Risk & Safety in Engineering

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Content of today

- Introduction to GeNIe
- Building a BPN
- Decision Analysis using BPNs
- Example 2 from Lecture 6

Introduction to GeNIe

- Graphical Network Interface
- GeNIe is the graphical interface to SMILE
- SMILE (Structural Modeling, Inference, and Learning Engine) is a fully platform independent library of C++ classes

  → possible to generate BPN automatically through SMILE
- Free available software GeNIe & SMILE

  http://genie.sis.pitt.edu/

Building a BPN

1st step:

Define the nodes / events

2th step:

Define the states of the nodes

3th step:

Connect the nodes by their dependencies

4th step:

Filling in the probability tables

Building a BPN

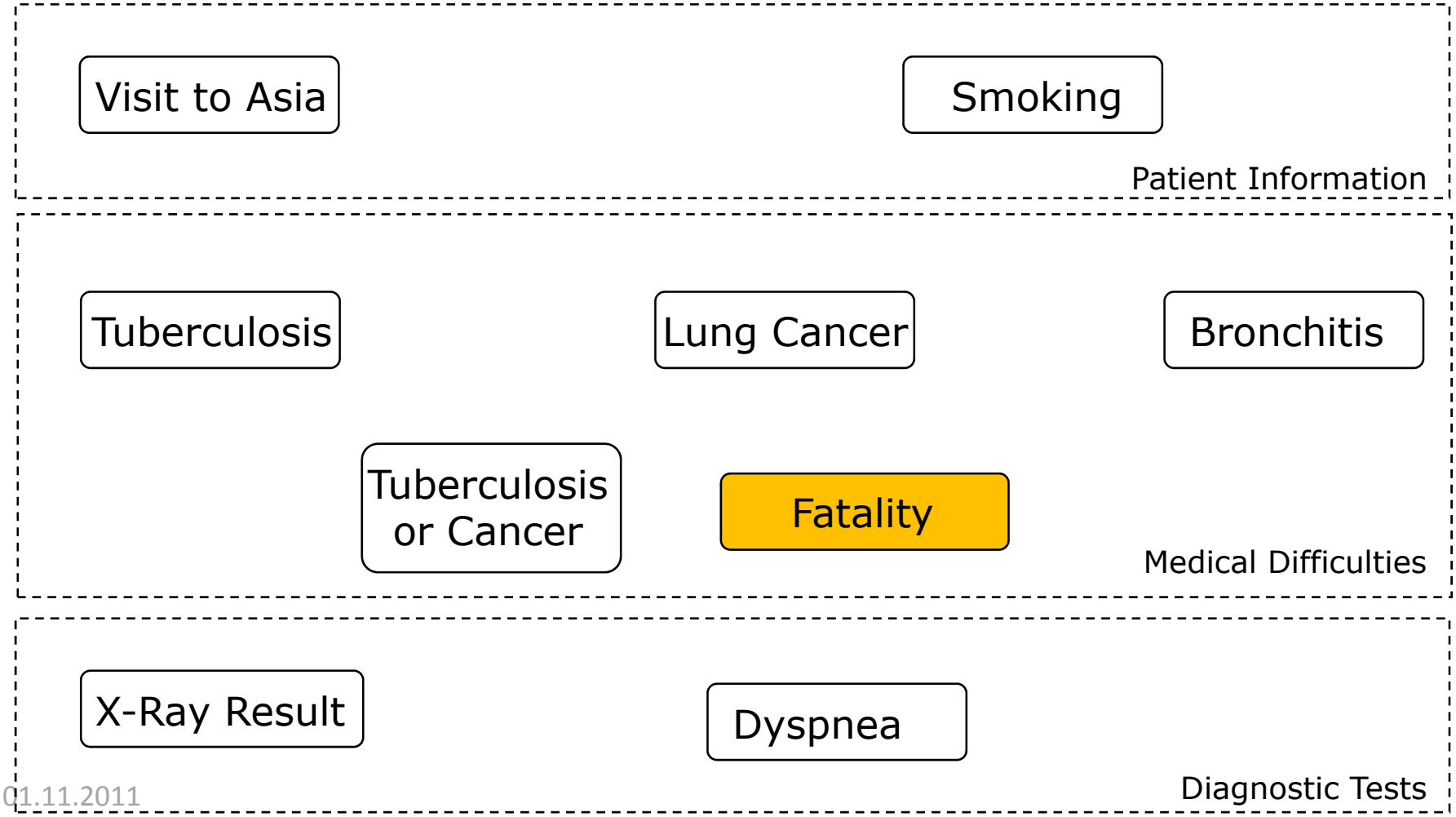
Example from Medical Diagnostics

A BPN should be created to assess the probability dying by a disease concerning the lungs (Tuberculosis, Lung Cancer or Bronchitis). Two information about a patient are available: whether he was in Asia during the last 5 years and whether he smokes or not. Diagnostic Tests (X-Ray and check for Dyspnea) can support the estimation of a disease.

Building a BPN

1st step: Define the nodes / events
2th step: Define the states of the nodes
3th step: Connect the nodes by their dependencies
4th step: Filling in the probability tables

Example from Medical Diagnostics



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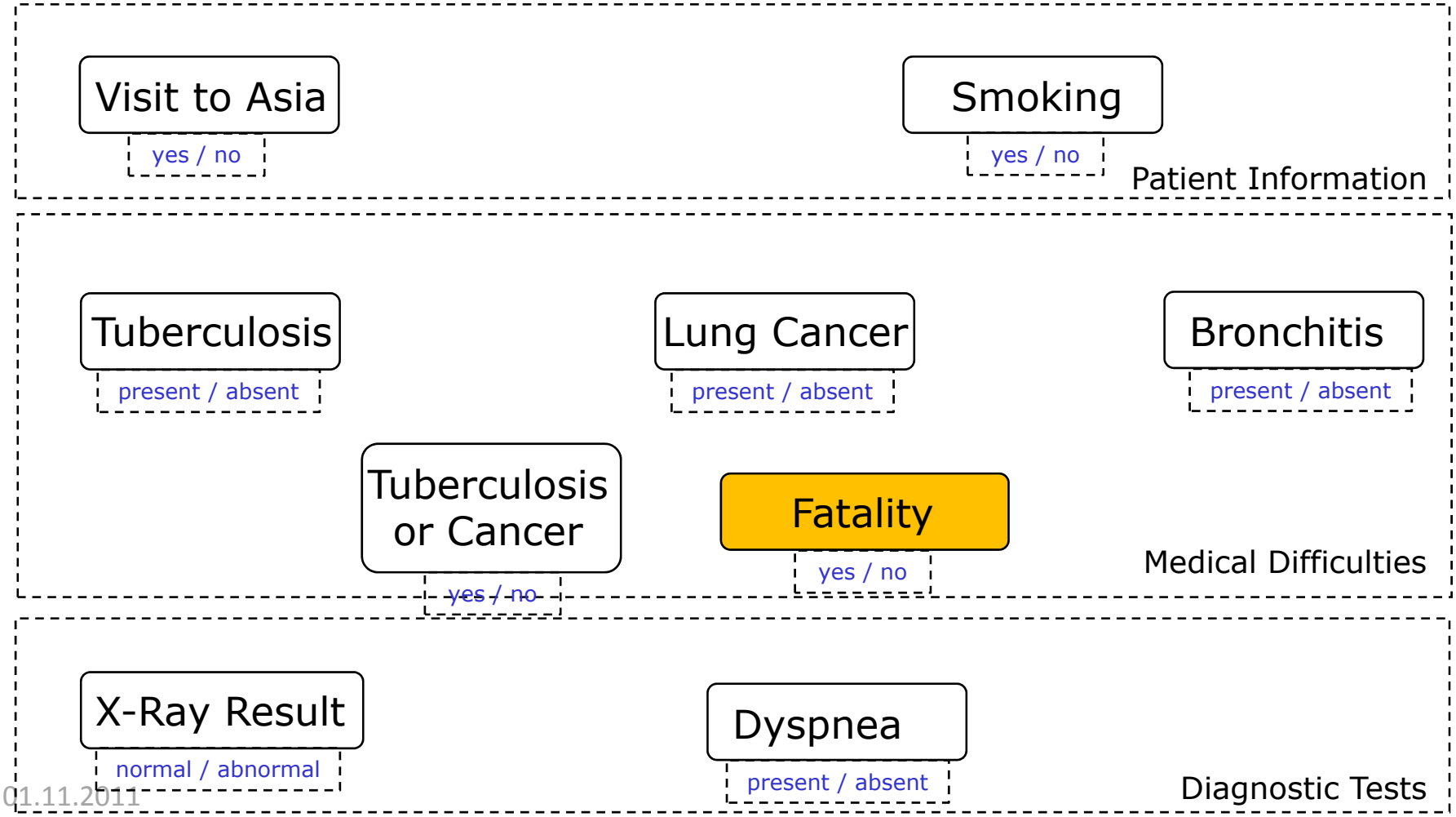

