SecDefender: Detecting Low-Quality Models in Multidomain Federated Learning Systems

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Additional Experimental Results

A Model Architecture Used

Table 1 presents the model architectures employed in our experiments and the respective datasets. Additionally, we provide the hyperparameters utilized for each dataset.

Table 1: Model Architecture for six different datasets

Dataset	**Model Structure**
HAR	FC (561x1128) FC+Relu (128/6)
Fashion-MNIST	Conv+BN+Relu (5x1x16), MaxPool (2x2) Conv+BN+Relu (5x16x32), MaxPool (2x2), FC (1568/10)
FEDMNIST MNIST	Conv+BN+Relu (5x1x32), MaxPool (2x2) Conv+BN+Relu (5x32x64), MaxPool(2x2) FC (3136/10)
GTSR	Conv+Relu (3x3x32), MaxPool (2x2), Conv+Relu (3x32x64), MaxPool (2x2) FC+Relu (2304/128), FC (128/10)
CIC-Darknet2020	FC+Relu (79/64), FC+Relu (64/32), FC (32/4)

B Impact of the poisoning with and without SecDefender

The tables from 2 to 7 show the attack success rates (ASR) and target misclassification rates (TMR) of the model performance on the selected datasets under various attack scenarios without the SecDefender method. Similarly, the tables from 8 to 13 show the attack success rates (ASR) and target misclassification rates (TMR) of the performance effectiveness of SecDefender on the datasets under different defense scenarios.

Table 2: Evaluation of the impact of full-round targeted label flipping attacks. The table compares attack success rates (ASR) for various LF scenarios.

$nLF \rightarrow$		Single-label				Double-label				Triple-label			
$Att_{ratio}\% \downarrow$	$m \downarrow$	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST
0	0	0.1656	2.442	0.309	0.526	0.1656	4.116	0.209	0.41	0.1656	7.407	0.308	0.314
10%	1	0.1633	2.941	0.372	0.526	0.1628	4.342	0.362	0.387	0.1624	7.6	0.351	0.354
	2	0.1644	2.812	0.397	0.626	0.1633	4.504	0.409	0.437	0.1627	7.941	0.371	0.407
	3	0.1644	3.098	0.477	0.724	0.1633	4.759	0.472	0.502	0.1629	7.801	0.403	0.442
20%	1	0.1633	3.215	0.395	0.603	0.1628	4.655	0.388	0.437	0.1629	7.771	0.369	0.399
	2	0.1644	3.206	0.474	0.748	0.1633	4.837	0.481	0.509	0.1631	7.939	0.421	0.469
	3	0.1644	3.705	0.531	0.839	0.1636	5.051	0.546	0.615	0.1631	8.265	0.496	0.583
30%	1	0.1633	3.25	0.419	0.606	0.1628	4.932	0.413	0.441	0.1631	8.013	0.388	0.386
	2	0.1644	3.581	0.493	0.847	0.1636	5.412	0.526	0.543	0.1633	8.425	0.431	0.546
	3	0.1644	4.16	0.609	1.065	0.1636	5.668	0.583	0.691	0.1633	8.272	0.517	0.748
40%	1	0.1633	3.49	0.433	0.71	0.1628	4.966	0.458	0.442	0.1632	8.187	0.401	0.421
	2	0.1644	4.382	0.524	0.968	0.1636	5.737	0.542	0.594	0.1635	8.939	0.4378	0.647
	3	0.1655	5.047	0.709	1.2	0.1636	6.549	0.659	0.72	0.1632	9.557	0.6196	1.013
50%	1	0.1633	3.797	0.423	0.755	0.1631	5.541	0.475	0.513	0.1634	8.498	0.419	0.445
	2	0.1644	4.886	0.611	1.007	0.1636	5.736	0.588	0.658	0.1632	9.286	0.529	0.711
	3	0.1655	5.825	0.838	1.245	0.1636	7.388	0.803	0.797	0.1632	10.049	0.674	1.103

Table 3: Evaluation of the impact of mid-round targeted label flipping attacks. The table compares attack success rates (ASR) for various LF scenarios.

$nLF \rightarrow$		Single-label				Double-label				Triple-label			
$Att_{ratio}\% \downarrow$	$m \downarrow$	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST
0	0	0.1656	2.442	0.309	0.526	0.1656	4.116	0.209	0.41	0.1656	7.407	0.308	0.314
10%	1	0.1622	2.458	0.335	0.526	0.1628	4.11	0.327	0.409	0.1624	7.275	0.324	0.377
	2	0.1622	2.729	0.373	0.521	0.1628	4.201	0.351	0.407	0.1624	7.364	0.344	0.371
	3	0.1622	2.519	0.399	0.553	0.1628	4.241	0.369	0.4562	0.1624	7.371	0.37	0.389
20%	1	0.1622	2.552	0.350	0.537	0.1628	4.21	0.335	0.412	0.1624	7.381	0.331	0.368
	2	0.1622	2.608	0.390	0.554	0.1628	4.241	0.365	0.420	0.1624	7.304	0.361	0.375
	3	0.1622	2.4345	0.438	0.6495	0.1628	4.175	0.401	0.495	0.1624	7.372	0.397	0.407
30%	1	0.1622	2.644	0.360	0.562	0.1628	4.089	0.342	0.412	0.1624	7.280	0.339	0.362
	2	0.1622	2.714	0.402	0.579	0.1628	4.241	0.385	0.459	0.1624	7.408	0.377	0.385
	3	0.1622	2.598	0.463	0.708	0.1628	4.098	0.435	0.5102	0.1624	7.372	0.4102	0.436
40%	1	0.1622	2.593	0.368	0.536	0.1628	4.211	0.347	0.418	0.1624	7.202	0.348	0.368
	2	0.1622	2.574	0.424	0.655	0.1628	4.151	0.406	0.473	0.1624	7.338	0.393	0.410
	3	0.1622	2.581	0.504	0.755	0.1628	4.272	0.454	0.566	0.1624	7.357	0.448	0.481
50%	1	0.1622	2.626	0.374	0.555	0.1628	4.197	0.361	0.429	0.1624	7.376	0.354	0.381
	2	0.1622	2.583	0.449	0.707	0.1628	4.166	0.415	0.663	0.1624	7.199	0.406	0.436
	3	0.1622	2.653	0.565	0.867	0.1628	4.085	0.473	0.615	0.1624	7.378	0.481	0.513

