

Supplementary File

Article Title

Fusing Exploration and Exploitation: Hybrid Fireworks–Whale Optimization for Multi-Objective Independent Task Scheduling in Cloud Environments

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Supplementary Table 1: Performance Comparison of Standalone Metaheuristics - Part 1

Cloudlets	WOA	FWA	SEQ	PAR	FWA-Encircle	WOA-Spark
Makespan Time (s)						
100	3.247	2.359	2.556	2.110	2.142	2.610
150	3.238	2.707	2.800	2.413	2.596	3.057
200	3.260	2.842	3.572	3.258	2.952	3.300
250	4.013	3.140	4.091	3.684	2.964	3.675
300	5.314	5.755	5.065	5.202	3.623	4.093
350	4.809	6.799	7.221	6.635	4.025	4.671
400	5.837	9.115	9.571	5.362	5.293	4.892
450	5.496	11.914	10.548	5.653	5.051	5.369
500	5.988	16.775	13.751	6.156	5.526	5.650
Fitness Score						
100	1.330	1.338	1.360	1.384	1.371	1.390
150	0.898	0.901	0.912	0.923	0.917	0.928
200	0.676	0.679	0.686	0.695	0.693	0.698
250	0.541	0.542	0.552	0.556	0.556	0.559
300	0.450	0.452	0.459	0.463	0.462	0.463
350	0.384	0.384	0.392	0.395	0.390	0.395
400	0.336	0.334	0.345	0.345	0.343	0.346
450	0.289	0.293	0.305	0.307	0.308	0.311
500	0.256	0.259	0.276	0.276	0.274	0.276
RAM Utilization * 100 (%)						
100	2.185	2.692	2.548	2.842	2.822	2.490
150	2.297	2.607	2.589	2.816	2.687	2.469
200	2.408	2.672	2.354	2.495	2.618	2.491
250	2.311	2.705	2.365	2.488	2.775	2.501
300	2.489	2.718	2.314	2.366	2.684	2.558
350	2.440	2.354	2.138	2.228	2.771	2.601
400	2.580	2.264	2.171	2.728	2.692	2.724
450	2.731	2.376	2.233	2.710	2.894	2.798
500	2.760	2.331	2.300	2.756	2.753	2.967

Supplementary Table 2: Performance Comparison of Standalone Metaheuristics - Part 2

Cloudlets	WOA	FWA	SEQ	PAR	FWA-Encircle	WOA-Spark
Bandwidth Utilization * 100 (%)						
100	2.206	2.713	2.574	2.867	2.849	2.514
150	2.326	2.640	2.623	2.848	2.721	2.501
200	2.444	2.711	2.398	2.541	2.654	2.540
250	2.348	2.753	2.408	2.540	2.826	2.551
300	2.540	2.774	2.370	2.423	2.736	2.621
350	2.492	2.429	2.210	2.292	2.831	2.670
400	2.643	2.325	2.230	2.800	2.758	2.810
450	2.800	2.448	2.318	2.793	2.965	2.887
500	2.835	2.407	2.403	2.844	2.826	3.065
CPU Utilization (MIPS)						
100	38326	50431	46937	53467	52740	44835
150	58494	68177	67272	74053	70613	61456
200	75483	85577	70011	74968	82340	74393
250	79858	98233	78757	83893	101186	83632
300	94639	104948	79694	80488	102910	91967
350	95712	82128	66818	70216	110484	97830
400	104926	69865	58948	98528	99803	104663
450	110386	69013	62343	102483	114374	107435
500	110419	62392	54311	97568	99754	113449
Power Consumption (W)						
100	14.201	14.230	14.188	14.236	14.246	14.190
150	14.273	14.319	14.331	14.384	14.342	14.283
200	14.386	14.447	14.366	14.398	14.422	14.369
250	14.405	14.553	14.390	14.424	14.609	14.424
300	14.569	14.639	14.452	14.410	14.599	14.518
350	14.552	14.447	14.342	14.353	14.665	14.528
400	14.587	14.333	14.305	14.610	14.578	14.557
450	14.683	14.403	14.306	14.523	14.681	14.552
500	14.661	14.345	14.283	14.518	14.555	14.643

Supplementary Table 3: Performance Comparison of Recent Standard Approaches - Part 1

Cloudlets	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircle	WOA-Spark
Makespan Time (s)							
100	2.972	3.147	3.124	2.556	2.110	2.142	2.610
150	3.137	2.971	3.345	2.800	2.413	2.596	3.057
200	3.105	3.293	3.667	3.572	3.258	2.952	3.300
250	3.573	3.543	4.018	4.091	3.684	2.964	3.675
300	6.086	4.039	5.161	5.065	5.202	3.623	4.093
350	7.320	4.424	5.435	7.221	6.635	4.025	4.671
400	9.502	5.032	6.146	9.571	5.362	5.293	4.892
450	15.303	5.538	8.007	10.548	5.653	5.051	5.369
500	20.327	6.079	7.105	13.751	6.156	5.526	5.650
Fitness Score							
100	1.324	1.335	1.291	1.360	1.384	1.371	1.390
150	0.898	0.899	0.891	0.912	0.923	0.917	0.928
200	0.677	0.676	0.673	0.686	0.695	0.693	0.698
250	0.542	0.542	0.540	0.552	0.556	0.556	0.559
300	0.452	0.451	0.449	0.459	0.463	0.462	0.463
350	0.386	0.384	0.384	0.392	0.395	0.390	0.395
400	0.339	0.337	0.336	0.345	0.345	0.343	0.346
450	0.303	0.300	0.299	0.305	0.307	0.308	0.311
500	0.274	0.269	0.269	0.276	0.276	0.274	0.276
RAM Utilization * 100 (%)							
100	2.670	2.259	4.352	2.548	2.842	2.822	2.490
150	2.344	2.426	2.228	2.589	2.816	2.687	2.469
200	2.523	2.440	2.251	2.354	2.495	2.618	2.491
250	2.491	2.467	2.293	2.365	2.488	2.775	2.501
300	2.133	2.483	2.194	2.314	2.366	2.684	2.558
350	2.195	2.586	2.385	2.139	2.229	2.771	2.601
400	2.224	2.649	2.398	2.171	2.728	2.692	2.724
450	2.042	2.701	2.286	2.233	2.710	2.894	2.798
500	2.147	2.763	2.601	2.300	2.756	2.754	2.967

Supplementary Table 4: Performance Comparison of Recent Standard Approaches - Part 2