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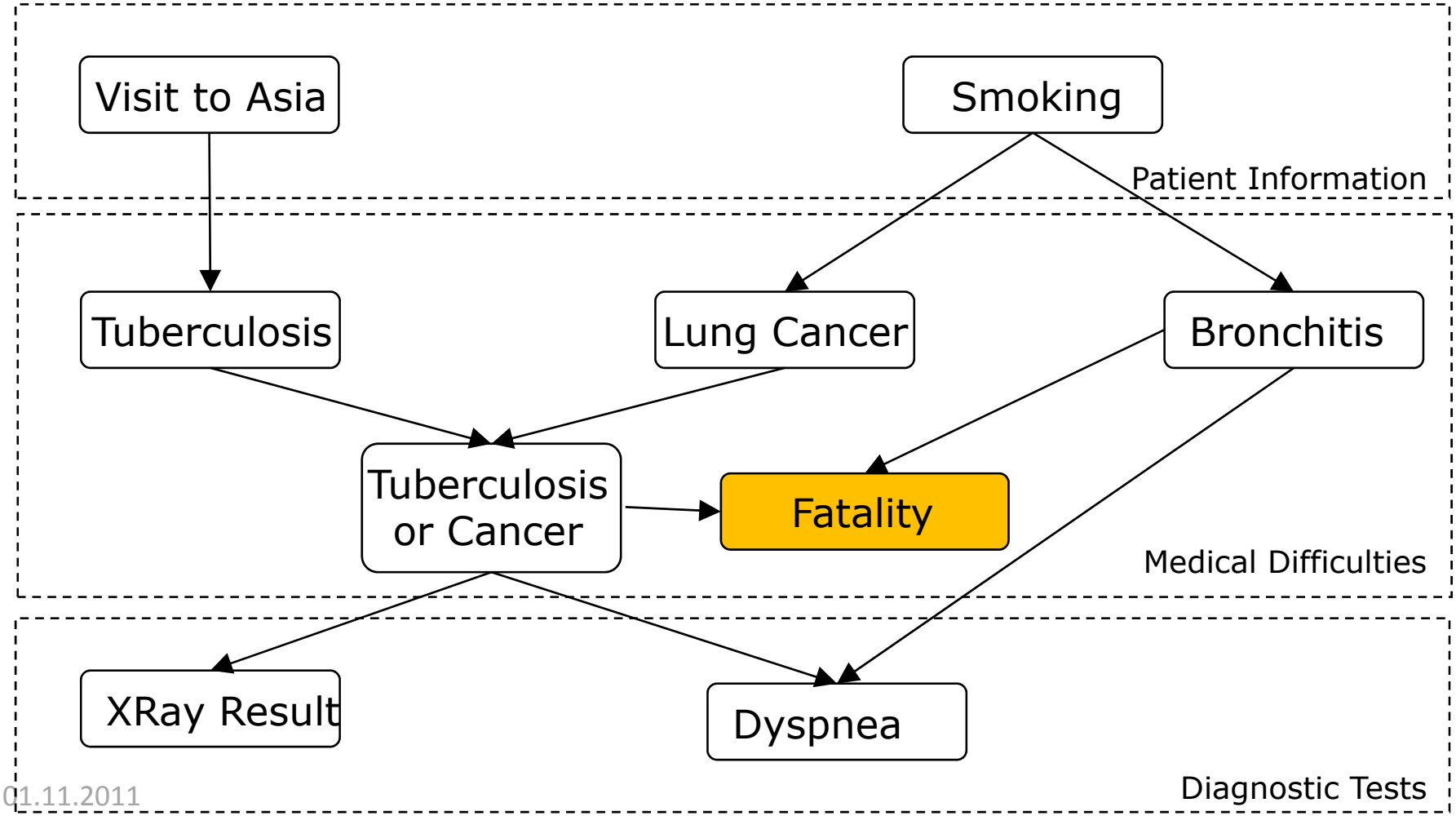

