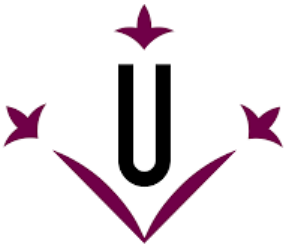

Universitat de Lleida

Preferential attachment

Report

Made by
Oriol Alàs Cercós, Sergi Simón Balcells

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Universitat de Lleida
Escola Politècnica Superior
Grau en Enginyeria Informàtica
CiG

Professorate:
Francesc Sebé

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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

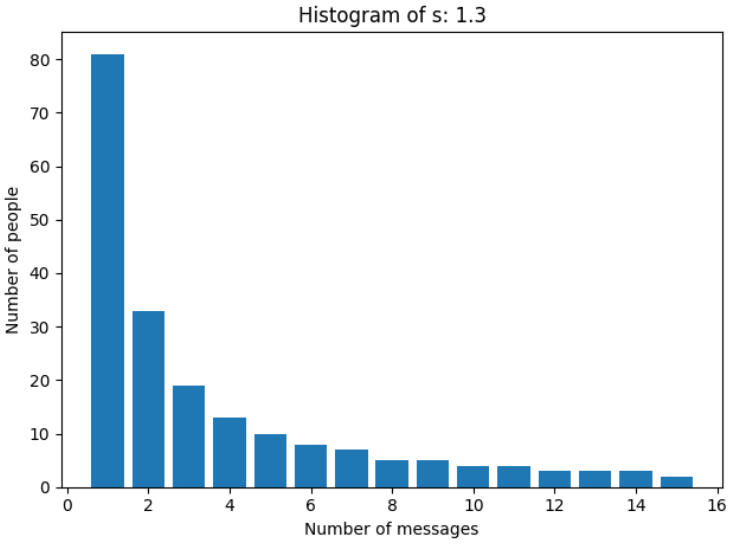

Figure 1: Histogram of Zipf Distribution using $s = 1.3$

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	8.6	1.68	1.9267
4	7.1	2.48	2.24
5	9.3	2.46	2.58
6	15.8	5.22	3.9733
7	23.8	7.22	2.6867
8	28.7	4.6	3.0267
9	31.7	4.82	2.6667
10	48.0	4.76	3.4867
11	66.2	6.42	4.3333
12	81.5	8.26	4.7333
	32.07	4.792	3.1653

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

3 s: 1,4

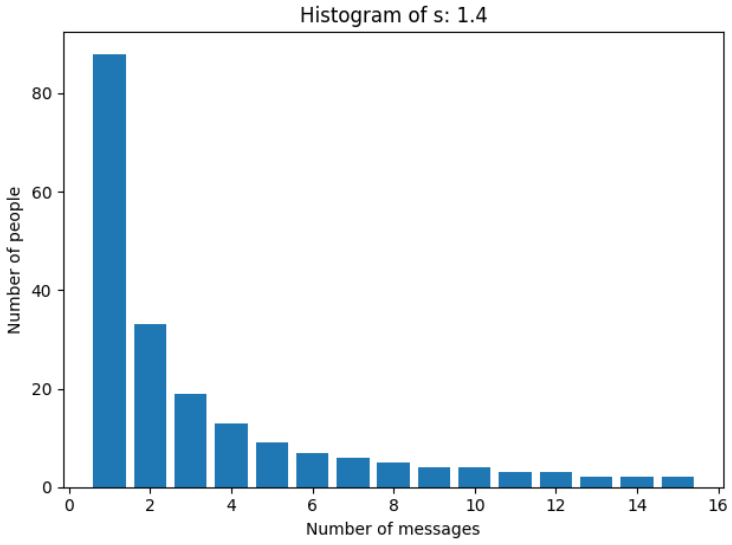

Figure 2: Histogram of Zipf Distribution using $s = 1.4$

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	5.3	3.48	2.2333
4	20.1	9.54	2.72
5	38.1	8.22	3.4267
6	38.3	5.74	4.46
7	51.5	4.7	4.56
8	52.3	7.36	5.82
9	49.3	14.3	4.98
10	53.2	10.76	6.1467
11	84.5	15.02	6.2467
12	103.2	16.82	6.7533
	49.58	9.594	4.7347

