Bảng kết quả (%) của mô hình huấn luyện tập trung và phân tán (FedAvg, dữ liệu IID) trên MNIST và CIFAR-10

| | | $acc_{micro}$ | $acc_{macro}$ | $P_{macro}$ | $R_{macro}$ | $F1_{macro}$ |
|---|---|---|---|---|---|---|
| MNIST | Centralized | **97.07** | - | **97.04** | **97.03** | **97.04** |
| | FedAvg (IID) | 90.36 | 90.34±2.24 | 90.37±2.29 | 90.25±2.22 | 90.12±2.29 |
| CIFAR-10 | Centralized | **61.91** | - | **61.7** | **62.01** | **61.72** |
| | FedAvg (IID) | 53.83 | 53.83±3.14 | 53.46±3.19 | 53.85±3.26 | 53±3.21 |

Bảng kết quả (%) trên người dùng cục bộ của tập dữ liệu MNIST

| | $acc_{micro}$ | $acc_{macro}$ | $P_{macro}$ | $R_{macro}$ | $F1_{macro}$ |
|---|---|---|---|---|---|
| FedAvg | 85.03 | 82.14±14.76 | 82.03±13.88 | 81.54±14.33 | 79.43±16.83 |
| FedPer | 77.29 | 75.48±14.84 | 76.07±14.99 | 74.01±15.13 | 72.32±15.99 |
| FedAvgMeta | 84.84 | 81.56±16.68 | 80.71±17.02 | 81.18±16.16 | 78.31±19.8 |
| FedPerMeta | 75.91 | 74.11±16.2 | 75.68±15.94 | 72.93±15.58 | 71.22±16.77 |
| FedMeta(MAML) | 92.99 | 91.14±5.99 | 90.56±6.24 | 90.98±5.9 | 90.16±6.28 |
| FedMeta(Meta-SGD) | 98.02 | 96.35±4.62 | 96.49±4.1 | 95.64±5.94 | 95.80±5.51 |
| **FedMeta-Per(MAML)** | **99.37** | **99.12±1.29** | **99.11±1.3** | **98.82±1.99** | **98.94±1.6** |
| **FedMeta-Per(Meta-SGD)** | 98.92 | 98.15±3.32 | 98.42±1.95 | 98.42±1.96 | 98.20±2.94 |

Bảng kết quả (%) trên người dùng mới của tập dữ liệu MNIST

| | $acc_{micro}$ | $acc_{macro}$ | $P_{macro}$ | $R_{macro}$ | $F1_{macro}$ |
|---|---|---|---|---|---|
| FedAvg | 83.92 | 81.69±19.71 | 79.57±20.18 | 80.46±17.84 | 77.66±22.54 |
| FedPer | 78.3 | 76.19±18.79 | 75.91±17.52 | 74.73±17.32 | 72.72±19.3 |
| FedAvgMeta | 84.34 | 82.37±17.42 | 81.38±16.25 | 80.91±15.62 | 78.78±19.31 |
| FedPerMeta | 77.47 | 75.56±20.33 | 75.09±19.52 | 74.92±18.85 | 72.60±21.37 |
| FedMeta(MAML) | 92.96 | 91.88±5.88 | 90.14±7.97 | 90.74±5.95 | 90.02±7.34 |
| FedMeta(Meta-SGD) | 96.39 | 93.53±8.39 | 93.73±10.26 | 88.65±14.06 | 89.31±14.56 |
| **FedMeta-Per(MAML)** | 93.6 | 93.57±5.58 | 93.64±5.56 | 90.98±6.98 | 91.83±6.43 |
| **FedMeta-Per(Meta-SGD)** | **96.62** | **95.88±3.58** | **95.73±4.11** | **94.34±5.05** | **94.85±4.61** |

