Scalable Machine Learning at Yahoo

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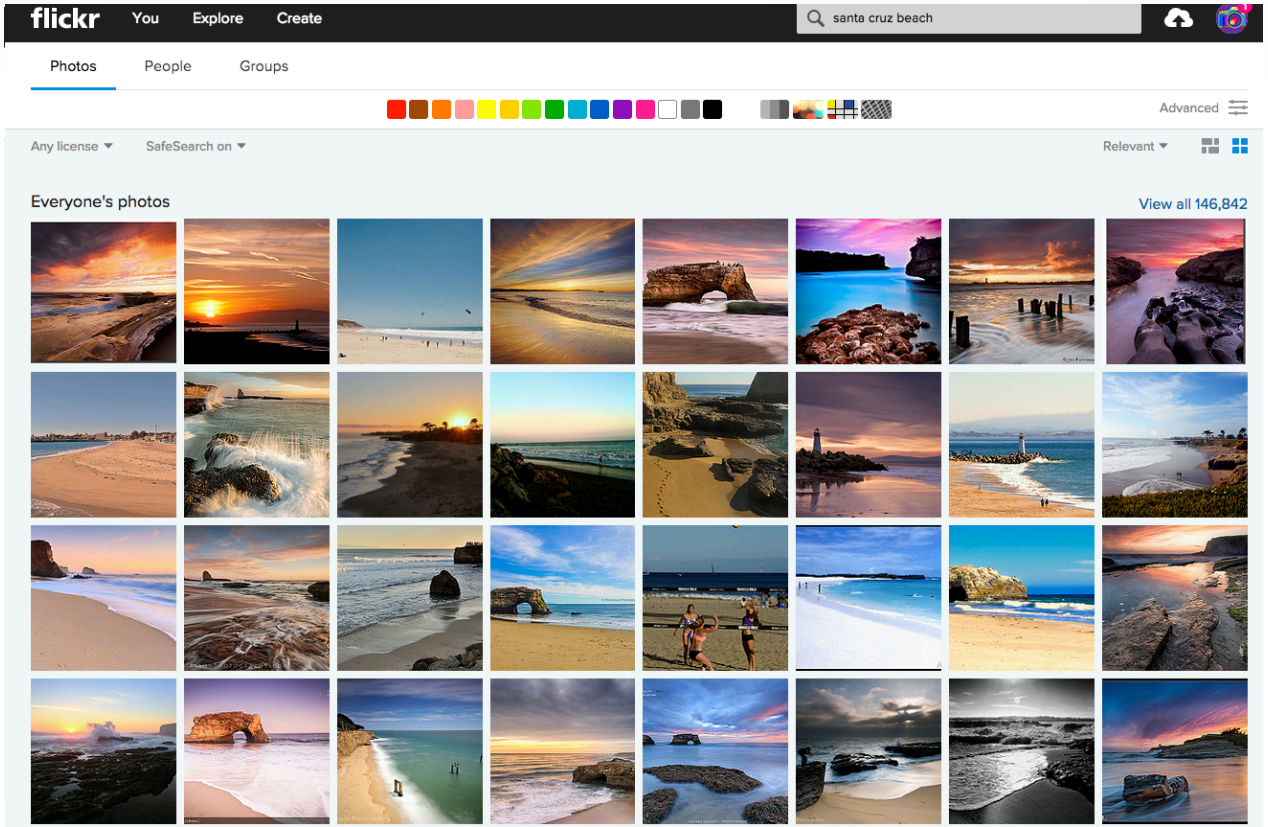
VP Architecture, Yahoo

Agenda

- Use Cases
- Challenge
- Our Approach
- Algorithms
  1. Logistic Regression
  2. Word Embedding
  3. Deep Learning

