- Building Brains -

Parallel training strategies for large-scale deep learning

IBM Center for Open Source Data and AI Technologies (CODAIT)

Romeo Kienzler

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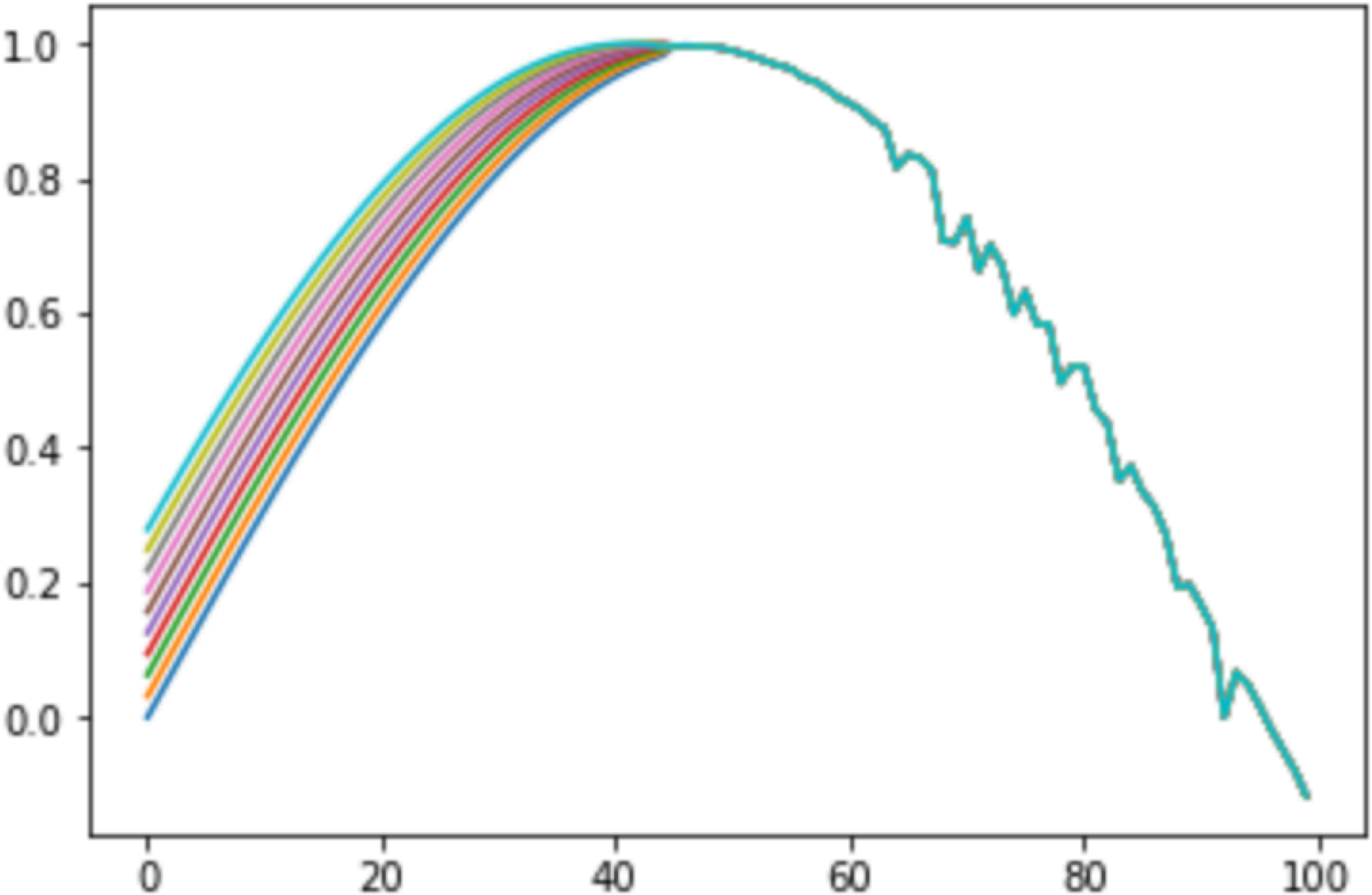
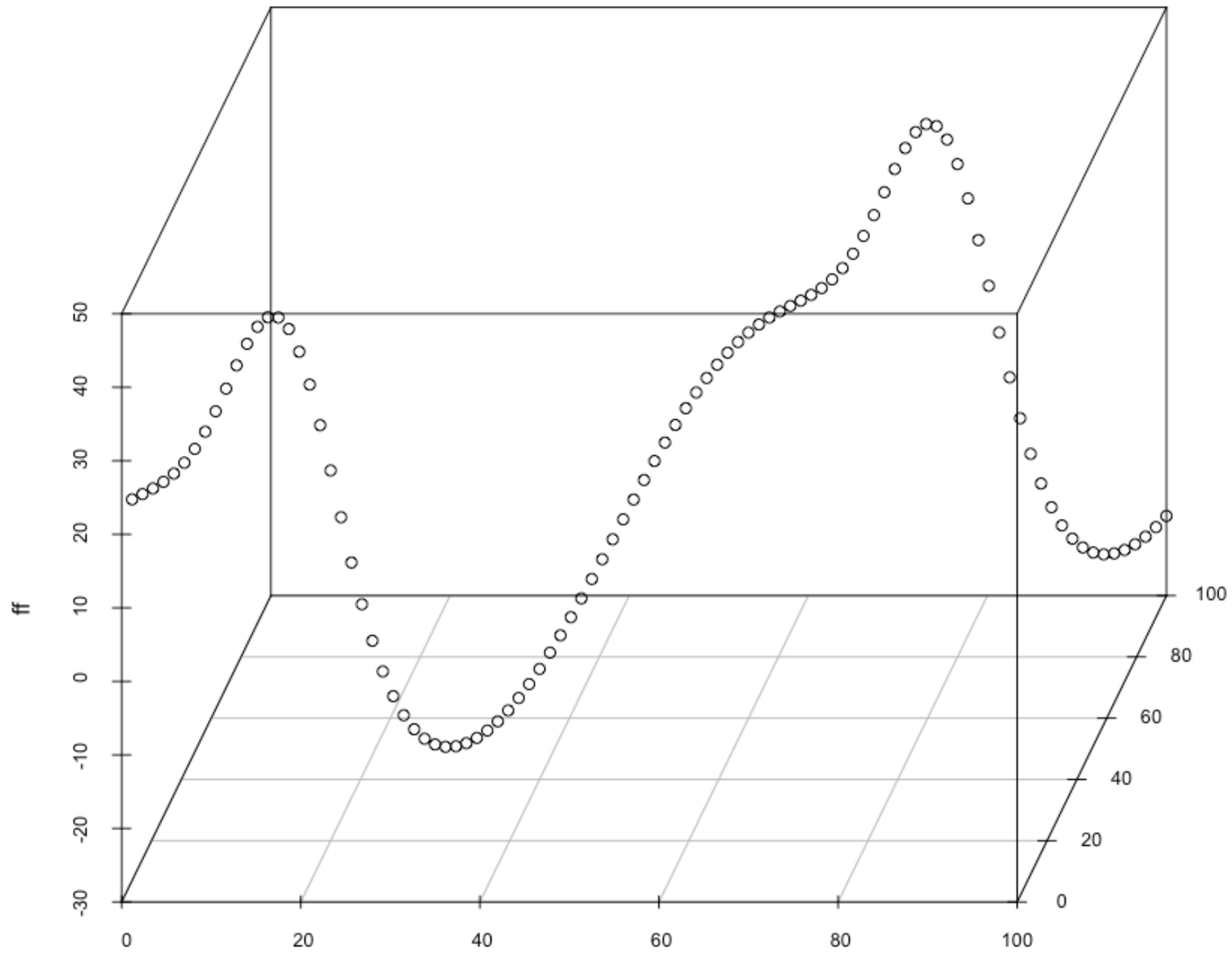
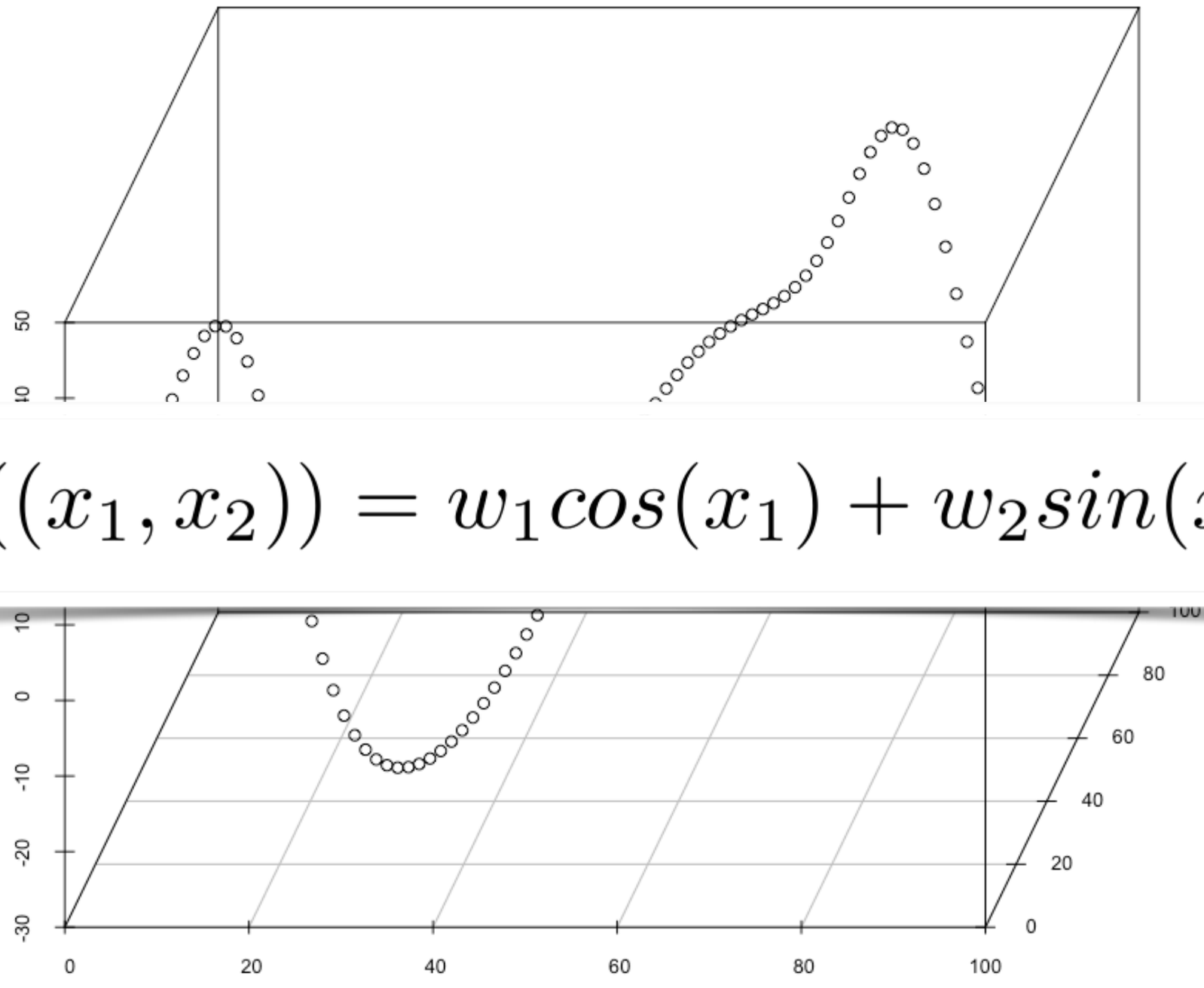
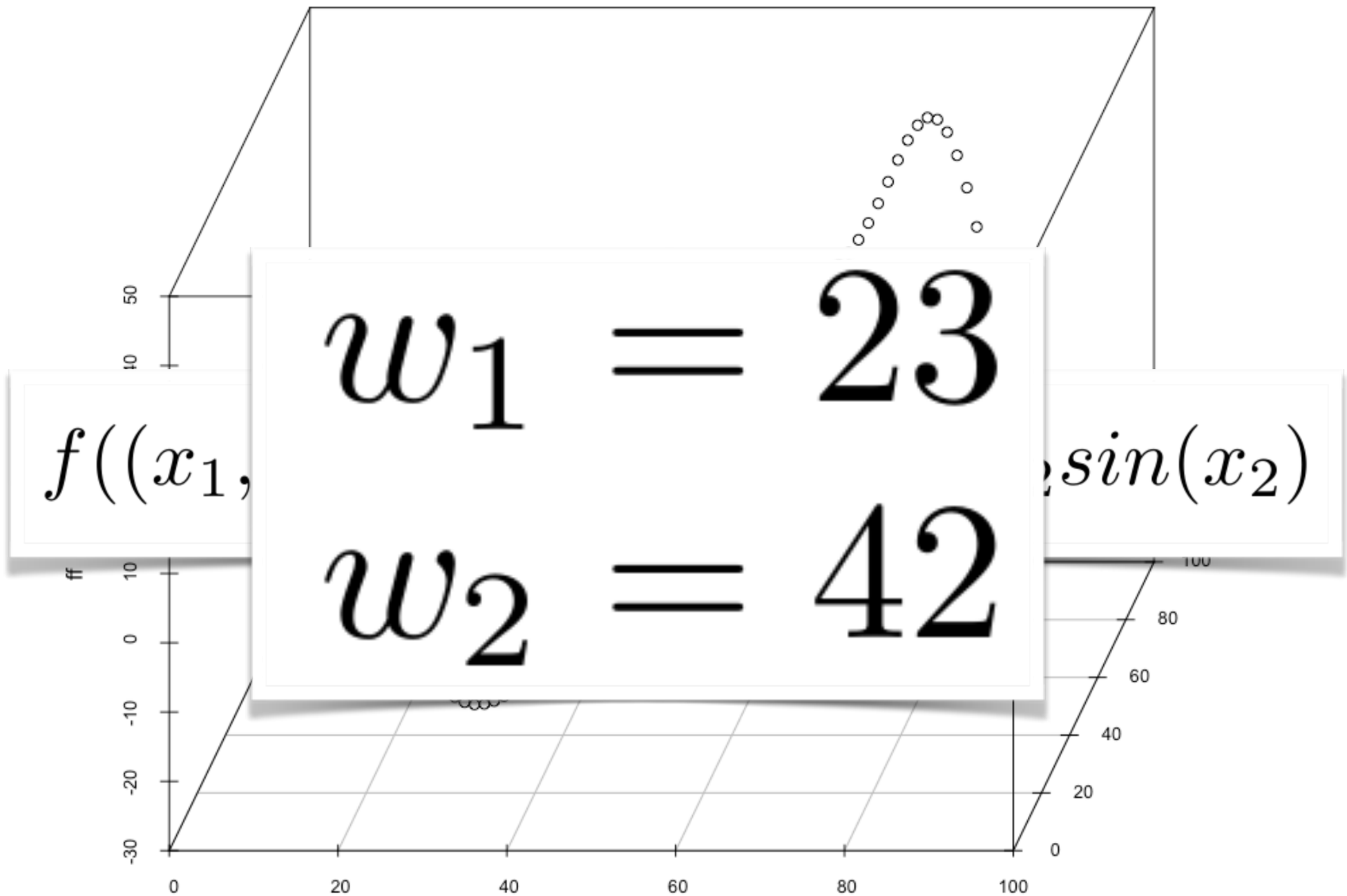


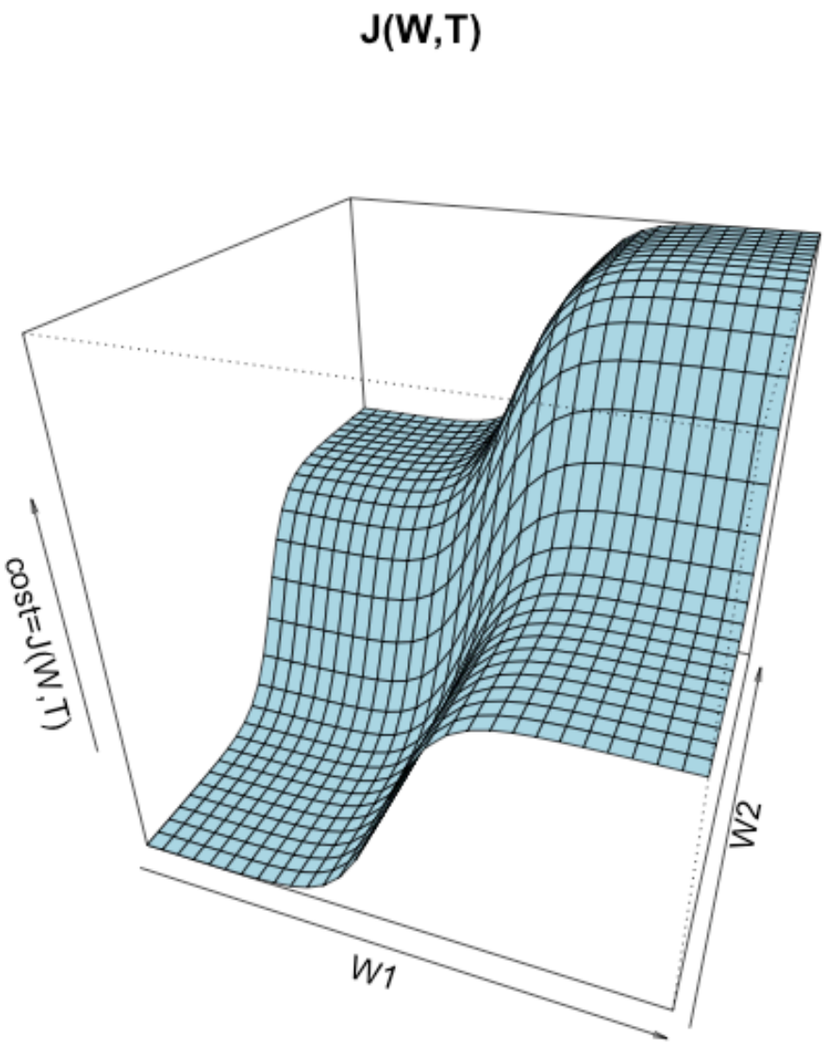




$$f((x_1, x_2)) = w_1 cos(x_1) + w_2 sin(x_2)$$



gradient descent



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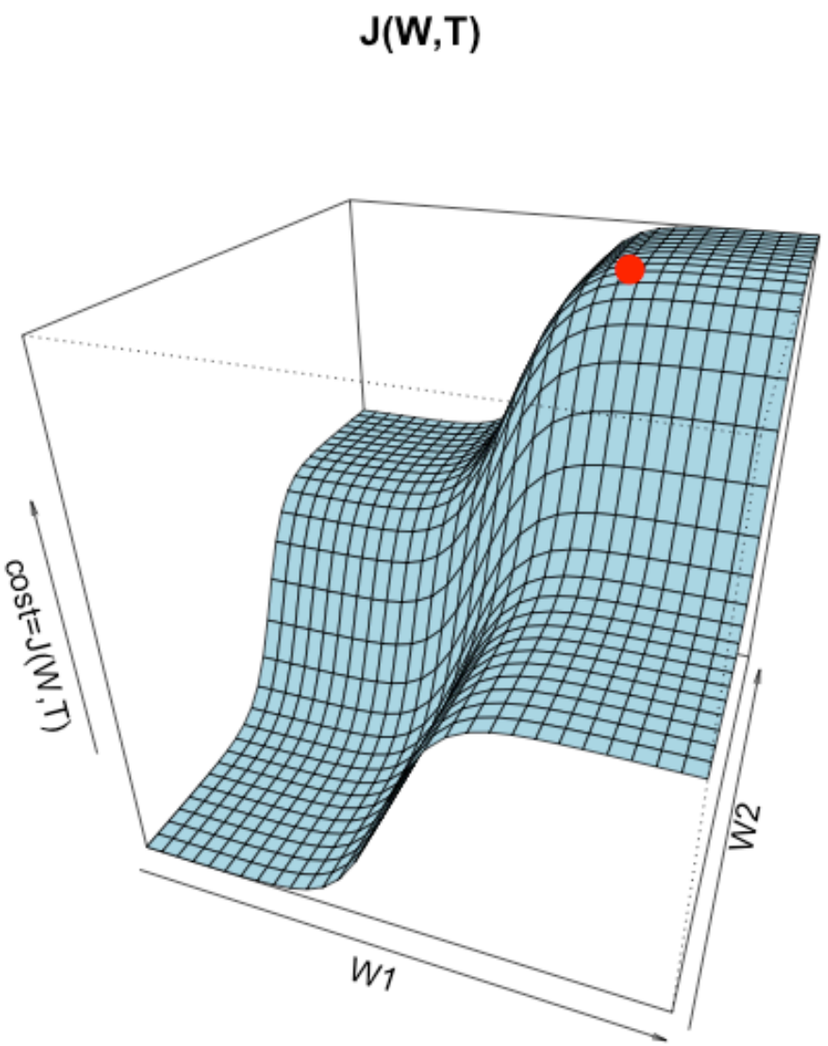