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

4 s: 1,5

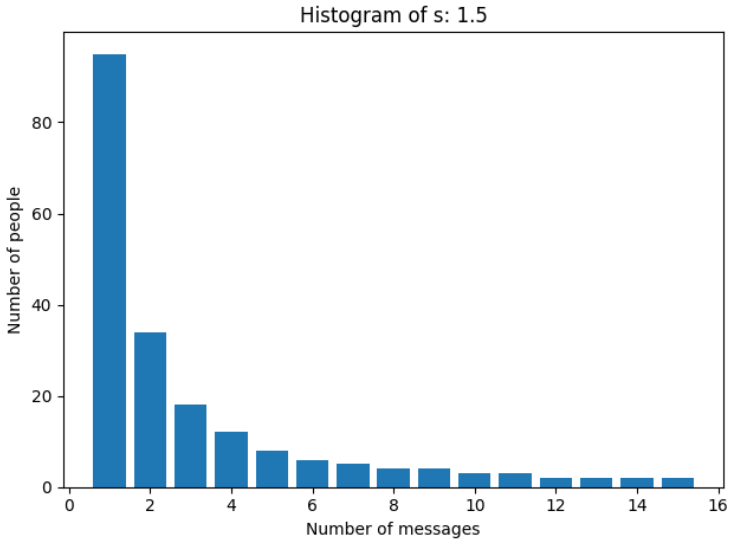

Figure 3: Histogram of Zipf Distribution using $s = 1.5$

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	3.1	3.52	2.6
4	5.3	5.6	3.68
5	7.3	10.86	4.0467
6	11.4	9.54	4.2467
7	25.0	13.24	6.1733
8	27.7	13.3	4.7733
9	29.7	10.52	5.54
10	23.5	11.58	7.4267
11	27.3	14.54	6.0733
12	30.9	23.02	9.1
	19.12	11.572	5.366

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

5 s: 1,6

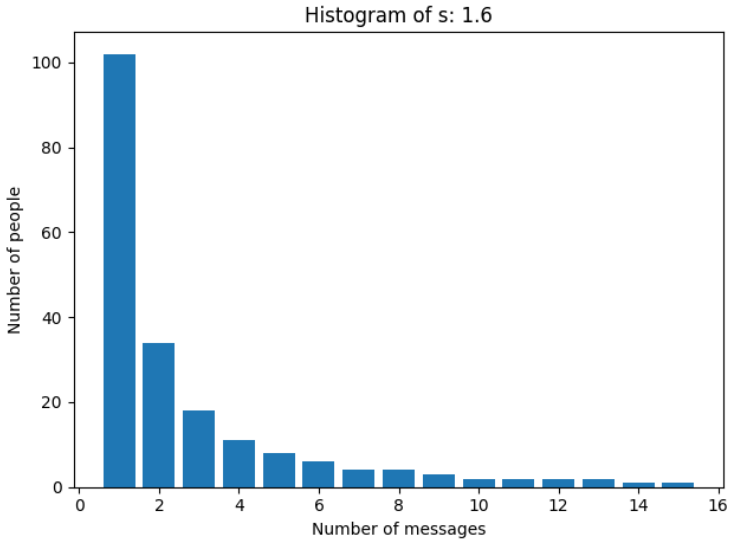

Figure 4: Histogram of Zipf Distribution using $s = 1.6$

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	6.6	3.0	2.6667
4	10.9	3.5	3.2067
5	13.5	3.9	4.12
6	14.0	3.48	4.1333
7	13.9	4.34	4.5067
8	20.7	8.42	5.36
9	24.4	9.6	4.1733
10	26.4	7.8	5.8667
11	31.2	7.28	4.9333
12	37.7	8.26	4.46
	19.93	5.958	4.3427

