SEMINAR ABSTRACT
ARGUMENTATION

Introduction to Formal Argumentation

Sarah Gaggl

Dresden, 17th October 2016
Organisation

Learning Outcomes

• The students will get an overview of recent research topics within the field of abstract argumentation
• The students will be able to write a scientific article and give a scientific presentation
• The students will participate in a peer-reviewing process

Organisation:

• 3 introductory lectures
  • Lecture 1: 17.10.2016
  • Lecture 2: 24.10.2016
  • Lecture 3: 07.11.2016
• In last lecture (07.11.2016): article selection
• Students will read related literature and write a seminar paper of 4-5 pages till 9.12.2016
• Each student will review 3 seminar papers from colleagues: 12.12.2016-6.1.2017
• Revised version of seminar paper are due to 20.1.2017
• Each student will give a 20 min talk (plus 10 min discussion) about his/her article: 23.1.2017-27.1.2017
• Send the slides no later than 1 week before presentation to sarah.gaggl@tu-dresden.de for feedback
Plato’s Dialectic

The dialectical method is discourse between two or more people holding different points of view about a subject, who wish to establish the truth of the matter guided by reasoned arguments.

The Republic (Plato), 348b
Plato’s Dialectic

The dialectical method is discourse between two or more people holding different points of view about a subject, who wish to establish the truth of the matter guided by reasoned arguments.

The Republic (Plato), 348b

Leibniz’ Dream

“The only way to rectify our reasonings is to make them as tangible as those of the Mathematicians, so that we can find our error at a glance, and when there are disputes among persons, we can simply say: Let us calculate [calculemus], without further ado, to see who is right.”

Leibniz, Gottfried Wilhelm, The Art of Discovery 1685, Wiener 51
Abstract Argumentation [Dung, 1995]

- In abstract argumentation frameworks (AFs) statements (called arguments) are formulated together with a relation (attack) between them.
- Abstraction from the internal structure of the arguments.
- The conflicts between the arguments are resolved on the semantical level.
Abstract Argumentation [Dung, 1995]

- In abstract argumentation frameworks (AFs) statements (called arguments) are formulated together with a relation (attack) between them.
- Abstraction from the internal structure of the arguments.
- The conflicts between the arguments are resolved on the semantical level.
Argumentation Nowadays

Abstract Argumentation [Dung, 1995]

- In abstract argumentation frameworks (AFs) statements (called arguments) are formulated together with a relation (attack) between them.
- Abstraction from the internal structure of the arguments.
- The conflicts between the arguments are resolved on the semantical level.
Abstract Argumentation [Dung, 1995]

- In abstract argumentation frameworks (AFs) statements (called arguments) are formulated together with a relation (attack) between them.
- Abstraction from the internal structure of the arguments.
- The conflicts between the arguments are resolved on the semantical level.
Argumentation Nowadays

Abstract Argumentation [Dung, 1995]

- In abstract argumentation frameworks (AFs) statements (called arguments) are formulated together with a relation (attack) between them.
- Abstraction from the internal structure of the arguments.
- The conflicts between the arguments are resolved on the semantical level.

TU Dresden, 17th October 2016  Seminar Abstract Argumentation
Argumentation Nowadays

Abstract Argumentation [Dung, 1995]

- In abstract argumentation frameworks (AFs) statements (called arguments) are formulated together with a relation (attack) between them.
- Abstraction from the internal structure of the arguments.
- The conflicts between the arguments are resolved on the semantical level.
Abstract Argumentation [Dung, 1995]

- In abstract argumentation frameworks (AFs) statements (called arguments) are formulated together with a relation (attack) between them.
- Abstraction from the internal structure of the arguments.
- The conflicts between the arguments are resolved on the semantical level.
Decision Support

TU Dresden, 17th October 2016
Seminar Abstract Argumentation
slide 13 of 69
Social Networks
Roadmap for the Lecture

- Introduction
- Abstract Argumentation Frameworks
  - Syntax
  - Semantics
  - Properties of Semantics
- Implementation Techniques
  - Reduction-based vs. Direct Implementations
  - Reductions to SAT
  - Reductions to ASP
- Generalizations of Abstract Argumentation Frameworks
- Students’ Topics
Introduction

**Argumentation:**

...the study of processes “concerned with how assertions are proposed, discussed, and resolved in the context of issues upon which several diverging opinions may be held”.