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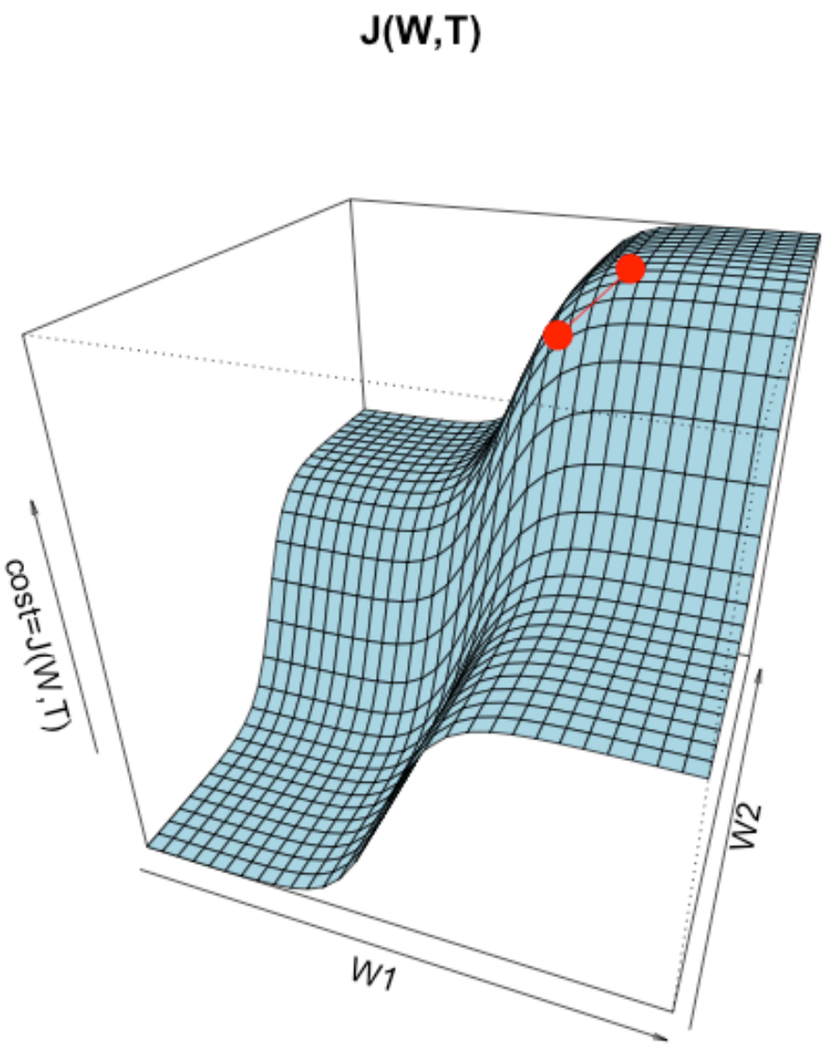
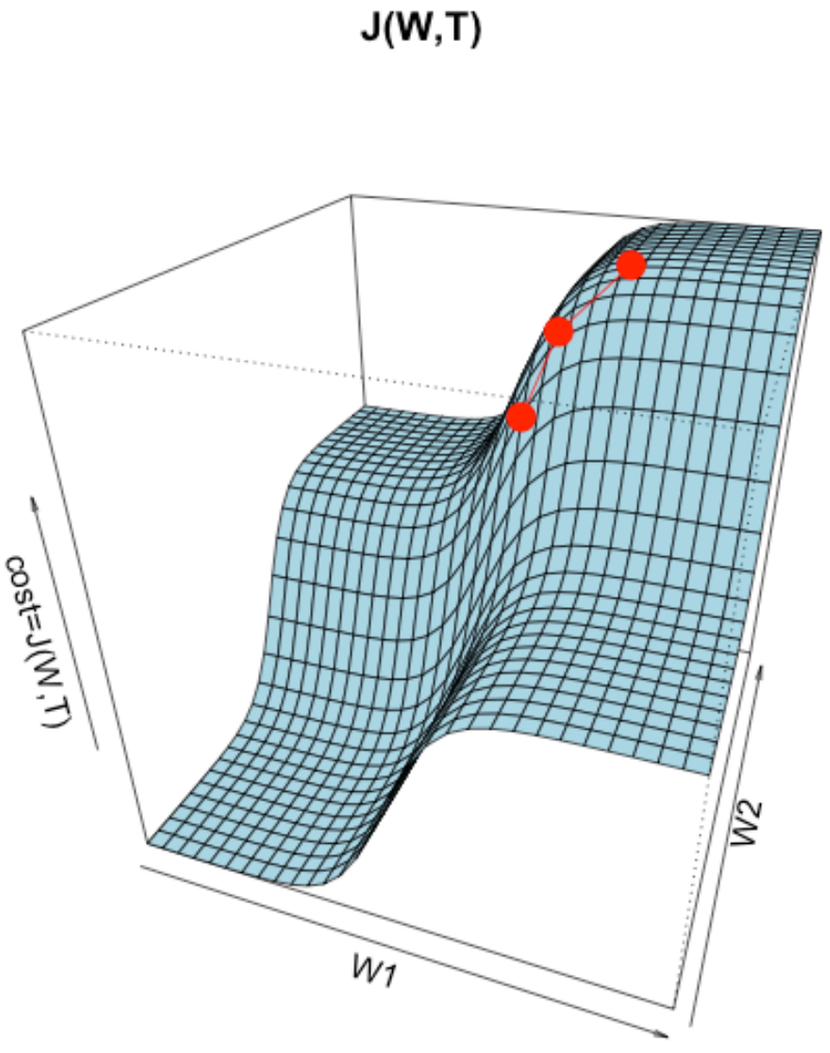


gradient descent



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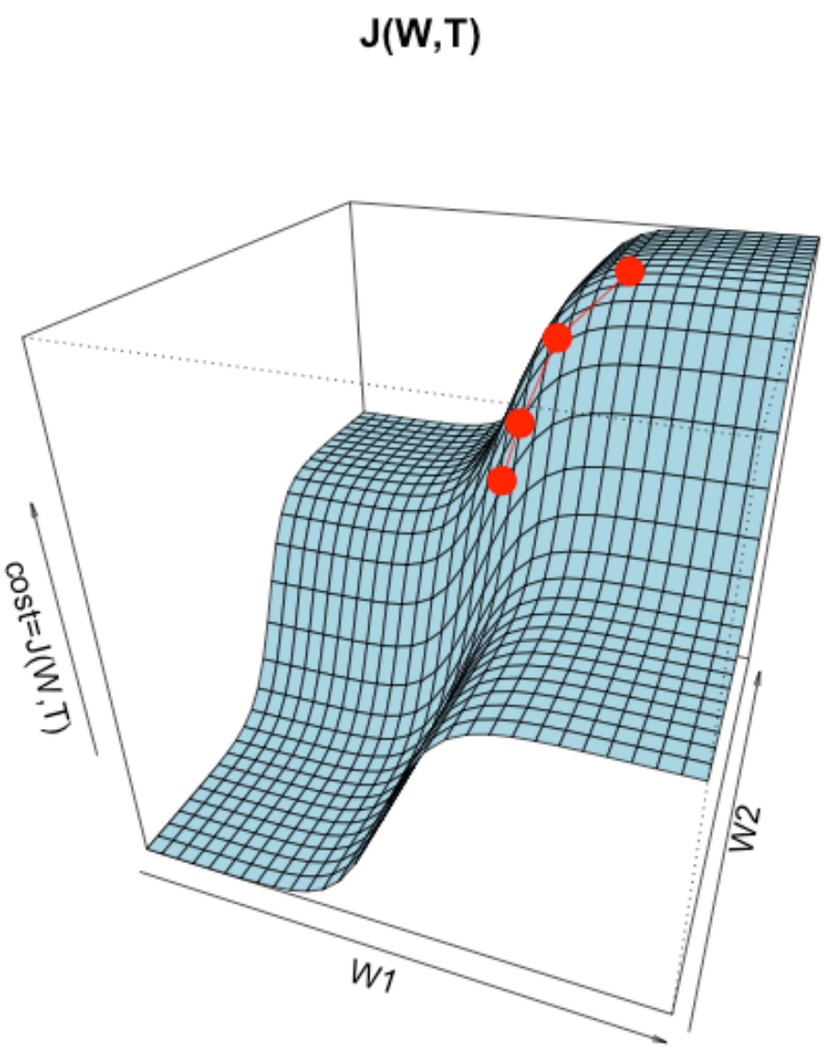

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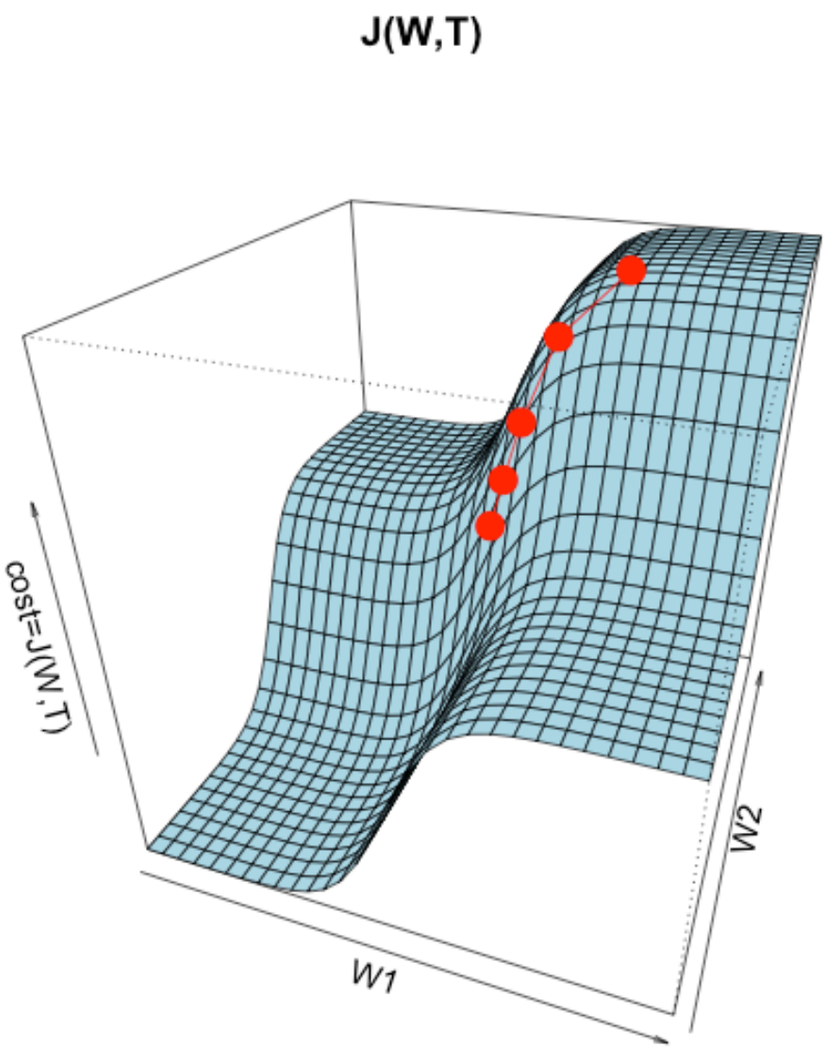
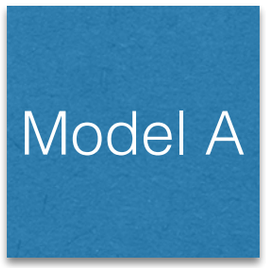


parallelisation

- inter-model parallelism
- data parallelism
- intra-model parallelism
- pipelined parallelism

inter-model parallelism

aka. hyper parameter space exploration / tuning



inter-model parallelism

aka. hyper parameter space exploration / tuning

inter-model parallelism

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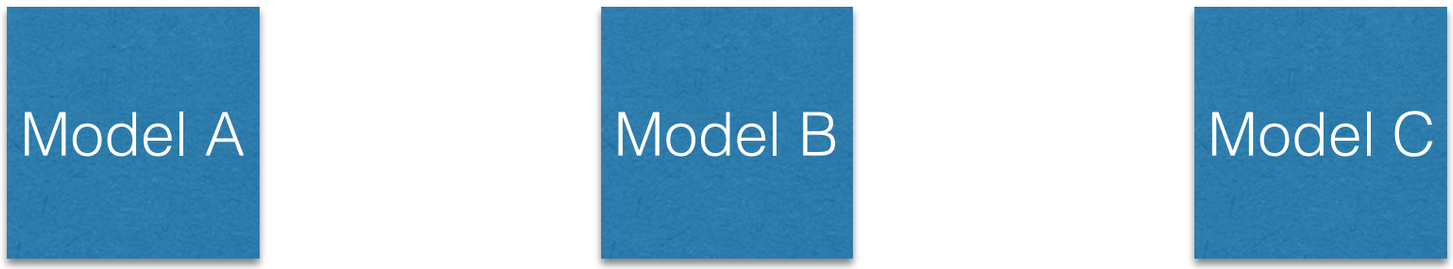

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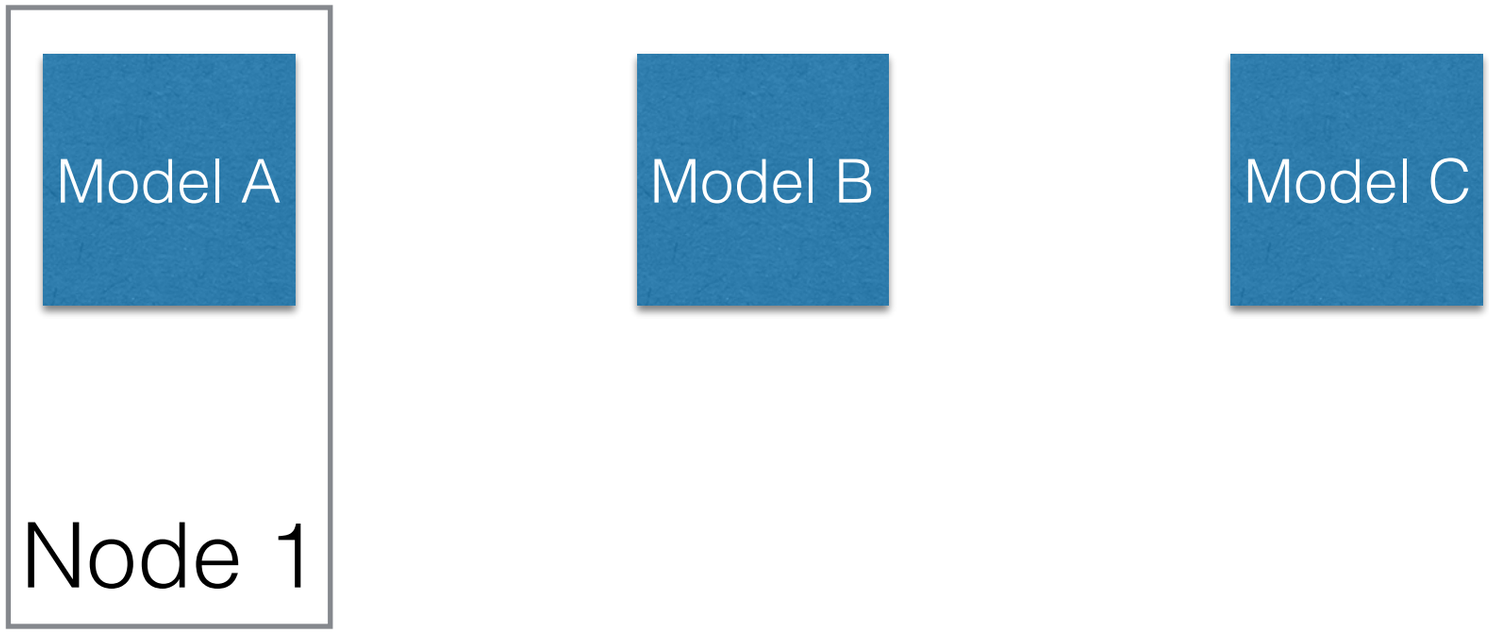

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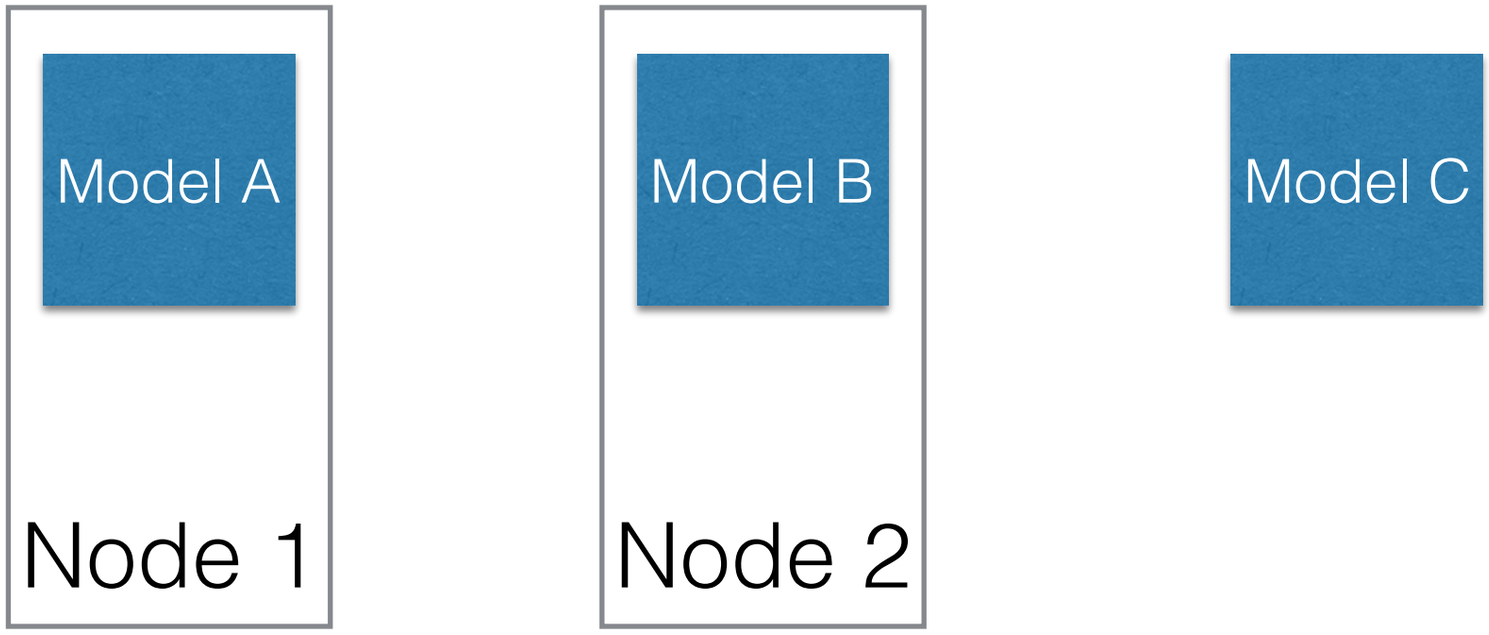