Table 4: Evaluation of the impact of end-round targeted label flipping attacks. The table compares attack success rates (ASR) for various LF scenarios.

$nLF \rightarrow$		Single-label				Double-label				Triple-label			
$Att_{ratio}\% \downarrow$	$m \downarrow$	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST
0	0	0.1656	2.442	0.309	0.526	0.1656	4.116	0.209	0.41	0.1656	7.407	0.308	0.314
10%	1	0.1622	2.601	0.343	0.529	0.1628	4.098	0.323	0.43	0.1624	7.293	0.322	0.378
	2	0.1622	2.741	0.371	0.582	0.1628	4.158	0.354	0.458	0.1624	7.41	0.345	0.396
	3	0.1622	2.669	0.399	0.663	0.1628	4.078	0.381	0.522	0.1624	7.353	0.370	0.395
20%	1	0.1622	2.739	0.351	0.526	0.1628	4.203	0.334	0.438	0.1624	7.195	0.333	0.379
	2	0.1622	2.593	0.337	0.659	0.1628	4.115	0.374	0.475	0.1624	7.321	0.365	0.425
	3	0.1622	2.5975	0.429	0.743	0.1628	4.244	0.415	0.611	0.1624	7.35	0.397	0.460
30%	1	0.1622	2.599	0.354	0.534	0.1628	4.396	0.343	0.444	0.1624	7.199	0.340	0.383
	2	0.1622	2.568	0.406	0.681	0.1628	4.037	0.392	0.547	0.1624	7.342	0.383	0.442
	3	0.1622	2.716	0.471	0.864	0.1628	4.211	0.436	0.635	0.1624	7.243	0.428	0.487
40%	1	0.1622	2.493	0.358	0.582	0.1628	4.014	0.349	0.459	0.1624	7.279	0.345	0.394
	2	0.1622	2.501	0.422	0.764	0.1628	4.182	0.411	0.554	0.1624	7.303	0.399	0.489
	3	0.1622	2.75	0.504	0.955	0.1628	4.144	0.469	0.711	0.1624	7.247	0.452	0.585
50%	1	0.1622	2.598	0.366	0.619	0.1628	4.186	0.364	0.464	0.1624	7.389	0.355	0.396
	2	0.1622	2.589	0.458	0.828	0.1628	4.112	0.435	0.481	0.1624	7.264	0.418	0.512
	3	0.1622	2.754	0.575	1.083	0.1628	4.192	0.47	0.82	0.1624	7.391	0.489	1.013

Table 5: Evaluation of the impact of full-round targeted label flipping attacks. The table compares target misclassification rate (TMR) for various LF scenarios.

$nLF \rightarrow$		Single-label				Double-label				Triple-label			
$Att_{ratio}\% \downarrow$	$m \downarrow$	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST
0	0	0.8252	3.009	0.89	01.19	0.8252	10.558	0.949	1.06	0.8252	18.437	0.92	0.824
10%	1	0.6517	3.643	0.953	1.161	0.7135	10.87	1.009	1.017	0.7327	18.674	0.984	0.914
	2	0.6517	3.564	0.984	1.371	0.7146	10.911	1.076	1.294	0.7331	18.894	1.018	0.995
	3	0.6529	3.853	1.096	1.448	0.7144	11.204	1.155	1.161	0.7331	18.974	1.061	1.037
20%	1	0.6517	3.973	0.989	1.313	0.7133	11.144	1.055	1.078	0.7336	18.802	1.013	0.964
	2	0.6529	3.965	1.095	1.456	0.7143	11.328	1.102	1.141	0.7325	18.946	1.089	1.136
	3	0.654	4.472	1.173	1.629	0.7149	11.704	1.256	1.274	0.7332	19.554	1.172	1.279
30%	1	0.6514	4.022	1.021	1.313	0.7129	11.557	1.094	1.078	0.7338	19.281	1.042	1.033
	2	0.6555	4.344	1.129	1.548	0.7143	11.948	1.243	1.182	0.7319	19.592	1.1	1.252
	3	0.6547	5.124	1.28	1.806	0.715	12.435	1.306	1.373	0.7324	19.604	1.219	1.508
40%	1	0.6536	4.25	1.051	1.433	0.7138	11.643	1.143	1.087	0.7332	19.432	1.062	1.04
	2	0.6569	5.157	1.172	1.747	0.7136	12.391	1.267	1.271	0.7372	20.205	1.166	1.393
	3	0.658	6.018	1.41	2.005	0.713	13.583	1.407	1.461	0.73	20.563	1.335	1.835
50%	1	0.6551	4.661	1.066	1.465	0.7151	12.492	1.185	1.165	0.7323	19.618	1.089	1.107
	2	0.6577	5.938	1.284	1.713	0.7138	12.391	1.337	1.361	0.7298	20.576	1.23	1.466
	3	0.6599	6.859	1.567	2.073	0.7135	14.673	1.571	1.522	0.7274	21.375	1.407	1.813

Table 6: Evaluation of the impact of mid-round targeted label flipping attacks. The table compares target misclassification rate (TMR) for various LF scenarios.

