of capacity to blockchain mining resource requirements. Similarly, average mining energy needed for PoS, PoW, and PoA based consensus models was evaluated, and can be observed from table 4 as follows,

NBM	**E (mJ) RMN [3]**	**E (mJ) AAMN [6]**	**E (mJ) DLH [14]**	**E (mJ) HBS BA**
10k	1.03	0.90	1.28	0.90
20k	1.88	1.28	2.10	1.50
30k	3.54	1.75	3.53	2.52
40k	6.21	2.33	5.69	4.07
50k	8.88	5.28	9.43	6.74
60k	11.43	11.30	14.58	10.66
70k	14.93	18.95	21.17	15.73
80k	20.03	21.56	25.99	19.31
90k	22.76	21.34	27.56	20.47
120k	23.77	24.27	30.02	22.30
140k	26.48	27.19	33.54	24.92
160k	29.19	30.11	37.07	27.53
180k	31.90	33.04	40.59	30.15
200k	34.61	35.96	42.76	32.38
220k	37.32	38.89	44.83	34.58
240k	40.03	41.81	48.14	37.14
260k	42.74	44.74	51.46	39.69
275k	45.45	47.66	54.77	42.25
290k	48.16	50.58	58.08	44.81
300k	50.87	53.51	65.60	48.57

Table 4. Average mining energy needed for PoS, PoA, and PoW consensus w.r.t. number of blocks in the blockchain

From this evaluation, it can be observed that the proposed model has 6% lower energy consumption than RMN [3], 9.4% lower energy consumption than AAMN [6], and 15.5% lower energy consumption than DLH [14] for PoS, PoW, and PoA based consensus. Similarly, evaluation of average throughput in blocks mined per minute is tabulated w.r.t. number of blocks used for mining (NBM) in table 5, wherein DPoS consensus model was used.

NBM	T (bpm) RMN [3]	T (bpm) AAMN [6]	T (bpm) DLH [14]	T (bpm) HBS BA
10k	40.00	42.86	31.03	43.45
20k	23.08	27.27	18.75	26.25
30k	12.24	20.69	11.54	16.15
40k	6.49	14.63	6.74	9.44
50k	3.85	11.54	4.33	6.06
60k	3.02	3.77	2.51	3.52
70k	2.33	2.05	1.74	2.35
80k	1.77	1.29	1.19	1.61
90k	1.30	1.51	1.12	1.50
120k	1.34	1.32	1.06	1.43
140k	1.19	1.17	0.94	1.27
160k	1.08	1.05	0.85	1.14
180k	0.98	0.95	0.77	1.04
200k	0.90	0.87	0.71	0.95
220k	0.83	0.80	0.69	0.90
240k	0.78	0.74	0.65	0.84
260k	0.72	0.69	0.60	0.78
275k	0.68	0.65	0.56	0.73
290k	0.64	0.61	0.53	0.69
300k	0.61	0.58	0.50	0.65

Table 5. Average throughput for DPoS consensus w.r.t. number of blocks in the blockchain

From this evaluation, it can be observed that the proposed model is 9% better throughput than RMN [3], 15% better throughput than AAMN [6], and 16.5% better throughput than DLH [14] for DPoS based consensus. This is because of optimum miner selection, and improving the mapping efficiency of capacity to blockchain mining resource requirements. Similarly, average throughput for PoS, PoW, and PoA based consensus models was evaluated, and can be observed from table 4 as follows,

NBM	**T (bpm) RMN [3]**	**T (bpm) AAMN [6]**	**T (bpm) DLH [14]**	**T (bpm) HBS BA**
10k	29.27	33.33	23.38	32.73
20k	16.00	23.53	14.29	20.00
30k	8.48	17.14	8.51	11.91
40k	4.83	12.90	5.27	7.38
50k	3.38	5.69	3.18	4.45
60k	2.63	2.65	2.06	2.81
70k	2.01	1.58	1.42	1.91
80k	1.50	1.39	1.15	1.55
90k	1.32	1.41	1.09	1.47
120k	1.26	1.24	1.00	1.35
140k	1.13	1.10	0.89	1.20
160k	1.03	1.00	0.81	1.09
180k	0.94	0.91	0.74	1.00
200k	0.87	0.83	0.70	0.93
220k	0.80	0.77	0.67	0.87
240k	0.75	0.72	0.62	0.81
260k	0.70	0.67	0.58	0.76
275k	0.66	0.63	0.55	0.71
290k	0.62	0.59	0.52	0.67
300k	0.59	0.56	0.46	0.62

Table 6. Average throughput for PoS, PoA, and PoW consensus w.r.t. number of blocks in the blockchain

From this evaluation, it can be observed that the proposed model is 4.9% better throughput than RMN [3], 6.5% better throughput than AAMN [6], and 10.5% better throughput than DLH [14] for PoA, PoW, and PoS based consensus. Due to these improvements, the proposed model showcases high scalability, and better mining performance. This ensures that the model is applicable for high-speed, low energy, and high throughput application scenarios.

5. Conclusion and future scope

The proposed HBSBA model uses a combination of GA & PSO based approaches for high-throughput, low delay, and low-energy mining operations. This is because of the incorporation of average mining delay during miner node grouping, and internal resource selection processes. The model was tested on various consensus methods, and it was observed that HBSBA outperformed RMN [3], AAMN [6], and DLH [14] models in terms of mining delay, throughput, and energy requirement parameters. The proposed model was observed to be 9.4% faster than RMN [3], 10.5% faster than AAMN [6], and 14.6% faster than DLH [14], while the proposed model had6.5% lower energy consumption than RMN [3], 8.9% lower energy consumption than AAMN [6], and 14.1% lower energy consumption than DLH [14]when averaged forDPoS, PoS, PoW, and PoA based consensus. Due to this improvement in performance, the proposed model is useful for a wide variety of high-speed, and low-energy blockchain storage applications. In future, researchers can further optimize model's performance via use of deep learning for miner node selection, and incorporation of other QoS parameters like computational complexity, resource utilization, and fault tolerance during the mining process. Furthermore, researchers can also explore utilization of Q-learning based approaches, which will assist in application of reward-based miner selection, to achieve better mining performance under different network scenarios.

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