Distributed Learning and You

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Me?

Hi, I'm Ruksi.

Machine Learning Engineer
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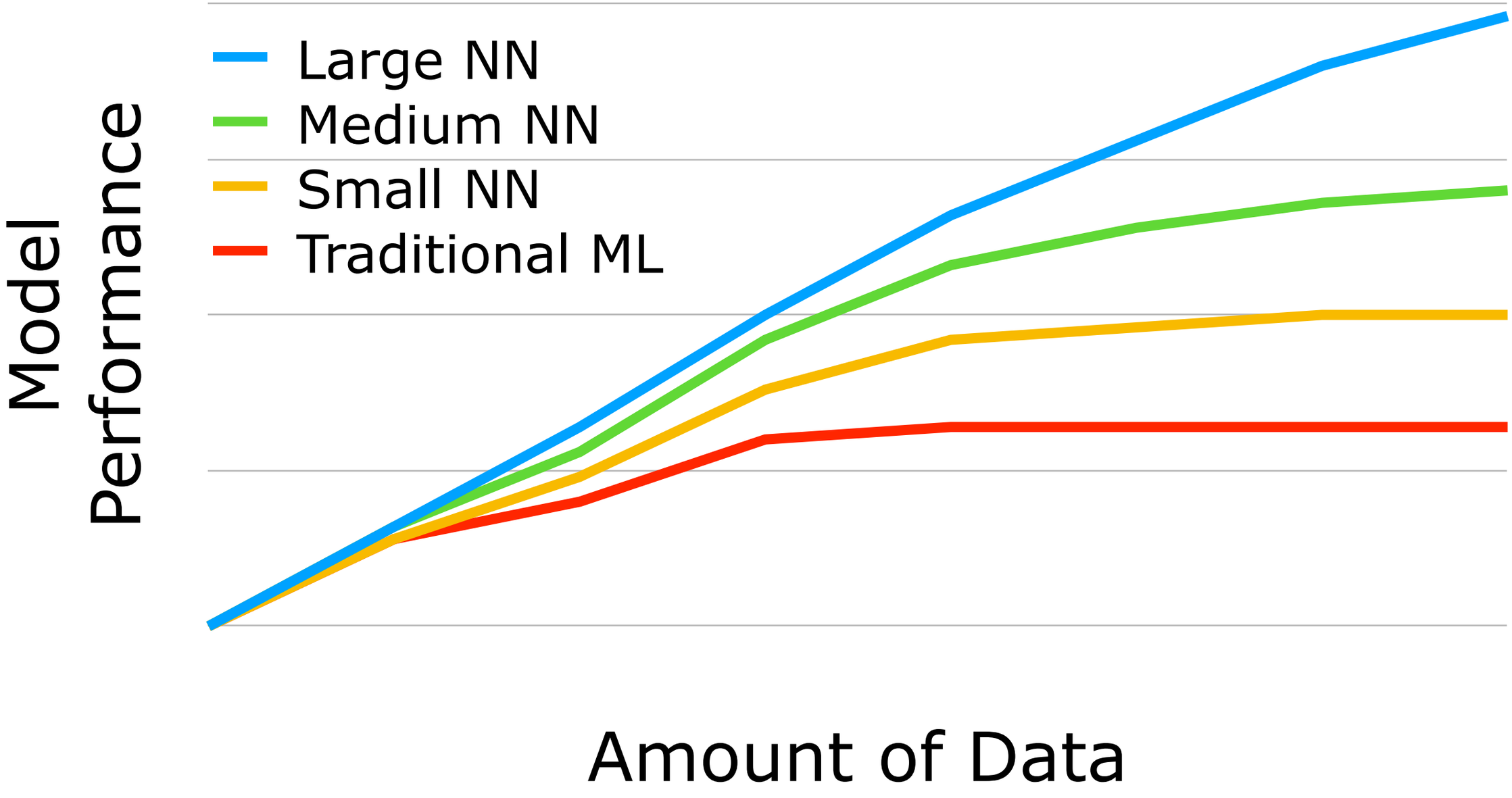
Scale Drives Deep Learning Process



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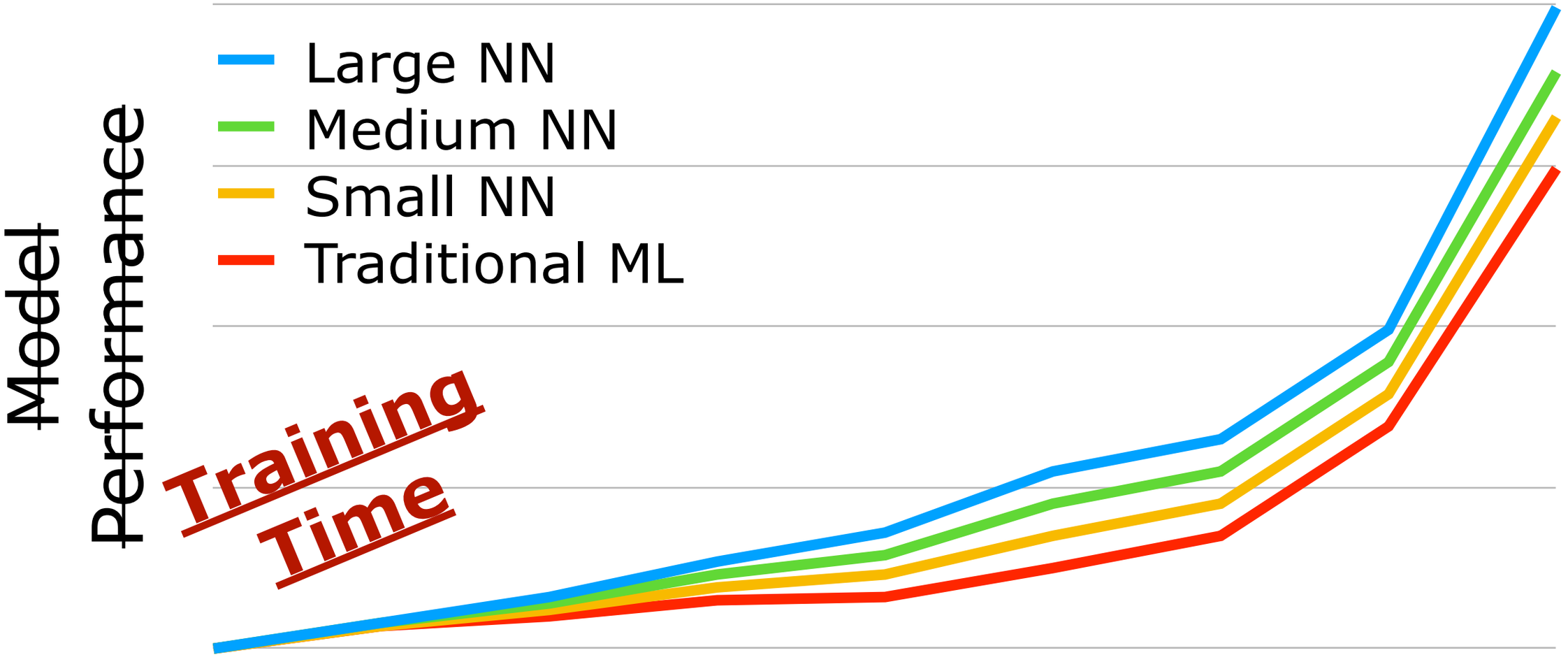
original: Andrew Ng Coursera lectures

Scale Makes Everything Slow

~~Scale Drives Deep Learning Process~~



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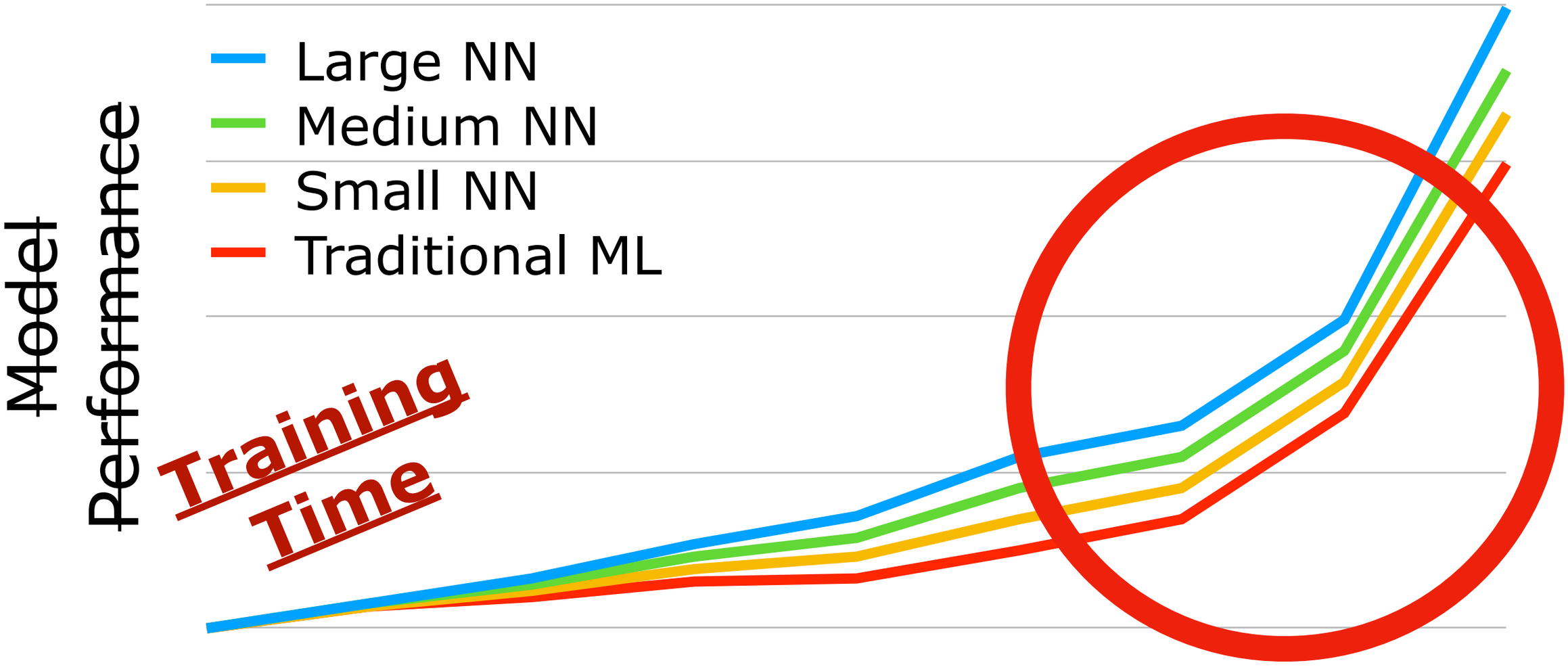

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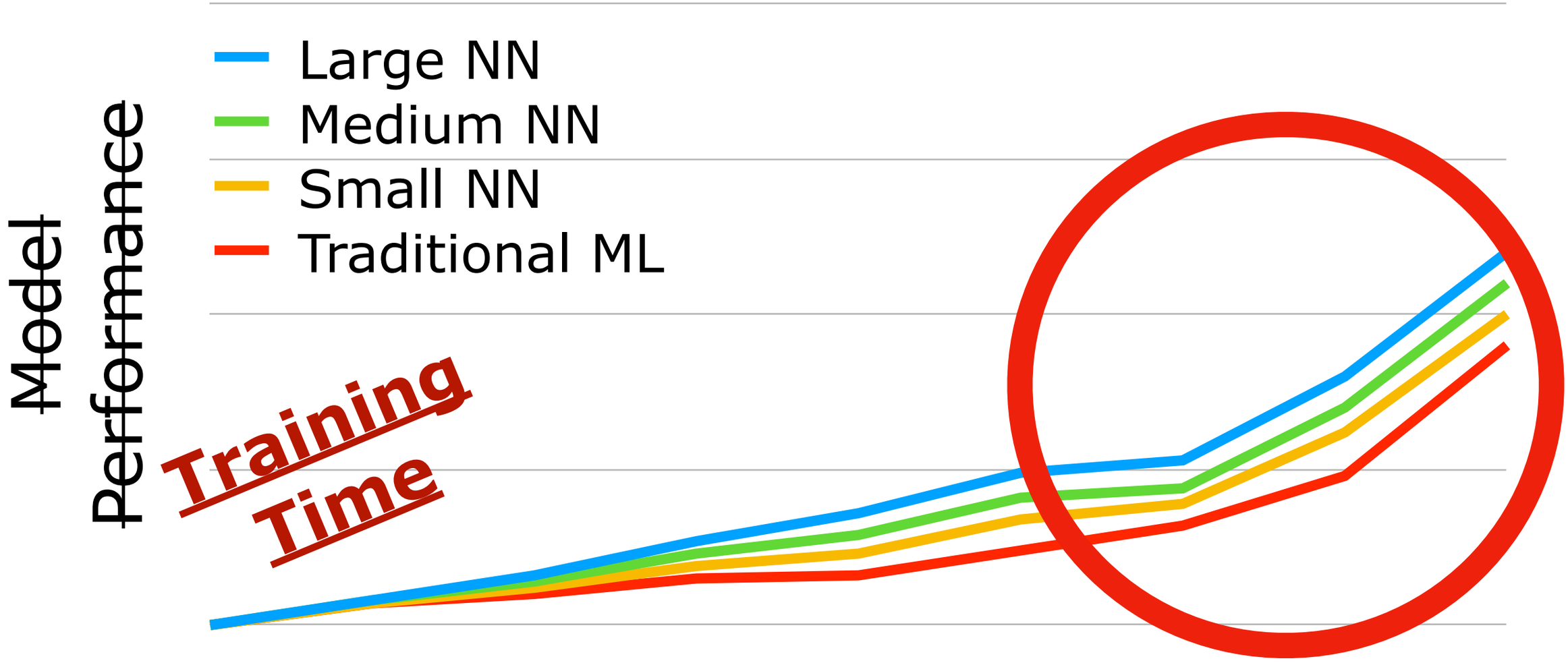

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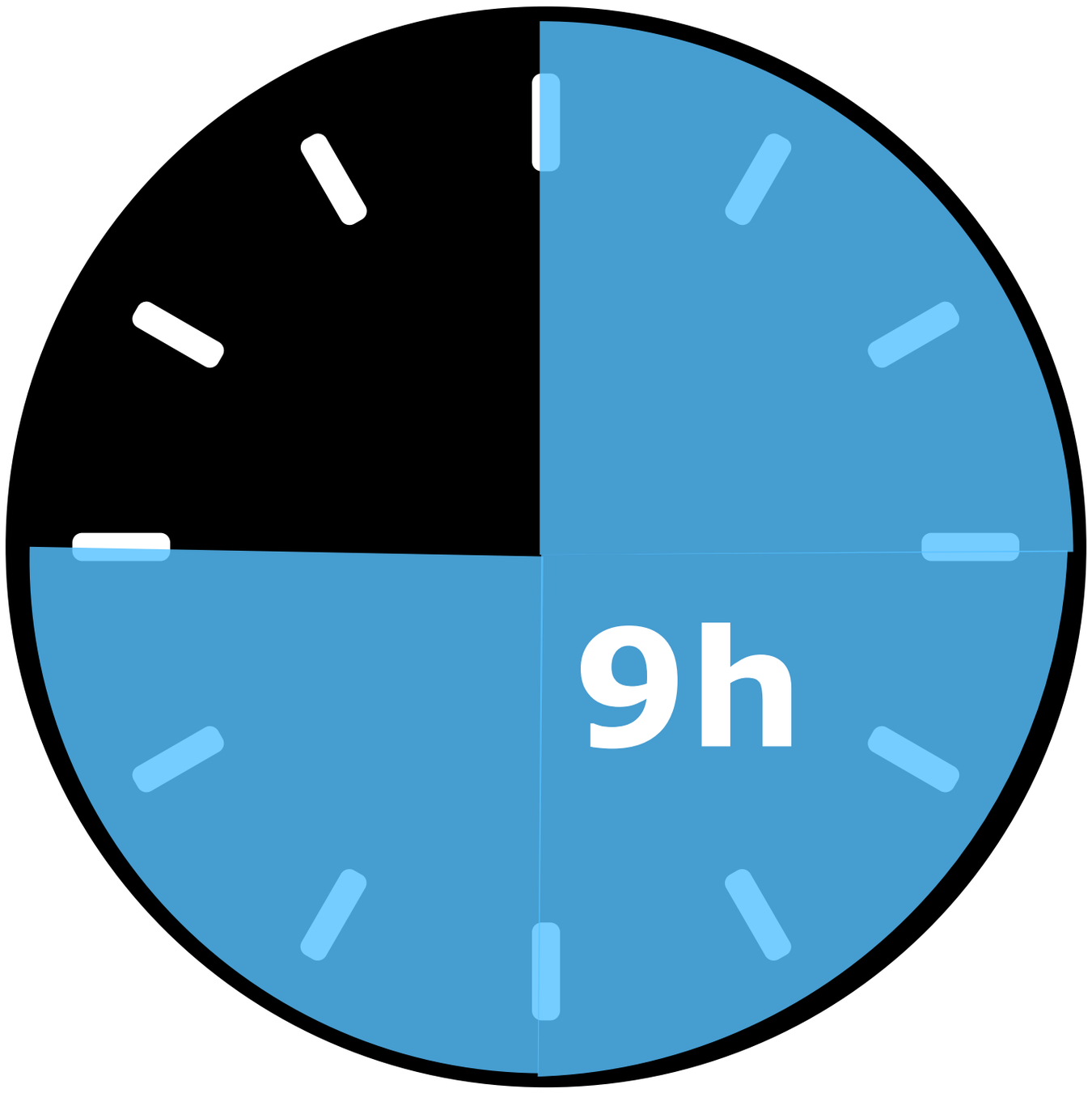

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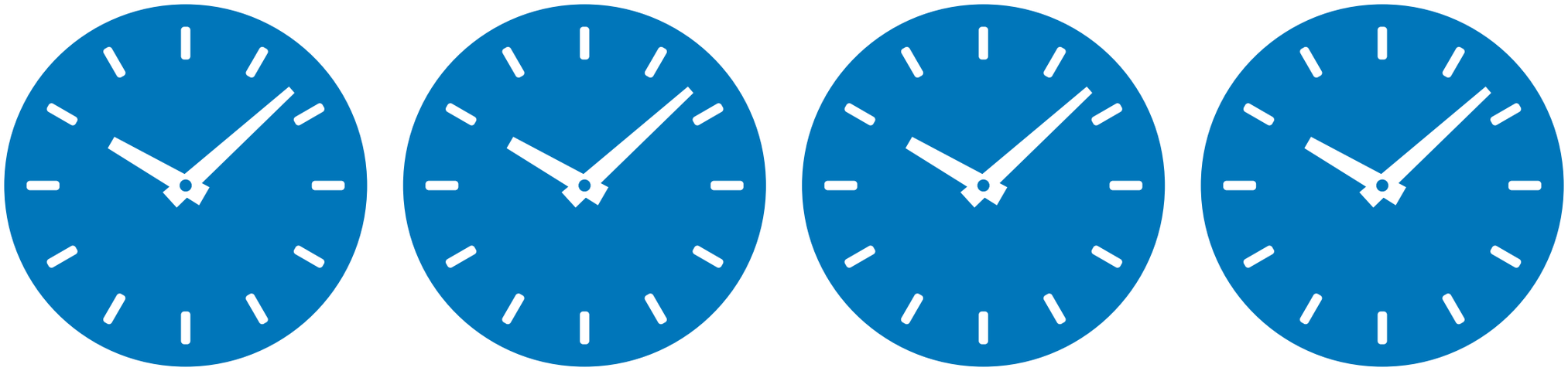

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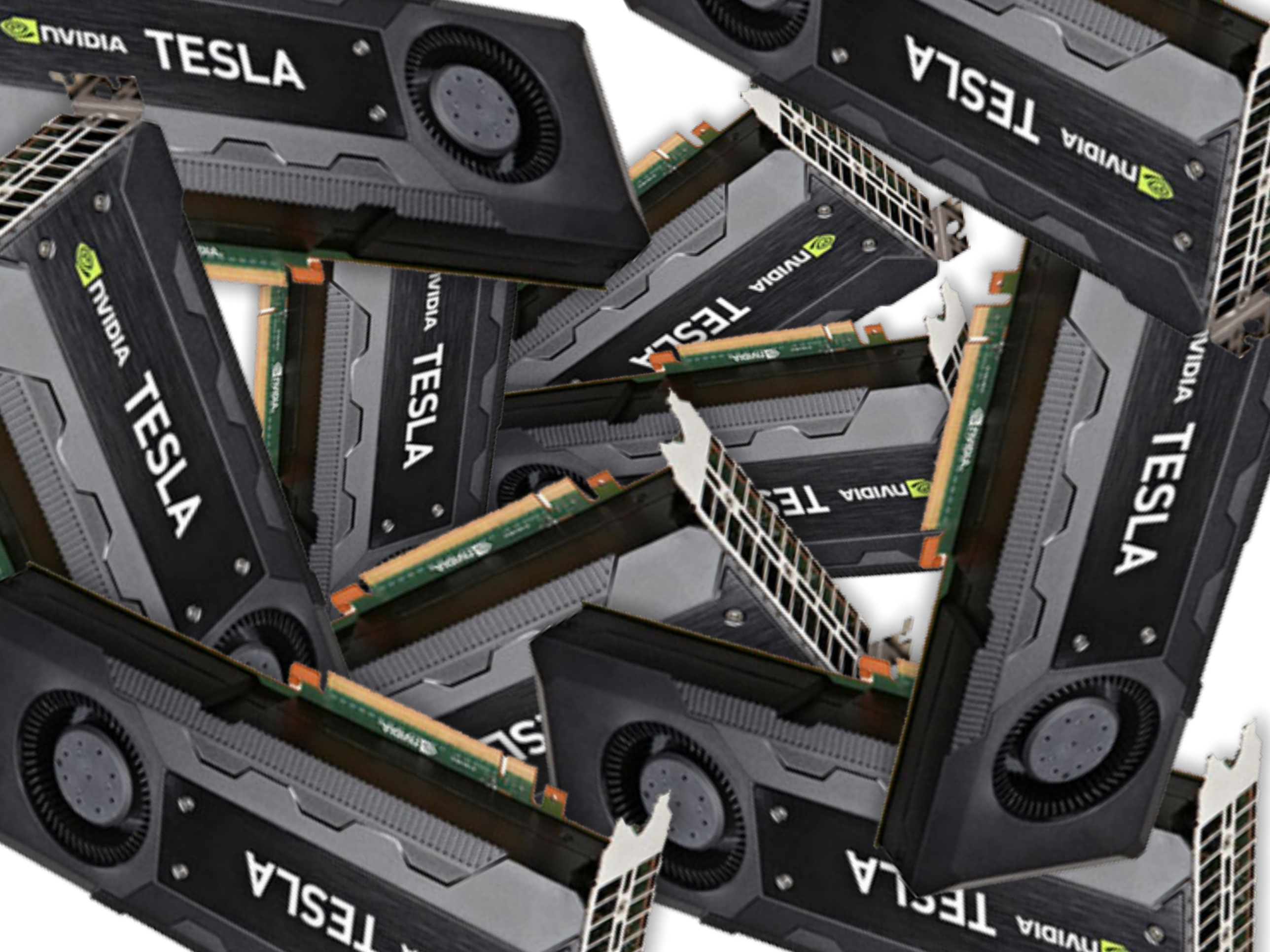
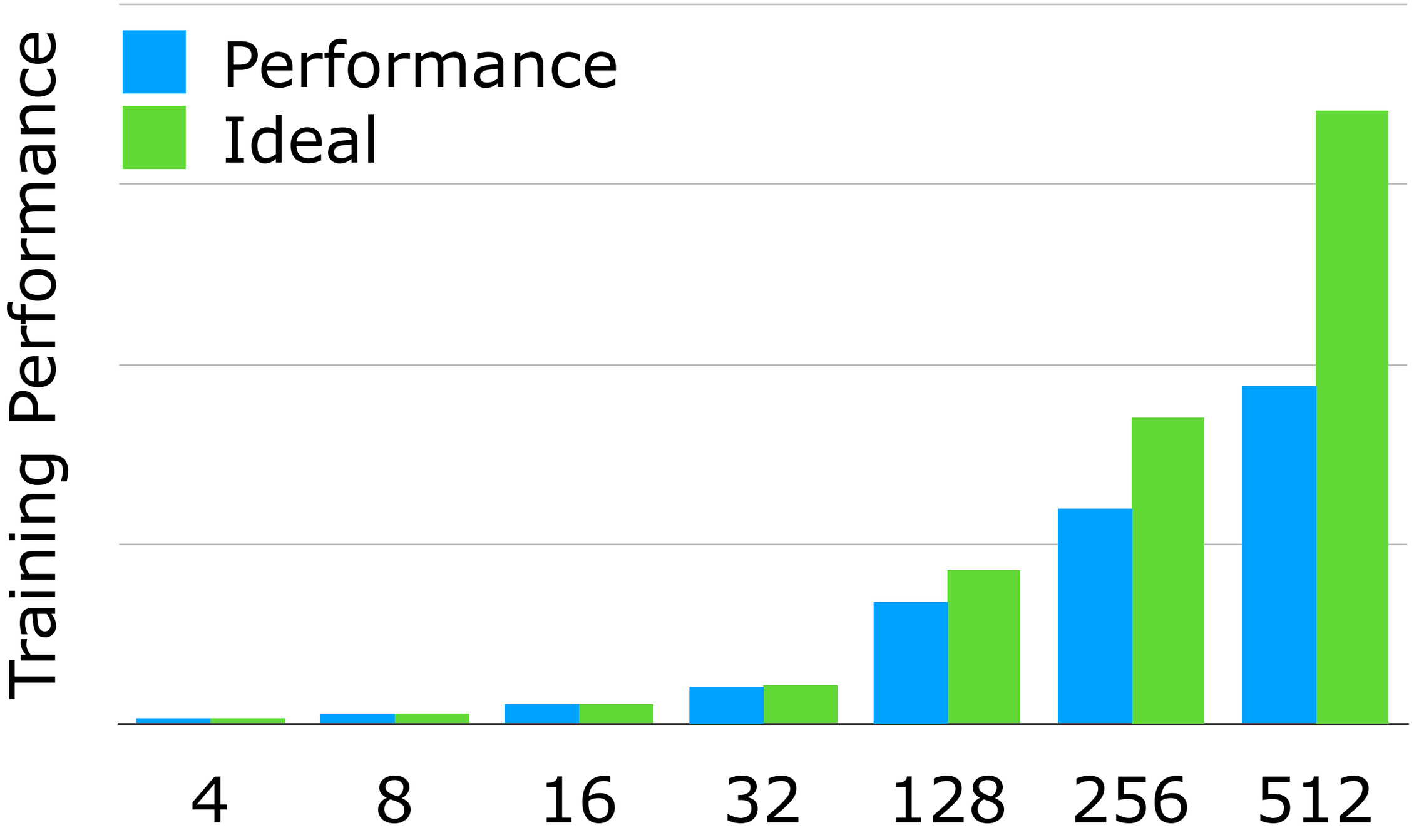

NVIDIA TESLA

Scaling Efficiency



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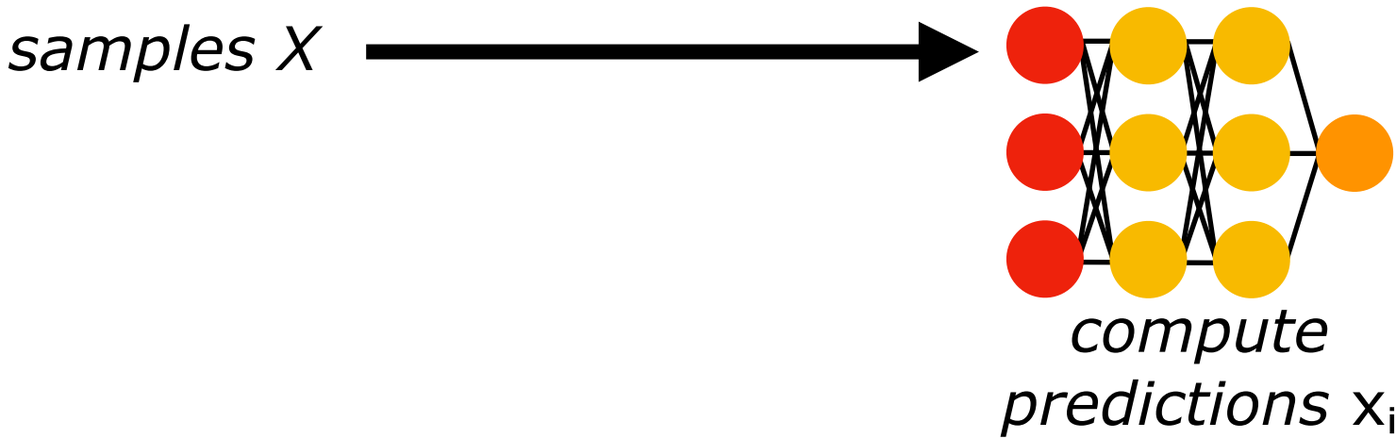
Deep Learning is Innately Sequential

Training Loop



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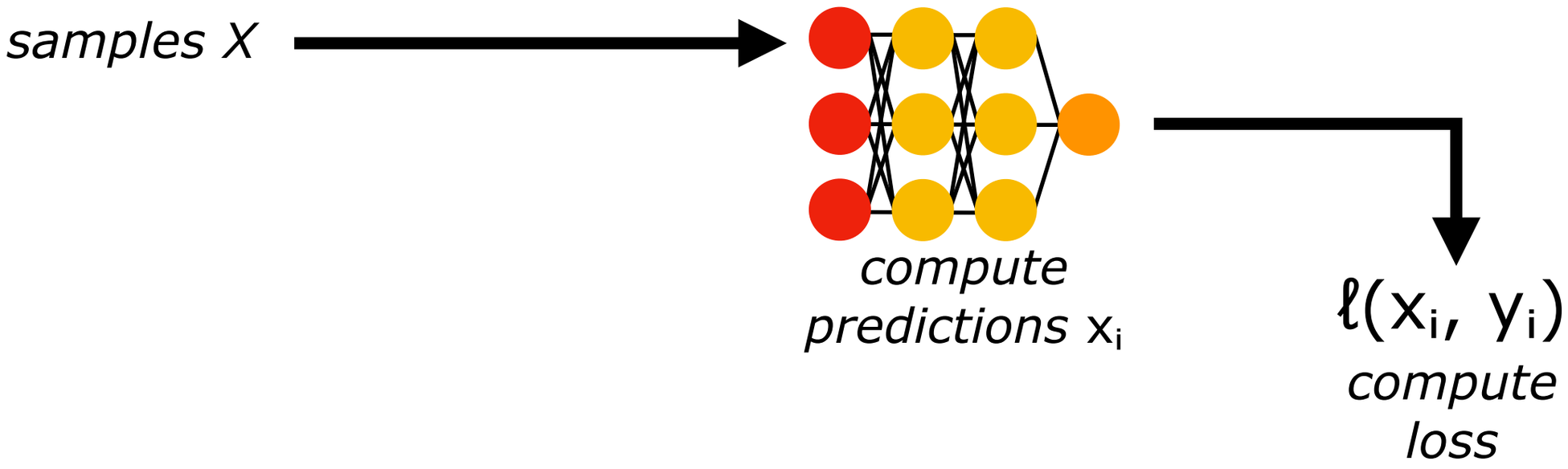
Training Loop



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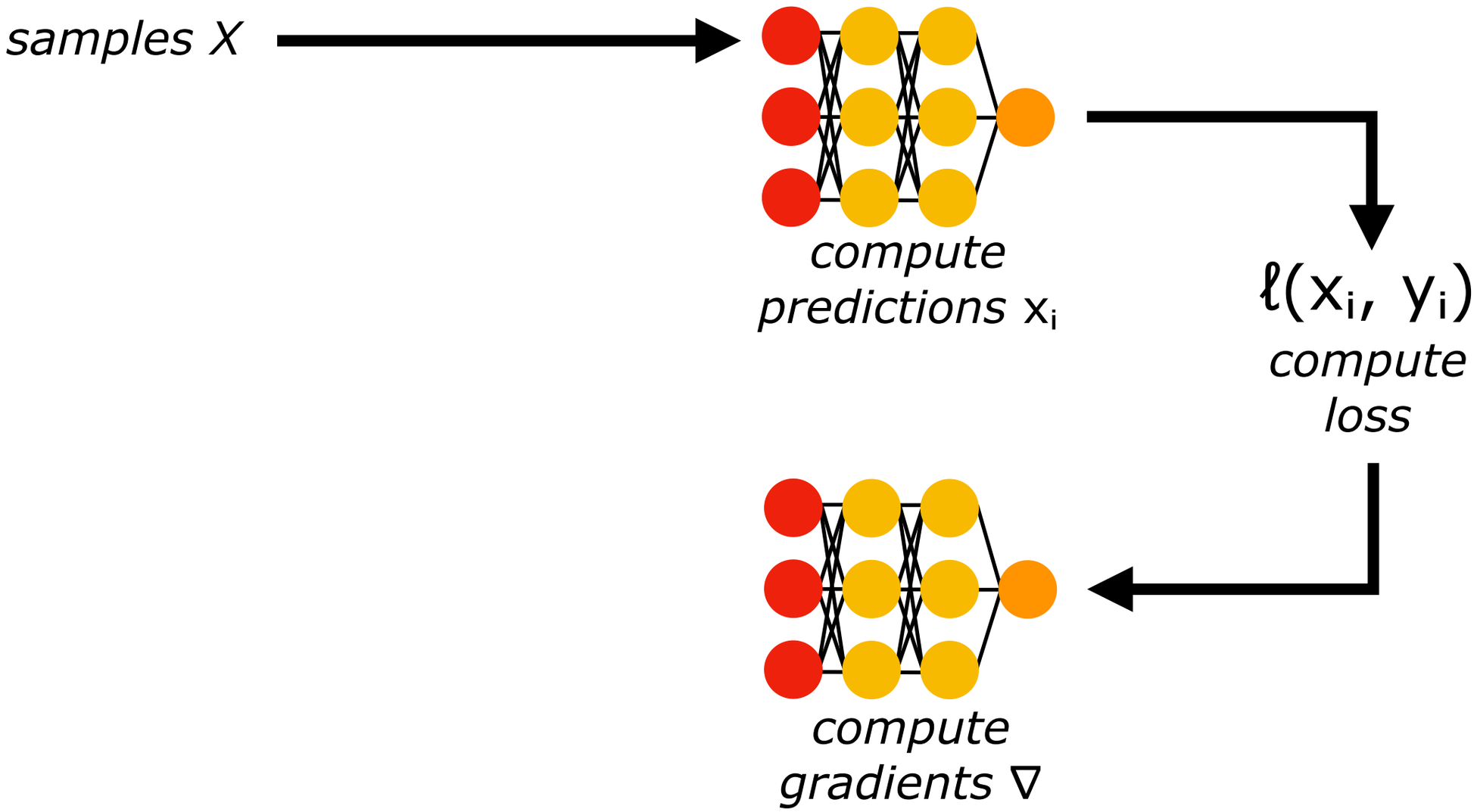
Training Loop