Cloudlets	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircle	WOA-Spark
Bandwidth Utilization * 100 (%)							
100	2.693	2.282	4.376	2.574	2.867	2.849	2.514
150	2.370	2.459	2.257	2.623	2.848	2.721	2.501
200	2.558	2.474	2.287	2.398	2.541	2.654	2.540
250	2.535	2.514	2.336	2.409	2.540	2.826	2.551
300	2.189	2.528	2.244	2.370	2.423	2.736	2.621
350	2.246	2.639	2.437	2.210	2.292	2.831	2.670
400	2.299	2.716	2.467	2.230	2.800	2.759	2.810
450	2.133	2.769	2.349	2.318	2.793	2.966	2.887
500	2.217	2.836	2.671	2.403	2.844	2.826	3.065
CPU Utilization (MIPS)							
100	40523	40308	42106	46937	53467	52740	44835
150	60007	62546	55670	67272	74053	70613	61456
200	79824	75628	68018	70011	74968	82340	74393
250	88393	86838	78020	78757	83893	101186	83632
300	69998	94452	78391	79694	80488	102910	91967
350	73669	104010	88539	66818	70216	110484	97830
400	69773	105588	87521	58948	98528	99803	104663
450	46599	107084	78703	62343	102483	114374	107435
500	39250	108618	94636	54311	97568	99754	113449
Power Consumption (W)							
100	14.203	14.183	14.183	14.188	14.236	14.246	14.190
150	14.281	14.304	14.273	14.331	14.384	14.342	14.283
200	14.412	14.402	14.378	14.366	14.398	14.422	14.369
250	14.518	14.513	14.447	14.390	14.424	14.609	14.424
300	14.402	14.565	14.439	14.453	14.410	14.599	14.518
350	14.434	14.626	14.556	14.343	14.353	14.665	14.528
400	14.408	14.671	14.539	14.306	14.610	14.579	14.557
450	14.273	14.650	14.461	14.307	14.523	14.681	14.552
500	14.249	14.703	14.575	14.283	14.518	14.555	14.643

Friedman test for MakespanTime: Statistic = 33.8667, p-value = 4.2950e-05

Supplementary Table 5: Nemenyi Post Hoc Test (p-values) for MakespanTime at Cloudlets = 100

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.0044	0.7960	0.9821	0.9989	0.1239	0.0068	0.0028	0.4095
FWA	0.0044	1.0000	0.4095	0.1239	0.0477	0.9821	1.0000	1.0000	0.7960
OBDFWA	0.7960	0.4095	1.0000	0.9997	0.9917	0.9656	0.4882	0.3362	0.9997
GAGWO	0.9821	0.1239	0.9997	1.0000	1.0000	0.7267	0.1639	0.0918	0.9656
MWOA	0.9989	0.0477	0.9917	1.0000	1.0000	0.4882	0.0668	0.0334	0.8555
SEQ	0.1239	0.9821	0.9656	0.7267	0.4882	1.0000	0.9917	0.9656	0.9997
PAR	0.0068	1.0000	0.4882	0.1639	0.0668	0.9917	1.0000	1.0000	0.8555
FWA-Encircling	0.0028	1.0000	0.3362	0.0918	0.0334	0.9656	1.0000	1.0000	0.7267
WOA-Spark	0.4095	0.7960	0.9997	0.9656	0.8555	0.9997	0.8555	0.7267	1.0000

Friedman test for Fitness: Statistic = 38.8267, p-value = 5.2930e-06

Supplementary Table 6: *Nemenyi Post Hoc Test (p-values) for Fitness at Cloudlets = 100*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.6501	1.0000	0.9999	0.9821	0.9400	0.0477	0.2702	0.0156
FWA	0.6501	1.0000	0.5695	0.9036	0.0918	0.9997	0.9400	0.9997	0.7960
OBDFWA	1.0000	0.5695	1.0000	0.9997	0.9917	0.9036	0.0334	0.2126	0.0104
GAGWO	0.9999	0.9036	0.9997	1.0000	0.8555	0.9967	0.1639	0.5695	0.0668
MWOA	0.9821	0.0918	0.9917	0.8555	1.0000	0.3362	0.0011	0.0156	0.0002
SEQ	0.9400	0.9997	0.9036	0.9967	0.3362	1.0000	0.6501	0.9656	0.4095
PAR	0.0477	0.9400	0.0334	0.1639	0.0011	0.6501	1.0000	0.9989	1.0000
FWA-Encircling	0.2702	0.9997	0.2126	0.5695	0.0156	0.9656	0.9989	1.0000	0.9821
WOA-Spark	0.0156	0.7960	0.0104	0.0668	0.0002	0.4095	1.0000	0.9821	1.0000

Friedman test for RAMUtilization: Statistic = 32.4288, p-value = 7.8026e-05

Supplementary Table 7: *Nemenyi Post Hoc Test (p-values) for RAMUtilization at Cloudlets = 100*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.1639	0.1069	1.0000	0.0003	0.7625	0.0566	0.0918	0.9232
FWA	0.1639	1.0000	1.0000	0.3362	0.6891	0.9876	1.0000	1.0000	0.9232
OBDFWA	0.1069	1.0000	1.0000	0.2403	0.7960	0.9656	1.0000	1.0000	0.8555
GAGWO	1.0000	0.3362	0.2403	1.0000	0.0014	0.9232	0.1429	0.2126	0.9876
MWOA	0.0003	0.6891	0.7960	0.0014	1.0000	0.1239	0.9036	0.8271	0.0477
SEQ	0.7625	0.9876	0.9656	0.9232	0.1239	1.0000	0.9036	0.9541	1.0000
PAR	0.0566	1.0000	1.0000	0.1429	0.9036	0.9036	1.0000	1.0000	0.7267
FWA-Encircling	0.0918	1.0000	1.0000	0.2126	0.8271	0.9541	1.0000	1.0000	0.8271
WOA-Spark	0.9232	0.9232	0.8555	0.9876	0.0477	1.0000	0.7267	0.8271	1.0000

Friedman test for BandwidthUtilization: Statistic = 32.7625, p-value = 6.7960e-05

Supplementary Table 8: *Nemenyi Post Hoc Test (p-values) for BandwidthUtilization at Cloudlets = 100*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.1872	0.1069	1.0000	0.0003	0.7267	0.0566	0.0785	0.9232
FWA	0.1872	1.0000	1.0000	0.3362	0.6501	0.9946	0.9999	1.0000	0.9400
OBDFWA	0.1069	1.0000	1.0000	0.2126	0.7960	0.9748	1.0000	1.0000	0.8555
GAGWO	1.0000	0.3362	0.2126	1.0000	0.0011	0.8810	0.1239	0.1639	0.9821
MWOA	0.0003	0.6501	0.7960	0.0011	1.0000	0.1429	0.9036	0.8555	0.0477
SEQ	0.7267	0.9946	0.9748	0.8810	0.1429	1.0000	0.9232	0.9541	1.0000
PAR	0.0566	0.9999	1.0000	0.1239	0.9036	0.9232	1.0000	1.0000	0.7267
FWA-Encircling	0.0785	1.0000	1.0000	0.1639	0.8555	0.9541	1.0000	1.0000	0.7960
WOA-Spark	0.9232	0.9400	0.8555	0.9821	0.0477	1.0000	0.7267	0.7960	1.0000

Friedman test for CPUUtilization: Statistic = 33.0667, p-value = 5.9908e-05

Supplementary Table 9: Nemenyi Post Hoc Test (p-values) for CPUUtilization at Cloudlets = 100

