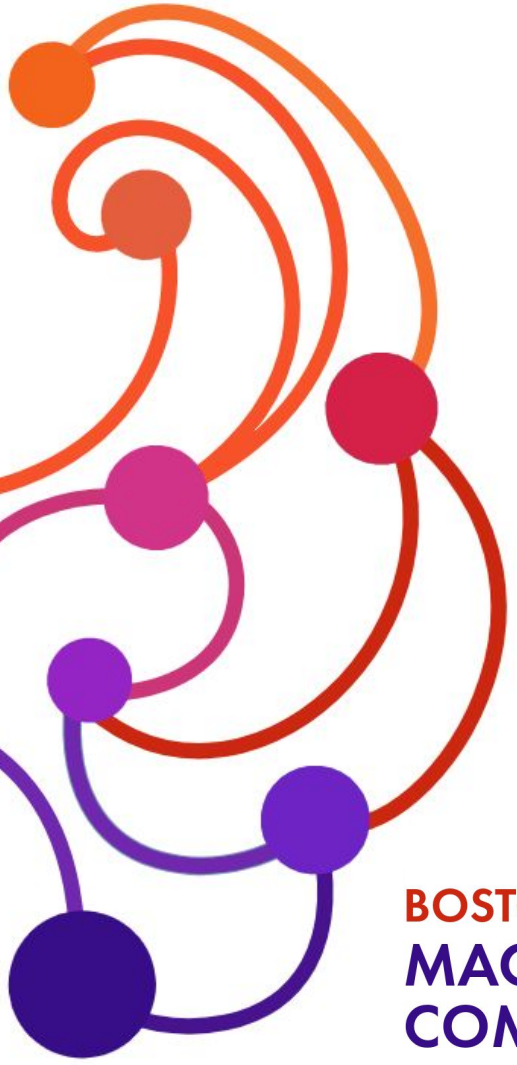

Large Scale Distributed Deep Networks

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Previous Limitations with Distributed Training

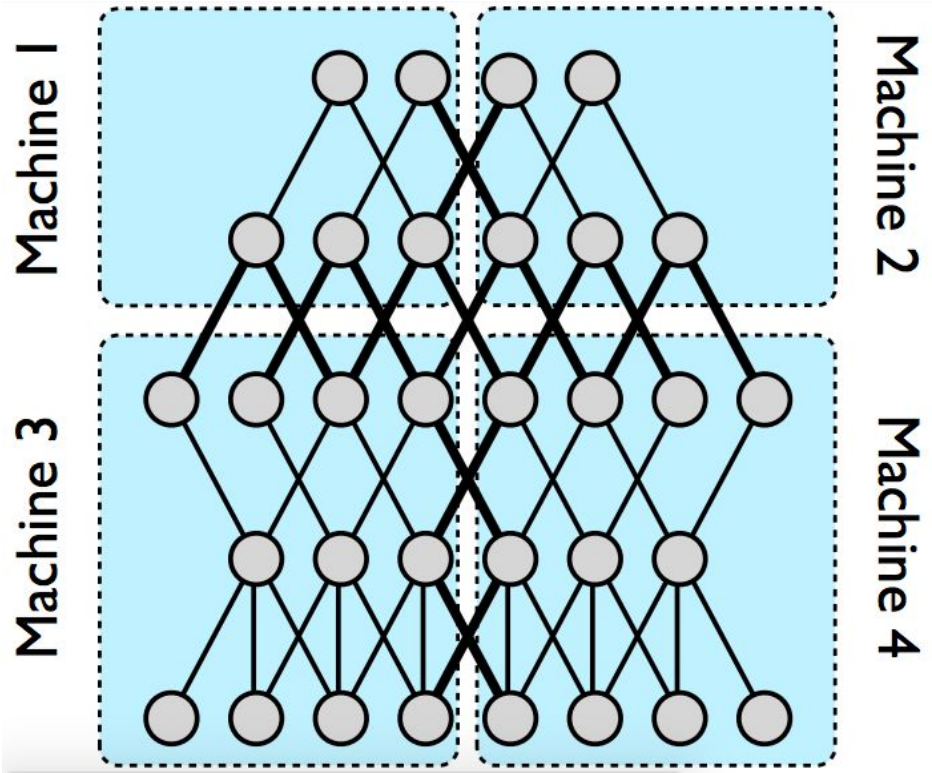
- Large models cannot fit onto a single GPU
- Previous distributed algorithms assumed convexity or sparsity
- MapReduce and GraphLab are not suitable
- Goal of this work:
  - Asynchronous
  - Distributed
  - No assumptions on architecture, sparsity, and convexity