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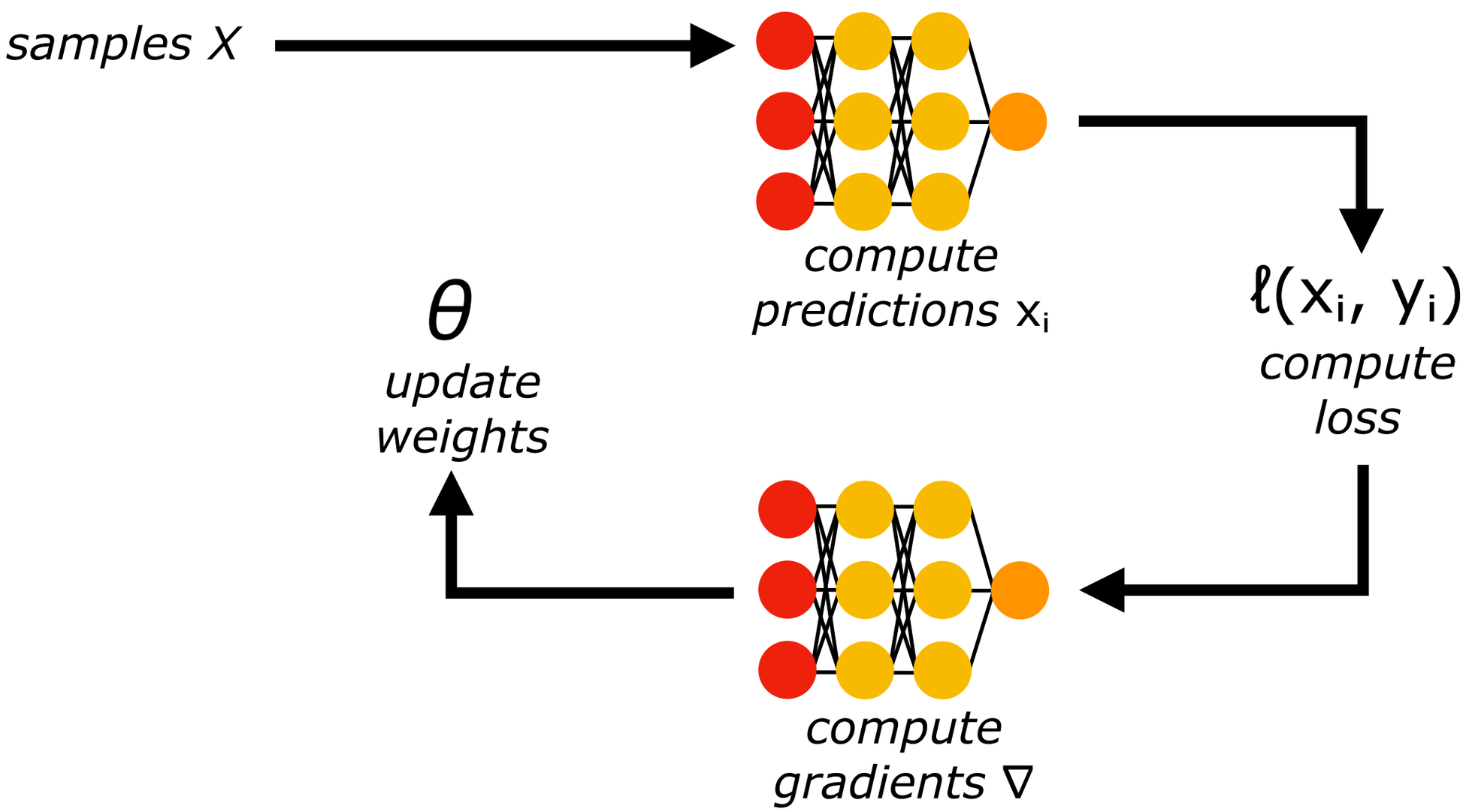
Training Loop



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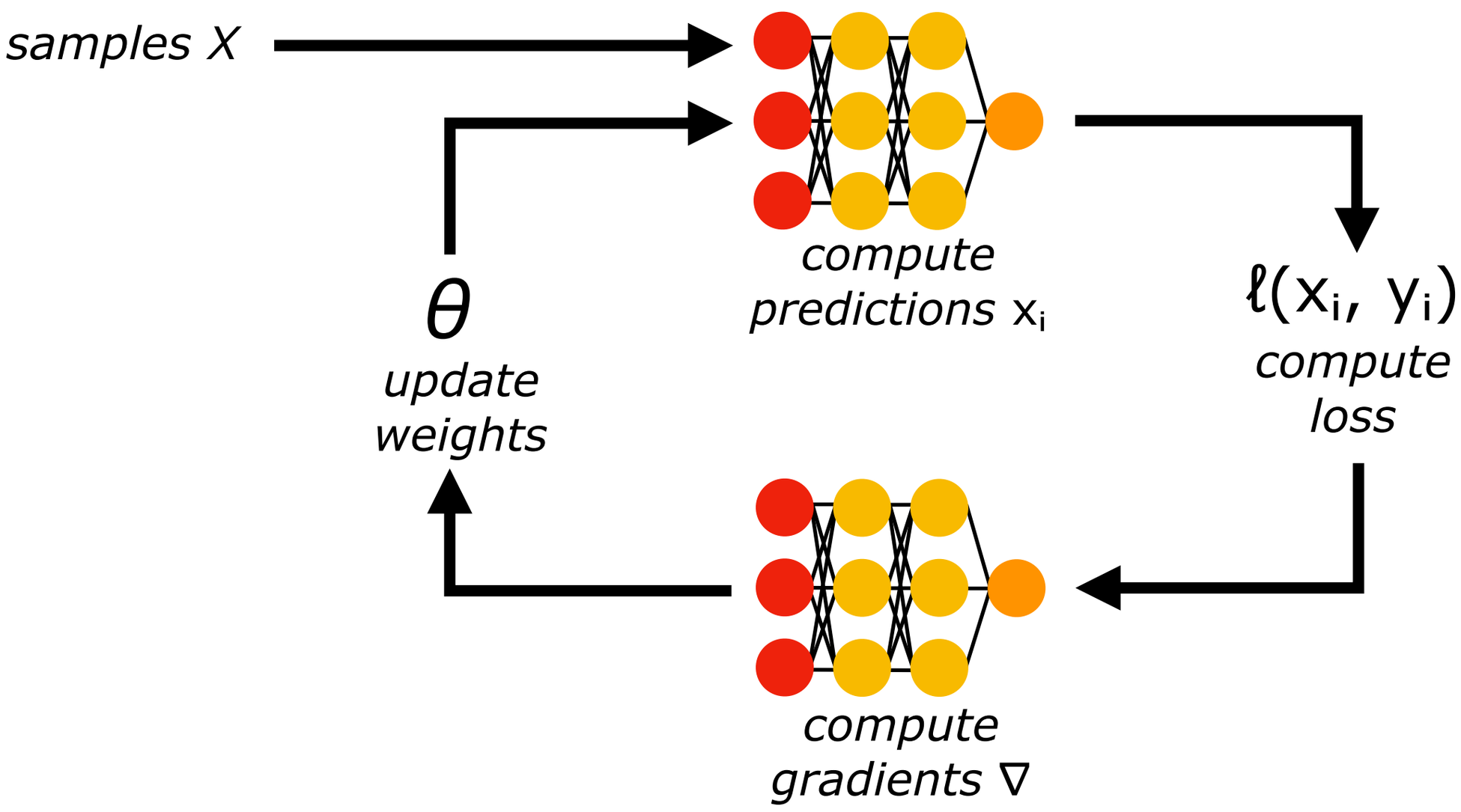
Training Loop



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(innately sequential)

Two Main Branches of Distributed Learning

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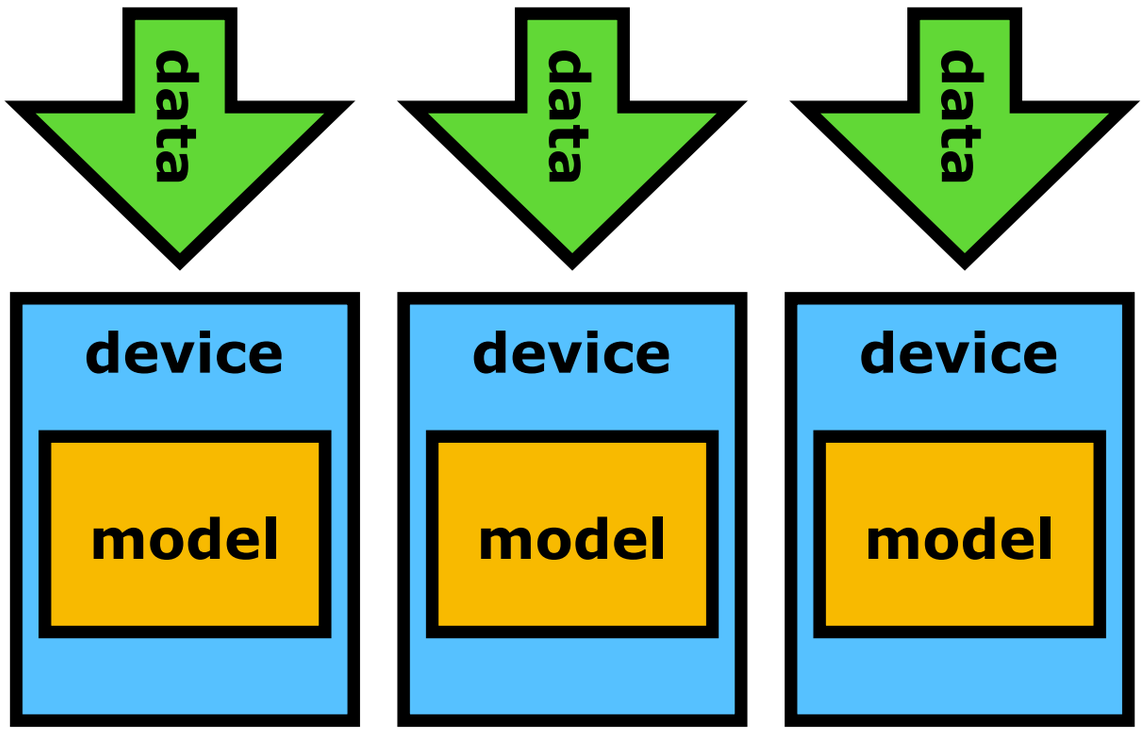
Data Parallelization

Model Parallelization

Data Parallelization



Model Parallelization

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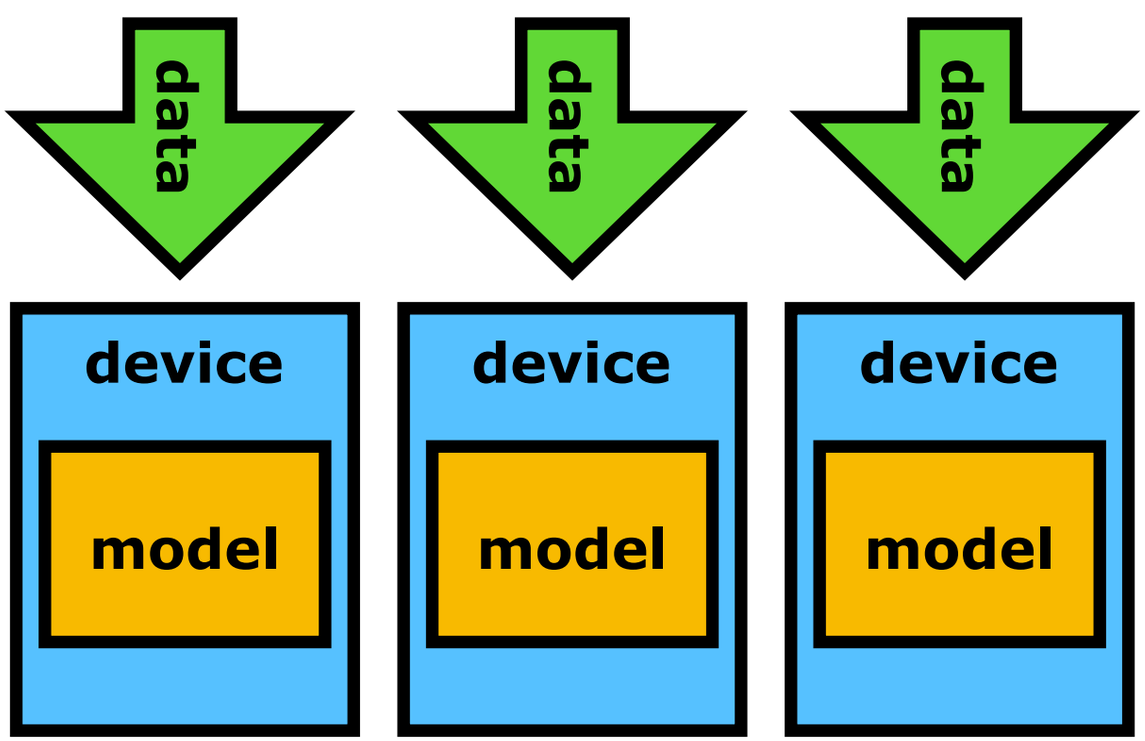
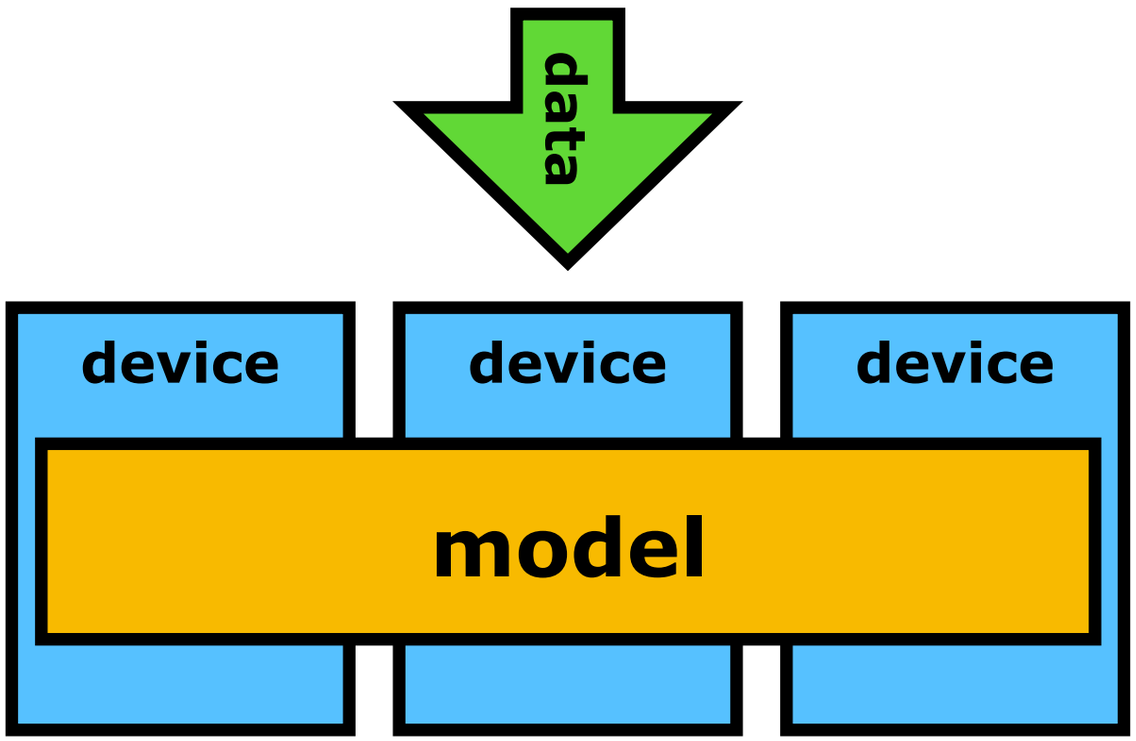
Data Parallelization



Model Parallelization



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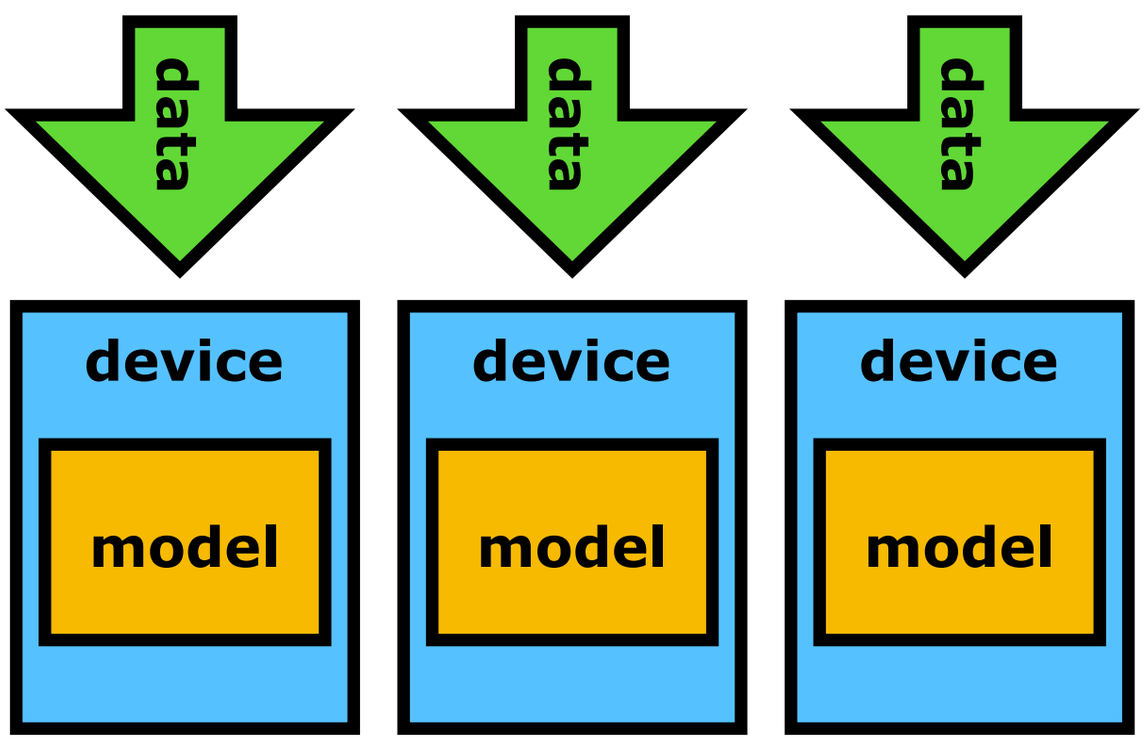
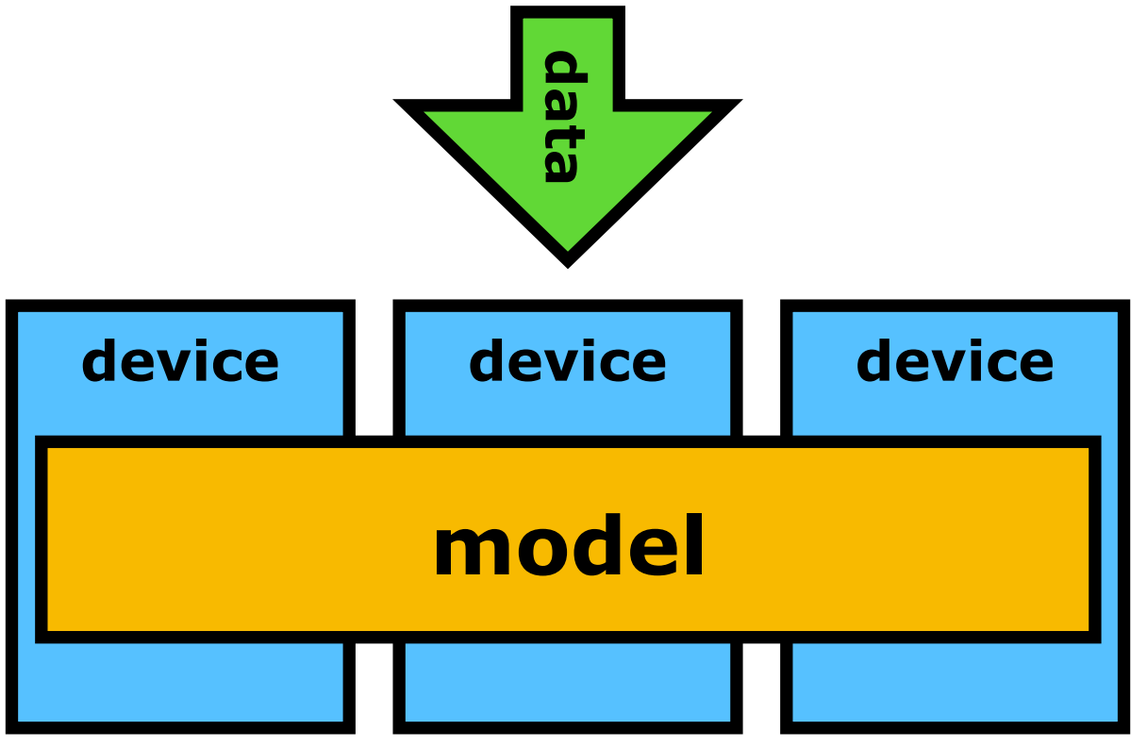
Data Parallelization



Model Parallelization



Synchronize weights θ to
train models fast.

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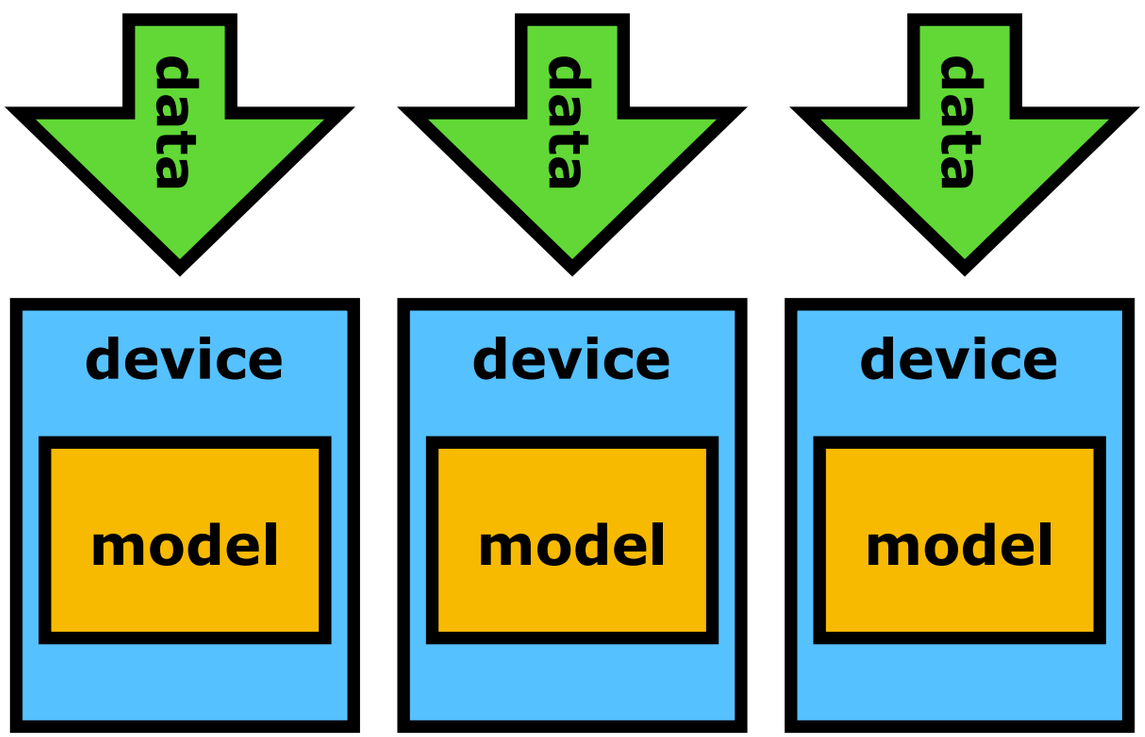
Data Parallelization



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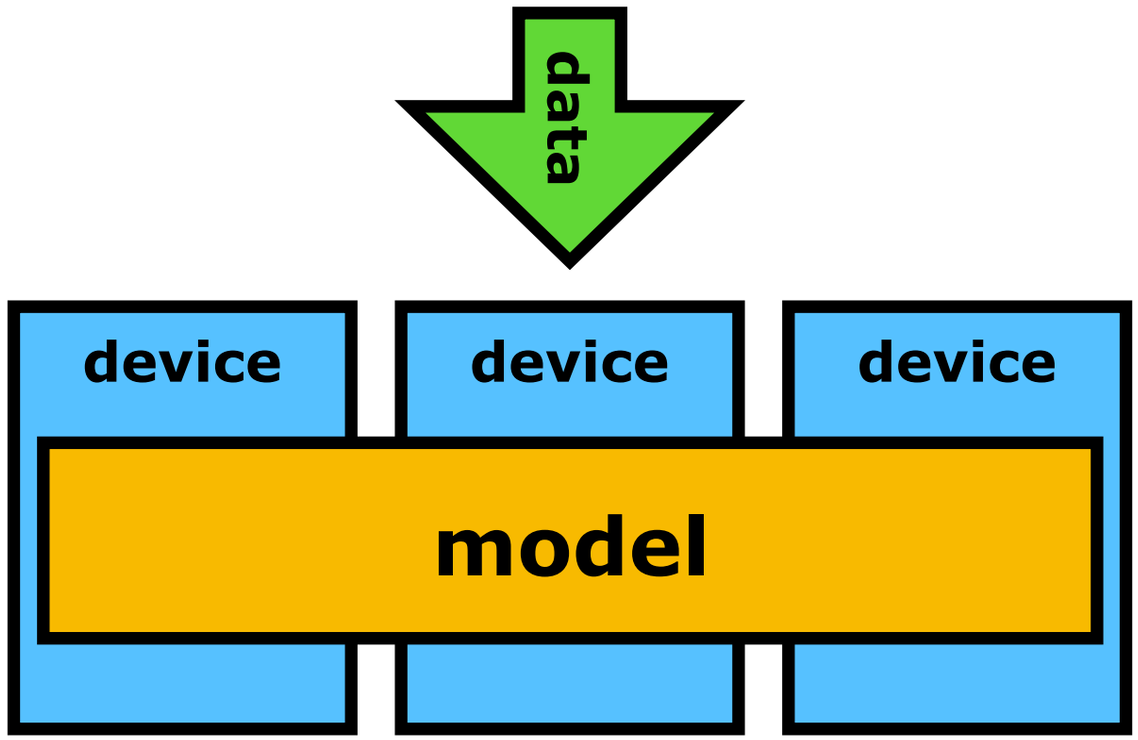

Partition a model to
build huge models.

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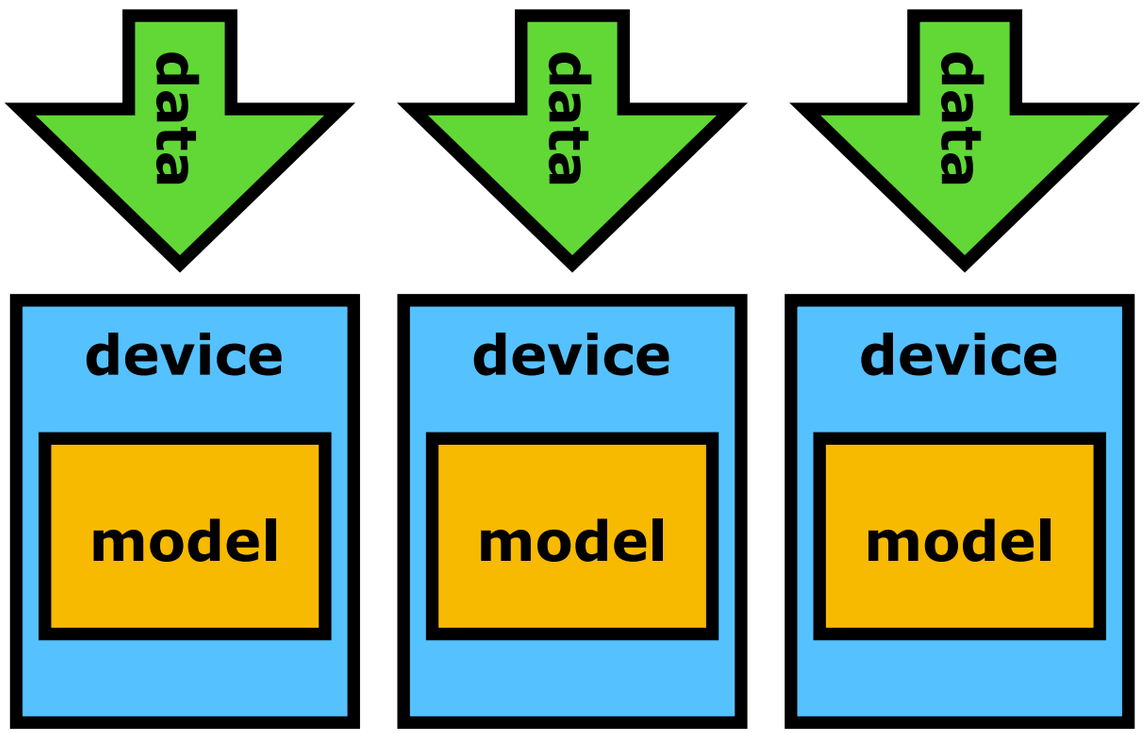
Data Parallelization



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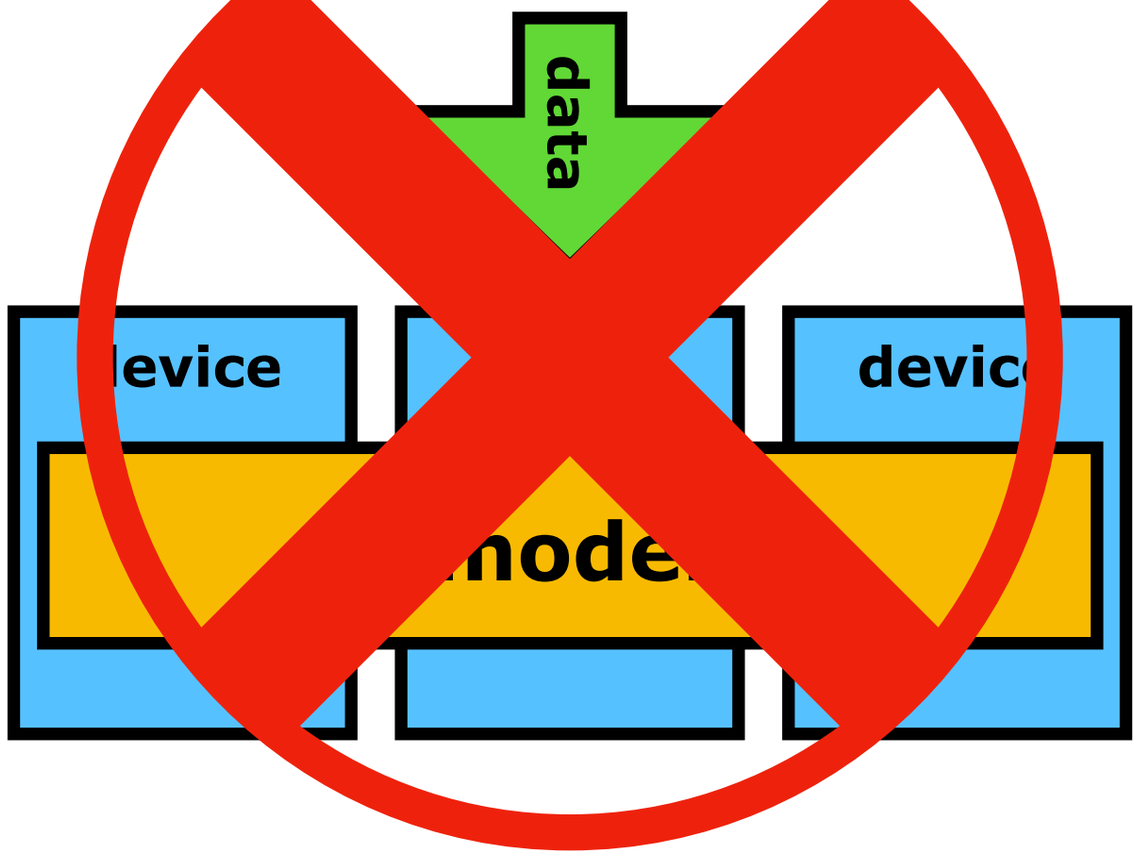

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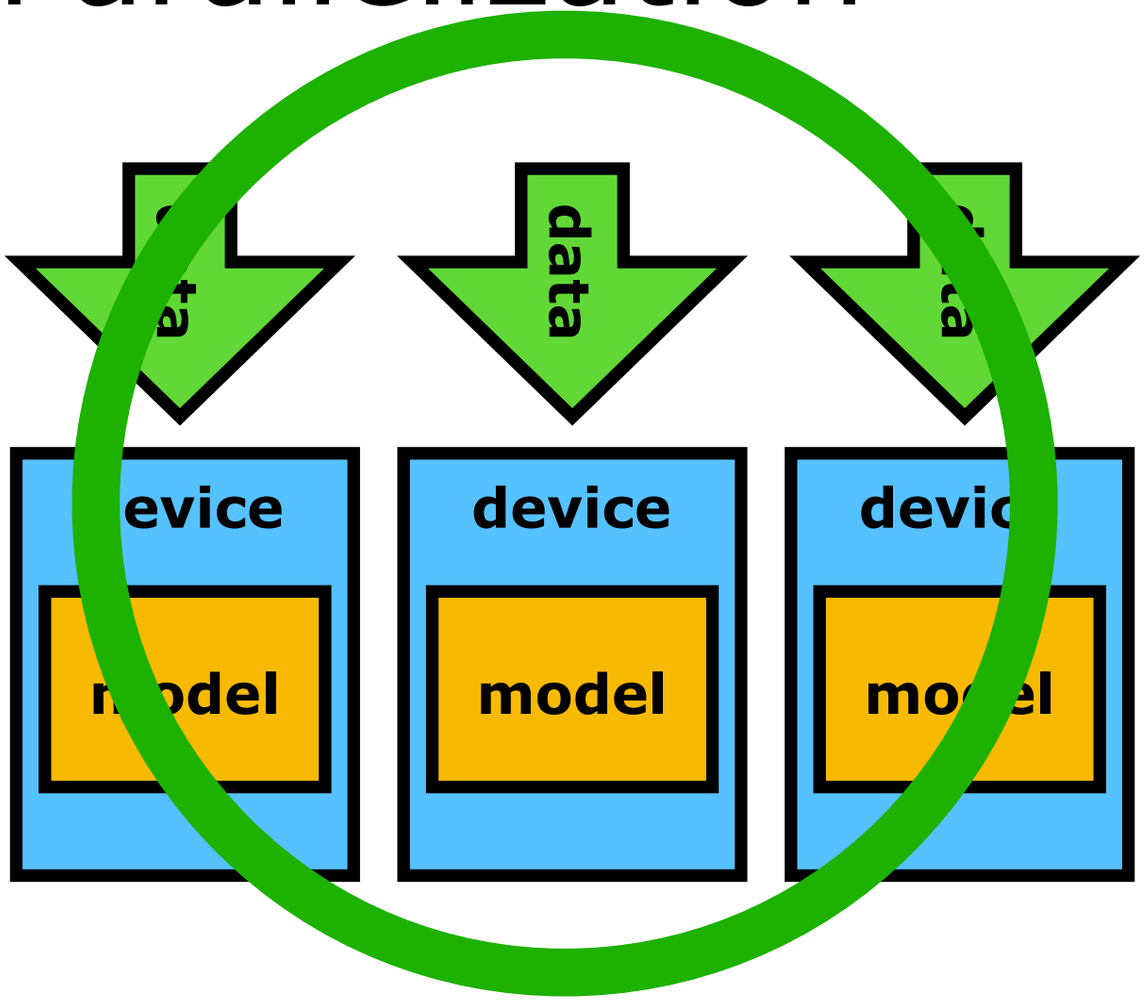

