



Real-World Federated Learning on Edge Devices with NVFLARE

NVFLARE DAY 2025





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Task: Image Classification with CIFAR-10

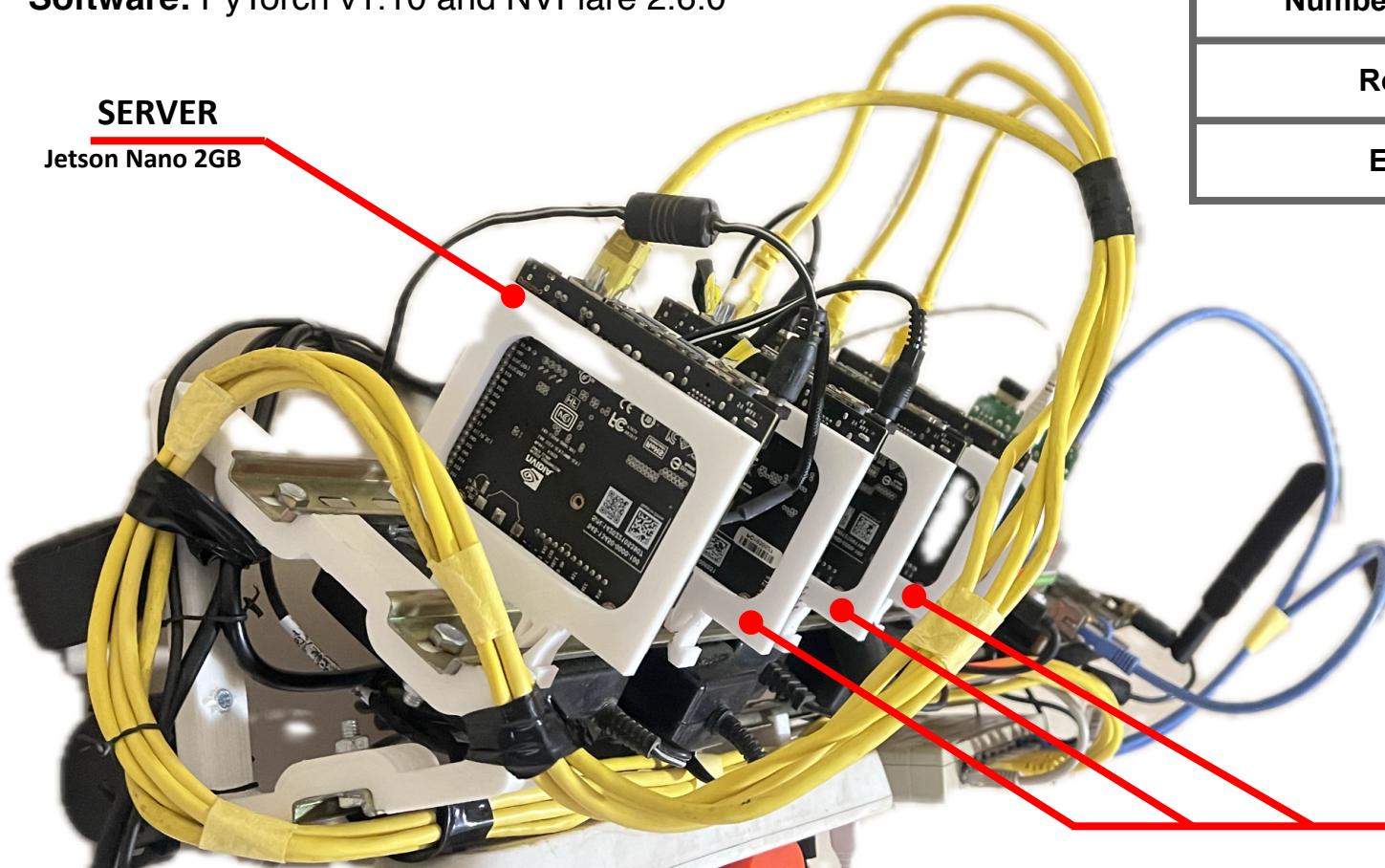
Admin/Lead Researcher: Macbook Pro / PC

Software: PyTorch v1.10 and NVFlare 2.6.0

Number of Admin/Server	1/1
Number of Clients	3
Rounds	5
Epoch	5

SERVER

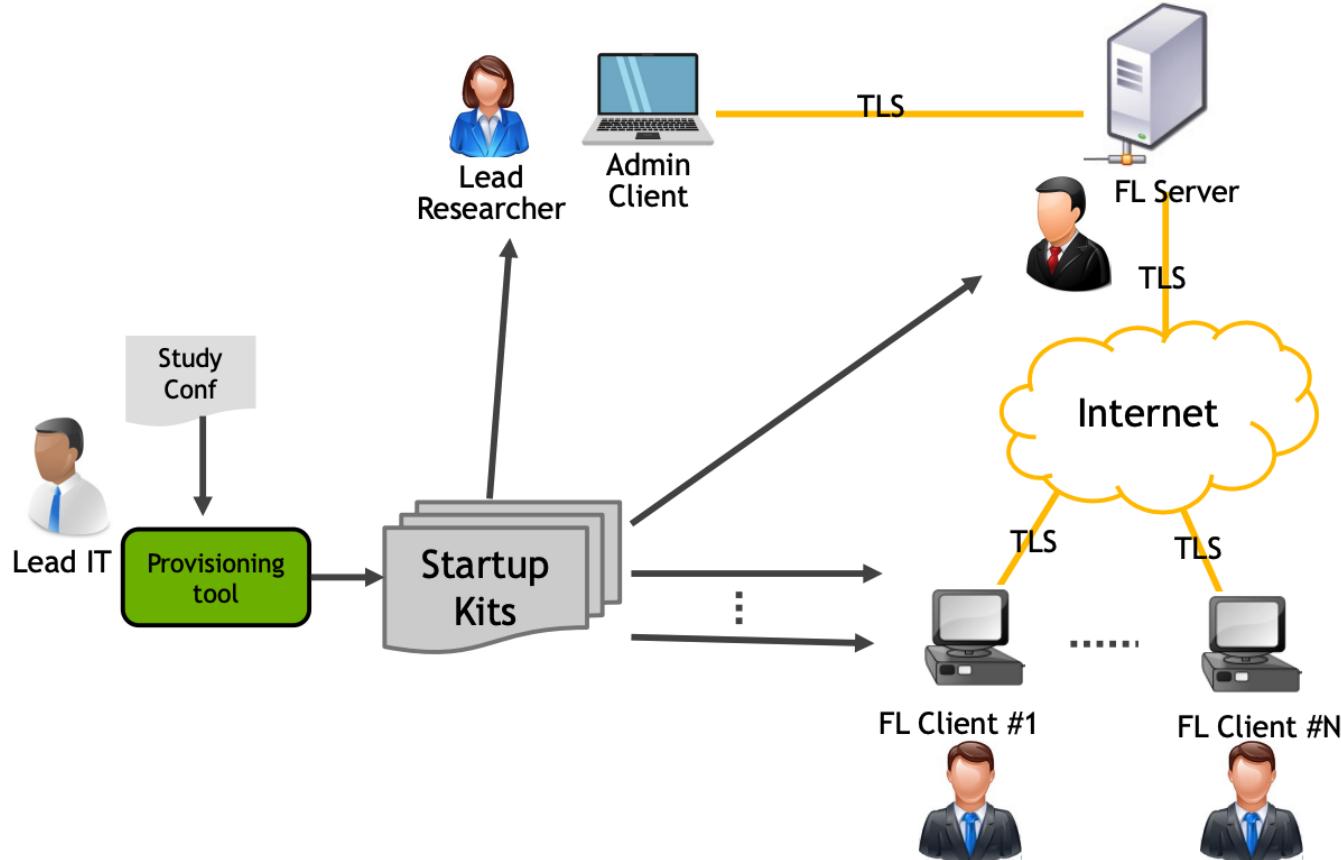
Jetson Nano 2GB



CLIENTS

Jetson Nano 4GB

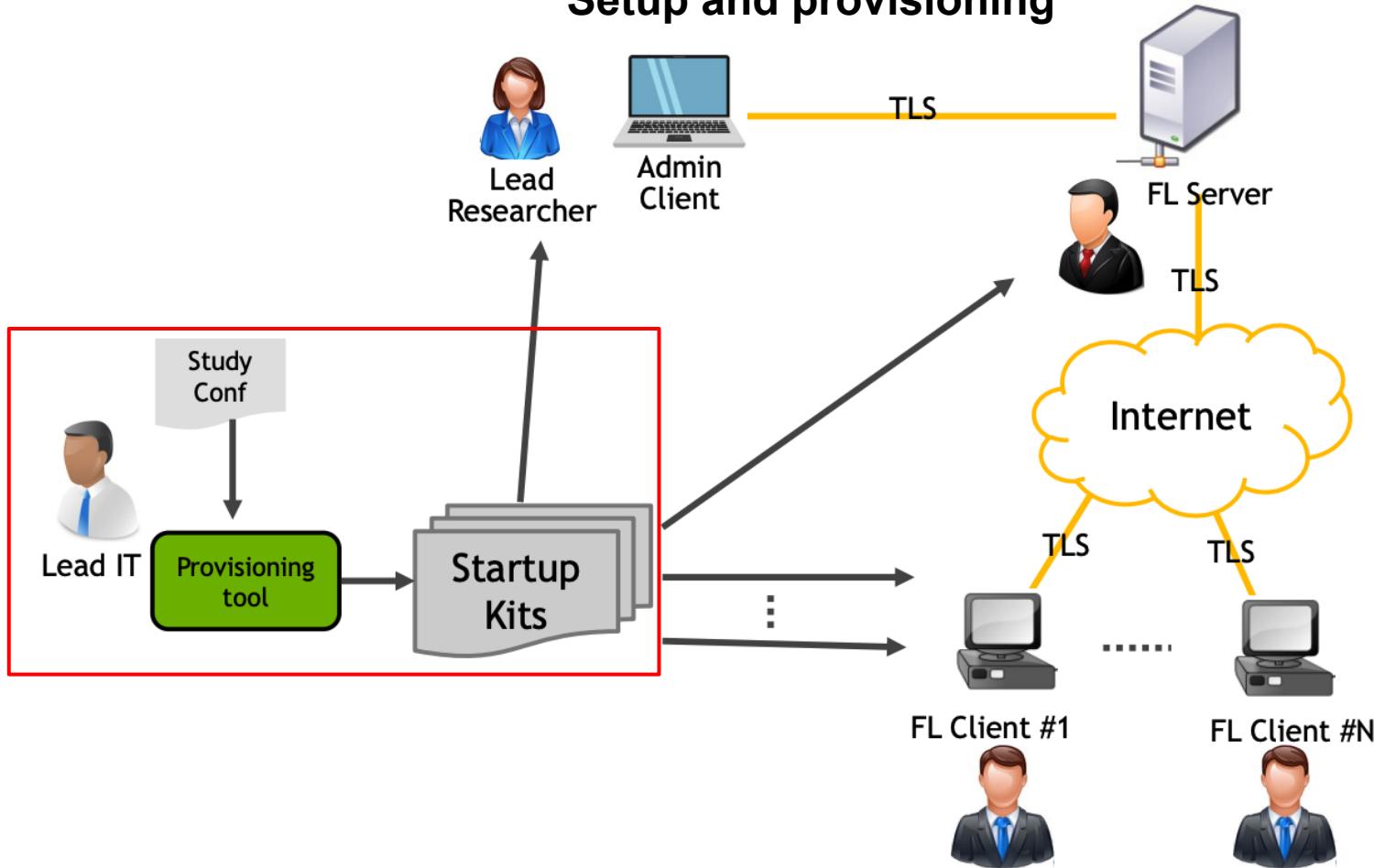
NVFLARE Workflow



Users: A human participant in an FL project, assigned a role (e.g., Project Admin, Org Admin, Lead Researcher)

Clients: A computing site/application that runs the NVFLARE client software and participates in federated learning

