Experience of Google's latest Deep Learning library, TensorFlow, with Docker in a WLCG cluster

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We conceive a first use-case scenario of the TensorFlow library to create the Deep Learning models. A single library that can distribute computations to the various platforms and systems, would significantly simplify the use of Deep Learning algorithms in high energy physics. Docker presents a solution in which we can merge the application libraries into a production-level WLCG computing cluster. We therefore employ the Docker container environments for TensorFlow and present the first use in our grid system.

Motivation

Basics

- HEP could benefit from more sophisticated approaches like Deep Learning.
- New algorithms are extremely computer-intensive.
- Such algorithms often support multi-threading or distributions in computers.

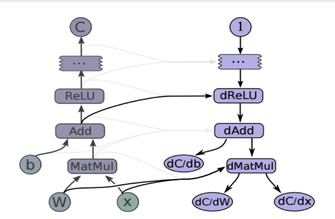
Grid clusters without GPUs

- Many CPUs in the WLCG clusters are available.
- Typically, no GPUs.
- Need of external common machine learning library.

Google TensorFlow

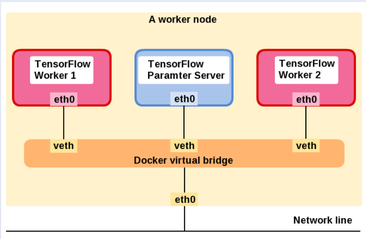
- Released in Nov., 2016.
- Open source and free licensed. Communities are grown.
- Flexible in heterogeneous platforms and environments.
- Designed for large-scale distributed devices and computers.
- Reducing complexity of machine learning algorithms.

Architecture of TensorFlow



[db, dW, dx] = tf.gradients(C, [b, W, x])

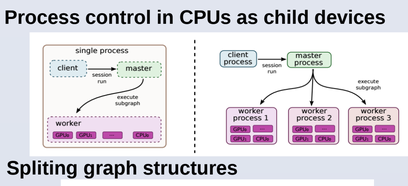
Basic operations in TensorFlow



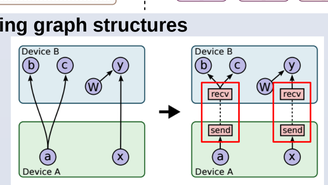
Multiple TensorFlow CPU workers with a Docker bridge network

Docker offers an open platform to build, ship and run different application in virtual Linux environments. To satisfy diverse sets of the WLCG clusters, TensorFlow nodes can be loaded by Docker containers.

Process control in CPUs as child devices



Spliting graph structures



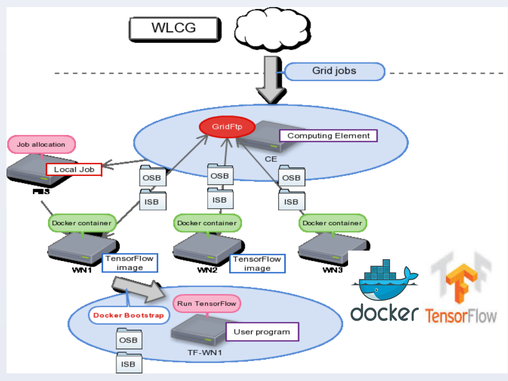
Graph workflow in TensorFlow

The architecture of TensorFlow is based on graph representations and how they are distributed. TensorFlow can become a generic interface for not only expressing machine learning algorithms such as Deep Neural Network (DNN), also particular computer-intensive tasks.

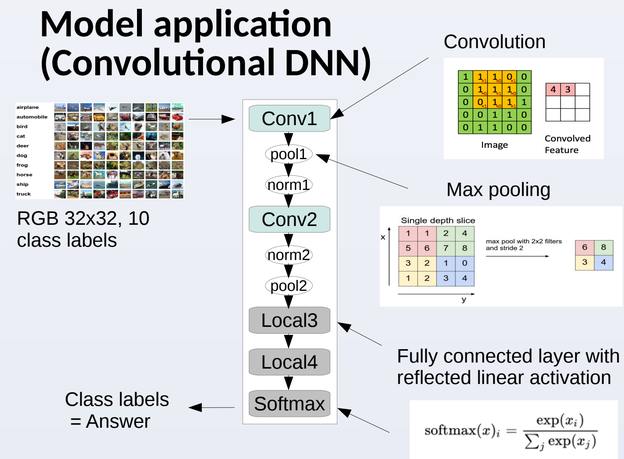
Model

Grid job workflow is extended by a concept of Docker container technology. Without any modifications in the WLCG clusters, the TensorFlow library and different execution environments are instantly loaded.

Grid job workflow using multiple CPU mode



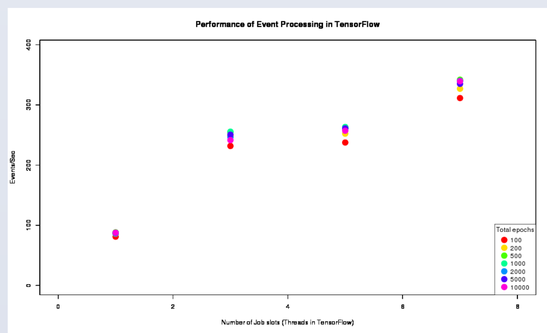
Model application (Convolutional DNN)



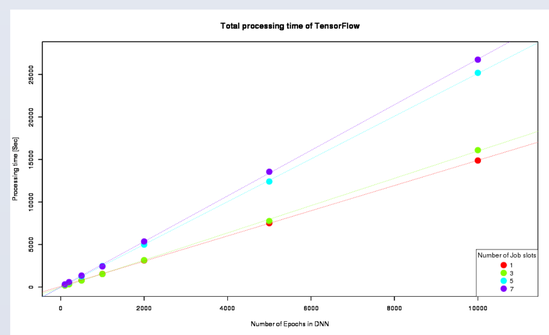
Convolutional Deep Neural Network is one of the best image classification algorithms which can resolve classification problems, i.e. S/B discrimination and jet identification, in HEP.

Results

TensorFlow version r0.8 allows for building the multiple CPU workers. Exploratory performance measurements are done. A standard scenario is performed using DNN with a CPU communication mode among a parameter server and some workers.



Event processing rate vs number of job slots using TensorFlow



Total processing time vs number of epochs In TensorFlow

TensorFlow offers an increase in event rate at no cost in terms of local configurations.

- TensorFlow has many attractive features for Physics applications in the WLCG clusters.
- Advantages in computations based on Tensor + Graph approach in a large-scale distributed environments.
- Docker + worker nodes are very flexible and nearly effortless. Applicable for special environments of MC simulations, physics analysis etc.
- Reducing the event processing rate so that it can deliver higher usability for end-users.

"Tensorflow: Large-scale machine learning on heterogeneous distributed systems." arXiv preprint arXiv:1603.04467 (2016).

"Docker experience at INFN-Pisa Grid Data Center." Journal of Physics: Conference Series. Vol. 664. No. 2. IOP Publishing, 2015.

TensorFlow tutorials Version r0.10

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