Improving Batch Support in Open Source Kubernetes

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Our Team

- Part of the Google Kubernetes Engine (GKE)
- Focused mostly on Open Source (OSS) work in both sig-scheduling* and sig-apps
- Our goal is to improve the batch experience in Kubernetes

** SIG: Special Interest Group that operate under an open governance model*

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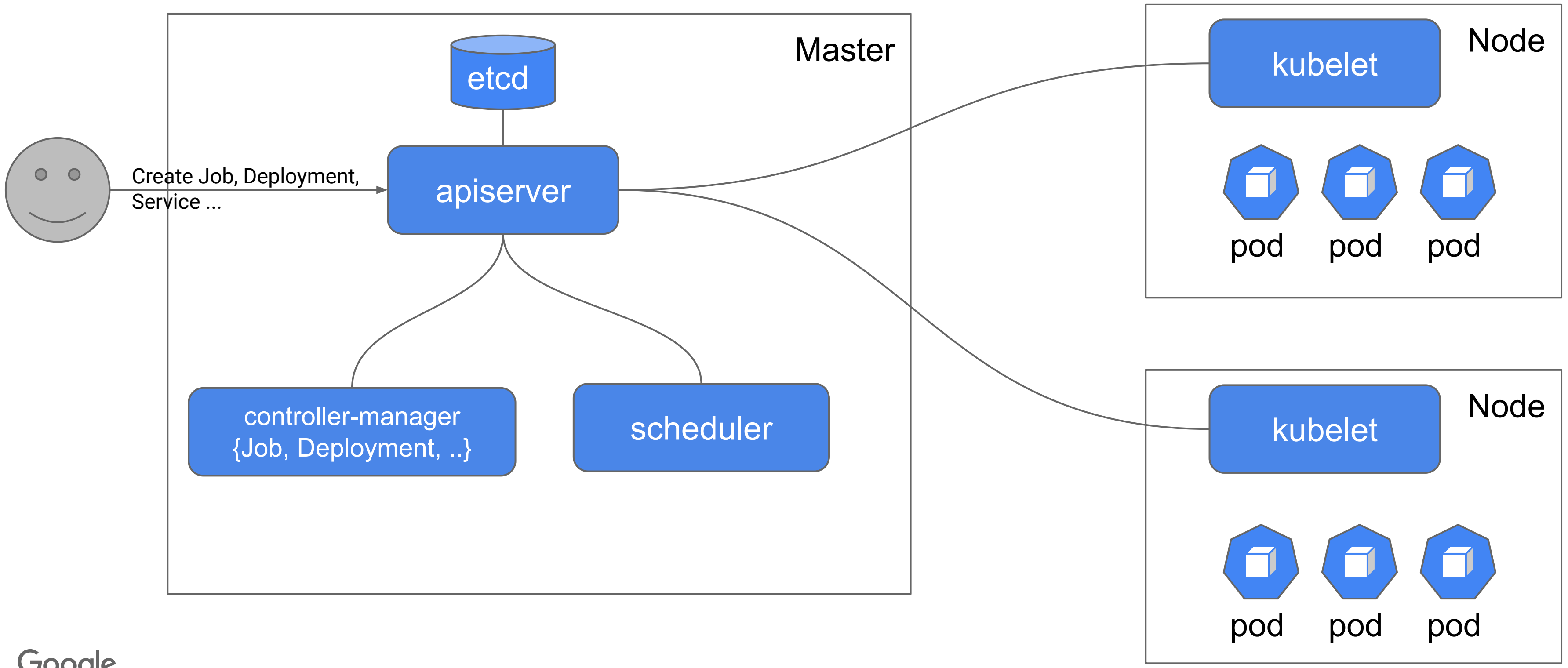
Background: Kubernetes Architecture


Master
etcd
apiserver
Create Job, Deployment, Service ...
controller-manager {Job, Deployment, ..}
scheduler
Node
kubelet
pod
pod
pod
Node
kubelet
pod
pod
pod

