ANNOUNCEMENTS

- MIDTERM NEXT WEEK

LOGISTICS
- IN-CLASS, DURING CLASS TIME
  (EMAIL ME ASAP IF YOU CANNOT MAKE IT FOR SOME REASON)
- OPEN-BOOK. BRING & REFER TO PAPERS, NOTES, ETC.
- DO NOT CHEAT... PLEASE

PARTICIPATION
- THANKS FOR ALL THE NOTES. THEY HAVE BEEN VERY INFORMATIVE
- VERY FEW SIMULATIONS, ETC. THOUGH
  HINT: IF SOMEONE WANTS TO LOOK AT SF VS SRTF VS SRSE FROM TIENAS TODAY ON SIMULATE TIENAS
Today's Plan

- Some General Terms & Ideas
  - Work Conservation
  - Gang Scheduling
  - Locality, Delay
  - Smallest First (SF), Shortest Remaining Time (SRTF), Smallest Remaining Service First (SRSSF)

- ML Training Jobs

- Scheduling Challenges/Scheduling

General Terms

Work Conservation
- Showed up in the Philly paper
- Pareto efficiency by another name
- Use as many resources as possible.

Gang Scheduling
Locality

Delay Scheduling

pthread -set affinity -nPC

JCT

Localities $E[SCT] = x$ $x \leq y$

$R_{OPT} \times E[SCT] = y$

$x = 1ms$

$y = 1ms$

Smallest Job First
Shortest Remaining Time First / Shortest Remaining Processing Time (SRPT)

Smallest Remaining Service First

SRPT

SETF

b \times c^2

Machine Learning Jobs

High Level Goal
- Focusing on Supervised Learning
- Training Data

\[ X: \begin{bmatrix} \vdots \end{bmatrix} \quad y: \begin{bmatrix} \vdots \end{bmatrix} \]

- Find program \( M \) such that

\[ \forall x \in \mathbb{R}^d \exists \varepsilon > 0 \quad \text{s.t. } \exists \gamma \in \mathbb{R} \quad \text{it generalizes} \]

- Recent Observations about Generalization

\[ \text{size, smoothness} \]

\[ \text{SGD \& the standard training loop} \]

\[ \lim_{\varepsilon \to 0} \frac{f(x + \varepsilon) - f(x)}{\varepsilon} \]

\[ \frac{df}{dx} \]

Compute Gradient (Direction & Magnitude of Change)

\[ M_{k+1}(x) \rightarrow \varepsilon \rightarrow M_k \]
Implementation

- Data Parallel

Parameter Server

Group Communication Primitives

All Reduce
Locality in ML Training

Gang Scheduling in ML Training

Why Focus on Job Completion Time (JCT) for ML?
Multi-Armed Bandits & Gittins Index

Gittins Index, measure of reward achieved through a stochastic process

In Timeslots \( \sup_{\Delta \in \mathcal{S}} \frac{P(\text{Job complete in } S_{\Delta})}{E(\text{Service required by job in } S_{\Delta})} \)

The Problem with Pre-emption
So, How Much Does Locality Really Matter?