Analyzing coalitions in iterative social network design using argumentation theory

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Introduction: What are we talking about?

GALP symposium

The symposium brings together researchers working at the interface of the three disciplines of game theory, logic and argumentation. Particularly, the involved research topics are games and logic, argumentation and games, argumentation and logic.

Our position

Our work fits in the topic of argumentation and games.

A Soccer Example

- AC Milan buys midfielder Ronaldinho from Barcellona FC.
- Now Barcellona FC needs one midfielder, thus it buys midfielder Keita from Siviglia FC.
- Generally speaking, buying one player can trigger several changes in the teams.
- Moreover, if Ronaldinho plays well with others players from Barcellona FC (e.g., player Messi), this can lead to more changes since they may want to join him in AC Milan.
- If another soccer team wants to buy, for example, the player Messi it can approach him directly or it can start such a chain of reactions (e.g., buying midfielder Ronaldinho first).

Arguing about coalition formation

An Argumentation-Based Model for Reasoning About Coalition Structures

- Amgoud [ArgMAS 2005] shows how to instantiate preference-based argumentation with a task-based coalition formation theory based on [Shehory and Kraus 1998].
- Each argument is an argument to form a coalition in the task-based coalition formation theory.
- There is an attack if two coalitions share the same task and if the second argument is not preferred over the first one.

Arguing on coalition view

Drawback

- A drawback of this abstract approach is that it is less clear where the preferences among coalitions come from.
- Intuitively, individual agent prefers a coalition over the others. In this model, why a coalition is preferred over the others?
- This is a coalition formation approach. Could this approach really be used in coalitional game theory?

How to use a theory of coalition formation based on argumentation?

We propose to use our argumentation framework for coalition formation in the context of iterative social network design.

- We define four viewpoints.
- The designer starts with the top viewpoint, and refines it in each step to the row below it.
- It can well be that the designer encounters a problem in a more refined view and then has to adapt the more abstract views, leading to the iterative design cycle.

Four viewpoints

- **Coalition view**: coalitions are abstract entities and we only specify whether the creation of one coalition will block the creation of another coalition;
- **Dynamic dependence view**: we detail the agents in the coalitions and their dependences;
- **Power view**: we detail the powers and goals of the individual agents;
- **Agent view**: we detail the beliefs, decisions and goals of the agents;

Background

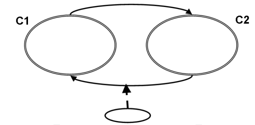
TROPOS methodology: introduces dependence networks for requirements engineering

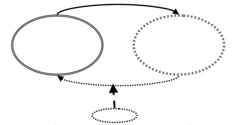
Four viewpoints: a summary [Boella et al. 2008]

Definition	t_1	t_2	Example

Coalition View

Coalitions, potential coalitions and vulnerable coalitions
Preference between coalitions (stability)
Attacks, second-order and higher order





C1 and C2 are two subsets of nodes belonging to a Grid-based virtual organization.
Before, C1 and C2 are two coalitions attacking each other then a preference relation attacks one of the attacks and coalition C2 is rejected.

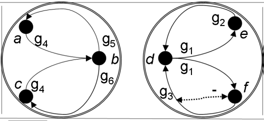
Dynamic Dependence View

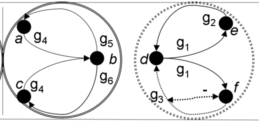
⟨A, G, T, dyndep⁺, dyndep⁻, ≥⟩

$dyndep^+: A \times 2^A \times 2^A \rightarrow 2^{2^G}$

$dyndep^-: A \times 2^A \times 2^A \rightarrow 2^{2^G}$

$\geq: A \rightarrow 2^G \times 2^G$





a	b	g_4 : to save the file comp.log
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d	e, f	g_1: to run the file results.mat
f	d [f]	g_3: to save the file satellite.mpeg
e	d	g_2: to open the file dataJune.mat

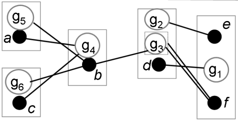
Power View

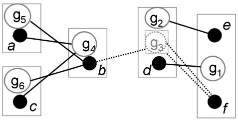
⟨A, G, X, T, goals, power-goals⁺,⁻, power⟩