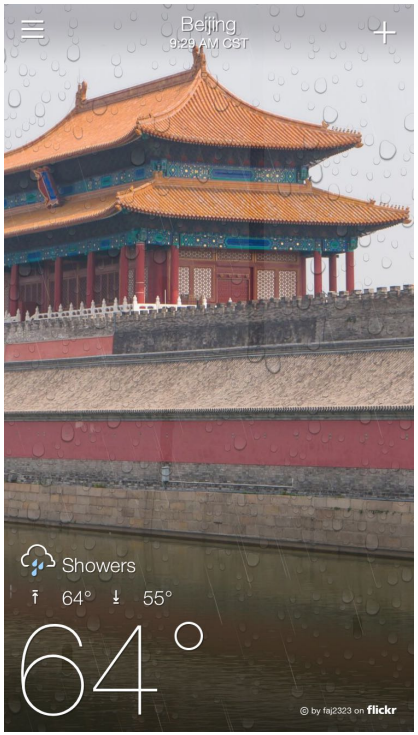
ML User Case: Flickr



- 1TB free storage
- 10 billion photos
  - 7.5 million per day
  - No tags for most photos
- Search: private/public
  - Computed tag
- Scene detection
  - Beach, Sunset, …
- Object recognition
  - Lighthouse, Sea arch, …

YAHOO!

ML Use Case: Yahoo Weather



- Beauty
  - Computational assessed
- Relevant scene
  - Location
  - Time
  - Mostly cloudy
  - Partly cloudy
  - Shower
  - …

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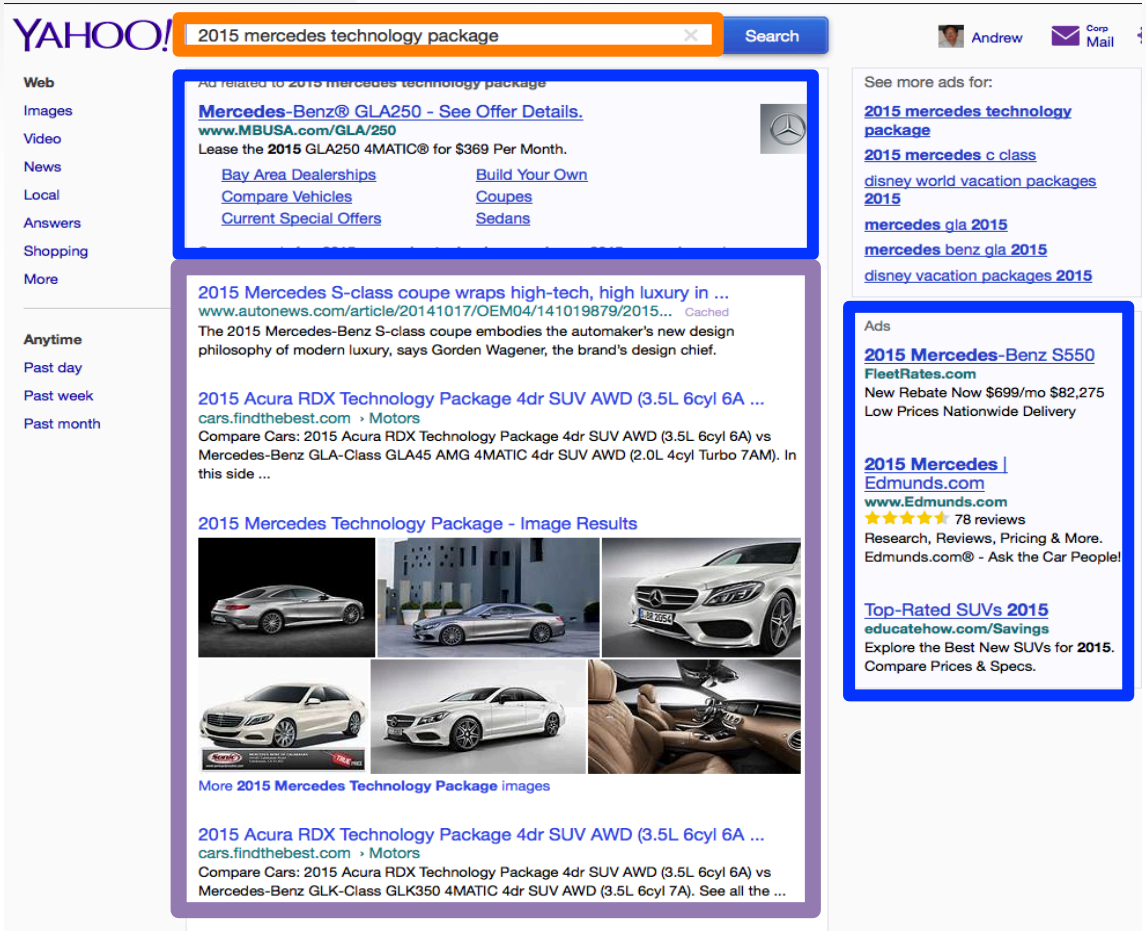
ML Use Case: Search



