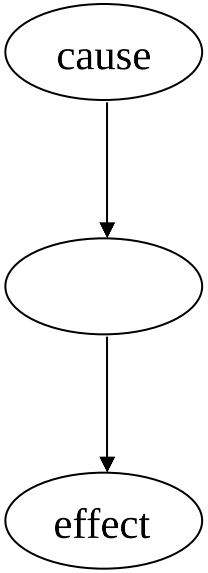
Inference in belief networks

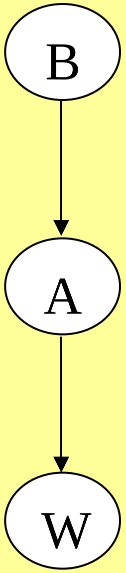
- Basic task: Determine posterior probability of a set of query variables given exact values for some evidence variables:

$$P(\ Query\ |\ Evidence\ )$$

Kinds of probabilistic inference (I)

- Diagnostic inferences
  - inference from effects to causes: P(cause | effect)
  - inference from symptoms to disease: P(disease | symptom)



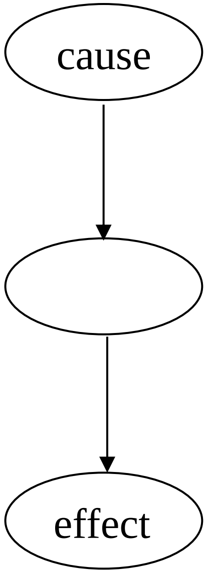


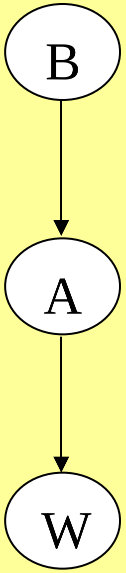
Example query:

P(B | W)

Kinds of probabilistic inference (II)

- Causal inferences
  - inference from causes to effects: P(effect | cause)
  - inference from diseases to symptoms: P(symptom | disease)



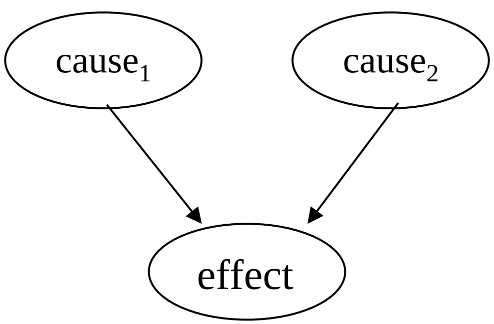


Example query:

P(W | B)

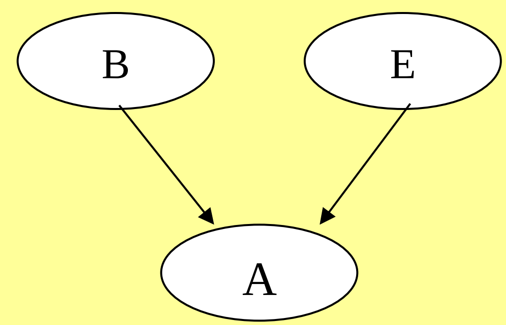
Kinds of probabilistic inference (III)

- Intercausal inferences
  - between causes of a common effect
  - $P(\text{cause}_1 \mid \text{cause}_2, \text{effect})$
  - $P(\text{disease}_1 \mid \text{disease}_2, \text{symptom})$



Example query:

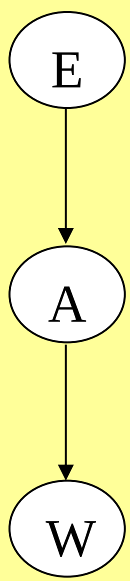
$P(B \mid E, A)$



Note: $P(B \mid A) \gg P(B \mid E, A)$
called "explaining away"

Kinds of probabilistic inference (IV)

- Mixed inferences
  - combining two or all of diagnostic, causal, intercausal



Example query:

$P(A \mid W, \neg E)$

Mixing diagnostic and causal inferences

Examples of probabilistic inference (I)

Prior probabilities (no evidence)	
P(Earthquake)	= 0.0003
P(Burglary)	= 0.0001
P(Radio)	= 0.00047
P(Watson)	= 0.4
P(Gibbon)	= 0.044

Suppose Watson calls	
P(Earthquake | Watson)	= 0.00036
P(Burglary | Watson)	= 0.00019
P(Radio | Watson)	= 0.00052
P(Watson | Watson)	= 1
P(Gibbon | Watson)	= 0.047

