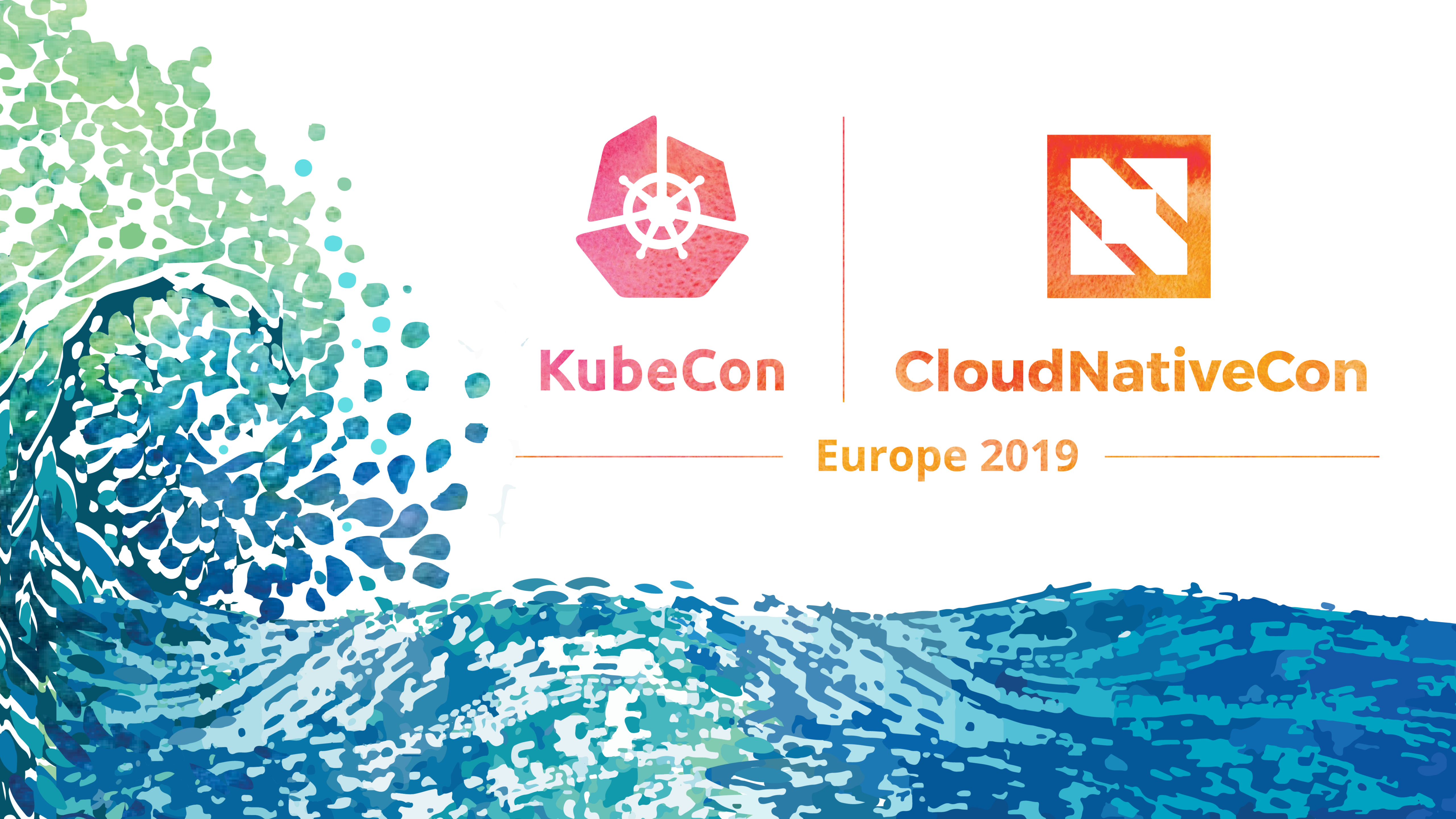

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Large Scale Distributed Deep Learning with Kubernetes Operators

Yong Tang – MobileIron

Yuan Tang – Ant Financial

Speakers

- Yong Tang
  - GitHub: yongtang
  - SIG IO Lead & Maintainer: TensorFlow
  - Maintainer: CoreDNS and Docker
  - Director of Engineering, MobileIron

