Preferential attachment

Report

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1 Introduction

Using an anonymous and unlinkable ring signature-based forum, the way of choosing the K set of the signature ring can affect the privacy of users. In this report is demonstrated that preferential attachment way makes users more anonymous and invulnerable from knowing its messages than uniformly random manner.

1.1 Simulation program

The simulation forum program was made in `python3`. The code can be found here. Its execution was made using 200 people and Zipf distribution to determine the number of messages of each member. Also, was parametrized the maximum number of messages from an author, in order to know which member can have the worst privacy. In all cases of s from 1.3 to 2.0, the number of messages determined from the distribution is 305.

The K, the size of the ring signature, ranges from 3 to 12. In order to compare the different ways of determining the signature, it is compared with authors of 1, 5 and 15 messages.

The number of each table is calculated as an average of 10 random seeds for sampling the distribution. So, the meaning of 1 message (msm) and $K = 4$ and $s = 1.3$ means that on an average of 10 times, has a privacy score of 13.4. The score of each element is calculated by:

$$privacyScore(X) = \frac{\#X \text{ has signed a message}}{\#X \text{ has really sended a message}}$$

Given all the privacy scores of the different rings using a specific Zipf distribution, then is calculated the average of an specific member of them in order to compare, in general terms, the privacy between different Zipf distributions and the different ring-signature methods.
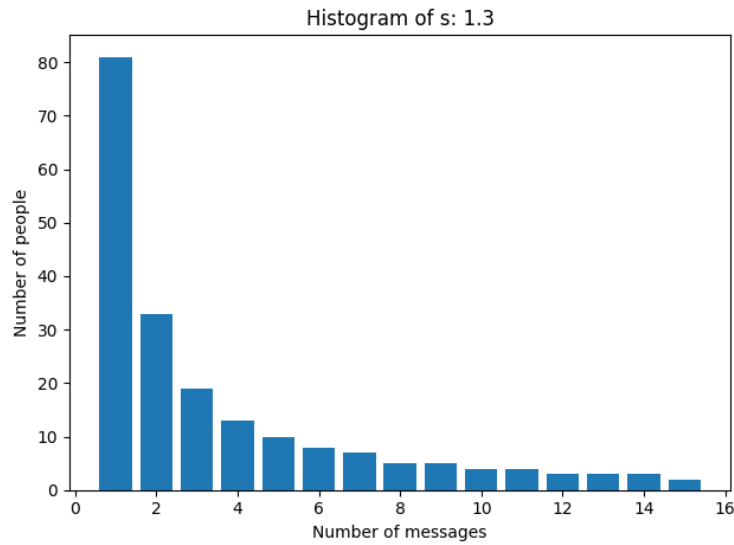
2 s: 1,3

Figure 1: Histogram of Zipf Distribution using $s = 1.3$

K	1msm	5msm	15msm
3	10.4	2.34	1.4533
4	13.4	2.86	1.7533
5	17.7	3.76	1.9533
6	21.4	4.34	2.2133
7	24.8	4.82	2.4933
8	28.7	5.62	2.72
9	32.5	6.36	2.9267
10	36.7	7.16	3.2533
11	40.8	7.96	3.3867
12	44.9	8.84	3.5467
	27.13	5.406	2.57

Table 1: Simulation method:uniform simulation S:1.3

K	1msm	5msm	15msm
3	6.5	2.0	2.3733
4	15.7	2.9	2.6
5	20.7	4.58	2.72
6	26.4	4.9	2.5667
7	35.2	4.18	3.0067
8	40.4	6.5	4.4733
9	45.8	5.98	3.4867
10	54.0	7.02	4.2667
11	58.0	4.82	4.0867
12	61.5	14.02	5.3067
	36.42	5.69	3.4887

