CS 440
Introduction to Artificial Intelligence

Lecture 14:

Bayesian Networks and Markov Processes

3 March 2020

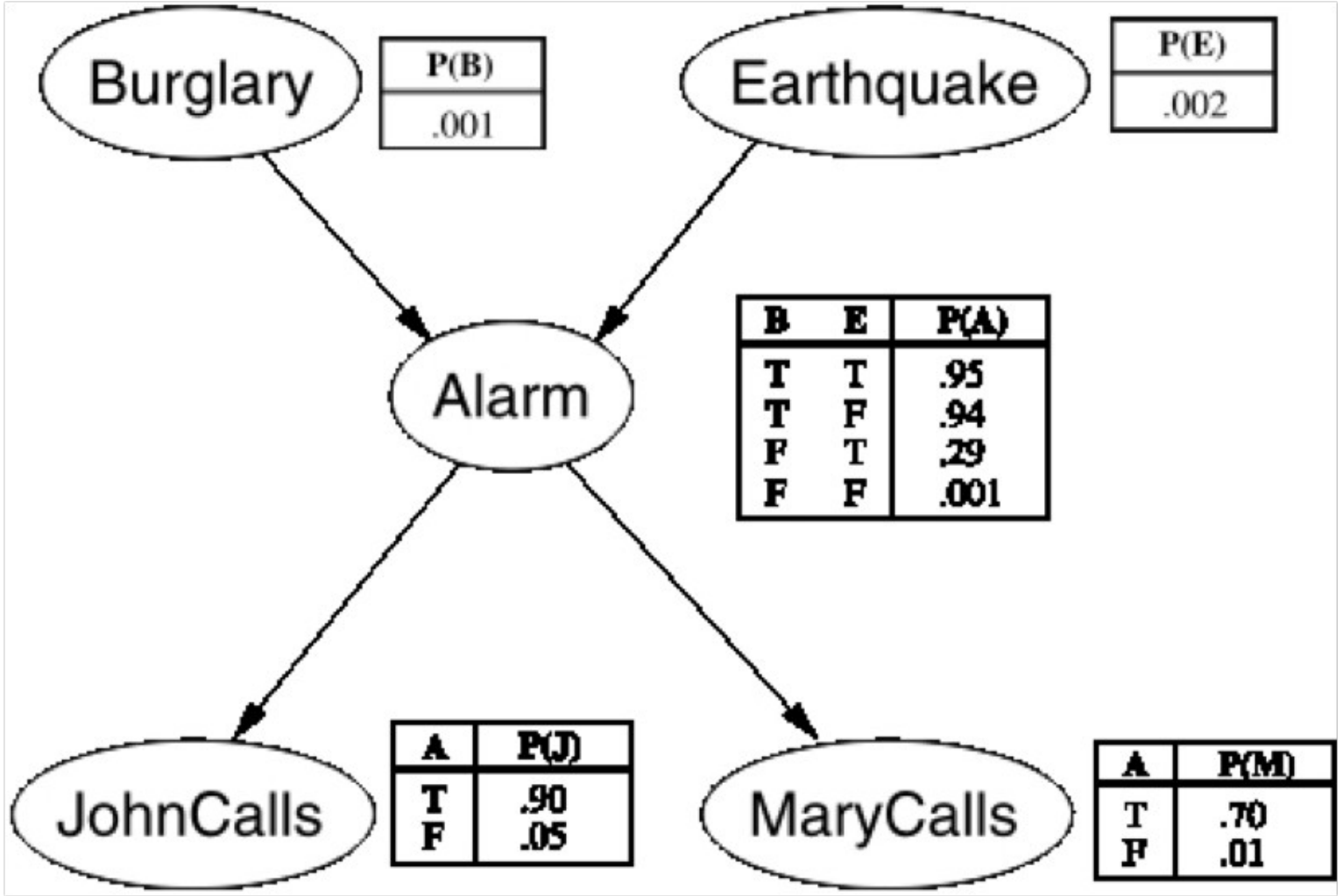
Bayes' Theorem

- Alice has lung cancer, what is the probability she is a smoker?
  - Given p(smoker), p(cancer) and p(cancer|smoker)
  - Can you compute p(smoker|cancer)?
  - We know that p(smoker|cancer) equal to the number of people who are smokers with cancer over the total number of people with cancer.
    - $p(\text{smoker}|\text{cancer}) = n_{\text{smokers,cancer}}/n_{\text{cancer}}$
    - But we don't know $n_{\text{smokers,cancer}}$ or n_{cancer}
  - Define n to be the size of our total population
    - We don't know what n is
    - $n_{\text{cancer}} = n*p(\text{cancer})$
    - $n_{\text{smokers}} = n*p(\text{smoker})$
    - $n_{\text{smokers,cancer}} = n_{\text{smokers}} * p(\text{cancer}|\text{smoker}) = n*p(\text{smoker})*p(\text{cancer}|\text{smoker})$
    - $p(\text{smoker}|\text{cancer}) = p(\text{smoker})*p(\text{cancer}|\text{smoker}) / p(\text{cancer})$

