BAYESIAN NETWORKS

Today

- Definition of Bayesian networks
- Reading off independencies
  - Types of Connection
  - D-separation algorithm

Bayesian Networks

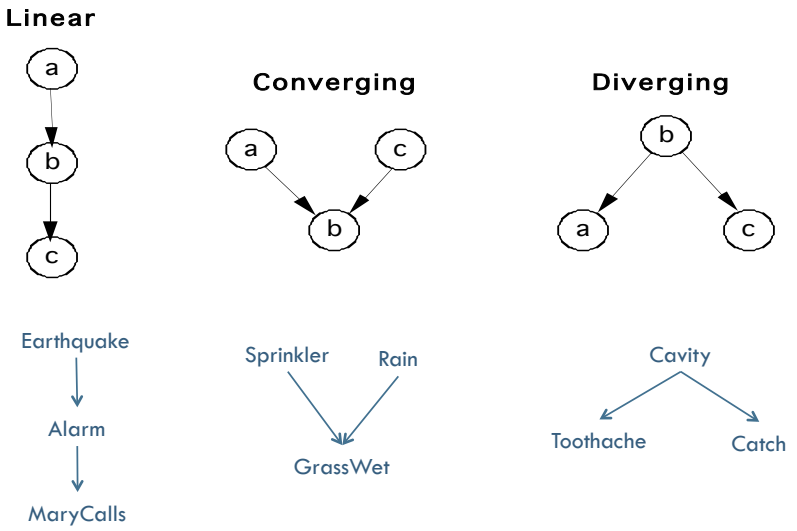
- A Bayesian Network is a directed acyclic graph that represents the conditional independencies of a set of random variables
  - Each random variable corresponds to a node
  - A directed edge represents a direct influence
  - The conditional distribution of each node given its parents must be explicitly specified

Representing the joint using a BN

- Given a BN over a set of random variables, the joint distribution can be factor as

$$p(x_1, \ldots, x_N) = \prod_{i=1}^{N} p(x_i | \text{parents}(x_i))$$

Three Types of Connections



Connection patterns and independence

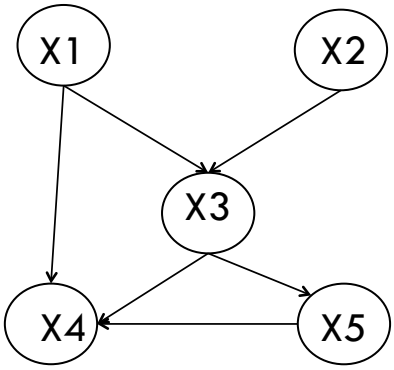
- **Linear connection:**
- **Converging connection:**
- **Divergent connection:**

D-Separation

- Algorithm to determine independencies in BN
- Query: Are two variables X_i and X_j independent?
- Check all paths between X_i and X_j
  - If all paths are blocked, then independent
  - If any path is not blocked then not independent

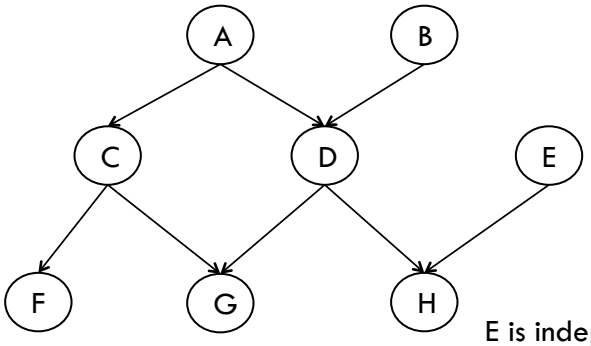
A path is blocked if for any connection on the path the two end variables are independent

List the independencies in the following Bayesian Network



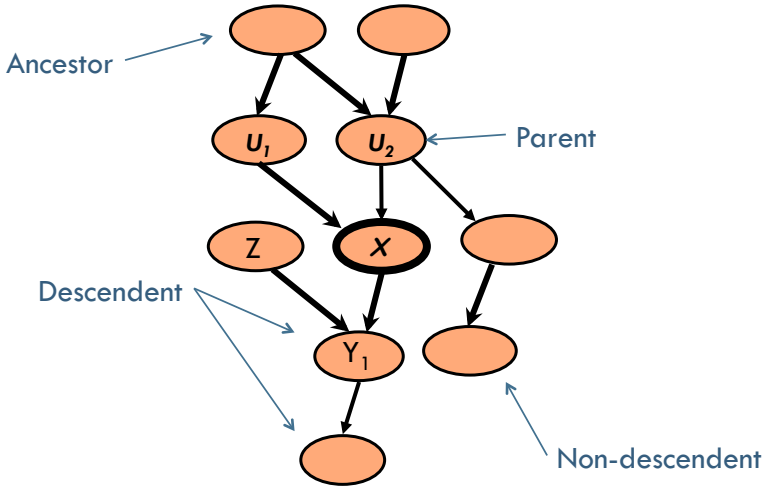
X2 is independent of X3?
X2 is independent of X4?
X2 is independent of X4 given X3?
What would make X2 and X4 ind.?

List the independencies in the following Bayesian Network



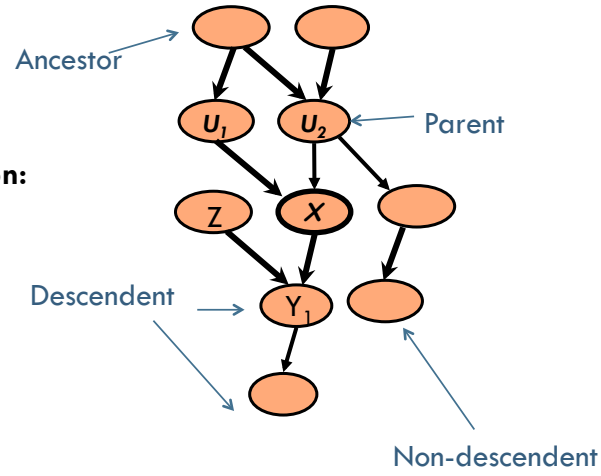
E is independent of G?
C is independent of D?
C is independent of D given G?
F is independent of A given {C,D}?

Bayesian Networks terminology



Independence assumptions encoded in the Bayesian Network

Local Markov Assumption:
A node X is independent of its non-descendants given its parents



Independence assumptions encoded in the Bayesian Network

Markov Blanket:
A node X is conditionally independent of all other nodes given its parents, children, and children's parents