SplitFed
Federated Learning meets Split Learning

PRESENTED BY

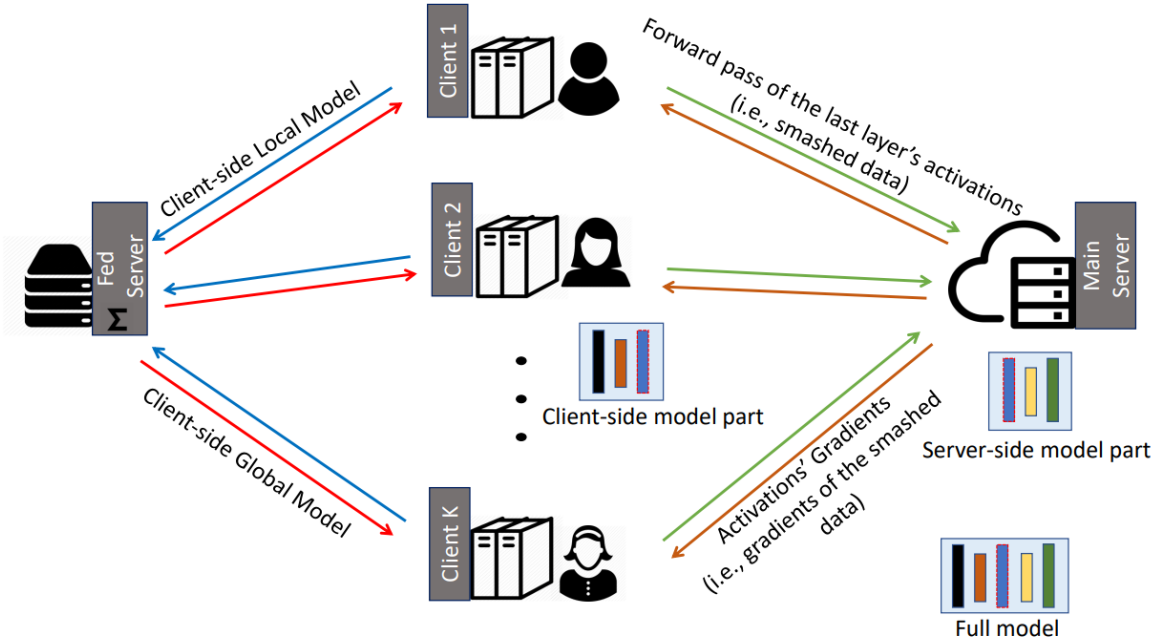
0424052053 - MOBASWIRUL ISLAM

Research Paper

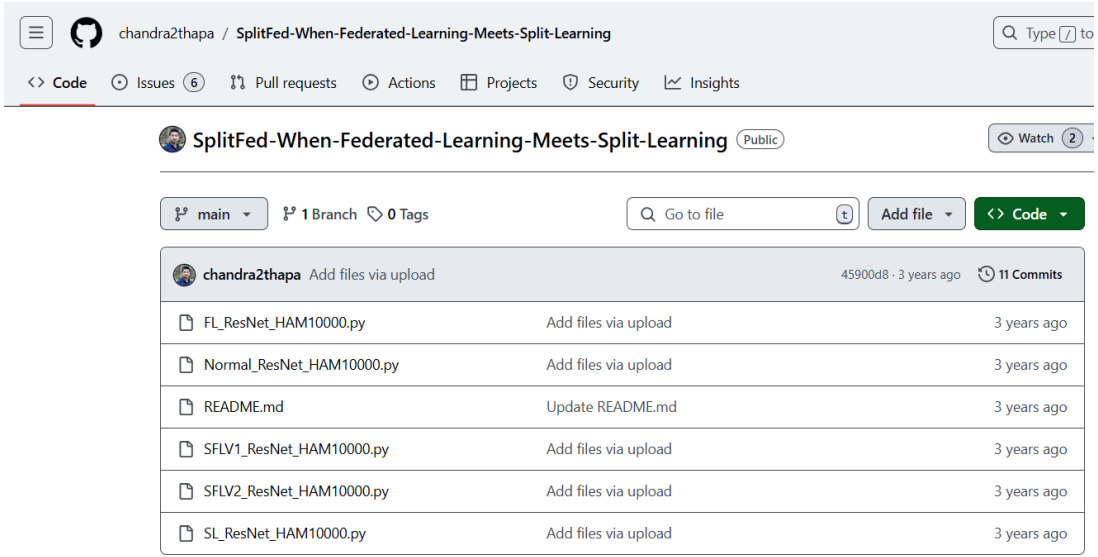
SplitFed: When Federated Learning Meets Split Learning