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Building a BPN

Example from Medical Diagnostics

Getting the probabilities of conditional events:

- Statistics / Data
- Reliability Theory
- Engineering judgment / Experts

Building a BPN

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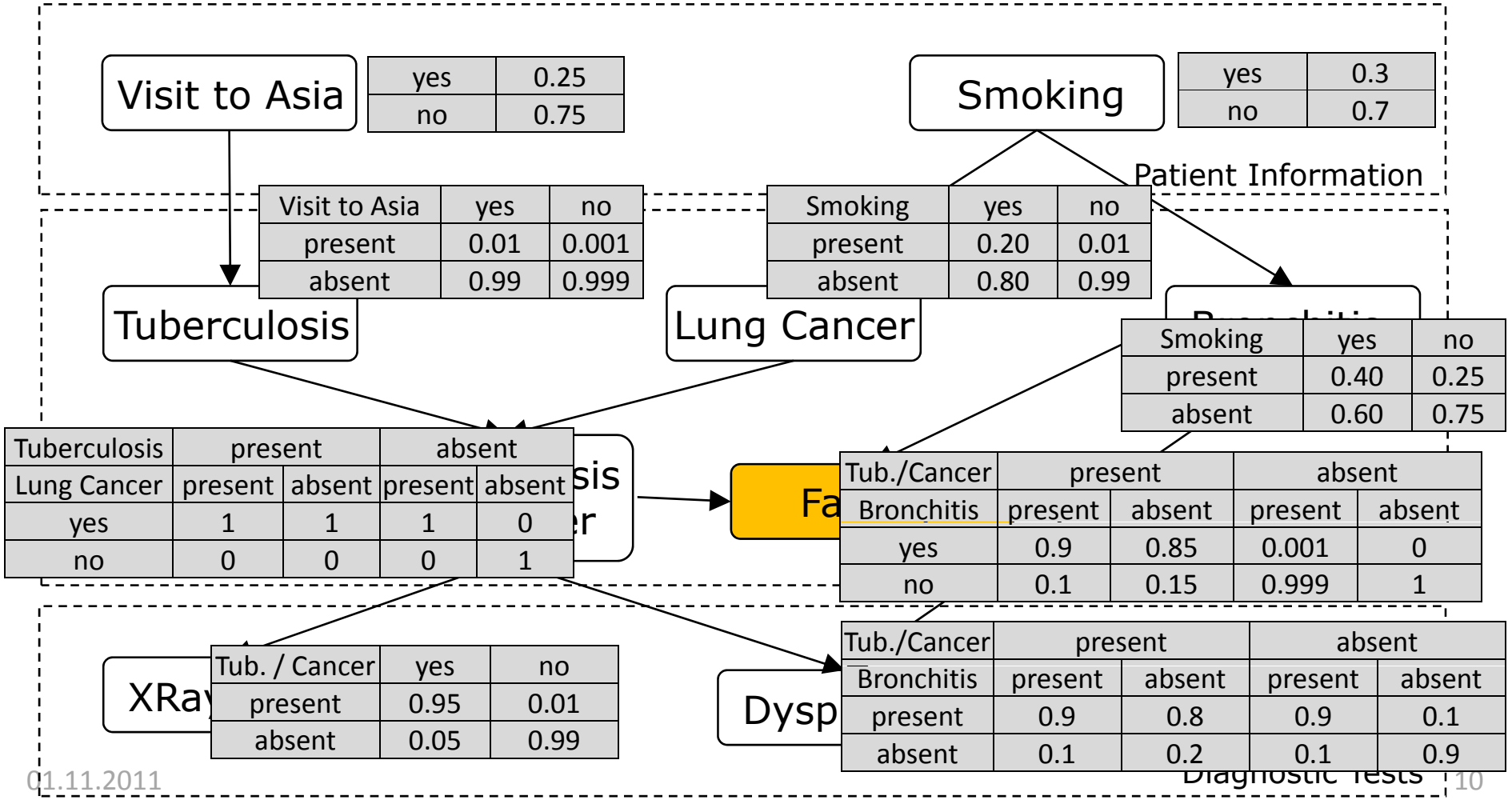
Example from Medical Diagnostics

