Evaluation report of polar codes

In this report the performance of polar codes will be evaluated. A specific decoder implementation with the use of likelihood cashes will be used for the evaluation. According to [1] a complexity of O (N log N) should be achieved.

For each evaluation random messages will be generated and compared after the decoding. The following parameters are relevant for those evaluations:

Blocklength:
Blocklength (Length of code word) is defined by the amount of bits which will be transferred through the binary erasure channel.

Information bitrate:
The relation between information bits and parity bits. (Information bitrate of 0.5 and blocklength of 8 would mean 4 bits of parity and 4 bits of information. Information bitrate of 0.25 and a blocklength of 8 would mean 2 information bits and 6 parity bits)

Epsilon:
Epsilon defines the erasure rate of the binary erasure channel. (An Epsilon of 0.25 would mean that 25% of the code word will be erased)

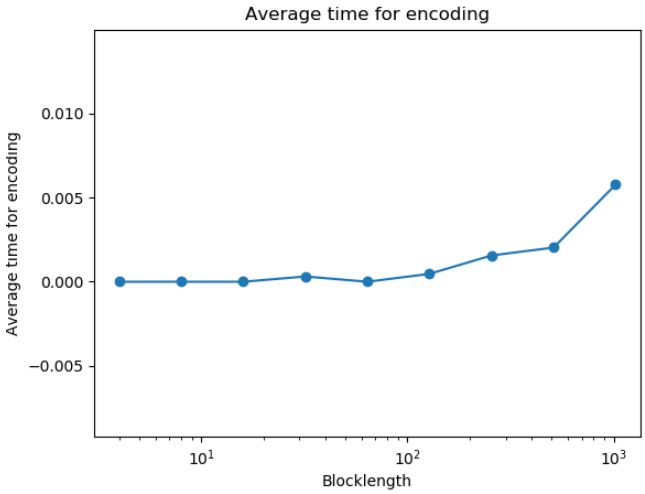
Error rate:
The rate of unsuccessful decoded messages (code words which could not be decoded). An error rate of 0.5 would mean, that 50% of all code words could not be decoded.

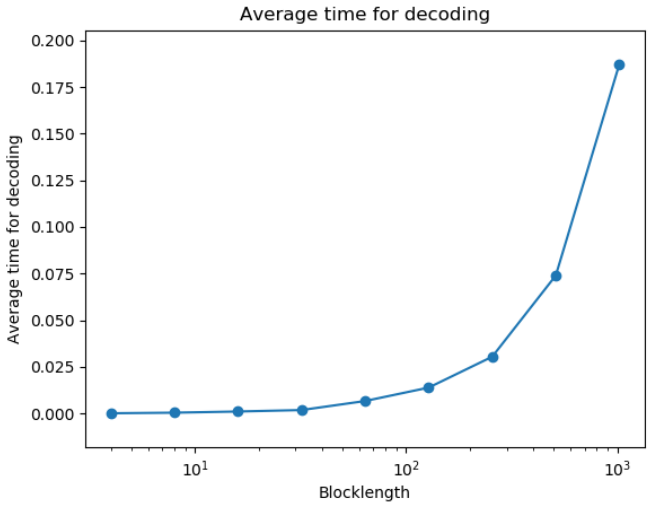
Time:
Time will be measured in seconds.

[1] http://ipgdemos.epfl.ch/polarcodestutorial/

Time and space complexity:

In the first evaluation the complexity of the decoder (O (N log N)) will be evaluated. Every blocklength between 4 and 1024 will be tested with 100 iterations per blocklength. Information bitrate will be 0.5 and an epsilon of 0.25. The X-Axis (Blocklength) is scaled logarithmic:





