

Energy Optimization of Cloud Data Centers Using Federated Learning Server Workload Allocation

Table of Contents

1	Supplementary Materials.....	2
1.1	Server Workload Shift Logs	2
	Workload shifted from Server-100 to Server-55	2
1.3	Servers Status	3
1.4	KPI Results	5
2	Simulation Results.....	6

1 Supplementary Materials

1.1 Server Workload Shift Logs

Workload shifted from Server-6 to Server-95	Workload shifted from Server-58 to Server-34
Workload shifted from Server-8 to Server-95	Workload shifted from Server-61 to Server-38
Workload shifted from Server-9 to Server-99	Workload shifted from Server-62 to Server-30
Workload shifted from Server-10 to Server-99	Workload shifted from Server-63 to Server-30
Workload shifted from Server-14 to Server-1	Workload shifted from Server-64 to Server-44
Workload shifted from Server-15 to Server-1	Workload shifted from Server-65 to Server-44
Workload shifted from Server-16 to Server-3	Workload shifted from Server-68 to Server-49
Workload shifted from Server-18 to Server-3	Workload shifted from Server-69 to Server-49
Workload shifted from Server-20 to Server-22	Workload shifted from Server-73 to Server-71
Workload shifted from Server-21 to Server-93	Workload shifted from Server-75 to Server-71
Workload shifted from Server-24 to Server-93	Workload shifted from Server-76 to Server-39
Workload shifted from Server-25 to Server-23	Workload shifted from Server-78 to Server-72
Workload shifted from Server-26 to Server-2	Workload shifted from Server-82 to Server-4
Workload shifted from Server-28 to Server-2	Workload shifted from Server-83 to Server-4
Workload shifted from Server-29 to Server-17	Workload shifted from Server-84 to Server-54
Workload shifted from Server-32 to Server-17	Workload shifted from Server-86 to Server-54
Workload shifted from Server-33 to Server-19	Workload shifted from Server-88 to Server-85
Workload shifted from Server-35 to Server-37	Workload shifted from Server-89 to Server-52
Workload shifted from Server-36 to Server-66	Workload shifted from Server-90 to Server-52
Workload shifted from Server-40 to Server-66	Workload shifted from Server-91 to Server-7
Workload shifted from Server-41 to Server-66	Workload shifted from Server-92 to Server-7
Workload shifted from Server-42 to Server-51	Workload shifted from Server-94 to Server-74
Workload shifted from Server-46 to Server-51	Workload shifted from Server-96 to Server-12
Workload shifted from Server-50 to Server-45	Workload shifted from Server-97 to Server-79
Workload shifted from Server-53 to Server-60	Workload shifted from Server-98 to Server-79
Workload shifted from Server-56 to Server-60	Workload shifted from Server-100 to Server-55
Workload shifted from Server-57 to Server-11	

1.3 Servers Status

Table I. Initial Status of Servers

Before Applying FL (Initial Status)					
Server ID	CPU Usage (%)	Memory Usage (GB)	Storage Usage (TB)	Network Usage (Gbps)	Power Consumption (W)
Server-1	86.68	19.16	3.18	1.5	223.36
Server-2	70.66	18.09	1	9.05	191.32
Server-3	23.24	27.11	0.87	6.38	96.48
Server-4	65.44	4.18	1.14	6.13	180.88
Server-5	67.49	37.73	2.63	5.38	184.98
Server-6	32.74	49.49	2	9.37	115.48
Server-7	61.7	13.49	1.94	0.65	173.4
Server-8	47.96	59.44	0.38	7.79	145.92
Server-9	46.17	30.6	0.84	9.1	142.34
Server-10	55.41	4.43	1.07	7.58	160.82
Server-11	38.15	13.45	2.52	2.82	126.3
Server-12	32.3	63.34	3.57	5.44	114.6
Server-13	28.18	50.57	3.06	0.77	106.36
Server-14	32.64	10.12	2.77	0.6	115.28
Server-15	23.54	20.14	3.07	6.64	97.08
Server-16	78.23	62.89	1.14	7.82	206.46
Server-17	55.94	21.79	0.76	4.27	161.88
Server-18	20.85	33.78	0.89	7.92	91.7
Server-19	55.52	26.94	1.03	0.97	161.04
Server-20	11.13	49.99	1.79	1.26	72.26
⋮					
Server-100	73.01	22.6	0.35	8.82	196.02

