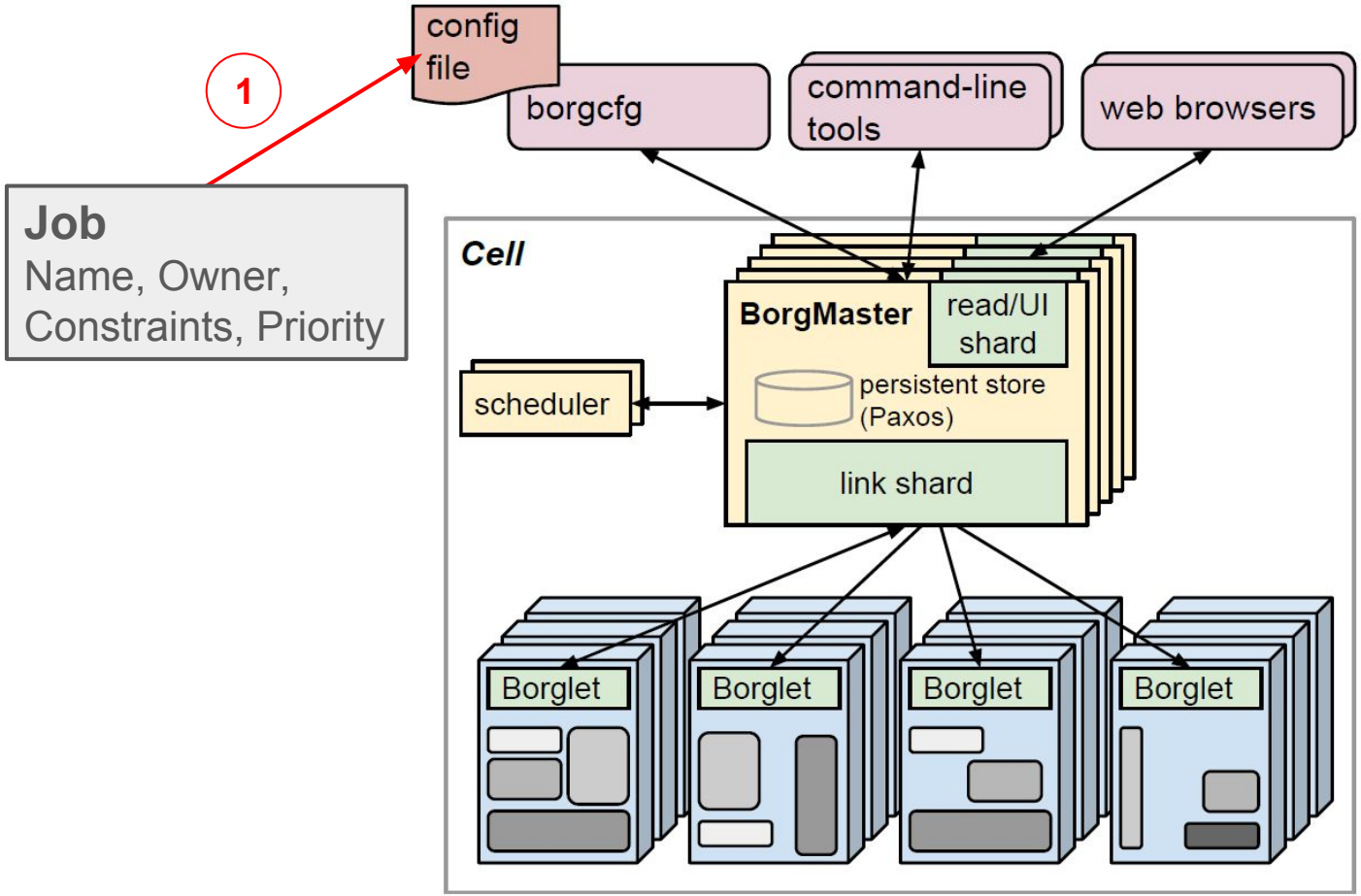



config file
borgcfg
command-line tools
web browsers
Cell
BorgMaster
read/UI shard
persistent store (Paxos)
scheduler
link shard
Borglet
Borglet
Borglet
Borglet