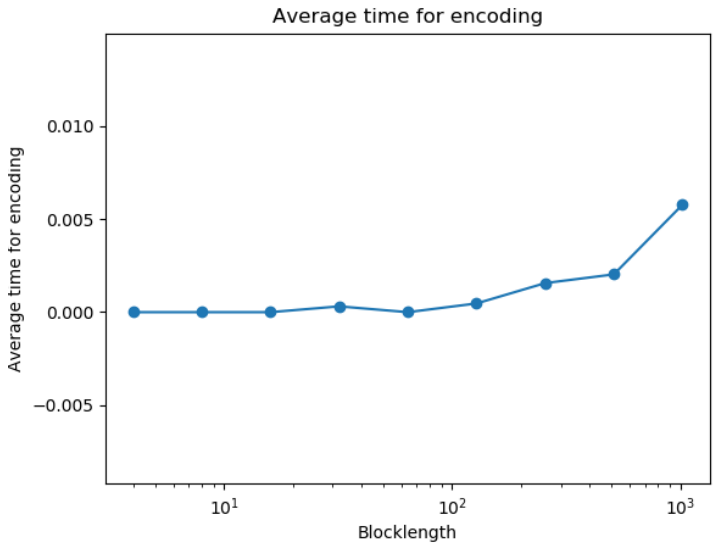
The results show that the complexity of encoding is almost linear (O (N log N)). (Note that the complexity appears as polynomial because of the logarithmic scale)

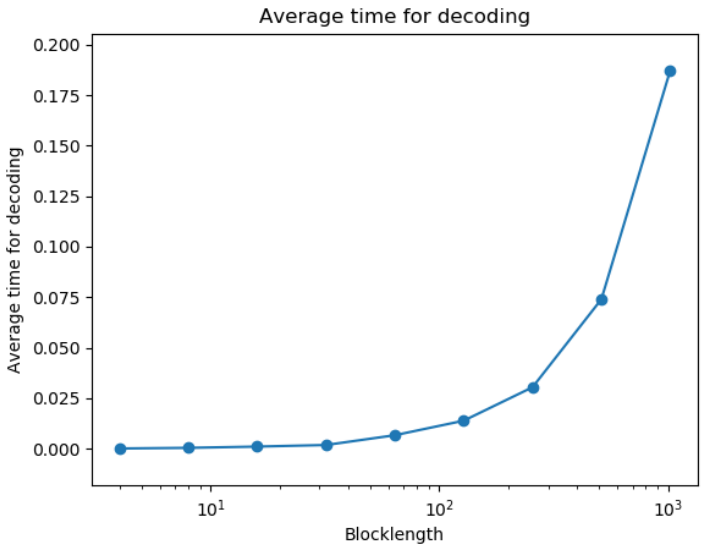
Blocklengths:

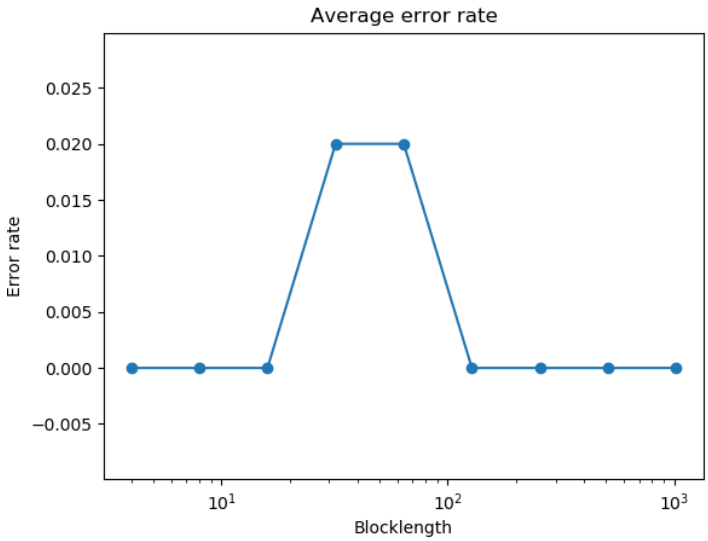
In this test the influence of the blocklength on the error rate will be evaluated.