Examples of probabilistic inference (II)

Prior probabilities (no evidence)	
P(Earthquake)	= 0.0003
P(Burglary)	= 0.0001
P(Radio)	= 0.00047
P(Watson)	= 0.4
P(Gibbon)	= 0.044

Suppose radio report of earthquake		
P(Earthquake | Radio)	=	0.57
P(Burglary | Radio)	=	0.0001
P(Radio | Radio)	=	1
P(Watson | Radio)	=	0.45
P(Gibbon | Radio)	=	0.083

Examples of probabilistic inference (III)

Prior probabilities (no evidence)	
$P(E)$	$= 0.0003$
$P(B)$	$= 0.0001$

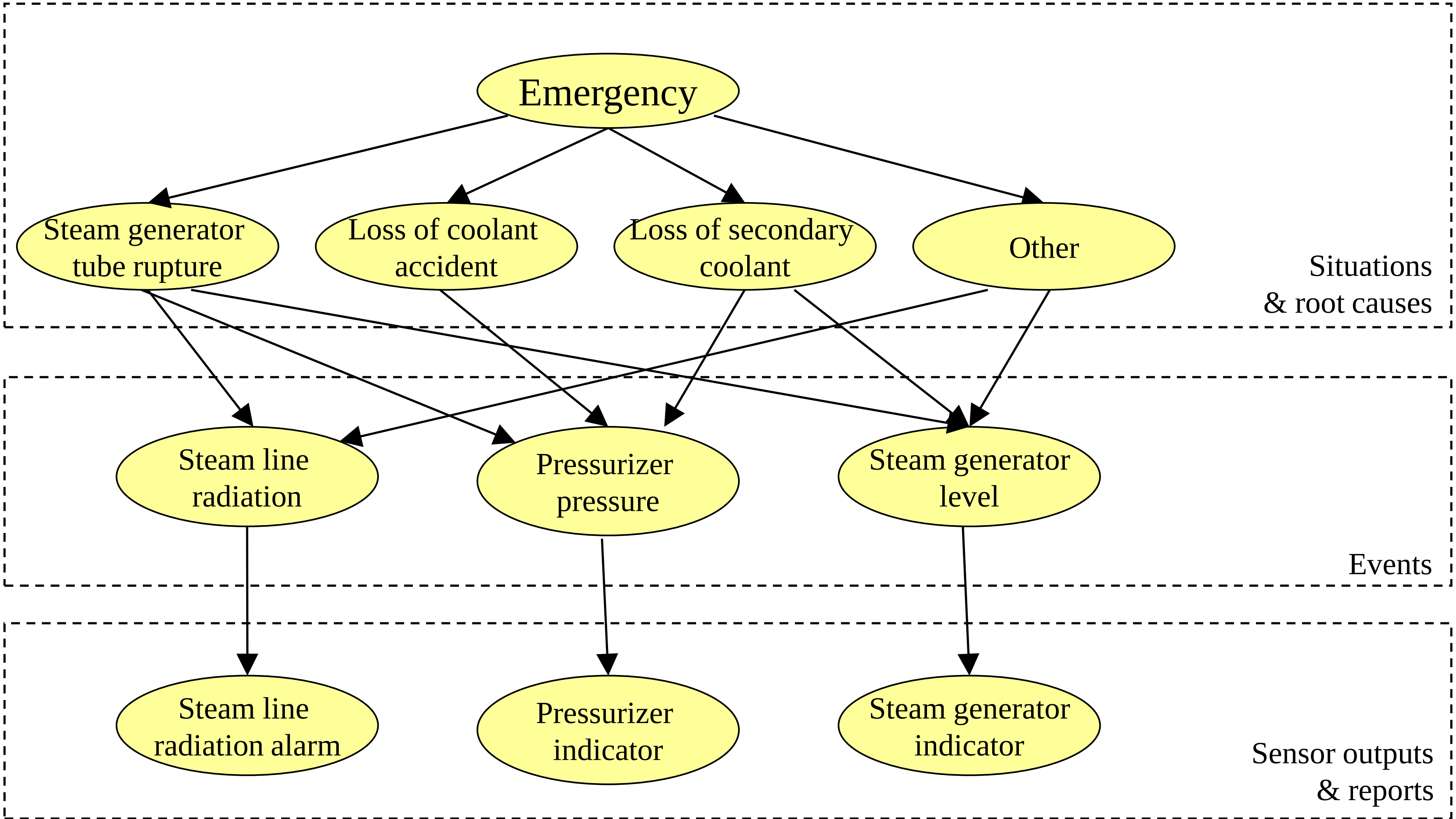
Suppose Watson calls	
$P(E \mid W)$	$= 0.00036$
$P(B \mid W)$	$= 0.00019$

