<h1 align = 'center'> Tensorflow </h1>

<h1 align = 'center'> Large-Scale Machine Learning on </h1>

<h1 align = 'center'>Heterogeneous Distributed Systems </h1>

(Preliminary White Paper, by google, November 9, 2015)

Outline

- What is tensorflow ?
- Programming Model and Basic Concepts
  - Operations and Kernels
  - Sessions
  - Variables
- Implementation
  - Devices
  - Variables

- Gradient Computation
- Input Operations
- Queues
- Tools: Tensorboard
- Tools: Visualization of Summary Data

<h1 align = 'center'> Whats is tensorflow? </h1>

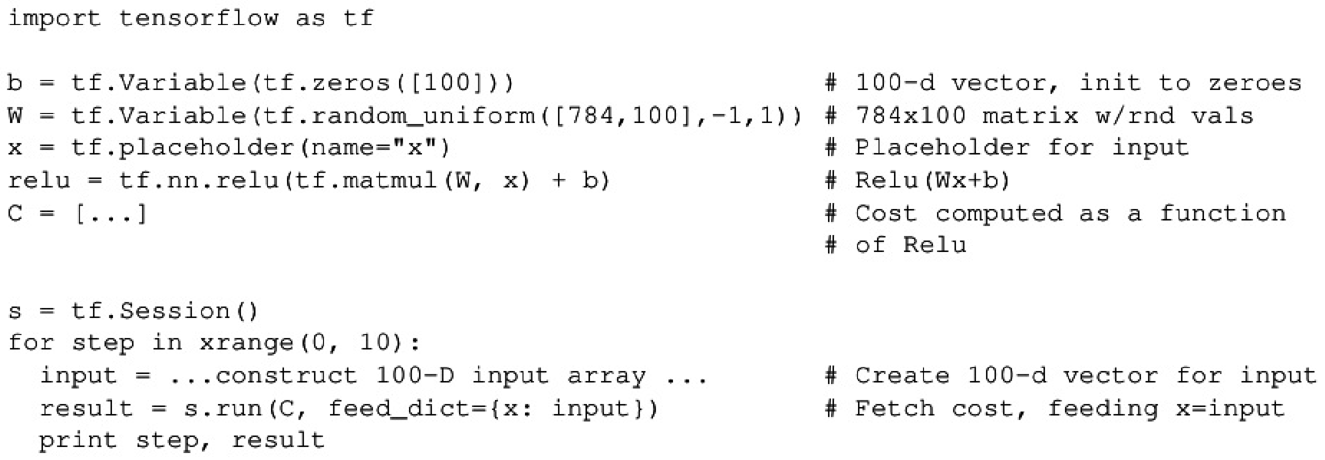
A heterogeneous, distributed system to specify various machine learning algorithms, and an implementation for executing such algorithm.

A tensor is a typed, multi-dimensional array with support for variety of element types.

<h1 align = 'center'> Programming Model and Basic Concepts </h1>

- Computation are represented by directed graph
  - Each node has one or more input and output, and represent instantiation of an operation
  - Value flowing along these edges are called tensor
- Nodes for persistent state and for branching and looping control
- Python and C++ as supported front end languages for building computational graph

<h1 align = 'center'> Example TensorFlow code fragment </h1>



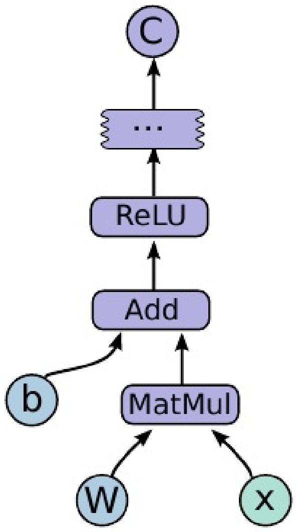
```
import tensorflow as tf

b = tf.Variable(tf.zeros([100]))                   # 100-d vector, init to zeroes
W = tf.Variable(tf.random_uniform([784,100],-1,1)) # 784x100 matrix w/rnd vals
x = tf.placeholder(name="x")                       # Placeholder for input
relu = tf.nn.relu(tf.matmul(W, x) + b)             # Relu(Wx+b)
C = [...]                                          # Cost computed as a function
                                                   # of Relu

s = tf.Session()
for step in xrange(0, 10):
  input = ...construct 100-D input array ...       # Create 100-d vector for input
  result = s.run(C, feed_dict={x: input})          # Fetch cost, feeding x=input
  print step, result
```

