



# Unfolding Crime Scenarios with Variations

## A Method for Building a Bayesian Network for Legal Narratives

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## Example: the Anjum murder case

Anjum murder case [Crombag and Israëls, 2008].

- Leo de Jager was found dead in the yard of a boarding house in Anjum;
- Cause of death: fractured skull, brain damage;
- Autopsy: someone hit Leo on the head with a sharp object;
- Leo's blood found in hallway of boarding house.

There is no evidence to show *who* hit Leo.



## Example: two scenarios for Anjum

### Scenarios:

*Marjan van der E., owner of the boarding house, wanted to frame Leo for the cannabis operation in her shed. She drugged Leo, had him sign a fake contract and hit him on the head with a hammer. She then dragged him to the door and neighbor Beekman dragged Leo from there to yard.*

*Marjan van der E. and neighbour Beekman wanted to frame Leo for the cannabis operation. Marjan drugged Leo and had him sign a fake contract. Beekman hit Leo on the head with a hammer and dragged him to the front yard.*



## Narrative and probability

Form multiple scenarios describing what may have happened

- Narrative provides a context for the evidence;
- Narrative can help find which variables are relevant and which are not.



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But: Forensic evidence (DNA analysis of blood in hallway) comes with probabilities.

- A probabilistic approach (such as Bayesian networks) can reason with such probabilities.



# The project

Designing and Understanding Forensic Bayesian Networks with Arguments and Scenarios ([www.ai.rug.nl/~verheij/nwofs](http://www.ai.rug.nl/~verheij/nwofs))

Goal: understand the connection between the three approaches.

- Probability
- Narrative
- Argumentation



# This talk

Topic: designing a Bayesian network with narrative.

1. Four idioms to capture scenarios in a Bayesian network;
2. Method of unfolding scenarios to guide the construction of a Bayesian network.



# This talk

## Overview of the talk:

- Background
- Design method
- Conclusion

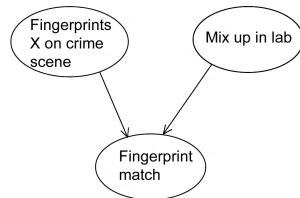




## Bayesian networks

A Bayesian network represents a joint probability distribution.

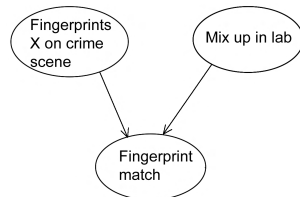
- Nodes represent variables (throughout this talk: binary variables);
- Absence of an edge means independence between variables;
- Conditional probability tables give probabilities.



## Bayesian networks

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	Mix up = yes		Mix up = no	
	FP X = yes	FP X = no	FP X = yes	FP X = no
match = yes	0.2	0.1	0.9	0.001
match = no	0.8	0.9	0.1	0.999

## Legal applications of Bayesian networks

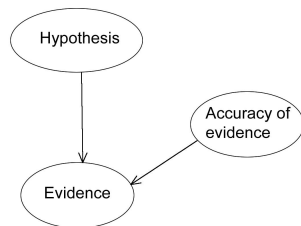
Bayesian networks are popular as applied to legal cases.

- The Netherlands Forensic Institute (Nederlands Forensisch Instituut, NFI) uses Bayesian models to analyse their results;
- A number of researchers have been working on Bayesian networks and law:
  - Keppens [2011]: arguments and Bayesian networks in law;
  - Hepler, Dawid and Leucari [2004]: use often recurring substructures;
  - Fenton, Neil and Lagnado [2013]: a list of legal idioms.



## Legal idioms

- Fenton, Neil and Lagnado's legal idioms:
  - building blocks for Bayesian network
  - recurring patterns, can be used in various networks
- We intend to develop narrative idioms to represent scenarios



## Scenarios

A scenario is a coherent presentation of a collection of states and events, after Bex [2011]

*X needed money, so X decided to break in. X broke the window of the house, went in and took some items from the house.*



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Coherence:

- The scenario as a whole is more than the sum of its parts;
- Our belief in the entire scenario strengthens as soon as we believe more in one element.



