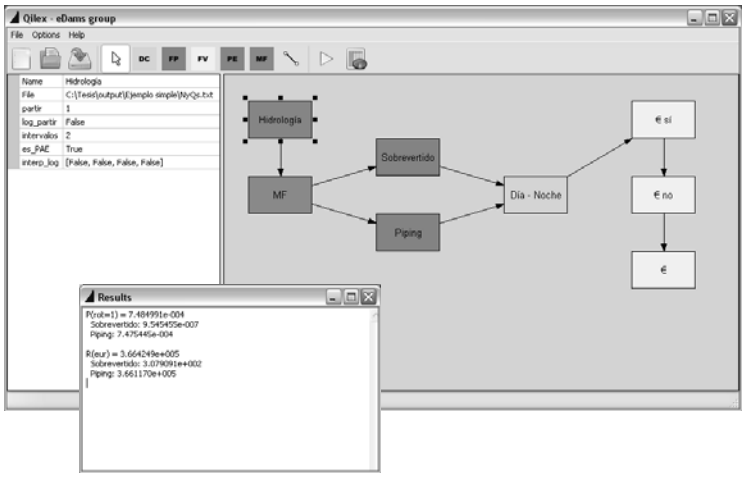
UPV software for risk models

Armando Serrano Lombillo
arserlom@doctor.upv.es
www.edams.upv.es

iPresas eDams

UNIVERSIDAD POLITECNICA DE VALENCIA

Risk analysis is feasible



Contents

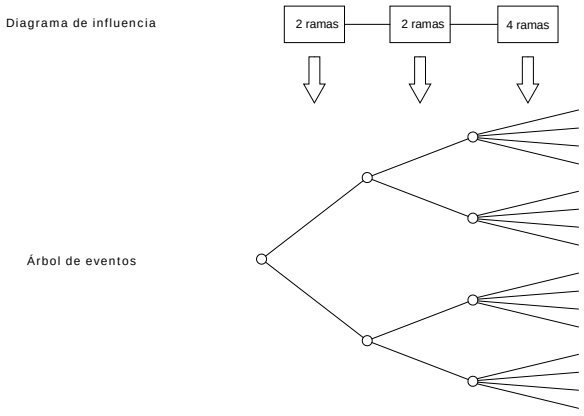
Review of previous concepts

- Risk
- Event trees
- Influence diagrams

From influence diagrams to event trees

- An event tree is a detailed representation of al the possibilities that can lead to failure.
- You use it to make the calculations.
- An influence diagram is a compact conceptual representation.
- With the proposed software, you can easily go from influence diagrams to event trees.

From influence diagrams to event trees



Node types

- Discrete
- FunProb
- FunVal
- PE (Exceedance Probability)
- MF (Failure Modes)

'Discrete' type nodes

- You know all the branches completely (probabilities and values).
- Probabilities must add up 1.
- Examples: Season, day/night, number of working gates...

'FunProb' type nodes

- Yes/no choice with a probability function.
- Instead of a function, you can also supply an interpolation table (1d or 2d).
- Example: Does the dam break by overtopping?
  - p_{cond}(yes) = f(level)
  - p_{cond}(no) = 1 – f(level)

'FunVal' type nodes

- You obtain a new value as a function of past values.
- It is the same as an only branch with conditional probability of 1 and a value which is a function.
- Instead of a function, you can also supply an interpolation table (1d or 2d).
- Example: damage downstream of the dam:
  - damage = f(Q) p_{cond} = 1

'PE' type nodes

- You have a table relating PE and values.
  - You break the table in a number of intervals
  - You generate a branch for each interval
  - Prob = $PE_{i+1} - PE_i$
  - Val = Average(val_{i+1}, val_i)
- Examples: maximum pool level, seismic acceleration, previous pool level.

'MF' type nodes

- The only node that lets you connect more than one child node.
- You can consider non mutually exclusive possibilities.
- You can apply advanced techniques such as Common Cause Adjustment or freezing of probabilities and/or values.