Setup and provisioning



Provision

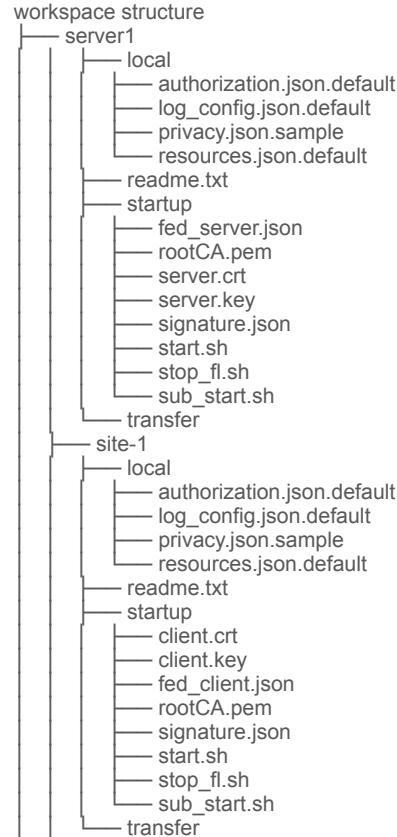
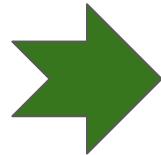
```
> nvflare provision -p jetson-project.yml -w ./prod_workspace
```



Lead IT

participants:

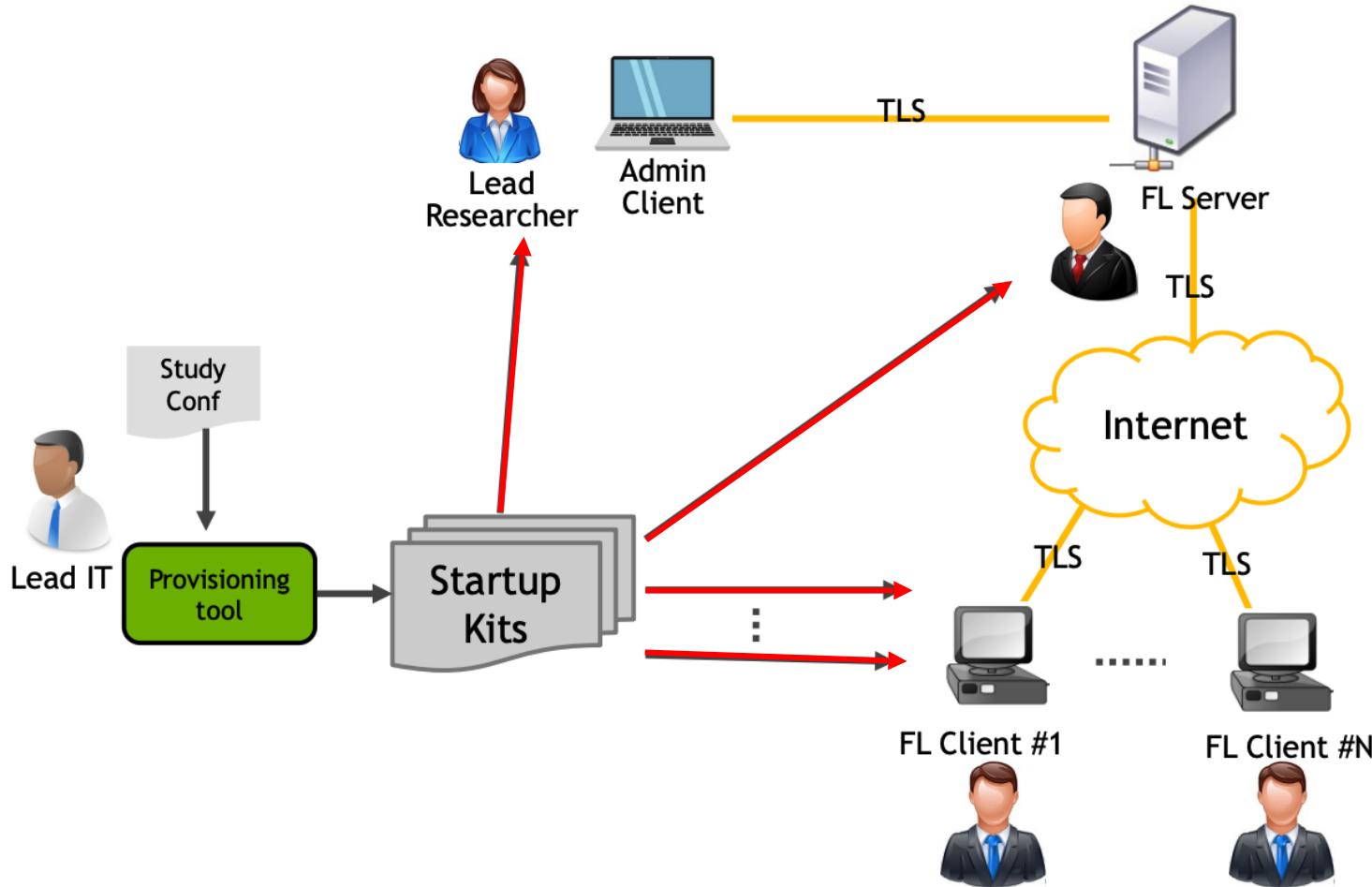
- **name: server1**
type: server
org: nvidia
fed_learn_port: 8002
admin_port: 8003
host: 192.168.1.102
- **name: site-1**
type: client
org: nvidia
host: 192.168.1.65
enable_byoc: true
- **name: site-2**
type: client
org: nvidia
host: 192.168.1.67
enable_byoc: true
- **name: site-3**
type: client
org: nvidia
host: 192.168.1.66
enable_byoc: true
- **name: admin@nvidia.com**
type: admin
org: nvidia
role: project_admin