Table 2: Simulation method:preferential attachment simulation S:1.3

3   s: 1,4
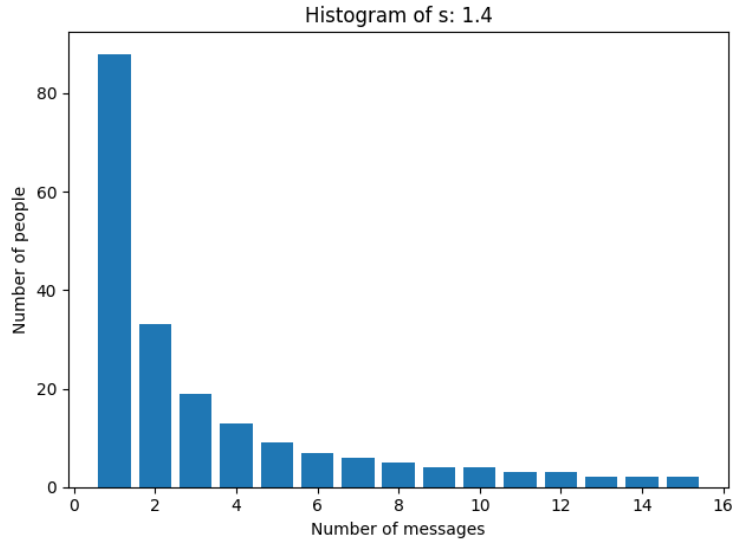
Figure 2: Histogram of Zipf Distribution using $s = 1.4$

K	1msm	5msm	15msm
3	10.0	2.24	1.4133
4	13.4	2.8	1.6333
5	17.5	3.72	1.8067
6	20.1	4.1	2.1467
7	24.4	4.74	2.2867
8	27.7	5.36	2.5467
9	31.2	6.04	2.7133
10	33.1	6.32	3.0933
11	38.0	7.12	3.1467
12	42.7	7.88	3.3867
	25.81	5.032	2.4173

Table 3: Simulation method:uniform simulation S:1.4

K	1msm	5msm	15msm
3	8.1	4.04	2.0267
4	20.1	4.34	2.9067
5	26.1	7.38	2.3333
6	37.7	6.2	3.2067
7	42.3	8.86	4.06
8	43.9	7.56	3.9333
9	52.3	8.8	3.78
10	62.1	7.92	4.8333
11	91.8	11.76	4.3267
12	93.2	12.86	5.4133
	47.76	7.972	3.682

Table 4: Simulation method:preferential attachment simulation S:1.4

4   s: 1,5
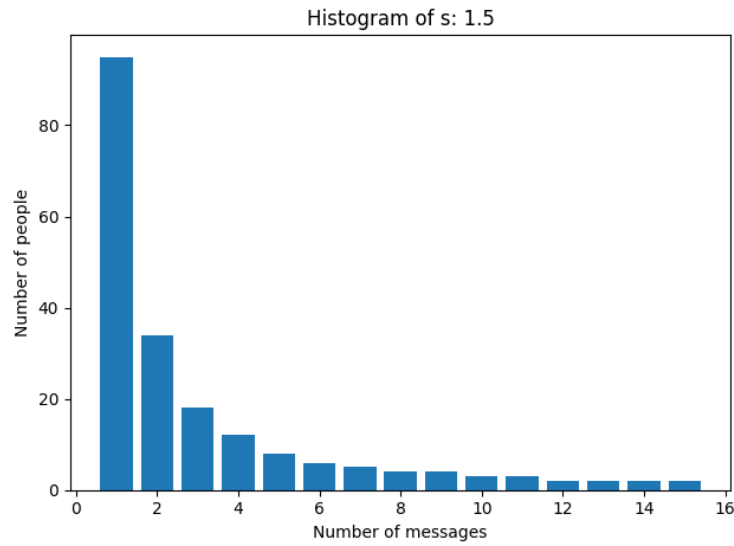
Figure 3: Histogram of Zipf Distribution using $s = 1.5$

K	1msm	5msm	15msm
3	8.9	2.12	1.3933
4	12.2	2.5	1.62
5	16.0	3.16	1.7733
6	18.6	3.9	2.0733
7	22.2	4.58	2.1867
8	25.3	4.98	2.38
9	30.0	5.66	2.5867
10	31.9	6.36	2.88
11	34.9	7.02	3.0333
12	39.4	7.14	3.2867
	23.94	4.742	2.3213