[Bench-Capon and Dunne, Argumentation in AI, AIJ 171:619-641, 2007]
Introduction

Argumentation:

...the study of processes “concerned with how assertions are proposed, discussed, and resolved in the context of issues upon which several diverging opinions may be held”.

[Bench-Capon and Dunne, Argumentation in AI, AIJ 171:619-641, 2007]

Formal Models of Argumentation are concerned with

- representation of an argument
- representation of the relationship between arguments
- solving conflicts between the arguments (“acceptability”)
Increasingly important area

- “Argumentation” as keyword at all major AI conferences
- dedicated conference: COMMA, TAFA workshop; and several more workshops
- specialized journal: Argument and Computation (Taylor & Francis)
- two text books:
Increasingly important area

- “Argumentation” as keyword at all major AI conferences
- dedicated conference: COMMA, TAFA workshop; and several more workshops
- specialized journal: Argument and Computation (Taylor & Francis)
- two text books:

Handbook of Formal Argumentation HOFA

- http://formalargumentation.org
- Volume 1 to appear in 2017
**The Overall Process**

### Steps

- Starting point: knowledge-base
- Form arguments
- Identify conflicts
- Abstract from internal structure
- Resolve conflicts
- Draw conclusions
The Overall Process

Steps

- Starting point: knowledge-base
- Form arguments
- Identify conflicts
- Abstract from internal structure
- Resolve conflicts
- Draw conclusions

Example

$$\Delta = \{s, r, w, s \rightarrow \neg r, r \rightarrow \neg w, w \rightarrow \neg s\}$$
The Overall Process

Steps

- Starting point: knowledge-base
- **Form arguments**
- Identify conflicts
- Abstract from internal structure
- Resolve conflicts
- Draw conclusions

Example

\[ \Delta = \{s, r, w, s \rightarrow \neg r, r \rightarrow \neg w, w \rightarrow \neg s\} \]

\[ \langle\{w, w \rightarrow \neg s\}, \neg s\rangle \]

\[ \langle\{s, s \rightarrow \neg r\}, \neg r\rangle \]

\[ \langle\{r, r \rightarrow \neg w\}, \neg w\rangle \]
The Overall Process

Steps

- Starting point: knowledge-base
- Form arguments
- Identify conflicts
- Abstract from internal structure
- Resolve conflicts
- Draw conclusions

Example

\[ \Delta = \{ s, r, w, s \rightarrow \neg r, r \rightarrow \neg w, w \rightarrow \neg s \} \]

\[ \langle \{ w, w \rightarrow \neg s \}, \neg s \rangle \]

\[ \langle \{ s, s \rightarrow \neg r \}, \neg r \rangle \rightarrow \langle \{ r, r \rightarrow \neg w \}, \neg w \rangle \]
The Overall Process

Steps
- Starting point: knowledge-base
- Form arguments
- Identify conflicts
- Abstract from internal structure
- Resolve conflicts
- Draw conclusions

Example

\[ \Delta = \{s, r, w, s \rightarrow \neg r, r \rightarrow \neg w, w \rightarrow \neg s\} \]

\[ F_\Delta : \]

TU Dresden, 17th October 2016  Seminar Abstract Argumentation  slide 24 of 69
The Overall Process

Steps

• Starting point: knowledge-base
• Form arguments
• Identify conflicts
• Abstract from internal structure
• Resolve conflicts
• Draw conclusions

