These is the test result of round 1/5. During the federated learning process, each client trains its own local model on a subset of the data for several epochs. In this case, five clients each trained their model over five epochs, processing small batches of data at each step. The training loss, which measures how far the model's predictions are from the actual labels, started relatively high (around 0.75) and gradually decreased with each epoch. This decline in loss indicates that the models were successfully learning patterns in the data, improving their ability to classify network traffic as either normal or indicative of an attack. After each client completed its local training, the model parameters (weights) from all clients were averaged to create a new, aggregated global model.

Following the aggregation, the updated global model was tested on a separate set of data that the clients had not seen during training. The evaluation showed an average test loss of 0.0090 and an accuracy of 80.83%, meaning the model correctly classified about 81% of the test samples. This result suggests that the federated learning process not only allowed individual clients to learn effectively from their local data but also enabled the global model to generalize well to unseen data. The steady decrease in loss and relatively high test accuracy reflect that the model is performing well at identifying patterns associated with normal and attack traffic across different clients and data splits.

```
Dataset created and saved to 'network_traffic.csv'
Training client 1/5 for round 1/5
Client 1, Epoch 1/5, Batch 1, Loss: 0.7557
Client 1, Epoch 1/5, Batch 2, Loss: 0.7285
Client 1, Epoch 1/5, Batch 3, Loss: 0.7201
Client 1, Epoch 1/5, Batch 4, Loss: 0.7028
Client 1, Epoch 1/5, Batch 5, Loss: 0.6936
Client 1, Epoch 1/5, Average Loss: 0.0600
Client 1, Epoch 2/5, Batch 1, Loss: 0.6900
Client 1, Epoch 2/5, Batch 2, Loss: 0.6792
Client 1, Epoch 2/5, Batch 3, Loss: 0.6657
Client 1, Epoch 2/5, Batch 4, Loss: 0.6772
Client 1, Epoch 2/5, Batch 5, Loss: 0.6648
Client 1, Epoch 2/5, Average Loss: 0.0563
Client 1, Epoch 3/5, Batch 1, Loss: 0.6478
Client 1, Epoch 3/5, Batch 2, Loss: 0.6496
Client 1, Epoch 3/5, Batch 3, Loss: 0.6364
Client 1, Epoch 3/5, Batch 4, Loss: 0.6311
Client 1, Epoch 3/5, Batch 5, Loss: 0.6486
Client 1, Epoch 3/5, Average Loss: 0.0536
Client 1, Epoch 4/5, Batch 1, Loss: 0.5986
Client 1, Epoch 4/5, Batch 2, Loss: 0.6281
Client 1, Epoch 4/5, Batch 3, Loss: 0.6107
Client 1, Epoch 4/5, Batch 4, Loss: 0.6218
Client 1, Epoch 4/5, Batch 5, Loss: 0.6196
Client 1, Epoch 4/5, Average Loss: 0.0513
Client 1, Epoch 5/5, Batch 1, Loss: 0.5833
Client 1, Epoch 5/5, Batch 2, Loss: 0.5928
Client 1, Epoch 5/5, Batch 3, Loss: 0.5845
Client 1, Epoch 5/5, Batch 4, Loss: 0.6010
Client 1, Epoch 5/5, Batch 5, Loss: 0.6164
Client 1, Epoch 5/5, Average Loss: 0.0496
```

```
Training client 2/5 for round 1/5
Client 2, Epoch 1/5, Batch 1, Loss: 0.7392
Client 2, Epoch 1/5, Batch 2, Loss: 0.7355
Client 2, Epoch 1/5, Batch 3, Loss: 0.7217
Client 2, Epoch 1/5, Batch 4, Loss: 0.7122
Client 2, Epoch 1/5, Batch 5, Loss: 0.6967
Client 2, Epoch 1/5, Average Loss: 0.0601
Client 2, Epoch 2/5, Batch 1, Loss: 0.6958