Chandra Thapa, Pathum Chamikara, Mahawaga Arachchige, Seyit Camtepe, Lichao Sun

Conference: AAAI - `22



SplitFed Recap



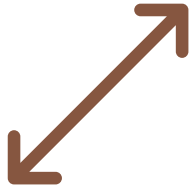
https://github.com/chandra2thapa/SplitFed-When-Federated-Learning-Meets-Split-Learning

Implementation

SIMULATION ONLY

Cloud VM and Storage

1 Server



3 Clients

Google Bucket

```
class MessageType(Enum):...

class Message:...


def send_message_as_json(client_socket, message_type, sender="", receiver = "", content = ""):...

def receive_message_as_json(client_socket):...

def send_file(client_socket, directory_path, file_path, message_type = MessageType.REQUEST_TO_SEND_FILE):...

def receive_file(client_socket, directory_path, file_path, message_type = MessageType.SEND_FILE):...
```

Methodology

CUSTOM SERVER SOCKET SCHEME

```python
class ClientModel(nn.Module):
    def __init__(self):
        super(ClientModel, self).__init__()
        self.flatten = nn.Flatten()
        self.fc1 = nn.Linear(784, 128)
        self.activation1 = nn.ReLU()

    def forward(self, x):...
```

```python
class ServerModel(nn.Module):
    def __init__(self):
        super(ServerModel, self).__init__()
        self.fc1 = nn.Linear(128, 64)
        self.activation1 = nn.ReLU()
        self.fc2 = nn.Linear(64, 10)
        self.activation2 = nn.Softmax(dim=1)

    def forward(self, x):...
```

Split Fed (Separate Client and Server Network)

```
for epoch in range(TOTAL_GLOBAL_EPOCH):
    for i, (images, labels) in enumerate(train_loader):
        images, labels = images.to(device), labels.to(device)
        client_optimizer.zero_grad()
        split_layer_tensor = client_model(images)
        split_layer_tensor = split_layer_tensor.detach().requires_grad_(True)

        grads = comm_with_server(labels, split_layer_tensor, epoch, i)

        split_layer_tensor.backward(grads)
        client_optimizer.step()
```

Split Fed Mechanism – Client Side

```python
def communicate_with_server_during_training(labels, split_layer_tensor, epoch, i):
    global client_socket

    torch.save(labels, f"{client_file_directory_path}/labels_{epoch}_{i}.pt")
    torch.save(split_layer_tensor, f"{client_file_directory_path}/split_layer_tensor_{epoch}_{i}.pt")

    send_file(client_socket, client_file_directory_path, file_path: f"labels_{epoch}_{i}.pt")
    send_file(client_socket, client_file_directory_path, file_path: f"split_layer_tensor_{epoch}_{i}.pt")

    grads_message = receive_message_as_json(client_socket)
    if grads_message.message_type == MessageType.REQUEST_TO_SEND_FILE:
        receive_file(client_socket, server_file_directory_path, file_path: f"grads_{epoch}_{i}.pt")
        grads = torch.load(f"{server_file_directory_path}/grads_{epoch}_{i}.pt")

        return grads

    return None
```

Split Fed Mechanism – Client Side

Split Fed Mechanism Server Side

```python
def start_training(client_socket, client_name):
    global specific_client_file_directory_path, device, CLIENT_EPOCH_COUNT, CLIENT_MODEL_PATH
    print(f"Client {client_name} training started.")

    server_model = ServerModel().to(device)
    server_optimizer = optim.Adam(server_model.parameters(), lr=0.001)
    loss_criteria = nn.CrossEntropyLoss()

    final_client_model_path = None
    final_validation_loader_path = None

    while True:
        try:
            msg = receive_message_as_json(client_socket)
            if msg.message_type == MessageType.REQUEST_TO_SEND_FILE:...

            elif msg.message_type == MessageType.REQUEST_TO_SEND_FINAL_MODEL:...

            elif msg.message_type == MessageType.TRAINING_DONE:...

            elif msg.message_type == MessageType.REQUEST_TO_SEND_VALIDATION_LOADER:...

            elif msg.message_type == MessageType.REQUEST_TO_SEND_MODEL:...

            elif msg.message_type == MessageType.REQUEST_FOR_AGGREGATED_MODEL:...

            else:...

        except ConnectionResetError:
            print(f"Client {client_name} forcibly disconnected.")
            break
```

