USING FABRICS TO ACCELERATE DEEP LEARNING

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AGENDA

- What is AI
- Where can fabrics help
- Some real world examples
WHAT IS AI
AI IS TRANSFORMING INDUSTRIES

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Early adoption

Source: Intel forecast
ARTIFICIAL INTELLIGENCE

A program that can sense, reason, act, and adapt

MACHINE LEARNING
Algorithms whose performance improve as they are exposed to more data over time

DEEP LEARNING
Subset of machine learning in which multilayered neural networks learn from vast amounts of data
Machine Learning
How do you engineer the best features?

Deep Learning
How do you guide the model to find the best...
WHERE CAN FABRICS HELP
MORE SOPHISTICATED ALGORITHMS

Some Popular Topologies (*Not to be confused with Network topologies!*)

Topologies: Network Depth is of importance

Faster & Less Accurate \[ \leftrightarrow \] More Accurate

- **ResNet-50**
- **ResNet-152 Layers**

**AlexNet, 8 Layers (2012)**

**VGG, 19 Layers (2014)**

**GoogleNet, 22 Layers (2014)**

**Visual Geom. Group (VGG)**

**Google**

**Microsoft**
WHAT IS A FRAMEWORK

A high-level software tool, typically open-sourced, which is used by most deep learning practitioners to facilitate model development. Each framework includes essential deep learning building blocks such as model libraries, computational graphing, APIs, tools and more. Each framework also has unique advantages/disadvantages in stability, speed, scalability, data integration, flexibility, iteration speed, debuggability, etc.

Popular Frameworks:
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Popular Frameworks:

- Caffe
- Caffe2
- TensorFlow
- mxnet
- Torch
- CNTK
- Theano
- Chainer

OpenFabrics Alliance Workshop 2018
Properties of Neural Networks[1]:
Results get better with
- More Data
- Bigger models
- More computation

Training is not a one time effort
- Many operational neural networks as part of different applications
- Each neural network may be trained with domain specific training sets
- Evolving input data sets drives the need for re-training

Google Brain’s Jeff Dean quantifies benefits of reducing the time to train:

- Minutes, hours:
  - Interactive research
  - Instant gratification of results
- 1-4 Days:
  - Tolerable
  - Interactivity replaced by running many experiments in parallel
- 1-4 weeks:
  - High value experiments only
  - Progress stalls
- >1 Month:
  - Don’t even try.

Jeff Dean: Large-Scale Deep Learning for Intelligent Computer Systems (GoogleBrain)

Striving for interactive research drives need for more computational power and multi-node training options.
TOWARDS MULTI-NODE TRAINING

Let’s solve this problem using DL

Start with a single server
Interesting results.
Drive for better accuracy

- More data for better results
- Now training takes much longer
- How to scale and keep time-to-train manageable

Options

- Scale out training infrastructure
- Multi-Node
- Fabric interconnected training

Increased accuracy and reduced time to train

Single server takes too long to train now
WHY MULTI-NODE TRAINING

- Data size and model complexity growing
- Need timely training or re-training of models
- AI shifting from fast single nodes to clusters
  - Data and model parallelism, and smart node grouping can keep scaling efficient
  - Proven near linear scalability; 97% scalability up to 256 Xeon Phi™ servers with Omni-Path and Resnet-50

As scale node count, interconnect performance and scalability is critical

- Models are trained in an iterative manner requiring inter-node communication to proceed
- Injection bandwidth and scalable latency are key for iterative global weight updates
- Multi-MB Collective operations on the critical path for communications

Model parallelism

- Share the Neural Network across many nodes
- Communication occurs for layers in each iteration; creates lots of communication
- Only as fast as slowest machine due to interactivity of code
Data parallelism

- Each system runs on its own dataset
- Communication occurs at each iteration, but less frequently than model parallelism
- Fast, non-blocking communication best to insure computation is not waiting on data.
### DATA PARALLELISM

- **Forward prop is all compute, communication during back propagation**
- **Size of weights exchanged during comm phase depends only on topology[1], *not* on framework**
- **Implied barrier at iteration boundary**
- **Compute/comm overlap heavily dependent on framework implementation**

[1] Neural network topology! ;-)
INTERESTING FABRIC FEATURES FOR AI

- **Higher Bandwidth**
  - data set ingest into training
  - large hyper-parameter set communications

- **Increased MPI message rate per core** – helps model parallelism
- **scalable latency**
AI ON HPC
SCALING EFFICIENCY

Scaling Efficiency on TACC Stampede2
Intel® Caffe ResNet-50 on ImageNet-1K
With Xeon PHI™ & Intel® OPA comparison

- 97% scaling efficiency from 4 to 256 Intel® Xeon Phi™
  7250 nodes interconnected with Intel® OPA
- Convergence with Top1/5 > 74%/92%
- 4 - 256 node runs: batch size of 16 per node, scaling efficiency of 97% in 63 minutes

Scaling Efficiency on BSC MareNostrum 4
Intel® Caffe Resnet-50 on ImageNet-1K
Intel® Xeon® Scalable Processor 8160 & Intel® OPA comparison

- Convergence with Top1/5 > 74%/92%
- 4 - 256 node runs: Batch size of 32 per node, 90% scaling efficiency, Total time to train: 70 Minutes

Strong multi-node training, with high accuracy with Intel® OPA

More Information
- https://www.bsc.es/user-support/mn4.php
- http://portal.tacc.utexas.edu/user-guides/stampede2
- IBM claims 95% scaling efficiency and Facebook claims 89%
AI ON HPC

- **MIT Lincoln Lab Supercomputing Center (LLSC)**
  - Address the learning phase of DL/AI especially for autonomous systems and device physics with enormous amounts of Big Data

- **Pittsburg Supercomputing Center: Bridges[1]**
  - 301 institutions
  - 1008 projects
  - 3682 users
  - 101 fields of science

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THANK YOU
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