UNIVERSITY OF CAMBRIDGE

http://mlsys.cst.cam.ac.uk

Flower Practicals

Federated Learning

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v1.0

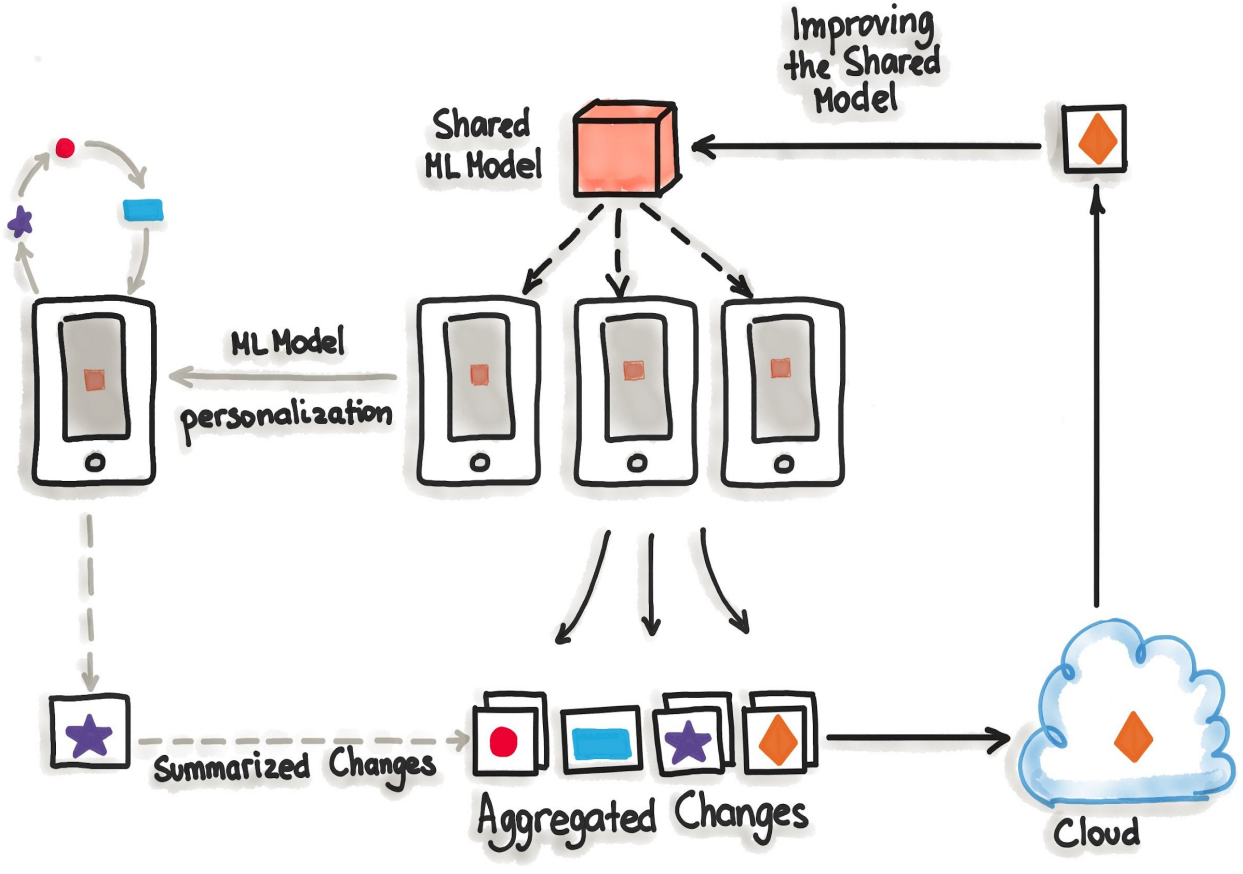
