Argument Strength and Probability

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Workshop on Argument Strength

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30-11-2016

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Argumentation and Probability Theory

- Argumentation-as-inference is a form of nonmonotonic logic
  - Qualitative approaches to reasoning with uncertain, incomplete and inconsistent information
- So relations are to be expected, but little systematic work on this (until recently)
  - Unlike in other branches of nonmonotonic logic

Overview

- Three kinds of uses of probability theory w.r.t. argumentation
- What is wrong with taking abstract argumentation as the starting point
- Sjoerd Timmer's work on explaining Bayesian Networks with argumentation

Part 1:
Three kinds of uses of probability theory w.r.t. argumentation

Three kinds of uses of probability theory w.r.t. argumentation

- Modelling metalevel arguments about probabilistic models
  - E.g. Nielsen & Parsons (AIJ 2007), Bex & Renooij (COMMA 2016)
- Modelling intrinsic uncertainty within arguments
  - As traditionally in NML
- Modelling extrinsic uncertainty about arguments

Extrinsic uncertainty about arguments

- Uncertainty about whether an argument's premises are in a belief or knowledge base
  - Induces uncertainty about whether arguments with these premises can be constructed
- Examples:
  - Will the court accept this testimony as admissible evidence?
  - Which implicit premise did an agent have in mind when uttering an argument?
  - Is the other dialogue participant aware of this?
  - …

Recent work: on intrinsic or extrinsic uncertainty?

Riveret et al. (JURIX 2007, COMMA 2008):
(Define probabilities over arguments in a model of debate with a neutral adjudicator)
"a probability distribution is assumed with respect to the adjudicator's acceptance of the parties' statements".
"… construction chance …"
Extrinsic uncertainty

Li, Oren & Norman (TAFA 2011):
(Extending Dung-style abstract argumentation with probability distributions over arguments)
"These probabilities represent the likelihood of existence of a specific argument …"
Extrinsic uncertainty?

Dung & Thang (COMMA 2010):
(Extend abstract and assumption-based argumentation with probabilities)
Their examples are about intrinsic uncertainty.

Probabilistic abstract argumentation frameworks

- Li, Oren & Norman (TAFA 2011)
- A triple (Args,Attacks,Pr), where
  - Args is a set (of arguments)
  - Attacks Args × Args
  - Pr: Args [0,1] is a probability function over Args.

Hunter (2012-) on “epistemic” vs. “justification” perspectives

Epistemic perspective:
“The probability distribution over arguments is used directly to identify which arguments are believed”
"The higher the probability of an argument, the more it is believed".
"If an attacker is assigned a high degree of belief, then the attacked argument is assigned a low degree of belief, and vice versa“
The topology of the ‘Dung graph’ is fixed
‘Rationality’ constraint: If A attacks B and Pr(A) > 0.5, then Pr(B) ≤ 0.5

Justification perspective:
The probability of an argument A “is treated as the probability that A is a justified point (i.e. that it is a self-contained, and internally valid, contribution) and should therefore appear in the graph“
There is uncertainty about the topology of the Dung graph

Part 2:
What is wrong with taking abstract argumentation as the starting point?

Probabilistic abstract argumentation frameworks

- Li, Oren & Norman (TAFA 2011)
- A triple (Args,Attacks,Pr), where
  - Args is a set (of arguments)
  - Attacks Args × Args
  - Pr: Args [0,1] is a probability function over Args.

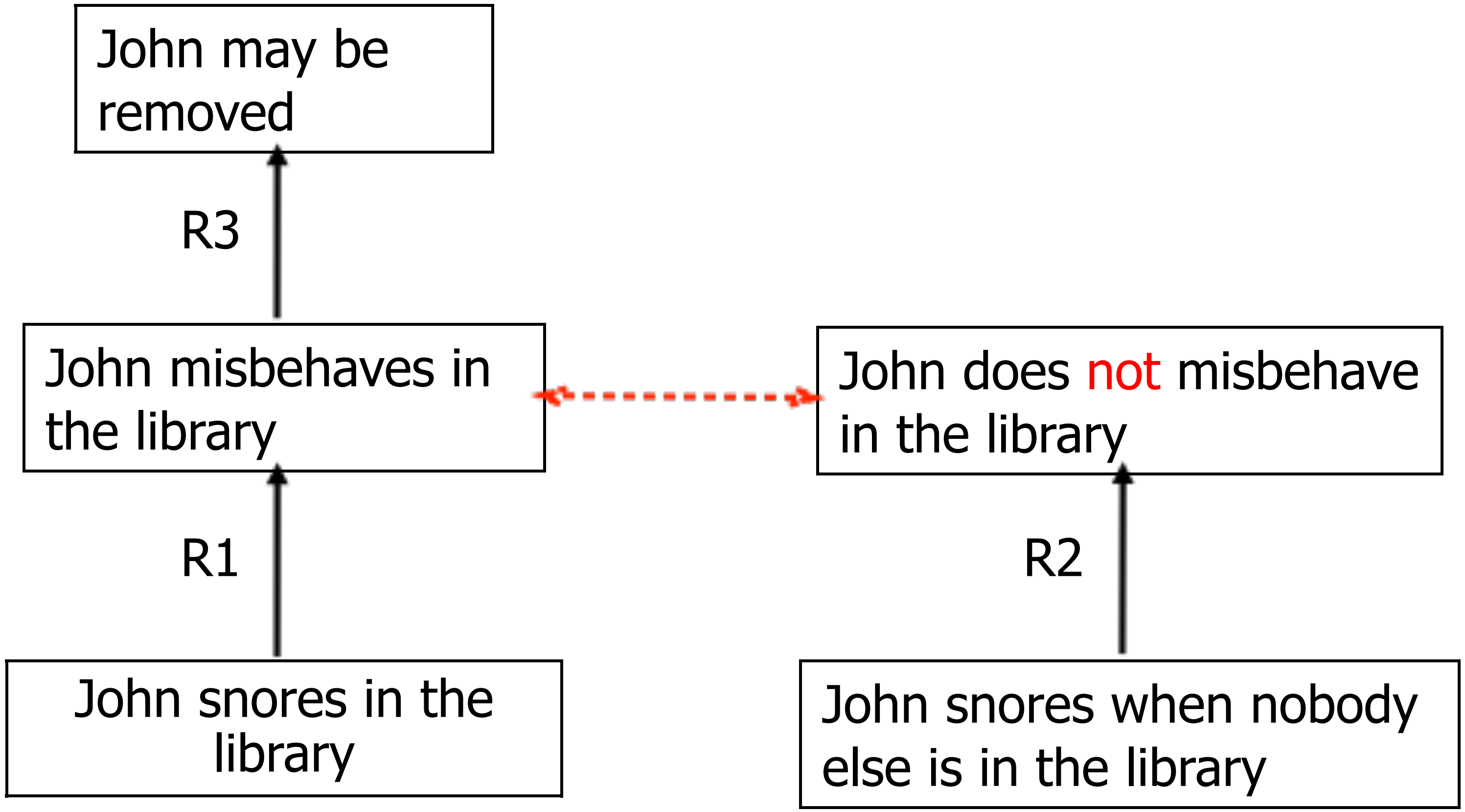
Arguments are neither statements that can be true or false, nor events that can have outcomes, so it makes no sense to speak of the probability of an argument.
Further clarification is needed:
- Extrinsic uncertainty: Pr(A) = Pr(p) of some statement p *about* A
- Intrinsic uncertainty: ??