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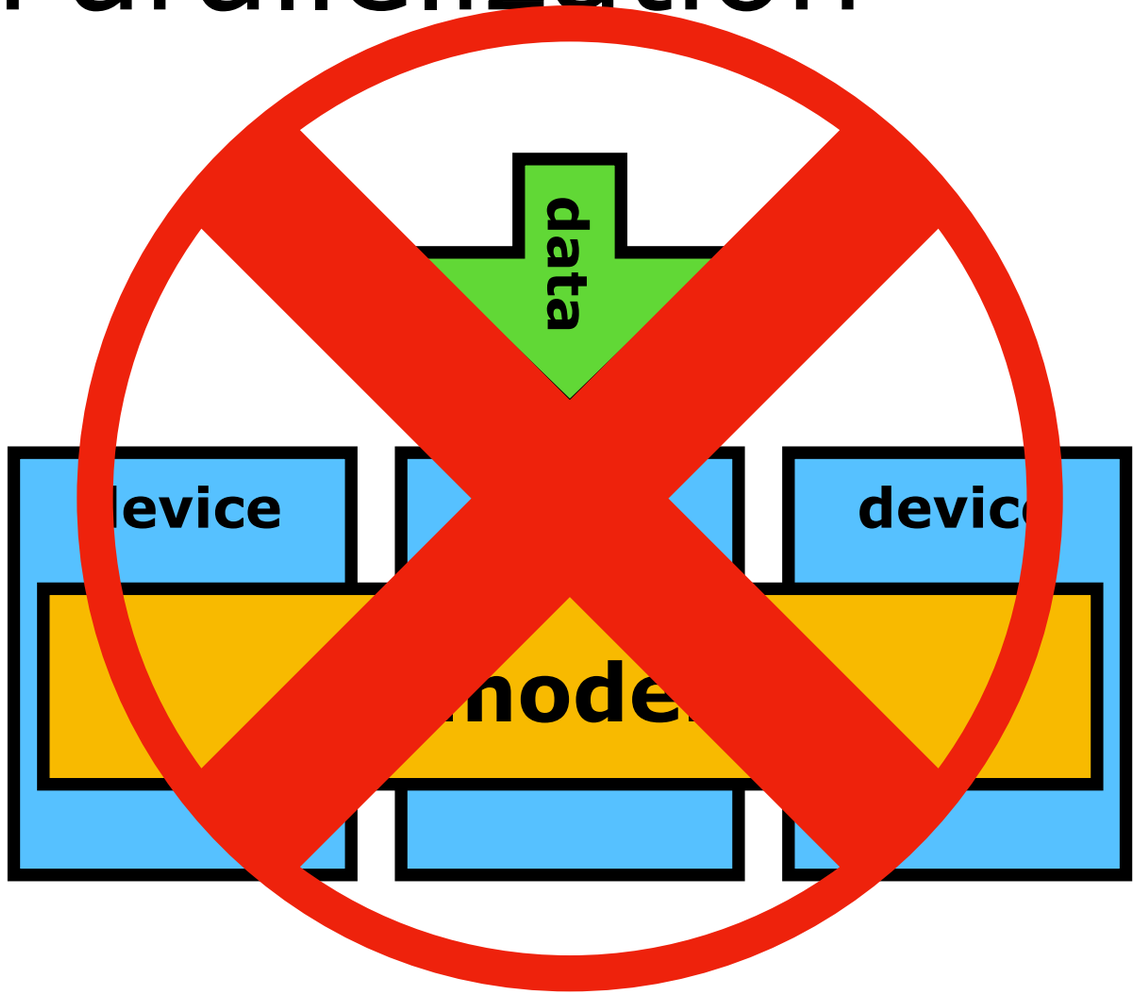

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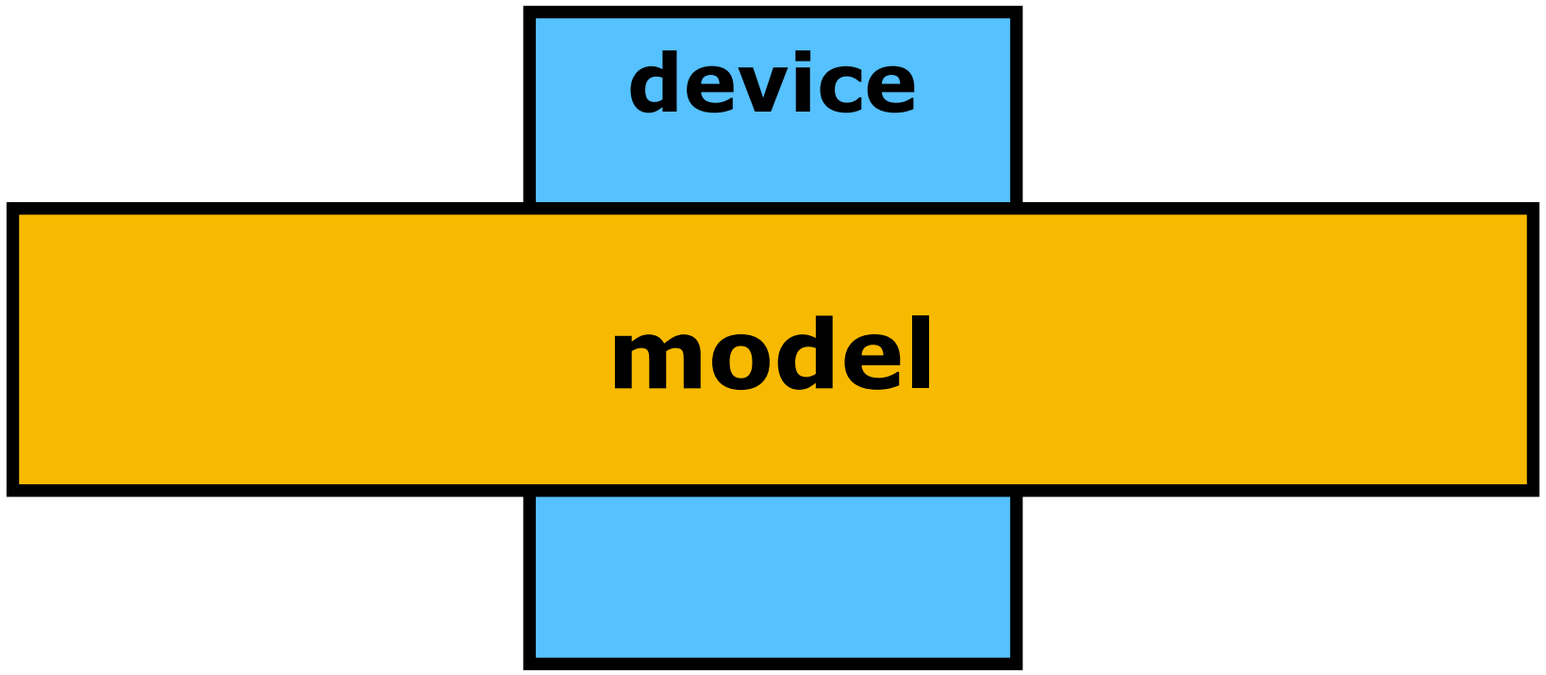

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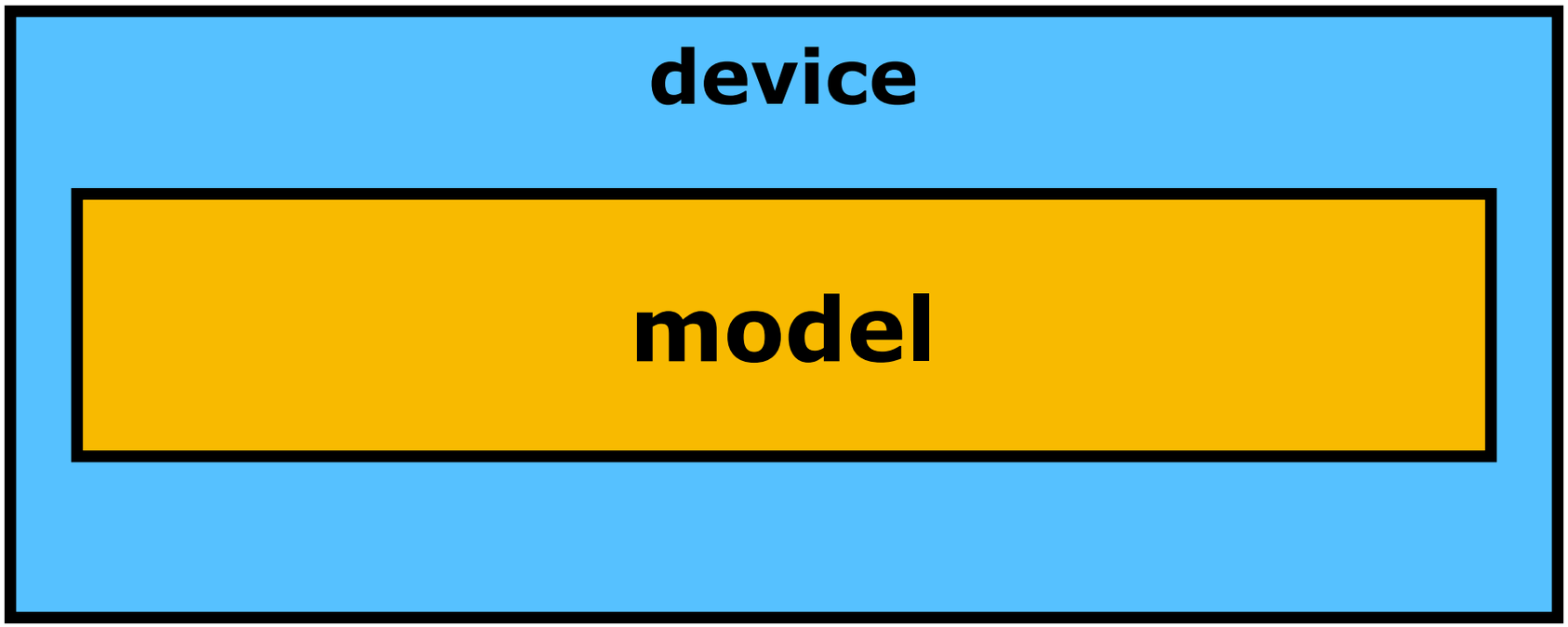

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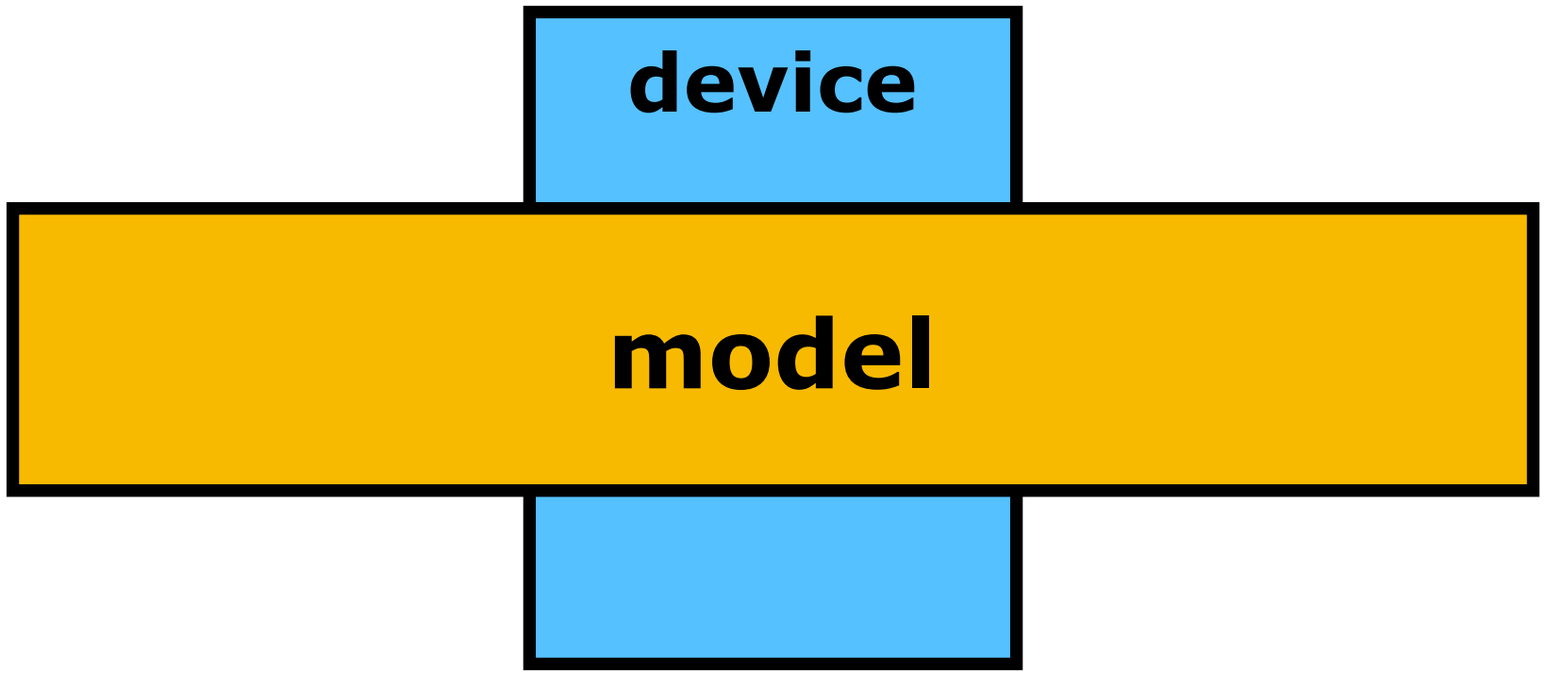

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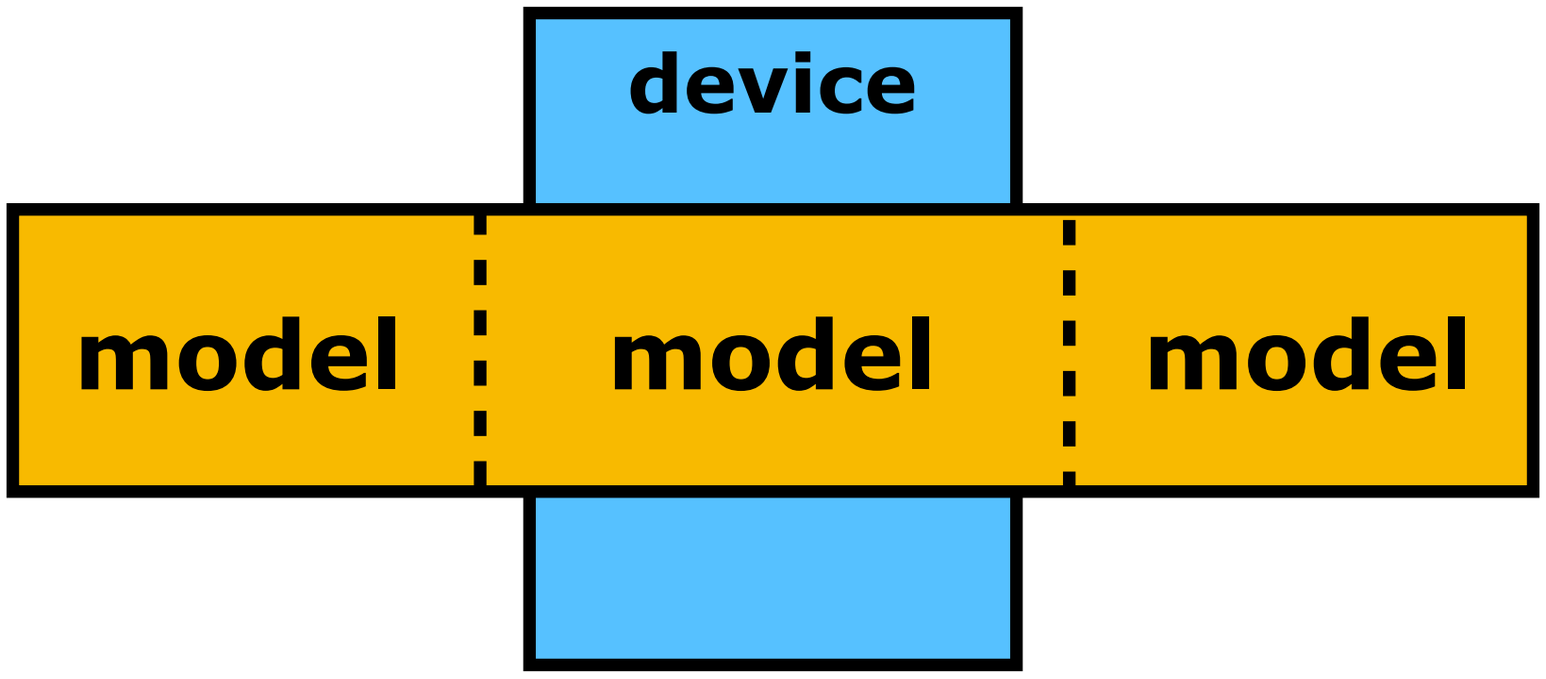

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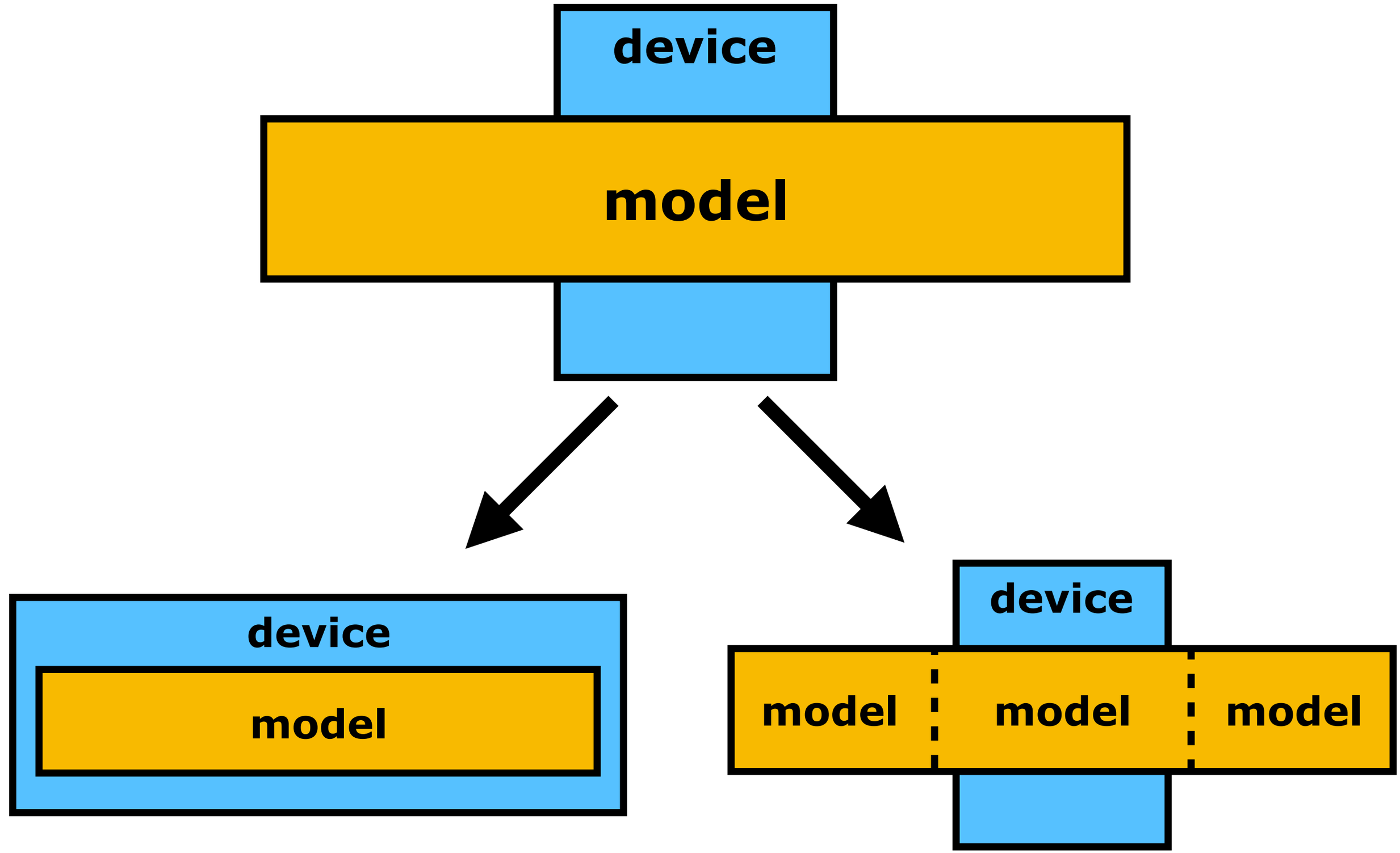

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some training data

data

device

model

data

device | **device** | **device**

model

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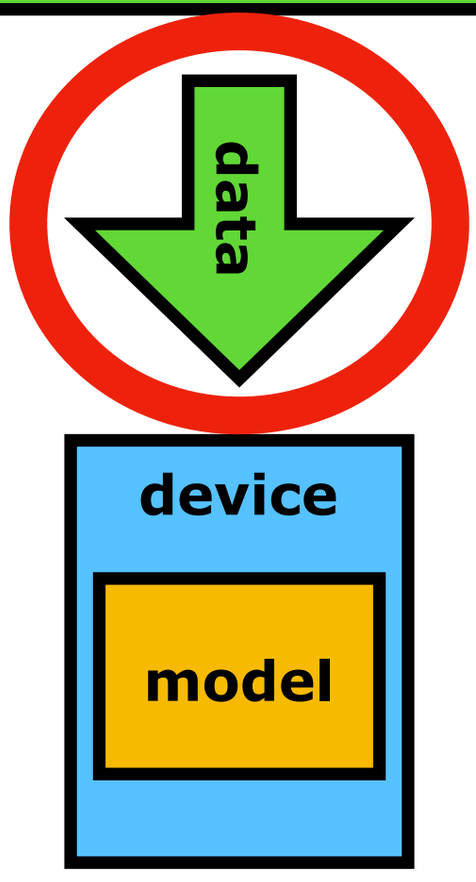
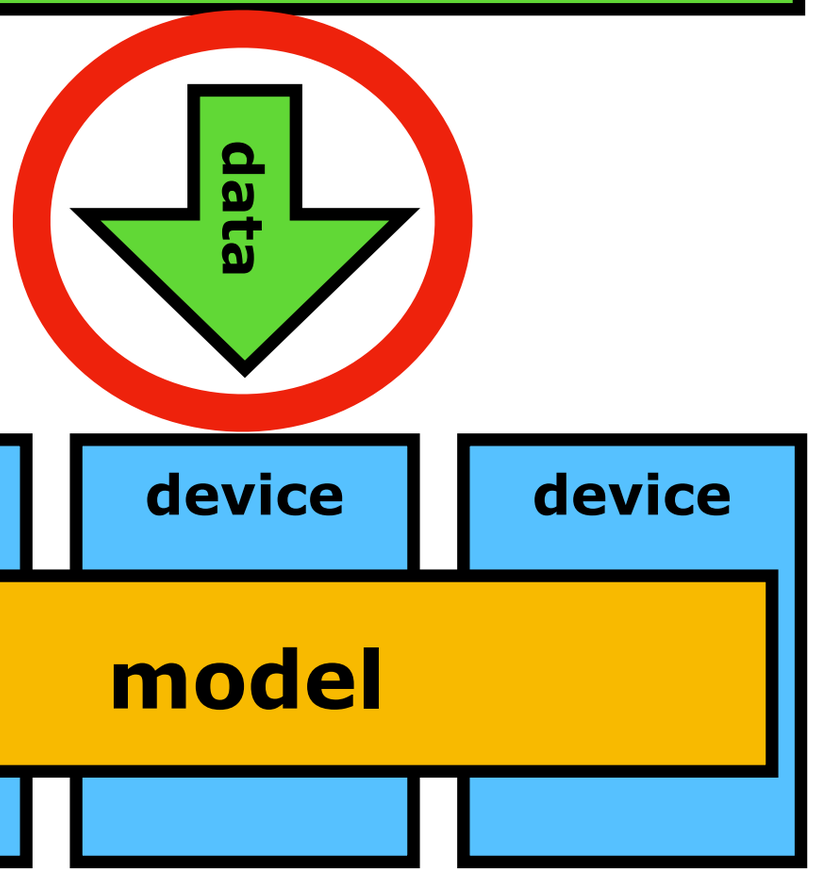
a lot of training data





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a lot of training data

data

data

data

data

device **model**

device **model**

device **model**

device **device** **device** **model**

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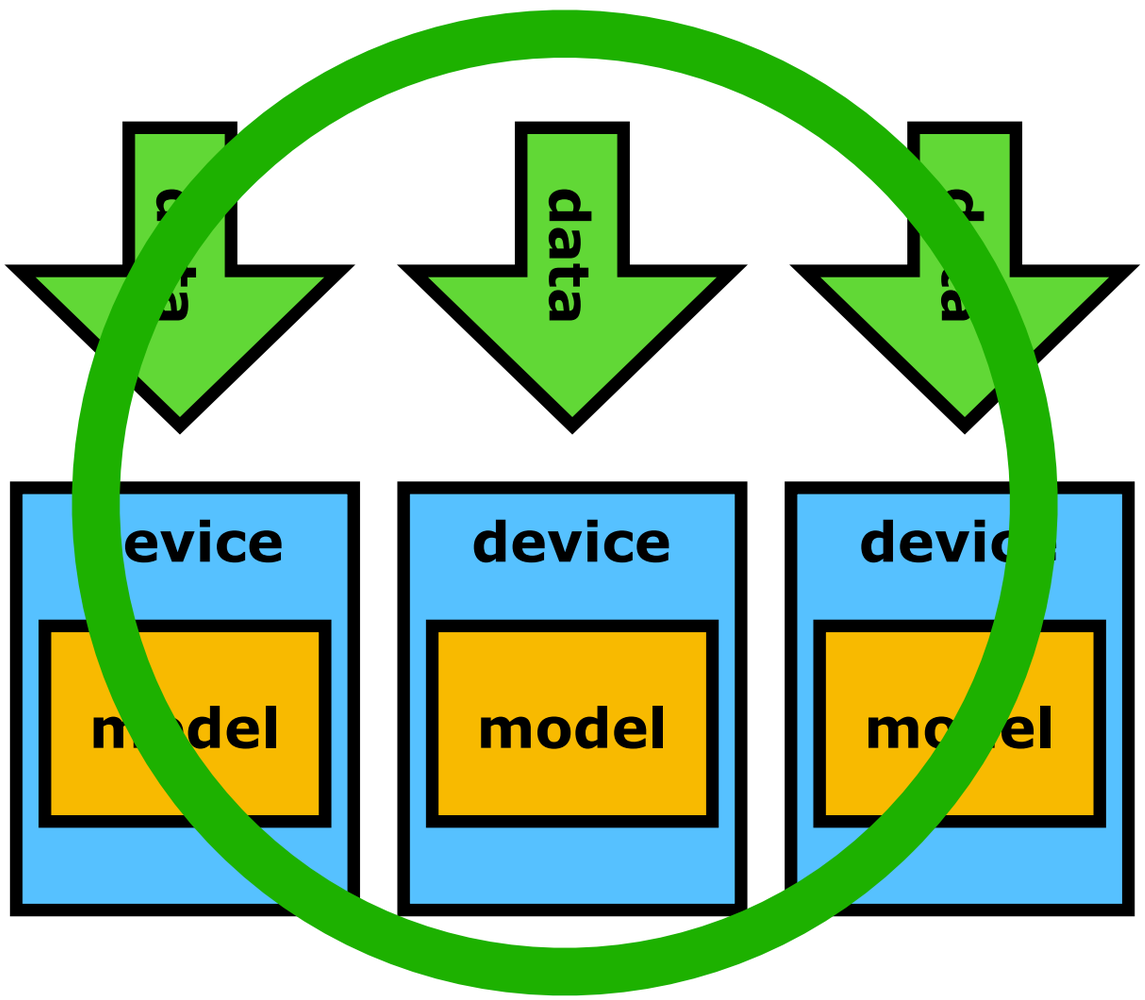
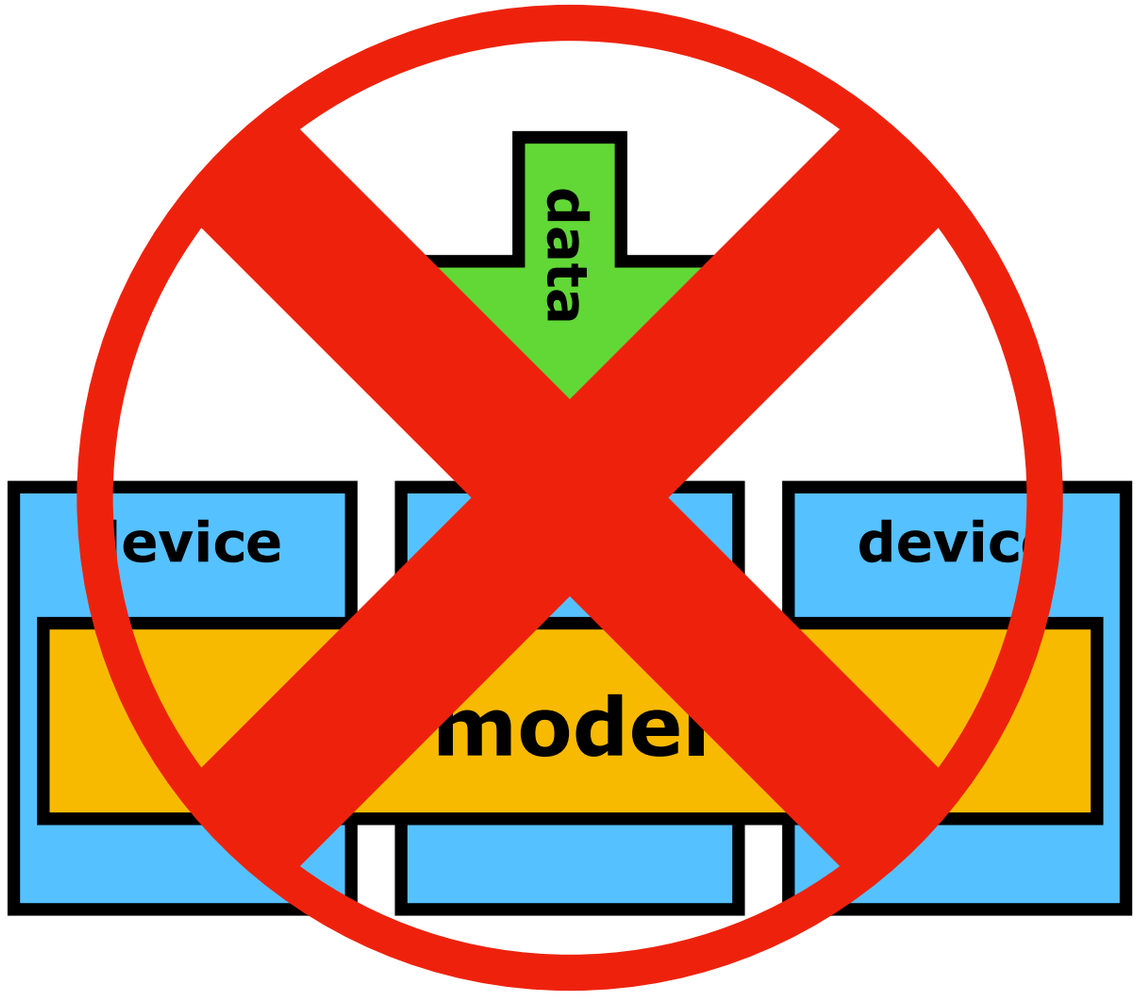
Data Parallelization



Model Parallelization



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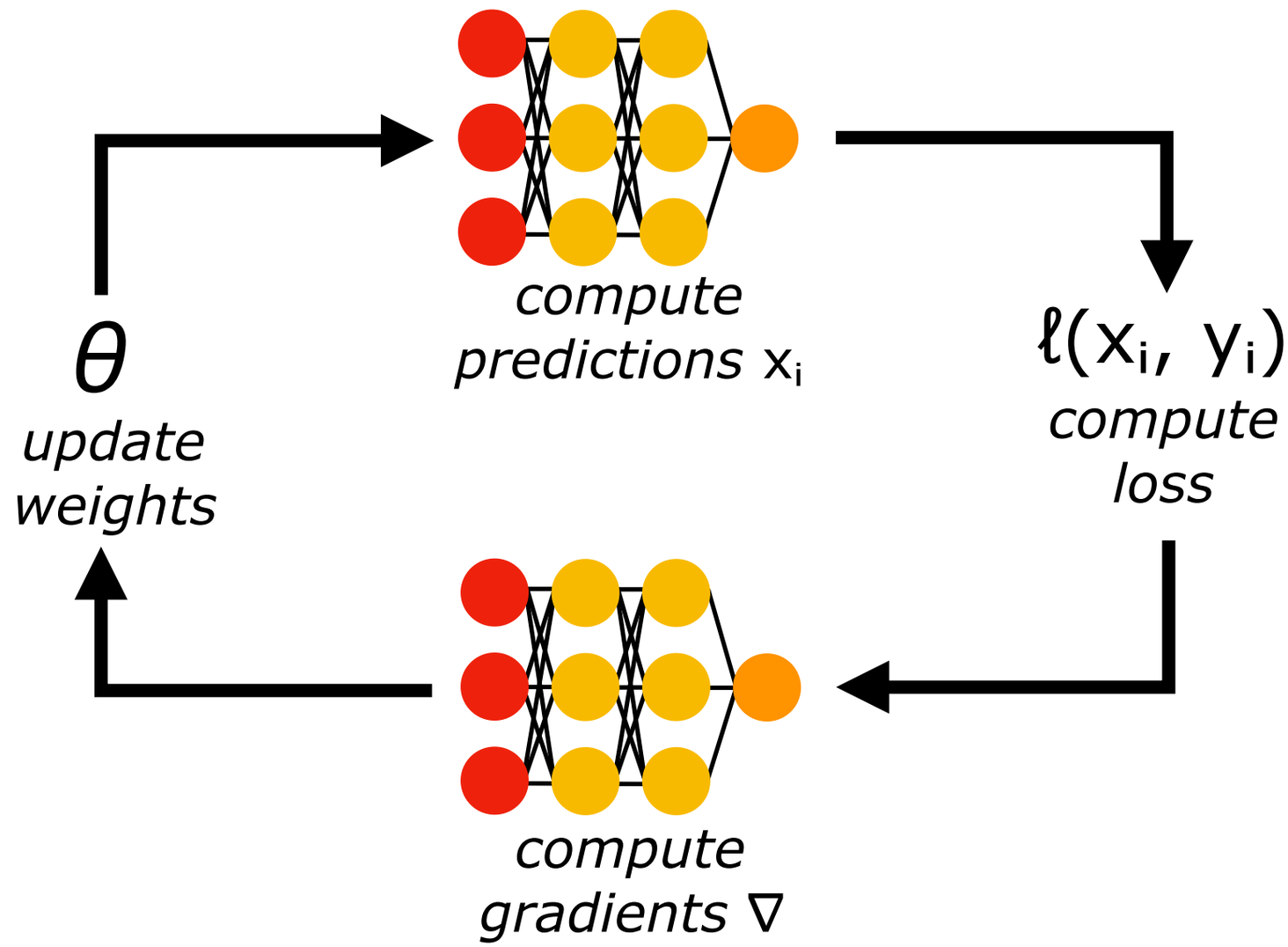
The Brief History of Distributed Learning

