UberShuffle: Faster Distributed Learning via Erasure Coded Data Shuffling

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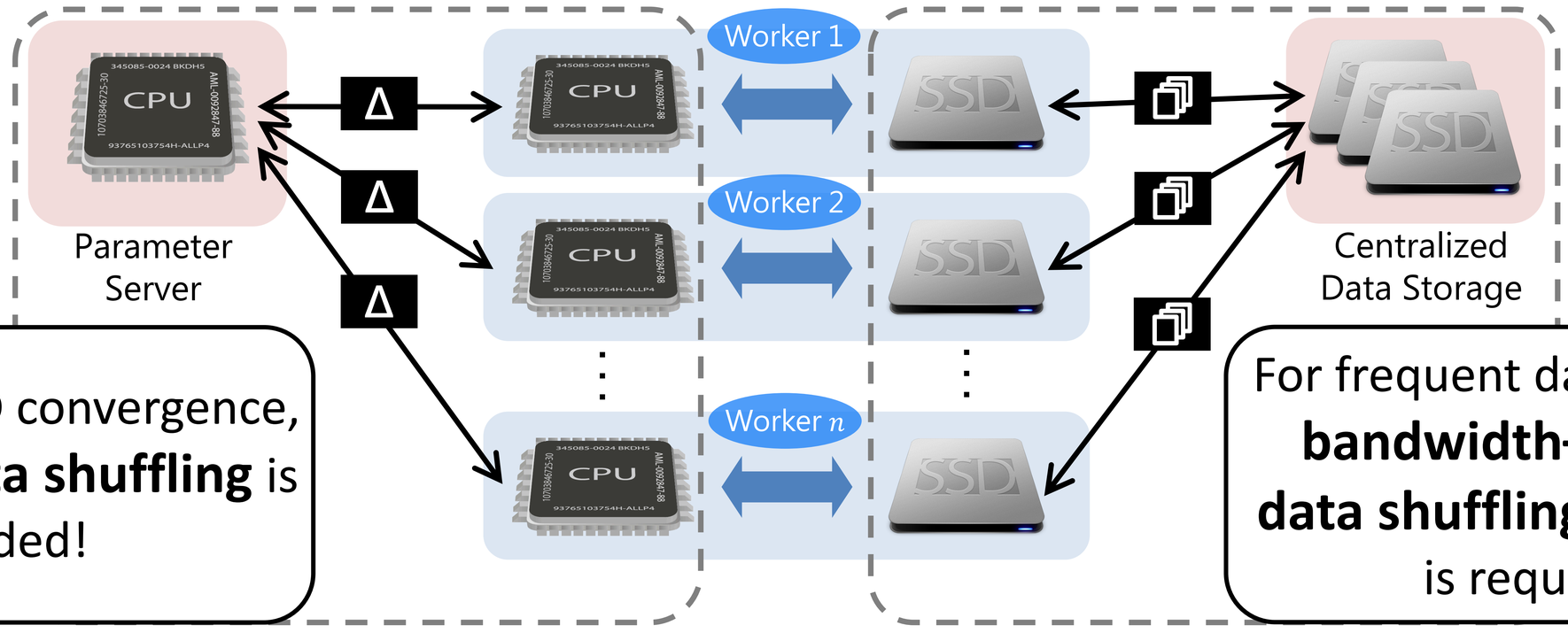
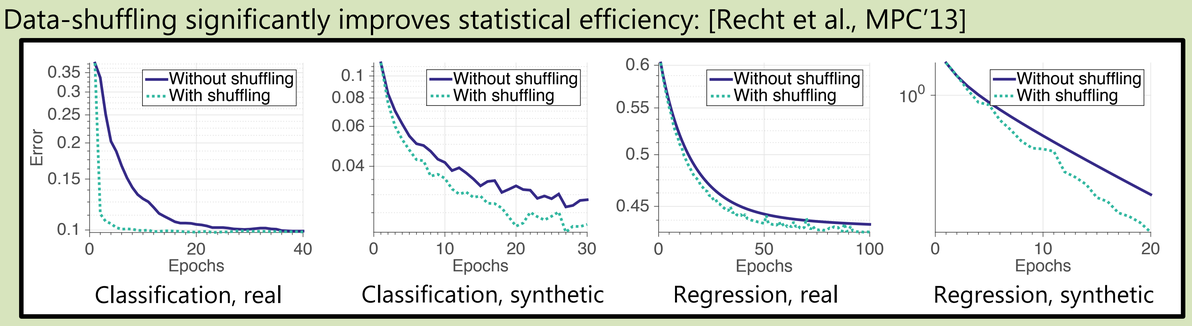


For faster SGD convergence, **frequent data shuffling** is needed!

