# Cause and Effect in Uncertainty

#### Cause and Effect

What is the probability of a cause given some evidence?

What is the probability of an effect given some evidence?

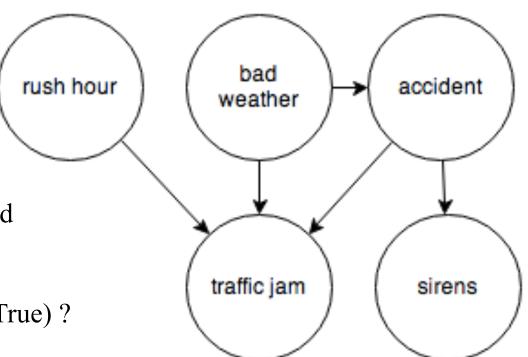
What is the cause of the car not starting?

What is the probability that the car not Main fuse Battery age **Alternator** okay 99.0 blown 1.0 new old new 40.0 do 40 Okay 99.7 Faulty 0.30 starting is caused by a faulty alternator? Charging system Okay 49.8 Faulty 50.2 P(Alternator=Faulty|CarStarts=False)? Yoltage at plug Battery voltage Distributer strong 36.3 weak 17.8 strong 41.1 weak 17.8 dead 41.0 Okay 99.0 Faulty 1.0 45.9 Spark plugs okay 70.0 too\_wide 10.0 fouled 20.0 Headlights bright 38.7 dim 17.3 off 44.0 Air filter Spark quality clean 90.0 good 25.4 bad 23.3 very\_bad 51.2 dirty 10.0 🗖 Spark timing Fuel system 89.3 9.21 good Okay 90.0 bad Faulty 10.0 veru\_bad 1.49 Air system Okay 84.0 Faulty 16.0 Starter Motor Starter system Okay 99.5 Faulty 0.50 Okay 59.6 Faulty 40.4 Car starts Car cranks

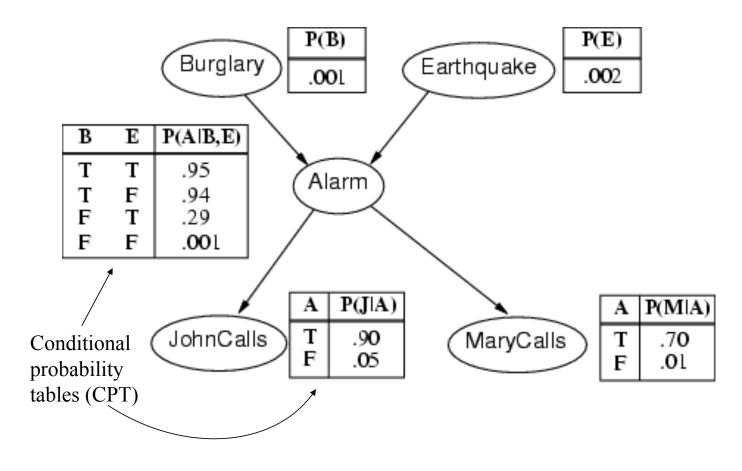
True 49.7 False 50.3 Will there be a traffic jam?

What is the probability that the bad weather will cause a traffic jam?

P(TrafficJam=True|BadWeather=True)?



### Burglary network



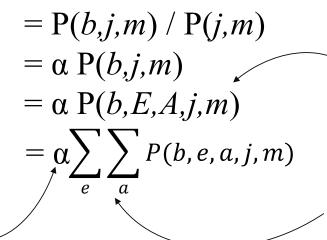
Simplification:
We will only be handling variables with Boolean values

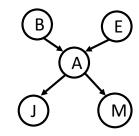
## Inference by Enumeration

• Bayes Nets represent a joint probability Simple query on the burglary network:

What is the probability of there being a burglary if John and Mary called?

Normalization constant





Need to include the variables that are related but value is not known

Capital letters to indicate unknown values

Sum over the possible values for the variables where the values are not known

### Inference by Enumeration

$$P(b|j,m) = \alpha \sum_{e} \sum_{a} P(b,e,a,j,m)$$
This is ugly.
And we don't know it.
$$= \alpha P(b) \sum_{e} P(e) \sum_{a} P(a|b,e) P(j|a) P(m|a)$$
We do know all of these terms

Now we can lookup each term in the CPT in the Bayes Net

**Evaluation Tree** 