Suppose Watson calls and report of earthquake on radio	
$P(E \mid W, R)$	$= 0.62$
$P(B \mid W, R)$	$= 0.00017$

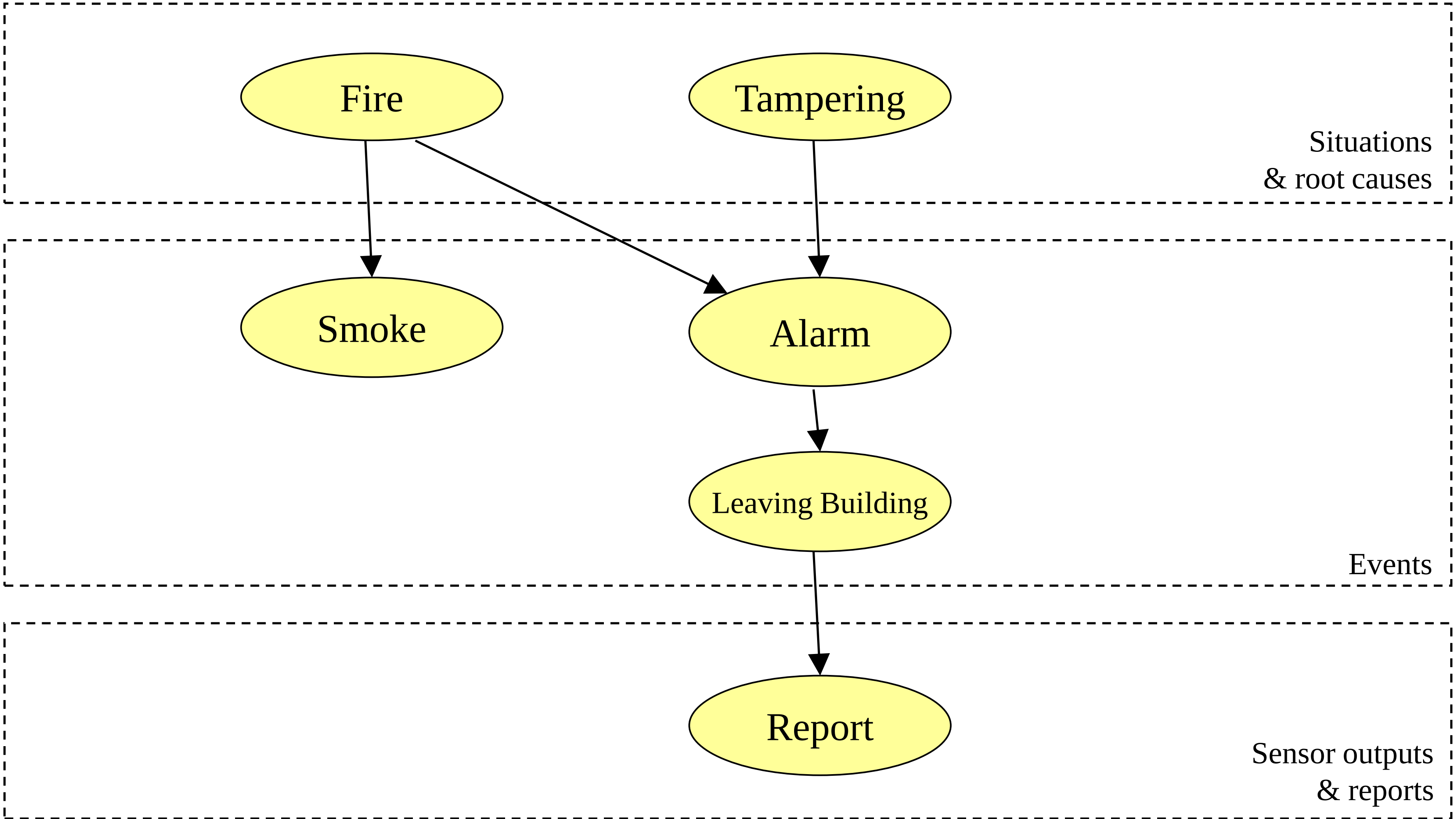
Suppose Watson calls and no report of earthquake on radio	
$P(E \mid W, \neg R)$	$= 0.000036$
$P(B \mid W, \neg R)$	$= 0.00019$

