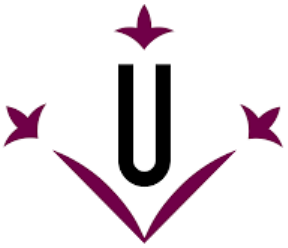

Universitat de Lleida

Preferential attachment

Report

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Delivery
28th of May, 2020

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Contents

List of Figures

List of Tables

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 an 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 different ring-signature methods.

2 s: 1,3

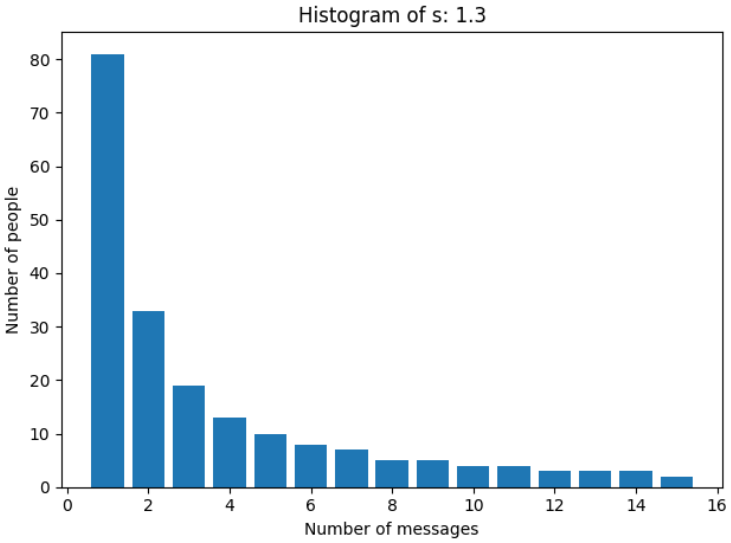

Figure 1: Histogram of Zipf Distribution using $s = 1.3$

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: Uniformly random choice of Zipf distribution s:1.3

K	1msm	5msm	15msm
3	10.7	2.1	1.98
4	16.9	3.82	2.4
5	24.0	4.6	2.4867
6	28.1	5.22	2.4733
7	35.1	6.06	3.5
8	41.5	7.04	2.8733
9	43.4	6.24	4.5
10	53.4	7.42	3.66
11	58.2	8.64	3.64
12	63.6	8.54	4.0933
	37.49	5.968	3.1607

Table 2: Preferential attachment choice of Zipf distribution s:1.3

3 s: 1,4

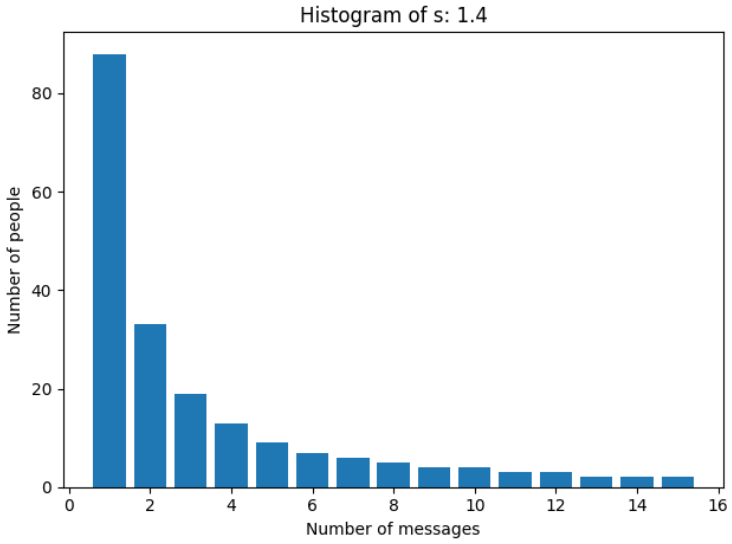

Figure 2: Histogram of Zipf Distribution using $s = 1.4$

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: Uniformly random choice of Zipf distribution s:

K	1msm	5msm	15msm
3	10.6	2.12	2.24
4	17.7	3.48	2.4
5	25.6	3.66	2.8733
6	33.0	4.3	2.88
7	38.1	5.66	3.4667
8	45.1	6.1	3.28
9	46.5	7.18	4.1267
10	53.2	8.6	3.88
11	56.6	8.32	4.28
12	72.8	7.26	3.58
	39.92	5.668	3.3007

Table 4: Preferential attachment choice of Zipf distribution s:1.4

4 s: 1,5

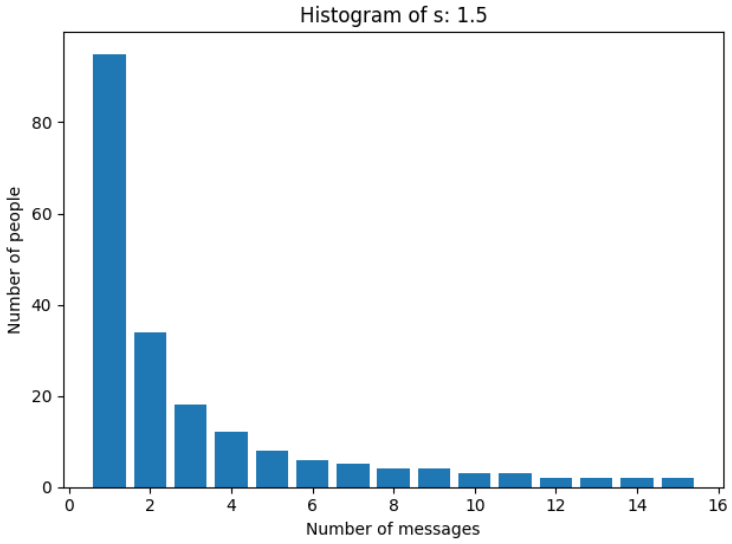

Figure 3: Histogram of Zipf Distribution using $s = 1.5$

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: Uniformly random choice of Zipf distribution s: 1.5

K	1msm	5msm	15msm
3	7.9	2.26	1.98
4	12.3	3.6	2.12
5	18.6	4.0	3.0867
6	22.0	4.96	2.7
7	30.0	5.9	3.6667
8	34.4	6.74	3.4333
9	40.2	6.06	3.7133
10	39.4	6.4	4.5467
11	49.2	7.2	4.0933
12	49.0	7.78	3.6867
	30.3	5.49	3.3027

Table 6: Preferential attachment choice of Zipf distribution s:1.5

5 s: 1,6

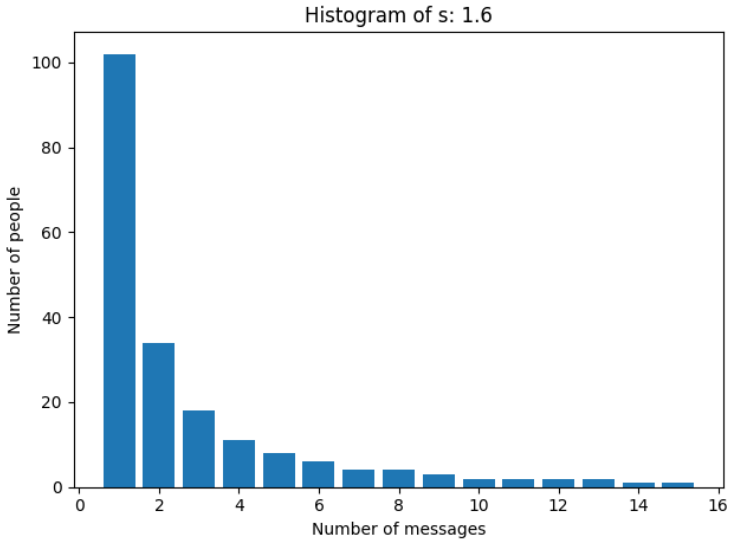

Figure 4: Histogram of Zipf Distribution using $s = 1.6$

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: Uniformly random choice of Zipf distribution s:1.6

K	1msm	5msm	15msm
3	7.1	2.2	1.8333
4	13.3	3.16	2.2
5	17.4	3.44	2.2867
6	19.6	4.84	2.7
7	25.6	5.32	2.9133
8	28.9	6.74	3.8
9	35.5	6.2	4.0933
10	37.5	6.26	4.1267
11	44.4	8.82	3.64
12	43.1	6.14	4.12
	27.24	5.312	3.1713

