A Protocol for Multiparty Argumentation among Focused Agents

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Introduction

- Multiparty argumentation
  - $n > 2$ agents exchange arguments on a common gameboard
  - No central computation
  - No coordination
  - $\Rightarrow$ What are the outcomes reached?
- Important questions
  - What is a “correct” collective outcome?
  - What is a good protocol for discussion?

Introduction

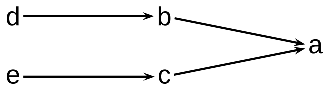
- Preliminary study
  - Agents focused on the status of a single specific argument
  - Same argumentation semantics

    $\Rightarrow$ Dung's grounded semantics
  - Same set of arguments
  - But agents may disagree on attack relations

Argumentation systems [Dung, 95]

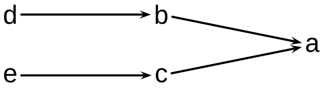
- Argumentation system $\langle A, R \rangle$
  - A : set of arguments
  - R : attack relation
- Argumentation graph

$$\text{AS} = \langle \{a, b, c, d, e\}, \{(b, a), (c, a), (d, b), (e, c)\} \rangle$$



Acceptability [Dung, 95]

$$\text{AS} = \langle \{a,b,c,d,e\}, \{(b,a),(c,a),(d,b),(e,c)\} \rangle$$



- S **collectively defends** $a \in A$ iff $\forall b \in A$ such that bRa, $\exists c \in S$ such that cRb

Acceptability [Dung, 95]

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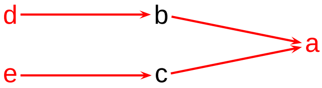
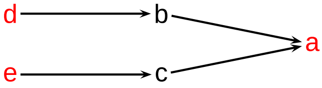


- S **collectively defends** $a \in A$ iff $\forall b \in A$ such that bRa, $\exists c \in S$ such that cRb
  - $\{d, e\}$ collectively defends a

Acceptability [Dung, 95]

$$\text{AS} = \langle \{a, b, c, d, e\}, \{(b, a), (c, a), (d, b), (e, c)\} \rangle$$



- S is a **grounded extension** iff S is the least fixed point of the characteristic function of AS
- F: $2^A \rightarrow 2^A$ with $F(S) = \{a$ such that S collectively defends $a\}$
- Always exists a unique grounded extension, denoted by $\mathcal{E}(\text{AS})$
  - $\mathcal{E}(\text{AS}) = \{a, d, e\}$

Agents' preferences

- Agents are **focused** on the same argument
- **Issue** d of the debate
  - $\longrightarrow$ agents prefer state of the debate where d has the same acceptability status as in their individual system.
- Two sets of agents:
  - $CON = \{a_i \in N | d \notin \mathcal{E}(AS_i)\}$
  - $PRO = \{a_i \in N | d \in \mathcal{E}(AS_i)\}$

Gameboard

- Common gameboard: weighted argumentation system
- Weight of an attack relation:

$$|\text{agents who asserted this attack}| - |\text{agents who opposed it}|$$

- Denoted by $xR_\alpha y$
- $\langle A(GB), M \rangle$ where
  - $M \subseteq A(GB) \times A(GB)$
  - xMy when $\{xR_\alpha y | \alpha > 0\}$

Simple protocol

- $AS^t(GB)$: argumentation system after round t
- **Permitted moves**:
  - Positive assertions of attacks
  - Contradictions of already introduced attacks
- **Relevant moves**:
  - PRO agent: puts the issue back in $\mathcal{E}(AS^t(GB))$
  - CON agent: drops the issue from $\mathcal{E}(AS^t(GB))$
- $RP_i^t \subseteq \{(x,y) | x,y \in A\}$: attack or non-attack relations added on GB by a_i at time t

Simple protocol

1. Agents report their individual view on the issue to the central authority, which then assign (privately) each agent to PRO or CON.
2. The first round starts with the issue on the gameboard and the turn given to CON.
3. Until a group of agents cannot move, we have:
   a. agents independently propose moves to the central authority;
   b. the central authority picks the first (or at random) relevant move, update the gameboard, and passes the turn to the other group

