Computational Arguments

and their application in Computational Sociology

Paolo Torroni & Simone Gabbriellini

DISI, University of Bologna

Outline of the talk

- The future
- Argumentation
- Social networks
- Two applications
- What you can do with us

THE FUTURE

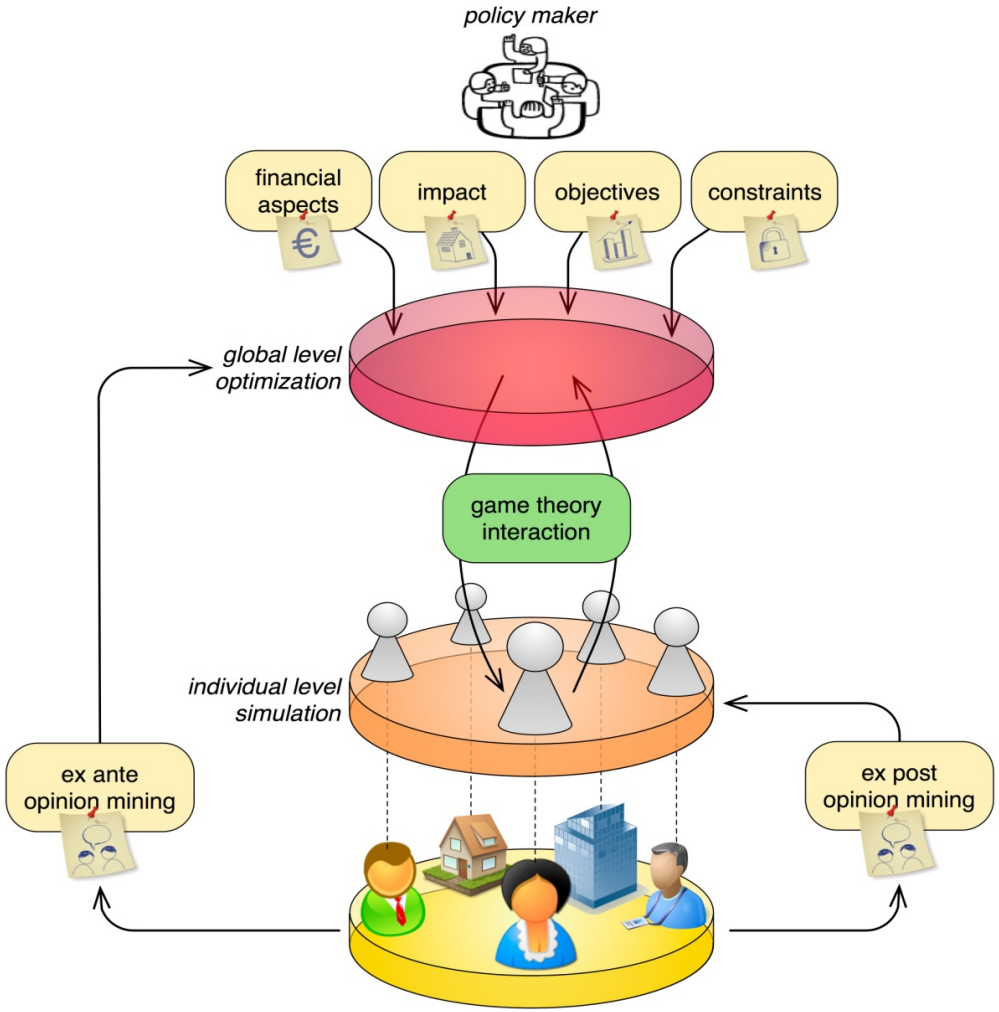
The Answer to the Ultimate Question of Life, The Universe, and Everything

- "The ultimate goal of the **FuturICT** project is to understand and manage complex, global, socially interactive systems, with a focus on sustainability and resilience. "
- "FuturICT will build a Living Earth Platform, a **simulation, visualization and participation platform** to **support decision-making of policy-makers**, **business people** and **citizens**"
- "Integrating ICT, Complexity Science and the Social Sciences will create a paradigm shift, facilitating a symbiotic co-evolution of ICT and society"
- "**Everything might happen to us**, from a Big Brother Society to a Participatory Market Society. We will have to take the right decisions - but our society is not well prepared for these choices. To prevent our society from running into a Dark Age of Information, a public debate is urgently needed"

[FutureICT.eu]

E-Policy

Engineering the POlicy-making LIfe CYcle



Next set of slides courtesy of **Massimiliano Giacomin**
http://www.ing.unibs.it/~giacomin/

ARGUMENTATION

What's argumentation? (1)

- A framework for practical and uncertain reasoning able to cope with partial and inconsistent knowledge
  - philosophical roots: Aristotle, Toulmin (1958)
  - in AI: R.P. Loui (1987), J. Pollock (1987), G. Simari & Loui (1992)

- Reasoning consists in two main activities:

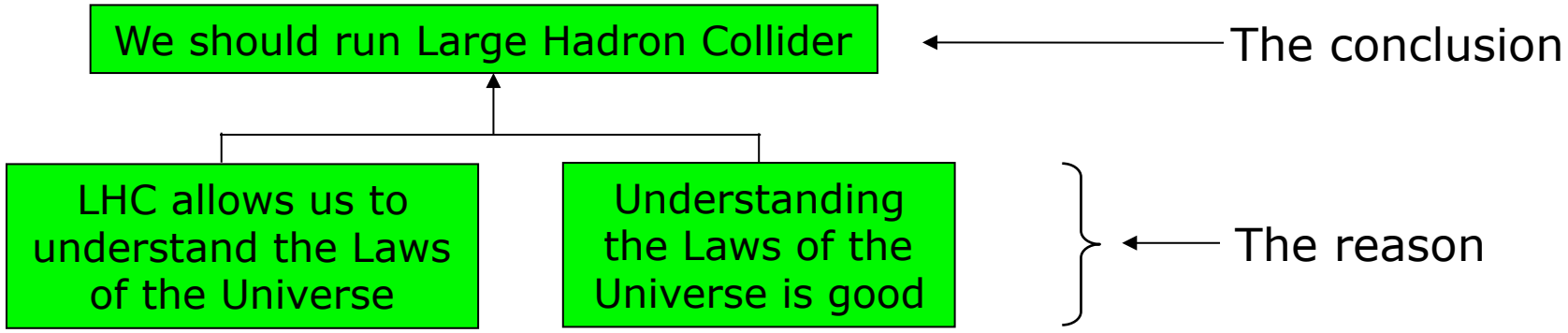
  - construction of arguments

    Argument = a conclusion (belief, action, goal, etc.) and
    a reason (premises) supporting the conclusion itself

  - evaluation of arguments

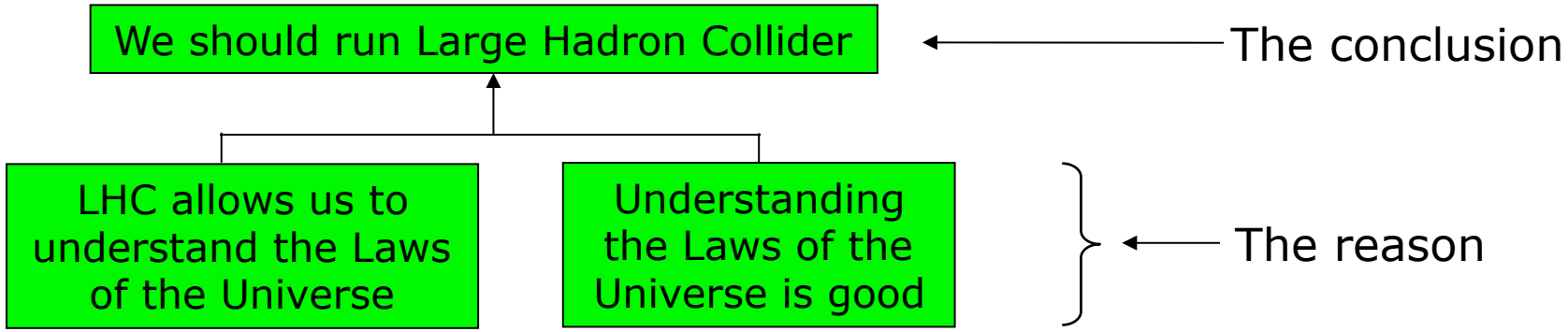
    Arguments may conflict:
    decide the set of arguments and conclusions "justified"
    (w.r.t. available knowledge)

An informal example (1)



We are justified in believing that we should run LHC ☺

An informal example (2)



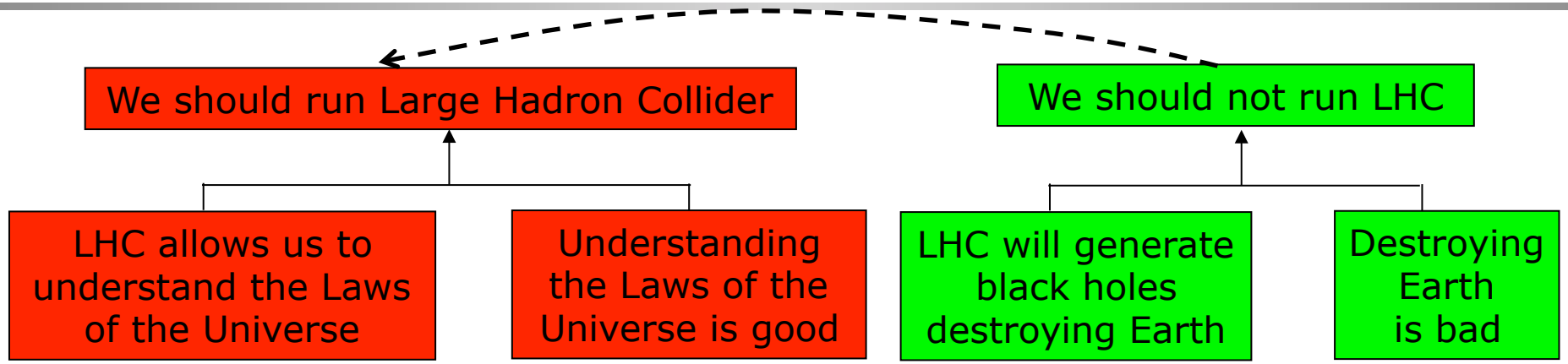
We are justified in believing that we should run LHC ☺

BUT

In Argumentation (and in real life as well):

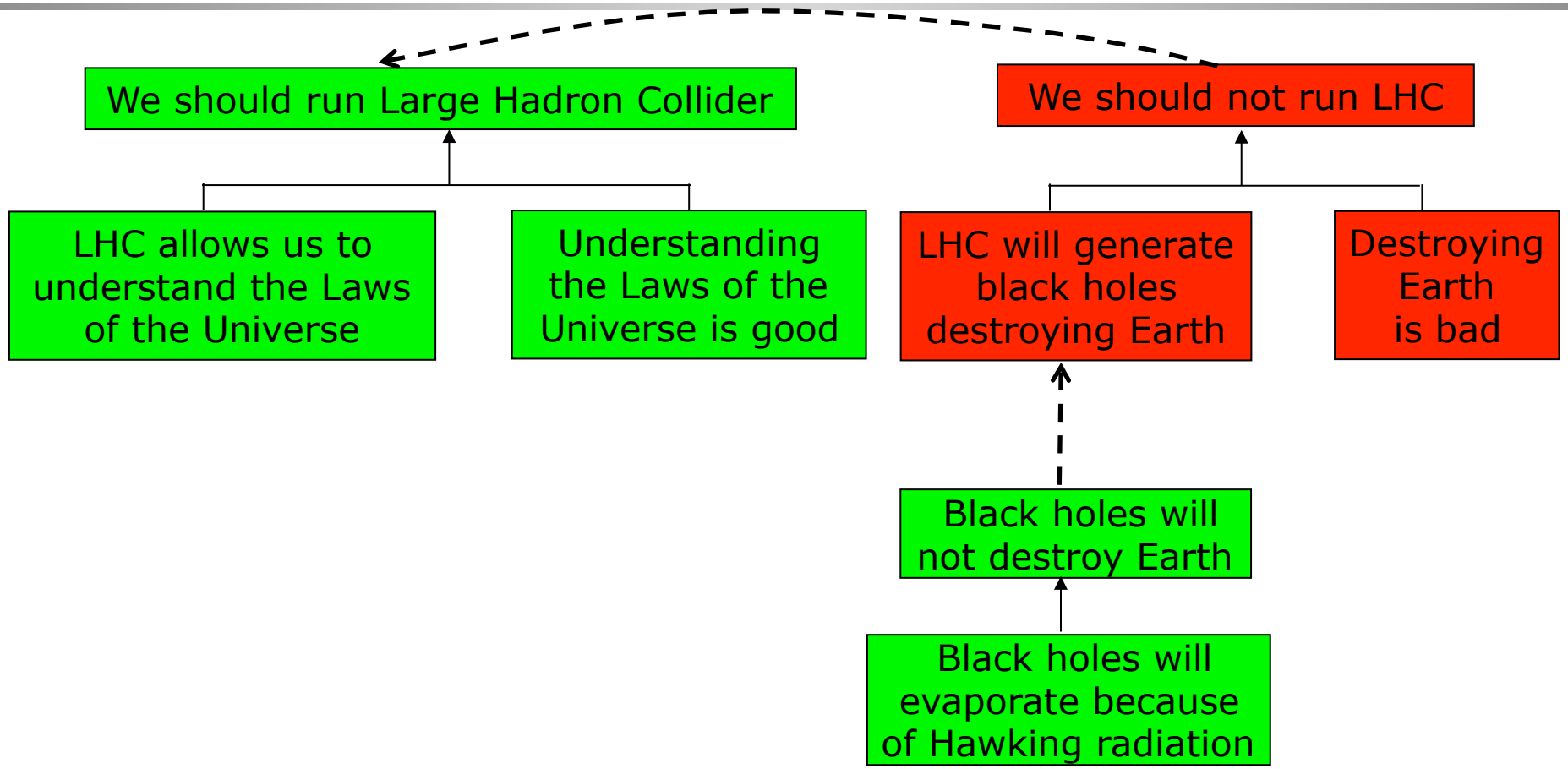
- reasons are not necessary "conclusive"
  (they don't logically entail conclusions)
- arguments and conclusions can be "retracted"
  in front of new information, i.e. counterarguments

An informal example (3)



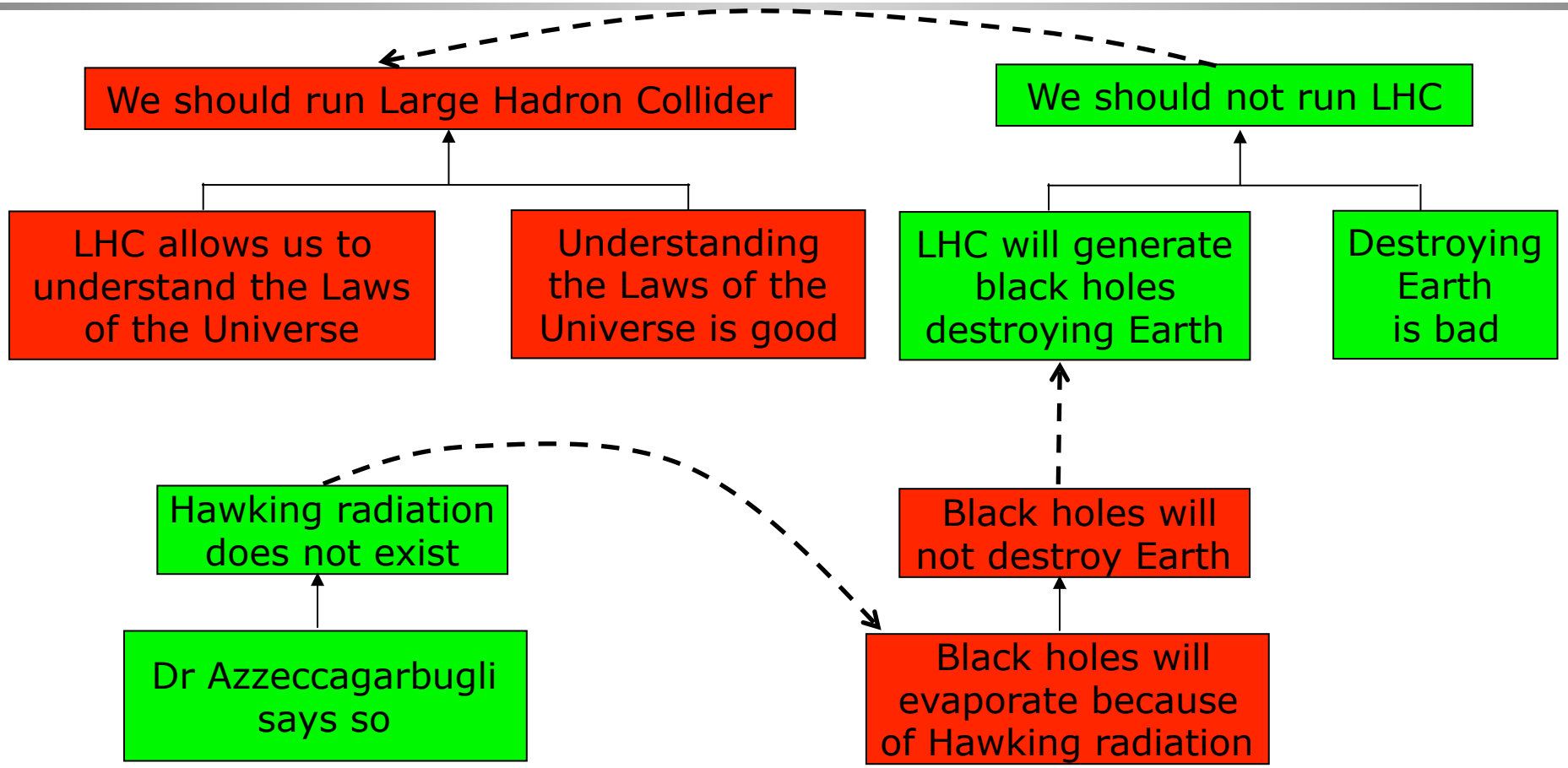
Now we are justified in believing that we should not run LHC ☹

An informal example (4)



