CS 744: PIPEDREAM

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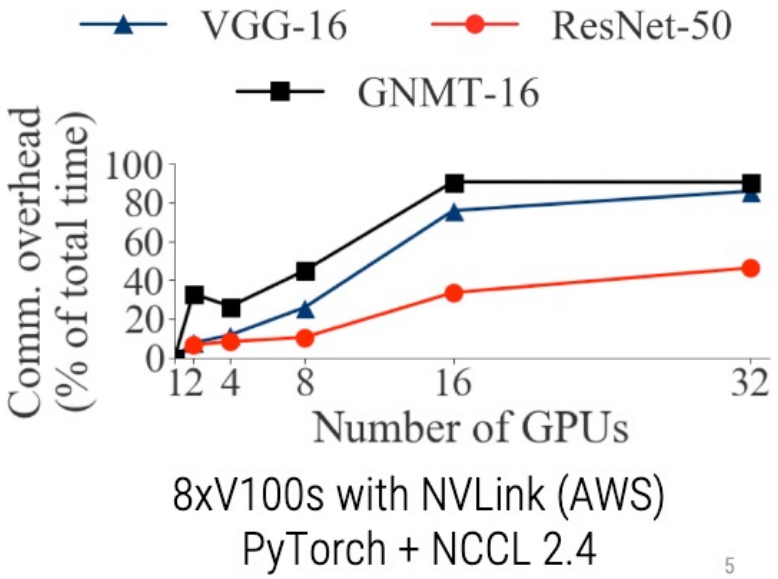
ADMINISTRIVIA

- Assignment 2 is due Wednesday AM!

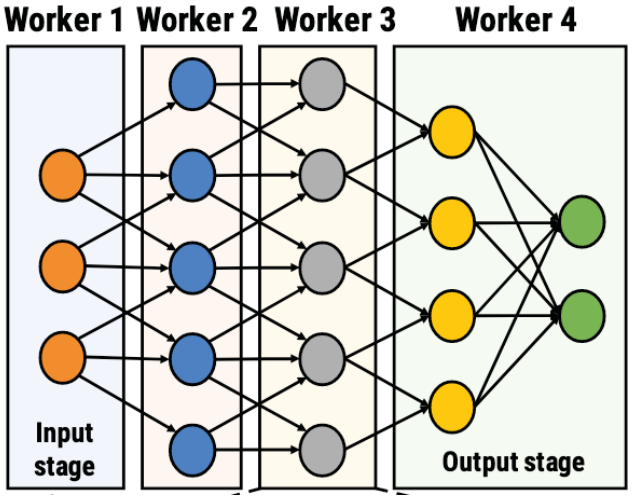
- Course project preference sheet: Out today!
  - Propose your own?
  - Or rank 1 through 5 of some project ideas we have

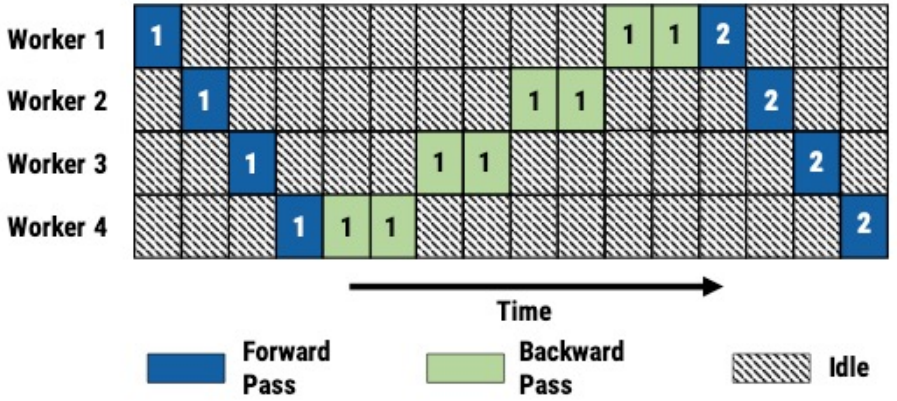
LIMITATIONS OF DATA PARALLEL



"fraction of training time spent in communication stalls"

