Distributed Learning over Unreliable Networks

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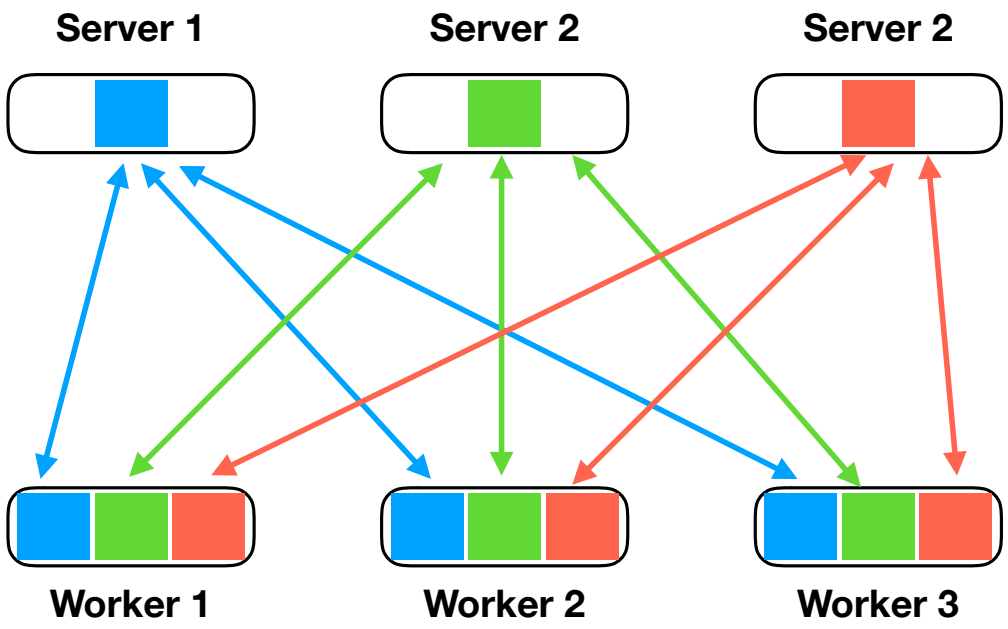
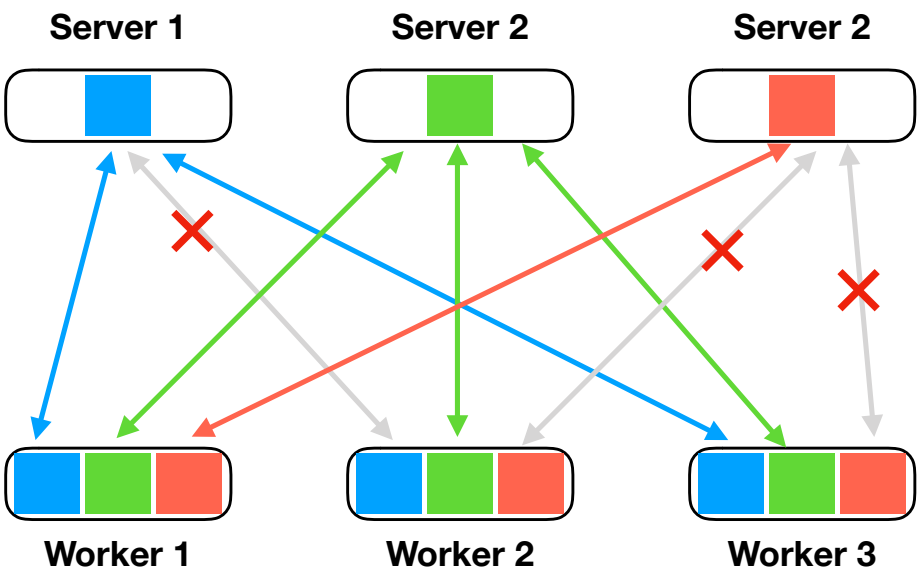
AllReduce SGD