Example

\[ \Delta = \{ s, r, w, s \rightarrow \neg r, r \rightarrow \neg w, w \rightarrow \neg s \} \]

\[ F_\Delta : \]

\[ \text{pref}(F_\Delta) = \{ \emptyset \} \]

\[ \text{stage}(F_\Delta) = \{ \{ \alpha \}, \{ \beta \}, \{ \gamma \} \} \]
The Overall Process

Steps
- Starting point: knowledge-base
- Form arguments
- Identify conflicts
- Abstract from internal structure
- Resolve conflicts
- Draw conclusions

Example

\[ \Delta = \{s, r, w, s \rightarrow \neg r, r \rightarrow \neg w, w \rightarrow \neg s\} \]

\[ Cn_{\text{pref}}(F_\Delta) = Cn(\top) \]

\[ Cn_{\text{stage}}(F_\Delta) = Cn(\neg r \lor \neg w \lor \neg s) \]
Some Remarks

- Main idea dates back to Dung [1995]; has then been refined by several authors (Prakken, Gordon, Caminada, etc.)
- Separation between logical (forming arguments) and nonmonotonic reasoning ("abstract argumentation frameworks")
- Abstraction allows to compare several KR formalisms on a conceptual level ("calculus of conflict")
The Overall Process (ctd.)

Some Remarks

- Main idea dates back to Dung [1995]; has then been refined by several authors (Prakken, Gordon, Caminada, etc.)
- Separation between logical (forming arguments) and nonmonotonic reasoning ("abstract argumentation frameworks")
- Abstraction allows to compare several KR formalisms on a conceptual level ("calculus of conflict")

Main Challenge

- All Steps in the argumentation process are, in general, intractable.
- This calls for:
  - careful complexity analysis (identification of tractable fragments)
  - re-use of established tools for implementations (reduction method)
Classical Arguments [Besnard & Hunter, 2001]

- Given is a KB (a set of propositions) $\Delta$
- argument is a pair $(\Phi, \alpha)$, such that $\Phi \subseteq \Delta$ is consistent, $\Phi \models \alpha$ and for no $\Psi \subset \Phi$, $\Psi \models \alpha$
- conflicts between arguments $(\Phi, \alpha)$ and $(\Phi', \alpha')$ arise if $\Phi$ and $\alpha'$ are contradicting.
Approaches to Form Arguments

Classical Arguments [Besnard & Hunter, 2001]

- Given is a KB (a set of propositions) $\Delta$
- argument is a pair $(\Phi, \alpha)$, such that $\Phi \subseteq \Delta$ is consistent, $\Phi \models \alpha$ and for no $\Psi \subset \Phi$, $\Psi \models \alpha$
- conflicts between arguments $(\Phi, \alpha)$ and $(\Phi', \alpha')$ arise if $\Phi$ and $\alpha'$ are contradicting.

Example

$\langle \{s, s \rightarrow \neg r\}, \neg r \rangle \rightarrow \langle \{r, r \rightarrow \neg w\}, \neg w \rangle$
Approaches to Form Arguments

Classical Arguments [Besnard & Hunter, 2001]

- Given is a KB (a set of propositions) $\Delta$
- argument is a pair $(\Phi, \alpha)$, such that $\Phi \subseteq \Delta$ is consistent, $\Phi \models \alpha$ and for no $\Psi \subset \Phi$, $\Psi \models \alpha$
- conflicts between arguments $(\Phi, \alpha)$ and $(\Phi', \alpha')$ arise if $\Phi$ and $\alpha'$ are contradicting.