jetson-project.yml

prod_workspace

Add distribute the credentials to FL server and FL clients



Distribute Credential across devices



Lead IT

server1 => Server (Jetson Nano 2GB)

```
> george@Georges-MacBook-Pro prod_workspace % scp -r jetson_fl_project/prod_00/server1 george@jetson-nano-2g.local:/home/george/Documents
```

site-1 => Client1 (Jetson Nano 4GB)

```
> george@Georges-MacBook-Pro prod_workspace % scp -r jetson_fl_project/prod_00/site-1 george@jetson-n2.local:/home/george/Documents
```

site-2 => Client2 (Jetson Nano 4GB)

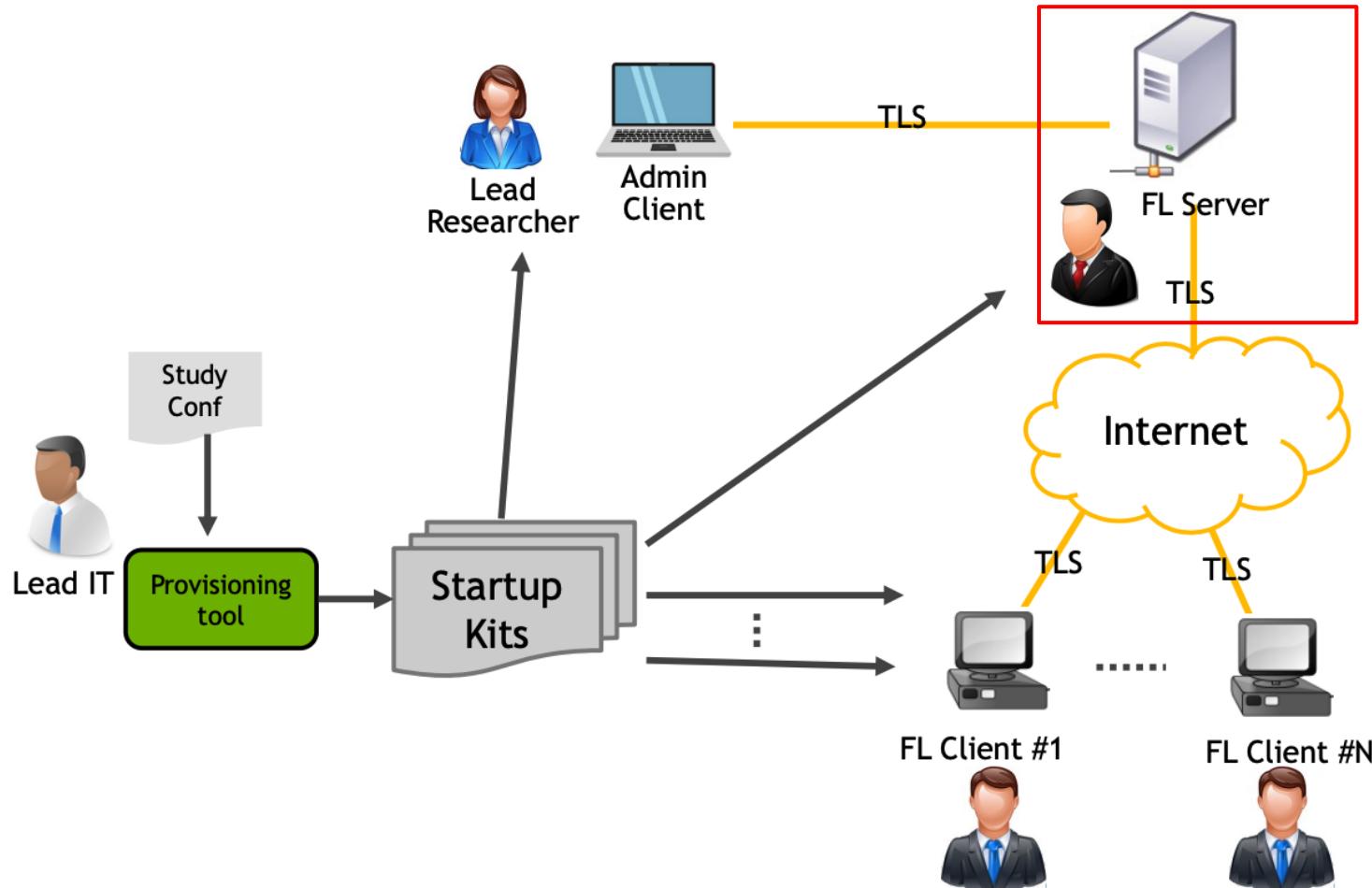
```
> george@Georges-MacBook-Pro prod_workspace % scp -r jetson_fl_project/prod_00/site-2 george@jetson-n3.local:/home/george/Documents
```

site-3 => Client3 (Jetson Nano 4GB)

```
> george@Georges-MacBook-Pro prod_workspace % scp -r jetson_fl_project/prod_00/site-3 george@jetson-n4.local:/home/george/Documents
```