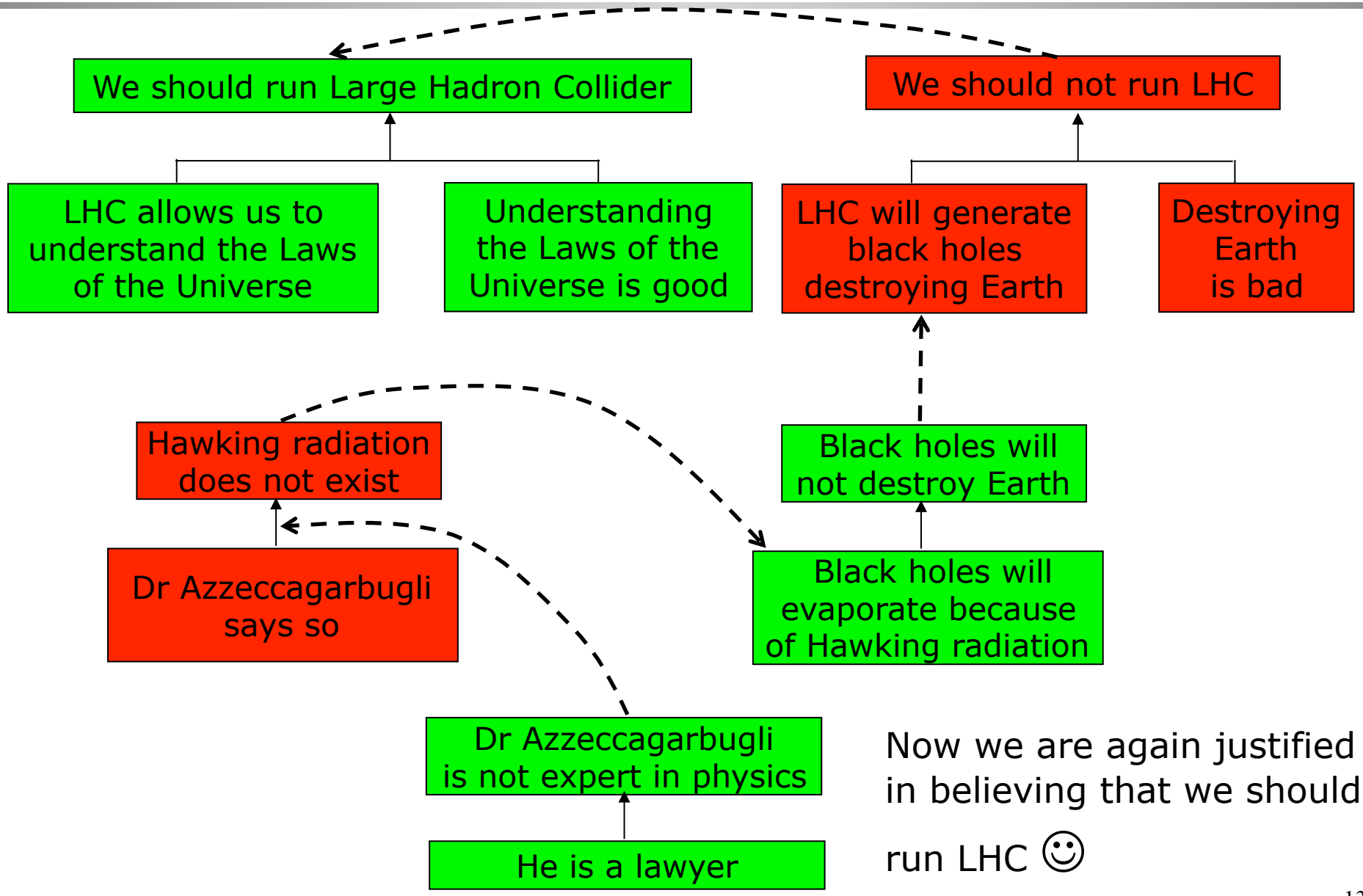
Now we are again justified in believing that we should run LHC ☺

An informal example (5)



Now we are again justified in believing that we should not run LHC ☹

An informal example (6)



Now we are again justified in believing that we should run LHC ☺

What's argumentation? (2)

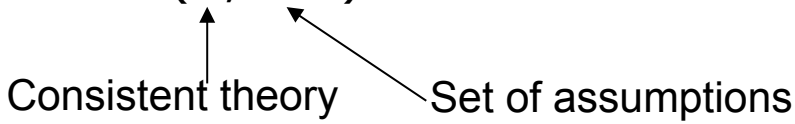
The elements of an argumentation system

- The definition of argument
  (possibly including an underlying logical language +
  a notion of logical consequence)
- The notion of conflict between arguments
- The notion of defeat (successful attack)
- An argumentation semantics selecting acceptable (justified) arguments

Definition of argument: several possibilities (1)

- ASSUMPTION-BASED ARGUMENTATION

Given a knowledge base (K, Ass)



ARGUMENT for p:

(A, p) such that

- $A \subseteq Ass$
- $A \cup K$ is consistent and entails p
- There is no $A' \subset A$ such that $A' \cup K$ entails p

ATTACKS to an argument: on its assumptions

[see Besnard&Hunter, Dung-Kowalski-Toni]

Definition of argument: several possibilities (2)

- ARGUMENT SCHEMES

  - correspond to recurring patterns of reasoning
  - have associated "critical questions"

Example: Expert Testimony [WALTON 1996]

E is expert on D

E says P

P is in D

Therefore, P is the case

Critical questions:

Is E biased?

Is P consistent with what other experts say?

Is P consistent with known evidence?

Definition of argument: several possibilities (3)

- ARGUMENT SCHEMES IN A MEDICAL APPLICATION

Viability Scheme

Organ **O** of donor **D** is available
No contraindications are known for donating **O** to recipient **R**
Therefore, organ **O** is viable

CRITICAL QUESTIONS:

Does donor **D** have a contraindication for donating organ **O**?

Nonviability Scheme

Donor **D** of organ **O** has condition **C**
C is a contraindication are for donating **O**
Therefore, organ **O** is nonviable

[Tolchinsky et al, 2006]

Definition of argument: several possibilities (4)

- STABLE MARRIAGE PROBLEM
  - Arguments of the kind <Alice, John>
  - <Barbara, John> attacks <Alice, John> if John prefers Barbara to Alice

… … …

In general

Arguments take different forms
(domain-independent vs. domain dependent)
Concern different kinds of conclusions
(beliefs, goals, intentions, …)

In the examples we will refer to rule-based approaches…

Rule-based approaches

- ARGUMENT

  a tree made up of rules of inference constructed from
  a set of premises to reach a conclusion

- Two kinds of rules:

  $A \rightarrow B$: deductive - “indefeasible”

  $A \Rightarrow B$: non-deductive - “defeasible”

$$\left.\begin{array}{l} A\ (0.7) \\ B\ (0.9) \end{array}\right\} \rightarrow \neg C\ (0.7)$$

$$D\ (0.9) \Rightarrow C\ (0.8)$$

- A strength value may be associated to premises and rules, giving rise to argument strength

See [J.Pollock, 1992], [G. Vreeswijk, 1997], …

Rule-based approaches (2)

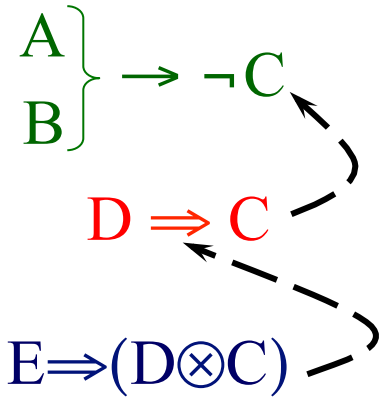
Notion of conflict

- Rebutting:
  an argument attacks another one by denying its [possibly intermediate] conclusion
- Undercutting:
  an argument attacks the applicability of a defeasible rule of inference

Notion of defeat

An argument α defeats β iff:

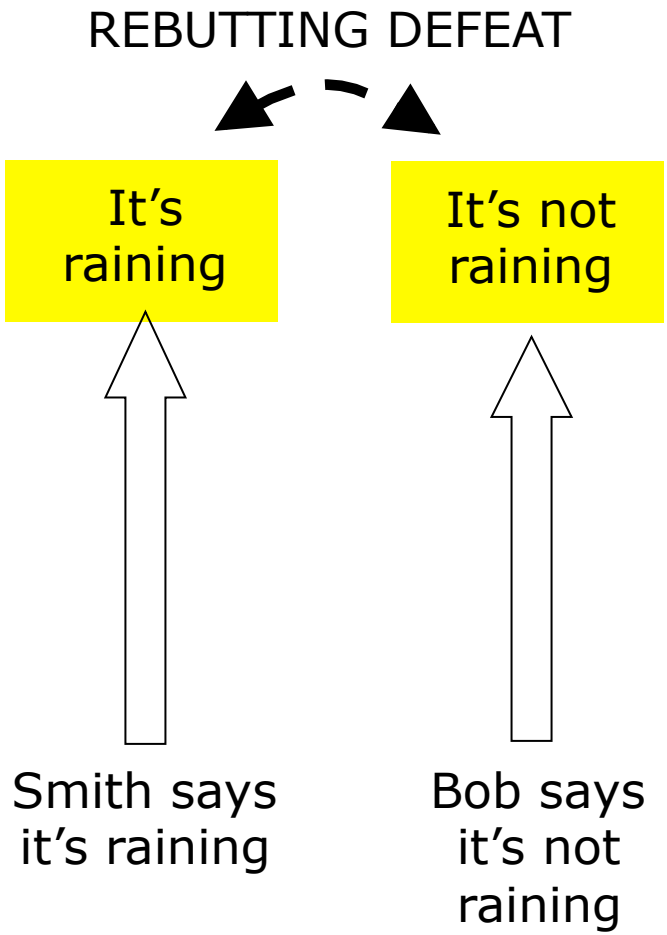
- α undercuts β, or
- α rebuts β and
  α is not weaker than β



[Pollock 92]

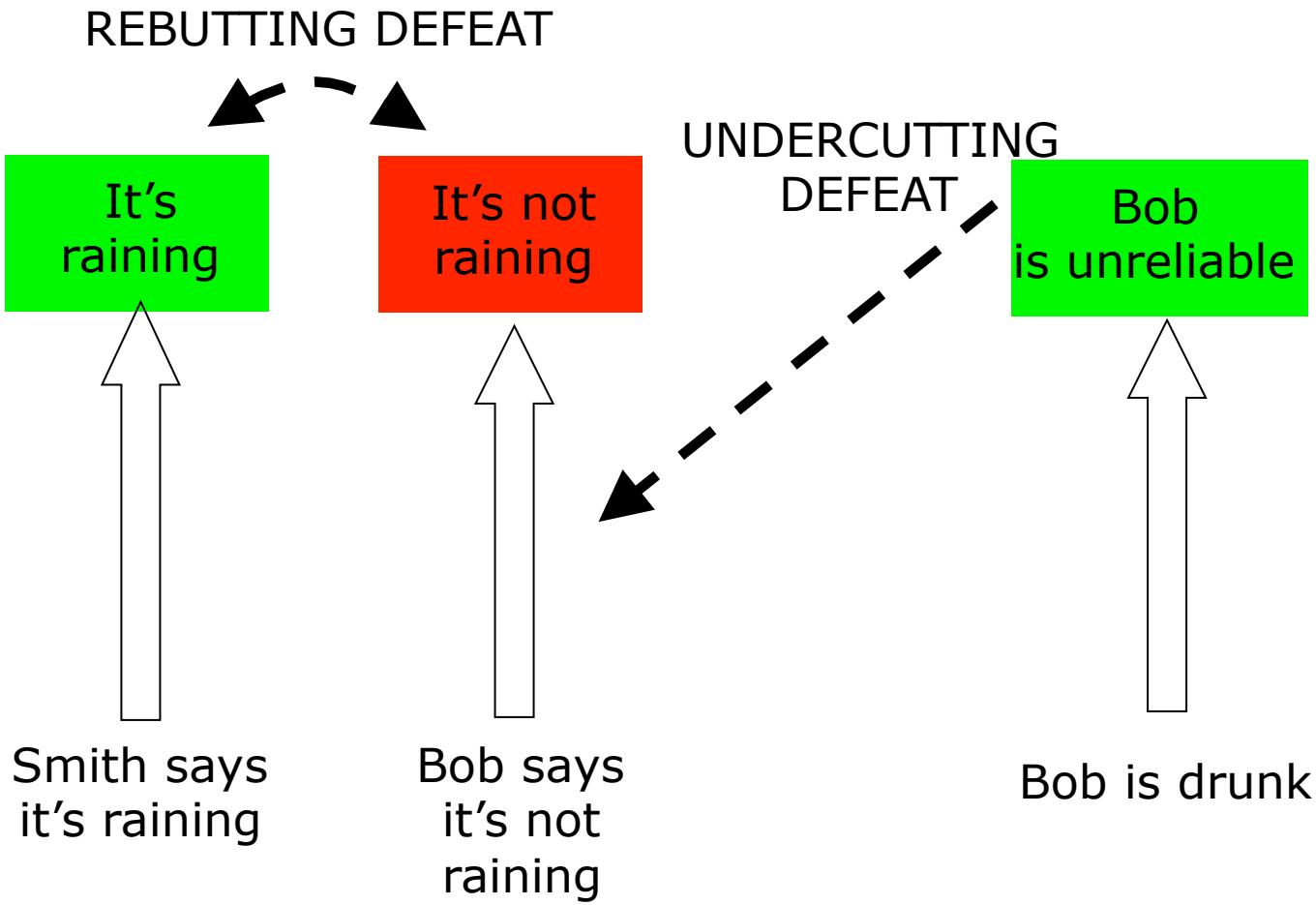
Rule-based approaches (3)

EXAMPLE



Rule-based approaches (4)

EXAMPLE



An argumentation spot

Advantageous features

- Different kinds of arguments can be represented
- Able to handle uncertain and inconsistent knowledge
- A “natural” representation + justification of choices

- Internal **reasoning** of single agents (reasoning about beliefs, goals, …)
- Negotiation and **dialogue** between agents

- **Applications**: Decision Support, Medical Reasoning, Legal Reasoning, E-democracy, Social Simulations, Sentiment Analysis …

What's abstract argumentation?

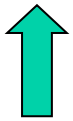
Usually "abstract" stands for a difficult thing… Here it means "simple"!

What's abstract argumentation?

Usually "abstract" stands for a difficult thing… Here it means "simple"!

The elements of an argumentation system

- An underlying logical language + a notion of logical consequence
- The definition of argument
- The notion of conflict between arguments
- The notion of defeat (successful attack)
- An argumentation semantics that select acceptable (justified) arguments



Abstract argumentation focuses on this aspect

Dung's argumentation framework

[Dung '95]

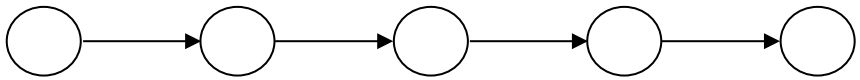
AF = <*A*, →>

attack (or defeat) relation
[unspecified definition]

Arguments [origin and structure not specified]

- Graphical representation as a directed graph [defeat graph], e.g.

Representation of LHC example



Dung's argumentation framework

[Dung '95]

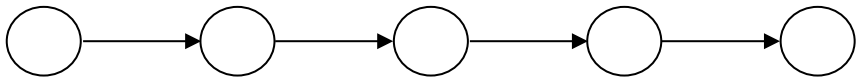
AF = <*A*, →>

attack (or defeat) relation
[unspecified definition]

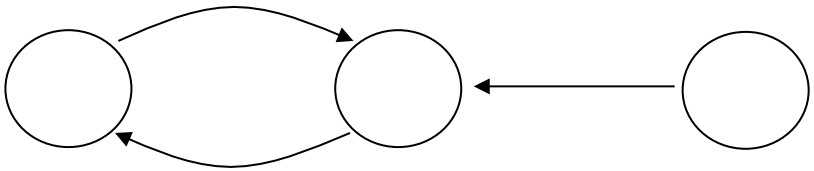
Arguments [origin and structure not specified]

- Graphical representation as a directed graph [defeat graph], e.g.

Representation of LHC example



Representation of weather example



Dung's argumentation framework (2)

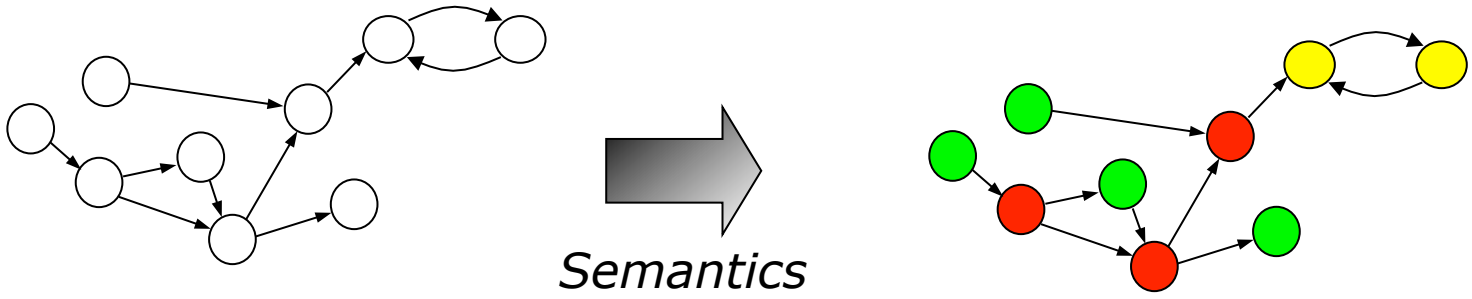
So, what remains to be done?

