Argumentation-based Negotiation with Incomplete Opponent Profiles

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Main Elements of "Classical" ABN

- Conflict resolution concerning a specific issue (*e.g.* price of a product)
- Agents choose offers that are likely to be accepted by the opponent and exchange arguments that support these offers
- Supporting arguments are either based on proponent's theorie or based on the opponent's profile
- Search for an agreement through the exchanged arguments
- A proponent defends the supporting arguments by attacking the opponent's arguments that attack them, etc.

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Motivation for CAFs

- Qualitative representation of uncertainty (useful when no quantitative information is available)
- Possibility to take into account different profiles (notion of completions)
- Control arguments $\simeq$ persuasive arguments used in a persuasion phase in a negotiation dialogue
  $\rightarrow$ reinstatement of rejected arguments that defend the proponent's offer in the opponent's theory
- Possibility to take into consideration both the certain and uncertain knowledge on the opponent
- QBF-based model for computing the persuasive arguments

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Originality of our Approach

- Proponent selects the best offer based on its own theory, but it uses the arguments in the opponent's theory for defending it $\rightarrow$ facilitates persuasion.
- Someone can use arguments for convincing its opponent even though it has not these arguments in its theory (i.e. it doesn't believe to these reasons for supporting his offer).

Originality of our Approach

- In classical approaches agents try to change the opinion of their opponent by sending one or several (usually separately) arguments for supporting an offer
  Agents try to attack (one by one) all the opponent's arguments that attack its arguments until this is possible.
- In our approach the control arguments accompany the supporting (in the opponent's theory) argument and defend this argument against all the possible attacks at once.
- As experiments show the results are improved. In case of success no other exchange is necessary
  $\rightarrow$ number of messages is minimized (very useful in time constraint situations)

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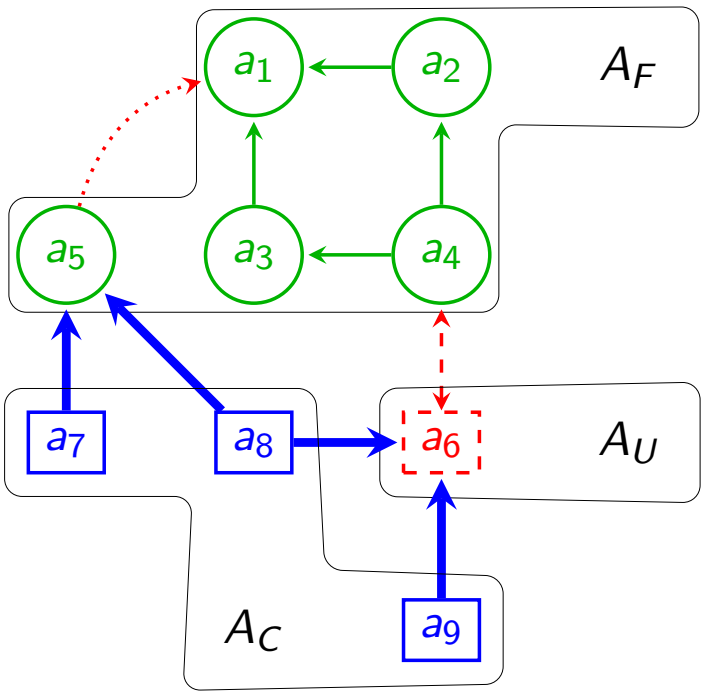
Control Argumentation Framework (CAF)