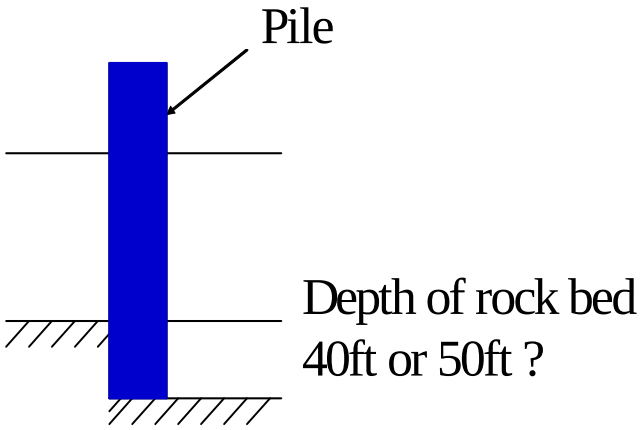


Decision Analysis using BPNs

The different types of decision analysis

- Prior
- Posterior
- Pre-posterior

What pile length should be applied ?



a_0 : Choose a 40 ft pile
a_1 : Choose a 50 ft pile

States of nature (depth to rock bed)
θ_0 : Rock bed at 40 ft
θ_1 : Rock bed at 50 ft

$$P'(\theta_0) = 0.7$$
$$P'(\theta_1) = 0.3$$

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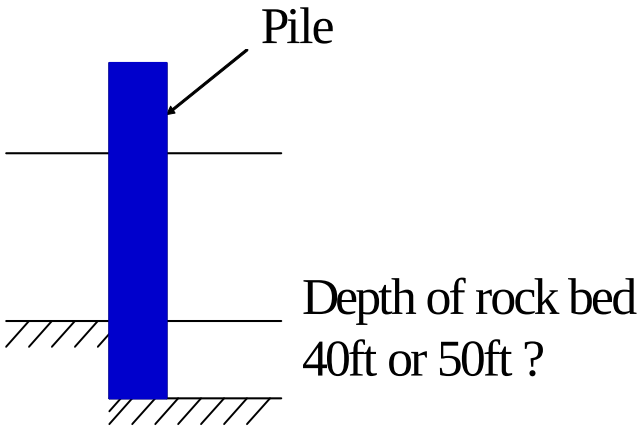

What pile length should be applied

given a indication (z_0 / z_1 / z_2) of a ultrasonic test?

Decision Analysis using BPNs

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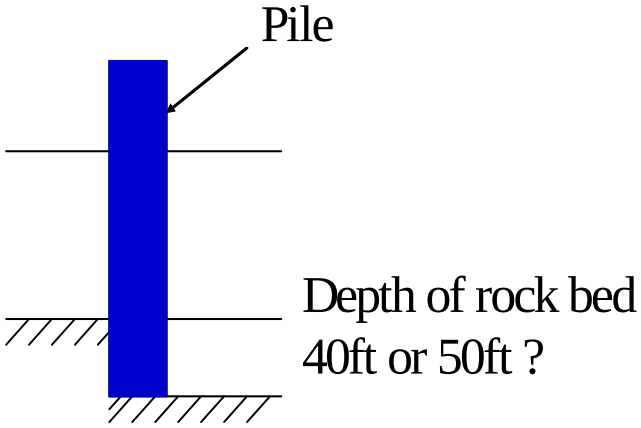

Likelihoods of the different indications/test results given the various possible states of nature for an ultrasonic test $P\left[z_k \middle| \theta_j \right]$

True state / Test result	θ_0 40 ft – depth	θ_1 50 ft – depth
z_0 – 40 ft indicated	0.6	0.1
z_1 – 50 ft indicated	0.1	0.7
z_2 – 45 ft indicated	0.3	0.2