ARGUMENT EVALUATION:

GIVEN AN ARGUMENTATION FRAMEWORK,
DETERMINE THE JUSTIFICATION STATE
(ALSO CALLED DEFEAT STATUS) OF ARGUMENTS,
IN PARTICULAR: **WHAT ARGUMENTS** EMERGE UNDEFEATED
FROM THE CONFLICT, I.E. **ARE ACCEPTABLE?**

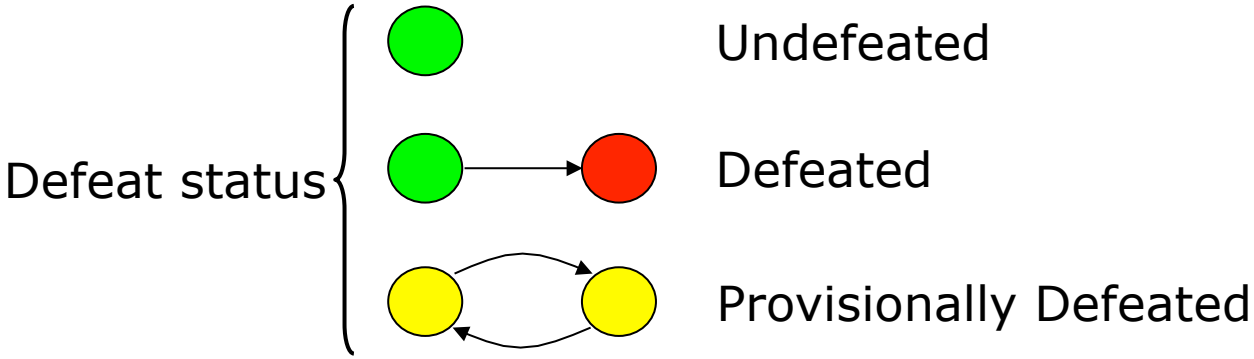
Argumentation semantics

- Specification of a method for argument evaluation, or of criteria to determine, given a set of arguments, their “defeat status”



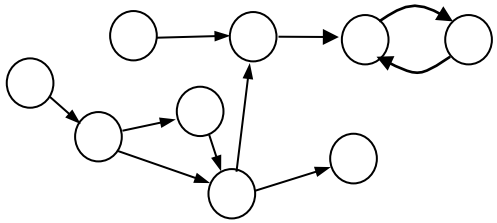
Argumentation Framework

Defeat status



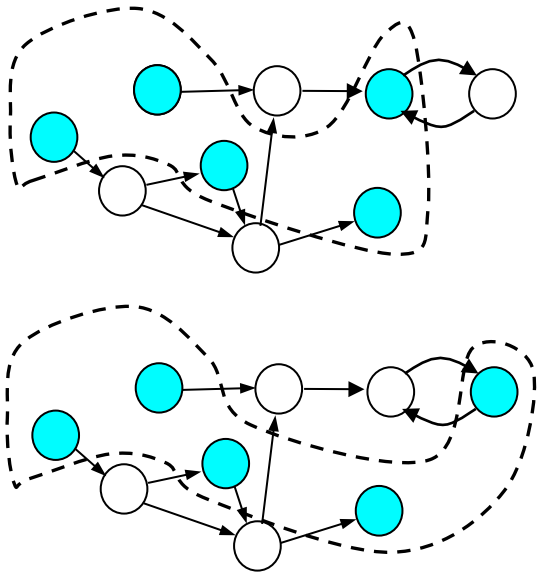
Extension-based semantics

- Given AF

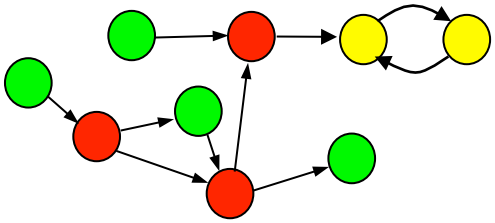


a semantics S identify

Set of extensions $\mathcal{E}_S(AF)$

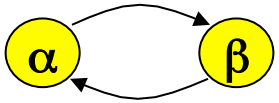


Defeat Status
(Justification Status)

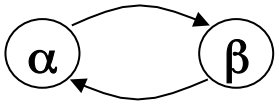


[Justified arguments:
belong to all extensions]

Unique-status vs. multiple-status semantics

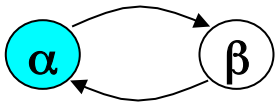


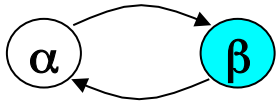
Unique-Status Semantics



Unique extension: empty set
α and β directly unjustified
(provisionally defeated)

Multiple-Status Semantics





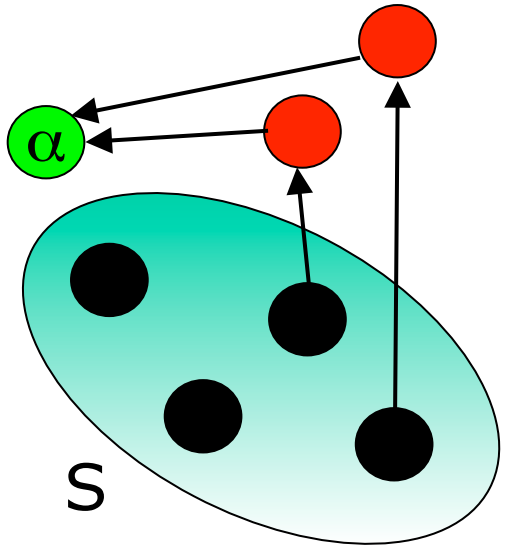
⇒ α and β unjustified (provisionally defeated)

The core of Dung's theory: complete "semantics"

Acceptability

α acceptable w.r.t. ("defended by") S

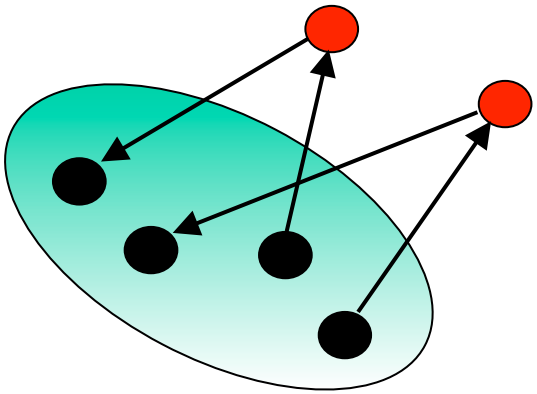
- all attackers of α are attacked by S



Admissible set S

- conflict-free
- every element acceptable w.r.t. S

  (defends all of its elements)



IF

also includes all acceptable elements w.r.t. itself

Complete semantics

Complete extension

All traditional semantics select complete extensions

Complete "semantics": examples

Chain

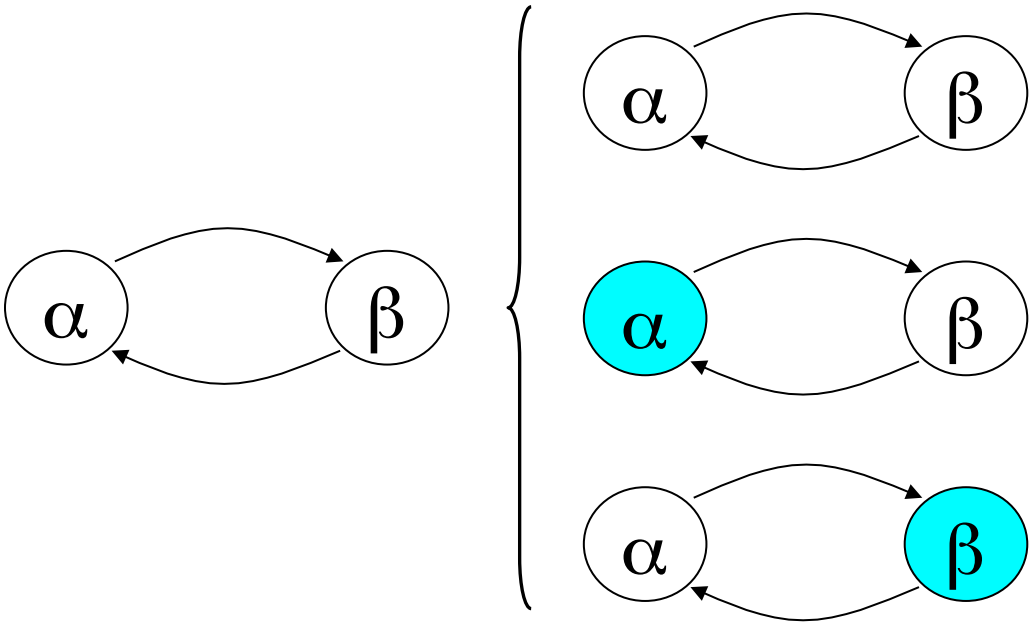
Admissible sets:

$\emptyset$, $\{\alpha\}$, $\{\alpha, \gamma\}$

Only one complete extension:

$\mathcal{E}_{CO}(AF) = \{\{\alpha, \gamma\}\}$

Nixon Diamond



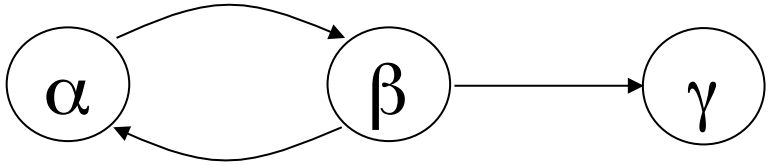
All admissible sets are complete

$\mathcal{E}_{CO}(AF) =$

$\{ \emptyset, \{\alpha\}, \{\beta\} \}$

Complete "semantics": examples (2)

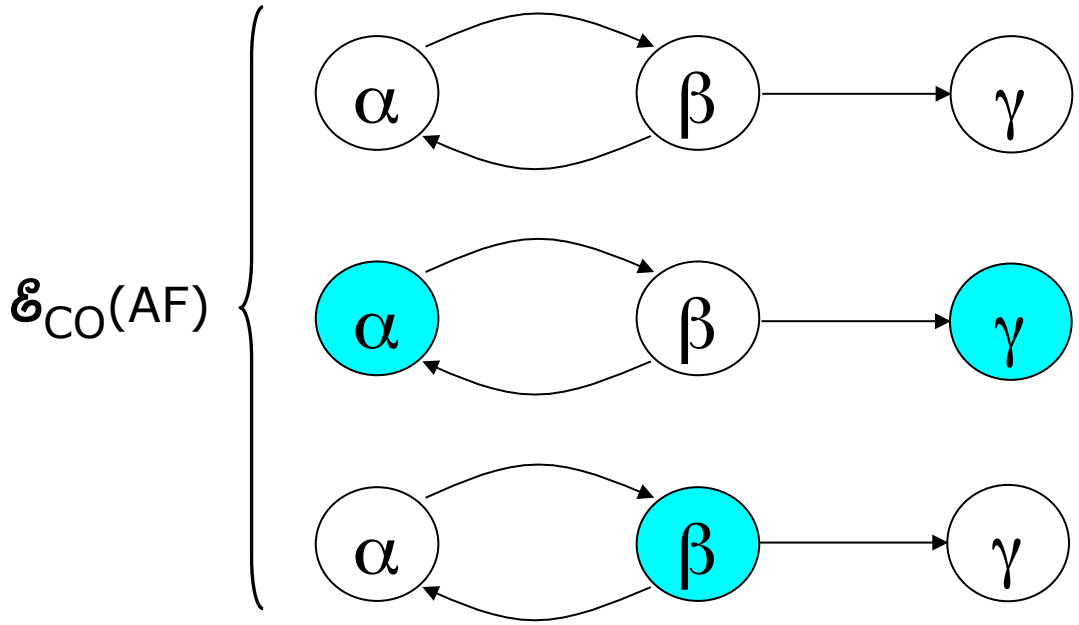
Nixon Diamond + node



Admissible sets:

ø, {α}, {β}, {α, γ}

$\mathcal{E}_{CO}(AF)$ =



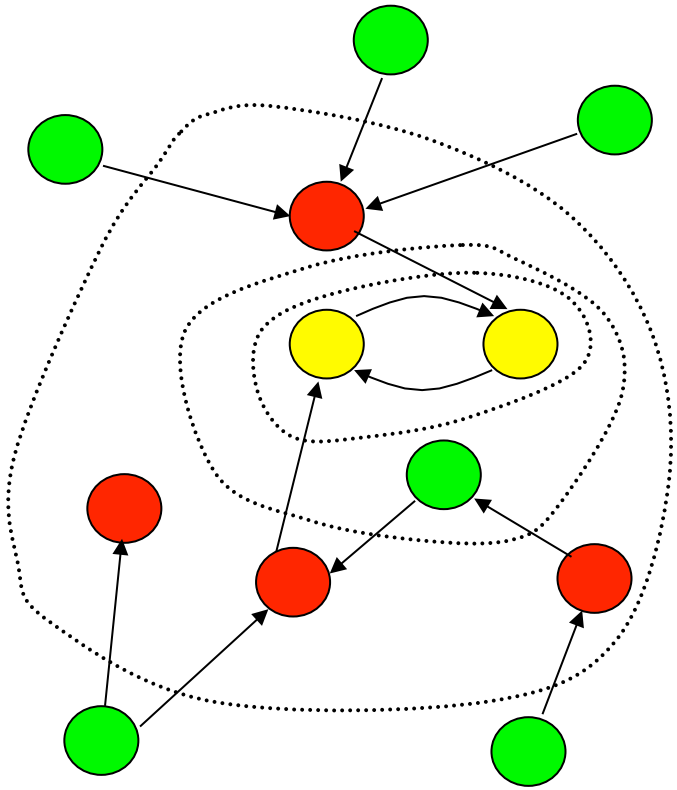
$\mathcal{E}_{CO}(AF)$ = {

ø

{α, γ},

{β} }

The Grounded Semantics: a unique status approach

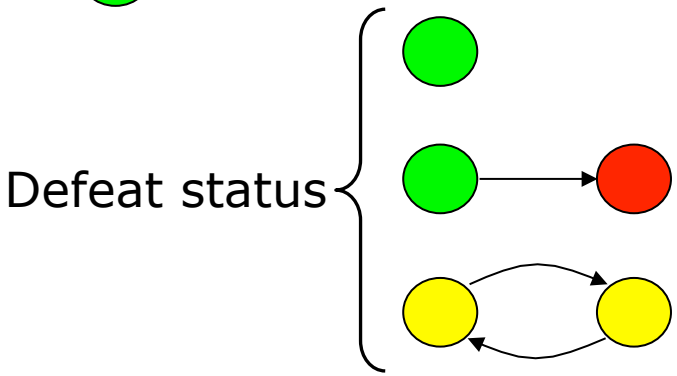


Grounded extension GE(AF):

Least complete extension

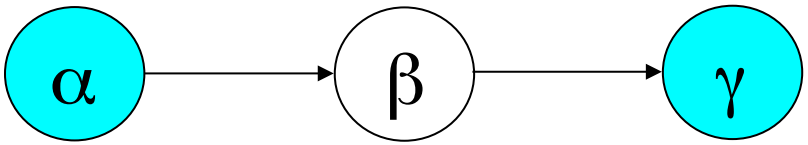
⇒ included in all extensions of any traditional semantics

⇒ Grounded semantics is the "most skeptical" one



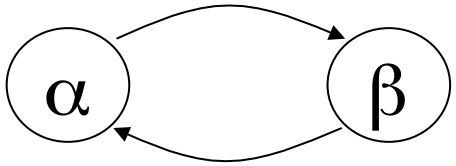
Grounded semantics: examples

Chain



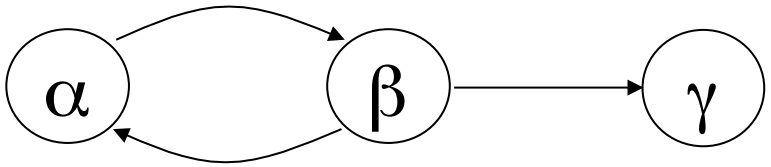
GE(AF) = {α, γ}

Nixon Diamond



GE(AF) = ø

Nixon Diamond + node



GE(AF) = ø

Floating arguments: a problem for grounded semantics

- Actually, grounded semantics is polynomially computable
- But sometimes we want a more discriminative behavior

THE CASE OF FLOATING ARGUMENTS

Grounded Semantics

What we want (?)

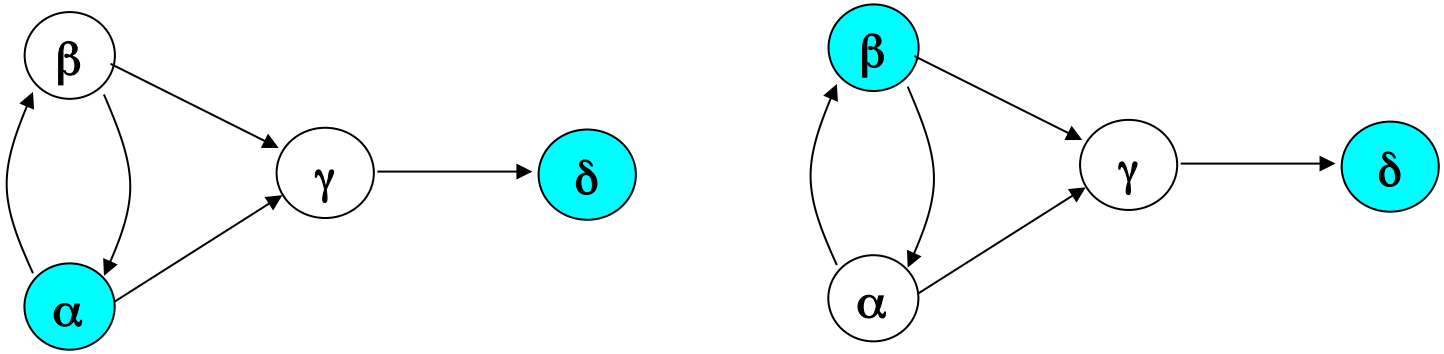
- A problem for all possible unique status approaches

➡ Let us consider multiple status approaches!

Stable Semantics

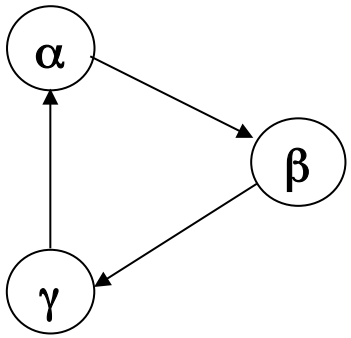
Stable extension = conflict-free set attacking all outside arguments

THE CASE OF FLOATING ARGUMENTS



$\mathcal{E}_{ST}(AF) = \{ \{\alpha, \delta\}, \{\beta, \delta\} \}$ $\Rightarrow$ δ is justified

ODD-LENGTH CYCLES: A PROBLEM FOR STABLE SEMANTICS



No stable extension exists!