Shared Training Loop



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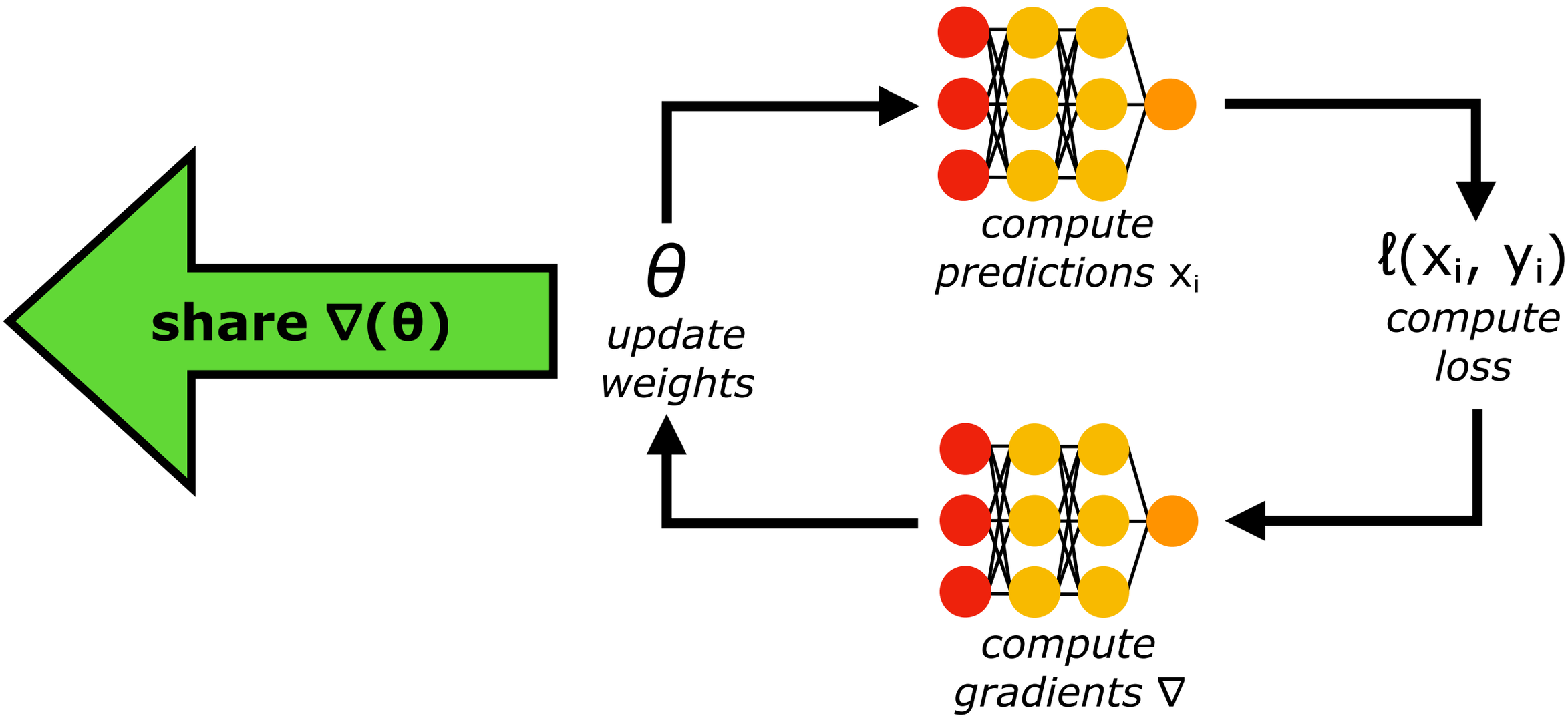
(innately sequential)

Shared Training Loop



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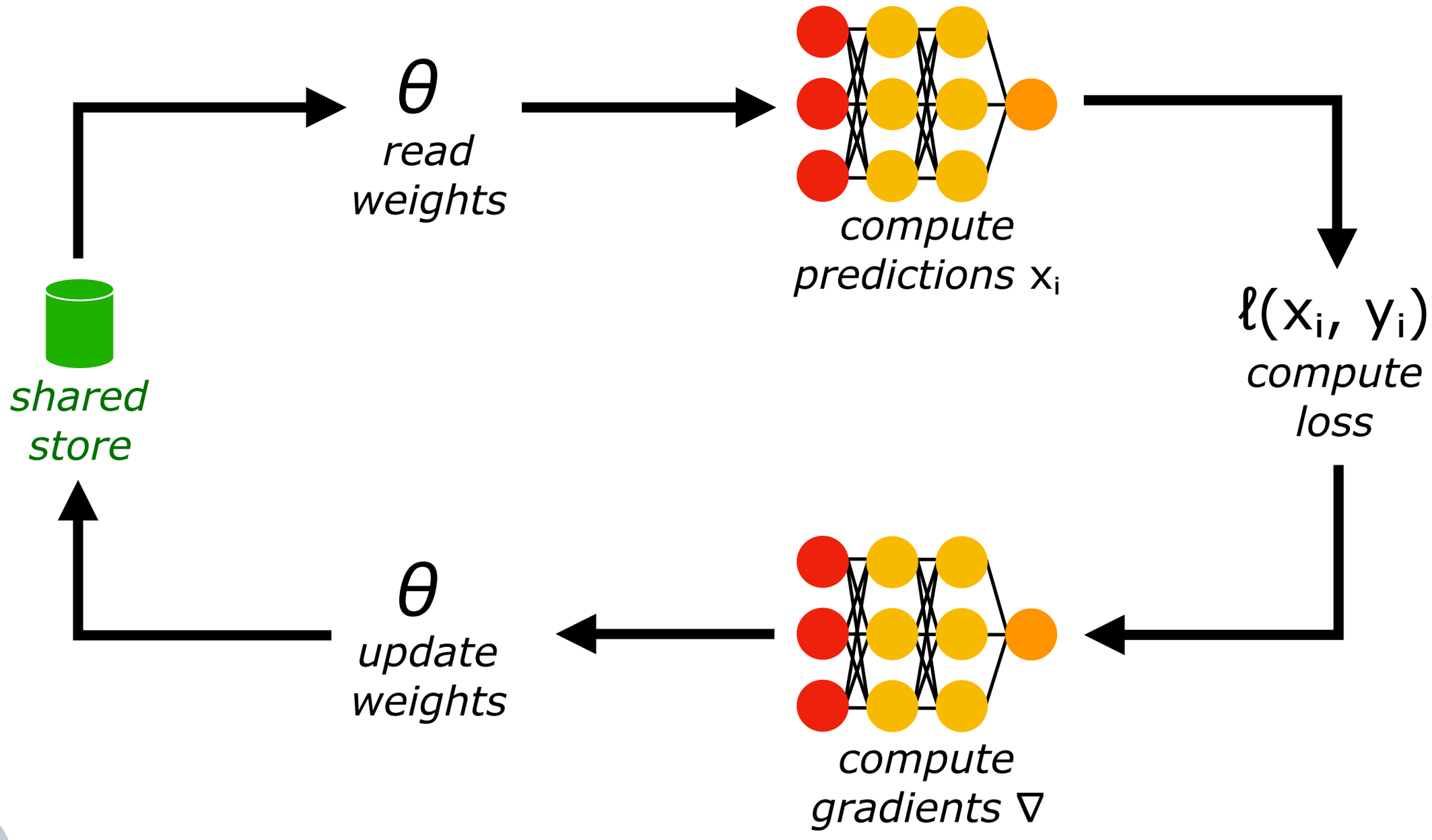
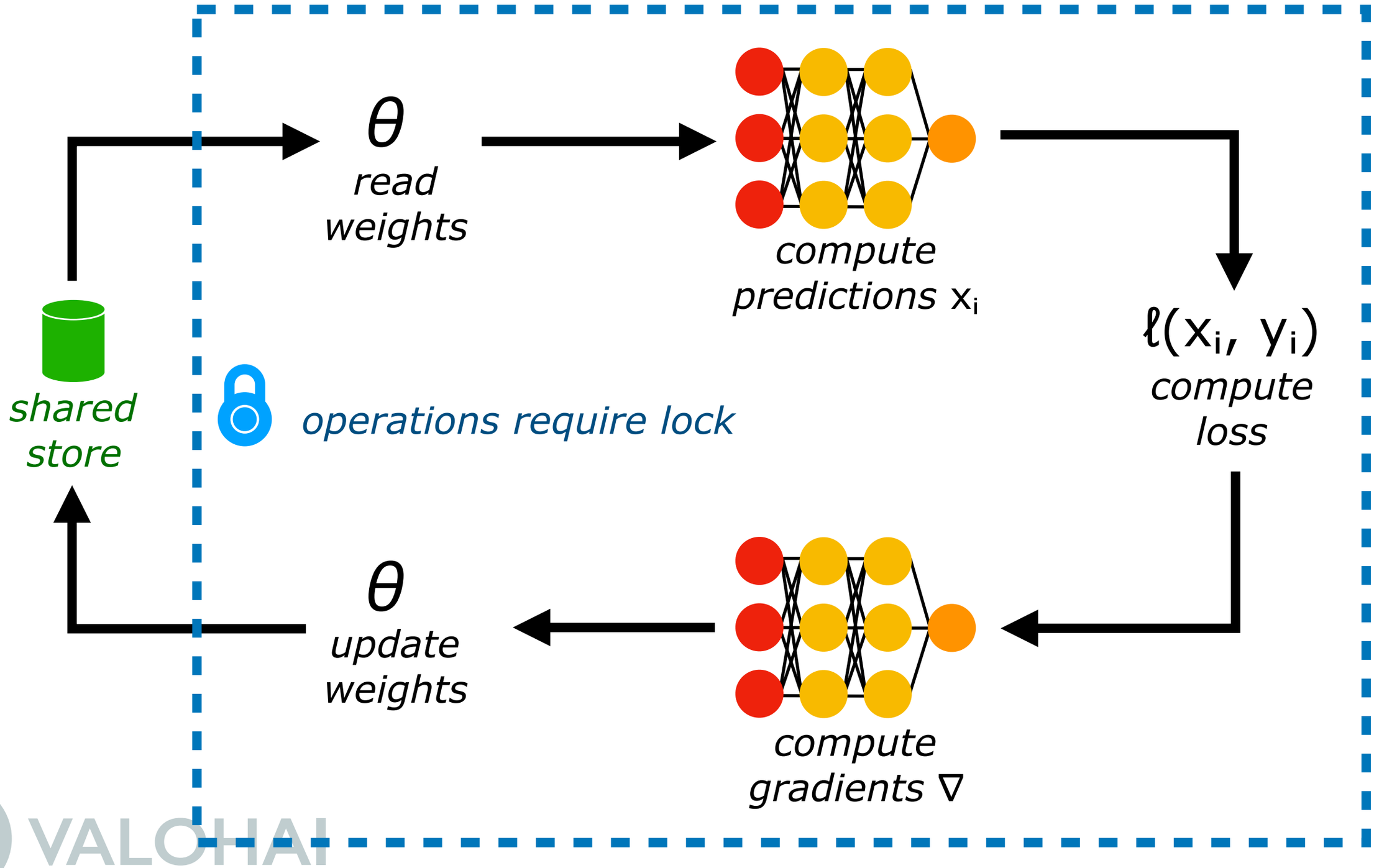
(innately sequential)

Shared Training Loop

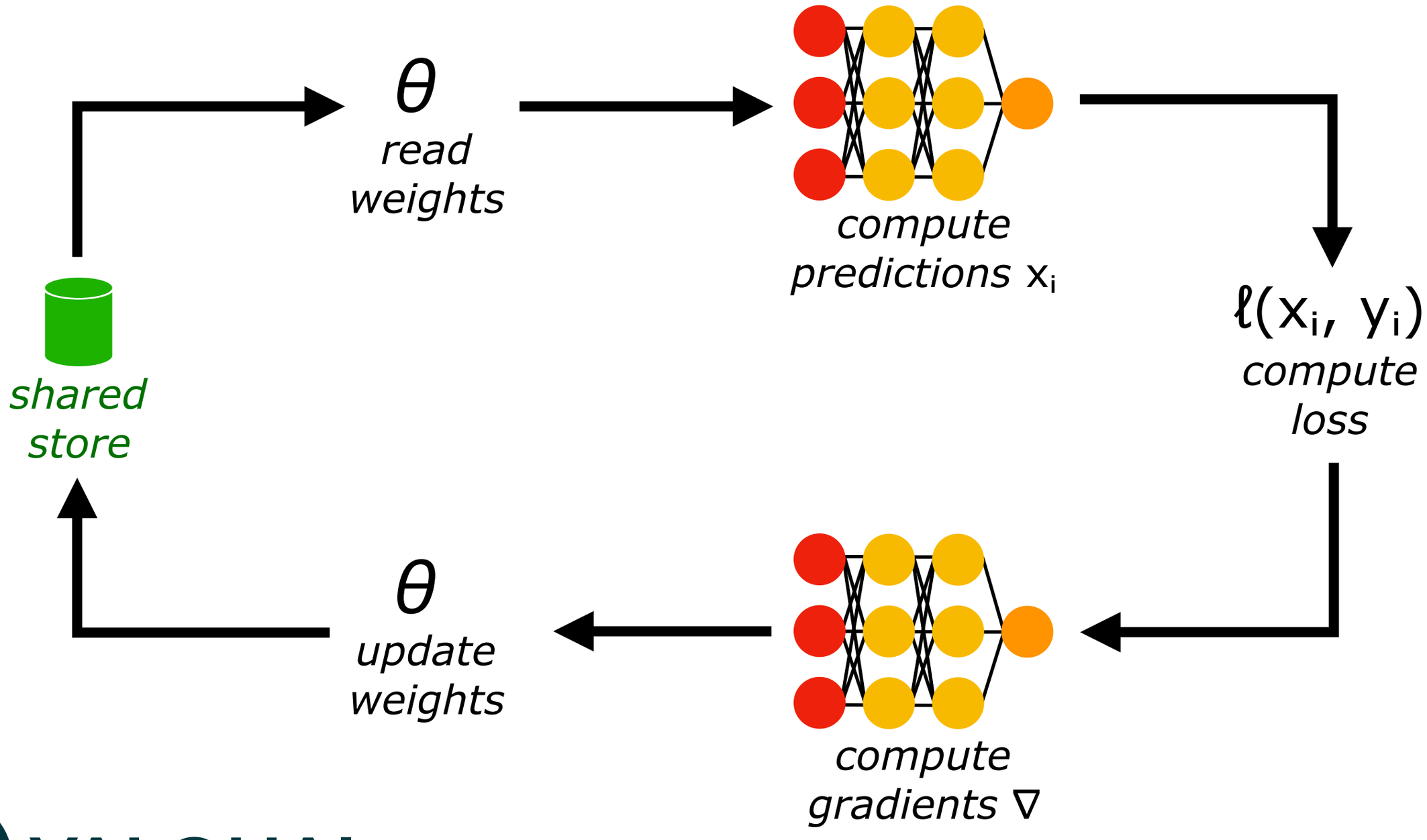


Locking Updates



Lock-free Updates

(The Hogwild)



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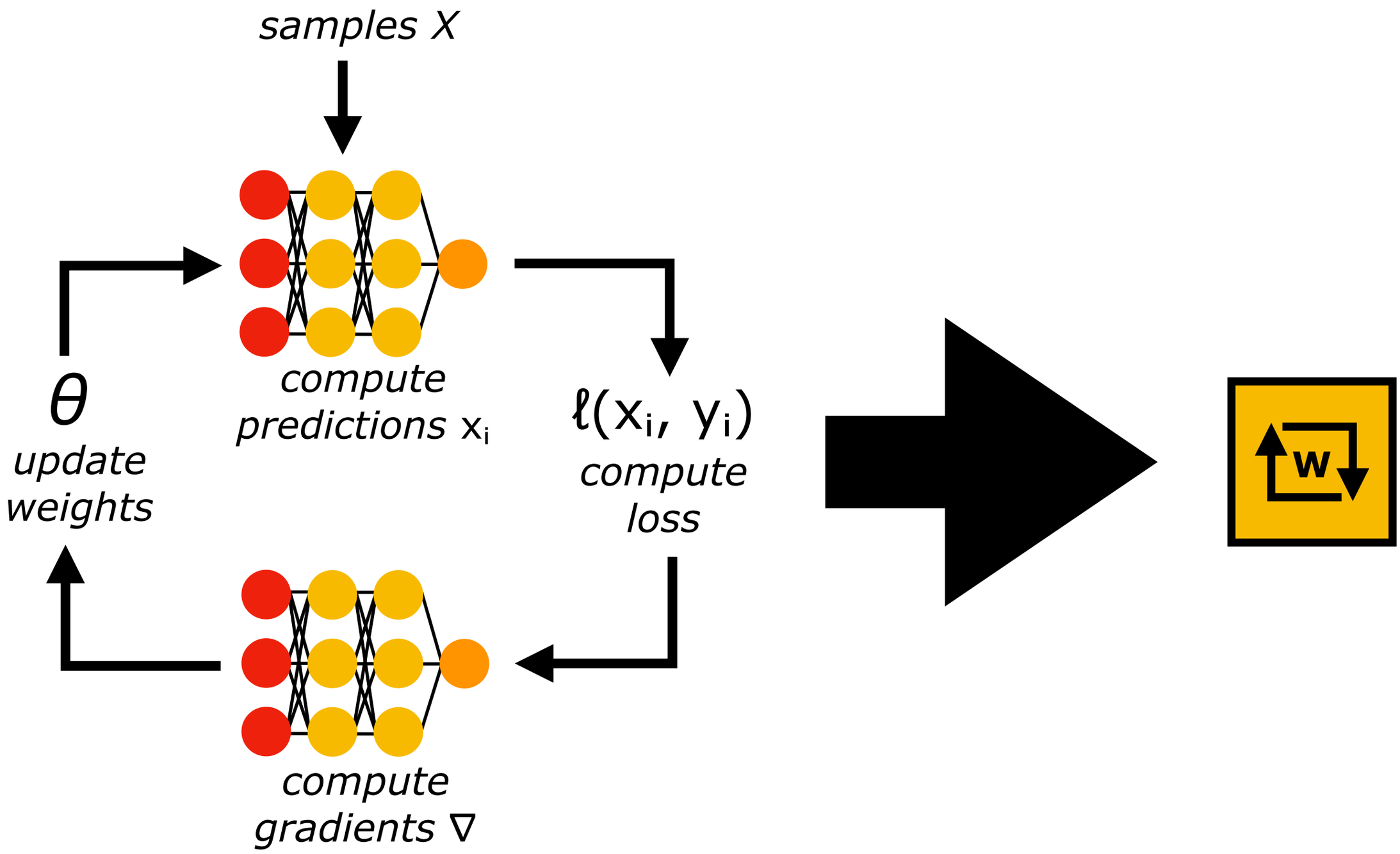
Notation



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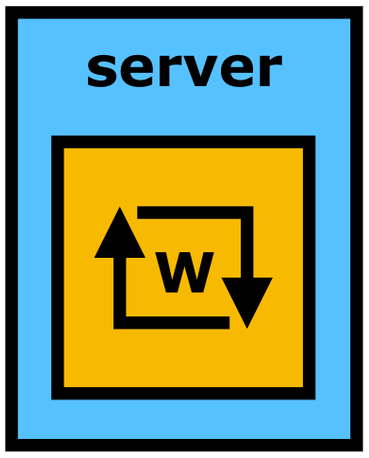
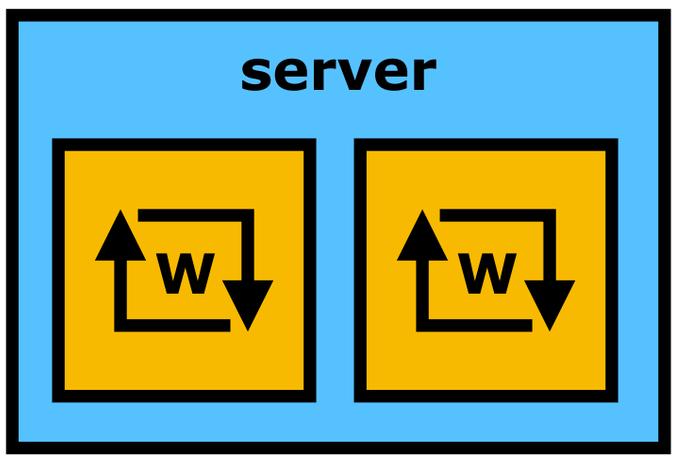
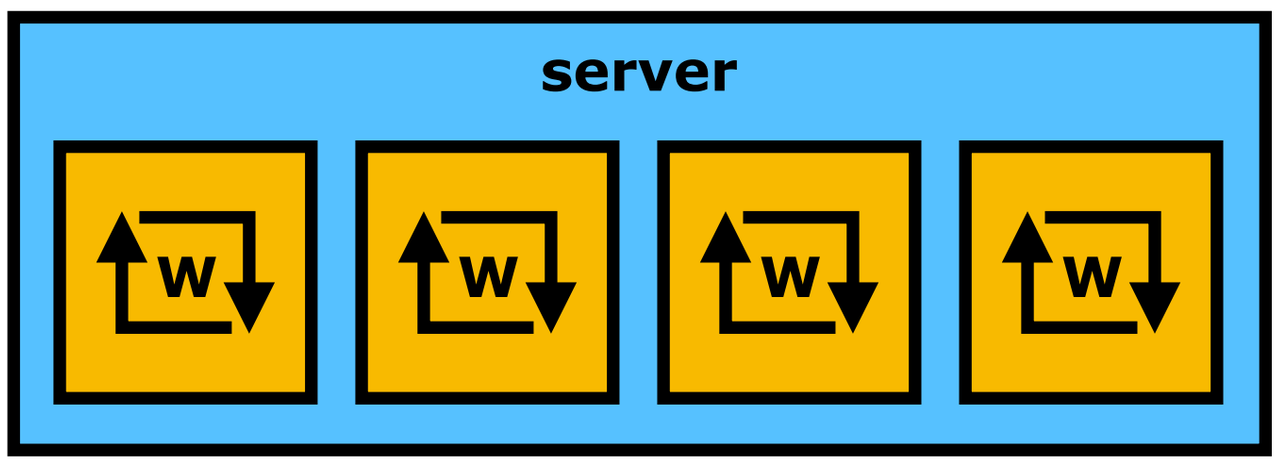
Notation



Usually
worker count == number of GPUs



Each server has limited network bandwidth.



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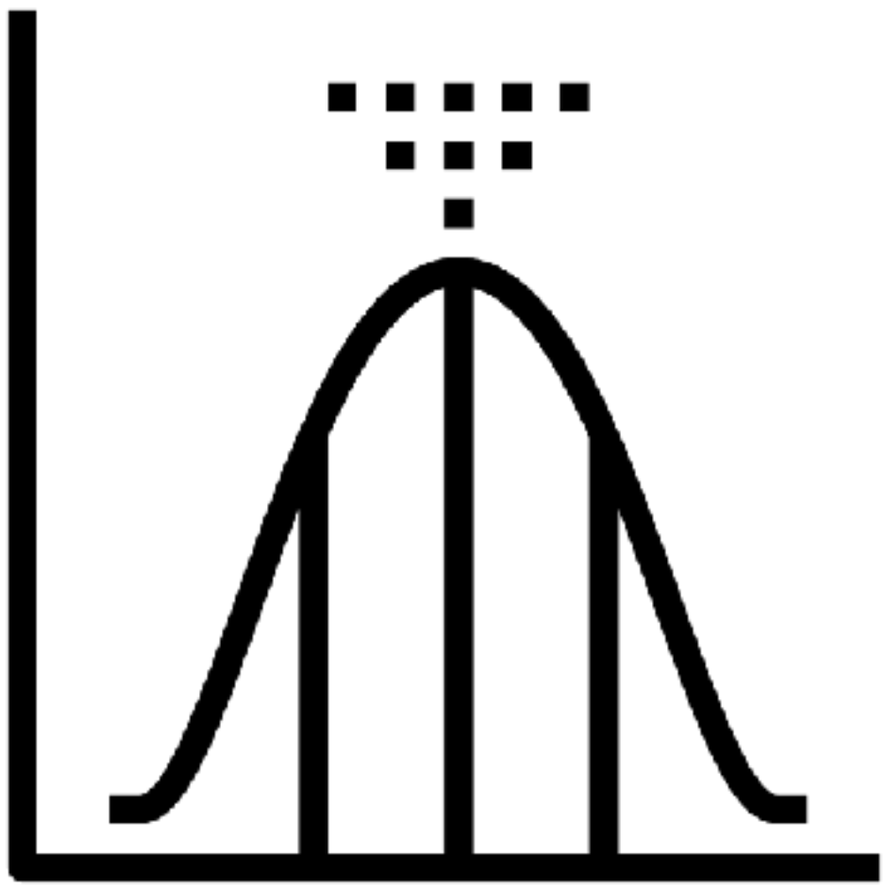

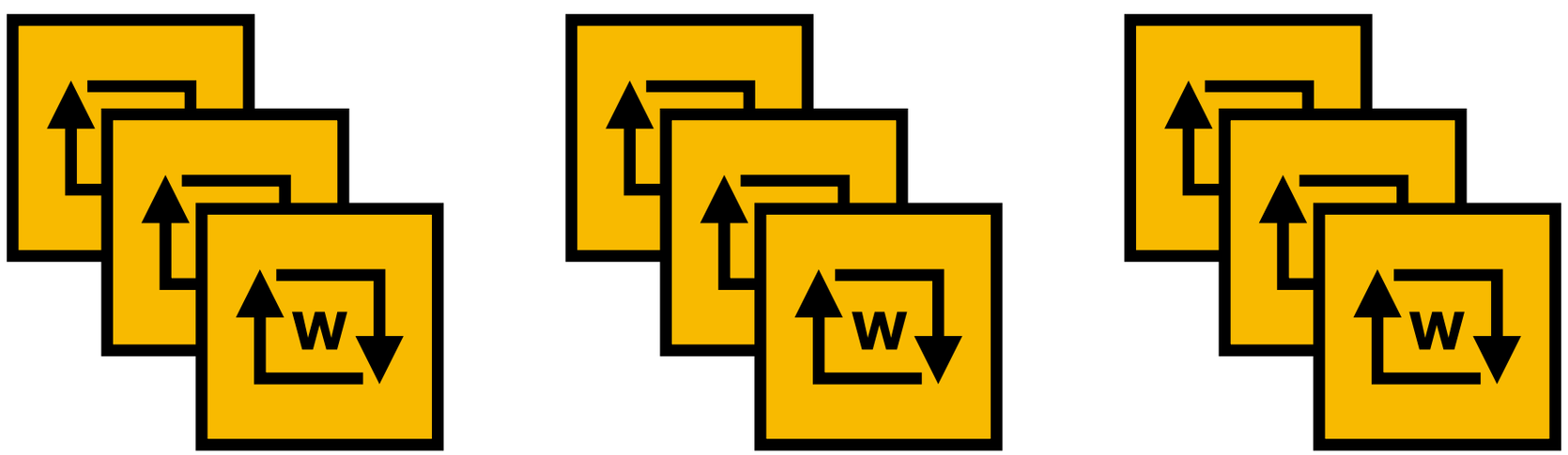

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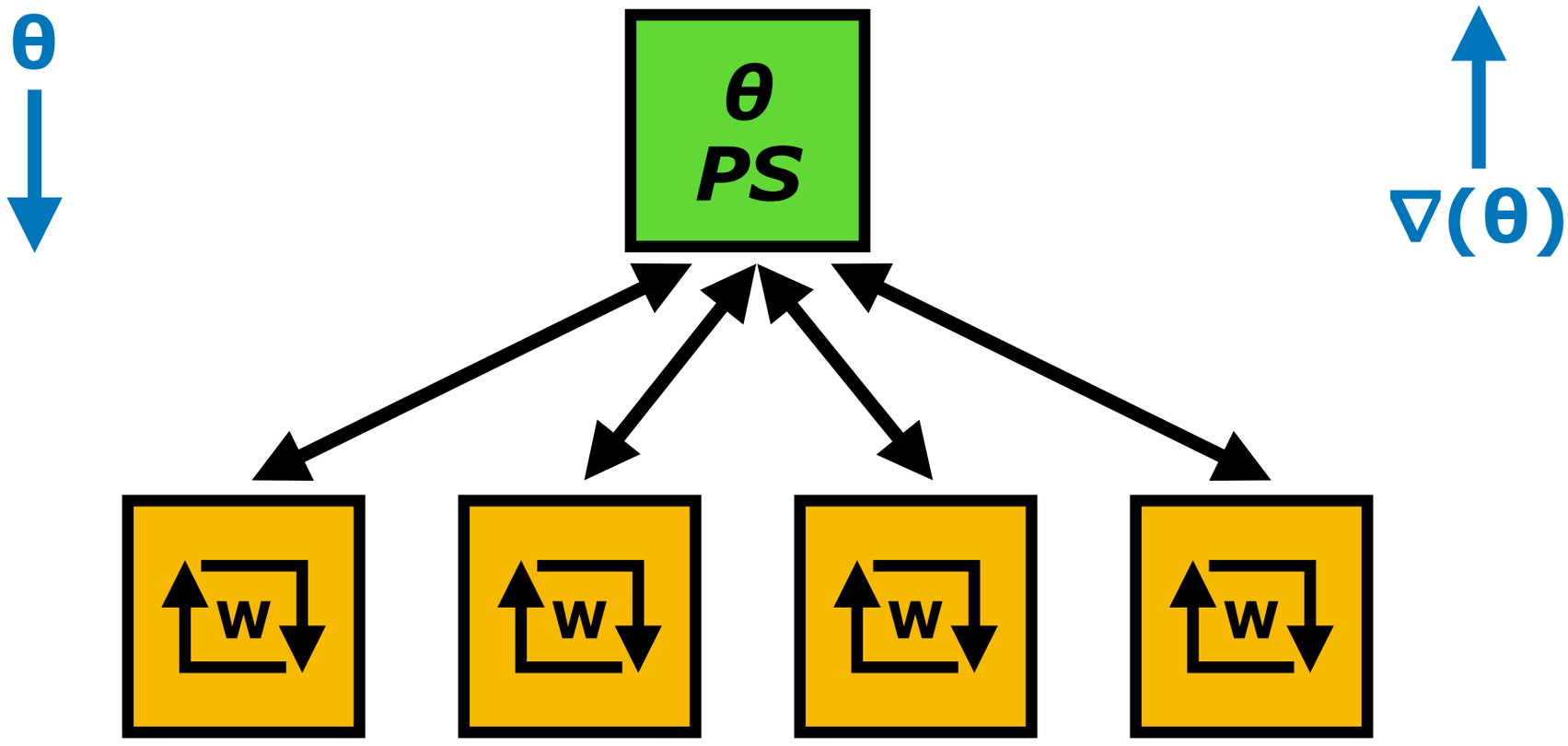
Asynchronous Stochastic Gradient Descent

(Parameter Server)



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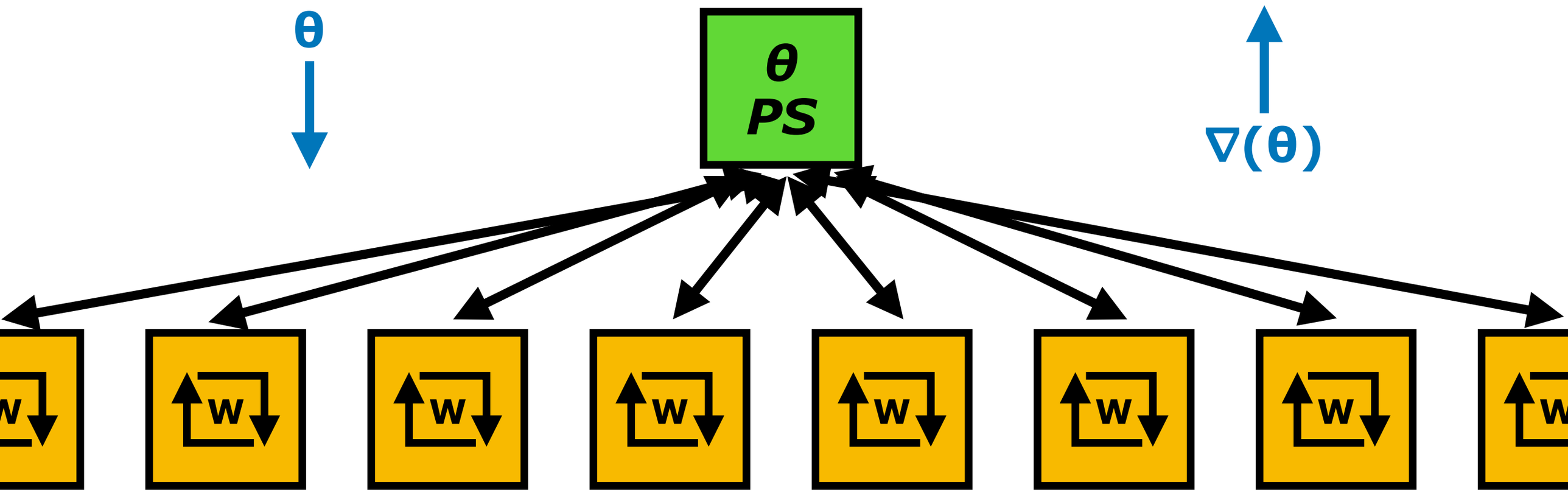

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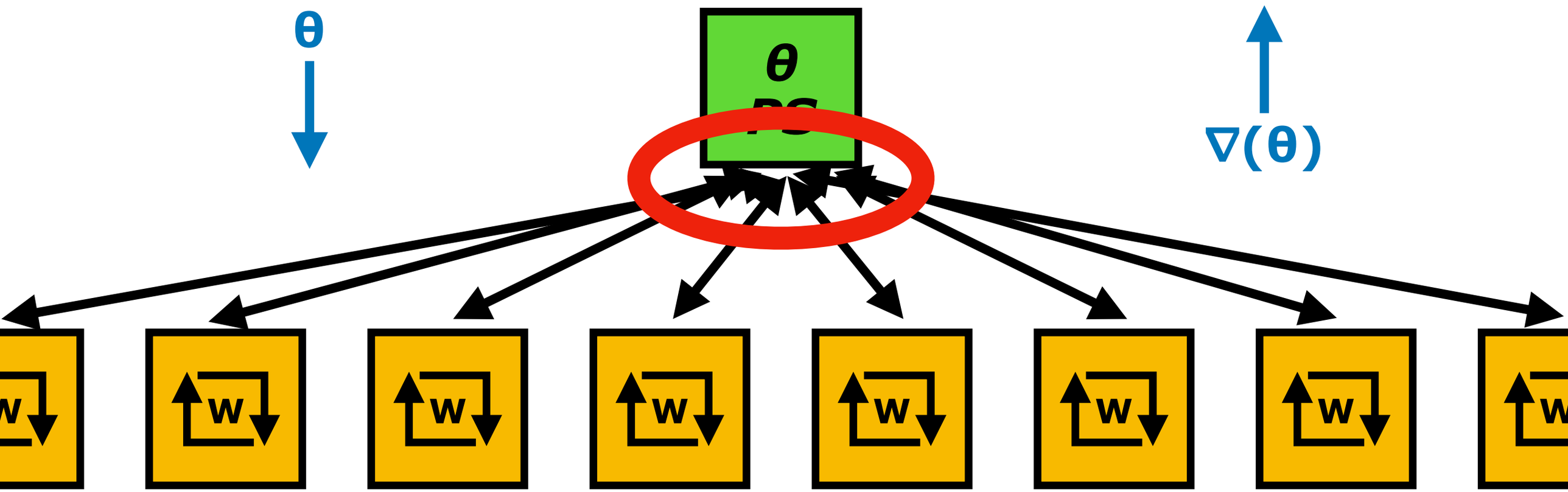
Asynchronous Stochastic Gradient Descent