$nLF \rightarrow$		Single-label				Double-label				Triple-label			
$Att_{ratio}\% \downarrow$	$m \downarrow$	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST
0	0	0.8252	3.009	0.89	01.19	0.8252	10.558	0.949	1.06	0.8252	18.437	0.92	0.824
10%	1	0.6506	3.015	0.908	1.195	0.7136	10.34	0.975	1.019	0.7329	18.387	0.943	0.963
	2	0.6506	3.345	0.944	1.216	0.7136	10.403	1.002	1.036	0.7329	18.414	0.971	0.953
	3	0.6506	3.083	0.973	1.273	0.7136	10.570	1.028	1.127	0.7329	18.374	1.001	0.976
20%	1	0.6506	3.181	0.923	1.234	0.7136	10.615	0.986	1.053	0.7329	18.441	0.954	0.958
	2	0.6506	3.213	0.964	1.259	0.7136	10.57	1.027	1.058	0.7329	18.369	0.996	0.974
	3	0.6506	3.321	1.018	1.398	0.7136	10.594	1.077	1.139	0.7329	18.401	1.042	0.979
30%	1	0.6506	3.222	0.934	1.252	0.7136	10.478	0.999	1.05	0.7329	18.330	0.966	0.932
	2	0.6506	3.306	0.975	1.304	0.7136	10.57	1.06	1.111	0.7329	18.548	1.019	0.964
	3	0.6506	3.159	1.05	1.405	0.7142	10.365	1.121	1.171	0.7329	18.401	1.064	1.021
40%	1	0.6506	3.152	0.945	1.223	0.7136	10.485	1.008	1.055	0.7329	18.353	0.979	0.9765
	2	0.6506	3.147	1.009	1.363	0.7147	10.526	1.089	1.12	0.7329	18.376	1.04	1.015
	3	0.6506	3.012	1.09	1.462	0.7142	10.542	1.156	1.212	0.7323	18.328	1.11	1.077
50%	1	0.6506	3.19	0.946	1.215	0.7136	10.561	1.031	1.058	0.7329	18.53	0.990	0.989
	2	0.6506	3.197	1.032	1.442	0.7152	10.544	1.106	1.368	0.7327	18.146	1.06	1.037
	3	0.6506	3.221	1.169	1.597	0.7149	10.427	1.176	1.273	0.7314	18.529	1.152	1.114

Table 7: Evaluation of the impact of end-round targeted label flipping attacks. The table compares target misclassification rate (TMR) for various LF scenarios.

$nLF \rightarrow$		Single-label				Double-label				Triple-label			
$Att_{ratio}\% \downarrow$	$m \downarrow$	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST
0	0	0.8252	3.009	0.89	01.19	0.8252	10.558	0.949	1.06	0.8252	18.437	0.92	0.824
10%	1	0.6506	3.162	0.919	1.269	0.7136	10.399	0.973	1.001	0.7329	18.441	0.943	0.967
	2	0.6506	3.379	0.945	1.263	0.7136	10.564	1.008	1.106	0.7329	18.373	0.977	0.985
	3	0.6506	3.216	0.976	1.407	0.7136	10.391	1.042	1.219	0.7329	18.427	1.101	0.996
20%	1	0.6506	3.302	0.928	1.254	0.7136	10.553	0.990	1.102	0.7329	18.262	0.957	1.006
	2	0.6506	3.153	0.955	1.389	0.7136	10.505	1.037	1.155	0.7329	18.348	1.004	1.018
	3	0.6506	3.159	1.013	1.496	0.7136	10.601	1.091	1.288	0.7329	18.292	1.044	1.065
30%	1	0.6506	3.245	0.931	1.26	0.7136	10.372	1.006	1.0937	0.7329	18.292	0.971	0.974
	2	0.6506	3.13	0.988	1.442	0.7136	10.322	1.068	1.234	0.7327	18.444	1.031	1.046
	3	0.6506	3.282	1.068	1.644	0.7103	10.631	1.13	1.323	0.7316	18.388	1.082	1.100
40%	1	0.6506	3.052	0.935	1.308	0.7136	10.381	1.015	1.118	0.7329	18.299	0.981	1.009
	2	0.6506	3.102	1.009	1.523	0.735	10.464	1.096	1.212	0.7305	18.391	0.995	1.016
	3	0.6506	3.306	1.103	1.75	0.7103	10.506	1.176	1.398	0.7305	18.391	1.11	1.23
50%	1	0.6506	3.201	0.943	1.327	0.7136	10.588	1.040	1.131	0.7329	18.307	0.995	1.016
	2	0.6506	3.14	1.052	1.589	0.7124	10.502	1.135	1.151	0.7306	18.411	1.072	1.142
	3	0.6506	3.307	1.188	1.881	0.7082	10.592	1.18	1.528	0.7286	18.445	1.156	1.803

Table 8: Evaluation of the effectiveness of SecDefender against full-round targeted label flipping attacks. The table compares attack success rates (ASR) for various LF scenarios.