Run1:

Information Bitrate:	0.25
Epsilon:	0.7



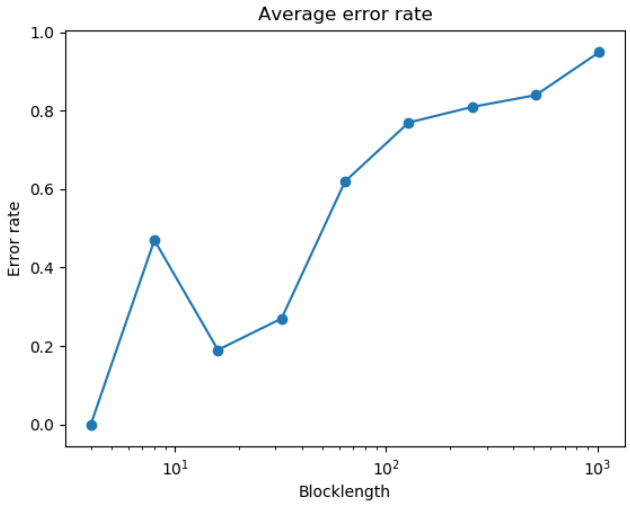




The time for encoding and decoding is similar to the previous test. Therefore the complexity of O (N log N) could be proven. There is a small rise of errors of blecklengths 32 and 64. After the error rate drops again to 0. In further tests with this configuration, a fluctuation of error rates before the blocklength of 64 could have always been observed and then the error rate always drops to 0.

Run2:

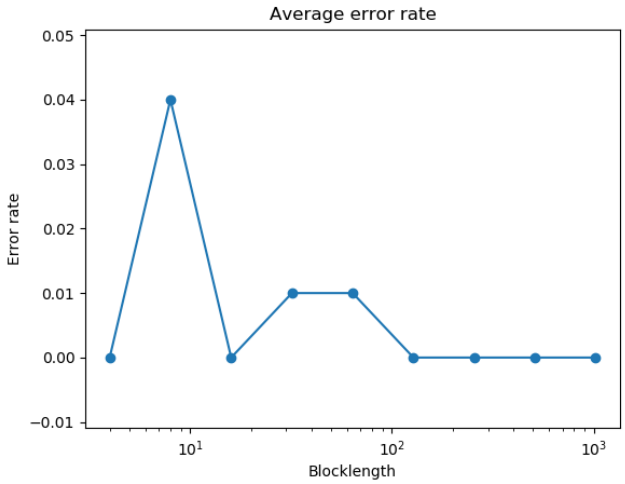
Information Bitrate:	0.75
Epsilon:	0.2



In this scenario the error rate fluctuates at the beginning and after a blocklength of 32 it rises constantly. This shows that having a lower information bitrate (More parity checks per code word) has a larger impact of transferring successful message over the BEC than the erasure rate itself.

Run3:

Information Bitrate:	0.2
Epsilon:	0.5

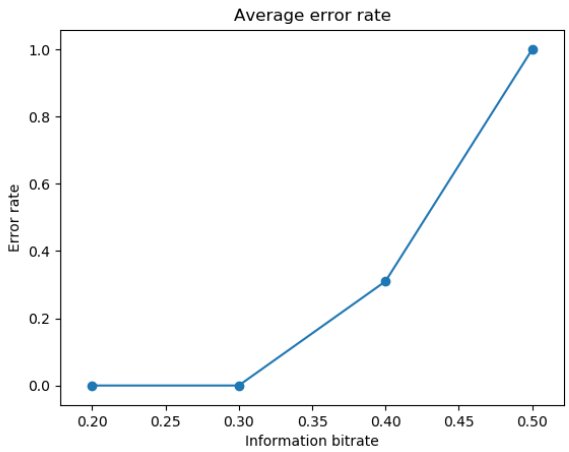


This configuration proves that in order to have an efficient transmission a low information bitrate is necessary. It also proves, that the channel capacity improves with the blocklength (The longer the length, the more mistakes can be corrected).

