基于 Apache* Spark* 的大规模分布式机器学习实践

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Content

- Project Overview
- Distributed ML on Spark
  - Fraud Detection: End-to-End Solution for Top Payments Company
  - Large-scale, Sparse Logistic Regression for Click-through and Purchase Rate Predictions
  - Deep (Convolutional) neural network
- Infrastructure support for distributed ML
  - Parameter server

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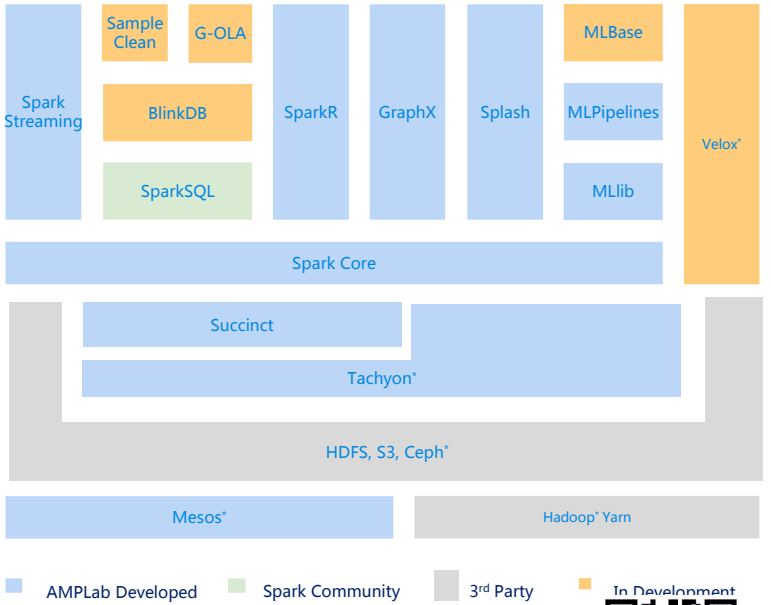
Project Overview

- Research and open source project initiated by UC Berkeley AMPLab
- Intel is closely collaborating with AMPLab and the community on open source development
  - One of the earliest adopters of Spark* (since 2012)
    - Many key contributions (Netty shuffle, FairScheduler, "yarn-client" mode, …)
  - Collaborating on other components in BDAS (e.g., Tachyon*, SparkR, …)
- Intel is partnering with many "web-scale" companies
  - Free! No commercial solution or Consultations
  - Online-LDA, Word2Vec (Merged)
  - SparseML (Separated package)
  - E.g., Tencent, PayPal*, Alibaba*, Baidu*/iQiyi, JD.com, Youku*, etc.

BDAS: Berkeley Data Analytics Stack
(Ref: https://amplab.cs.berkeley.edu/software/)



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Large-Scale Distributed ML on Apache Spark

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Fraud Detection on Apache Spark

Goal:

- Given transaction details, classify if it’ s fraud or normal

Evaluation Matrices

- Recall = predicted fraud / all real fraud transaction.
- Precision = predicted fraud correctly / predicted fraud

Fraud can mean:

Buying with stolen credit cards
Abusing promotional pr
Account takeover
Spamming other users

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Intel Customer Story

Problem statement and Pain points

- An old rule-based system that needs significant improvement
- Turn to Spark for data statistics and model training
- Need Neural Network for Fraud Detection on their Spark 1.4 cluster

Intel Solution

- Implement Neural Network on Spark and help integrate

Business Result

- Neural network model performs better than other algorithm
- Machine Learning system overtakes rule-based system and exceeds expectation
- Improve precision by 15%, improve recall by 30%

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Solution Architecture Overview