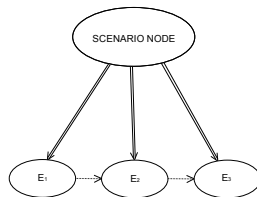
## Four narrative idioms

- Scenario idiom
- Subscenario idiom
- Variation idiom
- Merged scenarios idiom



## The scenario idiom

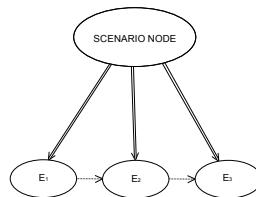
- A node (binary) for each state/event in the scenario. Draw dependencies between states/events;
- A scenario node (binary), connected to all states/events in that scenario.





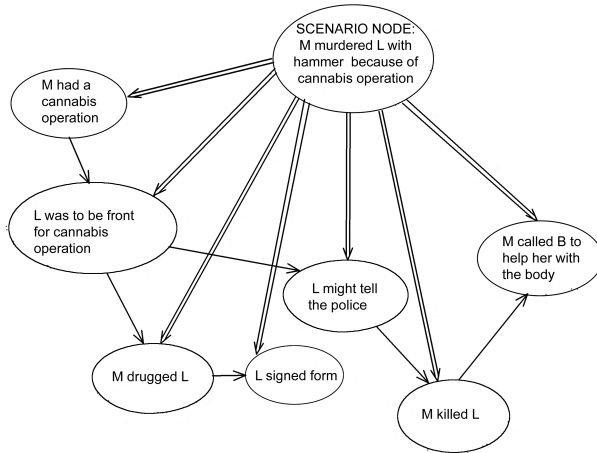
## The scenario idiom: probabilities

- If a scenario is true, it is implied that all states and events in it are true;
- A state or event can occur without the scenario being true.

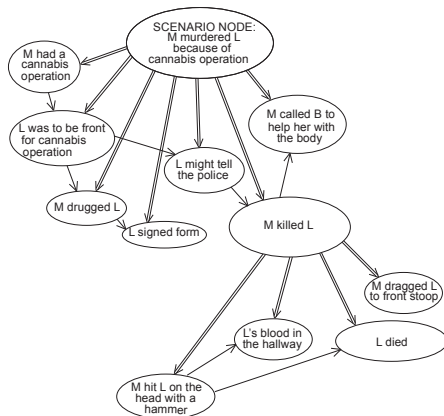


	ScN = y	ScN = n
Event = y	1	...
Event = n	0	...

## Instance of the scenario idiom

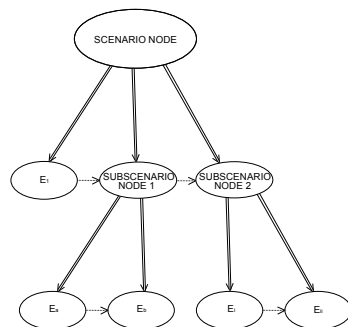


## Instance of subscenario idiom

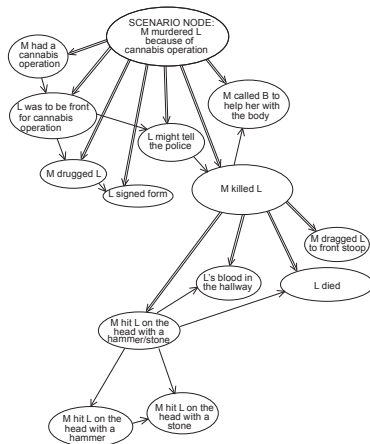


## The subscenario idiom

- A scenario node
- State and event nodes
- Subscenario node(s)



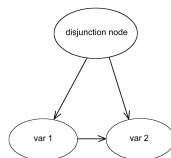
## An instance of the variation idiom



## The variation idiom

- A node (binary) for each variation;
- A (binary) disjunction node with arrows to all variation nodes;
- An arrow between the variations.