(and also imposing Ø is not satisfactory)

Preferred semantics

Stable extensions are maximal complete extensions

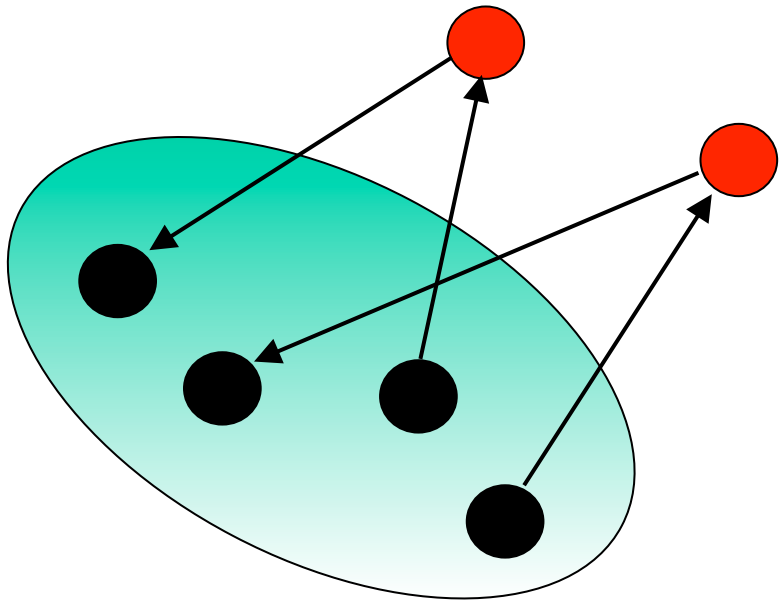
- conflict-free: by definition
- admissible: every argument attacking an extension is outside
  ⇒ attacked by the extension itself
- maximal: no argument can be included!

Preferred semantics [P.M. Dung, '95]

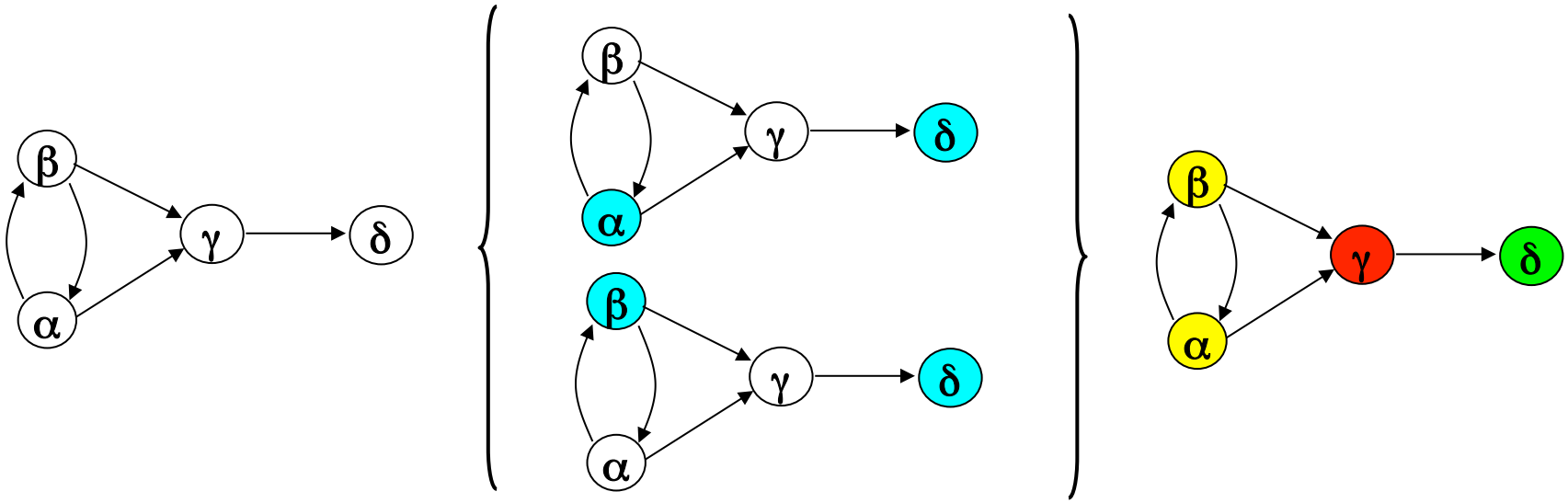
Preferred extension

Maximal complete extension = max Set:

- is conflict-free
- defends all of its elements

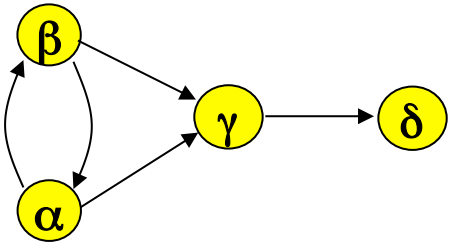


Preferred semantics and floating arguments

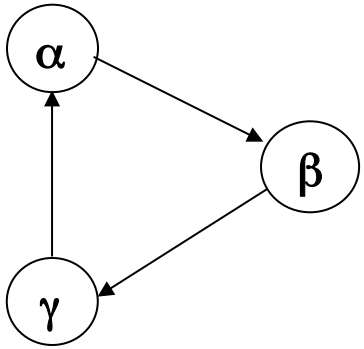


$\mathcal{E}_{PR}(AF) = \mathcal{E}_{ST}(AF) = \{ \{\alpha, \delta\}, \{\beta, \delta\} \}$ $\Rightarrow$ δ is justified

Grounded semantics:



Preferred semantics and odd-length cycles



$\mathcal{E}_{PR}(AF) = \{\emptyset\}$

$\mathcal{E}_{ST}(AF) = \emptyset$

$\mathcal{E}_{GE}(AF) = \{\emptyset\}$

A big difference, isn't it?

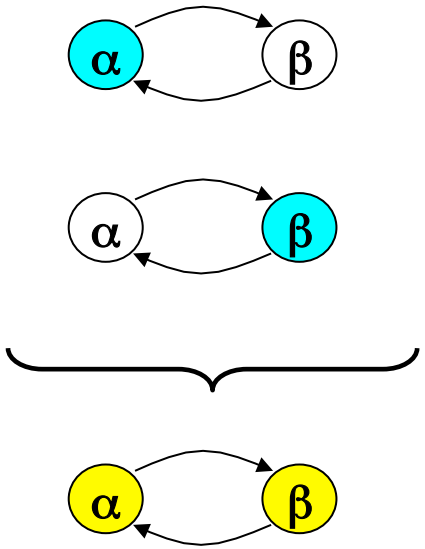
No argument justified w.r.t. grounded and preferred semantics

- Like stable semantics, preferred semantics handles the case of floating arguments (differently than grounded semantics)
- W.r.t. stable semantics it behaves "better" in the case of odd-length cycles (like grounded semantics)

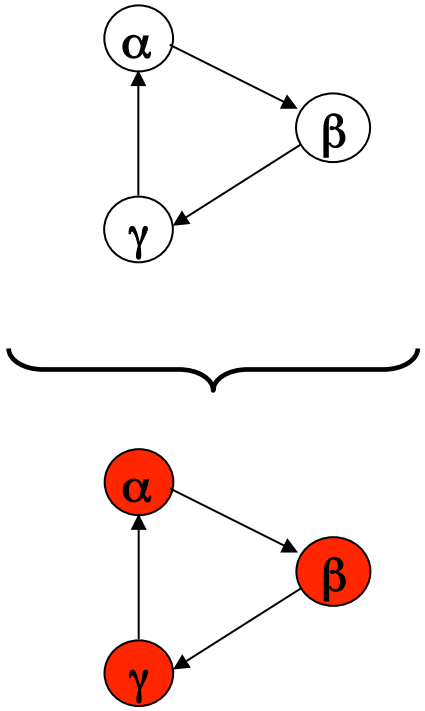
So, what remains to be done?

Preferred Semantics and cycles

Even-length cycle



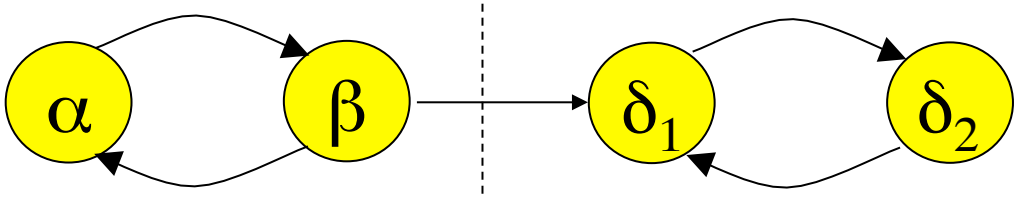
Odd-length cycle



A different treatment for even and odd-length cycles.

Is it just a matter of symmetry and elegance?

Preferred Semantics and cycles (continued)



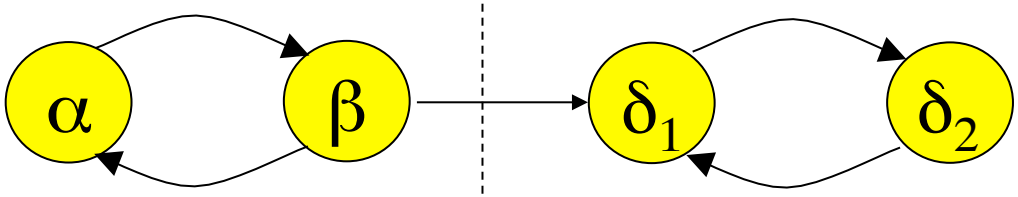
vs

$\mathcal{E}_{PR}(AF) =$

$\{\{\alpha, \delta_1\}, \{\alpha, \delta_2\},$

$\{\beta, \delta_2\}\}$

Preferred Semantics and cycles (continued)

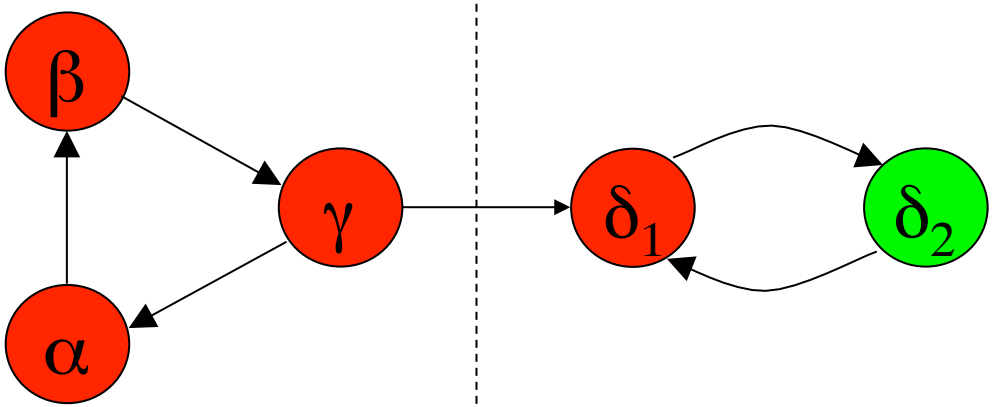


$\mathcal{E}_{PR}(AF)$ =

$\{\{\alpha, \delta_1\}, \{\alpha, \delta_2\},$

$\{\beta, \delta_2\}\}$

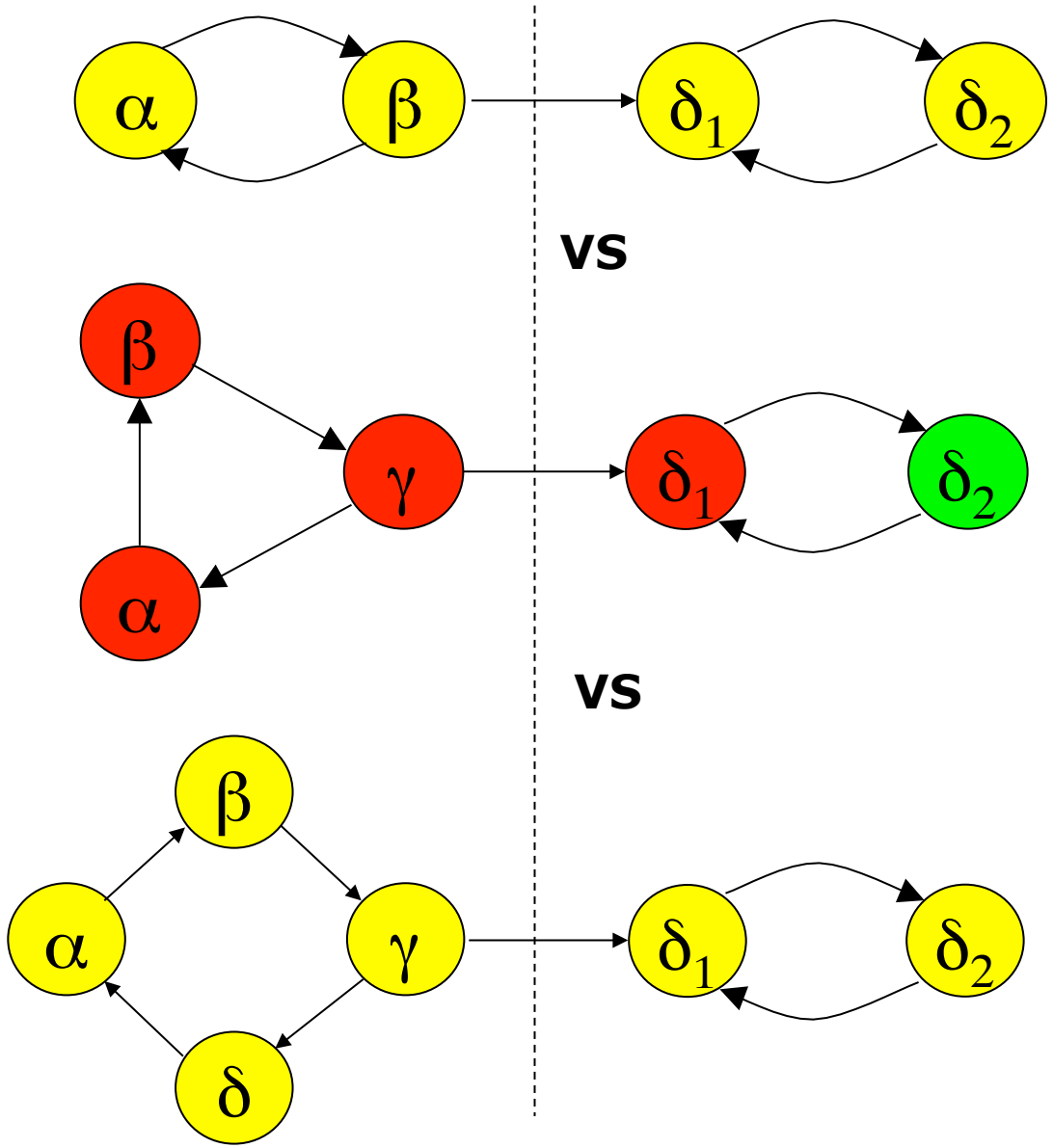
vs



$\mathcal{E}_{PR}(AF) = \{\{\delta_2\}\}$

vs

Preferred Semantics and cycles (continued)



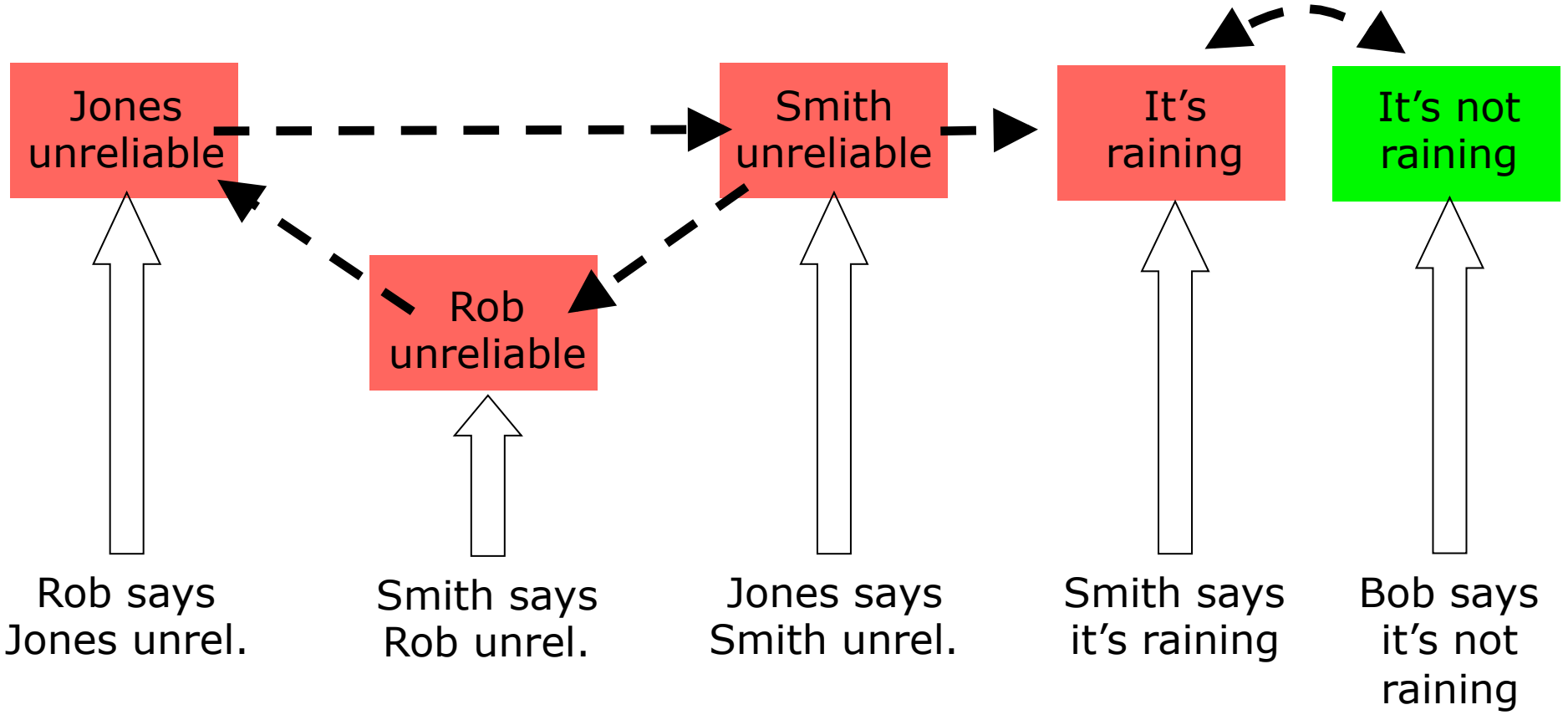
$\mathcal{E}_{PR}(AF)$ =
$\{\{\alpha, \delta_1\}, \{\alpha, \delta_2\}, \{\beta, \delta_2\}\}$