Preferences in abstract argumentation

- PAFs: extend (*args,attack*) to (*args,attack*,)
  - a is an ordering on args
  - A *defeats* B iff A attacks B and not A < B
  - Apply Dung's theory to (*args,defeat*)
- Implicitly assumes that all attacks are independent from each other
- Assumption not satisfied in general =>
  - Properties not inherited by all instantiations
  - possibly violation of rationality postulates

R1: If you snore, you misbehave
R2: If you snore when nobody else is around, you don’t misbehave
R3: If you misbehave in the library, the librarian may remove you

R1 < R2 < R3



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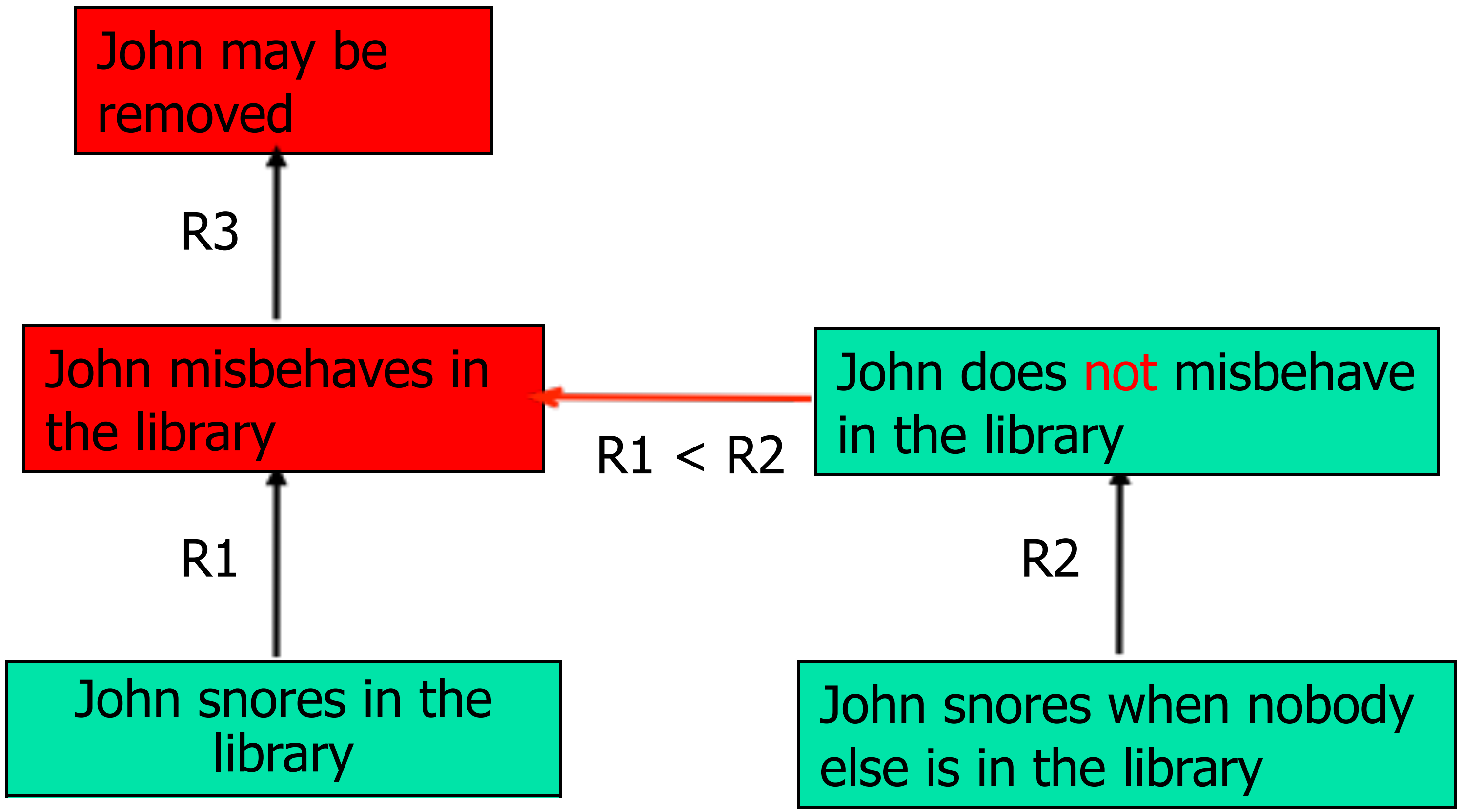