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.0068	0.9656	0.9989	0.9821	0.1239	0.0104	0.0044	0.5695
FWA	0.0068	1.0000	0.2126	0.0668	0.1639	0.9917	1.0000	1.0000	0.7267
OBDFWA	0.9656	0.2126	1.0000	0.9999	1.0000	0.7960	0.2702	0.1639	0.9967
GAGWO	0.9989	0.0668	0.9999	1.0000	1.0000	0.4882	0.0918	0.0477	0.9400
MWOA	0.9821	0.1639	1.0000	1.0000	1.0000	0.7267	0.2126	0.1239	0.9917
SEQ	0.1239	0.9917	0.7960	0.4882	0.7267	1.0000	0.9967	0.9821	0.9967
PAR	0.0104	1.0000	0.2702	0.0918	0.2126	0.9967	1.0000	1.0000	0.7960
FWA-Encircling	0.0044	1.0000	0.1639	0.0477	0.1239	0.9821	1.0000	1.0000	0.6501
WOA-Spark	0.5695	0.7267	0.9967	0.9400	0.9917	0.9967	0.7960	0.6501	1.0000

Friedman test for PowerConsumption: Statistic = 13.7643, p-value = 8.8119e-02

Supplementary Table 10: Nemenyi Post Hoc Test (p-values) for PowerConsumption at Cloudlets = 100

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.9541	1.0000	0.9748	0.9821	0.9232	1.0000	0.9946	0.9821
FWA	0.9541	1.0000	0.7960	0.3362	0.3720	0.2126	0.9876	1.0000	0.3720
OBDFWA	1.0000	0.7960	1.0000	0.9989	0.9994	0.9917	0.9994	0.9400	0.9994
GAGWO	0.9748	0.3362	0.9989	1.0000	1.0000	1.0000	0.9232	0.5695	1.0000
MWOA	0.9821	0.3720	0.9994	1.0000	1.0000	1.0000	0.9400	0.6101	1.0000
SEQ	0.9232	0.2126	0.9917	1.0000	1.0000	1.0000	0.8271	0.4095	1.0000
PAR	1.0000	0.9876	0.9994	0.9232	0.9400	0.8271	1.0000	0.9994	0.9400
FWA-Encircling	0.9946	1.0000	0.9400	0.5695	0.6101	0.4095	0.9994	1.0000	0.6101
WOA-Spark	0.9821	0.3720	0.9994	1.0000	1.0000	1.0000	0.9400	0.6101	1.0000

Friedman test for MakespanTime: Statistic = 19.9467, p-value = 1.0540e-02

Supplementary Table 11: Nemenyi Post Hoc Test (p-values) for MakespanTime at Cloudlets = 200

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.2702	0.9400	0.9997	0.9400	0.9989	0.9989	0.9036	0.9967
FWA	0.2702	1.0000	0.9656	0.6501	0.0068	0.0477	0.7267	0.9821	0.7960
OBDFWA	0.9400	0.9656	1.0000	0.9989	0.2126	0.5695	0.9997	1.0000	0.9999
GAGWO	0.9997	0.6501	0.9989	1.0000	0.6501	0.9400	1.0000	0.9967	1.0000
MWOA	0.9400	0.0068	0.2126	0.6501	1.0000	0.9997	0.5695	0.1639	0.4882
SEQ	0.9989	0.0477	0.5695	0.9400	0.9997	1.0000	0.9036	0.4882	0.8555
PAR	0.9989	0.7267	0.9997	1.0000	0.5695	0.9036	1.0000	0.9989	1.0000
FWA-Encircling	0.9036	0.9821	1.0000	0.9967	0.1639	0.4882	0.9989	1.0000	0.9997
WOA-Spark	0.9967	0.7960	0.9999	1.0000	0.4882	0.8555	1.0000	0.9997	1.0000

Friedman test for Fitness: Statistic = 38.4533, p-value = 6.2067e-06

Supplementary Table 12: *Nemenyi Post Hoc Test (p-values) for Fitness at Cloudlets = 200*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.7960	0.9989	1.0000	0.9967	0.3362	0.0334	0.3362	0.0044
FWA	0.7960	1.0000	0.9917	0.9400	0.2702	0.9989	0.7960	0.9989	0.4095
OBDFWA	0.9989	0.9917	1.0000	1.0000	0.8555	0.7960	0.2126	0.7960	0.0477
GAGWO	1.0000	0.9400	1.0000	1.0000	0.9656	0.5695	0.0918	0.5695	0.0156
MWOA	0.9967	0.2702	0.8555	0.9656	1.0000	0.0477	0.0017	0.0477	0.0001
SEQ	0.3362	0.9989	0.7960	0.5695	0.0477	1.0000	0.9917	1.0000	0.8555
PAR	0.0334	0.7960	0.2126	0.0918	0.0017	0.9917	1.0000	0.9917	0.9997
FWA-Encircling	0.3362	0.9989	0.7960	0.5695	0.0477	1.0000	0.9917	1.0000	0.8555
WOA-Spark	0.0044	0.4095	0.0477	0.0156	0.0001	0.8555	0.9997	0.8555	1.0000

Friedman test for RAMUtilization: Statistic = 25.0836, p-value = 1.5046e-03

Supplementary Table 13: *Nemenyi Post Hoc Test (p-values) for RAMUtilization at Cloudlets = 200*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.0668	0.9748	0.9989	0.9967	1.0000	0.7960	0.2403	0.4882
FWA	0.0668	1.0000	0.6101	0.3362	0.0044	0.1239	0.9036	0.9999	0.9917
OBDFWA	0.9748	0.6101	1.0000	1.0000	0.6101	0.9946	0.9999	0.9036	0.9876
GAGWO	0.9989	0.3362	1.0000	1.0000	0.8555	0.9999	0.9917	0.6891	0.9036
MWOA	0.9967	0.0044	0.6101	0.8555	1.0000	0.9821	0.2702	0.0278	0.0918
SEQ	1.0000	0.1239	0.9946	0.9999	0.9821	1.0000	0.9036	0.3720	0.6501
PAR	0.7960	0.9036	0.9999	0.9917	0.2702	0.9036	1.0000	0.9946	0.9999
FWA-Encircling	0.2403	0.9999	0.9036	0.6891	0.0278	0.3720	0.9946	1.0000	1.0000
WOA-Spark	0.4882	0.9917	0.9876	0.9036	0.0918	0.6501	0.9999	1.0000	1.0000

Friedman test for BandwidthUtilization: Statistic = 25.7584, p-value = 1.1551e-03

