Eliminating Double I/O Amplifications of Hashing Indexes for Persistent Memory

Paper ID: 98

Experiment 1

Uniform Throughput (Mops/s)	Insert	Positive Search	Negative Search	Delete
DASH	1.283140158	3.333146	3.33464	1.898662
CCEH	0.7034597	2.145908	1.229131	0.715493
Level	0.557574666	1.050534	1.051344	0.937153
Clevel	0.143133	0.990972	0.811196	0.299471
ElimDA	3.922547	3.346601	4.670862	1.891378
Zipfian Throughput (Mops/s)	Insert	Positive Search	Negative Search	Delete
DASH	1.053913	3.336167	3.332858	1.607616
CCEH	0.589479	2.046681	0.713374	1.224438
Level	0.474362	1.032295	1.05248	0.809582
Clevel	0.137404	0.997262	0.812245	0.295755
ElimDA	3.008584	3.519766	5.613479	1.617426

Experiment 2

Uniform Insert Throughput (Mops/s)	Thread=1	2	4	8	16	24
DASH	1.080309792	2.067467027	3.54139375	5.265225163	5.601201605	5.560437909
CCEH	0.6927915	1.33181725	2.43652025	4.08677525	5.44514925	5.66926275
Level	0.517253332	0.566679181	0.706762602	0.864436573	1.014259263	1.056101841
Clevel	0.14161	0.272089	0.504664	0.903298	1.399661	1.716833
ElimDA	3.922547	5.90649575	8.58111	10.24791425	10.604887	10.34217225
Uniform Positive Search Throughput (Mops/s)	Thread=1	2	4	8	16	24
DASH	3.333146	5.646048	9.280315	13.539036	17.525591	18.408078
CCEH	2.145908	4.352373	9.02399	15.176016	19.615334	20.702171
Level	1.050534	1.738362	3.092409	4.906786	6.404106	7.143704
Clevel	0.990972	1.81147	3.56415	6.773919	12.12053	16.35713
ElimDA	3.232066	6.387864	12.12249	23.365308	45.662673	55.570597
Uniform Negative Search Throughput (Mops/s)	Thread=1	2	4	8	16	24
DASH	3.33464	5.642306	9.312879	13.537437	17.621648	18.535994
CCEH	0.715493	1.414038	2.708599	4.740526	7.459968	7.946879
Level	1.051344	1.735256	3.113679	4.901411	6.449082	7.051144
Clevel	0.811196	1.542197	3.005827	5.733635	10.279313	13.616402
ElimDA	4.670862	8.87574	16.60734	29.580412	55.667738	76.696932
Uniform Delete Throughput (Mops/s)	Thread=1	2	4	8	16	24
DASH	1.898662	3.598952	5.935547	8.094248	7.910209	8.000926
CCEH	1.229131	2.490614	4.70361	7.886595	8.918177	10.328562
Level	0.937153	1.531833	2.772285	4.398251	5.593817	5.666127
Clevel	0.299471	0.559957	1.03137	1.956335	3.418501	4.645158
ElimDA	1.891378	3.798717	7.616011	13.927861	24.542764	24.506147
Zipfian Insert Throughput (Mops/s)	Thread=1	2	4	8	16	24
DASH	1.053913	2.036119	3.449268	5.292045	5.805819	5.4589
CCEH	0.589479	1.18045	2.285433	4.021246	5.582147	5.985942
Level	0.474362	0.757504	0.973837	1.374645	1.461386	1.382936
Clevel	0.137404	0.261074	0.491295	0.887227	1.380396	1.717355
ElimDA	3.008584	4.897	7.575156	9.482418	10.345348	10.289691
Zipfian Positive Search Throughput (Mops/s)	Thread=1	2	4	8	16	24
DASH	3.336167	5.586168	9.299656	13.530452	17.573843	18.276381
CCEH	2.046681	4.19717	8.781548	15.505613	19.346186	20.01743
Level	1.032295	1.740166	3.093239	4.901955	6.396258	7.103214
Clevel	0.997262	1.877826	3.626865	6.997729	13.112314	18.246416
ElimDA	3.519766	6.928298	13.35923	25.556109	47.885502	67.231218
Zipfian Negative Search Throughput (Mops/s)	Thread=1	2	4	8	16	24
DASH	3.332858	5.648635	9.31015	13.563526	17.526157	18.38305
CCEH	0.713374	1.405746	2.7034	4.67963	7.465958	7.823678
Level	1.05248	1.740997	3.098963	4.889724	6.410645	7.096786
Clevel	0.812245	1.534612	2.948581	5.728126	10.174163	12.411457
ElimDA	5.613479	10.54812	19.2525	33.885931	67.479925	93.789639
Zipfian Delete Throughput (Mops/s)	Thread=1	2	4	8	16	24
DASH	1.607616	3.240823	5.494735	7.556856	7.241076	7.64346
CCEH	1.224438	2.468547	4.720928	7.922391	9.215614	10.335044
Level	0.809582	1.383746	2.516669	4.048322	5.082029	5.198309
Clevel	0.295755	0.55504	1.008447	2.030666	3.581514	4.975246
ElimDA	1.617426	3.226754	6.254576	10.807295	18.029505	21.031336