Hello World!

```
job hello_world = {
    runtime = { cell = 'ic' }
    binary = '.../hello_world_webserver'
    args = { port = '%port%' }
    requirements = {
        ram = 100M
        disk = 100M
        cpu = 0.1
    }
    replicas = 10000
}
```

(Example taken from John Wilkes's presentation at EuroSys 2015)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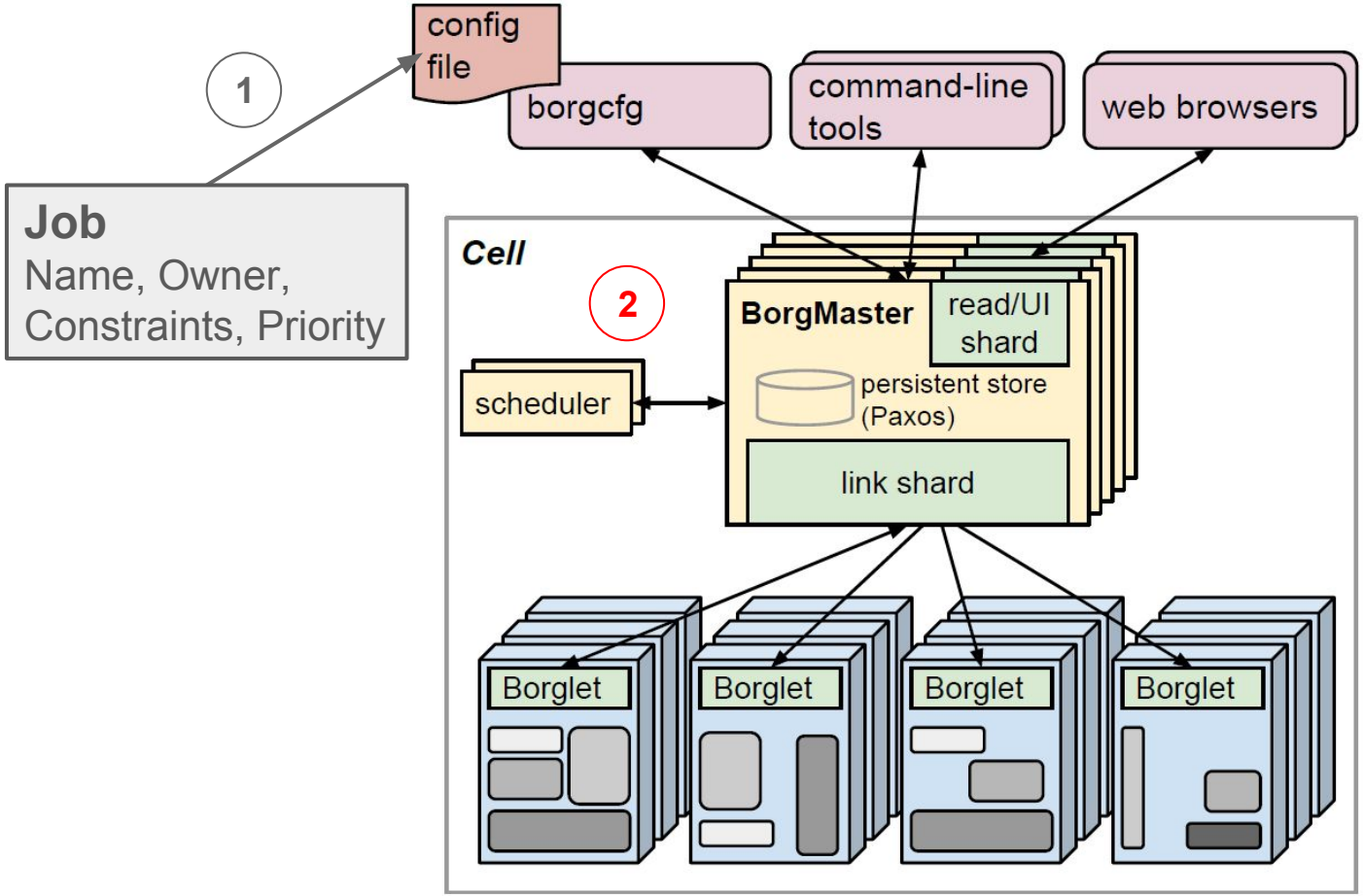
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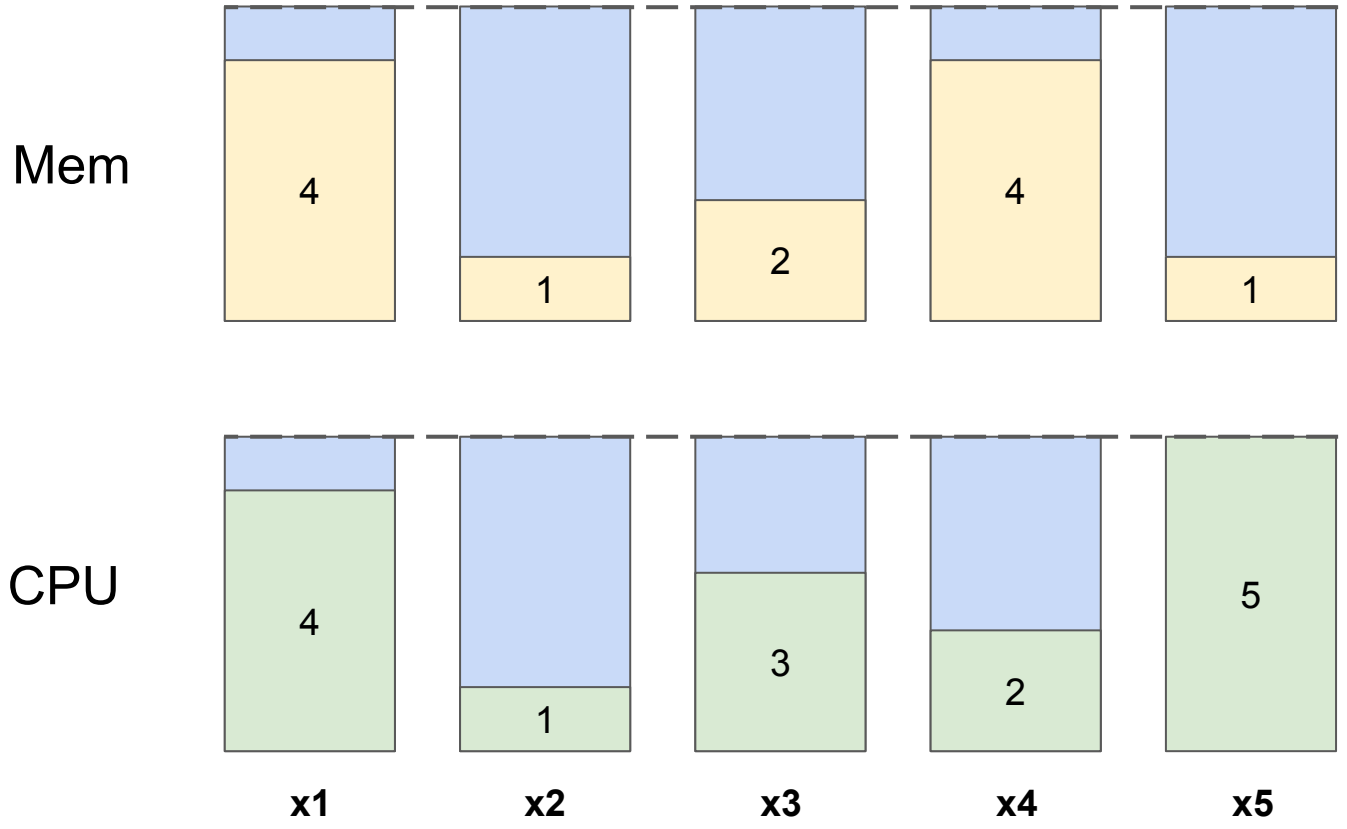
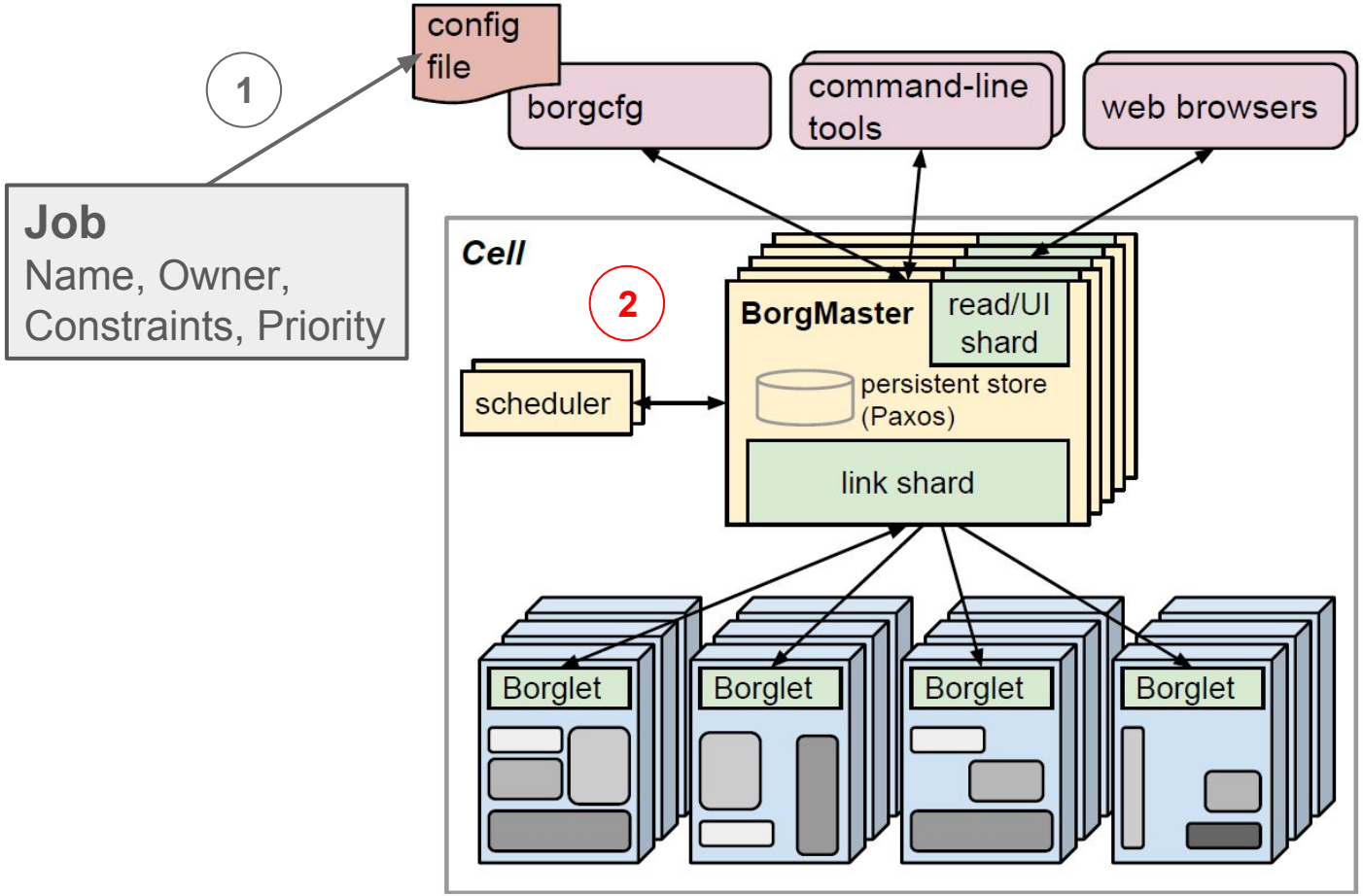
Scheduler