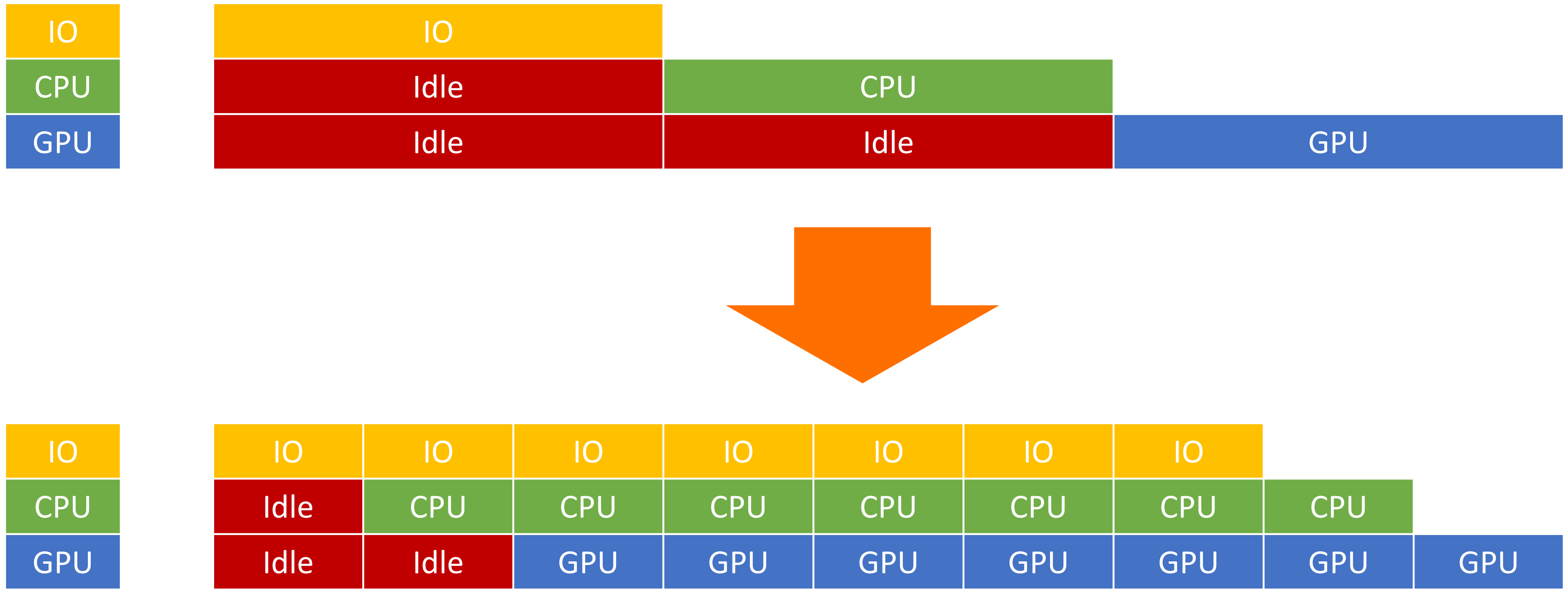
- Yuan Tang
  - GitHub: terrytangyuan
  - Member: Kubeflow
  - Maintainer: TensorFlow, MXNet, XGBoost
  - Senior Software Engineer, Ant Financial

