Optimising TensorFlow performance on CPUs

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Overview

1. TensorFlow and why bother with CPUs?
2. Threading and choosing the right package
3. Performance results
4. Summary

TensorFlow and why bother with CPUs?

TensorFlow

- “Open source framework for dataflow and differentiable programming”
- Very popular for machine learning/deep learning
- Graph/Operator architecture enables parallelism
- Some operators implemented using parallel “Eigen”, “MKL-DNN”, or “cuDNN” kernels on CPU and GPU

Why bother?

Deep Learning:

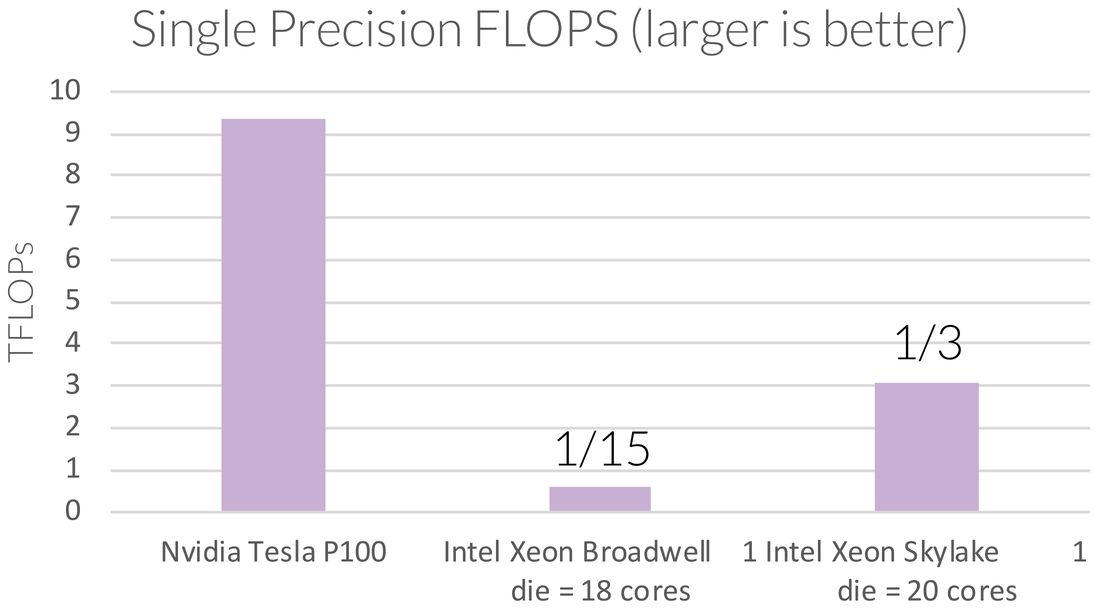
- Very compute intensive (matrix multiplication)
- Modern CPU and GPU hardware well-suited
- Specialised hardware features for Deep Learning and inference available

CPU vs GPU:

- GPUs often faster but not always available
- If I/O is a bottleneck, GPU advantage can be small

Why bother?

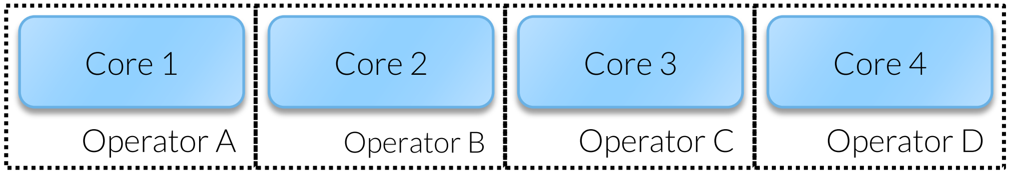
What the datasheets say: GPU card vs 1 CPU die



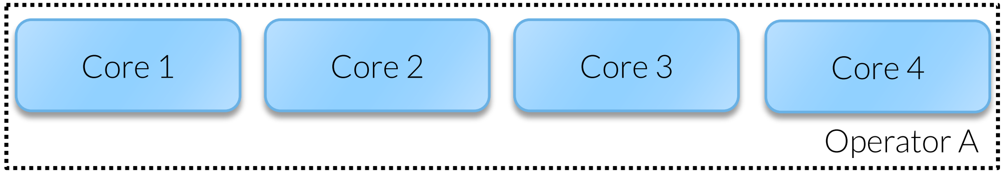
Threading and choosing the right package

Thread Parallelism in TensorFlow on CPUs

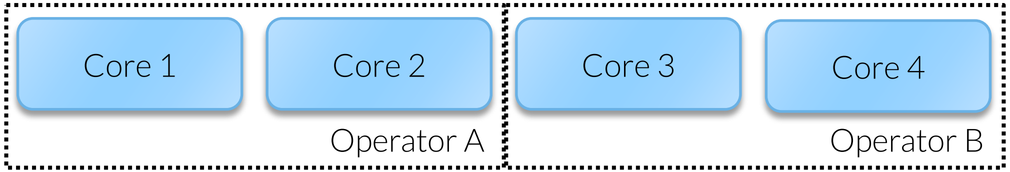
1. Inter-operator – multiple operators in parallel



