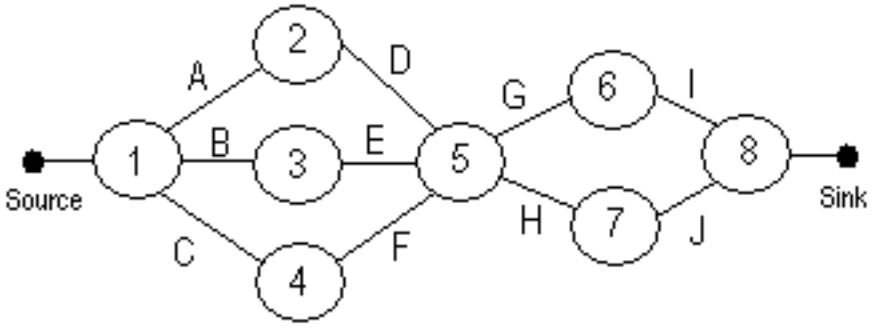
ECE 541 Homework 2

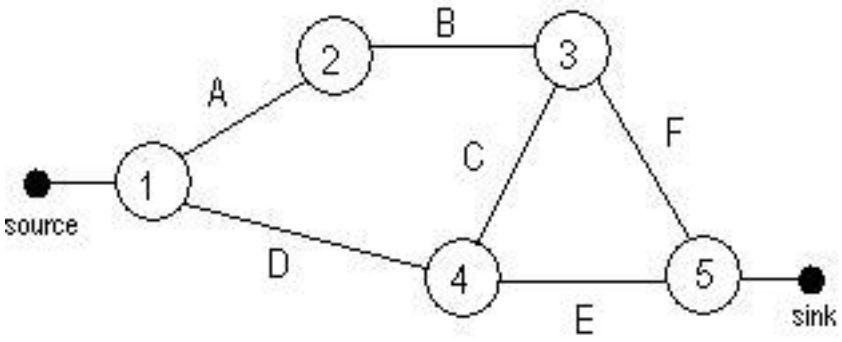
Assigned Tuesday, September 1, 2009
Due Tuesday, September 8, 2009

Assume that all component failures are independent unless otherwise stated.

1. A monitoring system consists of a group of four sensors, a main data processor, a backup data processor, and a communication link between the group of sensors and the data processors. For the monitoring system to be operational, three of the four sensors must be functional, the communication link must be functional, and either the main or backup data processor must be functional.
   (a) Draw the fault tree diagram for the monitoring system.
   (b) Provide the reliability function $Pr\{S > t\}$, where S is the time of failure. Define the notation you use (for example, "Let $F_c(t)$ be the failure distribution of the communication link.").
2. You are designing a system that will include a control module and some number of computation modules. The control module has an exponential failure distribution with mean-time-to-failure 1000 hours. Each computation module has an exponential failure distribution with mean-time-to-failure 200 hours. A working system must contain a working control module and at least one working computation module.
   (a) Draw the reliability block diagram for a system containing the control module and two computation modules.
   (b) For a system with two computation modules, provide the system reliability function $Pr\{S > t\}$, where S is the time of failure. Define the notation you use. Use this reliability function and your knowledge of the failure distributions of the components to calculate the probability that the system is still working at time 400 hours (provide the numerical value here, not just the formula).
   (c) Repeat part (b) for a system with three computation modules.
   (d) Repeat part (b) for a system with four computation modules.
   (e) Repeat part (b) for a system with five computation modules.
   (f) What is the impact of increasing redundancy on the failure of the system?
3. Determine whether or not the following reliability graphs are series-parallel.

