Logic for AI

Master 1 IFI

Andrea G. B. Tettamanzi

Nice Sophia Antipolis University

Computer Science Department

andrea.tettamanzi@unice.fr

Session 8

Argumentation

Agenda

- Introduction
- Argumentation Frameworks
- Semantics

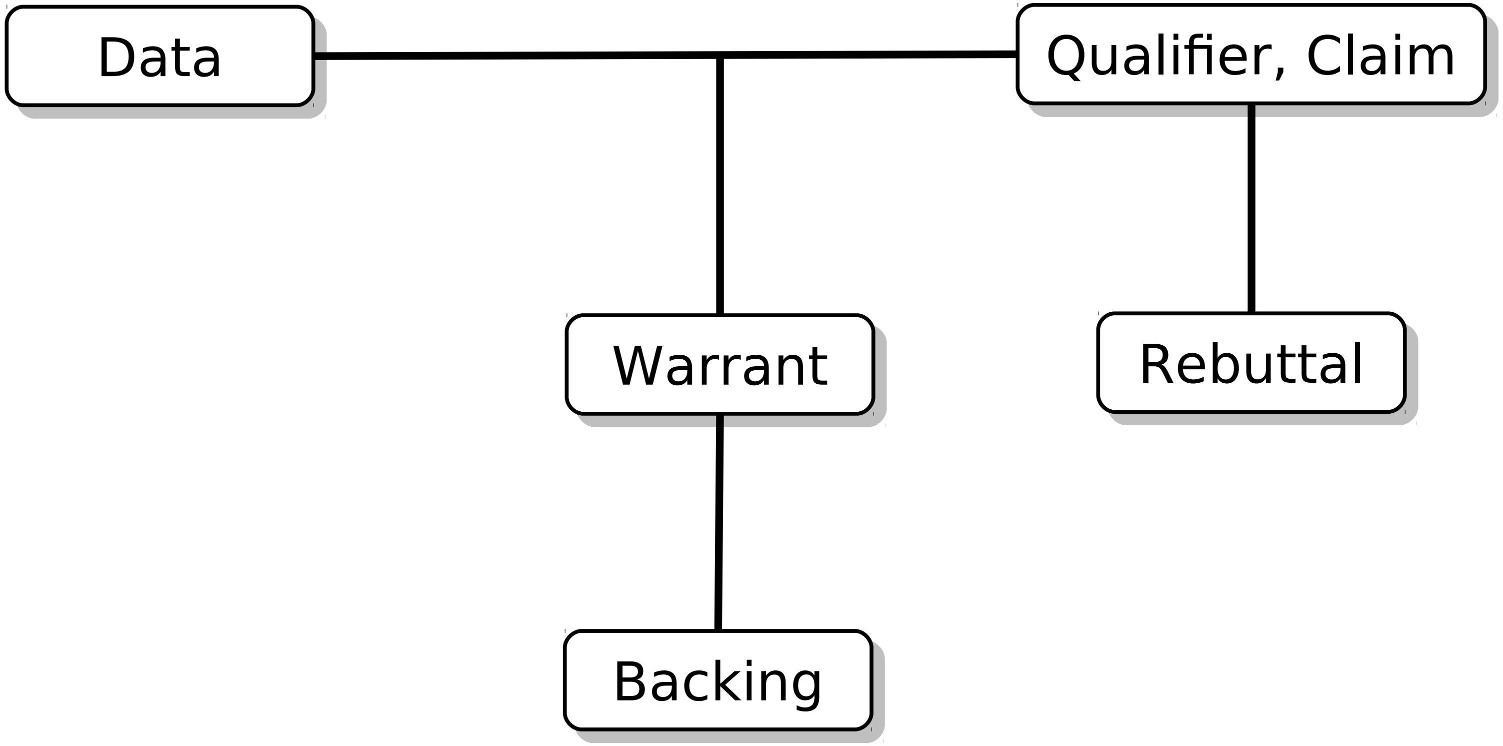
Introduction

- Argumentation is the interdisciplinary study of how conclusions can be reached through logical reasoning
- In AI: a tool to provide a proof-theoretic semantics for non-monotonic logic
- Non-monotonic logic is any formal framework devised to capture and represent *defeasible* inference
  - The reasoner draws conclusions tentatively, reserving the right to retract them in the light of further information
  - Dealing with conflicts
  - We touched upon this notion in the lecture on Belief Revision
  - Another noteworthy formalism is default logic, which we will not cover

Why do we argue?