Table 8: Preferential attachment choice of Zipf distribution s:1.6

6 s: 1,7

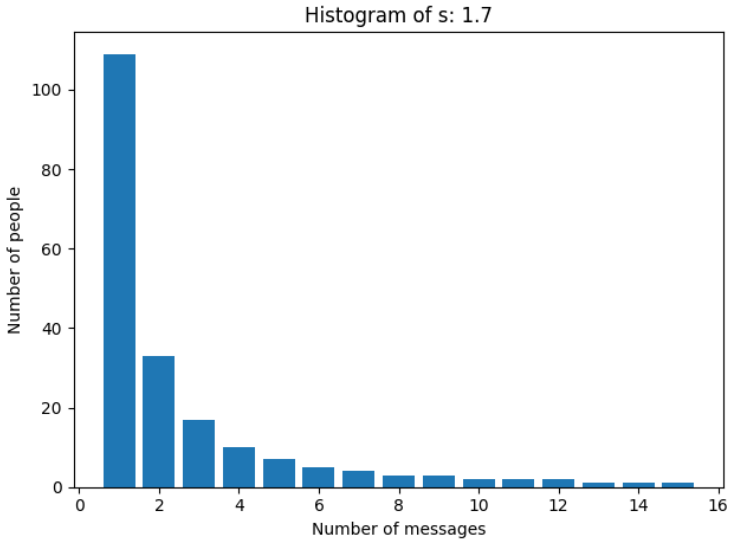

Figure 5: Histogram of Zipf Distribution using $s = 1.7$

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: Uniformly random choice of Zipf distribution s:1.7

K	1msm	5msm	15msm
3	9.6	1.9	1.78
4	13.3	2.96	2.2733
5	18.1	3.58	2.52
6	22.3	3.62	2.7933
7	26.4	4.26	2.8867
8	32.7	4.76	3.2333
9	36.0	6.52	4.08
10	41.0	5.18	3.8133
11	43.6	7.5	4.02
12	47.6	6.32	3.34
	29.06	4.66	3.074

Table 10: Preferential attachment choice of Zipf distribution s:1.7

7 s: 1,8

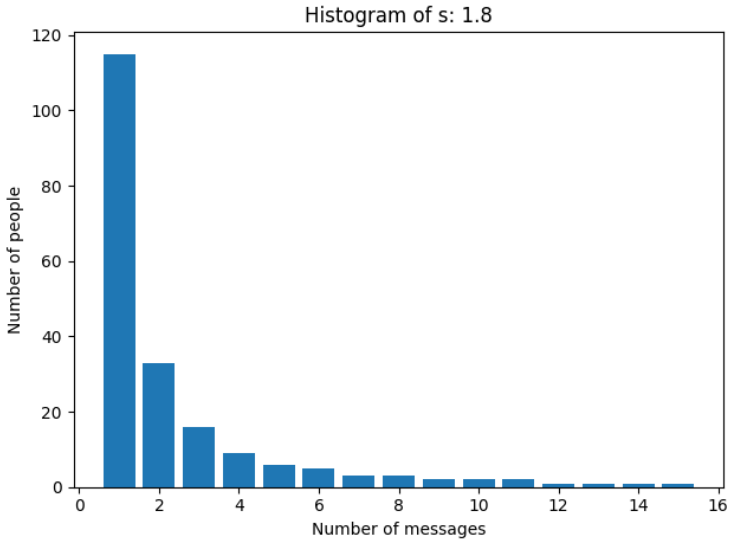

Figure 6: Histogram of Zipf Distribution using $s = 1.8$

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: Uniformly random choice of Zipf distribution s:1.8

K	1msm	5msm	15msm
3	7.3	2.68	1.8667
4	10.9	3.54	2.2933
5	15.1	2.9	2.2267
6	19.8	3.96	2.9067
7	23.9	3.04	2.96
8	27.8	4.16	3.6733
9	32.5	4.22	4.36
10	35.9	5.3	3.6267
11	35.3	4.56	3.8267
12	42.2	5.44	3.8733
	25.07	3.98	3.1613