From: google whitepaper on tensorflow

<h1 align = 'center'> computation graph </h1>



From: google whitepaper on tensorflow

<h1 align = 'center'> Operations and Kernels </h1>

- An **operation** has a name and represents an abstract computation (e.g., “matrix multiply”, or “add”).
- A **kernel** is a particular implementation of an operation for running on CPU or GPU.

<h1 align = 'center'> Session </h1>

- Client program interact with tensorflow system via session.
- One of the main operation is **Run** method
- tensorflow compute the transitive closure of all nodes that must be executed in order to compute the outputs in **Run**

In most computations a graph is executed multiple times. Most tensors do not survive past a single execution of the graph.

<h1 align = 'center'> Variables </h1>

Variable is a special kind of operation that returns a handle to

a persistent mutable tensor that survives across executions of a graph.

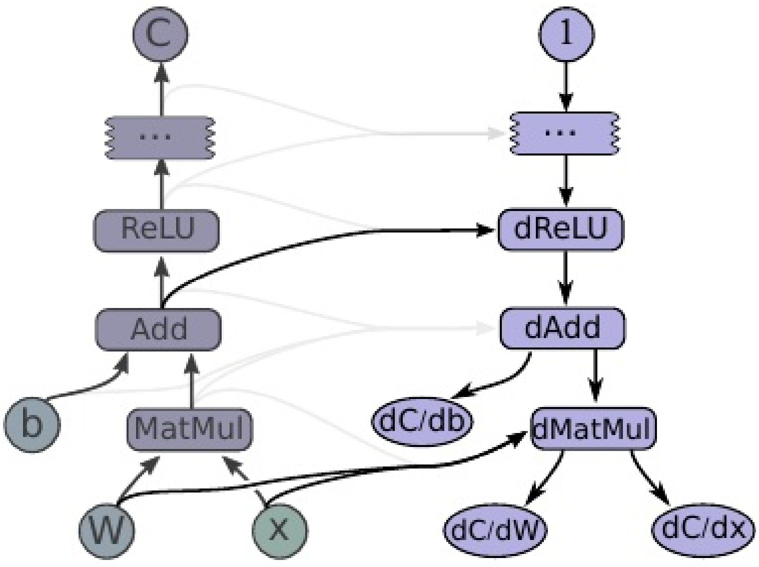
<h1 align = 'center'> Implementation </h1>

- Client uses session interface to communicate with master and one or more worker processes.
- worker process are responsible for arbitrating access to CPU cores or GPU cards.
- Worker execute graph nodes on those devices as instructed by the master.

<h1 align = 'center'> Devices </h1>

- Devices are the computational heart of TensorFlow.
- Each worker manges one more more devices.
- Example device names are "/job:localhost/device:cpu:0" or "/job:worker/task:17/device:gpu:3"

<h1 align = 'center'> Gradient Computation </h1>
Tensorflow has inbuild support for automatic gradient computation.



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<h1 align = 'center'> Input Operations </h1>

- Special input operation nodes for training large scale model.
- Typically configured with filesnames

