# Building a Big Data Chapel

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DoD

# Overview

- Big Data?
- Chapel on Mesos
- libhdfs3
- Machine Learning
- Current Projects

# Big Data?

**“Software, systems, and runtimes supporting – *at minimum* – resilient database style operations and features at scale.”**

# Chapel on Mesos

# Chapel on Mesos

- What is Mesos?
  - Cluster/Cloud orchestration technology
  - Event/Actor/CSP communication model
    - Uses futures, options, and libevent/libev
  - cgroup containers
    - Specially identified pid_t's operating under kernel-level resource isolation
  - Emphasizes multi-tenancy, over-subscription

# Chapel on Mesos

- Definitions
  - Mesos-Agents

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- Definitions
  - Mesos-Agents
  - Mesos-Master(s)
  - Mesos-Framework
    - Executor
    - Scheduler

# Chapel on Mesos

- Frameworks can be general or technology specific
  - General deployment solution
    - Aurora, Marathon, Chronos
  - Technology-specific deployment
    - Myriad (Hadoop-Yarn), Spark, Hadoop, MPI, Chapel

# Chapel on Mesos

- Built a Mesos Scheduler for Chapel
  - User-friendly, integrates w/GASNET Customized Spawning
  - GASNET feature request
  - Consistently handles <= 32 tasks “well”
    - Greedy “task packing”

# Chapel on Mesos

- **Next work?**
  - Needs a Customized Executor!
    - Handling task start-up issues
    - Exponential back-off
    - Core binding
  - Needs deployment hints added to Scheduler!
  - Mesos-Agents need CPU Isolation**

# Chapel on Mesos

- Thank you to GASNET team
  - For providing the new Custom Spawning feature!

# Chapel HDFS Support

# libhdfs

- Apache's libhdfs
  - C wrapper library for Java Hadoop jars
  - This complicates life for Mesos users
    - Mesos “sandbox” needs libjvm.(so/a) and Hadoop jars
    - Deploy using Docker images?
      - Several hundreds of megabytes or gigabyte images

# libhdfs3

- PivotalHD
  - libhdfs3 rooted in the native-hadoop project
  - C++ implementation of HDFS protocol for client applications
  - Deployment complications gone!
    - New complications related to HDFS deployment configuration!

# libhdfs3

- Chapel runtime
  - Very approachable and well organized
  - Moving between Chapel code and the runtime was easy
  - Runtime's io system “plugin-like” design
  - ~1-2 weeks to get something working**
  - Took a couple months on/off again work to debug and tune

** Working != perfect

# libhdfs3

- libhdfs3 now an CHPL_AUX_IO option in the runtime's io system!
  - Thank you Chapel team for sheparding!
- Next?
  - GlusterFS support
    - Avoid cgroup container access to FUSE
    - Initial version complete
    - Needs testing

# Machine Learning with Chapel

# Machine Learning

- Implemented
  - RandomForest (C++/Chapel)
  - Stochastic Logistic Regression (Python/Chapel)
  - Latent Dirichlet Allocation (Octave/Chapel)
- Measuring training time!
- Execution Environment
  - Amazon EC2 node
  - Chapel 0.13
    - jemalloc
    - qthreads
    - hwloc
  - CHPL_FLAGS=--fast --vectorize

# Machine Learning

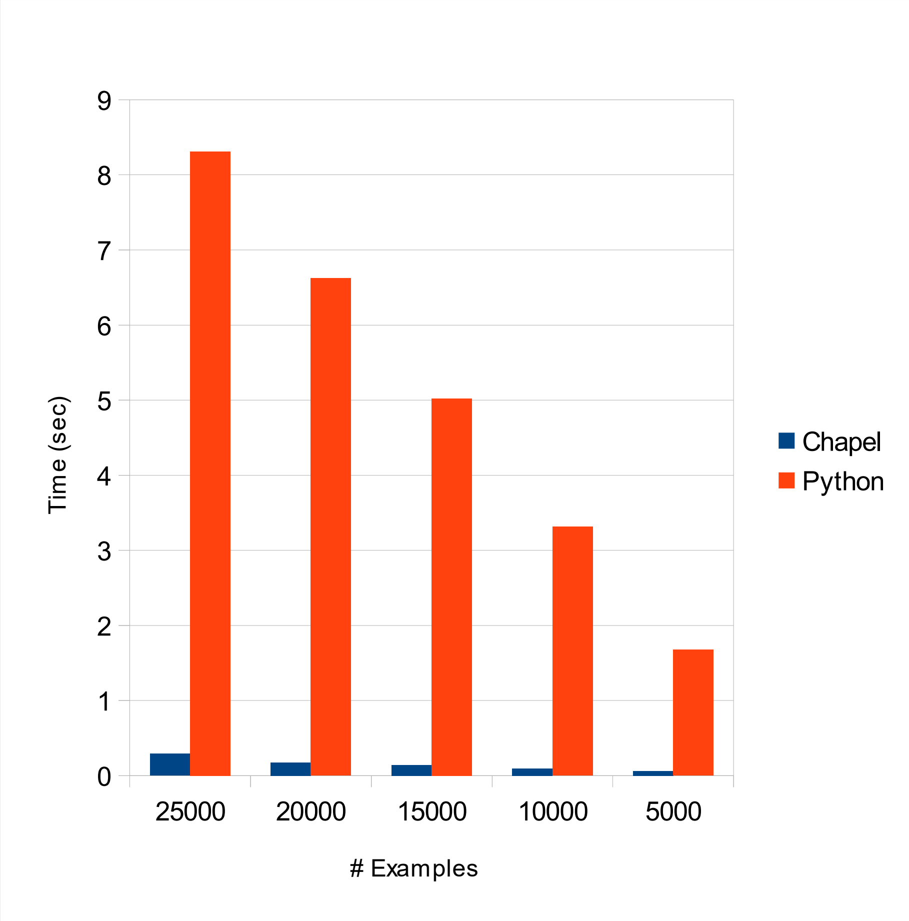
- Removed from evaluation
  - RandomForest (C++/Chapel)
- 0.13 compiler caught use of undocumented features the 0.12 compiler permitted
  - Specifically domain-related
  - Implementation heavily leveraged the undocumented features :(
  - Not enough time to fix the spaghetti code's issues

