Lecture 7: Argumentation I

Peter McBurney

November 2019

(with thanks to Elizabeth Black)

Today

1. Introduction to Artificial Intelligence (FMT)
2. Probabilistic Reasoning I (FMT)
3. Probabilistic Reasoning II (FMT)
4. Sequential Decision Making (FMT)
5. Game Theory (FMT)
6. Temporal Probabilistic Reasoning (FMT)
7. Argumentation I (PMcB)
8. Argumentation II (PMcB)
9. (A peek at) Machine Learning (PMcB)
10. AI & Ethics (SS)

Today

- Introduction
- Abstract argumentation
- Extension-based semantics
- Complete semantics
- Grounded semantics
- Preferred semantics
- Stable semantics
- Argument acceptance

What is an argument?

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“A statement, reason, or fact for or against a point.”
http://www.dictionary.com/browse/argument

“ A course of reasoning aimed at demonstrating truth or false-hood” https://www.thefreedictionary.com/argument

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We should go on holiday to Costa Rica because we’ll see lots of amazing animals.

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"The evidence for a flat earth is derived from many different facets of science and philosophy. The simplest is by relying on ones own senses to discern the true nature of the world around us. The world looks flat, the bottoms of clouds are flat, the movement of the sun; these are all examples of your senses telling you that we do not live on a spherical heliocentric."
world. www.theflatearthsociety.org

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"…I still have a dream, a dream deeply rooted in the American dream – one day this nation will rise up and live up to its creed, "We hold these truths to be self evident: that all men are created equal." I have a dream ..."
—Martin Luther King Jr. (1963)

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Argumentation theory

"Argumentation is a verbal, social, and rational activity aimed at convincing a reasonable critic of the acceptability of a standpoint by putting forward a constellation of propositions justifying or refuting the proposition expressed in the standpoint."

Van Eemeren and Grootendorst [2004]: *A Systematic Theory of Argumentation*.

BUT:

- Participants to arguments may have other purposes besides persuasion (eg, inquiry, negotiation, deliberation, etc).
- Arguments may involve utterances other than propositions (eg, promises, commands, images).

Examples of argumentation

Plato and Aristotle: dialectics.

Luca della Robbia

1437 - 1439

Examples of argumentation

Leaders' debate (ITV/REX)

Examples of argumentation

Examples of argumentation

2 **Look at the process of forming an opinion as an internal argument with yourself, a mental debate, so to speak.** This means looking at all sides of the issue, pro and con.

https://www.wikihow.com/Form-an-Opinion

Why do we want machines that can argue?

Argumentation theory allows us to deal with incomplete, uncertain, inconsistent knowledge, conflicting opinions, expressed in different media and formats – all typical of the real world.

Argumentation theory is inherently suited to providing explanations, and supports interactions between

- humans and machines (where humans can challenge, question, and input into the machine's reasoning)

- machines and machines (M2M communications).

Computational argumentation began in the 1980s, as researchers in the first wave of successful AI (Expert Systems) sought to provide explanations for automated decision systems (XAI).

Argumentation theory

Argumentation theory is concerned with **acceptability** conditions for arguments in relation to other arguments.

For example

a1	We should go to the park for a picnic, that's cheap and I don't have much money at the moment.
a2	But I'm cold today, we should go to the café instead.
a3	You won't be cold this afternoon, the forecast says it's going to be really hot.

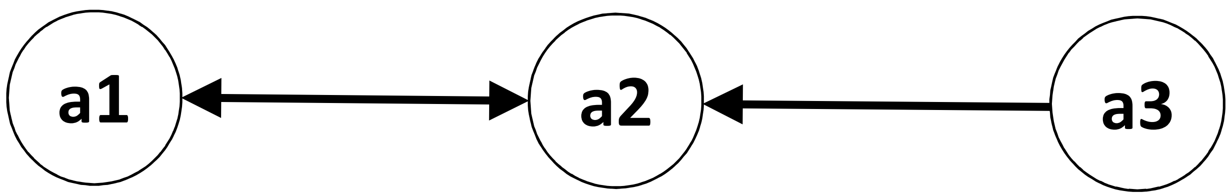
Arguments can **attack** one another.

Attack relations

a1 We should go to the park for a picnic, that will be the cheapest option.

a2 But I’m cold today, we should go to the café instead.

a3 You won’t be cold this afternoon, the forecast says it’s going to be really hot.



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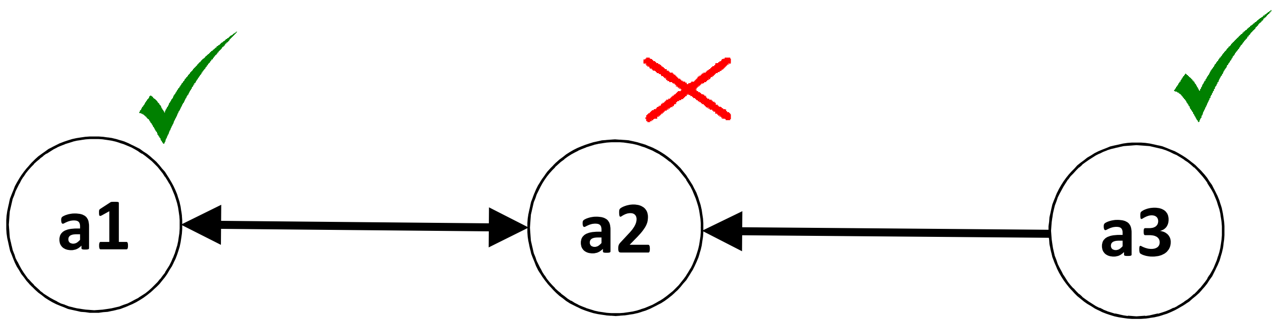

Approaches to argumentation

Argumentation can be formally studied from different angles.

- As a **dialogue** mechanism.
- By considering the **structure** of arguments and how this affects the attack relation between them.
- From an **abstract** point of view. We assume that an attack relation is given and we want to reason about what it is reasonable to conclude.

We will focus on abstract argumentation.

Abstract argumentation

Abstract argumentation disregards the internal structure of arguments and focusses instead on acceptability conditions that allow certain sets of arguments to co-exist in a *rational* manner.

P. M. Dung, "On the acceptability of arguments and its fundamental role in non-monotonic reasoning, logic programming and n-person games." *Artificial Intelligence*, 77:321–357, 1995.

Received the 2018 AIJ Classic Paper Award, which recognizes a paper published at least 15 years ago that has shown to be exceptional in its significance and impact.

Abstract argumentation

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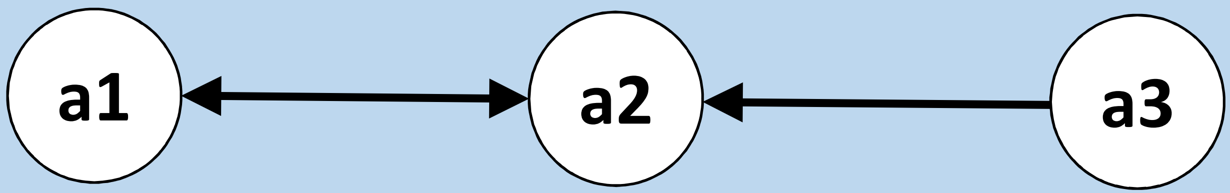


This is an abstract representation of the arguments above and the attacks between them.

Abstract argumentation

Abstract argumentation framework

An **abstract argumentation framework** is a tuple $\langle S, R \rangle$ where S is a set of **arguments** and $R \subseteq S \times S$ is an **attack relation**.

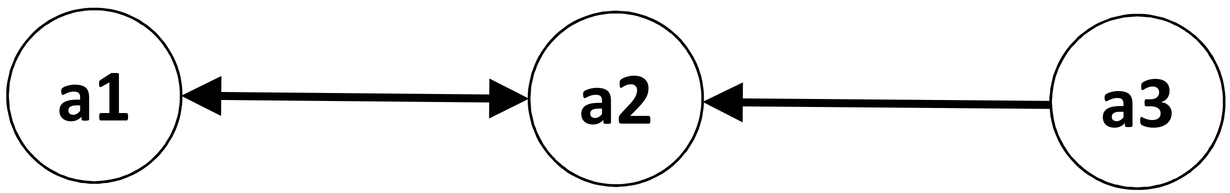
For $a, b \in S$, $(a, b) \in R$ means that argument a **attacks** argument b.

Sometimes we will use the term *argumentation framework* instead of *abstract argumentation framework*.

Abstract argumentation frameworks

An abstract argumentation framework is represented as a directed graph, where nodes represent arguments and an arrow from node x to node y indicates an attack from argument x to argument y.

