DEPARTAMENTO DE COMPUTACION

Facultad de Ciencias Exactas y Naturales - UBA

Abstract Argumentation Systems:
A Brief Introduction

– *Guillermo R. Simari* (grs@cs.uns.edu.ar)

Laboratorio de Investigación y Desarrollo en Inteligencia Artificial (LIDIA)

Instituto de Ciencias e Ingeniería de la Computación

Departamento de Ciencias e Ingeniería de la Computación

UNIVERSIDAD NACIONAL DEL SUR

Bahia Blanca - ARGENTINA

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Abstract Argumentation

Argumentation Conceptual View

Definition of Status of Arguments
Definition of Defeat among Arguments
Definition of Conflict among arguments
Definition of Argument
Definition of the Underlying (Logical) Language

Abstract Argumentation Frameworks

- *The formalism is built around a set of arguments and an attack relation.*
- *The abstraction comes from assuming these two things as given and not explaining how the arguments are built or how the attack relation is defined.*
- *The basic theory considers the arguments as atomic.*
- *At this level of abstraction, the theory can be simplified to the point where all the fine details arising from the expression of the interaction provided by the attack relation can be carefully studied to define the set of arguments' status.*

Conceptual View

Definition of Status of Arguments
Definition of Defeat among Arguments
Definition of Conflict among arguments
Definition of Argument
Definition of the Underlying (Logical) Language

Going back to the conceptual view, if we abstract away of all but the definition used to decide the status of arguments we can characterize a very interesting and rich formal structure.

Abstract Argumentation Frameworks

On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming and n-person games.

Phan Minh Dung.

Artificial Intelligence Journal

77(2):321-358, 1995.

Abstract Argumentation Frameworks

An *Abstract Argumentation Framework* AF is a pair:

$$< AR, \mathcal{R} >$$

$AR =$ Set of Arguments

$$\mathcal{R} \subseteq AR \times AR$$

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Set of Arguments

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Given two arguments $A,\ B \in AR$, the meaning of $(A,\ B) \in \mathcal{R}$ is that A *attacks* B.

Also it is said that A is an *attacker* of B or that that A is a *counterargument* for B.

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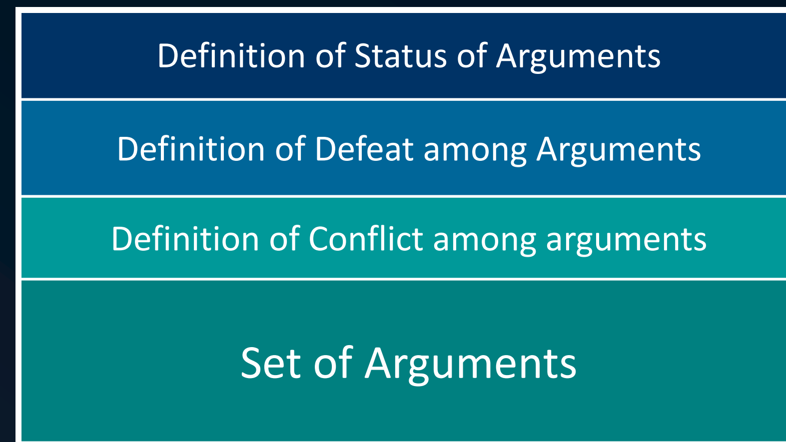

Remember that in the conceptual view two steps are necessary:

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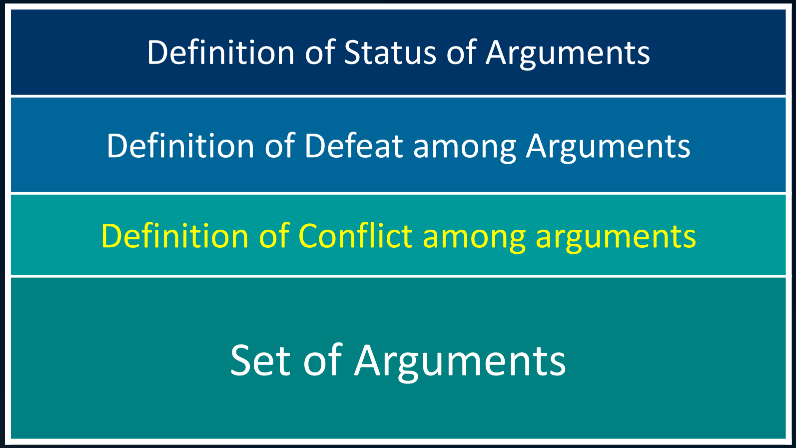

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- first introduce the definition of how arguments are in conflict, and

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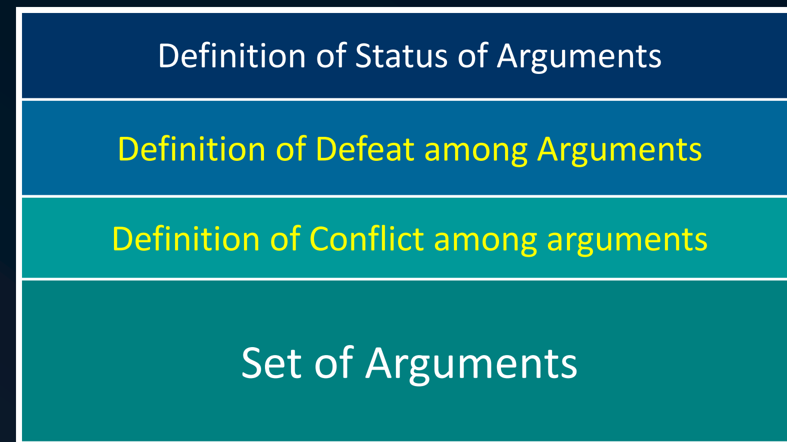

Remember that in the conceptual view two steps are necessary:

- first introduce the definition of how arguments are in conflict, and
- then define how the conflict is resolved creating the defeat relation.

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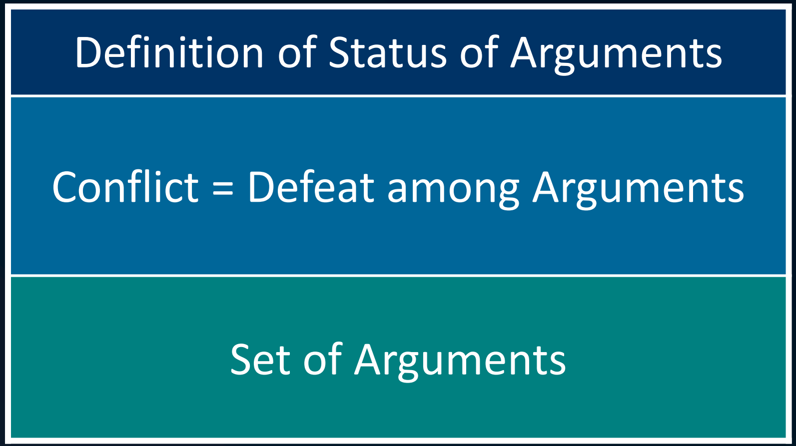


Remember that in the conceptual view two steps are necessary:

- first introduce the definition of how arguments are in conflict, and
- then define how the conflict is resolved creating the defeat relation.