R1: If you snore, you misbehave
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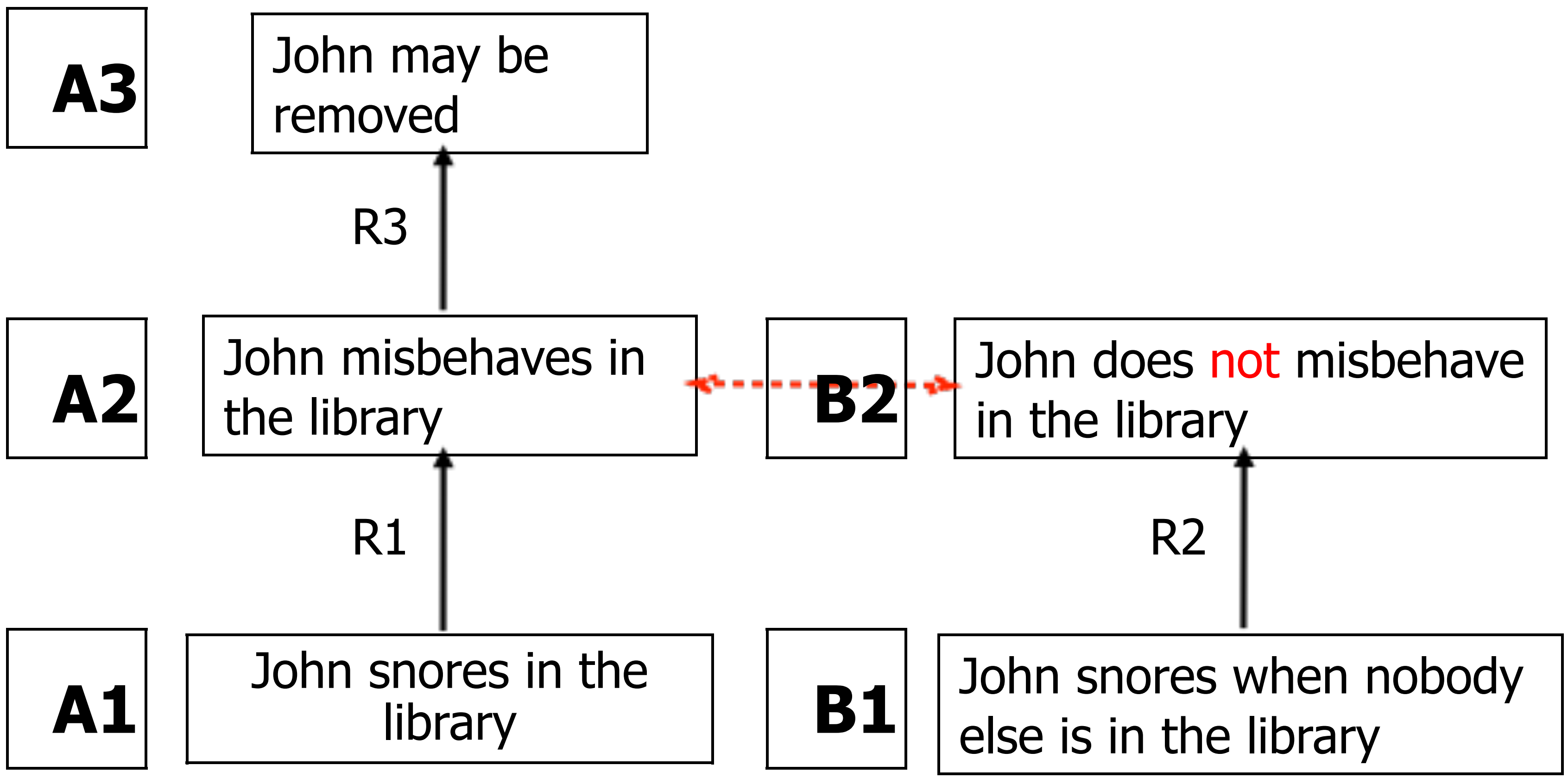
R1 < R2 < R3 so A2 < B2 < A3 (with last link)



R1: If you snore, you misbehave

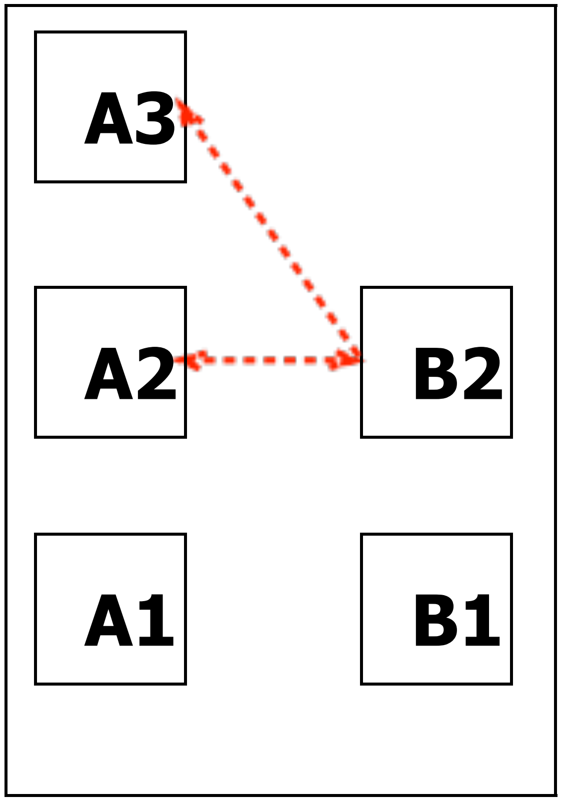
R2: If you snore when nobody else is around, you do