(Parameter Server)



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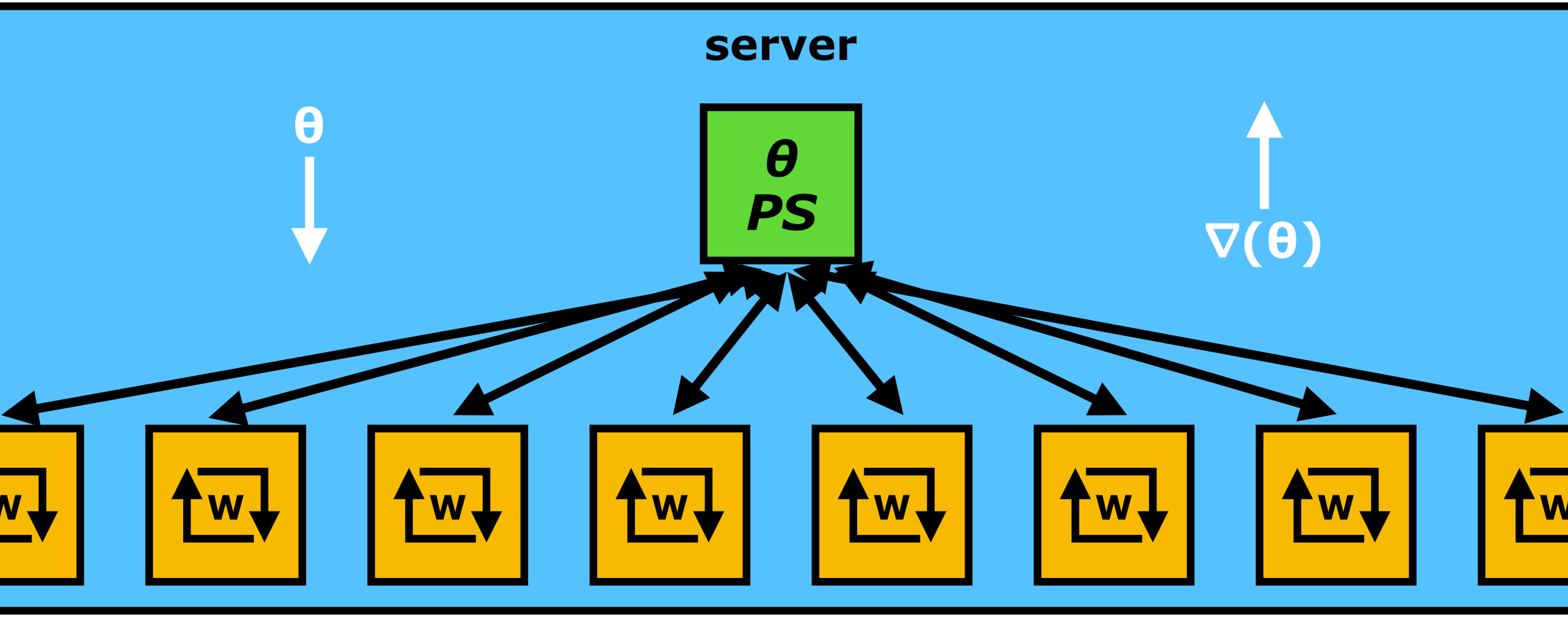
Asynchronous Stochastic Gradient Descent

(Parameter Server)



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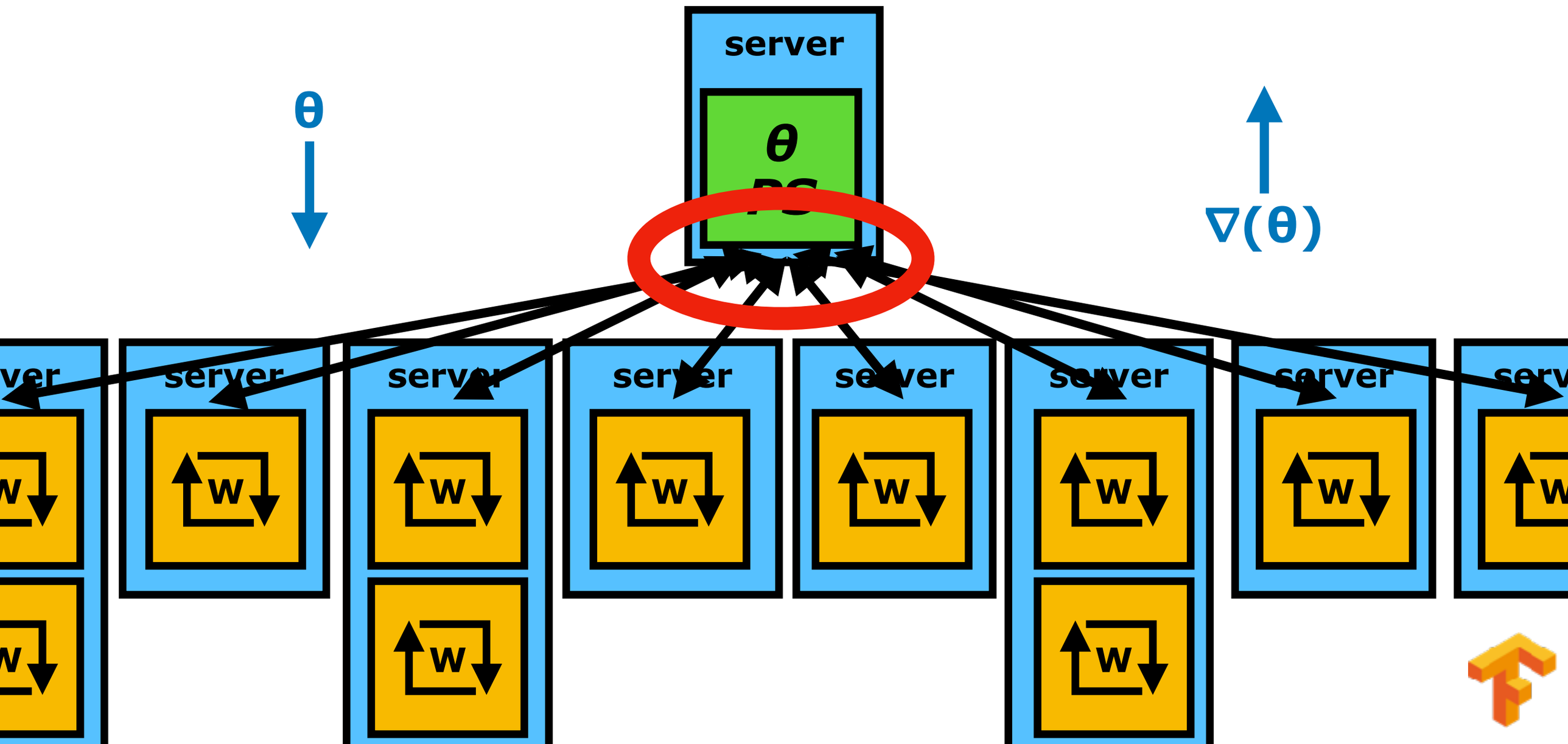
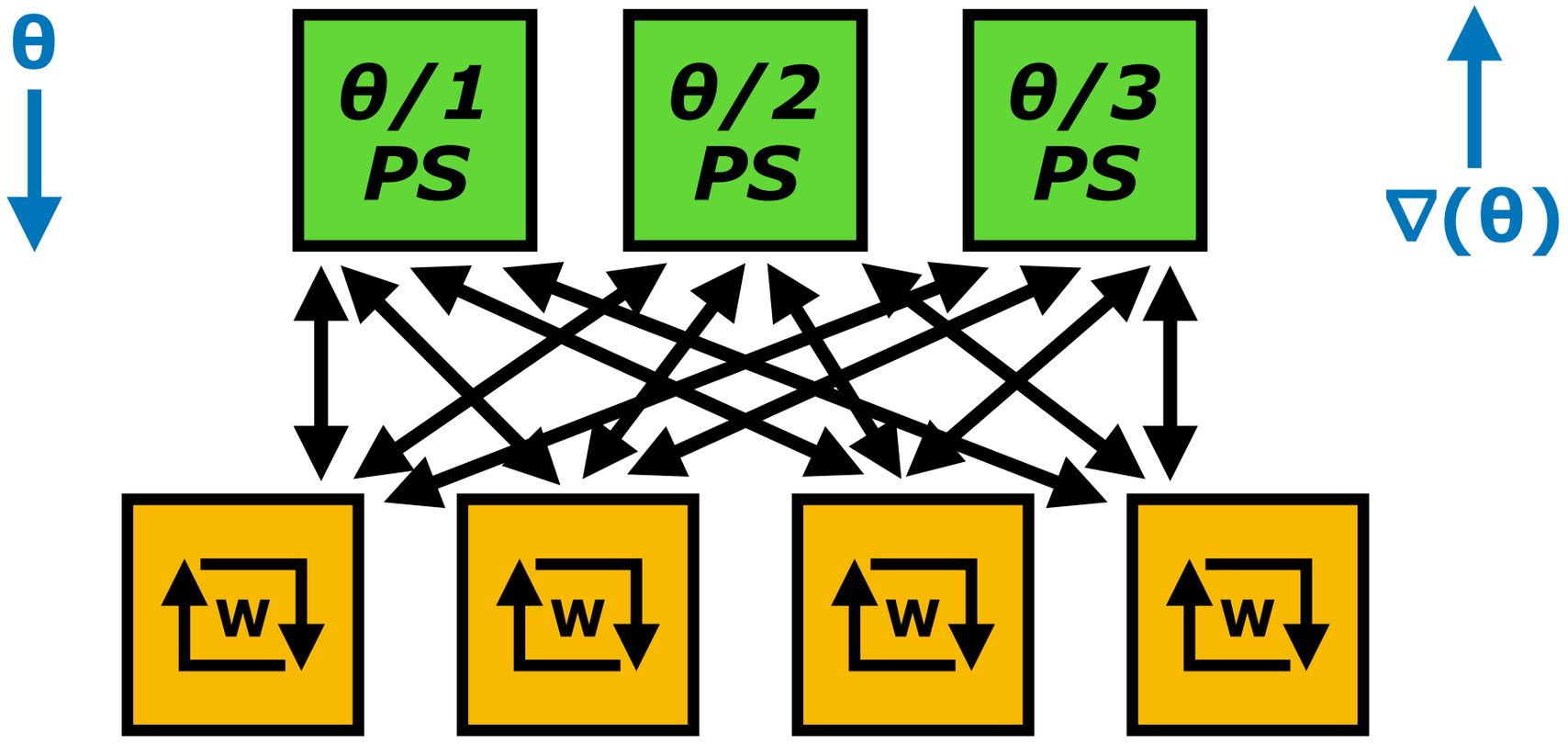
Asynchronous Stochastic Gradient Descent

(Parameter Server)



Asynchronous Stochastic Gradient Descent

(Parameter Server Cluster)



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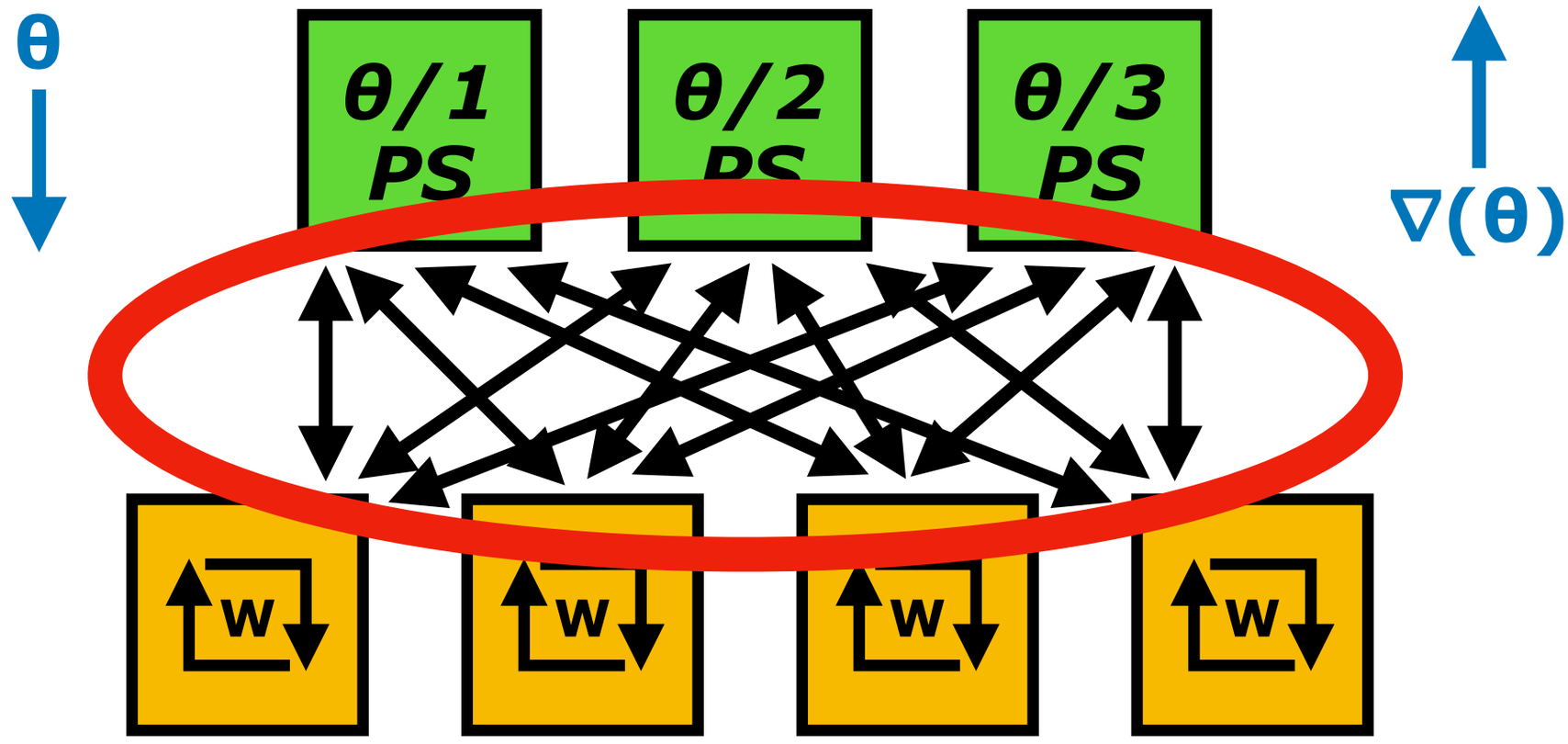
Asynchronous Stochastic Gradient Descent

(Parameter Server Cluster)



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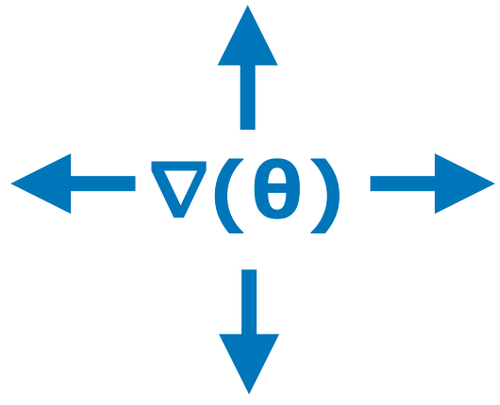
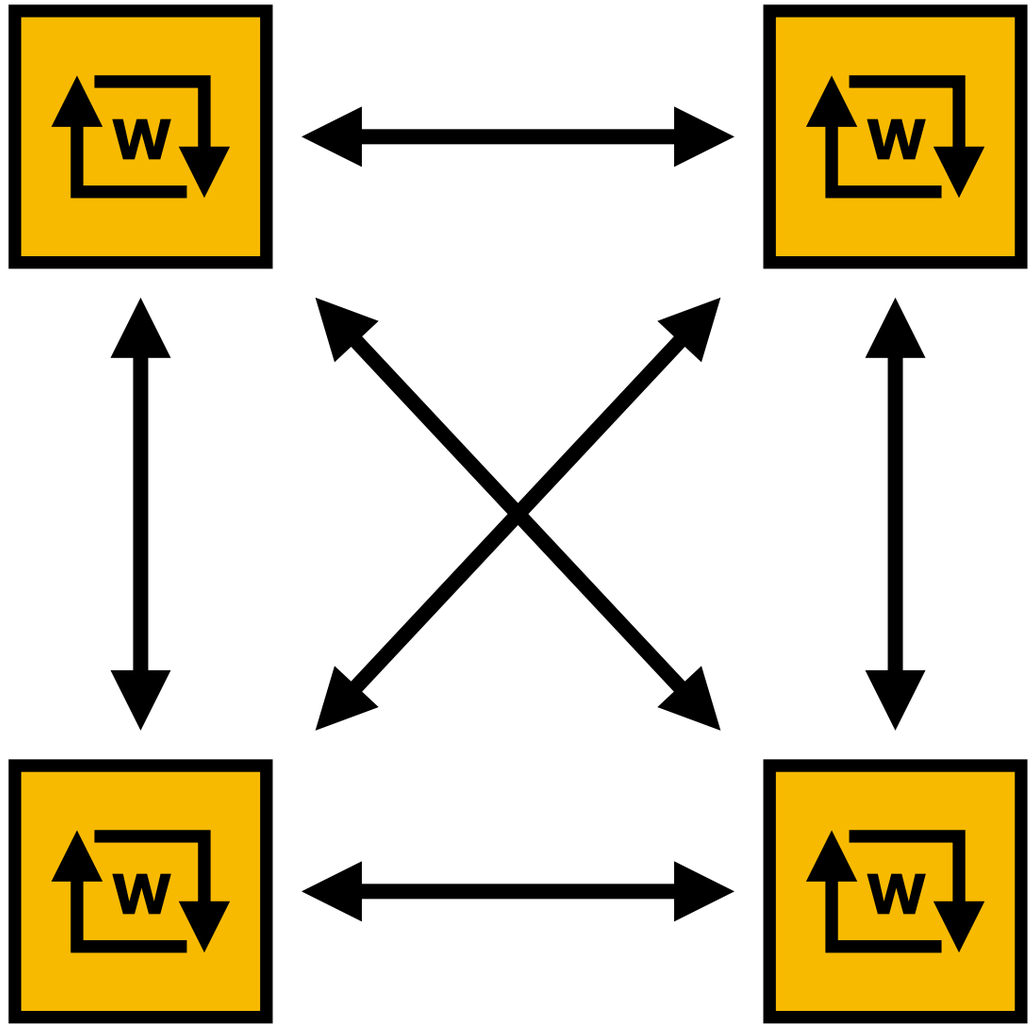
Synchronous Allreduce





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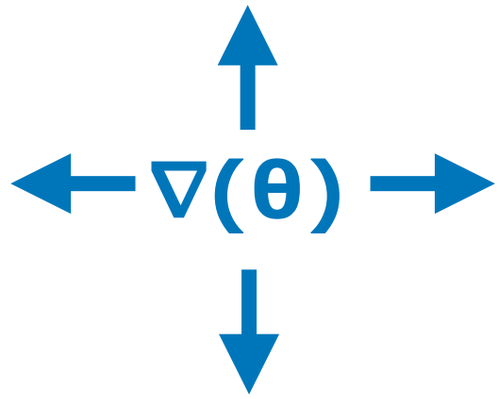

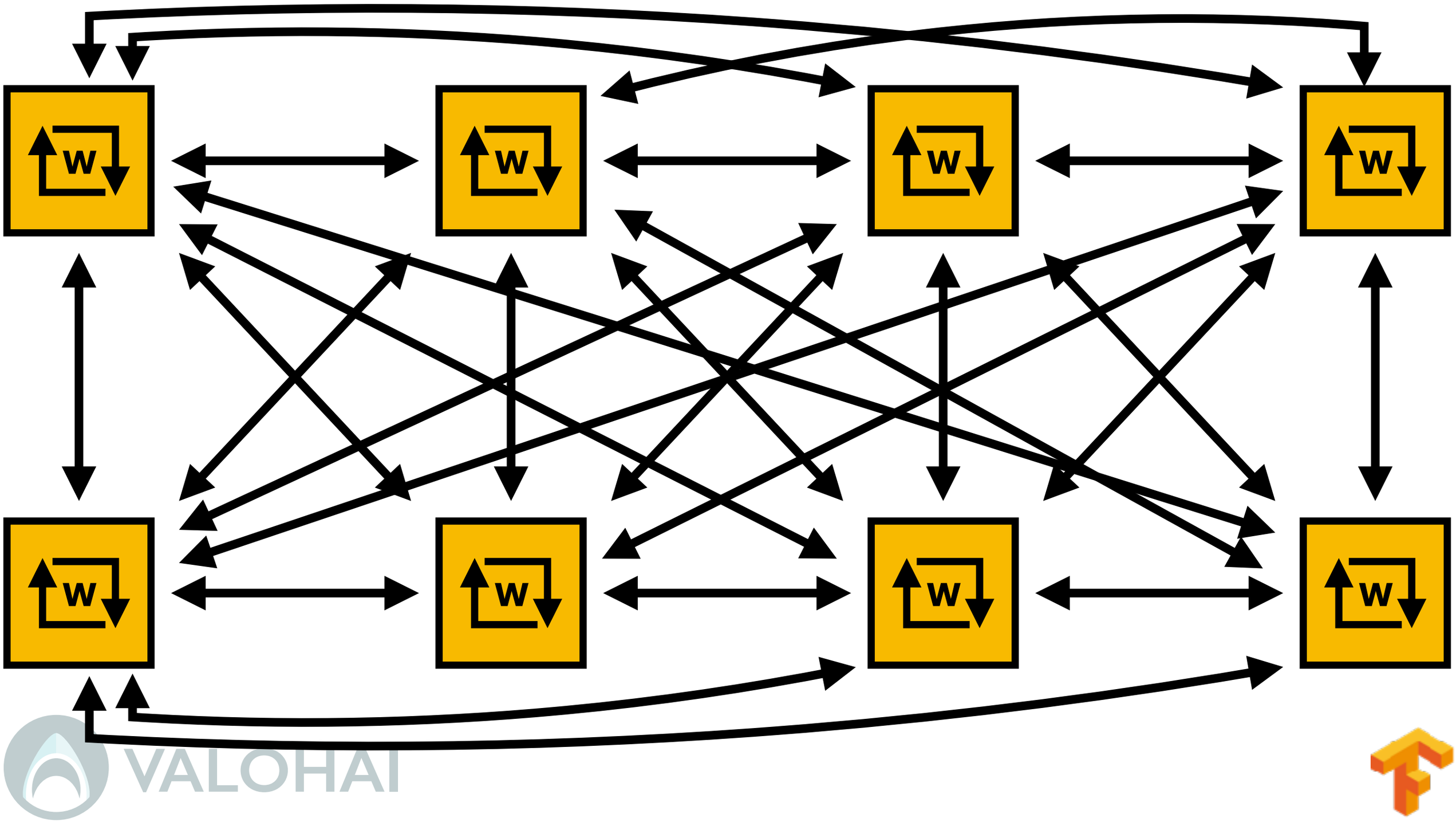

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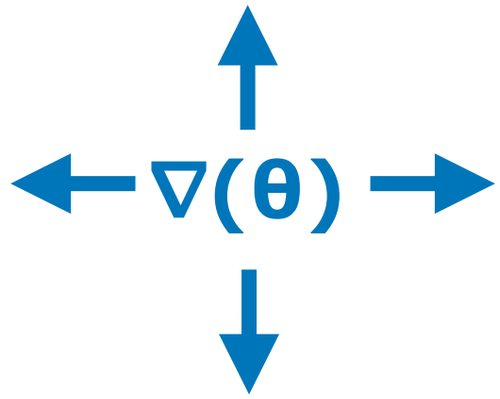

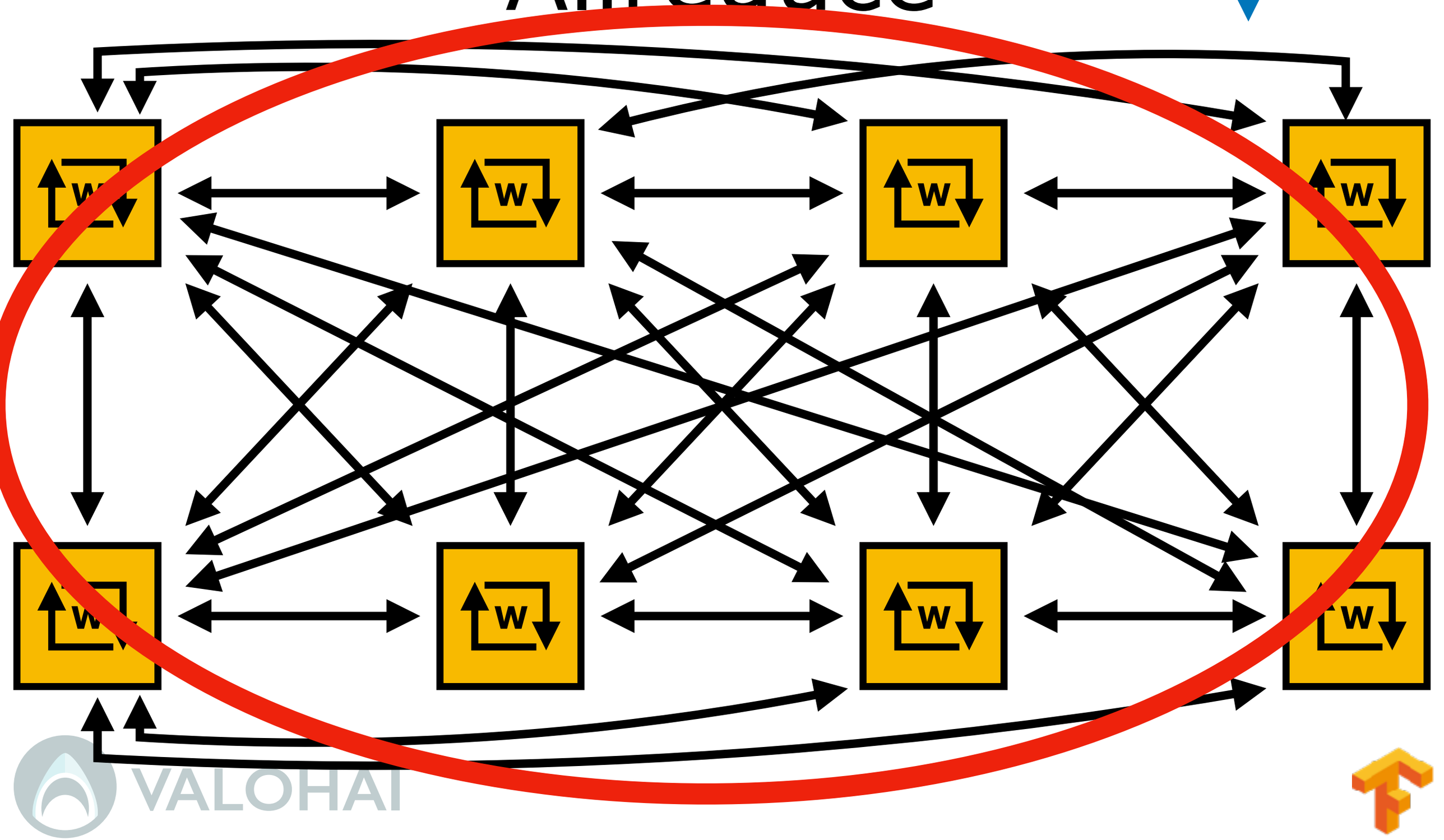

VALOHAI

Butterfly Allreduce

VALOHAI

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Worker 1 0

Worker 2 1

Worker 3 2

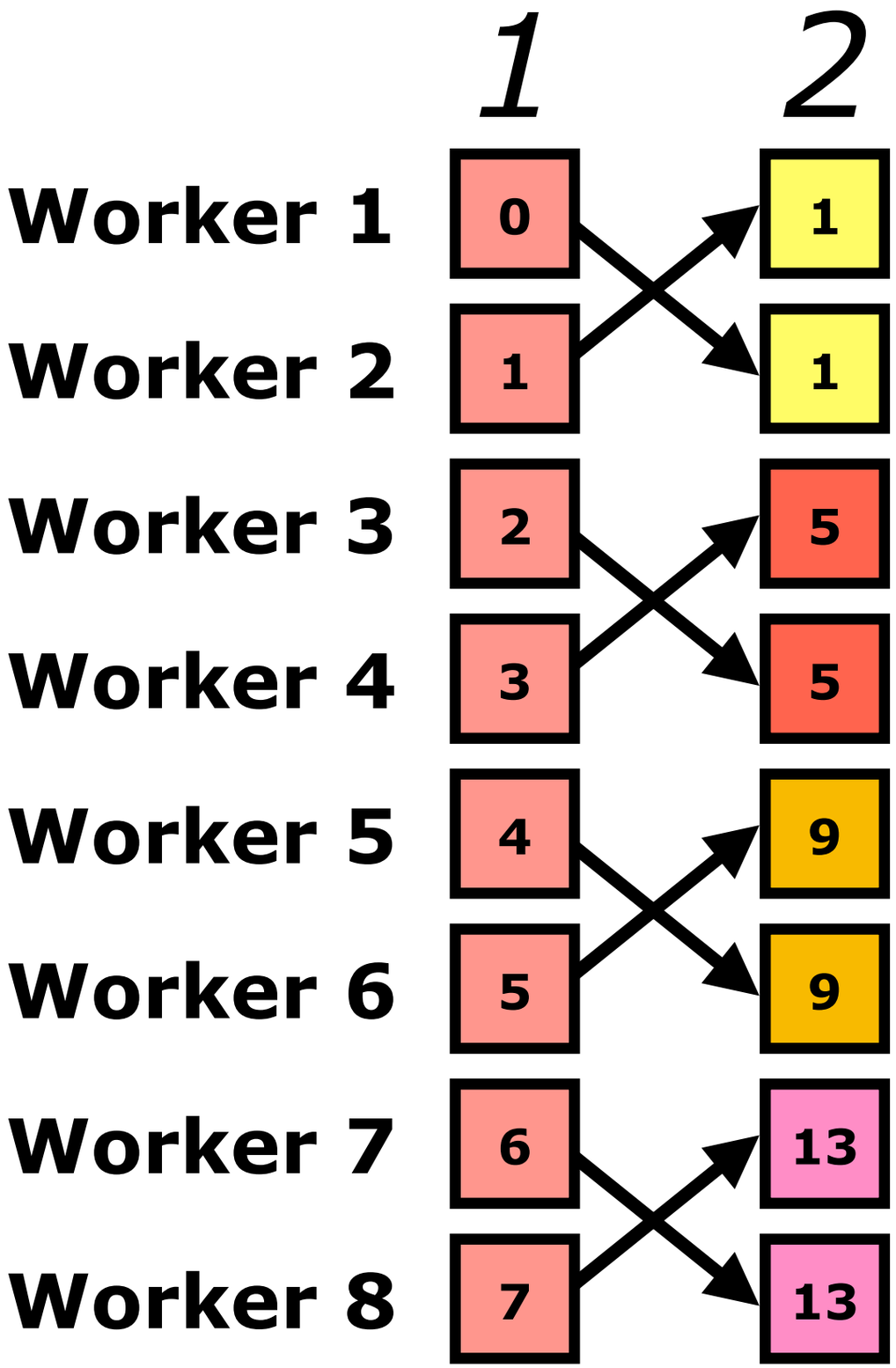
Worker 4 3

Worker 5 4

Worker 6 5

Worker 7 6

Worker 8 7



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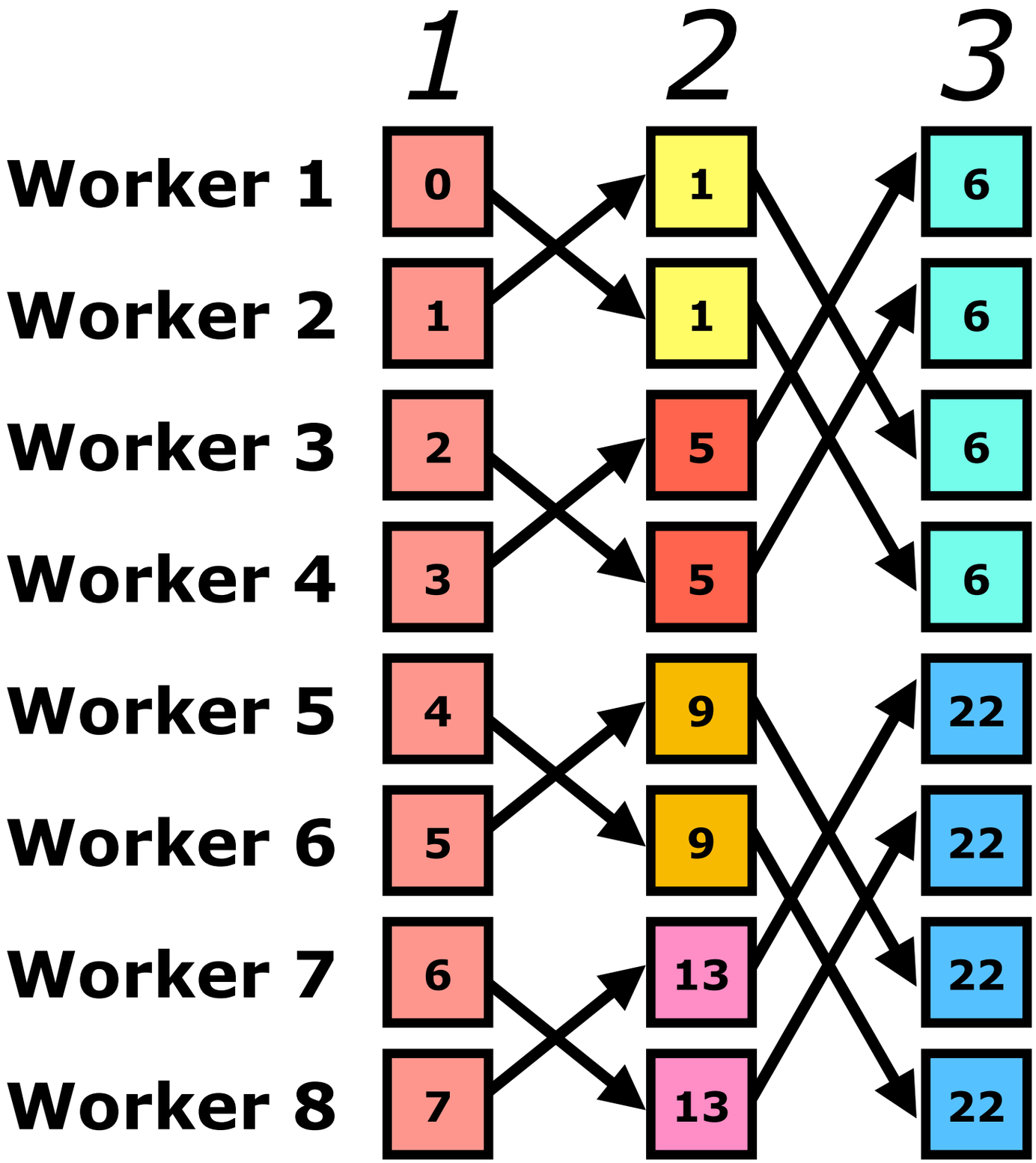
How Butterfly Allreduce Works