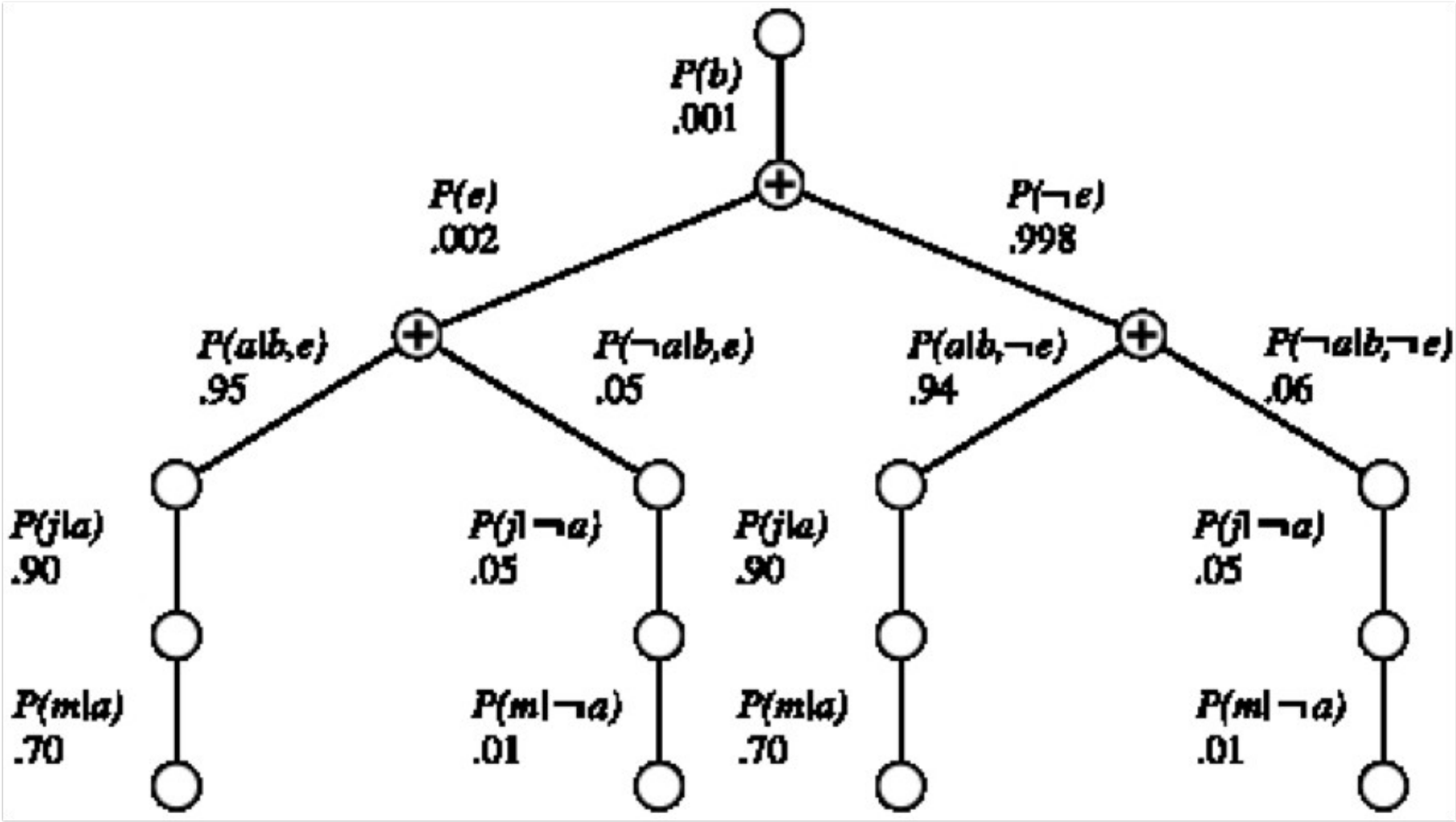
Bayes' Theorem

- **Congratulations, you just derived Bayes' Theorem!!!!**
  - **p(y|x) = p(y)*p(x|y) / p(x)**