- Schedules from high priority to low priority, with round-robin scheduling within each priority band
- Feasibility checking
  - What machines can I run the task on?
- Scoring
  - Which machine should I run the task on?

Task
1 CPU, 1 GB mem



(All machines have 5 units of each resource)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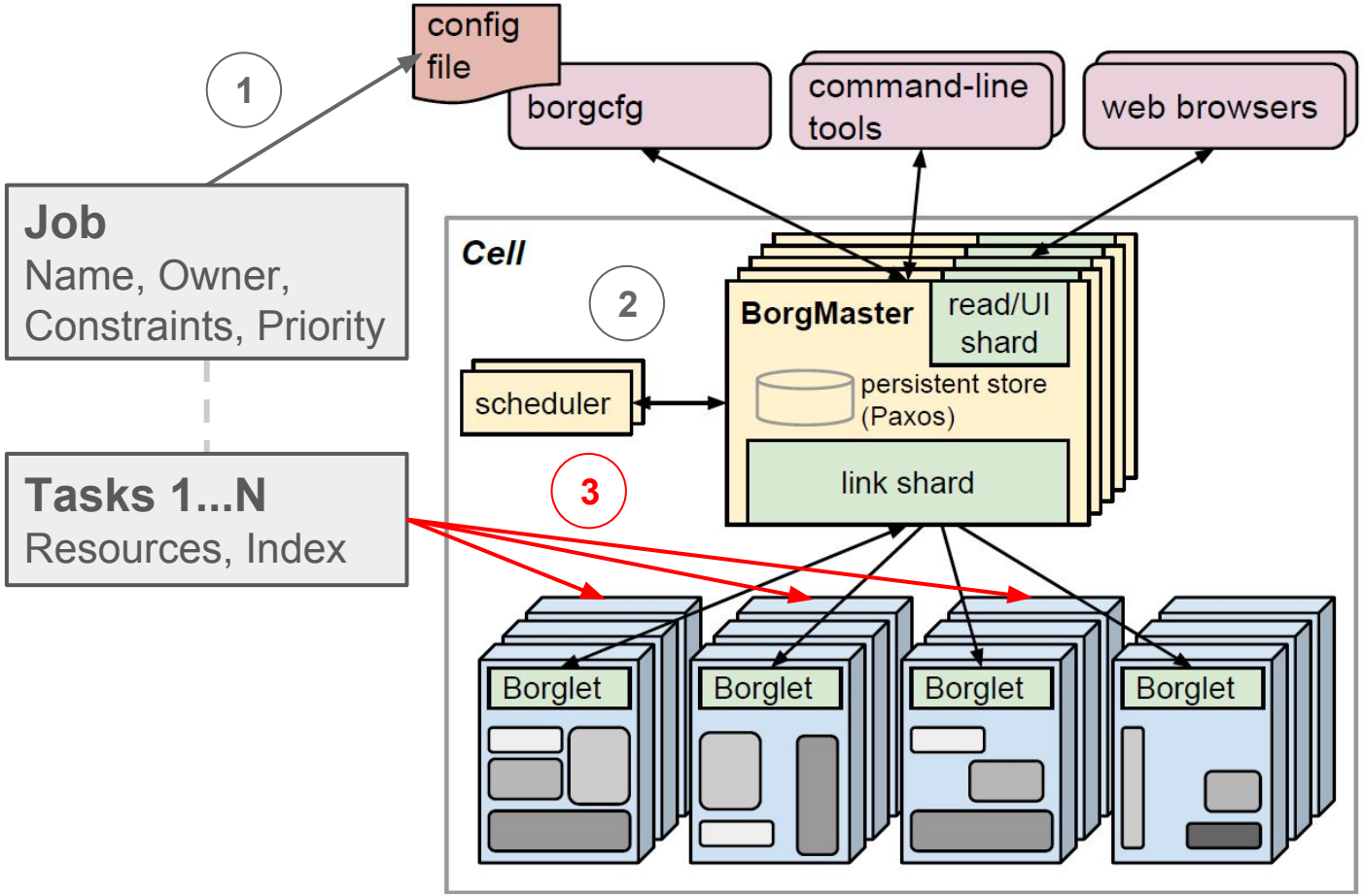
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3
Tasks 1...N
Resources, Index
Borglet
Borglet
Borglet
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Scalability