DistBelief Framework

- Eventually became TensorFlow
- Automatic parallelization, synchronization, and communication
- Model parallelism
  - Multithread on single machine
  - Message passing across machines
- Data parallelism
  - Multiple copies of model across cluster

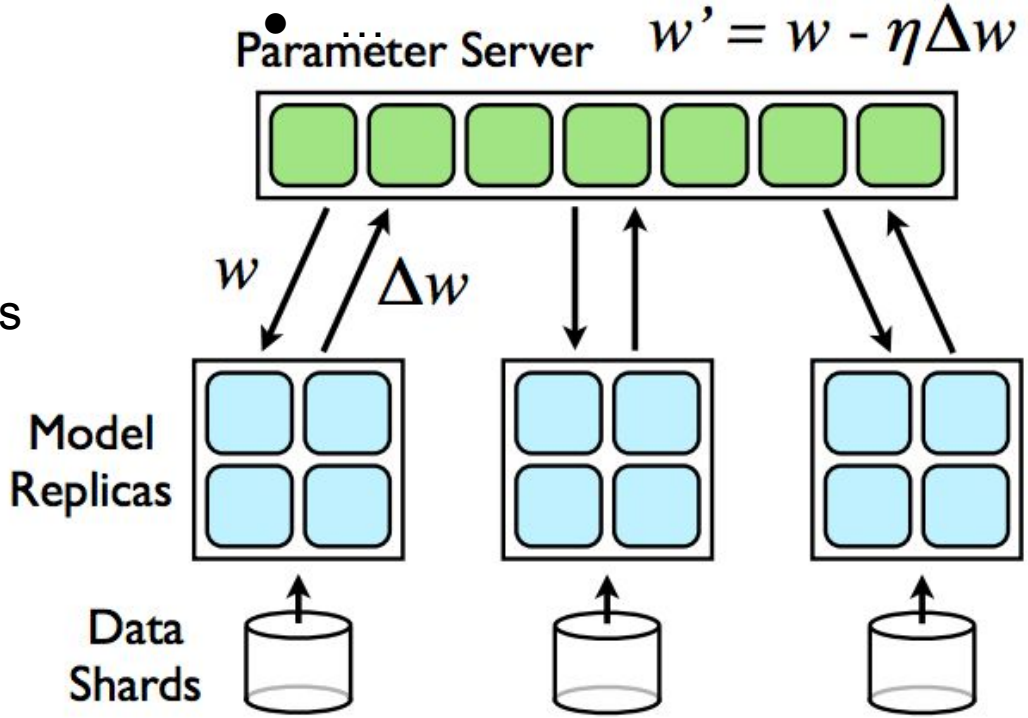
Model Parallelism

- Image depicts a single replicated model across four machines
- Blue box/machine is a **partition**
- Parameters communicated once (thick black lines)
- Node parallelized within partition



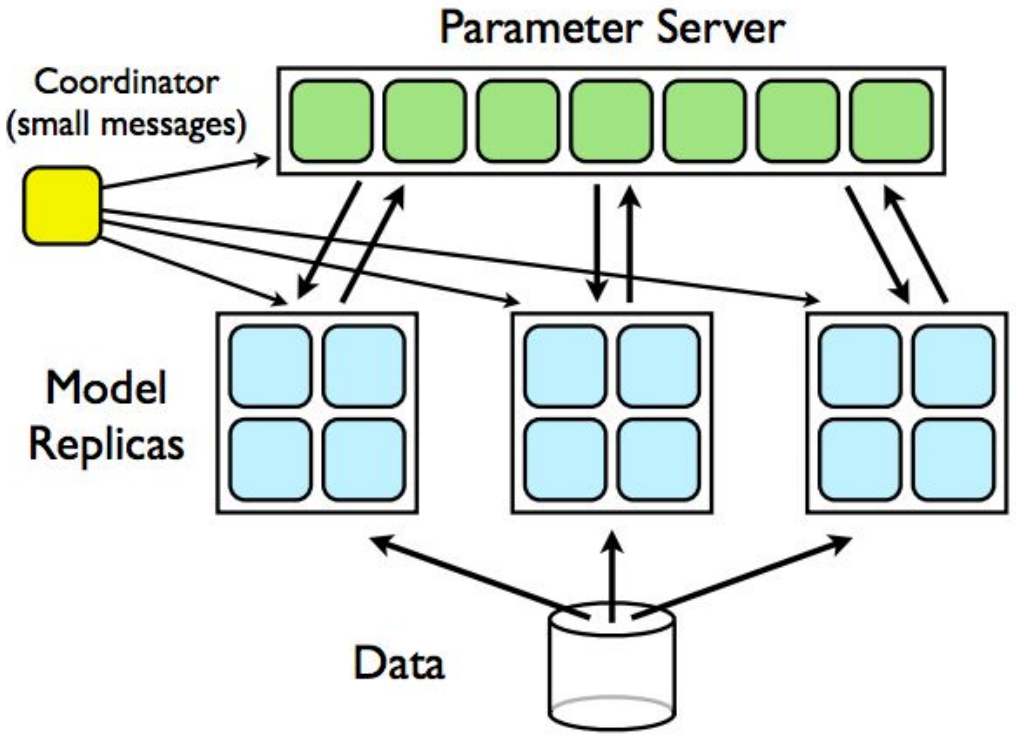
Downpour Stochastic Gradient Descent (SGD)