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

6 s: 1,7

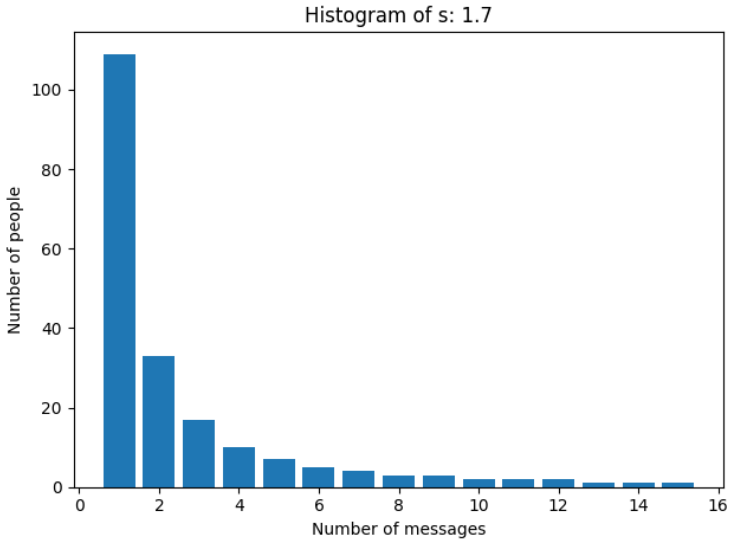

Figure 5: Histogram of Zipf Distribution using $s = 1.7$

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	7.3	3.28	2.6667
4	11.9	3.5	3.02
5	15.1	4.4	3.2733
6	18.6	4.7	3.4133
7	24.3	6.22	3.76
8	27.3	5.0	3.52
9	34.5	8.54	4.54
10	56.5	10.28	4.8067
11	58.5	5.56	4.7467
12	72.7	7.34	5.98
	32.67	5.882	3.9727

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

7 s: 1,8

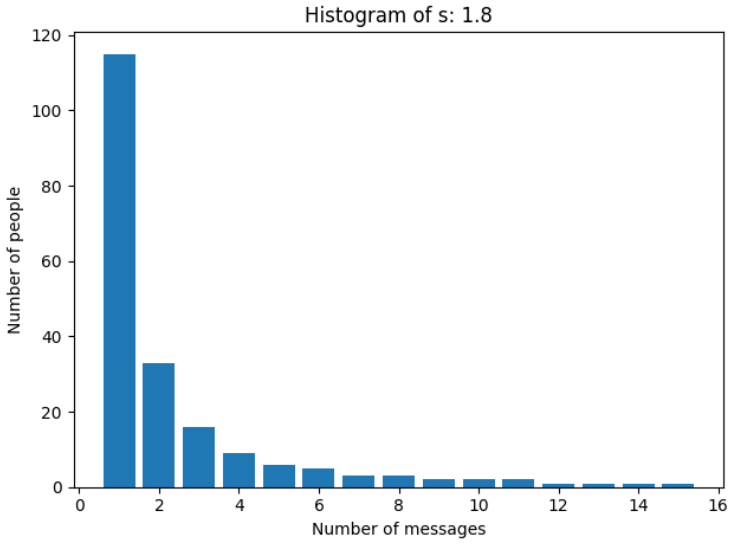

Figure 6: Histogram of Zipf Distribution using $s = 1.8$

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	5.0	1.92	2.28
4	7.8	2.18	3.0333
5	11.7	3.96	3.02
6	14.3	3.02	3.4267
7	14.8	4.78	4.9
8	19.0	3.5	3.9467
9	19.9	2.24	5.54
10	18.3	4.24	6.1333
11	16.8	3.54	5.8133
12	17.7	3.54	6.1467
	14.53	3.292	4.424