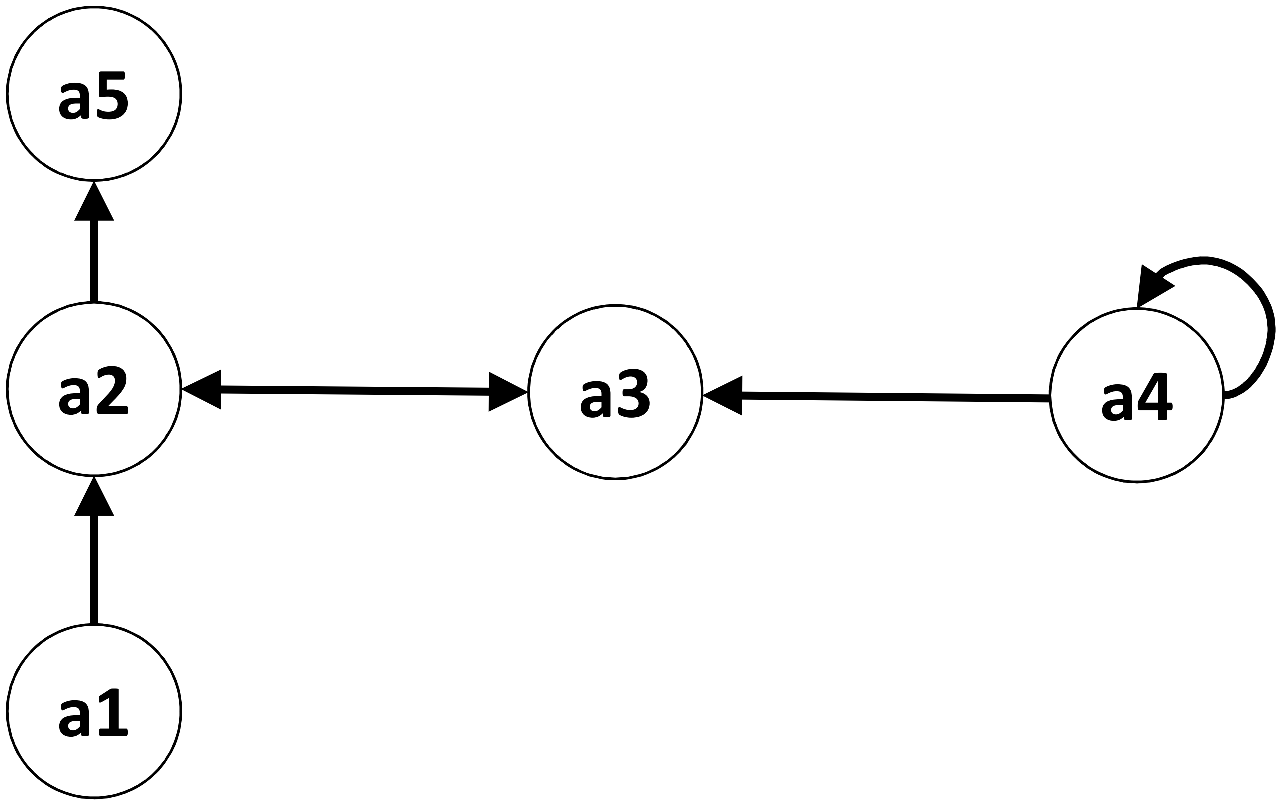
The abstract argumentation framework $\langle S, R \rangle$ where $S = \{a1, a2, a3\}$ and $R = \{(a1, a2), (a2, a1), (a3, a2)\}$ can be represented as:



Another example

$S = \{a1, a2, a3, a4, a5\}$

$R = \{(a1, a2), (a2, a5), (a2, a3), (a3, a2), (a4, a3), (a4, a4)\}$



Argumentation semantics

An argumentation framework $\langle S, R \rangle$ can be given semantics in different ways. The idea is to analyse what sets of arguments one can reasonably accept given the attack relation.

The semantics can be defined through different approaches:

- Via **extensions** (subsets of S with special properties)
- Via **labels** (labelling functions on S with special properties)
- Via **equations** (solutions to a system of equations describing the interactions in the argumentation framework $\langle S, R \rangle$)

Extension-based semantics

A subset of the set of arguments with special properties is defined (**extensions**):

- An extension is a set of arguments that are jointly “acceptable”.
- Arguments are justified according to their statuses in these extensions.

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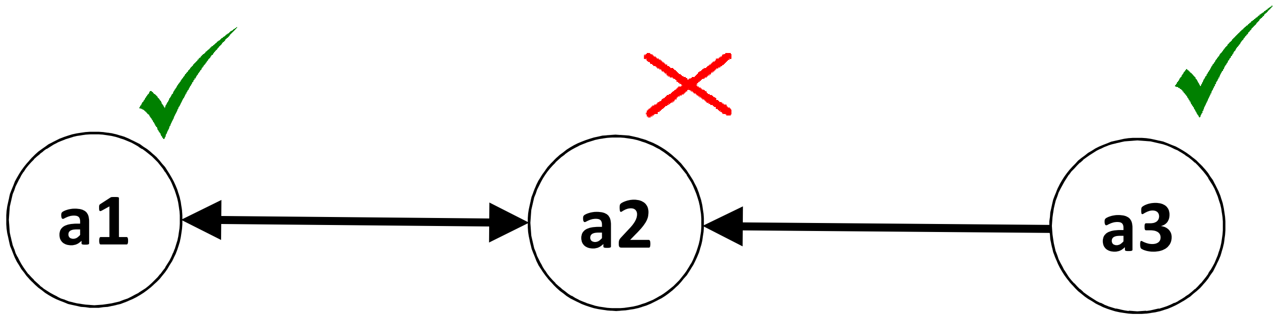


Extension-based semantics

A subset of the set of arguments with special properties is defined (**extensions**):

- An extension is a set of arguments that are jointly “acceptable”.
- Arguments are justified according to their statuses in these extensions.

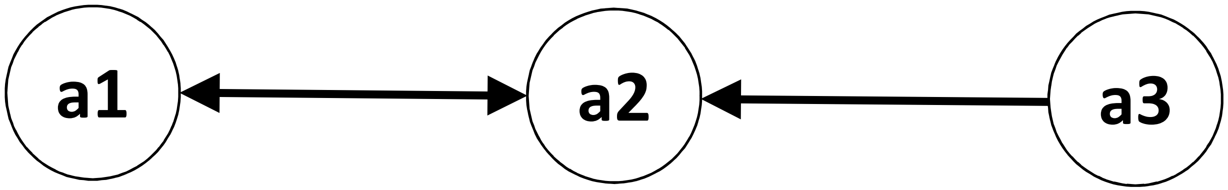
Before we can formally introduce extensions, we need to present some concepts.

Conflict-free sets

A set $T \subseteq S$ is **conflict-free** if and only if there are no arguments in T that attack each other. Formally:

For all $a, b \in T$, $(a, b) \notin R$.

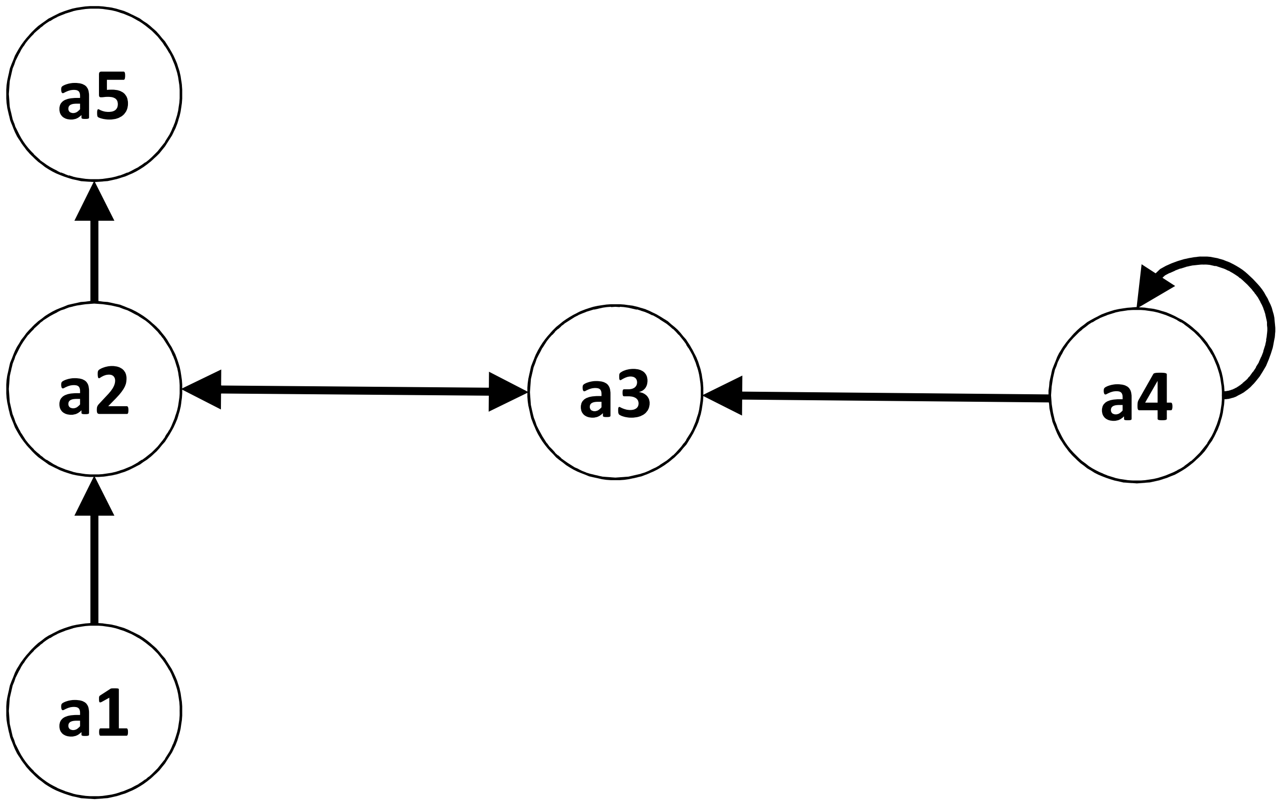
Example. The conflict free subsets of S are:
$\{\ \}, \{a1\}, \{a2\}, \{a3\}, \{a1, a3\}$.