TensorFlow

kubernetes

Kubeflow

Orchestration for Deep Learning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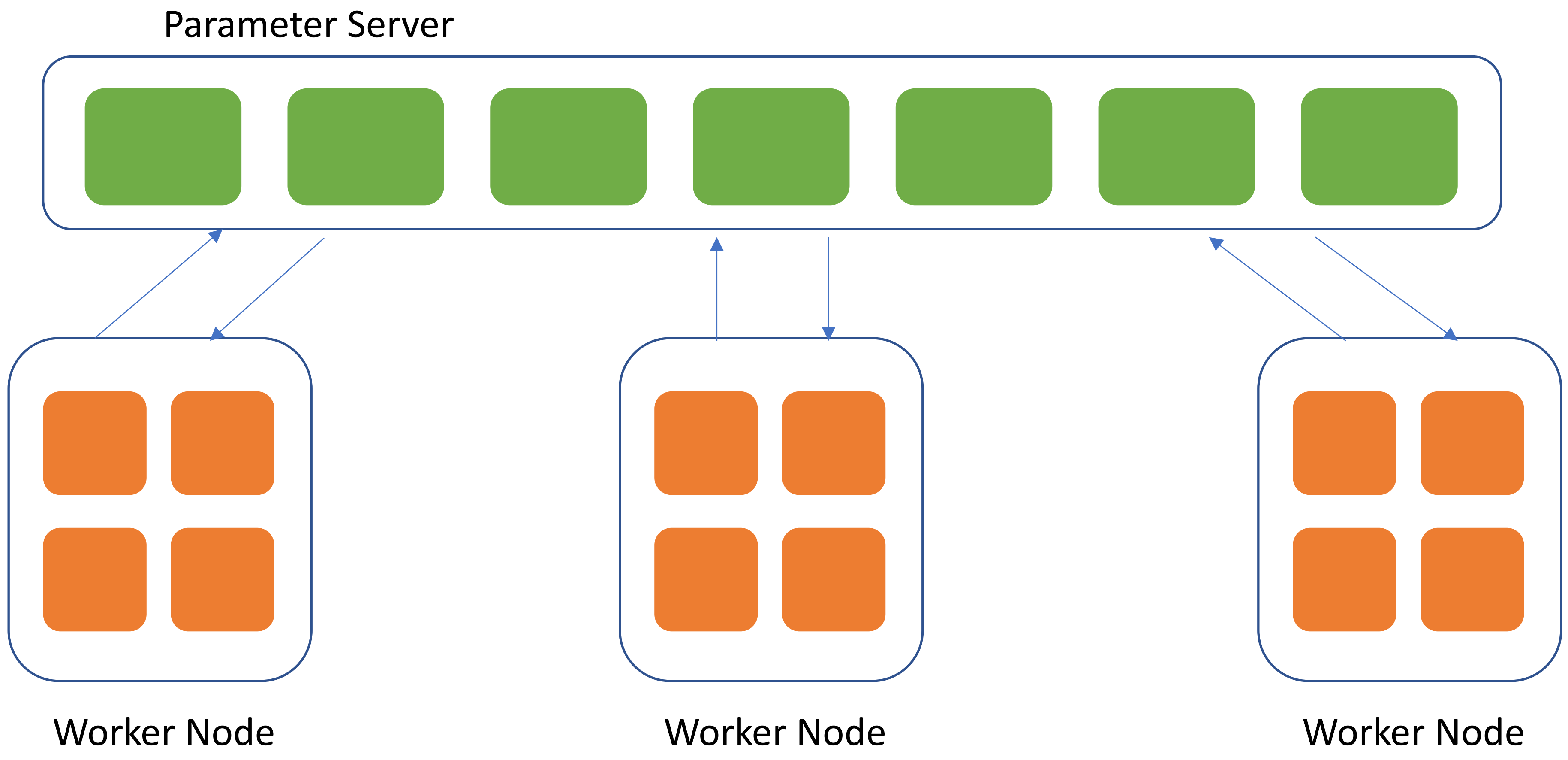
Parameter Server