- Score caching
  - Cache score of machine until task or machine changes
- Equivalence classes
  - Only score one task per equivalence class
- Relaxed randomization
  - Score a random subset of feasible machines

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- Scheduling a cell’s workload down to 300s compared to 3 days

Availability

- Replication
- Admission control
  - Job resource limits are checked against user quota
- Reduction of external dependencies
  - Simple, low-level tools for deploying instances
- Cell independence
- Tasks continue to run even if Borglet and Borgmaster fail

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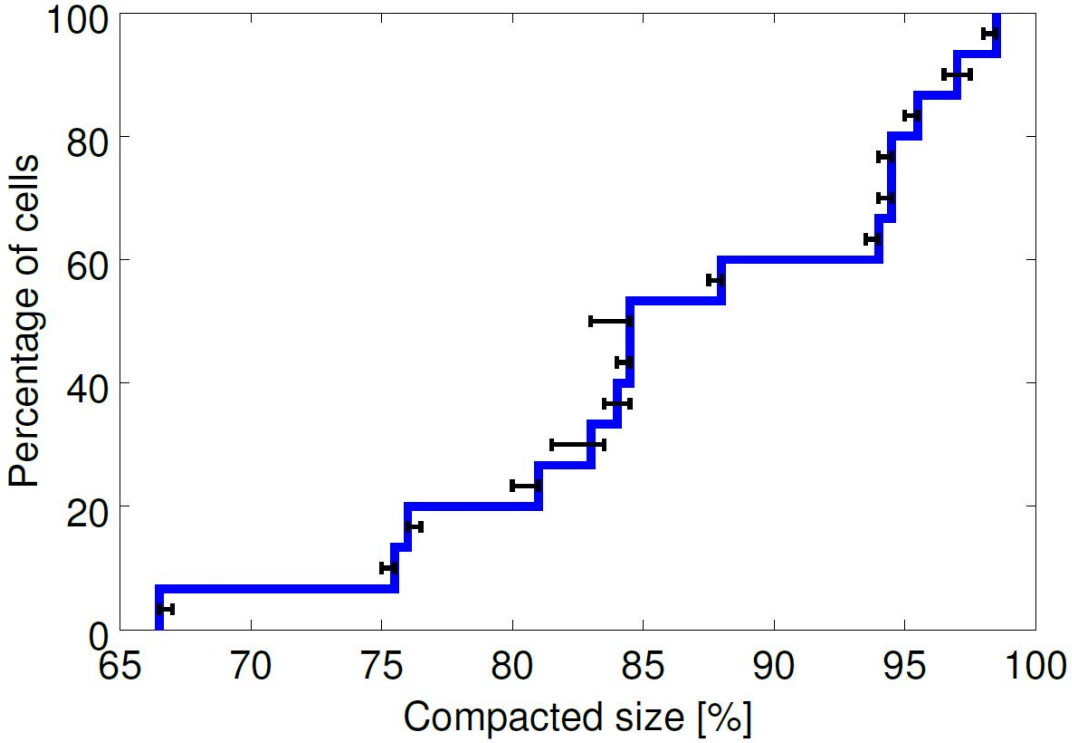