Burglary "explained away"

Example: Nuclear power plant operations

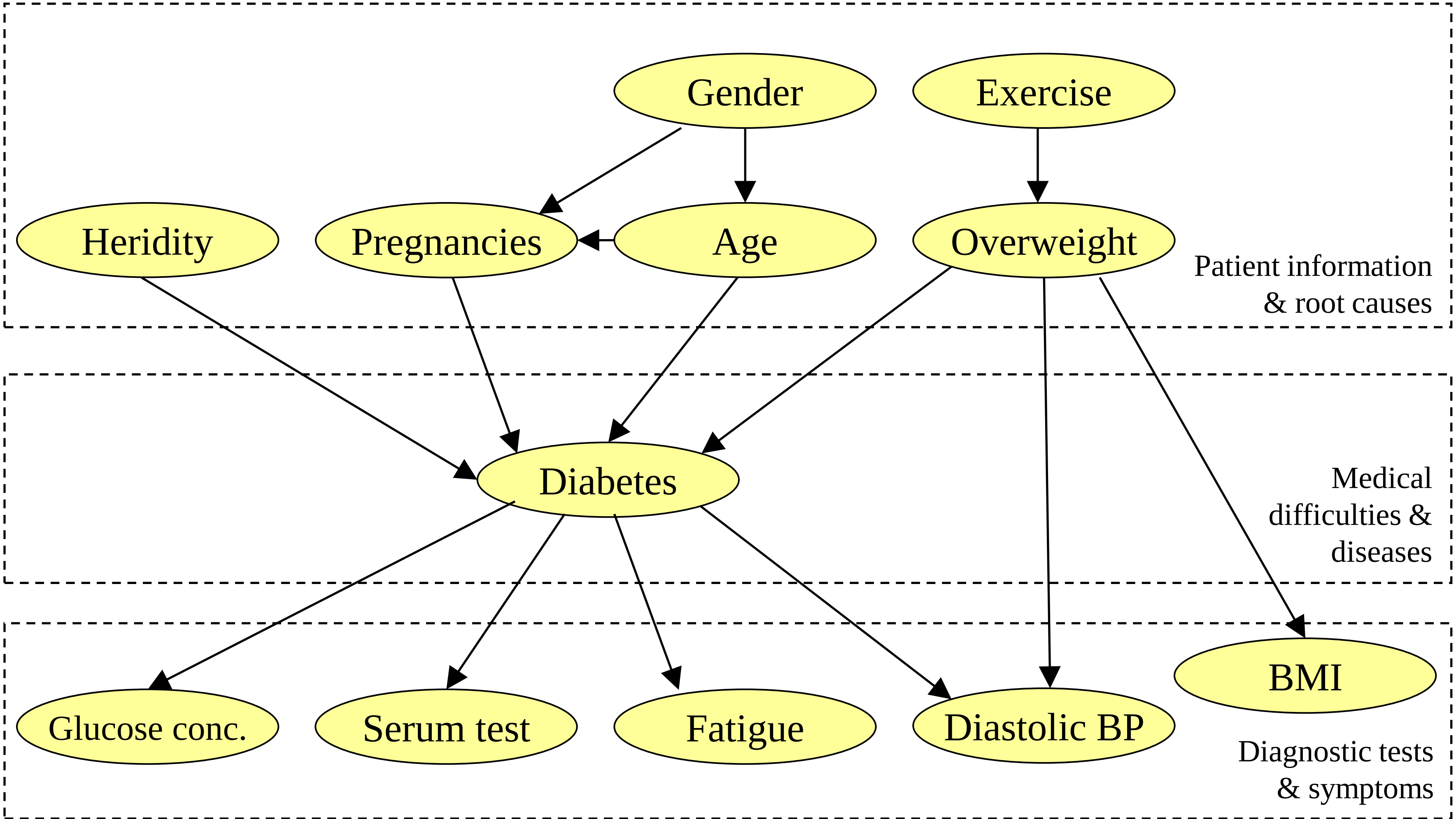


Example: Fire alarms



Report: “report of people leaving building because a fire alarm went off”

Example: Medical diagnosis of diabetes



Example: User needs assistance