Distribution Strategy - Reduce

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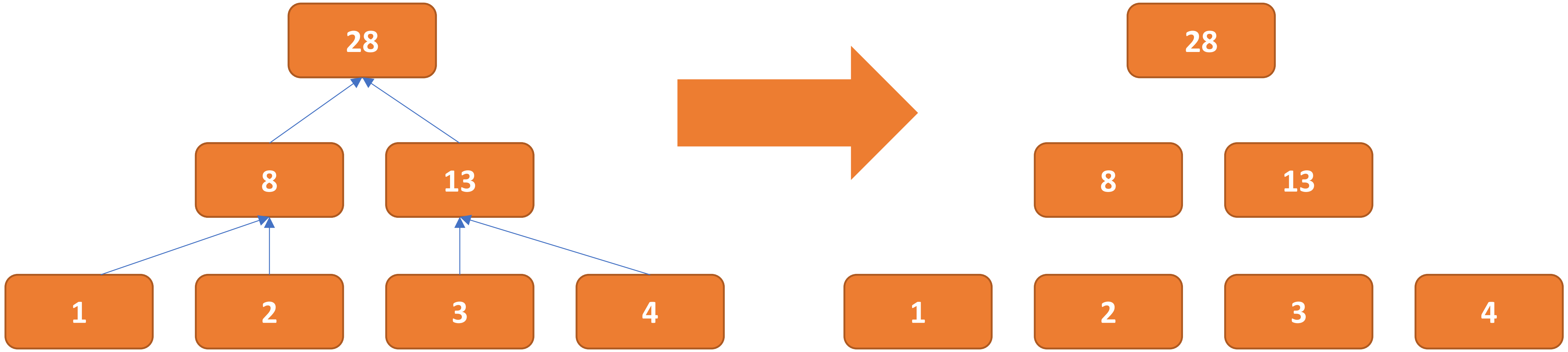
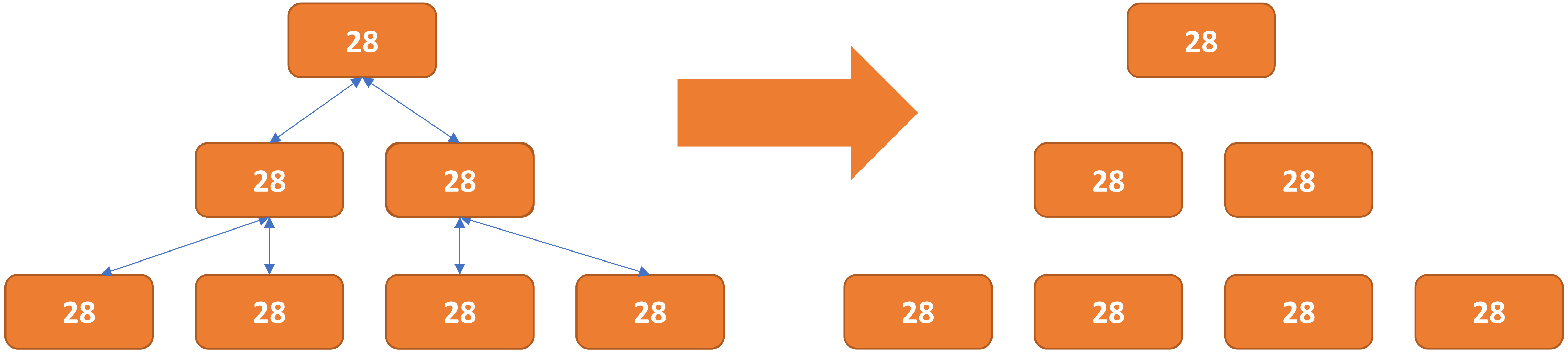


Distribution Strategy - AllReduce



AllReduce == Reduce + Broadcast

Parameter Server

- Parallelize on a machine
- Parallelize in a cluster
- Controversial
- Cross device communication cost
- Huge efforts invested over the years

Orchestration for Deep Learning

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Stateful Metadata

Lifecycle Management

Kubernetes for Orchestration

Kubernetes Operators for ML

Kubernetes Operators

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Kubeflow

- TF Operator
- PyTorch Operator
- MPI Operator

Kubernetes Operators

	TF Operator	PyTorch Operator	MPI Operator
Framework Support	TensorFlow	PyTorch	HOROVOD TF/Keras/MXNet/PyTorch OpenMPI
Distribution Strategy & Backend	tf.distribute MPI/NCCL/PS/TPU	torch.distributed Gloo/MPI/NCCL	horovod DistributedOptimizer (MPI Only)

TFJob vs. MPIJob

```
apiVersion: "kubeflow.org/v1beta1”
kind: TFJob
metadata:
 name: distributed-training
spec:
 tfReplicaSpecs:
   Worker:
    replicas: 4
    template:
     spec:
      containers:
      - name: tensorflow
       image: distributed_training_tf:latest
       resources:
        limits: nvidia.com/gpu: 4
        command: "python tf_benchmarks.py"
```

```
apiVersion: "kubeflow.org/v1alpha2”
kind: MPIJob
metadata:
 name: distributed-training
spec:
 mpiReplicaSpecs:
   Worker:
    replicas: 4
    template:
     spec:
      containers:
      - name: tensorflow
       image: distributed_training_hovorod:latest
       resources:
        limits: nvidia.com/gpu: 4
        command: ”mpirun python hovorod_benchmarks.py"
```

TensorFlow 101

```
import tensorflow as tf
import tensorflow_io.mnist as mnist_io

dataset = mnist_io.MNISTDataset(image_filenames, label_filenames)
dataset = dataset.map(
   lambda x, y: (tf.image.convert_image_dtype(x, tf.float32), y)).batch(1000)

model = tf.keras.models.Sequential([
   tf.keras.layers.Flatten(input_shape=(28, 28)),
   tf.keras.layers.Dense(512, activation=tf.nn.relu),
   tf.keras.layers.Dropout(0.2),
   tf.keras.layers.Dense(10, activation=tf.nn.softmax)
])

model.compile(loss='mse', optimizer='sgd’)
model.fit(dataset, epochs=2000)
model.evaluate(dataset)
```