$goals: A \times 2^X \rightarrow 2^G$

$power\text{-}goals^{+,-}: 2^A \rightarrow 2^{(A \times G)}$

$power: 2^A \rightarrow 2^G$





Goals

a	g_4
c	g_4
b	g_5
b	g_6
d	g_1
f	g_3
e	g_2

Power

a	g_5
c	g_6
b	g_4
d	g_2,g_3
f,e	g_1

Power-goals

f	f	g_3

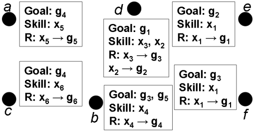
Agent View

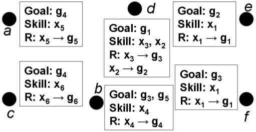
⟨A, G, X, T, goals, skills, R⟩

$goals: A \times 2^X \rightarrow 2^G$

$skills: A \rightarrow 2^X$

$R: 2^X \rightarrow 2^G$





Skills

a	x_5
c	x_6
b	x_4
d	x_2, x_3
f	x_1
e	x_1

R

x_1	g_1
x_2	g_2
x_3	g_3
x_4	g_4
x_5	g_5
x_6	g_6

Argumentation framework

Methodology

When people encounter that the abstract nature of Dung's argumentation theory makes it difficult to represent an example of argumentation

- first inclination is to *extend* Dung's theory, for example with
    - preferences among arguments
    - value arguments
    - second- and higher-order attack relations
    - support relations among arguments

Our proposal

We propose to instantiate Dung's theory rather than to extend it.

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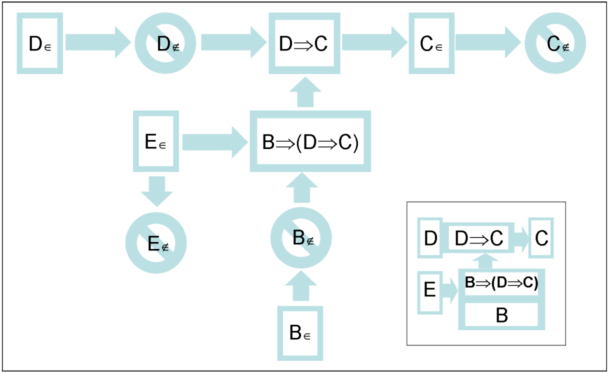
Higher order attacks

Barringer et al.

Barringer *et al.* argue that the attack of B to $D \Rightarrow C$ can itself be attacked.



Representation theory

A theory of meta-argumentation

Our theory of meta-argumentation can be seen as a special kind of representation, namely as representation by an argumentation theory where the set of arguments is extended. It is based on the following three steps:

1. Extend the set of arguments with auxiliary arguments; we call the extended set ‘meta-arguments’.
2. Calculate the extensions of the extended theory using one of Dung’s semantics; we call them ‘meta-extensions’.
3. For each meta-extension, filter out the auxiliary arguments; the resulting sets of arguments are the extensions of the theory.