Today

- Centralised to Federated
- Strategies
- Heterogeneous Datasets

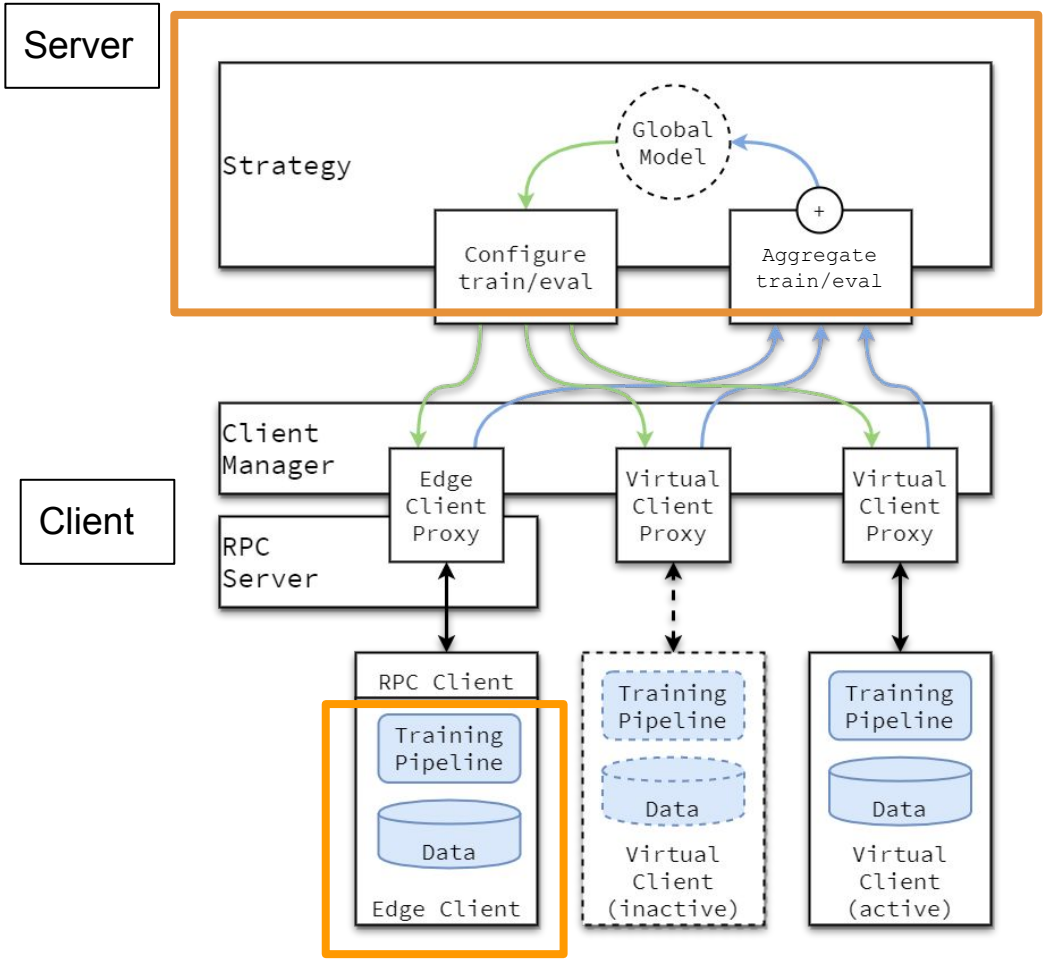
Code: https://github.com/pedropgusmao/fl_tutorials