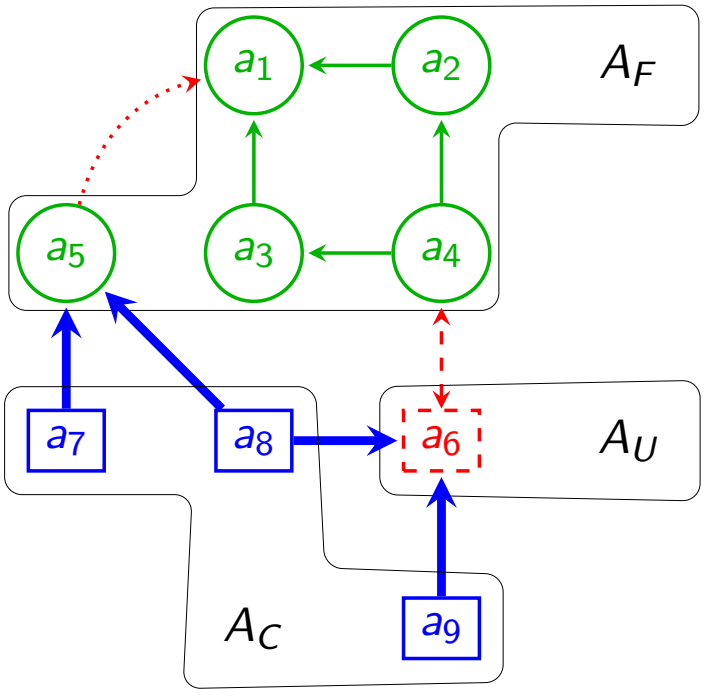
[AAAI 2018] Dimopoulos, Mailly and Moraitis



- Fixed part: circle arguments + plain arrows
- Uncertain part:
  - dashed arguments
  - dotted arrows
  - two-heads dashed arrows
- Control part: square arguments + bold arrows

Control Argumentation Framework (CAF)

[AAAI 2018] Dimopoulos, Mailly and Moraitis



- Fixed part: circle arguments + plain arrows
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- certain knowledge: always exist

Control Argumentation Framework (CAF)

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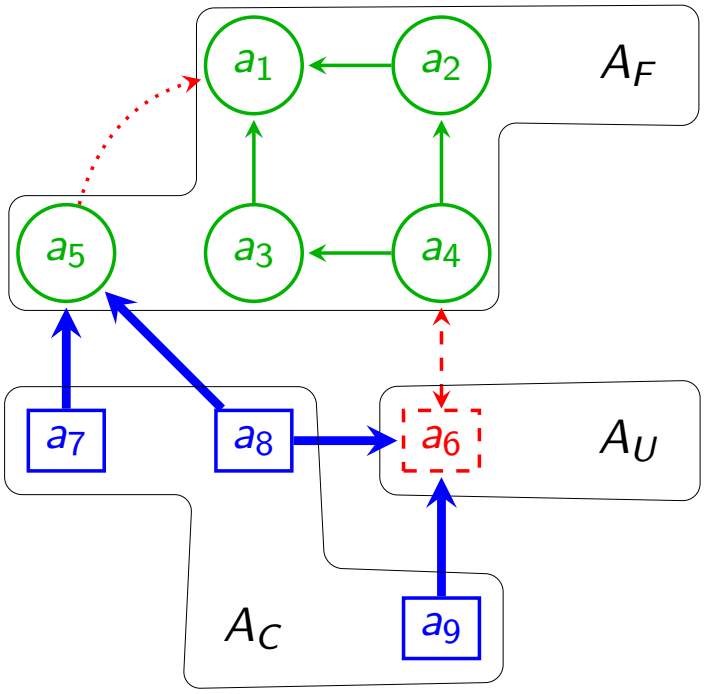

- Fixed part: circle arguments + plain arrows
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- Control part: square arguments + bold arrows

- the argument could exist, or not

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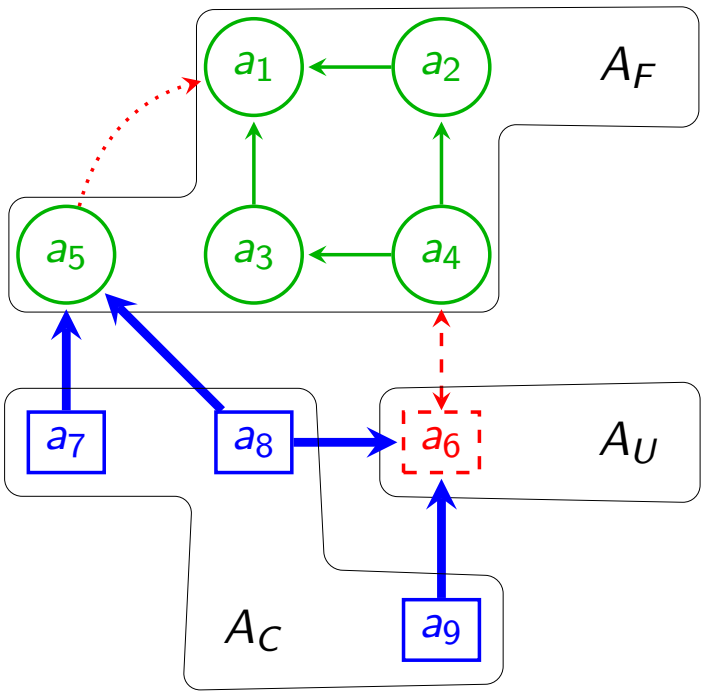