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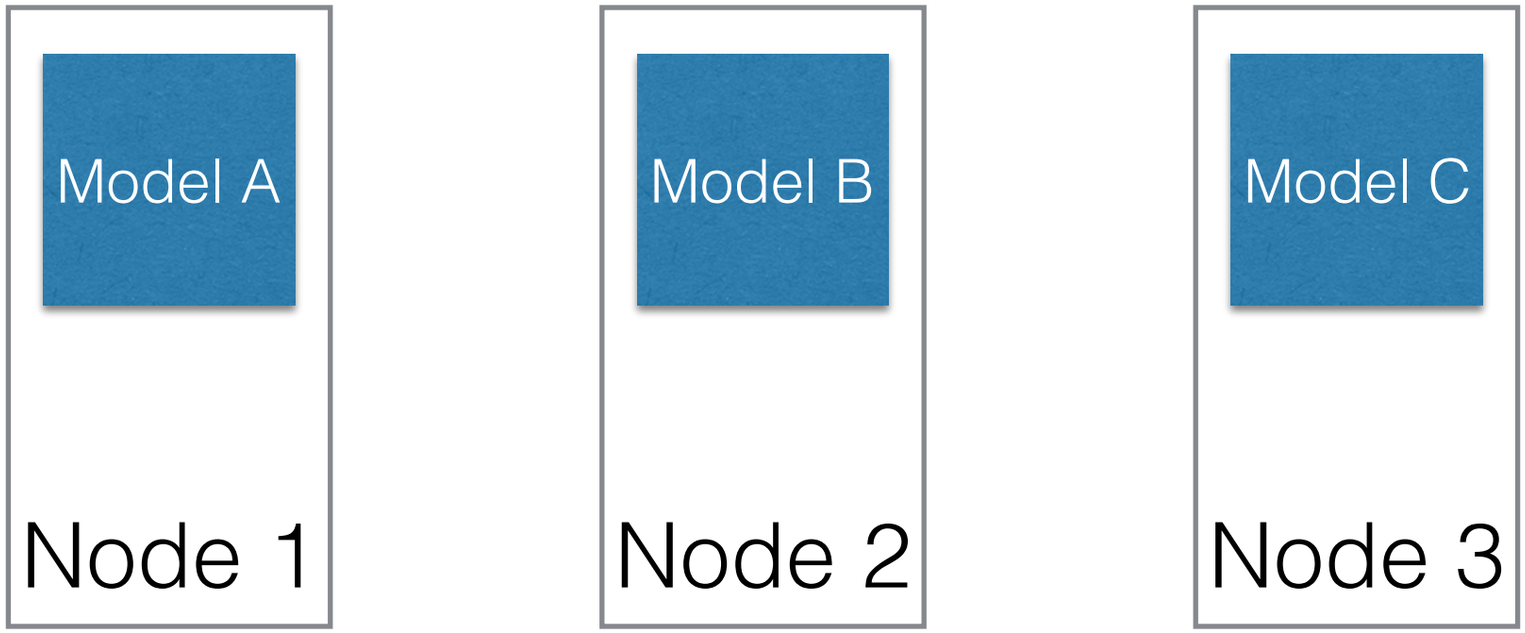

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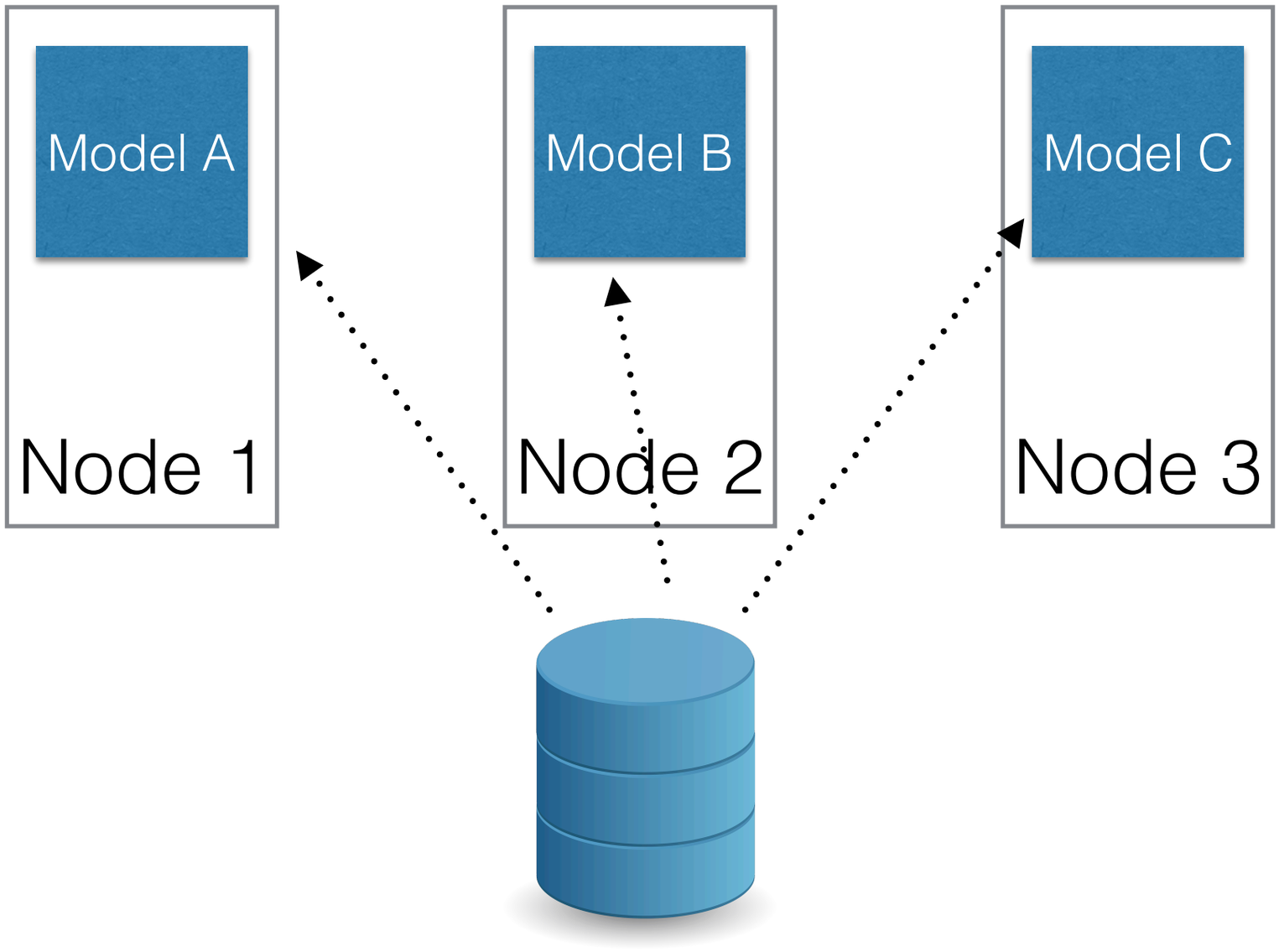
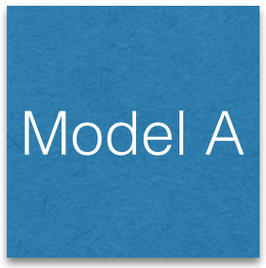


data parallelism

aka. “Jeff Dean style” parameter averaging



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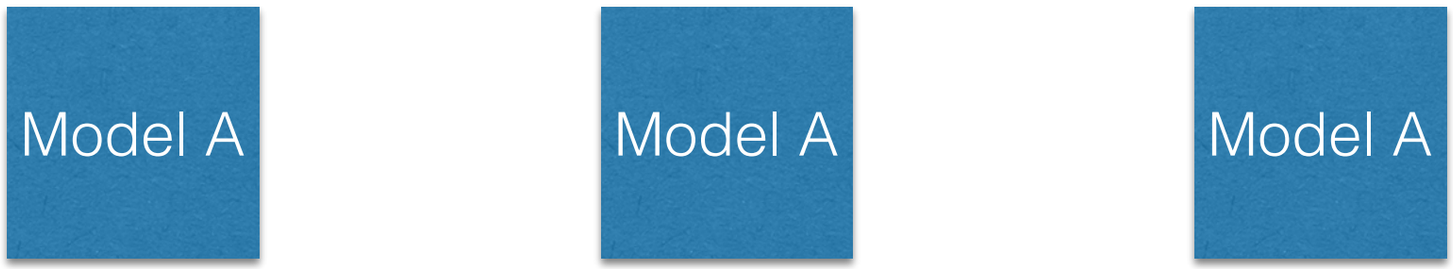

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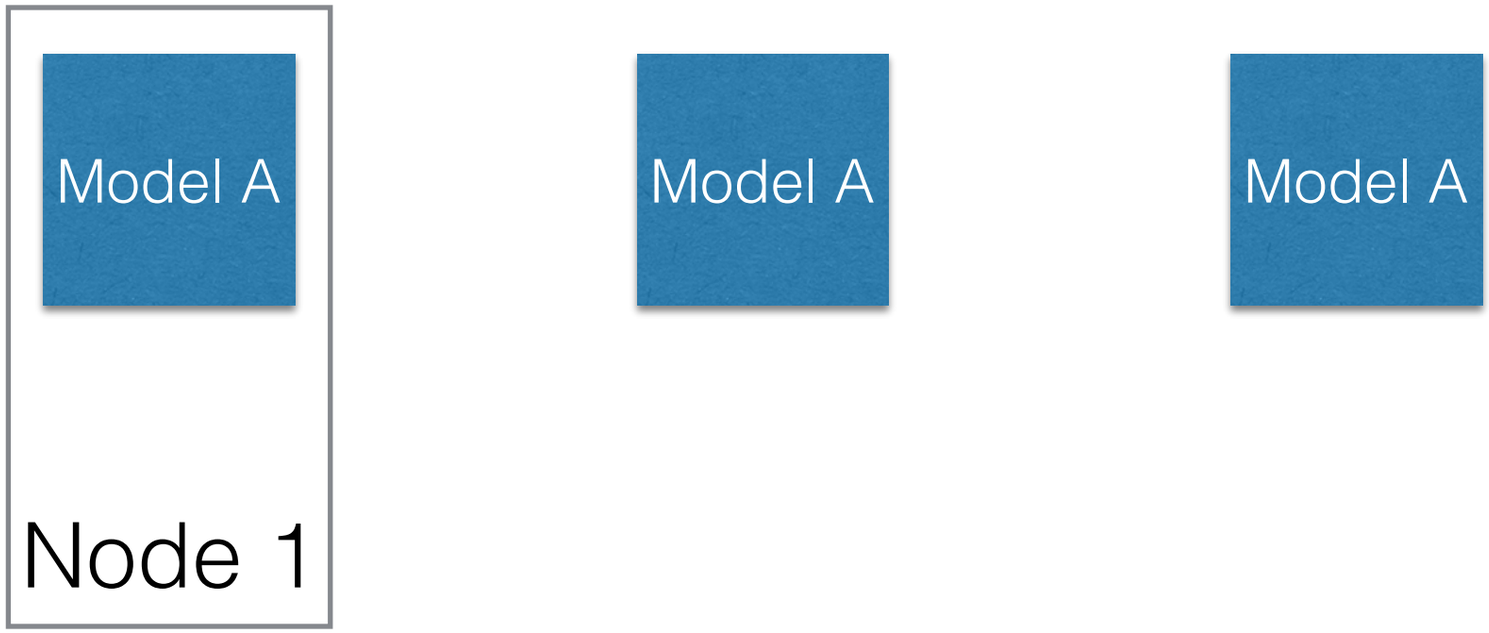

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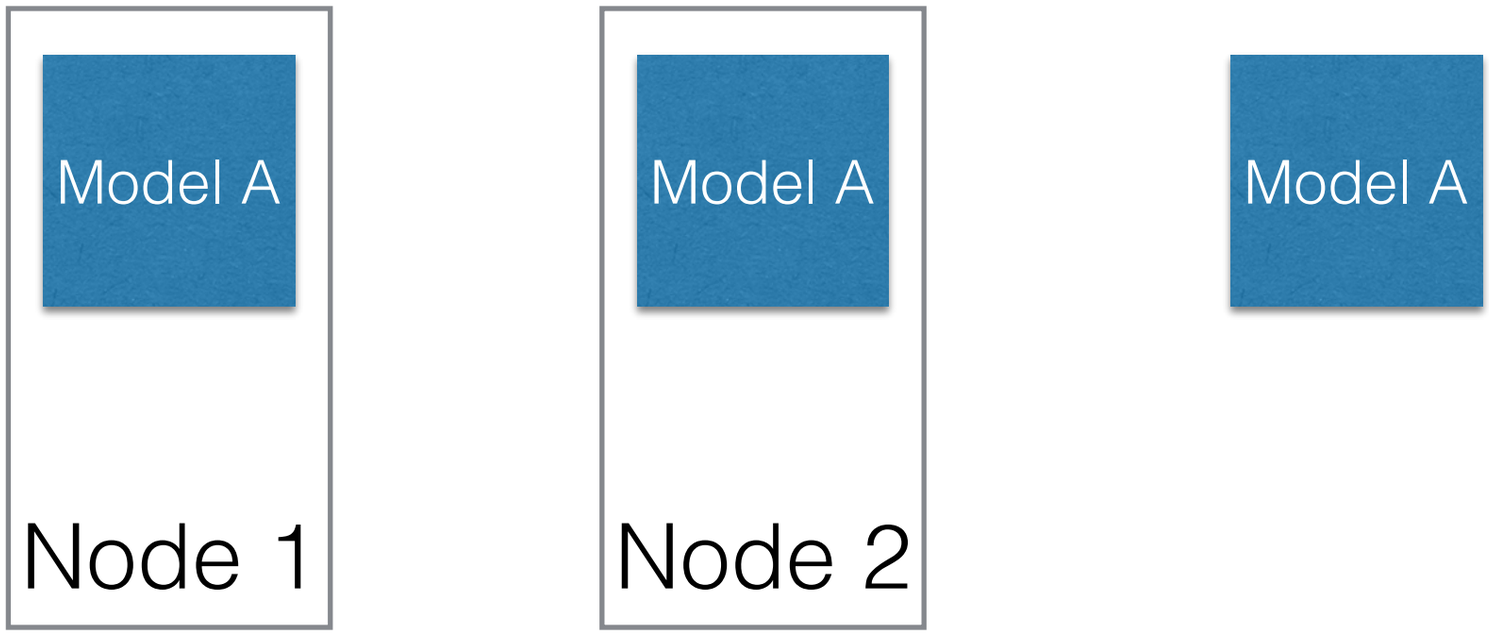

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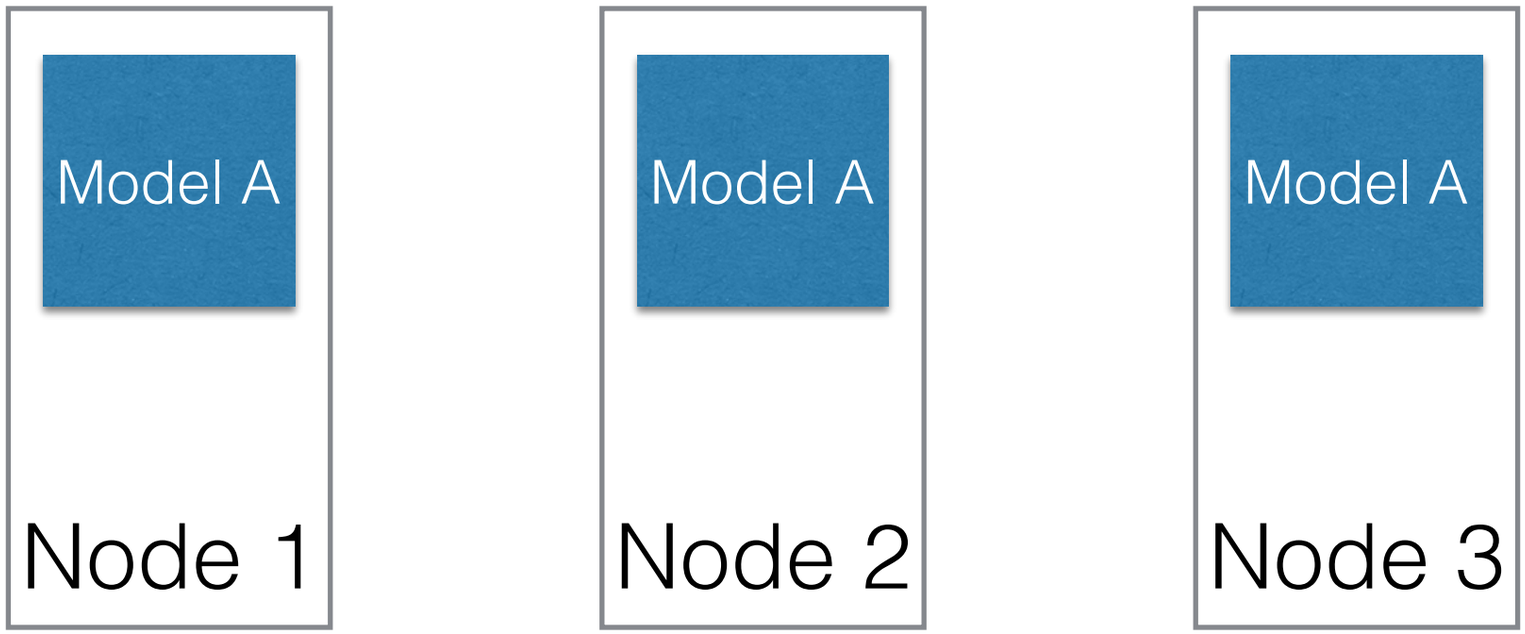
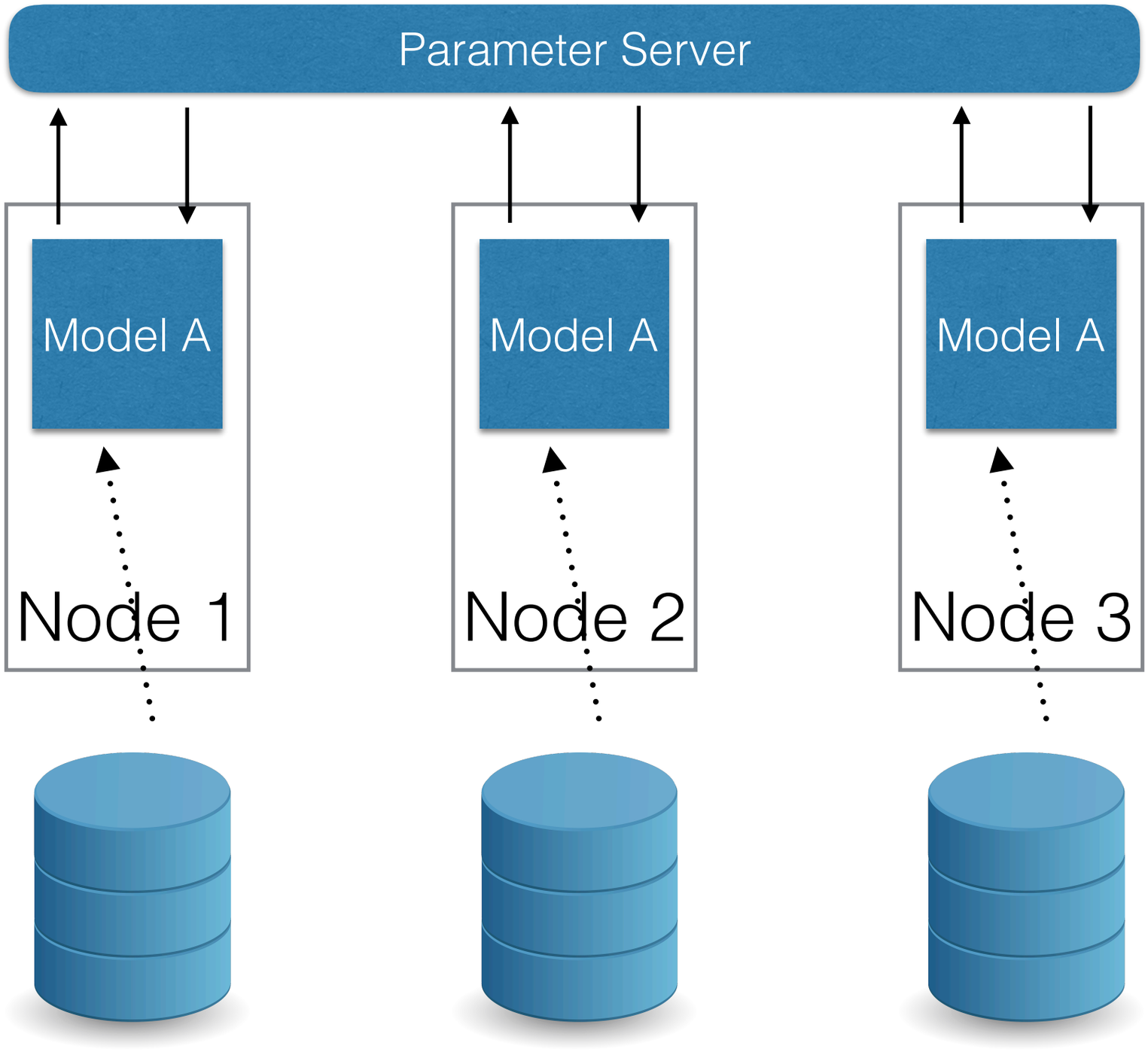