Experiment 3

Uniform YCSB-A Throughput (Mops/s)	Thread=1	2	4	8	16	24
CCEH	1.941595	3.613314	6.282357	9.603273	10.940991	11.432127
Clevel	0.215008	0.419314	0.809303	1.53451	2.702261	3.576111
ElimDA	2.153351	4.168346	7.992823	14.501894	24.835698	32.031866
Uniform YCSB-B Throughput (Mops/s)	Thread=1	2	4	8	16	24
CCEH	1.553614	3.214115	6.395054	10.17395	12.110555	13.752623
Clevel	0.547787	1.032996	1.977721	3.493462	4.435138	5.079593
ElimDA	2.505578	5.062449	10.14597	18.927396	35.804383	51.360795
Uniform YCSB-D Throughput (Mops/s)	Thread=1	2	4	8	16	24
DASH	2.547534	4.556558	7.806189	10.655705	9.969395	9.275043
CCEH	1.519133	3.087774	6.070746	9.841329	11.607526	12.588382
Level	0.872114	1.425969	1.972523	3.644325	4.716346	5.236053
Clevel	0.575072	1.102422	2.145923	4.137716	7.2416	9.988099
ElimDA	2.329925	4.855599	9.456401	19.6514	30.821283	37.014447
Uniform YCSB-F Throughput (Mops/s)	Thread=1	2	4	8	16	24
DASH	1.361149	2.770951	4.811631	7.28332	7.353183	7.086551
CCEH	0.732373	1.389933	2.745591	4.836576	6.132695	6.397954
Level	0.694532	1.239523	2.192028	3.537363	4.236918	4.501145
Clevel	0.237316	0.453495	0.884652	1.651285	2.836115	3.920888
ElimDA	2.47666	4.507954	7.88224	11.008584	12.664491	12.987161

Experiment 4

Average Latency (µs)	Insert	Positive Search	Negative Search	Delete
DASH	1.044361667	0.373066833	0.5000925	0.718684667
CCEH	1.524968333	0.386246	1.176861667	0.728425333
Level	1.570881667	0.5450395	1.077073333	1.039588333
Clevel	7.030871667	1.033883333	1.263503333	3.415083333
ElimDA	0.256943833	0.530895833	0.277182	0.588333667
Tail Latency (µs)	Insert	Positive Search	Negative Search	Delete
DASH	1.835166667	0.924166667	0.814833333	1.379166667
CCEH	2.243333333	1.098333333	1.776166667	1.322833333
Level	3.057166667	1.446333333	1.527166667	1.833166667
Clevel	9.195833333	2.0745	1.710333333	4.414666667
ElimDA	2.850333333	0.914333333	0.641833333	1.054833333

Experiment 5

Generality Throughput (Mops/s)	Thread=1	2	4	8
DASH	1.283140158	2.072691605	3.53174895	5.360657633
CCEH	0.7034597	1.34320045	2.45769145	4.14895545
Level	0.557574666	0.657257436	0.72774372	0.870801715
Clevel	0.143133	0.2713206	0.5084744	0.9096078
ElimDA-ADR	2.5782742	3.833981	5.321804	6.3865466
ElimDA	3.922547	5.90649575	8.58111	10.24791425

Experiment 6

Storage Traffic	Write Traffic (GB)	Read Traffic (GB)
DASH	35.11431432	33.44651294
CCEH	21.9854815	128.2352502
Level	27.12402272	74.41524744
Clevel	41.02325344	102.6981823
ElimDA	14.68339324	5.334648371

Experiment 7

	Number of inserted items=20M	40M	60M	80M	100M
DRAM Space(MB)	353.9335938	632.4375	997.4414063	1189.441406	1599.445313
PMEM Space(MB)	3084.32	6166.57	11822.5	12330.8	12331.2
Ratio(%)	11.47525528	10.25590401	8.436806143	9.646100871	12.97071909

Experiment 8

Variable Size Throughput (Mops/s)	Value size=16B	32B	64B	128B	256B
DASH	4.761206	4.370462	4.012544	3.648672	2.531003
Clevel	1.75256215	1.7737998	1.7562037	1.771669775	1.741172375

