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Tutorial on Argumentation Technology for Artificial Intelligence

September 24th
KI 2019, Kassel

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Tutorial Overview

9:00 - 9:30 Part1: Introduction (Philipp Cimiano)

9:30 - 10:30 Part2: Argument Mining and Assessment (Henning Wachsmuth)

10:30 - 11:00 Coffee Break

11:00 - 12:00 Part3: Argument Retrieval (Benno Stein)

12:00 - 12:30 Part4: Argumentation-based aggregation of evidence for decision support

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Tutorial on Argumentation Technology for Artificial Intelligence Part 1: Introduction

Prof. Dr. Philipp Cimiano (Bielefeld University)
Prof. Dr. Benno Stein (Bauhaus-University Weimar)
Prof. Dr. Henning Wachsmuth (Paderborn University)

Introduction

- What is Argumentation?
- The „classic“ origins of argumentation
- Validity of arguments
- Toulmin’s model
- Argumentation Schemas
- Argumentation in Artificial Intelligence
  - Structured Argumentation
  - Abstract Argumentation
- Terminology

Introduction

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Arguments provide the basis for exchanging standpoints

We should leave the EU because EU membership is reducing our control and sovereignty in domestic affairs.

We should not leave the EU because we would loose three million jobs.

What is argumentation?

- Argumentation is a communicative and interactional act complex aimed at resolving a difference in opinion with the addressee by putting forward a constellation of propositions the arguer can be held accountable for to make the standpoint at issue acceptable to a rational judge who judges reasonably.
- F.H. van Eemeren, Bart Gassen, E.C.W. Krabbe, A.F. Snoeck Henkelmann, B. Verheb, J.H.M. Wagemans, „Handbook of Argumentation“, Chapter 1 „Argumentation Theory“

What is argumentation?

- Argumentation is a **communicative** and interactional **act complex** aimed at resolving a difference in opinion with the addressee by putting forward a constellation of propositions the arguer can be held accountable for to make the standpoint at issue acceptable to a rational judge who judges reasonably.

- Not just a „structural entity“, but a communicative act complex consisting of a functional combination of communicative moves.

What is argumentation?

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- Argumentation is an interactional act complex directed at eliciting a response that indicates acceptance of the standpoint that is defended.
- So argumentation is a dialogue, either explicit or implicit.

What is argumentation?

- Argumentation is a communicative and interactional act complex aimed at resolving a **difference in opinion with the addressee** by putting forward a constellation of propositions the arguer can be held accountable for to make the standpoint at issue acceptable to a rational judge who judges reasonably.

- Argumentation arises in response to, or in anticipation of, a difference of opinion, whether this difference of opinion is real or merely imagined. More other than not, the difference in opinion does not take the shape of a full disagreement, dispute, or conflict, but remains basic: There is one party that has an opinion and there is another party that is in doubt as to whether to accept this opinion. **Argumentation comes into play in cases when people start defending a view they assume not to be shared by others.**

What is argumentation?

- Argumentation is a communicative and interactional act complex aimed at resolving a difference in opinion with the addressee by **putting forward a constellation of propositions the arguer can be held accountable** for to make the standpoint at issue acceptable to a rational judge who judges reasonably.
- Putting forward arguments is not merely an expressive act free of obligations. When you put forward an argument, you are accountable in the sense that you have to accept and acknowledge the consequences of your position and be consistent.

What is argumentation?

- Argumentation is a communicative and interactional act complex aimed at resolving a difference in opinion with the addressee by putting forward a constellation of propositions the arguer can be held accountable for to make the standpoint at issue acceptable to **a rational judge who judges reasonably.**

- There are also requirements on the addressee, who is supposed to judge using reason, that is not emotionally charged, that is tempered, objective, consistent, etc.

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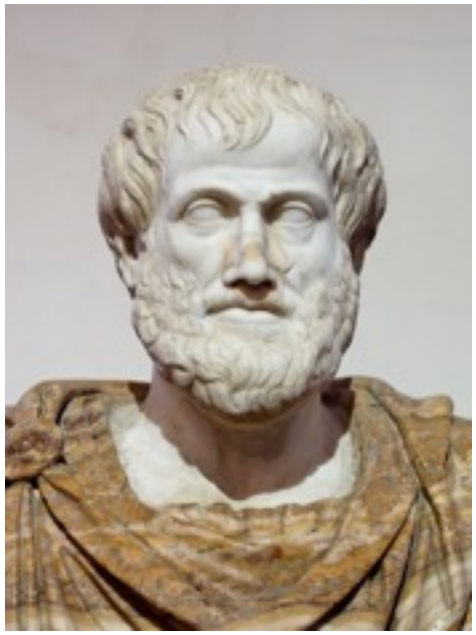
The „classic“ origins of argumentation