Example

Other Approaches

- Arguments are trees of statements
- claims are obtained via strict and defeasible rules
- different notions of conflict: rebuttal, undercut, etc.
Dung’s Abstract Argumentation Frameworks

Example

\begin{itemize}
\item Abstract from the concrete content of arguments but only consider the relation between them
\item Semantics select subsets of arguments respecting certain criteria
\item Simple, yet powerful, formalism
\item Most active research area in the field of argumentation.
\item "plethora of semantics"
\end{itemize}
Dung’s Abstract Argumentation Frameworks

Example

Main Properties

- Abstract from the concrete content of arguments but only consider the relation between them
- Semantics select subsets of arguments respecting certain criteria
- Simple, yet powerful, formalism
- Most active research area in the field of argumentation.
  - “plethora of semantics”
Dung’s Abstract Argumentation Frameworks

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 the conflicts ("attacks")
Dung’s Abstract Argumentation Frameworks

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 the conflicts ("attacks")

Example

\[ F = (\{a, b, c, d, e\}, \{(a, b), (c, b), (c, d), (d, c), (d, e), (e, e)\}) \]
Basic Properties

Conflict-Free Sets

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

Conflict-Free Sets

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

Example

$cf(F) = \{a, c\}$,
Conflict-Free Sets

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

Example

$$cf(F) = \{ \{a, c\}, \{a, d\} \},$$
Basic Properties

Conflict-Free Sets

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

Example

cf($F$) = $\{\{a, c\}, \{a, d\}, \{b, d\}\}$,
Basic Properties

Conflict-Free Sets

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

Example

$$cf(F) = \{\{a, c\}, \{a, d\}, \{b, d\}, \{a\}, \{b\}, \{c\}, \{d\}, \emptyset\}$$
Admissible Sets [Dung, 1995]

Given an AF $F = (A, R)$. A set $S \subseteq A$ is admissible in $F$, if

- $S$ is conflict-free in $F$
- each $a \in S$ is defended by $S$ in $F$
  - $a \in A$ is defended by $S$ in $F$, if for each $b \in A$ with $(b, a) \in R$, there exists a $c \in S$, such that $(c, b) \in R$. 
Admissible Sets [Dung, 1995]

Given an AF $F = (A, R)$. A set $S \subseteq A$ is admissible in $F$, if

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

Example

$\text{adm}(F) = \{a, c\}$,
Basic Properties (ctd.)

Admissible Sets [Dung, 1995]

Given an AF $F = (A, R)$. A set $S \subseteq A$ is admissible in $F$, if

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

Example

$\text{adm}(F) = \{ \{a, c\}, \{a, d\} \}$,
Basic Properties (ctd.)

Admissible Sets [Dung, 1995]

Given an AF $F = (A, R)$. A set $S \subseteq A$ is admissible in $F$, if

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

Example

$$adm(F) = \{ \{a, c\}, \{a, d\}, \{b, d\} \}$$
Basic Properties (ctd.)

Admissible Sets [Dung, 1995]

Given an AF $F = (A, R)$. A set $S \subseteq A$ is admissible in $F$, if

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

Example

$$adm(F) = \{\{a, c\}, \{a, d\}, \{b, d\}, \{a\}, \{b\}, \{c\}, \{d\}, \emptyset\}$$
Dung’s Fundamental Lemma

Let $S$ be admissible in an AF $F$ and $a, a'$ arguments in $F$ defended by $S$ in $F$. Then,

1. $S' = S \cup \{a\}$ is admissible in $F$
2. $a'$ is defended by $S'$ in $F$
Semantics

Naive Extensions

Given an AF $F = (A, R)$. A set $S \subseteq A$ is a naive extension of $F$, if

- $S$ is conflict-free in $F$
- for each $T \subseteq A$ conflict-free in $F$, $S \nsubseteq T$
Naive Extensions

Given an AF $F = (A, R)$. A set $S \subseteq A$ is a naive extension of $F$, if

- $S$ is conflict-free in $F$
- for each $T \subseteq A$ conflict-free in $F$, $S \not\subset T$

Example

Naive($F$) = \{\{a, c\},

TU Dresden, 17th October 2016  Seminar Abstract Argumentation  slide 48 of 69
Given an AF $F = (A, R)$. A set $S \subseteq A$ is a **naive extension** of $F$, if

- $S$ is conflict-free in $F$
- for each $T \subseteq A$ conflict-free in $F$, $S \not\subseteq T$

**Example**

$$naive(F) = \{\{a, c\}, \{a, d\}\}$$
Naive Extensions

Given an AF $F = (A, R)$. A set $S \subseteq A$ is a naive extension of $F$, if

- $S$ is conflict-free in $F$
- for each $T \subseteq A$ conflict-free in $F$, $S \not\subset T$

Example

![Diagram with nodes a, b, c, d, e and edges between them.