$\mathcal{E}_{PR}(AF) = \{\{\delta_2\}\}$

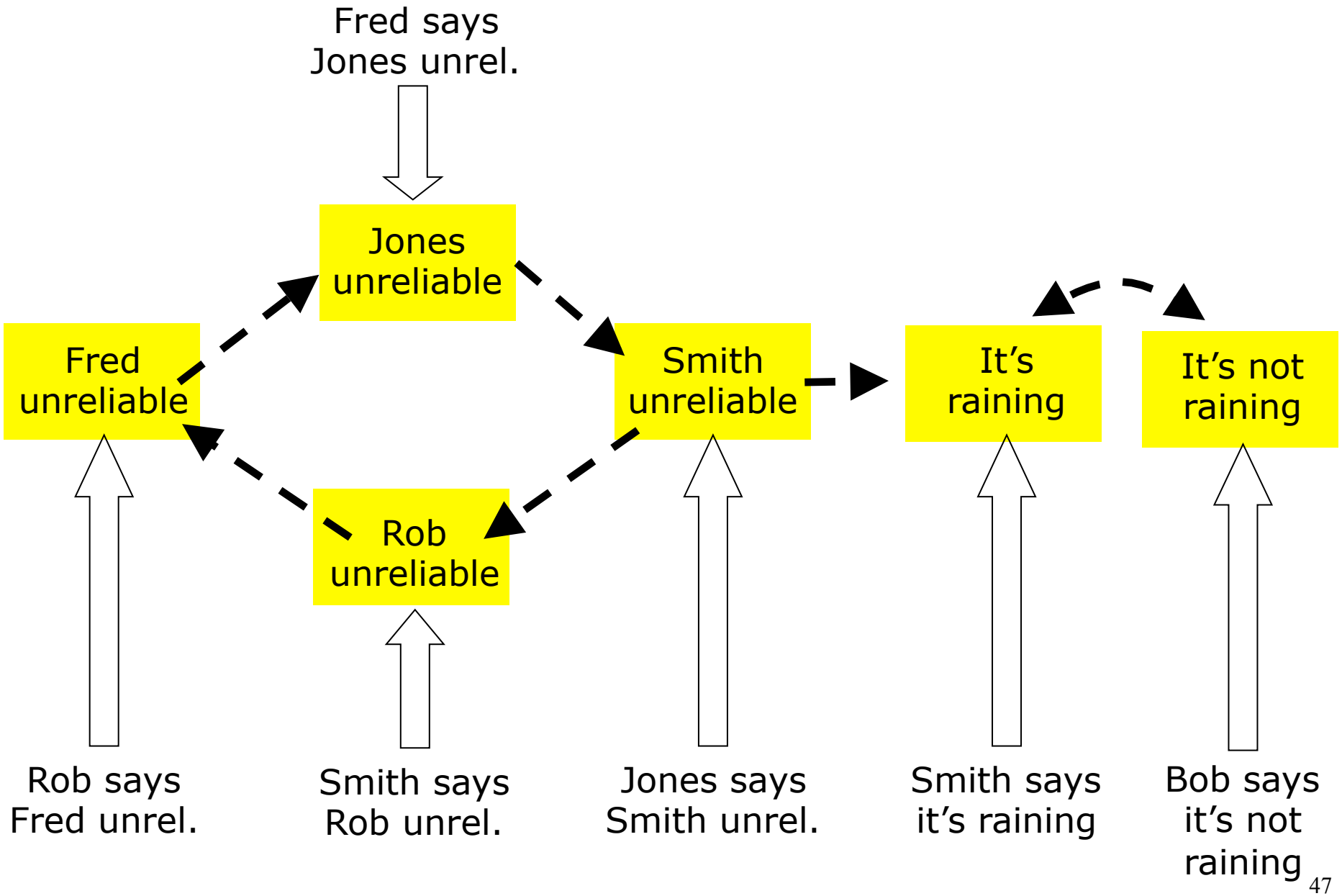
$\mathcal{E}_{PR}(AF)$ =
$\{\{\alpha, \gamma, \delta_2\}, \{\beta, \delta, \delta_1\}, \{\beta, \delta, \delta_2\}\}$

NB: grounded semantics yields the empty set in all cases

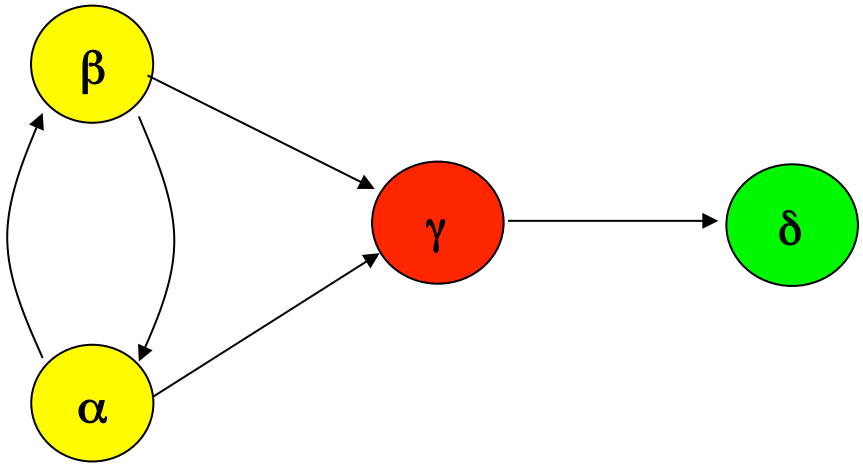
Pollock example revisited (1)



Pollock example revisited (2)

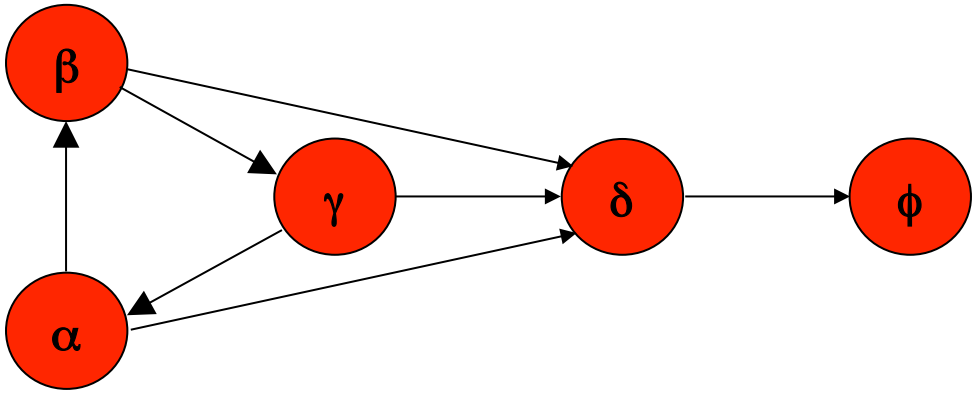


Preferred Semantics and Floating Arguments again…



[two preferred extensions]

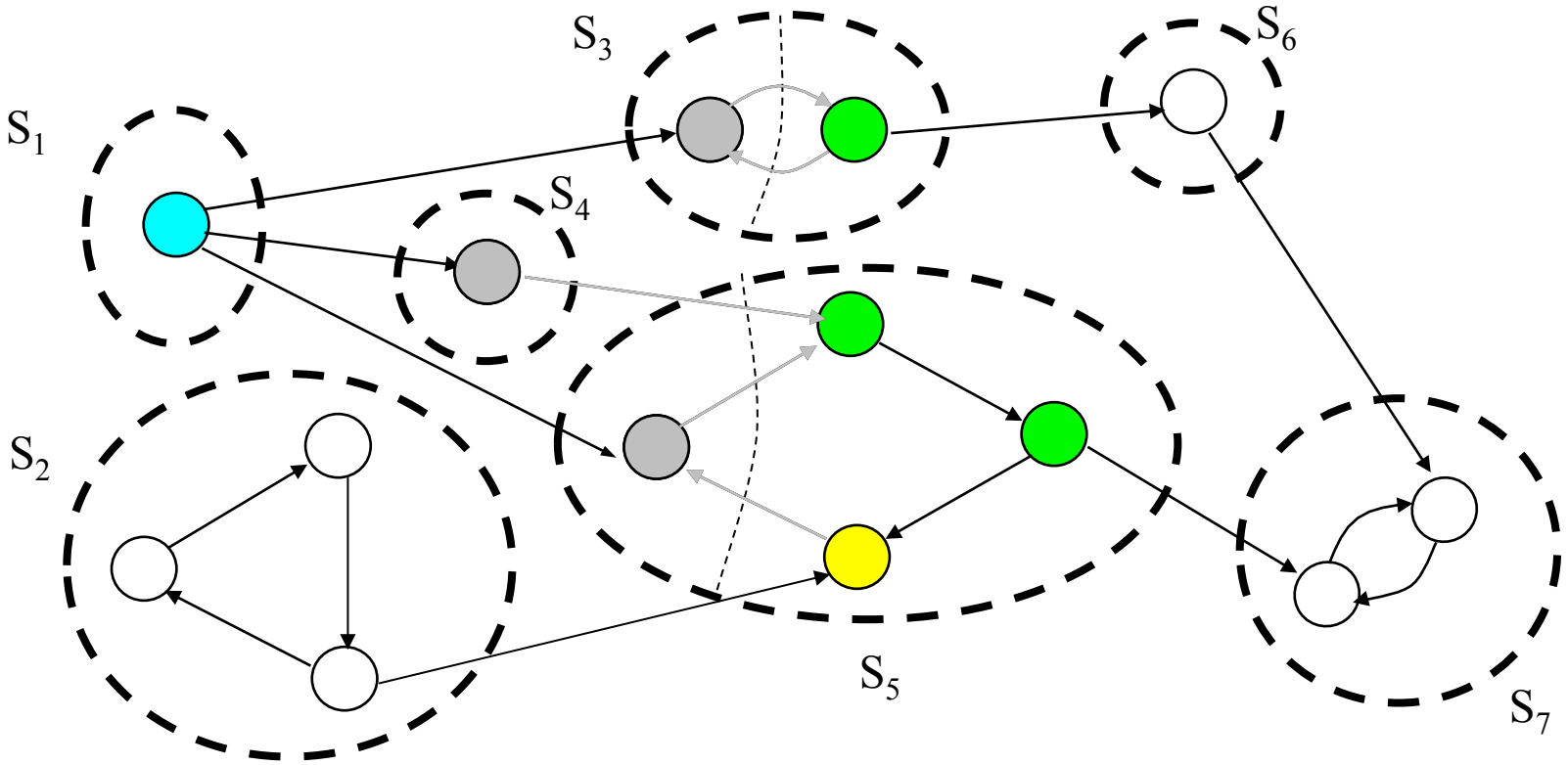
vs



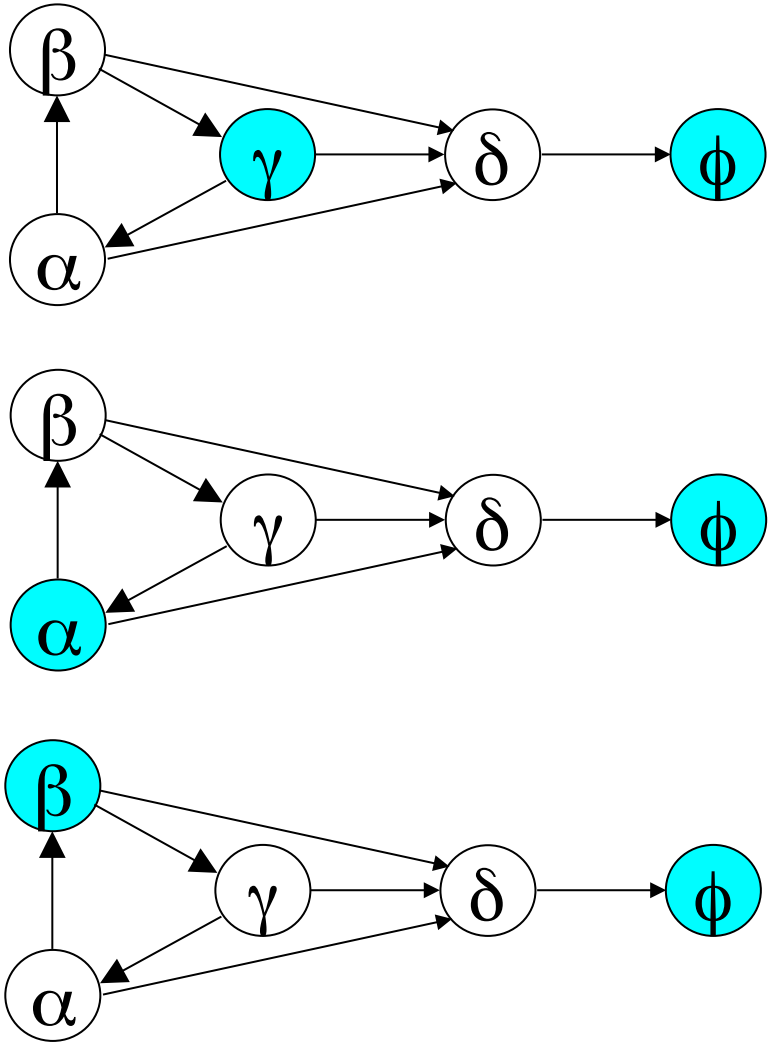
[empty set is the unique preferred extension]

NB: grounded semantics yields the empty set in both cases

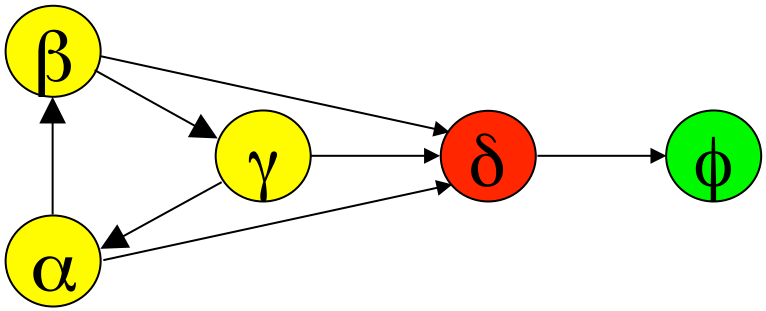
A possible solution: SCC and CF2 Semantics



Floating arguments with a three-length cycle



CF2 Extensions: {γ,ϕ}, {α,ϕ}, {β,ϕ}



Defeat status

Other semantics…

- Semi-stable semantics [Verheij'96, Caminada'06]
- Stage semantics [Verheij'96]
- Two approaches to the problems of self-attacking arguments and general odd-length cycles of attack [G. Bodanza, F. Tohmé '08]
- Ideal semantics [Dung, Mancarella, Toni'06]
- The family of prudent semantics [Coste-Marquis, Devred, Marquis'05]
- Robust semantics [H. Jakobovits, D. Vermeir '99]
- AD1, AD2, CF1 semantics [Baroni&Giacomin'04 and '05]
- Resolution-based version of any semantics [Baroni&Giacomin'08]

Semantics evaluation

- What principle-based criteria for semantics evaluation?
  - > Sample properties of individual extensions
  - > Sample properties of sets of extensions

Conflict-freeness, admissibility, reinstatement

Conflict-free principle (satisfied by all semantics)

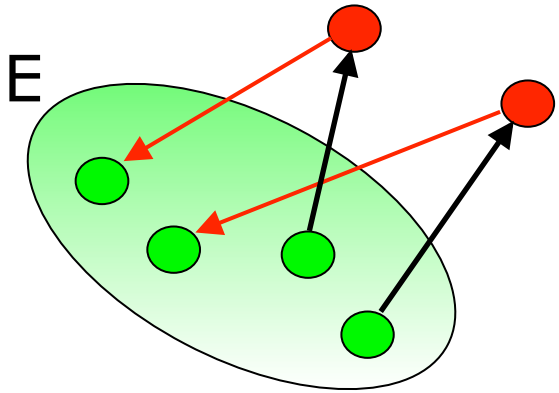
A semantics S satisfies the "conflict-free principle" iff

$\forall$ AF, $\forall$ E$\in\mathcal{E}_S$(AF) E is conflict-free

Admissibility

$\forall$ AF, $\forall$ E $\in\mathcal{E}_S$(AF)

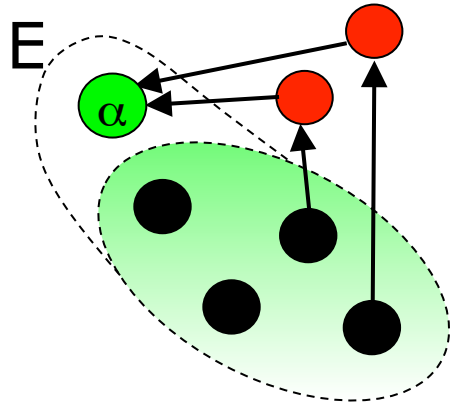
- E is conflict-free
- E defends all of its arguments



Reinstatement

$\forall$ AF, $\forall$ E$\in\mathcal{E}_S$(AF)

- if E "defends" α then $\alpha\in$E

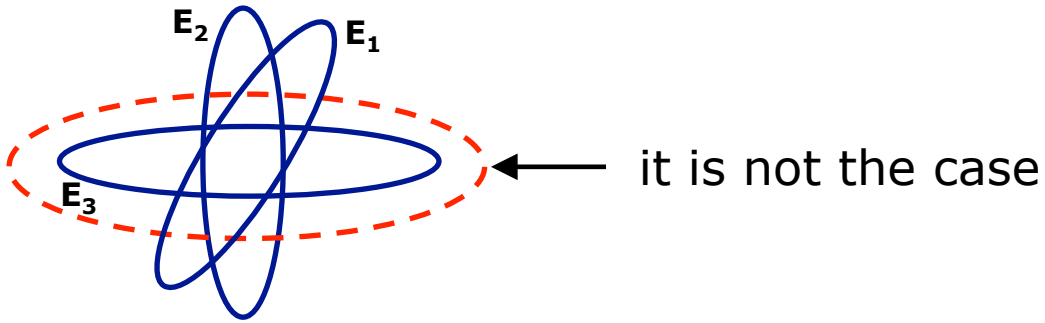


I-maximality principle

I-maximality principle

A semantics S satisfies the "I-maximality principle" iff

$\forall$ AF, $\forall$ $E_1, E_2 \in \mathcal{E}_S(AF)$ if $E_1 \subseteq E_2$ then $E_1 = E_2$



- Grounded and preferred semantics satisfy I-maximality
- Complete semantics do not

Directionality principle

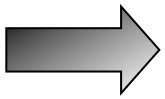
Basic idea

Extension membership of an argument is determined by its ancestors, while it is not affected by the arguments it defeats

Definition

$\forall$ AF, $\forall$ U "unattacked set" of AF,

$$\{(E \cap U) \mid E \in \mathcal{E}_{\mathbf{S}}(AF)\} \quad = \quad \mathcal{E}_{\mathbf{S}}(AF_{\downarrow U})$$



Extensions can be constructed "incrementally" along the graph

Skepticism related criteria

The informal notion of skepticism

Making “less|more committed choices” for arguments,
i.e. assigning to them “less|more decided” justification states.