- The origins of argumentation can be traced back to the „classical“ disciplines of dialectic, logic and rhetoric:
  - **dialectic:** a form of reasoning based upon dialogue in which arguments and counter-arguments are exchanged to advocate certain positions Aristotle mentions Zeno of Elea (490-430 BC), Socrates and Platon as „inventors“ of the dialectical method, classically understood as subsuming „logics“ as representing the valid patterns of „reasoning“
  - **rhetoric:** the art of delivering (persuasive) speeches in public life regarding judicial and political issues in front of a judging audience; ancient sources attribute the „invention“ of rhetoric to Sicilian lawyers Corax and Tisias as well as the philosopher Empedocles, the so called „*sophists“ (Protagoras of Abdera, Georgias of Leontini, Produces of Ceos, Hippies of Elis) manifested themselves as the teachers of rhetoric.*

Aristotle as a central figure

- Aristotle (384-322 BC) was the first to write extensively on the aims, structure, rules and strategies for dialectical debates
- Published a handbook of philosophical debates known as the „Topics“ (Topica) consisting of eight books.
- A large part of the Topics was devoted to the discussion of about 300 „topoi“.
- The topoi (Greek: place) stand for valid types of argument patterns from which specific arguments can be instantiated from (locative metaphor)
- Nowadays, we would say that topoi are early forms of what is now called „argumentation schemes“ (more on this later)



The Athenian dialectical procedure

- The Athenian philosophical debate follows a clearly defined protocol
- Debate takes place in front of an audience involving a questioner and answerer as main participants.
- Opening stage: determine which participant plays which role
    - **Questioner:** poses the problem or dilemma by putting forward a propositional question which offers the choice of two contradictory „standpoints“ (e.g. Should we have death penalty?)
    - **Answerer:** selects either the positive or negative answer as his thesis (e.g. We should have death penalty.)
    - Questioner has the role of constructing a refutation, i.e. a deductively valid argument consisting of at least two premises and a conclusion that contradicts the thesis of the Answerer.

Origin of logics: deductively valid arguments

- Aristotle as the father of formal (propositional) logic
- Did not use logical symbols and formulas as we nowadays do for logics (syntax)
- **BUT:** analyzed and regimented a part of Greek language so as to unambiguously express statements that according to his theory are valid reasoning patterns.
- Syllogisms: valid patterns of deductive reasoning

	Affirmative	Negative
Universal	A-statements Form: Every S is a P Example: Every swan is a predator.	E-statements Form: No S is a P Example: No swan is a predator.
Particular	I-statements Form: Some S is a P Example: Some swan is a predator.	O-statements Form: Some S is not a P Example: Some swan is not a predator.

- Btw.: The stoics also had logical systems, but we know less nowadays of the logics used by the stoics (see van Eemeren et al. 2014)

Syllogisms in action

All birds fly.

All swans are birds.

———————————

All swans fly.

No bird is a predator.

All swans are birds.

———————————

No swan is a predator.

Syllogisms in action

A All birds fly.

A All swans are birds.

———————————

A All swans fly.

No bird is a predator.

All swans are birds.

———————————

No swan is a predator,

Syllogisms in action

A All birds fly.

A All swans are birds.

———————————

A All swans fly.

E No bird is a predator.

A All swans are birds.

———————————

E No swan is a predator,

Syllogisms in action

B
A All birds fly.
R
B
A All swans are birds.
R ——————————
A All swans fly.

