Scaling Deep Learning Training to 256 GPUs

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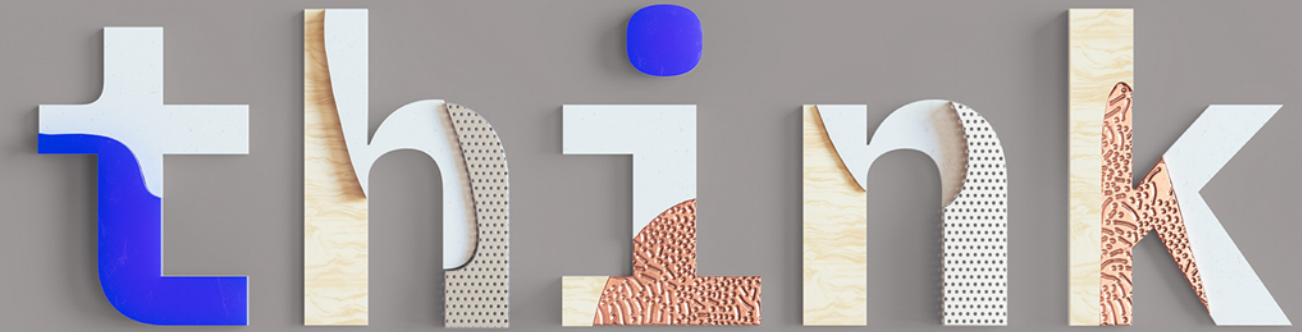


A new era of computing

Tabulating Systems Era

Programmable Systems Era

Programmable Systems Era

You are here

Data is the Next Natural Resource

Sensors & Devices (Image, video, audio, text, ...)

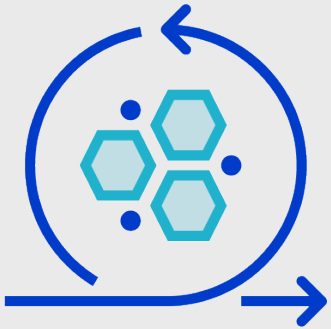
Social Media (Image, video, audio, text, ...)