Split Fed Mechanism Server Side

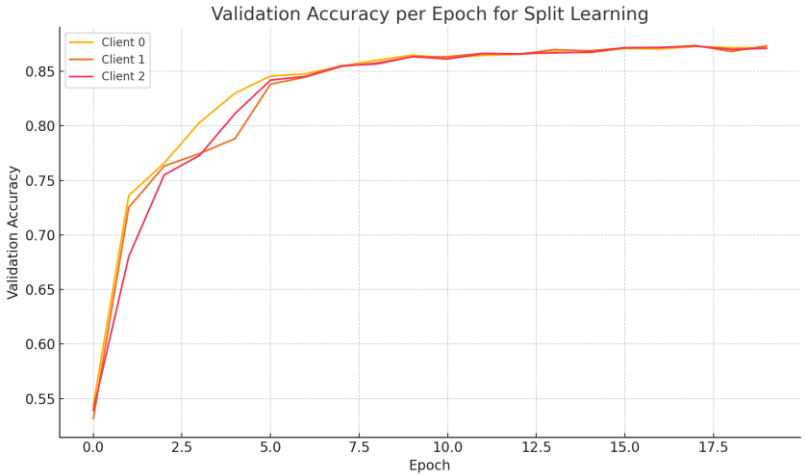
```
if msg.message_type == MessageType.REQUEST_TO_SEND_FILE:
    labels_path = msg.content
    receive_file(client_socket, specific_client_file_directory_path, labels_pat
    slt_message = receive_message_as_json(client_socket)
    if slt_message.message_type == MessageType.REQUEST_TO_SEND_FILE:
        slt_path = slt_message.content
        receive_file(client_socket, specific_client_file_directory_path, slt_pa
        labels = torch.load(f"{specific_client_file_directory_path}/{labels_pat
        split_layer_tensor = torch.load(f"{specific_client_file_directory_path}

        server_optimizer.zero_grad()
        server_output = server_model(split_layer_tensor)
        loss = loss_criteria(server_output, labels)

        # print to log file
        with open(f"shared_files/server/{server_log_file}", "a") as log_file:
            log_file.write(f"{clients_nos[client_name]},{labels_path},loss,{los

        loss.backward()
        server_optimizer.step()
        split_layer_tensor.retain_grad()
        torch.save(split_layer_tensor.grad, f"{specific_client_file_directory_p

        send_file(client_socket, specific_client_file_directory_path, file_path: f
    else:
        print("Invalid message 1.")
```