## Bảng kết quả (%) trên người dùng cục bộ của tập dữ liệu CIFAR-10

| | $acc_{micro}$ | $acc_{macro}$ | $P_{macro}$ | $R_{macro}$ | $F1_{macro}$ |
|---|---|---|---|---|---|
| FedAvg | 19.02 | 19.29±25.11 | 15.57±23.7 | 20.65±25.55 | 16.85±23.92 |
| FedPer | 13.22 | 12.99±19.39 | 18.34±28.59 | 14.14±20.83 | 10.52±14.91 |
| FedAvgMeta | 40.3 | 38.47±31.52 | 32.84±32.06 | 39.33±30.35 | 33.81±30.61 |
| FedPerMeta | 18.57 | 17.48±22.55 | 20.02±27.4 | 18.43±23.47 | 14.54±18.67 |
| FedMeta(MAML) | 69.02 | 68.76±14.86 | 67.42±21.16 | 66.56±13.48 | 61.14±20 |
| FedMeta(Meta-SGD) | 78.63 | 78.73±11.59 | 74.65±21.12 | 75.25±14.09 | 72.87±18.31 |
| **FedMeta-Per(MAML)** | **86.6** | **86.52±6.31** | **86.43±5.88** | **85.47±6.87** | **85.33±6.77** |
| **FedMeta-Per(Meta-SGD)** | 85.61 | 85.68±7.22 | 86.26±6.35 | 85.36±6.83 | 85.08±7.32 |

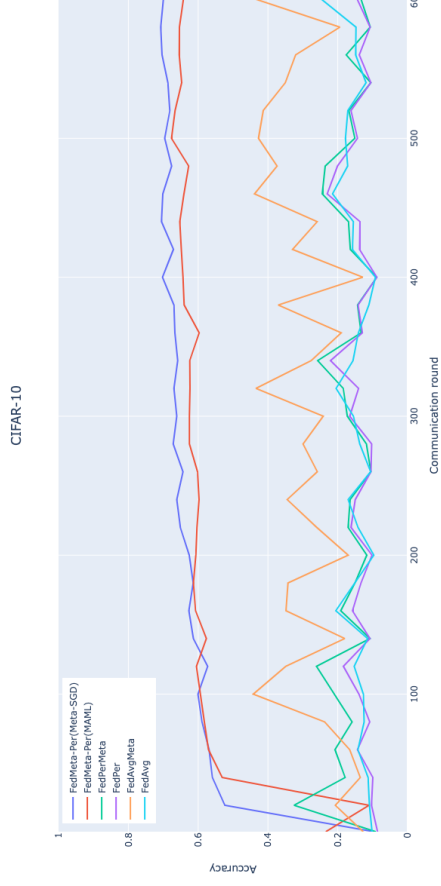## Bảng kết quả (%) trên người dùng mới của tập dữ liệu CIFAR-10

| | $acc_{micro}$ | $acc_{macro}$ | $P_{macro}$ | $R_{macro}$ | $F1_{macro}$ |
|---|---|---|---|---|---|
| FedAvg | 24.63 | 24.83±22.57 | 18.36±20.15 | 24.44±21.95 | 20.52±20.45 |
| FedPer | 14.4 | 14.52±20.15 | 12.59±20.65 | 14.23±19.58 | 10.66±13.79 |
| FedAvgMeta | 43.39 | 43.54±18 | 33.45±21.44 | 42.87±16.98 | 35.14±17.22 |
| FedPerMeta | 13.33 | 13.57±19.62 | 11.99±19.52 | 13.53±19.08 | 10.05±13.17 |
| FedMeta(MAML) | 61.69 | 61.64±12.49 | 52.66±26.06 | 59.94±12.35 | 50.76±19.2 |
| FedMeta(Meta-SGD) | 68.36 | 67.89±15.11 | **70.3±22.37** | 66.86±15.02 | 60.24±21.52 |
| **FedMeta-Per(MAML)** | 64.22 | 63.70±12.29 | 57.06±24.99 | 61.63±12.66 | 53.68±19.06 |
| **FedMeta-Per(Meta-SGD)** | **69.97** | **69.13±14.63** | 66.53±24.91 | **67.82±15.34** | **62.42±20.94** |