- Fixed part: circle arguments + plain arrows
- Uncertain part:
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- the attack could exist, or not

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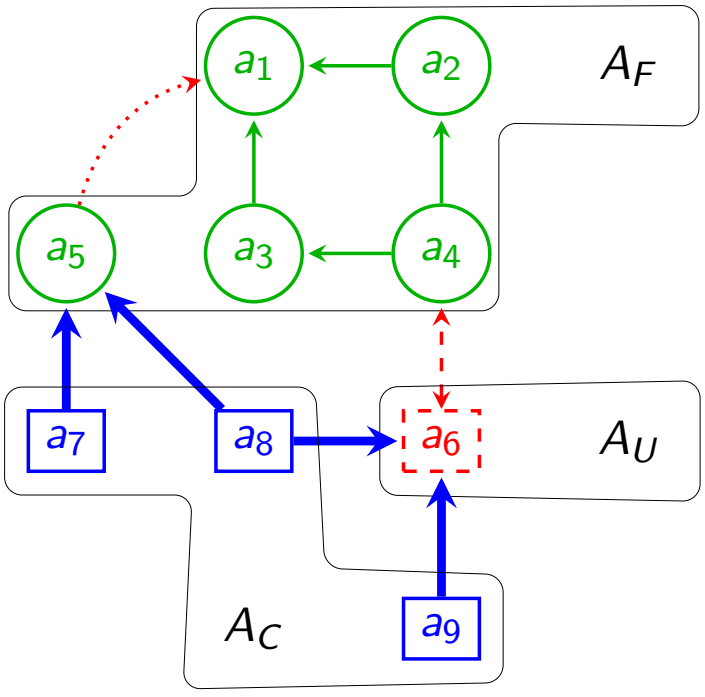

- Fixed part: circle arguments + plain arrows
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- the attack exists (if both arguments exist), but we are not sure of the direction

Control Argumentation Framework (CAF)

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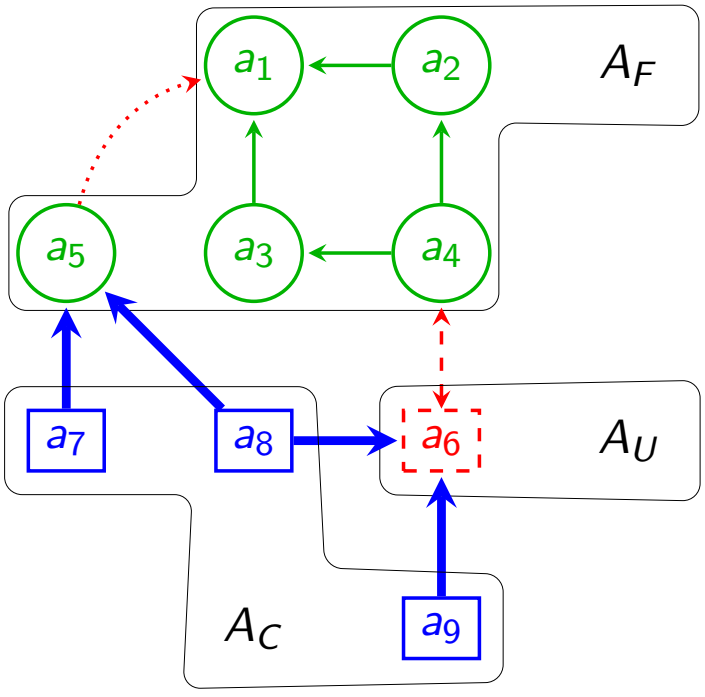