- **Information-seeking:** an agent seeks to answer some question(s) with the help of another agent, who knows the answer
- **Inquiry:** agents collaborate to answer a question, whose answer they do not know
- **Persuasion:** an agent seeks to persuade another to accept a proposition they do not currently endorse
- **Negotiation:** bargaining over allocation of resources
- **Deliberation:** decide which action(s) should be adopted in a given situation
- **Eristic:** verbal quarrel rather than physical fighting to solve a dispute

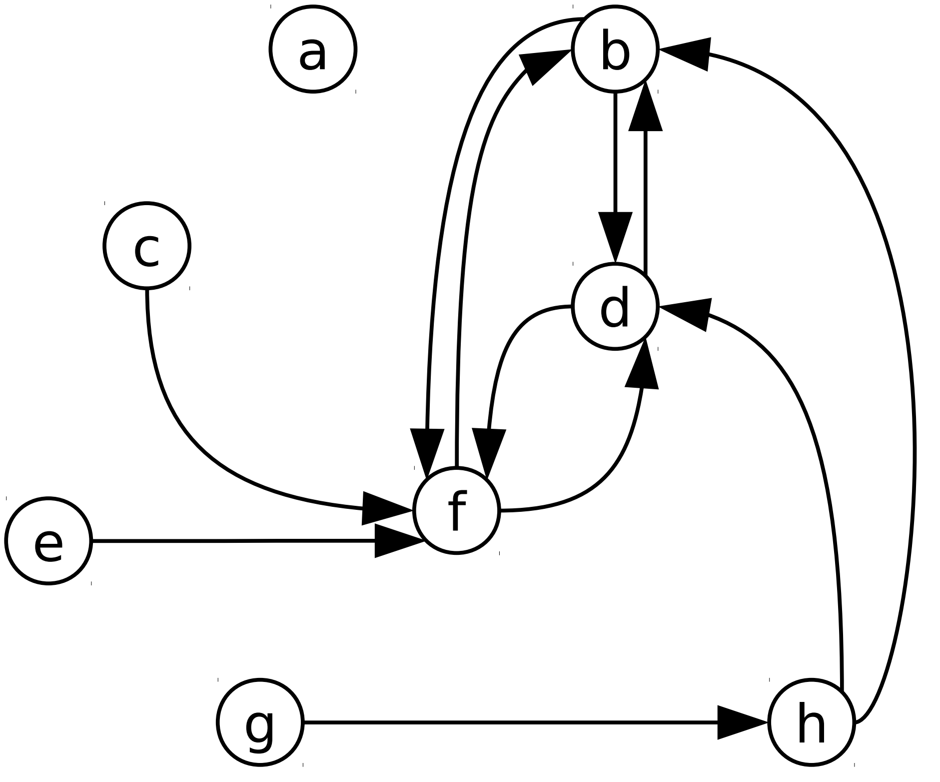
Toulmin Model of Arguments



Abstract Argumentation

- Proposed by Phan Minh Dung at IJCAI 1993
- Basic ideas:
  - Disregard the internal structure of arguments
  - Consider only how they attack each other
- An argumentation framework is defined as a pair <*A*, *attacks*>
  - *A* is a set of arguments (abstract elements)
  - *attacks* is a binary relation on *A*, the attack relation
- An argumentation framework can be viewed as a graph

Example



Semantics

- A **semantics** for an argumentation framework is a way to identify sets of arguments “surviving the conflict together”
- What this intuitive notion means exactly depends on the particular semantics
- Semantics of argumentation framework can be stated as
  - Extensions (sets of accepted arguments)
  - Labelings (mappings assigning labels to arguments)