Supplementary Table 14: *Nemenyi Post Hoc Test (p-values) for BandwidthUtilization at Cloudlets = 200*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.0785	0.9748	0.9997	0.9967	1.0000	0.7960	0.2126	0.4095
FWA	0.0785	1.0000	0.6501	0.3022	0.0055	0.1429	0.9232	1.0000	0.9980
OBDFWA	0.9748	0.6501	1.0000	0.9999	0.6101	0.9946	0.9999	0.8810	0.9748
GAGWO	0.9997	0.3022	0.9999	1.0000	0.9036	1.0000	0.9821	0.5695	0.7960
MWOA	0.9967	0.0055	0.6101	0.9036	1.0000	0.9821	0.2702	0.0230	0.0668
SEQ	1.0000	0.1429	0.9946	1.0000	0.9821	1.0000	0.9036	0.3362	0.5695
PAR	0.7960	0.9232	0.9999	0.9821	0.2702	0.9036	1.0000	0.9917	0.9997
FWA-Encircling	0.2126	1.0000	0.8810	0.5695	0.0230	0.3362	0.9917	1.0000	1.0000
WOA-Spark	0.4095	0.9980	0.9748	0.7960	0.0668	0.5695	0.9997	1.0000	1.0000

Friedman test for CPUUtilization: Statistic = 21.3333, p-value = 6.3127e-03

Supplementary Table 15: *Nemenyi Post Hoc Test (p-values) for CPUUtilization at Cloudlets = 200*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.1639	0.9821	0.9999	0.9400	0.9989	0.9967	0.9036	0.9967
FWA	0.1639	1.0000	0.7960	0.4095	0.0028	0.0230	0.6501	0.9400	0.6501
OBDFWA	0.9821	0.7960	1.0000	0.9997	0.3362	0.7267	1.0000	1.0000	1.0000
GAGWO	0.9999	0.4095	0.9997	1.0000	0.7267	0.9656	1.0000	0.9917	1.0000
MWOA	0.9400	0.0028	0.3362	0.7267	1.0000	0.9997	0.4882	0.1639	0.4882
SEQ	0.9989	0.0230	0.7267	0.9656	0.9997	1.0000	0.8555	0.4882	0.8555
PAR	0.9967	0.6501	1.0000	1.0000	0.4882	0.8555	1.0000	0.9997	1.0000
FWA-Encircling	0.9036	0.9400	1.0000	0.9917	0.1639	0.4882	0.9997	1.0000	0.9997
WOA-Spark	0.9967	0.6501	1.0000	1.0000	0.4882	0.8555	1.0000	0.9997	1.0000

Friedman test for PowerConsumption: Statistic = 4.7197, p-value = 7.8707e-01

Supplementary Table 16: *Nemenyi Post Hoc Test (p-values) for PowerConsumption at Cloudlets = 200*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.9997	1.0000	0.9967	0.9999	0.9967	1.0000	0.9997	1.0000
FWA	0.9997	1.0000	1.0000	1.0000	1.0000	0.9036	0.9997	0.9656	1.0000
OBDFWA	1.0000	1.0000	1.0000	0.9994	1.0000	0.9876	1.0000	0.9980	1.0000
GAGWO	0.9967	1.0000	0.9994	1.0000	1.0000	0.7960	0.9967	0.9036	0.9999
MWOA	0.9999	1.0000	1.0000	1.0000	1.0000	0.9232	0.9999	0.9748	1.0000
SEQ	0.9967	0.9036	0.9876	0.7960	0.9232	1.0000	0.9967	1.0000	0.9656
PAR	1.0000	0.9997	1.0000	0.9967	0.9999	0.9967	1.0000	0.9997	1.0000
FWA-Encircling	0.9997	0.9656	0.9980	0.9036	0.9748	1.0000	0.9997	1.0000	0.9917
WOA-Spark	1.0000	1.0000	1.0000	0.9999	1.0000	0.9656	1.0000	0.9917	1.0000

Friedman test for MakespanTime: Statistic = 25.5117, p-value = 1.2725e-03

Supplementary Table 17: *Nemenyi Post Hoc Test (p-values) for MakespanTime at Cloudlets = 300*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.6101	0.7960	1.0000	0.7267	0.9821	0.9656	0.9541	1.0000
FWA	0.6101	1.0000	0.0128	0.7625	0.0084	0.0785	0.0566	0.9989	0.6891
OBDFWA	0.7960	0.0128	1.0000	0.6501	1.0000	0.9997	0.9999	0.1069	0.7267
GAGWO	1.0000	0.7625	0.6501	1.0000	0.5695	0.9400	0.9036	0.9876	1.0000
MWOA	0.7267	0.0084	1.0000	0.5695	1.0000	0.9989	0.9997	0.0785	0.6501
SEQ	0.9821	0.0785	0.9997	0.9400	0.9989	1.0000	1.0000	0.3720	0.9656
PAR	0.9656	0.0566	0.9999	0.9036	0.9997	1.0000	1.0000	0.3022	0.9400
FWA-Encircling	0.9541	0.9989	0.1069	0.9876	0.0785	0.3720	0.3022	1.0000	0.9748
WOA-Spark	1.0000	0.6891	0.7267	1.0000	0.6501	0.9656	0.9400	0.9748	1.0000

Friedman test for Fitness: Statistic = 38.7200, p-value = 5.5396e-06

Supplementary Table 18: *Nemenyi Post Hoc Test (p-values) for Fitness at Cloudlets = 300*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.1639	0.9917	0.9967	0.9997	0.2702	0.0068	0.6501	0.0044
FWA	0.1639	1.0000	0.7267	0.6501	0.0334	1.0000	0.9821	0.9967	0.9656
OBDFWA	0.9917	0.7267	1.0000	1.0000	0.8555	0.8555	0.1239	0.9917	0.0918
GAGWO	0.9967	0.6501	1.0000	1.0000	0.9036	0.7960	0.0918	0.9821	0.0668
MWOA	0.9997	0.0334	0.8555	0.9036	1.0000	0.0668	0.0007	0.2702	0.0004
SEQ	0.2702	1.0000	0.8555	0.7960	0.0668	1.0000	0.9400	0.9997	0.9036
PAR	0.0068	0.9821	0.1239	0.0918	0.0007	0.9400	1.0000	0.6501	1.0000
FWA-Encircling	0.6501	0.9967	0.9917	0.9821	0.2702	0.9997	0.6501	1.0000	0.5695
WOA-Spark	0.0044	0.9656	0.0918	0.0668	0.0004	0.9036	1.0000	0.5695	1.0000

Friedman test for RAMUtilization: Statistic = 24.3478, p-value = 2.0033e-03

Supplementary Table 19: *Nemenyi Post Hoc Test (p-values) for RAMUtilization at Cloudlets = 300*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.4483	0.9400	1.0000	0.8810	1.0000	0.9980	0.7625	0.9994
FWA	0.4483	1.0000	0.0190	0.3720	0.0104	0.2403	0.0918	0.9999	0.8555
OBDFWA	0.9400	0.0190	1.0000	0.9656	1.0000	0.9917	0.9999	0.0785	0.6101
GAGWO	1.0000	0.3720	0.9656	1.0000	0.9232	1.0000	0.9994	0.6891	0.9980
MWOA	0.8810	0.0104	1.0000	0.9232	1.0000	0.9748	0.9989	0.0477	0.4882
SEQ	1.0000	0.2403	0.9917	1.0000	0.9748	1.0000	1.0000	0.5287	0.9876
PAR	0.9980	0.0918	0.9999	0.9994	0.9989	1.0000	1.0000	0.2702	0.9036
FWA-Encircling	0.7625	0.9999	0.0785	0.6891	0.0477	0.5287	0.2702	1.0000	0.9821
WOA-Spark	0.9994	0.8555	0.6101	0.9980	0.4882	0.9876	0.9036	0.9821	1.0000