R3: If you misbehave in the library, the librarian may

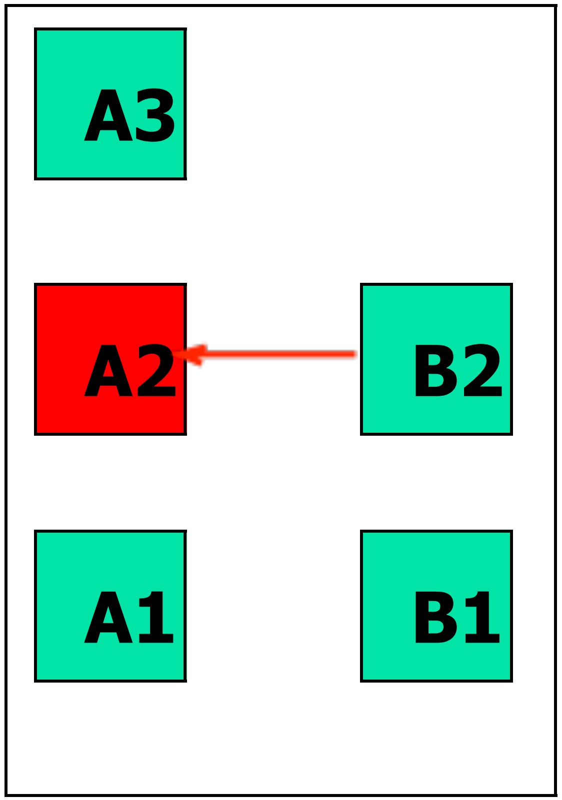
Does not recognise that B2's attacks on A2 and A3 are the same

R1 < R2 < R3 so A2 < B2 < A3 (with last link)