- Fixed part: circle arguments + plain arrows
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- exist only if the agent selects the arguments

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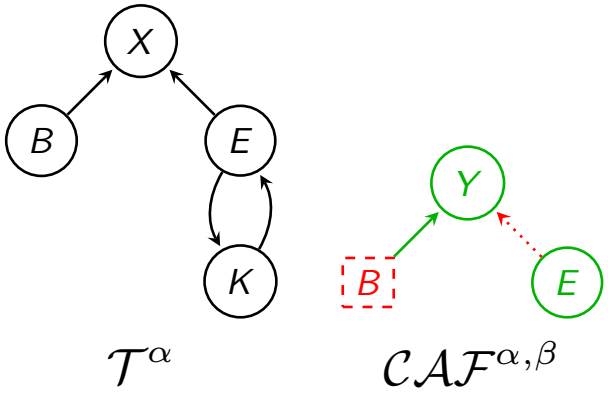
Negotiation Theories

Negotiation theory of an agent α: $\mathcal{T} = \langle \mathcal{O}, \mathcal{T}^{\alpha}, \mathcal{CAF}^{\alpha,\beta}, \mathcal{F}^{\alpha} \rangle$ with

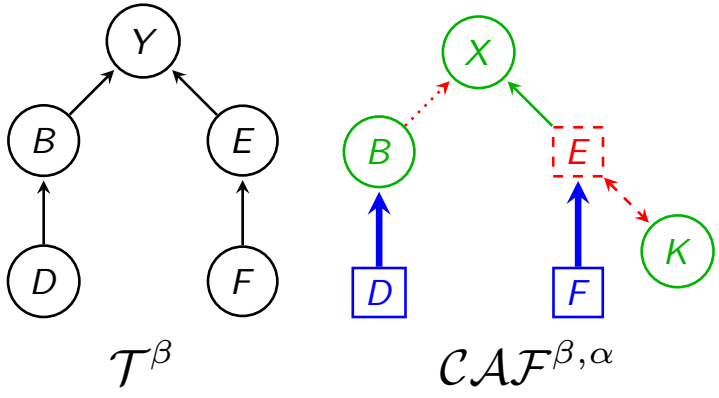
- $\mathcal{O}$: set of offers
- $\mathcal{T}^{\alpha}$: the agent's AF
- $\mathcal{CAF}^{\alpha,\beta}$: the knowledge of α about his opponent β
- $\mathcal{F}^{\alpha} : \mathcal{O} \rightarrow 2^{{A_p}^{\alpha}}$ maps offers to the arguments supporting them

