Belief Function Machine Review

Sushila Shenoy
University of Kansas
July 24, 2003

Topics

- New Features
  - Normalization
  - Approximation
- Java GUI
  - Demonstration
  - To Do

Normalization

- Previously no intermediate normalization
- For some problems, the mass on the empty set grows too large
  - e.g. Target Identification Problem
- Normalization after each combination gives accurate results for these problems with negligible additional solve time.

Normalization

- SOLVE command
  - 3rd argument added
    - 0: No normalization. (default)
    - 1: Use normalization.

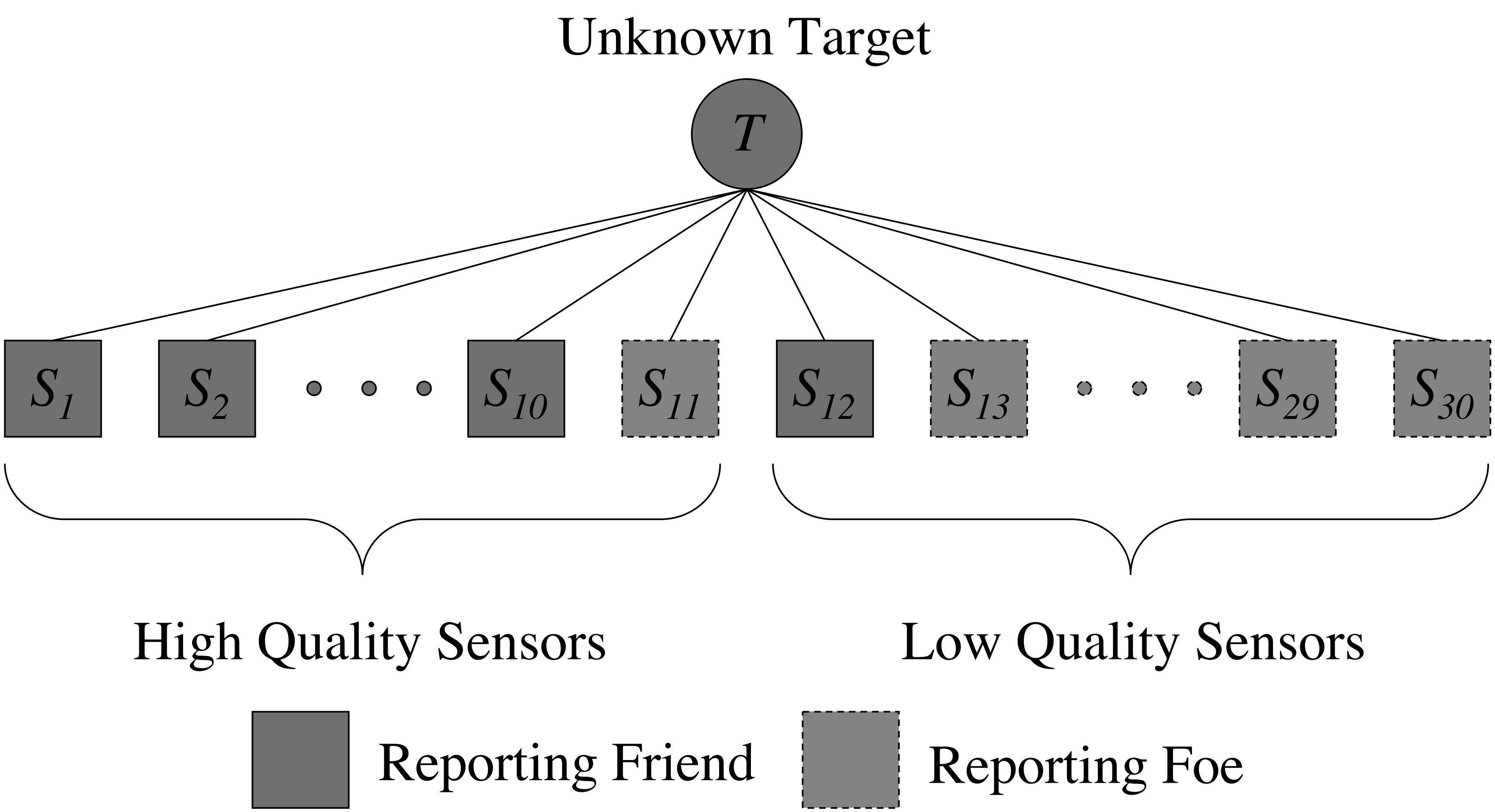
```
solve(list_bels, list_vars, normmode);
```

Target Identification Problem

- Unknown target T is either a friend or a foe
- 30 sensors S_i
  - 11 high quality (99% probability of accuracy)
  - 19 low quality (90% probability of accuracy)

From Cobb, B. & P. Shenoy, *A Comparison of Methods for Transforming Belief Function Models to Probability Models*, ECSQUARU 2003.