$naive(F) = \{\{a, c\}, \{a, d\}, \{b, d\}\}$,
Semantics

Naive Extensions
Given an AF $F = (A, R)$. A set $S \subseteq A$ is a naive extension of $F$, if
- $S$ is conflict-free in $F$
- for each $T \subseteq A$ conflict-free in $F$, $S \not\subseteq T$

Example

$\text{naive}(F) = \{\{a, c\}, \{a, d\}, \{b, d\}, \{a\}, \{b\}, \{c\}, \{d\}, \emptyset\}$
Semantics (ctd.)

Grounded Extension [Dung, 1995]

Given an AF $F = (A, R)$. The unique grounded extension of $F$ is defined as the outcome $S$ of the following “algorithm”:

1. put each argument $a \in A$ which is not attacked in $F$ into $S$; if no such argument exists, return $S$;

2. remove from $F$ all (new) arguments in $S$ and all arguments attacked by them (together with all adjacent attacks); and continue with Step 1.

Example

ground$(F) = \{\{a\}\}$
Grounded Extension [Dung, 1995]

Given an AF $F = (A, R)$. The unique grounded extension of $F$ is defined as the outcome $S$ of the following “algorithm”:

1. put each argument $a \in A$ which is not attacked in $F$ into $S$; if no such argument exists, return $S$;

2. remove from $F$ all (new) arguments in $S$ and all arguments attacked by them (together with all adjacent attacks); and continue with Step 1.

Example

$\text{ground}(F) = \{ \{a\} \}$
Complete Extension [Dung, 1995]

Given an AF \((A, R)\). A set \(S \subseteq A\) is complete in \(F\), if

- \(S\) is admissible in \(F\)
- each \(a \in A\) defended by \(S\) in \(F\) is contained in \(S\)
  - Recall: \(a \in A\) is defended by \(S\) in \(F\), if for each \(b \in A\) with \((b, a) \in R\), there exists a \(c \in S\), such that \((c, b) \in R\).
Complete Extension [Dung, 1995]

Given an AF $(A, R)$. A set $S \subseteq A$ is complete in $F$, if

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

Example

\[
\text{comp}(F) = \{\{a, c\}\},
\]
Semantics (ctd.)

**Complete Extension [Dung, 1995]**

Given an AF \((A, R)\). A set \(S \subseteq A\) is **complete** in \(F\), if

- \(S\) is admissible in \(F\)
- each \(a \in A\) defended by \(S\) in \(F\) is contained in \(S\)
  - Recall: \(a \in A\) is defended by \(S\) in \(F\), if for each \(b \in A\) with \((b, a) \in R\), there exists a \(c \in S\), such that \((c, b) \in R\).

**Example**

\[
\text{comp}(F) = \{\{a, c\}, \{a, d\}\},
\]

TU Dresden, 17th October 2016  Seminar Abstract Argumentation  slide 56 of 69
Complete Extension [Dung, 1995]

Given an AF \((A, R)\). A set \(S \subseteq A\) is complete in \(F\), if

- \(S\) is admissible in \(F\)
- each \(a \in A\) defended by \(S\) in \(F\) is contained in \(S\)
  - Recall: \(a \in A\) is defended by \(S\) in \(F\), if for each \(b \in A\) with \((b, a) \in R\), there exists a \(c \in S\), such that \((c, b) \in R\).

Example

\[\text{comp}(F) = \{\{a, c\}, \{a, d\}, \{a\}\}\]
Semantics (ctd.)

