Nhat Huy Le

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1 Methodology

1.1 Data Collection and Processing

For each federated aggregation method (e.g., FedAvg, FedProx, FedDyn, SCAFFOLD, MOON, FedGen, FedNTD), we run experiments over 13 rounds. In each round we record:

- **RMSE** (Root Mean Squared Error)

- **MAE** (Mean Absolute Error)

- R^2 (Coefficient of Determination)

This data is recorded per method as:

```
MethodName
Version, RMSE, MAE, R2, Timestamp
... (13 rounds)
```

1.2 Normalization and Adjustment of Metrics

RMSE and MAE: For each method, RMSE and MAE are normalized using min–max normalization:

$$\text{NormRMSE}_i = \frac{\text{RMSE}_i - \min_j \text{RMSE}_j}{\max_j \text{RMSE}_j - \min_j \text{RMSE}_j}, \quad \text{NormMAE}_i = \frac{\text{MAE}_i - \min_j \text{MAE}_j}{\max_j \text{MAE}_j - \min_j \text{MAE}_j}.$$

R^2 **Adjustment:** Since our R^2 values are negative, we first shift them so that the minimum R^2 for a method becomes zero:

$$R^2_{\text{shifted},i} = R^2_i - \min_j R^2_j.$$

Then we normalize the shifted values:

$$\text{Norm}R^2_i = \frac{R^2_{\text{shifted},i}}{\max_j R^2_{\text{shifted},j}}.$$

To integrate R^2 into our composite metric (since higher R^2 is better, but errors should be minimized), we define:

$$\text{R2Loss}_i = 1 - \text{Norm}R^2_i.$$

1.3 Composite Metric Calculation

The composite metric is defined as a weighted sum of the normalized metrics:

$$\text{Composite}_i = w_1 \cdot \text{NormRMSE}_i + w_2 \cdot \text{NormMAE}_i + w_3 \cdot \text{R2Loss}_i,$$

where w_1, w_2, and w_3 are weights chosen based on the importance assigned to RMSE, MAE, and R^2 respectively (e.g., $w_1 = w_2 = w_3 = \frac{1}{3}$). This composite score is computed for each of the 13 rounds per method.