In this formalism the attack always succeds, *i.e.*, every attack is in fact a defeat.

Defining the Status of Arguments: Argumentation Semantics

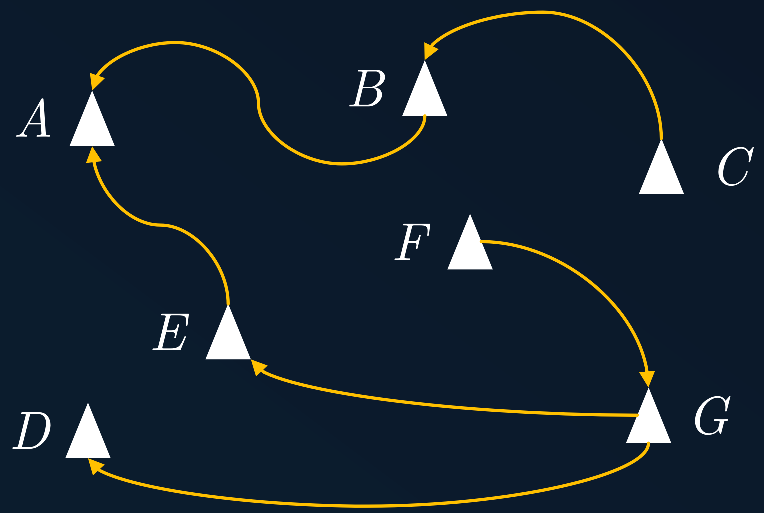
Abstract Argumentation Frameworks

The following is an example of an argumentation framework:

$\mathrm{AF} = < AR, \mathcal{R} >$ where

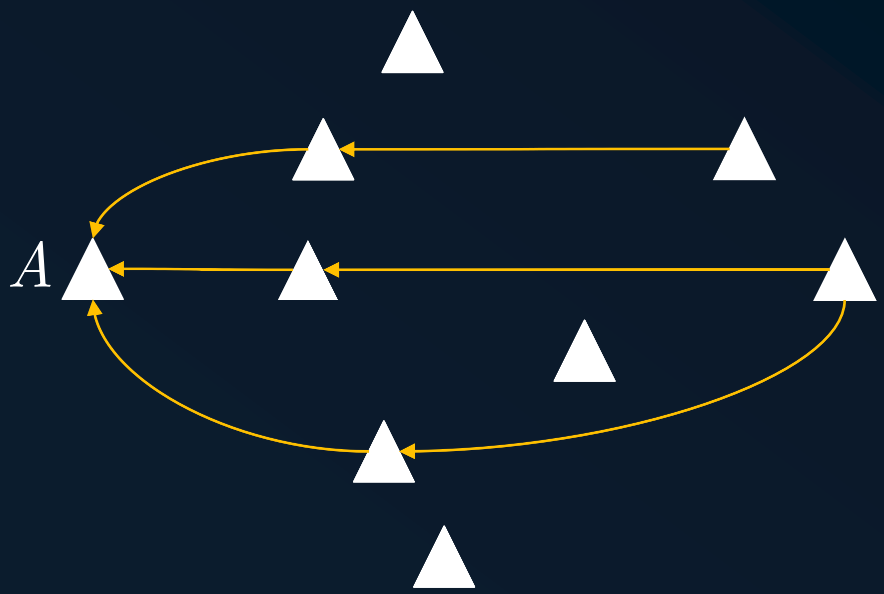
- $AR = \{\ A,\ B,\ C,\ D,\ E,\ F,\ G\ \}$
- $\mathcal{R} = \{(B,\ A),\ (C,\ B),\ (E,\ A),\ (G,\ E),\ (F,\ G),\ (G,D)\}$

Below the framework is visualized as a graph where the nodes are labelled by the arguments and the arcs represent the attack relation:



Aceptability in a Framework

- Given an abstract framework $\mathrm{AF} = < AR, \mathcal{R} >$, a set $S \subseteq AR$ ***attacks*** an argument $A \in AR$ if some argument $B \in S$ attacks A.