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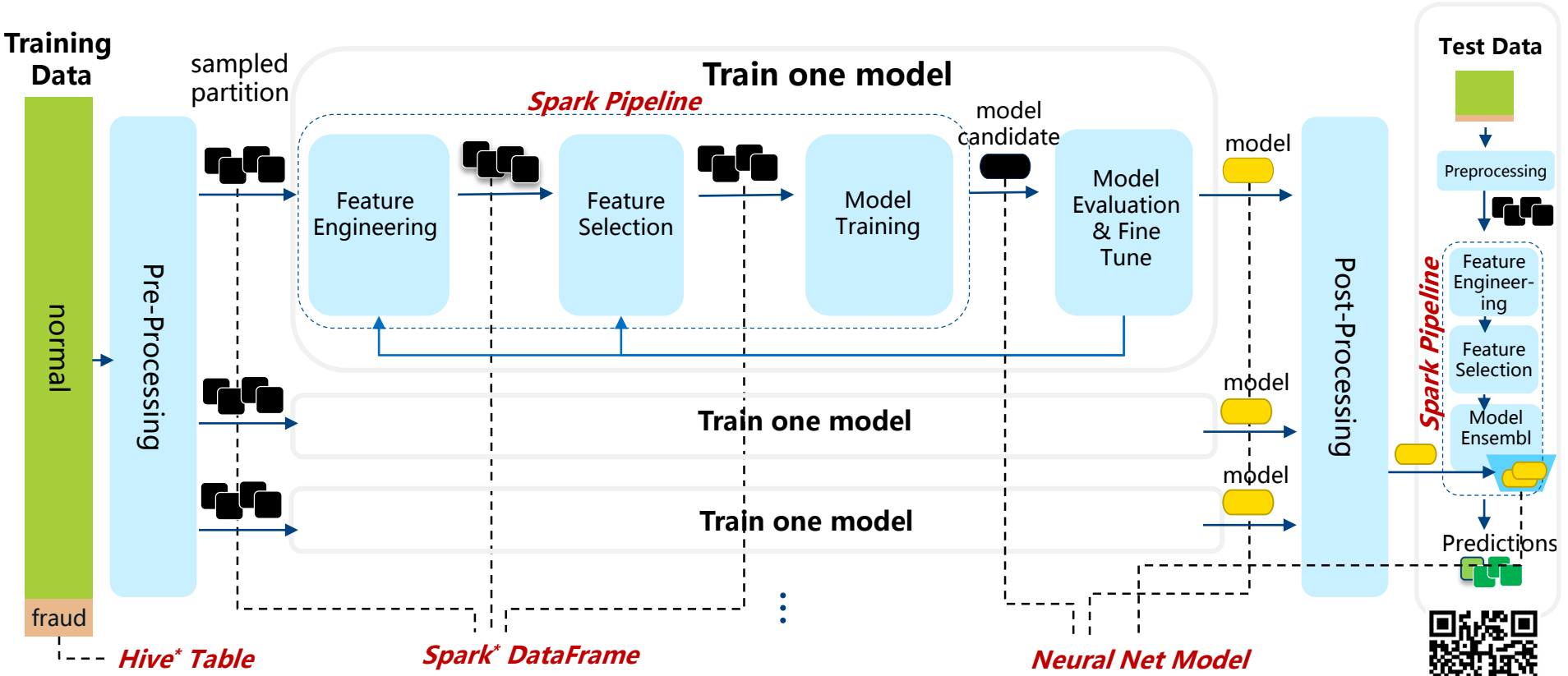

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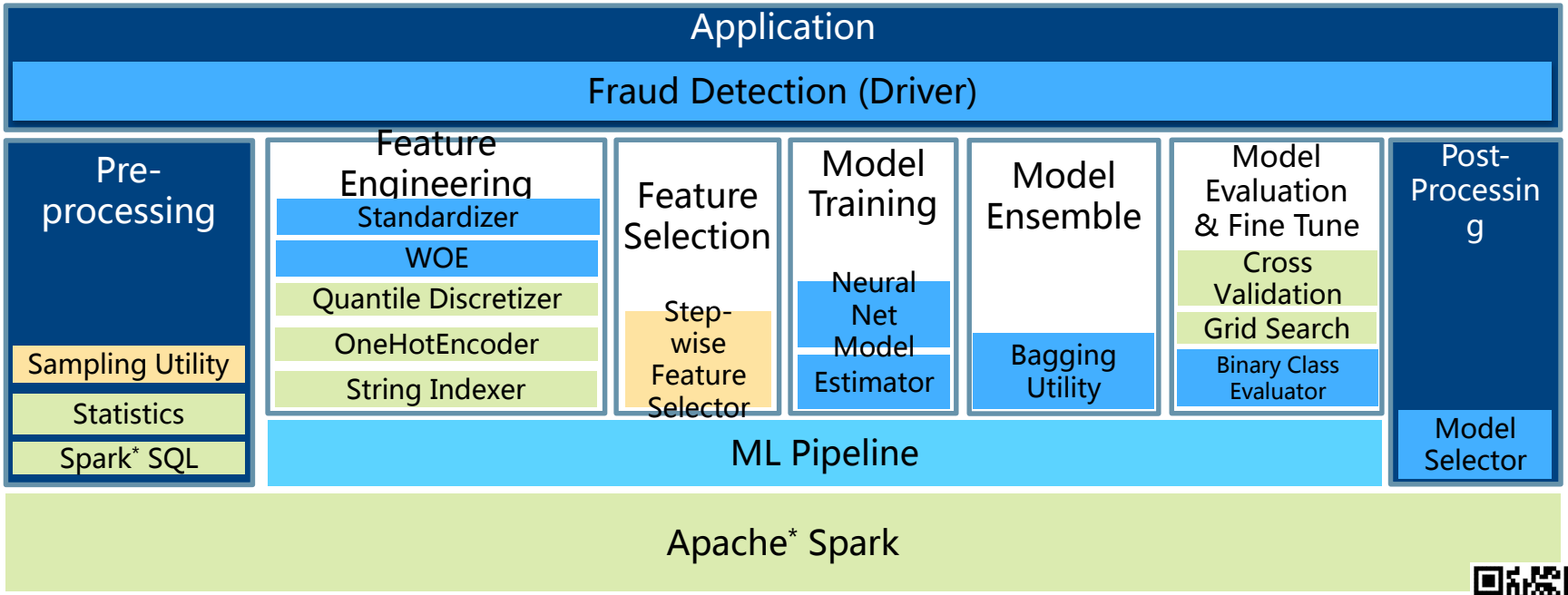
Tool Stack Overview