Semantics Properties

- A set *S* of arguments is **conflict-free** if there are no arguments *a* and *b* in *S* such that *a attacks b*
- An argument a in A is **acceptable** w.r.t. a set S of arguments iff for each argument b in A, if *b attacks a*, then b is attacked by S
- A conflict-free set of arguments S is **admissible** iff each argument in S is acceptable w.r.t. S
- **strongly admissible** iff every argument defended by S is in S
- An extension S is **i-maximal** iff no proper subset of S is an extension

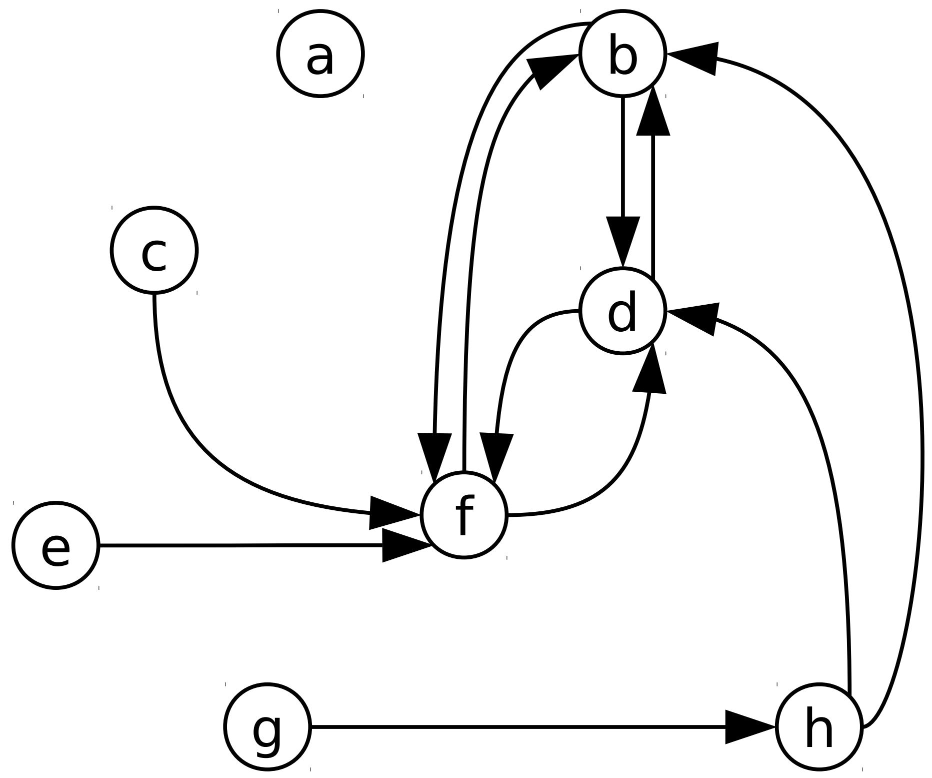
Complete Extension

- Admissible (thus conflict-free)
- Each defended argument is included (reinstatement)

- Intuitively, the notion of complete extensions captures the kind of confident rational agent who believes in everything it can defend.