Example of Negotiation Theories

Agent α: X supports O

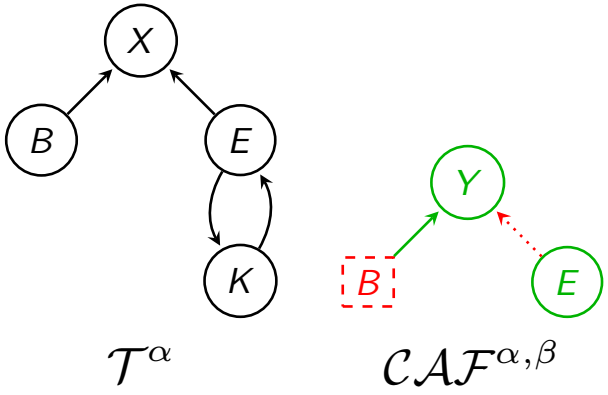


Agent β: Y supports O

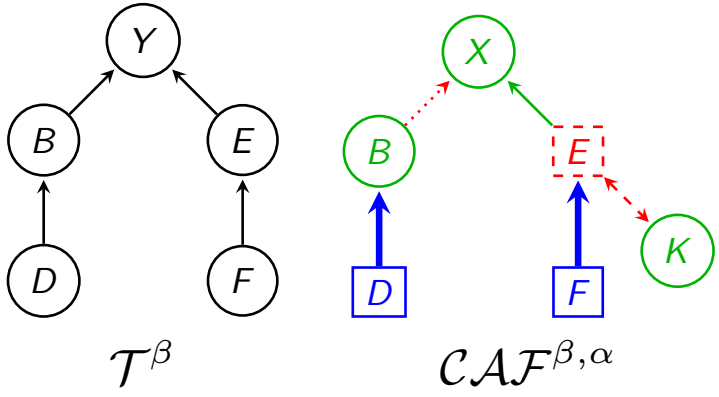


Bidding Strategy

Agent α: X supports O



Agent β: Y supports O

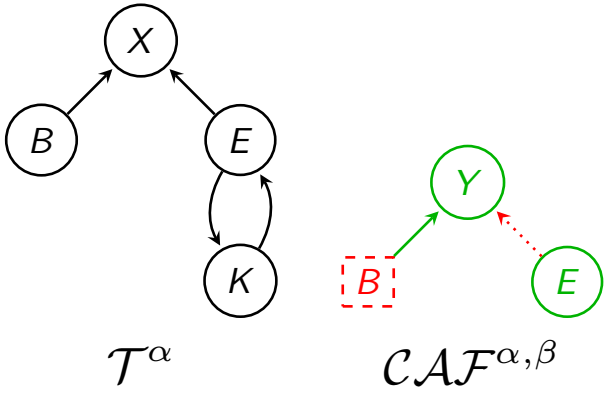


α's turn: X is not accepted in $\mathcal{T}^{\alpha}$, so α cannot support the (unique) offer O

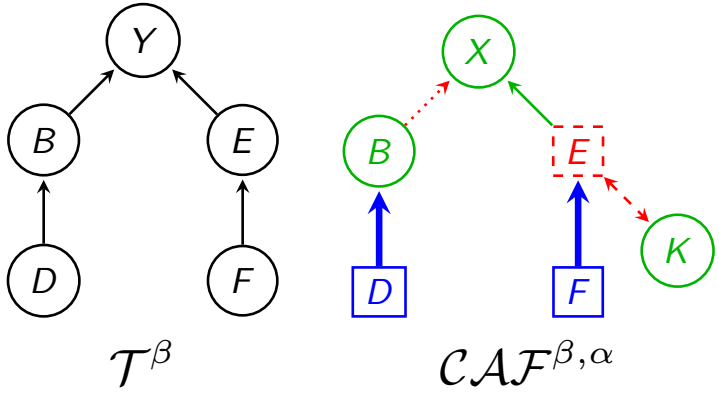
$\rightarrow$ the token goes to β

Bidding Strategy

Agent α: X supports O



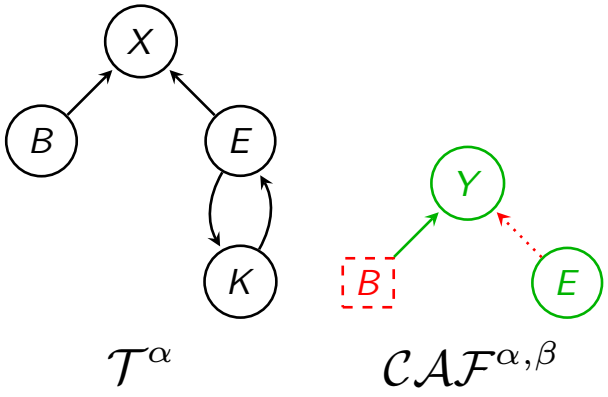
Agent β: Y supports O



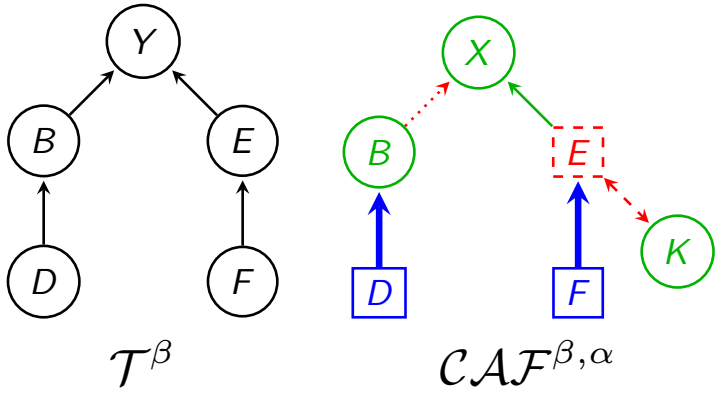
β's turn: best offer according to β's personnal AF is O because the supporting argument Y is accepted in $\mathcal{T}^{\beta}$