Friedman test for BandwidthUtilization: Statistic = 24.0268, p-value = 2.2682e-03

Supplementary Table 20: *Nemenyi Post Hoc Test (p-values) for BandwidthUtilization at Cloudlets = 300*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.4095	0.9400	1.0000	0.8810	1.0000	0.9980	0.8555	0.9980
FWA	0.4095	1.0000	0.0156	0.3022	0.0084	0.2403	0.0785	0.9989	0.8810
OBDFWA	0.9400	0.0156	1.0000	0.9748	1.0000	0.9876	0.9999	0.1239	0.5287
GAGWO	1.0000	0.3022	0.9748	1.0000	0.9400	1.0000	0.9997	0.7625	0.9917
MWOA	0.8810	0.0084	1.0000	0.9400	1.0000	0.9656	0.9989	0.0785	0.4095
SEQ	1.0000	0.2403	0.9876	1.0000	0.9656	1.0000	0.9999	0.6891	0.9821
PAR	0.9980	0.0785	0.9999	0.9997	0.9989	0.9999	1.0000	0.3720	0.8555
FWA-Encircling	0.8555	0.9989	0.1239	0.7625	0.0785	0.6891	0.3720	1.0000	0.9980
WOA-Spark	0.9980	0.8810	0.5287	0.9917	0.4095	0.9821	0.8555	0.9980	1.0000

Friedman test for CPUUtilization: Statistic = 25.9200, p-value = 1.0839e-03

Supplementary Table 21: *Nemenyi Post Hoc Test (p-values) for CPUUtilization at Cloudlets = 300*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.5695	0.7267	1.0000	0.7267	0.9917	0.9656	0.9656	1.0000
FWA	0.5695	1.0000	0.0068	0.7267	0.0068	0.0918	0.0477	0.9967	0.6501
OBDFWA	0.7267	0.0068	1.0000	0.5695	1.0000	0.9967	0.9997	0.0918	0.6501
GAGWO	1.0000	0.7267	0.5695	1.0000	0.5695	0.9656	0.9036	0.9917	1.0000
MWOA	0.7267	0.0068	1.0000	0.5695	1.0000	0.9967	0.9997	0.0918	0.6501
SEQ	0.9917	0.0918	0.9967	0.9656	0.9967	1.0000	1.0000	0.4882	0.9821
PAR	0.9656	0.0477	0.9997	0.9036	0.9997	1.0000	1.0000	0.3362	0.9400
FWA-Encircling	0.9656	0.9967	0.0918	0.9917	0.0918	0.4882	0.3362	1.0000	0.9821
WOA-Spark	1.0000	0.6501	0.6501	1.0000	0.6501	0.9821	0.9400	0.9821	1.0000

Friedman test for PowerConsumption: Statistic = 18.3087, p-value = 1.9027e-02

Supplementary Table 22: *Nemenyi Post Hoc Test (p-values) for PowerConsumption at Cloudlets = 300*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.9967	0.7960	1.0000	0.6101	0.9876	0.6101	0.9989	1.0000
FWA	0.9967	1.0000	0.2702	0.9980	0.1429	0.6891	0.1429	1.0000	0.9656
OBDFWA	0.7960	0.2702	1.0000	0.7625	1.0000	0.9994	1.0000	0.3362	0.9400
GAGWO	1.0000	0.9980	0.7625	1.0000	0.5695	0.9821	0.5695	0.9994	1.0000
MWOA	0.6101	0.1429	1.0000	0.5695	1.0000	0.9917	1.0000	0.1872	0.8271
SEQ	0.9876	0.6891	0.9994	0.9821	0.9917	1.0000	0.9917	0.7625	0.9994
PAR	0.6101	0.1429	1.0000	0.5695	1.0000	0.9917	1.0000	0.1872	0.8271
FWA-Encircling	0.9989	1.0000	0.3362	0.9994	0.1872	0.7625	0.1872	1.0000	0.9821
WOA-Spark	1.0000	0.9656	0.9400	1.0000	0.8271	0.9994	0.8271	0.9821	1.0000

Friedman test for MakespanTime: Statistic = 24.1068, p-value = 2.1991e-03

Supplementary Table 23: *Nemenyi Post Hoc Test (p-values) for MakespanTime at Cloudlets = 400*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.7960	0.0918	1.0000	0.9400	0.2126	1.0000	1.0000	0.9989
FWA	0.7960	1.0000	0.9400	0.9541	1.0000	0.9917	0.9036	0.8271	0.3362
OBDFWA	0.0918	0.9400	1.0000	0.2403	0.7960	1.0000	0.1639	0.1069	0.0104
GAGWO	1.0000	0.9541	0.2403	1.0000	0.9946	0.4483	1.0000	1.0000	0.9748
MWOA	0.9400	1.0000	0.7960	0.9946	1.0000	0.9400	0.9821	0.9541	0.5695
SEQ	0.2126	0.9917	1.0000	0.4483	0.9400	1.0000	0.3362	0.2403	0.0334
PAR	1.0000	0.9036	0.1639	1.0000	0.9821	0.3362	1.0000	1.0000	0.9917
FWA-Encircling	1.0000	0.8271	0.1069	1.0000	0.9541	0.2403	1.0000	1.0000	0.9980
WOA-Spark	0.9989	0.3362	0.0104	0.9748	0.5695	0.0334	0.9917	0.9980	1.0000

Friedman test for Fitness: Statistic = 36.2133, p-value = 1.6049e-05

Supplementary Table 24: *Nemenyi Post Hoc Test (p-values) for Fitness at Cloudlets = 400*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.0918	0.7960	0.9917	1.0000	0.0104	0.0230	0.4095	0.0017
FWA	0.0918	1.0000	0.9400	0.5695	0.1239	0.9989	0.9999	0.9989	0.9656
OBDFWA	0.7960	0.9400	1.0000	0.9989	0.8555	0.5695	0.7267	0.9997	0.2702
GAGWO	0.9917	0.5695	0.9989	1.0000	0.9967	0.1639	0.2702	0.9400	0.0477
MWOA	1.0000	0.1239	0.8555	0.9967	1.0000	0.0156	0.0334	0.4882	0.0028
SEQ	0.0104	0.9989	0.5695	0.1639	0.0156	1.0000	1.0000	0.9036	0.9999
PAR	0.0230	0.9999	0.7267	0.2702	0.0334	1.0000	1.0000	0.9656	0.9989
FWA-Encircling	0.4095	0.9989	0.9997	0.9400	0.4882	0.9036	0.9656	1.0000	0.6501
WOA-Spark	0.0017	0.9656	0.2702	0.0477	0.0028	0.9999	0.9989	0.6501	1.0000