The latter is needed to make the probability table express that exactly one variation holds.



## The variation idiom

Probabilities:

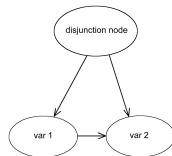
- If the disjunction node is false, neither of the variations can be true;
- If the disjunction node is true and one variation is false, the other variation must be true.

	disj = yes		disj = no	
	v1 = yes	v1 = no	v1 = yes	v1 = no
v2 = yes	...	1	0	0
v2 = no	...	0	1	1

## The variation idiom: considerations

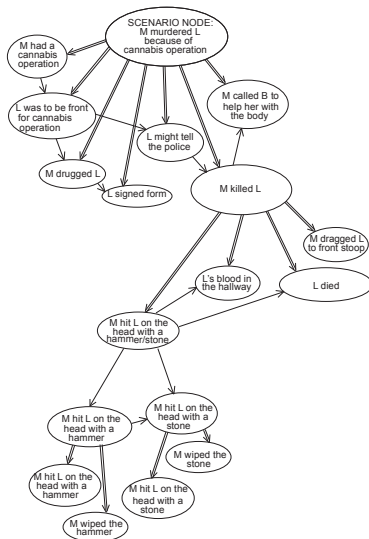
### Considerations:

- Model variations as separate binary nodes: this allows for variations of subscenarios;
- Arrows point from disjunction node to variation nodes. Directing them from variation to disjunction will violate the scenario idiom.



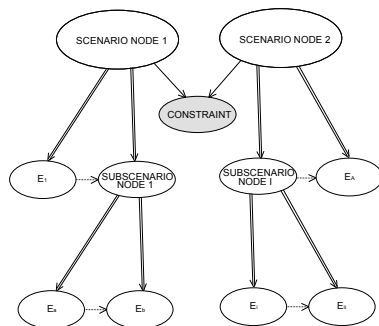


## An instance of the variation idiom



## The merged scenarios idiom

- To compare various scenarios, we need all scenario idioms in one Bayesian network;
- With the merged scenarios idiom, the scenario idioms can be combined;
- The merged scenarios idiom puts a constraint on the scenario nodes.



## Where are we

1. Four idioms to capture scenarios in a Bayesian network;
2. **Method of unfolding scenarios to guide the construction of a Bayesian network.**



## Unfolding a scenario

- Narrative can be told at various levels of detail;
- In a criminal trial, certain parts require much detail;
- With the method of unfolding, a Bayesian network is built up gradually by asking for more and more detail about a scenario.



## The method of unfolding

- Start with an initial scenario, i.e.:

*Marjan had a cannabis operation. She wanted to use Leo as a front for this cannabis operation. She drugged him because she wanted him to sign a contract. Leo signed the contract. Marjan was worried Leo might tell the police, so Marjan killed Leo with a hammer in the hallway. After this, she went to call Beekman, who helped her to drag the body to the front yard.*

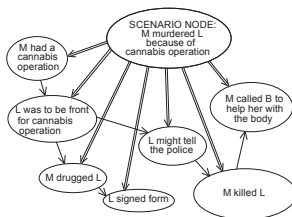


## The method of unfolding

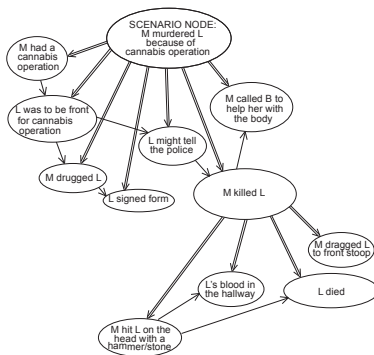
- Start with an initial scenario,
- Model in Bayesian network with (sub)scenario idiom;
- Go through each element and decide whether it needs more detail:
  1. Is there direct evidence for the state or event? If so, no unfolding is required;
  2. Is there relevant evidence for details of a subscenario for this state or event? If so, unfold;
  3. Would it be possible to find relevant evidence for details in a subscenario for this state or event? If so, unfold.
- Unfold elements by replacing them with subscenarios.