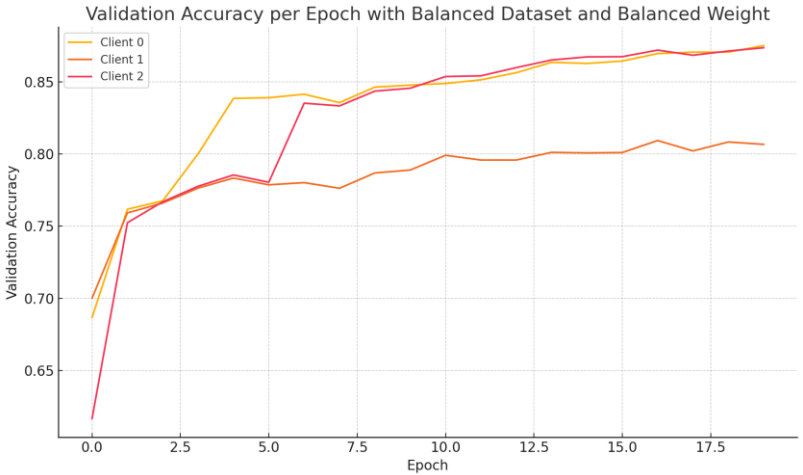
Split Fed Mechanism – Client Side (Model Aggregation)

```python
def communicate_with_fed_server(client_model, epoch, validation_loader=None):
    global client_socket
    if validation_loader:...

    if epoch == -1:...

    else:
        torch.save(client_model.state_dict(), f"{client_file_directory_path}/client_model_{e
        send_file(client_socket, client_file_directory_path, file_path: f"client_model_{epoch}.

        while True:
            message = receive_message_as_json(client_socket)
            file_path = None
            if message.message_type == MessageType.VALIDATION_DONE:
                print(f"Validation {epoch}: {message.content}")
                send_message_as_json(client_socket, MessageType.VALIDATION_RECEIVED, UNIQUE_
                # print(f"Waiting for aggregated model for epoch {epoch}")
                time.sleep(5)
                while True:
                    send_message_as_json(client_socket, MessageType.REQUEST_FOR_AGGREGATED_M
                    resp = receive_message_as_json(client_socket)
                    if resp.message_type == MessageType.SEND_AGGREGATED_MODEL:
                        file_path = resp.content
                        receive_file(client_socket, server_file_directory_path, file_path)

                        client_model.load_state_dict(torch.load(f"{server_file_directory_pat

                        break
                    else:
                        time.sleep(2)
                break
```

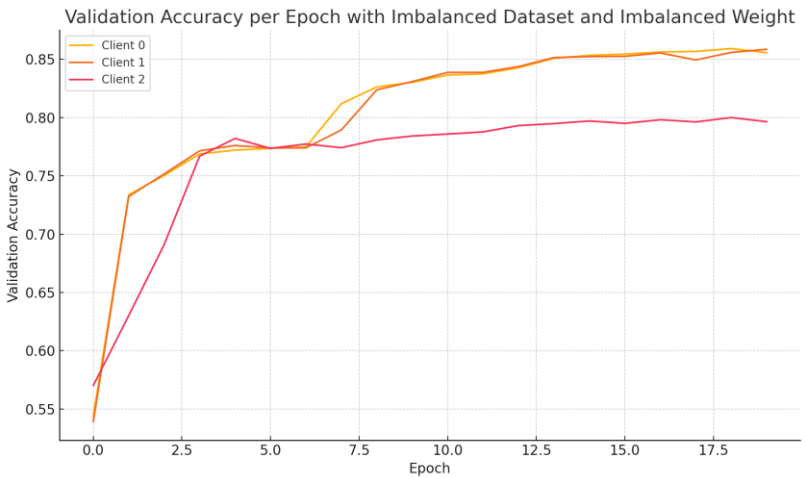
```
        elif msg.message_type == MessageType.REQUEST_FOR_AGGREGATED_MODEL:
            epoch = int(msg.content)
            with epoch_count_lock:
                if CLIENT_EPOCH_COUNT[epoch] == TOTAL_CLIENTS:
                    send_fed_avg_model_to_clients(client_socket, epoch)
                else:...
        else:...
    except ConnectionResetError:...

def send_fed_avg_model_to_clients(client_socket, epoch, send = True):
    global clients, clients_lock, AGGREGATION_DONE
    if not AGGREGATION_DONE[epoch]:
        fed_avg_model = get_fed_avg_model(epoch)
        torch.save(fed_avg_model.state_dict(), f"shared_files/server/fed_avg_model_{epoch}.pt")
        AGGREGATION_DONE[epoch] = True
    if send:
        send_file(client_socket, directory_path: "shared_files/server", file_path: f"fed_avg_model_{epoch}.pt", MessageType.SEND_AGGREGATED_MODEL)

def get_fed_avg_model(epoch):
    global device, CLIENT_WEIGHT, CLIENT_MODEL_PATHS, TOTAL_CLIENTS
    fed_avg_client_model = ClientModel().to(device)
    for i in range(TOTAL_CLIENTS):
        temp_client_model = ClientModel().to(device)
        temp_client_model.load_state_dict(torch.load(CLIENT_MODEL_PATHS[i][epoch]))
        for fed_avg_param, client_param in zip(fed_avg_client_model.parameters(), temp_client_model.parameters()):
            fed_avg_param.data += client_param.data * CLIENT_WEIGHT[i]
    return fed_avg_client_model
```