C
E No bird is a predator.
L
A All swans are birds.
R ——————————
E No swan is a predator,
N
T

Aristotle's theory of fallacies

- In „Sophistic Refutations", Aristotle identifies the following „fallacies" or „wrong moves" in dialectical debate:

- **Linguistic fallacies**
  - Homonymy or equivocation
  - Amphiboly
  - Composition or division
  - Accent or intonation
  - Form of expression
- **Non-linguistic fallacies**
  - Accident (False Predication)
  - Secundum quid (False Omission of Qualification)
  - Ignoratio elenchi (Ignorance of Refutation)
  - Begging the Question
  - False Cause
  - …

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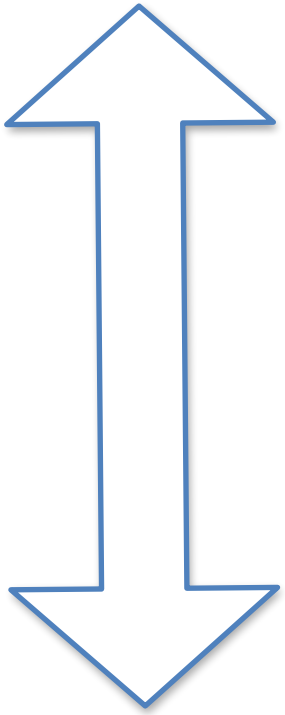
Validity of Arguments

Britain should leave the EU because Boris thinks so.

Invalid



Berlin is a major city because all capitals are major cities and Berlin is the capital of Germany.

Valid

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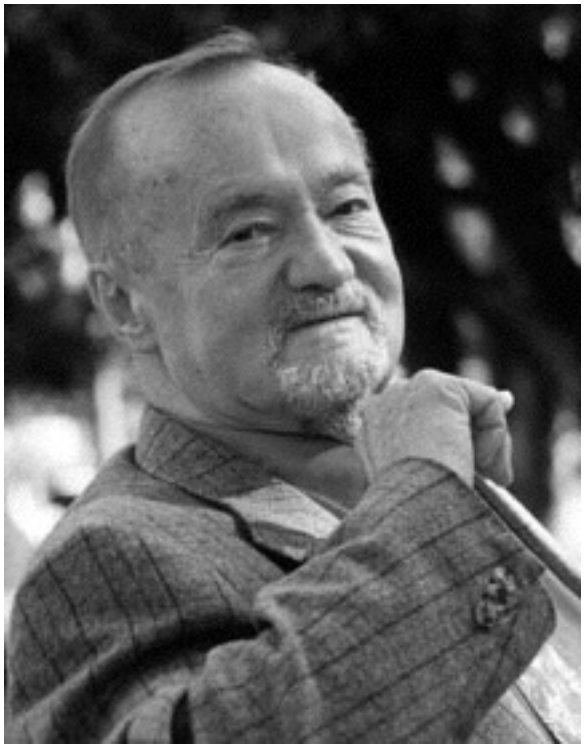
Toulmin's Model



American philosopher of British origin.

1922-2009

The Uses of Argument. Cambridge Univ. Press, 1958

Toulmin's Model

The Uses of Argument. Cambridge Univ. Press, 1958

Seminal work moving away from a purely logical/deductive notion of argument validity.
He was convinced that formal criteria as they are used in logic are **irrelevant** to the assessment of argument as it occurs in practice. He rejected what he called the „geometric model" of argumentation that follows purely deductive conclusion.

He had a „procedural" conceptualization according to which validity can not be defined on purely logical terms, but in terms of procedures in accordance with the specific soundness conditions of the field or subject concerned. So validity is field-dependent / subject-related.

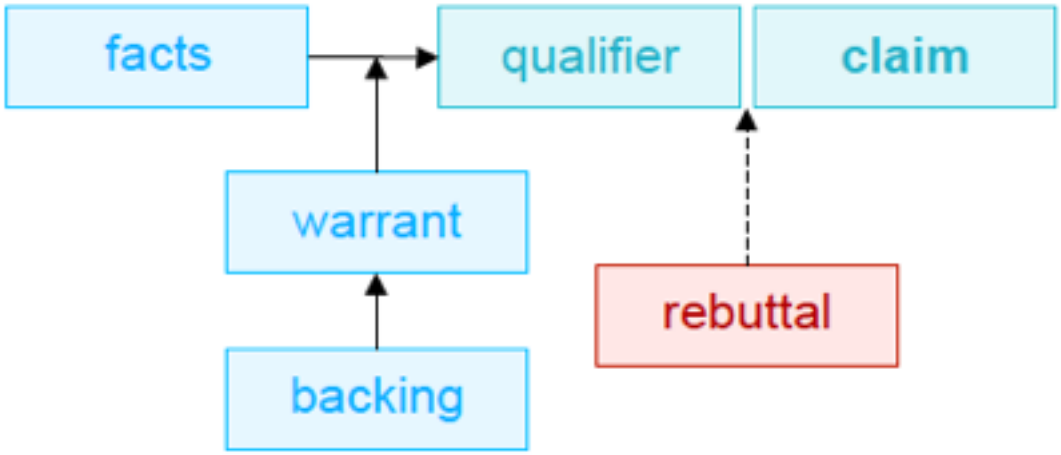
Toulmin coined the notion of „substantial" or „non-analytic" arguments in which the conclusion provides truly new information that does not trivially follow (in the logical sense) from the premises.