Move each site onto the corresponding device

Working with Server



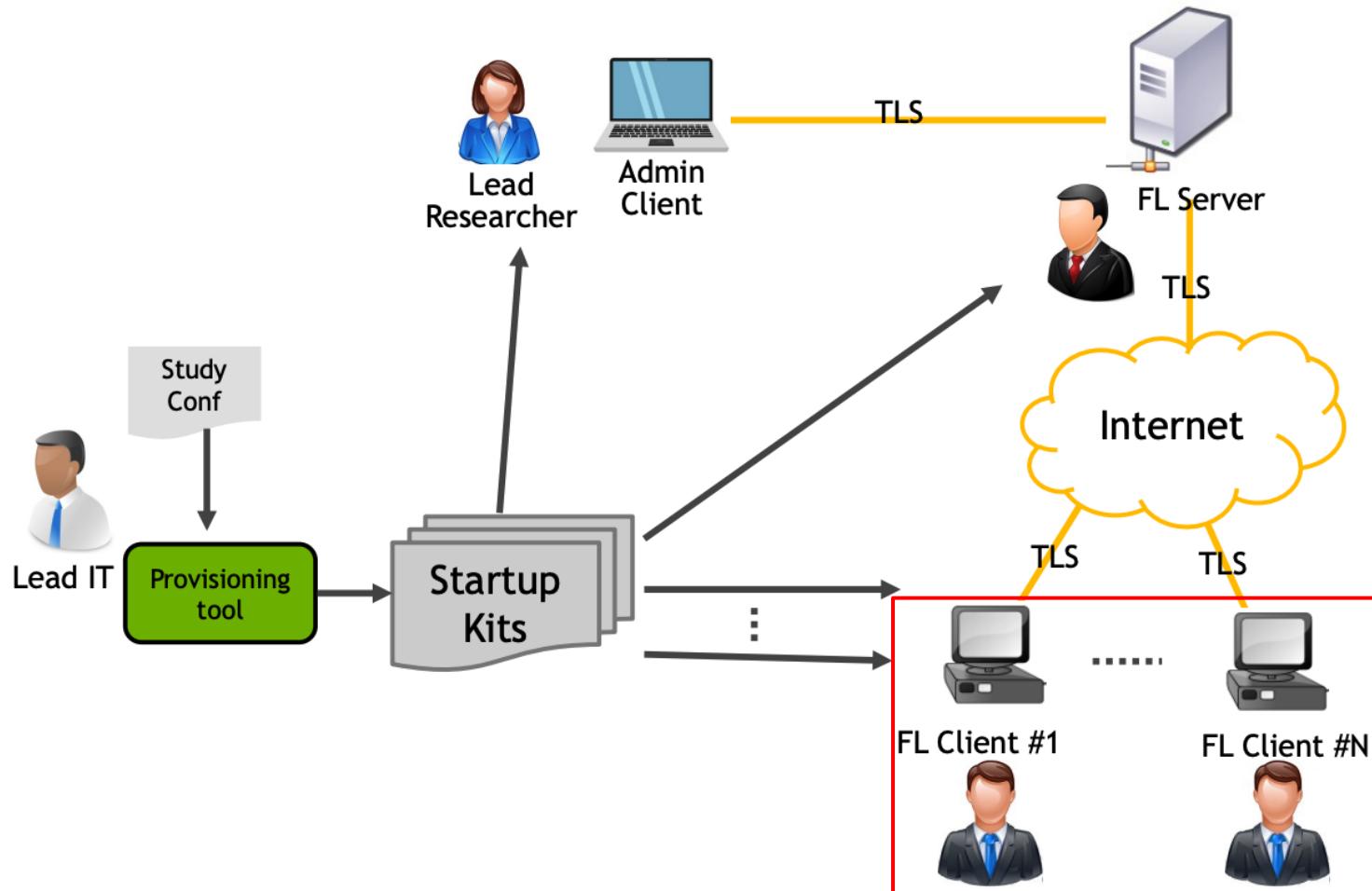
Start the Server



FL Server

```
(nvflare-env) george@jetson-nano-2g:~/Documents/server1/startup$ ./start.sh
(nvflare-env) george@jetson-nano-2g:~/Documents/server1/startup$ WORKSPACE set to /home/george/Documents/server1/
startup/..
PYTHONPATH is /local/custom:
start fl because of no pid.fl
new pid 8692
2025-07-16 23:42:11,420 - ServerDeployer - INFO - server heartbeat timeout set to 600
2025-07-16 23:42:12,190 - CoreCell - INFO - server: creating listener on grpc://0:8002
2025-07-16 23:42:12,776 - CoreCell - INFO - server: created backbone external listener for grpc://0:8002
2025-07-16 23:42:12,781 - conn_manager - INFO - Connector [CH00002 PASSIVE tcp://0:63449] is starting
2025-07-16 23:42:13,284 - CoreCell - INFO - server: created backbone internal listener for tcp://localhost:63449
2025-07-16 23:42:13,294 - conn_manager - INFO - Connector [CH00001 PASSIVE grpc://0:8002] is starting
2025-07-16 23:42:13,305 - Cell - INFO - Register blob CB for channel='aux_communication', topic='*'
2025-07-16 23:42:13,309 - FederatedServer - INFO - max_reg_duration=60.0
2025-07-16 23:42:13,312 - AuxRunner - INFO - registered aux handler for topic ObjectStreamer.Request
2025-07-16 23:42:13,315 - AuxRunner - INFO - registered aux handler for topic ObjectStreamer.Abort
2025-07-16 23:42:13,319 - AuxRunner - INFO - registered aux handler for topic fed.event
2025-07-16 23:42:13,352 - ObjectStreamer - INFO - registered processor_factory: channel='log_streaming' topic='*'
    ChunkConsumerFactory
2025-07-16 23:42:13,359 - ServerDeployer - INFO - deployed FLARE Server.
2025-07-16 23:42:13,424 - Server - INFO - added secure port at 0.0.0.0:8002
2025-07-16 23:42:13,433 - hci - INFO - Starting Admin Server server1 on Port 8003
2025-07-16 23:42:13,433 - root - INFO - Server started
2025-07-16 23:42:13,816 - ServerState - INFO - Got the primary sp: server1 fl_port: 8002 SSID:
ebc6125d-0a56-4688-9b08-355fe9e4d61a. Turning to hot.
```

Working with FL clients



Start the FL Clients



FL Client -1

```
(nvflare-env) george@jetson-n2:~/Documents/site-1/startup$ ./start.sh
(nvflare-env) george@jetson-n2:~/Documents$ WORKSPACE set to /home/george/Documents/site-1/startup/..
PYTHONPATH is /local/custom:
start fl because of no pid.fl
new pid 8033
2025-07-18 00:08:47,231 - FederatedClient - INFO - Successfully registered client:site-1 for project jetson_fl_project.
2025-07-18 00:08:47,236 - FederatedClient - INFO - Got engine after 0.882779598236084 seconds
2025-07-18 00:08:47,239 - FederatedClient - INFO - Got the new primary SP: grpc://server1:8002
```



