

UNIVERSITÁ DI PISA

PEER TO PEER SYSTEMS AND BLOCKCHAINS

MID TERM

Analysing the Chord DHT

Author:

Carmine CASERIO



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1 Describing the implementation

The Chord simulation routing process needs first of all the number of bits m and the number of peers p that participate to the simulation.

As first thing, it initializes the peers by assigning them the result of the SHA-1 of a random Long and it fills the FingerTable of each peer (implemented as an `ArrayList`, since it has at most logarithmic dimension in terms of the number of peers - at most, because in case of two or more equal fingers, just one has been taken into account, together with the number of repetitions of the finger). After this initialization procedure, the routing process has been simulated over:

- 3 very uncrowded situations, in which the choice for p varies from approximatively the 1%, to the 3% and to the 5% of the range $[0, 2^m]$; in this situations the number of peers is much smaller when compared to the number of possible identifiers;
- 3 uncrowded situations, in which p varies from approximately the 10%, to the 13% and to the 15% of the range $[0, 2^m]$;
- 3 standard situations in which p is from about the 40%, to the 43% and to the 45% of the range $[0, 2^m]$;
- 3 crowded situations in which p is from about the 60%, to the 63% and to the 65% of the range $[0, 2^m]$;
- 3 very crowded situations in which p is from about the 80%, to the 85% and to the 90% of the range $[0, 2^m]$.

All these simulations are analysed in the next section.

The results obtained for the routing destination peers of all the paths and from the load balancing are shown in the two last sections for just one representative of each situation. The average path length is exposed just below each analysed case and it never exceeds the value 3, at least by using $m = 15$, as it was done in this report.

2 Description of the experiment

By using the same number of bits $m = 15$ for all the experiments, by obtaining a range of values in $[0, 32.768]$, the results obtained are shown below.

2.1 Very uncrowded situations

In this case, the number of peers used in these tests are equal to:

- the 1% of 2^m , that is $p = 327$;
- the 3% of 2^m , that is $p = 983$;
- the 5% of 2^m , that is $p = 1.638$.

2.1.1 Case with 1% of 2^{15}

In this case, since the ring is very uncrowded, the simulation gives the following results:

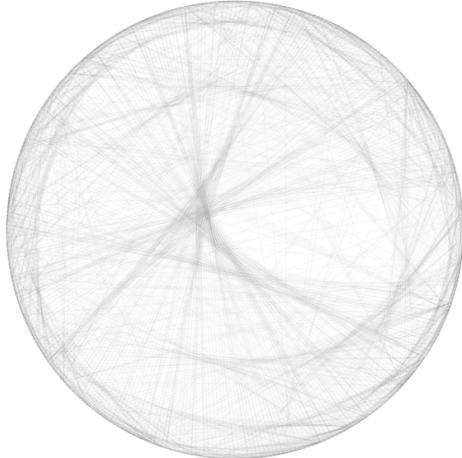


Figure 1: Chord ring 1% filled

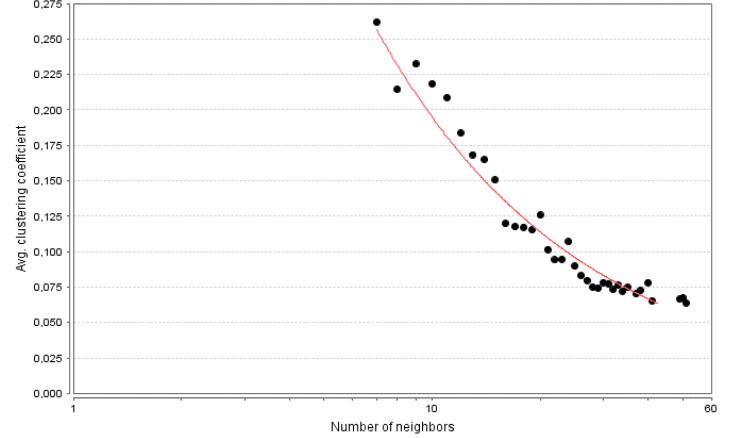


Figure 2: Average clustering coefficient compared to the number of neighbours

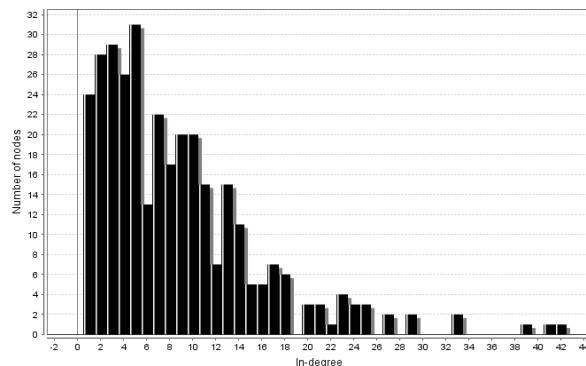


Figure 3: Number of nodes compared to the in-degree

In this simulation the average length of the path is of 2,828746 peers.

2.1.2 Case with 3% of 2^{15}

Similarly to before, the ring is very uncrowded, so the simulation gives the following results:

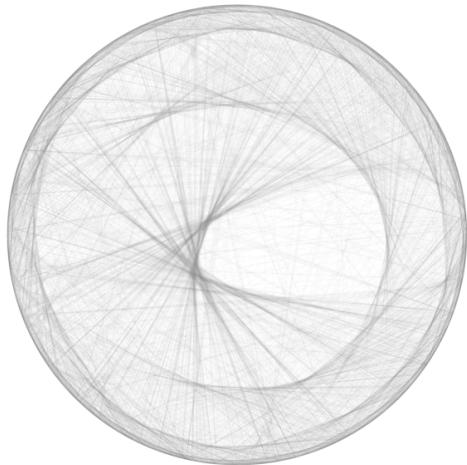


Figure 4: Chord ring 3% filled

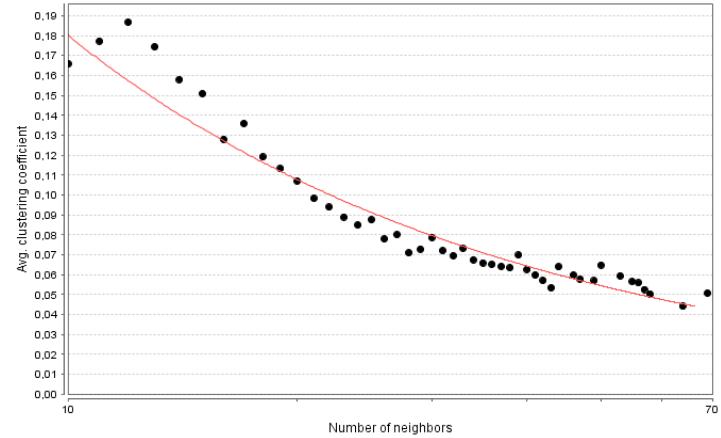


Figure 5: Average clustering coefficient compared to the number of neighbours

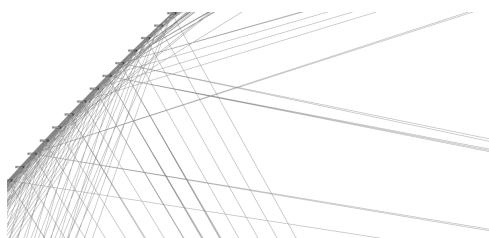


Figure 6: Detail of Chord ring 3% filled

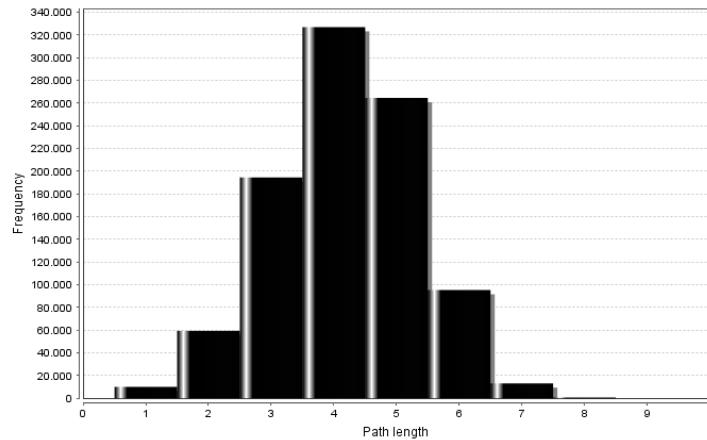


Figure 7: Frequency compared to the path length of the routing

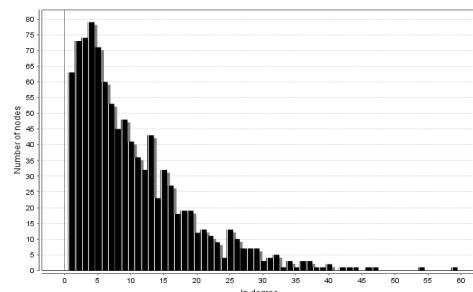


Figure 8: Number of nodes compared to the in-degree

In this case, the average length of the path is of 2,8809767 peers.

2.1.3 Case with 5% of 2^{15}

The last simulation of the very uncrowded situation gives the following results:

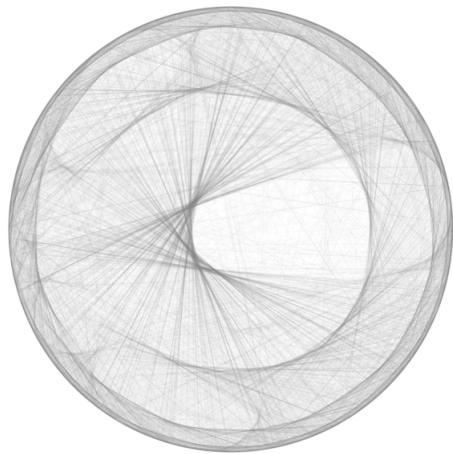


Figure 9: Chord ring 5% filled

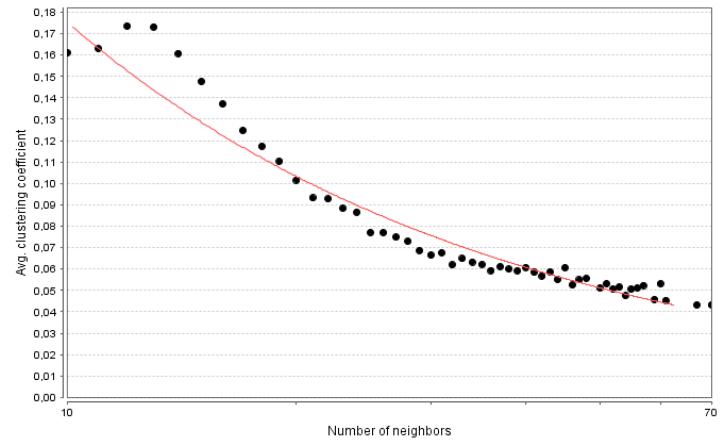


Figure 10: Average clustering coefficient compared to the number of neighbours

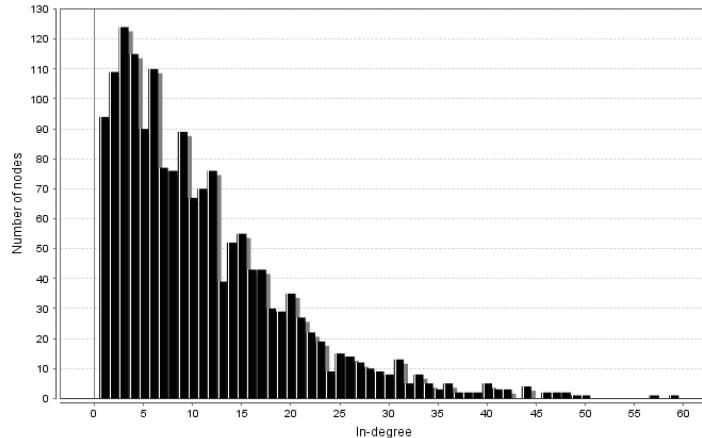


Figure 11: Number of nodes compared to the in-degree

In this last case, the average path length is of 2,8931625 peers.

The frequency-Path-Length chart has been exposed just once, since it is very similar for the other simulations.

2.2 Uncrowded situations

In this case, the number of peers used in these tests are equal to:

- the 10% of 2^m , that is $p = 3.276$;
- the 13% of 2^m , that is $p = 4.259$;
- the 15% of 2^m , that is $p = 4.915$.

2.2.1 Case with 10% of 2^{15}

In this first uncrowded situation, the simulation gives the following results:

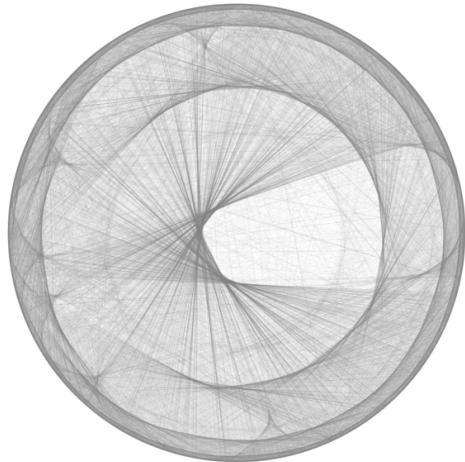


Figure 12: Detail of Chord ring 10% filled

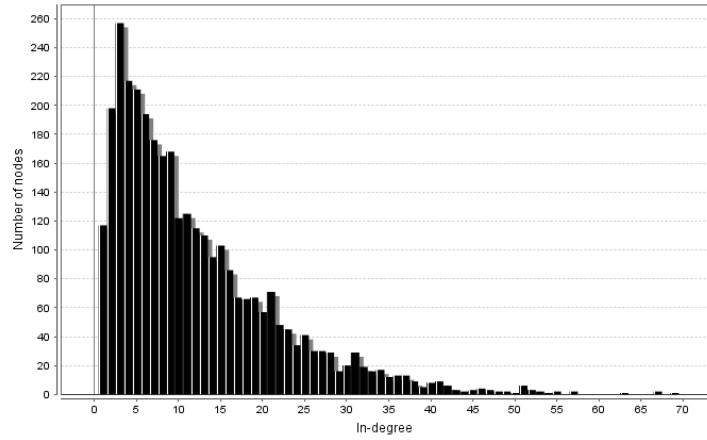


Figure 13: Number of nodes compared to the in-degree

2.2.2 Case with 13% of 2^{15}

This intermediate uncrowded situation has been simulated giving the following results:

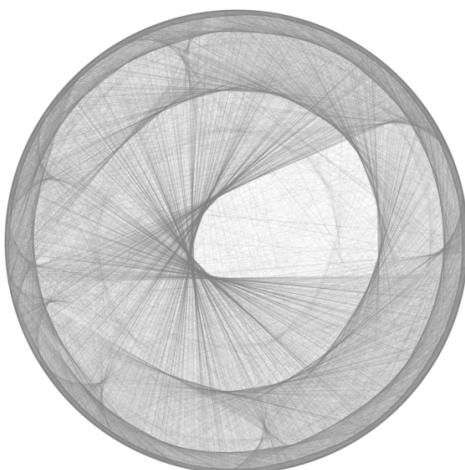


Figure 14: Chord ring 13% filled

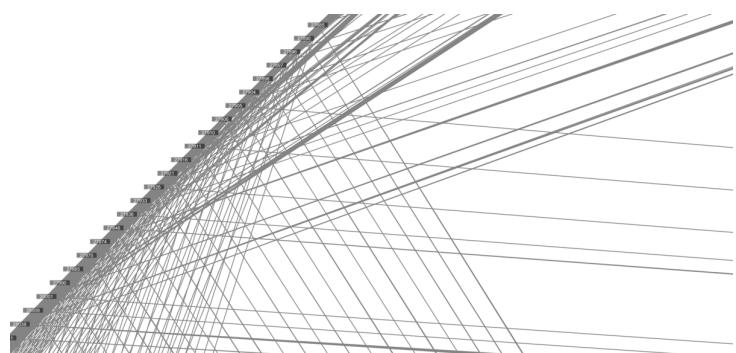


Figure 15: Detail of Chord ring 13% filled

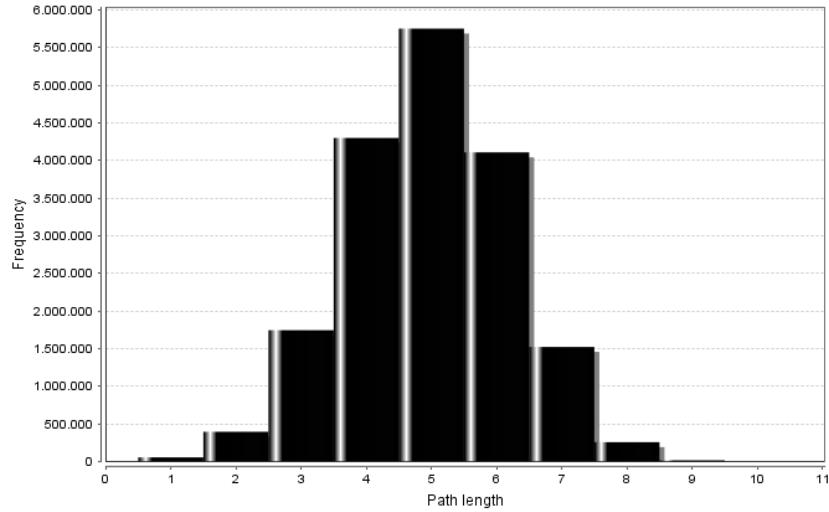


Figure 16: Frequency compared to the path length of the routing

2.2.3 Case with 15% of 2^{15}

The last uncrowded simulation has been performed by using a 15% filled Chord ring. The results are shown in the following:

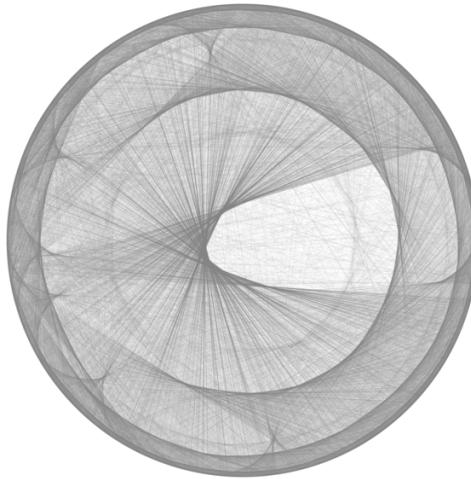


Figure 17: Detail of Chord ring 15% filled

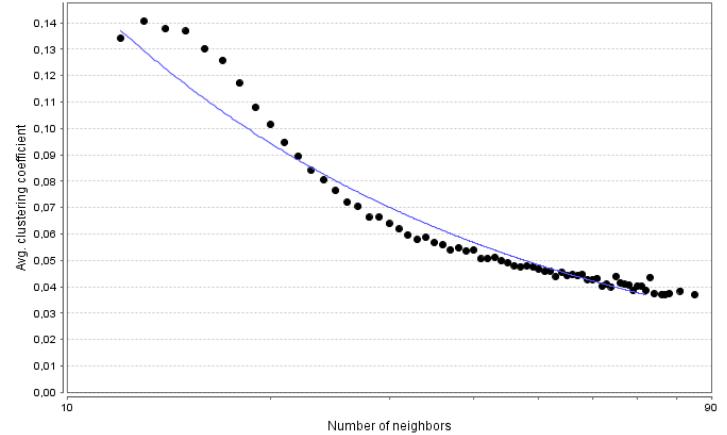


Figure 18: Average clustering coefficient compared to the number of neighbours

The number-of-nodes-In-Degree, frequency-Path-Length and average-clustering-coefficient-Number-Of-Neighbours charts have been exposed just once because they are very similar in these three cases.

The average path lengths of the three cases above are, respectively:

- 2,9551282 peers for the 10% case;
- 2,9305 peers for the 13% case;
- 2,9527977 peers for the 15% case.

2.3 Standard situations

In this case, the number of peers used in these tests are equal to:

- the 40% of 2^m , that is $p = 13.107$;
- the 43% of 2^m , that is $p = 14.090$;
- the 45% of 2^m , that is $p = 14.745$.

2.3.1 Case with 40% of 2^{15}

The standard situation in which the 40% of the Chord ring is filled, gives the results shown in the following:

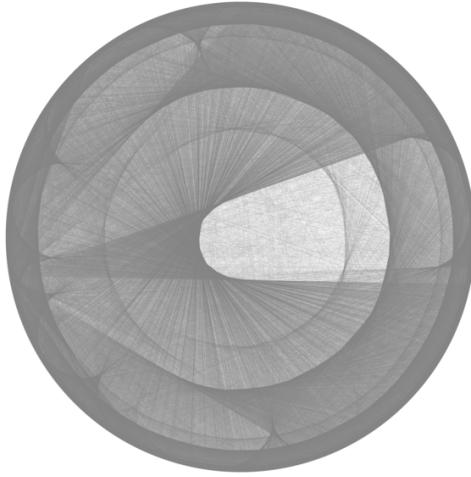


Figure 19: Chord ring 40% filled

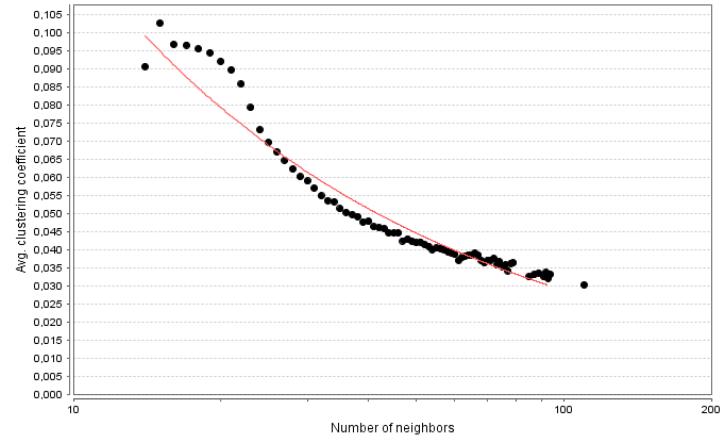


Figure 20: Average clustering coefficient compared to the number of neighbours

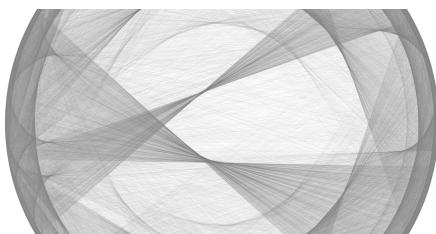


Figure 21: Chord ring 40% filled in more detail

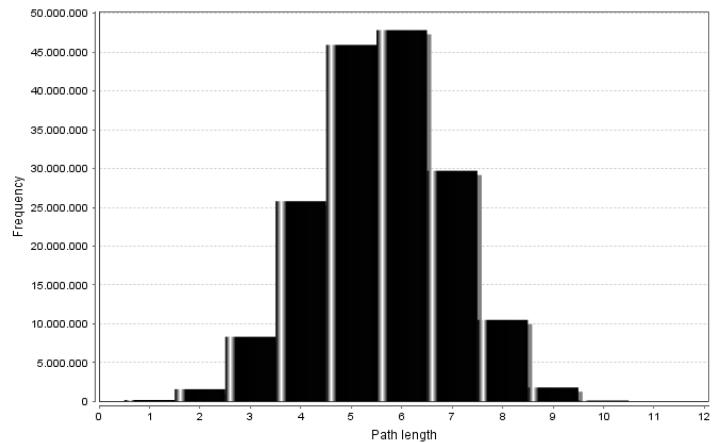


Figure 22: Frequency compared to the path length of the routing

In this case, the average path length is of 2,9965668 peers.

2.3.2 Case with 43% of 2^{15}

In this standard situation, the 43% of the Chord ring is filled; the simulation gives the following results:

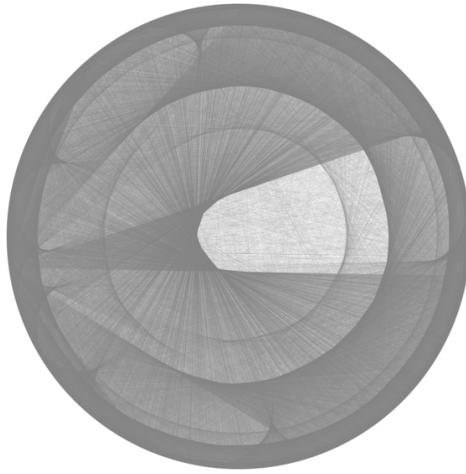


Figure 23: Chord ring 43% filled

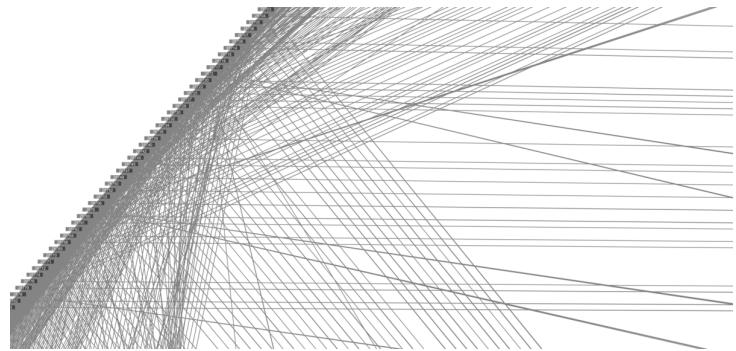


Figure 24: Detail of Chord ring 43% filled

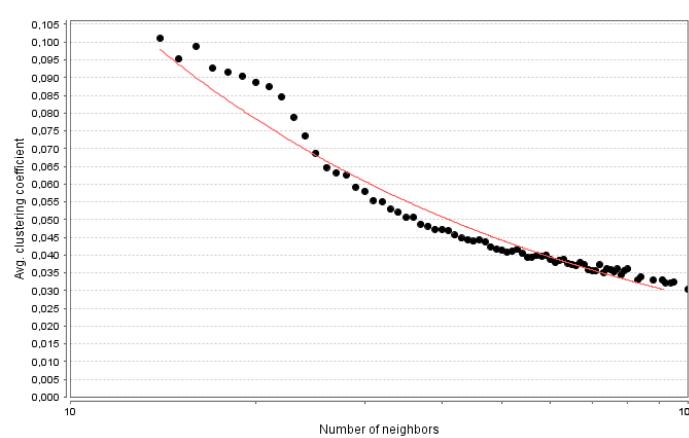


Figure 25: Average clustering coefficient compared to the number of neighbours

In this case, the average path length is of 2,982612 peers.

2.3.3 Case with 45% of 2^{15}

This standard simulation is the one with 45% of the Chord ring filled; it gives the following results:

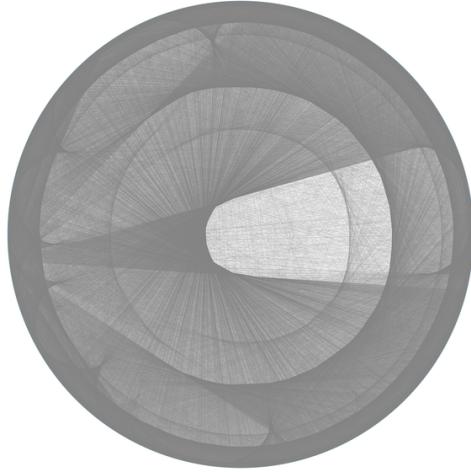


Figure 26: Chord ring 45% filled

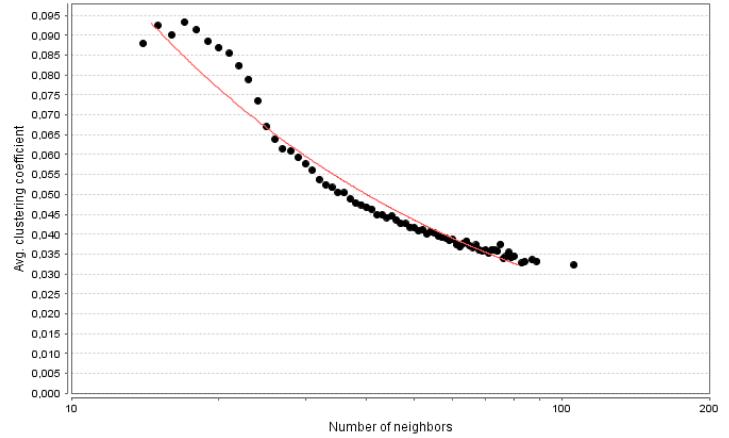


Figure 27: Average clustering coefficient compared to the number of neighbours

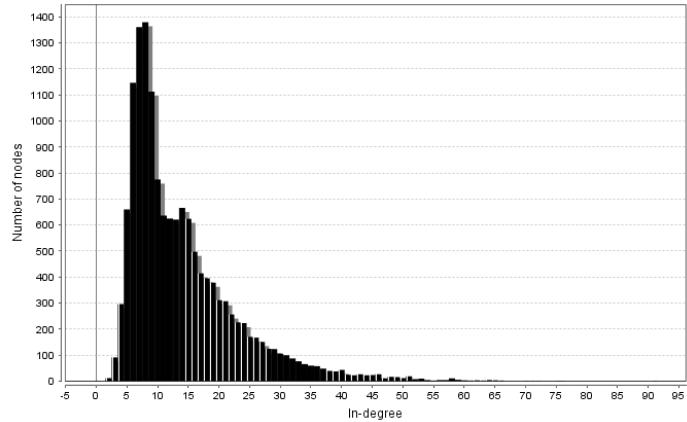


Figure 28: Number of nodes compared to the in-degree

In this case, the average path length is of 2,979654 peers.

For the standard situations above, the frequency-Path-Length and number-of-nodes-In-Degree charts have been exposed just once because they are very similar in all the three cases.