Toulmin's Model

Berlin is a major city because all capitals are major cities and Berlin is the capital of Germany.

This is an analytical and not a „substantial" argument.

Toulmin's Model



Facts: given data describing a state of affairs that are taken for granted

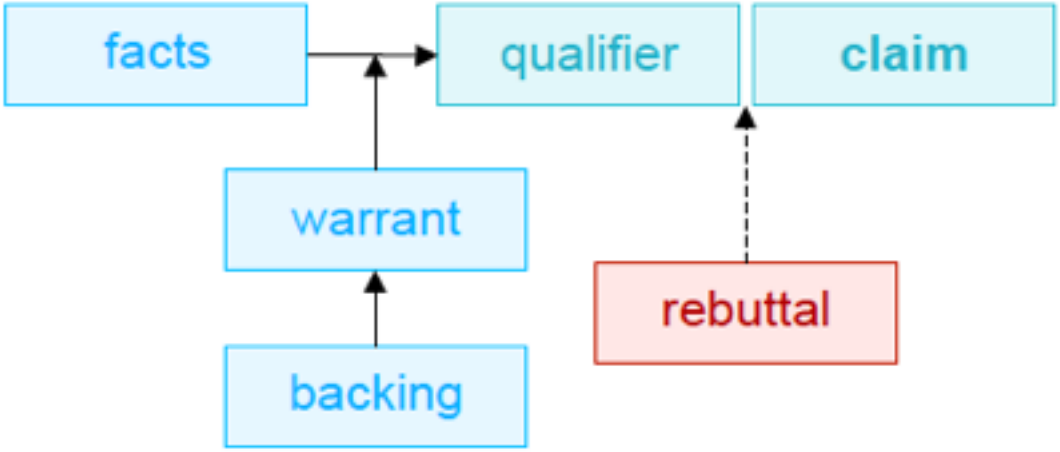
Warrant: the mechanism by which we are allowed to conclude / derive the claim from the facts. Will be in the general case field-dependent. The warrant „gives permission" to make the claim given the data. (moving from the data to the claim on the authority of the „warrant")

Backing: something which gives justification for the warrant

Qualifier: a modifier that restricts the universality of the claim

Claim: „substantial" conclusion

Toulmin's Model



Anne is one of Jack's sisters (**Fact**) → So: presumably (**Qualifier**) Anne has red hair. (**Claim**)

Any of Jacks's sisters may be taken to have red hair (**Warrant**)

?

All sisters of Jack have been previously observed to have red hair. (**Backing**)

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Argumentation Schemes (Walton et al. 2008)

- **Argumentation Schemes:** *„forms of argument (structures of inference) that represent structures of common types of arguments used in everyday discourse, as well as in special contexts like those of legal argumentation and scientific argumentation“* (Walton et al. 2008)

Argument from position to know	
Major premise	Source *a* is in the position to know about things in a certain subject domain S containing proposition A
Minor Premise	*a* asserts that A is true (false)
Conclusion	A is true (false)
Critical Question 1	Is *a* in a position to know whether A is true (false) ?
Critical Question 2	Is *a* an honest, trustworthy and reliable source?
Critical Question 3	Did *a* assert that A is true (false)?

Argumentation Schemes (Walton et al. 2008)

- Argumentation Schemes:
  - are the building blocks for dialogue-based exchange of standpoints in which
    - one party puts forth an argument as an instance of a schema
    - the other party (being cooperative and rational) either accepts the argument or challenges the argument by raising a critical question
  - non-normative but empirical approach to argumentation
  - 60+ argumentation schemes listed in Walton et al.'s book
  - represent non-defeasible patterns of reasoning that can be accepted for the sake of continuing the dialogue but can be challenged at all times as new evidence comes in.

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Structured Argumentation

- Here we mainly mention logic-based theories of argumentation, in particular the framework proposed by Besnard and Hunter (2008):

- Assumption, there is a knowledge base Δ with valid formulas.