## Unfolding the Anjum case



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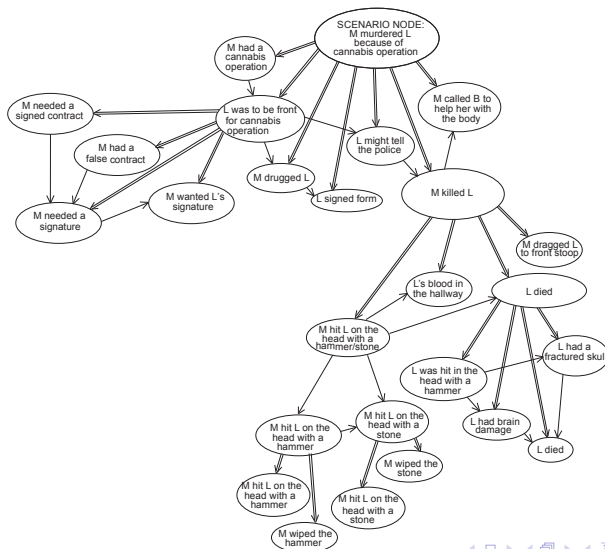






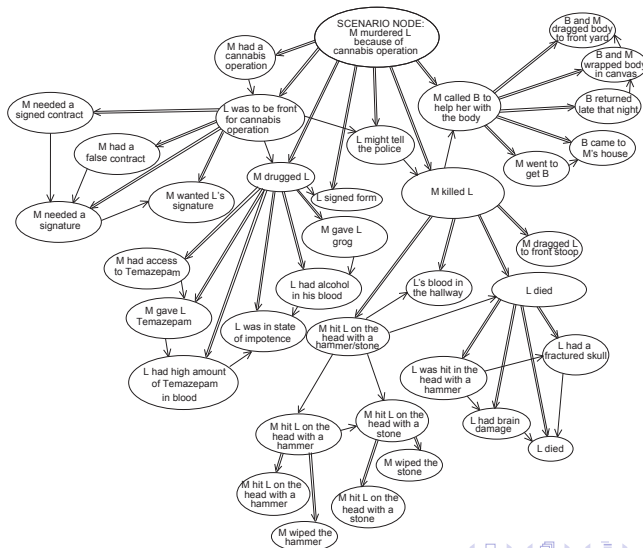


# Unfolding the Anjum case





# Unfolding the Anjum case



# The design method

1. Collect relevant scenarios;
2. Unfold each scenario using idioms and critical questions;
3. Merge the scenarios with the merged scenarios idiom;
4. Include evidence.



## Future work

- Are elicitation techniques adequate?
- A dynamical version of this method;
- A case study to test our method.



# Conclusion

- Using four narrative idioms we capture crime scenarios in a Bayesian network;
- The method of unfolding enables a gradual construction of a Bayesian network based on various scenarios;
- The result is a modular structure with relevant variables about a case.





- F.J. Bex. *Arguments, Stories and Criminal Evidence, a Formal Hybrid Theory*. Springer, Dordrecht, 2011.
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- A.B. Hepler, A.P. Dawid, and V. Leucari. Object-oriented graphical representations of complex patterns of evidence. *Law, Probability & Risk*, 6: 275–293, 2004.
- J. Keppens. On extracting arguments from Bayesian network representations of evidential reasoning. In K.D. Ashley and T.M. van Engers, editors, *The 13th International Conference on Artificial Intelligence and Law*, pages 141 – 150, New York, 2011. ACM.