Google

Background: Kubernetes Job vs HTCondor ClassAds

A similar key/value abstraction of resources and requests

```
apiVersion: batch/v1
kind: Job
metadata:
  name: simple
spec:
  template:
    spec:
      containers:
      - name: simple
        image: debian:buster
        command: ["/bin/true"]
        resources:
          requests:
            memory: "64Mi"
            cpu: "250m"
          limits:
            memory: "128Mi"
            cpu: "500m"
      nodeSelector:
        node.kubernetes.io/instance-type: e2-micro
  backoffLimit: 4
  parallelism: 10
  completions: 100
```

```
Arguments = ""
Cmd = "/bin/true"
RequestCpus = 1
RequestGPUs = 0
RequestMemory = 64
Requirements = (TARGET.InstanceType =?= "e2-micro") && ...
```

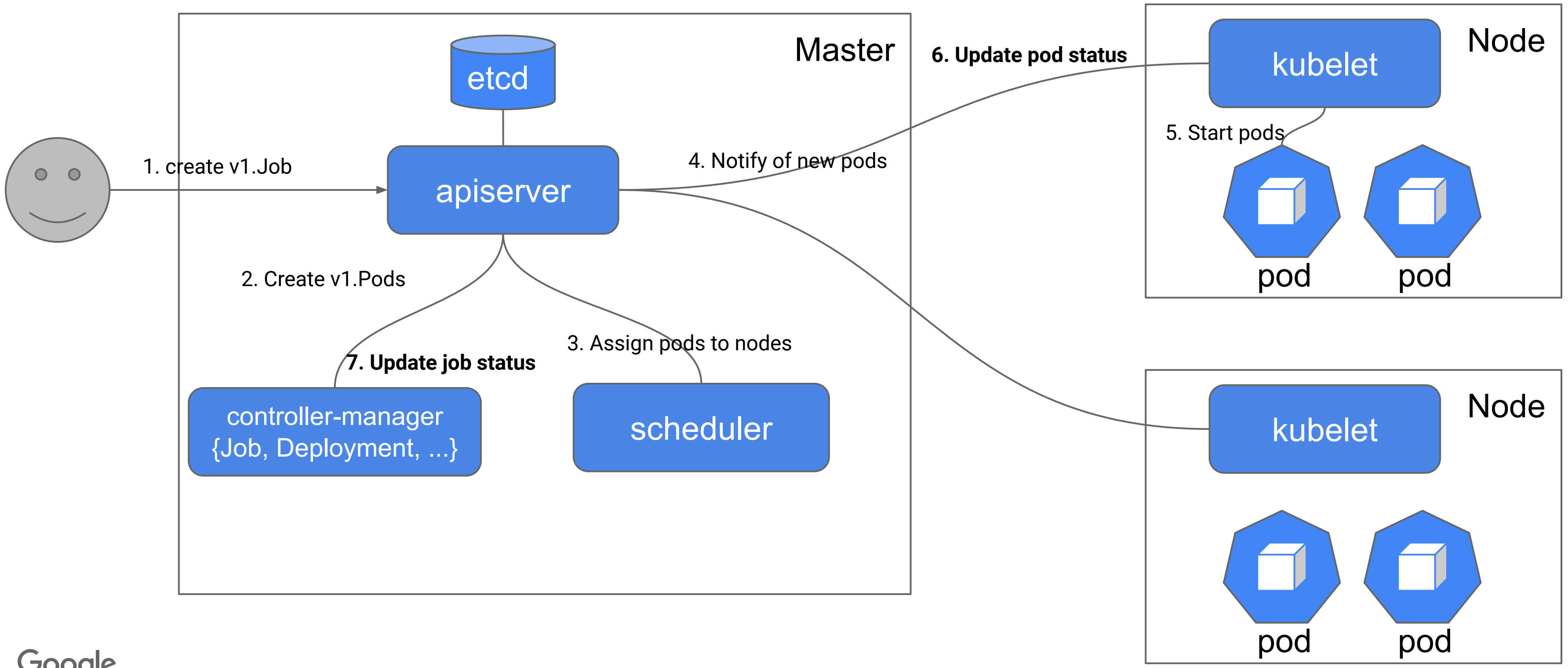
Requests "shares" for ¼ CPU both in cgroups scheduling sense and in the accounting of available resources for matchmaking.

Tightly pack containers for maximum hardware utilization!