Bảng 1: Bảng kết quả (%) trên tập dữ liệu CIFAR-10

| | | $acc_{micro}$ | $acc_{macro}$ | $P_{macro}$ | $R_{macro}$ | $F1_{macro}$ |
|---|---|---|---|---|---|---|
| local client | FedAvg | 19.02 | 19.29±25.11 | 15.57±23.7 | 20.65±25.55 | 16.85±23.92 |
| | FedPer | 13.22 | 12.99±19.39 | 18.34±28.59 | 14.14±20.83 | 10.52±14.91 |
| | FedAvgMeta | 40.3 | 38.47±31.52 | 32.84±32.06 | 39.33±30.35 | 33.81±30.61 |
| | FedPerMeta | 18.57 | 17.48±22.55 | 20.02±27.4 | 18.43±23.47 | 14.54±18.67 |
| | FedMeta(MAML) | 69.02 | 68.76±14.86 | 67.42±21.16 | 66.56±13.48 | 61.14±20 |
| | FedMeta(Meta-SGD) | 78.63 | 78.73±11.59 | 74.65±21.12 | 75.25±14.09 | 72.87±18.31 |
| | **FedMeta-Per(MAML)** | **86.6** | **86.52±6.31** | **86.43±5.88** | **85.47±6.87** | **85.33±6.77** |
| | **FedMeta-Per(Meta-SGD)** | 85.61 | 85.68±7.22 | 86.26±6.35 | 85.36±6.83 | 85.08±7.32 |
| new client | FedAvg | 24.63 | 24.83±22.57 | 18.36±20.15 | 24.44±21.95 | 20.52±20.45 |
| | FedPer | 14.4 | 14.52±20.15 | 12.59±20.65 | 14.23±19.58 | 10.66±13.79 |
| | FedAvgMeta | 43.39 | 43.54±18 | 33.45±21.44 | 42.87±16.98 | 35.14±17.22 |
| | FedPerMeta | 13.33 | 13.57±19.62 | 11.99±19.52 | 13.53±19.08 | 10.05±13.17 |
| | FedMeta(MAML) | 61.69 | 61.64±12.49 | 52.66±26.06 | 59.94±12.35 | 50.76±19.2 |
| | FedMeta(Meta-SGD) | 68.36 | 67.89±15.11 | **70.3±22.37** | 66.86±15.02 | 60.24±21.52 |
| | **FedMeta-Per(MAML)** | 64.22 | 63.70±12.29 | 57.06±24.99 | 61.63±12.66 | 53.68±19.06 |
| | **FedMeta-Per(Meta-SGD)** | **69.97** | **69.13±14.63** | 66.53±24.91 | **67.82±15.34** | **62.42±20.94** |

Bảng 2: Bảng kết quả (%) trên tập dữ liệu MNIST

| | | $acc_{micro}$ | $acc_{macro}$ | $P_{macro}$ | $R_{macro}$ | $F1_{macro}$ |
|---|---|---|---|---|---|---|
| local client | FedAvg | 85.03 | 82.14±14.76 | 82.03±13.88 | 81.54±14.33 | 79.43±16.83 |
| | FedPer | 77.29 | 75.48±14.84 | 76.07±14.99 | 74.01±15.13 | 72.32±15.99 |
| | FedAvgMeta | 84.84 | 81.56±16.68 | 80.71±17.02 | 81.18±16.16 | 78.31±19.8 |
| | FedPerMeta | 75.91 | 74.11±16.2 | 75.68±15.94 | 72.93±15.58 | 71.22±16.77 |
| | FedMeta(MAML) | 92.99 | 91.14±5.99 | 90.56±6.24 | 90.98±5.9 | 90.16±6.28 |
| | FedMeta(Meta-SGD) | 98.02 | 96.35±4.62 | 96.49±4.1 | 95.64±5.94 | 95.80±5.51 |
| | **FedMeta-Per(MAML)** | **99.37** | **99.12±1.29** | **99.11±1.3** | **98.82±1.99** | **98.94±1.6** |
| | **FedMeta-Per(Meta-SGD)** | 98.92 | 98.15±3.32 | 98.42±1.95 | 98.42±1.96 | 98.20±2.94 |
| new client | FedAvg | 83.92 | 81.69±19.71 | 79.57±20.18 | 80.46±17.84 | 77.66±22.54 |
| | FedPer | 78.3 | 76.19±18.79 | 75.91±17.52 | 74.73±17.32 | 72.72±19.3 |
| | FedAvgMeta | 84.34 | 82.37±17.42 | 81.38±16.25 | 80.91±15.62 | 78.78±19.31 |
| | FedPerMeta | 77.47 | 75.56±20.33 | 75.09±19.52 | 74.92±18.85 | 72.60±21.37 |
| | FedMeta(MAML) | 92.96 | 91.88±5.88 | 90.14±7.97 | 90.74±5.95 | 90.02±7.34 |
| | FedMeta(Meta-SGD) | 96.39 | 93.53±8.39 | 93.73±10.26 | 88.65±14.06 | 89.31±14.56 |
| | **FedMeta-Per(MAML)** | 93.6 | 93.57±5.58 | 93.64±5.56 | 90.98±6.98 | 91.83±6.43 |
| | **FedMeta-Per(Meta-SGD)** | **96.62** | **95.88±3.58** | **95.73±4.11** | **94.34±5.05** | **94.85±4.61** |