VoIP

Enterprise Data

Putting AI to use

Building and Leveraging Understanding



INGEST

LEARN

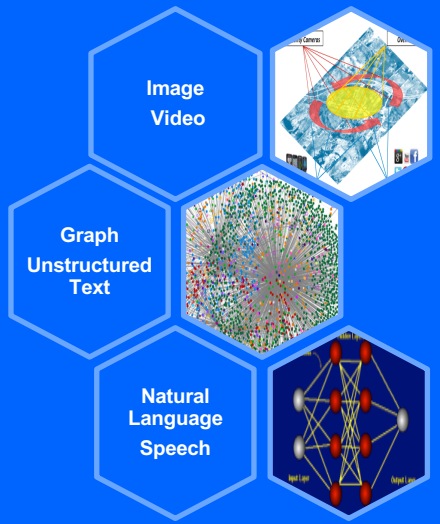
DEPLOY

From data to understanding

Data Sources

Devices, Sensors
Public Clouds
Private Clouds
On Premises Systems

Data Types



Business Problems

Security, fraud detection
Credit risk
Sentiment analysis
Advertising

Machine translation
Robotics
Interactive learning
Health analytics

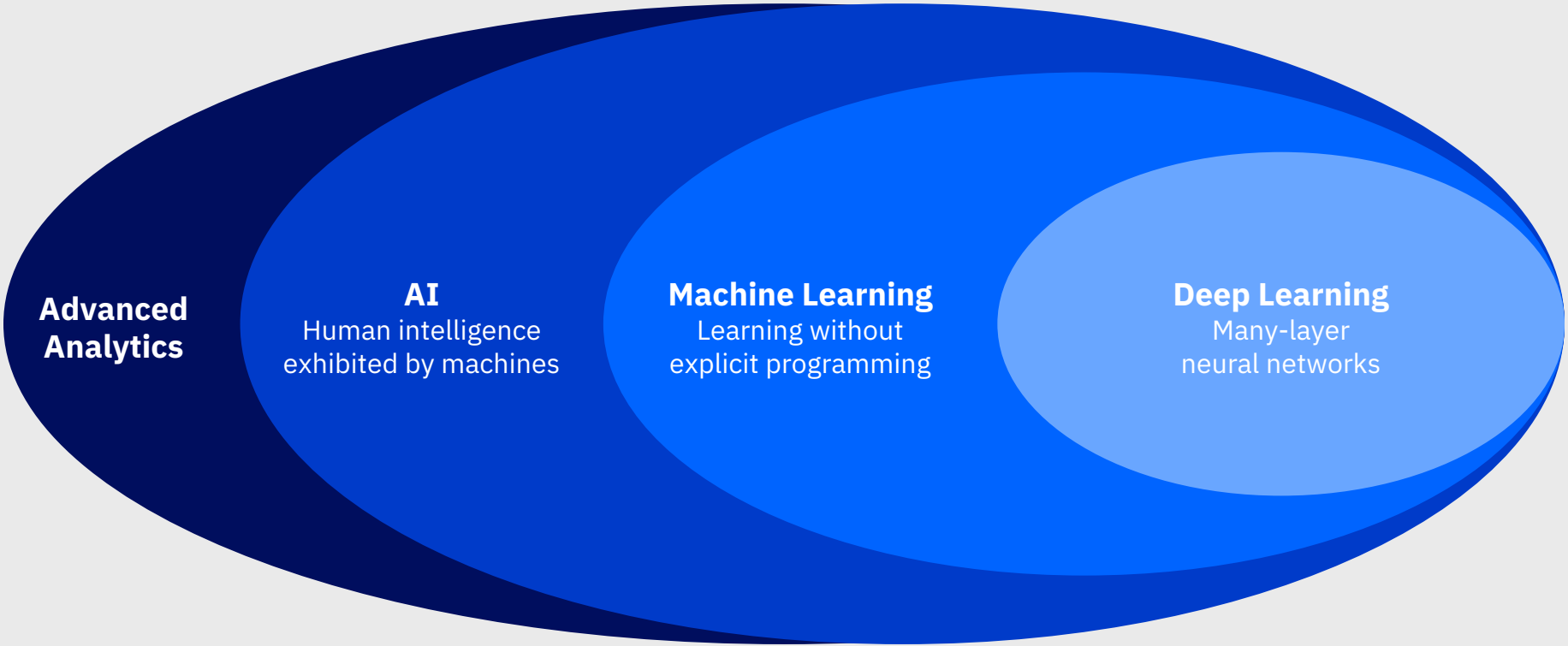
Driver assistance
Law enforcement
Insurance

Techniques

Modern models:
- Deep neural networks
  CNN, RNN, LSTM, ...
- Deep stacking networks...

Traditional algorithms:
- Linear regression
- Logistic regression
- Support vector machine
- Naïve Bayes classifier
- K-means clustering
- Random forests
- Decision trees

AI is fueled by machine and deep learning techniques



Developing AI function

DATA PREPARATION

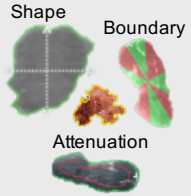
UP & RUNNING

BUILD, TRAIN, OPTIMIZE

DEPLOY & INFER

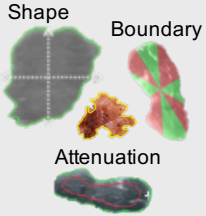
MAINTAIN ACCURACY

Accelerated training … days become hours



RECOGNITION

9 days



RECOGNITION

4 hours | 4 hours | 4 hours | 4 hours

Opens up new opportunities!

- Iterate more
- Create more accurate models
- Work on more problems
- Faster time to impact

54x

4 hours

Training workloads with PowerAI DDL !

IBM **PowerAI**

What’s in the training of deep neural networks?

Data

Millions of images, sentences

Terabytes

Neural network model

Billions of parameters

Gigabytes

Computation

Iterative gradient based search

Millions of iterations
Mainly matrix operations

Goal: Search for the best parameters to make model fit data.
Workload characteristics: Both compute and data intensive!