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Logistic Regression on Spark* with Mini-Batch SGD

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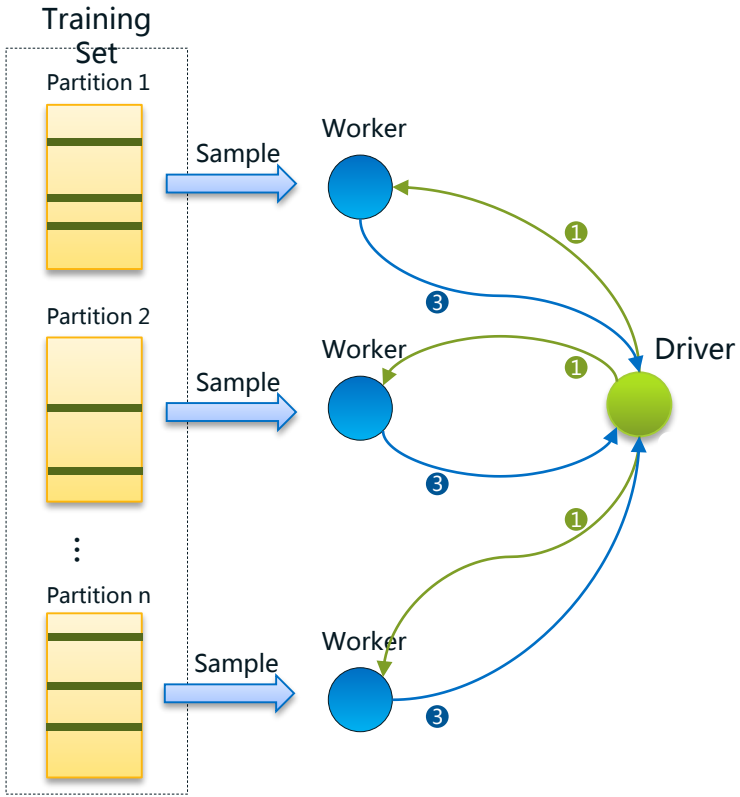

"Canonical" implementation

Repeat {

1. Driver broadcasts W to each worker

   Workers compute gradient for the next batch of B records from the training set

   Each task (running on workers) samples records from its data partition

3. Each task computes local gradient

   Aggregates gradient (possibly through tree aggregation)

   Driver updates weight

}

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Network and Memory Bottlenecks