Complete Extensions

$$\{\ \{a, c, d, e, g\},\ \{a, b, c, e, g\},\ \{a, c, e, g\}\ \}$$



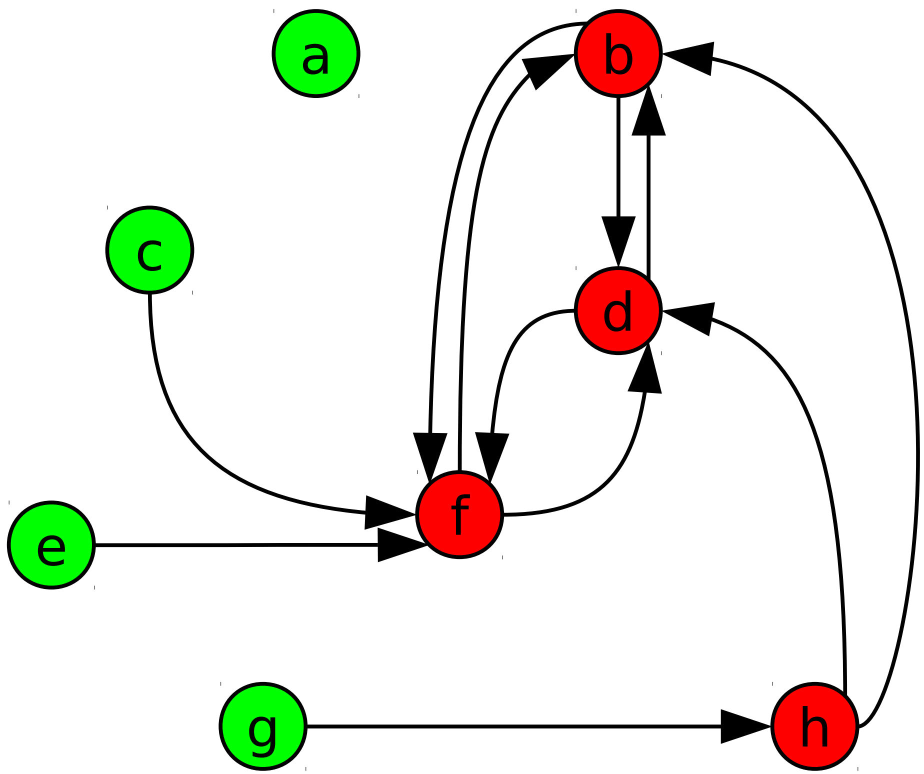
Grounded Extension

- Strongly admissible (thus conflict-free and admissible)
- Minimum complete extension

- Grounded extensions are “skeptical”

Grounded Extensions

$\{\ \{a, c, e, g\}\ \}$



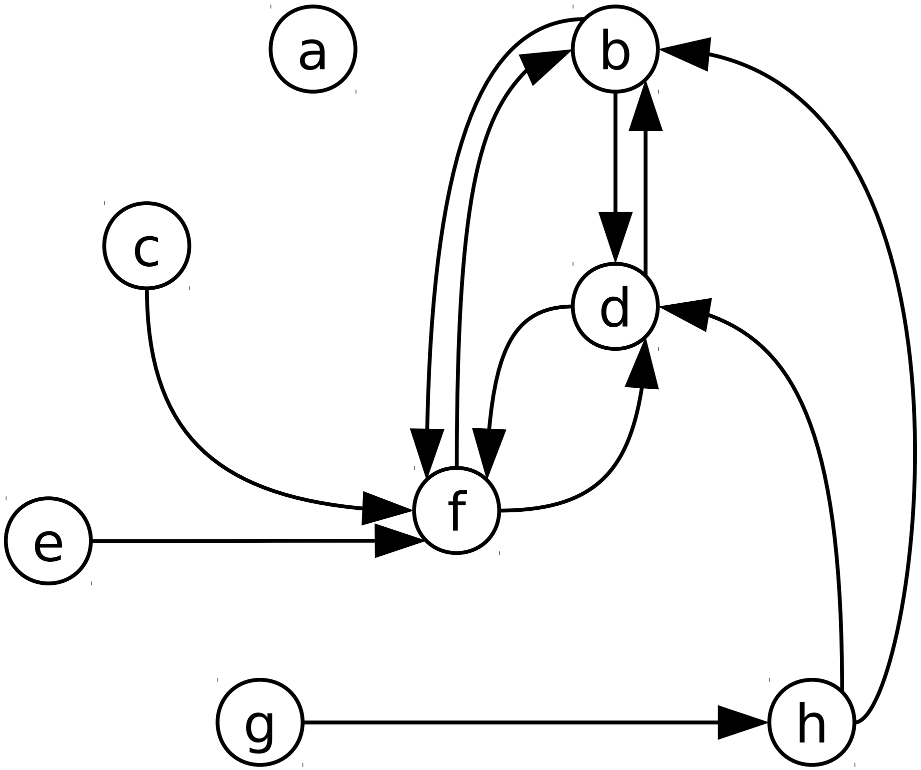
Preferred Extension

- Admissible (thus conflict-free)
- Maximal (w.r.t. set inclusion)
- Maximum complete extensions

- Preferred extensions are “credulous”