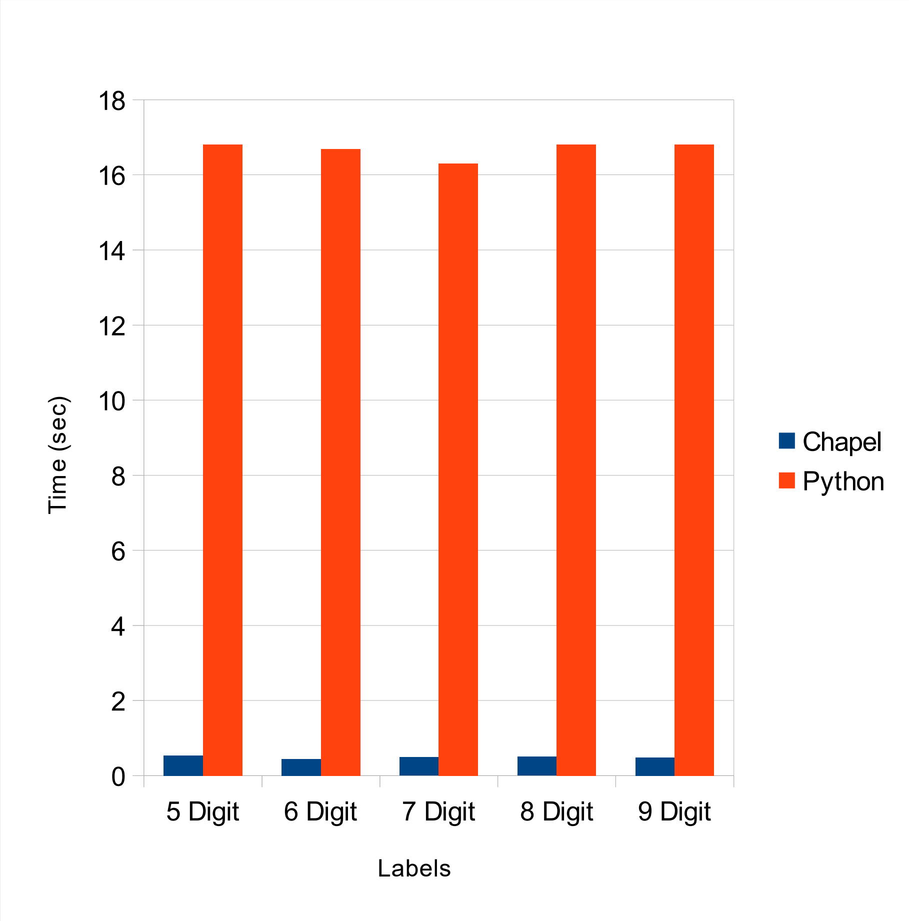
# Machine Learning

- Stochastic Logistic Regression
- Data set?
  - MNIST training data – hand-written numbers, {0..9}
  - Samples have 784 features
- Left of Slide Graph – Stratified samples (sklearn)
    - Label 5 - 25000 samples
    - Label 6 - 20000 samples
    - Label 7 - 15000 samples
    - Label 8 - 10000 samples
    - Label 9 – 5000 samples
- Right of Slide Graph - All training samples
    - 50000 per Label