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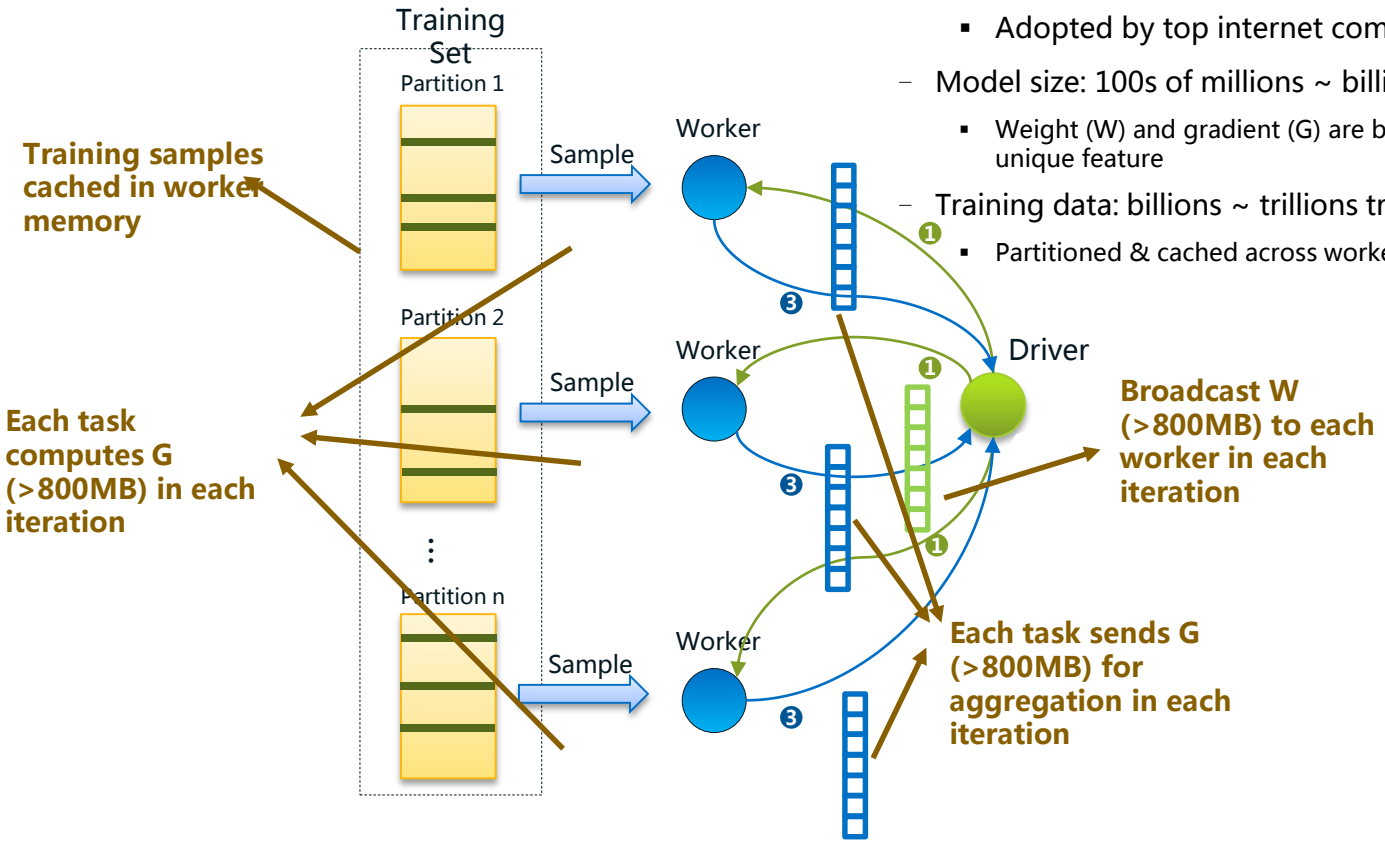
- Click-through and purchase rate predictions
  - Adopted by top internet companies
- Model size: 100s of millions ~ billions unique features
  - Weight (W) and gradient (G) are both double vector, one entry for each unique feature
- Training data: billions ~ trillions training samples
  - Partitioned & cached across workers