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

8 s: 1,9

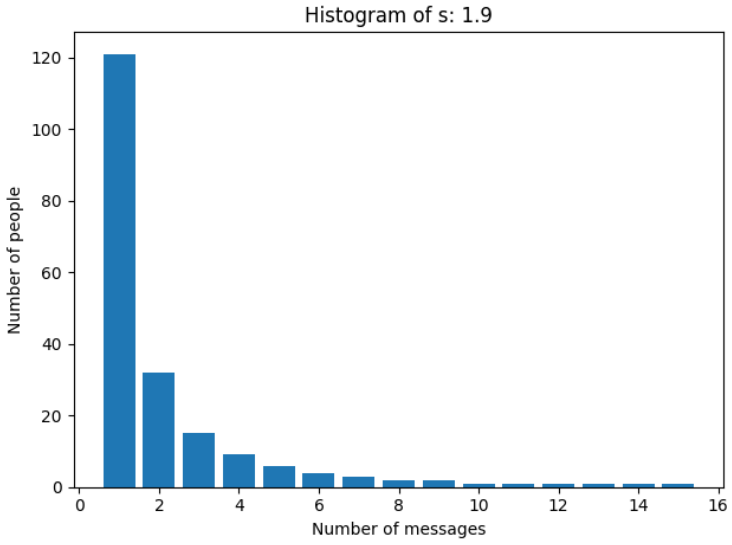

Figure 7: Histogram of Zipf Distribution using $s = 1.9$

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	4.9	2.8	2.4867
4	8.4	2.92	3.1267
5	23.7	3.18	3.6933
6	30.8	5.86	4.2667
7	17.9	4.84	4.0
8	32.1	6.12	4.7867
9	35.0	8.0	5.18
10	36.1	8.6	6.2867
11	37.4	8.66	6.0933
12	40.8	14.02	6.4933
	26.71	6.5	4.6413

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

9 s: 2,0

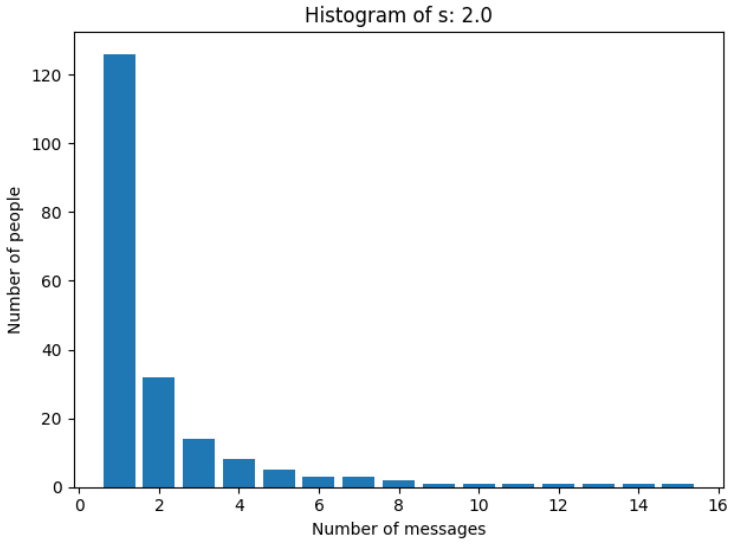

Figure 8: Histogram of Zipf Distribution using $s = 2.0$

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	6.6	2.22	2.2667
4	8.8	2.78	3.0733
5	10.5	3.56	3.2467
6	11.9	2.26	3.4533
7	13.7	3.66	3.4467
8	16.1	5.6	4.32
9	16.9	3.3	4.6133
10	21.7	3.8	4.6533
11	18.3	4.2	5.2333
12	19.0	4.06	5.7667
	14.35	3.544	4.0073

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