- Given a knowledge base Δ, an argument is a pair $\langle \Phi, \alpha \rangle$ such that:
  1. $\Phi \not\models \bot$
  2. $\Phi \models \alpha$
  3. Φ is a minimal set from Δ satisfying condition 2

Φ is called the support and α is called the consequent.

Structured Argumentation

- This framework allows to formally define some relations between arguments:

- **Conservative:**

  $An\ argument\ \ \langle \Phi, \alpha \rangle\ \ is\ more\ conservative\ than\ an\ argument\ \ \langle \Psi, \beta \rangle\ \ iff$
  $\Phi \subseteq \Psi\ \ and\ \ \beta \models \alpha$

- **Equivalence**:

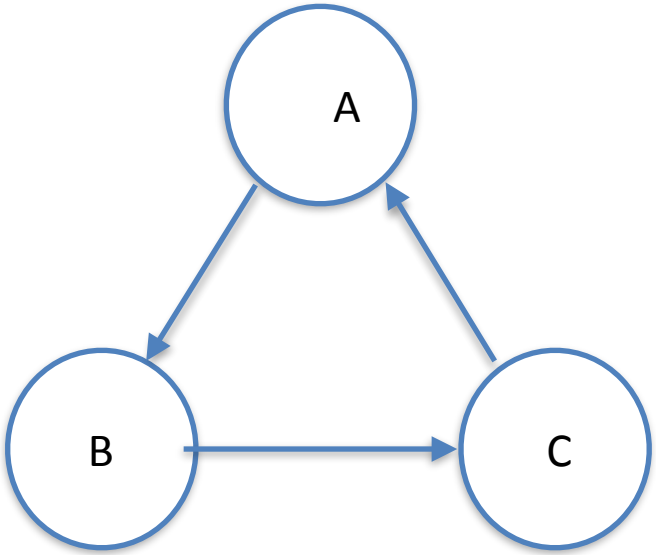
  $Two\ arguments\ \ \langle \Phi, \alpha \rangle\ \ and\ \ \langle \Psi, \beta \rangle\ \ are\ equivalent\ iff$
  $\Phi\ \ logically\ equivalent\ to\ \ \Psi\ \ and\ \ \alpha\ \ is\ logically\ equivalent\ to\ \ \beta.$

- **Defeater:**

  $A\ defeater\ for\ an\ argument\ \ \langle \Phi, \alpha \rangle\ \ is\ an\ argument\ \ \langle \Psi, \beta \rangle\ \ such\ that$
  $\beta \models \neg(\Phi_1 \wedge \cdots \wedge \Phi_n)\ \ for\ some\ \ \{\Phi_1, ..., \Phi_n\} \subseteq \Phi$

Abstract Argumentation (Dung 1995)

- Formal / mathematical study of the attack relation between arguments, independent of the actual content of the arguments.
- „Semantics“ selects subsets of arguments respecting certain criteria
- Simple yet powerful formalism
- Active research on different semantics



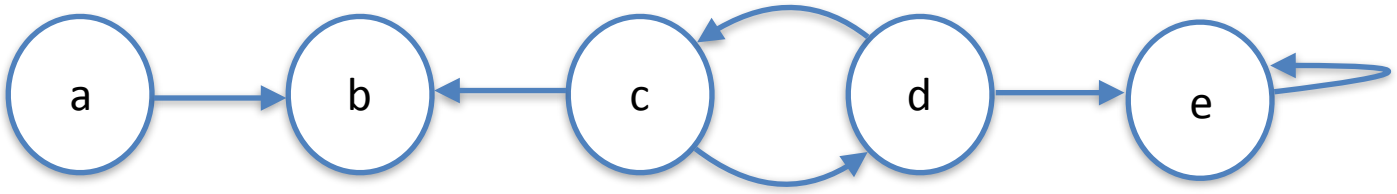
Abstract Argumentation (Dung 1995)

Definition: An **argumentation framework** (AF) is a pair *(A,R)* where

- A is a set of arguments
- $R \subseteq A \times A$ is a relation representing conflicts (aka „attacks)

