Exercise
for Lecture “P2P Systems”

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Exercise No. 11
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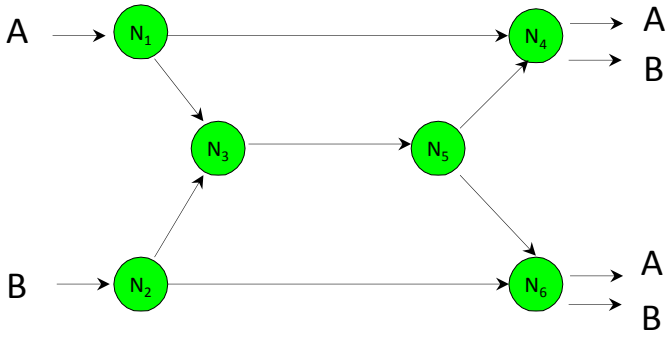
– Example Solution –

Problem 11.1 - Network Coding

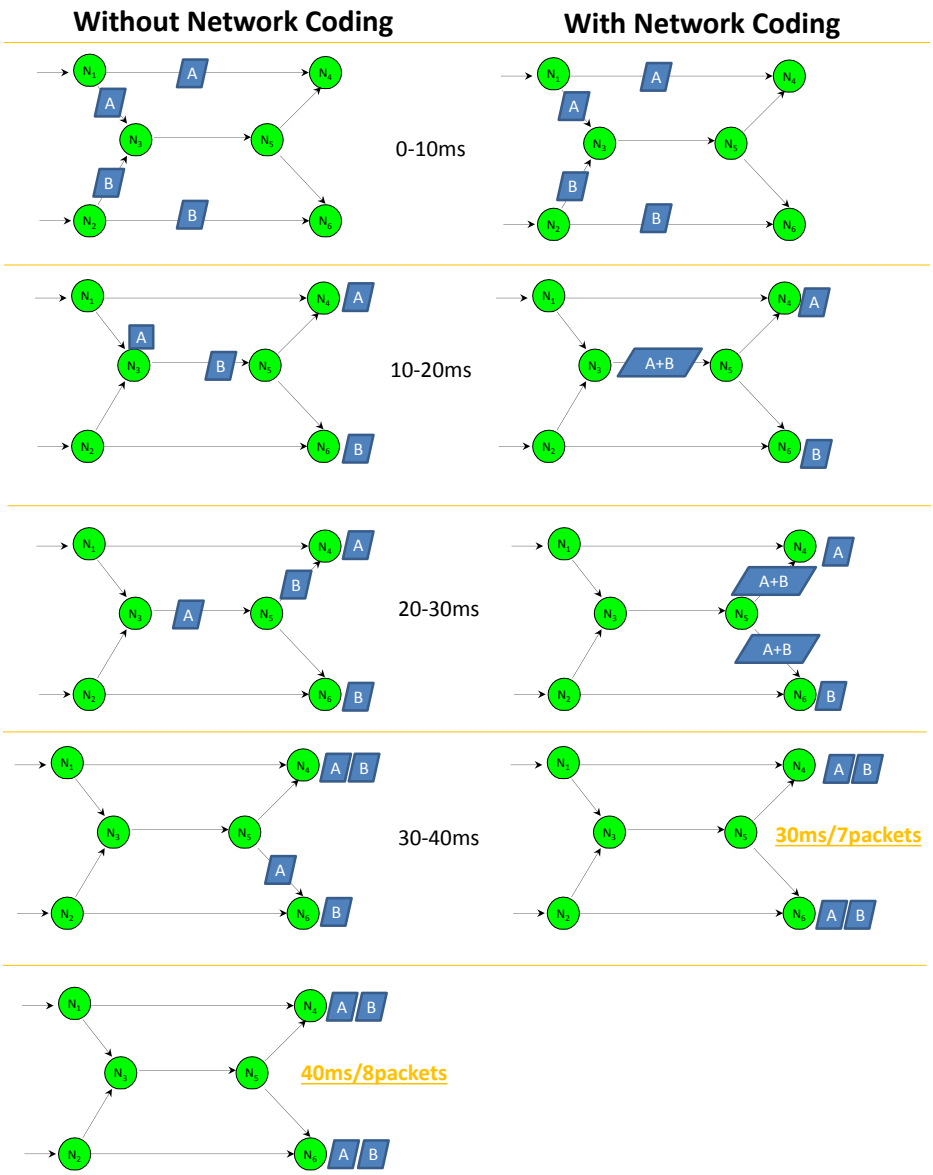
In the lecture you learned about Network Coding. In the following, the network nodes are named N and the chunks are noted by the letters A and B. Assume that one node can send and receive multiple chunks simultaneously. All links are of infinite bandwidth, except the link between N_3 and N_5 which can carry only one chunk at a time. It takes 10ms to transfer one chunk from one node to another. Futher assume N_1 to be in possession of chunk A and N_2 in possession of chunk B.