System for intense compute on big data

GPUs: Good for matrix computations! ~10 times faster than CPUs

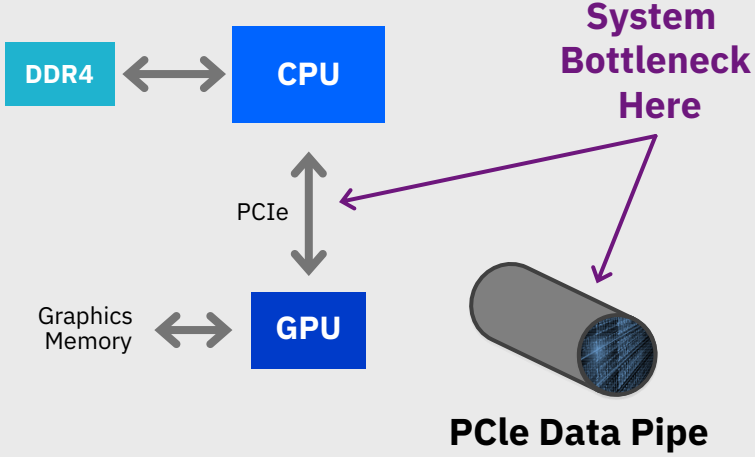
Software tools	Caffe, Torch, TensorFlow	Caffe, Torch, TensorFlow
System support		**PowerAI DDL**
Hardware	Single machine 1-4 GPUs	**Multiple Power machines** **256 GPUs**
Training time	**9 days!**	**4 hours!**

Challenge: Move data at high speed among GPUs on many machines

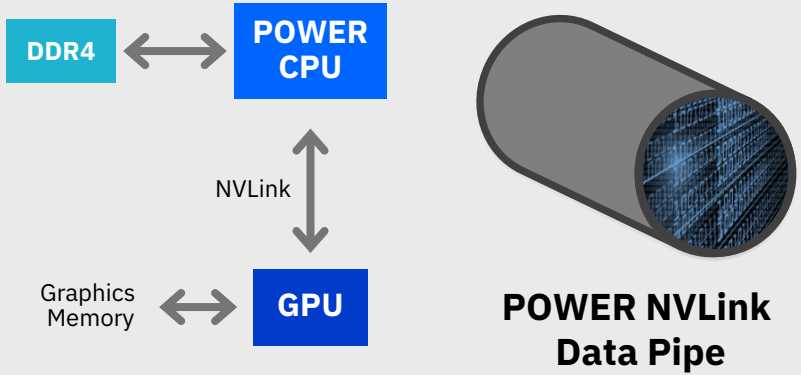
Unique innovation through OpenPOWER collaboration