Decision Analysis using BPNs

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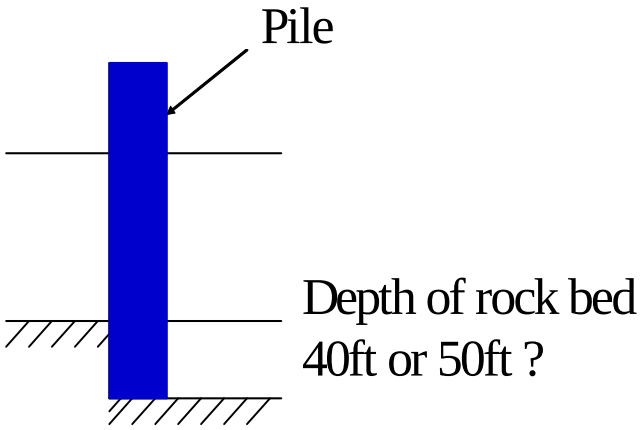

- Three different options for tests
  - no test → no cost
  - ultrasonic → 20 GE
  - probe → 50 GE

- How can be decided which test option carries the best efficiency?

Decision Analysis using BPNs

The different types of decision analysis

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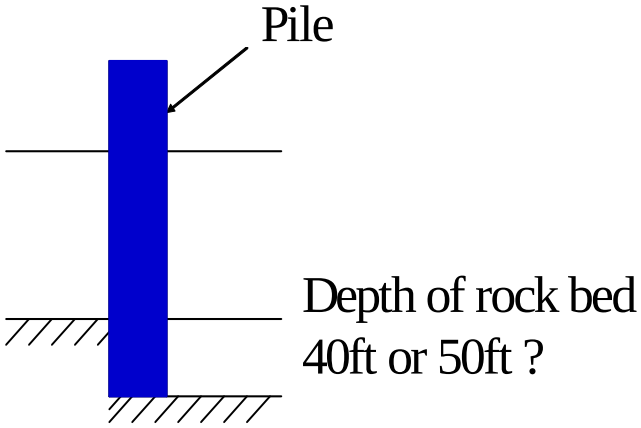

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Decision Analysis using BPNs