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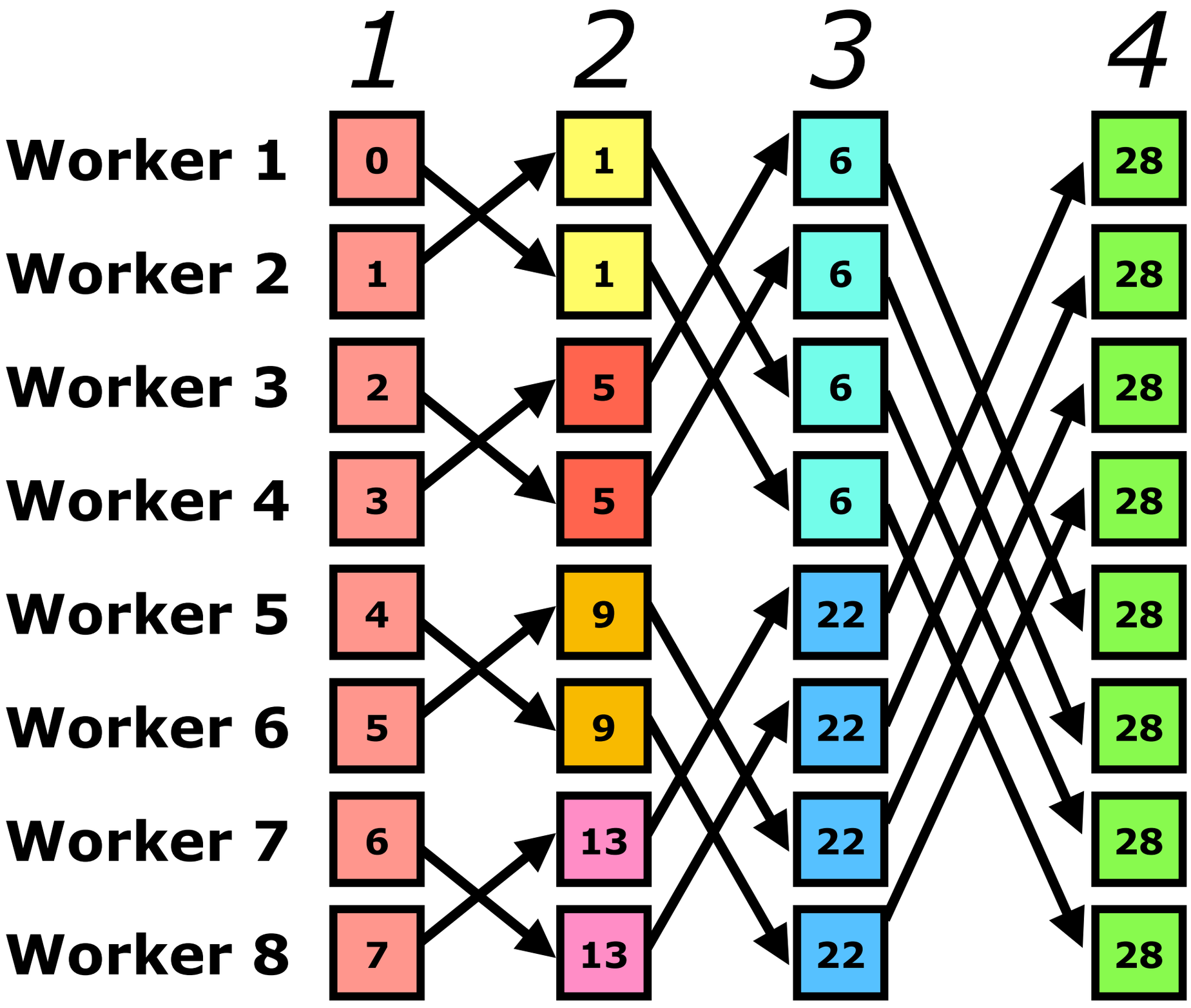
How Butterfly Allreduce Works



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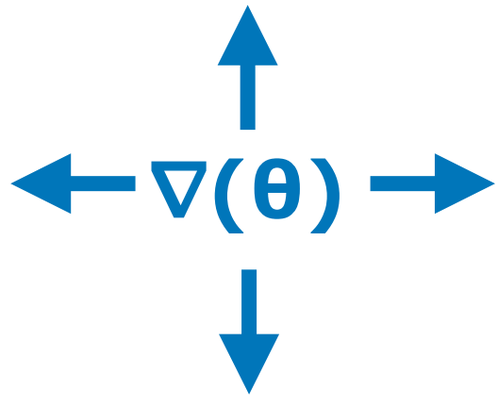
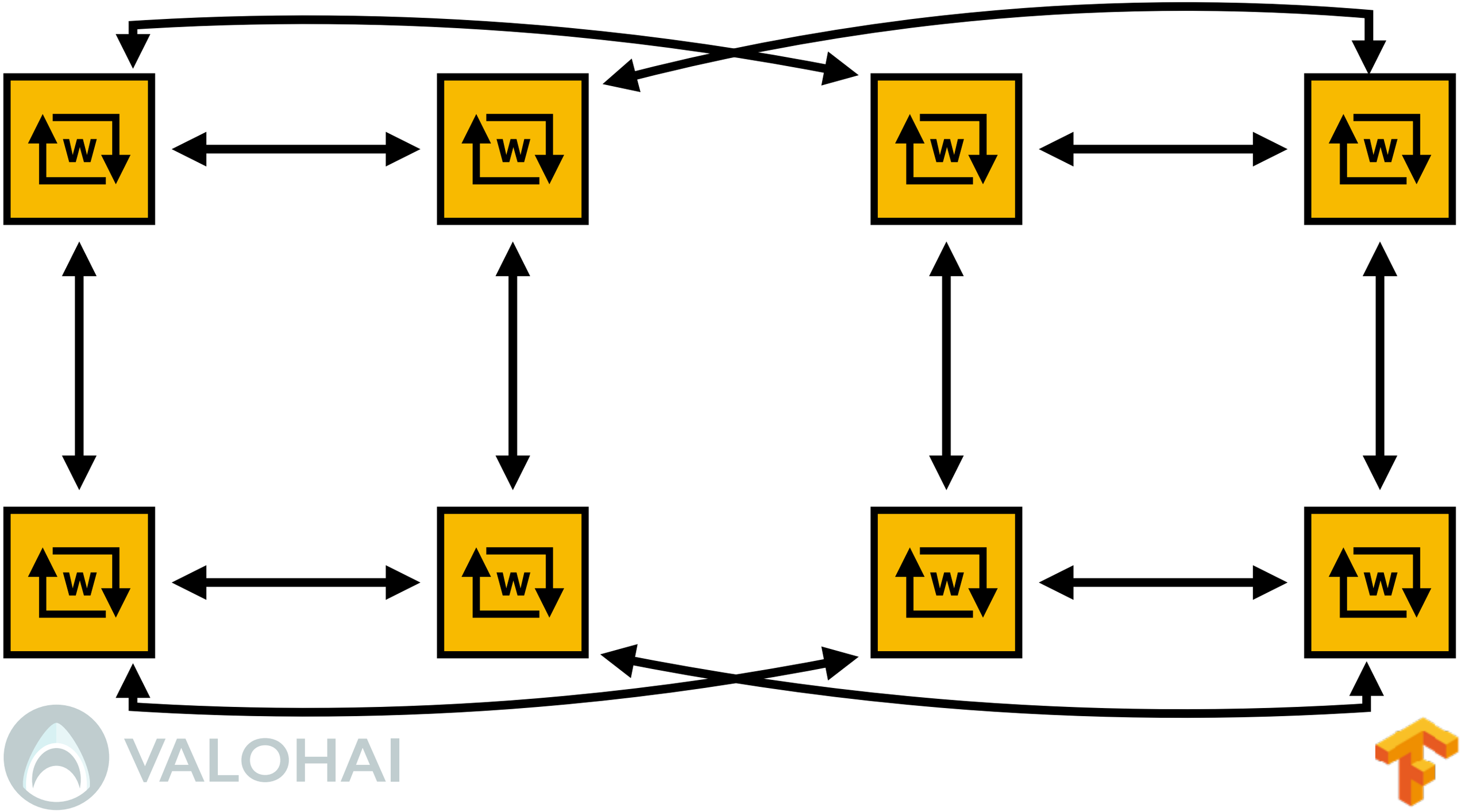
How Butterfly Allreduce Works

Butterfly Allreduce





VALOHAI

Ring Allreduce

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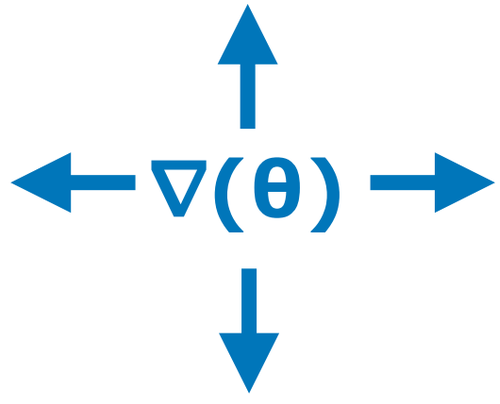
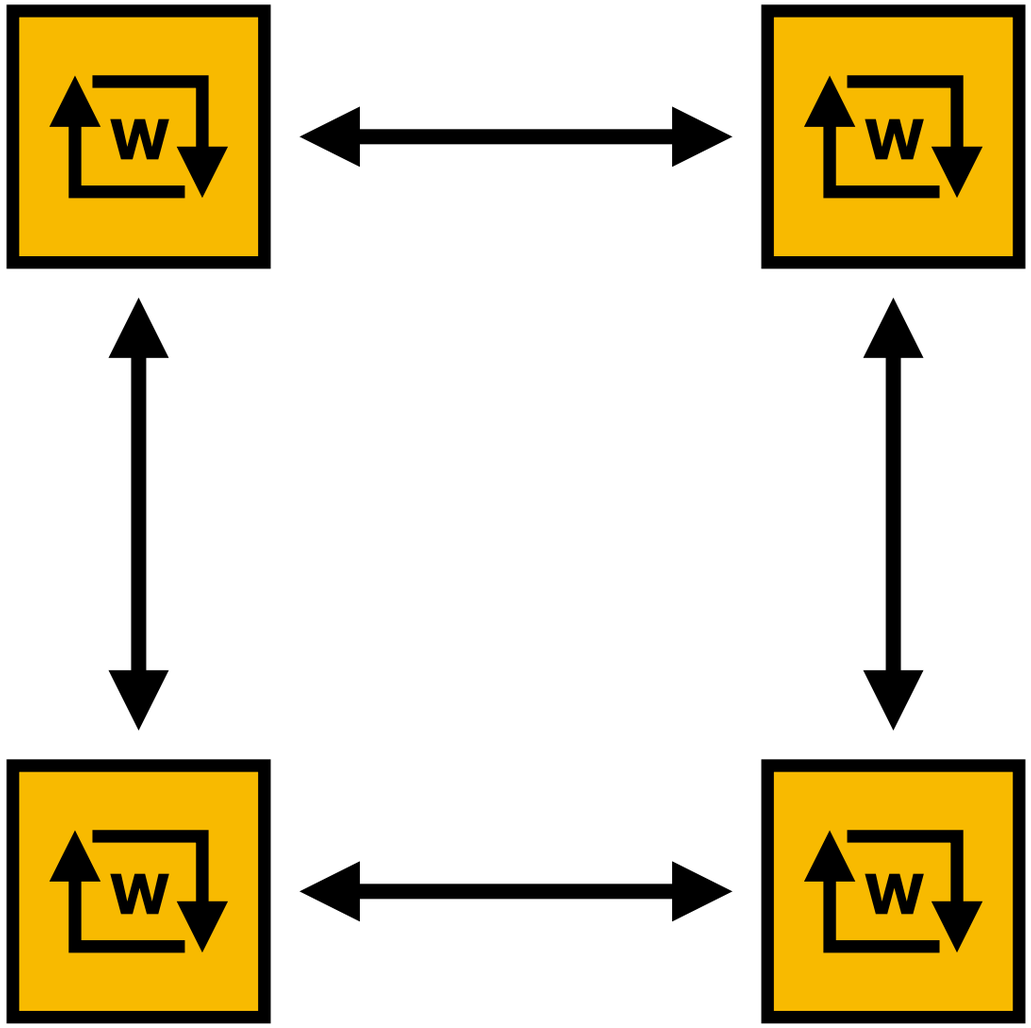
Ring Allreduce





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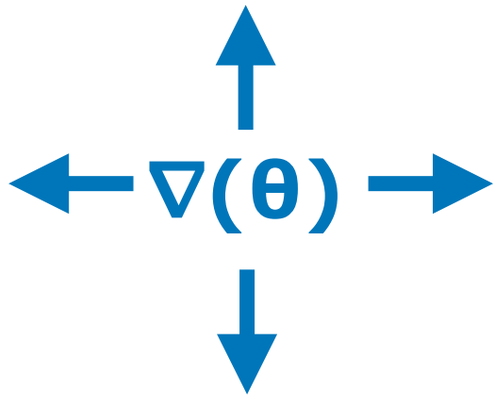
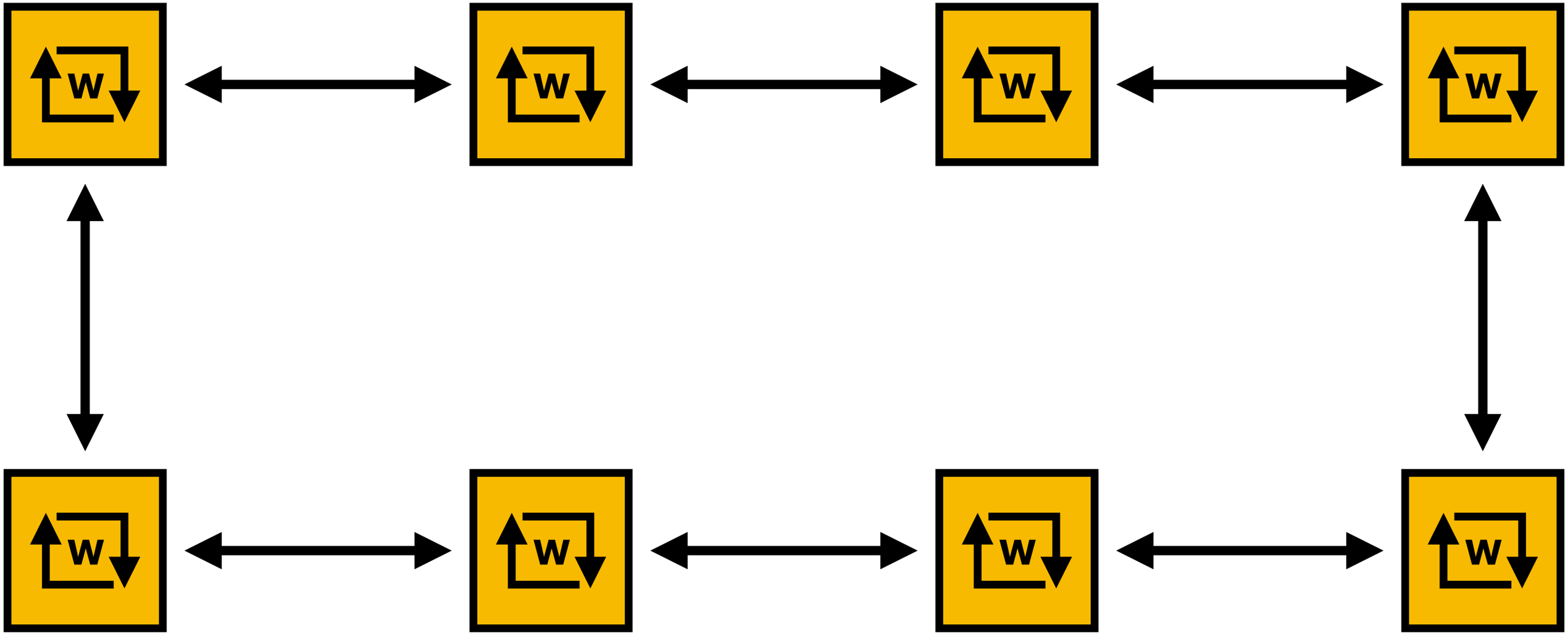
Ring Allreduce





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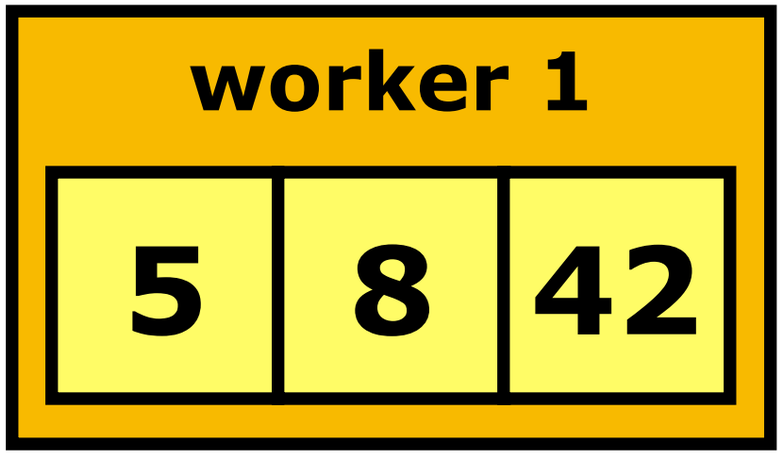
HOROVOD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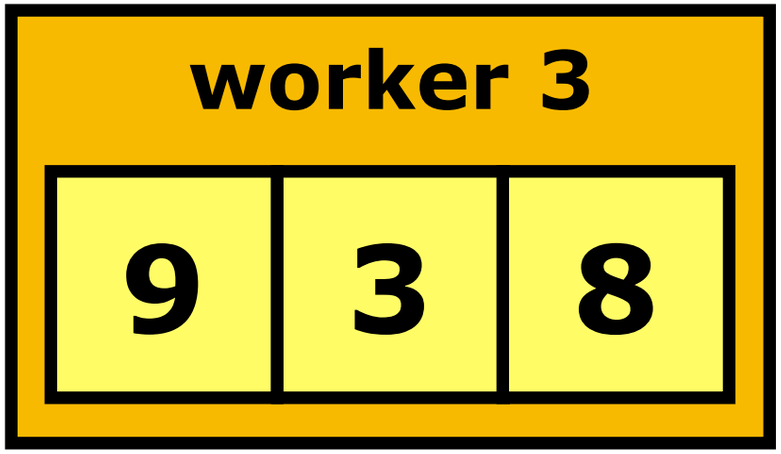
worker 3
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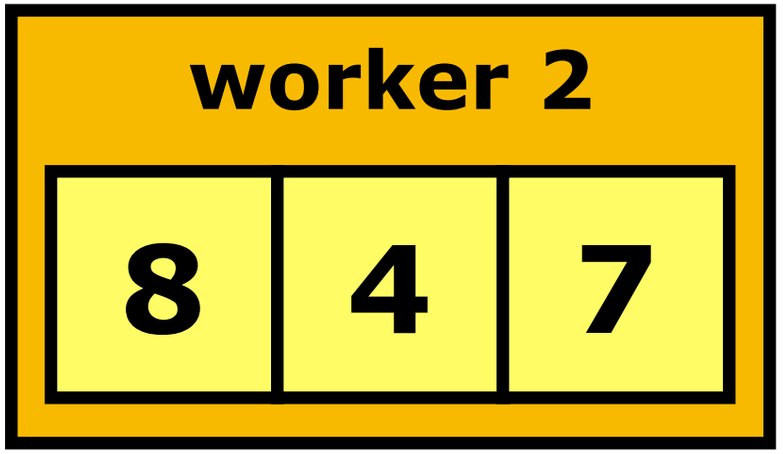
worker 2
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4
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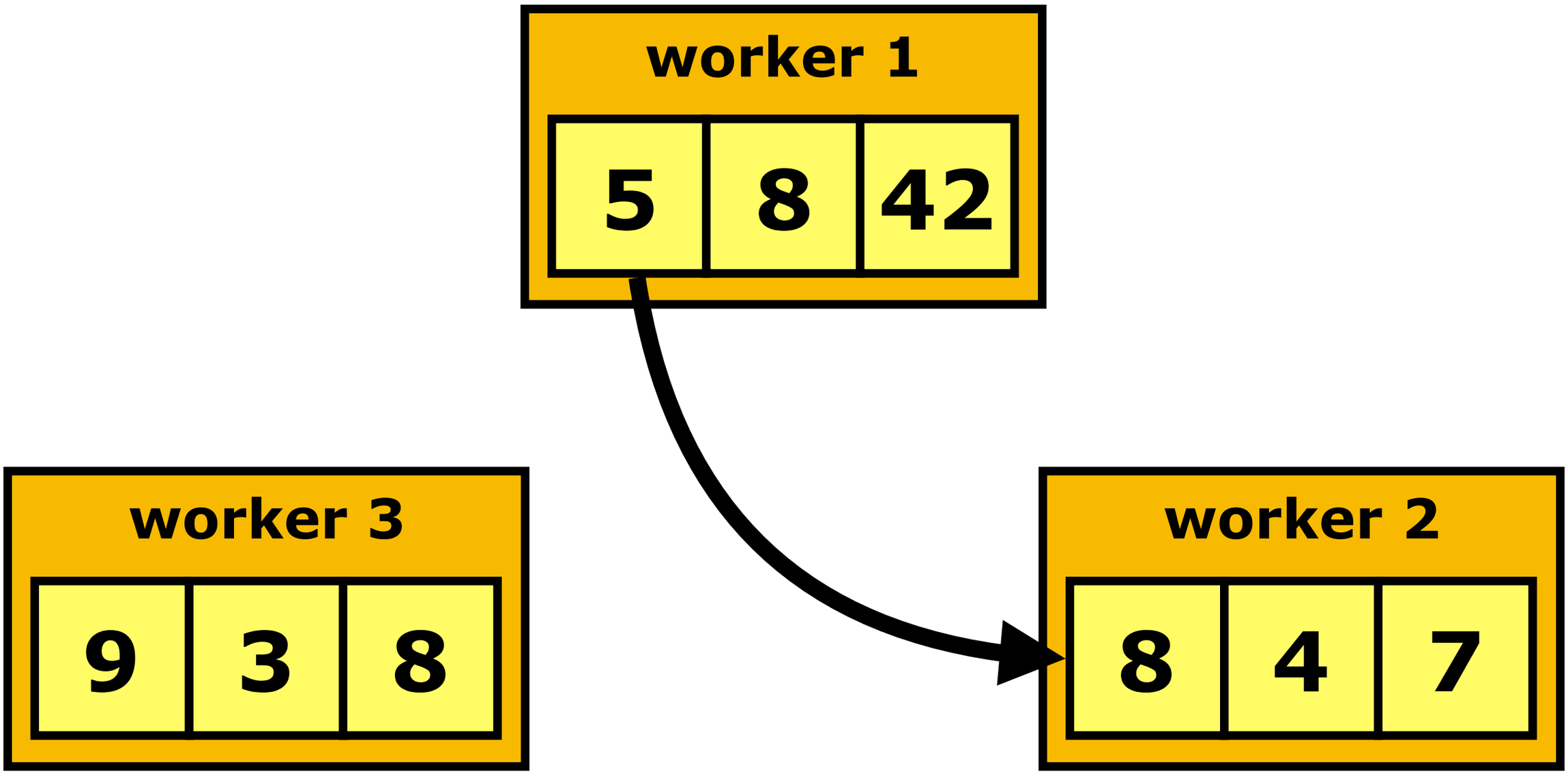
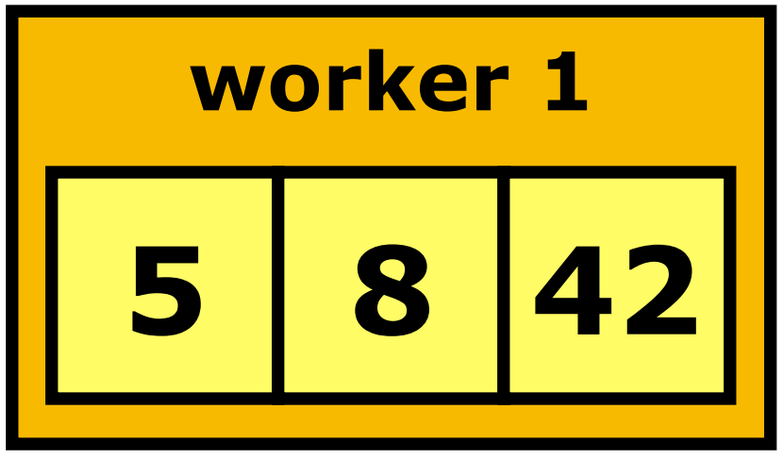
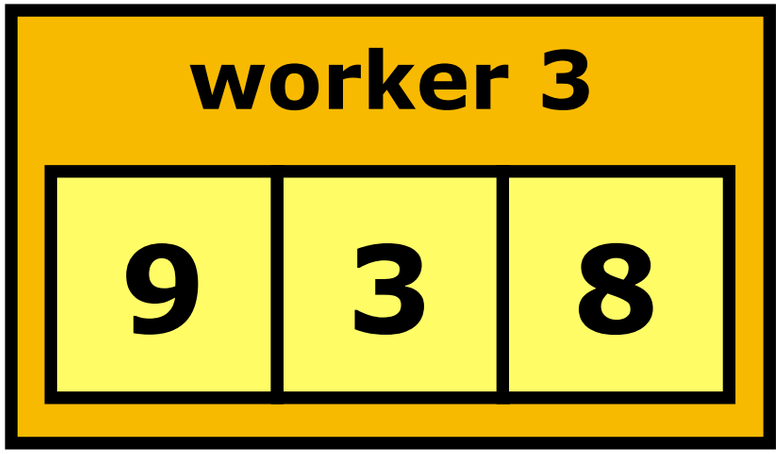
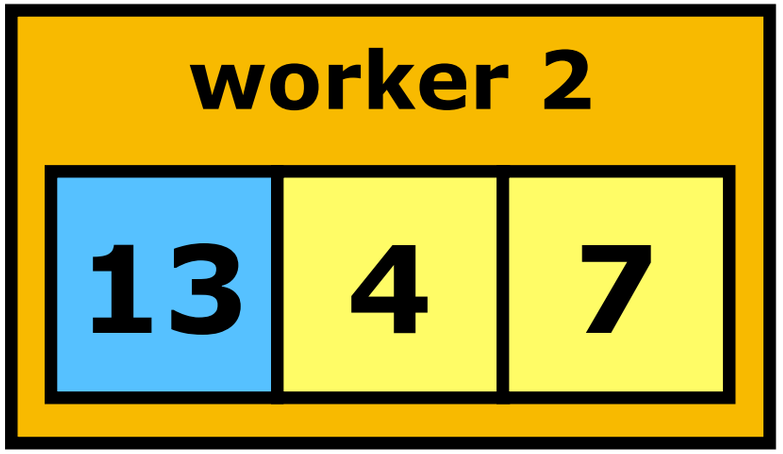


VALOHAI

How Ring Allreduce Works







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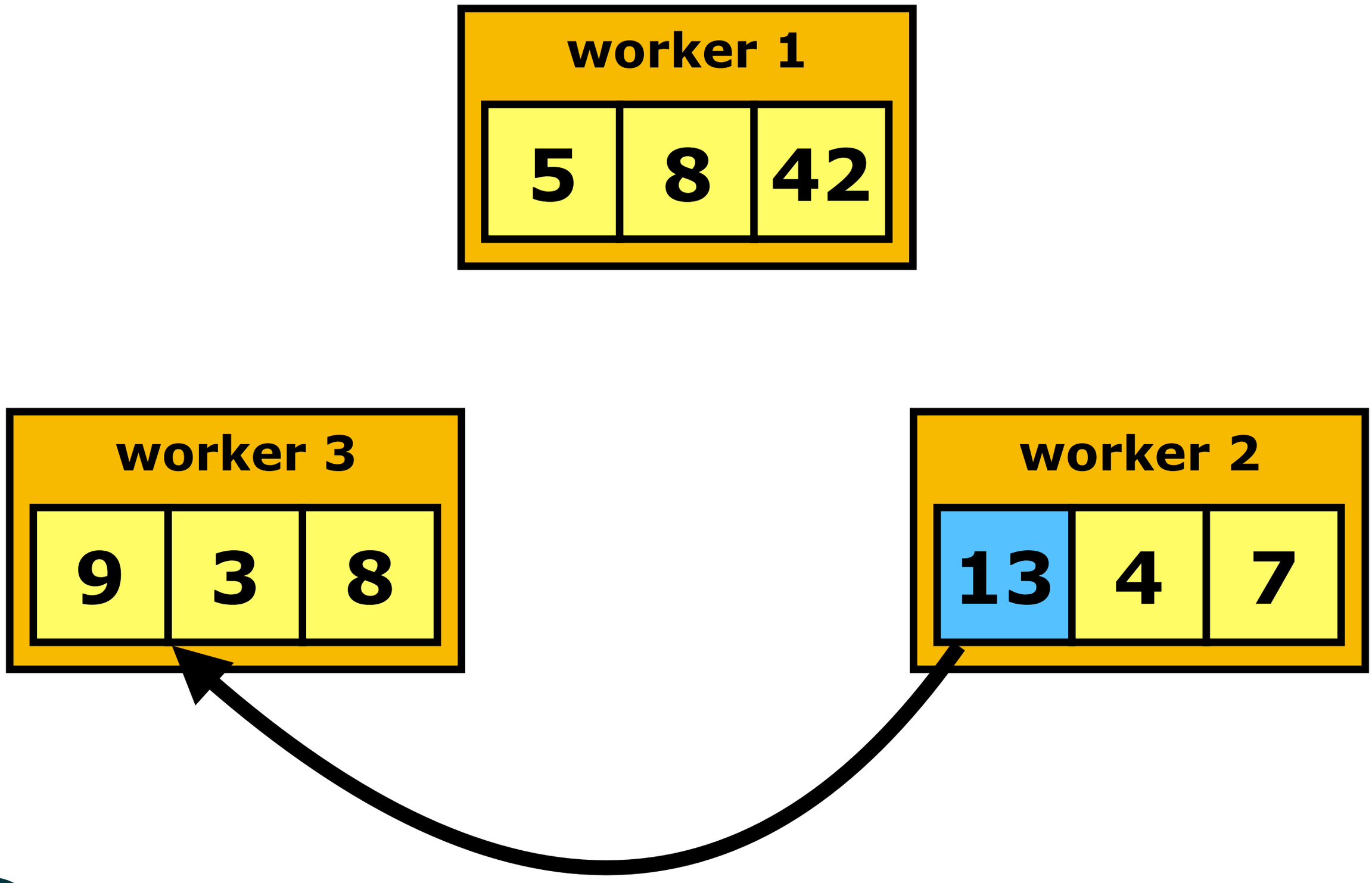
How Ring Allreduce Works



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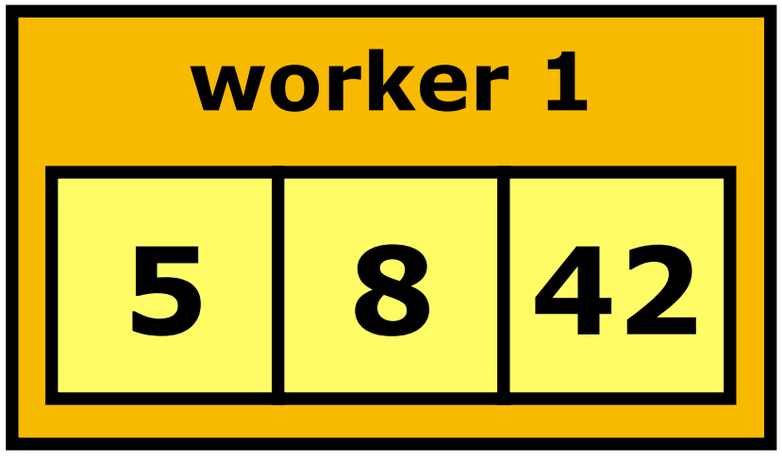
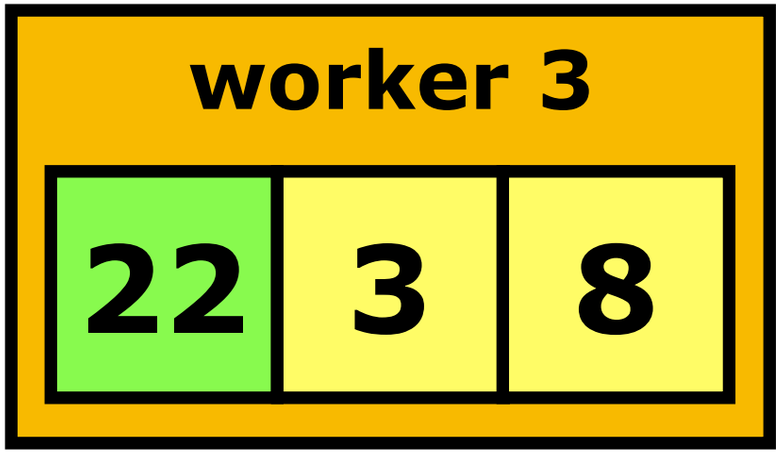
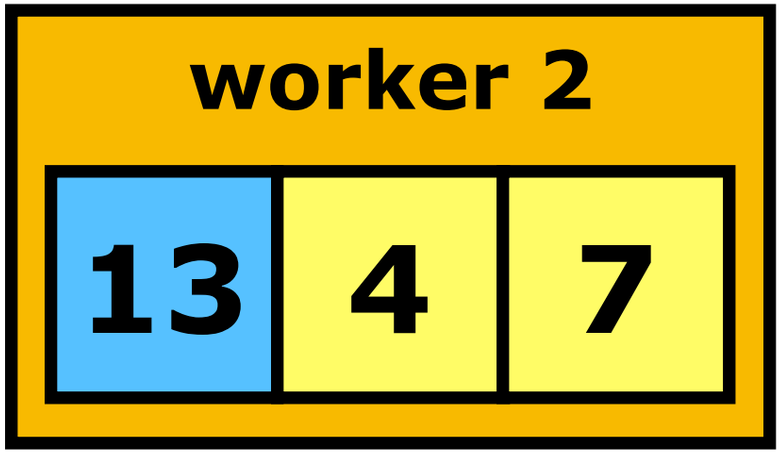
How Ring Allreduce Works