Which sets are conflict-free?

$S = \{a1, a2, a3, a4, a5\}$

$R = \{(a1, a2), (a2, a5), (a2, a3), (a3, a2), (a4, a3), (a4, a4)\}$



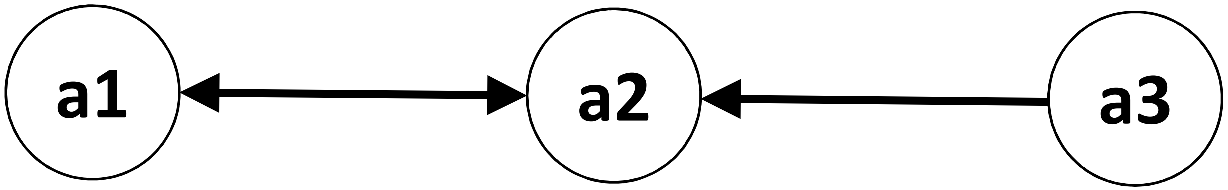
Argument defence

A set $T \subseteq S$ **defends** an argument $x \in S$ if and only if for every $y \in S$ such that y attacks x there is an element $z \in T$ such that z attacks y.

Example.

The set $\{a3\}$ defends $a1$.

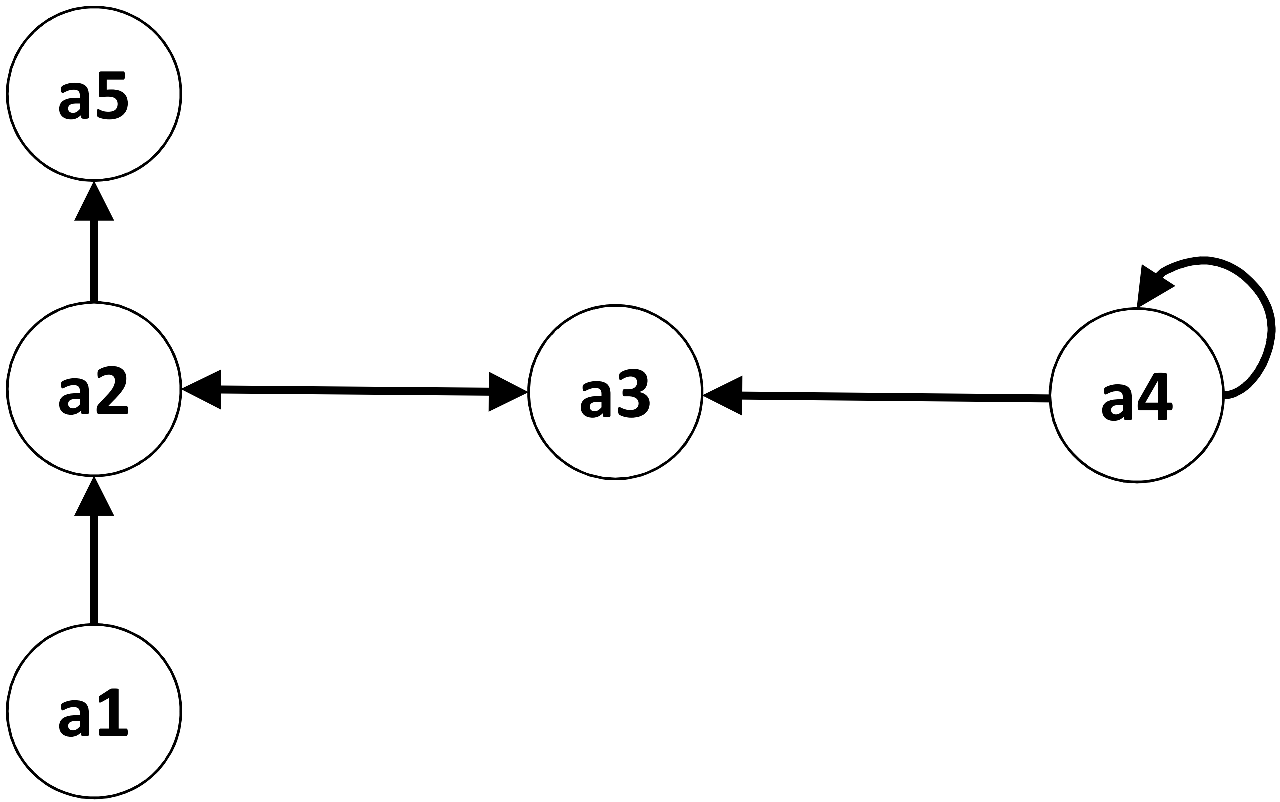
The set $\{\ \}$ defends $a3$.



Which sets defend each argument?

$S = \{a1, a2, a3, a4, a5\}$

$R = \{(a1, a2), (a2, a5), (a2, a3), (a3, a2), (a4, a3), (a4, a4)\}$

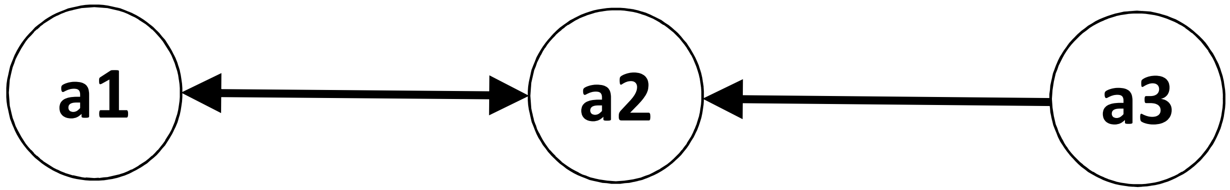


Admissible sets

A set $A \subseteq S$ is **admissible** if and only if A is conflict-free and A defends each argument that is a member of A.

Example.