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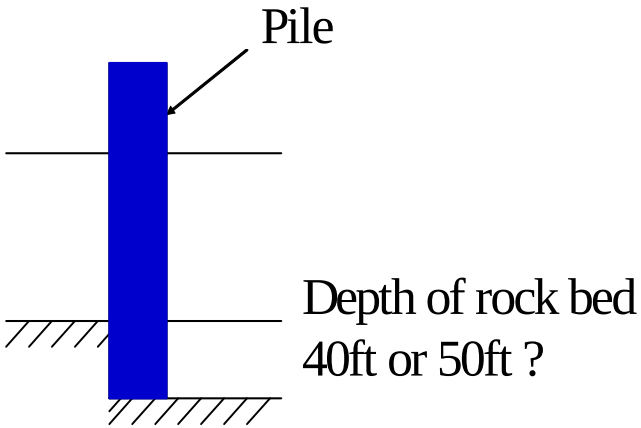
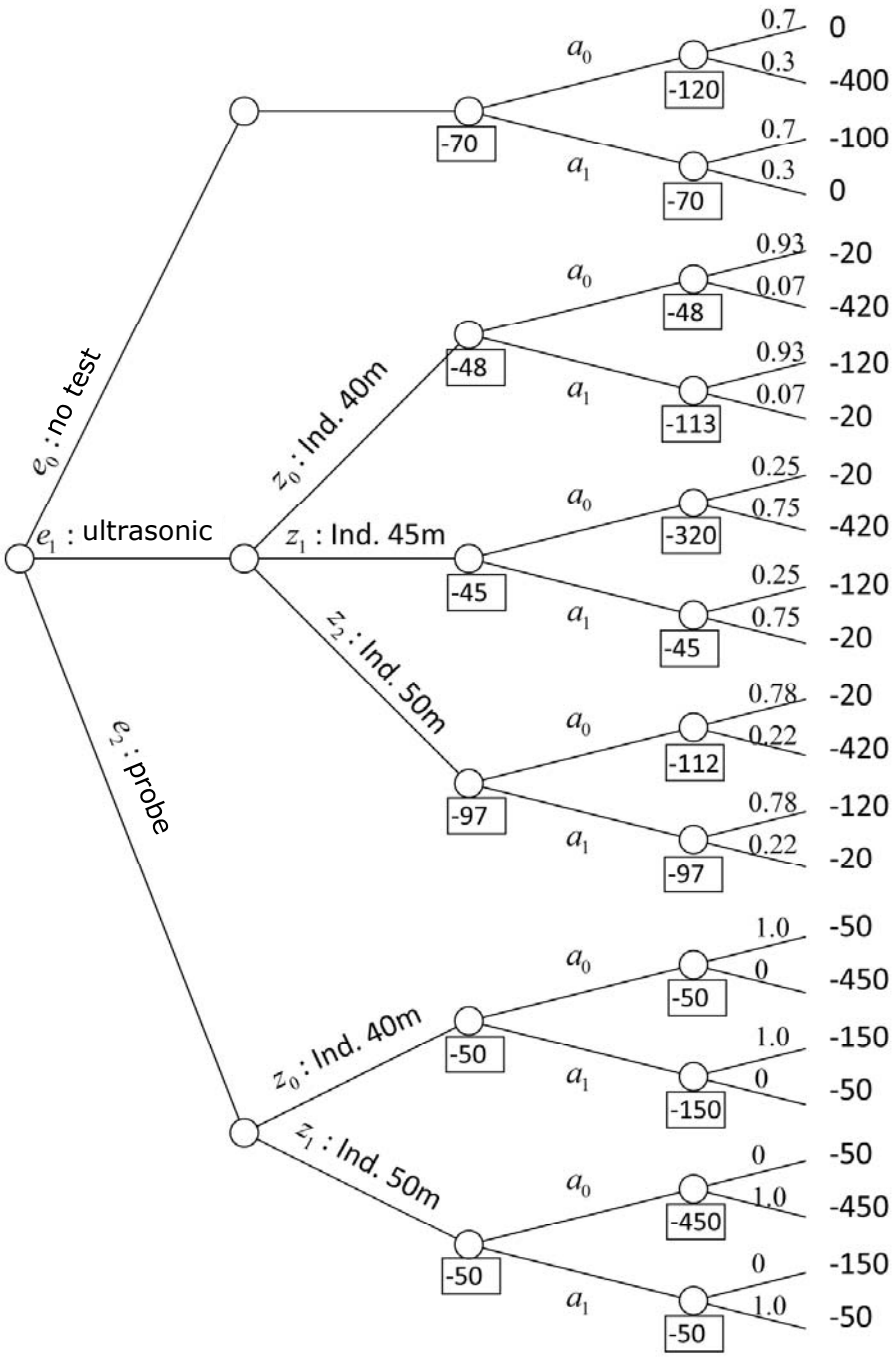


Likelihoods of the different indications/test results given the various possible states of nature for a probe test $P\left[z_k \middle| \theta_j \right]$

True state / Test result	θ_0 40 ft – depth	θ_1 50 ft – depth
z_0 – 40 ft indicated	1.0	0.0
z_2 – 50 ft indicated	0.0	1.0

Pre-Posteriori Analysis



Example 2 from Lecture 6

- **Alternative Design Solution**

  During the construction of a bridge it became apparent that a departure from original design would safe a lot of money. Originally it was planned to base the pillars of the bridge on deep bedrock. Alternatively, a foundation on the river sediments would safe money, however, with corresponding implication on the probability of failure (scouring, as a function of the water flow in the river). Make a risk based decision! [Alt. design solution yes or no] (all values are given corresponding to a 50 year period).

Example 2 from Lecture 6

- **Data:**

Exposure	
θ_i Max.Flow [cum/s]	$P(\theta_i)$
< 340	0.965
340 - 370	0.020
370 - 400	0.010
> 400	0.005

Consequences	
Original design / Safe	0 MU
Original Design / Fail	- 765 MU
Mod. Design / Safe	+ 150 MU
Mod. Design / Fail	- 615 MU

Original Design				
Perfor-mance	θ_i Max.Flow [cum/s]			
	< 340	340 - 370	370 - 400	> 400
Safe	0.999	0.99	0.98	0.9
Fail	0.001	0.01	0.02	0.1

Modified Design				
Perfor-mance	θ_i Max.Flow [cum/s]			
	< 340	340 - 370	370 - 400	> 400
Safe	0.99	0.9	0.5	0.2
Fail	0.01	0.1	0.5	0.8