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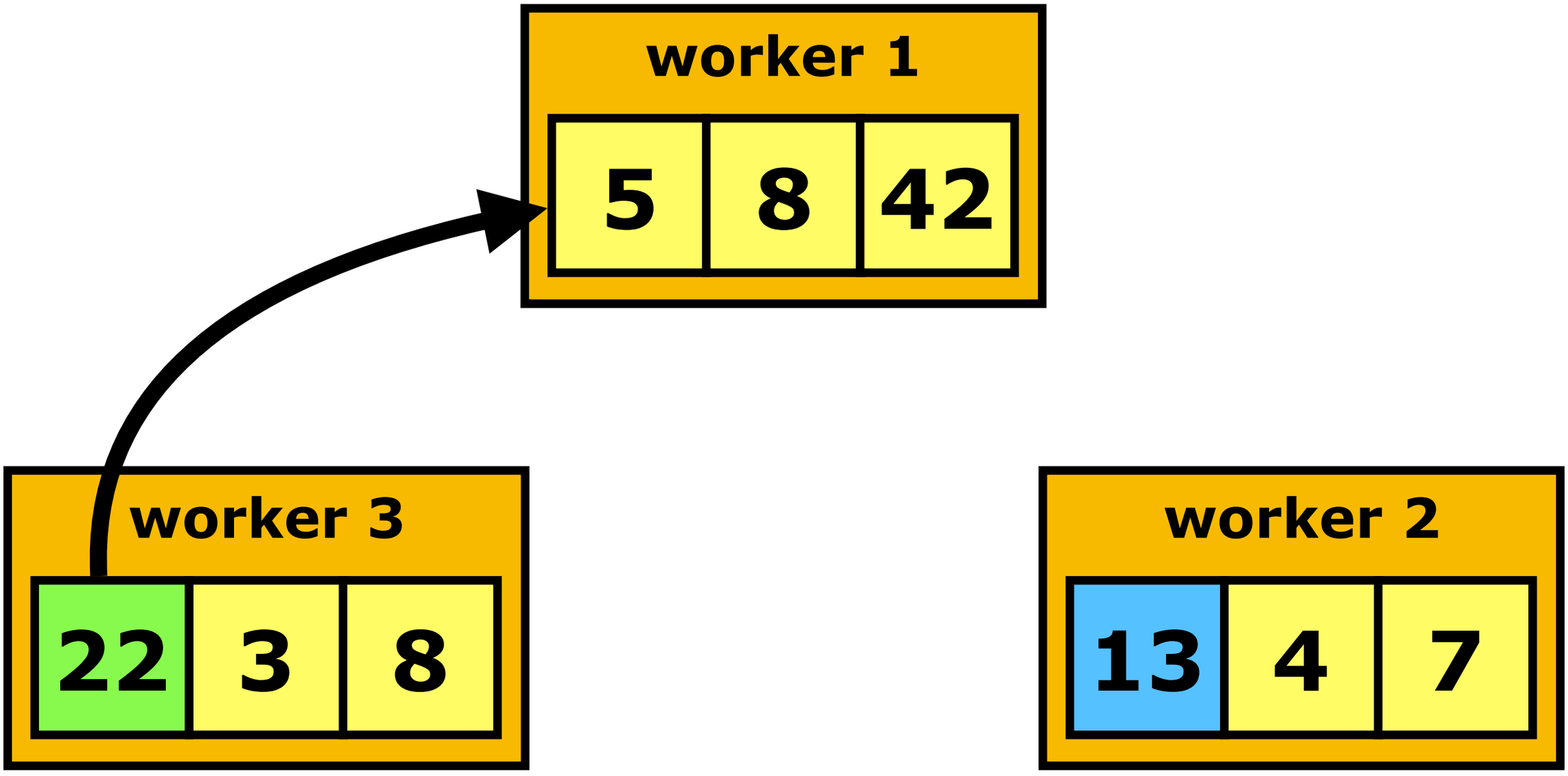
How Ring Allreduce Works



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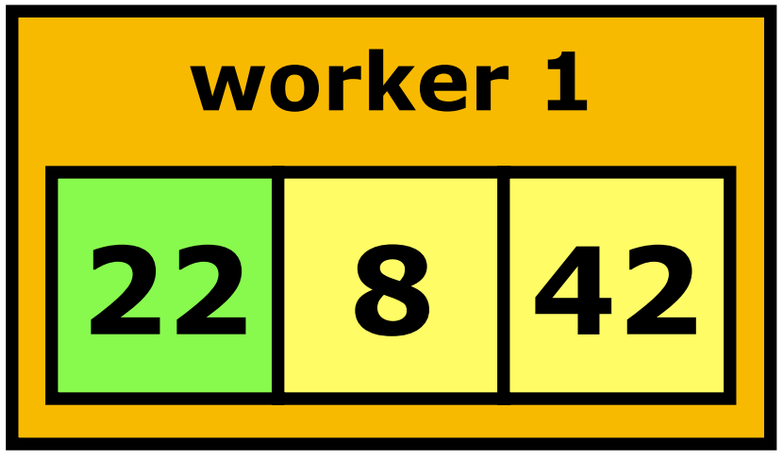
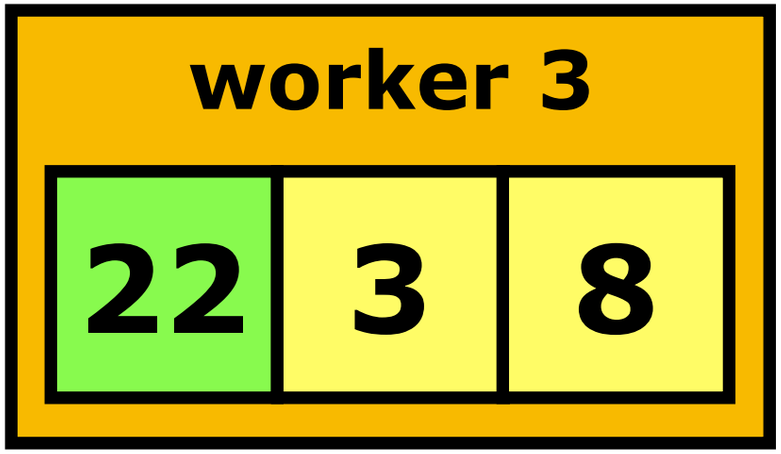
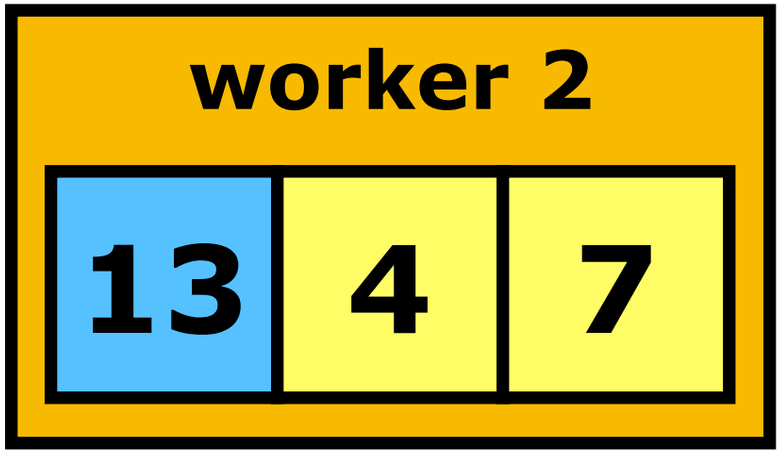
How Ring Allreduce Works







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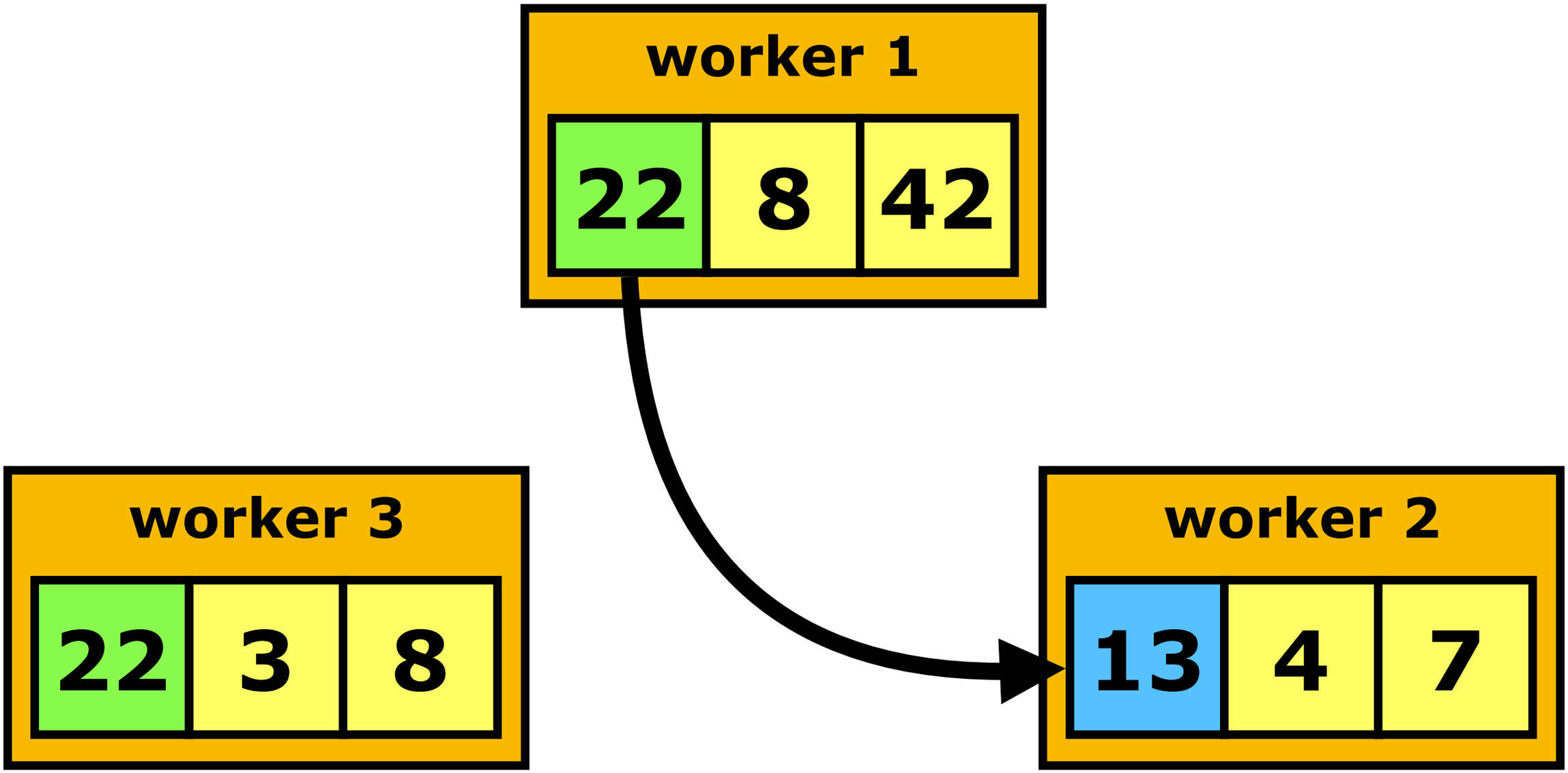

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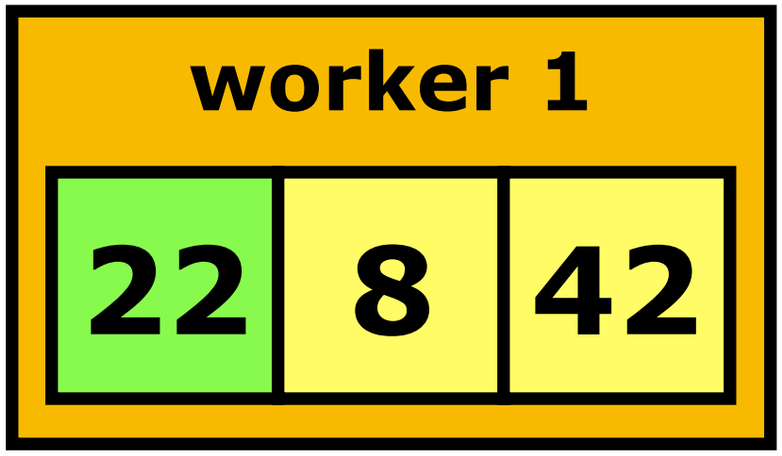
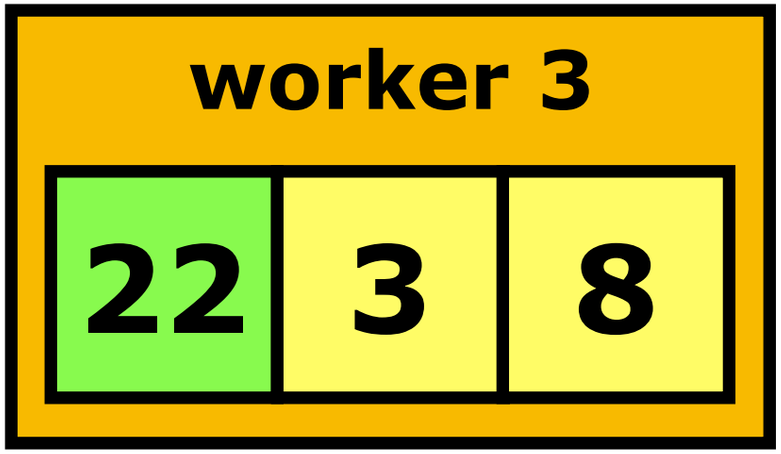
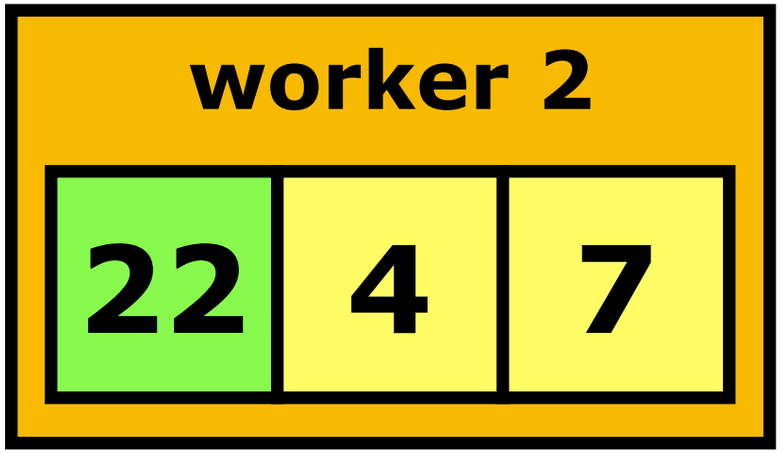
How Ring Allreduce Works







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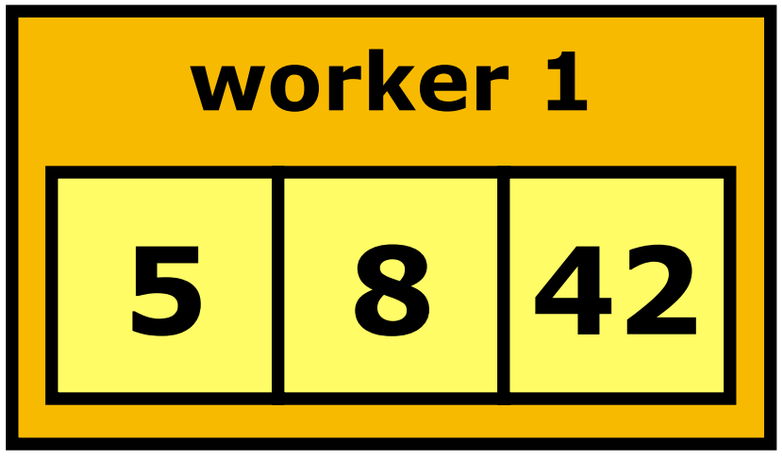
How Ring Allreduce Works


worker 1
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8
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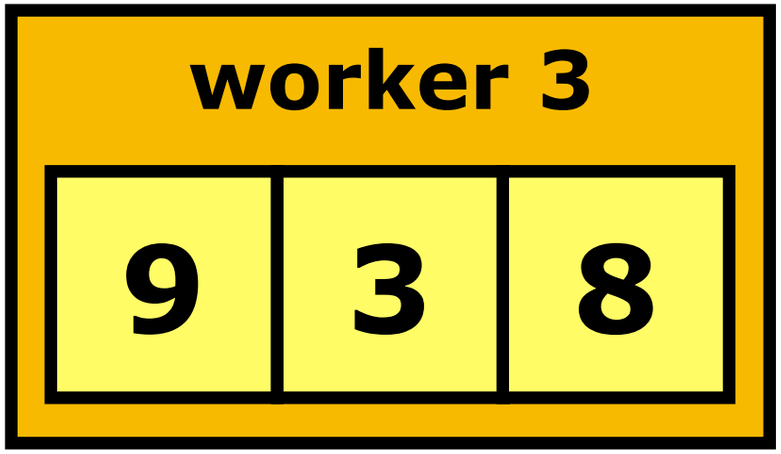
worker 3
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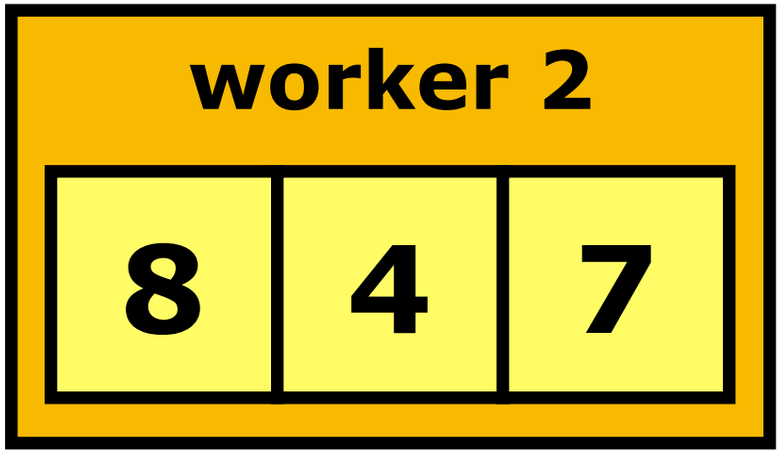
worker 2
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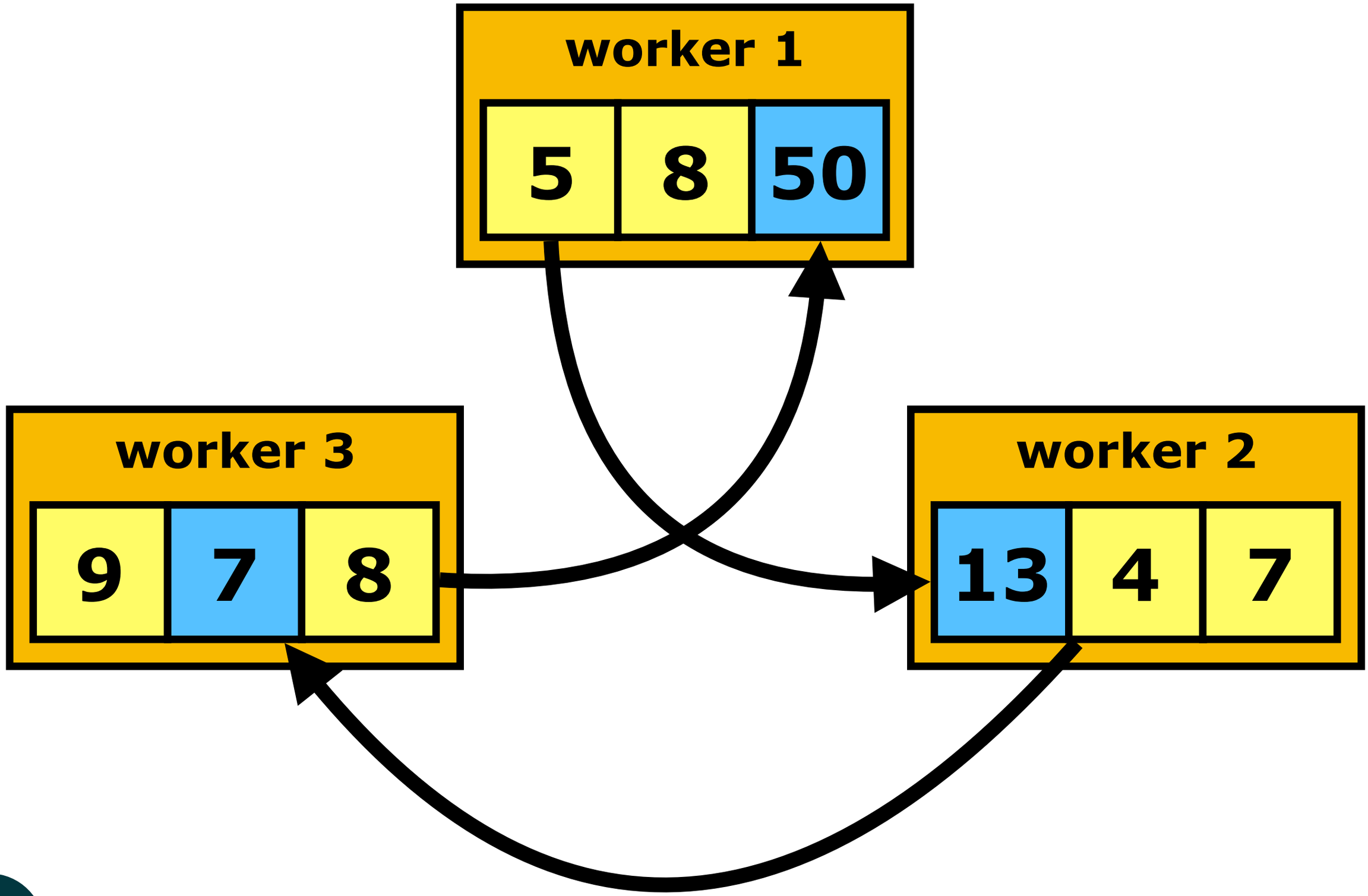

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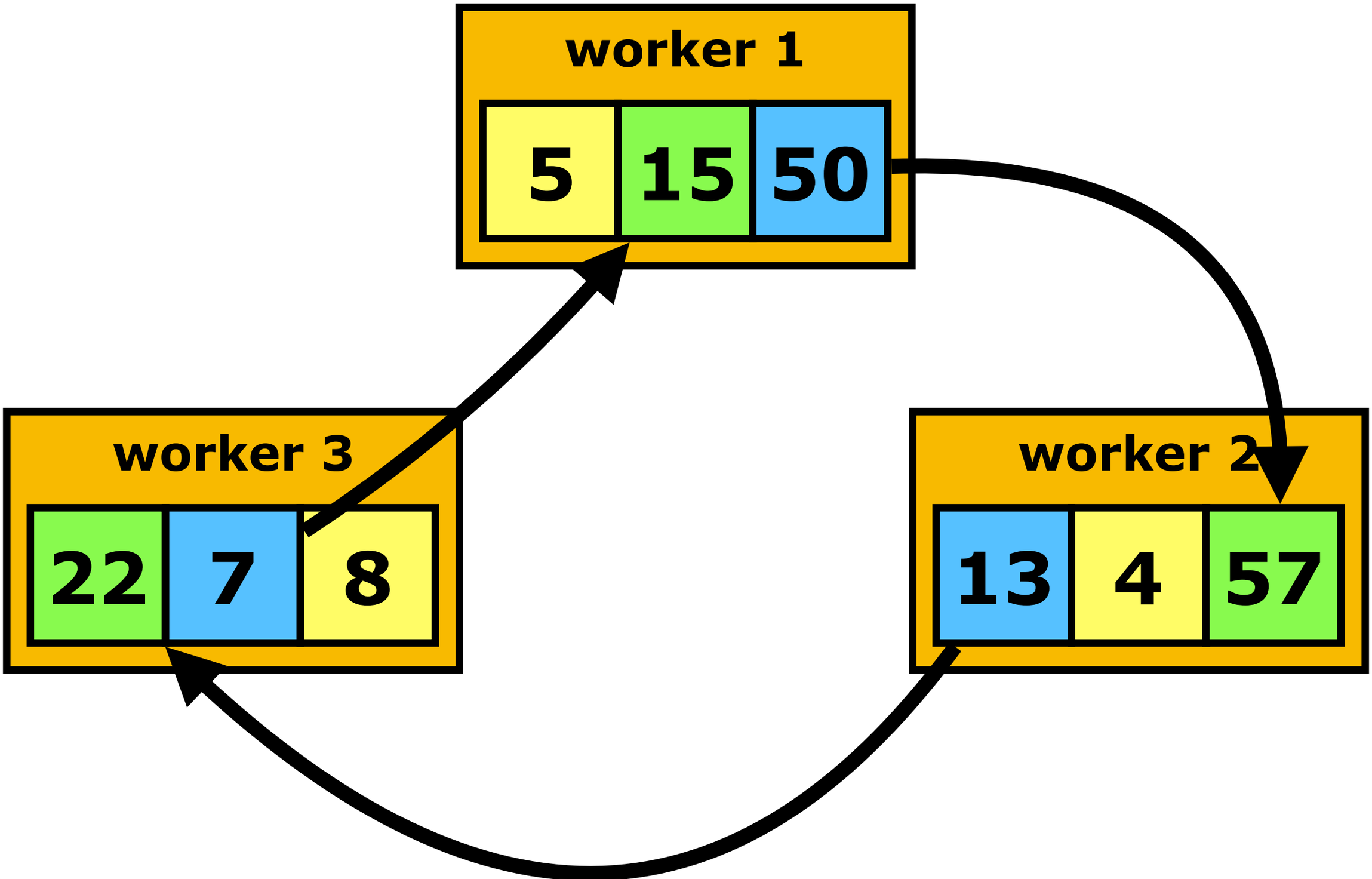
How Ring Allreduce Works



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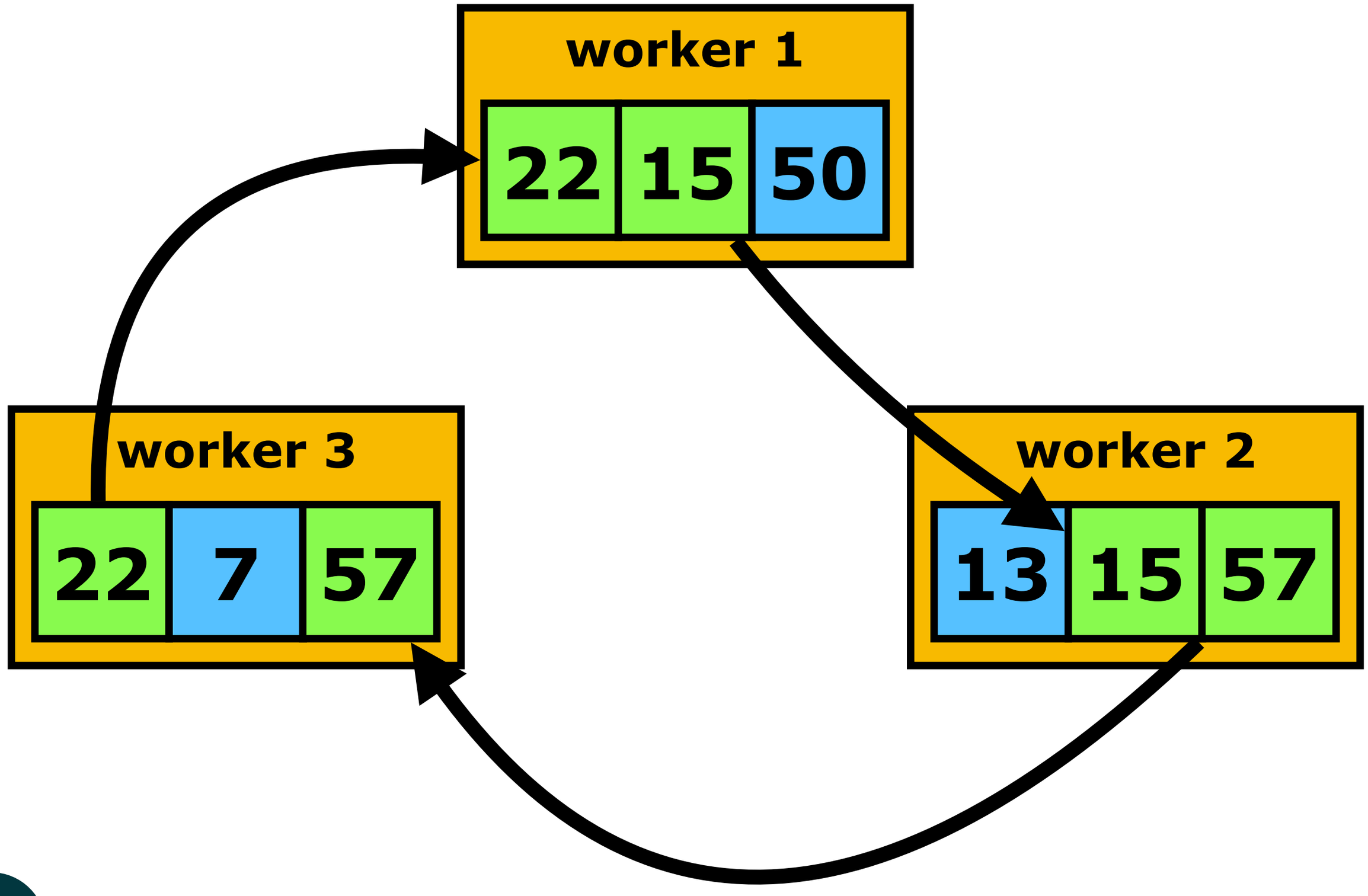
How Ring Allreduce Works



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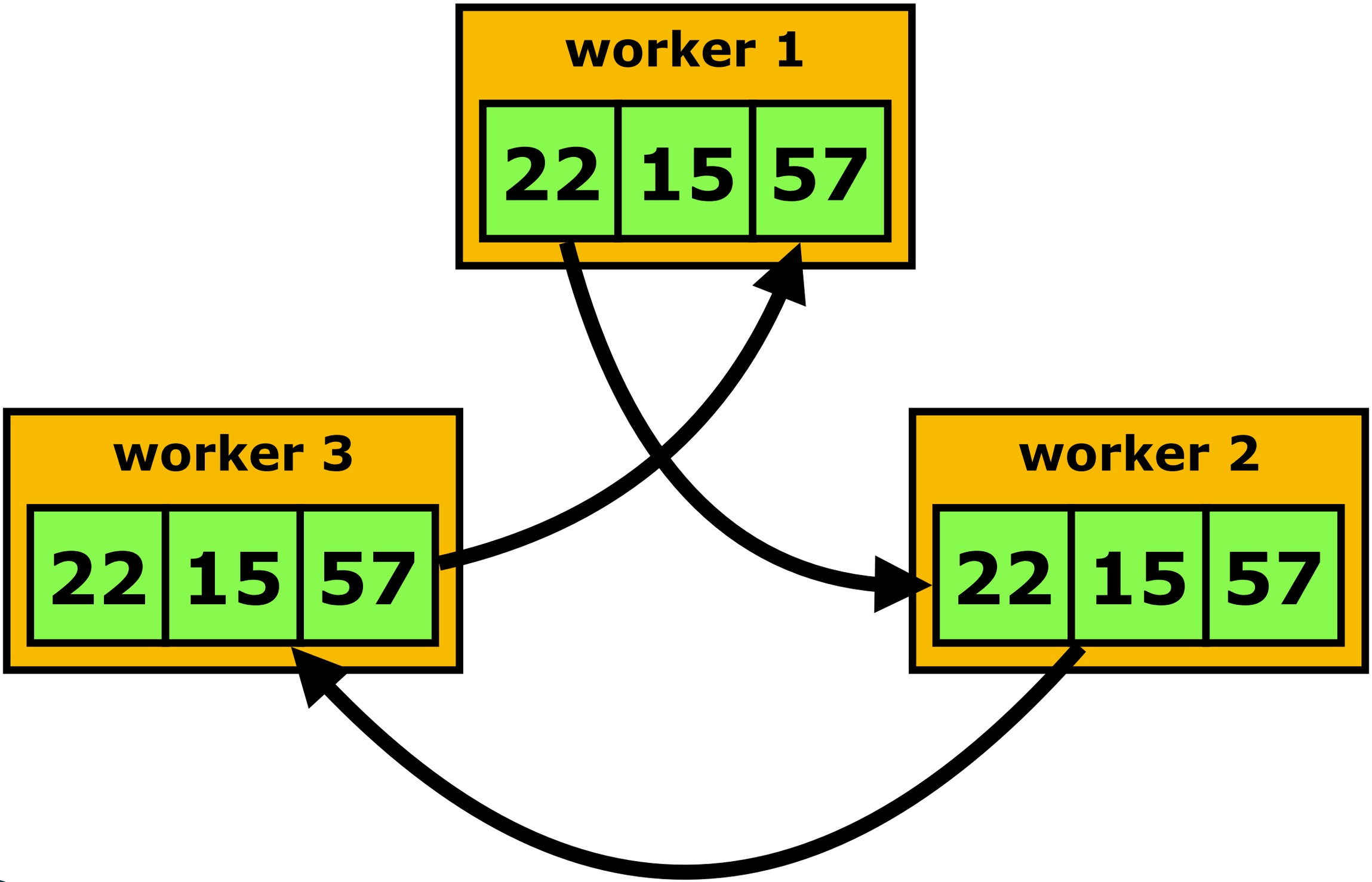
How Ring Allreduce Works



