## Question 1.

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The calculation of the throughput is similar to the exercise in the Tutorial lecture, where *n* packets were sent every time. In our case, n=2. The equations are still fully developed here:

Given that we send 2 frames together:

Thus:

Calculating the throughput:

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As we can see, the throughput is dependent on 2 parameters – and . By taking the throughput from the original protocol, which is:

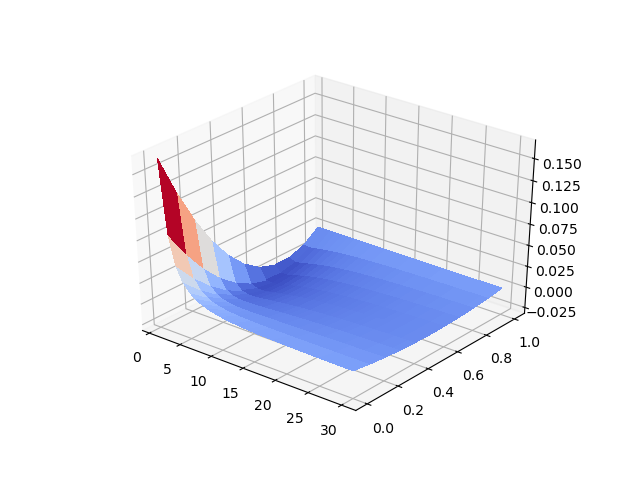
We are required to find the for which the equations holds:

For different values, the which results in the inequality is different. We use the graph to visualize. Using python, the throughput values were calculated for various values. 2 graphs are shown:

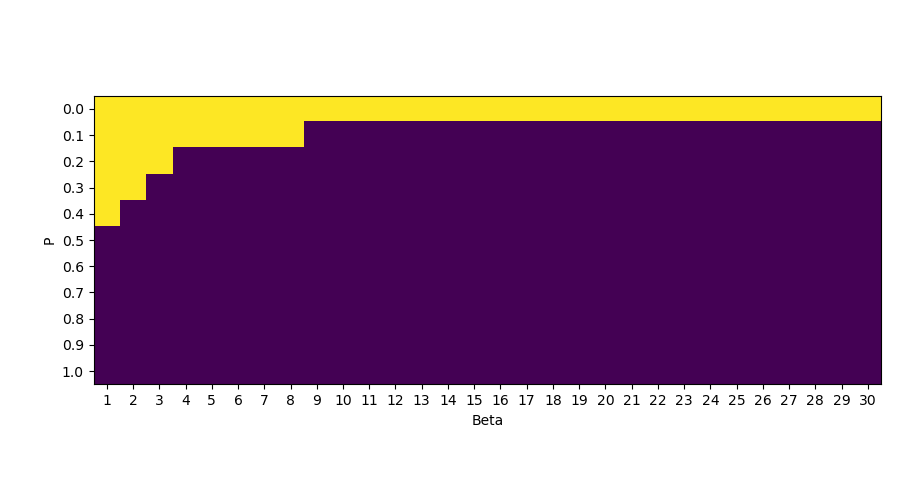
The first graph shows the result of the difference of the throughput values:

Where this values is positive, meaning using the original protocol is beneficial. Ranges used:

Result:



As we can see, where the probability of packet not being delivered is low, and Beta is low (propagation time is small), the original algorithm is more beneficial. To be sure, another binary chart shows yellow bricks where : (and purple if other)



We can observe that:

* With high error probability, the new protocol is beneficial
* If the error value is low, for certain Beta values we prefer the original algorithm
* If the error probability is 0, original protocol is better

All of those conclusions are also intuitive.

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Now, in the equation for the throughput calculation, , what changes is the value. Recalculating:

To validate our result, we calculate the average different between the average message in the original protocol, and in the protocol in this case:

We indeed see that on average the length of the successful transmission is less by :

* If error probability is 0, we always save time!
* As error probability increases, we save less time.

Which are intuitive conclusions.