

SYS-101:00030 (Federated Learning)

Architecture (what's inside)

- `src/data.rs`: MNIST loader with resilient download, parsing IDX, and IID splitter `split_train_data``.
- `src/common.rs`: Model definitions (linear softmax classifier), FedAvg, training/accuracy helpers, shared proto types.
- `src/bin/server.rs`: Parameter server (gRPC). Keeps per-model state (params, status, registered clients, round). `train`` runs federated rounds by simulating each registered client locally on IID splits of MNIST, then FedAvg, and updates global weights. No outbound RPC during training; simulation is internal.
- `src/bin/client.rs`: Interactive gRPC client. Can register (`join``), init model on server, trigger server training, fetch global model (`get``), run local train/test using server's model, and request server-side test.
- `src/bin/simple_demo.rs`: Non-gRPC, single-process demo of FedAvg on IID splits of MNIST.

How to use

1. Start server (new shell)

- `RUST_LOG=info cargo run --bin server --features grpc -- --address 127.0.0.1:50051``

2. Start client (new shell)

- `cargo run --bin client --features grpc -- --server-address 127.0.0.1:50051 --client-id demo``

3. In the client prompt, run in this order:

- `join`` — register this client (required).
- `server-init`` — initialize model on server.
- `get`` — fetch current global model (baseline params/status).
- `server-train 3`` — run 3 federated rounds (simulated local clients + FedAvg; server weights update).
- `server-test`` — evaluate global model on server MNIST test set.
- `get`` — confirm status/params changed.
- `train`` — local train on this client using latest global params.
- `test`` — local test on this client's data.

That's the whole flow: server simulates client training locally on IID MNIST splits, aggregates with FedAvg, and updates the global model; client CLI drives registration, init, training, testing, and local eval.

Example Run: Server Side:

```
Problems Output Debug Console Terminal Ports
Compiling flate2 v1.1.5
Compiling tonic v0.9.2
Compiling byteorder v1.5.0
Finished 'dev' profile [unoptimized + debuginfo] target(s) in 1m 45s
Running 'target/debug/server --address '127.0.0.1:50051''
[2025-12-10T11:14:29Z INFO server] Starting Parameter Server on 127.0.0.1:50051
[2025-12-10T11:18:12Z INFO server] Client registration request: client-5e05c0de for model mnist
[2025-12-10T11:18:12Z INFO server] Registered client client-5e05c0de for model mnist
[2025-12-10T11:18:22Z INFO server] Model initialization request for: mnist
[2025-12-10T11:18:22Z INFO server] Initialized model: mnist
[2025-12-10T11:18:31Z INFO server] Training request for model: mnist with 3 rounds
[2025-12-10T11:18:31Z INFO server] Starting federated training round for model 'mnist'
[2025-12-10T11:18:32Z INFO federated_learning::data] Loaded MNIST dataset:
[2025-12-10T11:18:32Z INFO federated_learning::data] Train images: [60000, 784]
[2025-12-10T11:18:32Z INFO federated_learning::data] Train labels: [60000]
[2025-12-10T11:18:32Z INFO federated_learning::data] Test images: [10000, 784]
[2025-12-10T11:18:32Z INFO federated_learning::data] Test labels: [10000]
[2025-12-10T11:18:32Z INFO server] Training model for client: client-5e05c0de
[2025-12-10T11:18:34Z INFO federated_learning::common] Epoch 0: loss = 2.2692, accuracy = 15.08%
[2025-12-10T11:18:57Z INFO server] Completed federated training round for model 'mnist'
[2025-12-10T11:18:57Z INFO server] Completed training round 1/3 for model mnist
[2025-12-10T11:18:57Z INFO server] Starting federated training round for model 'mnist'
[2025-12-10T11:18:58Z INFO federated_learning::data] Loaded MNIST dataset:
[2025-12-10T11:18:58Z INFO federated_learning::data] Train images: [60000, 784]
[2025-12-10T11:18:58Z INFO federated_learning::data] Train labels: [60000]
[2025-12-10T11:18:58Z INFO federated_learning::data] Test images: [10000, 784]
[2025-12-10T11:18:58Z INFO federated_learning::data] Test labels: [10000]
[2025-12-10T11:18:58Z INFO server] Training model for client: client-5e05c0de
[2025-12-10T11:19:00Z INFO federated_learning::common] Epoch 0: loss = 0.6876, accuracy = 78.25%
[2025-12-10T11:19:23Z INFO server] Completed federated training round for model 'mnist'
[2025-12-10T11:19:23Z INFO server] Completed training round 2/3 for model mnist
[2025-12-10T11:19:23Z INFO server] Starting federated training round for model 'mnist'
[2025-12-10T11:19:24Z INFO federated_learning::data] Loaded MNIST dataset:
[2025-12-10T11:19:24Z INFO federated_learning::data] Train images: [60000, 784]
[2025-12-10T11:19:24Z INFO federated_learning::data] Train labels: [60000]
[2025-12-10T11:19:24Z INFO federated_learning::data] Test images: [10000, 784]
[2025-12-10T11:19:24Z INFO federated_learning::data] Test labels: [10000]
[2025-12-10T11:19:24Z INFO server] Training model for client: client-5e05c0de
[2025-12-10T11:19:26Z INFO federated_learning::common] Epoch 0: loss = 0.5776, accuracy = 80.98%
[2025-12-10T11:19:49Z INFO server] Completed federated training round for model 'mnist'
[2025-12-10T11:19:49Z INFO server] Completed training round 3/3 for model mnist
[2025-12-10T11:22:05Z INFO server] Test request for model: mnist
[2025-12-10T11:22:06Z INFO federated_learning::data] Loaded MNIST dataset:
[2025-12-10T11:22:06Z INFO federated_learning::data] Train images: [60000, 784]
[2025-12-10T11:22:06Z INFO federated_learning::data] Train labels: [60000]
[2025-12-10T11:22:06Z INFO federated_learning::data] Test images: [10000, 784]
[2025-12-10T11:22:06Z INFO federated_learning::data] Test labels: [10000]
[2025-12-10T11:22:06Z INFO server] Model mnist test accuracy: 88.72%
```

Client Side:

```
Problems Output Debug Console Terminal Ports
Compiling clap v4.5.0
Compiling url v2.5.7
Compiling federated-learning v0.1.0 (/mnt/d/CNKL University/Y2_Sem1/SYS-101/Assessments/Assessment_3/OS-00030)
Compiling hyper v0.14.32
Compiling hyper-timeout v0.4.1
Compiling hyper-rustls v0.24.2
Compiling request v0.11.27
Compiling tonic v0.9.2
Finished 'dev' profile [unoptimized + debuginfo] target(s) in 1m 17s
Running 'target/debug/client --server-address '127.0.0.1:50051''
Federated Learning Client Interactive Mode
Available commands:
  join - Join the federated learning network
  train - Train the local model
  test - Test the local model
  get - Get model information from server
  server-test - Test the global model on server
  server-init - Initialize model on server
  server-train <rounds> - Start federated training on server
  quit - Exit the client

client> join
✓ Successfully joined the network

client> server-init
✓ Server model initialized

client> get
✓ Retrieved global model

client> server-train 3
Starting 3 federated training rounds...
✓ Federated training completed: 3 rounds

client> server-test
✓ Server model accuracy: 88.72%

client> get
✓ Retrieved global model

client> train
✓ Local training completed

client> test
✓ Local model accuracy: 89.41%

client> quit
Goodbye!
koset@TOPAL:/mnt/d/CNKL University/Y2_Sem1/SYS-101/Assessments/Assessment_3/OS-00030$
```