Simple protocol

Update operations after a relevant move is played on the gameboard:

- after an assertion xRy
  - if $xR_{\alpha}y \in A^t(GB)$ then $\alpha := \alpha + 1$
  - if $xR_{\alpha}y \notin A^t(GB)$ then the edge is created with $\alpha := 1$
  - otherwise the node of the new argument is created and the edge is created with $\alpha := 1$
- after a contradiction $x \not{R} y$ iff $x, y \in A^t(GB)$, then $\alpha := \alpha - 1$

Example

a_1 - $\mathcal{E}(AS_1) = \{a\}$

$b \longleftarrow a \longrightarrow c$

a_2 - $\mathcal{E}(AS_2) = \{a, c\}$

$a \longrightarrow b \longrightarrow c$

a_3 - $\mathcal{E}(AS_3) = \{a, b\}$

$a \qquad b \longrightarrow c$

- Issue of the debate: $\{c\}$
- $CON = \{a_1, a_3\}$, $PRO = \{a_2\}$
- $t = 0$
- $RP_1^0 = RP_2^0 = RP_3^0 = \emptyset$,
- $\mathcal{E}(AS^0(GB)) = \{c\}$

$AS^0(GB)$ $\qquad$ c

Example

a_1 - $\mathcal{E}(AS_1) = \{a\}$

$b \leftarrow a \rightarrow c$

a_2 - $\mathcal{E}(AS_2) = \{a, c\}$

$a \rightarrow b \rightarrow c$

a_3 - $\mathcal{E}(AS_3) = \{a, b\}$

$a \quad b \rightarrow c$

- Issue of the debate: $\{c\}$
- $CON = \{a_1, a_3\}$, $PRO = \{a_2\}$
- $t = 1$, a_1 plays for CON
- $RP_1^1 = \{(a, c)\}$, $RP_2^1 = RP_3^1 = \emptyset$,
- $\mathcal{E}(AS^1(GB)) = \{a\}$

$AS^1(GB)$ $\quad a \longrightarrow c$

Example

a_1 - $\mathcal{E}(AS_1) = \{a\}$

b ← a → c

a_2 - $\mathcal{E}(AS_2) = \{a, c\}$

a → b → c

a_3 - $\mathcal{E}(AS_3) = \{a, b\}$

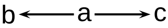
a b → c

- Issue of the debate: $\{c\}$
- $CON = \{a_1, a_3\}$, $PRO = \{a_2\}$
- $t = 2$, a_2 plays for PRO
- $RP_1^2 = \{(a, c)\}$, $RP_2^2 = \{(a, c)\}$, $RP_3^2 = \emptyset$,
- $\mathcal{E}(AS^2(GB)) = \{a, c\}$

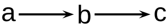
$AS^2(GB)$ a c

Example

a_1 - $\mathcal{E}(AS_1) = \{a\}$



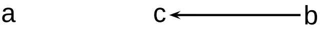
a_2 - $\mathcal{E}(AS_2) = \{a, c\}$



a_3 - $\mathcal{E}(AS_3) = \{a, b\}$

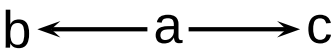
- Issue of the debate: $\{c\}$
- $CON = \{a_1, a_3\}$, $PRO = \{a_2\}$
- $t = 3$, a_3 plays for CON
- $RP_1^3 = \{(a, c)\}$, $RP_2^3 = \{(a, c)\}$, $RP_3^3 = \{(b, c)\}$,
- $\mathcal{E}(AS^3(GB)) = \{a, b\}$