FL Client -2

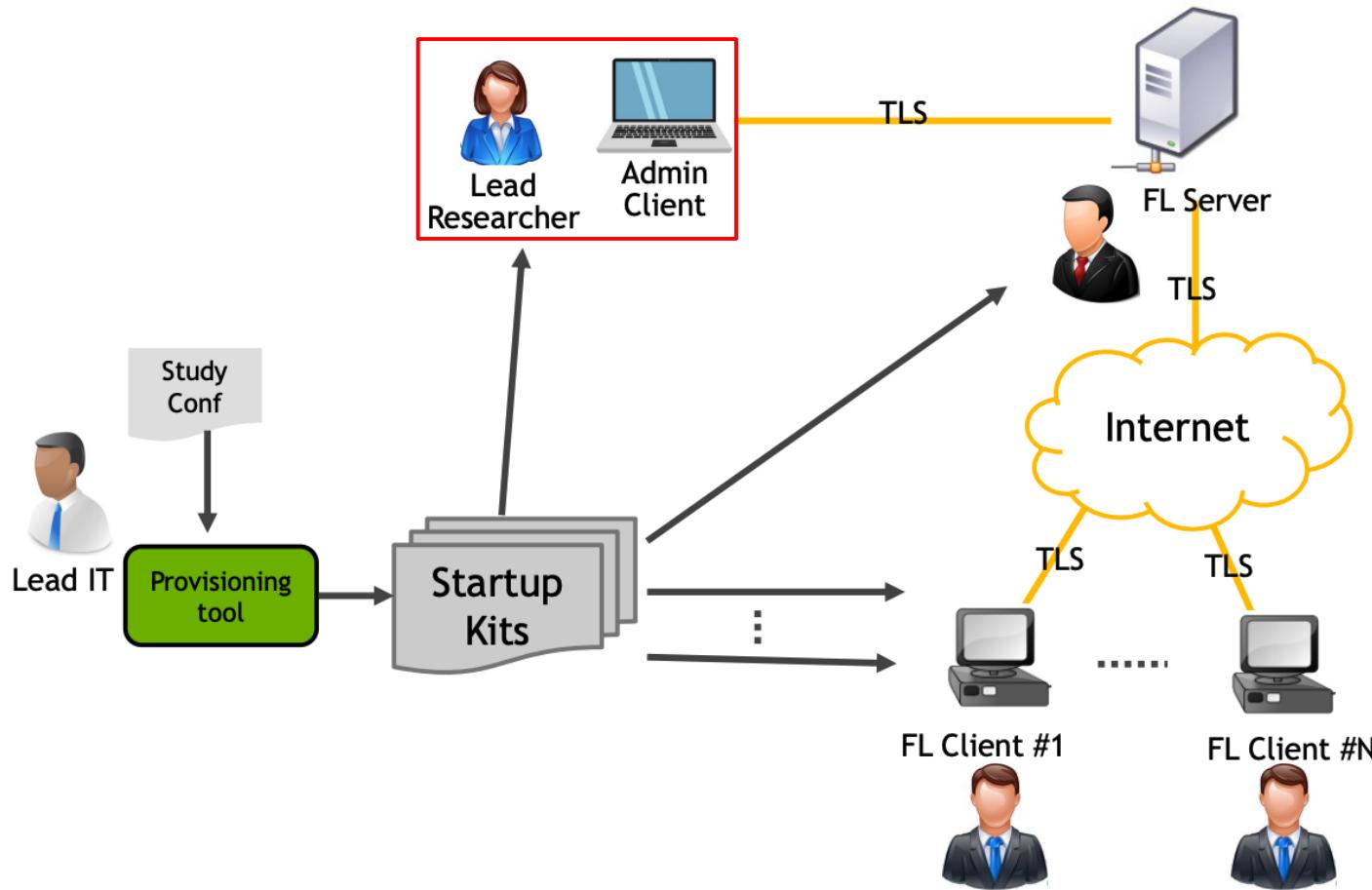
```
(nvflare-env) george@jetson-n3:~/Documents/site-2/startup$ ./start.sh
(nvflare-env) george@jetson-n3:~/Documents$ WORKSPACE set to /home/george/Documents/site-2/startup/..
PYTHONPATH is /local/custom:
start fl because of no pid.fl
new pid 6844
2025-07-17 06:52:41,558 - FederatedClient - INFO - Successfully registered client:site-2 for project jetson_fl_project.
2025-07-17 06:52:41,561 - FederatedClient - INFO - Got engine after 0.870030403137207 seconds
2025-07-17 06:52:41,563 - FederatedClient - INFO - Got the new primary SP: grpc://server1:8002
```



FL Client -3

```
(nvflare-env) george@jetson-n4:~/Documents/site-3/startup$ ./start.sh
(nvflare-env) george@jetson-n4:~/Documents$ WORKSPACE set to /home/george/Documents/site-3/startup/..
PYTHONPATH is /local/custom:
start fl because of no pid.fl
new pid 6593
2025-07-17 11:40:19,326 - FederatedClient - INFO - Successfully registered client:site-3 for project jetson_fl_project.
2025-07-17 11:40:19,332 - FederatedClient - INFO - Got engine after 0.9113898277282715 seconds
2025-07-17 11:40:19,334 - FederatedClient - INFO - Got the new primary SP: grpc://server1:8002
```

Working with Admin Client





Lead
Researcher

Start the Admin Client

```
(env-admin) george@Georges-MacBook-Pro prod_workspace % ./jetson_fl_project/  
prod_00/admin@nvidia.com/startup/fl_admin.sh  
User Name: admin@nvidia.com  
Trying to obtain server address  
Obtained server address: server1:8003  
Trying to login, please wait ...  
Logged into server at server1:8003 with SSID: ebc6125d-0a56-4688-9b08-355fe9e4d61a  
Type ? to list commands; type "? cmdName" to show usage of a command.
```

Admin Client APIs

```
> sys_info server
```

METRICS	VALUE
total	2067730432
available	1305690112
percent	36.9
used	642949120
free	653094912
active	613875712
inactive	513527808
buffers	46424064
cached	725262336
shared	34820096
slab	115167232
available_percent	63.1

```
> sys_info client site-1
```

METRICS	VALUE
total	4156657664
available	3399151616
percent	18.2
used	566804480
free	2857603072
active	524935168
inactive	538550272
buffers	34562048
cached	697688064
shared	29134848
slab	113930240
available_percent	63.1

Admin Client Starts the Experiment

```
> check_status client
-----
| CLIENT | APP_NAME | JOB_ID | STATUS |
-----
| site-1 | ? | ? | No Jobs |
| site-2 | ? | ? | No Jobs |
| site-3 | ? | ? | No Jobs |
-----
Done [155230 usecs] 2025-07-18 04:23:43.771360
> submit_job hello-pt-cifar10-fedavg
Submitted job: 8602a837-3161-4a0a-b104-4e6b0ffa69ad
Done [267952 usecs] 2025-07-18 04:23:52.390956
> check_status client
-----
| CLIENT | APP_NAME | JOB_ID | STATUS |
-----
| site-1 | app_site-1 | 8602a837-3161-4a0a-b104-4e6b0ffa69ad | starting |
| site-2 | app_site-2 | 8602a837-3161-4a0a-b104-4e6b0ffa69ad | starting |
| site-3 | app_site-3 | 8602a837-3161-4a0a-b104-4e6b0ffa69ad | starting |
-----
> check_status client
-----
| CLIENT | APP_NAME | JOB_ID | STATUS |
-----
| site-1 | app_site-1 | 8602a837-3161-4a0a-b104-4e6b0ffa69ad | started |
| site-2 | app_site-2 | 8602a837-3161-4a0a-b104-4e6b0ffa69ad | started |
| site-3 | app_site-3 | 8602a837-3161-4a0a-b104-4e6b0ffa69ad | started |
-----
```



Lead
Researcher

Logs from the Server



FL Server

```
2025-07-17 10:55:05,691 - TaskScriptRunner - INFO - Epoch: 4/5, Iteration: 9000, Loss: 0.5168277079164982
2025-07-17 10:56:04,535 - TaskScriptRunner - INFO - Epoch: 4/5, Iteration: 12000, Loss: 0.5330372496644656
2025-07-17 10:56:14,391 - TaskScriptRunner - INFO - Finished Training
2025-07-17 10:56:14,409 - InProcessClientAPI - INFO - Try to send local model back to peer
2025-07-17 10:56:14,441 - ClientRunner - INFO - [identity=site-2, run=896b8203-1e74-48da-b6a8-b34a4cc19dd3,
peer=jetson_fl_project,
2025-07-17 10:56:16,929 - ReliableMessage - INFO - ReliableMessage is shutdown
2025-07-17 10:56:16,931 - ObjectStreamer - INFO - Stream Runer is Shut Down
2025-07-17 10:56:16,949 - conn_manager - INFO - Connection [CN00003 Not Connected] is closed PID: 12853
2025-07-17 10:56:16,968 - conn_manager - INFO - Connection [CN00002 Not Connected] is closed PID: 12876
2025-07-17 10:56:17,075 - conn_manager - INFO - Connection [CN00003 Not Connected] is closed PID: 12876
2025-07-17 10:56:17,078 - GrpcDriver - INFO - CLIENT: finished connection [CN00003 Not Connected]
2025-07-17 10:56:17,081 - FederatedClient - INFO - Shutting down client run: site-2
2025-07-17 10:56:17,521 - ClientRunner - INFO - [identity=site-2, run=896b8203-1e74-48da-b6a8-b34a4cc19dd3] - Client is
stopping ...
2025-07-17 10:56:19,052 - MPM - INFO - MPM: Good Bye!
2025-07-17 10:56:28,434 - JobExecutor - INFO - run (896b8203-1e74-48da-b6a8-b34a4cc19dd3): child worker process finished with RC 0
```