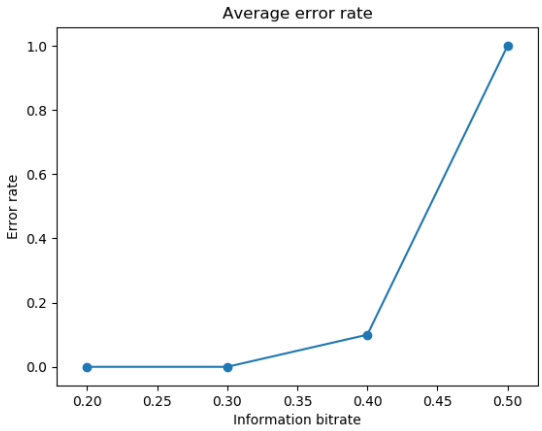
Finding best information bitrate:

In this evaluation a various blocklengths had been chosen. The Epsilon is fixed on 0.5. The information bit rate rises from 0.2 to 0.5 in order to find the best performance.

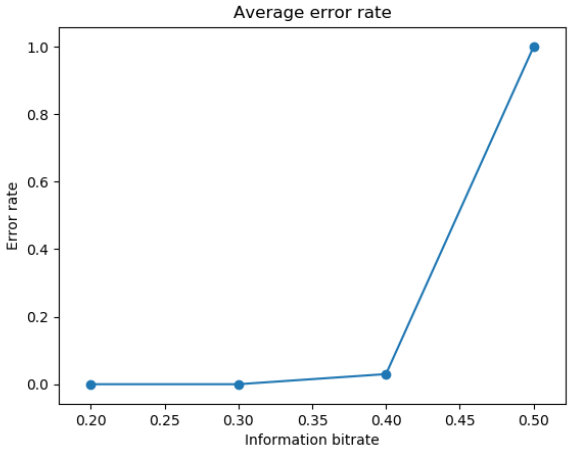
Blocklength: 2048 (2^11)



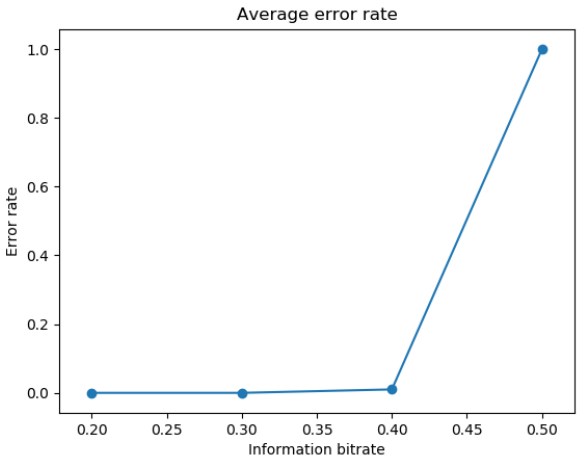
Blocklength: 4096 (2^12)

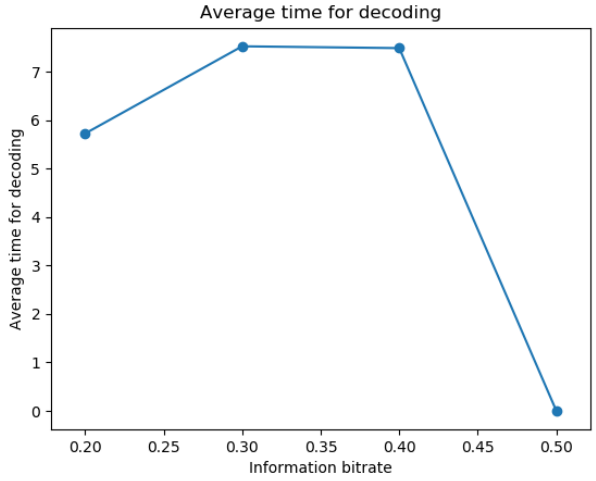


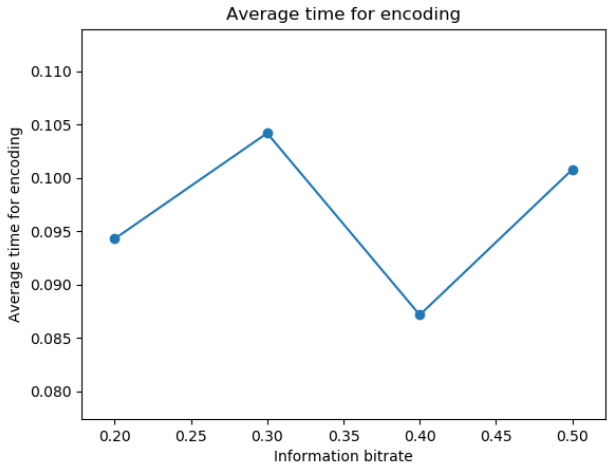
Blocklength: 8192 (2^13)