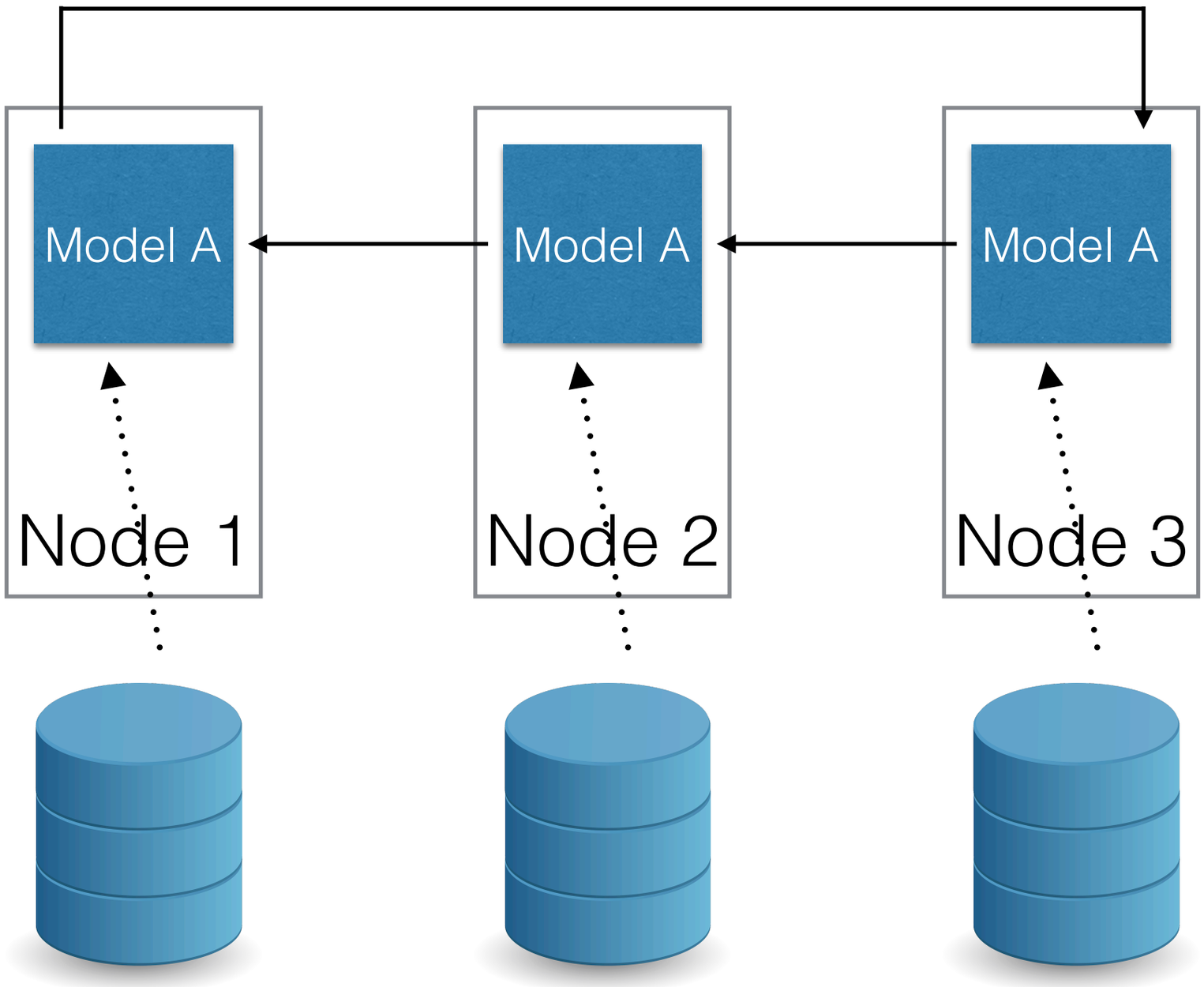
data parallelism

aka. “Jeff Dean style” parameter averaging

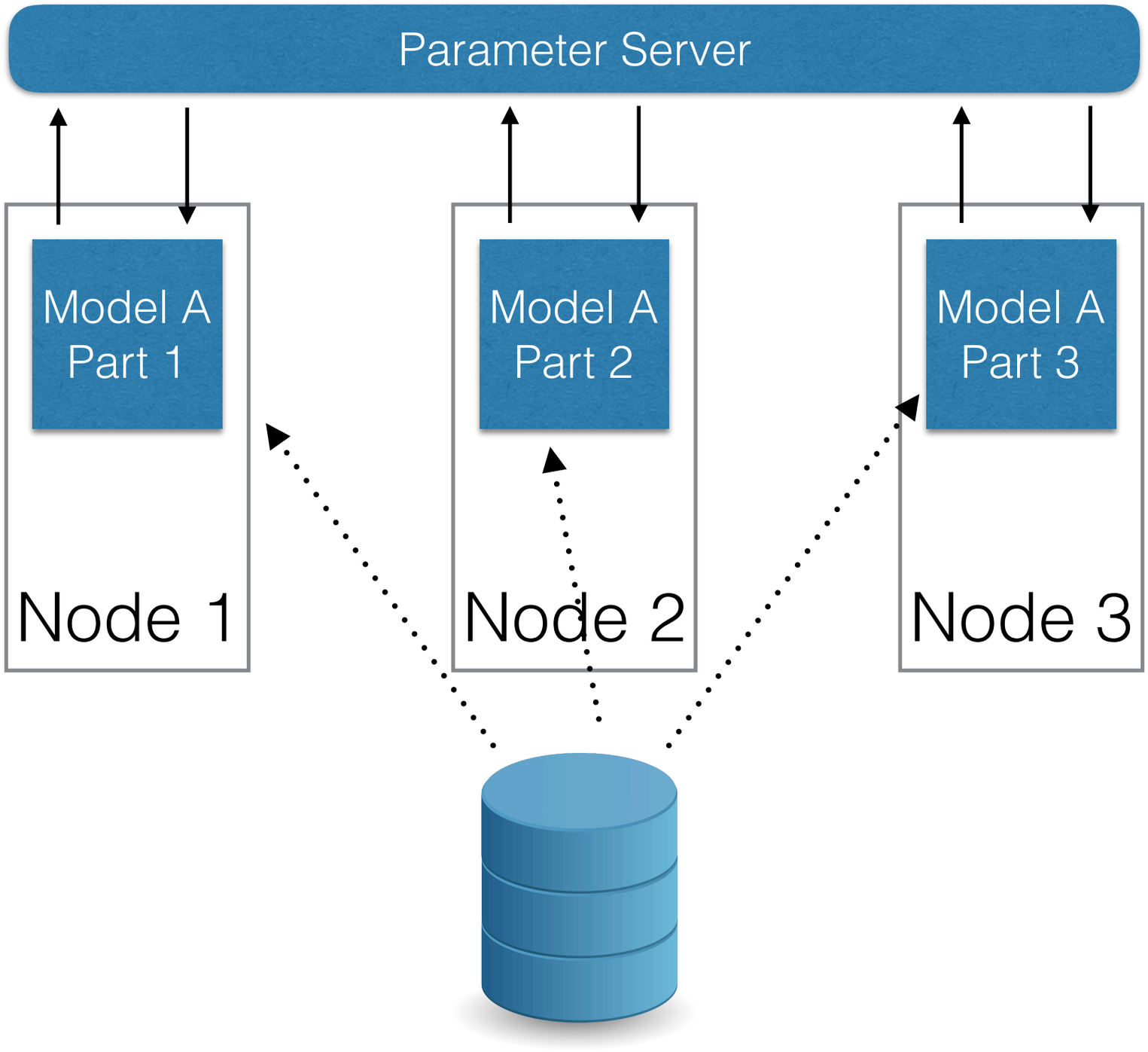


data parallelism

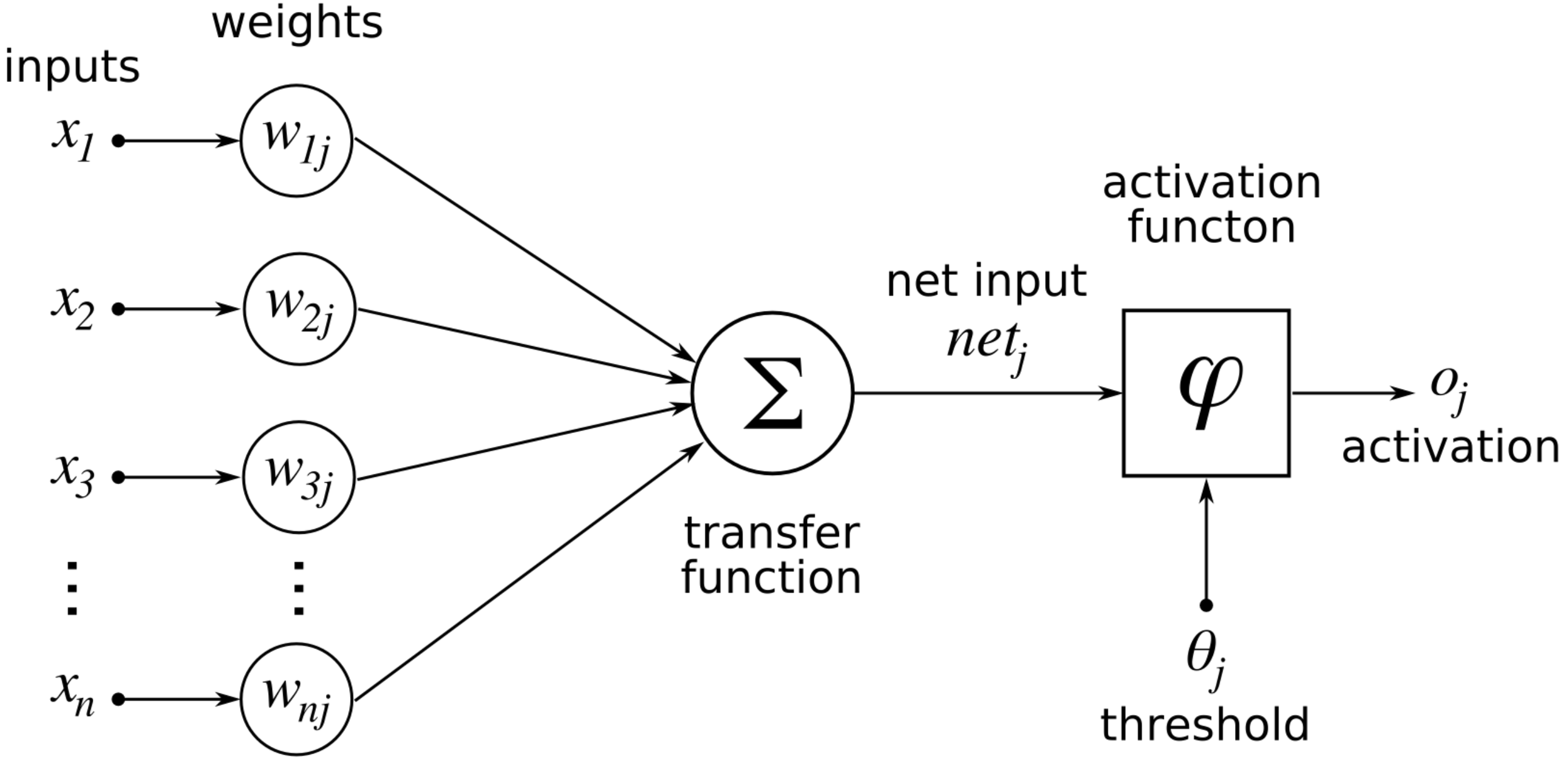
aka. “ReduceAll” parameter averaging



intra-model parallelism



intra-model parallelism



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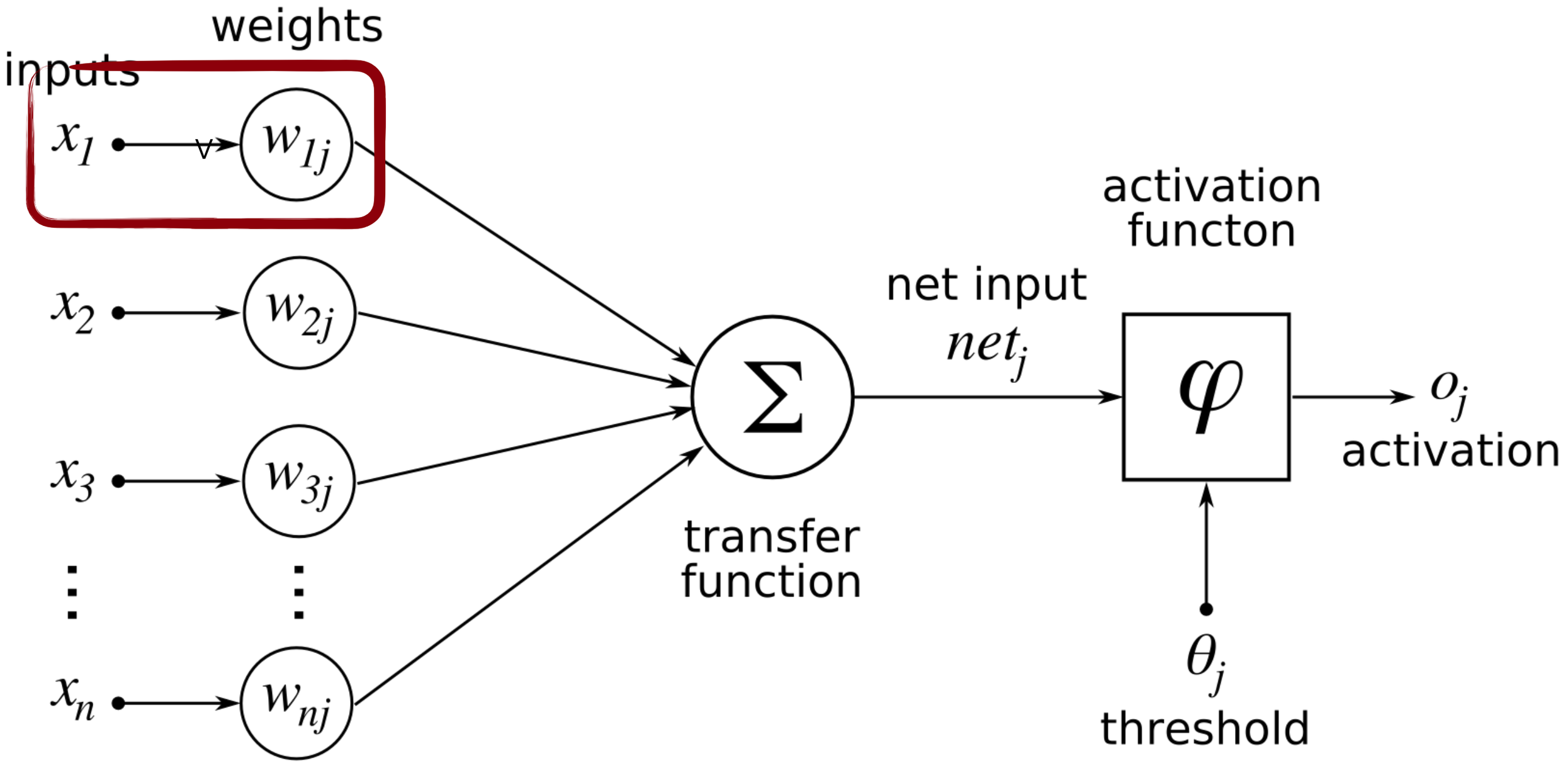

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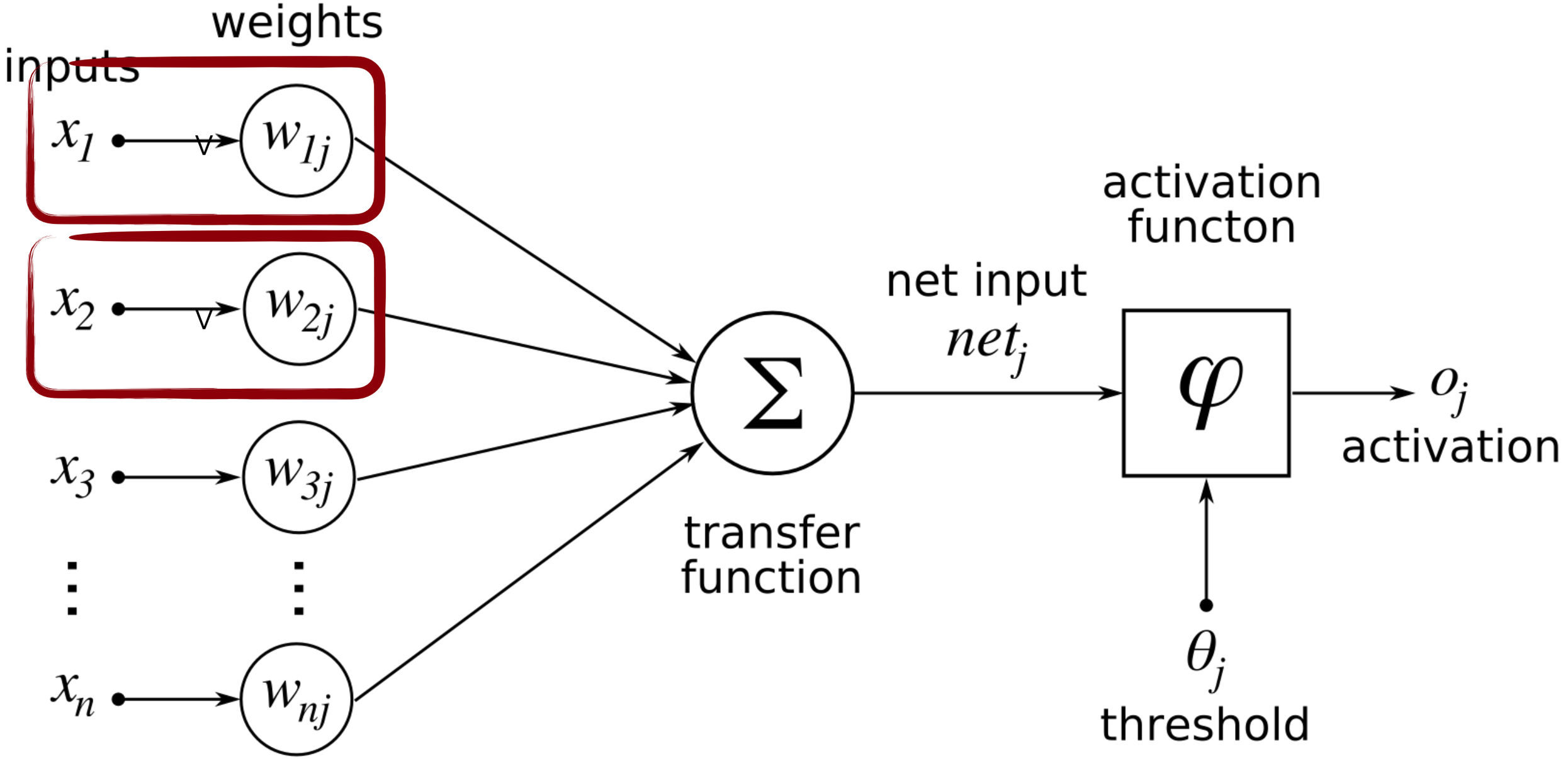