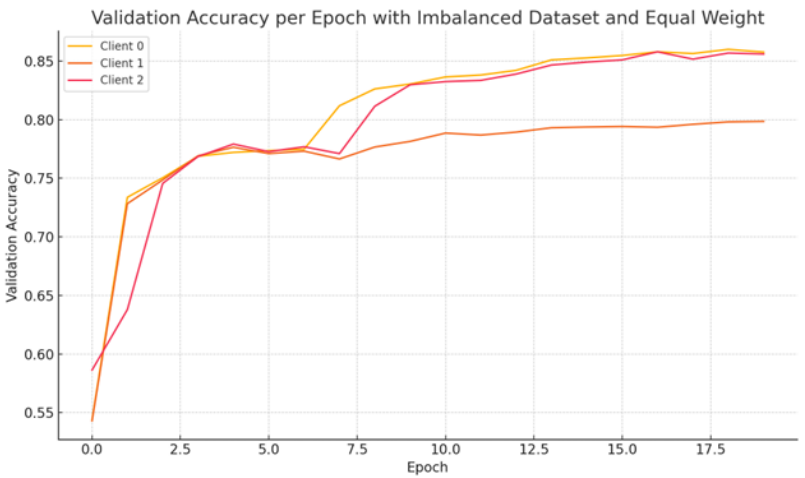
Split Fed Mechanism – Client Side (Model Aggregation)



