INTRODUCTION

**Harmony** is a heterogeneity-aware hierarchical coordination framework for high-performance Federated Learning. It effectively directs the training process to make it proceed in harmony through intelligently mediating the conflict caused by the heterogeneity in the following four folds:

- The static system heterogeneity caused by different hardware configurations;
- The dynamic system heterogeneity caused by resource contention at runtime;
- The data heterogeneity in each local device;
- The data heterogeneity in each global training round.

Q1: How is the system efficiency affected by the device type (static system heterogeneity) and the concurrently running foreground apps (dynamic system heterogeneity)?

Q2: How is the statistical efficiency affected by the local data distribution (local data heterogeneity) of each participating device?

Q3: How is the statistical efficiency affected by the global data distribution (global data heterogeneity) of the overall training data?

**System Overview**

① All the mobile devices participate in the first training round and complete local training.
② Local coordinator sends the following information to the central server.
③ Global coordinator well estimates the data distribution and predicts the runtime training capability.
④ Global coordinator intelligently selects the participating devices by jointly considering the homogeneity of the local training data and runtime training capability. Moreover, global coordinator fine-tunes the distribution of the overall training data.
⑤ Global coordinator broadcasts the coordination result to the corresponding selected devices.
⑥ Local coordinator then conducts the local training process based on the coordination result.
⑦ Local coordinator monitors real-time status and data.

**Evaluation**

Data distribution within the selected devices of different schemes (left column), and the overall data distribution (right column).

**Conclusion**

Harmony intelligently balances the model performance and training progress in a highly dynamic and heterogeneous training environment from two perspectives. The experiment results show that Harmony improves the model performance up to 27.62%, effectively accelerates the training speed by up to 3.29 ×, and achieves energy-saving up to 88.41%.