(a) CIFAR-10, new clients
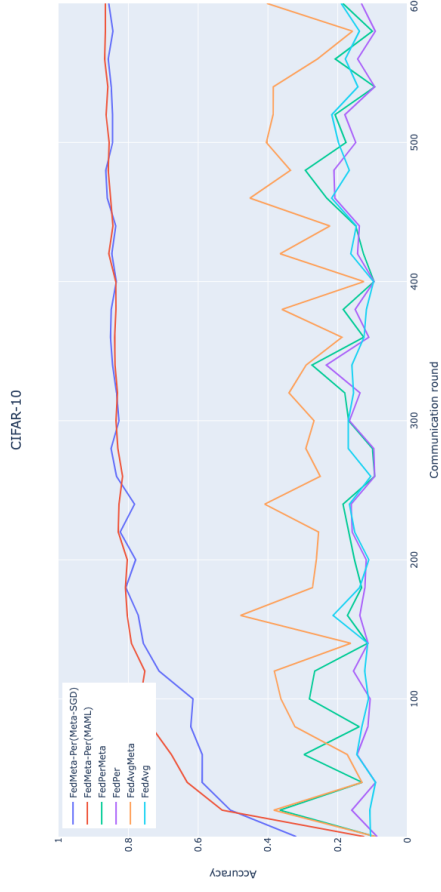
(b) CIFAR-10, local clients
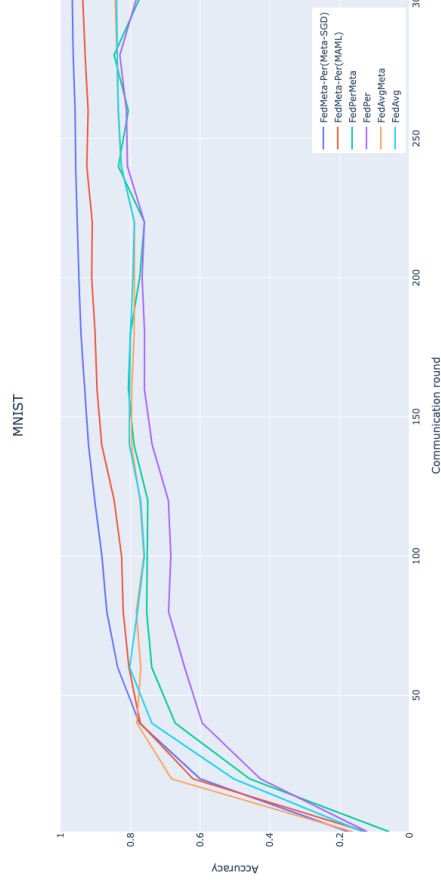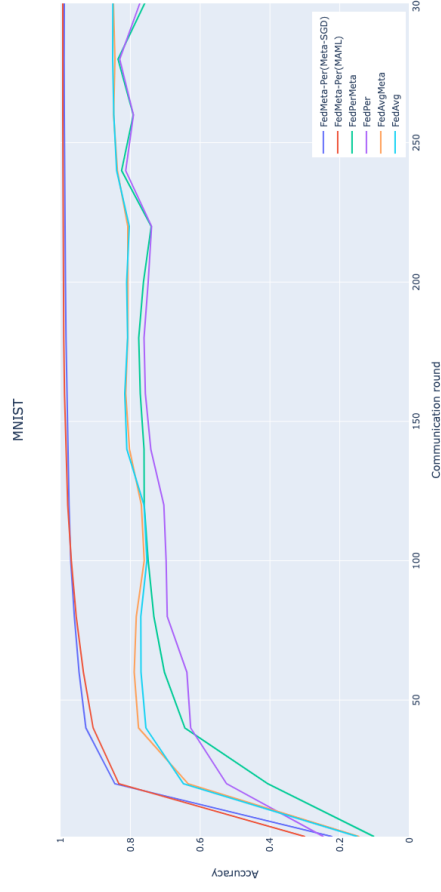
(c) MNIST, new clients