Friedman test for RAMUtilization: Statistic = 24.5333, p-value = 1.8642e-03

Supplementary Table 25: *Nemenyi Post Hoc Test (p-values) for RAMUtilization at Cloudlets = 400*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.9917	0.4095	1.0000	0.9967	0.7960	0.9917	0.9656	0.9400
FWA	0.9917	1.0000	0.9400	0.9821	1.0000	0.9989	0.6501	0.4882	0.4095
OBDFWA	0.4095	0.9400	1.0000	0.3362	0.9036	0.9997	0.0477	0.0230	0.0156
GAGWO	1.0000	0.9821	0.3362	1.0000	0.9917	0.7267	0.9967	0.9821	0.9656
MWOA	0.9967	1.0000	0.9036	0.9917	1.0000	0.9967	0.7267	0.5695	0.4882
SEQ	0.7960	0.9989	0.9997	0.7267	0.9967	1.0000	0.2126	0.1239	0.0918
PAR	0.9917	0.6501	0.0477	0.9967	0.7267	0.2126	1.0000	1.0000	1.0000
FWA-Encircling	0.9656	0.4882	0.0230	0.9821	0.5695	0.1239	1.0000	1.0000	1.0000
WOA-Spark	0.9400	0.4095	0.0156	0.9656	0.4882	0.0918	1.0000	1.0000	1.0000

Friedman test for BandwidthUtilization: Statistic = 25.2267, p-value = 1.4228e-03

Supplementary Table 26: *Nemenyi Post Hoc Test (p-values) for BandwidthUtilization at Cloudlets = 400*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.9917	0.4882	1.0000	0.9997	0.8555	0.9656	0.9656	0.8555
FWA	0.9917	1.0000	0.9656	0.9656	1.0000	0.9997	0.4882	0.4882	0.2702
OBDFWA	0.4882	0.9656	1.0000	0.3362	0.8555	0.9997	0.0334	0.0334	0.0104
GAGWO	1.0000	0.9656	0.3362	1.0000	0.9967	0.7267	0.9917	0.9917	0.9400
MWOA	0.9997	1.0000	0.8555	0.9967	1.0000	0.9917	0.7267	0.7267	0.4882
SEQ	0.8555	0.9997	0.9997	0.7267	0.9917	1.0000	0.1639	0.1639	0.0668
PAR	0.9656	0.4882	0.0334	0.9917	0.7267	0.1639	1.0000	1.0000	1.0000
FWA-Encircling	0.9656	0.4882	0.0334	0.9917	0.7267	0.1639	1.0000	1.0000	1.0000
WOA-Spark	0.8555	0.2702	0.0104	0.9400	0.4882	0.0668	1.0000	1.0000	1.0000

Friedman test for CPUUtilization: Statistic = 23.8933, p-value = 2.3881e-03

Supplementary Table 27: *Nemenyi Post Hoc Test (p-values) for CPUUtilization at Cloudlets = 400*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.7267	0.0668	0.9997	0.9036	0.1639	1.0000	1.0000	0.9999
FWA	0.7267	1.0000	0.9400	0.9656	1.0000	0.9917	0.9036	0.7960	0.4095
OBDFWA	0.0668	0.9400	1.0000	0.2702	0.7960	1.0000	0.1639	0.0918	0.0156
GAGWO	0.9997	0.9656	0.2702	1.0000	0.9967	0.4882	1.0000	0.9999	0.9821
MWOA	0.9036	1.0000	0.7960	0.9967	1.0000	0.9400	0.9821	0.9400	0.6501
SEQ	0.1639	0.9917	1.0000	0.4882	0.9400	1.0000	0.3362	0.2126	0.0477
PAR	1.0000	0.9036	0.1639	1.0000	0.9821	0.3362	1.0000	1.0000	0.9967
FWA-Encircling	1.0000	0.7960	0.0918	0.9999	0.9400	0.2126	1.0000	1.0000	0.9997
WOA-Spark	0.9999	0.4095	0.0156	0.9821	0.6501	0.0477	0.9967	0.9997	1.0000

Friedman test for PowerConsumption: Statistic = 26.4307, p-value = 8.8606e-04

Supplementary Table 28: *Nemenyi Post Hoc Test (p-values) for PowerConsumption at Cloudlets = 400*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.3720	0.0566	1.0000	0.9541	0.1069	1.0000	1.0000	1.0000
FWA	0.3720	1.0000	0.9967	0.5287	0.9821	0.9997	0.3362	0.4882	0.4882
OBDFWA	0.0566	0.9967	1.0000	0.1069	0.6501	1.0000	0.0477	0.0918	0.0918
GAGWO	1.0000	0.5287	0.1069	1.0000	0.9876	0.1872	1.0000	1.0000	1.0000
MWOA	0.9541	0.9821	0.6501	0.9876	1.0000	0.7960	0.9400	0.9821	0.9821
SEQ	0.1069	0.9997	1.0000	0.1872	0.7960	1.0000	0.0918	0.1639	0.1639
PAR	1.0000	0.3362	0.0477	1.0000	0.9400	0.0918	1.0000	1.0000	1.0000
FWA-Encircling	1.0000	0.4882	0.0918	1.0000	0.9821	0.1639	1.0000	1.0000	1.0000
WOA-Spark	1.0000	0.4882	0.0918	1.0000	0.9821	0.1639	1.0000	1.0000	1.0000

Friedman test for MakespanTime: Statistic = 34.1333, p-value = 3.8428e-05

Supplementary Table 29: *Nemenyi Post Hoc Test (p-values) for MakespanTime at Cloudlets = 500*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.0334	0.0477	1.0000	0.7267	0.2702	0.9917	0.9821	0.9989
FWA	0.0334	1.0000	1.0000	0.0104	0.8555	0.9967	0.3362	0.4095	0.0028
OBDFWA	0.0477	1.0000	1.0000	0.0156	0.9036	0.9989	0.4095	0.4882	0.0044
GAGWO	1.0000	0.0104	0.0156	1.0000	0.4882	0.1239	0.9400	0.9036	1.0000
MWOA	0.7267	0.8555	0.9036	0.4882	1.0000	0.9989	0.9967	0.9989	0.2702
SEQ	0.2702	0.9967	0.9989	0.1239	0.9989	1.0000	0.8555	0.9036	0.0477
PAR	0.9917	0.3362	0.4095	0.9400	0.9967	0.8555	1.0000	1.0000	0.7960
FWA-Encircling	0.9821	0.4095	0.4882	0.9036	0.9989	0.9036	1.0000	1.0000	0.7267
WOA-Spark	0.9989	0.0028	0.0044	1.0000	0.2702	0.0477	0.7960	0.7267	1.0000