2.4 Crowded situations

In this case, the number of peers used in these tests are equal to:

- the 60% of 2^m , that is $p = 19.660$;
- the 63% of 2^m , that is $p = 20.643$;
- the 65% of 2^m , that is $p = 21.299$.

2.4.1 Case with 60% of 2^{15}

The first crowded situation considered is the 60% filled Chord ring. The simulation over this situation gives the results shown below:

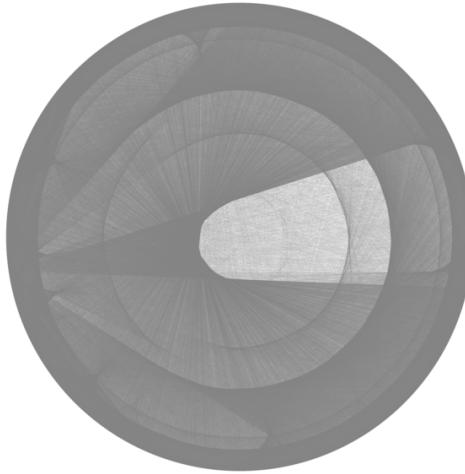


Figure 29: Chord ring 60% filled

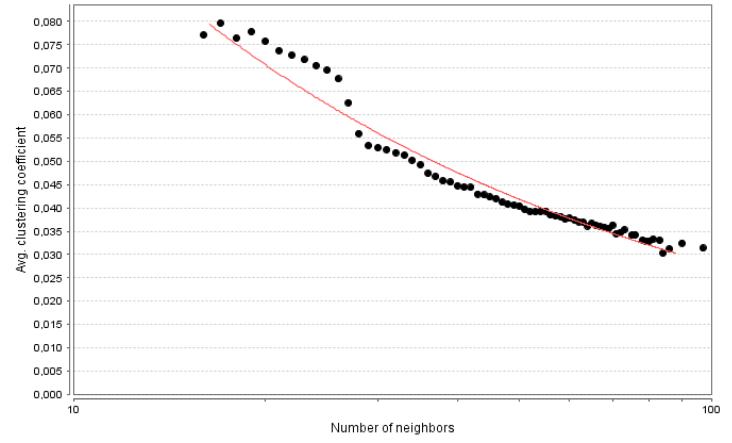


Figure 30: Average clustering coefficient compared to the number of neighbours

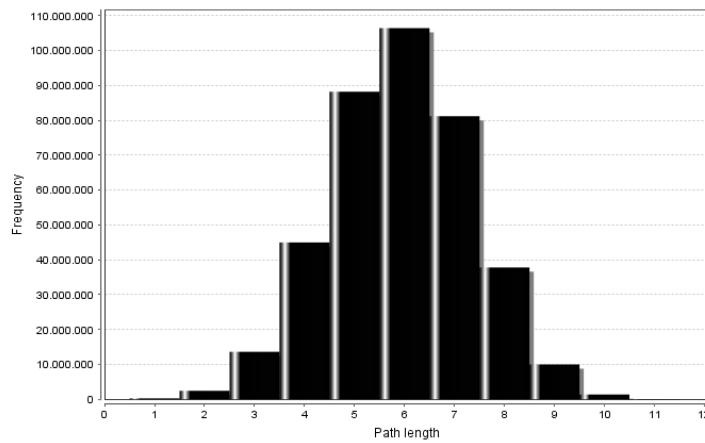


Figure 31: Frequency compared to the path length of the routing

In this case, the average length of the path is of 2,9877417 peers.

2.4.2 Case with 63% of 2^{15}

This crowded situation results in the following:

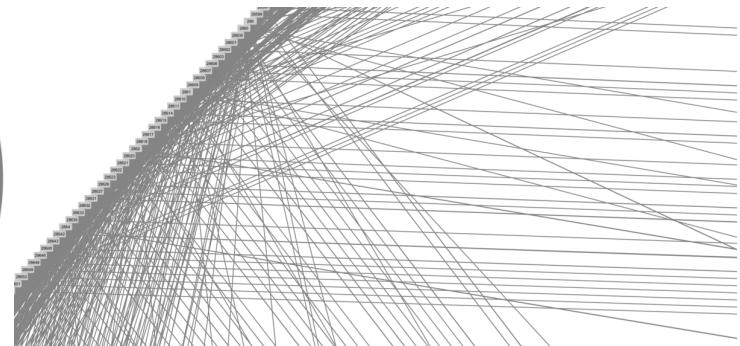
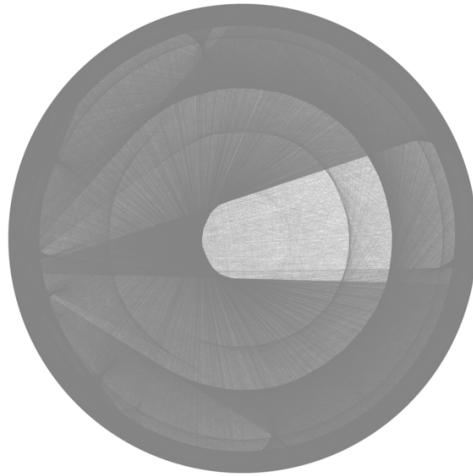


Figure 33: Detail of Chord ring 63% filled

Figure 32: Chord ring 63% filled

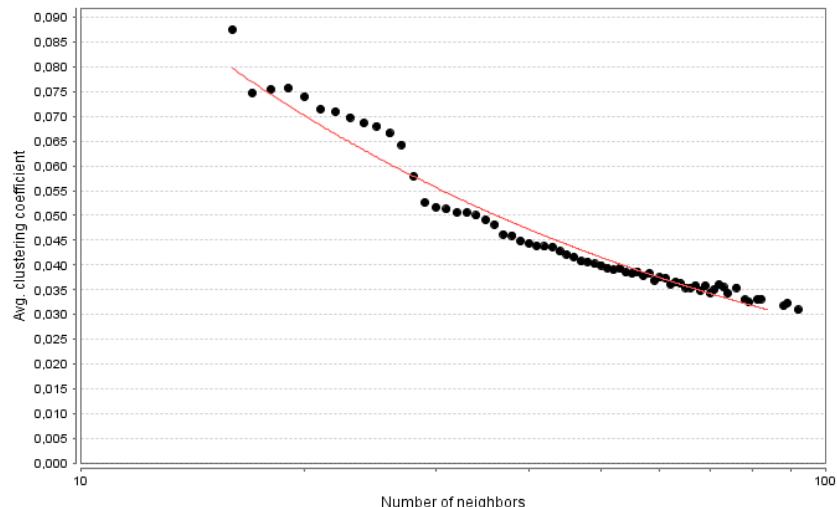


Figure 34: Average clustering coefficient compared to the number of neighbours

In this case, the average path length is of 2,9728723 peers.