Table II. Final Status of Servers

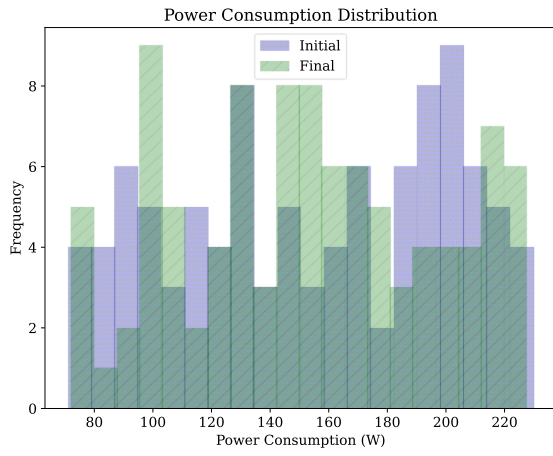
After Applying FL (Final Status)					
Server ID	CPU Usage (%)	Memory Usage (GB)	Storage Usage (TB)	Network Usage (Gbps)	Power Consumption (W)
Server-1	11.81	15.51	1.39	5.19	73.62
Server-2	20.33	1.81	1.77	1.28	90.66
Server-3	12.37	23.06	1.61	7.55	74.74
Server-4	39	18.87	3.69	2.4	128
Server-5	47.22	12.68	4	1.59	144.44
Server-6	68.3	6.4	1.06	6.19	186.6
Server-7	40.8	25.41	2.12	6.17	131.6
Server-8	77.05	32.18	2.82	6.51	204.1
Server-9	62.53	48.67	0.42	2.9	175.06
Server-10	72.47	60.48	0.2	2.2	194.94
Server-11	26.42	26.5	0.98	5.05	102.84
Server-12	41.72	7.55	2.42	5.19	133.44
Server-13	28.66	61.51	0.71	3.61	107.32
Server-14	80.19	47.84	0.68	9.08	210.38
Server-15	54.64	51.55	3.7	8.04	159.28
Server-16	56.85	48.3	1.7	0.19	163.7
Server-17	23.83	17.24	1.67	6.38	97.66
Server-18	54.8	55.74	2.5	3.2	159.6
Server-19	23.85	45.56	0.51	4.36	97.7
Server-20	62.36	60.68	2.77	7.26	174.72
⋮					
Server-100	88.33	22.57	1.38	9.44	226.66