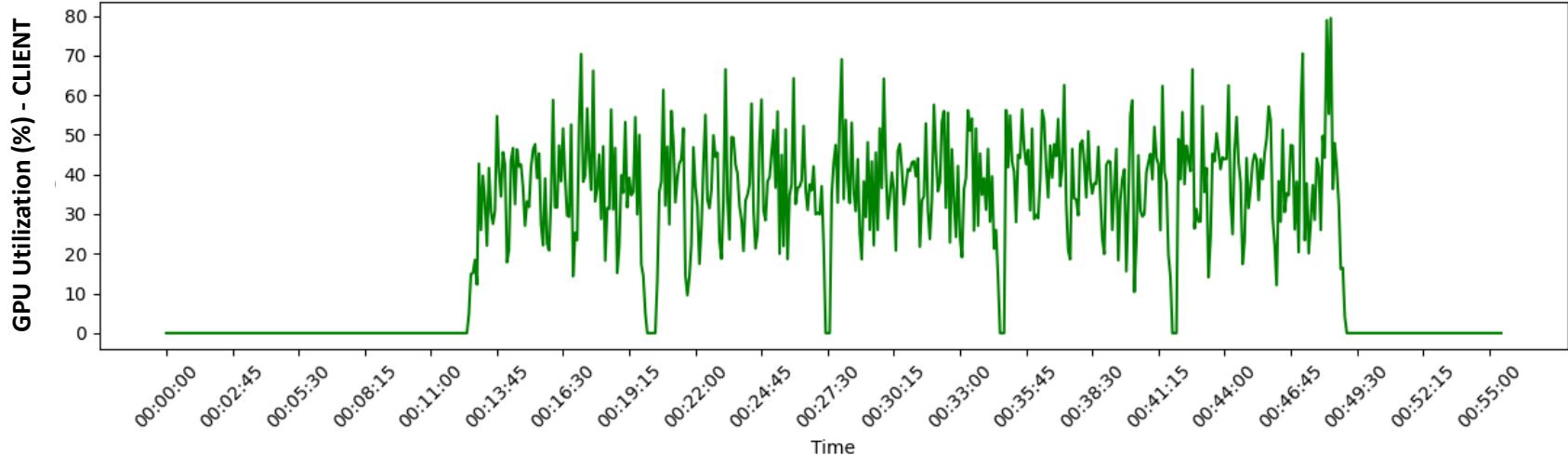
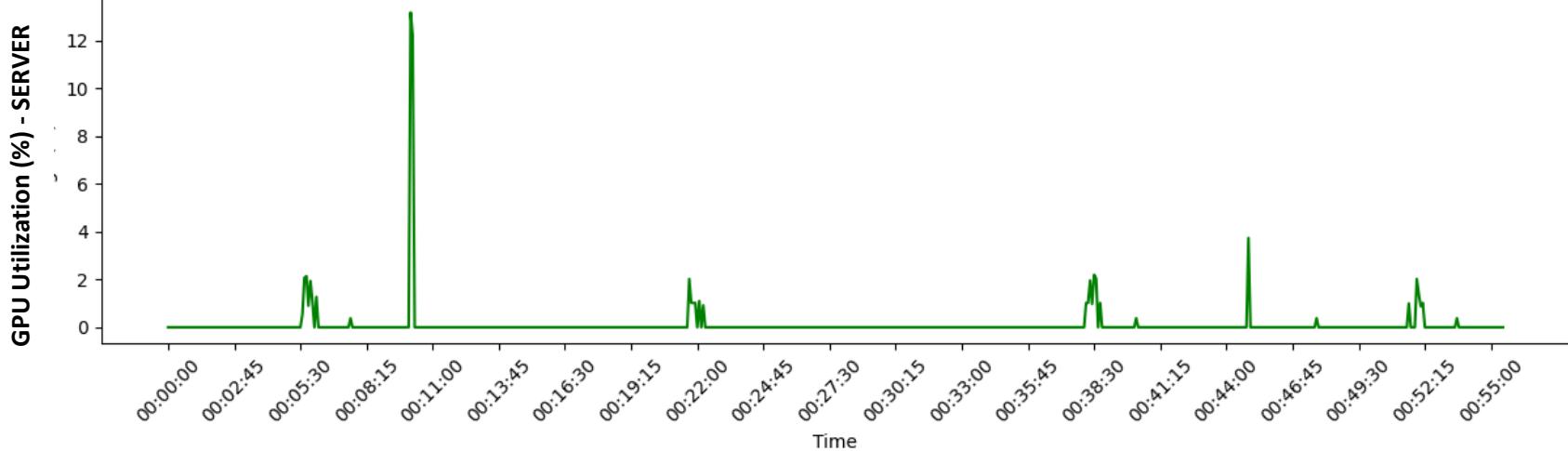
Admin Client Checks the Experiment Status