For frequent data shuffling, **bandwidth–efficient data shuffling algorithm** is required!

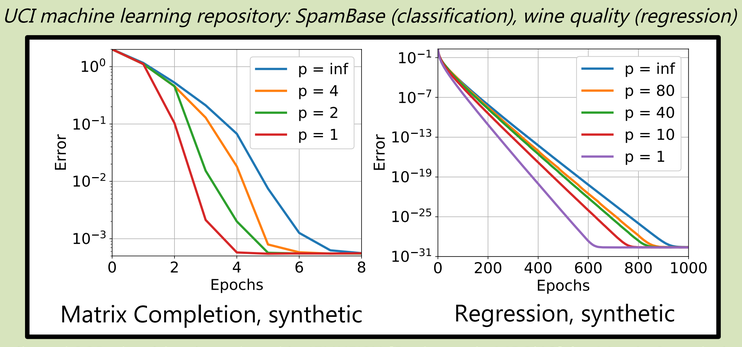
1. Data shuffling for statistical efficiency

Data-shuffling significantly improves statistical efficiency: [Recht et al., MPC'13]



UCI machine learning repository: SpamBase (classification), wine quality (regression)

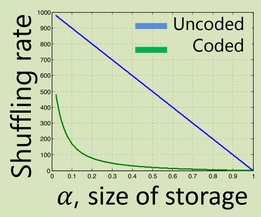
PSGD converges faster ***when data is shuffled more frequently.***



We use PSGD for Classification and Regression, and distributed SGD algorithm introduced in JELLYFISH [Recht et al., MPC'13] for Matrix Completion

2. Coded shuffling [1] Lee et al., NIPS MLSYS 2015, [2] Li et al., 2015

[1] Additional storage and **broadcast channel**
➔ Lower bandwidth for data shuffling!
([2] Additional computation ➔ Lower shuffle bandwidth for MR)

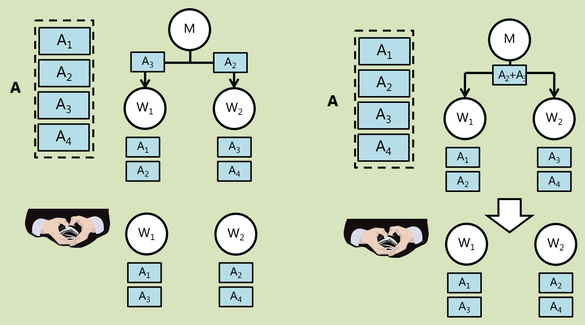


Theorem:
q = *the number of data points*
n = *the number of workers*
α = *the fraction of the data matrix that can be cached at each worker*
➔ *Coded shuffling achieves:*

$$R_c \to \frac{q(1-\alpha)}{\alpha n}$$

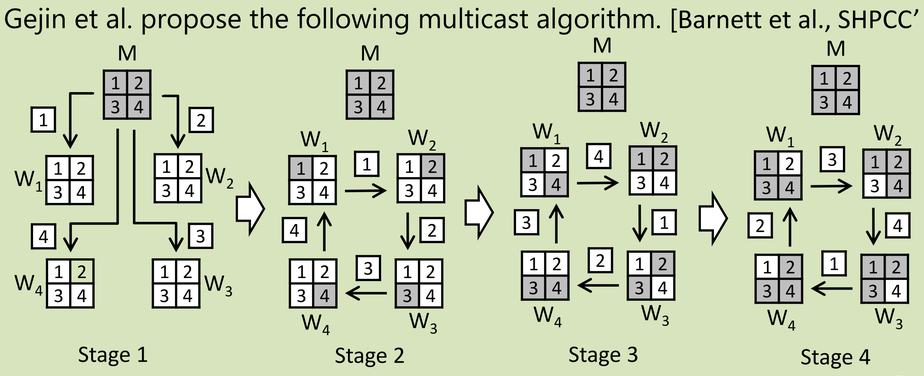
i.e., the coded shuffling can reduce the communication overhead by a factor of αn.