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Sparse Logistic Regression

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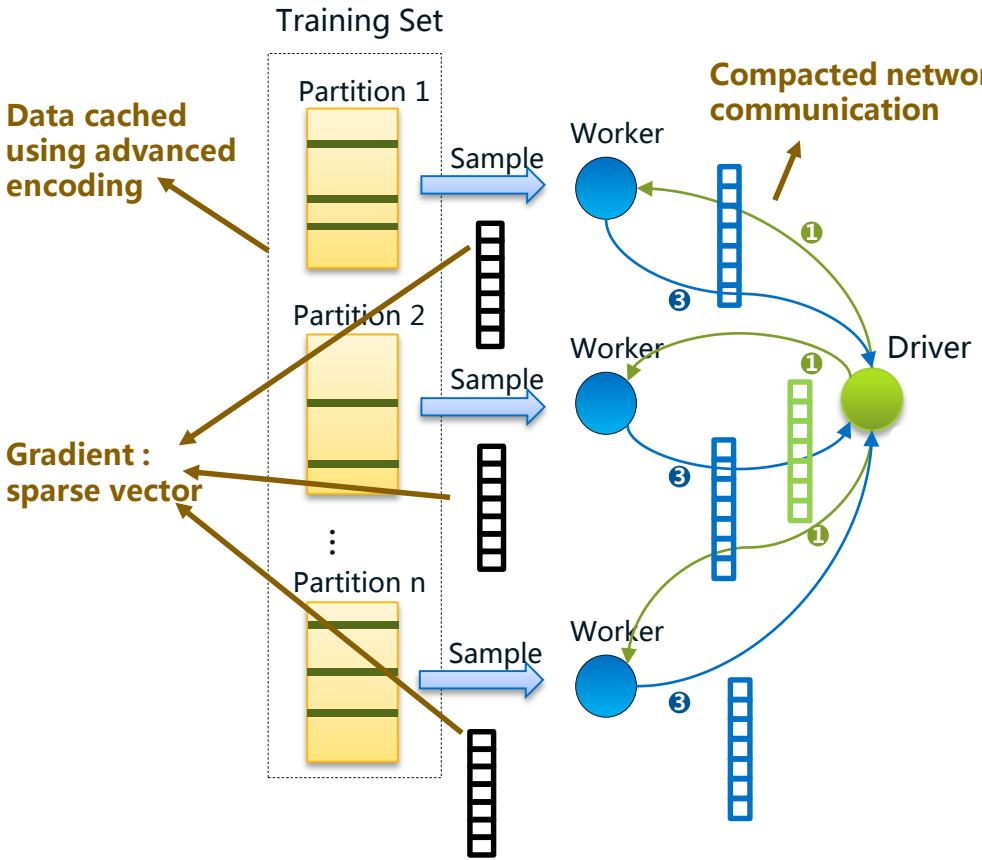

Click-through and purchase rate predictions

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Solution

- Cached using sparse format
  - Using float16 (instead of double values)
  - Extra Support for binary (0 or 1) values
- Only Calc & sync gradient with non-zero data
- Better Communication

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For more complete information about performance and benchmark results, visit www.intel.com/benchmarks.

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Distributed Neural Network

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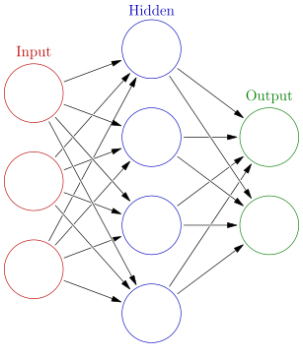
Multi-Layer Perceptron (MLP)

- Fully connected, feed-forward

Deep learning

- CNN, autoencoder, RBM, etc.



Training A Neural Network

Repeat {

1 Driver broadcasts parameters (weights & biases) to each worker

Workers process the next batch of ***B*** records from the training set

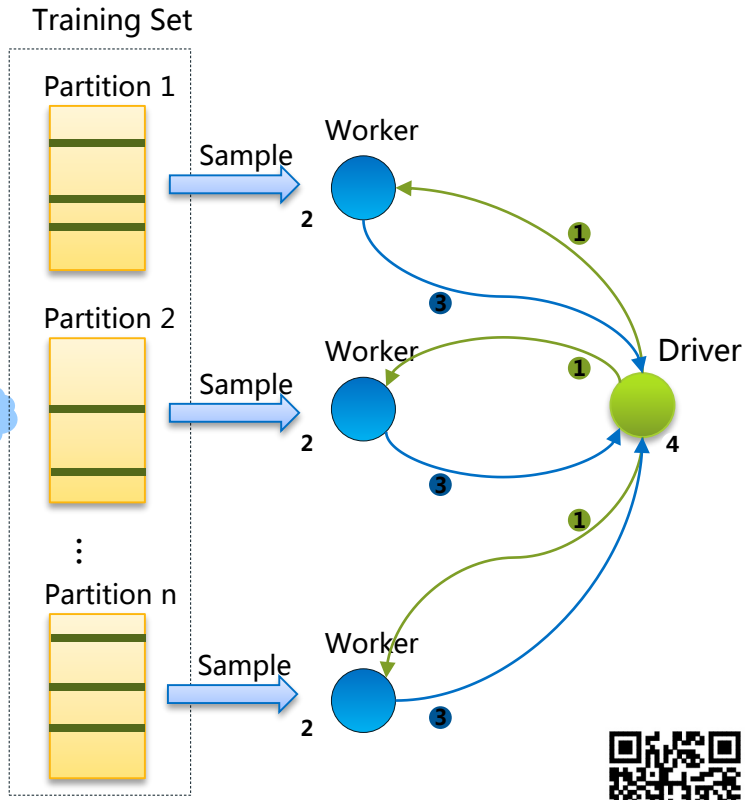
2 Each task (running on workers) samples records from its data partition

