APPENDIX

A. Experiments on Parameter Setting

Effect of # levels. We conduct experiments on the choice of the number of levels for M4 and the straw-man solution. As shown in Figure 1, choosing $\#\ lv = 4$ gives the best accuracy and a comparatively good speed for M4. So we design the M4 to have four levels. As shown in Figure 2, choosing $\#\ lv = 3$ gives a close to the best accuracy and a comparatively good speed for the straw-man solution. So we design the straw-man solution to have three levels.

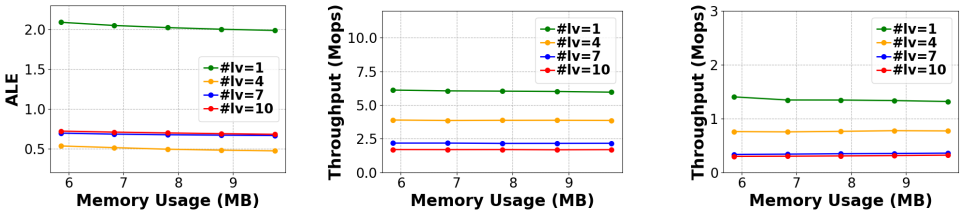
Effect of *w*. As shown in Figure 3, the optimal performance is achieved when $w = 3$. We conduct experiments on different M4-*META*s on various datasets. Altering the hash number w, we find that $w = 3$ and $w = 4$ yield similar accuracy. Since M4 with $w = 3$ runs faster than $w = 4$, we select $w = 3$ as our default setting.

Effect of *p*. As shown in Figure 4, M4 performs consistently regardless of the value of p. We query $p = 0.5, 0.75, 0.95$, and 0.99 respectively on different M4-*META* on various datasets. Results indicate that the accuracy under different settings of p is similar and follows a consistent trend. Users can set p to an arbitrary value. We default $p = 0.5$ for conducting other experiments.

B. Experiments on Speed

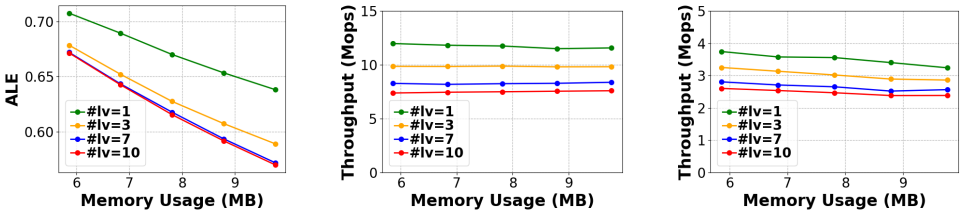
Insertion Throughput. As shown in Figure 5, the experiment results demonstrate that the insertion throughput of M4 is at the same level with the comparison frameworks. Specifically on the three real-world datasets, the insertion throughput of M4 is on average 0.80×, 0.71×, and 0.52× of those of the straw-man solution, and 1.30×, 1.16× and 0.71× of Cuckoo Filter.

Query Throughput. As shown in Figure 6, the experiment results demonstrate that the query throughput of M4 is at the same level with the comparison frameworks. Specifically on the three real-world datasets, the query throughput of M4 is on average 0.83×, 0.89×, and 0.53× of those of the straw-man solution, and 0.92×, 1.00× and 0.61× of Cuckoo Filter.



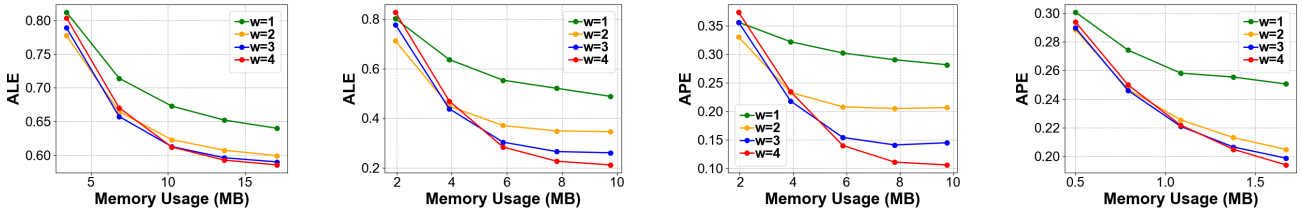
(a) ALE. (b) Insertion throughput. (c) Query throughput.