Client 2, Epoch 2/5, Batch 2, Loss: 0.6787
Client 2, Epoch 2/5, Batch 3, Loss: 0.6737
Client 2, Epoch 2/5, Batch 4, Loss: 0.6703
Client 2, Epoch 2/5, Batch 5, Loss: 0.6499
Client 2, Epoch 2/5, Average Loss: 0.0561
Client 2, Epoch 3/5, Batch 1, Loss: 0.6506
Client 2, Epoch 3/5, Batch 2, Loss: 0.6589
Client 2, Epoch 3/5, Batch 3, Loss: 0.6074
Client 2, Epoch 3/5, Batch 4, Loss: 0.6240
Client 2, Epoch 3/5, Batch 5, Loss: 0.6077
Client 2, Epoch 3/5, Average Loss: 0.0525
Client 2, Epoch 4/5, Batch 1, Loss: 0.6366
Client 2, Epoch 4/5, Batch 2, Loss: 0.5988
Client 2, Epoch 4/5, Batch 3, Loss: 0.5897
Client 2, Epoch 4/5, Batch 4, Loss: 0.5964
Client 2, Epoch 4/5, Batch 5, Loss: 0.6159
Client 2, Epoch 4/5, Average Loss: 0.0506
Client 2, Epoch 5/5, Batch 1, Loss: 0.5950
Client 2, Epoch 5/5, Batch 2, Loss: 0.5830
Client 2, Epoch 5/5, Batch 3, Loss: 0.5716
Client 2, Epoch 5/5, Batch 4, Loss: 0.6101
Client 2, Epoch 5/5, Batch 5, Loss: 0.5590
Client 2, Epoch 5/5, Average Loss: 0.0486
```

```
Training client 3/5 for round 1/5
Client 3, Epoch 1/5, Batch 1, Loss: 0.7549
Client 3, Epoch 1/5, Batch 2, Loss: 0.7314
Client 3, Epoch 1/5, Batch 3, Loss: 0.7142
Client 3, Epoch 1/5, Batch 4, Loss: 0.6881
Client 3, Epoch 1/5, Batch 5, Loss: 0.7075
Client 3, Epoch 1/5, Average Loss: 0.0599
Client 3, Epoch 2/5, Batch 1, Loss: 0.6851
Client 3, Epoch 2/5, Batch 2, Loss: 0.6918
Client 3, Epoch 2/5, Batch 3, Loss: 0.6800
Client 3, Epoch 2/5, Batch 4, Loss: 0.6694
Client 3, Epoch 2/5, Batch 5, Loss: 0.6670
Client 3, Epoch 2/5, Average Loss: 0.0566
Client 3, Epoch 3/5, Batch 1, Loss: 0.6553
Client 3, Epoch 3/5, Batch 2, Loss: 0.6485
Client 3, Epoch 3/5, Batch 3, Loss: 0.6355
Client 3, Epoch 3/5, Batch 4, Loss: 0.6366
Client 3, Epoch 3/5, Batch 5, Loss: 0.6387
Client 3, Epoch 3/5, Average Loss: 0.0536
Client 3, Epoch 4/5, Batch 1, Loss: 0.5960
Client 3, Epoch 4/5, Batch 2, Loss: 0.6029
Client 3, Epoch 4/5, Batch 3, Loss: 0.5867
Client 3, Epoch 4/5, Batch 4, Loss: 0.6120
Client 3, Epoch 4/5, Batch 5, Loss: 0.5917
Client 3, Epoch 4/5, Average Loss: 0.0498
Client 3, Epoch 5/5, Batch 1, Loss: 0.5736
Client 3, Epoch 5/5, Batch 2, Loss: 0.5340
Client 3, Epoch 5/5, Batch 3, Loss: 0.5796
Client 3, Epoch 5/5, Batch 4, Loss: 0.5853
Client 3, Epoch 5/5, Batch 5, Loss: 0.5912
Client 3, Epoch 5/5, Average Loss: 0.0477
```

```
Training client 3/5 for round 1/5
Client 3, Epoch 1/5, Batch 1, Loss: 0.7549
Client 3, Epoch 1/5, Batch 2, Loss: 0.7314
Client 3, Epoch 1/5, Batch 3, Loss: 0.7142
Client 3, Epoch 1/5, Batch 4, Loss: 0.6881
Client 3, Epoch 1/5, Batch 5, Loss: 0.7075
Client 3, Epoch 1/5, Average Loss: 0.0599
Client 3, Epoch 2/5, Batch 1, Loss: 0.6851
Client 3, Epoch 2/5, Batch 2, Loss: 0.6918
Client 3, Epoch 2/5, Batch 3, Loss: 0.6800
Client 3, Epoch 2/5, Batch 4, Loss: 0.6694
Client 3, Epoch 2/5, Batch 5, Loss: 0.6670
Client 3, Epoch 2/5, Average Loss: 0.0566
Client 3, Epoch 3/5, Batch 1, Loss: 0.6553
Client 3, Epoch 3/5, Batch 2, Loss: 0.6485
Client 3, Epoch 3/5, Batch 3, Loss: 0.6355
Client 3, Epoch 3/5, Batch 4, Loss: 0.6366
Client 3, Epoch 3/5, Batch 5, Loss: 0.6387
Client 3, Epoch 3/5, Average Loss: 0.0536
Client 3, Epoch 4/5, Batch 1, Loss: 0.5960
Client 3, Epoch 4/5, Batch 2, Loss: 0.6029