- Intention understanding
- Content ranking
- Query-Ads matching
- Ad click prediction

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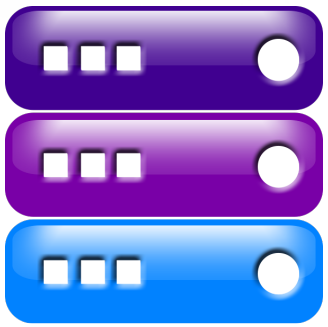
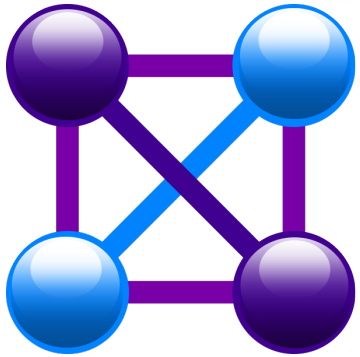
ML Challenge: Scale

1. Massive amount of examples
   - Naïve solutions take days/weeks
2. Billions of features
   - Model exceeds memory limits of 1 computer
3. Variety of algorithms
   - Different solutions required for scale-up

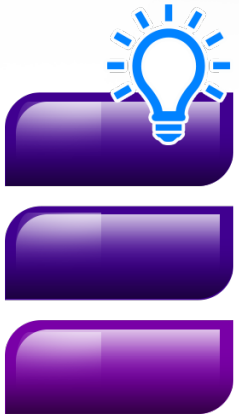
Massive Hadoop at Yahoo



600 PB
HDFS



40K
Computers



MACHINE
LEARNING

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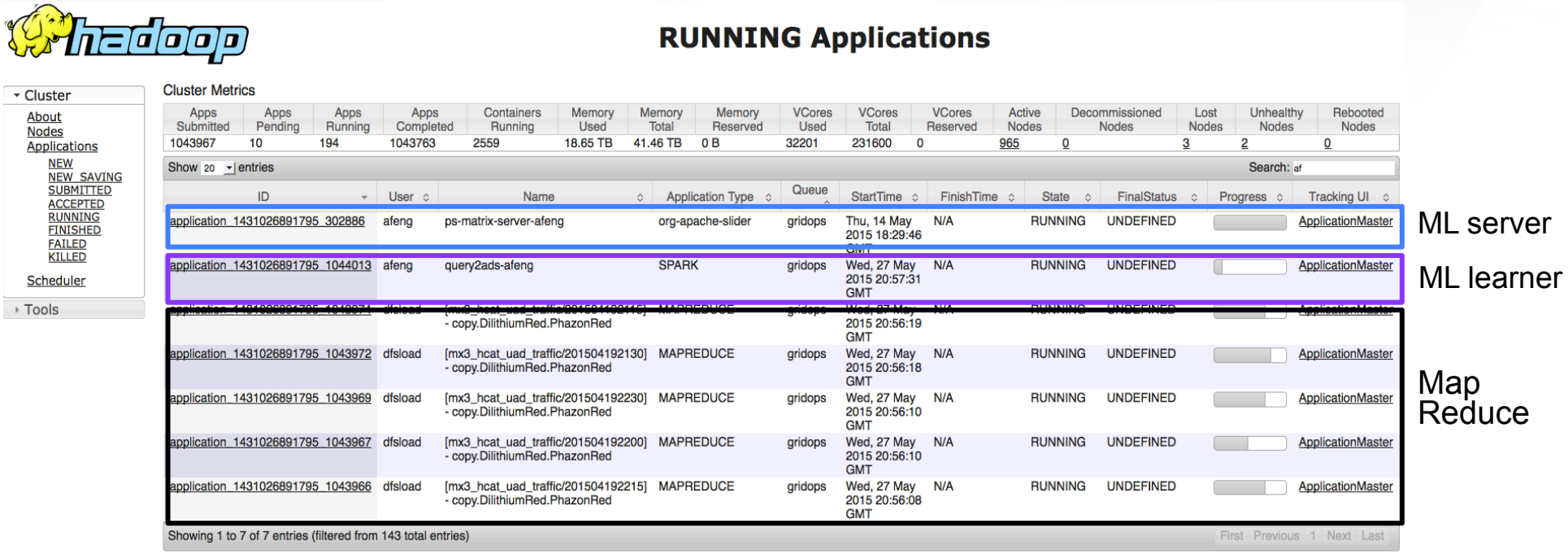
Scalable ML in Action