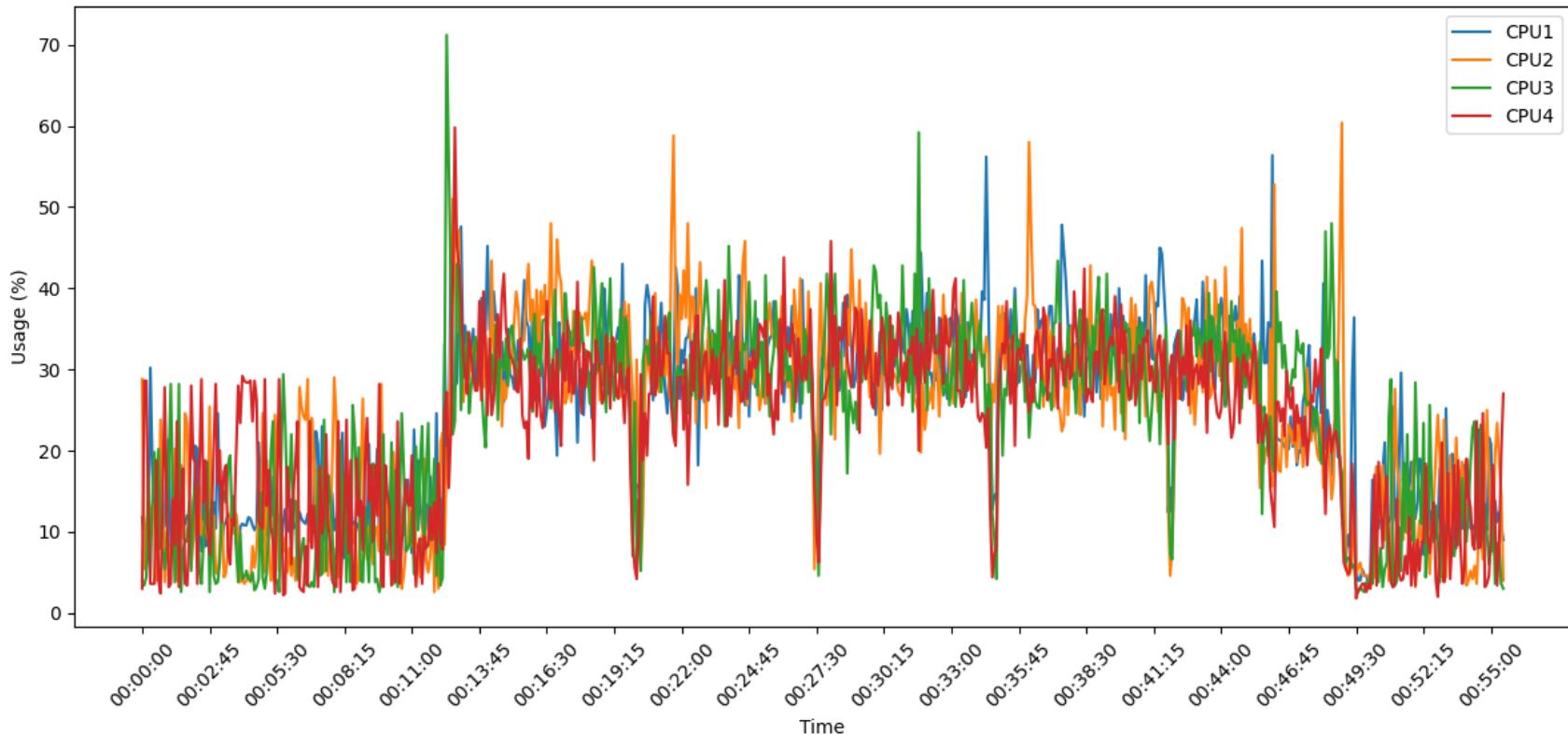
Lead
Researcher

```
> list_jobs
```

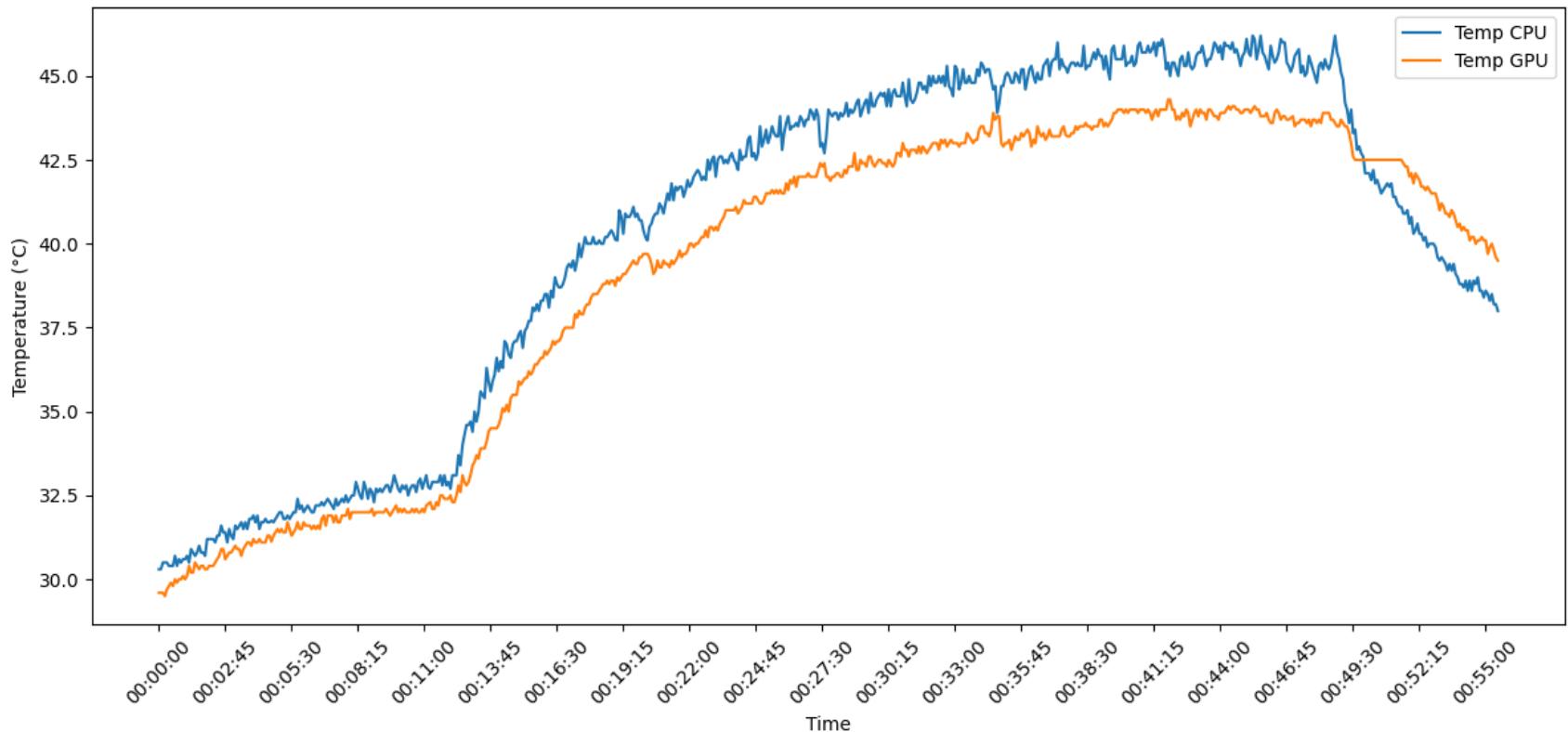
JOB ID	NAME	STATUS
8602a837-3161-4a0a-b104-4e6b0ffa69ad	hello-pt-cifar10-fedavg	RUNNING
8602a837-3161-4a0a-b104-4e6b0ffa69ad	hello-pt-cifar10-fedavg	FINISHED:COMPLETED