3 Each task computes the *forward* and *backpropagation* pass

4 Driver aggregates gradient

Driver updates parameters (weights & biases)

}



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Deep (Convolutional) Neural Network

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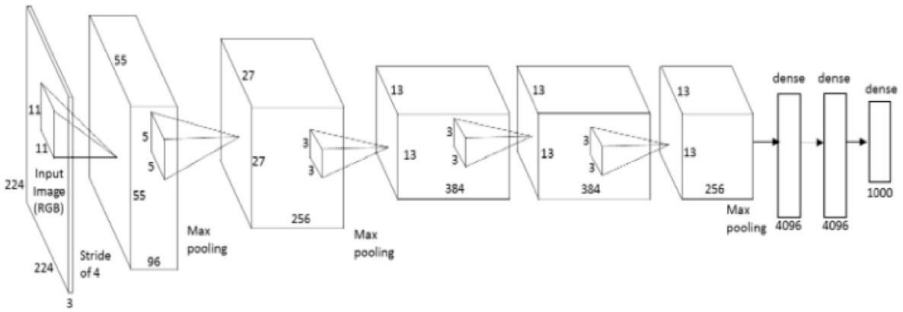
Intuitive API with layer-based interface




```
val trainData = loadData()
val model = new Sequential(...)
model += new Convolution(...)
model += new maxPooling(...)
...
val criterion = new ClassNLLCriterion()
val optimizer = new ParallelOptimizer (model, new SGD)
optimizer.setCrossValidation(evaluator.accuracy)
optimizer.setPath("./model_save.obj")
optimizer.optimize(trainData)
```

Built on top of standard Big Data platforms

- Easily utilize your existing clusters

Engaging industry users and community early

- Evolving with feedback from real-world use cases
- Community version compatible with Spark* MLP

Targeting Full function coverage:

- Auto Encoder, Sparse Encoder
- Convolution with max and avg pooling
- RBM and DBN

Benchmark with popular dataset / models

- GoogleNet, AlexNet on ImageNet

Easy MKL† integration for Intel® Architecture acceleration

Better communication: All-to-one, All-reduce on spark(CaffeOnSpark), ParameterS

†Free community license (https://software.intel.co
en-us/articles/free_mkl)

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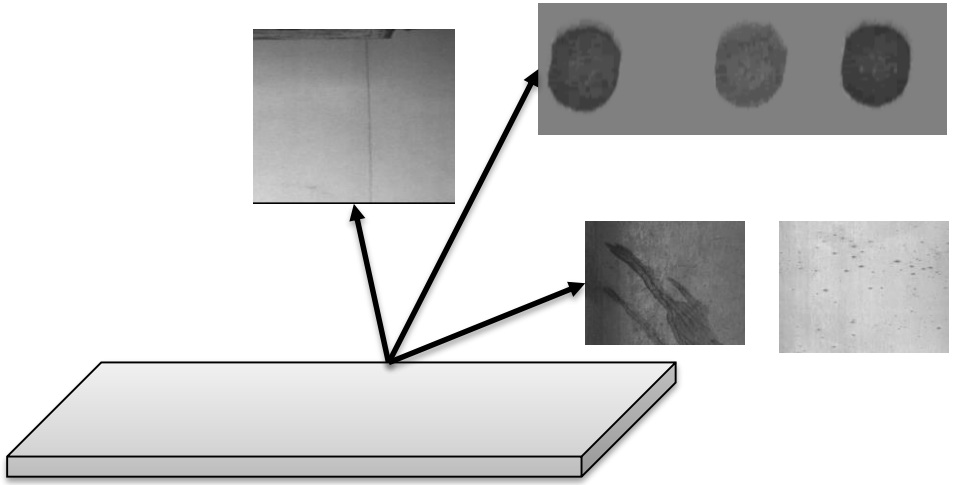
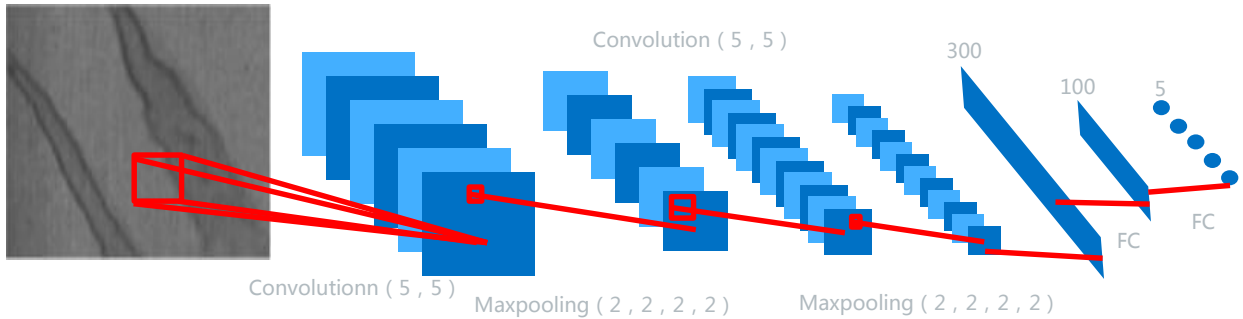
Flaw detection in steel product