Target Identification Problem



Target Identification Problem

- UIL Code: ‘uilfiles/friendfoe.txt’

```
DEFINE VARIABLE T {friend foe};

DEFINE RELATION S1 {T};
                ...
DEFINE RELATION S30 {T};

SET VALUATION S1 {(friend)} 0.99;
              ...
SET VALUATION S10 {(friend)} 0.99;
SET VALUATION S11 {(foe)} 0.99;
SET VALUATION S12 {(friend)} 0.90;
SET VALUATION S13 {(foe)} 0.90;
              ...
SET VALUATION S30 {(foe)} 0.90;
```

Demonstration

Demo of solution of Target Identification
Problem with and without normalization

Demonstration

Exact Solution

The Joint Bpa's and Plausibility Functions for 30 Sensors

$a \in 2^{\Theta_T}$	Un-normalized bpa	Normalized bpa (m)	Plausibility (Pl_m)
Ø	≈1	0	0
$\{t_1\}$	$\approx 1.00 \times 10^{-20}$	≈ 0.9090	≈ 0.9091
$\{t_2\}$	$\approx 1.00 \times 10^{-21}$	≈ 0.0909	≈ 0.0909
$\{t_1, t_2\}$	$\approx 1.00 \times 10^{-41}$	≈ 0.0000	1

Approximation

- The complexity of solving large problems increases exponentially
- Approximation allows faster solve times for large problems.

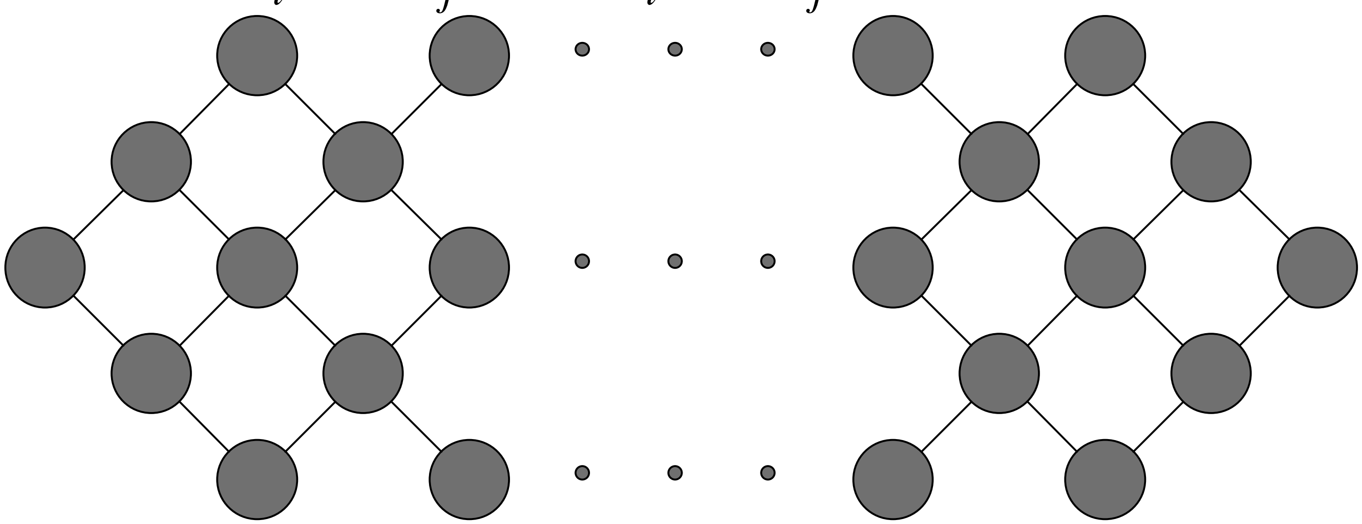
Approximation

- SOLVE command
  - 4th argument added
    - 0: No approximation. (default)
    - 1: Approximation with default threshold (2.22e-15).
    - *x*: Approximation with threshold *x*.

```
solve(list_bels, list_vars, normmode, threshold);
```