a) Consider the given topology and assume that network coding is not used. How long does it take at least to deliver the chunks A and B to both nodes N_4 and N_6? Additionally, state the number of messages which have to be exchanged between the nodes.

b) Now assume that network coding is used. How long does it take at least to deliver A and B and how many messages are send between the nodes?

Solution:



c) Consider the network coding example given in the lecture slides 24-26. What would change if Node 1 uses a) the coefficient vector (4, 6, 2) and b) the coefficient vector (4,6,3) instead of the vector (1, 3, 2)? Explain in both cases if Node 3 is able to compute M1, M2, and M3.

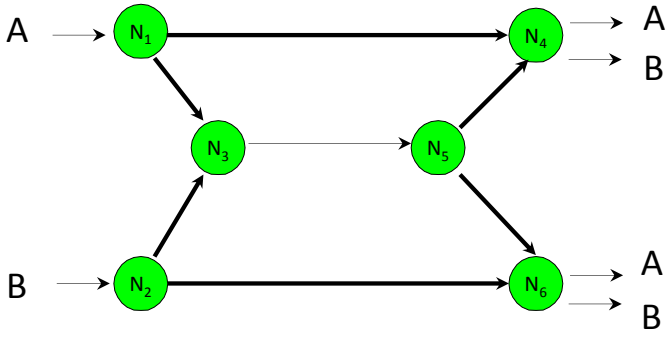
Solution:

a)

If Node 1 chooses (4,6,2) instead of (1,3,2), the following vectors are chosen: (4,6,2), (2,1,3), and (2,3,1). The first and the third vector are linearly depending. N_3 will receive the following messages: (1340,(40,60,20)), (207,(6,3,9)), and (67,(2,3,1)). The first and the third message are linearly depending. Based on this information the original messages cannot be reconstructed. However, in slide 26 a fourth message arrives (77,(1,3,4)) which is linearly independent to the first three messages arrived at N_3. Now, three linearly independent messages can be used to recalculate the original messages: (77,(1,3,4) or (1340,(40,60,20)), (207,(6,3,9)), and (67,(2,3,1)).

b)
If Node 1 chooses (4,6,3) instead of (1,3,2), the following vectors are chosen: (4,6,3), (2,1,3), and (2,3,1). The three vectors are linearly independent and, therefore, the original messages can be recalculated at M_3.

d) Assume the given network topology used for network coding. The messages M1, M2, and M3 contain the following information: M1=6, M2=2, M3=7. Now assume that the encoding vectors used by Node 1 to be: (2,1,5), (1,2,3), and (3,1,1). Node 2 used the vectors (7,3) and (1,2) for the encoding. Show how the nodes compute the encoded representation of the messages named X. Which information is exchanged by which nodes?



Solution:
The messages exchanged contain the linear combination and the corresponding coefficients, (linear combination, (coefficient 1, coefficient 2, coefficient 3)). The following 5 messages are send by the nodes.
N1 -> N2: (49,(2,1,5)), (31,(1,2,3))
N2 -> N3: (490,(20,10,50)), (93,(3,6,9))
N1 -> N3: (27,(3,1,1))