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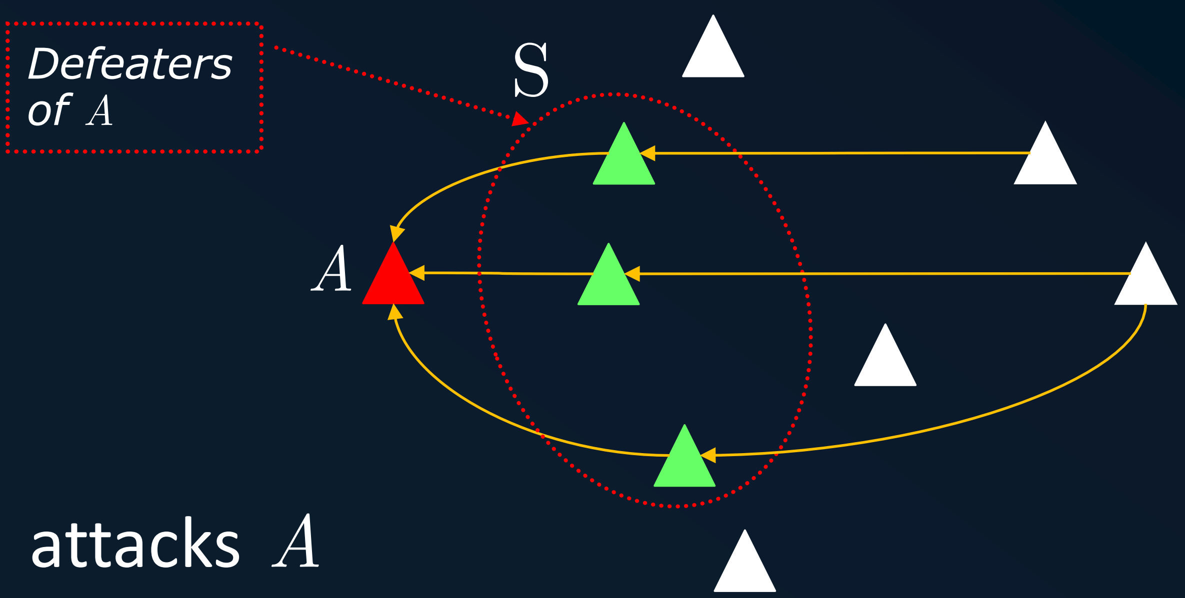
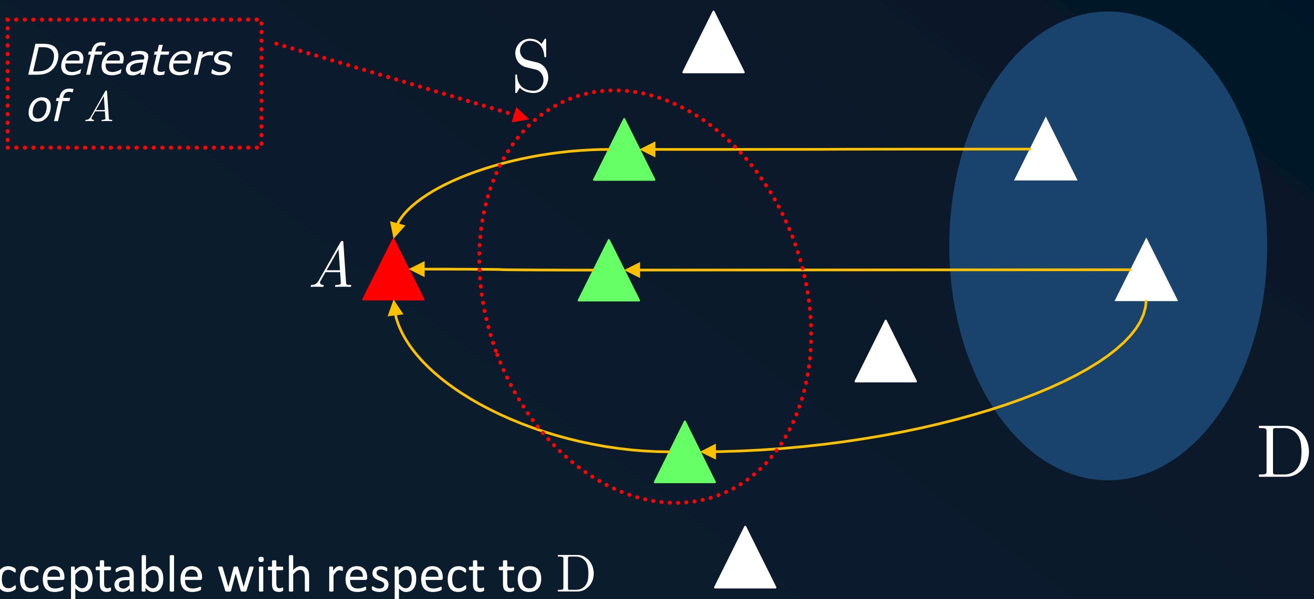


S attacks A

Aceptability in a Framework

- Given an abstract framework $\mathrm{AF} = < AR, \mathcal{R} >$, a set $S \subseteq AR$ ***attacks*** an argument $A \in AR$ if some argument $B \in S$ attacks A.
- An argument $A \in AR$ is ***acceptable with respect to a set*** $\mathrm{D} \subseteq AR$ iff for each argument $B \in AR$, if argument B attacks A then D attacks B.



A is acceptable with respect to D

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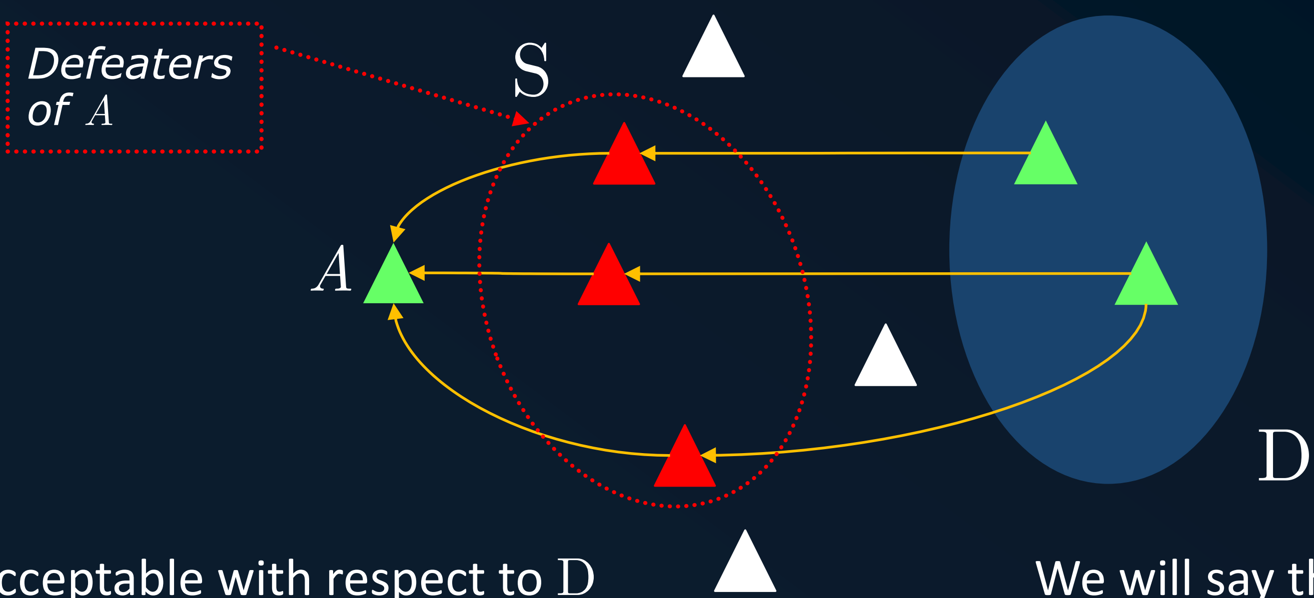


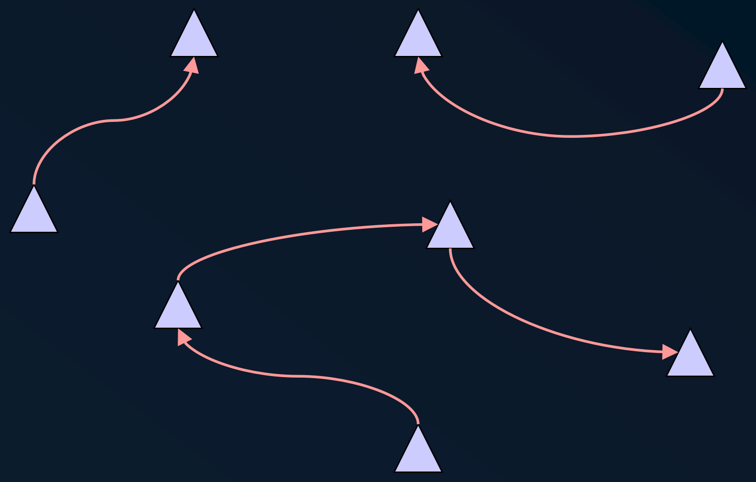
A is acceptable with respect to D

We will say that D defends A.