2. Intra-operator – single operator in parallel



3. Mixed inter-intra-operator parallelism



Allocating Threads

- Best inter/intra split depends on model:
  - How many operators can run in parallel
  - Sufficient work per operator for parallelisation
- Try out different combinations!
- Intel MKL-DNN and Eigen threading:
  `OMP_NUM_THREADS=#intra-operator threads`

Threading

Runtime configuration

- Use thread affinity – pin threads to cores
- Use low thread blocktime with Intel MKL-DNN
- Default in Conda package for TensorFlow (!)
- Use Conda package with “mkl_py<...>” build

Intel recommendation:

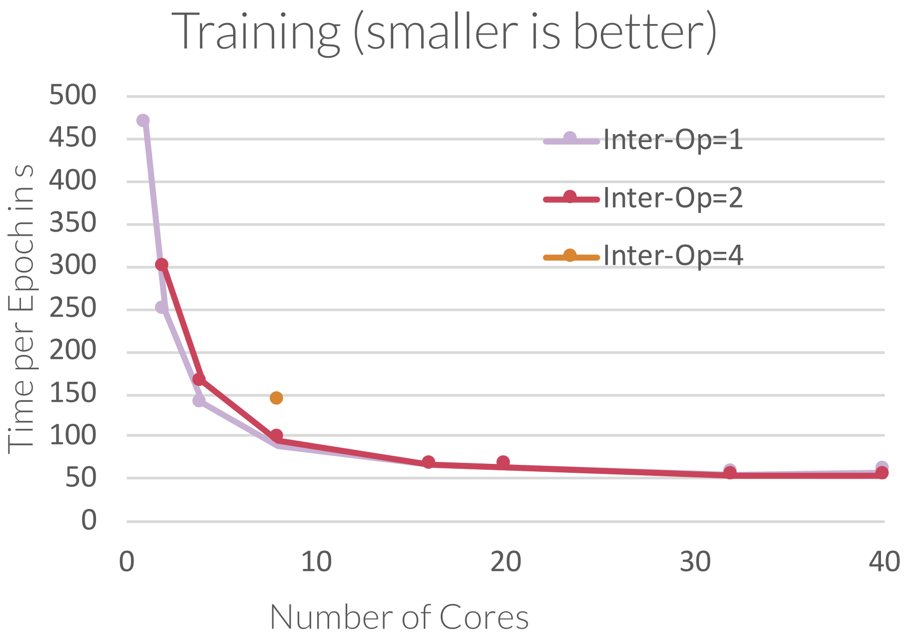
```
KMP_BLOCKTIME=0
KMP_AFFINITY=granularity=fine,compact,0,0
KMP_HW_SUBSET=1T
OMP_NUM_THREADS=intra_op_parallelism_threads
```

Performance results

Performance Results

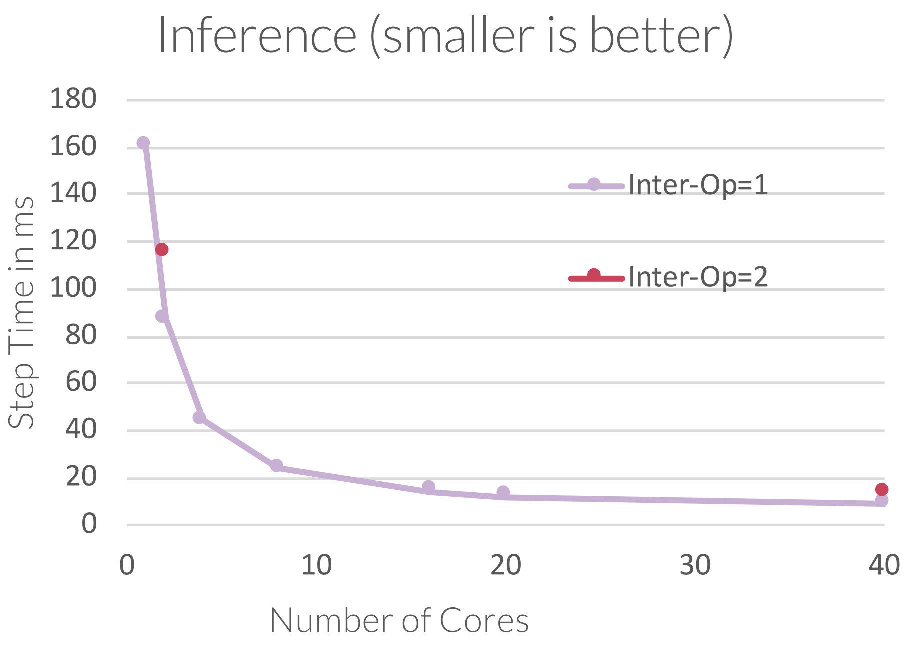
- Classification of video images
- Neural network based on Inception v3
- Work by C. Peat et al. (in publication)
- Test systems:
  1. Nvidia Tesla P100
  2. Intel Xeon Skylake 2.4 GHz x40 node
  3. Intel Xeon Broadwell 2.1 GHz x36 node
- Use optimal threading configuration