Friedman test for Fitness: Statistic = 35.0933, p-value = 2.5712e-05

Supplementary Table 30: *Nemenyi Post Hoc Test (p-values) for Fitness at Cloudlets = 500*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.0017	0.5695	0.9967	0.9917	0.0156	0.0156	0.3362	0.0044
FWA	0.0017	1.0000	0.4882	0.0334	0.0477	0.9997	0.9997	0.7267	1.0000
OBDFWA	0.5695	0.4882	1.0000	0.9656	0.9821	0.8555	0.8555	1.0000	0.6501
GAGWO	0.9967	0.0334	0.9656	1.0000	1.0000	0.1639	0.1639	0.8555	0.0668
MWOA	0.9917	0.0477	0.9821	1.0000	1.0000	0.2126	0.2126	0.9036	0.0918
SEQ	0.0156	0.9997	0.8555	0.1639	0.2126	1.0000	1.0000	0.9656	1.0000
PAR	0.0156	0.9997	0.8555	0.1639	0.2126	1.0000	1.0000	0.9656	1.0000
FWA-Encircling	0.3362	0.7267	1.0000	0.8555	0.9036	0.9656	0.9656	1.0000	0.8555
WOA-Spark	0.0044	1.0000	0.6501	0.0668	0.0918	1.0000	1.0000	0.8555	1.0000

Friedman test for RAMUtilization: Statistic = 33.2955, p-value = 5.4477e-05

Supplementary Table 31: *Nemenyi Post Hoc Test (p-values) for RAMUtilization at Cloudlets = 500*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.0785	0.1639	1.0000	0.8555	0.4483	1.0000	1.0000	0.9400
FWA	0.0785	1.0000	1.0000	0.1069	0.8810	0.9967	0.0566	0.1872	0.0008
OBDFWA	0.1639	1.0000	1.0000	0.2126	0.9656	0.9999	0.1239	0.3362	0.0028
GAGWO	1.0000	0.1069	0.2126	1.0000	0.9036	0.5287	1.0000	1.0000	0.9036
MWOA	0.8555	0.8810	0.9656	0.9036	1.0000	0.9994	0.7960	0.9656	0.1239
SEQ	0.4483	0.9967	0.9999	0.5287	0.9994	1.0000	0.3720	0.6891	0.0190
PAR	1.0000	0.0566	0.1239	1.0000	0.7960	0.3720	1.0000	0.9999	0.9656
FWA-Encircling	1.0000	0.1872	0.3362	1.0000	0.9656	0.6891	0.9999	1.0000	0.7960
WOA-Spark	0.9400	0.0008	0.0028	0.9036	0.1239	0.0190	0.9656	0.7960	1.0000

Friedman test for BandwidthUtilization: Statistic = 33.0667, p-value = 5.9908e-05

Supplementary Table 32: *Nemenyi Post Hoc Test (p-values) for BandwidthUtilization at Cloudlets = 500*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.0918	0.1639	1.0000	0.8555	0.4095	1.0000	1.0000	0.9400
FWA	0.0918	1.0000	1.0000	0.1239	0.9036	0.9989	0.0668	0.2126	0.0011
OBDFWA	0.1639	1.0000	1.0000	0.2126	0.9656	0.9999	0.1239	0.3362	0.0028
GAGWO	1.0000	0.1239	0.2126	1.0000	0.9036	0.4882	1.0000	1.0000	0.9036
MWOA	0.8555	0.9036	0.9656	0.9036	1.0000	0.9989	0.7960	0.9656	0.1239
SEQ	0.4095	0.9989	0.9999	0.4882	0.9989	1.0000	0.3362	0.6501	0.0156
PAR	1.0000	0.0668	0.1239	1.0000	0.7960	0.3362	1.0000	0.9999	0.9656
FWA-Encircling	1.0000	0.2126	0.3362	1.0000	0.9656	0.6501	0.9999	1.0000	0.7960
WOA-Spark	0.9400	0.0011	0.0028	0.9036	0.1239	0.0156	0.9656	0.7960	1.0000

Friedman test for CPUUtilization: Statistic = 34.1333, p-value = 3.8428e-05

Supplementary Table 33: *Nemenyi Post Hoc Test (p-values) for CPUUtilization at Cloudlets = 500*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.0156	0.0104	1.0000	0.5695	0.1239	0.8555	0.9036	1.0000
FWA	0.0156	1.0000	1.0000	0.0230	0.8555	0.9989	0.5695	0.4882	0.0068
OBDFWA	0.0104	1.0000	1.0000	0.0156	0.7960	0.9967	0.4882	0.4095	0.0044
GAGWO	1.0000	0.0230	0.0156	1.0000	0.6501	0.1639	0.9036	0.9400	1.0000
MWOA	0.5695	0.8555	0.7960	0.6501	1.0000	0.9967	0.9999	0.9997	0.4095
SEQ	0.1239	0.9989	0.9967	0.1639	0.9967	1.0000	0.9400	0.9036	0.0668
PAR	0.8555	0.5695	0.4882	0.9036	0.9999	0.9400	1.0000	1.0000	0.7267
FWA-Encircling	0.9036	0.4882	0.4095	0.9400	0.9997	0.9036	1.0000	1.0000	0.7960
WOA-Spark	1.0000	0.0068	0.0044	1.0000	0.4095	0.0668	0.7267	0.7960	1.0000

Friedman test for PowerConsumption: Statistic = 33.2421, p-value = 5.5700e-05

Supplementary Table 34: *Nemenyi Post Hoc Test (p-values) for PowerConsumption at Cloudlets = 500*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.0190	0.0230	1.0000	0.8555	0.0566	0.6501	0.8555	1.0000
FWA	0.0190	1.0000	1.0000	0.0190	0.6101	1.0000	0.8271	0.6101	0.0128
OBDFWA	0.0230	1.0000	1.0000	0.0230	0.6501	1.0000	0.8555	0.6501	0.0156
GAGWO	1.0000	0.0190	0.0230	1.0000	0.8555	0.0566	0.6501	0.8555	1.0000
MWOA	0.8555	0.6101	0.6501	0.8555	1.0000	0.8271	1.0000	1.0000	0.7960
SEQ	0.0566	1.0000	1.0000	0.0566	0.8271	1.0000	0.9541	0.8271	0.0400
PAR	0.6501	0.8271	0.8555	0.6501	1.0000	0.9541	1.0000	1.0000	0.5695
FWA-Encircling	0.8555	0.6101	0.6501	0.8555	1.0000	0.8271	1.0000	1.0000	0.7960
WOA-Spark	1.0000	0.0128	0.0156	1.0000	0.7960	0.0400	0.5695	0.7960	1.0000

Supplementary Table 35: *Synthetic GoCJ cloudlet-length distribution used in this study (adapted from Fig. 3 of Hussain et al., 2019, Computing and Informatics).*

Category	% of jobs	MI range (paper)	MI range (code)	Cumulative breakpoint
Small	20	15 000–55 000	$15-55 \times 10^3$	0.20
Medium	40	59 000–99 000	$59-99 \times 10^3$	0.60
Large	30	101 000–135 000	$101-135 \times 10^3$	0.90
Extra-large	6	150 000–337 500	$150-337 \times 10^3$	0.96
Huge	4	525 000–900 000	$525-900 \times 10^3$	1.00

Friedman test for Fitness at Cloudlets = 100: Statistic = 15.6000, p-value = 4.8477e-02

