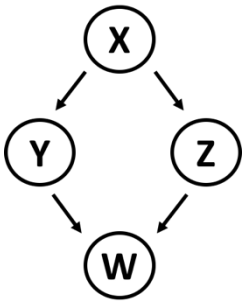
Problem Set 3

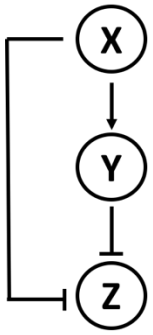
Feed-forward loop network motif

1. The four-node diamond pattern occurs when X regulates Y and Z, and both Y and Z regulate gene W.

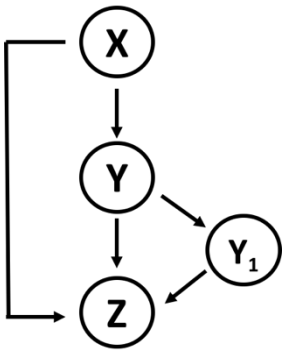


   a) How does the mean number of diamonds scale with network size in random ER networks?
   b) What are the distinct types of sign combinations of the diamond (where each edge is either activation "+" or repression "-")? How many of these are coherent?
   c) Consider a diamond with four activation edges. Assign activation thresholds to all edges. Analyze the dynamics of W following a step of S_x, for both AND and OR logic at the W promoter. Are there sign-sensitive delays?

2. Solve the dynamics of the Type-3 coherent FFL with AND logic at the Z promoter in response to steps of S_x. Here, AND logic means that Z is produced if both X* and Y* do not bind the promoter. Are there delays? What is the steady-state logic carried out by this circuit? Compare to the other coherent FFL types.



3. Consider a coherent type-1 FFL with nodes X, Y, and Z, which is linked to another coherent type-1 FFL in which Y activates Y_1, which activates Z.



   a) Sketch the dynamics of Z expression in response to steps of the signals S_x, S_y, and S_{y1} (steps in which one of the signals goes ON or OFF in the presence of the other signals). Can the dynamics of the interconnected circuit be understood based on the qualitative behavior of each FFL in isolation?
   b) Repeat for the case where Y represses Z, so that the X, Y, Z FFL is an incoherent type-1 FFL. Assume that Y_1 binding to the Z promoter can alleviate the repressing effect of Y.