1.4 KPI Results

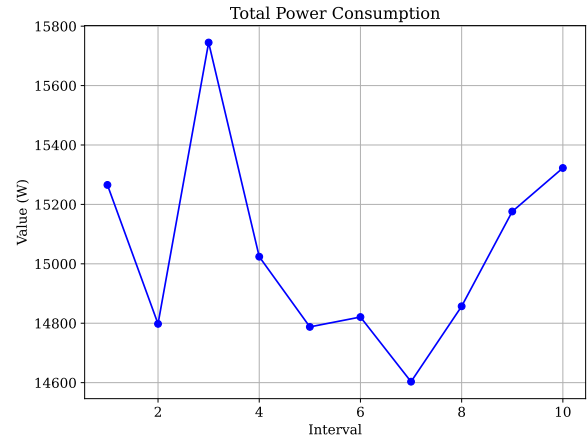
Table III. KPI Results

Server ID	MSE	RMSE	MAE	MAPE (%)	Max Error
Server-1	3.84E-28	1.96E-14	1.56E-14	1.04E-14	2.84E-14
Server-2	1.74E-27	4.17E-14	3.69E-14	2.99E-14	7.11E-14
Server-3	3.23E-28	1.80E-14	1.14E-14	5.85E-15	2.84E-14
Server-4	1.80E-27	4.24E-14	3.27E-14	2.14E-14	8.53E-14
Server-5	1.62E-28	1.27E-14	5.68E-15	3.55E-15	2.84E-14
Server-6	7.67E-28	2.77E-14	2.27E-14	1.78E-14	4.26E-14
Server-7	1.43E-27	3.79E-14	3.55E-14	2.68E-14	5.68E-14
Server-8	3.64E-28	1.91E-14	1.42E-14	9.03E-15	2.84E-14
Server-9	4.24E-28	2.06E-14	1.56E-14	1.02E-14	2.84E-14
Server-10	1.21E-27	3.48E-14	2.56E-14	1.61E-14	5.68E-14
Server-11	1.68E-27	4.09E-14	3.55E-14	2.43E-14	5.68E-14
Server-12	1.01E-28	1.00E-14	4.26E-15	3.21E-15	2.84E-14
Server-13	1.29E-27	3.60E-14	3.41E-14	2.68E-14	5.68E-14
Server-14	2.83E-28	1.68E-14	1.14E-14	1.07E-14	2.84E-14
Server-15	4.24E-28	2.06E-14	1.85E-14	1.70E-14	2.84E-14
Server-16	4.85E-28	2.20E-14	1.14E-14	1.09E-14	5.68E-14
Server-17	4.85E-28	2.20E-14	1.42E-14	1.22E-14	5.68E-14
Server-18	3.88E-27	6.23E-14	5.68E-14	5.29E-14	9.95E-14
Server-19	6.06E-29	7.78E-15	4.26E-15	4.09E-15	1.42E-14
Server-20	1.09E-27	3.30E-14	2.84E-14	2.05E-14	5.68E-14
⋮					
Server-100	4.44E-28	2.11E-14	1.71E-14	1.44E-14	2.84E-14

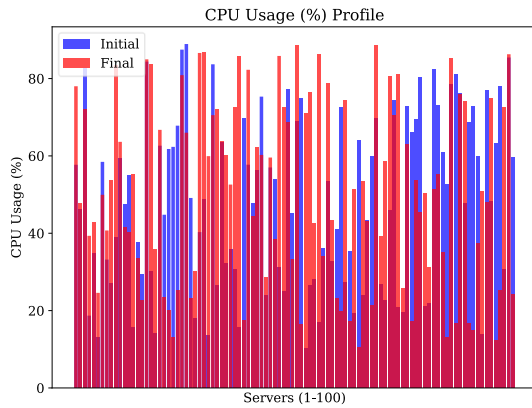
2 Simulation Results



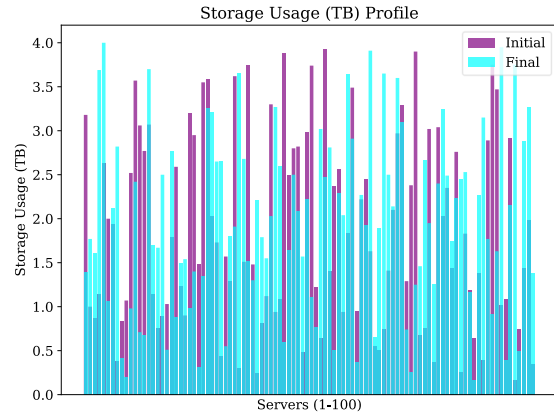
(a)



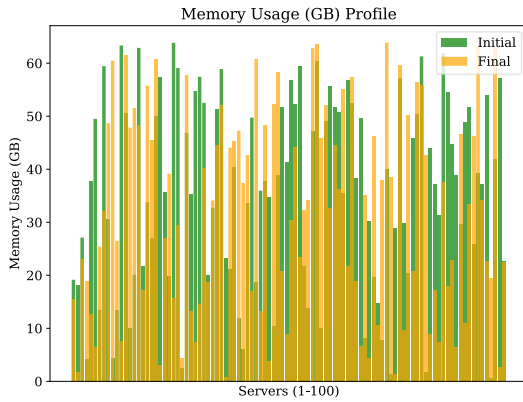
(b)