1. Centralised to Federated

Federated Learning



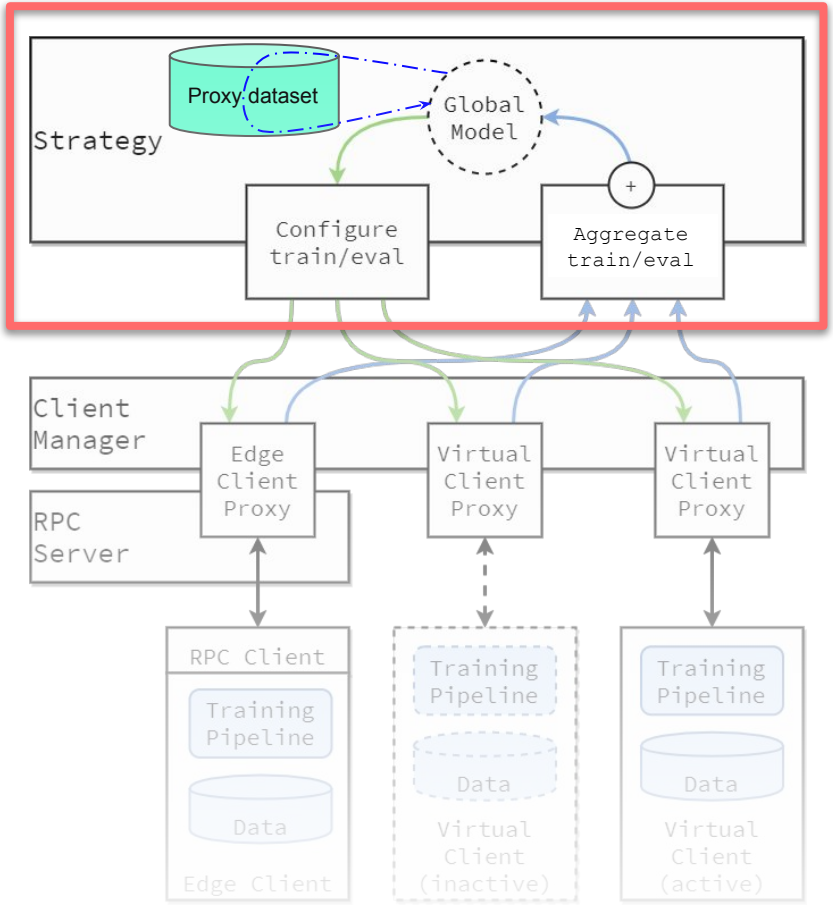
Federated Learning



2. Strategies

What can we use the Strategy for ?

- Customise **configuration** of the federated train/eval step
- Implement **new** aggregation **algorithms**
- Add a **“centralised” evaluation step** on the server
- Access and aggregate **metrics** from both train and eval federated steps



FedAvg with server learning rate

Algorithm 1 `FederatedAveraging`. The K clients are indexed by k; B is the local minibatch size, E is the number of local epochs, and η is the learning rate.

Server executes:

initialize w_0

for each round $t = 1, 2, \dots$ **do**

  $m \leftarrow \max(C \cdot K, 1)$

  $S_t \leftarrow$ (random set of m clients)

  for each client $k \in S_t$ **in parallel do**

    $w_{t+1}^k \leftarrow \text{ClientUpdate}(k, w_t)$

  $m_t \leftarrow \sum_{k \in S_t} n_k$

  $w_{t+1} \leftarrow \sum_{k \in S_t} \frac{n_k}{m_t} w_{t+1}^k$

ClientUpdate(k, w): *// Run on client k*

  $\mathcal{B} \leftarrow$ (split $\mathcal{P}_k$ into batches of size B)