Example Bayesian Network



Enumeration Tree



Discussion

- We computed probability of a call given that there is a burglary
  - P(call|burglary)
- How could we compute probability that there is a burglary given that you received a call?
  - P(burglary|call)

Discussion

- We computed probability of a call given that there is a burglary
  - P(call|burglary)
- How could we compute probability that there is a burglary given that you received a call?
  - P(burglary|call)
- One option - use Bayes theorem
  - P(burglary|call) = P(burglary) * P(call|burglary) / P(call)
  - Compute P(call) given enumeration tree

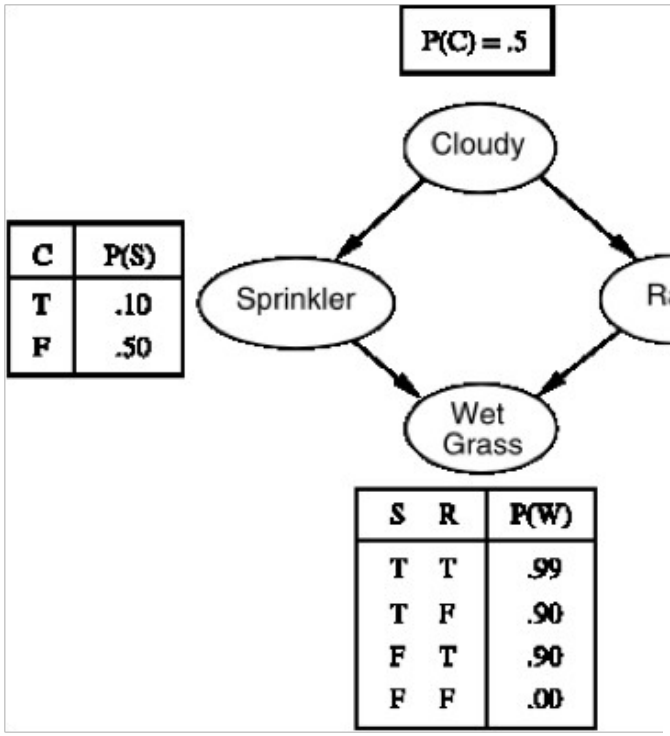
Bayesian Network: Formal Definition

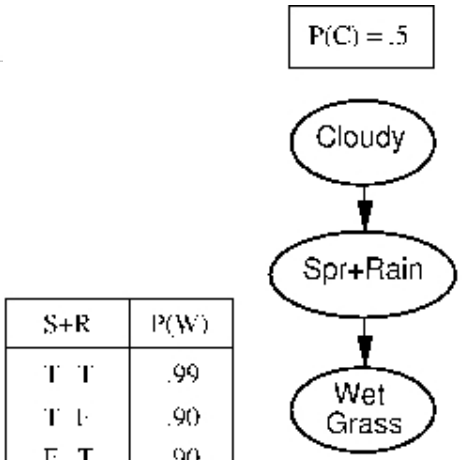
- Network used for burglary problem and example of a neural network.
- Nodes correspond to variables
- Connections indicate cause and effect
  - Example burglary effects probability alarm will go off
- Each node stores probability of variable given all possible settings of parents
  - Non-discrete variables need function mapping all possible settings of parents to probability distribution of child

Dependence

- Given a Bayesian network
- Observe a variable in the network
- What other variables are effected by observation?
  - Variables whose probability is effected by observation

Multiply Connected Network





Bayes' Theorem Example

- **Assume you are given the following**
  - **P(c) probability someone in construction business**
  - **P(a) probability someone is exposed to asbestos**
  - **P(a|c) probability someone exposed to asbestos given they work in construction**
  - **P(s) probability someone is a smoker**
  - **P(l) probability someone develops lung cancer**
  - **P(l|a) probability someone develops ling cancer given they were exposed to asbestos**
  - **p(l|s) probability of developing lung cancer given that someone is a smoker**
- **What is the probability someone who has lung cancer works in construction?**
- **What is the probability a smoker who works in construction will develop lung cancer?**
- **What is the probability someone who has lung cancer is both a smoker and works in construction?**