Mirror Strategy in TensorFlow

```
import tensorflow as tf
import tensorflow_io.mnist as mnist_io

dataset = mnist_io.MNISTDataset(...)

model = tf.keras.Sequential([...])

mirrored_strategy = tf.distribute.MirroredStrategy()
with mirrored_strategy.scope():
   model.compile(loss='mse', optimizer='sgd’)

model.fit(dataset, epochs=2000)
model.evaluate(dataset)
```

TensorFlow + Horovod

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```
import tensorflow as tf
import tensorflow_io.mnist as mnist_io
import horovod.keras as hvd

dataset = mnist_io.MNISTDataset(...)

model = tf.keras.Sequential([...])

opt = tf.train.AdagradOptimizer(0.01 * hvd.size())
opt = hvd.DistributedOptimizer(opt)

model.compile(loss='mse', optimizer=opt)

callbacks = [
    hvd.callbacks.BroadcastGlobalVariablesCallback(0),
]
model.fit(dataset, epochs=2000, callbacks=callbacks)
model.evaluate(dataset)
```

TensorFlow vs. Horovod

```
import tensorflow as tf
import tensorflow_io.mnist as mnist_io

dataset = mnist_io.MNISTDataset(...)

model = tf.keras.Sequential([...])

mirrored_strategy = tf.distribute.MirroredStrategy()
with mirrored_strategy.scope():
   model.compile(loss='mse', optimizer='sgd’)

model.fit(dataset, epochs=2000)
model.evaluate(dataset)
```

```
import tensorflow as tf
import tensorflow_io.mnist as mnist_io
import horovod.keras as hvd

dataset = mnist_io.MNISTDataset(...)

model = tf.keras.Sequential([...])

opt = tf.train.AdagradOptimizer(0.01 * hvd.size())
opt = hvd.DistributedOptimizer(opt)

model.compile(loss='mse', optimizer=opt)

callbacks = [
   hvd.callbacks.BroadcastGlobalVariablesCallback(0),
]
model.fit(dataset, epochs=2000, callbacks=callbacks)
model.evaluate(dataset)
```

PyTorch + Horovod

```
import torch
import horovod.torch as hvd

data_loader = torch.utils.data.DataLoader(train_dataset, batch_size=100)

model = ...

optimizer = torch.optim.SGD(model.parameters())
optimizer = hvd.DistributedOptimizer(
    optimizer, named_parameters=model.named_parameters())
hvd.broadcast_parameters(model.state_dict(), root_rank=0)

for epoch in range(100):
    for batch_idx, (data, target) in enumerate(data_loader):
        optimizer.zero_grad()
        output = model(data)
        loss = torch.nn.functional.F.nll_loss(output, target)
        loss.backward()
        optimizer.step()
```

Recall: TFJob vs. MPIJob

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```
apiVersion: "kubeflow.org/v1beta1”
kind: TFJob
metadata:
 name: distributed-training
spec:
 tfReplicaSpecs:
   Worker:
     replicas: 4
     template:
       spec:
         containers:
         - name: tensorflow
           image: distributed_training_tf:latest
           resources:
             limits: nvidia.com/gpu: 4
           command: "python tf_benchmarks.py"
```

```
apiVersion: "kubeflow.org/v1alpha2”
kind: MPIJob
metadata:
 name: distributed-training
spec:
 mpiReplicaSpecs:
   Worker:
     replicas: 4
     template:
       spec:
         containers:
         - name: tensorflow
           image: distributed_training_hovorod:latest
           resources:
             limits: nvidia.com/gpu: 4
           command: ”mpirun python hovorod_benchmarks.py"
```