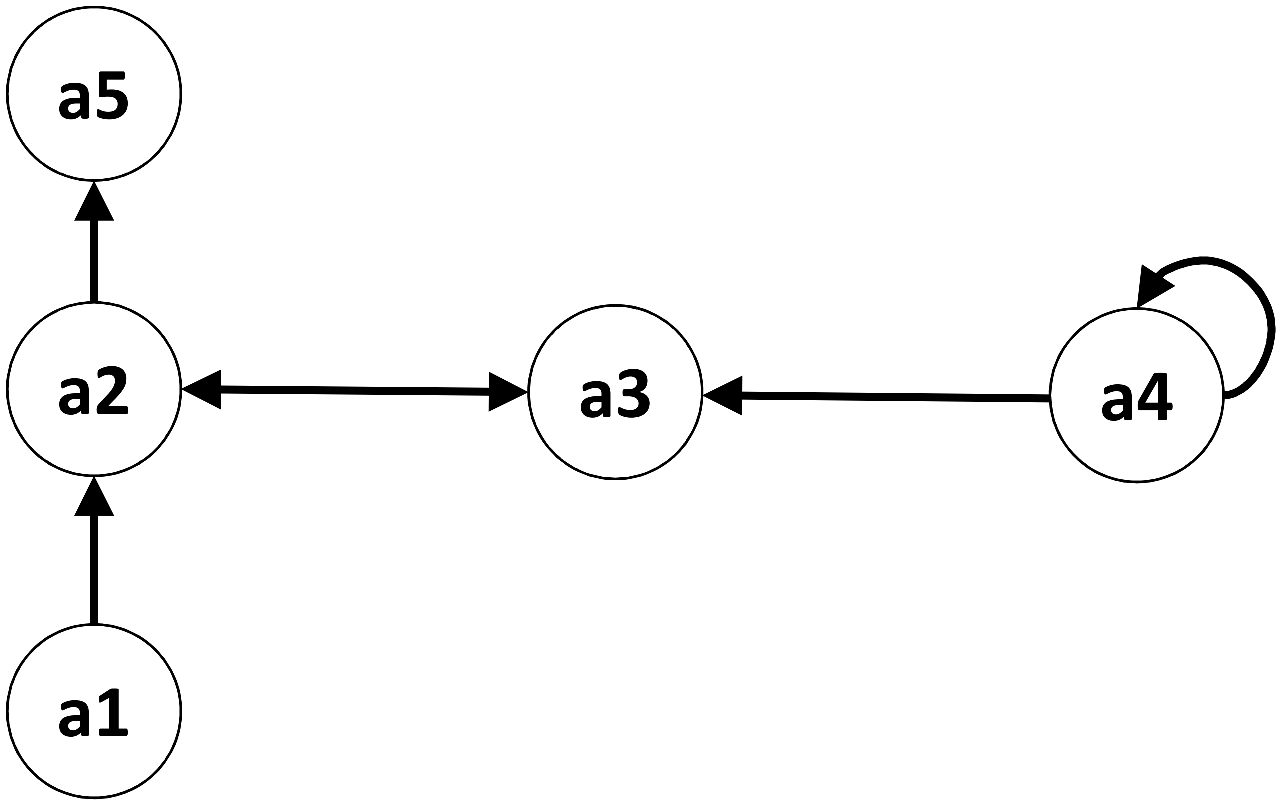
The admissible sets are: { }, $\{a1\}$, $\{a3\}$, $\{a1, a3\}$



Which sets are admissable sets?

$S = \{a1, a2, a3, a4, a5\}$

$R = \{(a1, a2), (a2, a5), (a2, a3), (a3, a2), (a4, a3), (a4, a4)\}$

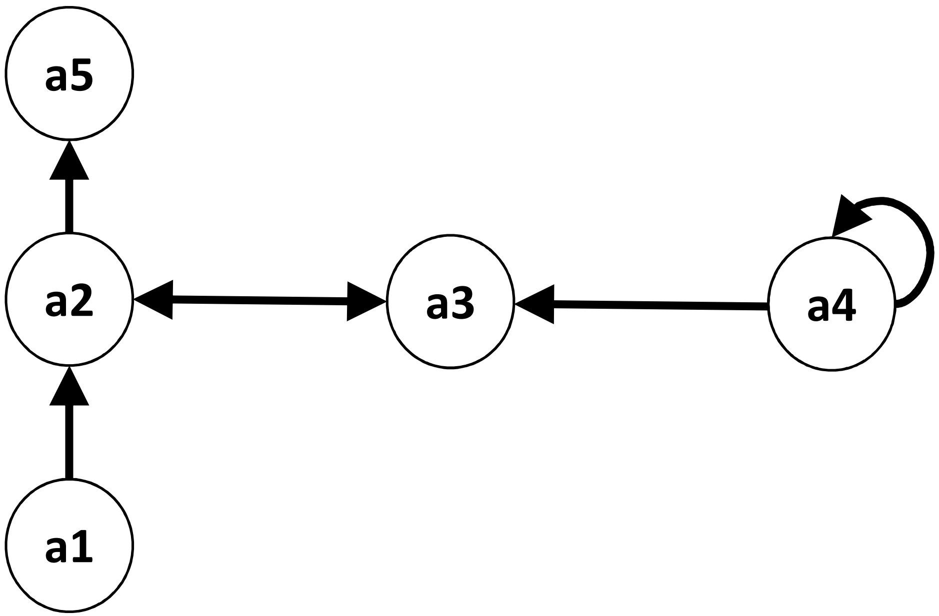


Complete semantics

The complete semantics aims to include in a set all arguments that the set can defend.

Complete extensions

A **complete extension** is an admissible set that includes **all** arguments it defends.



Example.

$E = \{a1, a5\}$ is a complete extension, since it is admissible and it defends both $a1$ and $a5$ (and doesn't defend any other arguments).

Note that $a3$ is not defended by E, since there is no argument in E that attacks $a4$, and $a4$ cannot be part of a conflict-free set.

The set $\{a1\}$ is not a complete extension, since it does not include $a5$, which it defends.

Exercise

Consider the set of arguments $S = \{a1, a2, a3, a4, a5\}$ and the attack relation $R = \{(a1, a2), (a3, a2), (a3, a4), (a4, a3), (a4, a5), (a5, a5)\}$.

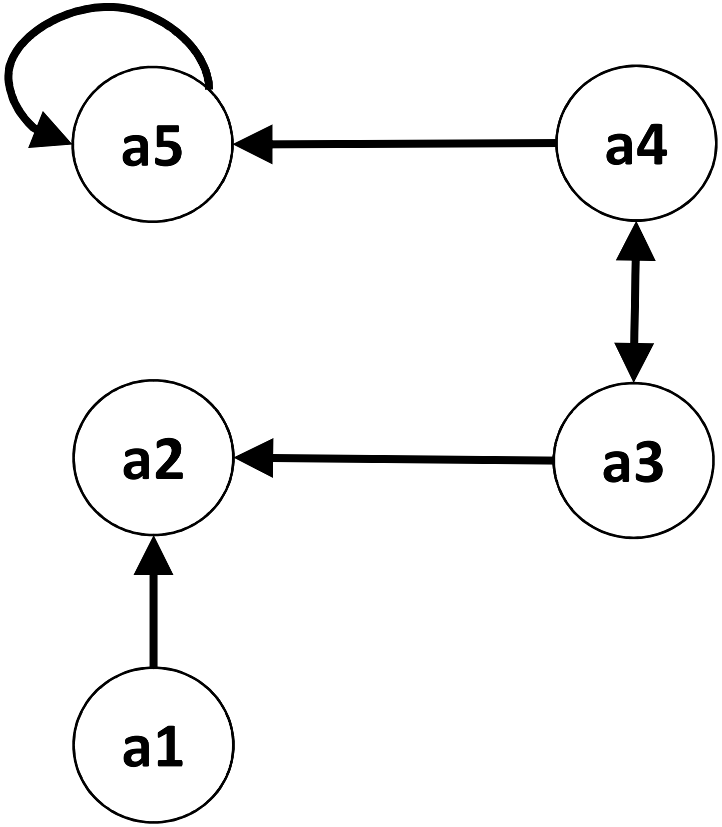
- Draw the argumentation framework.
- Compute all admissible subsets of S.
- Compute all complete extensions of $\langle S, R \rangle$.

Remember:

A set $A \subseteq S$ is **admissible** if and only if A is conflict-free and A defends each argument that is a member of A.

A **complete extension** is an admissible set that includes all arguments it defends.

Exercise



Admissible subsets:

$\{\ \}, \{a1\}, \{a3\}, \{a4\}, \{a1, a3\}, \{a1, a4\}$

Complete extensions:

$\{a1\}, \{a1, a3\}, \{a1, a4\}$

A set $A \subseteq S$ is **admissible** if and only if A is conflict-free and A defends each argument that is a member of A.
A **complete extension** is an admissible set that includes all arguments it defends.

Maximal and minimal subsets

Take $C \subseteq 2^S$, a **maximal subset** of S in C is a set $T \in C$ such that no other set in C strictly includes T.

Formally, T is a **maximal subset** of S in C if and only if $\nexists T' \in C$ such that $T \subsetneq T'$.

Example.

Take $S = \{a1, a2, a3\}$ and let $C = \big\{\{a1\}, \{a2\}, \{a1, a2\}, \{a2, a3\}\big\}$.

The maximal subsets of C in S are $\{a1, a2\}$ and $\{a2, a3\}$.

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Example.

Take $S = \{a1, a2, a3\}$ and let $C = \big\{\{a1\}, \{a2\}, \{a1, a2\}, \{a2, a3\}\big\}$.

The minimal subsets of C in S are $\{a1\}$ and $\{a2\}$.

Take S = {a1, a2, a3, a4} and let C = {{}, {a1}, {a2, a3}, {a2, a3, a4}}. Which of the following statements are true?

{a2, a3, a4} is a maximal subset of C in S.

{a1} is a maximal subset of C in S.

{a1} is a minimal subset of C in S.

{a2, a3} is a minimal subset of C in S.

Take S = {a1, a2, a3, a4} and let C = {{}, {a1}, {a2, a3}, {a2, a3, a4}}. Which of the following statements are true?

{a2, a3, a4} is a maximal subset of C in S.

{a1} is a maximal subset of C in S.

{a1} is a minimal subset of C in S.