$nLF \rightarrow$		Single-label				Double-label				Triple-label			
$Att_{ratio}\% \downarrow$	$m \downarrow$	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST
0	0	0.1656	2.442	0.309	0.526	0.1656	4.116	0.209	0.41	0.1656	7.407	0.308	0.314
10%	1	0.1572	2.482	0.295	0.479	0.1541	4.209	0.286	0.369	0.1508	7.6	0.308	0.336
	2	0.1577	2.508	0.330	0.532	0.1541	4.221	0.310	0.378	0.1514	7.435	0.316	0.35
	3	0.1578	2.758	0.346	0.571	0.1544	4.467	0.342	0.388	0.1515	7.891	0.354	0.343
20%	1	0.1572	2.631	0.295	0.538	0.1541	4.098	0.279	0.368	0.1510	7.473	0.310	0.329
	2	0.1578	2.651	0.327	0.58	0.1548	4.270	0.307	0.396	0.1516	7.722	0.319	0.355
	3	0.1577	2.697	0.358	0.549	0.1546	4.284	0.359	0.372	0.1523	7.702	0.355	0.354
30%	1	0.1572	2.492	0.292	0.563	0.1541	4.137	0.284	0.386	0.1511	7.45	0.309	0.353
	2	0.1578	2.686	0.349	0.603	0.1548	4.087	0.309	0.407	0.1516	7.797	0.322	0.344
	3	0.1578	2.875	0.392	0.537	0.1548	4.389	0.362	0.427	0.1525	7.721	0.338	0.362
40%	1	0.1574	2.764	0.300	0.542	0.1543	4.409	0.291	0.376	0.1488	7.41	0.311	0.351
	2	0.1593	2.692	0.334	0.602	0.1549	4.087	0.314	0.41	0.1491	7.496	0.316	0.358
	3	0.1584	2.904	0.324	0.699	0.1550	4.395	0.346	0.386	0.1494	7.958	0.323	0.354
50%	1	0.1579	2.692	0.299	0.512	0.1538	4.287	0.291	0.379	0.1488	7.526	0.310	0.358
	2	0.1584	2.620	0.338	0.561	0.1549	4.154	0.311	0.377	0.1486	7.352	0.329	0.360
	3	0.1583	3.04	0.363	0.619	0.1547	4.460	0.347	0.429	0.1493	7.999	0.315	0.377

Table 9: Evaluation of the effectiveness of SecDefender against mid-round targeted label flipping attacks. The table compares attack success rates (ASR) for various LF scenarios.

$nLF \rightarrow$		Single-label			Double-label			Triple-label		
$Att_{ratio}\% \downarrow$	$m \downarrow$	HAR	Fashion-MNIST	FEDMNIST	HAR	Fashion-MNIST	FEDMNIST	HAR	Fashion-MNIST	FEDMNIST
0	0	0.1656	2.442	0.309	0.1656	4.116	0.209	0.1656	7.407	0.308
10%	1	0.156	2.391	0.29	0.1538	4.112	0.280	0.1507	7.28	0.3
	2	0.156	2.413	0.297	0.1538	4.099	0.288	0.1507	5.411	0.305
	3	0.1559	2.497	0.313	0.1539	4.114	0.292	0.1507	7.114	0.305
20%	1	0.1559	2.413	0.289	0.1538	4.067	0.280	0.1506	7.291	0.3
	2	0.1558	2.338	0.294	0.1539	4.064	0.284	0.1506	7.278	0.302
	3	0.1558	2.364	0.325	0.1539	4.159	0.296	0.1506	7.319	0.309
30%	1	0.156	2.408	0.288	0.1538	1.195	0.28	0.1506	7.222	0.3
	2	0.1559	2.387	0.299	0.1539	4.136	0.285	0.1506	7.264	0.303
	3	0.1558	2.422	0.32	0.1539	1.235	0.298	0.1507	7.319	0.301
40%	1	0.1559	2.27	0.287	0.1538	4.108	0.280	0.1508	7.266	0.309
	2	0.1558	2.390	0.291	0.1539	4.136	0.284	0.1508	7.362	0.304
	3	0.1558	2.326	0.324	0.1539	4.086	0.289	0.1508	7.364	0.309
50%	1	0.1559	2.416	0.287	0.1538	4.106	0.280	0.1508	7.305	0.301
	2	0.1558	2.413	0.293	0.1539	4.114	0.289	0.1508	7.173	0.303
	3	0.1558	2.384	0.314	0.154	4.145	0.293	0.1508	7.286	0.303

Table 10: Evaluation of the effectiveness of SecDefender against end-round targeted label flipping attacks. The table compares attack success rates (ASR) for various LF scenarios.