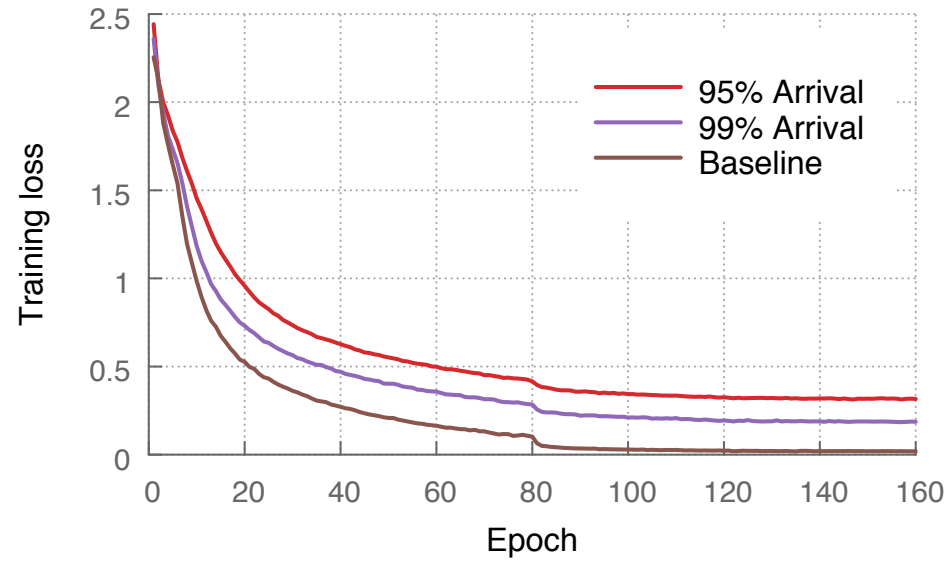


$$x_{t+1} = x_t - \boxed{\frac{1}{n}\sum_{i=1}^{n}} \nabla F(x_t; \xi_t^{(i)})$$

AllReduce

Unreliable Network





Sharing Gradients Won't Work

Reliable Parameter Server (RPS)

High Level: Share Models

Local Partition:

$$v_t^{(i)} = x_t^{(i)} - \gamma g_t^{(i)}, \quad v_t^{(i)} = \left(\left(v_t^{(i,1)}\right)^\top, \left(v_t^{(i,2)}\right)^\top, \cdots, \left(v_t^{(i,n)}\right)^\top \right)^\top.$$

Robust Averaging:

$$\tilde{v}_t^{(i)} = \frac{1}{|\mathcal{N}_t^{(i)}|} \sum_{j \in \mathcal{N}_t^{(j)}} v_t^{(i,j)}$$

Model Update:

$$x_{t+1}^{(i,j)} = \begin{cases} \tilde{v}_t^{(j)} & j \in \tilde{\mathcal{N}}_t^{(i)} \\ v_t^{(i,j)} & j \notin \tilde{\mathcal{N}}_t^{(i)} \end{cases}.$$

Convergence Rate

Assumptions:

$f(x)$ **Non Convex, with L-Lipschitz Gradient;**

$\mathbb{E}_{\xi\sim\mathcal{D}_i}\|\nabla F(x;\xi) - \nabla f_i(x)\|^2 \leq \sigma^2, \forall i, \forall x;$ **Bounded Data Variance**

$\frac{1}{n}\sum_{i=1}^{n} \left\| \nabla f_i(x) - \nabla f(x) \right\|^2 \leqslant \zeta^2, \quad \forall i, \forall x.$ **Bounded Dataset Difference**