ML server

ML learner

Map Reduce

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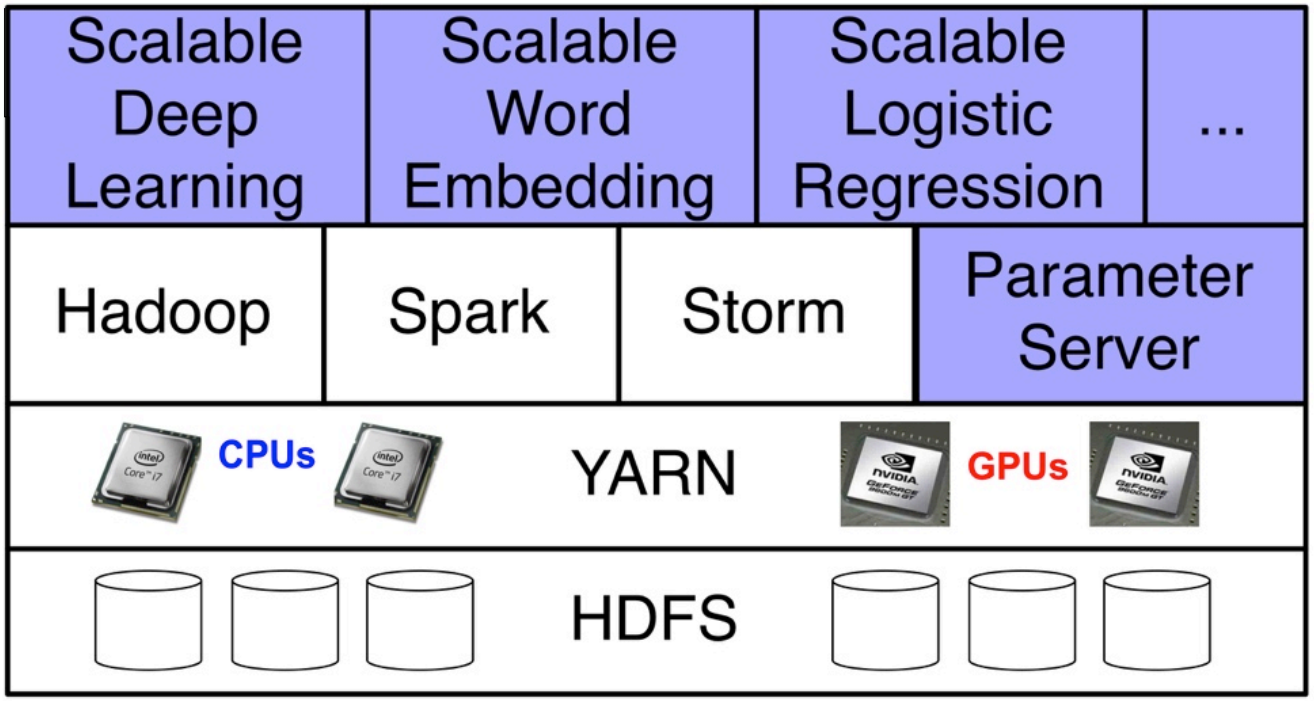
Architecture for Scalable ML



Examples of ML Algorithms

1. Logistic Regression
   - Problem: Model size
   - Solution: Spark + Parameter Server
2. Ad-Query Vectors
   - Problem: Model size + Training latency
   - Solution: Spark + Parameter Server
3. Deep Learning
   - Problem: Training latency
   - Solution: Spark + GPU + MPI

