

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	1.444633333	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					
DASH	66.0554	20M66.0554	30M53.2927	40M66.0554	50M82.4597	60M53.3501
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					
DASH	57.7984	80M66.0554	90M74.3123	100M82.434	110M79.1072	120M53.3446
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					
DASH	53.6829	140M57.7984	150M61.9269	160M66.0554	170M70.1838	180M74.3117
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					
DASH	78.4342	200M82.4434	210M84.9072	220M79.1159	230M63.3772	240M53.3364
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					
Thread-1	1.019021	20M1.701144	30M2.67022	40M4.148077	50M5.295827	60M6.442554
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					
Thread-1	8.876461	80M10.0626375	90M11.998766			
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