- Asynchronous SGD
- Uses Adagrad adaptive learning rate
- Asynchronously push gradients and pull parameters
- Replicated models traverse parameters landscape together in parallel
- Dataset divided evenly into shards



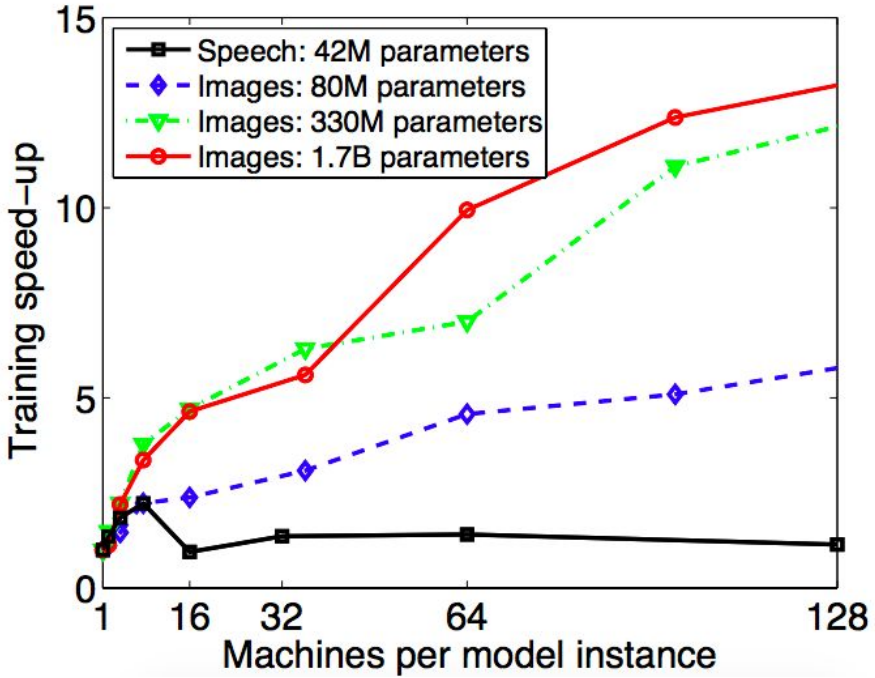
Sandblaster L-BFGS

- Limited-memory Broyden–Fletcher–Goldfarb–Shanno (L-BFGS)
- Communicate operations instead of values
- **Load balancing** - assign model replicas < 1/N of batch
  - Data parallelism