Aceptability in a Framework

An argument is clasified as justified if all its defeaters are arguments non justified.

An argument is clasified as not justified if at least one of its defeaters is a justified argument.



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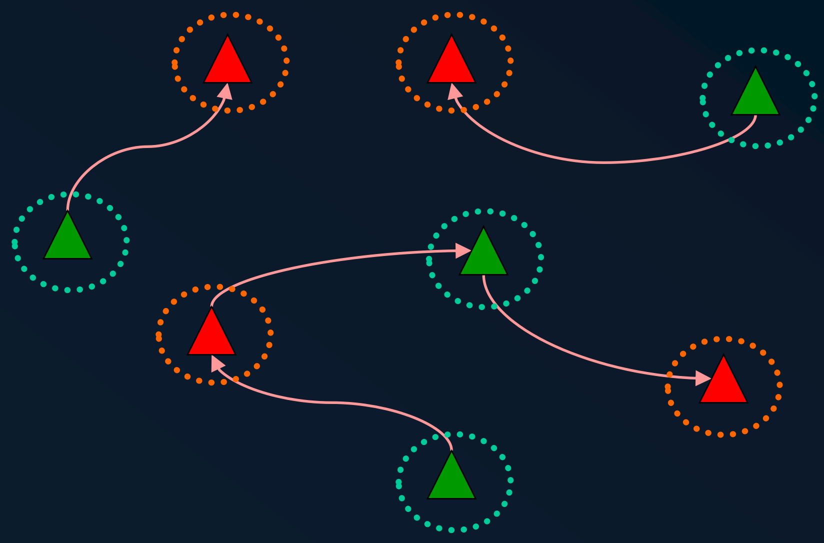

Aceptability in a Framework

- A set $\mathrm{S} \subseteq AR$ is said to be *conflict free* iff there are no $A, B \in \mathrm{S}$ such that A attacks B.
- A set $\mathrm{S} \subseteq AR$ is said to be *admissible* iff S is conflict free and defends all its elements. Trivially, the set $\varnothing$ is always admissible.

Let $\mathrm{AF} = < AR, \mathcal{R} >$ where

- $AR = \{\ A,\ B,\ C,\ D,\ E,\ F,\ G\ \}$
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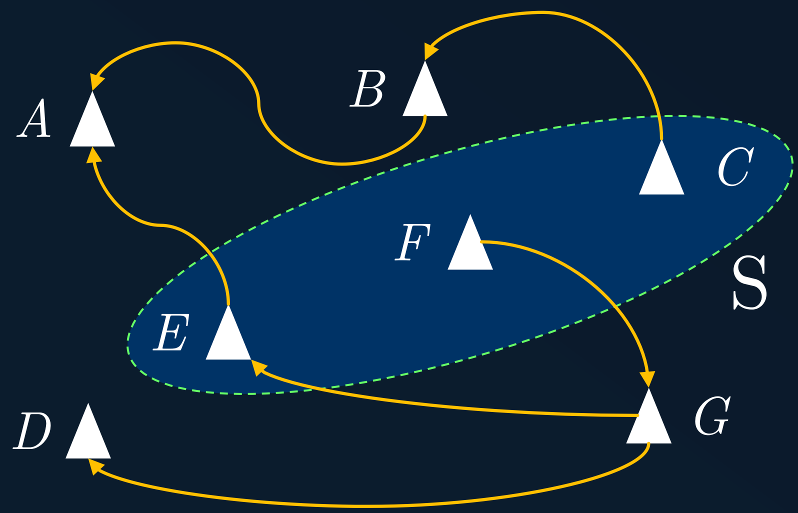

$\mathrm{S} = \{\ C,\ E,\ F\ \}$ is an admissible set.

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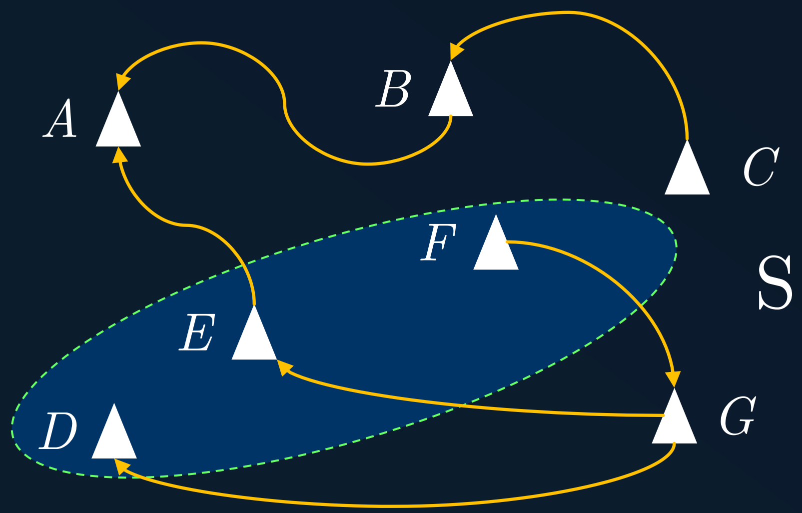

$\mathrm{S} = \{D,\ E,\ F\ \}$ is an admissible set.