Table 5: Simulation method:uniform simulation S:1.5

K	1msm	5msm	15msm
3	4.6	3.38	2.42
4	14.4	3.24	2.3133
5	18.9	5.32	4.2467
6	19.7	6.92	4.1133
7	30.8	6.1	3.8933
8	34.9	8.7	5.0533
9	41.0	6.64	4.3067
10	43.4	9.24	5.2933
11	50.7	6.08	6.6667
12	56.5	6.7	6.2467
	31.49	6.232	4.4553

Table 6: Simulation method:preferential attachment simulation S:1.5

5   s: 1,6
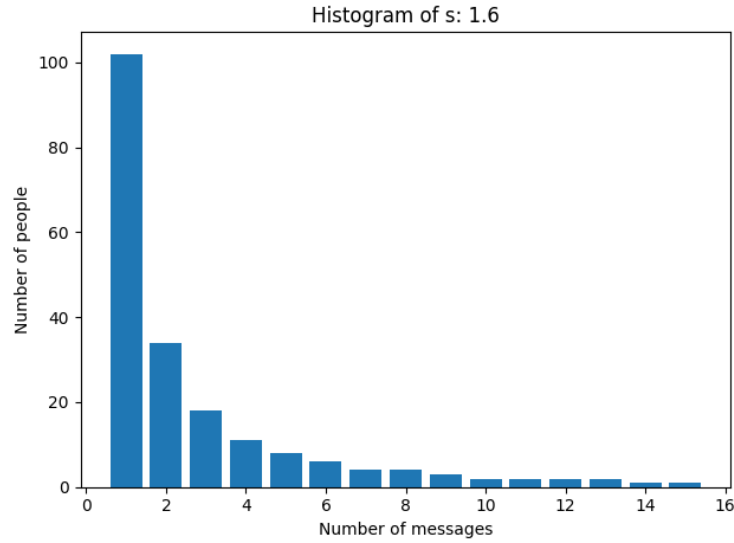
Figure 4: Histogram of Zipf Distribution using $s = 1.6$

K	1msm	5msm	15msm
3	8.3	2.22	1.3067
4	11.4	2.94	1.5667
5	15.3	3.28	1.7
6	17.8	3.92	1.9133
7	20.1	4.56	2.0333
8	23.0	5.1	2.24
9	27.3	5.44	2.4667
10	29.8	6.12	2.52
11	31.6	6.68	2.7133
12	35.0	7.18	2.9267
	21.96	4.744	2.1387

Table 7: Simulation method:uniform simulation S:1.6

K	1msm	5msm	15msm
3	8.8	2.96	2.04
4	15.0	3.3	2.7667
5	17.9	3.54	3.1333
6	21.9	5.22	3.24
7	26.5	3.28	3.0133
8	35.2	4.1	3.3933
9	35.3	6.14	3.68
10	47.2	6.48	3.6333
11	55.2	7.18	3.84
12	43.6	6.58	4.0733
	30.66	4.878	3.2813

Table 8: Simulation method:preferential attachment simulation S:1.6

6 s: 1,7
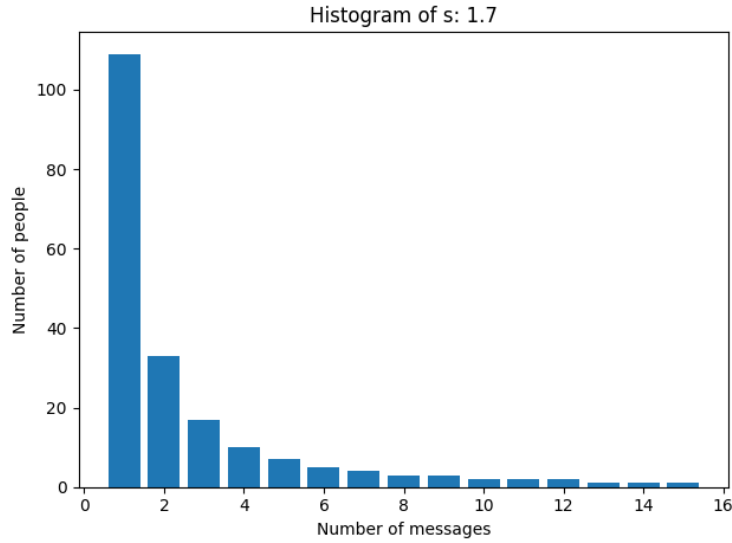
Figure 5: Histogram of Zipf Distribution using $s = 1.7$