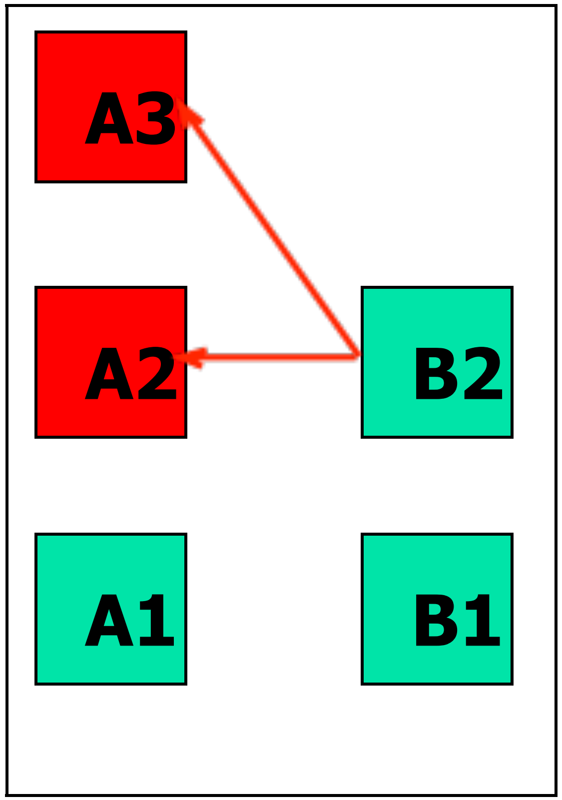
attacks



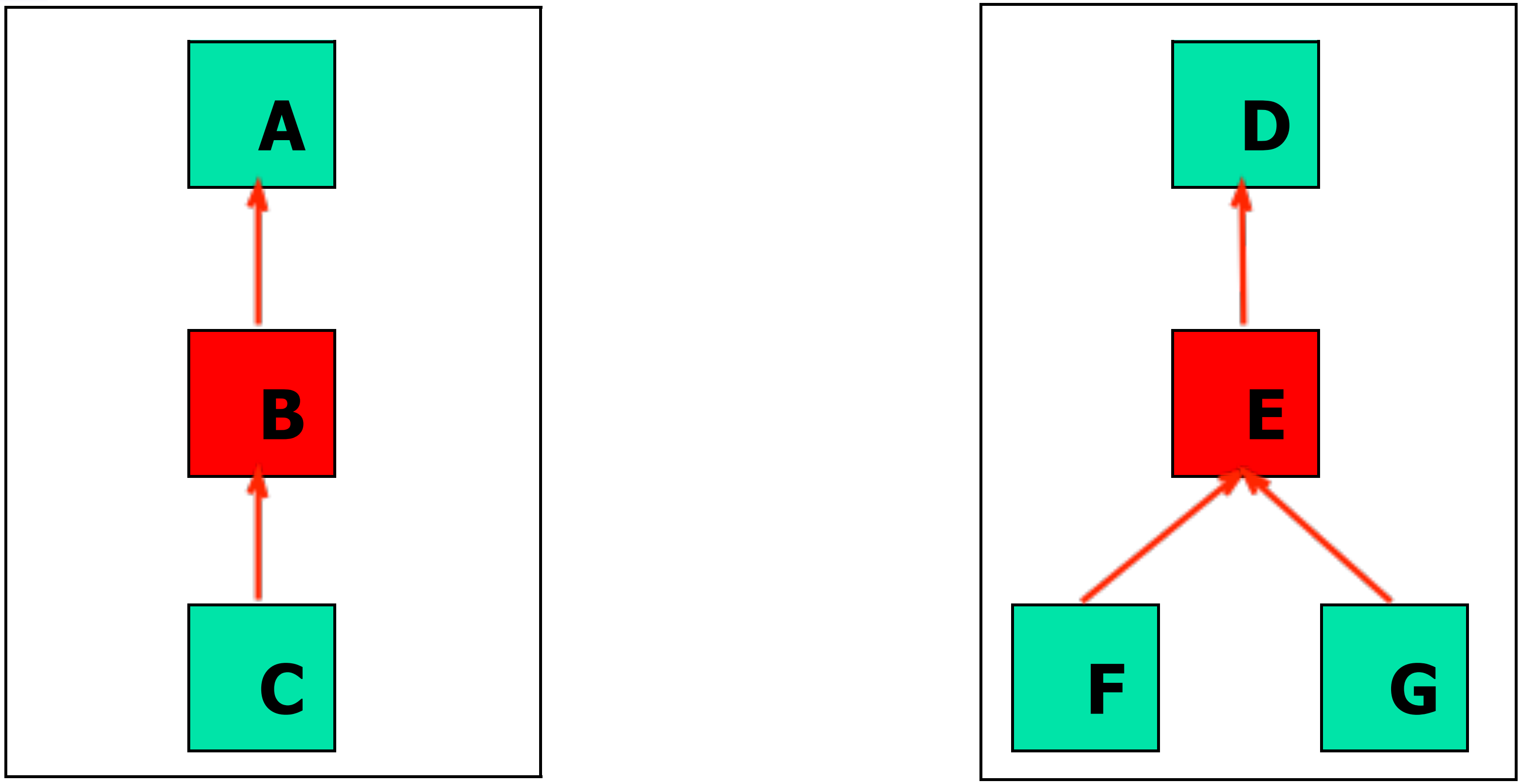
PAF-defeats



Correct defeats



Degrees of acceptability in abstract argumentation



In Grossi & Modgil (IJCAI 2015) D is more acceptable than A.
But what if F and G are attackable while C is not attackable?

Probabilistic abstract argumentation frameworks

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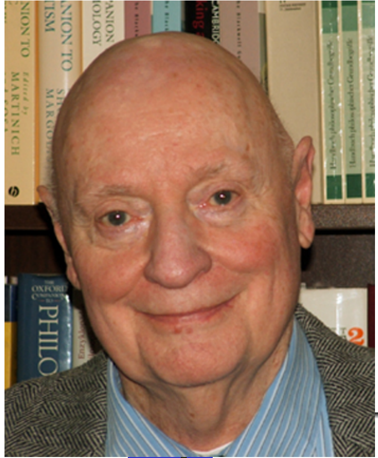


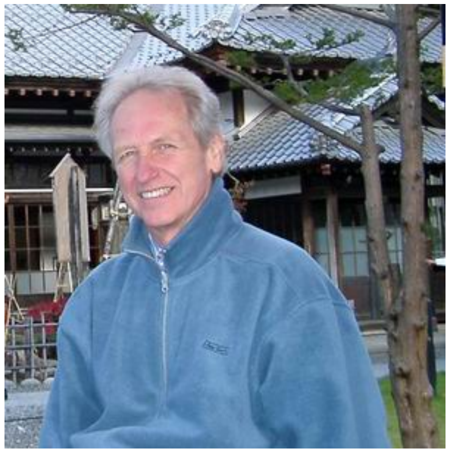
Nicholas Rescher

Two accounts of the fallibility of arguments

Tony Hunter

- Plausible Reasoning: all fallibility located in the premises
  - Assumption-based argumentation (Kowalski, Dung, Toni,…
  - Classical argumentation (Cayrol, Besnard & Hunter, …)
  - Tarskian abstract logic argumentation (Amgoud & Besnard)
- Defeasible reasoning: all fallibility located in the defeasible inferences
  - Pollock, Loui, Vreeswijk, Prakken & Sartor, …
- ASPIC+ combines these accounts

Robert Kowalski



John Pollock

Design choices may depend on the nature of arguments and attacks

- Hunter (IJAR 2013):
  - Instantiates Prob-AFs with classical-logic argumentation
  - An argument's probability equals the probability of the conjunction of its premises
    - Makes no sense (for intrinsic uncertainty) for argumentation with defeasible inference rules
    - E.g. the 'rationality' constraint: If A attacks B and Pr(A) > 0.5, then Pr(B) ≤ 0.5 makes no sense, since the premises of A and B can be jointly true

CL argumentation:
L = propositional
(S,p) is an argument iff
- S L, p L
- S |-PL p, S consistent
- No S' S satisfies all this

Epistemic extensions (Hunter IJAR 2013)

- S Args is an epistemic extension if S = {A Args | Pr(A) > 0.5}
- An epistemic extension is rational if Prob-AF satisfies the rationality constraint:
  - If A attacks B and Pr(A) > 0.5, then Pr(B) ≤ 0.5
- Not guaranteed to be logically closed: e.g. KB = {p,q}, Pr(p) = 0.7, Pr(q) = 0.7, Pr(p & q) = 0.49.

Bad practice: encoding natural language directly in AFs

Hunter (IJAR 2013):

- A1: From his symptoms, the patient most likely has a cold
- A2: However, there is a small possibility that the patient has influenza, since it is currently very common.

Hunter: "This representation hides the fact that the first argument is much more likely to be true than the second. If we use dialectical semantics to the above graph, then A1 is defeated by A2"
HP: but why does A2 attack A1?