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Let $\mathrm{AF} = < AR, \mathcal{R} >$ where

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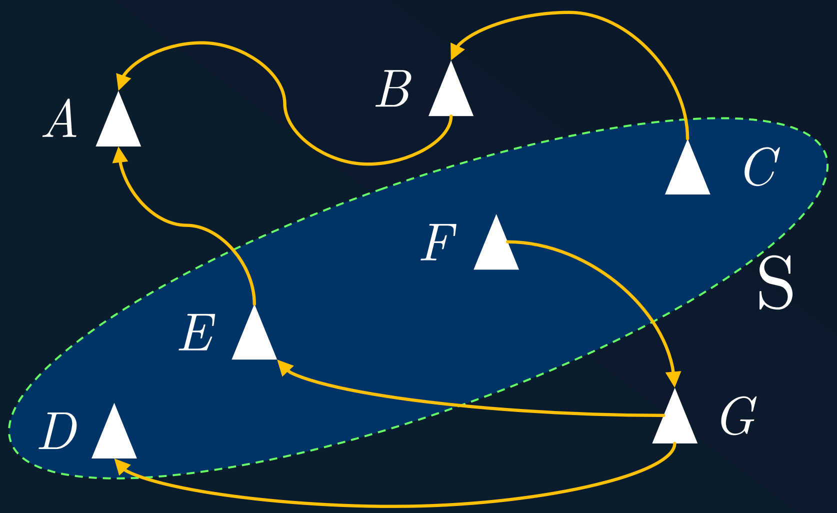

$\mathrm{S} = \{ C, D, E, F \}$ is an admissible set.

Aceptability in a Framework

- A set $\mathrm{S} \subseteq AR$ is a *complete extension* iff S is an admissible set such that for each argument $A \in AR$ defended by S, A is in S.
- Clearly, every complete extension is an admisible set.

Let $\mathrm{AF} = < AR, \mathcal{R} >$ where

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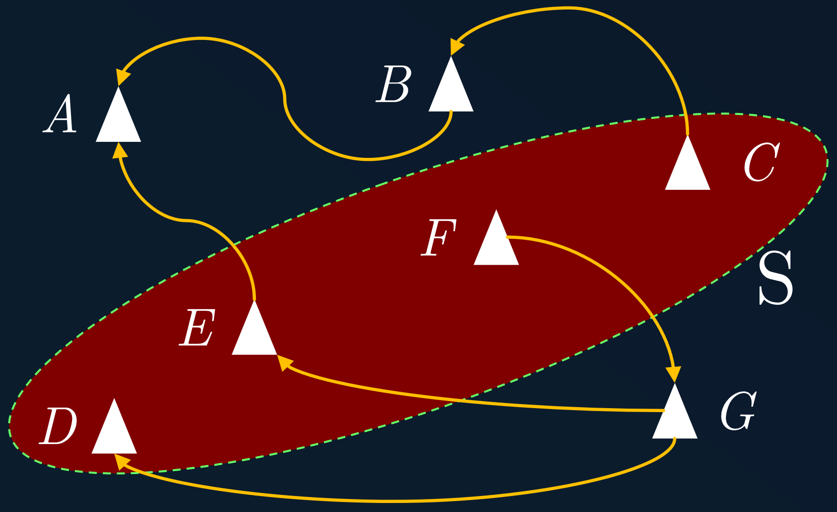

$\mathrm{S} = \{C, D, E, F\}$ is an admissible set and contains all the arguments it defends, therefore S is a complete extension.

Aceptability in a Framework

- A set $\mathrm{S} \subseteq AR$ is a *preferred extension* iff S is a $\subseteq$–maximal admissible set.
- Every preferred extension is a complete extension.

Let $\mathrm{AF} = < AR, \mathcal{R} >$ where

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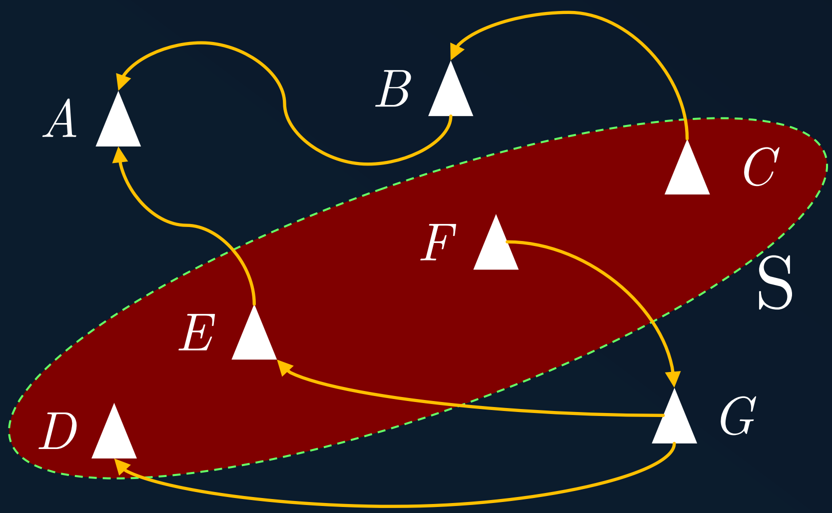

$\mathrm{S} = \{C,\ D,\ E,\ F\ \}$ is a preferred extension

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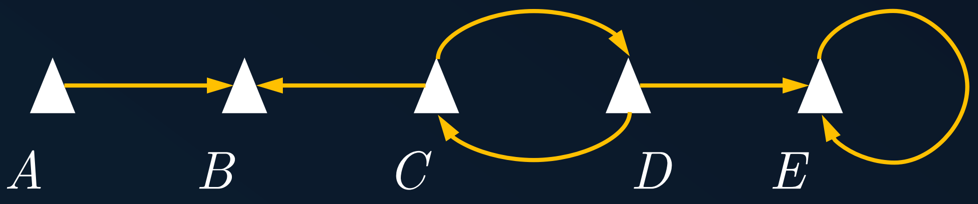

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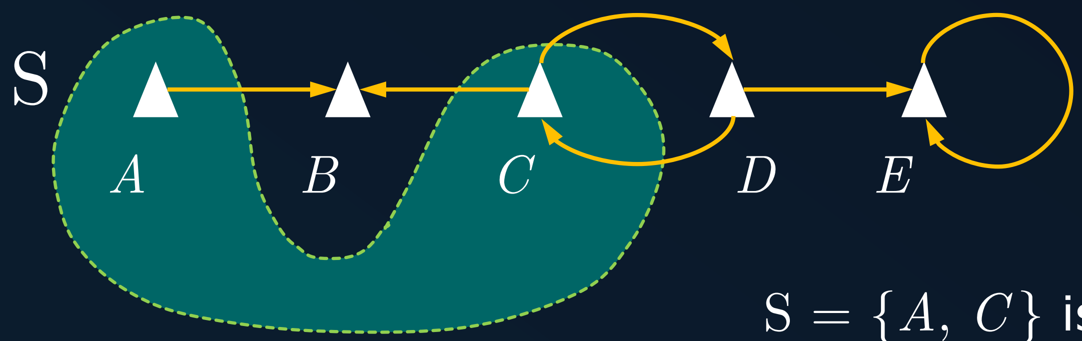

$\mathrm{S} = \{A,\ C\}$ is a preferred extension.