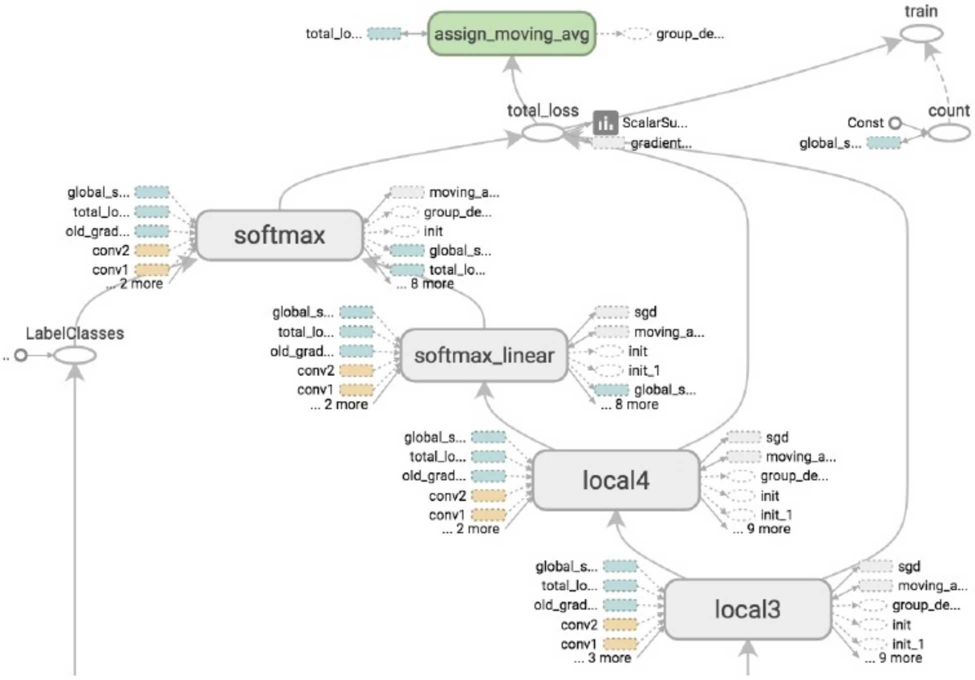
<h1 align = 'center'> Queues </h1>

- Allows hand off data thourgh Enqueue and Dequeue.
- Allow different portions of the graph to execute asynchronously.
- Allow data to be prefetched into queue while other previous batch is used.

<h1 align ='center'> tf.Data </center>

https://www.tensorflow.org/performance/datasets_performance (https://www.tensorflow.org/performance/datasets_performance)

<h1 align = 'center'> Tools: Tensorboard </h1> Allows Visualization of graph.



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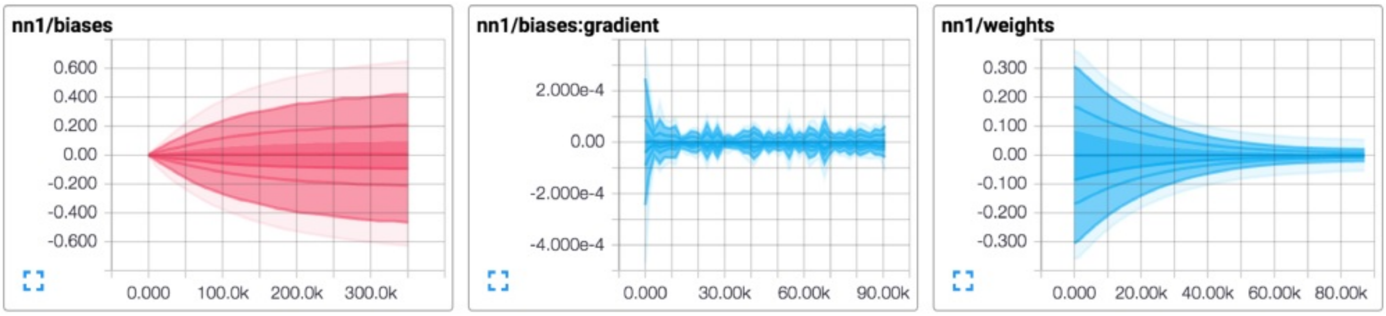
<h1 align = 'center'> Tools: Visualization of Summary Data </h1>
Allows examination the state of various aspectsof the model



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resoures

- https://www.tensorflow.org/ (https://www.tensorflow.org/)
- https://www.tensorflow.org/guide/ (https://www.tensorflow.org/guide/)
- Tensorflow dev summit 2018 (https://www.youtube.com/watch?v=RUougpQ6cMo&list=PLQY2H8rRoyvxjVx3zfw4vA4cvlKogyLNN)