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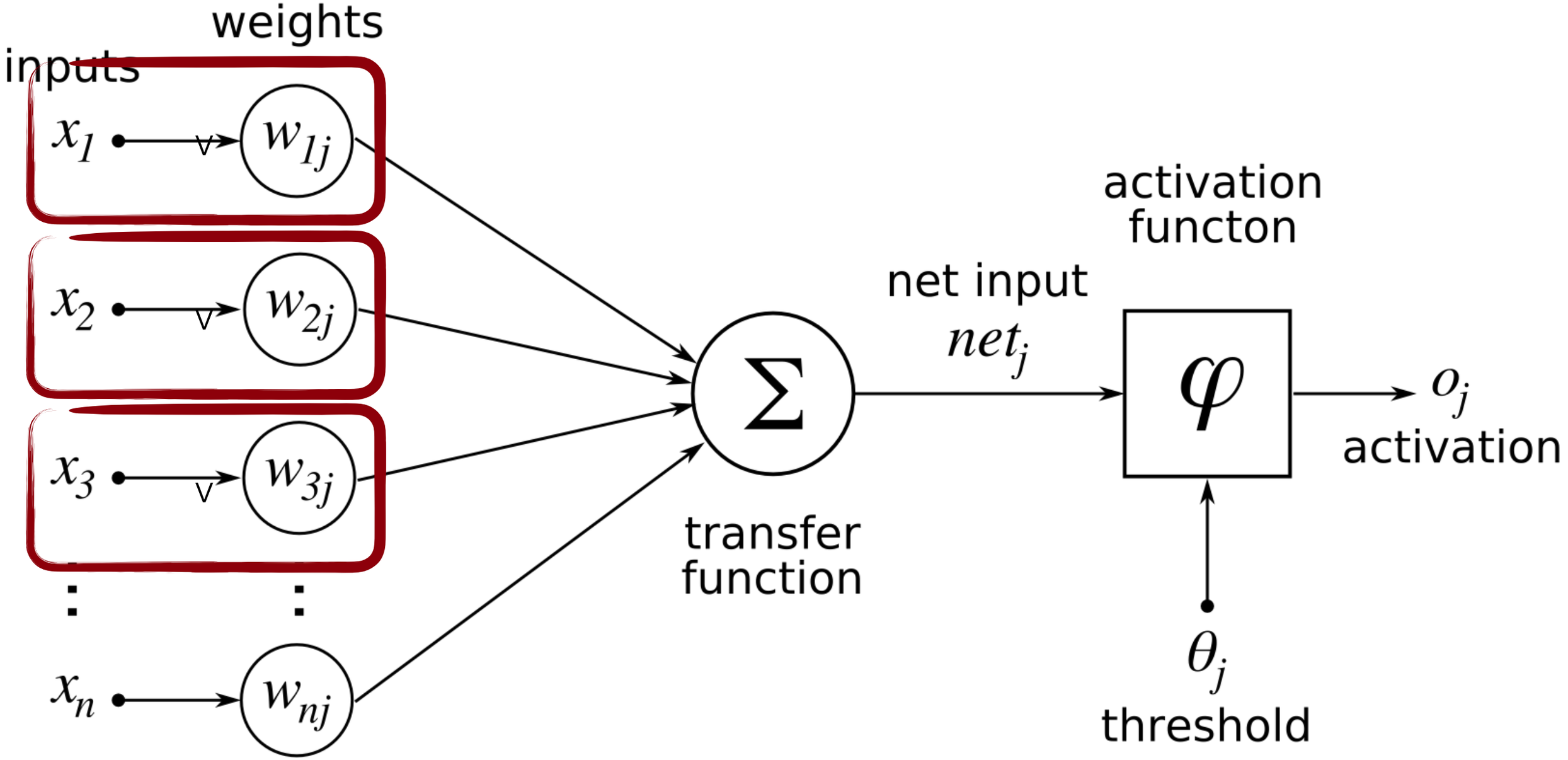

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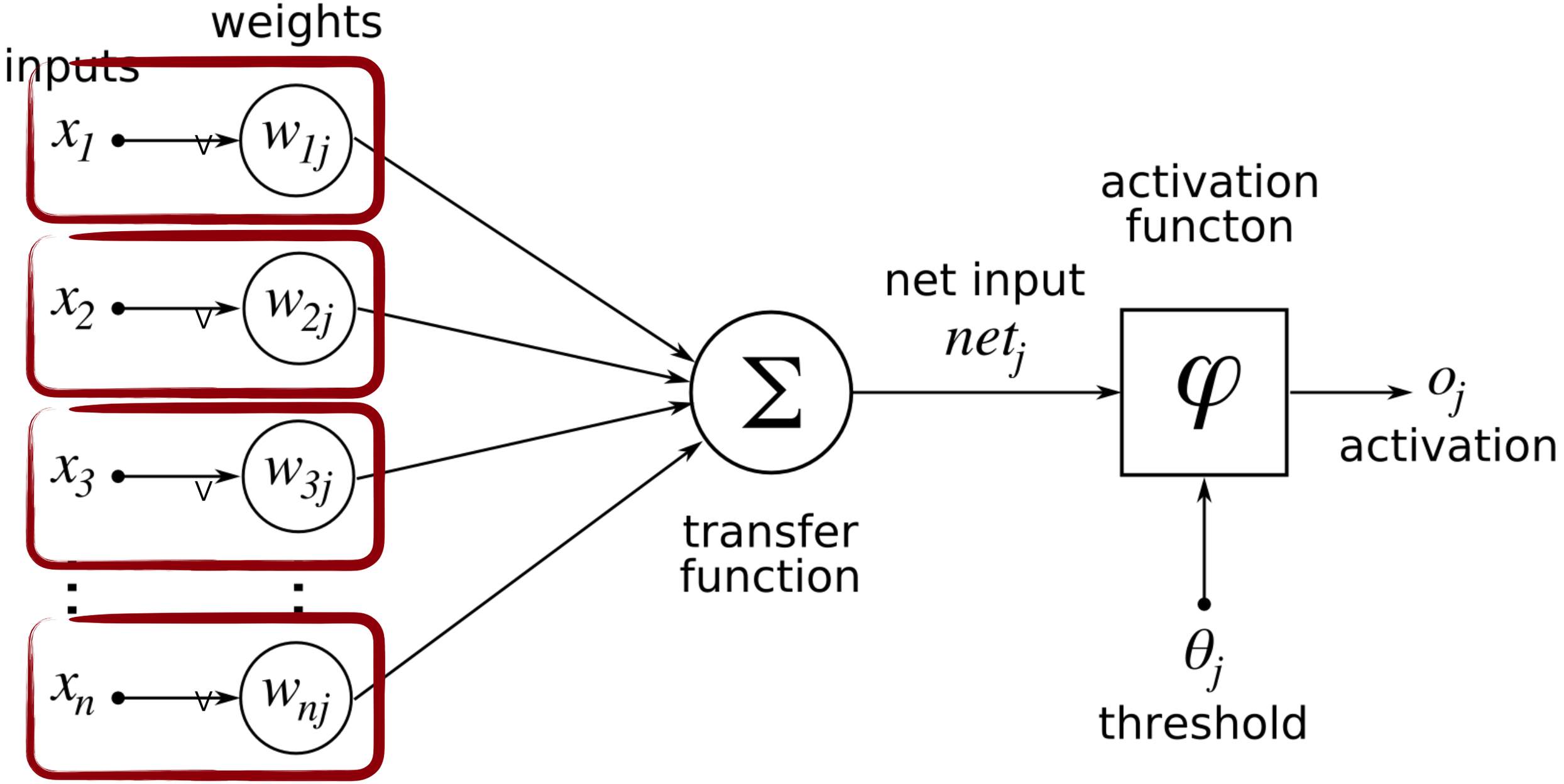
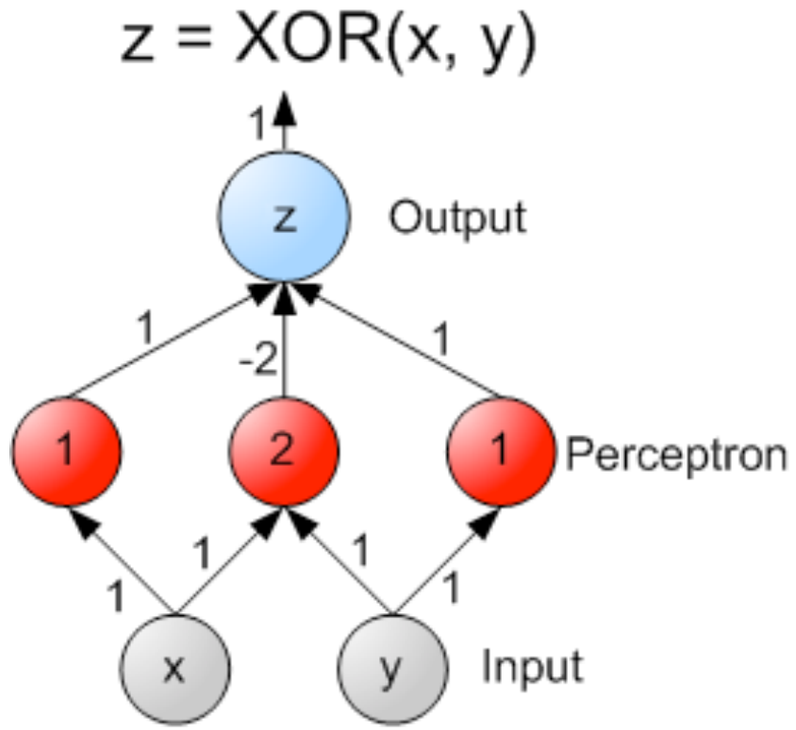
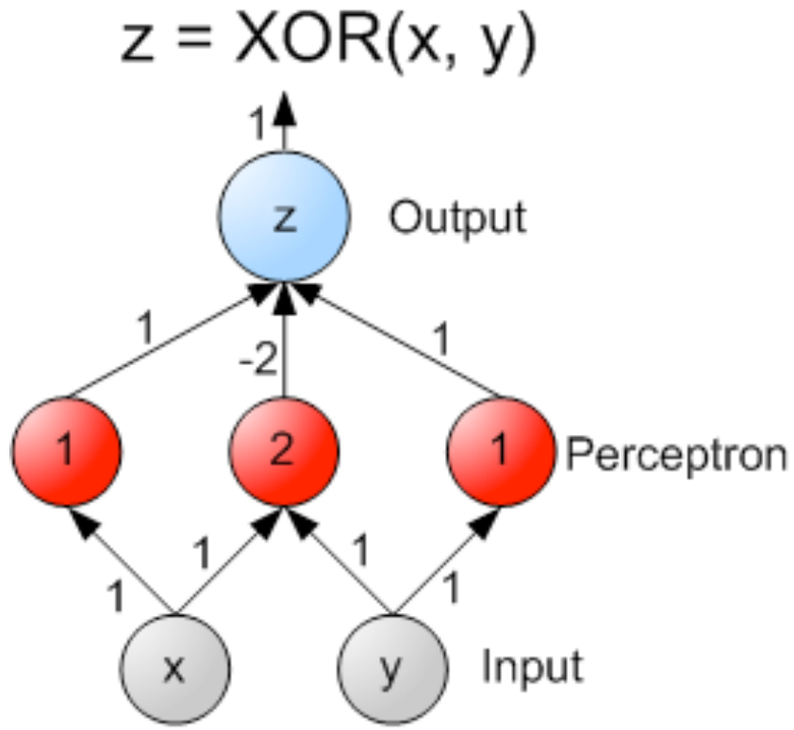


pipelined parallelism



pipelined parallelism



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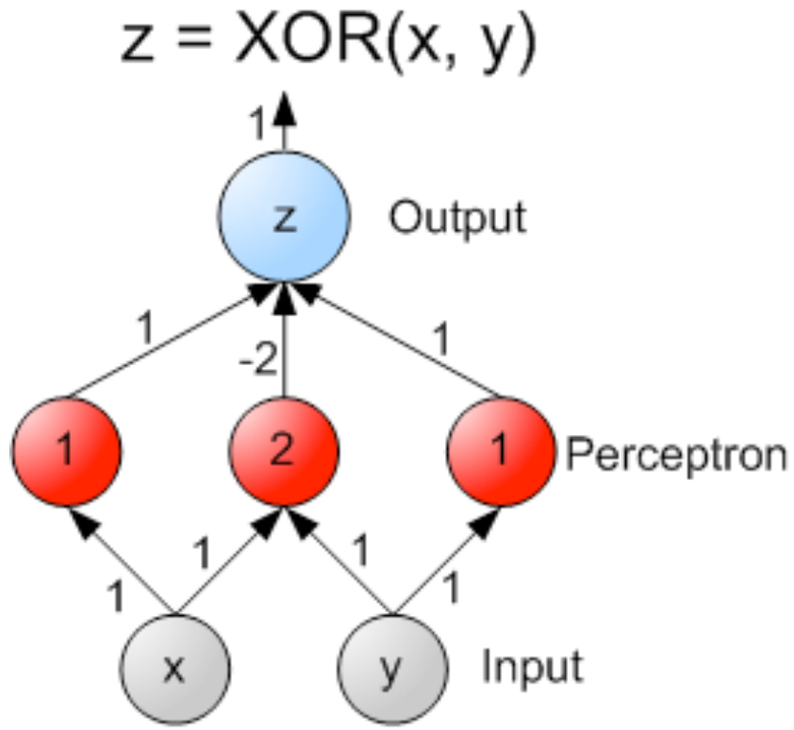
pipelined parallelism



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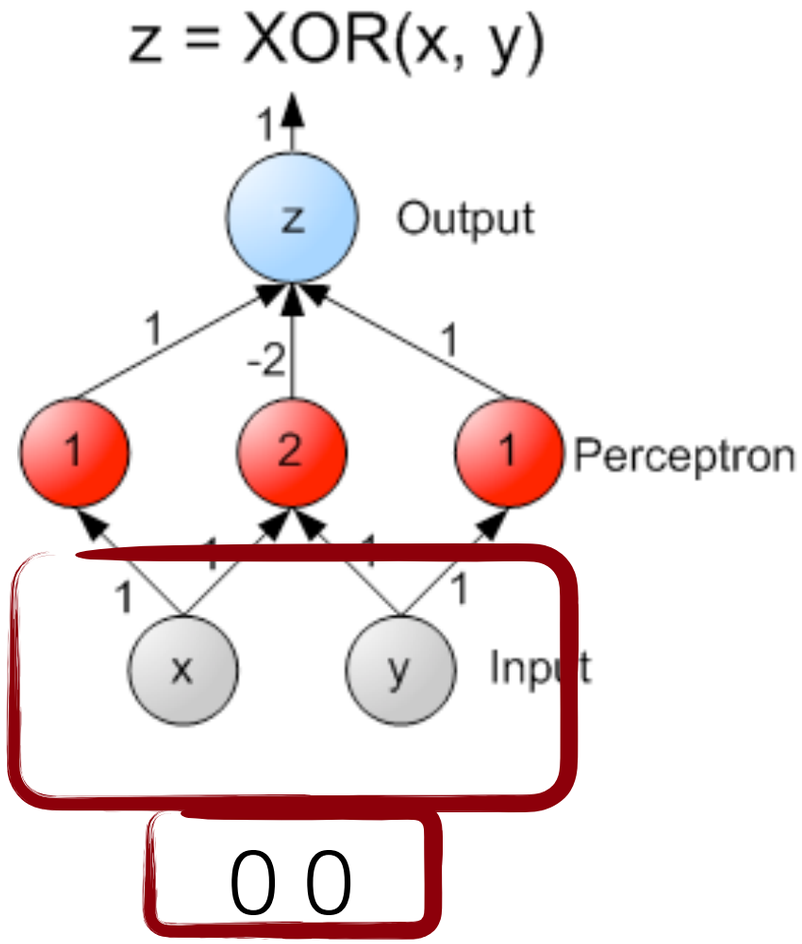
pipelined parallelism



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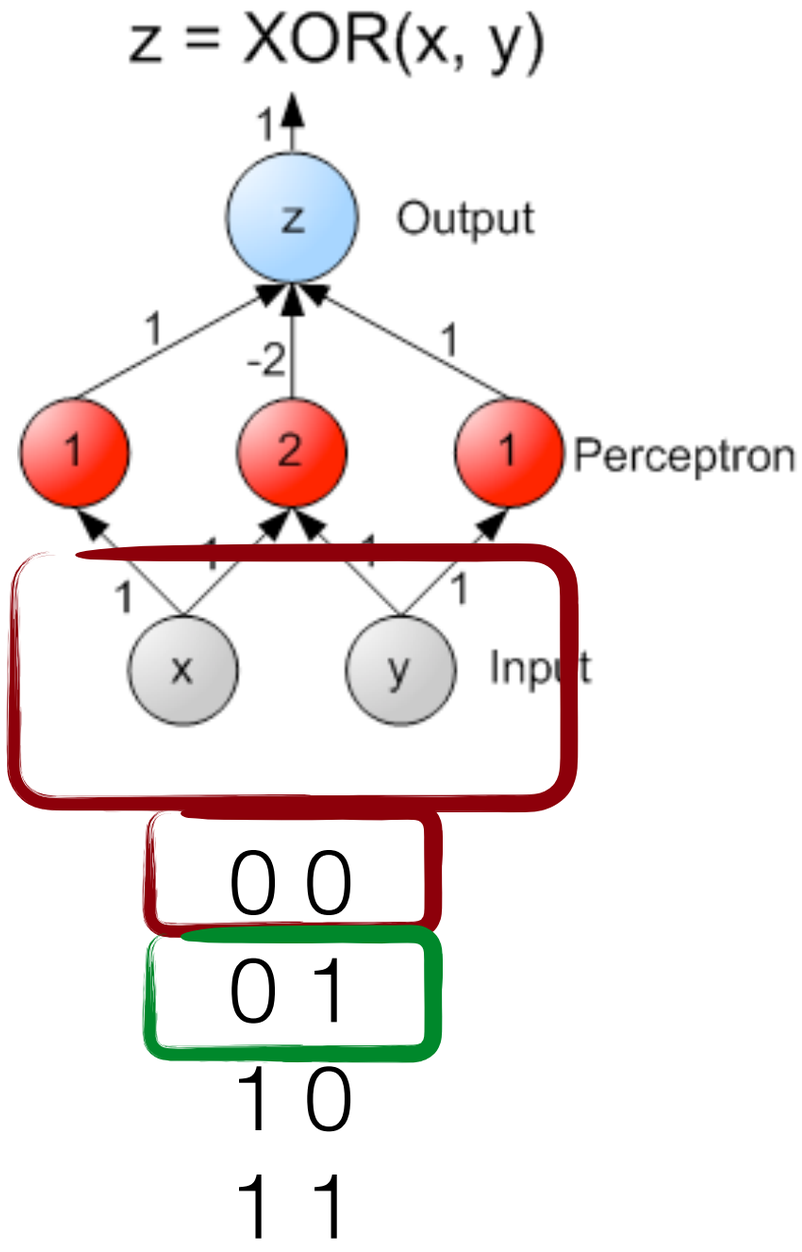

