

# ARTIFICIAL INTELLIGENCE & CYBER SECURITY

## BAYESIAN NETWORKS

*Example*

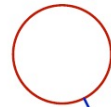
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# Modelling the Earthquake example

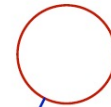
## Conditional Probability Tables

E	P(E)
$e$	0.001
$\neg e$	0.999

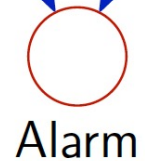
Earthquake



Burglar



B	P(B)
$b$	0.02
$\neg b$	0.98



Alarm

E	B	A	$P(A   E, B)$
$e$	$b$	$a$	0.97
$e$	$b$	$\neg a$	0.03
$e$	$\neg b$	$a$	0.29
$e$	$\neg b$	$\neg a$	0.71
$\neg e$	$b$	$a$	0.95
$\neg e$	$b$	$\neg a$	0.05
$\neg e$	$\neg b$	$a$	0.01
$\neg e$	$\neg b$	$\neg a$	0.99

## Reasoning

What is the probability of a burglary if the alarm called you?

$$P(b | a) = P(b, a) / P(a)$$

$$P(b, a) = P(e, b, a) + P(\neg e, b, a)$$

$$= P(a | e, b) P(e) P(b) + P(a | \neg e, b) P(\neg e) P(b)$$

$$= 0.97 \times 0.02 \times 0.001 + 0.95 \times 0.02 \times 0.999 = 0.019$$

$$P(a) = P(b, a) + P(\neg b, a)$$

$$P(\neg b, a) = P(e, \neg b, a) + P(\neg e, \neg b, a)$$

$$= P(a | e, \neg b) P(e) P(\neg b) + P(a | \neg e, \neg b) P(\neg e) P(b)$$

$$= 0.29 \times 0.98 \times 0.001 + 0.01 \times 0.98 \times 0.999 = 0.0101$$

$$P(a) = P(b, a) + P(\neg b, a) = 0.019 + 0.0101 = 0.0291$$

$$P(b | a) = 0.019 / 0.0291 \approx 0.6535$$

## Reasoning further

What is the probability of a burglary if the alarm called you and there was an earthquake?

$$P(b|a, e) = P(b, a, e) / P(a, e)$$

$$P(b, a, e) = P(a|e, b) P(e) P(b) = 0.97 \times 0.02 \times 0.001 = 1.94 \cdot 10^{-5}$$

$$P(a, e) = \dots \approx 2.861 \cdot 10^{-4}$$

$$P(b|a, e) = 1.94 \cdot 10^{-5} / 2.861 \cdot 10^{-4} = 0.0678$$

Notice how

$$P(b)(0.02) < P(b|a, e)(0.0678) \ll P(b|a)(0.6535)$$