Communication Network Problem

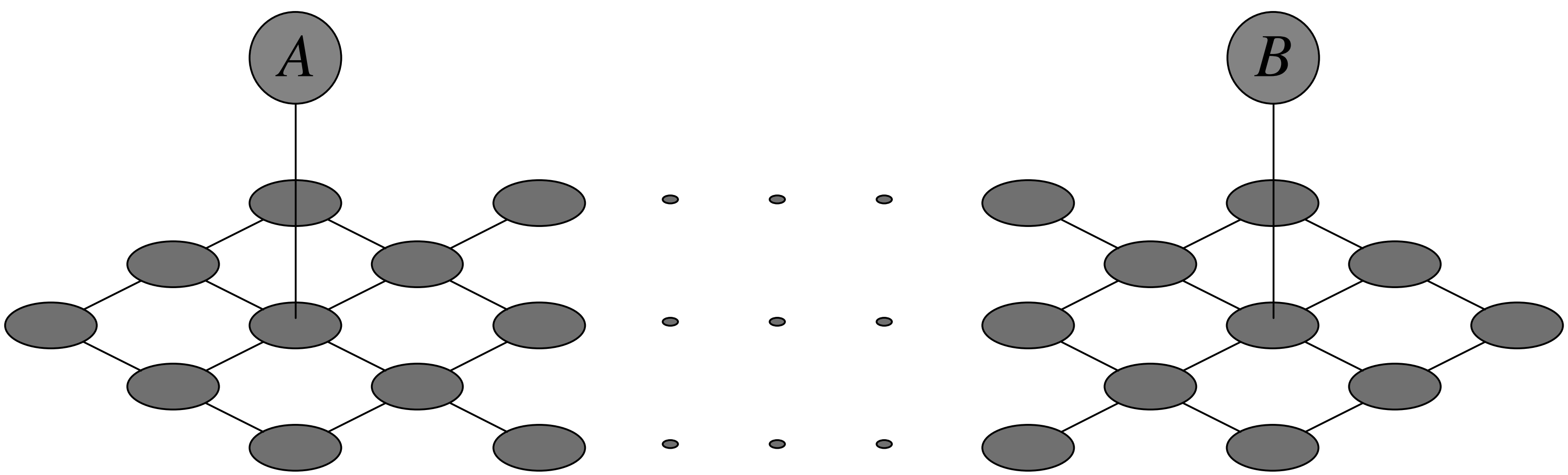
- Network of nodes arranged in 5 rows
  - Each link has a 90% reliability
    - $m(\{(n_i = \text{t}, n_j = \text{t}), (n_i = \text{f}, n_j = \text{f})\}) = 0.9$, $m(\Omega) = 0.1$



From Haenni, R. & Lehmann, N., *Resource Bounded and Anytime Approximation of Belief Function Computations*, International Journal of Approximate Reasoning, 2002.