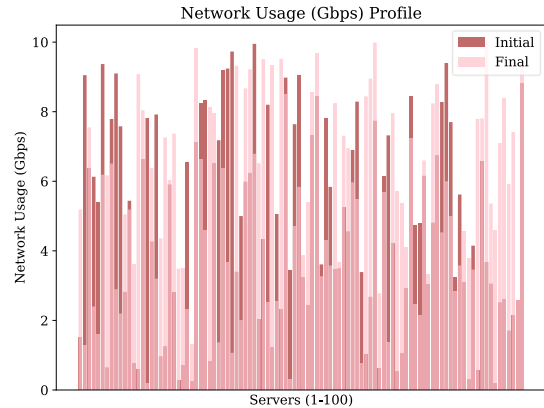
(c)



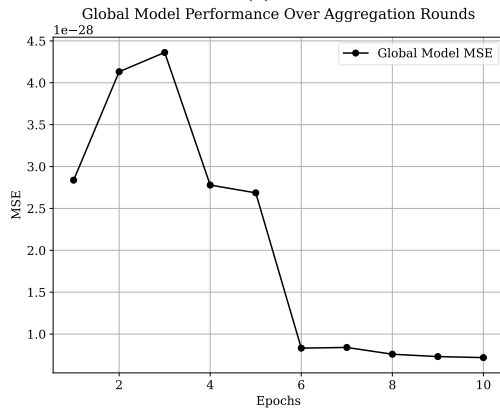
(d)



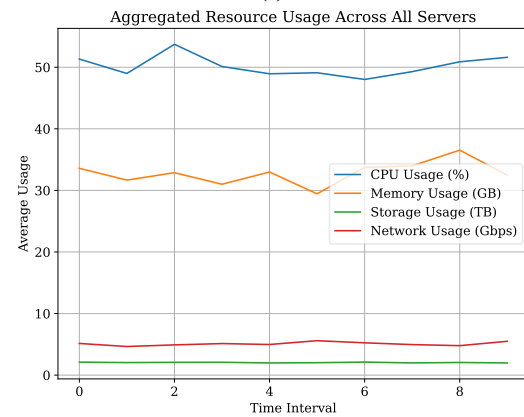
(e)



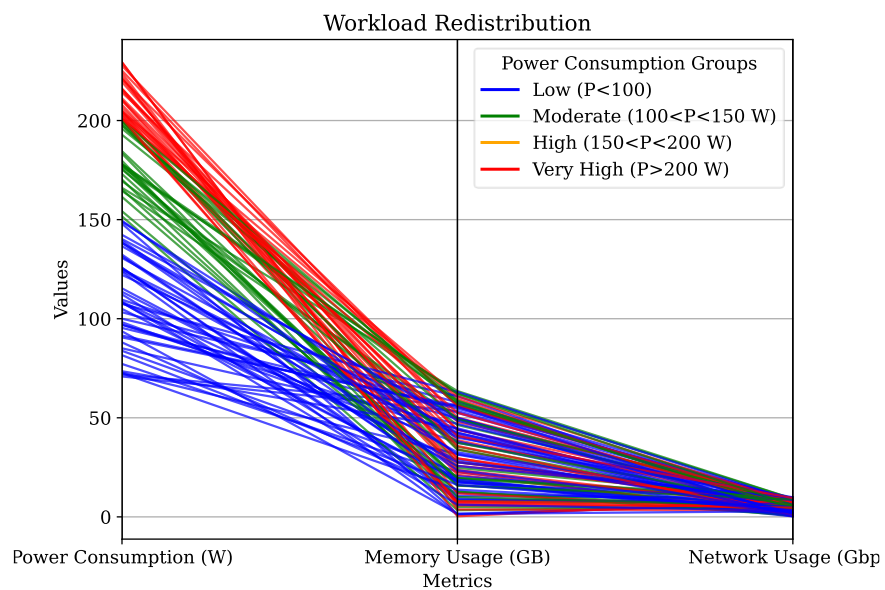
(f)



(g)



(h)



(i)

Fig. 1. Simulation Results of the paper: (a-b) Power consumption profile, (c-f) Resource usage, (g-h) Global model loss, and aggregated resource usage for 100 servers, (i) Workload distribution results, by clustering the servers