Supplementary Table 36: *Nemenyi Post Hoc Test (p-values) for Fitness at Cloudlets = 100*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.9998	1.0000	1.0000	0.9923	0.9923	0.9379	0.7809	0.5374
FWA	0.9998	1.0000	0.9984	0.9923	0.8737	1.0000	0.9984	0.9923	0.8737
OBDFWA	1.0000	0.9984	1.0000	0.9984	0.9923	1.0000	0.8737	0.6650	0.4115
GAGWO	1.0000	0.9923	0.9984	1.0000	0.9998	0.9379	0.7809	0.5374	0.2986
MWOA	0.9923	0.8737	0.9923	0.9998	1.0000	0.7809	0.6650	0.2055	0.0837
SEQ-Hybrid	0.9923	1.0000	1.0000	0.9379	0.7809	1.0000	0.9998	0.9923	0.9751
PAR-Hybrid	0.9379	0.9984	0.8737	0.7809	0.6650	0.9998	1.0000	1.0000	0.9984
Enc-Hybrid	0.7809	0.9923	0.6650	0.5374	0.2055	0.9923	1.0000	1.0000	1.0000
Spark-Hybrid	0.5374	0.8737	0.4115	0.2986	0.0837	0.9751	0.9984	1.0000	1.0000

Friedman test for Fitness at Cloudlets = 200: Statistic = 15.8667, p-value = 4.4329e-02

Supplementary Table 37: *Nemenyi Post Hoc Test (p-values) for Fitness at Cloudlets = 200*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.9998	1.0000	0.9984	0.9751	0.9998	0.9751	0.8737	0.6650
FWA	0.9998	1.0000	0.9923	0.9379	0.7809	1.0000	0.9998	0.9923	0.9379
OBDFWA	1.0000	0.9923	1.0000	1.0000	0.9984	0.9923	0.8737	0.6650	0.4115
GAGWO	0.9984	0.9379	1.0000	1.0000	0.4115	0.9379	0.6650	0.4115	0.2055
MWOA	0.9751	0.7809	0.9984	0.4115	1.0000	0.7809	0.4115	0.2055	0.0837
SEQ	0.9998	1.0000	0.9923	0.9379	0.7809	1.0000	0.9998	0.9923	0.9379
PAR	0.9751	0.9998	0.8737	0.6650	0.4115	0.9998	1.0000	1.0000	0.9984
FWA-Encircling	0.8737	0.9923	0.6650	0.4115	0.2055	0.9923	1.0000	1.0000	1.0000
WOA-Spark	0.6650	0.9379	0.4115	0.2055	0.0837	0.9379	0.9984	1.0000	1.0000

Friedman test for Fitness at Cloudlets = 300: Statistic = 15.7333, p-value = 4.6360e-02

Supplementary Table 38: *Nemenyi Post Hoc Test (p-values) for fitness at Cloudlets = 300*

	FWA	WOA	SEQ	PAR	FWAENCIRCLE	WOASPARK	MWOA	OBDFWA	GAGWO
FWA	1.0000	0.9751	1.0000	0.9998	0.9923	0.9379	0.7809	0.9998	0.9751
WOA	0.9751	1.0000	0.9751	0.7809	0.5374	0.2986	0.9998	0.9998	1.0000
SEQ	1.0000	0.9751	1.0000	0.9998	0.9923	0.9379	0.7809	0.9998	0.9751
PAR	0.9998	0.7809	0.9998	1.0000	1.0000	0.9984	0.4115	0.9751	0.7809
FWAENCIRCLE	0.9923	0.5374	0.9923	1.0000	1.0000	1.0000	0.2055	0.8737	0.5374
WOASPARK	0.9379	0.2986	0.9379	0.9984	1.0000	1.0000	0.0837	0.6650	0.2986
MWOA	0.7809	0.9998	0.7809	0.4115	0.2055	0.0837	1.0000	0.9751	0.9998
OBDFWA	0.9998	0.9998	0.9998	0.9751	0.8737	0.6650	0.9751	1.0000	0.9998
GAGWO	0.9751	1.0000	0.9751	0.7809	0.5374	0.2986	0.9998	0.9998	1.0000

Friedman test for Fitness at Cloudlets = 400: Statistic = 15.7333, p-value = 4.6360e-02

Supplementary Table 39: *Nemenyi Post Hoc Test (p-values) for fitness at Cloudlets = 400*

	FWA	WOA	SEQ	PAR	FWAENCIRCLE	WOASPARK	MWOA	OBDFWA	GAGWO
FWA	1.0000	0.8737	1.0000	0.9998	0.9923	0.9379	0.8737	0.9998	0.9923
WOA	0.8737	1.0000	0.8737	0.5374	0.2986	0.1344	1.0000	0.9923	0.9998
SEQ	1.0000	0.8737	1.0000	0.9998	0.9923	0.9379	0.8737	0.9998	0.9923
PAR	0.9998	0.5374	0.9998	1.0000	1.0000	0.9984	0.5374	0.9751	0.8737
FWAENCIRCLE	0.9923	0.2986	0.9923	1.0000	1.0000	1.0000	0.2986	0.8737	0.6650
WOASPARK	0.9379	0.1344	0.9379	0.9984	1.0000	1.0000	0.1344	0.6650	0.4115
MWOA	0.8737	1.0000	0.8737	0.5374	0.2986	0.1344	1.0000	0.9923	0.9998
OBDFWA	0.9998	0.9923	0.9998	0.9751	0.8737	0.6650	0.9923	1.0000	1.0000
GAGWO	0.9923	0.9998	0.9923	0.8737	0.6650	0.4115	0.9998	1.0000	1.0000

Friedman test for Fitness at Cloudlets = 500: Statistic = 16.0000, p-value = 4.2380e-02

Supplementary Table 40: *Nemenyi Post Hoc Test (p-values) for Fitness at Cloudlets = 500*

	WOA	FWA	OBDFWA	GAGWO	MWOA	SEQ	PAR	FWA-Encircling	WOA-Spark
WOA	1.0000	0.9751	1.0000	1.0000	1.0000	0.6650	0.8737	0.4115	0.2055
FWA	0.9751	1.0000	0.9984	0.9751	0.7809	1.0000	0.9984	0.9751	0.8737
OBDFWA	1.0000	0.9984	1.0000	0.9984	0.9984	0.8737	0.9751	0.6650	0.4115
GAGWO	1.0000	0.9751	0.9984	1.0000	0.9998	0.9379	0.7809	0.5374	0.2986
MWOA	1.0000	0.7809	0.9984	0.9998	1.0000	0.4115	0.6650	0.2055	0.0837
SEQ	0.6650	1.0000	0.8737	0.9379	0.4115	1.0000	1.0000	0.9984	0.9984
PAR	0.8737	0.9984	0.9751	0.7809	0.6650	1.0000	1.0000	0.9984	0.9984
FWA-Encircling	0.4115	0.9751	0.6650	0.5374	0.2055	0.9984	0.9984	1.0000	1.0000
WOA-Spark	0.2055	0.8737	0.4115	0.2986	0.0837	0.9984	0.9984	1.0000	1.0000