Communication Network Problem

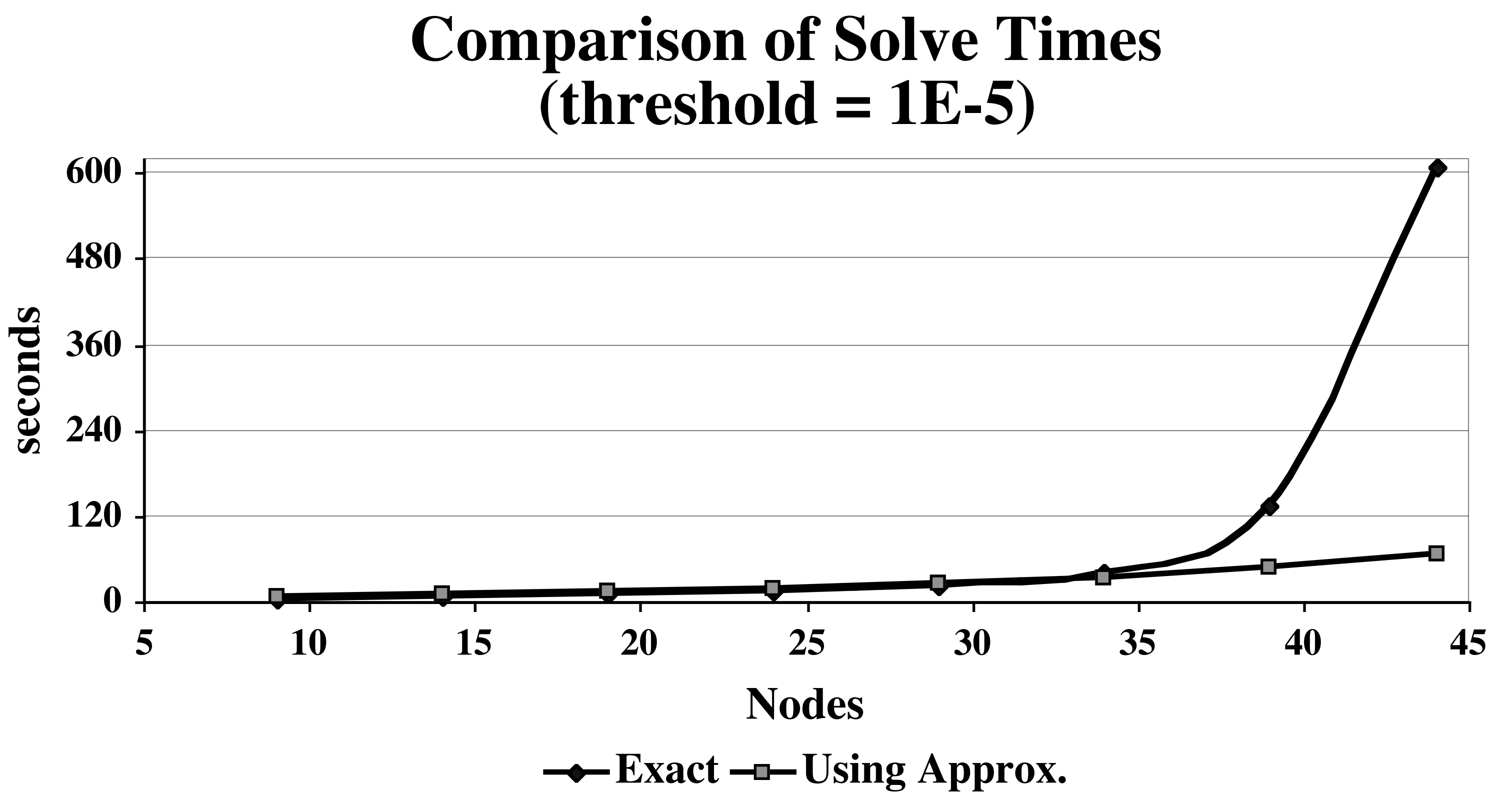
- Additional nodes *A* and *B* linked to network with 80% reliability.
- What is the reliability of the connection between *A* and *B*?