Bad practice: encoding natural language directly in AFs

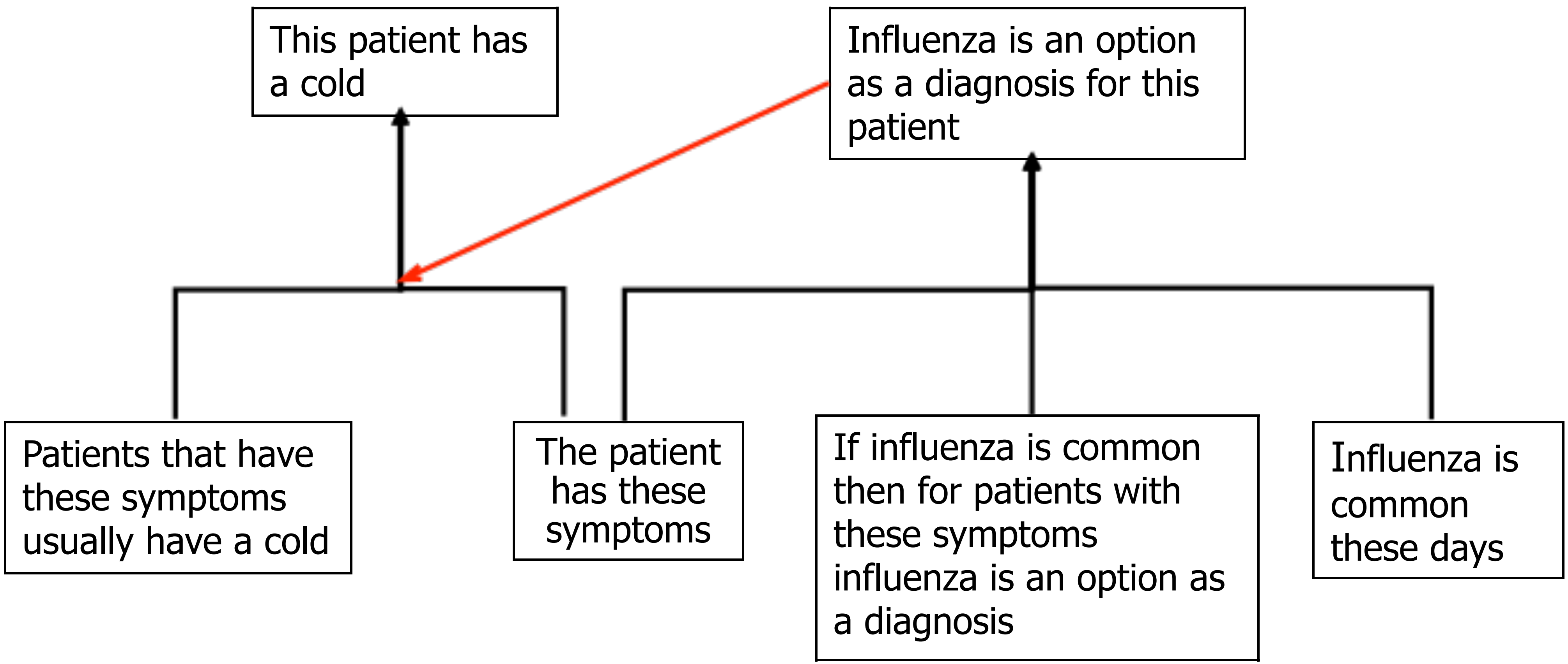
Hunter (IJAR 2013):

- A1: From his symptoms, the patient has a cold
- A2: Influenza is an option as a diagnosis for this patient, since it is currently very common.

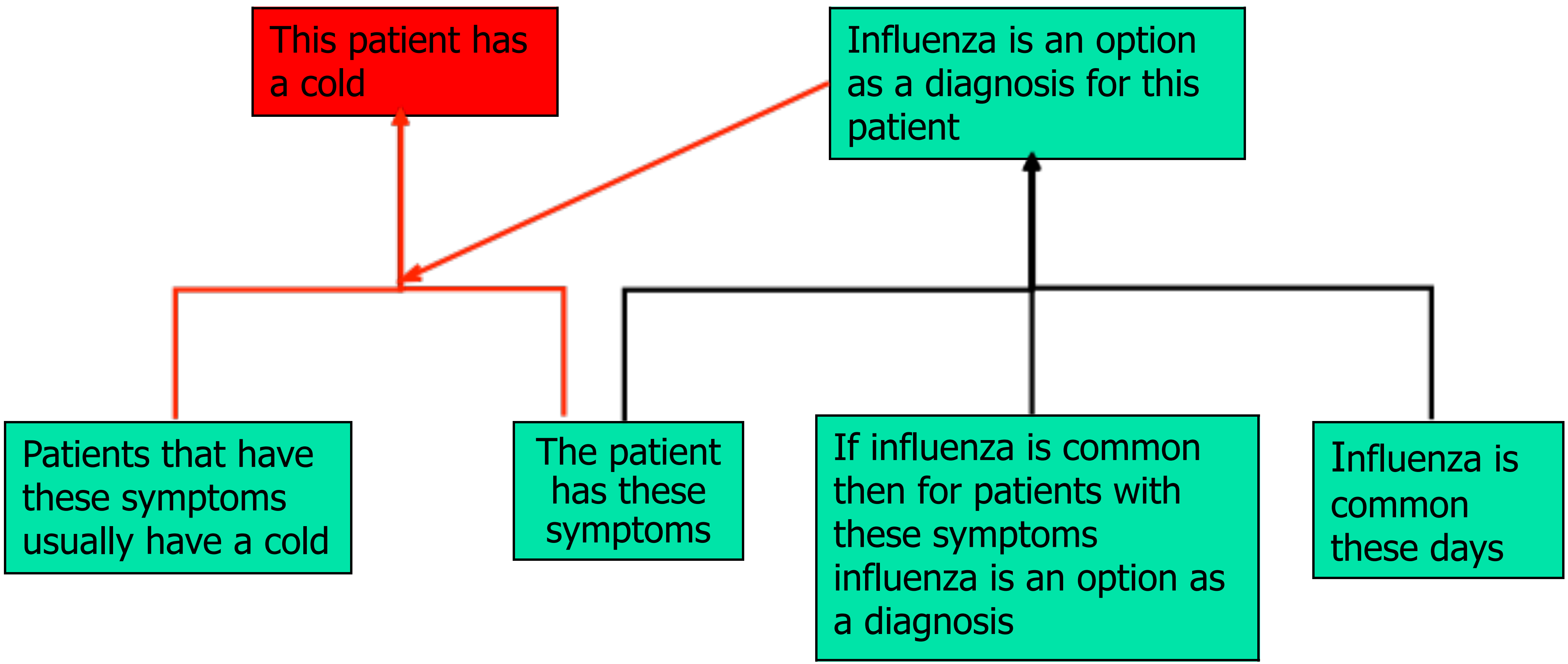
Pr(A1) = 0.9
Pr(A2) = 0.1

Hunter: "A better solution may be to translate the arguments to the following arguments that have the uncertainty removed from the textual descriptions and then to express the uncertainty in the probability function over the arguments …"
HP: but why does A2 attack A1?