Two kinds of skepticism relations

A *basic skepticism relation* $\preceq^{E}$ between sets of extensions:

$\mathcal{E}_1 \preceq^{E} \mathcal{E}_2$ denotes that $\mathcal{E}_1$ is “at least as skeptical as”

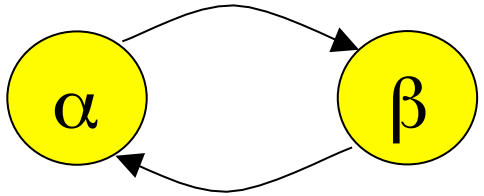
(or “not more committed” than) $\mathcal{E}_2$

A *skepticism relation* $\preceq^{A}$ between argumentation frameworks:

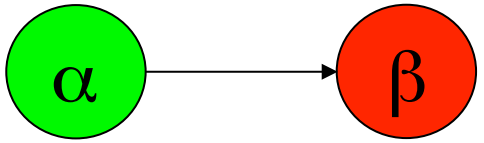
$AF_1 \preceq^{A} AF_2$ denotes that AF_1 is “at least as skeptical as” AF_2

Skepticism relation between argumentation frameworks

The Basic idea



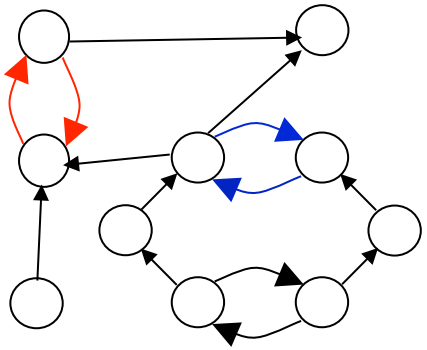
vs.



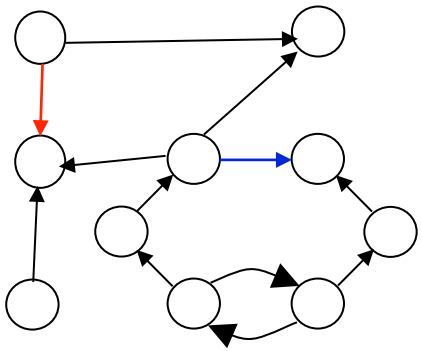
More skeptical
(less committed)

Less skeptical
(more committed)

The General relation



AF_1



AF_2

$AF_1 \sqsubseteq^A AF_2$

[partial order]

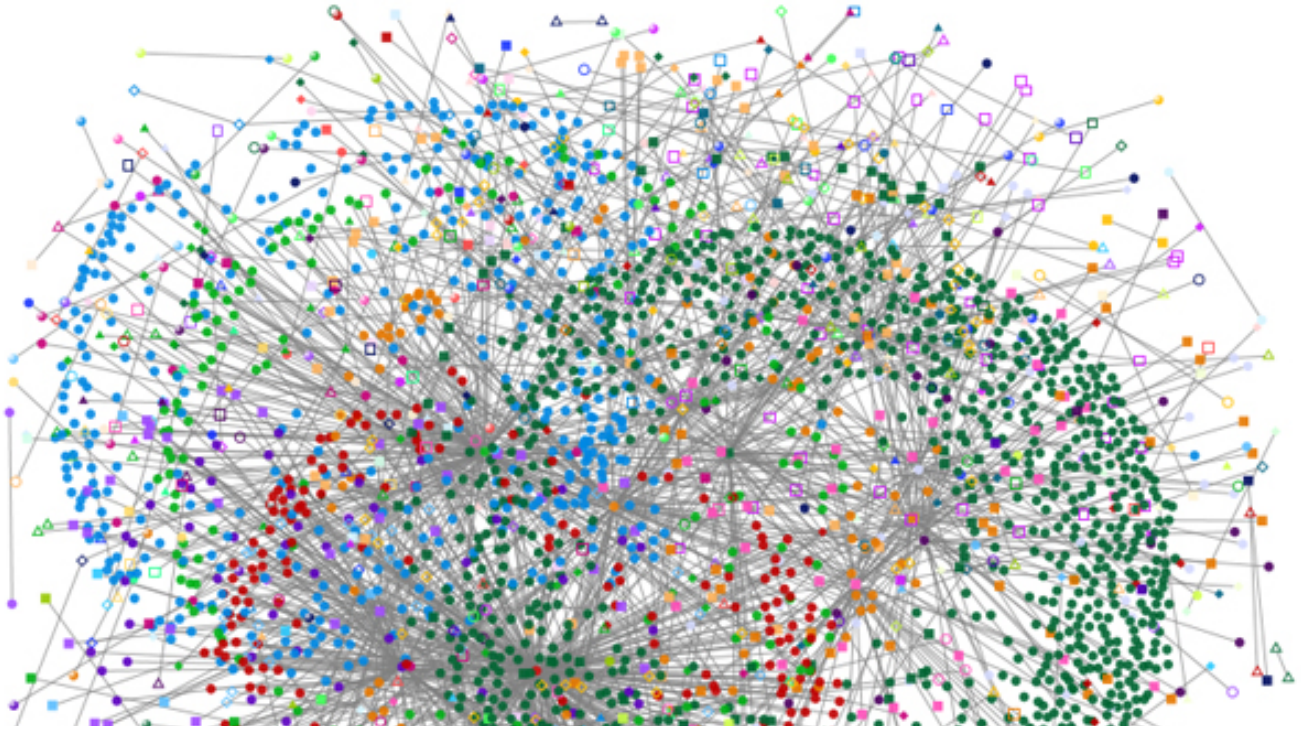
Abstract vs Natural Arguments

- No methodology for defining a mapping
- Problem with evaluation of semantics
  - What are "acceptable" arguments in concrete domains?
    - Cognitive perspective
    - Social perspective
  - Are abstract argumentation frameworks a "good" way to represent knowledge?

Arguments and social networks

- Argumentation to model social networks debates
- Trend: convergence of many reseach activities
  - Argumentation in multi-agent systems
  - Formal dialogues (e.g., persuasion)
  - Argumentation and trust
  - Abstract vs natural argumentation
  - Social simulations
  - Many issues in collective reasoning
    - Bottom-up argumentation
    - Argumentation and voting, social abstract argumentation
    - Weighted argumentation systems
    - Outcomes of multi-party persuasion
    - Argumentation to formalize/help/support/… online debates

SOCIAL NETWORKS



Social Network Analysis

- SNA studies social actors by means of graph theory
- A graph is an object $G = (V,E)$, where vertex are represented as a vector:
  - $V = \{v_1, v_2, v_3, \ldots, v_n\}$
- And links as a vector:
  - $E = \{e_1, e_2, e_3, \ldots, e_m\}$.

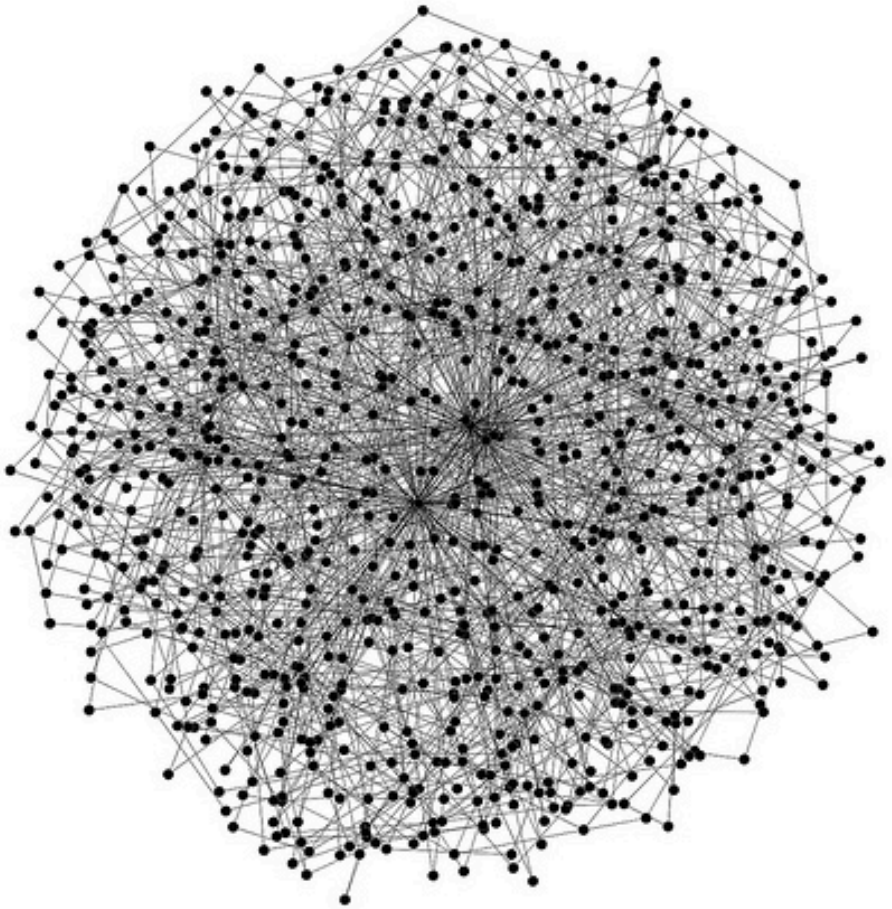
- **What does it make social networks so special?**

Random networks

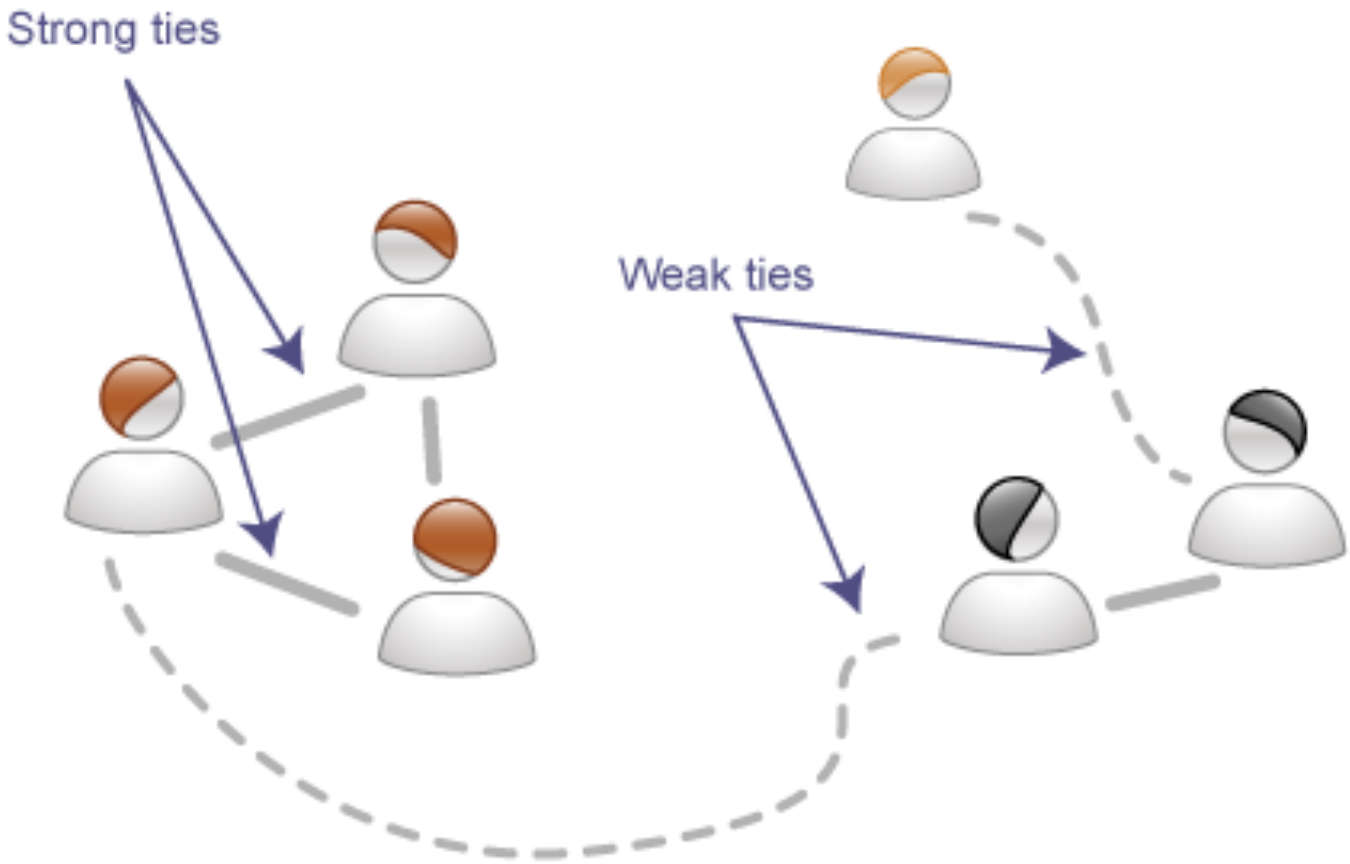
- First attempt to model social relations: random models (Erdos e Renyi).

- Pseudocode:

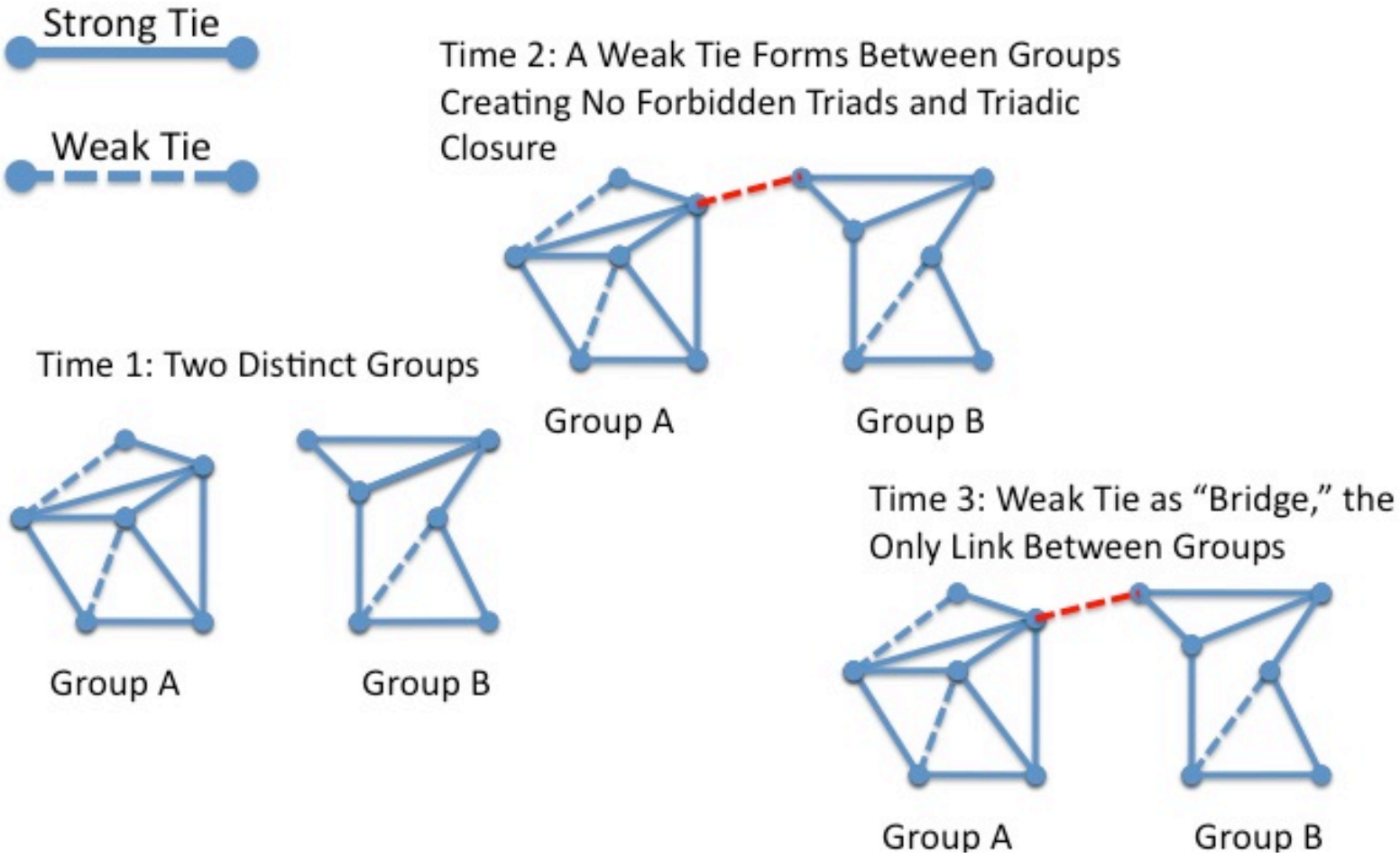
```
foreach pair [
    if random 1 < prob [
        create-a-link ]
]
```