{a2, a3} is a minimal subset of C in S.

Correct answers:
{a2, a3, a4} is a maximal subset of C in S.
{a1} is a maximal subset of C in S.

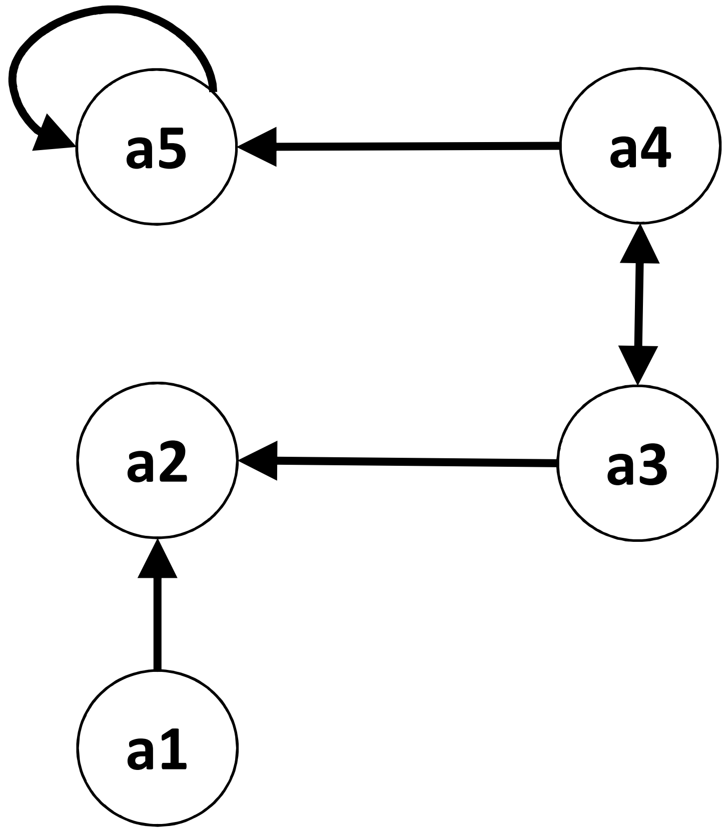
Grounded semantics

The grounded semantics aims to be cautious in the acceptance of arguments.

You can think of it as “Accept only what is not controversial”.

Grounded extension

The **grounded extension** is the minimal complete extension with respect to set inclusion (ie, the minimal subset of the set of complete extensions).



Example.

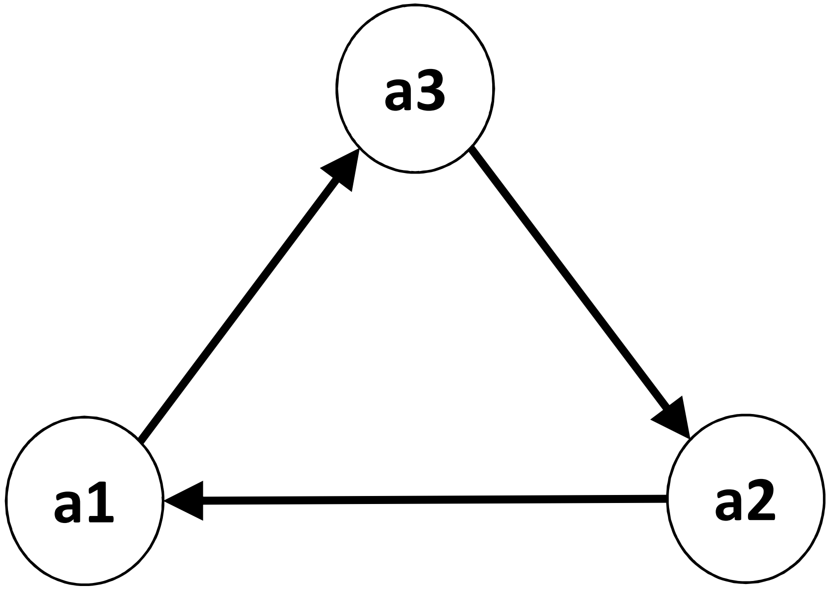
Complete extensions: $\{a1\}$, $\{a1, a3\}$, $\{a1, a4\}$.

Grounded extension: $\{a1\}$.

Grounded extension

The grounded extension always exists and it is unique.

The grounded extension can be empty.



Example.

Conflict-free subsets: $\{\ \}$, $\{a1\}$, $\{a2\}$ and $\{a3\}$.

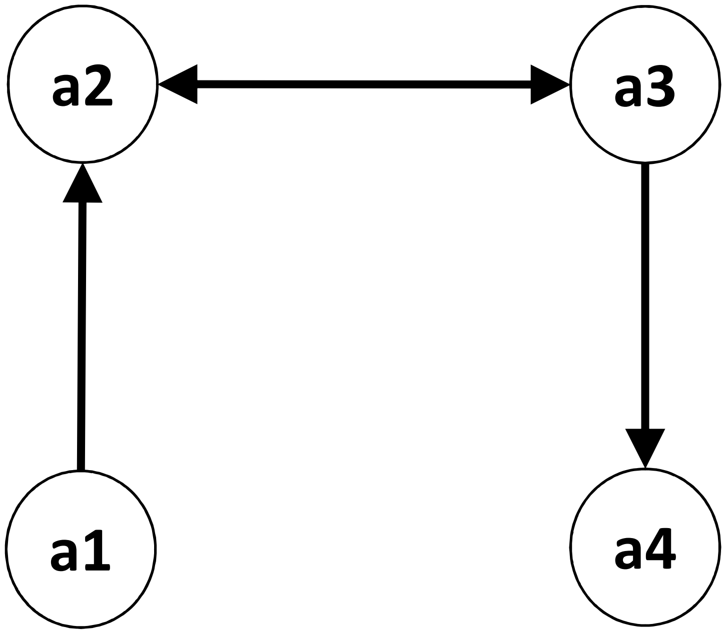
Admissible subsets: $\{\ \}$

Complete extensions: $\{\ \}$

Grounded extension: $\{\ \}$

Exercise

What is the grounded extension of the argumentation framework below?



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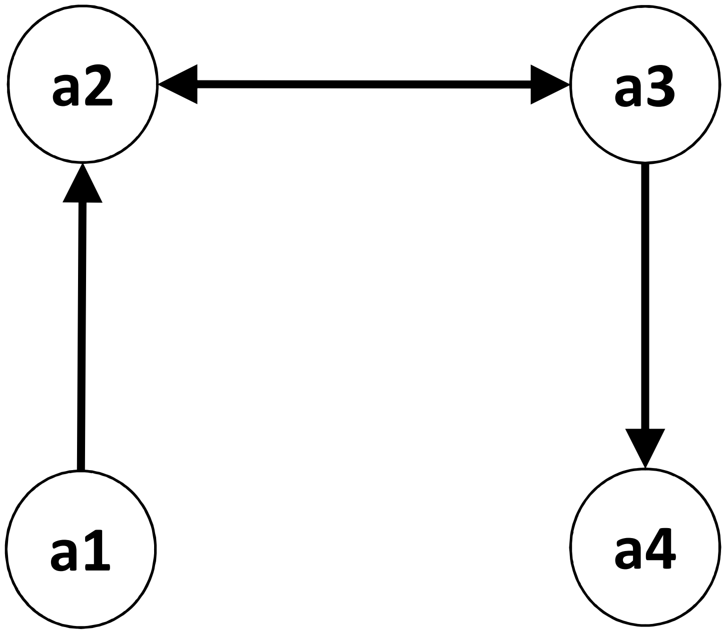


Conflict-free subsets: $\{\ \}$, $\{a1\}$, $\{a2\}$, $\{a3\}$, $\{a4\}$, $\{a1, a3\}$, $\{a1, a4\}$, $\{a2, a4\}$

Admissible subsets: $\{\ \}$, $\{a1\}$, {a3}, $\{a1, a3\}$

Complete extensions: $\{a1, a3\}$

Grounded extension: $\{a1, a3\}$

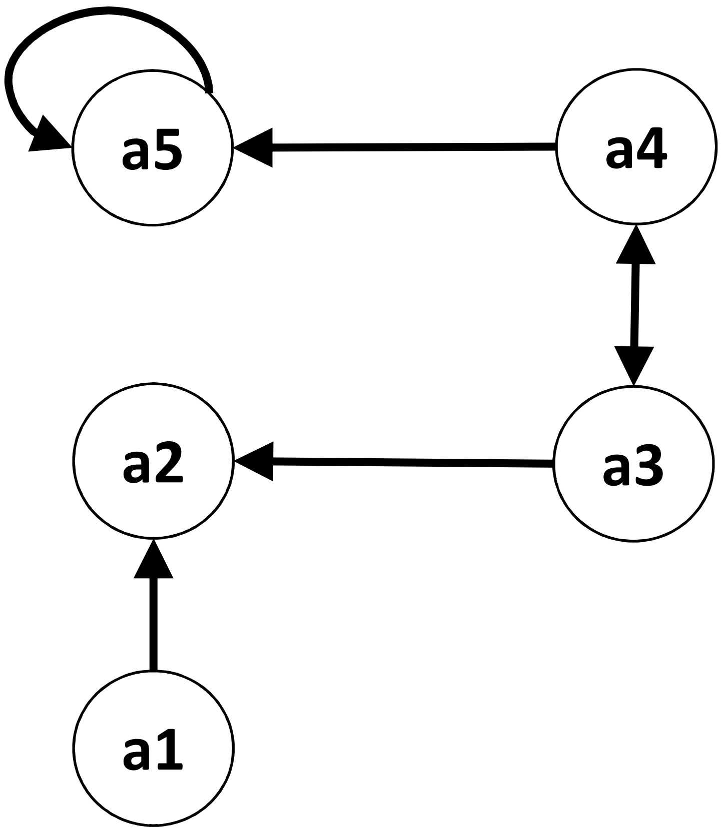
Preferred semantics

The preferred semantics tries to maximise the acceptance of arguments.