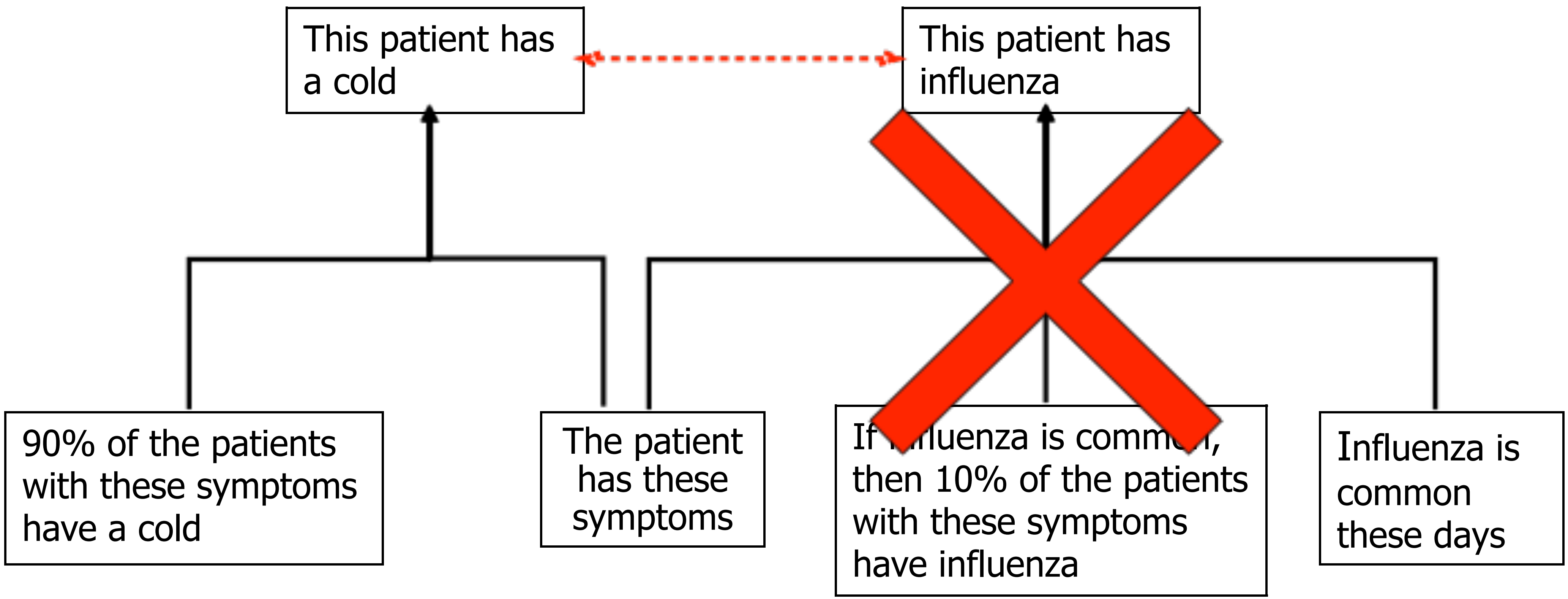
Modelling as statistical syllogism with undercutter



Modelling as statistical syllogism with undercutter



Modelling with two statistical syllogisms



Part 3: Sjoerd Timmer's work on explaining Bayesian Networks with argumentation

A simple ASPIC+ instantiation

- Arguments: Inference graphs where
  - Nodes are from L = predicate-logic literals
    - User-specified contrariness relations
  - Links are applications of defeasible inference rules
    - Probabilistically interpreted
- Constructed from a knowledge base K L
  - Necessary premises (the evidence)
- Attack:
  - On defeasible inferences (undercutting)
  - On conclusions of defeasible inferences (rebutting)
- Defeat: attack + argument ordering in terms of probability
- Argument evaluation with Dung (1995)

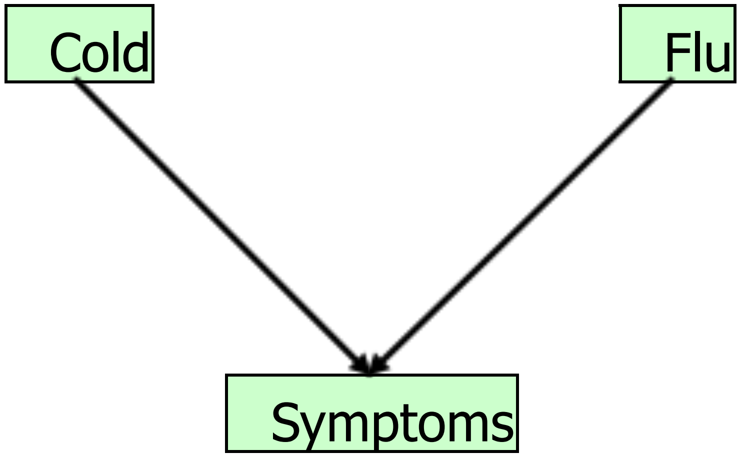
Explaining Bayesian networks with argumentation

- Sjoerd Timmer (2012-2016), e.g.
  - Timmer et al. (IJAR 2016)
  - Timmer (PhD thesis 2016/2017)
- Given a BN, derive an ASPIC+ structured AF that explains it.
- As above, with:
  - $\mathcal{L}$ = {V = v | V is a node in the BN and v is a possible value of V} U rule names
  - V = v contradicts V = v′ iff v ≠ v′.

Causal Bayesian networks

Pr(Cold)

Pr(Flu)



Pr(Symptoms | Cold & Flu)
Pr(Symptoms | Cold & ¬Flu)
Pr(Symptoms | ¬Cold & Flu)
Pr(Symptoms | ¬Cold & ¬Flu)

Pr(Cold | Symptoms)?
Pr(Flu | Symptoms)?

First method (JURIX 2014)

- For all variables V
- For every non-empty subset {V1,…,Vn} of variables in V’s Markov Blanket
- For every set of possible outcomes
- Create candidate rules

V1 = v1 , … , Vn = vn V = v

- Check the inferential strength of a rule: if too low, then discarded.