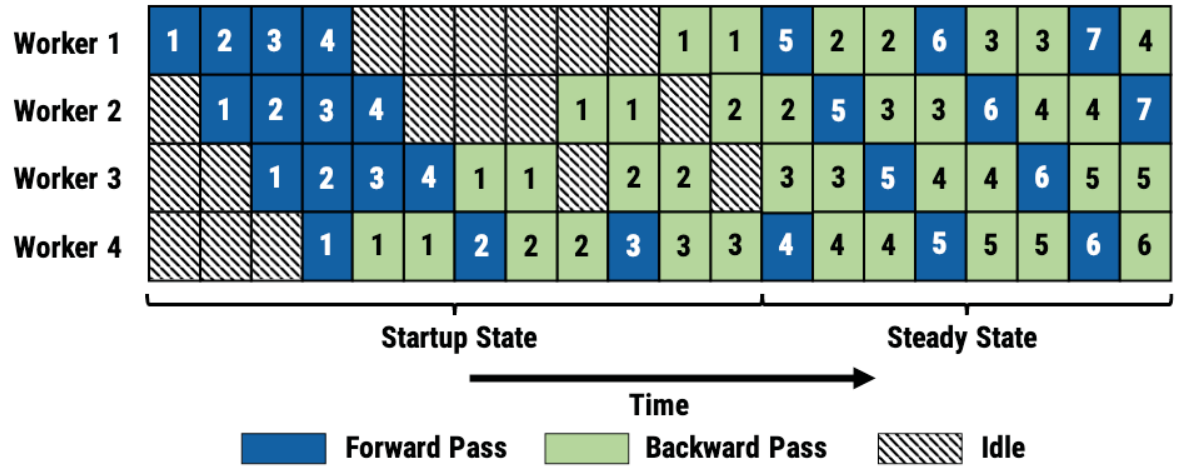
MODEL PARALLEL TRAINING





PIPELINE PARALLEL

Advantages?

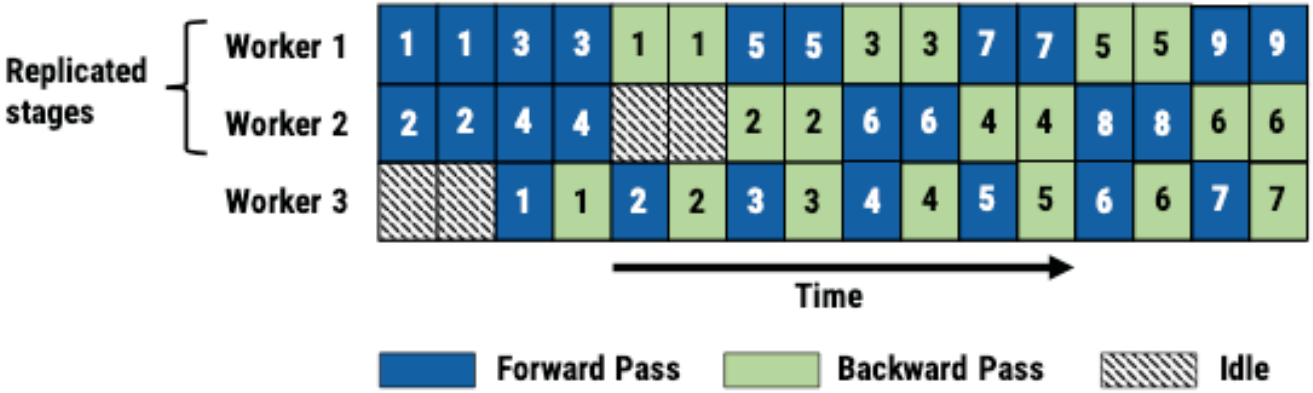


CHALLENGE 1: WORK PARTITIONING

Goal: Balanced stages in the pipeline. Why?

Steady state throughput is the throughput of the slowest stage

Stages can be replicated! Ex: Two stage pipeline, but first stage is replicated



WORK PARITIONING

Profiler: computation time for forward, backward for each layer
size of output activations, gradients (network transfer)
size of parameters (memory)

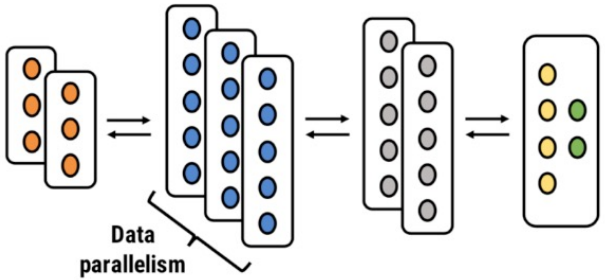
Dynamic programming algorithm

Intuition: Find optimal partitions within a server,
Then find best split across servers using that