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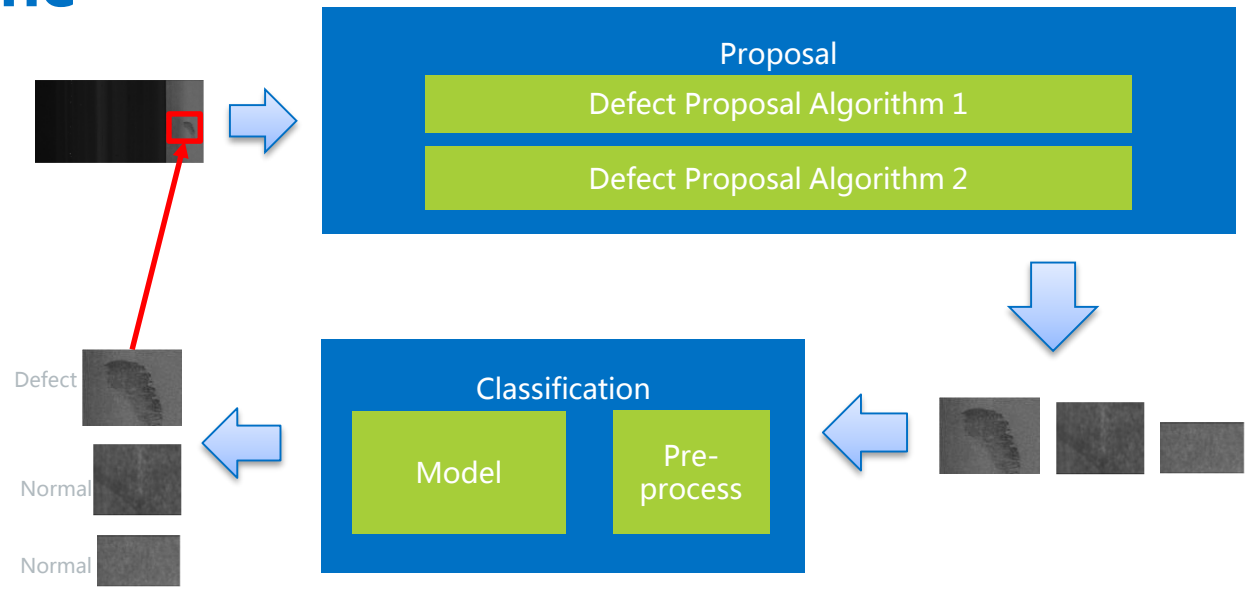
Pipeline



