

# 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'`

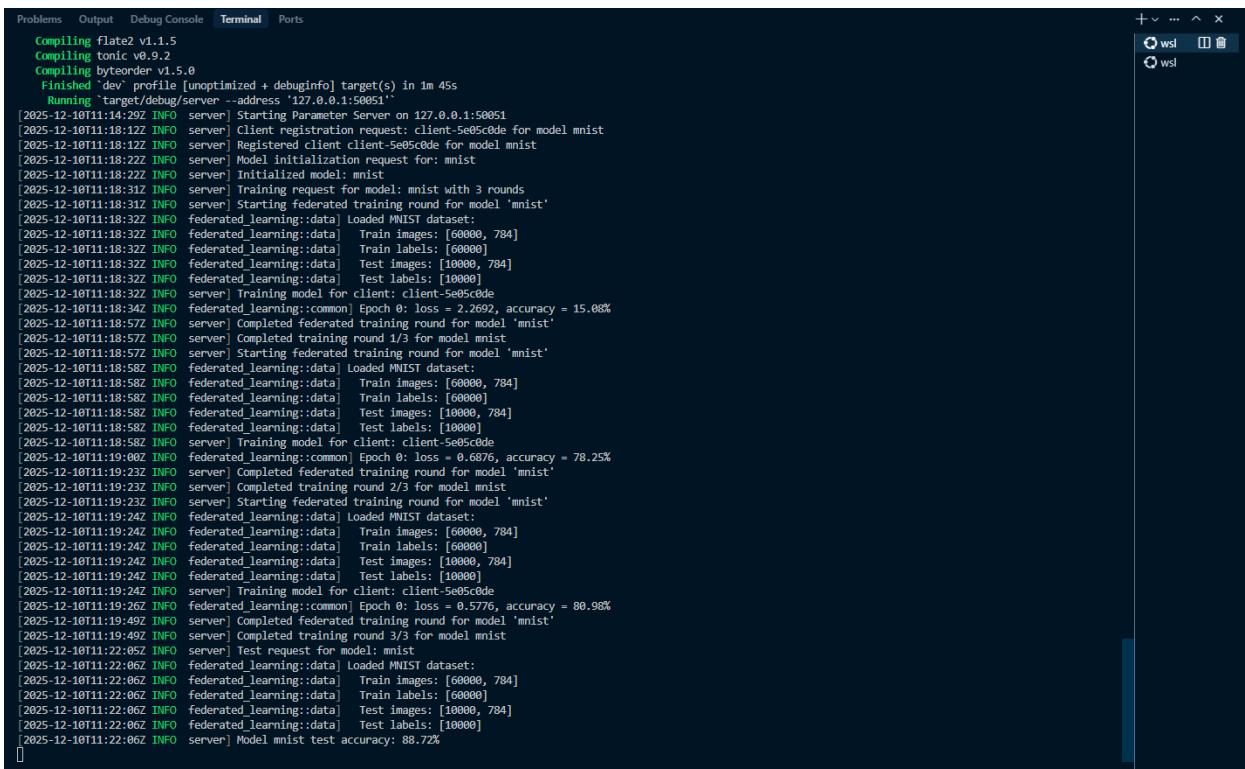
### 3. In the client prompt, run in this order:

- `'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.

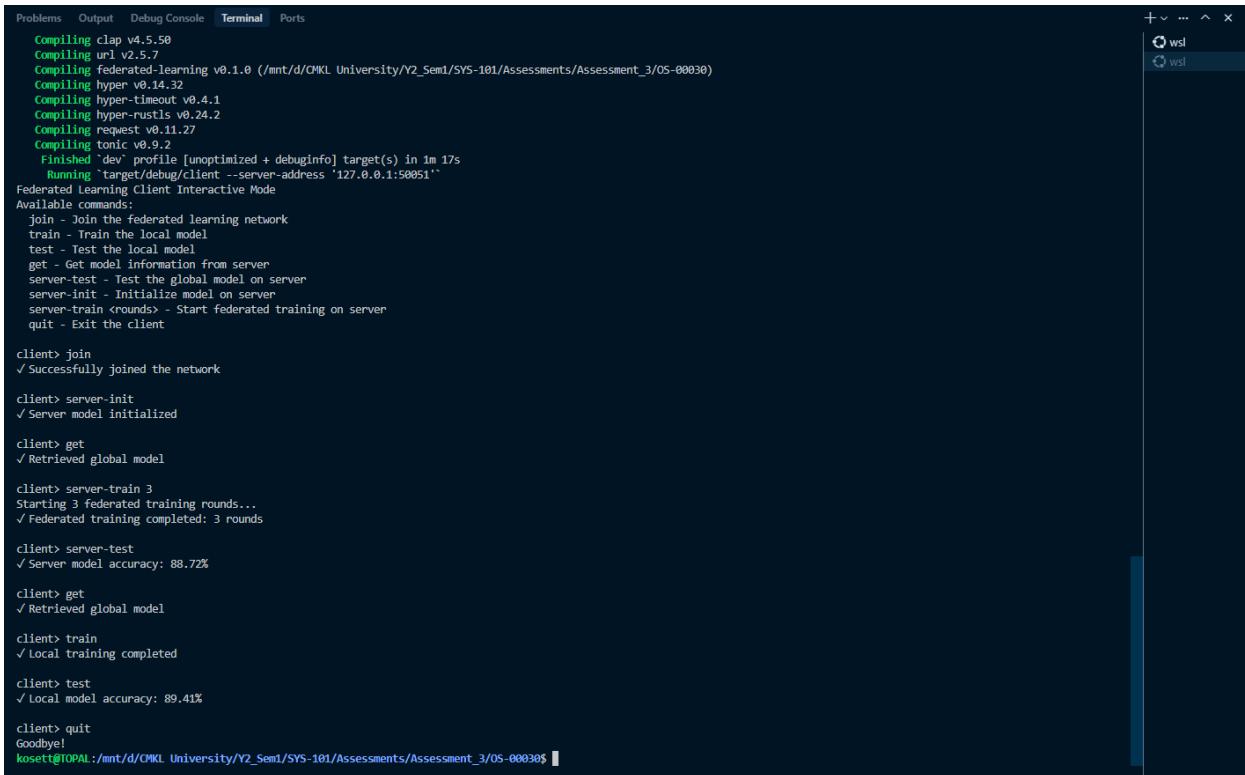
## Example Run:

### Server Side:



```
Problems Output Debug Console Terminal Ports
Compiling flate2 v1.1.5
Compiling tonic v0.9.2
Compiling bytencoder 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 = 15.88%
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 3/3 for model mnist
2025-12-10T11:19:49Z INFO [server] Completed training round 3/3 for model mnist
2025-12-10T11:20:05Z INFO [server] Test request for model: mnist
2025-12-10T11:22:06Z 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 v4.5.50
Compiling url v2.5.7
Compiling federated-learning v0.1.0 (/mnt/d/OMKL University/Y2_Sem1/SYS-101/Assessments/Assessment_3/05-00030)
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!
kosett@TOPAL:/mnt/d/OMKL University/Y2_Sem1/SYS-101/Assessments/Assessment_3/05-00030$
```