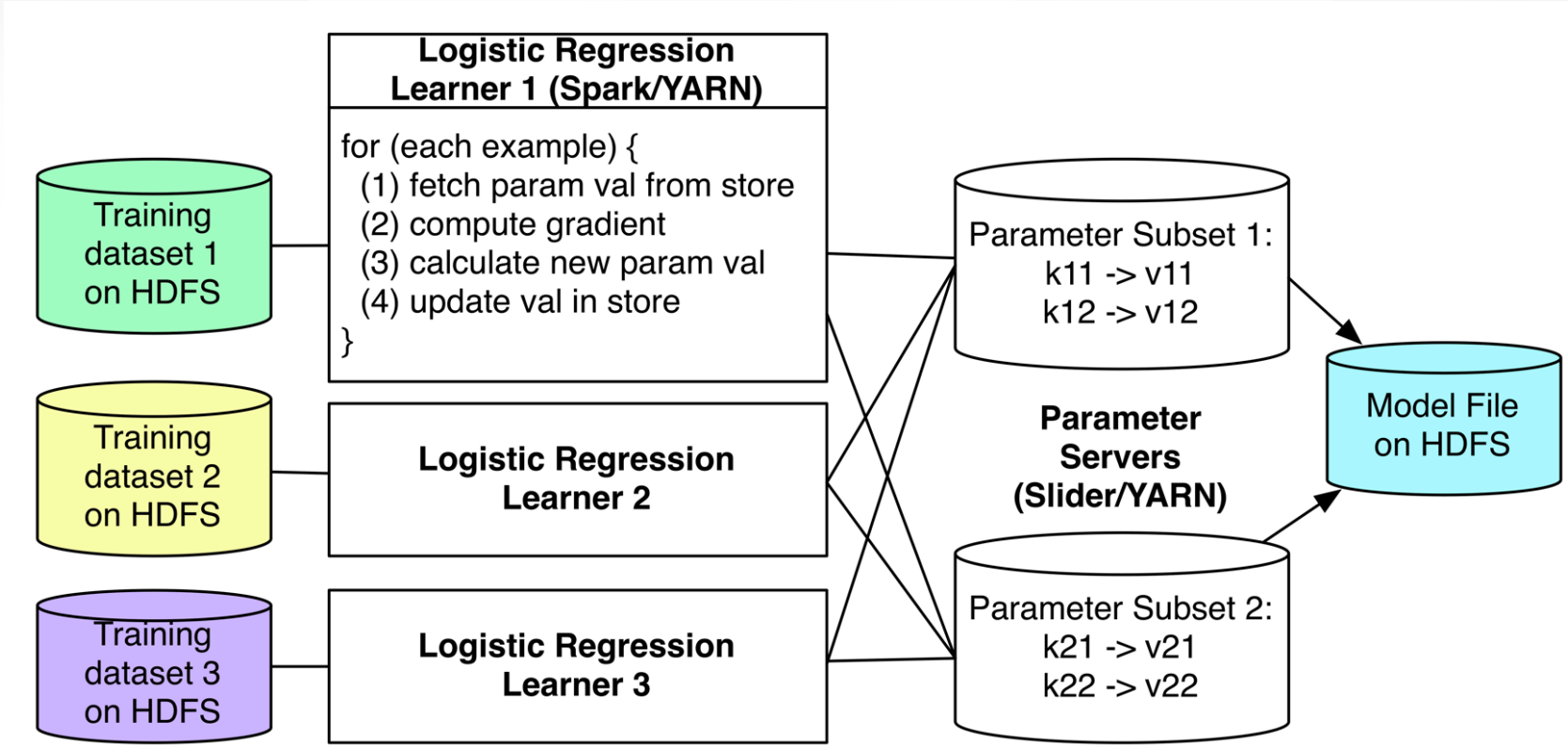
Algorithm 1: Logistic Regression

$$p(X_1, X_2, \ldots, X_p) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p)}}$$