  for each local epoch i from 1 to E **do**

    for batch $b \in \mathcal{B}$ **do**

      $w \leftarrow w - \eta \nabla \ell(w; b)$

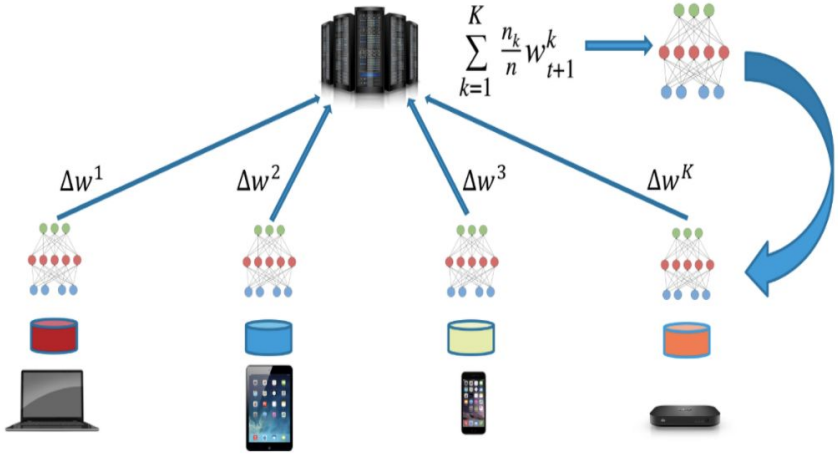
  return w to server

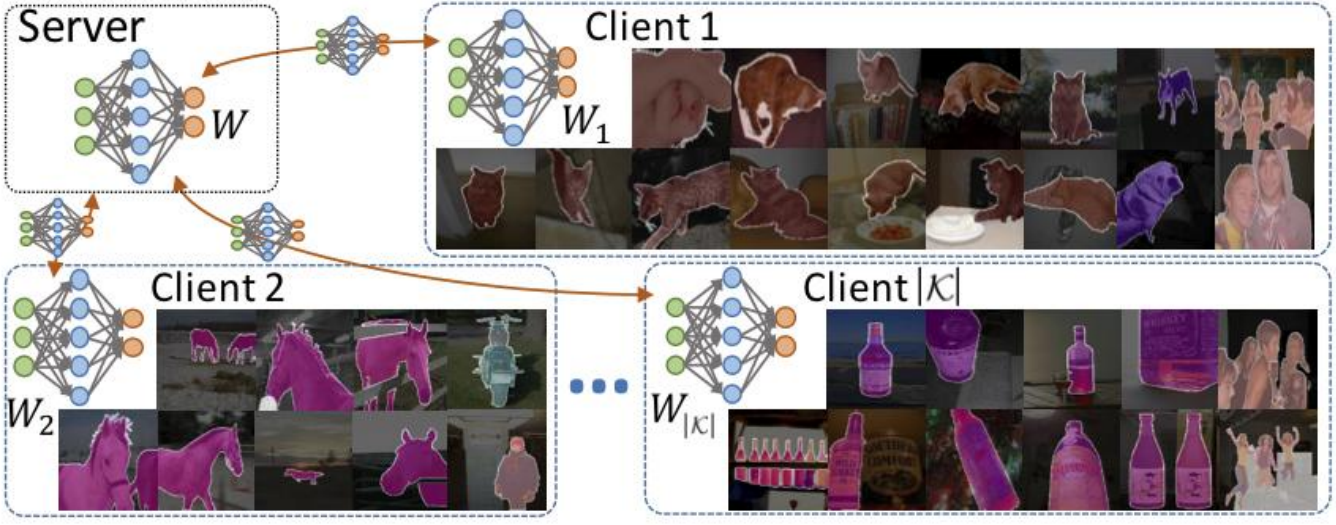
$$w_{t+1} \leftarrow \eta \sum_{k \in S_t} \frac{n_k}{m_t} g_k$$