You can think of it as “Accept as much as you can defend”.

Preferred extension

A **preferred extension** is a complete extension that is maximal with respect to set inclusion (ie, a maximal subset of the set of all complete extensions).



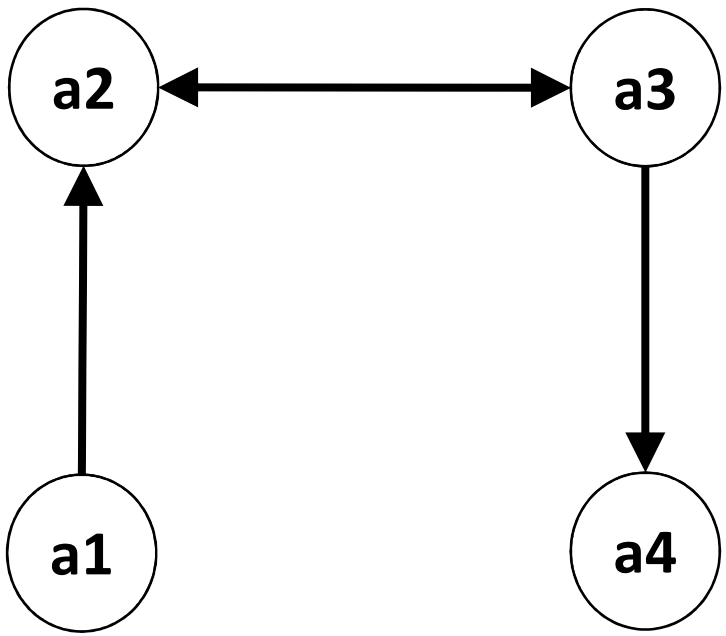
Example.

Complete extensions: $\{a1\}$, $\{a1, a3\}$, $\{a1, a4\}$.

Preferred extensions: $\{a1, a3\}$, $\{a1, a4\}$.

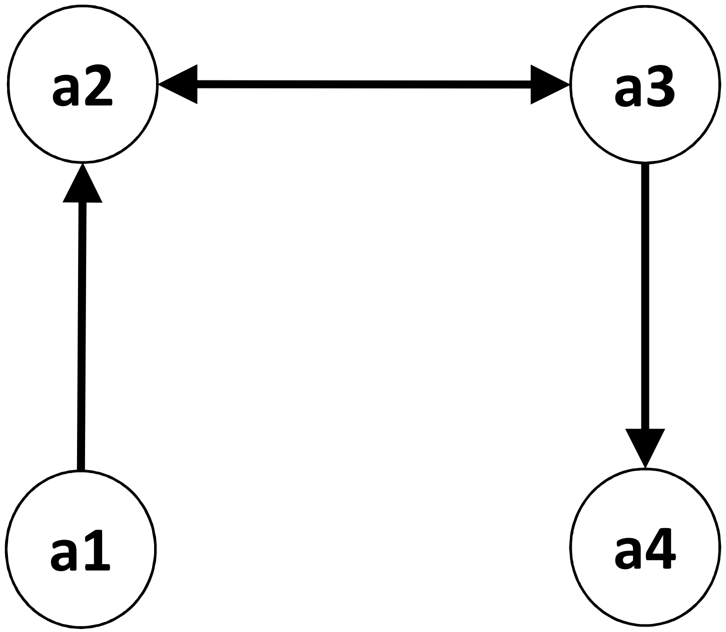
Exercise

What are the preferred extensions of the argumentation framework below?



Exercise

What are the preferred extensions of the argumentation framework below?



Conflict-free subsets: $\{\ \}$, $\{a1\}$, $\{a2\}$, $\{a3\}$, $\{a4\}$, $\{a1, a3\}$, $\{a1, a4\}$, $\{a2, a4\}$

Admissible subsets: $\{\ \}$, $\{a1\}$, $\{a3\}$, $\{a1, a3\}$

Complete extensions: $\{a1, a3\}$

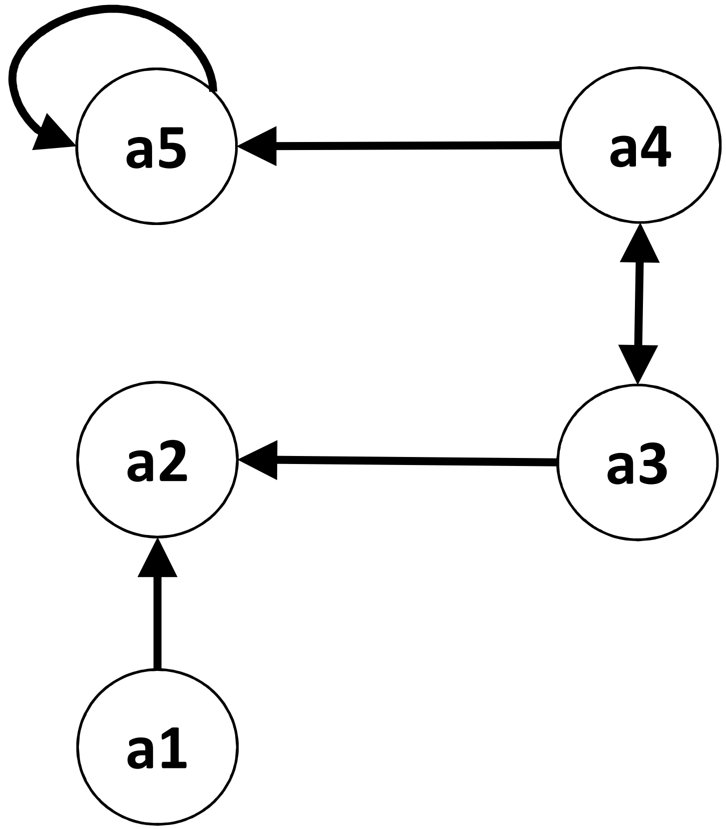
Preferred extensions: $\{a1, a3\}$

Grounded, complete and preferred extensions

Complete extensions: $\{a1\}$, $\{a1, a3\}$, $\{a1, a4\}$.

Preferred extensions: $\{a1, a3\}$, $\{a1, a4\}$.

Grounded extension: $\{a1\}$.

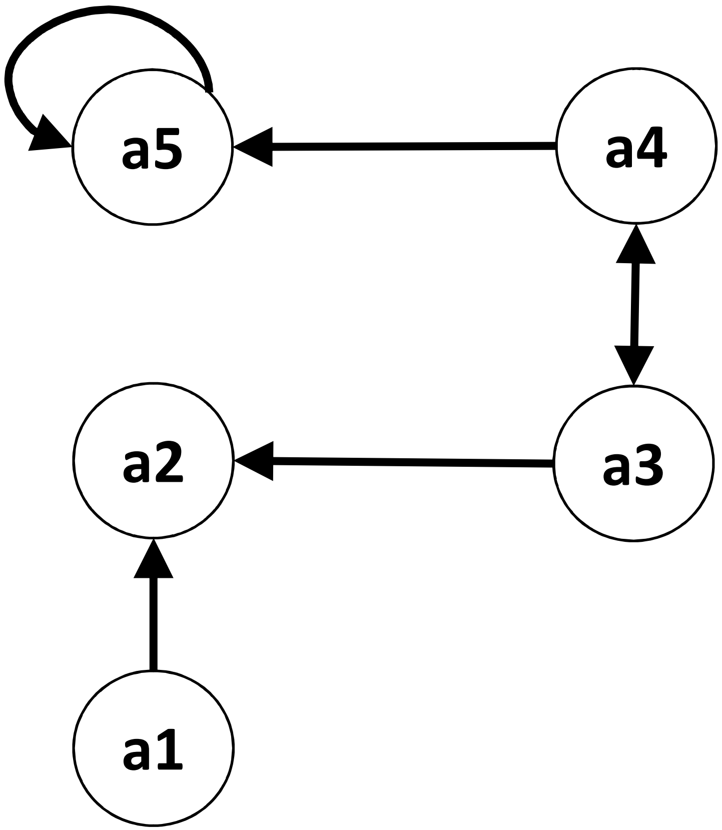


The grounded extension is included in all preferred extensions.