T: Total Iterations

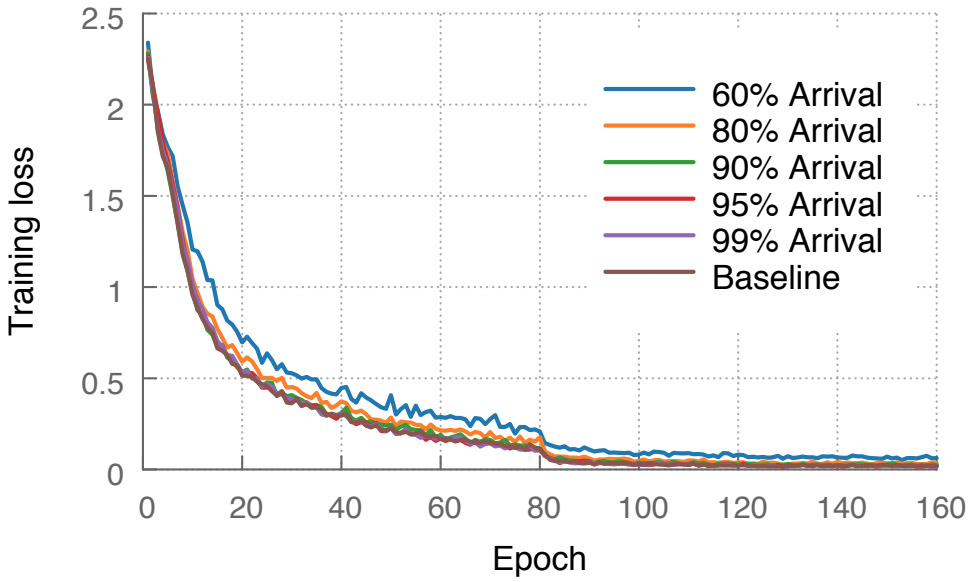
p: Package Dropping Rate

$$\frac{1}{T}\sum_{t=1}^{T}\mathbb{E}\left\| \nabla f(\overline{x}_t) \right\|^2 \lesssim \frac{(\sigma+\zeta)\left(1+\sqrt{p(1-p)}\right)}{(1-\sqrt{p})\sqrt{nT}} + \frac{1}{T}$$

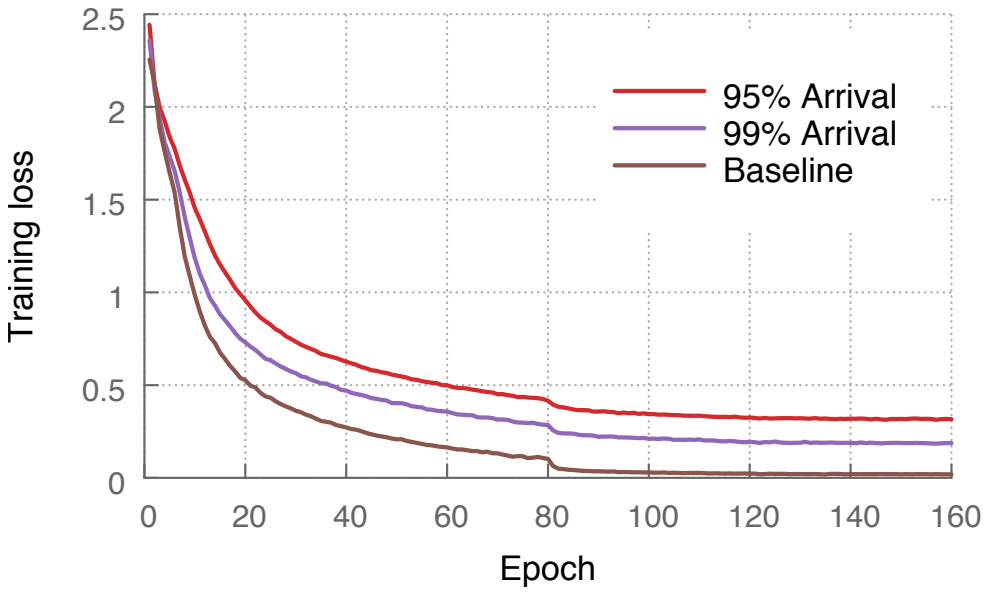
Experiments

16 NVIDIA TITAN Xp GPUs, ResNet-110 on CIFAR-10

RPS is **Robust**



Standard SGD is **Vulnerable**



Thanks

Welcome to Pacific Ballroom #97 to see the poster for more detail