CHALLENGE 2: WORK SCHEDULING

Traditional data parallel

- forward iter(i)
- backward iter(i)
- forward iter(i+1)
- …



Pipeline parallel: Worker can

- Forward pass to push to downstream
- Backward pass to push to upstream

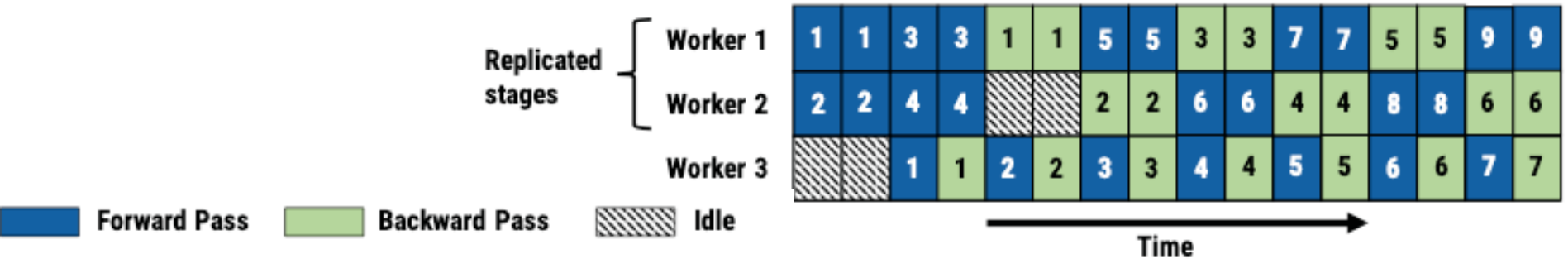
CHALLENGE 2: WORK SCHEDULING

Num active batches ~= num_workers / num_replicas_input

Schedule one-forward-one-backward (1F1B) – Worker 3

Round-robin for replicated stages → Worker 2

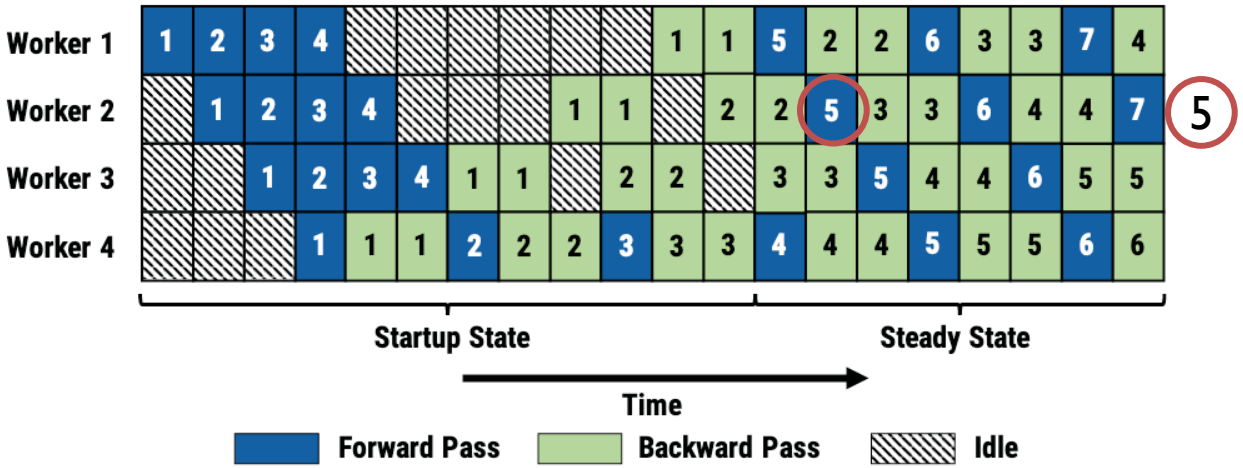
same worker for fwd, backward



CHALLENGE 3: EFFECTIVE LEARNING

Naïve pipelining

Different model versions forward and backward



CHALLENGE 3: EFFECTIVE LEARNING

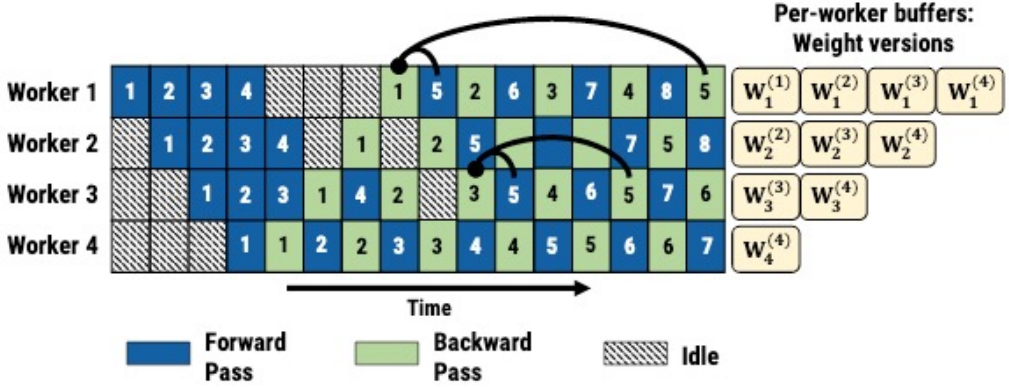
Weight stashing

- Maintain multiple versions of the weights
- One per active mini-batch

Use latest version for forward pass.

Retrieve for backward

No guarantees across stages!



STALENESS, MEMORY OVERHEAD

How to avoid staleness:

- Vertical sync

Memory overhead

- Similar to data parallel?

SUMMARY

Pipeline parallelism: Combine inter-batch and intra-batch

Partitioning: Replication, dynamic programming

Scheduling: 1F1B

Weight management: Stashing, vertical sync

DISCUSSION

https://forms.gle/5cf16BWn6Dziey6e6

List two takeaways from the following table

Model Name	Model Size	GPUs (#Servers x #GPUs/Server)	PipeDream Config	Speedup over DataParallel (Epoch Time)
Resnet-50	97MB	4x4 2x8	16 16	1× 1x
VGG-16	528MB	4x4 2x8	15-1 15-1	5.28x 2.98x
GNMT-8	1.1GB	3x4 2x8	Straight 16	2.95x 1x

What are some other workload scenarios (e.g. things we discussed for MapReduce or Spark) that could use similar ideas of pipelined parallelism? Develop such one example and its execution

NEXT STEPS

Next class: Parameter Server

Assignment 2 is due soon!

Course project preference form out today!