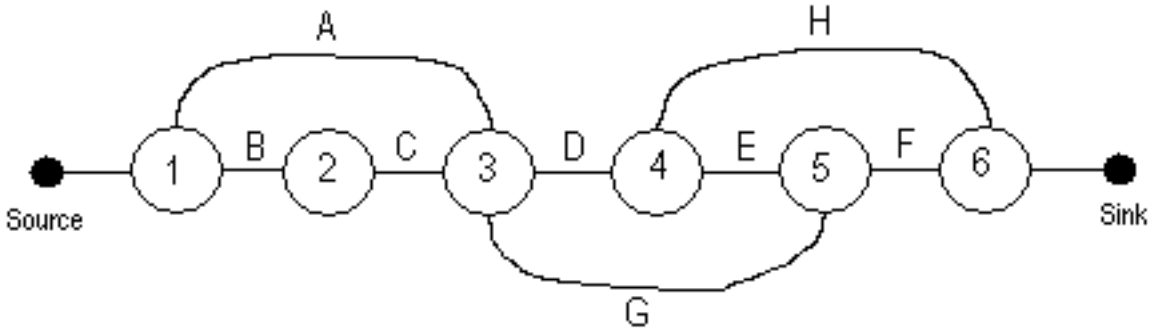


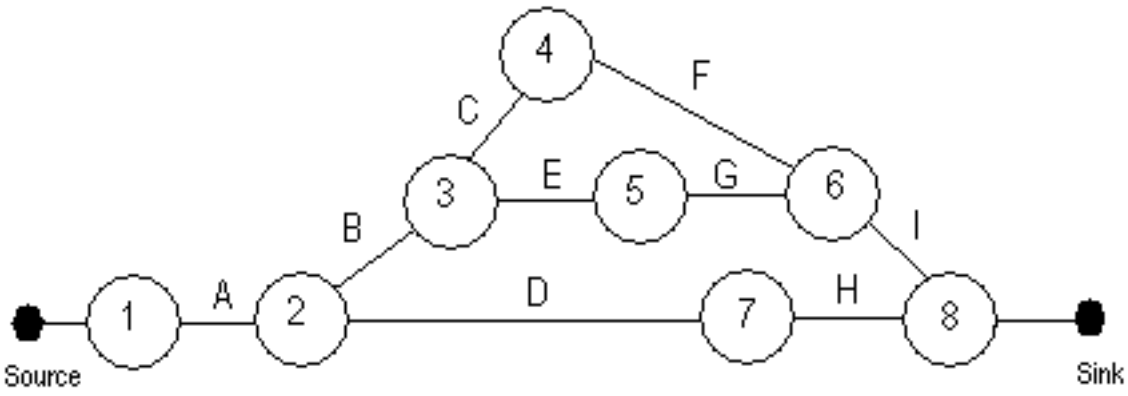
(a)



(b)

(c)





(d)

4. You own a shipping company and need to ship merchandise between City X and City W. Your company operates train routes between Cities X and Y, X and Z, Y and Z, Y and U, U and W, and Z and W. Randomly, vandals rip up the train tracks between the cities and prevent trains from operating on that segment of train tracks. System failure is when the vandalism prevents you from shipping merchandise between Cities X and W.

(a) Draw the reliability graph for system failure.

(b) Provide the reliability function $Pr\{S > t\}$, where S is the time of failure. Define the notation you use.

5. You have created a new invention and determined that the whole invention will fail if either (1) components C, D, and E all fail or (2) two out of three of components A, B, and D fail.

   (a) Determine an appropriate formalism (fault tree, reliability block diagram, or reliability graph), and draw the formalism for the failure of your invention.

   (b) Provide the reliability function $Pr\{S > t\}$, where S is the time of failure. Define the notation you use.

6. You want to travel from City A to City B, but there is no direct road from A to B. Instead, there is a system of roads that allow you to travel through Cities C, D, and E. The following road segments exist: A to C, A to D, A to E, C to D, D to E, C to B, and E to B. (Road segments allow travel in both directions, so road segment C to D means that you can also travel from D to C.) Traffic accidents occur randomly. A traffic accident prevents all travel on the affected road segment in either direction (i.e., the road segment "fails"). Failure of the system is when road segment "failures" prevent you from traveling from City A to City B.

   (a) Determine an appropriate formalism (fault tree, reliability block diagram, or reliability graph), and draw the formalism for the failure of the system.

   (b) Provide the reliability function $Pr\{S > t\}$, where S is the time of failure. Define the notation you use.