$nLF \rightarrow$		Single-label			Double-label			Triple-label		
$Att_{ratio}\% \downarrow$	$m \downarrow$	HAR	Fashion-MNIST	FEDMNIST	HAR	Fashion-MNIST	FEDMNIST	HAR	Fashion-MNIST	FEDMNIST
0	0	0.1656	2.442	0.309	0.1656	4.116	0.209	0.1656	7.407	0.308
10%	1	0.1571	2.414	0.292	0.1534	4.112	0.293	0.1507	5.411	0.301
	2	0.157	2.404	0.305	0.1534	4.075	0.296	0.1507	7.362	0.307
	3	0.157	2.414	0.324	0.1535	4.15	0.298	0.1508	7.287	0.331
20%	1	0.157	2.414	0.295	0.1534	4.069	0.292	0.1507	7.145	0.303
	2	0.157	2.390	0.293	0.1535	4.036	0.295	0.1506	7.307	0.305
	3	0.157	2.414	0.325	0.1536	4.054	0.297	0.1508	7.312	0.337
30%	1	0.157	2.346	0.293	0.1534	4.058	0.293	0.1506	7.196	0.304
	2	0.157	2.398	0.309	0.1535	4.14	0.295	0.1506	7.286	0.303
	3	0.157	2.436	0.311	0.1537	4.087	0.298	0.1507	7.3	0.307
40%	1	0.156	2.397	0.239	0.1534	4.082	0.285	0.149	7.228	0.303
	2	0.1558	2.385	0.303	0.1535	4.19	0.299	0.1507	7.3	0.303
	3	0.1558	2.403	0.303	0.1537	4.095	0.33	0.1508	7.3	0.309
50%	1	0.1559	2.354	0.294	0.1534	4.11	0.291	0.1506	7.318	0.302
	2	0.1558	2.402	0.305	0.1536	4.080	0.298	0.1487	7.3	0.304
	3	0.1557	2.413	0.309	0.1538	4.067	0.3	0.1495	7.322	0.302

Table 11: Evaluation of the effectiveness of SecDefender against full-round targeted label flipping attacks. The table compares target misclassification rates (TMR) for various LF scenarios.

$nLF \rightarrow$		Single-label				Double-label				Triple-label			
$Att_{ratio}\% \downarrow$	$m \downarrow$	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST	HAR	Fashion-MNIST	FEDMNIST	MNIST
0	0	0.8252	3.009	0.89	1.19	0.8252	10.558	0.949	1.06	0.8252	18.437	0.92	0.824
10%	1	0.7617	3.148	0.868	1.24	0.7582	10.381	0.923	0.1.003	0.762	18.639	0.916	0.889
	2	0.7643	3.1	0.874	1.28	0.7577	10.439	0.959	1.013	0.763	18.238	0.933	0.959
	3	0.7643	3.512	0.851	1.376	0.7574	10.696	0.990	1.011	0.7615	18.538	0.985	0.909
20%	1	0.7621	3.405	0.865	1.3	0.7580	10.654	0.918	1.004	0.7628	18.802	0.924	0.881
	2	0.7645	3.501	0.853	1.328	0.7578	10.709	0.966	1.039	0.763	18.196	0.937	0.989
	3	0.7625	3.554	0.946	1.307	0.7563	10.787	0.98	0.975	0.7617	19.152	0.990	0.97
30%	1	0.7629	3.247	0.860	1.3	0.7565	10.622	0.922	1.023	0.7629	18.744	0.928	0.897
	2	0.7657	3.547	0.905	1.371	0.7584	10.448	0.964	1.032	0.7616	18.964	0.942	0.969
	3	0.7623	3.139	0.974	1.371	0.7559	10.795	1.030	1.075	0.7610	18.9505	0.961	0.978
40%	1	0.7634	3.581	0.868	1.311	0.7567	10.618	0.929	0.987	0.7505	18.634	0.932	0.884
	2	0.7621	3.367	0.896	1.331	0.7577	10.191	0.969	1.035	0.75	18.531	0.936	0.998
	3	0.7646	3.751	0.888	1.402	0.7564	10.69	1.012	1.005	0.7466	19.043	0.942	0.965
50%	1	0.7635	3.367	0.864	1.242	0.7549	10.401	0.934	0.990	0.7503	18.51	0.942	0.894
	2	0.7662	3.310	0.900	1.308	0.7581	10.134	0.961	1.015	0.7471	18.960	0.943	0.992
	3	0.7639	3.825	0.935	1.322	0.7560	10.727	1.02	1.067	0.7472	19.229	0.908	0.978

Table 12: Evaluation of the effectiveness of SecDefender against mid-round targeted label flipping attacks. The table compares target misclassification rates (TMR) for various LF scenarios.

$nLF \rightarrow$		Single-label			Double-label			Triple-label		
$Att_{ratio}\% \downarrow$	$m \downarrow$	HAR	Fashion-MNIST	FEDMNIST	HAR	Fashion-MNIST	FEDMNIST	HAR	Fashion-MNIST	FEDMNIST
0	0	0.8252	3.009	0.89	0.8252	10.558	0.949	0.8252	18.437	0.92
10%	1	0.7622	3.017	0.864	0.7568	10.582	0.915	0.762	18.208	0.910
	2	0.762	3.04	0.868	0.7566	10.355	0.926	0.7619	18.405	0.92
	3	0.7621	3.1	0.876	0.7569	10.378	0.907	0.7617	18.378	0.899
20%	1	0.7621	3.04	0.862	0.7568	10.287	0.916	0.7618	18.415	0.91
	2	0.7619	2.931	0.863	0.7569	10.347	0.921	0.7616	18.372	0.913
	3	0.762	3.084	0.89	0.7569	10.317	0.91	0.7616	18.485	0.909
30%	1	0.7622	3.09	0.863	0.7569	10.365	0.913	0.7617	18.297	0.91
	2	0.7619	2.962	0.866	0.7568	10.334	0.922	0.7615	18.362	0.914
	3	0.7619	2.958	0.887	0.757	10.438	0.936	0.7615	18.288	0.893
40%	1	0.7622	2.851	0.86	0.7569	10.403	0.915	0.7603	18.313	0.91
	2	0.7621	2.995	0.86	0.7567	10.334	0.299	0.7602	18.125	0.915
	3	0.7622	2.904	0.888	0.757	10.255	0.926	0.7601	18.405	0.92
50%	1	0.762	2.993	0.859	0.7569	10.219	0.916	0.7306	18.463	0.910
	2	0.762	3.04	0.859	0.7568	10.300	0.928	0.7602	18.136	0.916
	3	0.7622	2.956	0.88	0.7517	10.407	0.928	0.76	18.333	0.897