2.4.3 Case with 65% of 2^{15}

The last crowded situation, in which the 65% of the Chord ring is filled with peers, has given the following results:

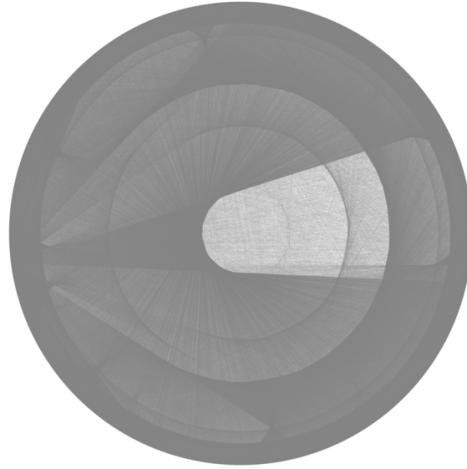


Figure 35: Chord ring 65% filled

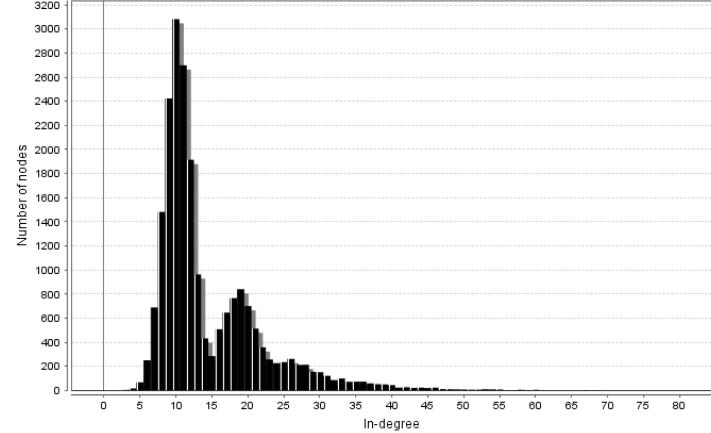


Figure 36: Number of nodes compared to the in-degree

In this case, the average path length is of 2,9741771 peers.

The average-clustering-coefficient-Number-Of-Neighbours chart isn't shown for this last situation because it is very similar to the previous one, as in the case of the frequency-Path-Length and the number-nodes-In-Degree charts that are not shown because they are very similar among them.

2.5 Very crowded situations

In this case, the number of peers used in these tests are equal to:

- the 80% of 2^m , that is $p = 26.214$;
- the 85% of 2^m , that is $p = 27.852$;
- the 90% of 2^m , that is $p = 29.491$.

2.5.1 Case with 80% of 2^{15}

In this very crowded situation, the results obtained by the simulation are shown in the following:

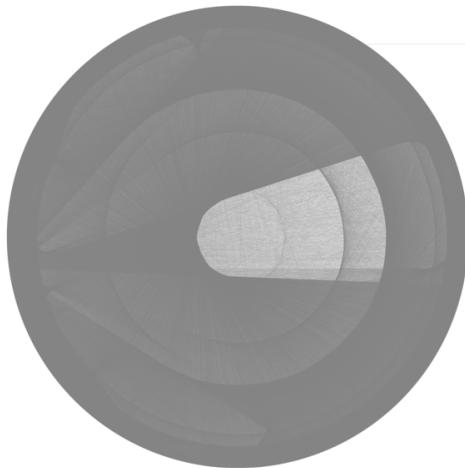


Figure 37: Chord ring 80% filled

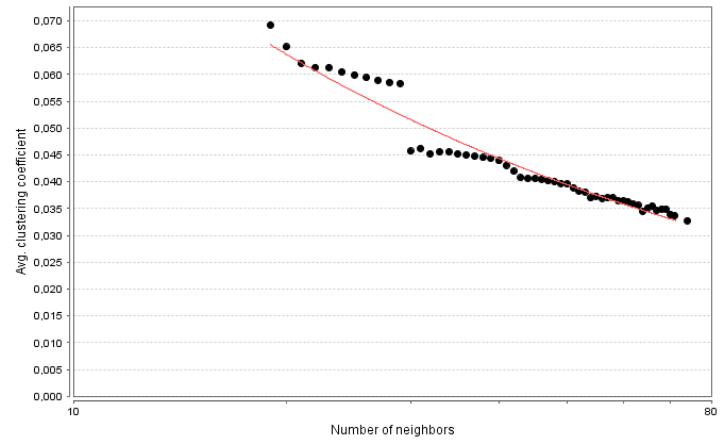


Figure 38: Average clustering coefficient compared to the number of neighbours

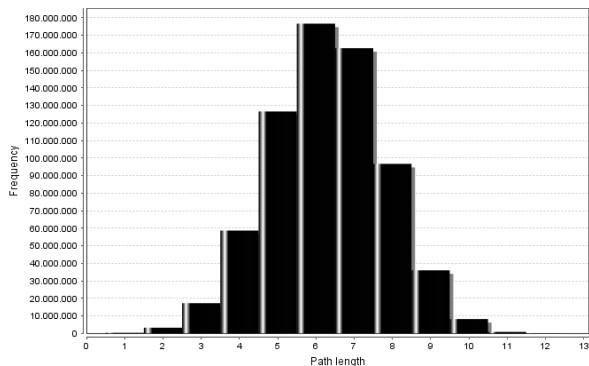


Figure 39: Frequency compared to the path length of the routing

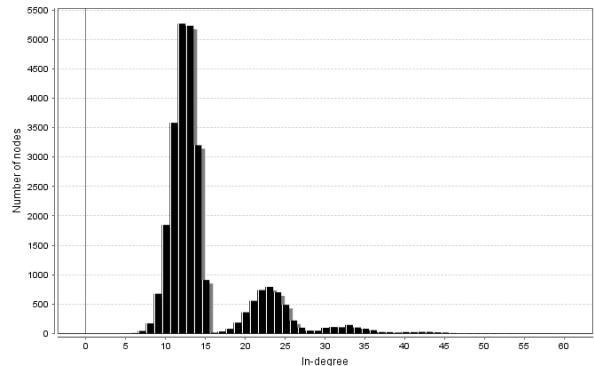


Figure 40: Number of nodes compared to the in-degree

In this case, the average path length is of 2,9551766 peers.

2.5.2 Case with 85% of 2^{15}

This very crowded situation, in which the 85% of the Chord ring is filled with peers, gives the following results:

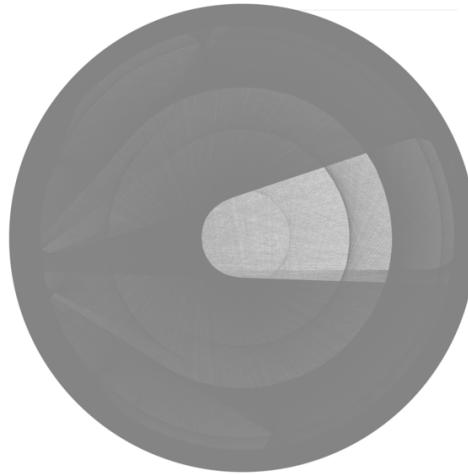


Figure 41: Chord ring 85% filled

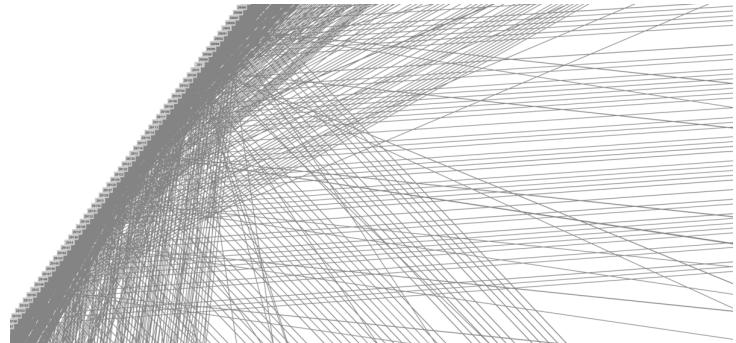


Figure 42: Detail of Chord ring 85% filled

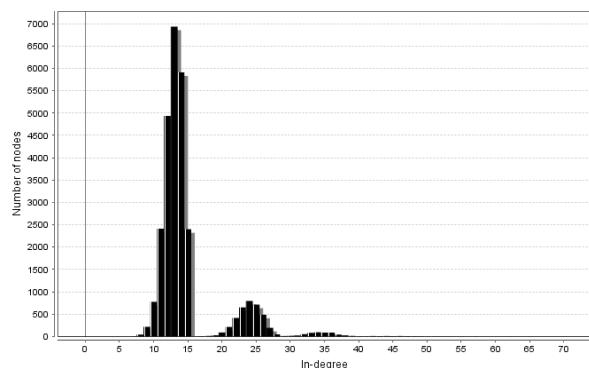


Figure 43: Number of nodes compared to the In-Degree

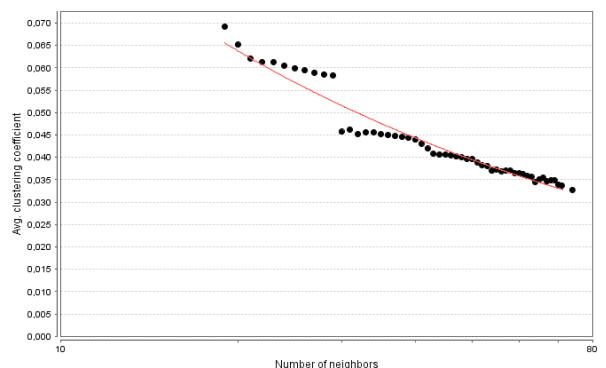


Figure 44: Average clustering coefficient compared to the number of neighbours

In this case, the average path length is of 2,9556227 peers.

2.5.3 Case with 90% of 2^{15}

The results given by the last executed simulation over the very crowded situation, are shown in the following:

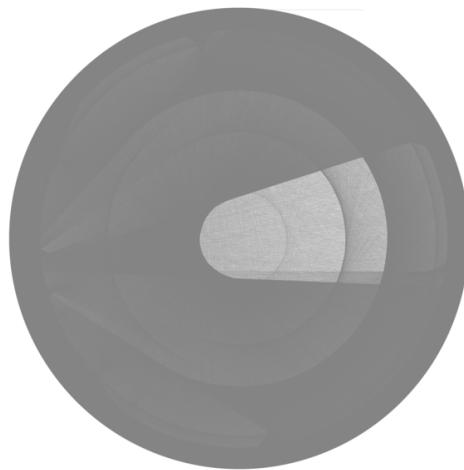


Figure 45: Chord ring 90% filled

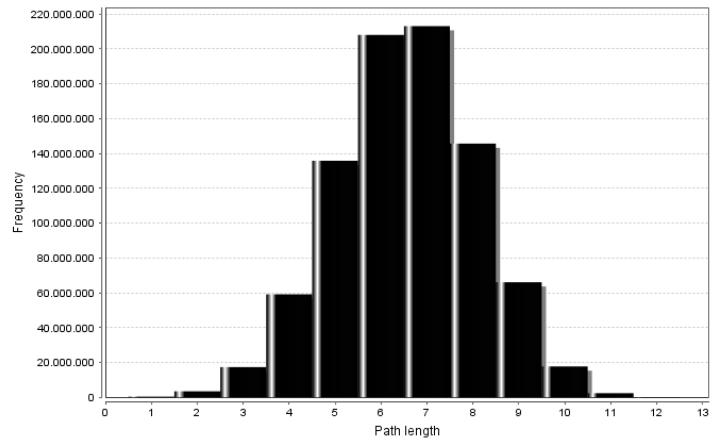


Figure 46: Frequency compared to the path length of the routing

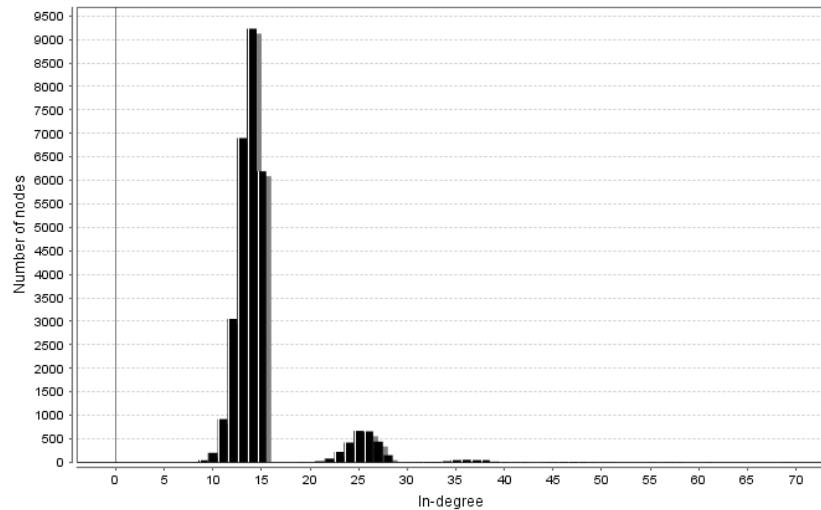


Figure 47: Number of nodes compared to the In-Degree

In this case the average path length is of 2,9491708 peers.

The frequency-path-length chart has not been shown in the 85% because it is very similar to the 80% situation.

3 Routing destination peers over all routes

This metric has been used for verifying the uniformity of the key distribution.

For each situation, one case has been taken into account; the results are shown in the following:

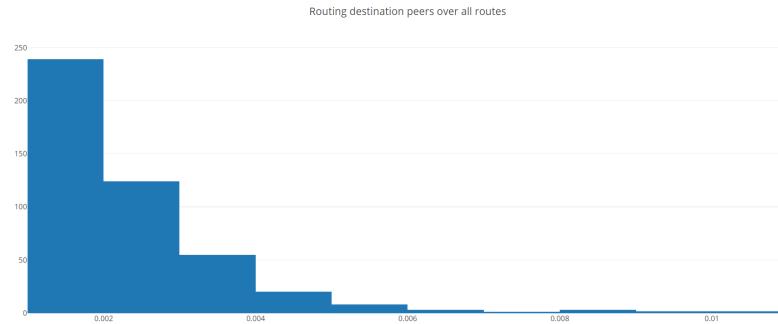


Figure 48: The destination peers in the 3% case

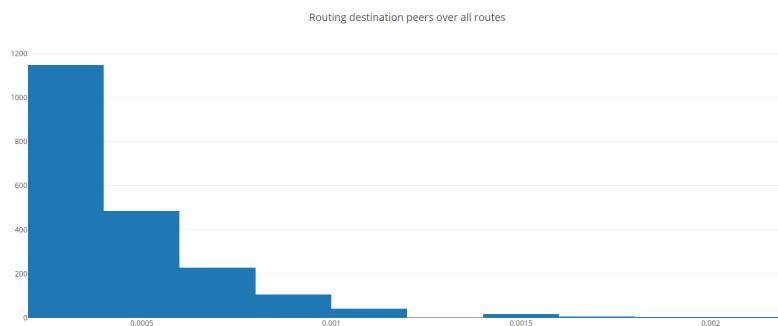


Figure 49: The destination peers in the 13% case

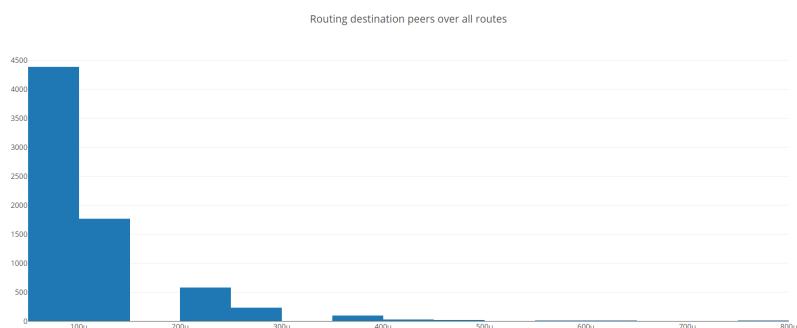


Figure 50: The destination peers in the 43% case

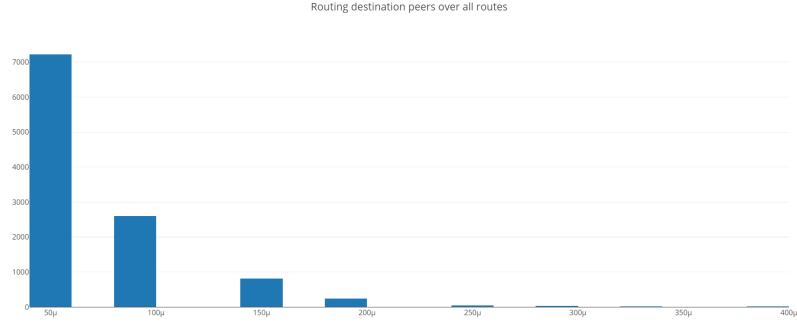


Figure 51: The destination peers in the 63% case

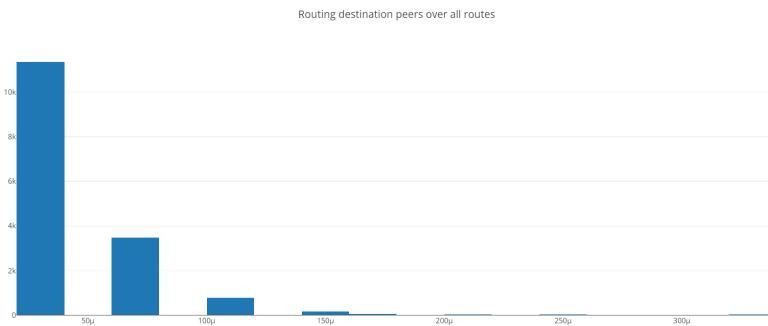


Figure 52: The destination peers in the 85% case

For each of the destination charts, the maximum value was not shown, because it's too high compared to the values that are present in the rest of the chart. This measurement has been calculated as the times in which the peer compares as ending node over all the ending nodes of the paths, that is equal to the number of paths, or simulation performed. The values obtained in this way are:

- For the 3% case, the maximum value is 0.12614445574771108;
- For the 13% case, the maximum value is 0.1559051420521249;
- For the 43% case, the maximum value is 0.18963804116394606;
- For the 63% case, the maximum value is 0.2083514992975827;
- For the 85% case, the maximum value is 0.22820623294556944;

4 Load balancing

The load balancing of the peers is shown below:

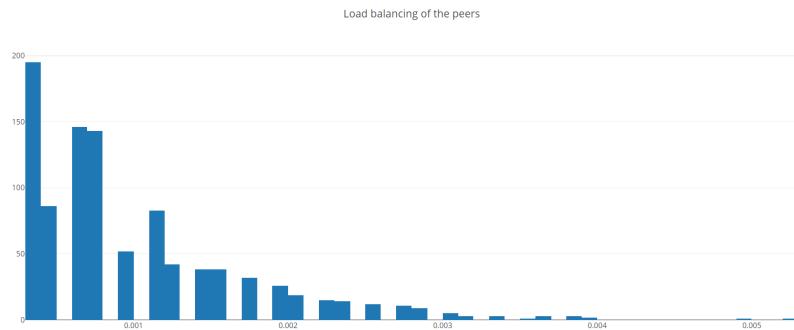


Figure 53: The load balancing of the peers in the 3% case

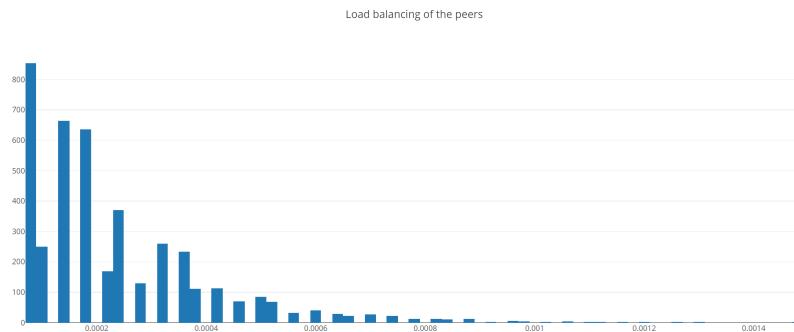


Figure 54: The load balancing of the peers in the 13% case

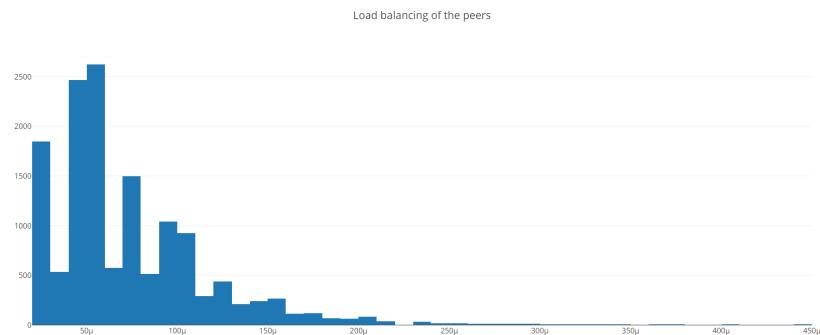


Figure 55: The load balancing of the peers in the 43% case

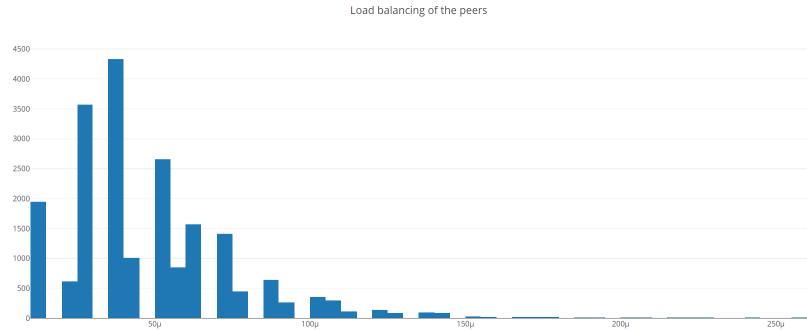


Figure 56: The load balancing of the peers in the 63% case

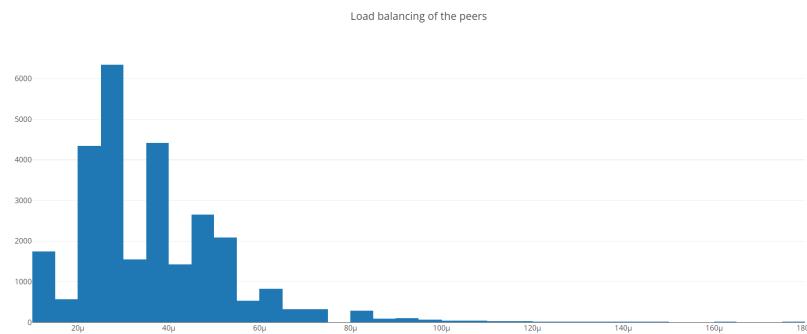


Figure 57: The load balancing of the peers in the 85% case

As can be seen from the previous pictures, there is some skewness in the load balancing of the peers. This measurement has been calculated as the times in which the peer compares as an intermediate or ending node in the current path over all the appearances of the same node in all the routing paths simulated.