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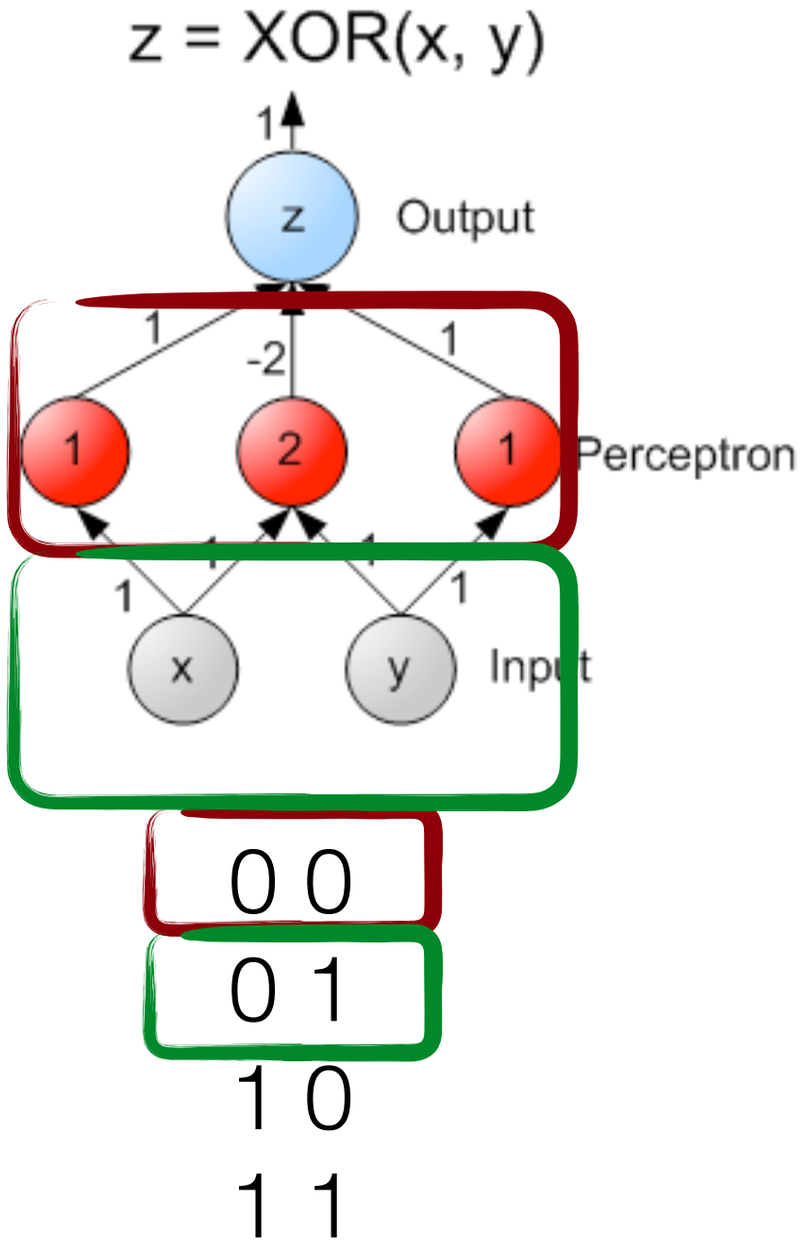

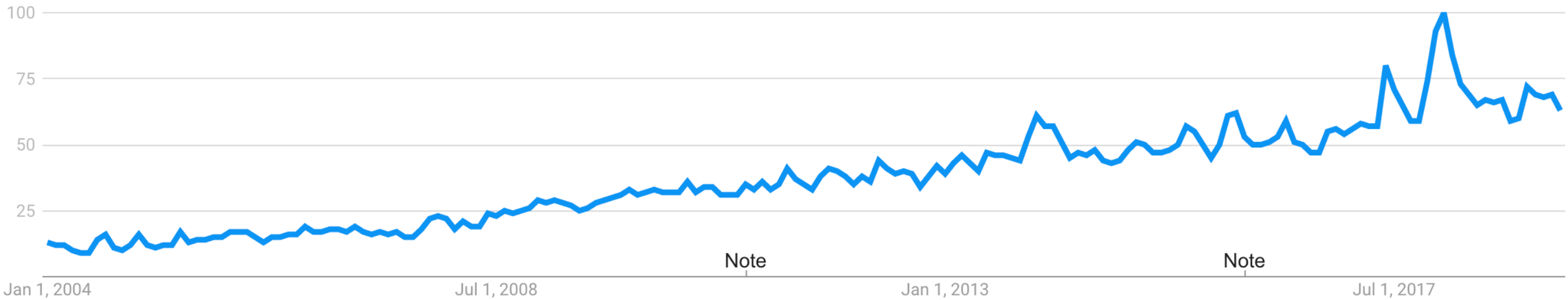
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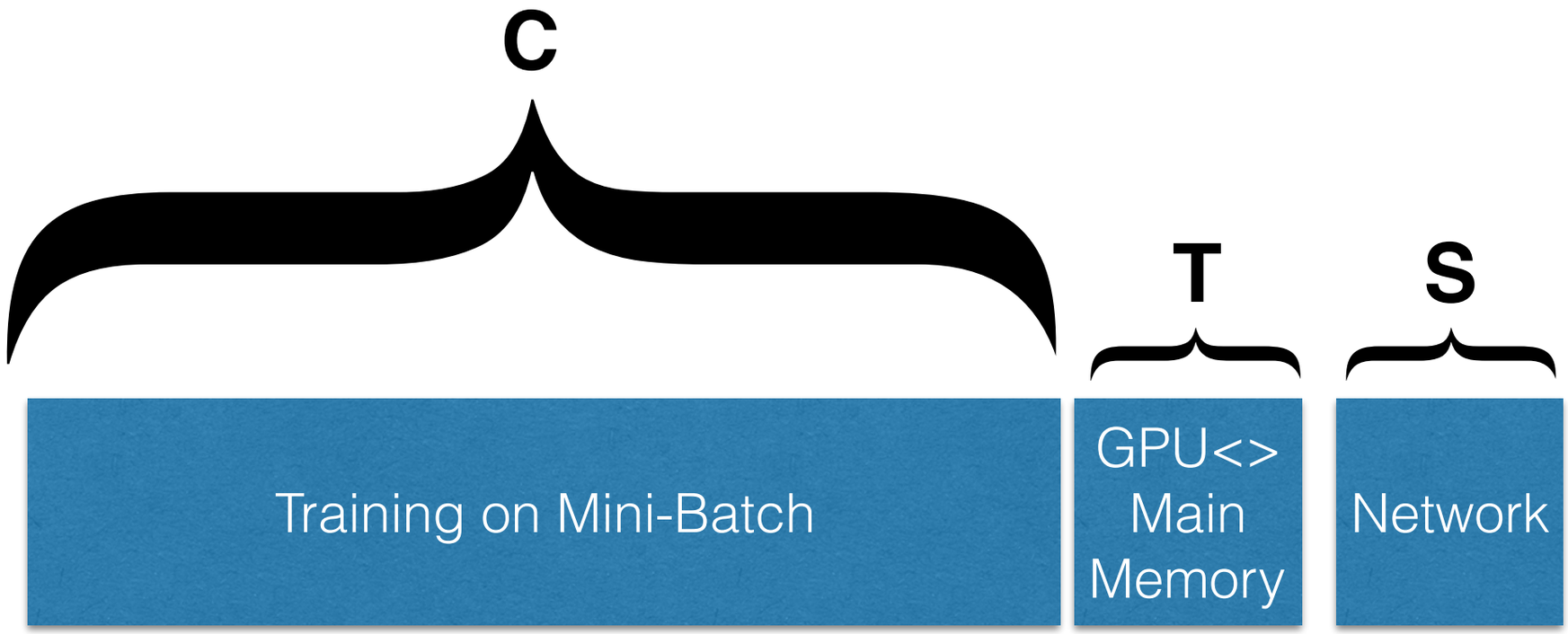
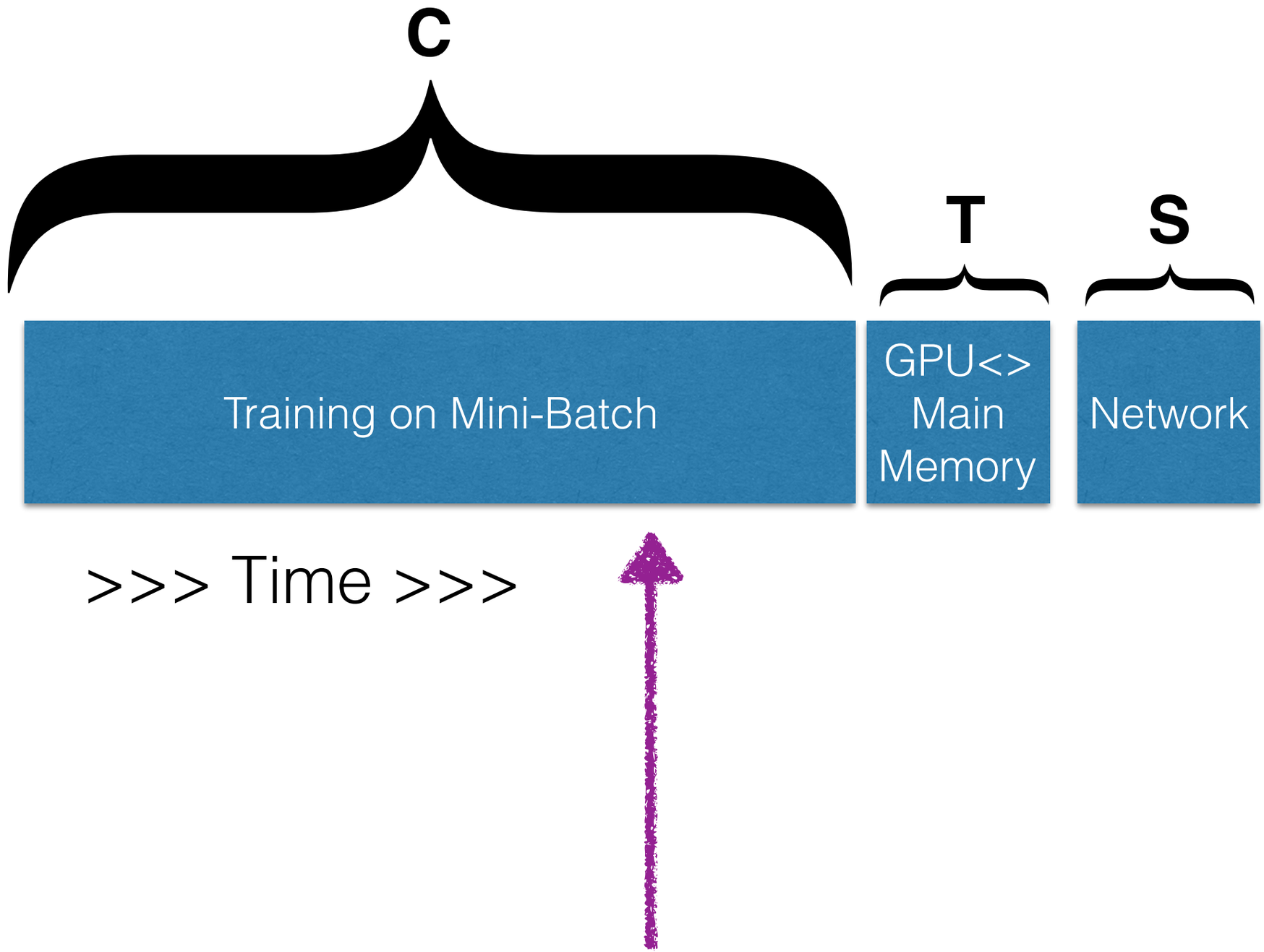
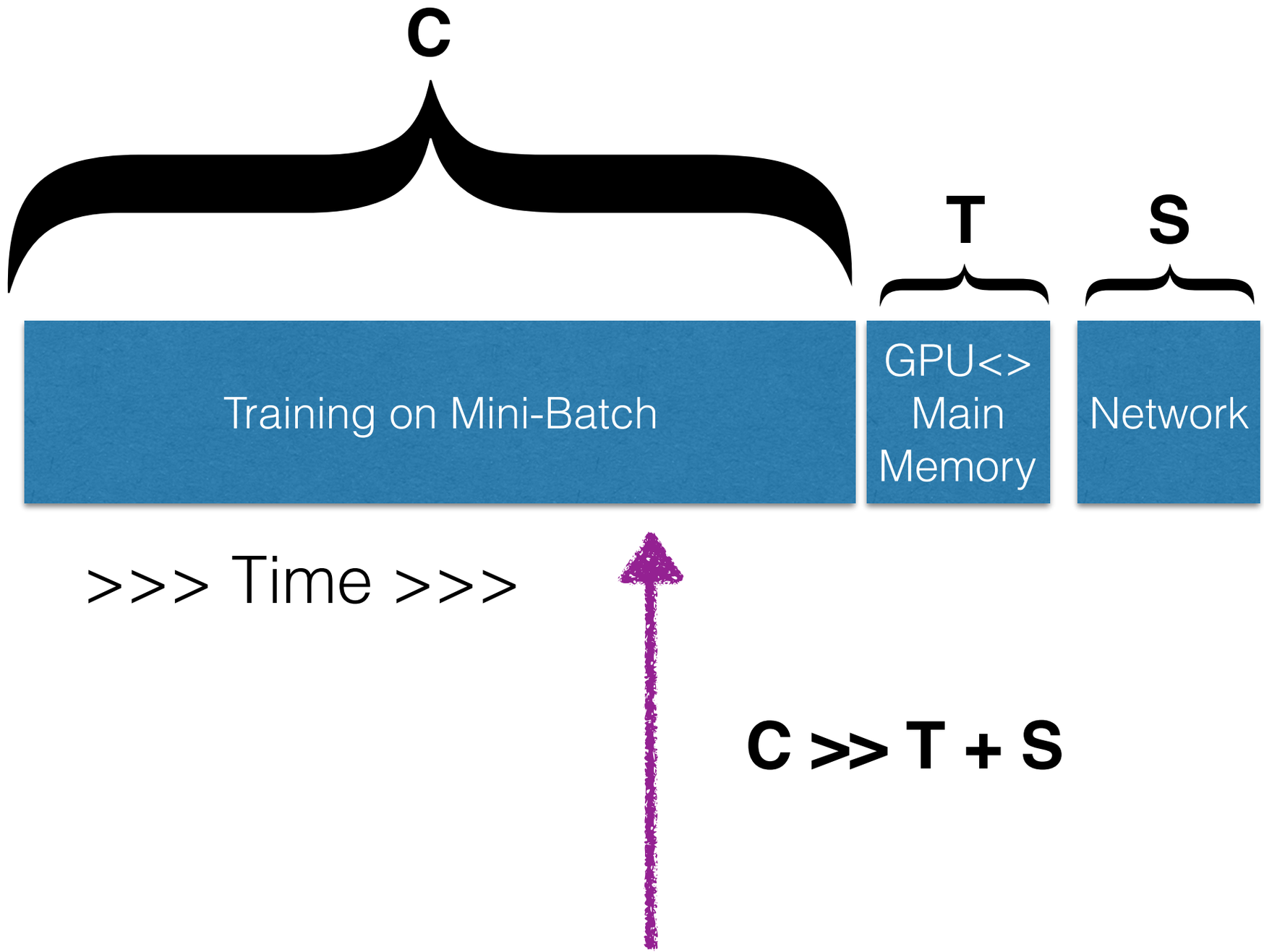
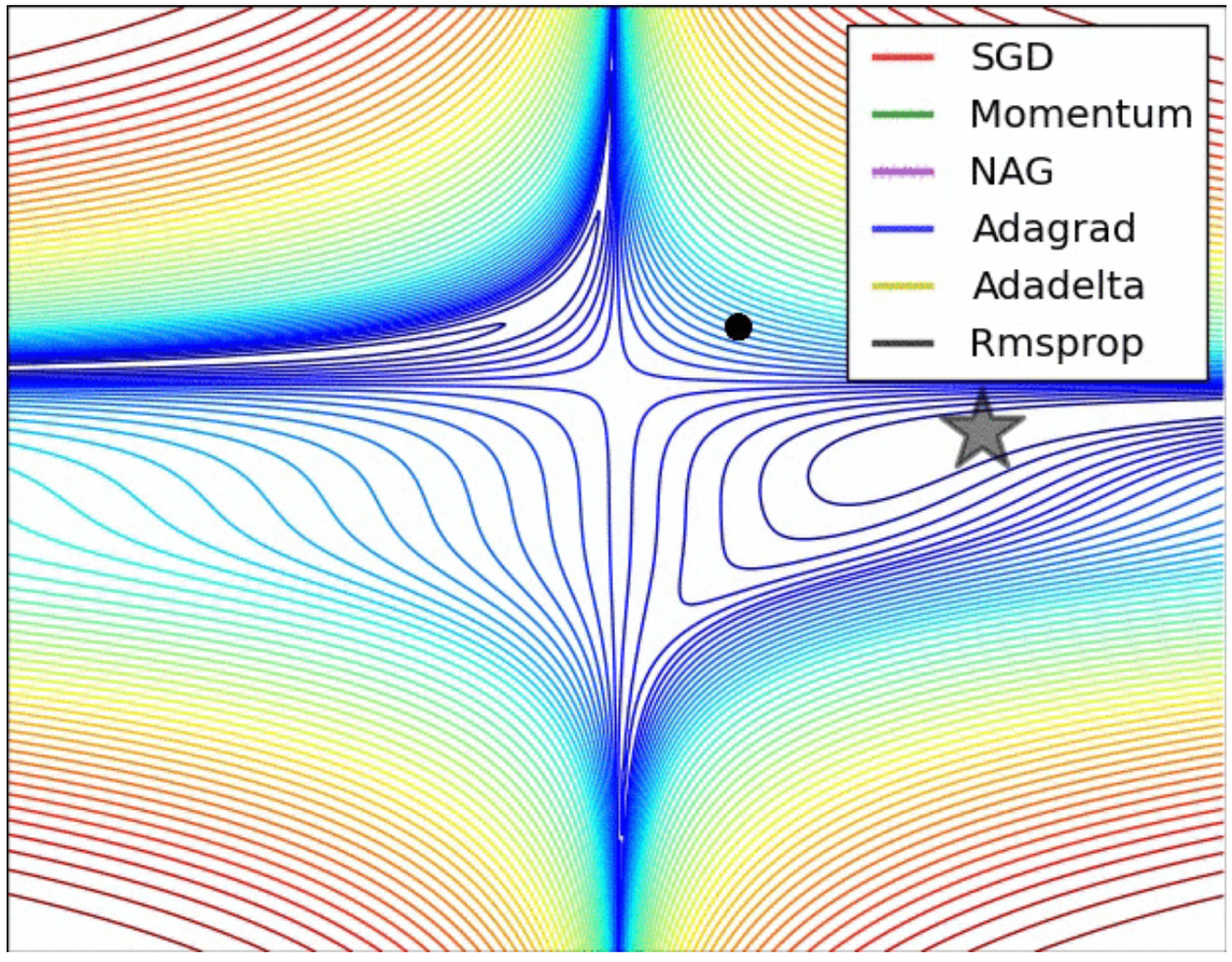
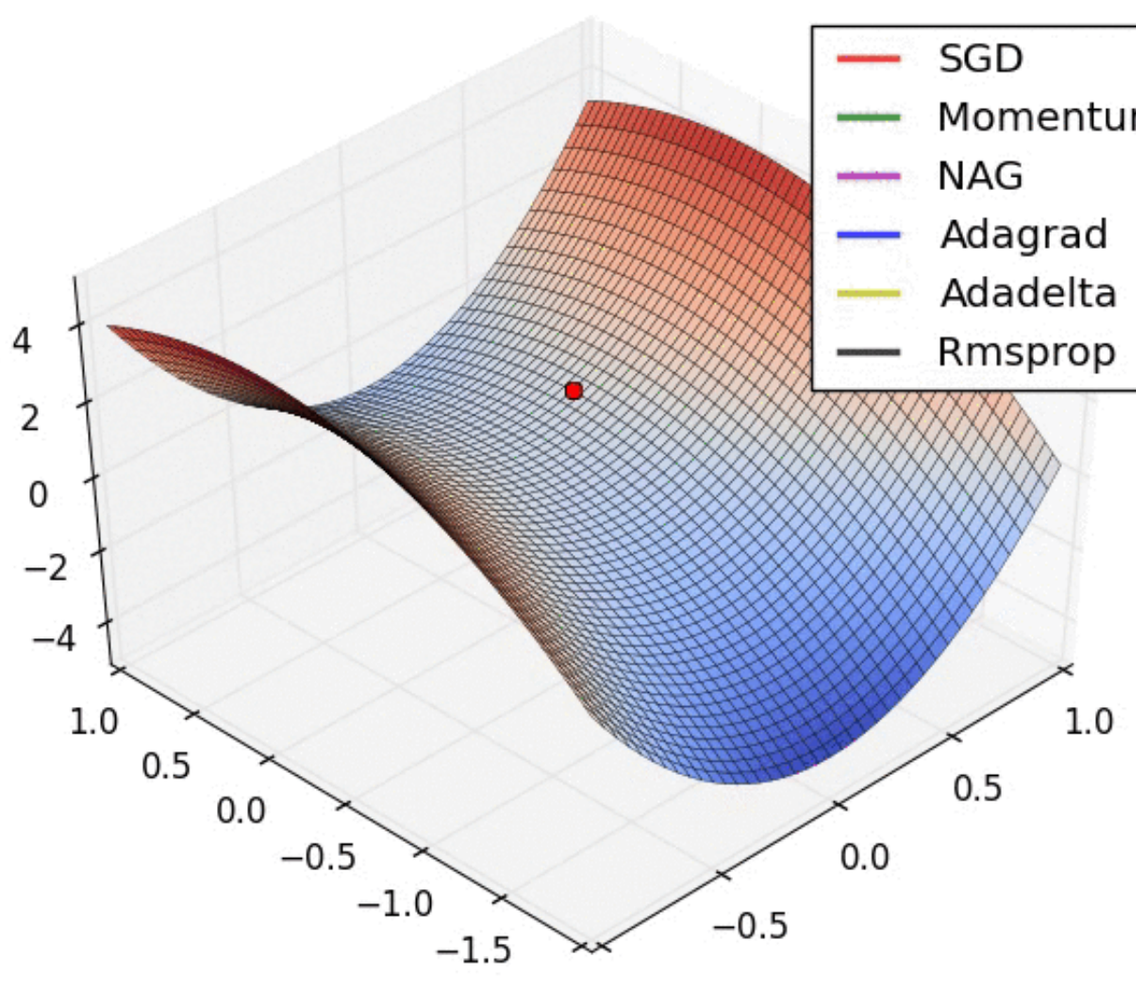