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Communication Model

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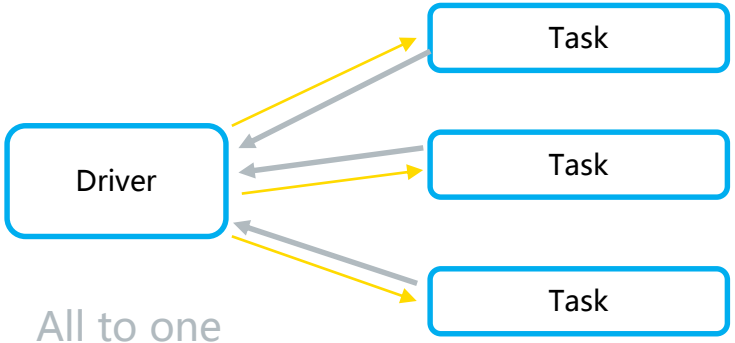
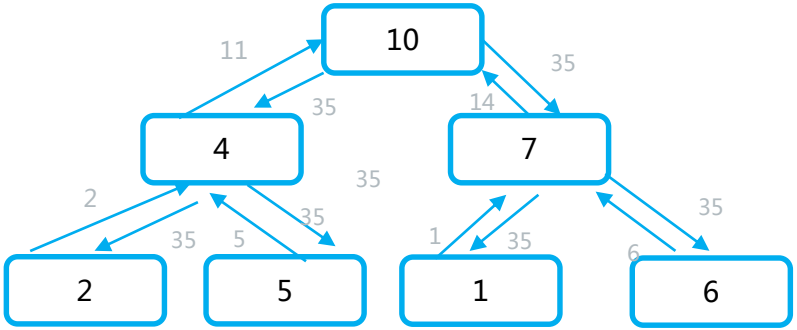
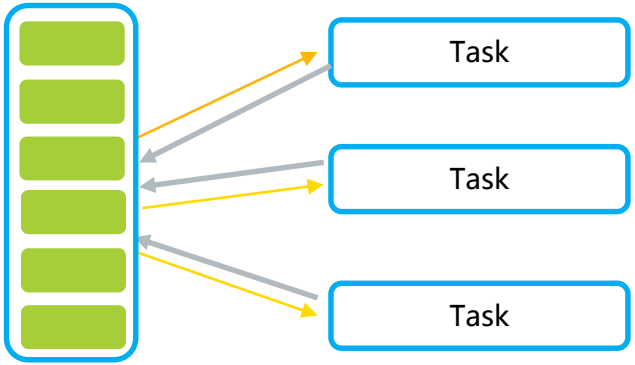


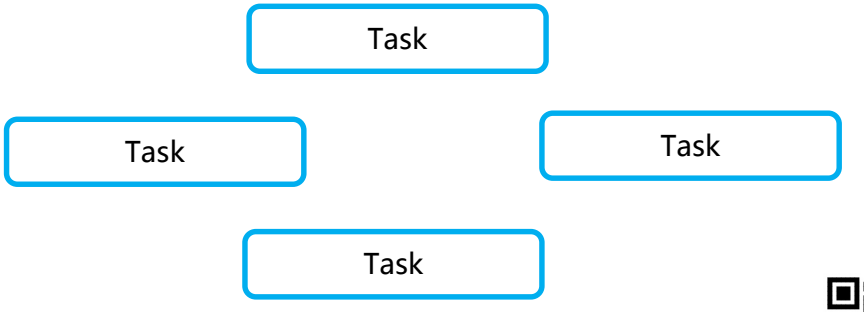
All to one



All reduce (tree aggregation)



Parameter Server



All reduce

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“Parameter Server” support?

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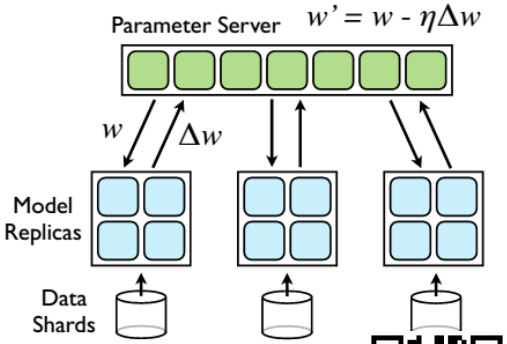
- Very large scale model/graph (billions of unique features)
- Leveraging further data sparsity in each worker (only a subset of weight vector needed)
- Possible weakly-synchronized model （BSP vs. SSP vs.ASP, etc.)
- Distributed parameter aggregation & update in Par " '
- Easily integration with Apache Spark*.
- Fault Torrance
- Co-partitioning



Source: Dean J, Corrado G, Monga R, et al. Large scale distributed deep networks[C]//Advances in neural information processing systems. 2012: 1223

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Reference & Resources

Intel packages

- https://github.com/intel-analytics/SparseML
- https://github.com/intel-analytics/FraudDetection

Intel Analytics:

- https://github.com/intel-analytics

Contact

- zhichao.li@intel.com

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