Table 13: Evaluation of the effectiveness of SecDefender against end-round targeted label flipping attacks. The table compares target misclassification rates (TMR) for various LF scenarios.

$nLF \rightarrow$		Single-label			Double-label			Triple-label		
$Att_{ratio}\% \downarrow$	$m \downarrow$	HAR	Fashion-MNIST	FEDMNIST	HAR	Fashion-MNIST	FEDMNIST	HAR	Fashion-MNIST	FEDMNIST
0	0	0.8252	3.009	0.89	0.8252	10.558	0.949	0.8252	18.437	0.92
10%	1	0.7617	3.04	0.861	0.7618	10.621	0.912	0.7619	18.4	0.916
	2	0.7617	3.01	0.871	0.7619	10.586	0.909	0.7618	18.409	0.894
	3	0.7616	3.04	0.862	0.7619	10.719	0.905	0.7618	18.402	0.891
20%	1	0.7621	3.04	0.863	0.7617	10.638	0.911	0.7618	18.119	0.91
	2	0.7615	2.995	0.827	0.7618	10.497	0.926	0.7616	18.258	0.901
	3	0.7615	3.04	0.864	0.7618	10.510	0.918	0.7616	18.3	0.921
30%	1	0.7616	2.981	0.864	0.7616	10.5	0.913	0.7617	18.193	0.909
	2	0.7614	2.973	0.870	0.7618	10.622	0.933	0.7616	18.4	0.929
	3	0.7616	3.133	0.843	0.7616	10.597	0.902	0.7614	18.4	0.9
40%	1	0.7625	3.067	0.862	0.7616	10.57	0.919	0.7526	18.44	0.901
	2	0.7621	3.1	0.864	0.7618	10.59	0.909	0.7613	18.4	0.911
	3	0.7621	2.987	0.838	0.7616	10.644	0.951	0.7609	18.4	0.926
50%	1	0.7624	2.924	0.862	0.7616	10.607	0.934	0.7613	18.3	0.91
	2	0.7622	3.06	0.87	0.7617	10.634	0.961	0.7523	18.4	0.914
	3	0.7622	2.99	0.855	0.7614	10.5	0.970	0.7535	18.4	0.903

C Hyperparameters

C.1 Analysis of hyperparameter MNIST

Table 14 comprehensively analyzes how batch size affects various performance metrics under non-IID MNIST conditions. Our findings indicate that while larger batch sizes generally enhance computational efficiency, they often degrade model performance metrics such as accuracy, F1-score, and precision. Furthermore, models trained with larger batch sizes exhibit increased vulnerability to poisoning attacks. Conversely, smaller batch sizes yield better global model performance in our benchmarks, as exemplified by the global model accuracy of 98.863% and source class recall of 97.614% achieved with a batch size of 10. These results highlight the critical role of batch size in balancing performance, efficiency, and security in federated learning systems.

Table 15 presents the influence of momentum on various performance metrics under non-IID MNIST conditions. Momentum, a hyperparameter that accelerates gradient descent, significantly impacts model performance. Our results indicate that a moderate momentum value of 0.5 or 0.6 generally yields optimal results for most metrics. A higher momentum of 0.9 can lead to performance degradation, particularly regarding source class recall (RecSc) and attack success rate (ASR). Table 16 shows the learning rate impact in the system for the MNIST dataset.

Table 14: Effect of local batch size in non-IID MNIST dataset

Metric ↓	Method ↓	Batch size		
		10	32	64
G_{Acc}	Baseline	98.731	98.386	98.130
	FedAvg	98.522	98.179	97.868
	SecDefender	**98.863**	98.458	98.167
$F1\text{-}Score$	Baseline	98.669	98.312	98.055
	FedAvg	98.463	98.134	97.814
	SecDefender	**98.851**	98.410	98.119
$Precision$	Baseline	98.786	98.416	98.141
	FedAvg	98.572	98.216	97.946
	SecDefender	**98.896**	98.440	98.193
$RecSc$	Baseline	98.094	97.559	97.213
	FedAvg	95.738	94.733	94.760
	SecDefender	**97.614**	95.568	95.302
ASR	Baseline	0.365	0.492	0.618
	FedAvg	0.857	1.432	1.624
	SecDefender	**0.449**	0.621	0.820
TMR	Baseline	0.989	1.349	1.669
	FedAvg	1.575	2.416	2.738
	SecDefender	**1.088**	1.568	1.967