K	1msm	5msm	15msm
3	7.4	1.98	1.2933
4	11.3	2.54	1.52
5	15.0	3.12	1.6533
6	17.4	3.52	1.86
7	19.4	4.04	2.0067
8	22.3	4.4	2.14
9	25.5	5.24	2.3133
10	27.8	5.9	2.4667
11	30.2	6.6	2.6333
12	34.0	6.94	2.8267
	21.03	4.428	2.0713

Table 9: Simulation method:uniform simulation S:1.7

K	1msm	5msm	15msm
3	8.7	2.68	2.16
4	12.8	2.54	2.6133
5	21.6	5.78	3.4467
6	20.9	3.3	3.44
7	24.0	4.76	3.18
8	28.7	7.42	3.5867
9	40.5	6.62	4.3333
10	41.6	8.38	4.2333
11	43.3	8.86	4.2133
12	54.6	3.92	5.1867
	29.67	5.426	3.6393

Table 10: Simulation method:preferential attachment simulation S:1.7

7   s: 1,8
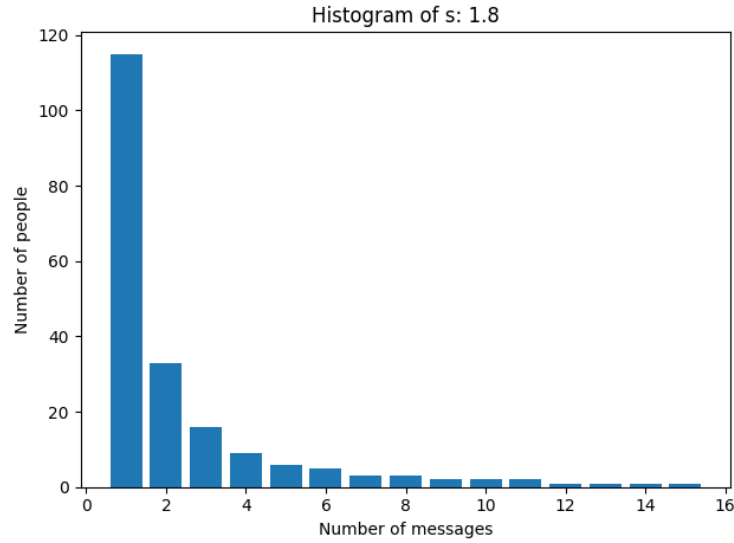
Figure 6: Histogram of Zipf Distribution using $s = 1.8$

K	1msm	5msm	15msm
3	7.0	2.1	1.2267
4	10.1	2.42	1.4933
5	13.9	3.02	1.6133
6	15.5	3.42	1.8467
7	19.7	4.04	1.88
8	21.0	4.58	2.0
9	23.9	4.86	2.2733
10	26.2	5.42	2.44
11	28.4	5.96	2.5667
12	31.9	6.38	2.6933
	19.76	4.22	2.0033

Table 11: Simulation method:uniform simulation S:1.8

K	1msm	5msm	15msm
3	6.2	3.32	2.0067
4	10.4	3.26	2.48
5	12.9	3.16	3.08
6	17.2	2.74	2.9333
7	20.3	3.86	3.4867
8	27.5	6.9	3.1
9	29.3	5.02	4.0733
10	24.6	4.38	4.5267
11	30.5	6.76	5.4133
12	34.6	7.3	4.7333
	21.35	4.67	3.5833