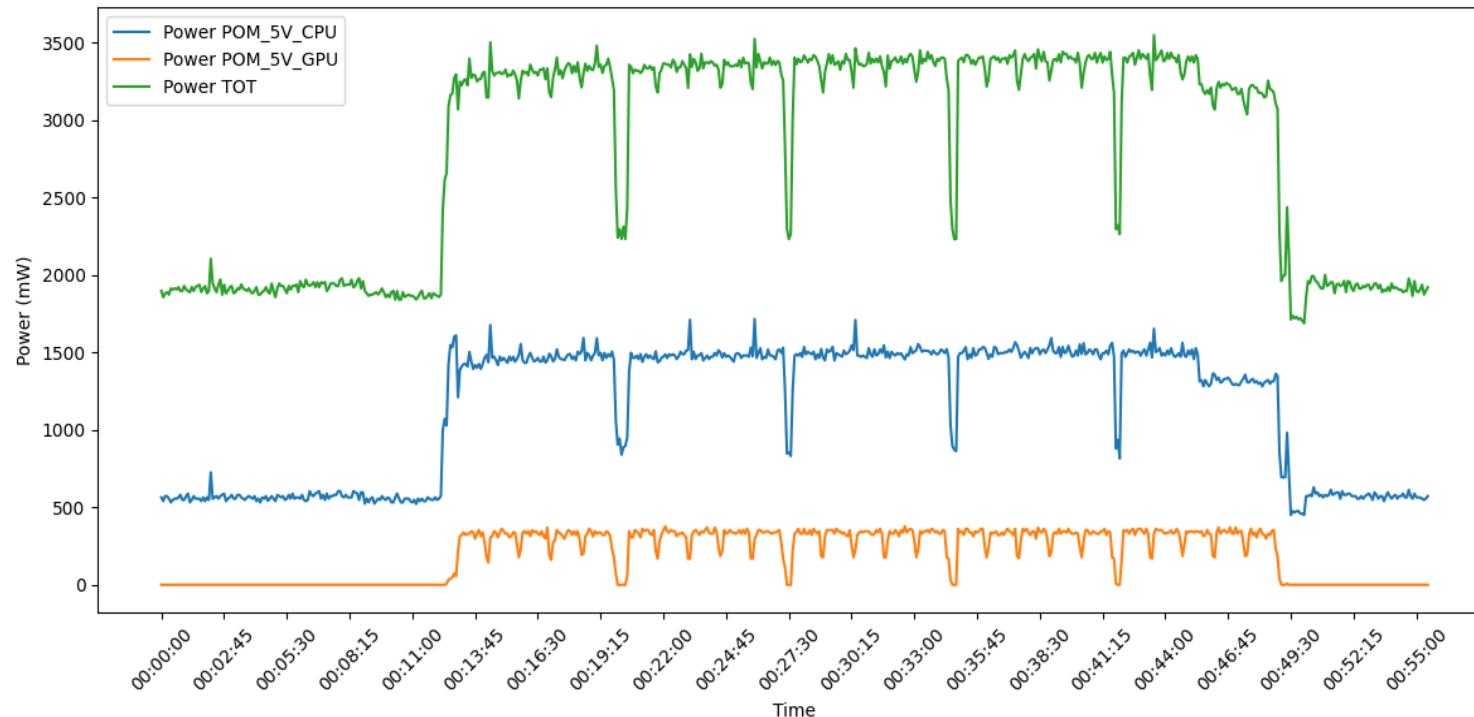
CPU Utilization (%) - CLIENT



Temperature (°C) - CLIENT



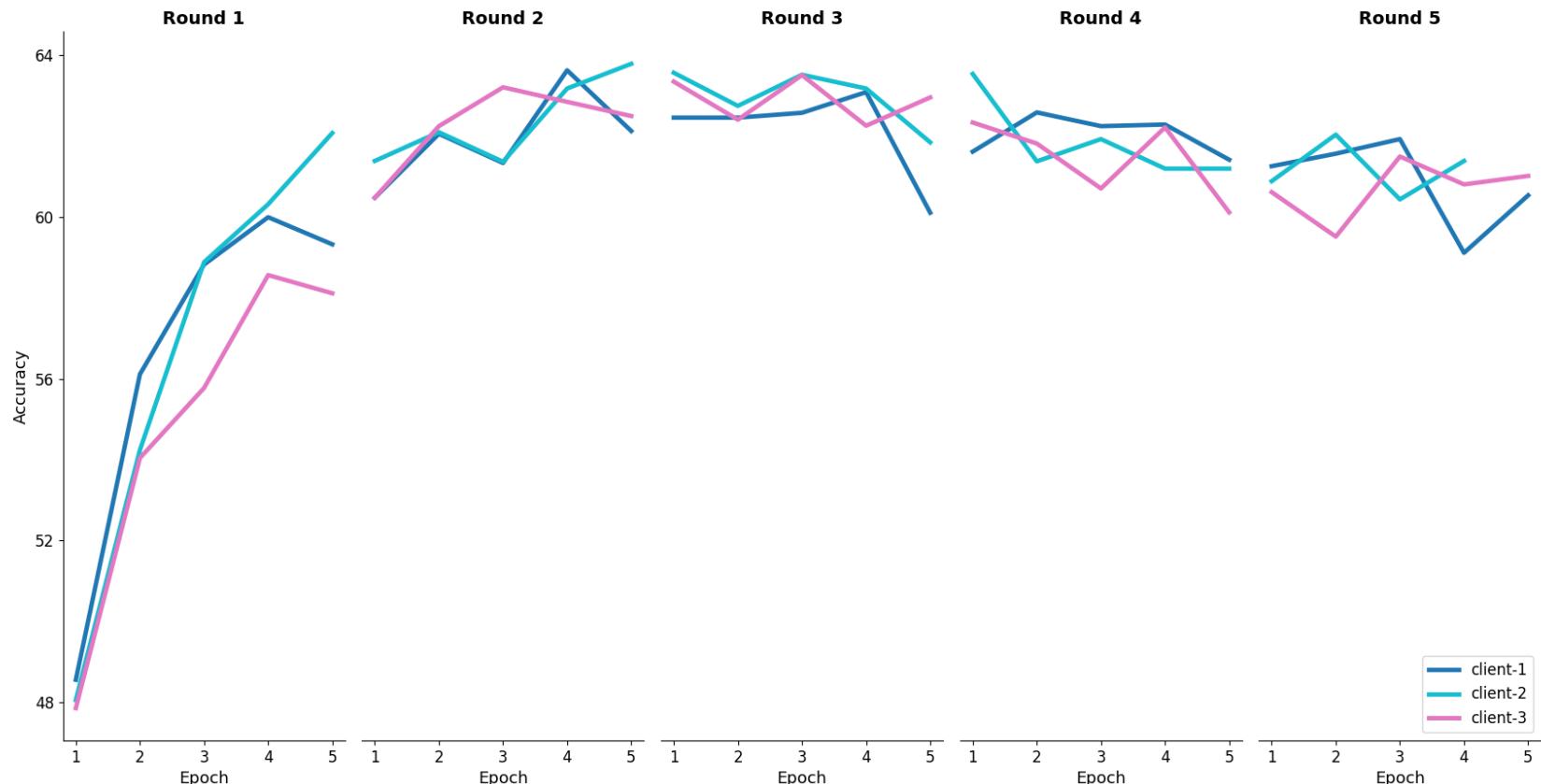
Power Consumption (mW) - CLIENT



Training Time: 41 minutes [for 5 rounds with 5 epochs each]

Power Consumed: **0.012 kilowatt-hour**

Accuracy Over Rounds

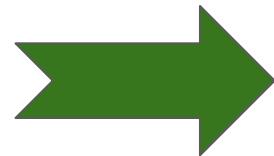


Future Work

Bigger Devices and Bigger Models

Replace the Jetson Nanos with Orin Nanos and scale up device count to test modern DL models under high resource demands

Jetson Nano



Jetson Orin Nano



Heterogeneous Setup

Running FL experiments across heterogeneous devices with containerized software in place of native installations

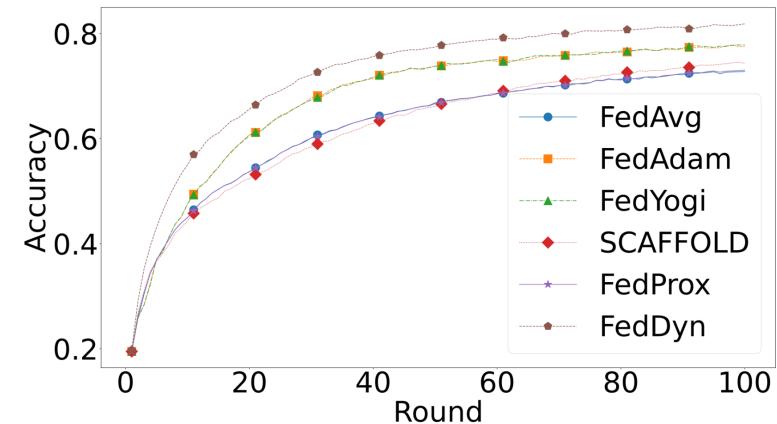


NVFLARE is **Platform-Agnostic**

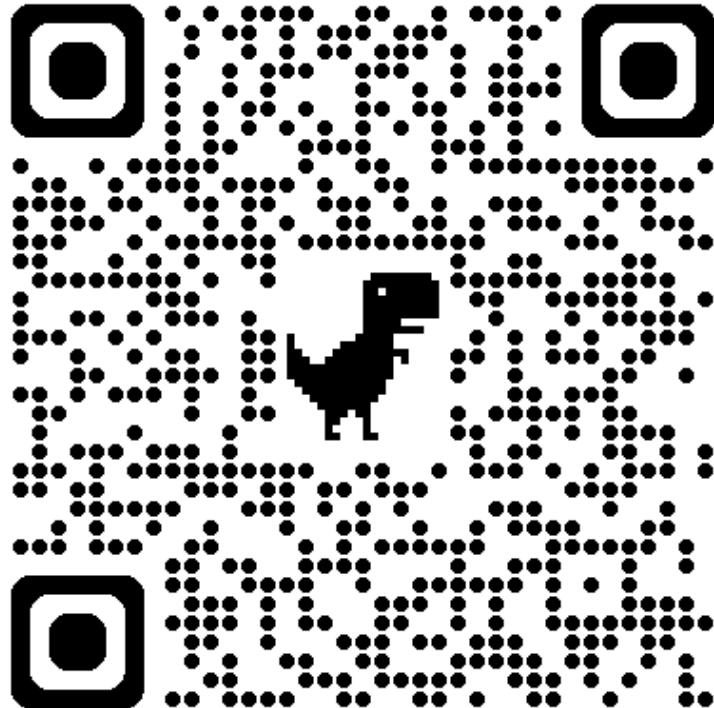
Finding the Cost of Privacy

Studying the impact of advance privacy settings such as homomorphic encryption/differential privacy, aggregating algos on system performance metrics

Differential Privacy		
Noise Level	Shared Percentile Threshold	Variable Selection
Homomorphic Encryption		
Bit sizes	Scaling	Polynomial Modulus



(a) Test accuracy vs. round



<https://github.com/gigwegbe/nvflare-on-jetson>