Client 3, Epoch 4/5, Batch 3, Loss: 0.5867
Client 3, Epoch 4/5, Batch 4, Loss: 0.6120
Client 3, Epoch 4/5, Batch 5, Loss: 0.5917
Client 3, Epoch 4/5, Average Loss: 0.0498
Client 3, Epoch 5/5, Batch 1, Loss: 0.5736
Client 3, Epoch 5/5, Batch 2, Loss: 0.5340
Client 3, Epoch 5/5, Batch 3, Loss: 0.5796
Client 3, Epoch 5/5, Batch 4, Loss: 0.5853
Client 3, Epoch 5/5, Batch 5, Loss: 0.5912
Client 3, Epoch 5/5, Average Loss: 0.0477
```

```
Training client 4/5 for round 1/5
Client 4, Epoch 1/5, Batch 1, Loss: 0.7513
Client 4, Epoch 1/5, Batch 2, Loss: 0.7355
Client 4, Epoch 1/5, Batch 3, Loss: 0.7215
Client 4, Epoch 1/5, Batch 4, Loss: 0.7080
Client 4, Epoch 1/5, Batch 5, Loss: 0.6923
Client 4, Epoch 1/5, Average Loss: 0.0601
Client 4, Epoch 2/5, Batch 1, Loss: 0.6866
Client 4, Epoch 2/5, Batch 2, Loss: 0.6795
Client 4, Epoch 2/5, Batch 3, Loss: 0.6715
Client 4, Epoch 2/5, Batch 4, Loss: 0.6643
Client 4, Epoch 2/5, Batch 5, Loss: 0.6739
Client 4, Epoch 2/5, Average Loss: 0.0563
Client 4, Epoch 3/5, Batch 1, Loss: 0.6359
Client 4, Epoch 3/5, Batch 2, Loss: 0.6408
Client 4, Epoch 3/5, Batch 3, Loss: 0.6139
Client 4, Epoch 3/5, Batch 4, Loss: 0.6297
Client 4, Epoch 3/5, Batch 5, Loss: 0.5880
Client 4, Epoch 3/5, Average Loss: 0.0518
Client 4, Epoch 4/5, Batch 1, Loss: 0.6237
Client 4, Epoch 4/5, Batch 2, Loss: 0.6136
Client 4, Epoch 4/5, Batch 3, Loss: 0.6030
Client 4, Epoch 4/5, Batch 4, Loss: 0.5928
Client 4, Epoch 4/5, Batch 5, Loss: 0.6170
Client 4, Epoch 4/5, Average Loss: 0.0508
Client 4, Epoch 5/5, Batch 1, Loss: 0.6237
Client 4, Epoch 5/5, Batch 2, Loss: 0.5931
Client 4, Epoch 5/5, Batch 3, Loss: 0.5763
Client 4, Epoch 5/5, Batch 4, Loss: 0.5435
Client 4, Epoch 5/5, Batch 5, Loss: 0.5847
Client 4, Epoch 5/5, Average Loss: 0.0487
```

```
Training client 5/5 for round 1/5
Client 5, Epoch 1/5, Batch 1, Loss: 0.7550
Client 5, Epoch 1/5, Batch 2, Loss: 0.7360
Client 5, Epoch 1/5, Batch 3, Loss: 0.7322
Client 5, Epoch 1/5, Batch 4, Loss: 0.7009
Client 5, Epoch 1/5, Batch 5, Loss: 0.7066
Client 5, Epoch 1/5, Average Loss: 0.0605
Client 5, Epoch 2/5, Batch 1, Loss: 0.7039
Client 5, Epoch 2/5, Batch 2, Loss: 0.6735
Client 5, Epoch 2/5, Batch 3, Loss: 0.6834
Client 5, Epoch 2/5, Batch 4, Loss: 0.6603
Client 5, Epoch 2/5, Batch 5, Loss: 0.6497
Client 5, Epoch 2/5, Average Loss: 0.0562
Client 5, Epoch 3/5, Batch 1, Loss: 0.6594
Client 5, Epoch 3/5, Batch 2, Loss: 0.6330
Client 5, Epoch 3/5, Batch 3, Loss: 0.6349
Client 5, Epoch 3/5, Batch 4, Loss: 0.6461
Client 5, Epoch 3/5, Batch 5, Loss: 0.6339
Client 5, Epoch 3/5, Average Loss: 0.0535
Client 5, Epoch 4/5, Batch 1, Loss: 0.6289
Client 5, Epoch 4/5, Batch 2, Loss: 0.6272
Client 5, Epoch 4/5, Batch 3, Loss: 0.6023
Client 5, Epoch 4/5, Batch 4, Loss: 0.6327
Client 5, Epoch 4/5, Batch 5, Loss: 0.5845
Client 5, Epoch 4/5, Average Loss: 0.0513
Client 5, Epoch 5/5, Batch 1, Loss: 0.5866
Client 5, Epoch 5/5, Batch 2, Loss: 0.5539
Client 5, Epoch 5/5, Batch 3, Loss: 0.5974
Client 5, Epoch 5/5, Batch 4, Loss: 0.5707
Client 5, Epoch 5/5, Batch 5, Loss: 0.5647
Client 5, Epoch 5/5, Average Loss: 0.0479
Round 1/5 completed.
Test set: Average loss: 0.0090, Accuracy: 2425/3000 (80.83%)
DDoS Detection Average Loss: 0.5818
Training client 1/5 for round 2/5
```