$AS^3(GB)$

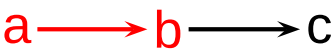


Example

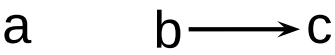
a_1 - $\mathcal{E}(AS_1) = \{a\}$



a_2 - $\mathcal{E}(AS_2) = \{a, c\}$

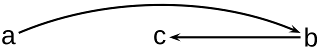


a_3 - $\mathcal{E}(AS_3) = \{a, b\}$



- Issue of the debate: $\{c\}$
- $CON = \{a_1, a_3\}$, $PRO = \{a_2\}$
- $t = 4$, a_2 plays for PRO
- $RP_1^4 = \{(a,c)\}$, $RP_2^4 = \{(a,c),(a,b)\}$, $RP_3^4 = \{(b,c)\}$,
- $\mathcal{E}(AS^4(GB)) = \{a, c\}$

$AS^4(GB)$



Example

a_1 - $\mathcal{E}(AS_1) = \{a\}$

b ← a → c

a_2 - $\mathcal{E}(AS_2) = \{a, c\}$

a → b → c

a_3 - $\mathcal{E}(AS_3) = \{a, b\}$

a   b → c

- Issue of the debate: $\{c\}$
- $CON = \{a_1, a_3\}$, $PRO = \{a_2\}$
- $t = 5$, a_3 plays for CON
- $RP_1^5 = \{(a, c)\}$, $RP_2^5 = \{(a, c), (a, b)\}$, $RP_3^5 = \{(b, c), (a, b)\}$,
- $\mathcal{E}(AS^5(GB)) = \{a, b\}$

$AS^5(GB)$ a   c ← b

Remarks

- Strategic manipulation by witholding an attack between arguments
- Group with the highest number of agents do not always win

Global arguments-control graph

- Gather all the attacks in the same argumentation graph
- Determine which group have the control over some path of this graph
  - → Possible strategy to reach its preferred outcome

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Global arguments-control graph (ACG)

The *global arguments-control graph (ACG)* $\langle A, L \rangle$ is constructed as follows:

1. $L = \cup_{i \in 1 \ldots n} R(i)$
2. Label each $(a, b) \in L$ by the sets $add_{(a,b)}$ and $rem_{(a,b)}$, with
   - $add_{(a,b)} = \{a_i \in N | (a, b) \subseteq R(i)\}$ and
   - $rem_{(a,b)} = \{a_i \in N | (a, b) \not\subseteq R(i)\}$

Control of an edge of the global arguments-control graph

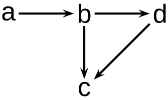
Notion of control in a global arguments-control graph

Let $X \in \{CON, PRO\}$. If $X = PRO$ (resp. CON), $\overline{X} = CON$ (resp. PRO).

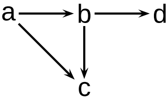
- **Constructive control**: $X^{+}_{(a,b)}$ iff $|add_{(a,b)} \cap X| > |rem_{(a,b)} \cap \overline{X}|$
  - the number of agents in X who can add (a, b) is greater than the number of agents in $\overline{X}$ who can remove it.
- **Destructive control**: $X^{-}_{(a,b)}$ iff $|rem_{(a,b)} \cap X| \geq |add_{(a,b)} \cap \overline{X}|$
  - the number of agents in X who can remove (a, b) is greater or equal than the number of agents in $\overline{X}$ who can add it.

Example

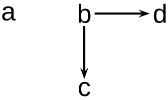
a_1 - $\mathcal{E}(AS_1) = \{a, d\}$



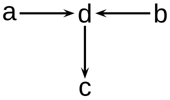
a_2 - $\mathcal{E}(AS_2) = \{a, d\}$



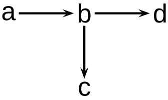
a_3 - $\mathcal{E}(AS_3) = \{a, b\}$



a_4 - $\mathcal{E}(AS_4) = \{a, b, c\}$



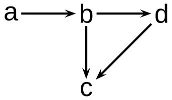
a_5 - $\mathcal{E}(AS_5) = \{a, d, c\}$



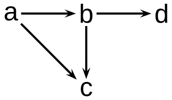
Issue of the dialogue: c. $CON = \{a_1, a_2, a_3\}$, $PRO = \{a_4, a_5\}$