Shared API and Best Practices

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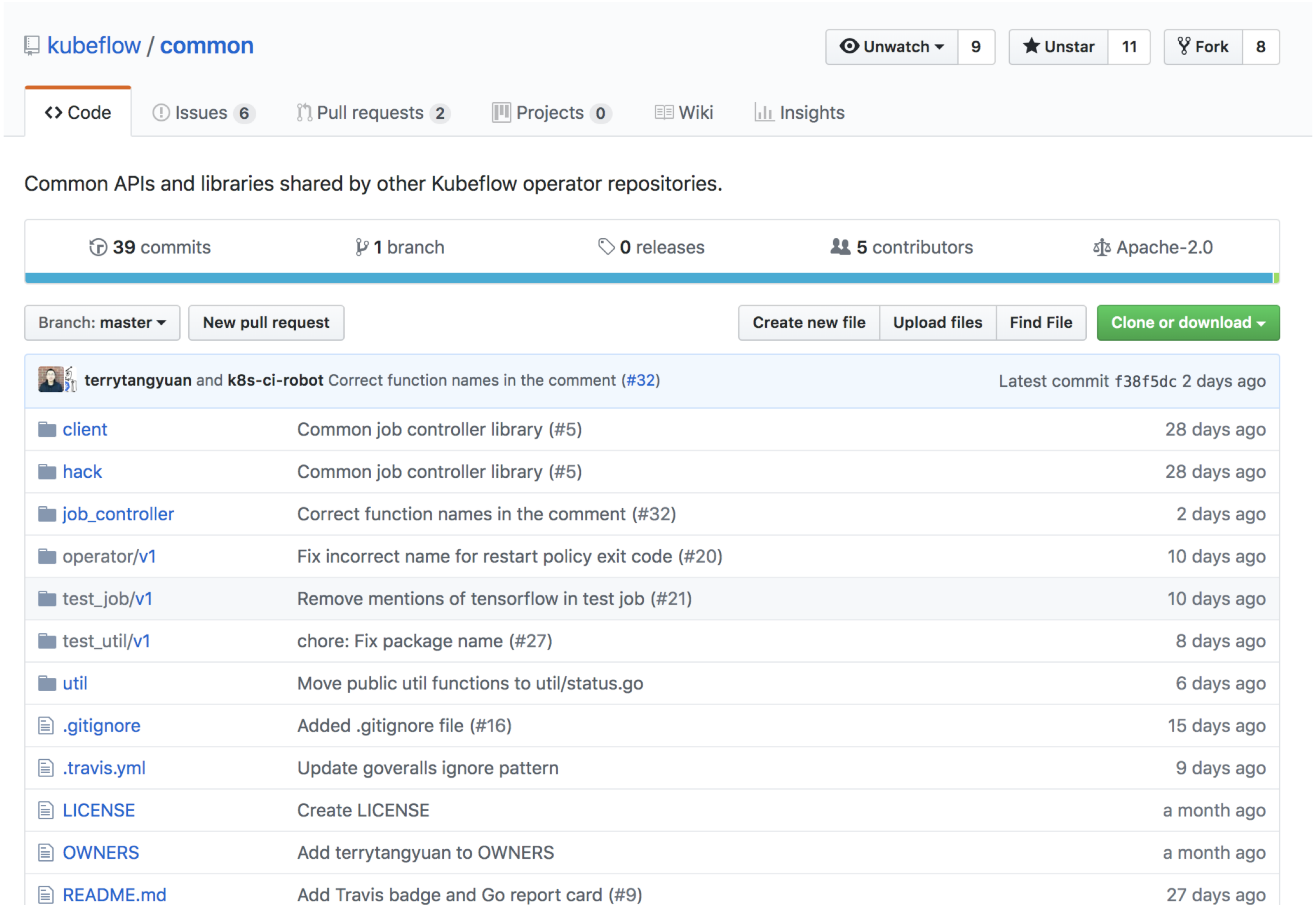

kubeflow / common

Unwatch 9 | Unstar 11 | Fork 8

Code | Issues 6 | Pull requests 2 | Projects 0 | Wiki | Insights

Common APIs and libraries shared by other Kubeflow operator repositories.

39 commits | 1 branch | 0 releases | 5 contributors | Apache-2.0

Branch: master | New pull request | Create new file | Upload files | Find File | Clone or download

terrytangyuan and k8s-ci-robot Correct function names in the comment (#32) — Latest commit f38f5dc 2 days ago

client	Common job controller library (#5)	28 days ago
hack	Common job controller library (#5)	28 days ago
job_controller	Correct function names in the comment (#32)	2 days ago
operator/v1	Fix incorrect name for restart policy exit code (#20)	10 days ago
test_job/v1	Remove mentions of tensorflow in test job (#21)	10 days ago
test_util/v1	chore: Fix package name (#27)	8 days ago
util	Move public util functions to util/status.go	6 days ago
.gitignore	Added .gitignore file (#16)	15 days ago
.travis.yml	Update goveralls ignore pattern	9 days ago
LICENSE	Create LICENSE	a month ago
OWNERS	Add terrytangyuan to OWNERS	a month ago
README.md	Add Travis badge and Go report card (#9)	27 days ago

Shared API and Best Practices

- Common and standardized API spec
- Base JobController interface
- JobController implementation utilities
- Testing utilities

THANK YOU