However, the theorem assumes:
(1) q grows to infinity
(2) perfect broadcast channel



3. Coded Shuffling for Multicast

Van de Gejin et al. propose the following multicast algorithm. [Barnett et al., SHPCC' 1994]



(For n= 4)

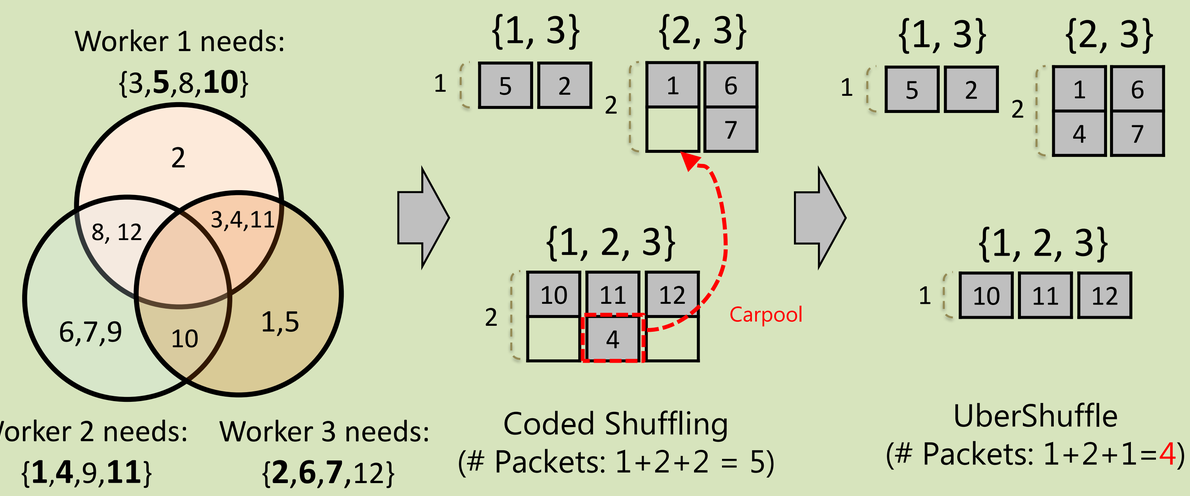
$$T_{multicast} = \left(\frac{2n-1}{n}\right) T_{unicast} \approx 2T_{unicast}$$

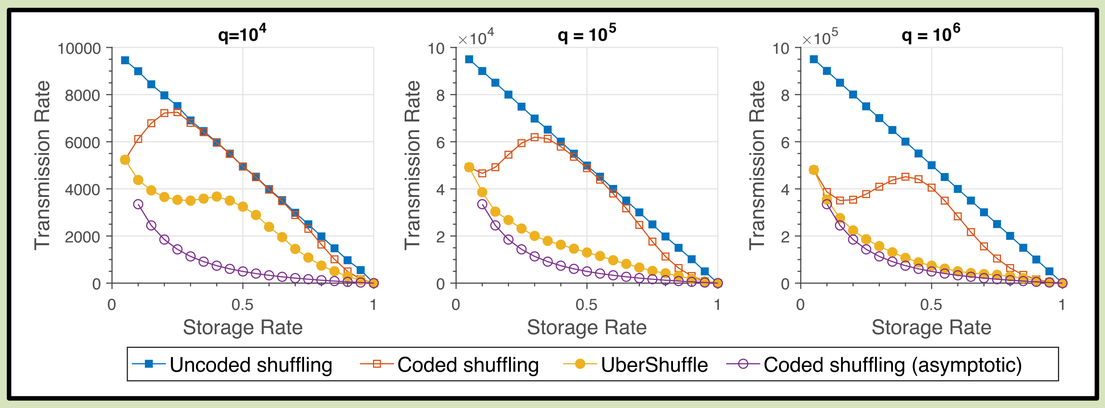
Hence, shuffling time of coded shuffling algorithm under multicast channel is:

$$T_{shuffle,multicast} \approx \frac{2q}{B}\left(\frac{1-\alpha}{\alpha n}\right) T_{unicast}$$

4. UberShuffle

Coded Shuffling's **strict asymptotic requirement** ➔ not optimal in practice!





➔ UberShuffle approaches the asymptotic result much faster!

5. Experimental Results

- Implemented using OpenMPI with C
- Runs Coded Shuffling / UberShuffle using **Multicast**
- EC2: 20 m3.xlarge workers + 1 m3.2xlarge master

Shuffling time: up to ***47.2%*** *↓*
Training time: up to ***32.1%*** *↓*