Example

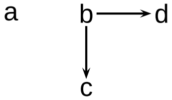
a_1 - $\mathcal{E}(AS_1) = \{a, d\}$



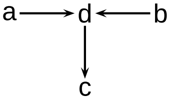
a_2 - $\mathcal{E}(AS_2) = \{a, d\}$



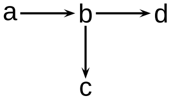
a_3 - $\mathcal{E}(AS_3) = \{a, b\}$



a_4 - $\mathcal{E}(AS_4) = \{a, b, c\}$

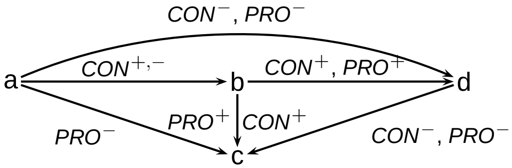


a_5 - $\mathcal{E}(AS_5) = \{a, d, c\}$



Issue of the dialogue: c. $CON = \{a_1, a_2, a_3\}$, $PRO = \{a_4, a_5\}$

Global arguments-control graph:



Property

Possible outcome for CON

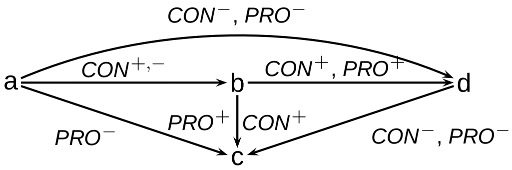
Issue of the dialogue: $d \in A$; global arguments-control graph: $ACG = \langle A, L \rangle$

- The issue d is a **possible outcome for CON** iff exists an odd-length path P in ACG whose final vertex is d such that for all attack edges $(a, b) \in P$ we have $\text{CON}^{+}_{(a,b)}$, and
  - either the first vertex x of P has no attacker, that is $\forall y \in A$, $(y, x) \notin L$
  - or CON agents can remove all the defense edges attacking x: for all edges $(y, x) \in P$, we have $CON^{-}_{(y,x)}$

Example: possible outcome for CON

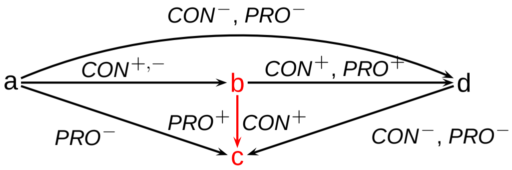
Issue of the dialogue: c. $CON = \{a_1, a_2, a_3\}$, $PRO = \{a_4, a_5\}$

Global arguments-control graph:



Example: possible outcome for CON

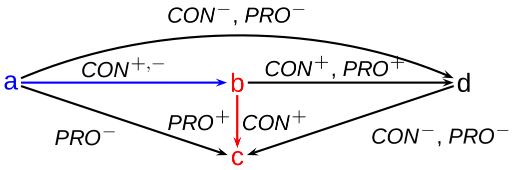
Issue of the dialogue: c. $CON = \{a_1, a_2, a_3\}$, $PRO = \{a_4, a_5\}$
Global arguments-control graph:



Example: possible outcome for CON

Issue of the dialogue: c. $CON = \{a_1, a_2, a_3\}$, $PRO = \{a_4, a_5\}$

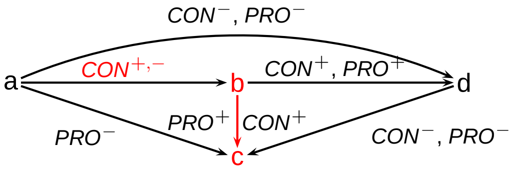
Global arguments-control graph:



Example: possible outcome for CON

Issue of the dialogue: c. $CON = \{a_1, a_2, a_3\}$, $PRO = \{a_4, a_5\}$

Global arguments-control graph:



Property

Possible outcome for PRO

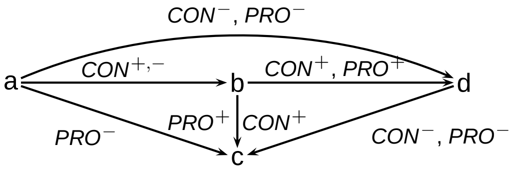
Issue of the dialogue: $d \in A$; global arguments-control graph: $ACG = \langle A, L \rangle$

- The issue d is a **possible outcome for** PRO iff there is a path P such that there
  - exists an argument x_1 such that $(x_1, d) \in P$ and $playable(x_1, d)_{CON}$,
  - exists an attack edge $(x_i, x_j) \in P$ such that $PRO^{-}_{(x_i, x_j)}$
  - exists an attack edge $(x_k, x_l) \in P$ which forbid every other attack against the issue d

Example: possible outcome for PRO

Issue of the dialogue: c. $CON = \{a_1, a_2, a_3\}$, $PRO = \{a_4, a_5\}$

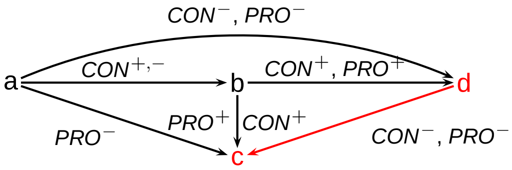
Global arguments-control graph:



Example: possible outcome for PRO

Issue of the dialogue: c. $CON = \{a_1, a_2, a_3\}$, $PRO = \{a_4, a_5\}$

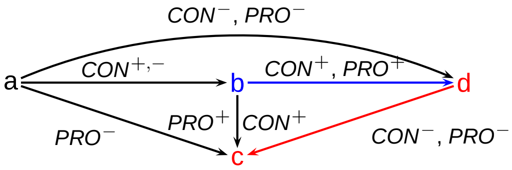
Global arguments-control graph:



Example: possible outcome for PRO

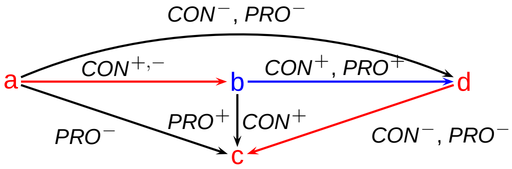
Issue of the dialogue: c. $CON = \{a_1, a_2, a_3\}$, $PRO = \{a_4, a_5\}$

Global arguments-control graph:



Example: possible outcome for PRO

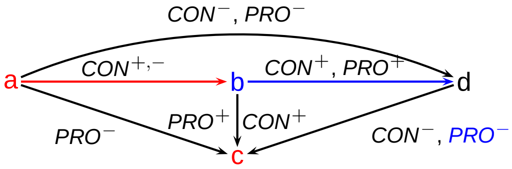
Issue of the dialogue: c. $CON = \{a_1, a_2, a_3\}$, $PRO = \{a_4, a_5\}$
Global arguments-control graph:



Example: possible outcome for PRO

Issue of the dialogue: c. $CON = \{a_1, a_2, a_3\}$, $PRO = \{a_4, a_5\}$

Global arguments-control graph:



Property

Necessary outcome

Issue of the dialogue: $d \in A$; global arguments-control graph: $ACG = \langle A, L \rangle$

The issue d is a **necessary outcome for** X iff d is not a possible issue for $\overline{X}$

Conclusion

- Conclusion
  - Multi-agent protocol
  - Focused agents with different view on the attack relations
  - Majoritarian approach
  - No central computation

  $\Rightarrow$ Framework sufficiently rich to witness a variety of different scenarii

  $\Rightarrow$ Necessary and sufficient conditions garanteeing/allowing a group of players to “win” the debate
- Future works
  - Agents focusing on several issues
  - Agents focusing on whole extensions

    $\longrightarrow$ complex preferences over combinations of issues
  - Agents do not share the same set of arguments

    $\longrightarrow$ how agents would react in the presence of arguments they were not aware before?