Think about you and your friends

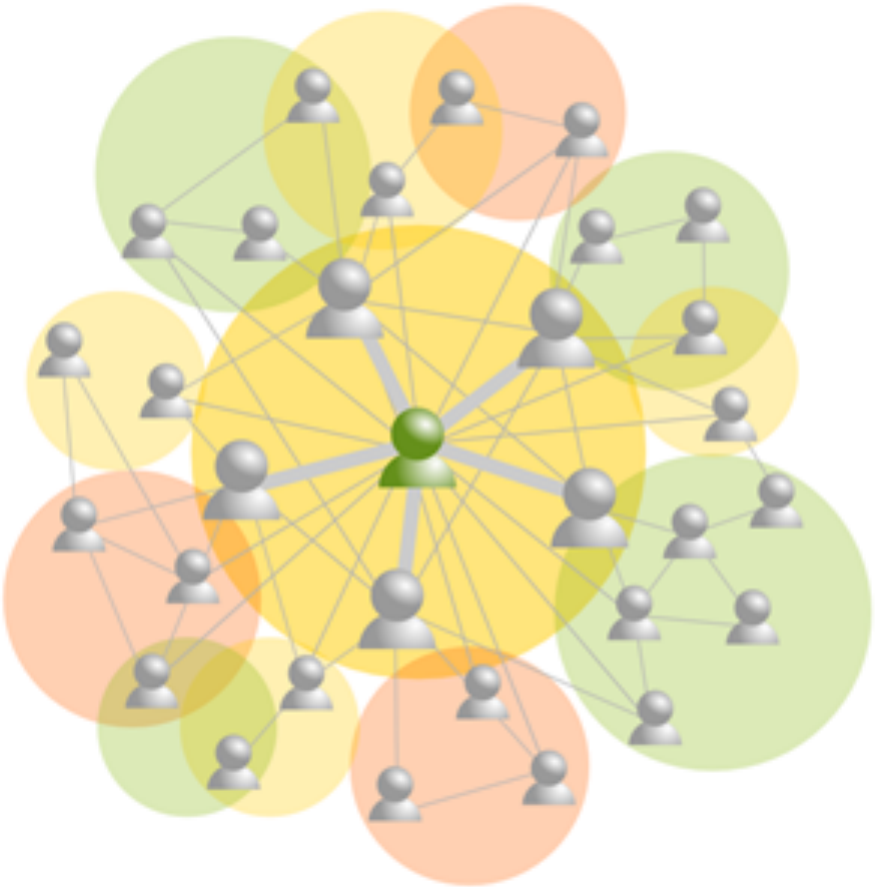


Why all bridges are weak ties



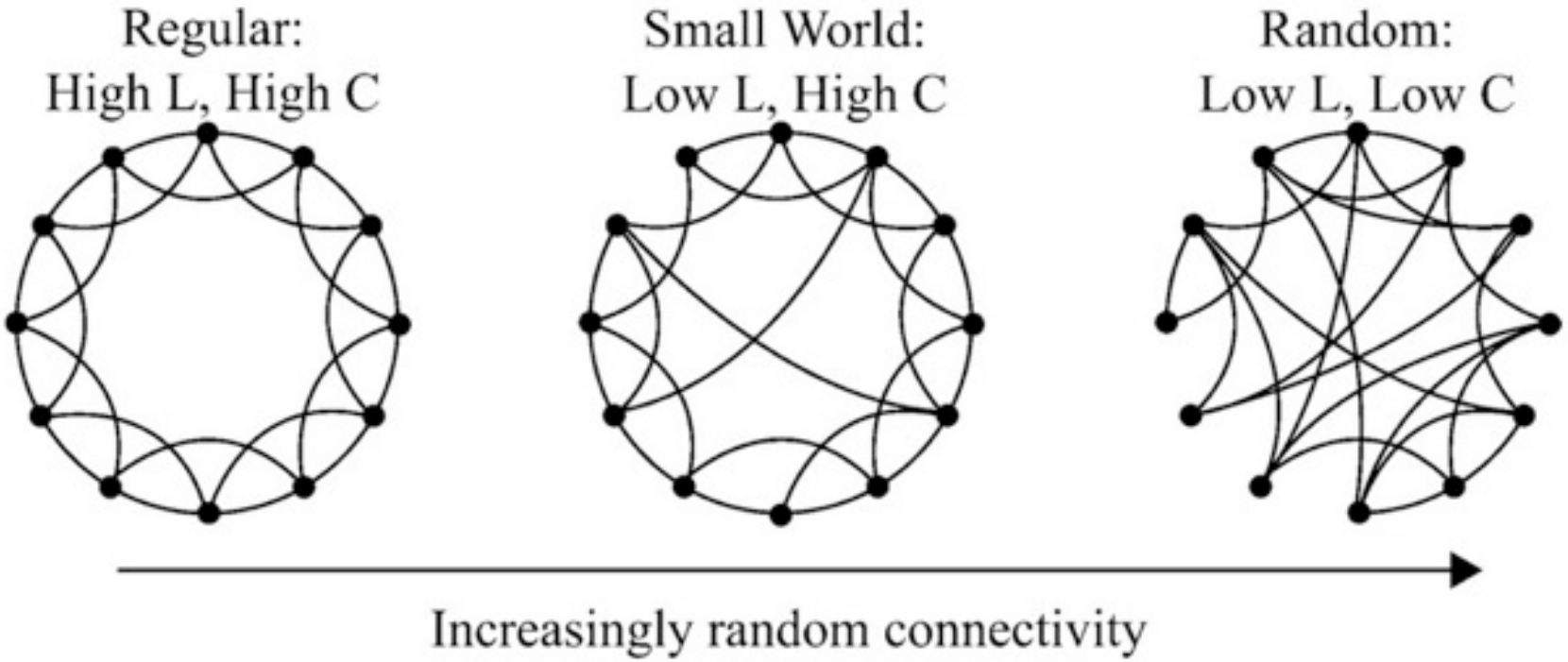
The strength of weak ties

CONNECTIONS THROUGH STRONG TIES



CONNECTIONS THROUGH WEAK TIES

Small World Model



Diffusion and network topologies

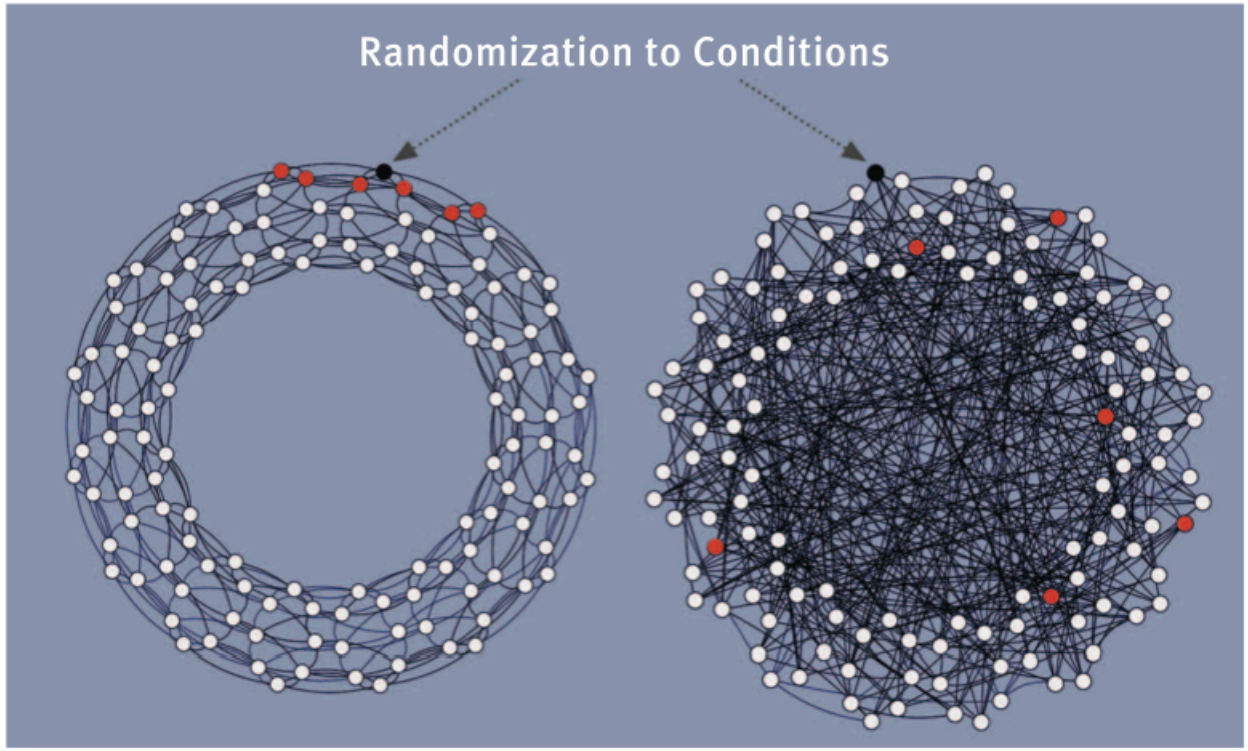
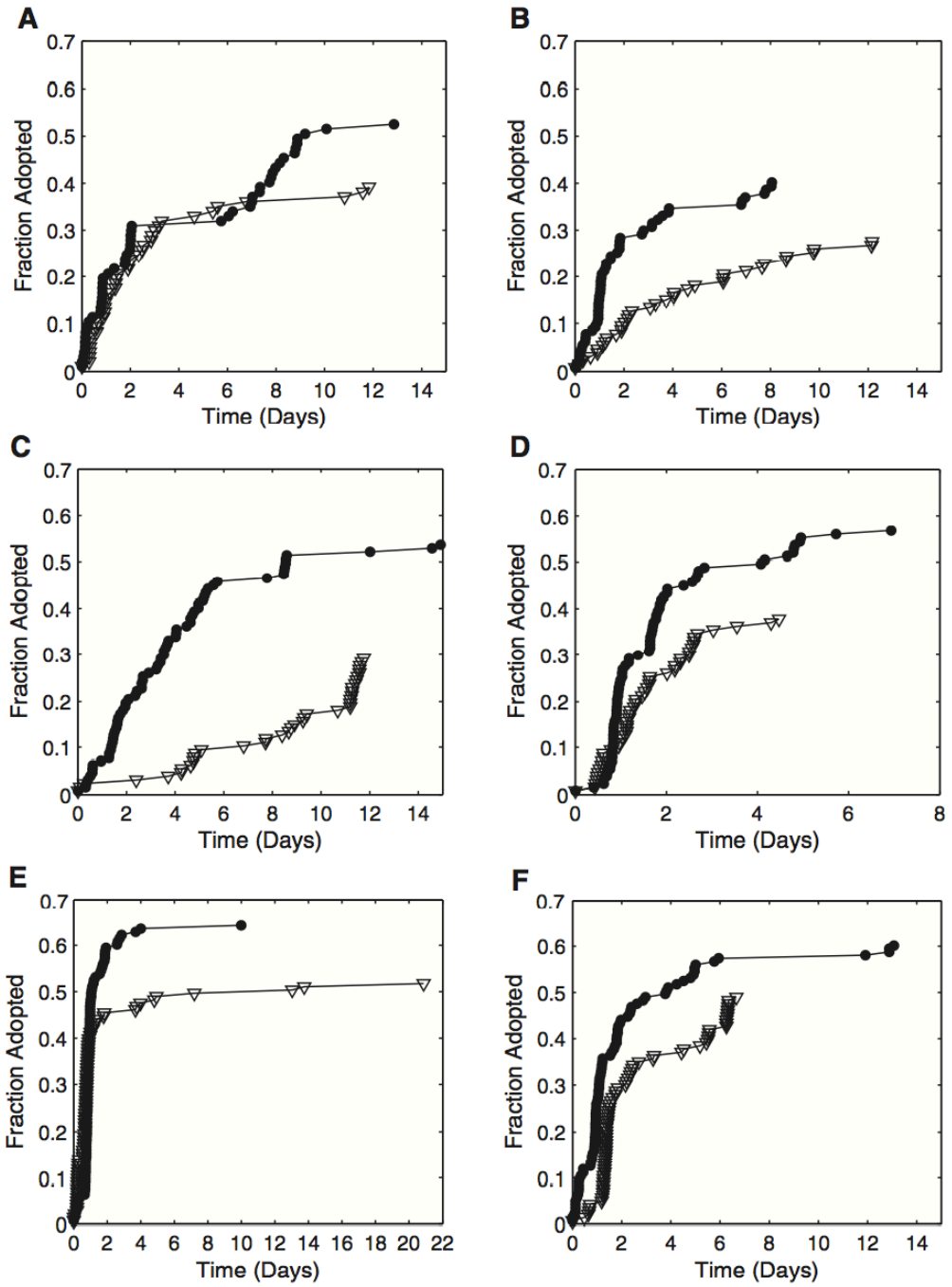


Fig. 1. Randomization of participants to clustered-lattice and random-network conditions in a single trial of this study ($N = 128$, $Z = 6$). In each condition, the black node shows the focal node of a neighborhood to which an individual is being assigned, and the red nodes correspond to that individual's neighbors in the network. In the clustered-lattice network, the red nodes share neighbors with each other, whereas in the random network they do not. White nodes indicate individuals who are not connected to the focal node.

Results

- adoption typically spread to a greater fraction of the population in the clustered networks (solid black circles) than in the random networks
- the behavior diffused more quickly (4 times faster) in the clustered networks than in the random networks
- redundant signals significantly increased the likelihood of adoption;
- social reinforcement from multiple health buddies made participants much more willing to adopt the behavior

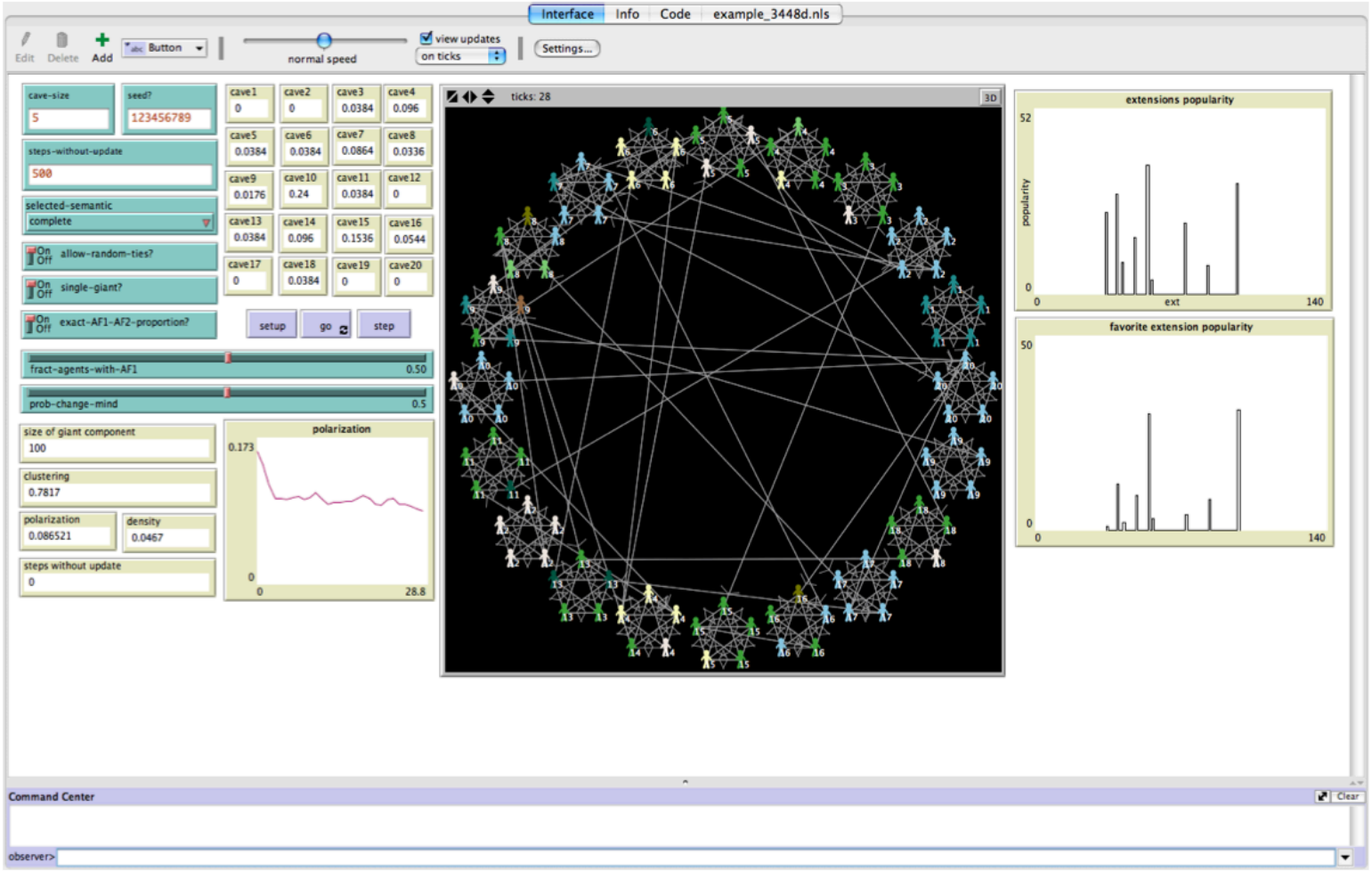


References

- Centola, D: The Spread of Behavior in an Online Social Network Experiment, *Science*, 329, 1194-1197, (2010)
- Erdős, P and Rényi, A: On Random Graph, *Publ. Math. Debrecen*, (1959)
- Granovetter, M.: The strength of weak ties: a network theory revisited. *Sociological Theory* 1, 201–233 (1983)
- Watts, D.J., Strogatz, S.H.: Collective dynamics of small-world networks. *Nature*, 393, 440–442 (1998)