When |β| > 100B,

- 100 Billion * 16 Bytes = 1.6 TB
- β exceeds memory limit of 1 computer

Logistic Regression: 1000x Scale-up



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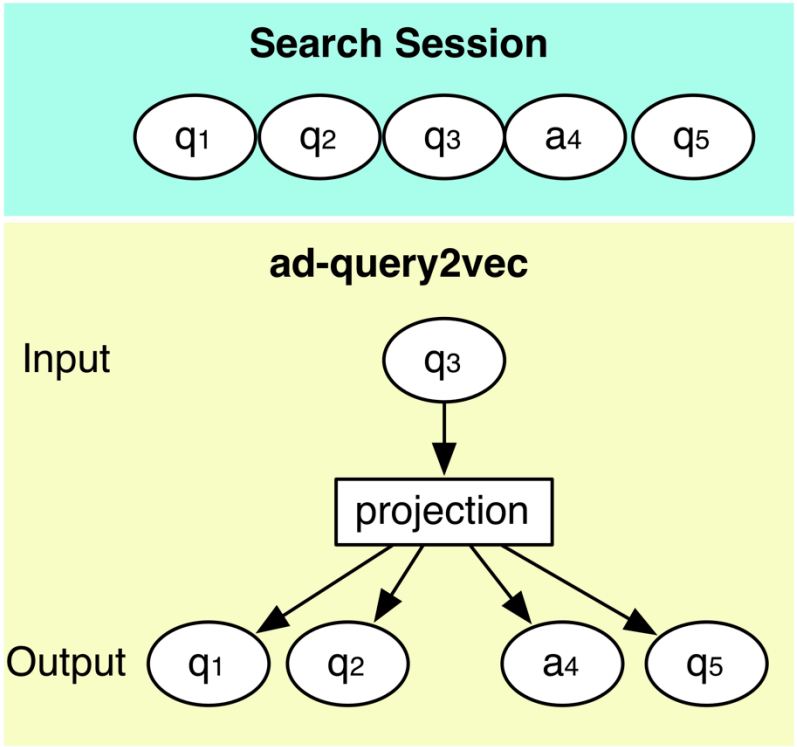
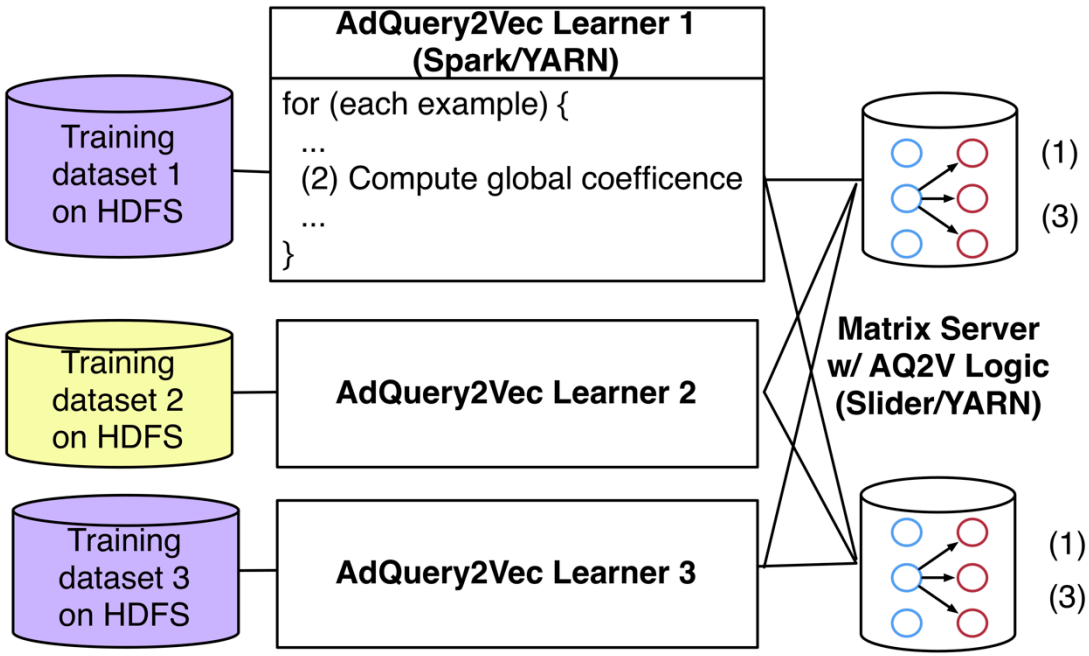
Algorithm 2: Ad-Query Vectors