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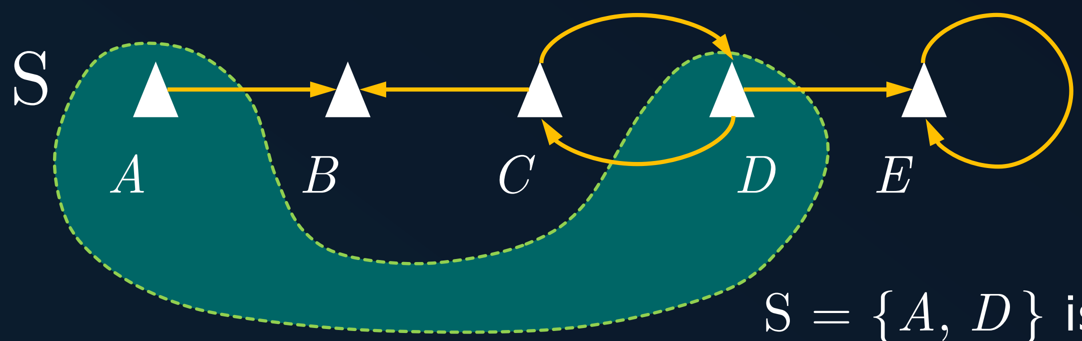

$\mathrm{S} = \{A,\ D\}$ is a preferred extension.

Aceptability in a Framework

➡ A set $\mathrm{S} \subseteq AR$ is a *stable extension* iff S is conflict-free and attacks *every* argument which is not in S.

Let $\mathrm{AF} = < AR, \mathcal{R} >$ where

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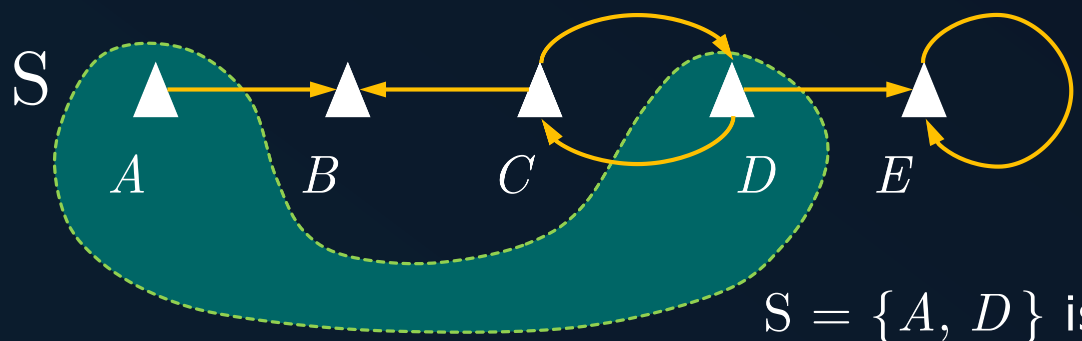

$\mathrm{S} = \{A,\ D\}$ is a stable extension, and this is the only one.

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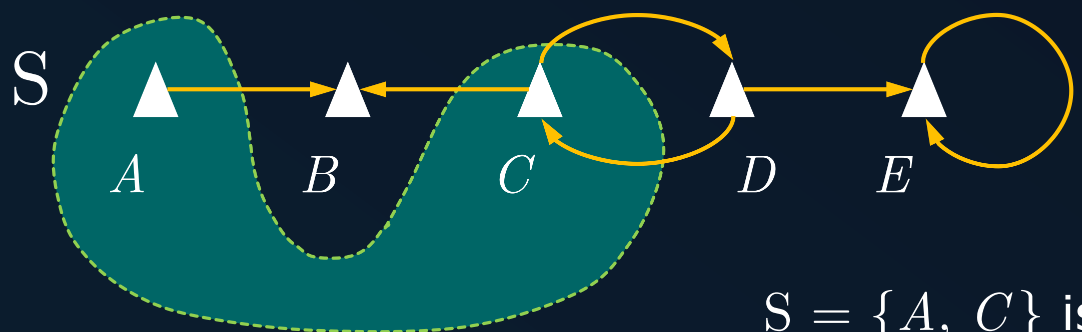

$\mathrm{S} = \{A,\ C\}$ is <u>not</u> a stable extension because is not attacking argument E.

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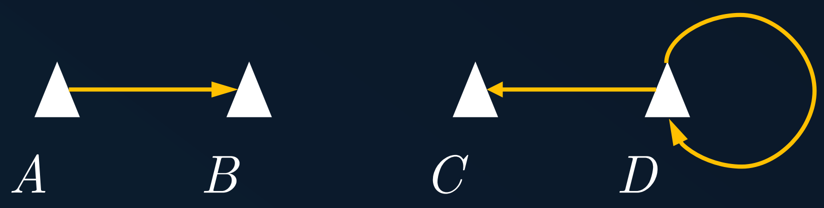


This framework has no estable extension.

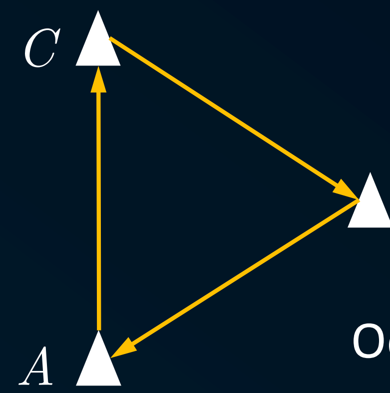
Cycles

- Cycles in a graph can be even or odd.

AF_1

Even Cycle

AF_2



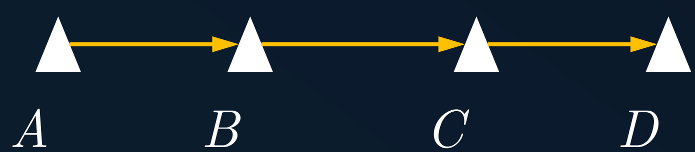
Odd Cycle

Framework AF_1 has two preferred extensions $\mathrm{S}_1=\{A\}$ and $\mathrm{S}_2=\{B\}$

Framework AF_2 has one preferred extension $\mathrm{S}=\{\ \}$

- Finite frameworks without cycles have a single extension and this extension is complete, preferred, and stable.