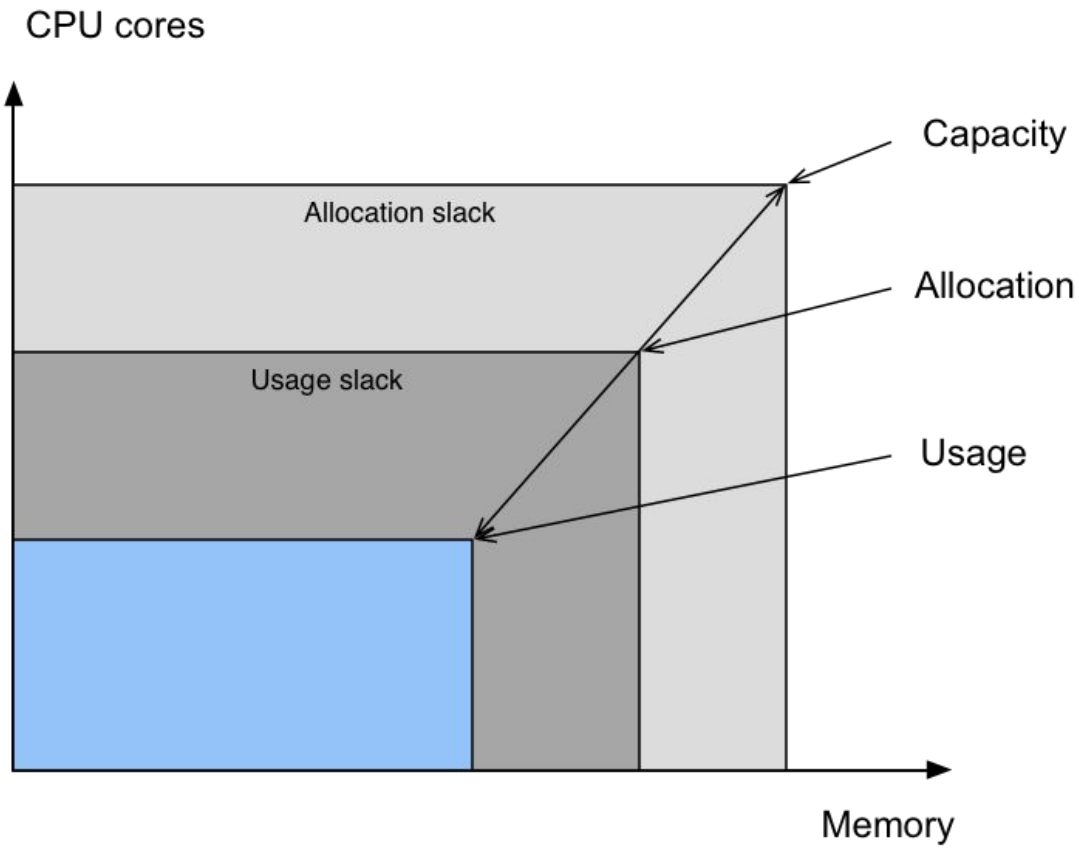
- 99.99% availability in practice

Cell Compaction



Utilization

- Cell sharing
  - Workload segregation would result in ~20-30% increase in cell size
- Resource requests
  - Fixed-size containers/VMs would require ~30-50% more resources in the median case
- Resource reclamation
  - ~90% of cells would need ~40-50% more machines


CPU cores
Capacity
Allocation slack
Allocation
Usage slack
Usage
Memory

Lessons Learned

1. Grouping mechanisms are restrictive
2. IP per machine vs IP per container
3. Allocs (or equivalent) are useful
4. Cluster management is more than scheduling
5. The master is the kernel of a distributed system