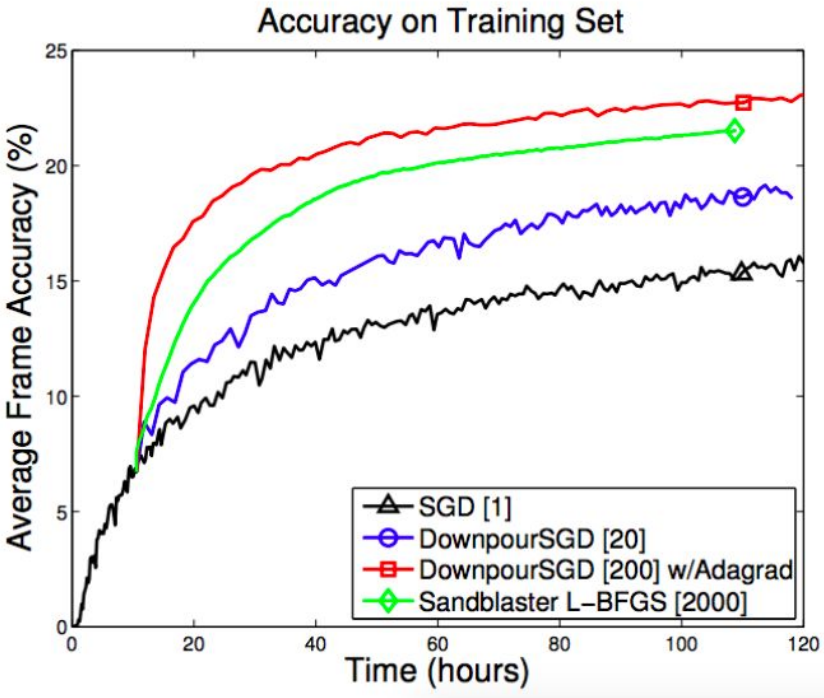


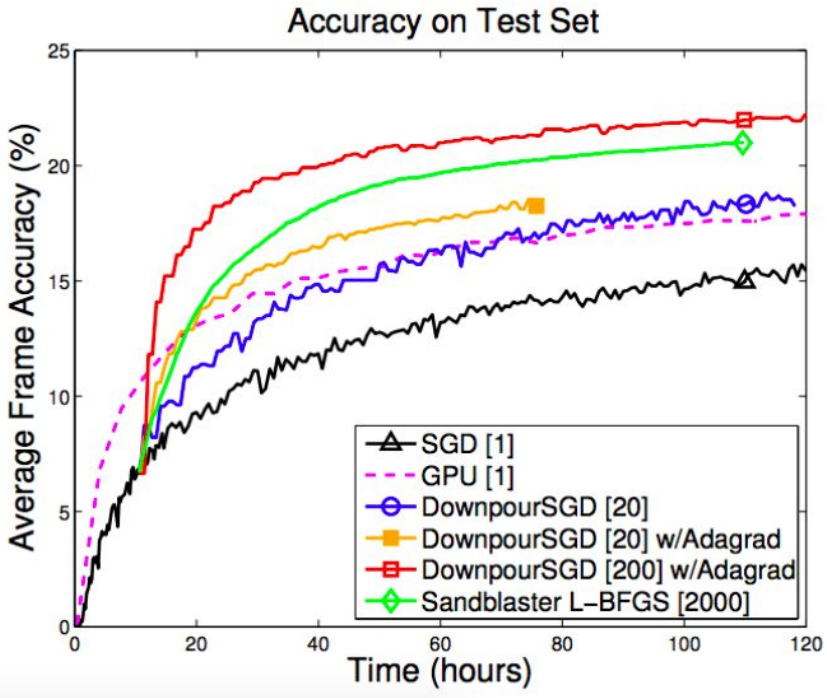
Machines per Model Instance

- Convnet for ImageNet
- RNN for speech
- Local connectivity - models that are not densely connected are more amenable for distributed training

