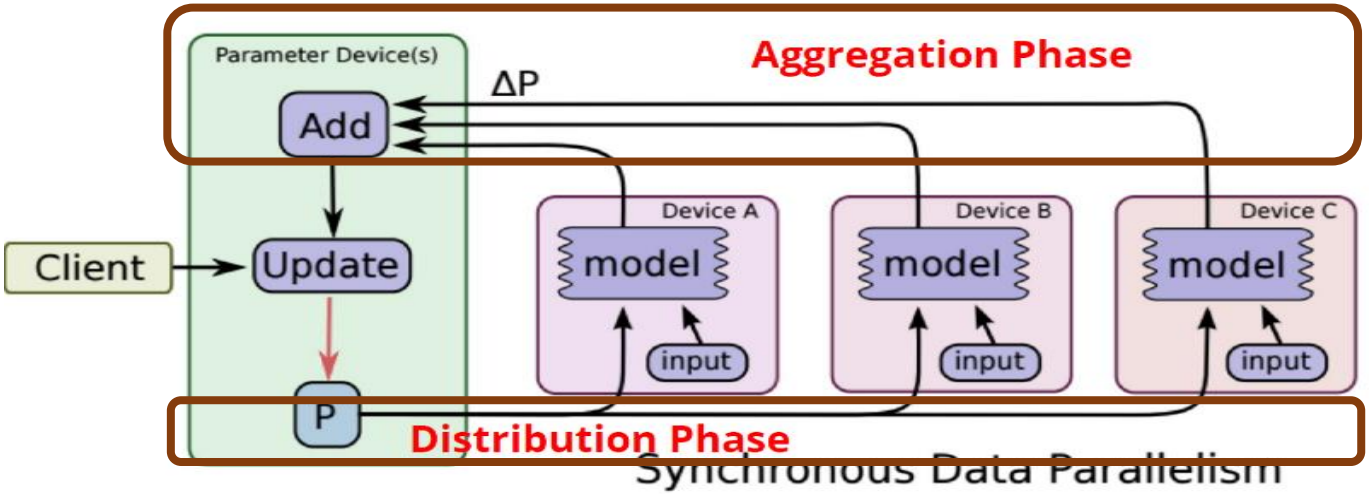
AI in network = Net For AI

(NOT “AI for Net”)

Jeffrey He, **Rachel Chen**, Qiaoling Wang

July 19th, Montreal

One typical use case: DNN training platform



[1] Michael Alan Chang, Aurojit Panda, Scott Shenker etc, "Network support for DNN Training", 2018 , UC Berkeley / Huawei workshop

- **Distribution phase : model parameters are distributed from the PS to all the workers**
- **Aggregation phase: workers calculate the gradients and send them to the PS(parameter sever)**
- **The traffic models of the two phases are one-to-many and many-to-one**
- **Reducing network traffic between PS and switch can accelerate the training**
- **Accelerating DNN training is very important, since one training takes up to tens of days**

CNN	Parameter Quantity (MB)	Single Iteration Time (s)	Total Training Time (Day)
AlexNet-v2	192	13.0	18.8
Inception-v3	106	4.3	6.23
Resnet-152	230	12.3	17.8
VGG-16	528	29.0	42.0

Note:
1 PS + 32 workers,
batch size=32,
1 epoch = 125114 iters,
100 epochs in total

Computing and multicast reduce network traffic

- **Data transmission between PS and workers takes the majority of the time.**
  - Take a 10GE-link as an example, the transmission time is up to dozens of times longer than the calculation time in one single iteration. (eg, VGG-16)

DNN model	Parameter Quantity(MB)	Calculation time (ms)	Single iteration (ms)	Theoretical Transmission (ms)	
			10 Gbps test results	10Gbps	40Gbps
Inception-v3	106	1035.7	1700	1017.6	254.4
Resnet-152	230	650.9	2781	2208	552
VGG-16	528	285.2	7114	5068.8	1267.2

- Scott Shenker's team (from UC Berkeley) add in-network computing and multicast to reduce the E2E training time of VGG-16 to 1/29 (when 32 servers were deployed) [1].

DNN Name	Baseline	Mult/Agg
VGG-16	42.08 sec	1.43 sec
Inception-v3	4.77 sec	1.05 sec
Resnet-200	13.89 sec	0.96 sec
Resnet-101	9.09 sec	1.01 sec

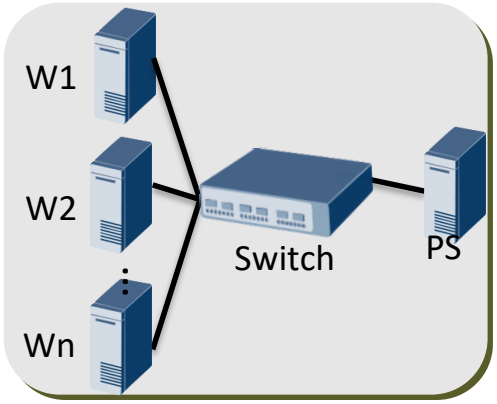
[1] Michael Alan Chang, Aurojit Panda, Scott Shenker etc,
"Network support for DNN Training", 2018 , UC Berkeley / Huawei workshop

Theoretically, when introduce in-network computing and multicast (involves 32 workers) , we can still use cheap 10GE switch rather than expensive 100GE.