>>> Time >>>









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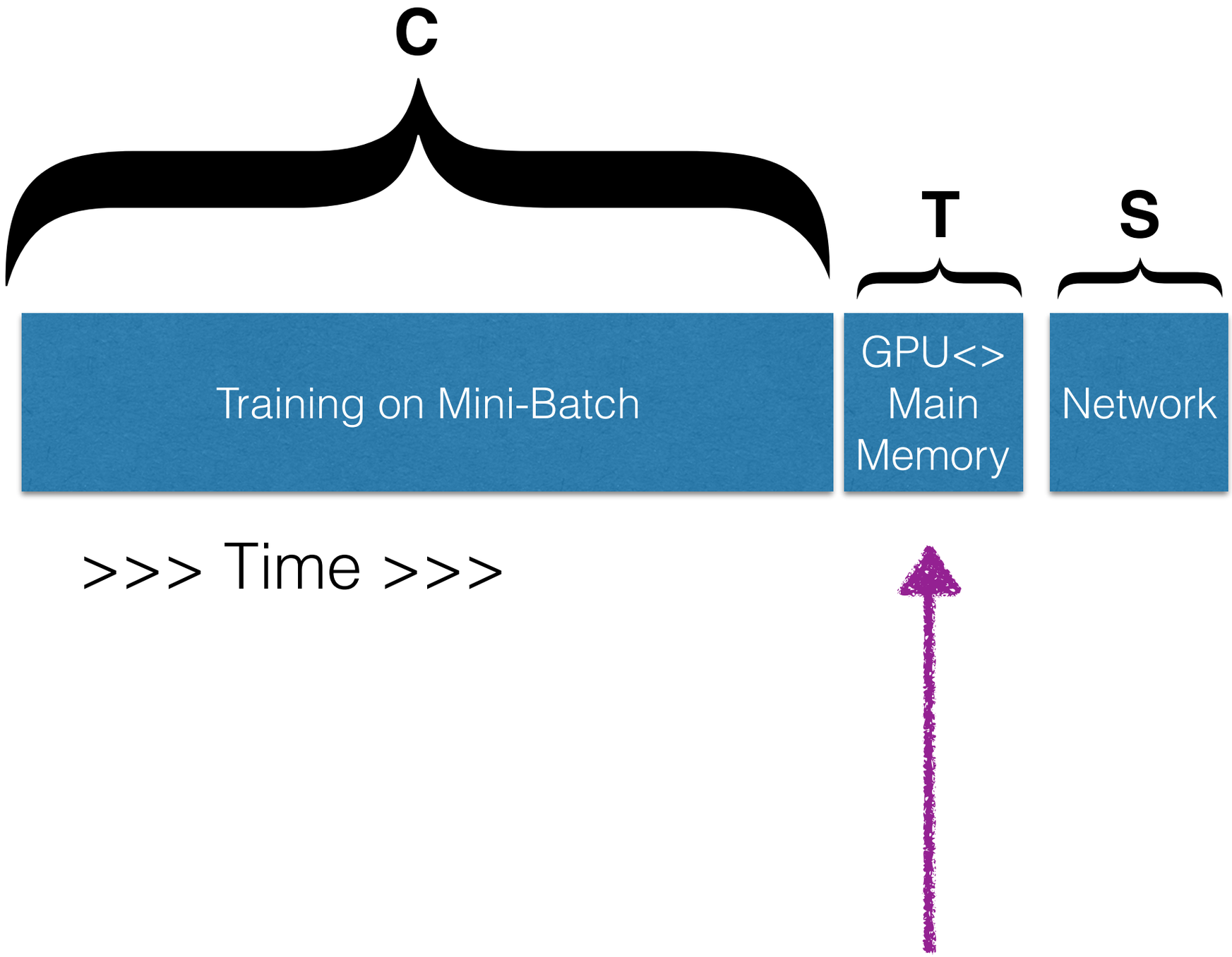
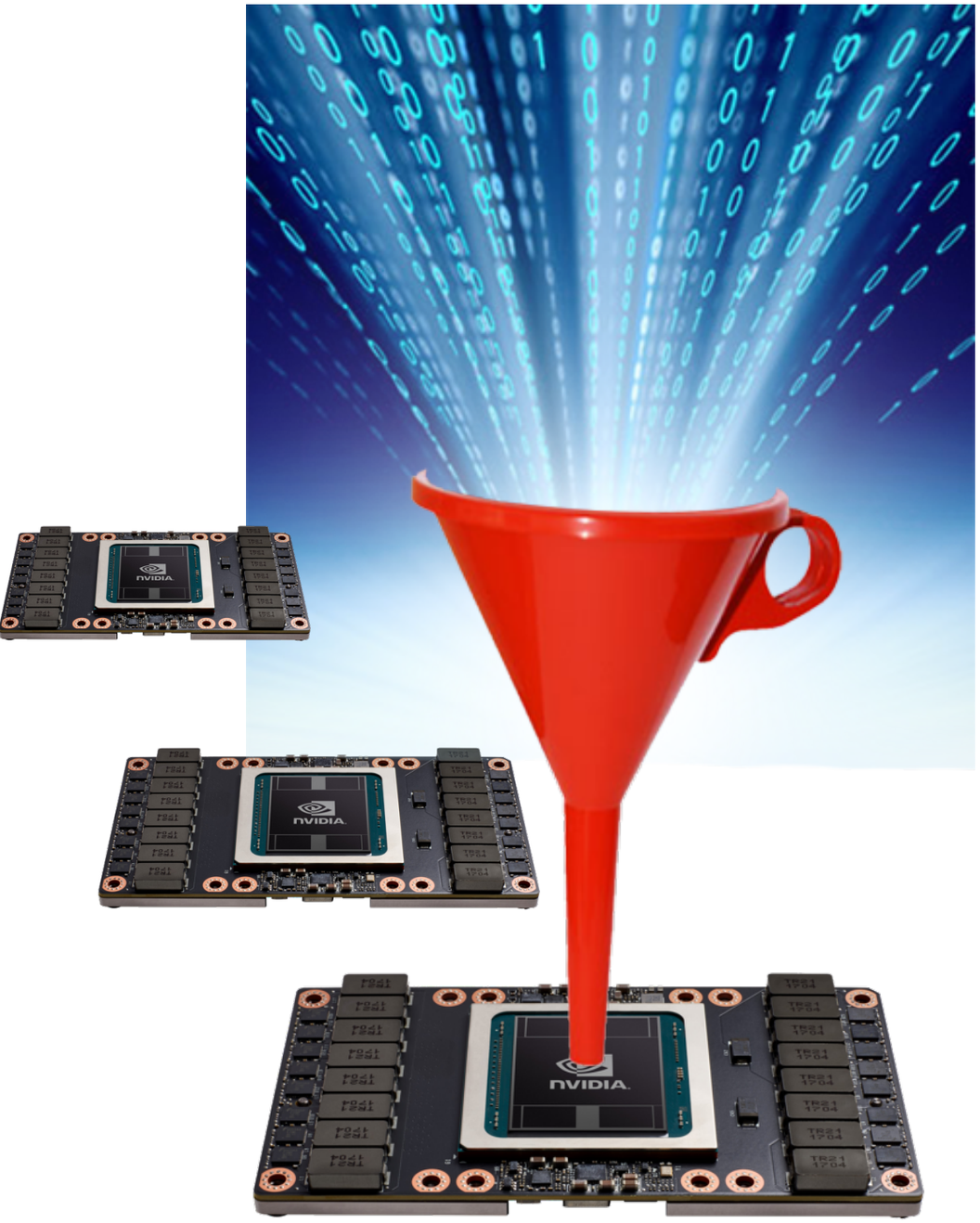