Blocklength 8192 (2^14):



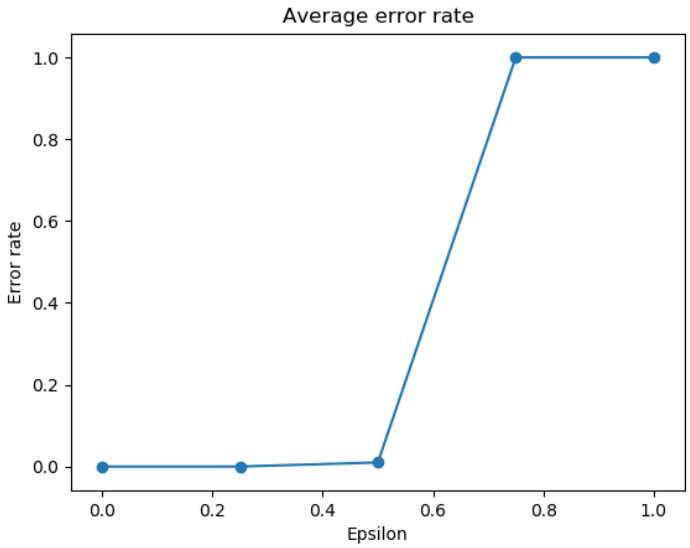

Average time for decoding
Average time for decoding
0
1
2
3
4
5
6
7
0.20
0.25
0.30
0.35
0.40
0.45
0.50
Information bitrate


Average time for encoding
Average time for encoding
0.080
0.085
0.090
0.095
0.100
0.105
0.110
0.20
0.25
0.30
0.35
0.40
0.45
0.50
Information bitrate

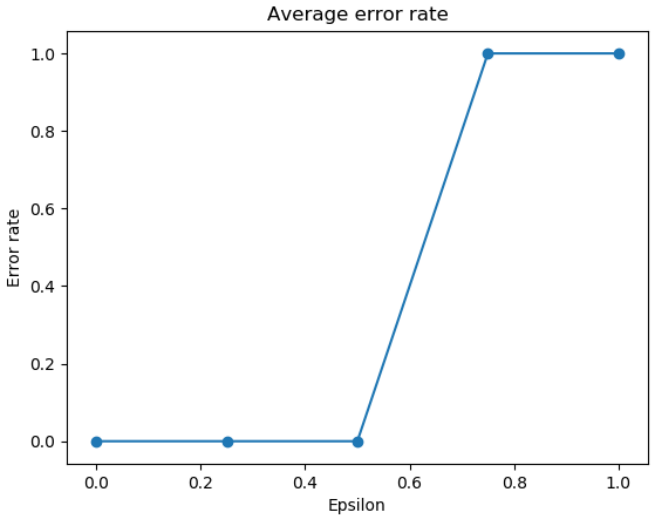
Varying epsilon rate:

In this evaluation the bitrate will be fixed on 0.3 and the epsilon erasure rate will slowly rise from 0 to 1. The test will be performed for different blocklengths:

Blocklength 128 (2^7)



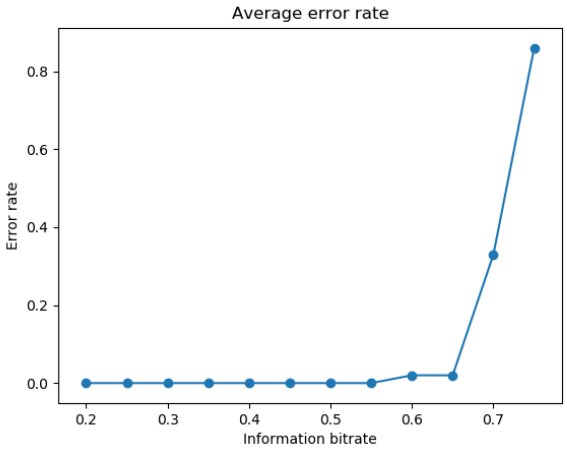
Blocklength: 8192 (2^13)