THE NEXT PLATFORM

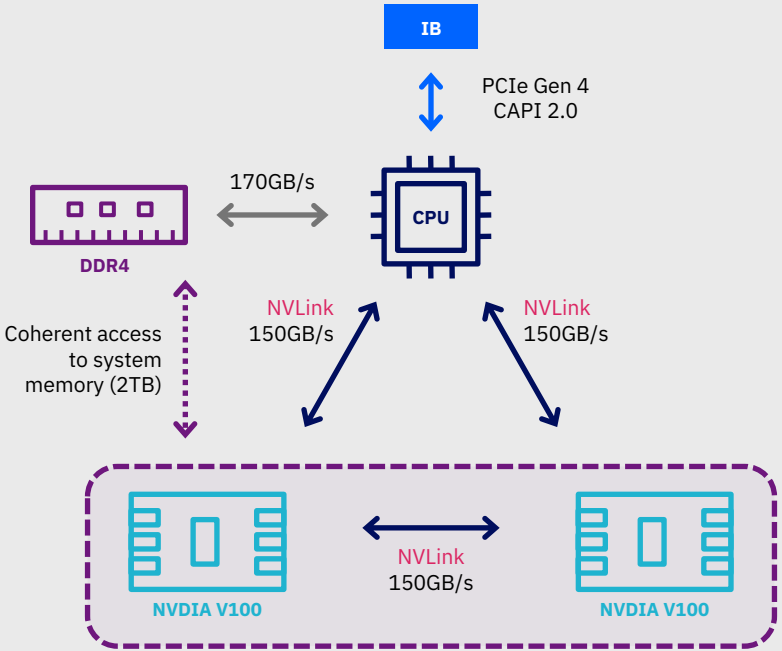
THE SYSTEM BOTTLENECK SHIFTS TO PCI-EXPRESS



POWER9 with Next Gen NVLink delivers 6-9.5x bandwidth

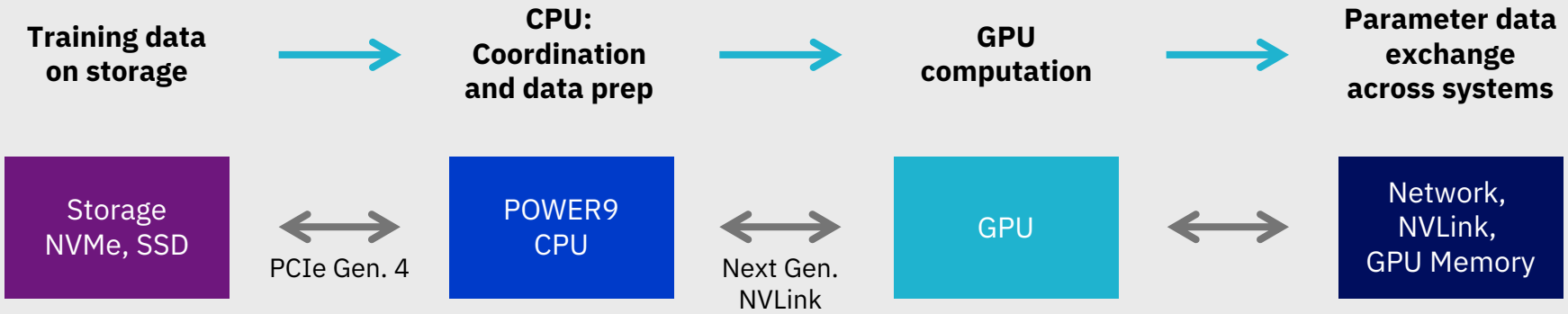


Designing a balanced system

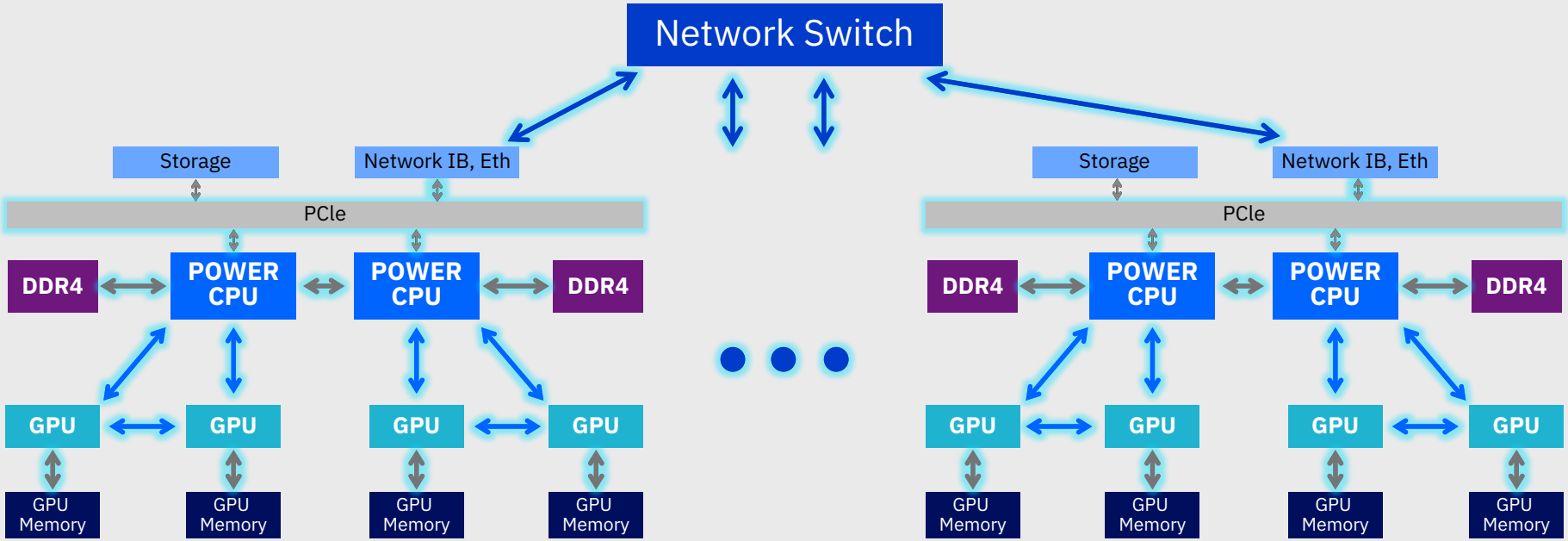


6x Faster CPU-GPU Data Communication
Enables Large Models with Large Input Data

Data processing stages for distributed deep learning



Communication paths



PowerAI DDL: Fully utilize bandwidth for links within each node and across all nodes
→ Learners communicate as efficiently as possible