Higher-order argumentation

Definition

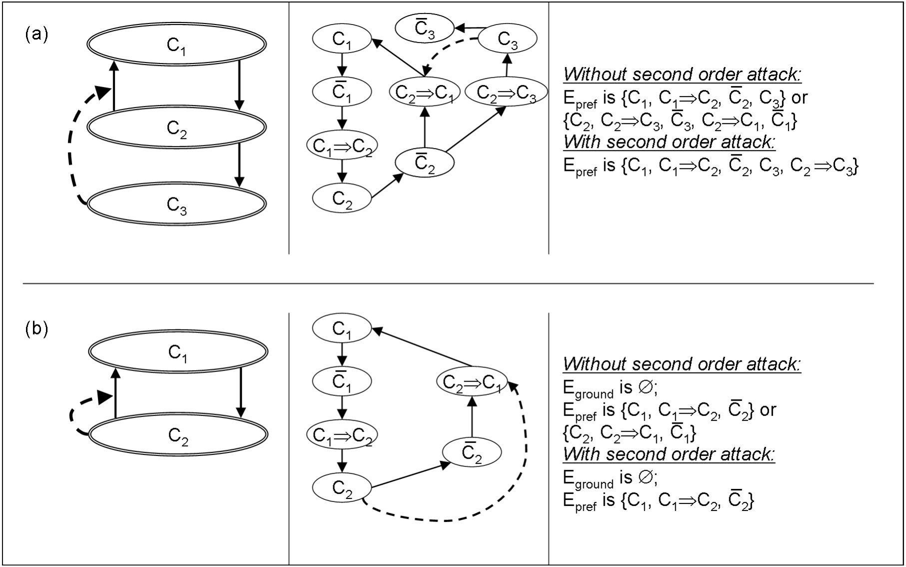
Let A_0 be a set of atomic arguments and $a_0 \notin A_0$ a dummy argument. Let the universe of arguments U of a higher -order argumentation framework be the minimal set of arguments such that $a_0 \in U$ and:

1. If a in A_0, $a_\in$ in U
2. If a, b in A_0, then $a \Rightarrow b$ in A_1 and in U
3. If a in A_0 and α in A_1, then $a \Rightarrow \alpha$ in A_1 and in U

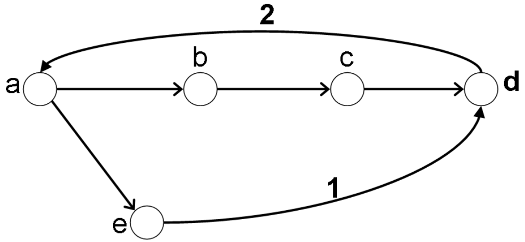
A higher-order argumentation framework is an argumentation framework $\langle \mathcal{A}, \rightarrow \rangle$, where we have:

1. $a_\in$ in $\mathcal{A}$ iff $a \in \mathcal{A}$, and if $a_\in$ in $\mathcal{A}$, then $a_\in \rightarrow a_\notin$.
2. if $a \Rightarrow \alpha$ in $\mathcal{A}$ then $a, \alpha \in \mathcal{A}$, and $a_\notin \rightarrow (a \Rightarrow \beta)$ and $(a \Rightarrow \beta) \rightarrow \beta$.
3. there are no other attacks involved with $a_\notin$, and $a \Rightarrow b$ does not attack any other arguments.

Example in coalition formation



Argumentation networks with voluntary attacks (with Dov Gabbay)



1	2	Labeling 1	Labeling 2	Labeling 3
+	+	+a, -b, +c, -d, -e	All indecided	
+	-	+a, -b, +c, -d, -e	All indecided	
-	+	-a, +b, -c, +d, +e	+a, -b, +c, -d, -e	All indecided
-	-	+a, -b, +c, -d, -e		

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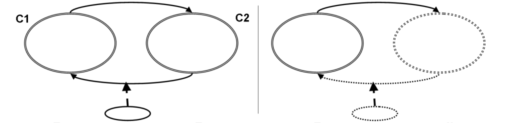

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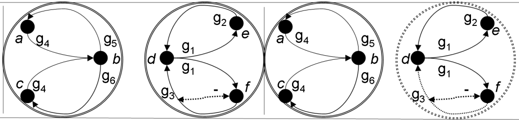

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Power View

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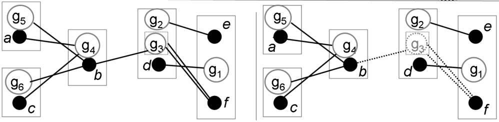