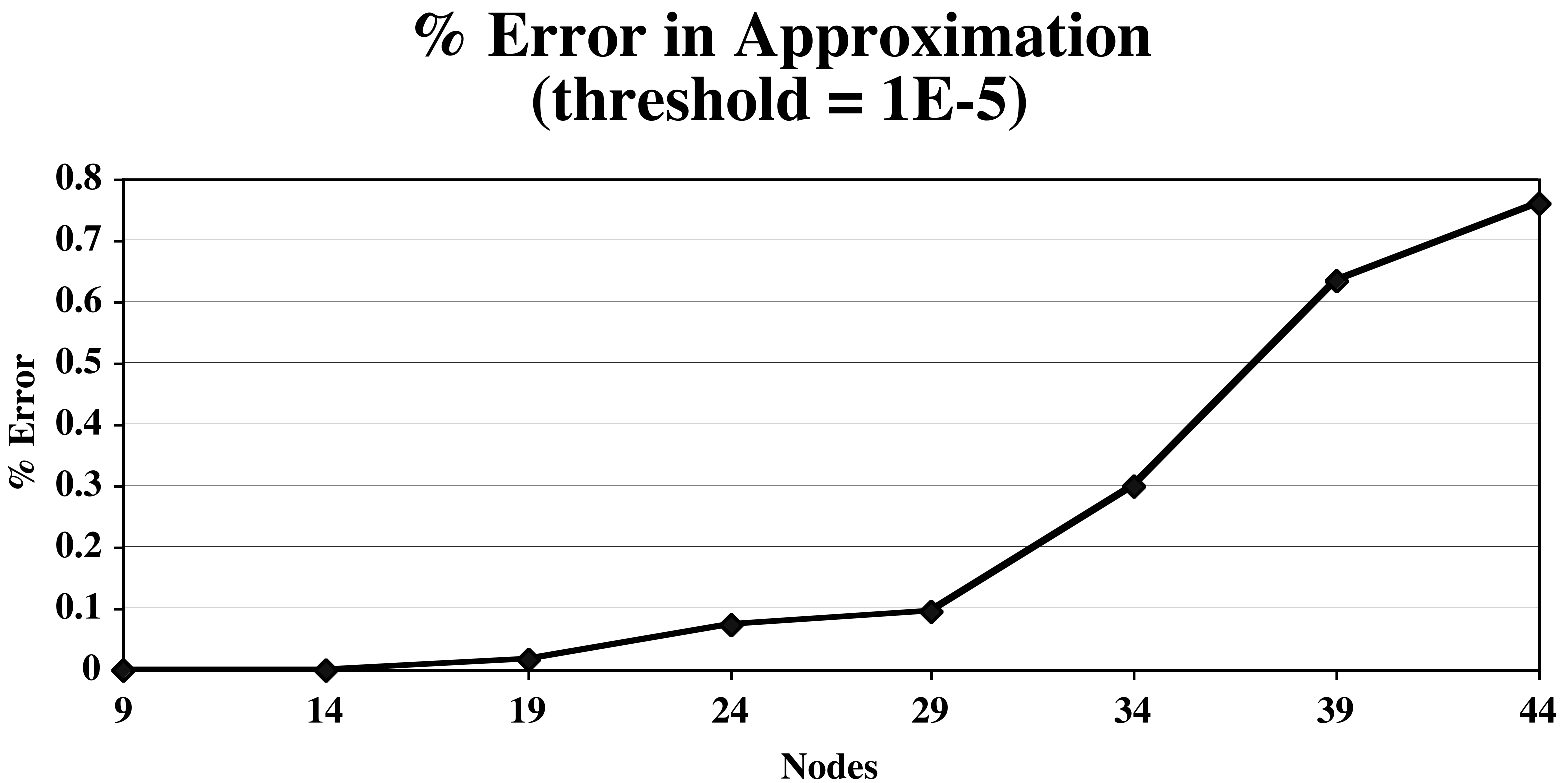
Communication Network Problem

- Measuring approximation performance by solve time and accuracy of solutions
  - Varying problem size (number of nodes)
  - Varying approximation threshold