Preferred Extensions

$\{\ \{a, c, d, e, g\},$
$\{a, b, c, e, g\}\ \}$



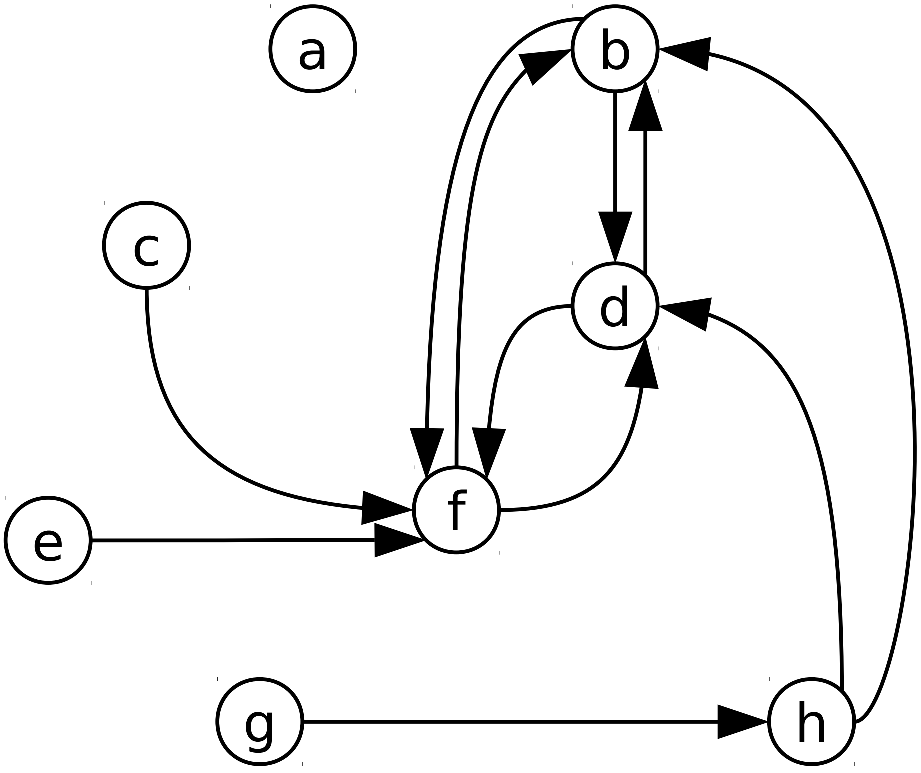
Stable Extension

- Complete extension
- Attacking all the arguments outside
- The absence of odd-length cycles is a sufficient condition for the existence of stable extensions

- Every stable extension is a preferred extension
  - but not *vice versa*

Stable Extensions

$$\{\ \{a, c, d, e, g\},\ \{a, b, c, e, g\}\ \}$$



Coherence

- An argumentation framework *AF* is **coherent** if each preferred extension of *AF* is also stable
- An argumentation framework *AF* is **relatively grounded** if its grounded extension coincides with the intersection of all preferred extensions
- There exists at least one stable extension in a coherent argumentation framework

Complete Labelings

- Arguments are labeled as { IN, OUT, UNDEC }
  - An argument is IN if all of its attackers are OUT
  - An argument is OUT if at least one of its attackers is IN
  - An argument is UNDEC otherwise

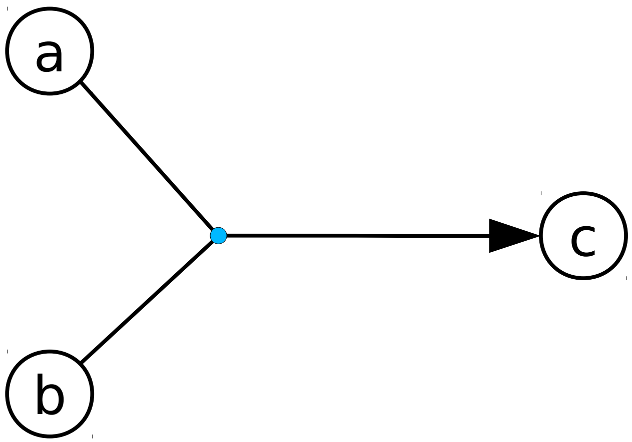
- Maximize UNDEC = Grounded Extension
- Maximize IN = Preferred Extension
- No UNDEC = Stable Extension