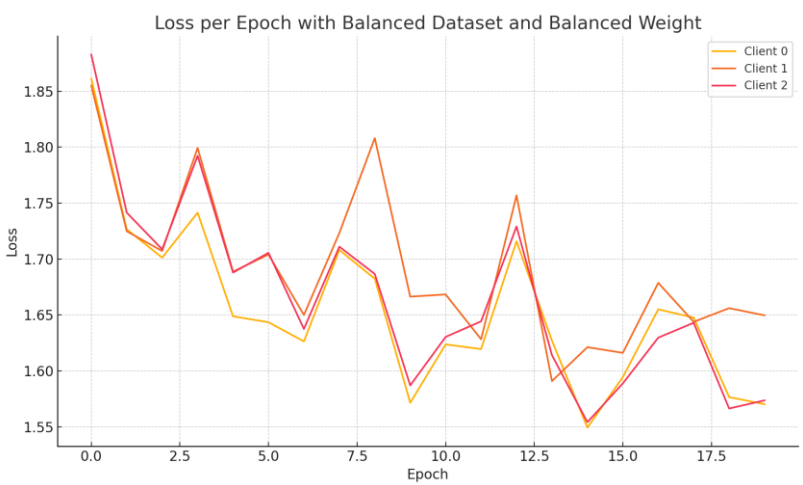


Results: Validation Accuracy

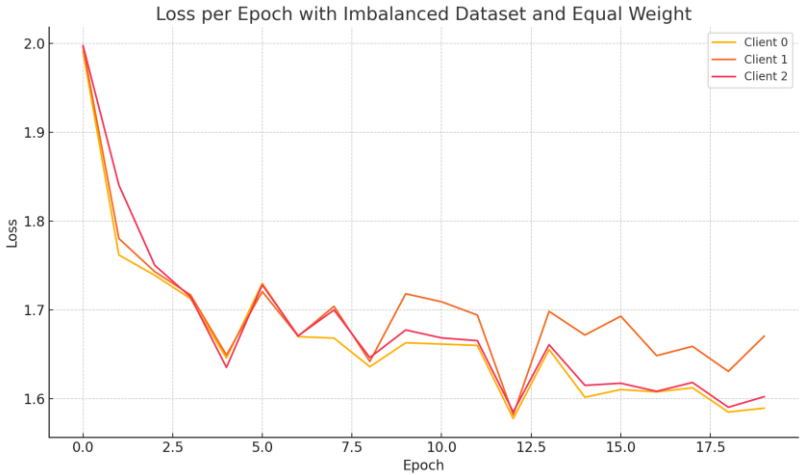


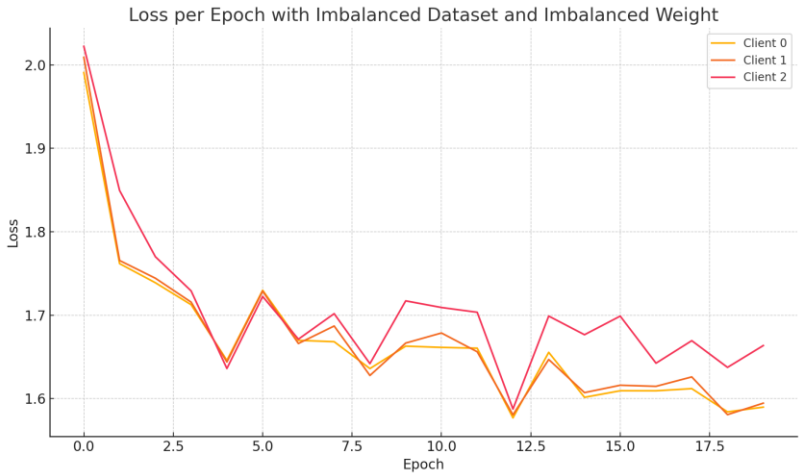


Results: Validation Accuracy

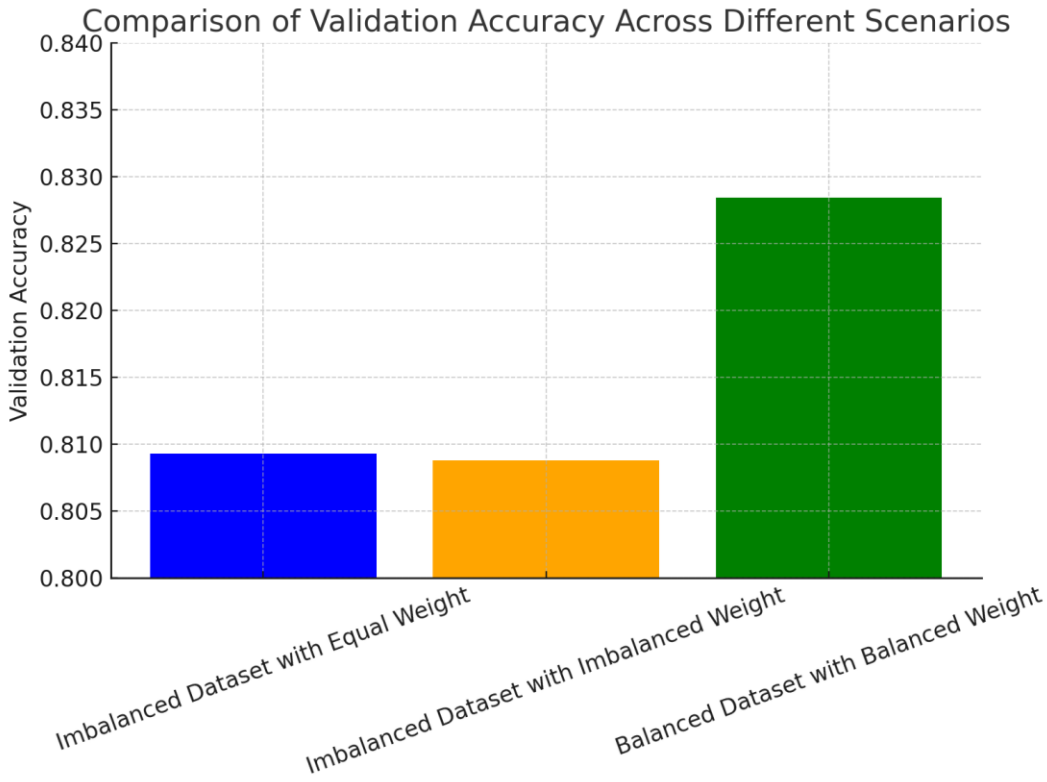


Results: Loss





Results: Loss



Results: Validation Accuracy

Further Experimentation

With more clients and Sophisticate Model

Giving weight based on the dataset instead of just dataset size.

Avoiding laggy clients

Thank You

HTTPS://GITHUB.COM/EZMATA-101/SFL