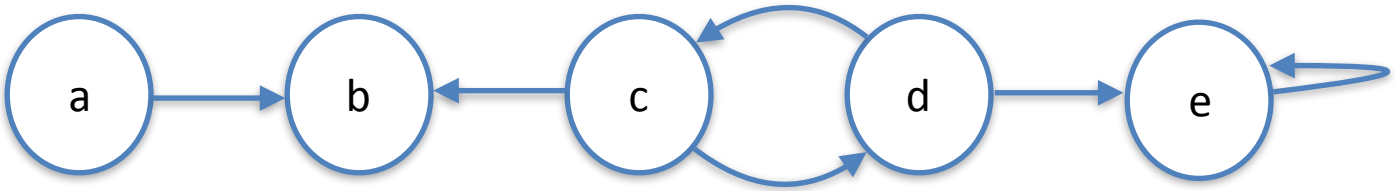
Example

F=({a,b,c,d,e},{(a,b),(c,b),(c,d),(d,c),(d,e),(e,e)}



Conflict-Free Set

Given an AF F=(A,R).
A set $S \subseteq A$ is conflict-free in F, if, for each $a, b \in S : (a, b) \notin R$



Conflict-Free Sets:

{a,c}

{a,d}

{b,d}

{a}

{b}

{c}

{d}

{}

Admissible Sets

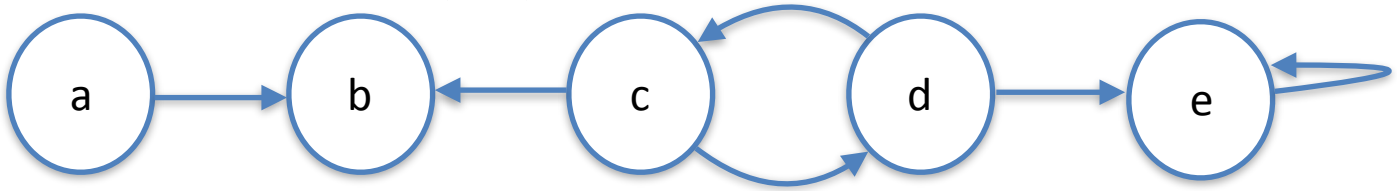
Def.: **Admissible Set**

Given an AF F=(A,R).

A set $S \subseteq A$ **is admissible** in F, if

- S is conflict-free
- each $a \in S$ is defended by S in F

$a \in S$ is defended by S in F, if for each $b \in A$ with $(b, a) \in R$, there exists $c \in S$, such that $(c, b) \in R$



Admissible Sets:

{a,c}

{a,d}

~~{b,d}~~

{a}

~~{b}~~

{c}

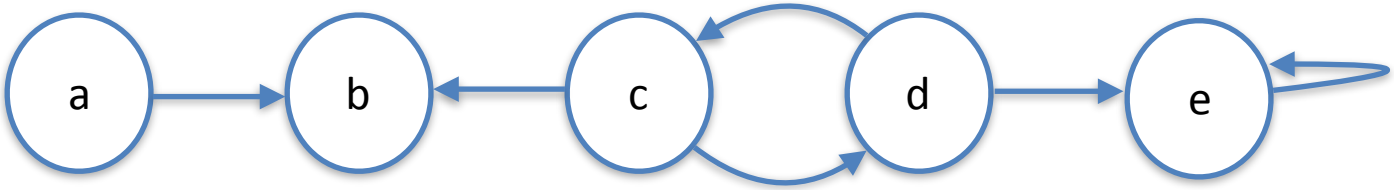
{d}

{}

Semantics (aka computing winning arguments)

Def.: **Grounded Extension**
Given an AF F=(A,R). The **unique** grounded extension of F is defined as the outcome S of the following procedure:

1. put each argument $a \in A$ which is not attacked in F into S; return {} if there is no such an argument
2. remove from F all arguments in S and all arguments attacked by them; continue with step 1



ground(F)=S={a}

Other Semantics

There is not a single way to interpret an argumentation framework.

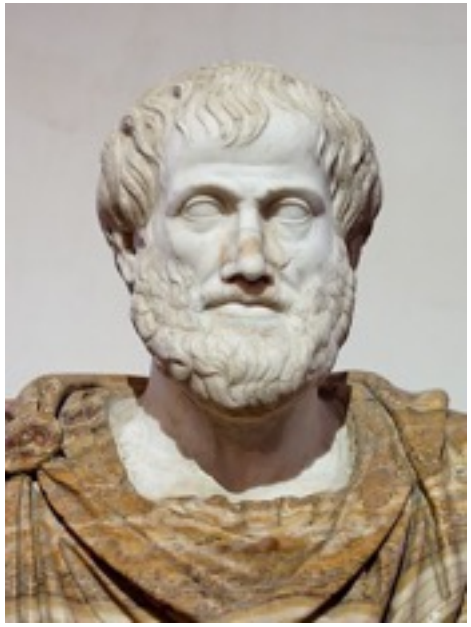
Besides the *grounded extension*, there are other extensions, such as the *preferred extension* or the *stable extension*, defining the so called **preferred semantics** and **stable semantics**, respectively, for argumentation frameworks.