Assign cgroups quota for ½ CPU cycles per 100msec period

`nodeSelector` *requires* nodes with labels; `nodeAffinity` expresses more complex selection, including *ranking*

Background: Kubernetes Core OSS Job Model



The Problem

- Support for batch lagged in core OSS Kubernetes
  - Most core kubernetes components are pod centric, not quite compatible with batch workloads

- A fragmented kubernetes batch ecosystem
  - Volcano, kubeflow, Spark operator each have their own job APIs and semantics

High-level Approach

- Enhance the core OSS kubernetes Job model, such that it can be used
    - directly for simple workloads
    - as a core resource for more advanced orchestrators or workloads (Queueing, MPI, ML etc.)

Google

Enhancing the Job Model

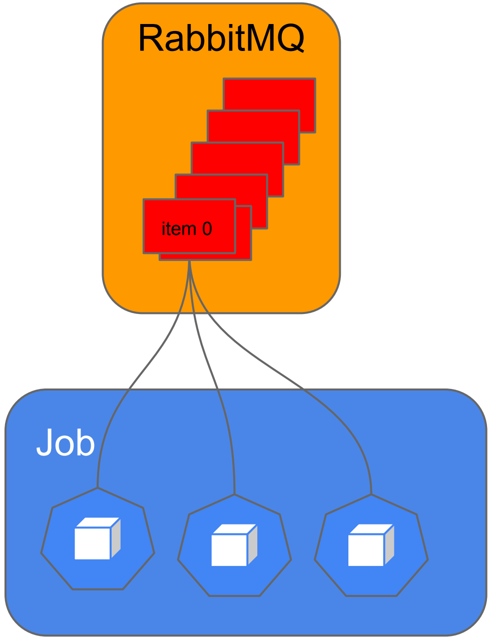
- Support indexed Jobs semantics with variable parallelism
  - **Problem:** Running large scale parallel jobs required setting up a message queue

- Robust tracking of Job completion status
  - **Problem:** All pod objects of a job must continue to exist in etcd until the job completes

- Automatic Job objects cleanup
  - **Problem:** Completed jobs continue to exist in etcd unless explicitly removed, hence impacting etcd performance

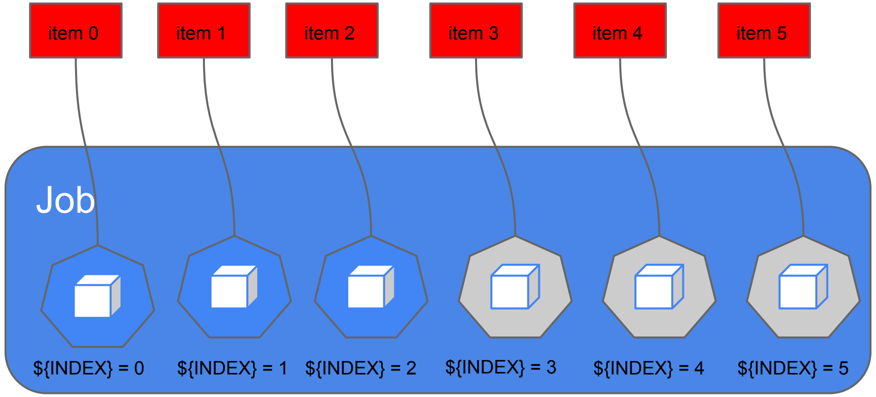
Shallow Dive on parallel execution for Jobs

with a work queue



```
apiVersion: batch/v1
kind: Job
spec:
  parallelism: 3
```

with Indexed Job



```
apiVersion: batch/v1
kind: Job
spec:
  parallelism: 3
  completions: 6
  completionMode: Indexed
```

Google

Quickly producing similar tasks in HTCondor

To produce a *cluster* of similar *processes* we can iterate in `condor_submit`:

```
Universe = Vanilla
Executable = cook
Output = meal$(Process).out
Args = -i $(Item)
Queue Item in (pasta, chicken)
```

```
apiVersion: batch/v1
kind: Job
spec:
  parallelism: 3
  completions: 6
  completionMode: Indexed
template:
  spec:
    containers:
      - image: 'docker.io/library/bash'
        command:
        - "bash"
        - "-c"
        - |
          items=(pasta chicken spinach tofu tacos rice)
          echo "Processing ${items[$INDEX]}"
```

Thanks, T.J.!