Performance Results – Training Scaling



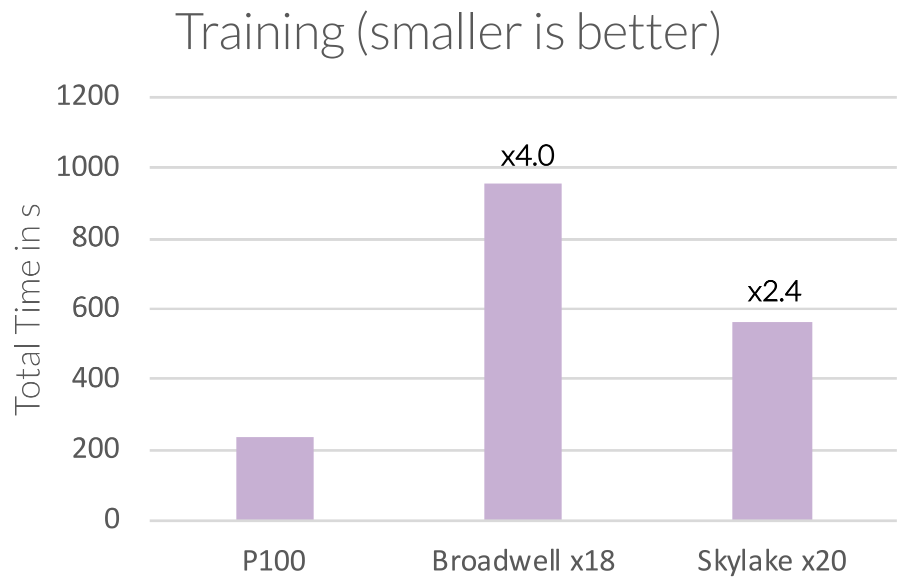
- Skylake node with 40 cores
- Total number of cores = Inter-Op x Intra-Op
- Batch Size 32

Performance Results – Inference Scaling



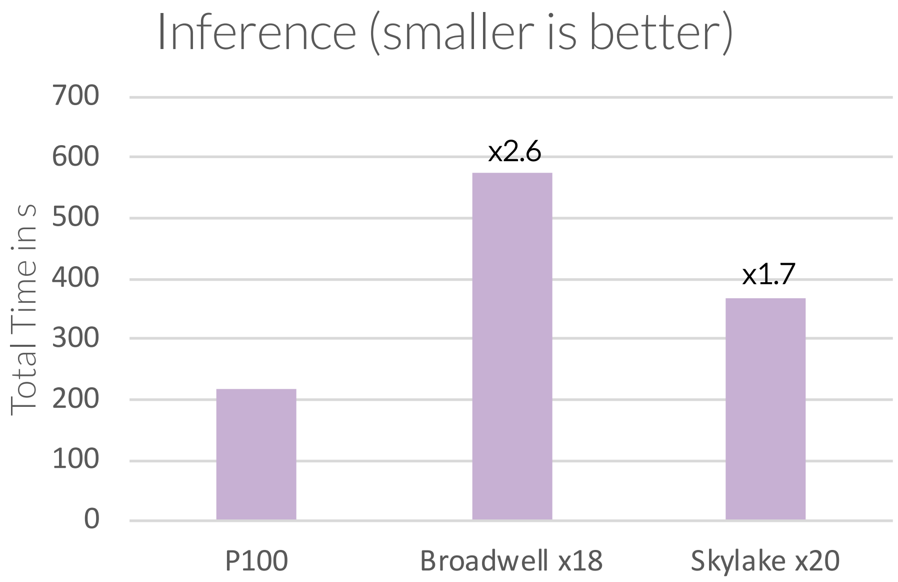
- Batch Size 128

Performance Results – Overall Training Time



- Batch Size 32 – not always ideal for performance
- Use all cores in a CPU die (1/2 node)
- CPU slower, but not order of magnitude

Performance Results – Overall Inference Time



- Batch Size 100
- CPU can be competitive!

Summary

Summary

- CPU can deliver competitive performance
- Explore MPI+Threading for further improvement
- Will depend on model and workflow
- Could run training on GPU, inference on CPU
- Check out mlperf.org!

Let us know if you would like help: support@nesi.org.nz

Thank you!