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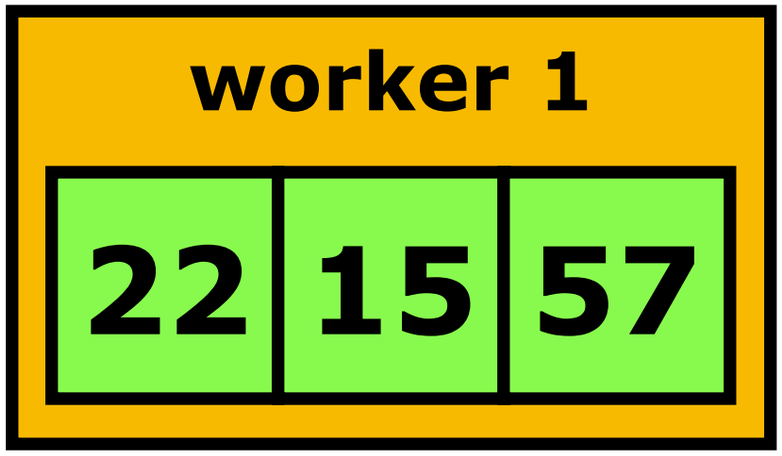
How Ring Allreduce Works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22
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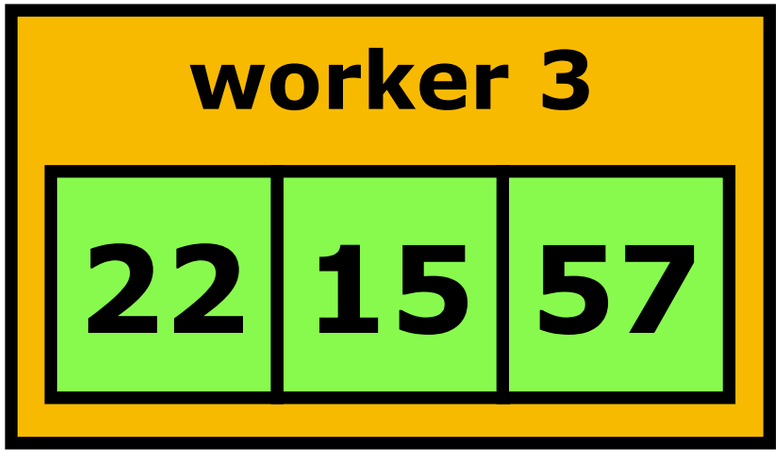
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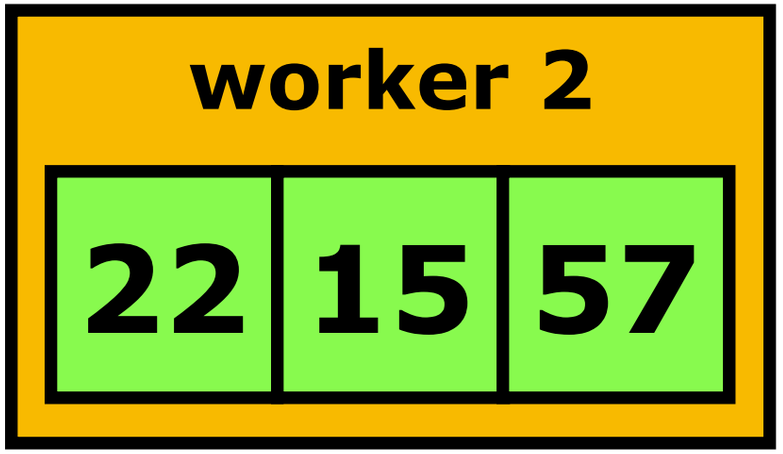
worker 2
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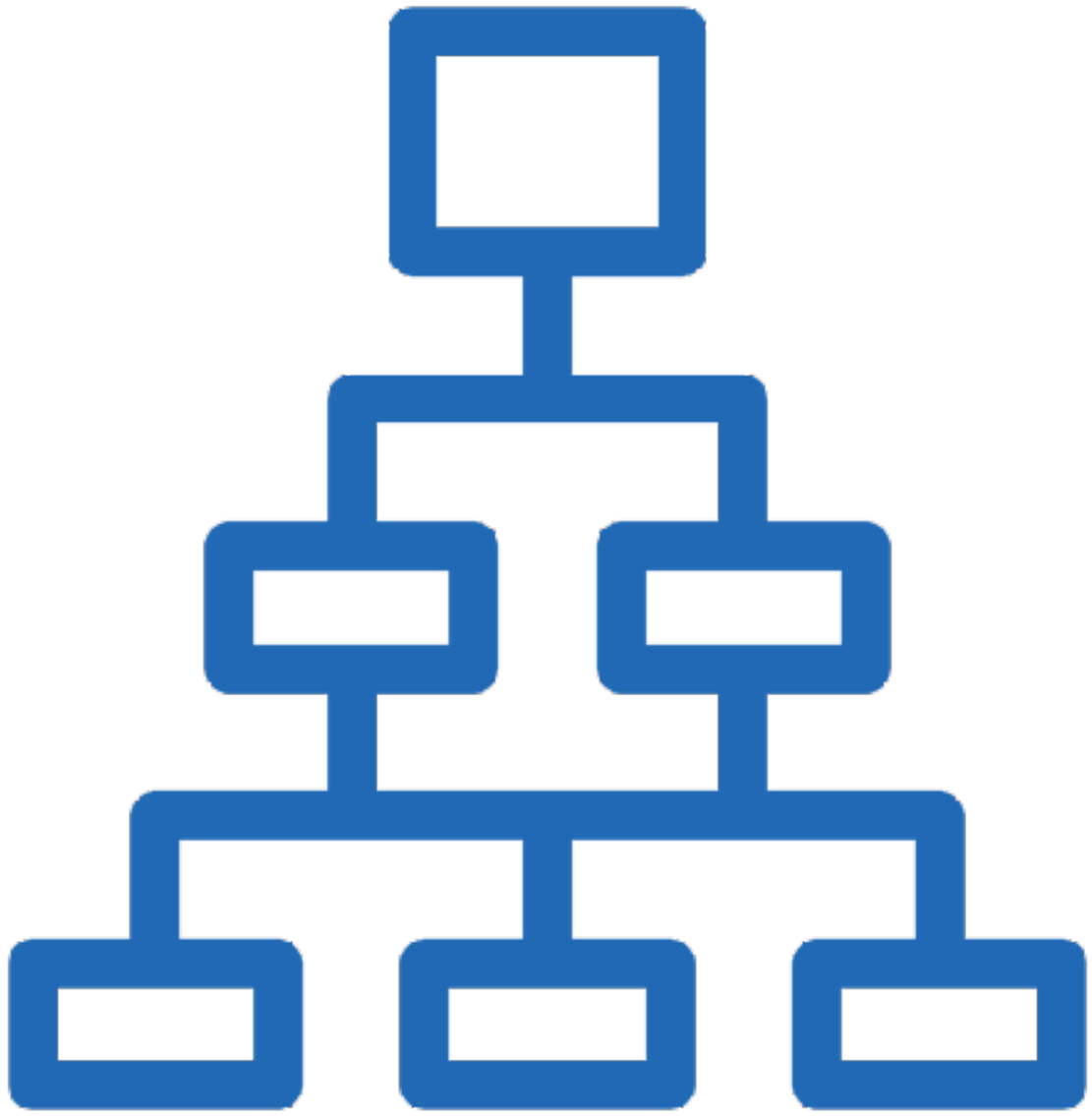

Hierarchical Allreduce

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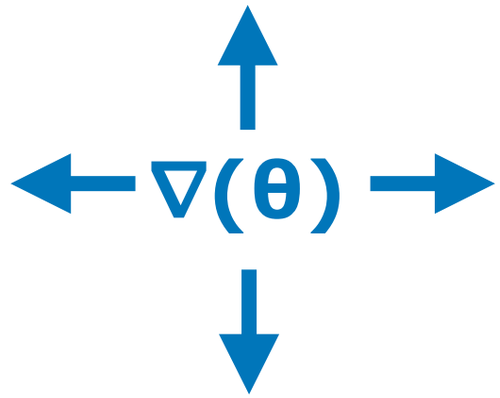
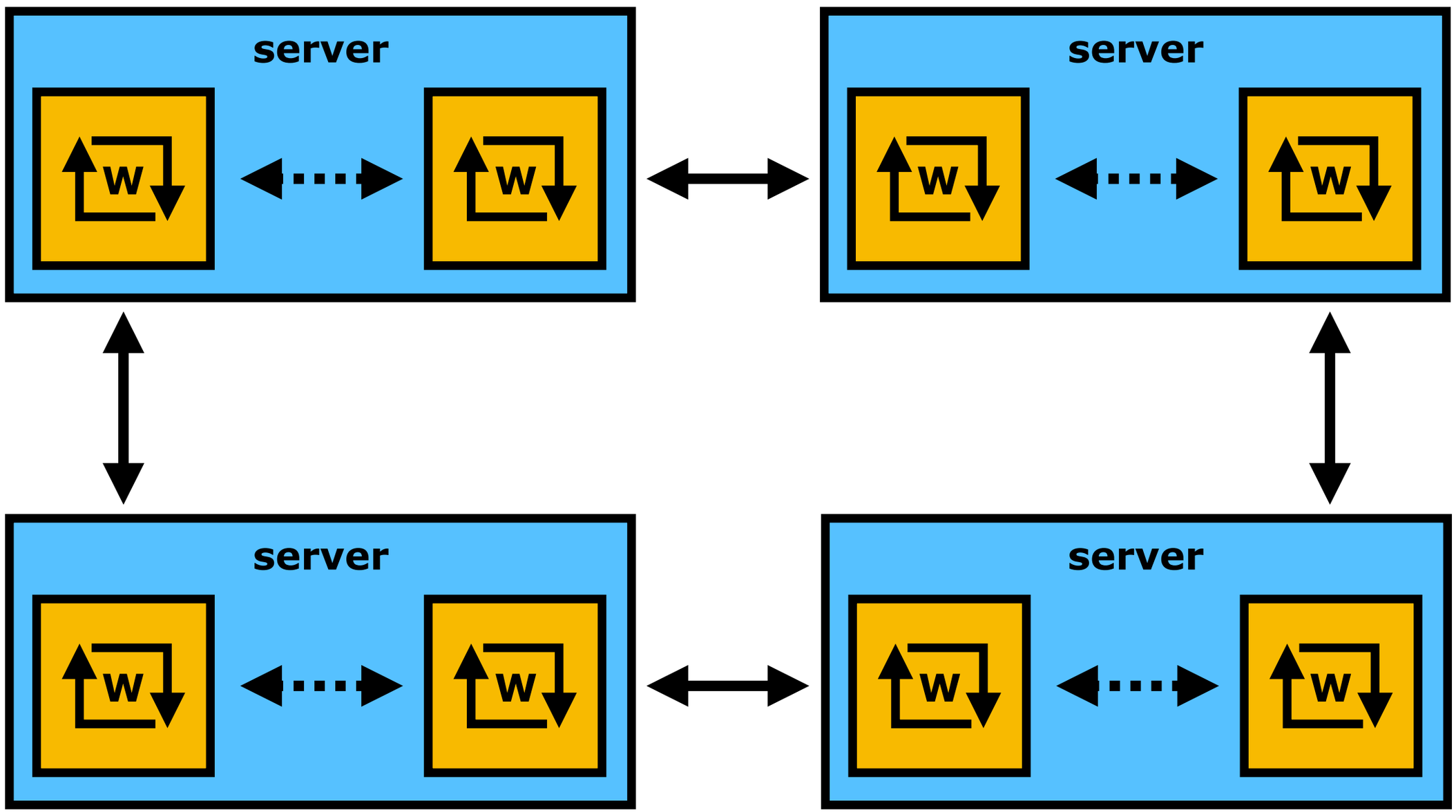
Hierarchical Allreduce





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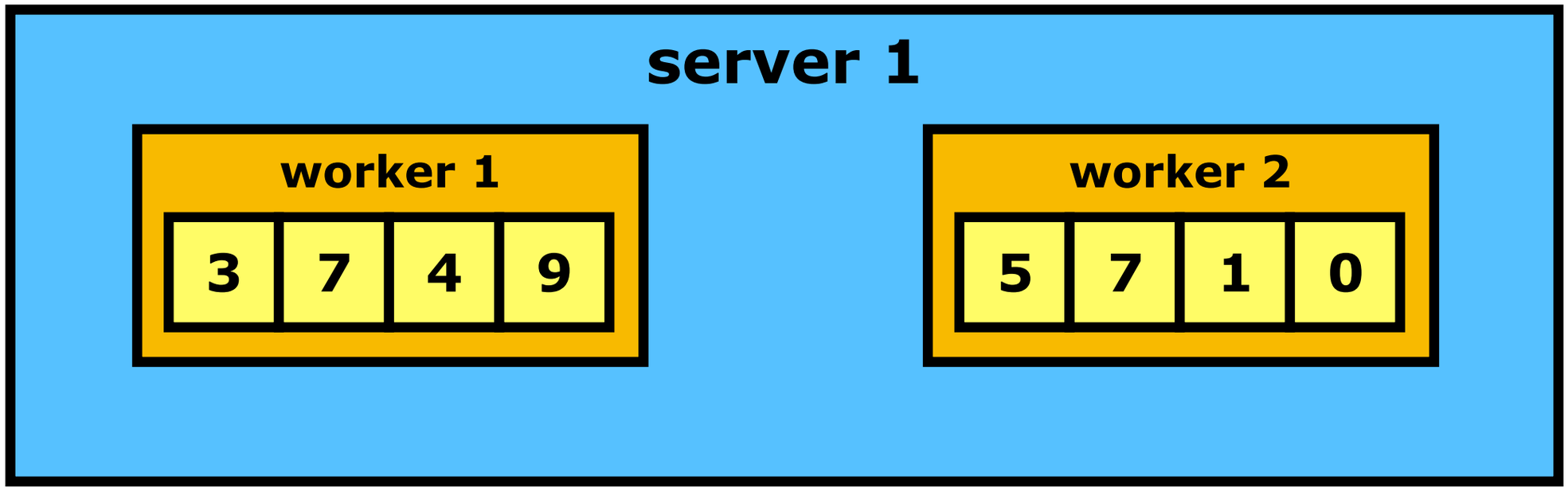
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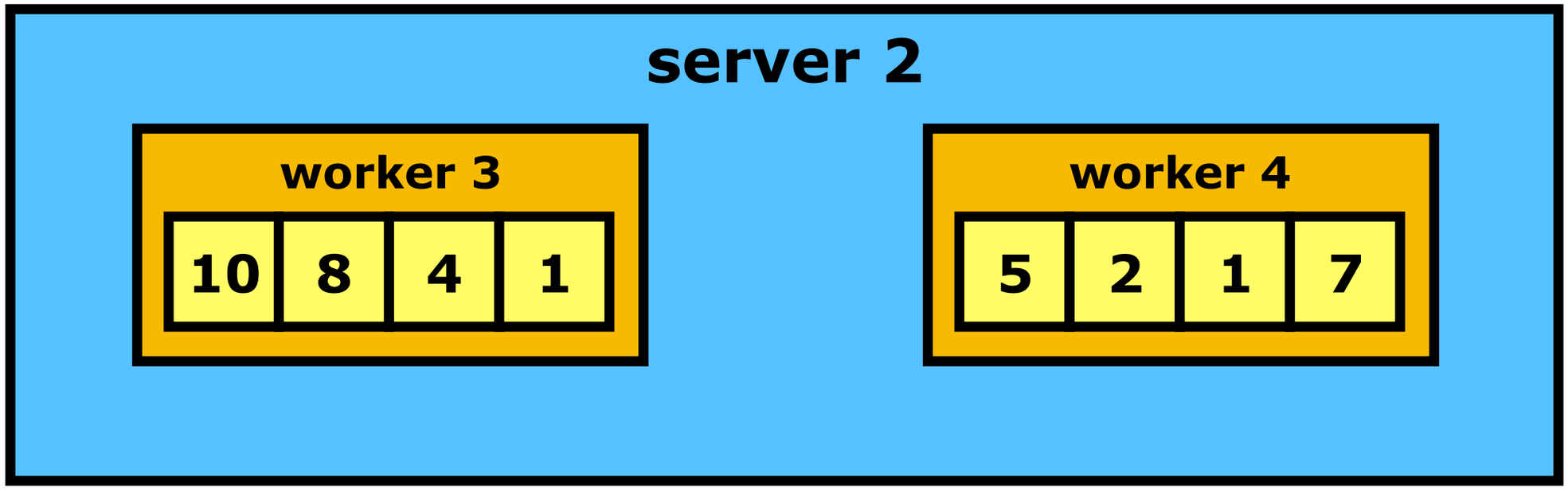
worker 1
3
7
4
9
worker 2
5
7
1
0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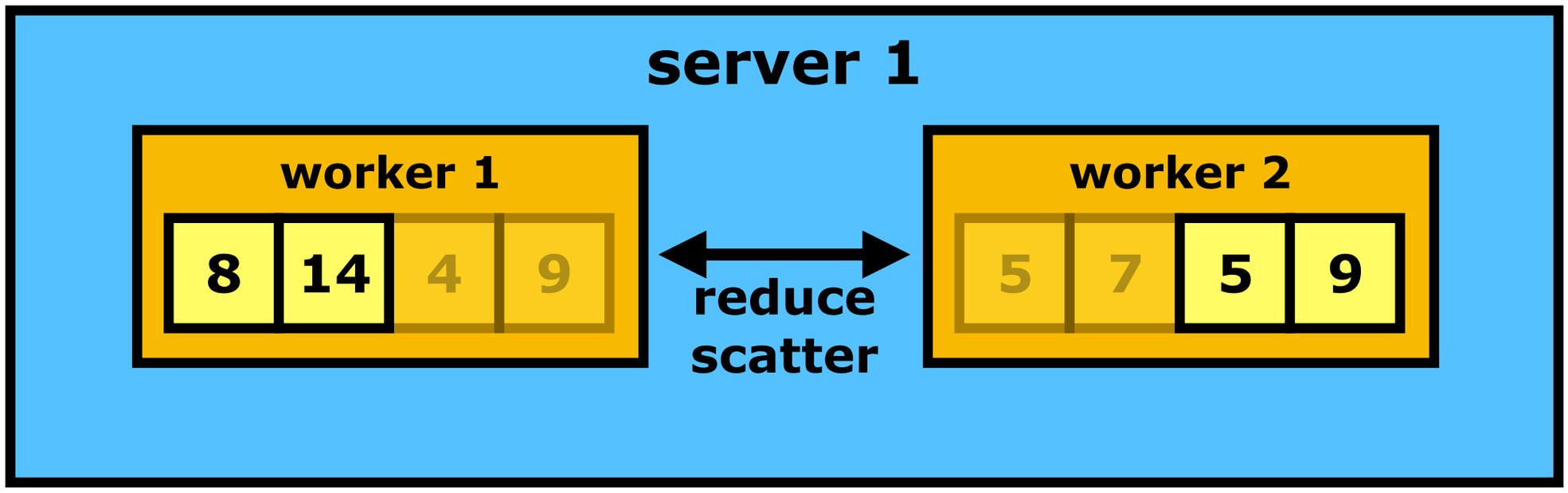
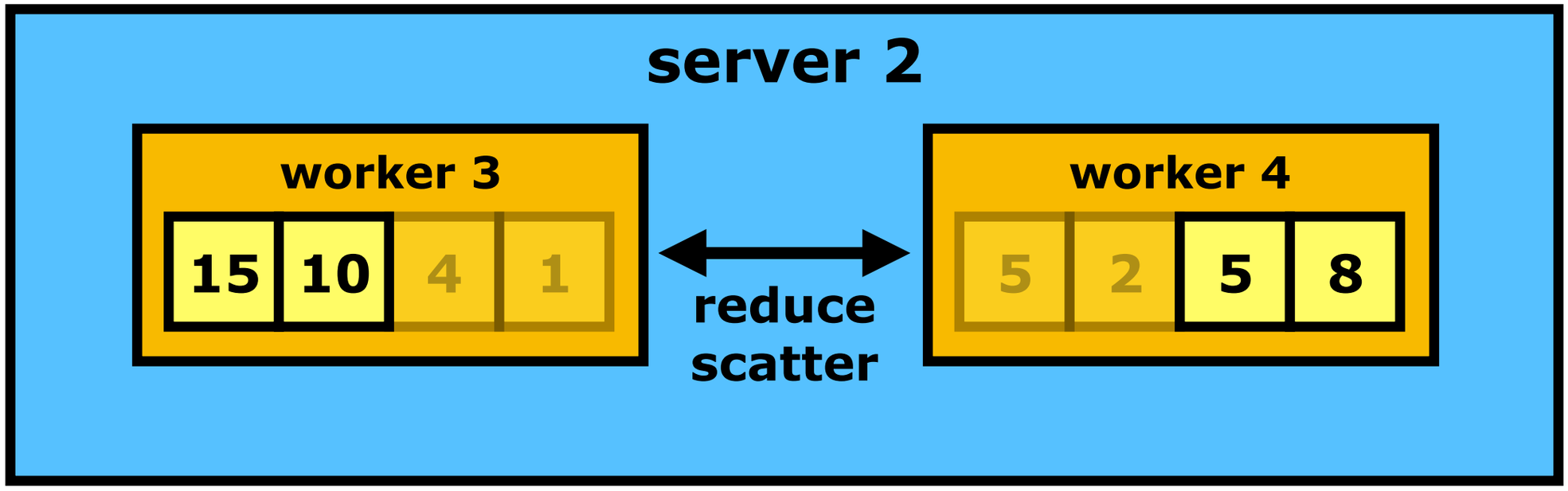
worker 3
10
8
4
1
worker 4
5
2
1
7





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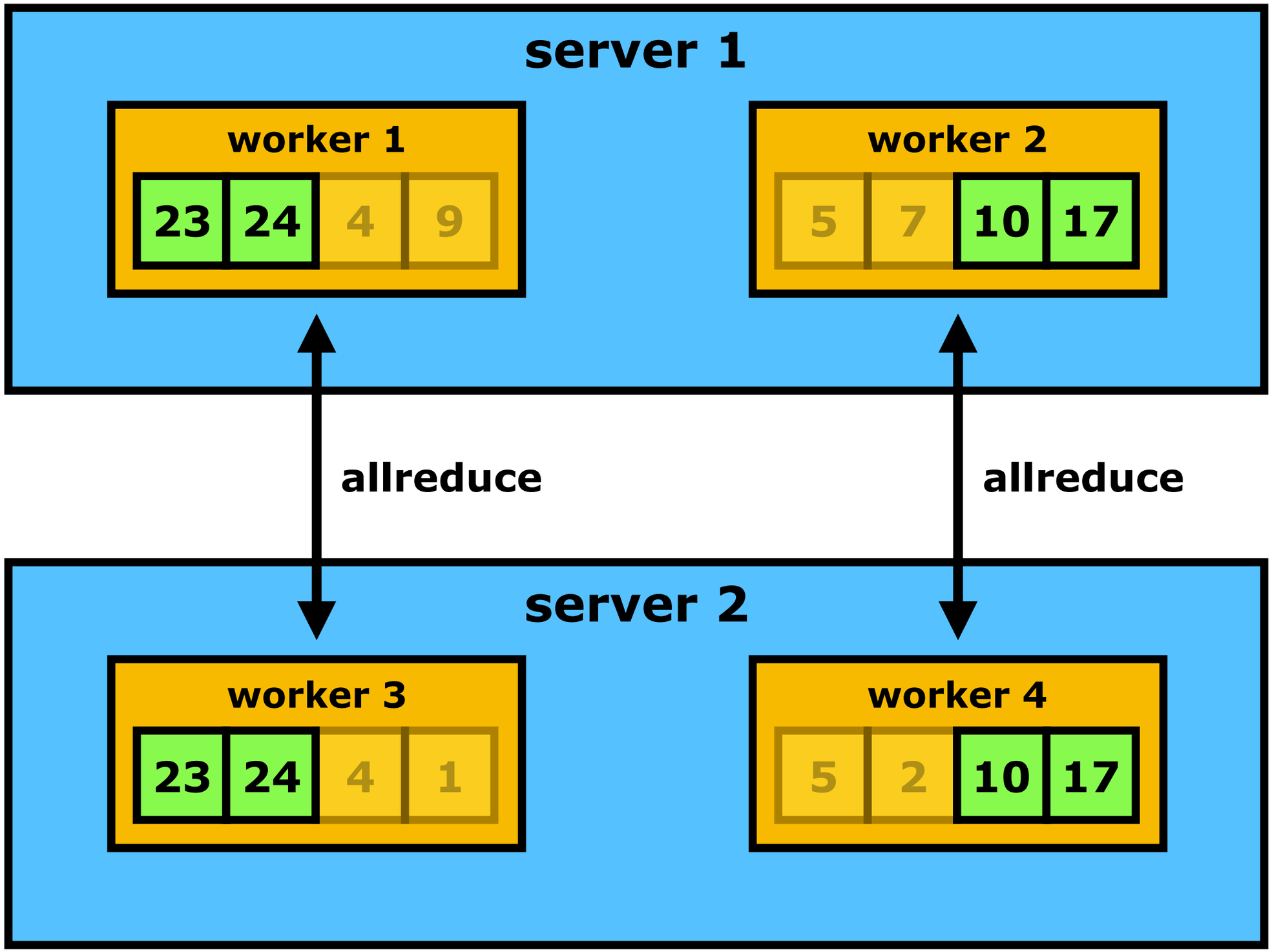
How Hierarchical Allreduce Works



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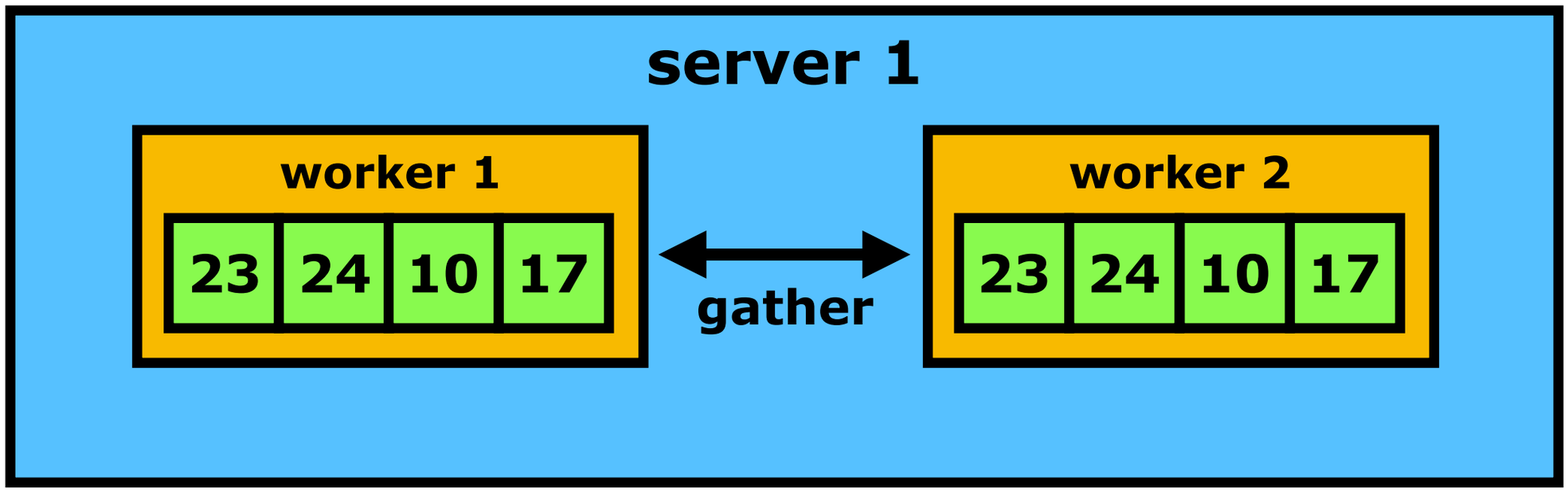
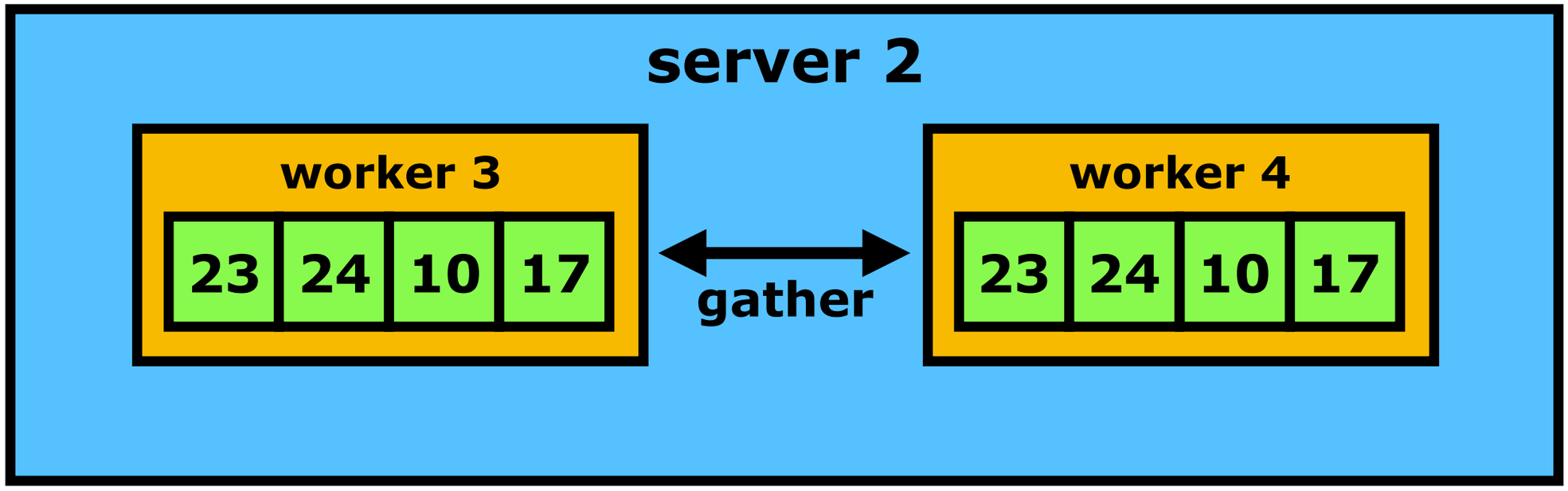
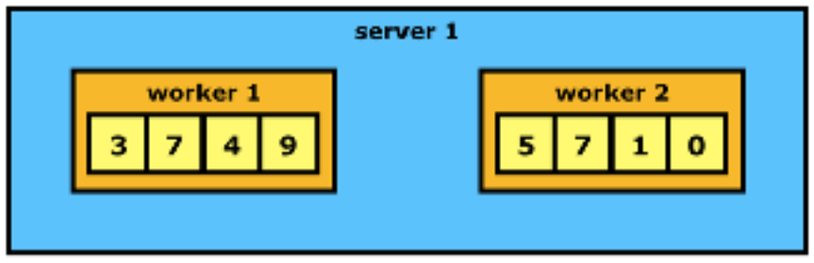
How Hierarchical Allreduce Works

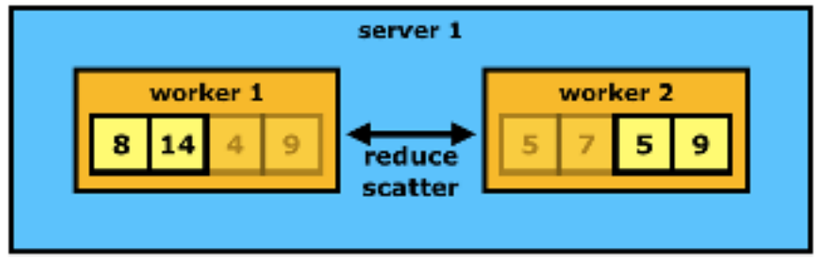

server 1
worker 1
23
24
10
17
gather
worker 2
23
24
10
17


server 2
worker 3
23
24
10
17
gather
worker 4
23
24
10
17

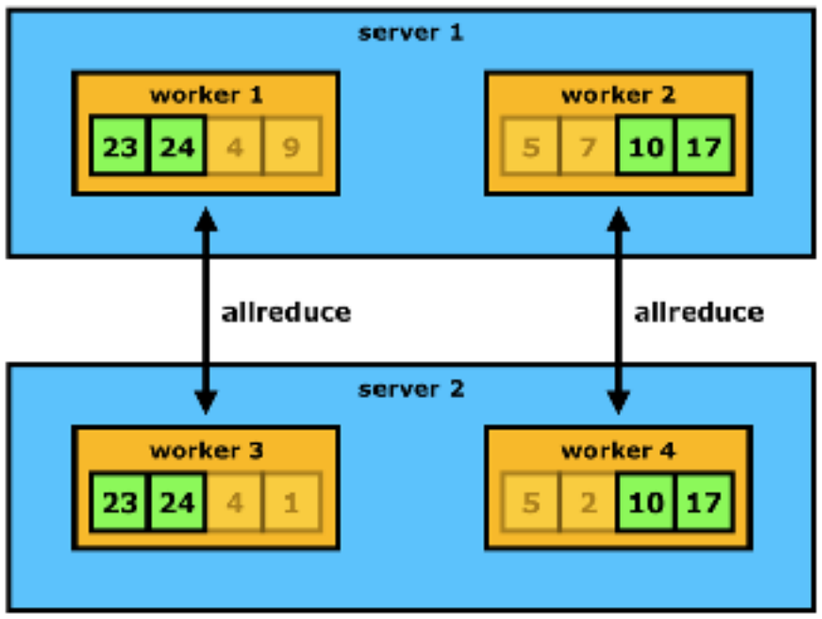
1. Setup



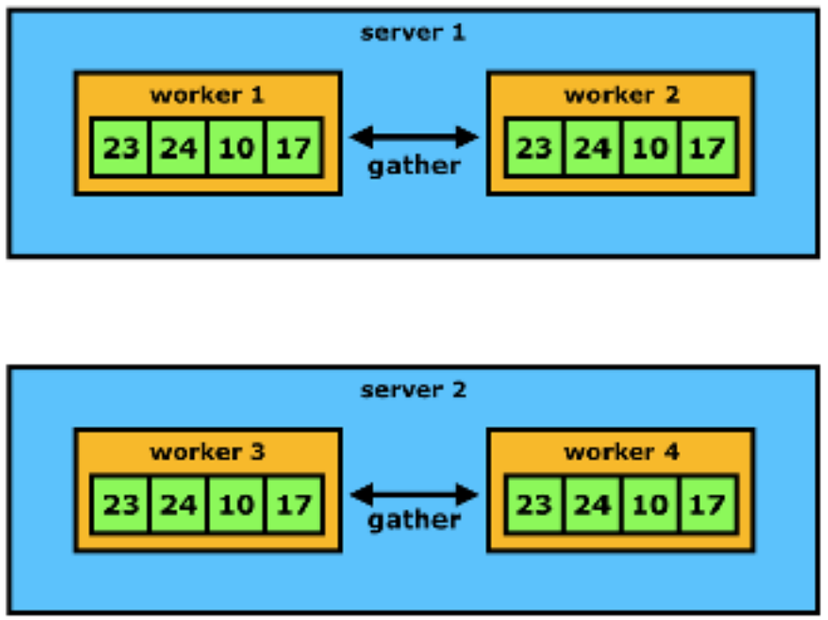
2. Local ReduceScatter



3. Global Allreduce



4. Local Gather



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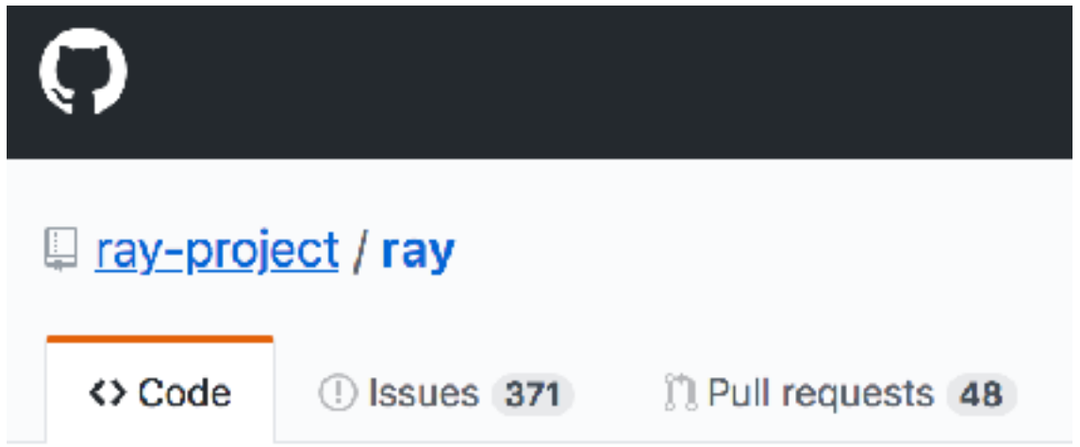
How Hierarchical Allreduce Works

Tools


ray-project / ray
Code
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Deep Learning Management Platform

Sources and Further Reading

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Feng Niu, Benjamin Recht, Christopher Ré, Stephen J. Wright

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Slim Fly: A Cost Effective Low-Diameter Network Topology
Maciej Besta, Torsten Hoefler

Accurate, Large Minibatch SGD: Training ImageNet in 1 Hour
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Horovod: Distributed Deep Learning in 5 Lines of Python
Uber Open Summit 2018

Distributed TensorFlow Documentation
TensorFlow

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Thank You!
and Q&A

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