Extending Dung's Framework

- Dung's framework captures negative interactions between arguments
- However, it does not capture several intuitive properties of human argumentation
  - Joint attack
  - Recursive/meta-arguments
  - Preferences
  - Support
  - Argument strength

Joint Attack

- Both *a* and *b* must be accepted in order for *c* not to be accepted
- All the previous results and definitions map directly
- Only the definition of *attacks* needs modification



Preference-Based Argumentation

- Witness *a* claims P, witness *b* claims ¬P, but *a* is more reliable than *b*
- A preference-based argumentation framework (PAF) is a triple <A, attacks, ≥ >, where ≥ is a partial ordering over A
- "$a \geq b$" states that a is preferred to b
- An AF is transformed into a PAF by shifting from the notion of attack to that of defeat
- *a defeats b* iff *a attacks b* and $a \geq b$

Strength

- Humans often claim that some arguments are stronger than others
- Such strength can come from
  - its internal structure—the validity of the inference pattern to check the tenability of the claim
  - its social consensus (e.g., the number of favorable and unfavorable votes)
  - the authority of the source (or the “reasoner”) offering it
    - May be a measure of the reliability of the source, like competence, expertise, trust, reputation, and the like

Fuzzy Labeling

- Let <*A*, →> be an abstract argumentation framework
- A fuzzy labeling is a total function $\alpha : A \rightarrow [0, 1]$

$$\alpha(a) \leq 1 - \max_{b:b \rightarrow a} \alpha(b)$$

- In addition arguments may have a "strength" in [0, 1]
  - Trustworthiness of their source, support, etc.
- In that case, *A* may be viewed as a fuzzy set
- A fuzzy reinstatement labeling is a fuzzy labeling such that

$$\alpha(a) = \min\{A(a), 1 - \max_{b:b \rightarrow a} \alpha(b)\}$$

Computing a Fuzzy Reinstatement Labeling

- We define the sequence

$$\alpha_0(a) = A(a)$$

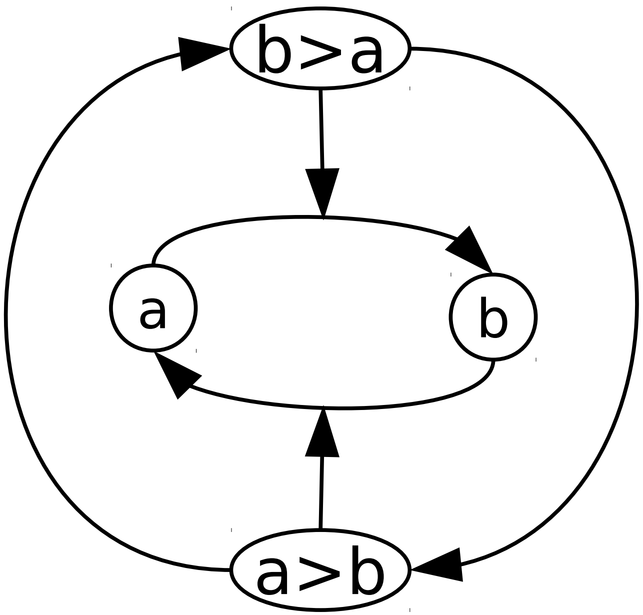
$$\alpha_{t+1}(a) = \frac{1}{2}\alpha_t(a) + \frac{1}{2}\min\{A(a), 1 - \max_{b:b\to a}\alpha_t(b)\}$$

- This sequence always converges
- Its limit is a fuzzy reinstatement labeling

$$\alpha(a) = \lim_{t\to\infty}\alpha_t(a)$$

Extended Frameworks

- The idea of these frameworks is to allow attacks on attacks
- Capturing preferences, undercuts, and the like in a natural way



Bipolar Argumentation

- Attacks between arguments allow for reinstatements to occur, allowing arguments to defend one another
- Arguments can also build on top of one another, or strengthen each other through support
- Bipolar argumentation frameworks allow arguments to interact by either attacking or supporting one another

$$< A, \textit{attacks}, \textit{supports} >$$

- Different formalisms treat support differently

Thank you for your attention