ElimDA	10.386038	9.658415	8.6240422	6.5575232	3.9948698	

Experiment 9

Load Factor (%)	Number of inserted items=10M	20M	30M	40M	50M	60M
DASH	66.0554	66.0554	53.2927	66.0554	82.4597	53.3501
CCEH	59.5719	59.5737	47.6062	59.5728	69.9493	47.5765
Level	90.8261	90.8261	68.1196	90.8261	56.7663	68.1196
Clevel	79.4729	34.0598	59.6046	79.4729	49.6705	59.6046
ElimDA	58.2397	58.4628	86.9331	58.575	73.2188	87.5213
Load Factor (%)	Number of inserted items=70M	80M	90M	100M	110M	120M
DASH	57.7984	66.0554	74.3123	82.434	79.1072	53.3446
CCEH	52.1537	59.5742	66.6419	70.1075	59.5115	47.6101
Level	79.4729	90.8261	51.0897	56.7663	62.443	68.1196
Clevel	69.5388	34.0598	44.7035	49.6705	54.6376	59.6046
ElimDA	51.3024	58.6313	65.9602	73.2891	80.618	87.6263
Load Factor (%)	Number of inserted items=130M	140M	150M	160M	170M	180M
DASH	53.6829	57.7984	61.9269	66.0554	70.1838	74.3117
CCEH	48.4817	52.1525	55.8725	59.5756	63.2159	66.6449
Level	73.7962	79.4729	85.1495	90.8261	48.2514	51.0897
Clevel	64.5717	69.5388	74.5058	34.0598	42.22	44.7035
ElimDA	48.0123	51.327	54.9932	58.6594	62.3257	65.9919
Load Factor (%)	Number of inserted items=190M	200M	210M	220M	230M	240M
DASH	78.4342	82.4434	84.9072	79.1159	63.3772	53.3364
CCEH	69.3263	70.0462	66.8545	59.503	51.8082	47.5918
Level	53.928	56.7663	59.6046	62.443	65.2813	68.1196
Clevel	47.187	49.6705	52.1541	54.6376	57.1211	59.6046
ElimDA	69.6581	73.3243	76.9905	80.6567	84.3127	87.5618

Experiment 10

Recovery Time (s)	Number of inserted items=10M	20M	30M	40M	50M	60M
Thread-1	1.019021	1.701144	2.67022	4.148077	5.295827	6.442554
Thread-2	0.641324	1.107109	1.744625	2.561423	2.57323	3.887687
Thread-4	0.318097	0.604255	0.889645	1.463234	1.348193	2.072193
Thread-8	0.279771	0.568726	0.83541	1.206373	1.238804	1.733268
Thread-16	0.28424	0.426633	0.557426	0.811576	1.044326	1.600264
Recovery Time (s)	Number of inserted items=70M	80M	90M			
Thread-1	8.876461	10.0626375	11.998766			
Thread-2	5.89861	5.911388	6.831252			
Thread-4	3.256454	4.028798	4.436944			
Thread-8	2.696686	2.515745	3.220148			
Thread-16	2.288776	2.900847	3.040928			

Experiment 11

Collecting Log Throughput (Mops/s)	Thread=1	2	4	8	16
# of CL=1024	4.062758	5.898733	7.964491	6.943793	7.416826
# of CL=2048	4.040215	5.840367	8.184908	8.915843	7.89085
# of CL=4096	4.079797	5.760904	8.034873	9.292678	9.000982
# of CL=8192	4.06137	5.903802	8.17561	9.549864	9.339322
# of CL=16384	3.935196	5.720275	7.374753	8.80099	8.595275

Experiment 12

Variable D-Bucket Size Throughput (Mops/s)	Insert	Positive Search
D-bucket=32B	3.145602	3.2799376
D-bucket=64B	3.5349648	3.2613828
D-bucket=128B	3.9359676	3.2646792
D-bucket=256B	4.2910248	3.222658
D-bucket=512B	4.250635	3.2026118
Variable P-Bucket Size Throughput (Mops/s)	Insert	Positive Search
P-bucket=1KB	3.4674334	3.5334476
P-bucket=2KB	3.8565558	3.4255384
P-bucket=4KB	4.2889746	3.2057322
P-bucket=8KB	4.6156216	2.7559206
P-bucket=16KB	4.7509992	2.3937694

Experiment 13

Limited Bandwidth Throughput (Mops/s)	Insert	Positive Search	Negative Search	Delete
DASH	1.458234086	5.727200204	5.283887372	1.69116178
CCEH	1.55430175	5.815483003	2.204991	3.16366375
Level	0.7559174	4.116745443	2.028443723	1.464621312
Clevel	0.497139711	5.582628	3.837661875	1.931646281
ElimDA	4.863269	23.041109	71.33224475	5.61832025