The grounded extension coincides with the intersection of all complete extensions.

Stable extension

A **stable extension** of an argumentation framework $\langle S, R \rangle$ is a preferred extension E such that for all $y \in S \setminus E$ there exists $x \in E$ such that $(x, y) \in R$ (in other words, for every argument y that isn't part of E, there is an argument in E that attacks y).



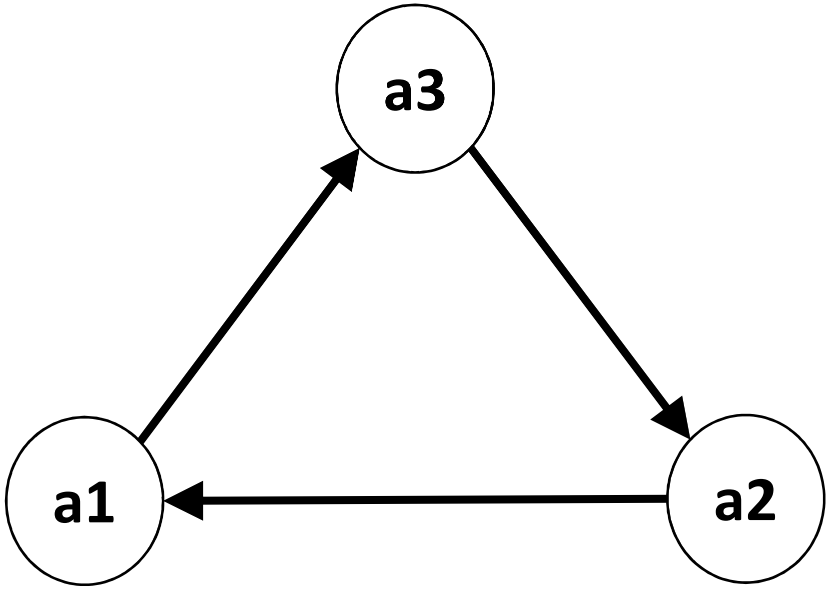
Example.

Preferred extensions: $\{a1, a3\}$, $\{a1, a4\}$.

Stable extensions: $\{a1, a4\}$.

Stable extension

Stable extensions do not always exist.



Example.

Conflict-free subsets: { }

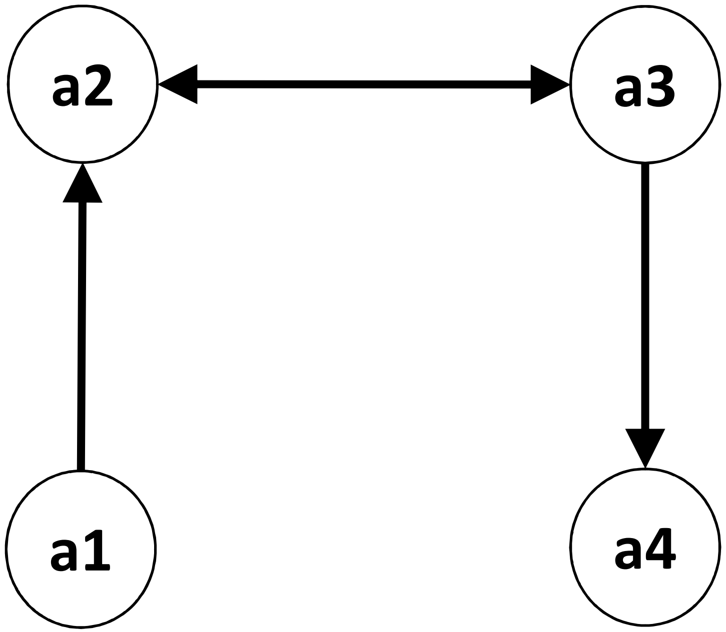
Admissible subsets: { }

Complete extensions: { }

No stable extension.

Exercise

What are the stable extensions of the argumentation framework below?



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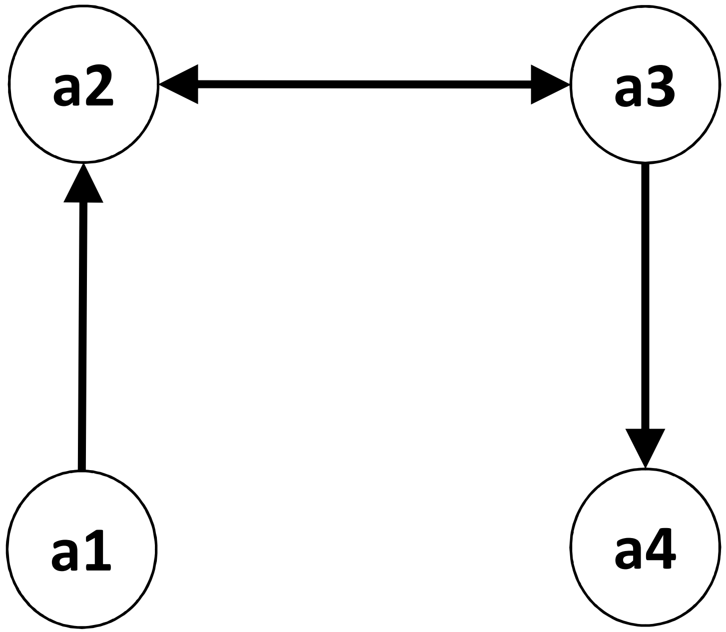


Conflict-free subsets: $\{\ \}$, $\{a1\}$, $\{a2\}$, $\{a3\}$, $\{a4\}$, $\{a1, a3\}$, $\{a1, a4\}$, $\{a2, a4\}$

Admissible subsets: $\{\ \}$, $\{a1\}$, $\{a3\}$, $\{a1, a3\}$

Complete extensions: $\{a1, a3\}$

Preferred extensions: $\{a1, a3\}$

Stable extensions: $\{a1, a3\}$

Credulous acceptance

An argument is **credulously accepted** by an argumentation framework under a particular semantics if and only if it is part of *at least one* of the extensions generated by those semantics.

For example, an argument is credulously accepted under the complete semantics if and only if it is part of at least one complete extension.

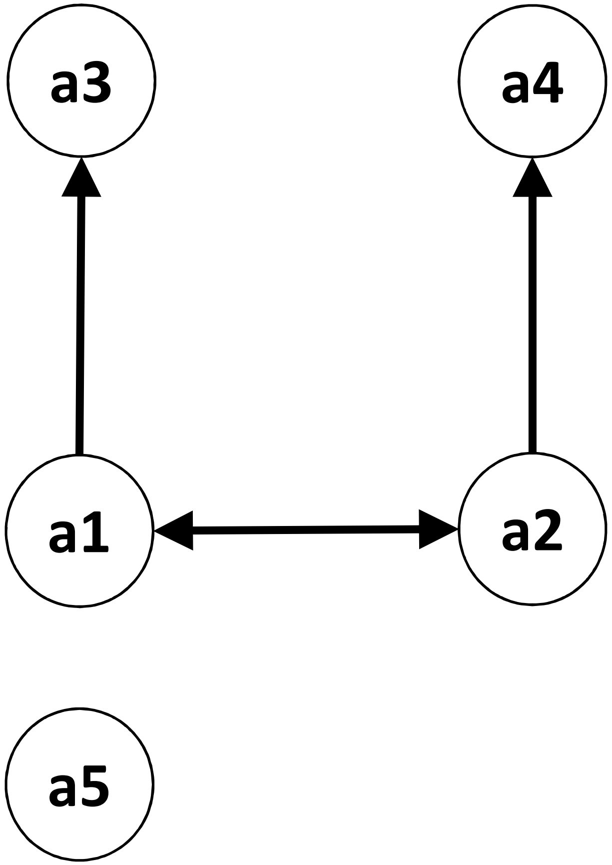
Skeptical acceptance

An argument is **skeptically accepted** by an argumentation framework under a particular semantics if and only if it is part of *all* of the extensions generated by those semantics.

For example, an argument is skeptically accepted under the complete semantics if and only if it is part of all of the complete extensions.

Exercise

For each of the following semantics, determine which arguments are credulously accepted and which arguments are skeptically accepted: complete, grounded, preferred, stable.