(d) MNIST, local clients
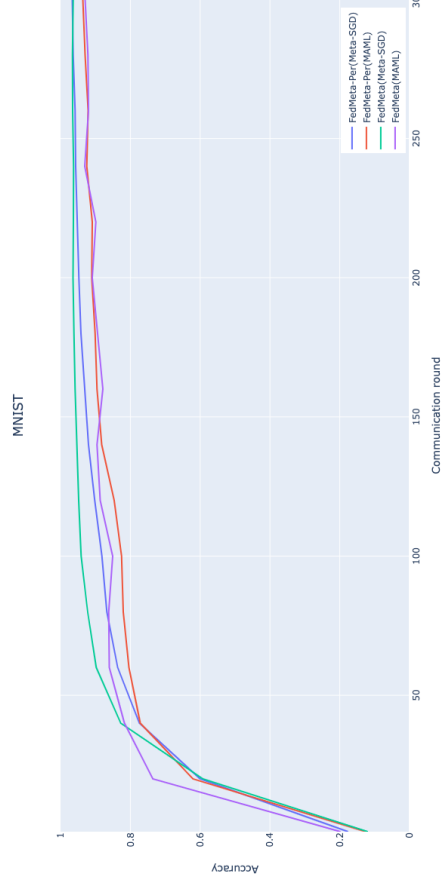
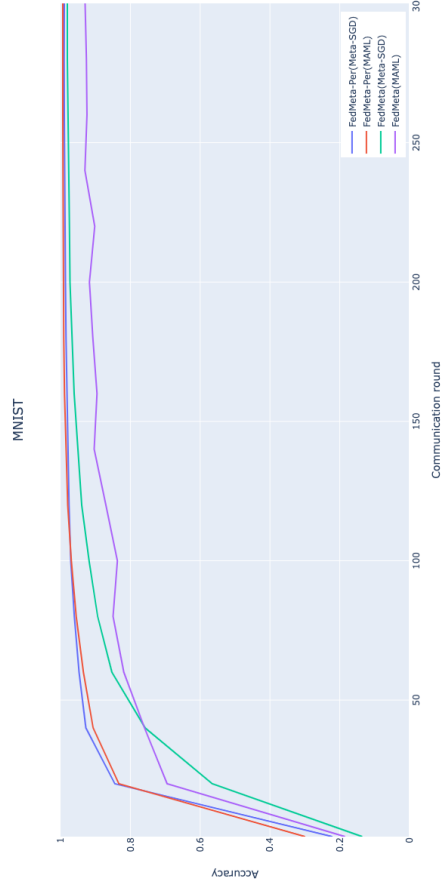FedMeta-Per vs. (FedAvg, FedAvgMeta, FedPer, FedPerMeta)

(a) CIFAR-10, new clients

(b) CIFAR-10, local clients

(c) MNIST, new clients

(d) MNIST, local clients

FedMeta-Per vs. FedMeta

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