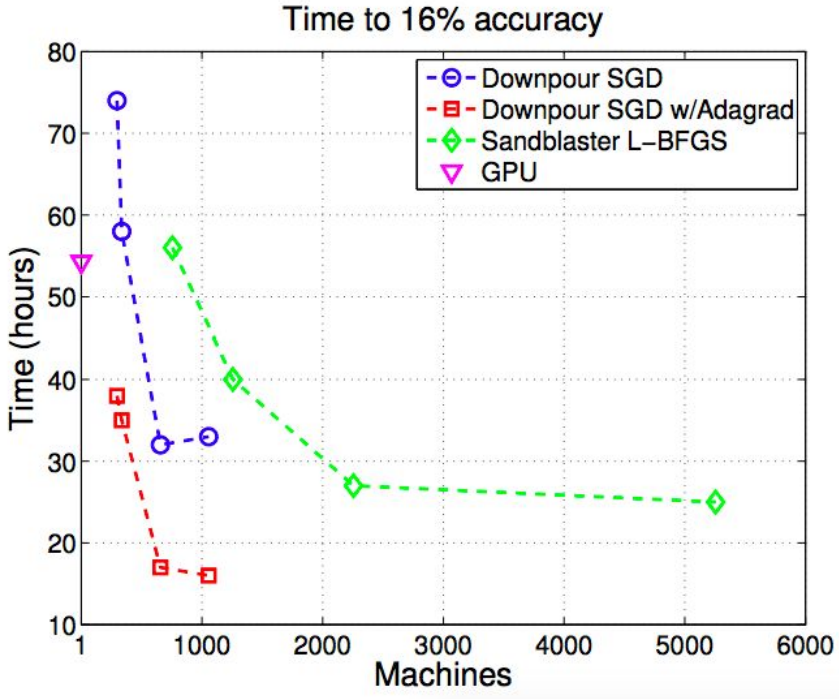


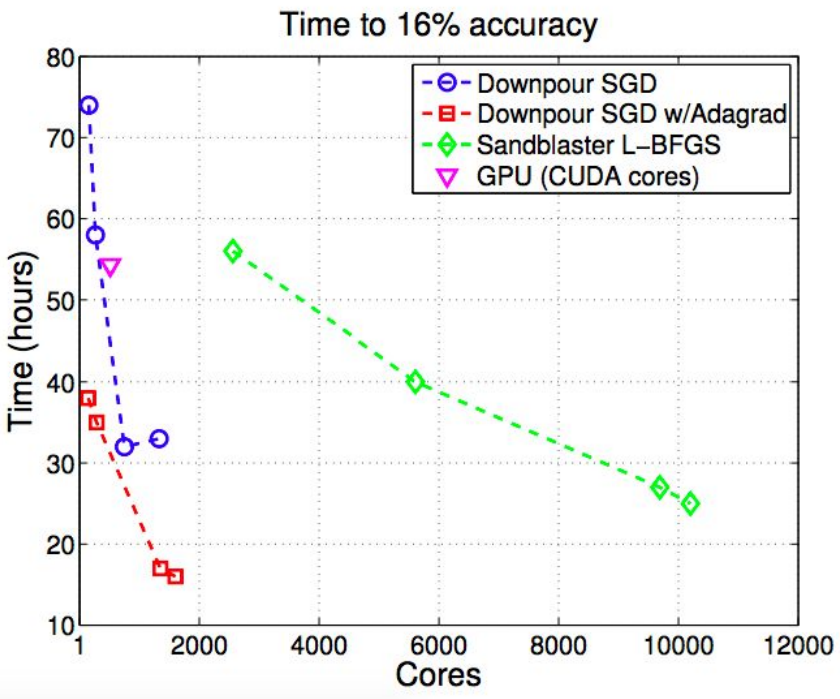
Accuracy over Time



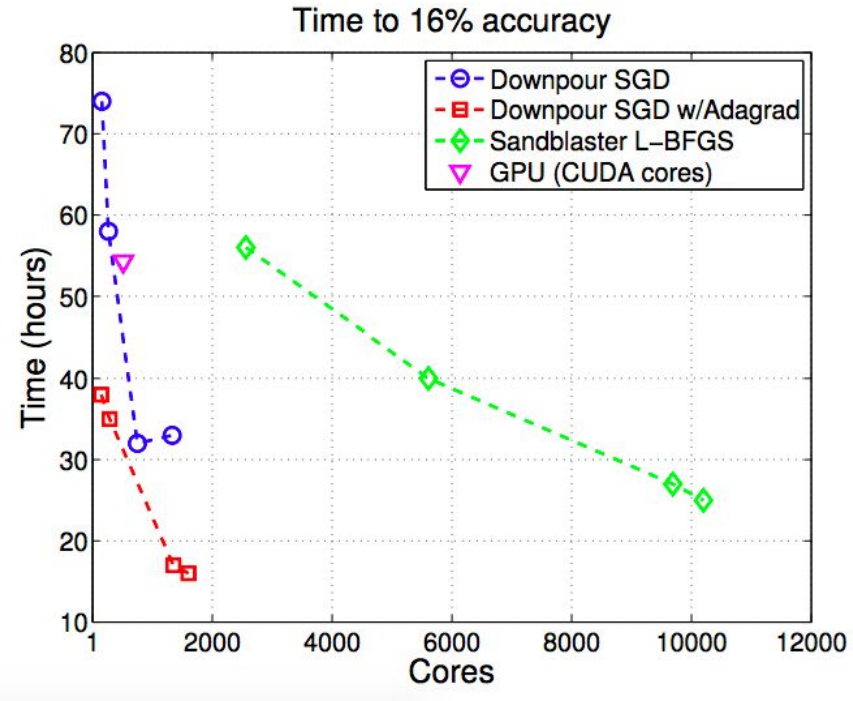


Training Time per Machine





Training Time per Cores



References and Further Reading

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4. **Deep Gradient Compression: Reducing the Communication Bandwidth for Distributed Training**
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