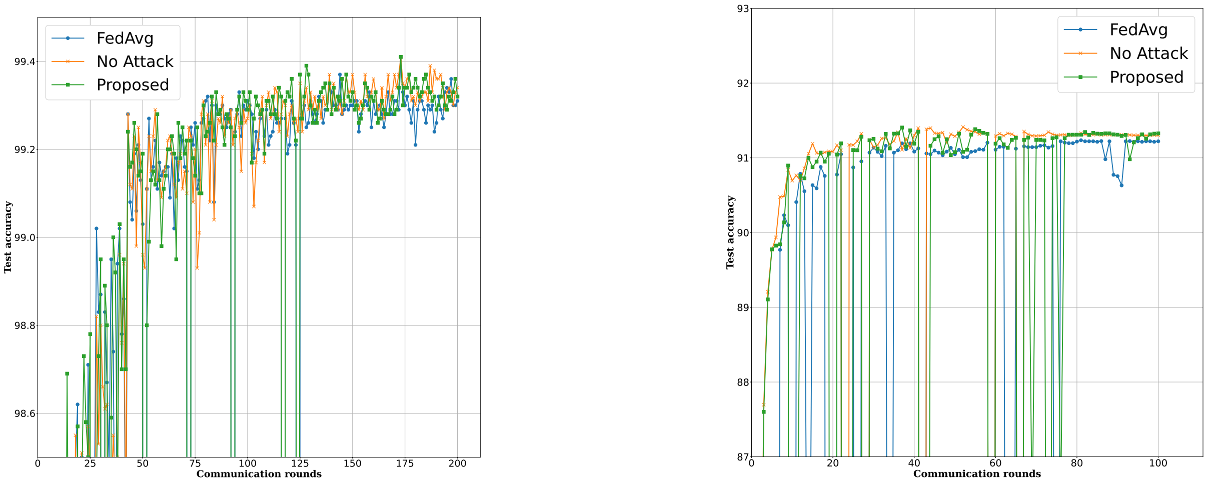
Table 15: Effect of momentum in non-IID MNIST dataset

Metric ↓	Method ↓	Momentum		
		0.5	0.6	0.9
G_{Acc}	Baseline	98.855	98.557	98.213
	FedAvg	98.820	98.557	97.774
	SecDefender	98.930	98.845	98.128
$F1\text{-}Score$	Baseline	98.795	98.504	98.161
	FedAvg	98.804	98.504	97.689
	SecDefender	98.883	98.808	98.081
$Precision$	Baseline	98.944	98.602	98.332
	FedAvg	98.853	98.602	97.854
	SecDefender	98.946	98.906	98.665
$RecSc$	Baseline	98.355	95.753	96.831
	FedAvg	95.984	95.753	93.234
	SecDefender	96.317	96.040	94.009
ASR	Baseline	0.321	0.873	0.561
	FedAvg	1.085	0.873	1.395
	SecDefender	0.3895	0.409	0.990
TMR	Baseline	0.878	1.582	1.719
	FedAvg	1.792	1.582	2.858
	SecDefender	0.983	1.058	2.159

Table 16: Effect of learning rate in non-IID MNIST dataset

Metric ↓	Method ↓	Learning rate		
		0.01	0.03	0.1
G_{Acc}	Baseline	98.875	98.299	98.855
	FedAvg	98.820	97.852	98.820
	SecDefender	98.913	98.177	98.930
$F1\text{-}Score$	Baseline	98.816	98.200	98.795
	FedAvg	98.815	97.733	98.804
	SecDefender	98.862	98.118	98.883
$Precision$	Baseline	98.889	98.311	98.944
	FedAvg	98.864	97.835	98.853
	SecDefender	98.924	98.188	98.946
$RecSc$	Baseline	98.269	97.930	98.355
	FedAvg	95.908	95.225	95.984
	SecDefender	96.192	95.392	96.317
ASR	Baseline	0.321	0.490	0.321
	FedAvg	0.840	1.074	1.085
	SecDefender	0.389	0.524	0.3895
TMR	Baseline	0.894	1.337	0.878
	FedAvg	1.694	2.433	1.792
	SecDefender	1.012	1.982	0.983

D Miscellaneous Figures



(a) MNIST dataset

(b) CIC-Darknet2020 dataset

Figure 1: Visualizing the performance comparison of a malicious client (one malicious) under various experimental conditions, no attack (baseline), attack without defense (FedAvg), and attack with defense (SecDefender).