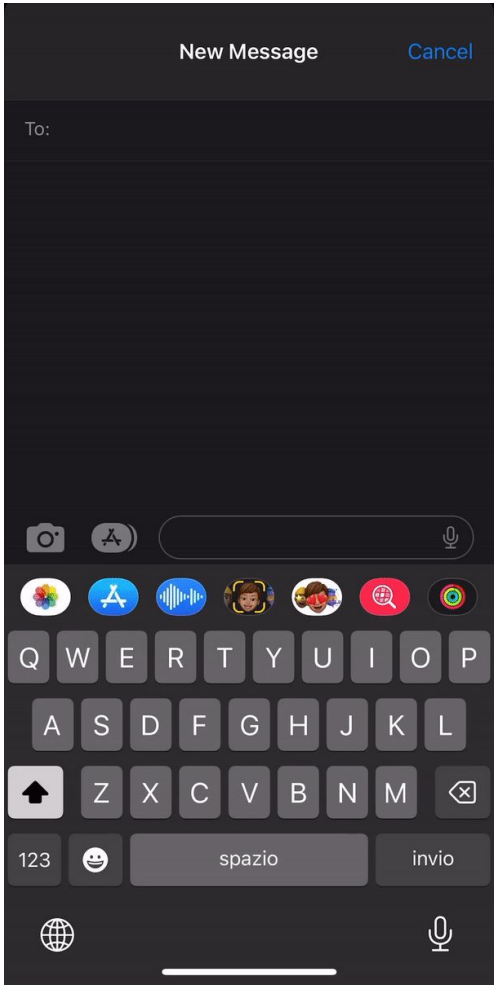
FedAdagrad
FedYogi
FedAdam

3. Heterogeneous Data

An intrinsic feature of FL: data heterogeneity





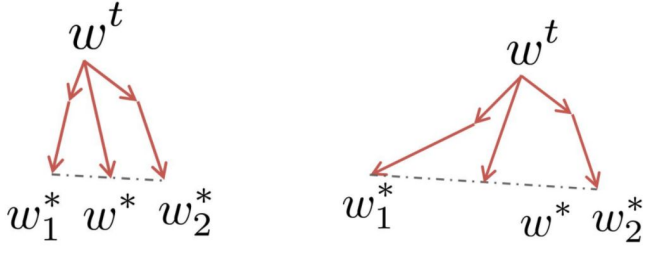


FedProx: Simple Modification to FedAvg

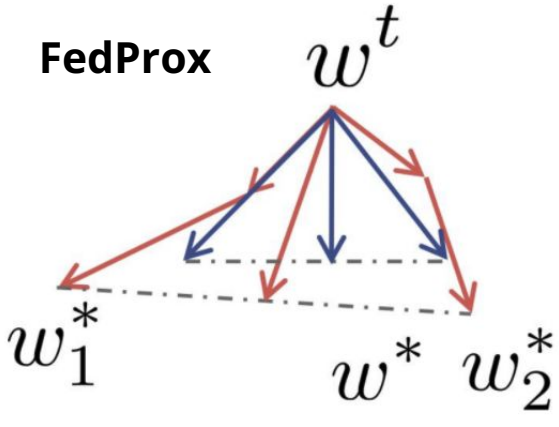
$$\min_{w_k} F_k(w_k) + \underbrace{\frac{\mu}{2} \left\| w_k - w^t \right\|^2}_{\text{proximal term}}$$

- proximal term *limits the impact of heterogeneous local updates*

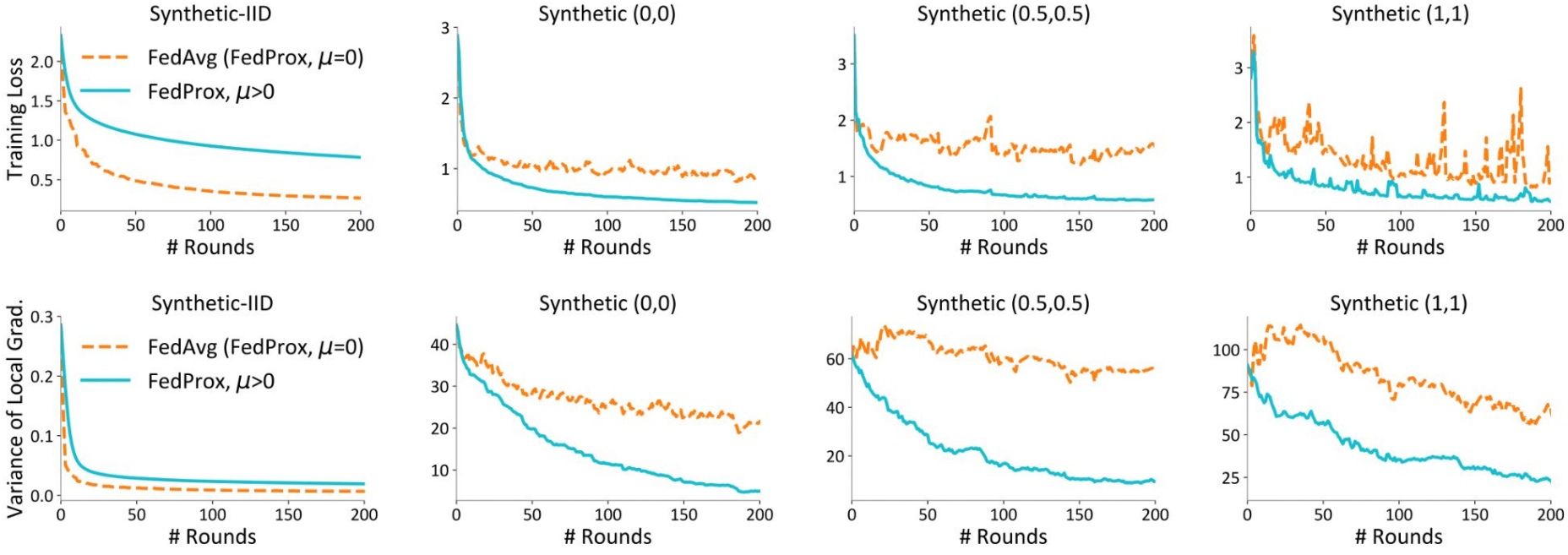
FedAvg



FedProx



Federated Optimization in Heterogeneous Networks



Ack: Result from "Federated Optimization in Heterogeneous Networks"

Summary

- Centralised to Federated
- Strategies
- Heterogeneous Datasets

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Thanks