# Machine Learning

## Model Training

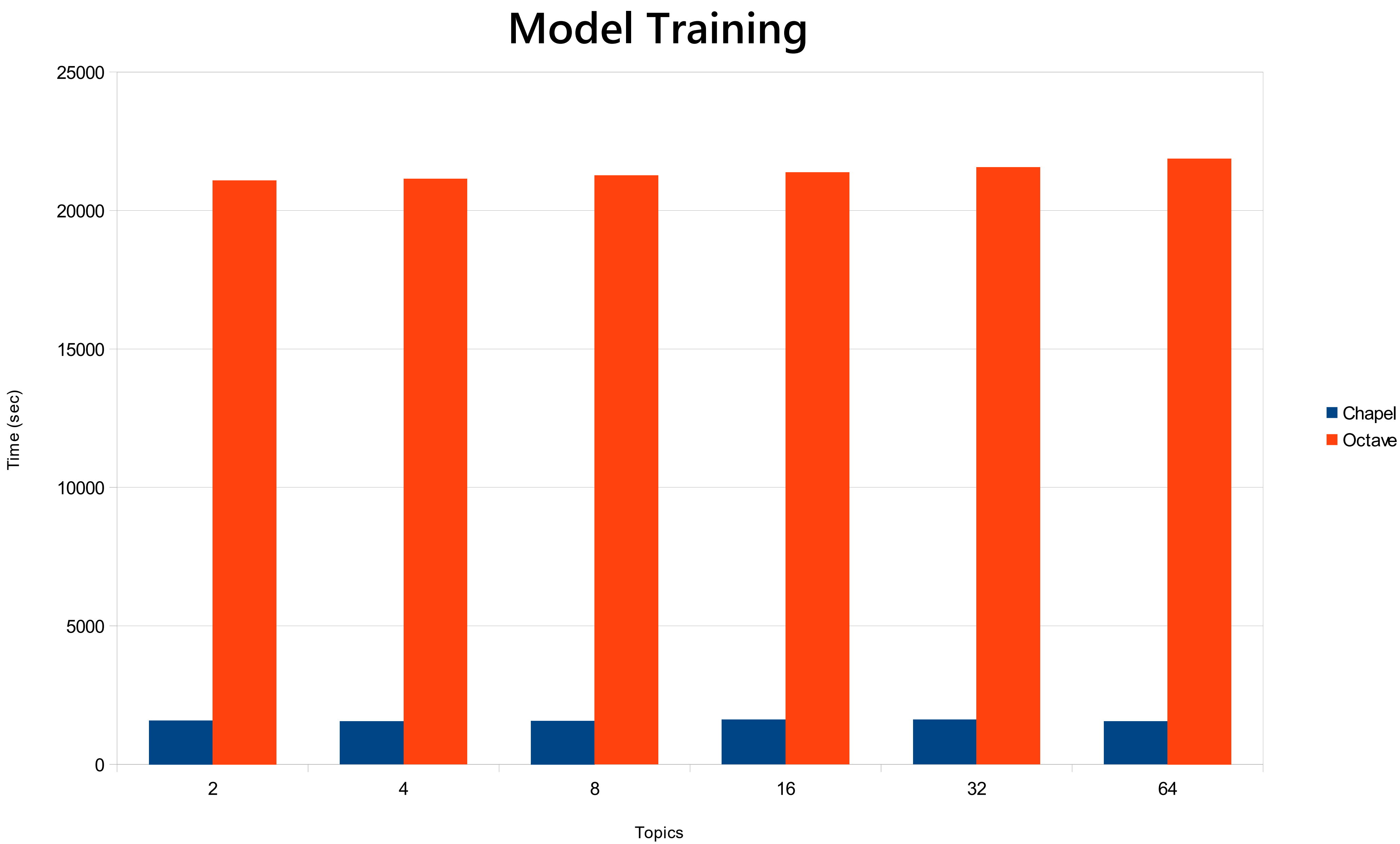


# Machine Learning

- Latent Dirichlet Allocation
- Data set?
  - Stored as doc/word count matrix
    - 6906 Words across 3000 Documents
- Performance for computing T topics
  - T = { 2, 4, 8, 16, 32, 64 }

# Machine Learning



# Machine Learning

## References – Latent Dirichlet Allocation

- D. Newman, A. Asuncion, P. Smyth, M. Welling. "Distributed Algorithms for Topic Models." JMLR 2009
- D. Newman, A. Asuncion, P. Smyth, M. Welling. "Distributed Inference for Latent Dirichlet Allocation." NIPS 2007
- http://www.ics.uci.edu/~asuncion/software/fast.htm

# Current Work

# Current Projects

- Resilient Key-Value storage for Chapel
  - Google's Big Table
- Log-Structured Merge Tree
  - Append-only log
  - Transaction is a tree
  - Transaction buffer is a forest
  - Compact forest operation
- Distributed domains/dmap support
- Implementation in progress

# Current Projects

- Directed Acyclic Graph processing for Chapel!
  - Tensorflow, Dask, Storm, Heron, Spark, Theano, etc
- Users build execution DAGs, runtime executes the DAG
- Graph optimizations/transformations
  - Optimization/Simplification/Computer Algebra (auto-differentiation)
  - Scheduling
  - Communications
  - Track Graph Execution for “replay/recovery”
- Prototype implementation – basic “calculator math”
  - Works for scalar-scalar and vector-vector
  - scalar-vector should be easy - has been problematic

# Thank you!

- Chapel Team
- GASNET Team
- Questions?