AF_3



Framework AF_3 has one extension $\mathrm{S} = \{A,\ C\}$

Cycles

S *is admissible iff* S *is conflict free and defends all its elements.*

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AF_1

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Framework AF_2 has one preferred extension $\mathrm{S} = \{\ \}$

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AF_3

Framework AF_3 has one extension $\mathrm{S} = \{A,\ C\}$

Cycles

- Cycles in a graph can be even or odd.

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Even Cycle

> *A set $\mathrm{S} \subseteq AR$ is a preferred extension iff S is a $\subseteq$−maximal admissible set.*

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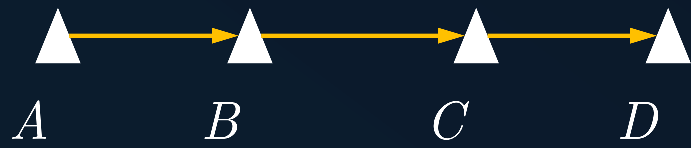
AF_3



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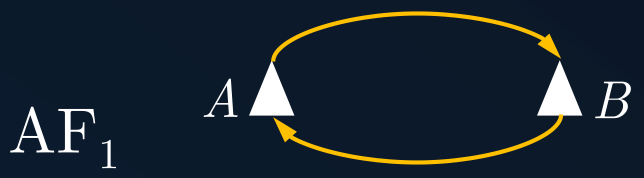

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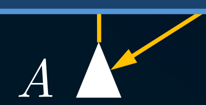

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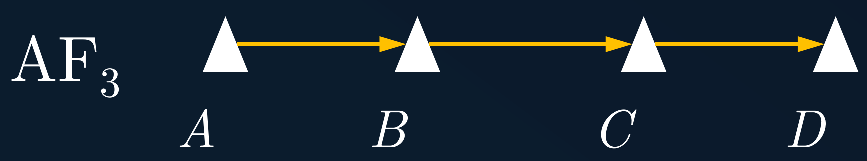

Framework AF_3 has one extension $\mathrm{S} = \{A,\ C\}$

Characterizing Extensions

- The characteristic function of an argument framework $\mathrm{AF} = < AR, \mathcal{R} >$ is defined as follows:

$$\mathrm{F}_{\mathrm{AF}}\colon 2^{AR} \longrightarrow 2^{AR}$$

$$\mathrm{F}_{\mathrm{AF}}(\mathrm{S}) = \{\ A \mid A \text{ is acceptable with respect to } \mathrm{S}\ \}, \quad \text{for all } \mathrm{S} \subseteq AR$$

i.e., $\mathrm{F}_{\mathrm{AF}}(\mathrm{S})$ is the set of all arguments S defends.

If it exists, the least fixpoint (with respect to set inclusion) is called *grounded extension.*

Characterizing Extensions

- Remember that an argument $A \in AR$ is acceptable with respect to a set $\mathrm{S} \subseteq AR$ iff for each argument $B \in \mathrm{S}$, if argument B attacks A then S attacks B.

- And, S is admissible iff S is conflict free and defends all its elements.

- Then, a conflict-free $\mathrm{S} \subseteq AR$ is an admissible set iff $\mathrm{S} \subseteq \mathrm{F}_{\mathrm{AF}}(\mathrm{S})$.

- A conflict-free $\mathrm{S} \subseteq AR$ is a complete extension iff S is a fixpoint of F_{AF}, *i.e.*, $\mathrm{S} = \mathrm{F}_{\mathrm{AF}}(\mathrm{S})$.

- If it exists, the least fixpoint (with respect to set inclusion) is called *grounded extension.*

Grounded Extension

Let $\mathrm{AF} = < AR, \mathcal{R} >$ where

- $AR = \{\ A,\ B,\ C,\ D\ \}$
- $\mathcal{R} = \{(A,\ B),\ (B,\ C),\ (C,\ D)\ \}$

$\mathrm{F}_{\mathrm{AF}}(\mathrm{S}) = \{\ A \mid A$ is acceptable with respect to $\mathrm{S}\ \}$,

AF

$$\begin{aligned} \mathrm{F}_{\mathrm{AF}}(\varnothing) &= \{A\} \\ \mathrm{F}_{\mathrm{AF}}(\{A\}) &= \{A,\ C\} \\ \mathrm{F}_{\mathrm{AF}}(\{A,\ C\}) &= \{A,\ C\} \end{aligned}$$

Framework AF has $\{A,\ C\}$ as the grounded extension

Acceptability in a Framework

Let $\mathrm{AF} = < AR, \mathcal{R} >$ where

- $AR = \{\ A,\ B\ \}$
- $\mathcal{R} = \{(A,\ B),\ (B,\ A)\}$

AF

$$\mathrm{F}_{\mathrm{AF}}(\varnothing) = \varnothing$$

The grounded extension of AF is $\varnothing$

Aceptability in a Framework

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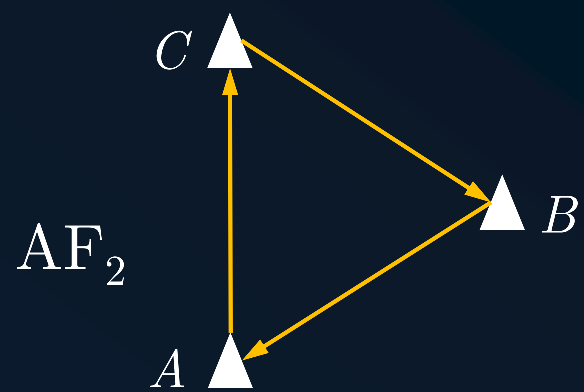

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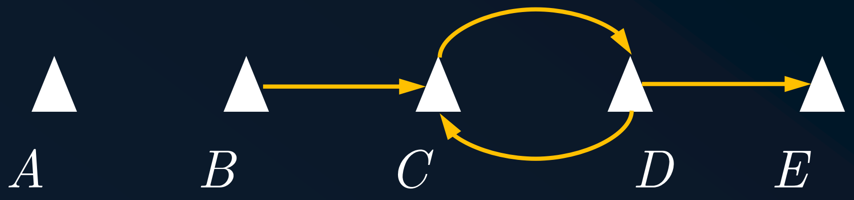


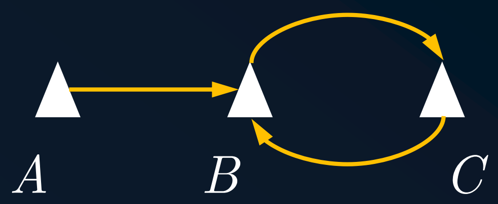
$$\begin{aligned} \mathrm{F}_{\mathrm{AF}}(\varnothing) &= \{A\} \\ \mathrm{F}_{\mathrm{AF}}(\{A\}) &= \{A\} \end{aligned}$$