Table 12: Simulation method:preferential attachment simulation S:1.8

8 s: 1,9
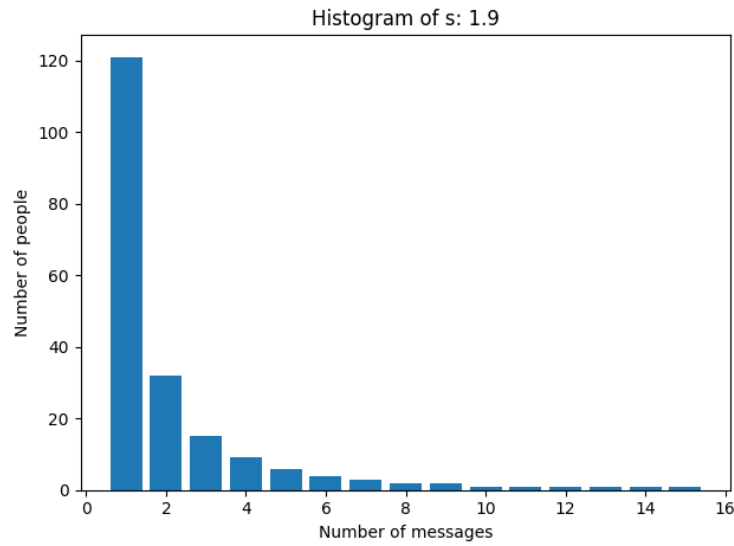
Figure 7: Histogram of Zipf Distribution using $s = 1.9$

K	1msm	5msm	15msm
3	6.0	1.72	1.2533
4	9.5	2.22	1.42
5	13.5	2.52	1.6
6	15.3	2.8	1.7933
7	17.9	3.28	1.8333
8	19.7	3.64	1.9933
9	22.1	3.82	2.1533
10	24.4	4.46	2.26
11	26.5	4.82	2.48
12	30.0	5.48	2.6
	18.49	3.476	1.9387

Table 13: Simulation method:uniform simulation S:1.9

K	1msm	5msm	15msm
3	5.0	3.14	2.62
4	9.5	2.2	2.8667
5	11.8	3.48	2.7533
6	16.5	5.68	3.4
7	18.9	3.4	3.6467
8	21.9	6.48	3.9133
9	25.3	6.9	4.8267
10	27.6	5.76	5.3667
11	27.8	9.62	4.8933
12	30.6	5.18	4.8733
	19.49	5.184	3.916

Table 14: Simulation method:preferential attachment simulation S:1.9

9 s: 2,0
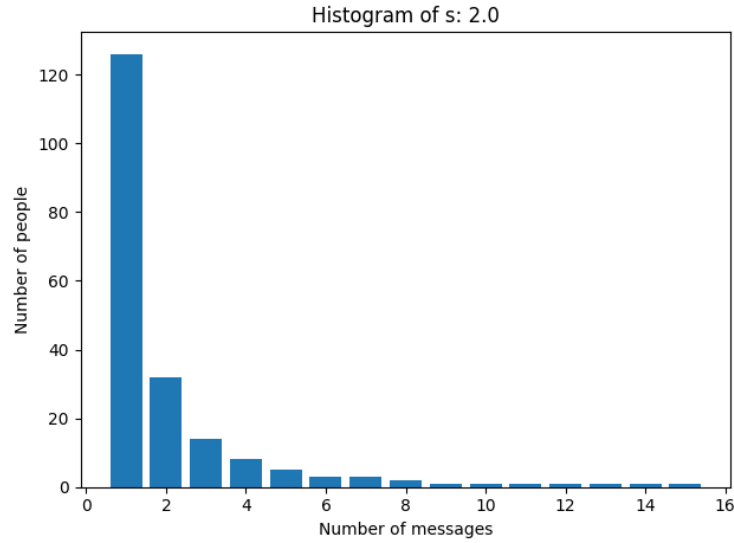
Figure 8: Histogram of Zipf Distribution using $s = 2.0$

K	1msm	5msm	15msm
3	6.4	2.0	1.2467
4	9.0	2.4	1.3933
5	12.9	2.8	1.6333
6	14.4	3.36	1.7133
7	17.5	3.84	1.8133
8	19.0	4.3	1.9933
9	21.6	4.8	2.04
10	23.2	5.24	2.2533
11	24.4	5.56	2.3533
12	28.4	5.88	2.5733
	17.68	4.018	1.9013

Table 15: Simulation method:uniform simulation S:2.0

K	1msm	5msm	15msm
3	6.0	2.5	2.3467
4	10.3	2.66	3.0667
5	14.3	2.52	3.14
6	15.7	5.1	3.3067
7	15.4	3.62	3.0333
8	16.8	4.18	4.3
9	21.7	5.3	4.6067
10	25.9	3.92	3.6533
11	26.6	5.62	4.0133
12	30.6	4.18	3.6933
	18.33	3.96	3.516

Table 16: Simulation method:preferential attachment simulation S:2.0