- Vector: numeric representation of queries/ads
  - Vector("san jose weather") ≈ Vector("weather 95113") ≈ Vector(ad123)
- Model size
  - 1 Billion* 300 dimensions = 2.4TB
- Vector computation (X*Y, aX+Y)
  - Took weeks for small datasets

* Yahoo Labs: http://bit.ly/1G3f6L2

Ad-Query2Vec: 100x Speed/Scale-up



- Computation on servers
  - (1) Negative sampling
  - (1) Compute gradient: X*Y
  - (3) Adjust vectors: Y=aX+Y
- Daily training enabled
  - weeks ➔ hours

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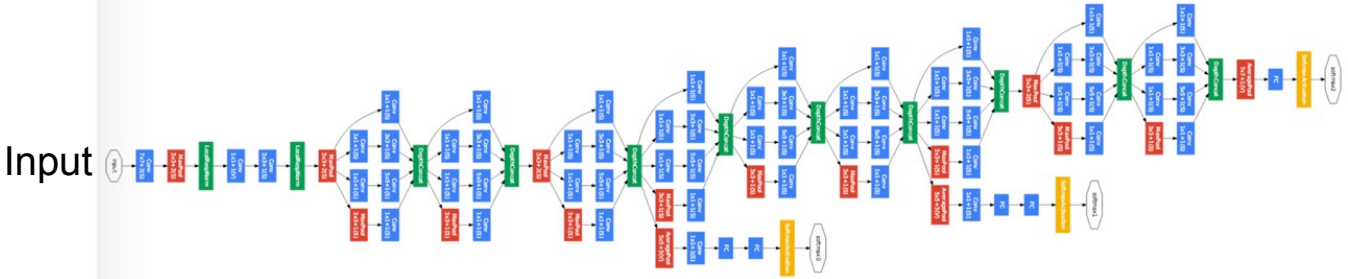
Algorithm 3: Deep Learning

- ILSVRC classification
  - Classify images to one of 1,000 categories
  - Dataset
    - 1.2 million images for training
    - 50,000 images for validation

- GoogLeNet: 2014 Winner
  - 22 layer deep network
    - Convolution, Pooling,…, Loss
  - Trained on Google DistBelief cluster (16,000 CPU cores)
- Training latency
  - **47 days** for 1 K40c GPU to achieve 88.9% top-5 accuracy http://bit.ly/1FtFMa4



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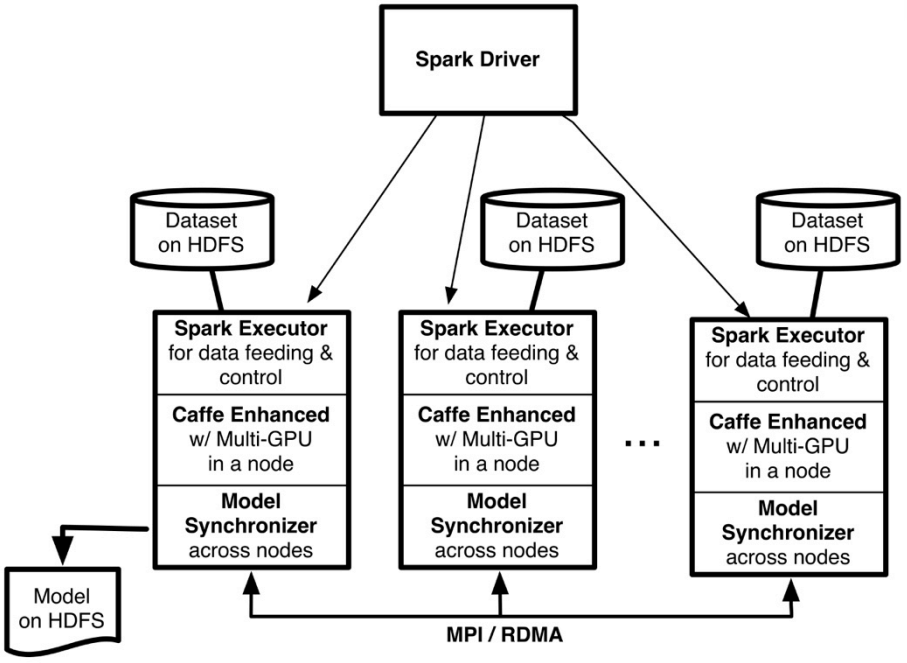
Deep Learning: Caffe-on-Spark with GPU