Recapitulation

- Discrete
- FunProb
- FunVal
- PE (Exceedance Probability)
- MF (Failure Modes)

Example

- Problem definition
- Event tree
- Influence diagram
- Results

Problem definition

- Calculate the incremental risk for the following embankment dam:
  - Crest level: 100 m
  - PAE-Nmax-Qmax-Qrot relation (divide in 3 intervals, linear interpolation)
  - Two failure modes under study:
    - Overtopping
    - Piping
  - Different damage functions for night and day
  - Recovery cost for the dam: $50 \cdot 10^6$ €

NyQs.txt

```
#c      Probabilidad Anual de Excedencia de niveles y caudales.
#c      Qmax es el caudal pico en el supuesto de que la presa no rompe.
#c      Qrot es el caudal pico en el supuesto de que la presa rompe.

#i      PAE     Nmax    Qmax    Qrot
        1       75      0       20000
        0.1     95      100     32000
        1e-4    100     1000    36000
        1e-6    105     10000   35000
```

Sobrevertido.txt

```
#c      Probabilidad condicional de rotura por sobrevertido.

#x      Nmax
        100     102     103     103.5   104

#y      rot
        0       1e-3    1e-2    0.2     1
```

Piping.txt

```
#c      Probabilidad condicional de rotura por 'piping'.

#x      Nmax
        50      100     105

#y      rot
        0       1e-3    0.1
```

D_N.txt

```
#c      Día - noche

#i      prob    momento
        0.6     dia
        0.4     noche
```

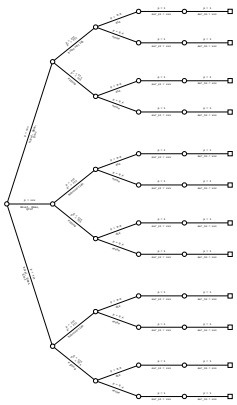
eur_si.txt

```
#c HIDROLÓGICO - PERDIDAS ECONÓMICAS - Con rotura

#s momento=dia
#x Qrot
100
2000
5000
10000
15000
50000

#y eur_si
0
1.1e6
55e6
220e6
440e6
550e6


#s momento=noche
#x Qrot
100
2000
5000
10000
15000
50000

#y eur_si
0
1e6
50e6
200e6
400e6
500e6
```

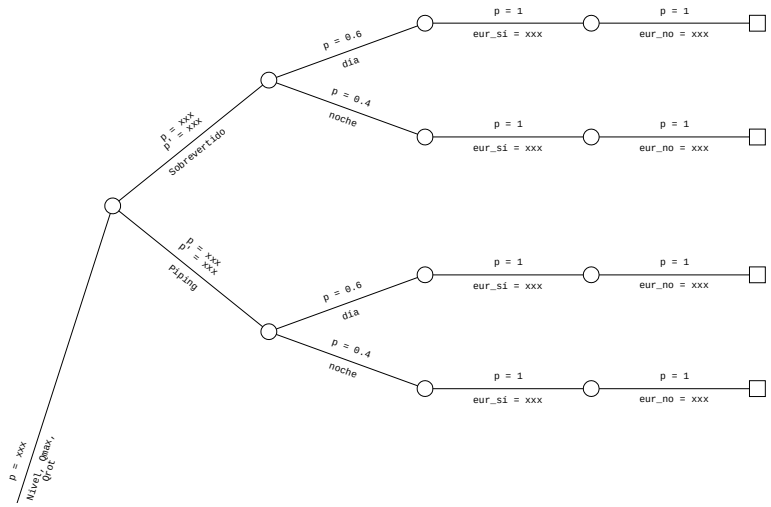
eur_no.txt

```
#c HIDROLÓGICO - PÉRDIDAS ECONÓMICAS - Sin rotura

#s momento=dia
#x Qmax
100
2000
5000
10000
15000
50000

#y eur_no
0
1.1e6
55e6
220e6
440e6
550e6


#s momento=noche
#x Qmax
100
2000
5000
10000
15000
50000

#y eur_no
0
1e6
50e6
200e6
400e6
500e6
```