Complete Extension [Dung, 1995]

Given an AF \((A, R)\). A set \(S \subseteq A\) is complete in \(F\), if

- \(S\) is admissible in \(F\)
- each \(a \in A\) defended by \(S\) in \(F\) is contained in \(S\)

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

Example

\[
\text{comp}(F) = \{\{a, c\}, \{a, d\}, \{a\}, \{e\}, \{d\}, \emptyset\}
\]
Properties of the Grounded Extension

For any AF $F$, the grounded extension of $F$ is the subset-minimal complete extension of $F$. 

Remark: Since there exists exactly one grounded extension for each AF $F$, we often write $\text{ground}(F) = S$ instead of $\text{ground}(F) = \{S\}$. 
### Properties of the Grounded Extension

For any AF $F$, the grounded extension of $F$ is the subset-minimal complete extension of $F$.

### Remark

Since there exists exactly one grounded extension for each AF $F$, we often write $\text{ground}(F) = S$ instead of $\text{ground}(F) = \{S\}$.
Preferred Extensions [Dung, 1995]

Given an AF $F = (A, R)$. A set $S \subseteq A$ is a preferred extension of $F$, if

- $S$ is admissible in $F$
- for each $T \subseteq A$ admissible in $F$, $S \not\subset T$
Preferred Extensions [Dung, 1995]

Given an AF $F = (A, R)$. A set $S \subseteq A$ is a preferred extension of $F$, if

- $S$ is admissible in $F$
- for each $T \subseteq A$ admissible in $F$, $S \not\subseteq T$

Example

$$
\text{pref}(F) = \{\{a, c\}, \{a, d\}, \{a\}, \{c\}, \{d\}, \emptyset\}
$$
Stable Extensions [Dung, 1995]

Given an AF $F = (A, R)$. A set $S \subseteq A$ is a **stable extension** of $F$, if

- $S$ is conflict-free in $F$
- for each $a \in A \setminus S$, there exists a $b \in S$, such that $(b, a) \in R$
Stable Extensions [Dung, 1995]

Given an AF $F = (A, R)$. A set $S \subseteq A$ is a stable extension of $F$, if

- $S$ is conflict-free in $F$
- for each $a \in A \setminus S$, there exists a $b \in S$, such that $(b, a) \in R$

Example

$stable(F) = \{a, e\}$
Stable Extensions [Dung, 1995]

Given an AF $F = (A, R)$. A set $S \subseteq A$ is a stable extension of $F$, if

- $S$ is conflict-free in $F$
- for each $a \in A \setminus S$, there exists a $b \in S$, such that $(b, a) \in R$

Example

$\text{stable}(F) = \{\{a, e\}, \{a, d\}\}$,
Stable Extensions [Dung, 1995]

Given an AF $F = (A, R)$. A set $S \subseteq A$ is a stable extension of $F$, if

- $S$ is conflict-free in $F$
- for each $a \in A \setminus S$, there exists a $b \in S$, such that $(b, a) \in R$

Example

$$stable(F) = \{\{a, e\}, \{a, d\}, \{b, d\}\},$$
Stable Extensions [Dung, 1995]

Given an AF $F = (A, R)$. A set $S \subseteq A$ is a stable extension of $F$, if

- $S$ is conflict-free in $F$
- for each $a \in A \setminus S$, there exists a $b \in S$, such that $(b, a) \in R$

Example

$stable(F) = \{\{a, e\}, \{a, d\}, \{b, d\}, \{a\}, \{b\}, \{c\}, \{d\}, \emptyset, \}$
Semantics (ctd.)

Some Relations

For any AF $F$ the following relations hold:

1. Each stable extension of $F$ is admissible in $F$
2. Each stable extension of $F$ is also a preferred one
3. Each preferred extension of $F$ is also a complete one
P. Baroni and M. Giacomin.
Semantics of abstract argument systems.

T.J.M. Bench-Capon and P.E.Dunne.
Argumentation in AI,
AIJ 171:619-641, 2007

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