We will not discuss these other semantics in detail here.

Terminology

- An **argument** consists of premises (propositions) and a conclusion (proposition)
- **Premises** are propositions assumed to be true.
  - Minor premise: A proposition that is specific to the case under consideration.
  - Major premise: A universal rule.
- **Enthymeme**: an argument that omits a conclusion or a premise.
- **Stance**: the position towards a proposition (assignment of truth value)
  - Synonyms: viewpoint, view, standpoint, stand, position
- **Claim**: a statement that conveys a standpoint.
- **Thesis / Major Claim:** the overall/summarizing claim in a debate

Terminology



I have evidence to know/belief that Socrates is mortal.

Stance

[Socrates is mortal]=true

Socrates is mortal.

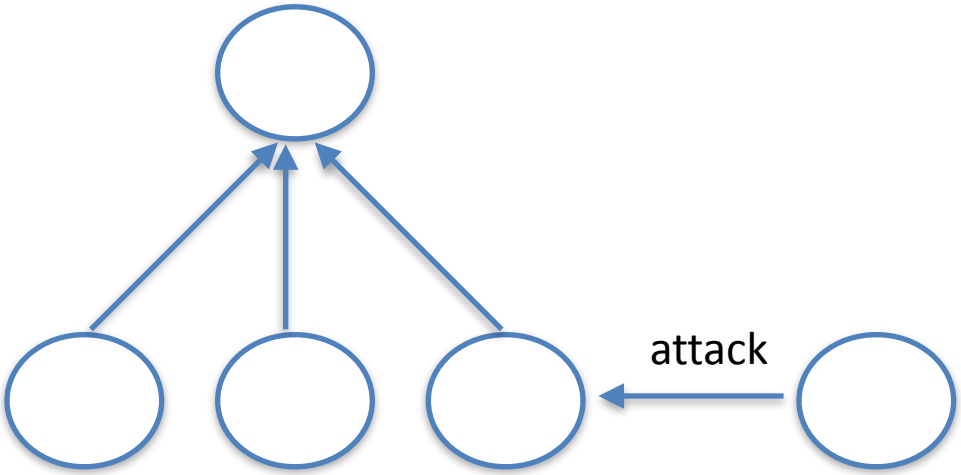
Claim

Galaxy Travel (courtesy of Benno Stein)

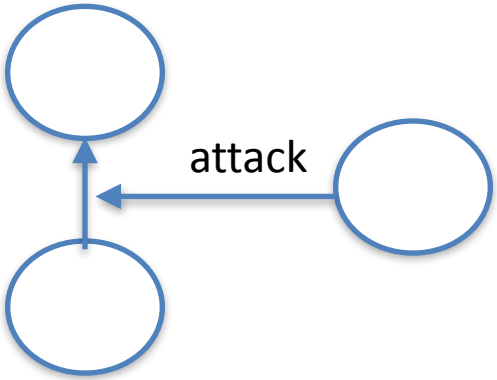
Thesis / Major Claim	Human beings will colonize other planets.
Claim	C1: Mankind will be able to travel to other galaxies.
Premises	P1: Photon drives can take you up to relativistic velocity. P2: In August 2019, Lightsail2 demonstrated its functioning. P3: NASA announces progress on torpor (human hibernation).

Terminology (2)

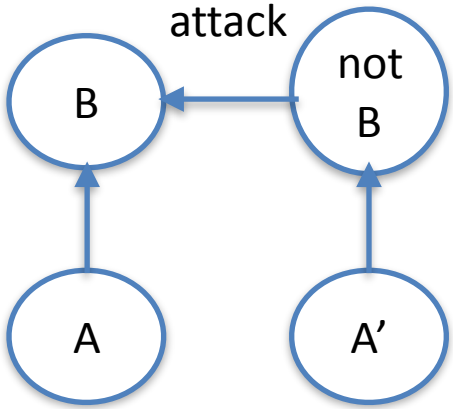
- Forms of attack (Pollock 1987)
  - **Underminer:**



  - **Undercutter:**



  - **Rebuttal:**



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