PowerAI DDL

Putting breakthrough deep learning times into the hands of customers

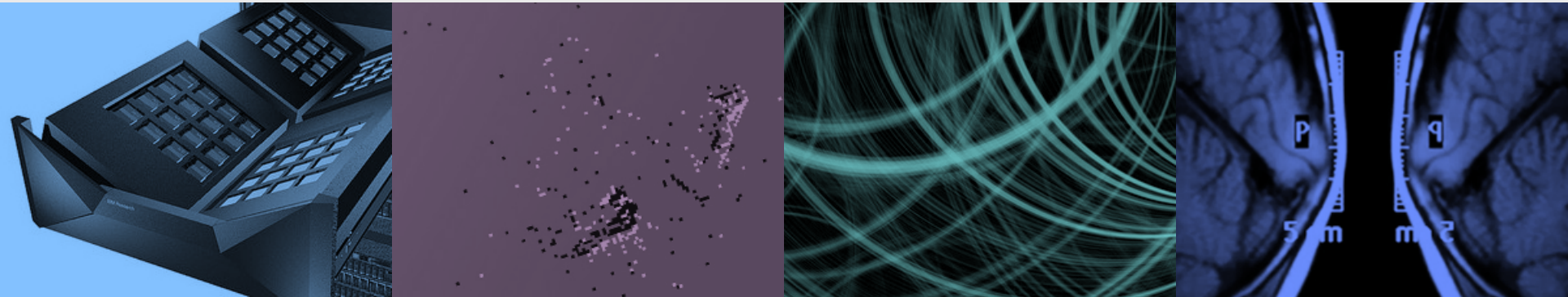
Communication Library for Distributed Deep Learning Training

- Enables deep learning software to scale to 100s of servers with GPUs
- Works across variety of system sizes
- Works with variety of network types, switch topologies

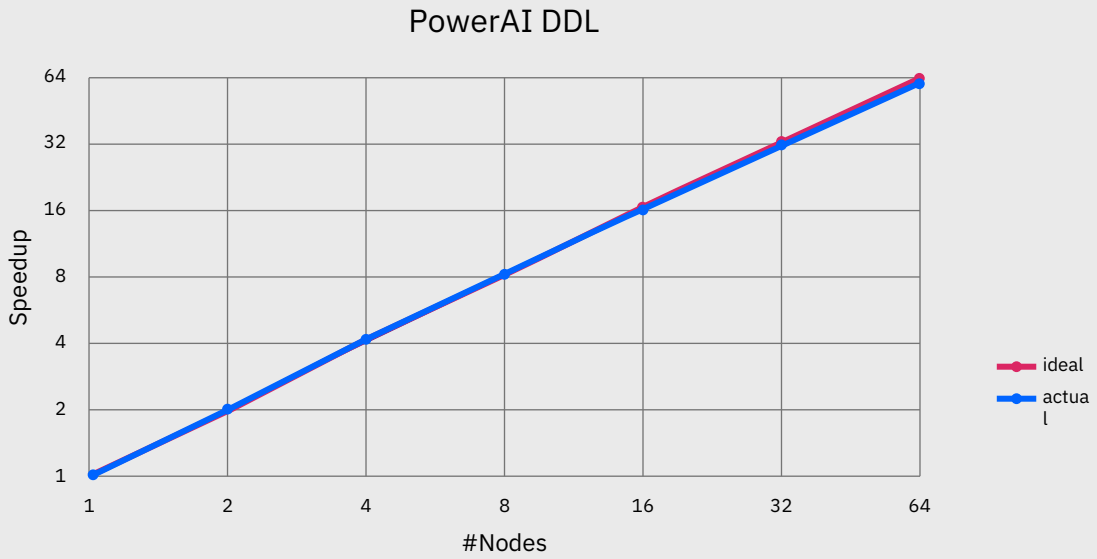
Released results @ 256 P100 GPUs

- Better scaling efficiency than Facebook AI Research: 95% (IBM) vs <90% (FB)
- Higher image recognition accuracy than Microsoft: 33.8% (IBM) vs 29.8% (MS)