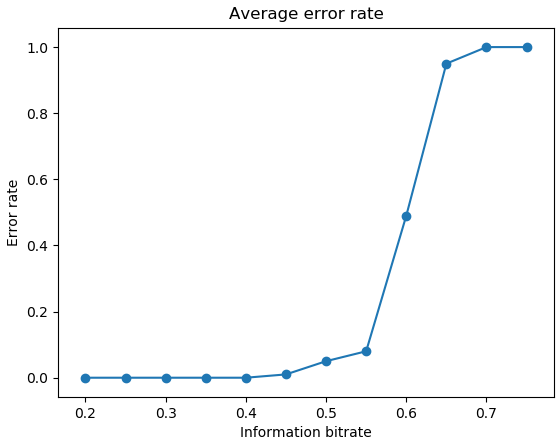
Ideal parameters:

The goal of this test is to find ideal parameters for the most efficient use of polar codes for a blocklength of 256. Different erasure rates will be tested to find the best bitrate configuration.

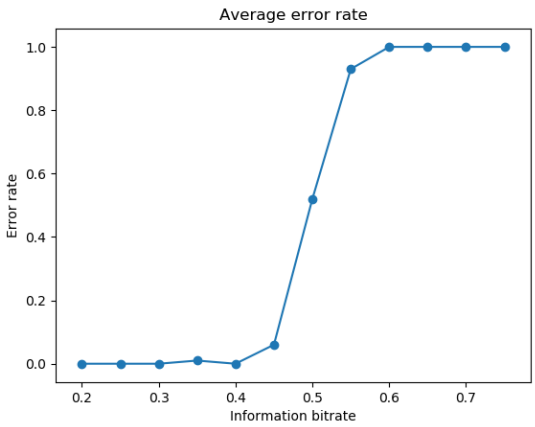
Epsilon: 0.2



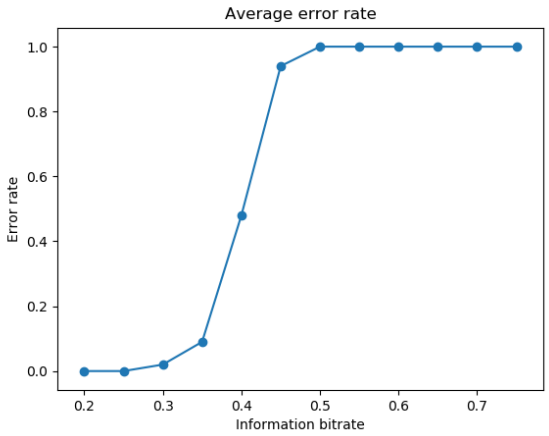
Epsilon: 0.3



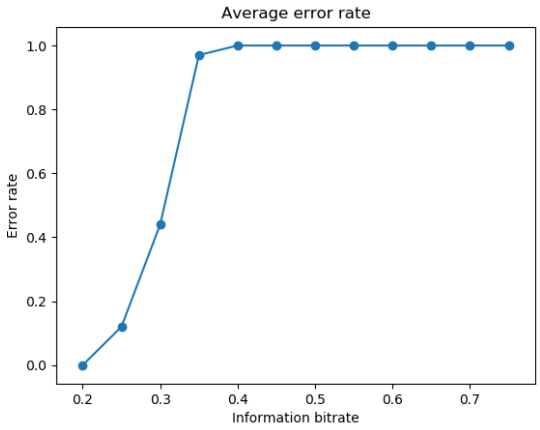
Epsilon: 0.4



Epsilon: 0.5



Epsilon: 0.6



The following table visualizes the ideal parameters for blocklengths of 256:

Epsilon:	**Ideal information bitrate:**	**Acceptable information bitrate:**
0.2	0.55	0.65
0.3	0.4	0.55
0.4	0.3	0.45
0.5	0.25	0.3
0.6	0.2	0.25