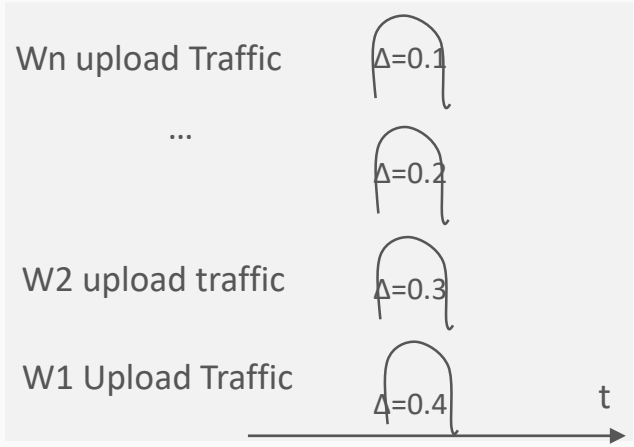
Why the E2E training time greatly reduced?

Aggregation phase

Traffic flow
1) from workers to switch
2) from switch to PS



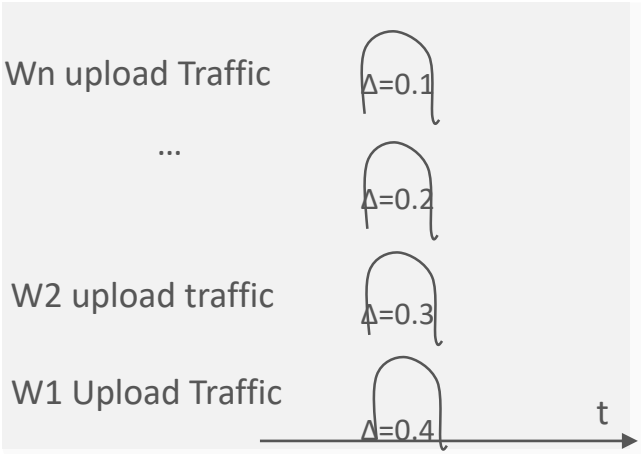
Traffic from workers to switch



Traffic from switch to PS

with “perfect” network scheduling and shaping

Traditional way: switch as traffic mover



after aggregation computing

Computing/Caching in net

Add “computation”: in-net aggregation and transfer results to PS, reducing traffic from switch to PS.

Add “cache”: store model parameters and distribute to workers, reducing network traffic from PS to switch.

Recent advances in research: Computing

- Amedeo Sapio, **Marco Canini**, etc. "In net computing is a dumb idea whose time has come ", Hotnets 2017
  - A large data reduction ratio (86.9%-89.3%) and a similar decrease in workers' computation time
  - https://dl.acm.org/citation.cfm?id=3152461
- Michael Alan Chang, **Scott Shenker**, etc. "ChangNetwork Evolution for DNNs", SysML, Feb 2018, Palo Alto, California
  - Optimizing the network fabric can improve DNN training time
  - https://www.sysml.cc/doc/182.pdf
- R. L. Graham, P. Lui, etc. Scalable Hierarchical Aggregation Protocol (SHArP): A Hardware Architecture for Efficient Data Reduction. In COM-HPC, 2016.
  - Improvement of a factor of 3.24 in the latency of a 4096 byte MPI_Allreduce() operations, declining from 46.93 to 14.48 microseconds.
  - https://ieeexplore.ieee.org/document/7830486/
- **NetCompute 2018:In-Network Computing workshop in sigcomm2018. (this August)**
  - https://conferences.sigcomm.org/sigcomm/2018/workshop-netcompute.html

Recent research: introduce other capabilities to network

- **In network cache (maybe obtain the capability similar to the multicast):**
  - Xin Jin etc, " NetCache: Balancing Key-Value Stores with Fast In-Network Caching", SOSP2017,(UCB: Ion Stocia team)
    - The throughput increases by 3-10 times. The query delay of 40% can be shortened by 50%.
    - https://www.cs.jhu.edu/~xinjin/files/SOSP17_NetCache.pdf
  - Xiaozhou Li etc," Be fast, cheap and in control with SwitchKV", (Princeton) NSDI'2016,
    - Increases the throughput by 5 times and improves the delay by 3 times.
    - https://dl.acm.org/citation.cfm?id=2930614

- **In network consensus**
  - Huynh Tu Dang etc, "Paxos Made Switch-y" , sigcomm CCR 2016,(Marco Canini team)
    - www.sigcomm.org/sites/default/files/ccr/papers/2016/April/0000000-0000002.pdf
  - Zsolt István etc," consensus in a box", NSDI 2016,
    - https://dl.acm.org/citation.cfm?id=2930639
  - Dan R. K. Ports etc, "Designing Distributed Systems Using Approximate Synchrony in Data Center Networks", (University of Washington)NSDI 2015.
    - https://www.usenix.org/system/files/conference/nsdi15/nsdi15-paper-ports.pdf
  - Jialin Li etc, "Eris: Coordination-Free Consistent Transactions Using In-Network Concurrency Control",(University of Washington) SOSP 2017.
    - https://syslab.cs.washington.edu/papers/eris-sosp17.pdf

Looks Promising? But…

- **Adding "X" functions into network violates "end-to-end argument"**
  - be cautious to add new functions if they are not used by majority of applications
  - Impact the TCP transport, security and privacy...

- **Or, maybe we can**
  - avoid to develop ad hoc solutions
  - develop new abstraction of data plane and new architecture to make full use of new programmable networks
  - Meanwhile, these capabilities are generic enough and decoupled from specific applications
  - Trial it firstly in constrained area of networks like DCN

Also keep in mind…

- **Existing programmable network devices were designed for forwarding, so limited for "X" functions**
  - the size of cache table
  - the number of bytes that the devices can manipulate on each packet
  - floating points
  - etc...

- **Probably a good research topic**
  - jump out from the off-shelf devices
  - find out the "sweet spot" between the pain(extra cost) and the gain
  - provide requirements for next generation of programmable devices
  - etc …

Any comments are welcomed.

For further discussion/ comments

chenlijuan5@Huawei.com