The grounded extension of AF is $\{\ A\ \}$

Aceptability in a Framework

Let $\mathrm{AF} = < AR, \mathcal{R} >$ where

- $AR = \{ A, B, C, D, E \}$
- $\mathcal{R} = \{(A, B), (C, B), (C, D), (D, C), (D, E), (E, E)\}$



$$
\begin{aligned}
\mathrm{F}_{\mathrm{AF}}(\varnothing) &= \{A\} \\
\mathrm{F}_{\mathrm{AF}}(\{A\}) &= \{A, C\} \\
\mathrm{F}_{\mathrm{AF}}(\{A, C\}) &= \{A, C\}
\end{aligned}
$$

The grounded extension of AF is $\{ A, C \}$

Remarks

- *Abstract argumentation frameworks represent a formalism that has been intensely studied.*
- *Several different connections with logic programming have been investigated.*
- *There are some other semantics not mentioned here: ideal, semi-stable, CF2, prudent, etc.*

Further topics

- *Argumentation and decision making (e.g., Amgoud et al., Atkinson, Bench-Capon, Ferretti et al.).*
- *Argumentation and negotiation (e.g., Parsons, McBurney, Rahwan).*
- *Argumentation with uncertainty formalisms (e.g., Simari, Chesñevar, Godo).*
- *Dialogical argumentation in multiple agents (e.g., Prakken, Parsons, Amgoud, Wooldridge, McBurney, Rahwan, Toni, Sadri, Torroni, Maudet, Kakas, Moratis, Black and Hunter).*
- *Implementations (e.g., Dungine and DLV systems for abstract argumentation, ASPIC, DeLP, and ABA systems for defeasible logics, and connection-graph systems for classical logic).*
- *Applications (e.g., law, medicine, e-commerce, etc.).*

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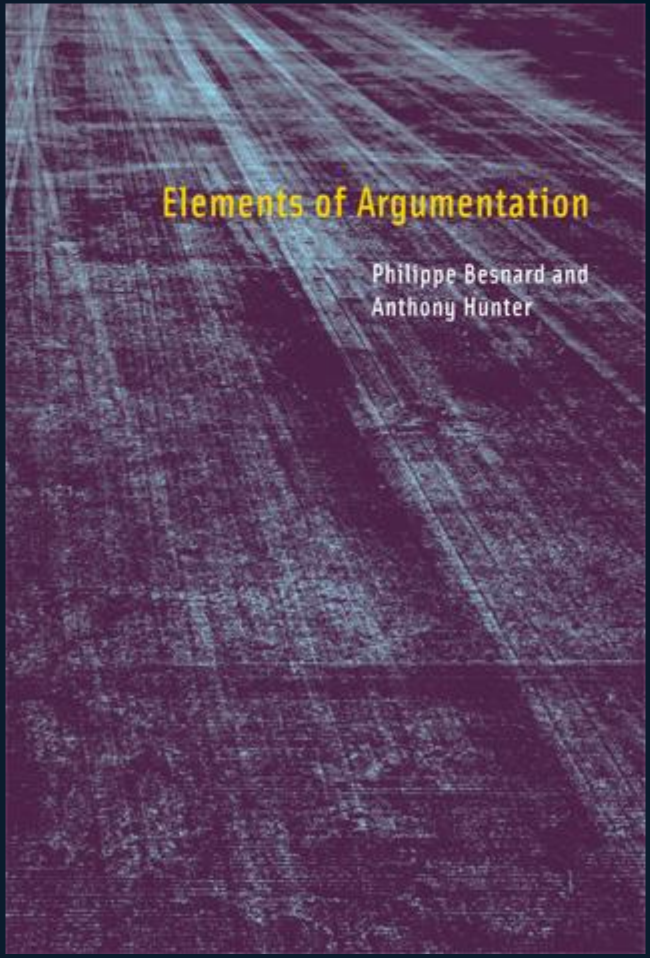
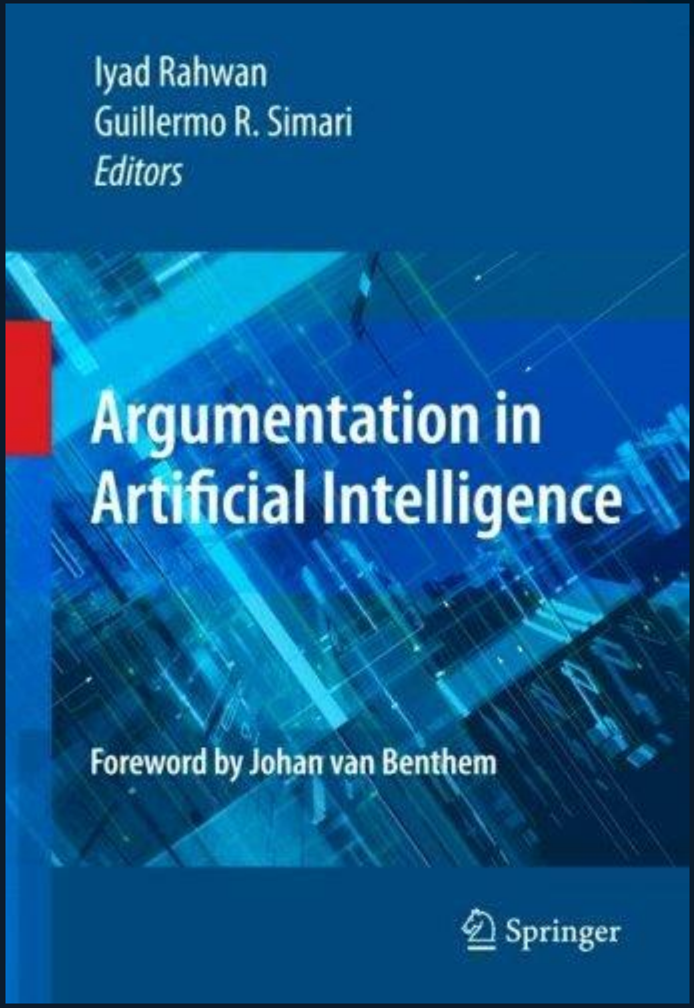
Chapter 2, *Abstract Argumentation*, of the book:



Elements of Argumentation
Philippe Besnard and Anthony Hunter
MIT Press, 2008
ISBN: 978-0-262-02643-7

References

Several Chapters of the book:



Argumentation in Artificial Intelligence
Iyad Rahwan and Guillermo R. Simari
Springer, 2009
ISBN: 978-0-387-98196-3

Thank you!