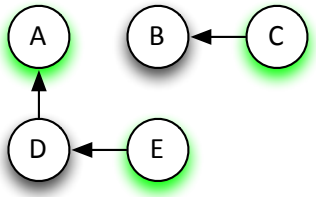
TWO APPLICATIONS

NetArg

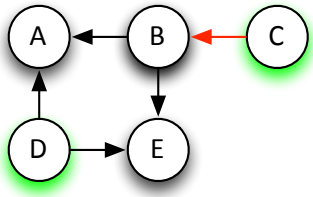

Interface
Info
Code
example_3448d.nls
Edit
Delete
Add
Button
normal speed
view updates
on ticks
Settings...
cave-size
5
seed?
123456789
steps-without-update
500
selected-semantic
complete
allow-random-ties?
single-giant?
exact-AF1-AF2-proportion?
setup
go
step
fract-agents-with-AF1
0.50
prob-change-mind
0.5
size of giant component
100
clustering
0.7817
polarization
0.086521
density
0.0467
steps without update
0
cave1
0
cave2
0
cave3
0.0384
cave4
0.096
cave5
0.0384
cave6
0.0384
cave7
0.0864
cave8
0.0336
cave9
0.0176
cave10
0.24
cave11
0.0384
cave12
0
cave13
0.0384
cave14
0.096
cave15
0.1536
cave16
0.0544
cave17
0
cave18
0.0384
cave19
0
cave20
0
polarization
0.173
0
0
28.8
ticks: 28
3D
extensions popularity
52
popularity
0
0
ext
140
favorite extension popularity
50
0
0
140
Command Center
Clear
observer>

Agent reasoning and interaction

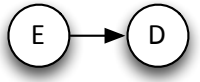
A1's Argumentation Framework



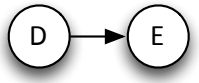
A2's Argumentation Framework



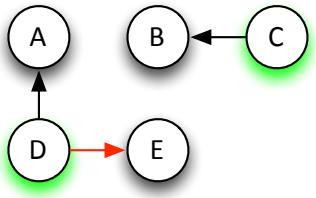
A1 says:



A2 does not trust A1 and rebuts:

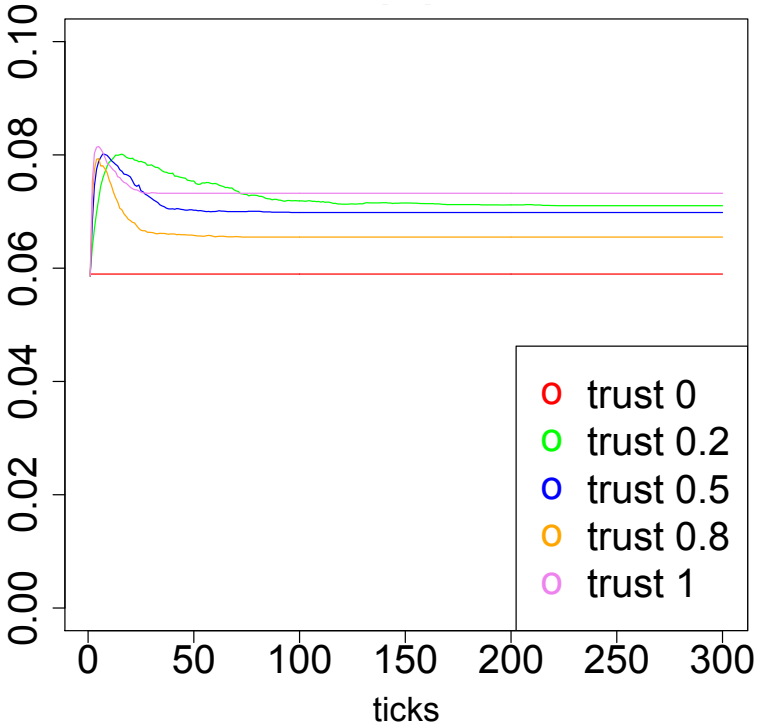


A1 trusts A2 and revises its AF:

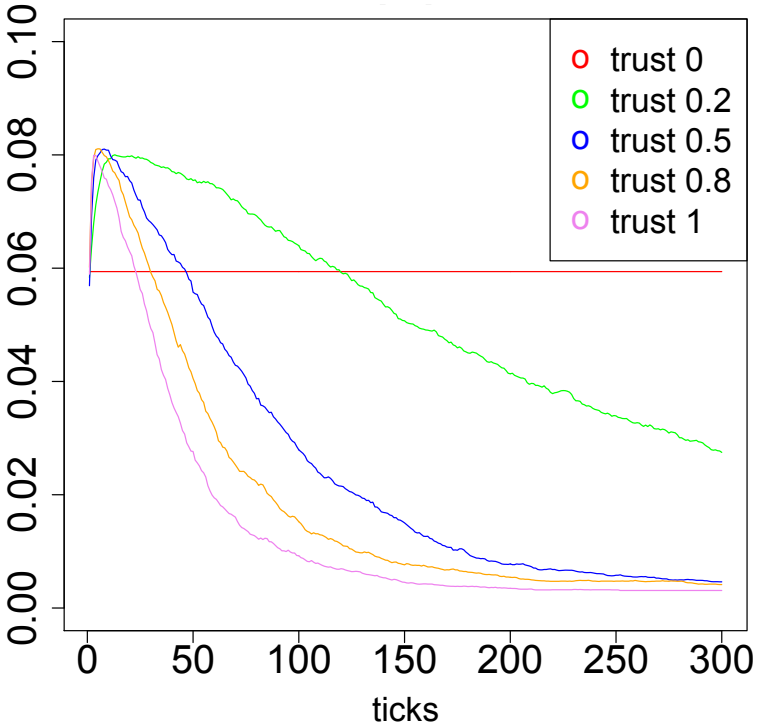


Experiments…

- No weak ties

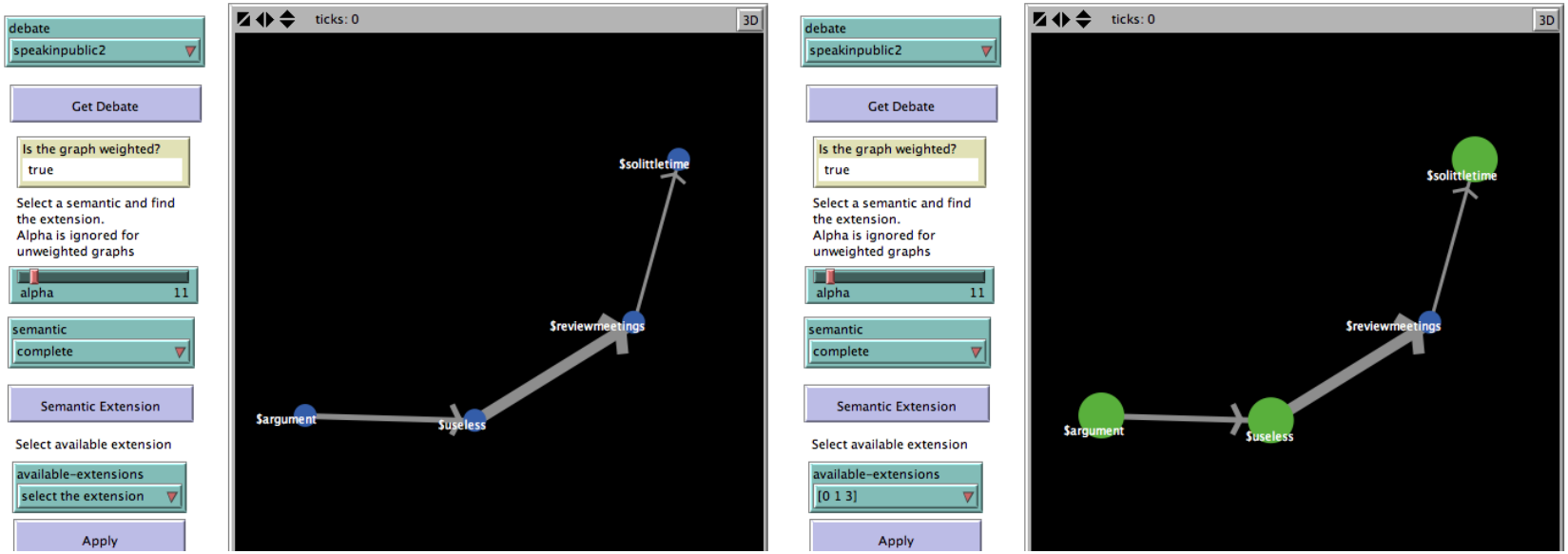


- Weak ties



TwitterArg

- Microdebates = Debates on Twitter
- *Can users argue better for their own reasons if they can better the others' reasons?*
- Simple syntax that allows us to visualize contrasting positions in a microdebate
- Re-tweet increases support to opinions



WHAT YOU CAN DO WITH US

Shorter-term future

- Crowdsourcing for argument tagging
- Argumentation dialogues and trust calibration in social networks
- What makes an argument strong?
- Engineering micro-debates
- Argument mining using COGITO
- You name it ☺

Crowdsourcing argument tagging

- **The DARPA Network Challenge**
- A competition to explore how social networking could be used to tackle broad problems and issues.

WE HAVE A WINNER!

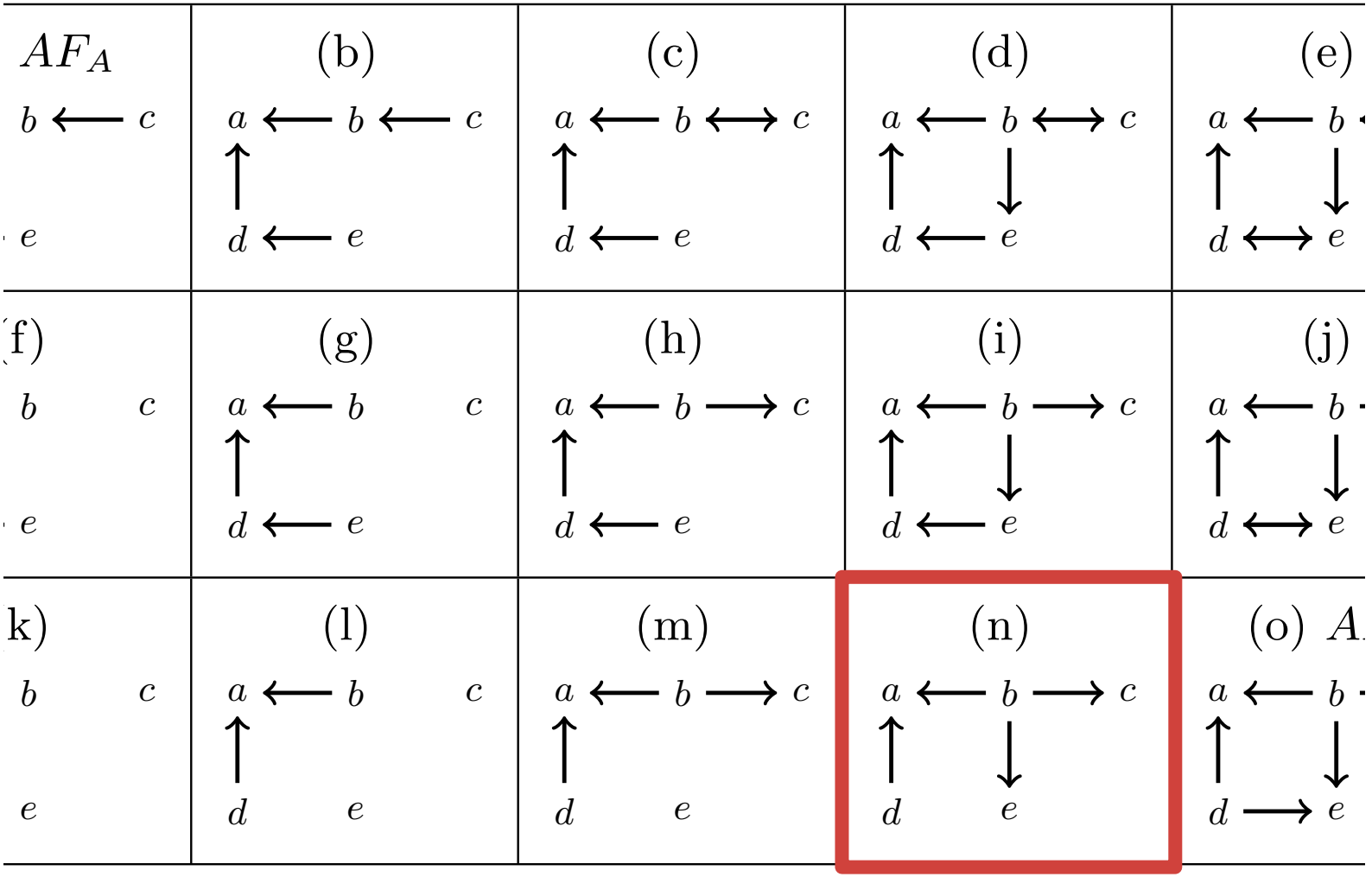
MIT RED BALLOON CHALLENGE TEAM

Read about the winner of the DARPA Network Challenge.

Trust calibration

- Many trust & reputation models in P2P networks
- Trust in social networks
  - Effect of social interaction on trust?
  - Effect of trust on social interaction?
- Simulations

What makes an argument strong?



Engineering micro-debates

- Server-side: Web service
- Client-side: Web vs Mobile/App
- Integration (Medium.com, Liquid Feedback, …)

Cliff Watson
Living a Venn diagram of runner, writer & Dad.

Published
May 2, 2013

Understandings & Epiphanies

Teens aren't abandoning "social." They're just using the word correctly.

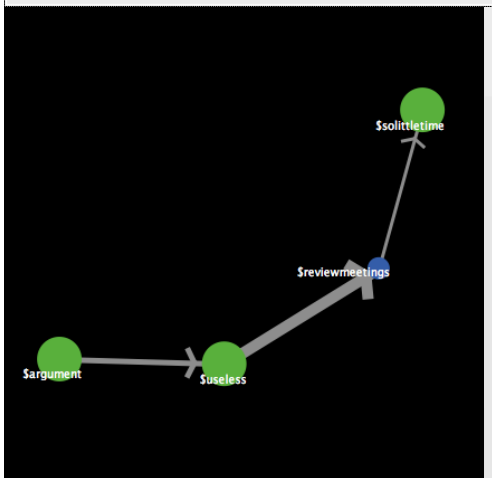
Advertisers are perplexed and a little angst-y.

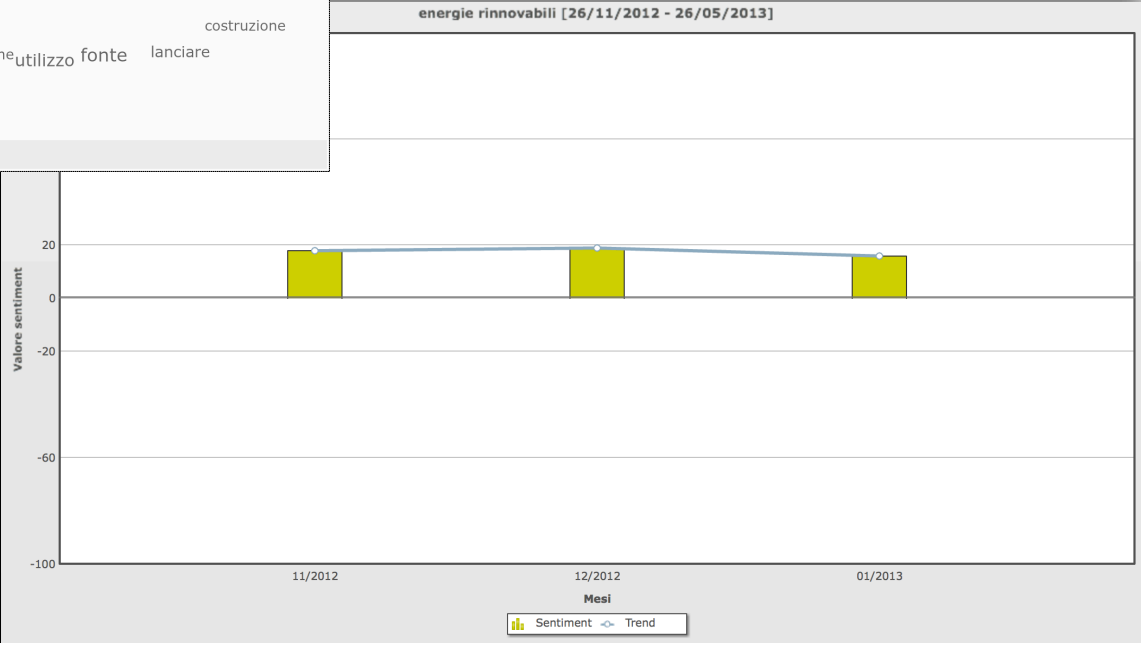
I know this, because I work in advertising. Wait. Don't stop reading because I admitted that. This isn't about advertising. It just happens to start there.

"Teens Are Leaving Social Media in Droves Oh My God We're Doomed Hold Me"

A few weeks ago, that was basically the subject line in every advertising industry newsletter. The source of the panic was a just-released study by Piper Jaffray that asked 5,000 teens to name their "Most Important

Argument mining with COGITO





THANKS!

Argumentation: selected references (1)

Landmark argumentation papers and books

S. Toulmin, "The Uses of Argument"
Cambridge University Press, 1958.

R. P. Loui, "Defeat Among Arguments: a System of Defeasible Inference", *Computational Intelligence*, vol. 3(3), 1987.

J. Pollock, "Defeasible Reasoning", *Cognitive Science*, vol. 11(4), 1987.

G. Simari & R. P. Loui, "A mathematical treatment of defeasible reasoning and its implementation", *Artificial Intelligence*, vol. 53(2-3), 1992.

Argumentation surveys

H. Prakken & G.A.W. Vreeswijk, "Logics for Defeasible Argumentation", in Handbook of Philosophical Logic, 2nd Edition, *Kluwer Academic Publishers, 2001.*

C.I. Chesnevar, A.G. Maguitman, R.P. Loui, "Logical models of argument", *ACM Computing Surveys*, vol. 32(4), 2000.

Argumentation: selected references (2)

Books

D. Walton, "Fundamentals of critical argumentation",
Cambridge University Press, 2006.

P. Besnard & A. Hunter, "Elements of Argumentation", *MIT Press*, 2008.

"Argumentation in Artificial Intelligence", edited by I. Rahwan and G. R. Simari,
Springer, August 2009.

Dung's influential paper on abstract argumentation

P.M. Dung, "On the Acceptability of Arguments and Its Fundamental
Role in Nonmonotonic Reasoning, Logic Programming, and n-Person Games",
Artificial Intelligence, vol. 77(2), 1995.