Time(%)	Time	Calls	Avg	Name
49.35%	29.581ms	1	29.581ms	[CUDA memcpy DtoH]
47.48%	28.462ms	1	28.462ms	[CUDA memcpy HtoD]
3.17%	1.9000ms	1	1.9000ms	naiveTransposeKernel



```
Time(%)   Time     Calls   Avg      Name
49.35%    29.581ms    1    29.581ms    [CUDA memcpy DtoH]
47.48%    28.462ms    1    28.462ms    [CUDA memcpy HtoD]
3.17%     1.9000ms    1    1.9000ms    naiveTransposeKernel
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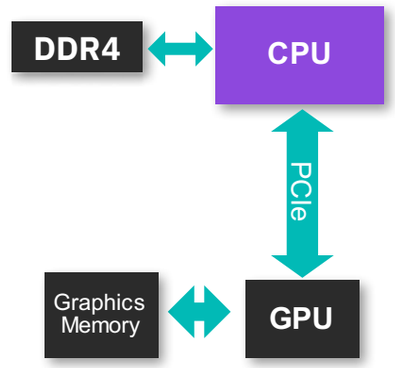
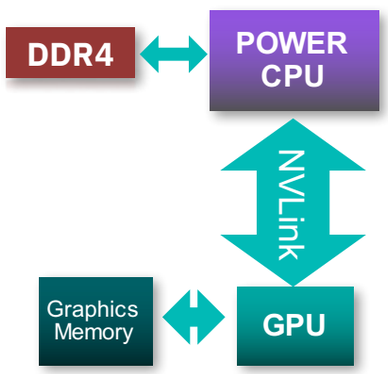
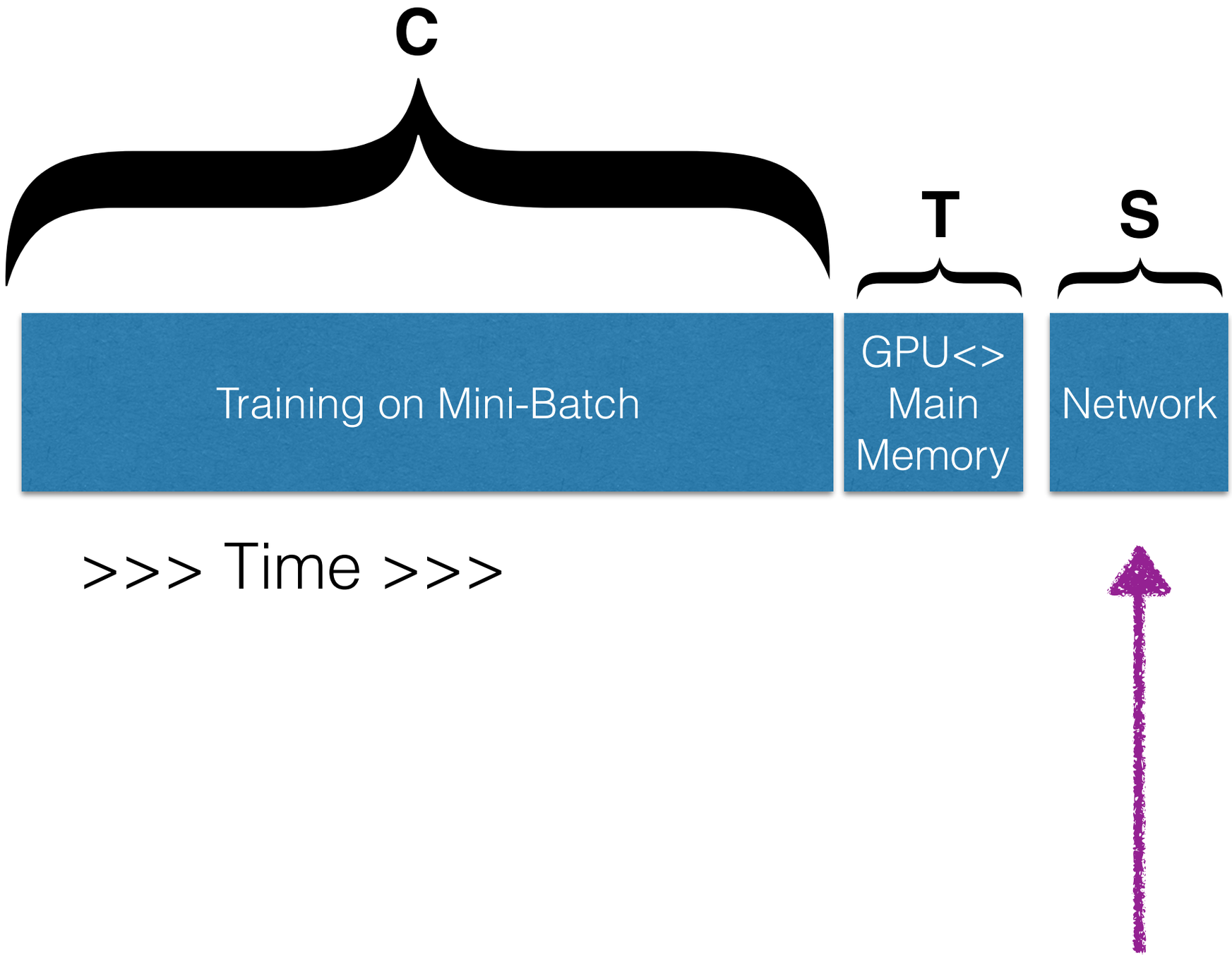


PCIe Gen3 – 32GB/sec

NVLink 1.0 – 80GB/sec

NVLink 2.0 – 150 GB/sec

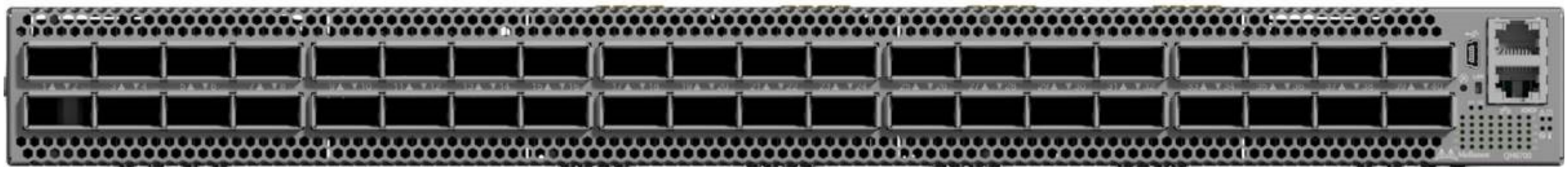




QM8700 Series - Mellanox Quantum™ HDR 200Gb/s InfiniBand Smart Switches

40-port Non-blocking HDR 200Gb/s InfiniBand Smart Switch

Mellanox provides the world's smartest switches, enabling in-network computing through the Co-Design Scalable Hierarchical Aggregation and Reduction Protocol (SHARP)™ technology. The QM8700 series has the highest fabric performance available in the market with up to 16Tb/s of non-blocking bandwidth with sub 90ns port-to-port latency.



Open MPI:
Open Source High Performance Computing

IBM Spectrum MPI

Accelerating high-performance application parallelization

Romeo Kienzler

Levels

Benefits

Current Members

How to Join

Current Members

Platinum Level

Google

IBM

Mellanox TECHNOLOGIES

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XILINX

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TensorFlow™ PYTORCH Chainer SnapML

Large Model Support (LMS)

Watson Machine Learning Accelerator

Distributed Deep Learning (DDL)

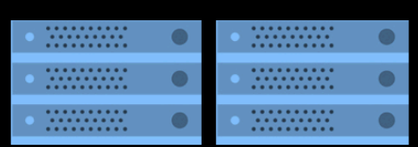
Elastic Distributed Inference (Preview)

IBM Spectrum Conductor
Cluster Virtualization, Elastic Training
Auto Hyper-Parameter Optimization

Deep Learning Impact (DLI) Module

Data & Model Management, ETL, Visualize, Advise

Accelerated Infrastructure



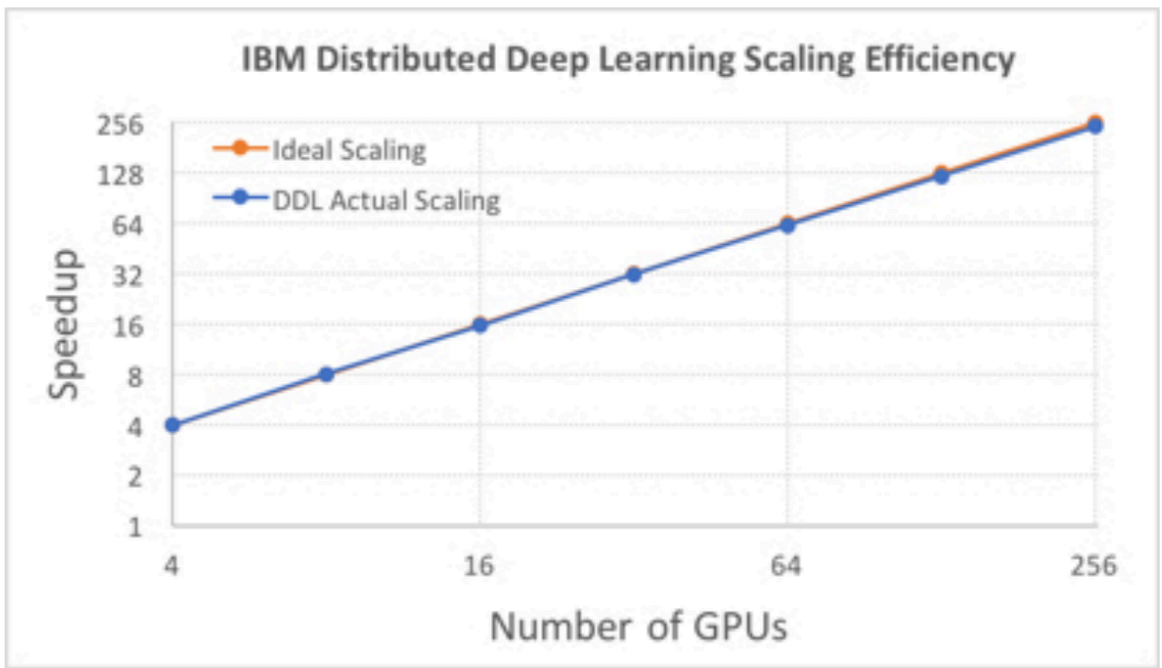
Accelerated Servers AC922

Storage (Spectrum Scale ESS)

August 8, 2017
Posted in: AI, Cognitive Computing

IBM Research achieves record deep learning performance with new software technology

Summary: IBM Research publishes in arXiv close to ideal scaling with new distributed deep learning software which achieved record communication overhead and 95% scaling efficiency on the Caffe deep learning framework over 256 NVIDIA GPUs in 64 IBM Power systems. Previous best scaling was demonstrated by Facebook AI Research of 89% for a training run on Caffe2, at higher communication overhead. IBM Research also beat Facebook's time by training the model in 50 minutes, versus the 1 hour Facebook took. Using this software, IBM Research achieved a new image recognition accuracy of 33.8% for a neural network trained on a very large data set (7.5M images). The previous record published by Microsoft demonstrated 29.8% accuracy.



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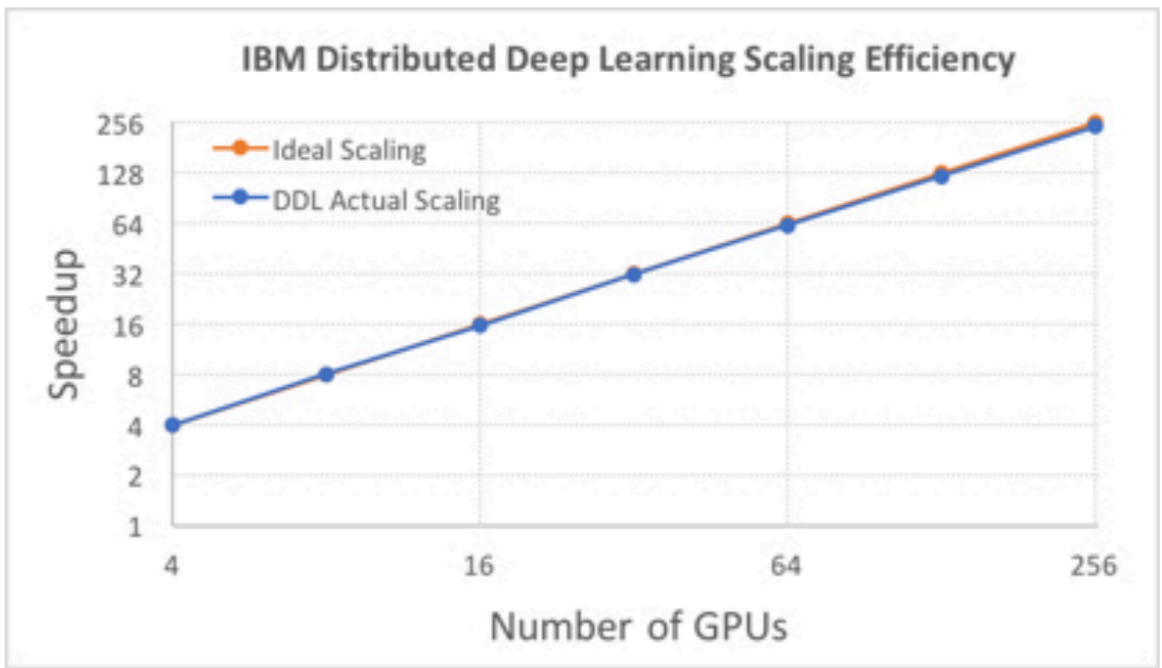

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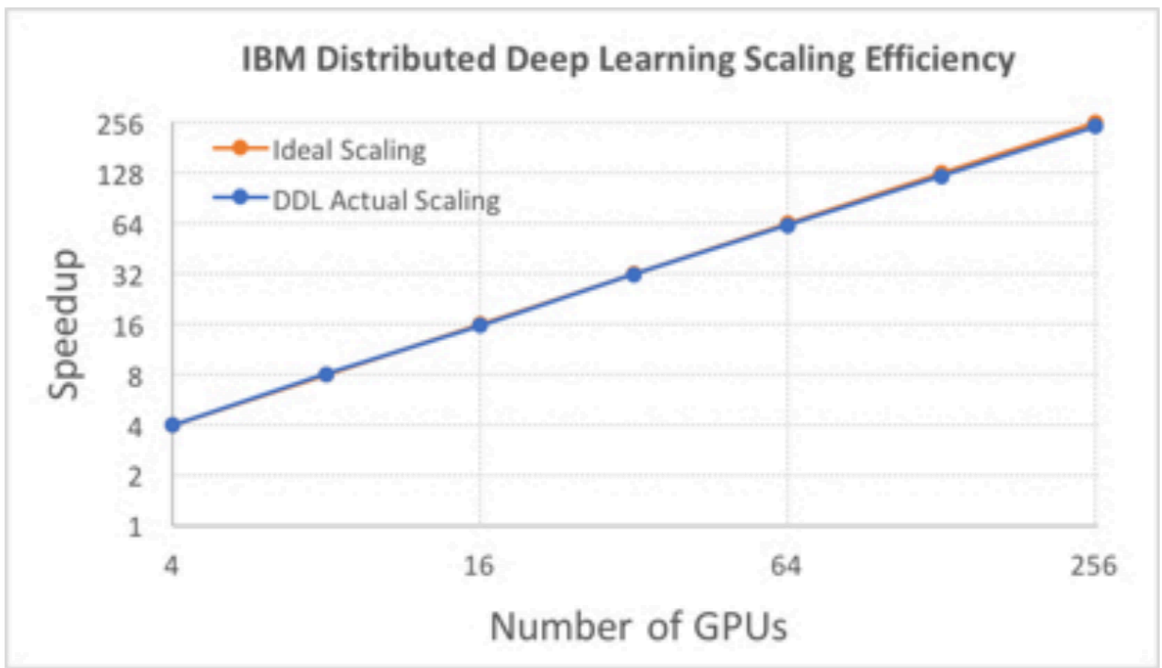

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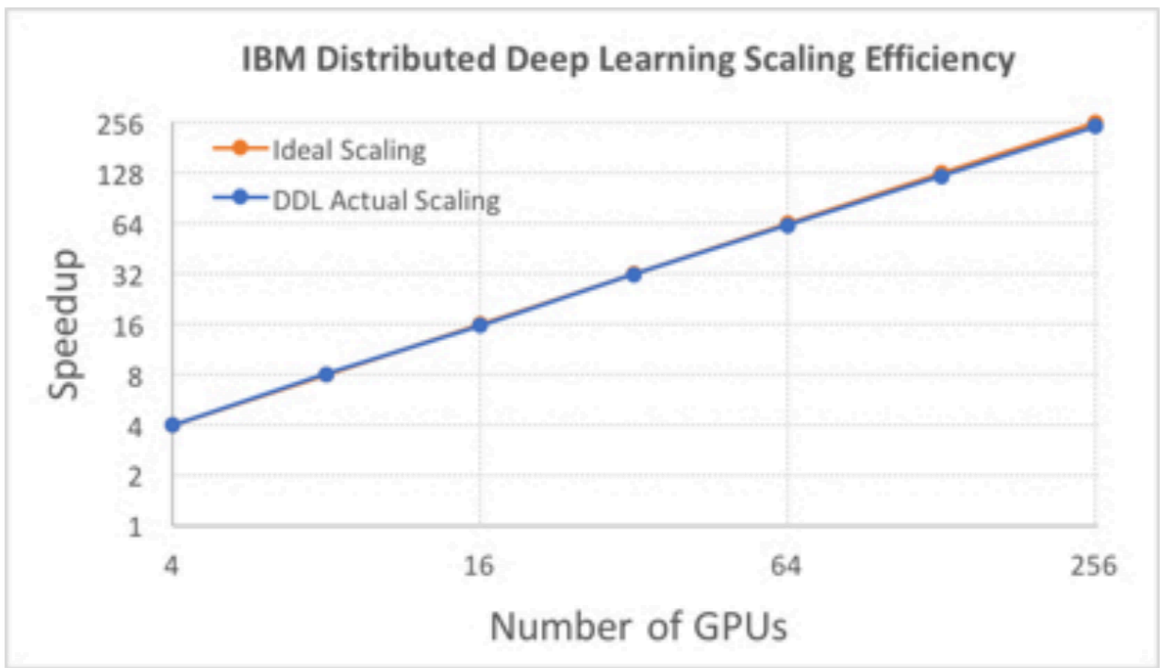
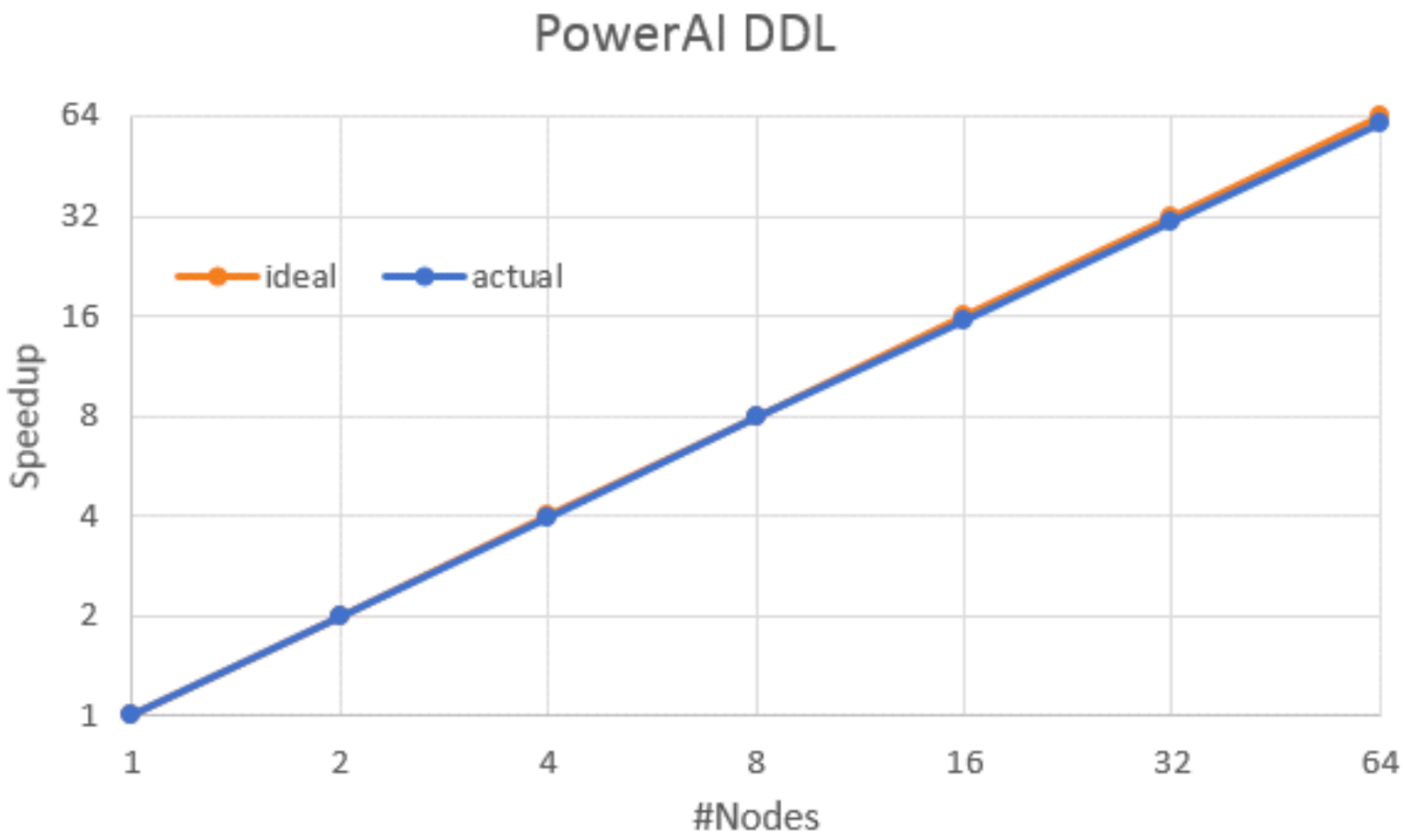
Accuracy
Microsoft: 29.8%
IBM: 33.8%





#GPUs	4	8	16	32	64	128	256
#Nodes	1	2	4	8	16	32	64
Speedup	1.0	2.0	3.9	7.9	15.5	30.5	60.6
Scaling efficiency	1.00	1.00	0.98	0.99	0.97	0.95	0.95

Figure 2: Resnet-50 for 1K classes using up to 256 GPUs with Caffe.

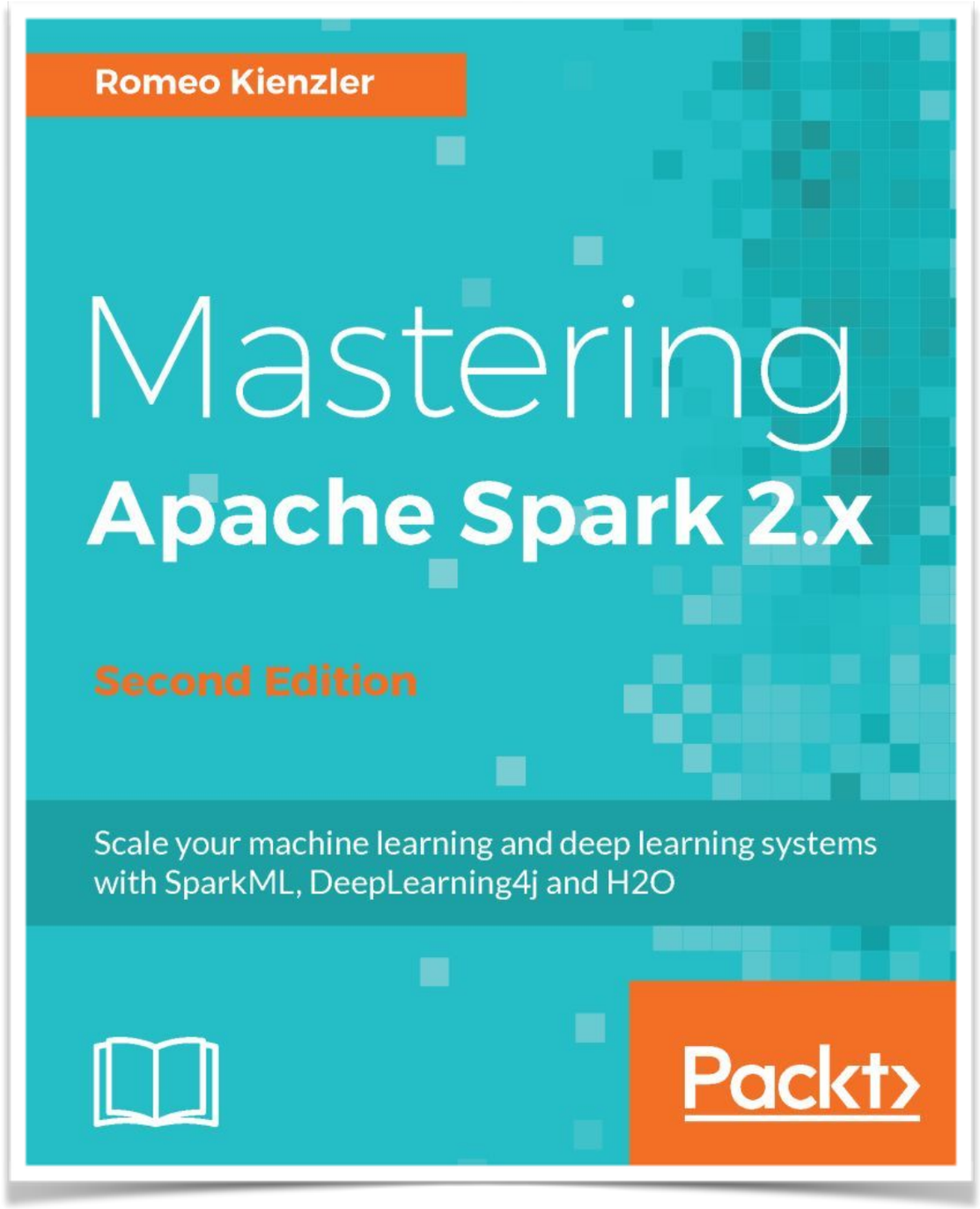
U.S. DEPARTMENT OF ENERGY

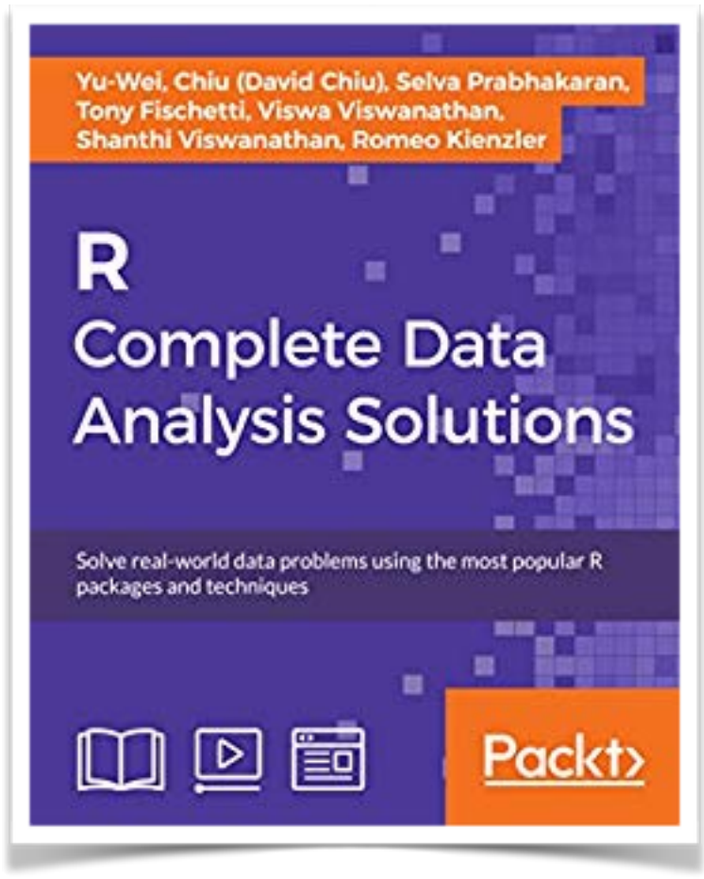
Office of Science

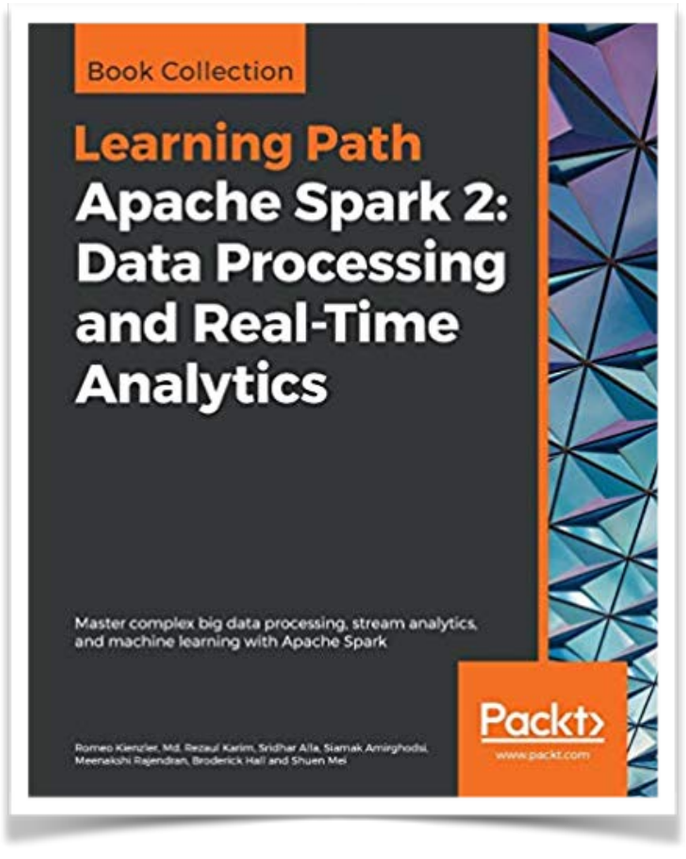
National Nuclear Security Administration

- 200 petaflops
- 4600 nodes
- 9200 Power9 CPU’s
- 220800 cores
- 1766400 hyper threads
- 27600 nVidia V100 GPUs
- 10 PB memory
- Power 15 MW
- 1% of Ethereum’s hash rate

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	**Summit** - IBM Power System AC922, IBM POWER9 22C 3.07GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband , IBM DOE/SC/Oak Ridge National Laboratory United States	2,282,544	122,300.0	187,659.3	8,806
2	**Sunway TaihuLight** - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway , NRCPC National Supercomputing Center in Wuxi China	10,649,600	93,014.6	125,435.9	15,371
3	**Sierra** - IBM Power System S922LC, IBM POWER9 22C 3.1GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband , IBM DOE/NNSA/LLNL United States	1,572,480	71,610.0	119,193.6	


Romeo Kienzler
Mastering
Apache Spark 2.x
Second Edition
Scale your machine learning and deep learning systems
with SparkML, DeepLearning4j and H2O
Packt>


Yu-Wei, Chiu (David Chiu), Selva Prabhakaran,
Tony Fischetti, Viswa Viswanathan,
Shanthi Viswanathan, Romeo Kienzler
R
Complete Data
Analysis Solutions
Solve real-world data problems using the most popular R
packages and techniques
Packt>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Applied AI with DeepLearning
www.coursera.ai/learn/ai

Advanced Data Science Capstone Project
https://www.coursera.org/learn/advanced-data-science-capstone

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