QUIC-FL: A Report

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CONTENTS

***Abstract*—This document is a report of the paper [1]. It summarizes the main contributions of the authors and analyzes the results obtained. This report also lists out possible future research in the area of Federated Learning (FL).**

1 PROBLEM STATEMENT

The authors of [1] consider the **Distributed Mean Estimation** problem, illustrated in Figure 1. Specifically, each client C_i sends data $\mathbf{x}_i$, quantized as $\mathbf{Y}_i \in \{0,1\}^b$, for $1 \leq i \leq n$. Here, b represents the number of bits used for quantization per client.

The server computes the estimates $\hat{\mathbf{X}}_i$ using the obtained $\mathbf{Y}_i$ as

$$\hat{\boldsymbol{\mu}} \triangleq \frac{1}{n}\sum_{i=1}^{n} \hat{\mathbf{X}}_i. \tag{1}$$

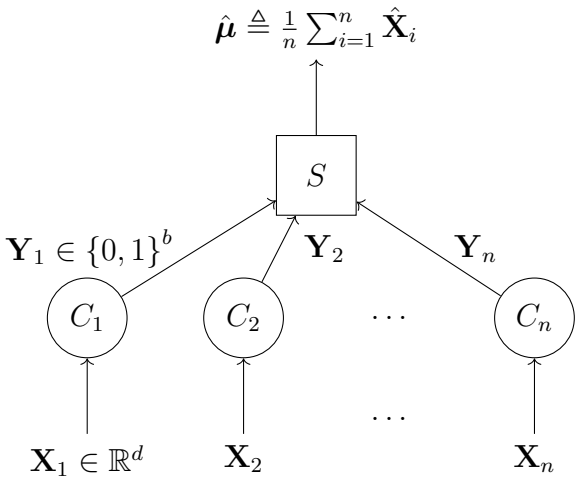

Fig. 1. An Illustration of the DME Problem.

The aim of the DME problem is to estimate the true mean $\boldsymbol{\mu} \triangleq \frac{1}{n}\sum_{i=1}^{n} \mathbf{X}_i$ using $\hat{\boldsymbol{\mu}}$ as defined in (1) with *minimal error* (see section 3.1).

2 GOALS OF THE PAPER

The goals of [1] are to develop a quantization scheme that, compared to other state-of-the-art methods (see section 7.1 for a list of such methods).

1) Less computational complexity compared to other methods, at *both* client and server.
2) Same (asymptotic) NMSE of $\mathcal{O}\left(\frac{1}{n}\right)$.
3) Same convergence rate.
4) Better compression ratio.

3 PRELIMINARIES

3.1 vNMSE and NMSE

The main performance metric used to assess a quantization scheme is the *squared error* of the estimated mean from the actual mean. To perform such an assessment, the authors define two quantities that will be useful.

Definition 1 (vNMSE)**.** *The* vector Normalized Mean Square Error *of* $\mathbf{x}$ *is defined as*

$$vNMSE \triangleq \frac{\mathbb{E}\left[\|\hat{\mathbf{x}}-\mathbf{x}\|_2^2\right]}{\|\mathbf{x}\|_2^2}. \tag{2}$$

Definition 2 (NMSE)**.** *The* Normalized Mean Square Error *in the case of the DME problem is defined as*

$$NMSE \triangleq \frac{\mathbb{E}\left[\|\hat{\boldsymbol{\mu}}-\boldsymbol{\mu}\|_2^2\right]}{\frac{1}{n}\sum_{i=1}^n \|\mathbf{x}_i\|_2^2} = \frac{\mathbb{E}\left[\left\|\hat{\boldsymbol{\mu}}-\frac{1}{n}\sum_{i=1}^n \mathbf{x}_i\right\|_2^2\right]}{\frac{1}{n}\sum_{i=1}^n \|\mathbf{x}_i\|_2^2}. \tag{3}$$

From 1 and 2, we can perform simple algebraic manipulations to obtain the following result.

Lemma 3.1.

Proof. □

References

[1] R. B. Basat, S. Vargaftik, A. Portnoy, G. Einziger, Y. Ben-Itzhak, and M. Mitzenmacher, "QUIC-FL: Quick unbiased compression for federated learning," 2023.