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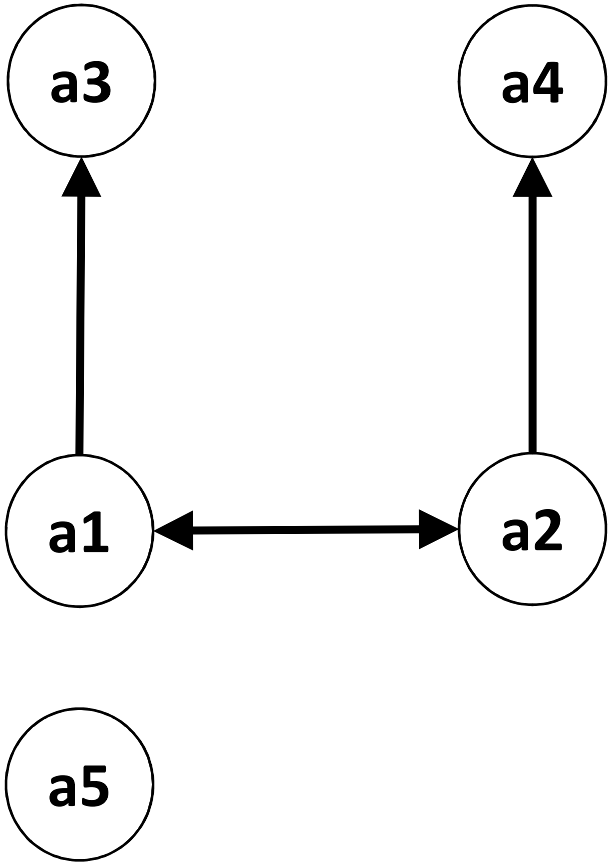

Conflict-free subsets: $\{\ \}$, $\{a1\}$, $\{a2\}$, $\{a3\}$, $\{a4\}$, $\{a5\}$, $\{a1, a4\}$, $\{a1, a5\}$, $\{a2, a3\}$, $\{a2, a5\}$, $\{a3, a4\}$, $\{a3, a5\}$, $\{a4, a5\}$, $\{a1, a4, a5\}$, $\{a2, a3, a5\}$, $\{a3, a4, a5\}$

Admissible subsets: $\{\ \}$, $\{a1\}$, $\{a2\}$, $\{a5\}$, $\{a1, a4\}$, $\{a1, a5\}$, $\{a2, a3\}$, $\{a2, a5\}$, $\{a1, a4, a5\}$, $\{a2, a3, a5\}$

Complete extensions: $\{a5\}$, $\{a1, a4, a5\}$, $\{a2, a3, a5\}$

Grounded extension: $\{a5\}$

Preferred extensions: $\{a1, a4, a5\}$, $\{a2, a3, a5\}$

Stable extensions: $\{a1, a4, a5\}$, $\{a2, a3, a5\}$

Exercise

Complete extensions: $\{a5\}$, $\{a1, a4, a5\}$, $\{a2, a3, a5\}$

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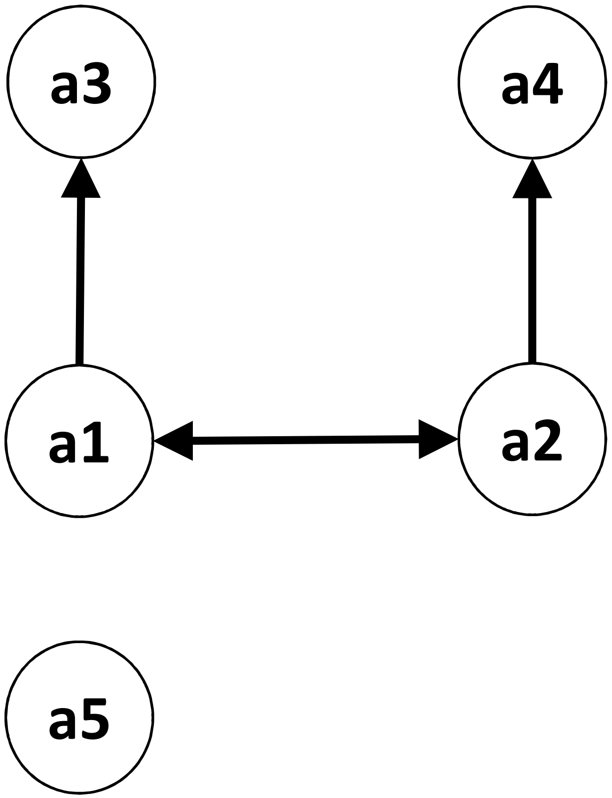


Credulously accepted complete: all arguments.

Skeptically accepted complete: $a5$.

Credulously/skeptically accepted grounded: $a5$.

Credulously accepted preferred/stable: all arguments.

Skeptically accepted preferred/stable: $a5$.

Exercise (will be added to tutorial sheet)

Consider the set of arguments $S = \{a1, a2, a3, a4, a5\}$ and the attack relation $R = \{(a1, a2), (a2, a1), (a2, a3), (a3, a4), (a4, a5), (a5, a3)\}$.

- Draw the argumentation framework.
- Compute all complete extensions of $\langle S, R \rangle$.
- Give the grounded extension and all preferred extensions of $\langle S, R \rangle$.
- Give a stable extension of $\langle S, R \rangle$ if it has one.

Summary

- This lecture we looked at different extension-based semantics that can be used to determine subsets of arguments one can reasonably accept.
- Next time, we look at different ways of computing the semantics.

Note: The following slides are added to clarify some aspects that students in the past seemed to be having trouble grasping.

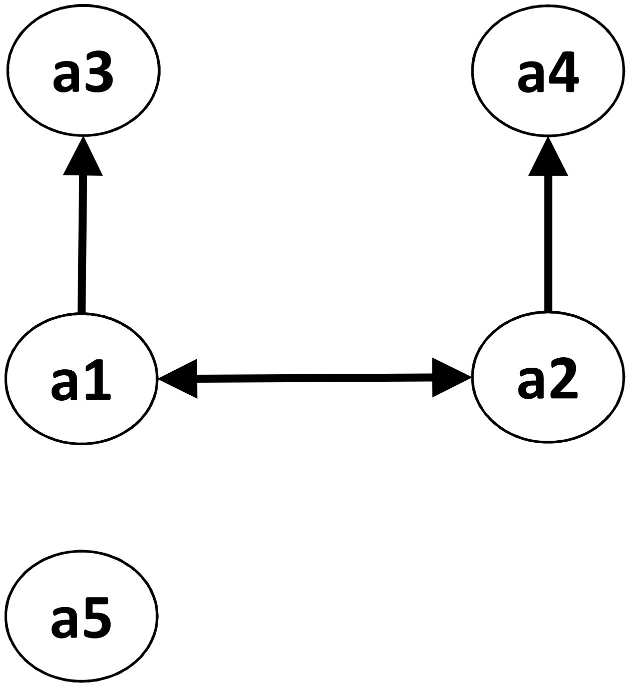
If there is an argument X that is not attacked by anything, then all sets defend X

Say we have an argument X that has no attackers. To check whether some set S = {A1, A2, …., AN} defends X, for each Y that attacks X we need to see if there is some argument Z in S such that Z attacks Y. Since there are no arguments that attack X, it will be true for any S that for all arguments Y that attack X, there is some argument Z in S that attacks Y.

If you're struggling to see why this is the case, think about the example "all the elephants in this room are pink". To check whether this is true, you need to check all the elephants in the room to see if they are pink. If there are no elephants in the room then the statement is true. Same thing holds above, if there are no arguments Y that attack X, then it will always be true that for all arguments Y that attack X, there is some argument in S that attacks Y.

If there is an argument X that is not attacked by anything, then all sets defend X

Say we have an argument X that has no attackers. To check whether some set S = {A1, A2, …., AN} defends X, for each Y that attacks X we need to see if there is some argument Z in S such that Z attacks Y. Since there are no arguments that attack X, it will be true for any S that for all arguments Y that attack X, there is some argument Z in S that attacks Y.



In this example (from slides 60 – 62) all subsets of the set of all arguments defend a5.

Examples:

{} defends a5.

{a2} defends a5.

{a5, a1} defends a5.

{a5} defends a5.

When is/isn't the empty set a complete extension?

If there is an argument X that is not attacked by anything, then all complete extensions will include X, and so the empty set is not a complete extension.

The reason for this is that if there is an argument X that is not attacked by anything, then all sets defend X (see previous slides if you don't understand this). Since complete extensions must contain everything that they defend, then all complete extensions must contain X.

If there is are no arguments that are not attacked by anything, then the empty set is a complete extension (and this is also the grounded extension).

The reason for this is that is if every argument has at least one attacker, then the empty set cannot defend any of those arguments (since it doesn't contain any arguments to attack their attackers) and so the empty set contains all the arguments it defends.