- Problem 1: too many rules
- Problem 2: no relation between BN and argument extensions

Second method (ECSQARU 2015, IJAR 2016)

- For a given node V of interest
- Create the node's support graph
  - Contains all possibly relevant information for V
- The support graph + evidence induce arguments for assignments to V
- Arguments for C now capture all 'reasons' pro and con C.
- (Example: P. 10 ICAIL 2015 or p. 11 ECSQARU)

Argument strength as posterior prob (IJAR 2016)

- Posterior probability:

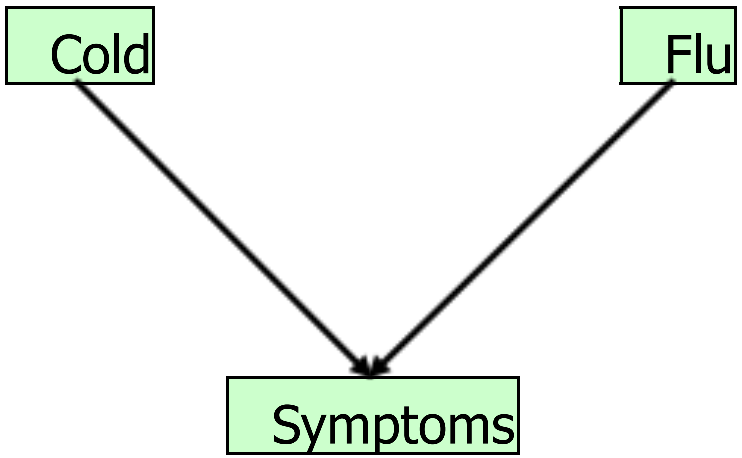
Pr(conclusion | premises & evidence)

- (Evidence not needed for node of interest)
- ...

Causal Bayesian networks

Pr(Cold)

Pr(Flu)



Pr(Symptoms | Cold & Flu)
Pr(Symptoms | Cold & ¬Flu)
Pr(Symptoms | ¬Cold & Flu)
Pr(Symptoms | ¬Cold & ¬Flu)

Pr(Cold | Symptoms)?
Pr(Flu | Symptoms)?

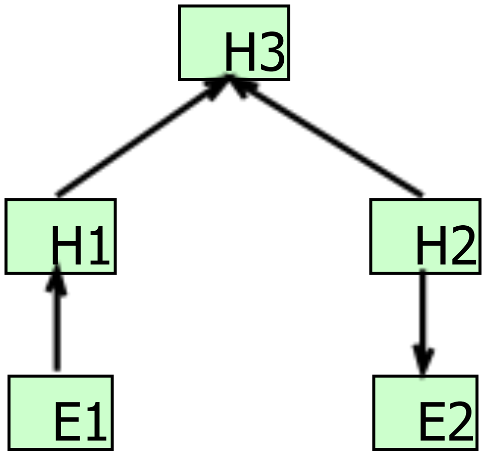
Properties

- The grounded extension equals the set of undefeated arguments.
- The grounded extension satisfies subargument closure, consistency (and strict closure)
- The strength of an argument for C equals the posterior probability of C in the BN
- If A is in the grounded extension, then A is the strongest argument for Conc(A).
- If A is in the grounded extension, then strength(A) > 0.5.

Conjecture

- The following is consistent:

E1 -> H1
E2 -> H2
H1 & H2 -> H3
Pr(H3 | E1 & E2) > Pr(H1 | E1 & E2)



Non-properties (1)

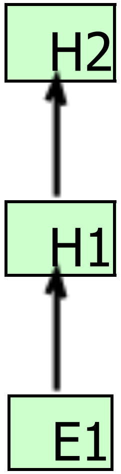
- An argument can never be stronger than one of its subarguments. Counterexample:

E1 -> H1 -> H2
E1 -> -H1 -> H2
The two argument for H2 are equally strong. If > 0.5, then one of the arguments for H1 or –H1 is weaker.

Non-properties (2)

- Consider Pr-AF = (Args,attacks,Pr) where

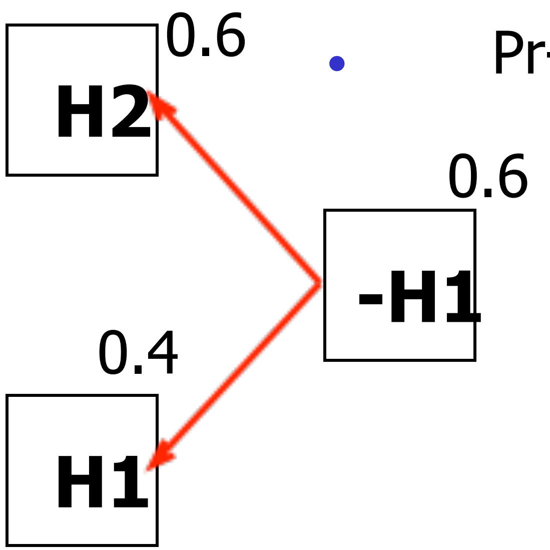
  Pr(A) = strength (A)
- The grounded extension is the epistemic extension. Counterexample:



E1 -> H1 -> H2
E1 -> -H1 -> H2
The two argument for H2 are equally strong. If > 0.5, then one of the arguments for H1 or –H1 is weaker.

Non-properties (3)

- Consider Pr-AF = (Args,attacks,Pr) where
  Pr(A) = strength (A)
- Pr-AF is rational. Counterexample.



Pr(E1 -> H1 -> H2) = 0.6
Pr(E1 -> H1) = 0.4
Pr(E1 -> -H1) = 0.6

E1 -> -H1 indirectly attacks E1 -> H1 -> H2 and both have strength > 0.5.

- But the rationality constraint does hold for direct attack.

Conclusions

- Recent work on probabilistic argumentation was not helpful in Timmer’s application
- Bottom-up approach can shed new (better?) light on probabilistic argumentation