Table 12: Preferential attachment choice of Zipf distribution s:1.8

8 s: 1,9

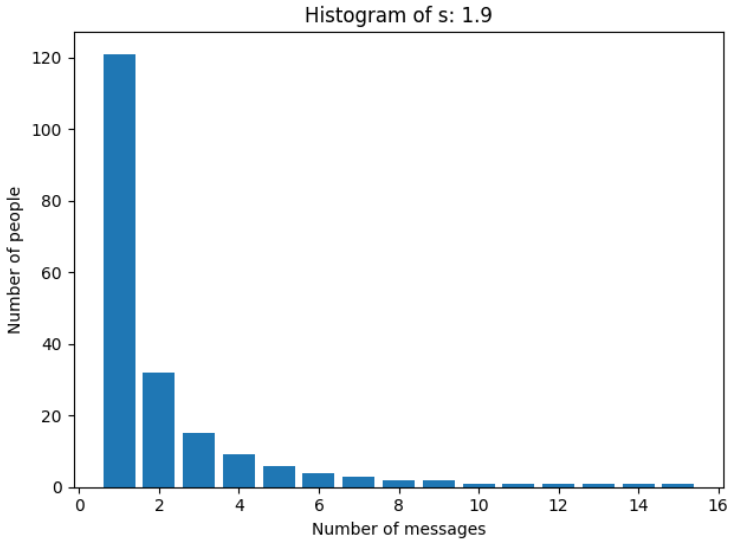

Figure 7: Histogram of Zipf Distribution using $s = 1.9$

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: Uniformly random choice of Zipf distribution s:1.9

K	1msm	5msm	15msm
3	6.9	3.04	1.9067
4	10.6	2.82	2.26
5	14.0	3.26	2.0533
6	18.1	5.44	2.3933
7	21.1	4.42	2.7533
8	24.4	6.64	3.1067
9	28.5	4.42	3.4
10	30.9	5.24	5.0533
11	39.2	6.96	4.2467
12	37.7	7.38	4.5933
	23.14	4.962	3.1767

Table 14: Preferential attachment choice of Zipf distribution s:1.9

9 s: 2,0

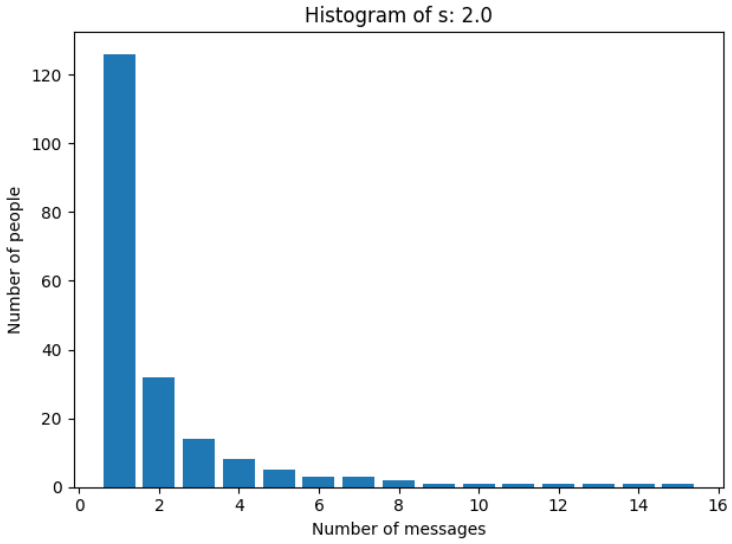

Figure 8: Histogram of Zipf Distribution using $s = 2.0$

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: Uniformly random choice of Zipf distribution s:2.0

K	1msm	5msm	15msm
3	6.5	2.62	1.66
4	9.5	3.1	2.1533
5	14.2	3.84	2.3933
6	17.5	4.42	2.74
7	20.7	5.42	2.7733
8	23.6	3.58	3.14
9	26.8	6.34	3.7667
10	29.2	4.94	3.14
11	32.0	5.5	3.7133
12	36.0	7.9	4.4933
	21.6	4.766	2.9973

Table 16: Preferential attachment choice of Zipf distribution s:2.0