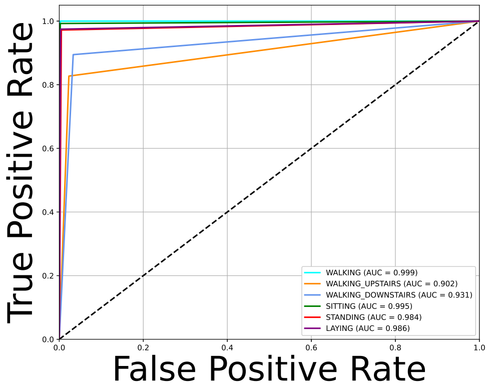


Figure 2: HAR Dataset

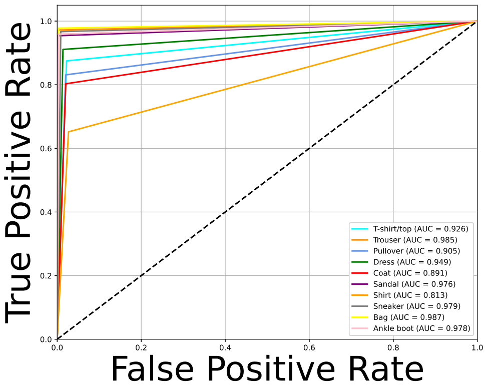


Figure 3: Fashion MNIST

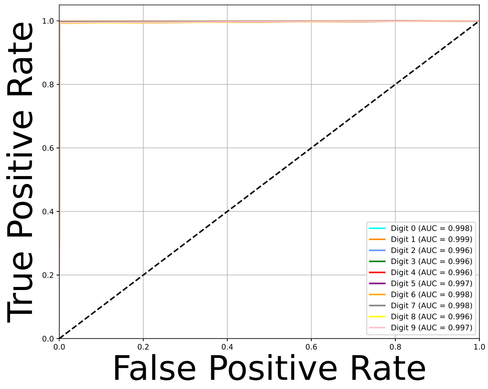


Figure 4: FEDMNIST

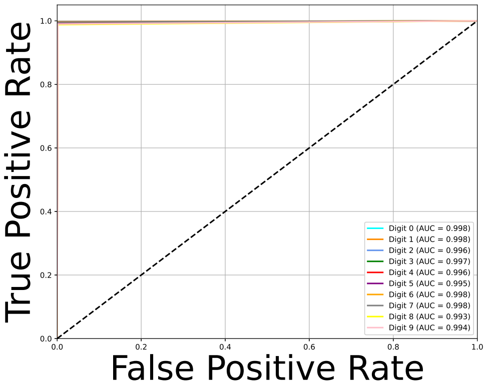


Figure 5: MNIST

Figure 6: SecDefender AUC-ROC Curve based on various datasets in the full-round attack scenario under IID conditions. In the extreme attack scenario with three malicious participants performing a triple-label flipping attack, 50% of the samples from the source class are flipped to the target class ($m = 3$, $n_{LF} = 3$, and $Att_{ratio} = 50$).

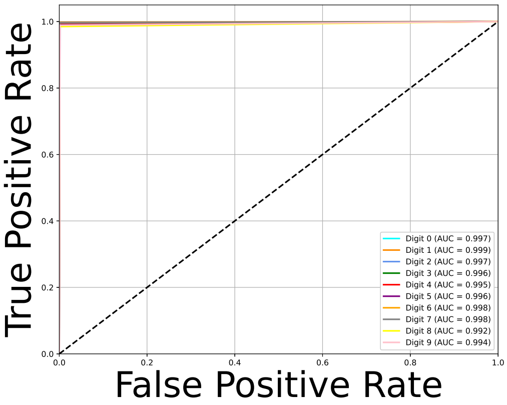


Figure 7: MNIST Dataset

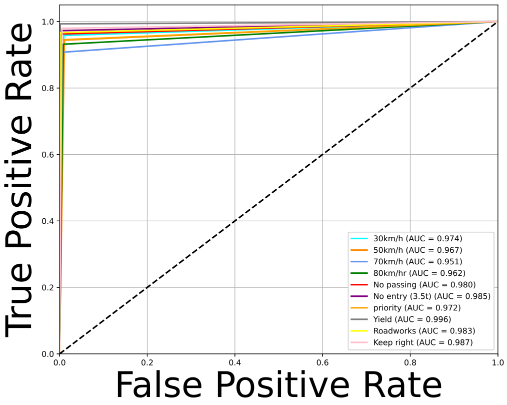


Figure 8: GTSR

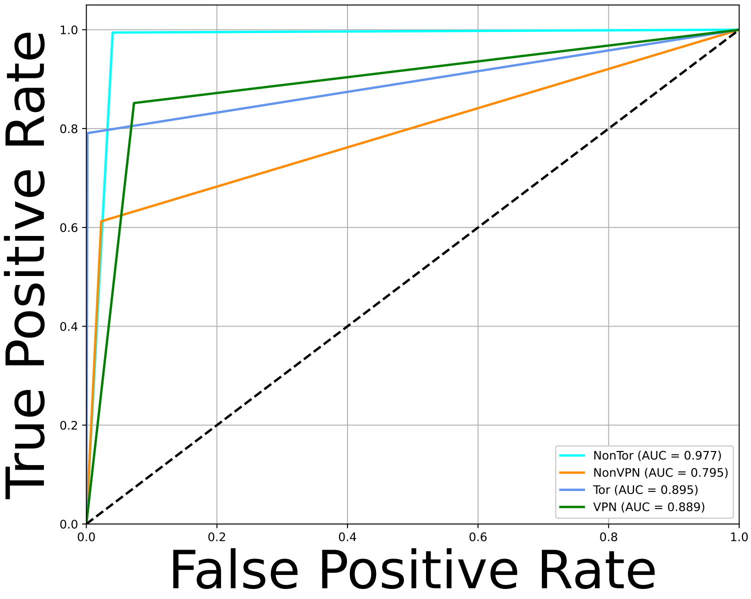


Figure 9: CIC-DARKNET2020

Figure 10: SecDefender AUC-ROC Curve based on various datasets in the full-round attack scenario under non-IID conditions. In the extreme attack scenario with three malicious participants performing a triple-label flipping attack, 50% of the samples from the source class are flipped to the target class .