- GPU + Infiniband
  - 10x computing speedup over CPU
  - 10x network speedup over Ethernet
- Caffe-on-Spark
  - Apache Spark (spark.apache.org)
    - open source for cluster computing
  - Caffe (caffe.berkeleyvision.org)
    - Open source for deep learning

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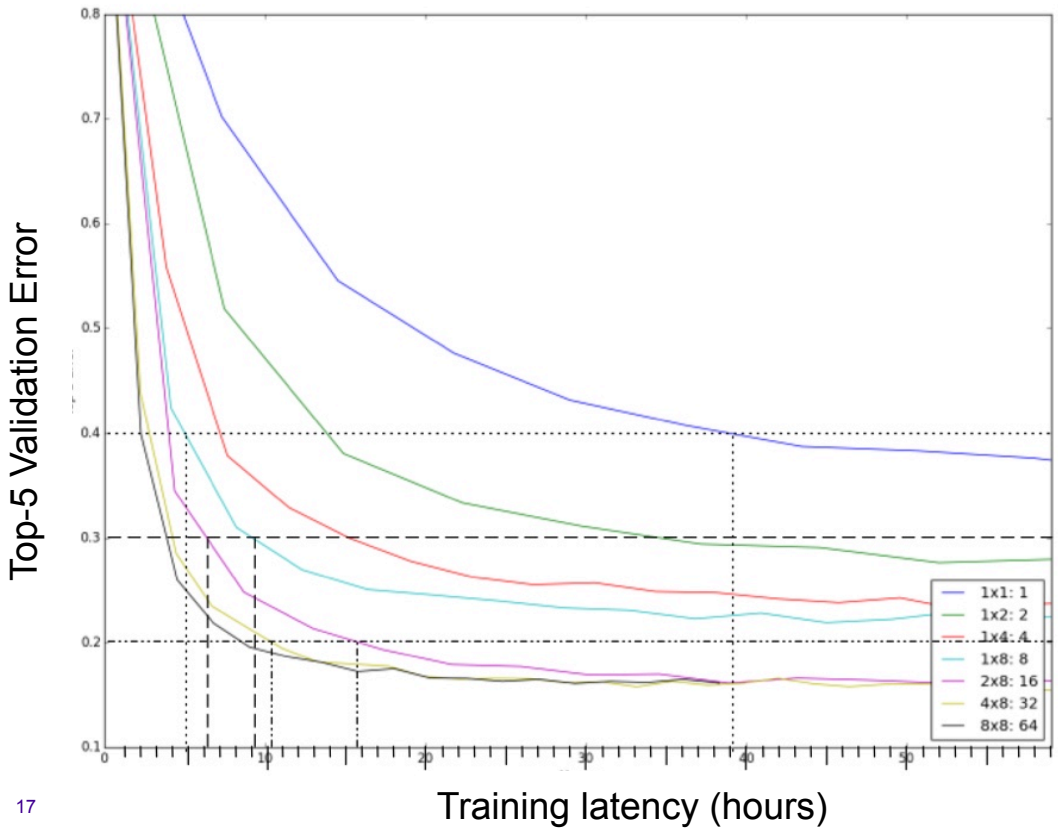
Deep Learning: 19x Speedup



- 1x1 GPU
  - 39 hours … 60% top-5 accuracy
- 4x8 GPUs
  - 10 hours … 80% top-5 accuracy
  - 19x speedup estimated over 1x1 GPU
    - We are working on larger speedup

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Summary

- Machine learning is critical for Yahoo business
  - Search, advertisement, Flickr, weather, recommendation, security, …
- Scalable ML platforms built on Hadoop & Spark
  - Heterogeneous cluster: CPU + GPU
  - Approximate computing

Additional Info

- Scalable machine learning
  - http://bit.ly/1NW3GvO
  - http://bit.ly/1VedY0f
- Flickr use case
  - http://bit.ly/1KEytuV
  - http://bit.ly/1KIDfof
- Yahoo Hadoop blog
  - http://yahoohadoop.tumblr.com/

Thanks! We are hiring. bigdata@yahoo-inc.com

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