TECHNICAL DETAILS:
https://arxiv.org/abs/1708.02188



PowerAI DDL training ResNet-50 1k Caffe



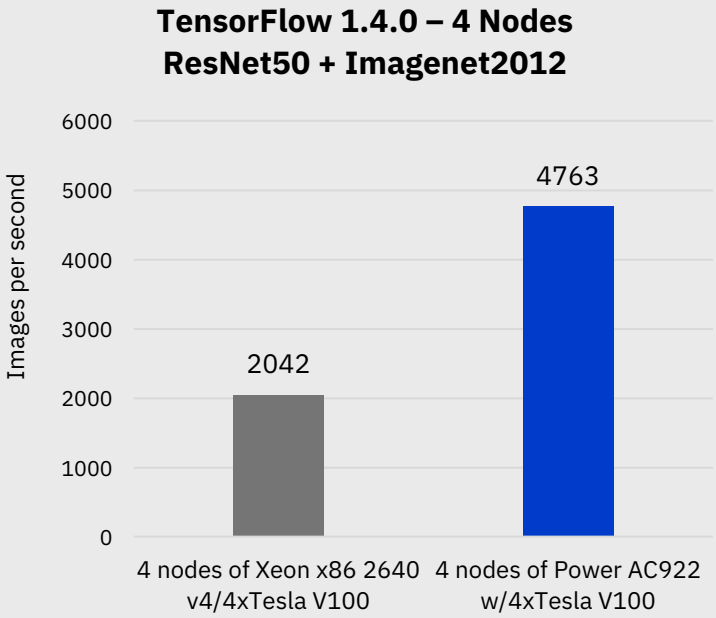
#GPUs	4	8	16	32	64	128	256
#Nodes	1	2	4	8	16	32	64
Speedup	1.0	2.0	3.9	7.9	15.5	30.5	60.6
Scaling efficiency	1.00	1.00	.98	.99	.97	.95	.95

Distributed Deep Learning: POWER9 with NVIDIA Tesla V100

2.3X more data processed on TensorFlow vs tested x86 systems

Maximize research productivity by training on more images in the same time with TensorFlow 1.4.0 running on a cluster of POWER9 AC922 servers with Nvidia Tesla V100 GPUs connected via NVLink 2.0

- **2.3X more images processed per second vs tested x86 systems**
- PowerAI Distributed Deep Learning (DDL) library provides innovative distribution methods enabling AI frameworks to scale to multiple servers leveraging all attached GPUs
- ResNet50 testing on ILSVRC 2012 dataset (aka Imagenet 2012)
  - Training on 1.2M images
  - Validation on 50K images



- Results are based IBM Internal Measurements running 1000 iterations of HPM Resnet50 on 1.2M images and validation on 50K images with Dataset from ILSVRC 2012 aka Imagenet 2012.
- Hardware: 4 nodes of Power AC922; 40 cores (2 x 20c chips), POWER9 with NVLink 2.0; 2.25 GHz, 1024 GB memory, 4xTesla V100 GPU ; Red Hat Enterprise Linux 7.4 for Power Little Endian (POWER9). Competitive stack: 4 nodes of 2x Xeon E5-2640 v4; 20 cores (2 x 10c chips) / 40 threads; Intel Xeon E5-2640 v4; 2.4 GHz; 1024 GB memory, 4xTesla V100 GPU, Ubuntu 16.04.
- Software: Tensorflow 1.4.0 framework and HPM Resnet50 https://github.com/tensorflow/benchmarks.gif (commit: f5d85aef) and with the following parameters:Batch-Size: 64 per GPU ; Iterations: 1100; Data: Imagenet; local-parameter-device: gpu; variable-update: replicated

Enterprise-ready
software distribution
built on open source

Performance
faster training times
for data scientists

Tools for ease
of development

IBM **PowerAI**