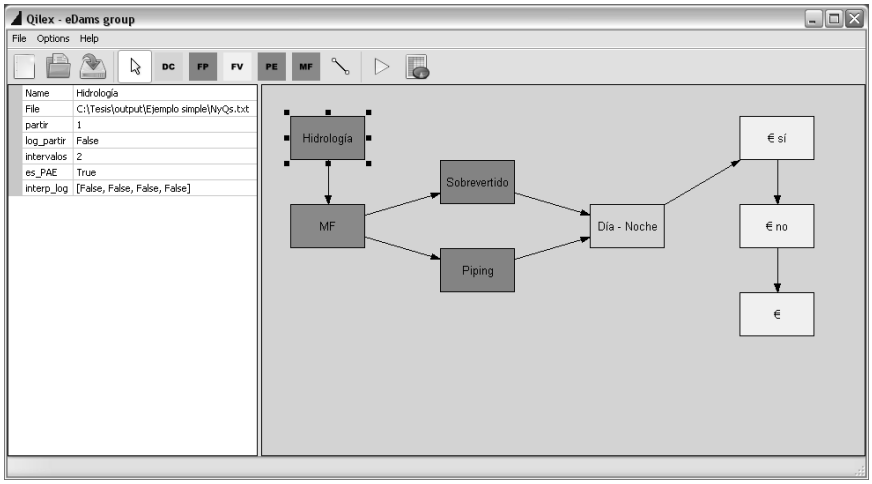
Event tree



Event tree



Influence diagram



Gross results

- [0.0, {'Nmax': 82.5, 'mf': 'Sobrevertido', 'eur_no': 0.0, 'Qmax': 37.5, 'momento': 'dia', 'Qrot': 24500.0, 'eur_si': 469857142.85714287, 'rot': 1}]
- [0.0, {'Nmax': 82.5, 'mf': 'Sobrevertido', 'eur_no': 0.0, 'Qmax': 37.5, 'momento': 'noche', 'Qrot': 24500.0, 'eur_si': 427142857.14285713, 'rot': 1}]
- [0.00026325, {'Nmax': 82.5, 'mf': 'Piping', 'eur_no': 0.0, 'Qmax': 37.5, 'momento': 'dia', 'Qrot': 24500.0, 'eur_si': 469857142.85714287, 'rot': 1}]
- [0.0001755, {'Nmax': 82.5, 'mf': 'Piping', 'eur_no': 0.0, 'Qmax': 37.5, 'momento': 'noche', 'Qrot': 24500.0, 'eur_si': 427142857.14285713, 'rot': 1}]
- [0.0, {'Nmax': 97.5, 'mf': 'Sobrevertido', 'eur_no': 56237500.0, 'Qmax': 5037.5, 'momento': 'dia', 'Qrot': 32000.0, 'eur_si': 493428571.4285714, 'rot': 1}]
- [0.0, {'Nmax': 97.5, 'mf': 'Sobrevertido', 'eur_no': 51125000.0, 'Qmax': 5037.5, 'momento': 'noche', 'Qrot': 32000.0, 'eur_si': 448571428.5714286, 'rot': 1}]
- [0.00018524943, {'Nmax': 97.5, 'mf': 'Piping', 'eur_no': 56237500.0, 'Qmax': 5037.5, 'momento': 'dia', 'Qrot': 32000.0, 'eur_si': 493428571.4285714, 'rot': 1}]
- [0.00012349962, {'Nmax': 97.5, 'mf': 'Piping', 'eur_no': 51125000.0, 'Qmax': 5037.5, 'momento': 'noche', 'Qrot': 32000.0, 'eur_si': 448571428.5714286, 'rot': 1}]
- [5.72727272727e-007, {'Nmax': 105.0, 'mf': 'Sobrevertido', 'eur_no': 220000000.0, 'Qmax': 10000.0, 'momento': 'dia', 'Qrot': 35000.0, 'eur_si': 502857142.85714287, 'rot': 1}]
- [3.81818181818e-007, {'Nmax': 105.0, 'mf': 'Sobrevertido', 'eur_no': 200000000.0, 'Qmax': 10000.0, 'momento': 'noche', 'Qrot': 35000.0, 'eur_si': 457142857.14285713, 'rot': 1}]
- [2.72727272727e-008, {'Nmax': 105.0, 'mf': 'Piping', 'eur_no': 220000000.0, 'Qmax': 10000.0, 'momento': 'dia', 'Qrot': 35000.0, 'eur_si': 502857142.85714287, 'rot': 1}]
- [1.81818181818e-008, {'Nmax': 105.0, 'mf': 'Piping', 'eur_no': 200000000.0, 'Qmax': 10000.0, 'momento': 'noche', 'Qrot': 35000.0, 'eur_si': 457142857.14285713, 'rot': 1}]

Aggregated results