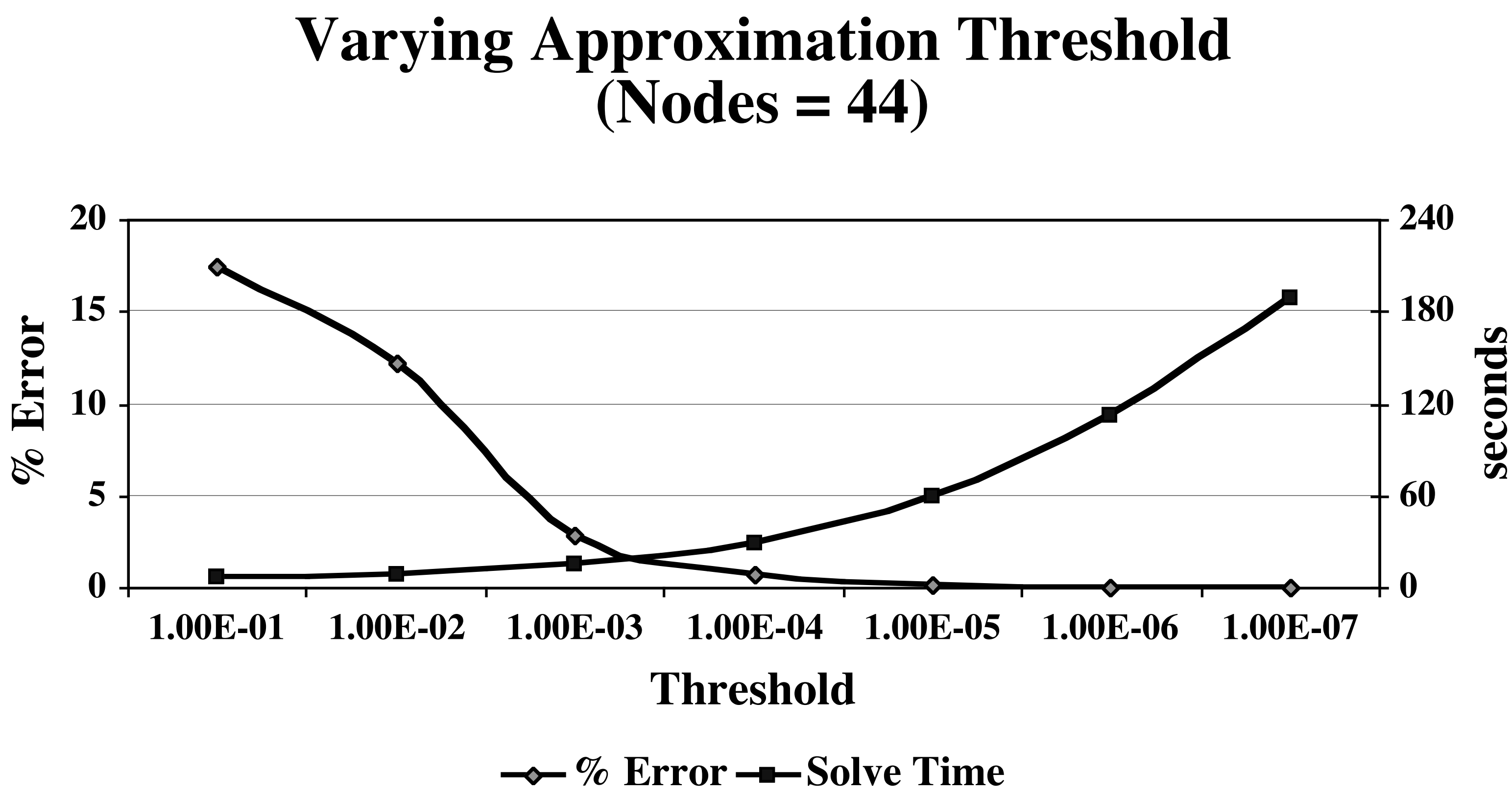
Communication Network Problem



Communication Network Problem



Communication Network Problem



Java GUI

- To install:
  - Download archive from http://www.business.ku.edu/home/pshenoy/BFM/
  - Extract archive to folder (e.g. ‘BFM072203’)
  - Start MATLAB
  - In MATLAB, type ‘edit classpath.txt’
  - Add ‘path_to_dir/BFM0702203/bfm.jar’ to the end of the classpath.txt.
    - e.g.‘C:\MATLABr13\work\BFM072203\bfm.jar’ on Windows
    - ‘/Applications/MATLAB/work/BFM072203/bfm.jar’ on Mac OS.
  - Restart MATLAB

Java GUI

- To run:
  - Start MATLAB
  - Make ‘BFM072203’ the working directory
  - Type ‘BFM.run’ and hit enter

Captain’s Decision Problem

- Variables:
  - A: Arrival delay (0 to 6 days)
  - D: Departure delay (0 to 3 days)
  - S: Sailing delay (0 to 3 days)
  - L: Loading delay (true or false)
  - M: Maintenance delay (true or false)
  - W: Weather (foul or fair)
  - R: Repair at sea (true or false)

From Almond, R., *Graphical Belief Modeling*, Chapman & Hall 1995

Captain’s Decision Problem

- What will the Arrival delay be?
  - Arrival delay is sum of departure and sailing delays
  - Departure delay depends on loading, maintenance and weather
  - Sailing delay depends on weather and repair
  - Weatherman is reliable 80% of the time
  - Imprecise conditional probabilities of repair at sea given maintenance

Java GUI

- To create a new node, double-click where you want to place the node
- Select the kind of node you want to create (Variable, Valuation, or Conditional Valuation)
- To move a node, simply drag it around
- To delete or edit a valuation or to solve for a variable, double-click on the valuation or variable.
- Results will appear in the MATLAB console

Java GUI - To Do

- Add more solving capabilities
  - Multiple variables
  - Normalization & Approximation
- Ability to save and load documents
- More user-friendly display of results
- Make everything look nicer