Goals

a	g_4
c	g_4
b	g_5
b	g_6
d	g_1
f	g_3
e	g_2

Power

a	g_5
c	g_6
b	g_4
d	g_2, g_3
f,e	g_1

Power-goals

f	f	g_3

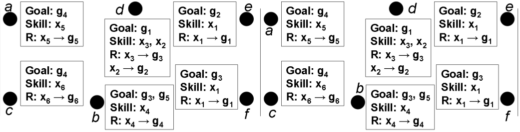
Agent View

$\langle A, G, X, T, goals, skills, R \rangle$

$goals: A \times 2^X \rightarrow 2^G$

$skills: A \rightarrow 2^X$

$R: 2^X \rightarrow 2^G$



Skills

a	x_5
c	x_6
b	x_4
d	x_2, x_3
f	x_1
e	x_1

R

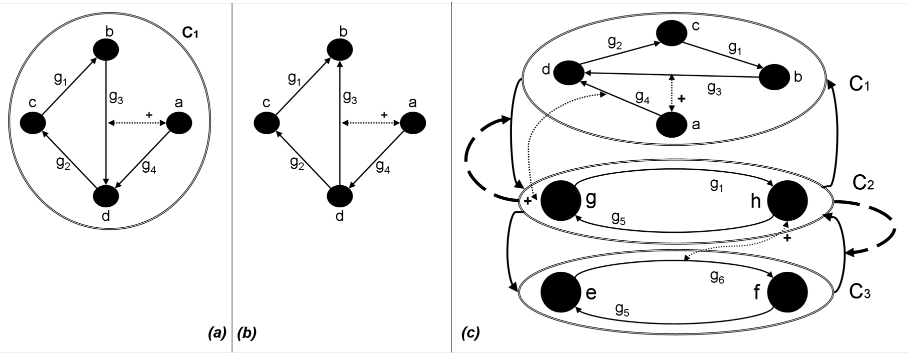
x_1	g_1
x_2	g_2
x_3	g_3
x_4	g_4
x_5	g_5
x_6	g_6

Arguing on dynamic dependence networks

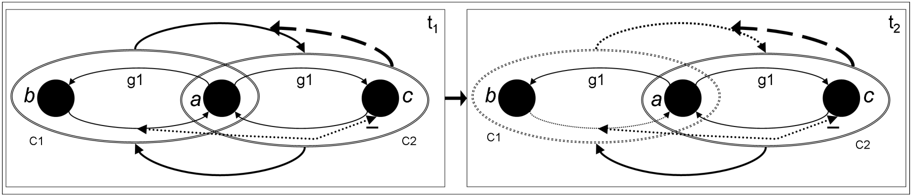
Research question

How to represent coalitions as sets of agents and dependencies and express the attacks between them in a refined level of abstraction?

Reciprocity based coalitions



Example



Current research

Argumentation compliance [Boella et al. 2005]

To check the compliance of interaction among agents with policies we need

- a formal language to express the policies,
- a formal language to express the interaction,
- a formal definition and algorithms to check compliance of interactions with the policies.

We propose to represent the agent interaction by Dung's theory of abstract argumentation.

To represent the policies we introduce a logic of argumentation compliance (LAC) capturing Dung's theory, based on connectives for attack and defend.

We extend it to a modal logic of abstract argumentation to define a wider range of policies.

Example

Reasoning about arguments in meta-argumentation is illustrated by the following dialogue:

A: I think arguments a and b defend argument c.

B: But argument d attacks argument c!

A: No problem, since argument a attacks argument d.

This dialogue illustrates how our logic contributes also to traditional argumentation theory.

LAC language

Given a set of arguments $A = \{a_1, \ldots, a_n\}$, we define the set L_0 of argument sets and the set L of LAA formulas as follows.

$$L_0: \ a_i \mid p \wedge q \qquad (p, q \in L_0)$$

$$L: \ (p \Rightarrow q) \mid (p \oslash q) \mid F(p) \mid S(p) \mid A(p) \mid P(p) \mid C(p) \mid G(p) \mid \neg\phi \mid (\phi \wedge \psi) \qquad (p, q \in L_0; \phi, \psi \in L)$$

Summary

Summary of the talk

- Use this theory of coalition formation based argumentation in iterative social network design;
- Instantiate Dung's argumentation framework using meta-argumentation rather than extend it;
- Use the coalition formation theory based on Sauro [PhD Thesis 2006];
- Argumentation compliance expressing policies and cheking them using a logic of argumentation starting from Boella et al. [ArgMAS 2005];

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Thank you!