Fig. 1: Effect of the number of levels on accuracy of M4.



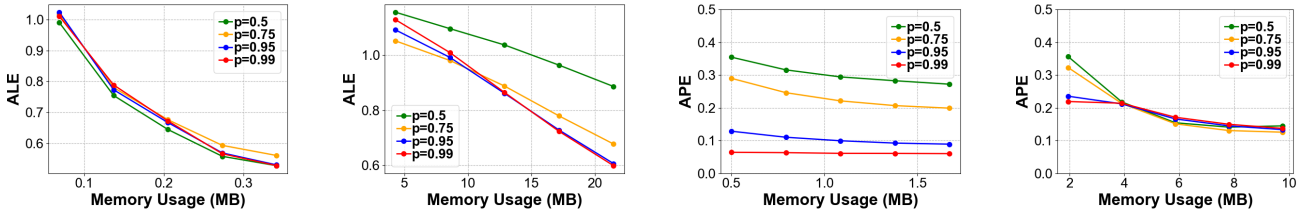
(a) ALE. (b) Insertion throughput. (c) Query throughput.

Fig. 2: Effect of the number of levels on accuracy of Straw-man.



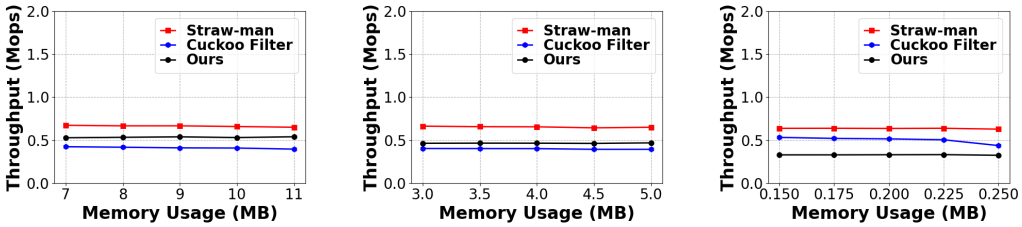
(a) M4-DDSketch on CAIDA. (b) M4-t-digest on MAWI. (c) M4-t-digest on MAWI. (d) M4-mReqSketch on IMC.

Fig. 3: Effect of w on accuracy.



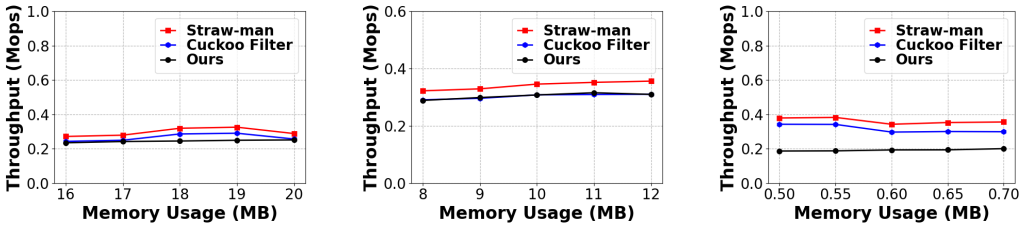
(a) M4-DDSketch on IMC. (b) M4-mReqSketch on CAIDA. (c) M4-mReqSketch on IMC. (d) M4-t-digest on MAWI.

Fig. 4: Effect of p on accuracy.



(a) CAIDA. (b) MAWI (c) IMC

Fig. 5: Insertion throughput on different datasets.



(a) CAIDA (b) MAWI (c) IMC

Fig. 6: Query throughput on different datasets.