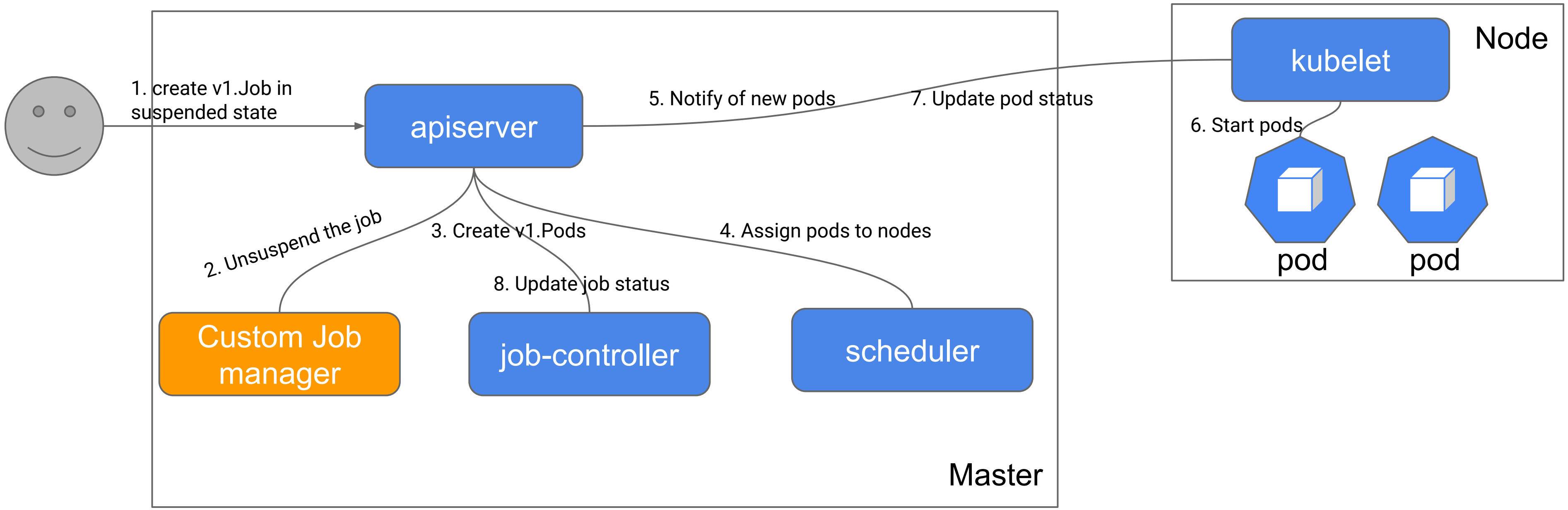
Google

Unifying the ecosystem around the k8s Job Model

We proposed hooks to allow higher level job schedulers to

- manage a k8s Job as a single entity
  - Added job suspend/resume semantics, job schedulers can use it to control when the job should start and whole job preemption
- define scheduling and provisioning properties
  - Proposed "JobClass" API to uniformly define job attributes
- define job grouping
  - Proposed a "JobGroup" API to uniformly define groups of related jobs (e.g., actors and learners in reinforcement learning)
- control Job scale-down behavior
  - Introduced "pod-deletion-cost" API to inform controllers which pods to delete first on scale down
  - Very similar to HTCondor preemption/defrag ranking. Cost can be proportional to "badput" estimate or literal financial cost of cloud hardware.

Hooking a job-level manager



Summary

- The Kubernetes community is investing more in Batch
- Our goal is to help unify the k8s batch ecosystem around the core API model
    - Makes the user experience more uniform, while allowing vendors to offer differentiation

Questions

HTCondor on Google Cloud

- Provision your own HTCondor cluster using the Google Cloud Marketplace!
- Google Cloud Storage is S3-interoperable with custom endpoint specification!
    - Working with ToddM to allow use of Cloud Storage `gs://` URIs and knob naming that access keys are for S3/HMAC generally (AWS, Google Cloud, IBM Cloud, Ceph, MinIO, etc.).

```
aws_access_key_id_file = key_id_filename
aws_secret_access_key_file = secret_access_key_filename
transfer_input_files = s3://storage.googleapis.com/test-adaf/infile
transfer_output_remaps = "output.dat = s3://storage.googleapis.com/test-adaf/outfile"
```

- Several key customers in research and private sector using HTCondor
- Working with CHTC team to adopt / improve 9.x security practices in the cloud