Bidding Strategy

Agent α: X supports O

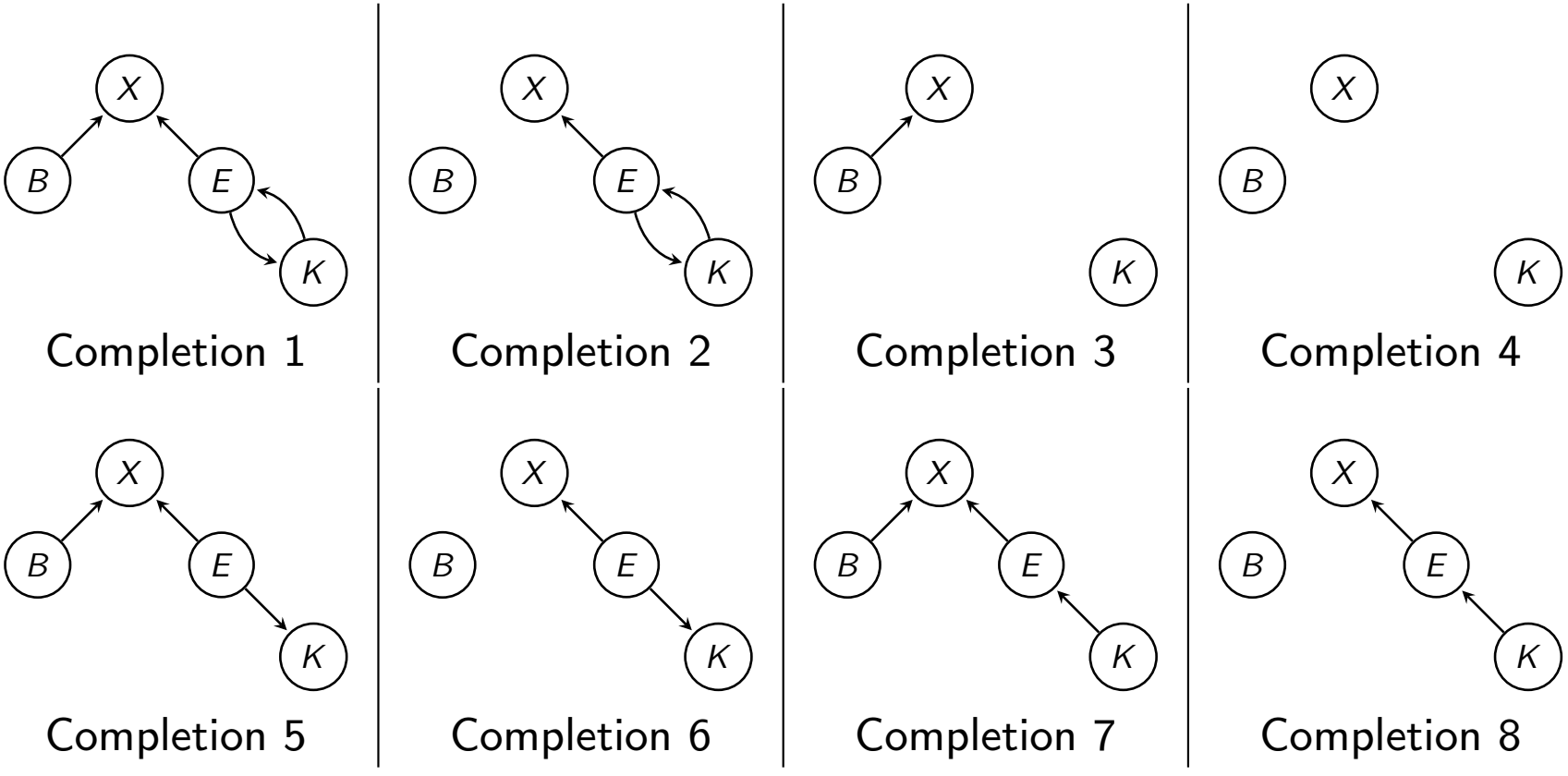


Agent β: Y supports O



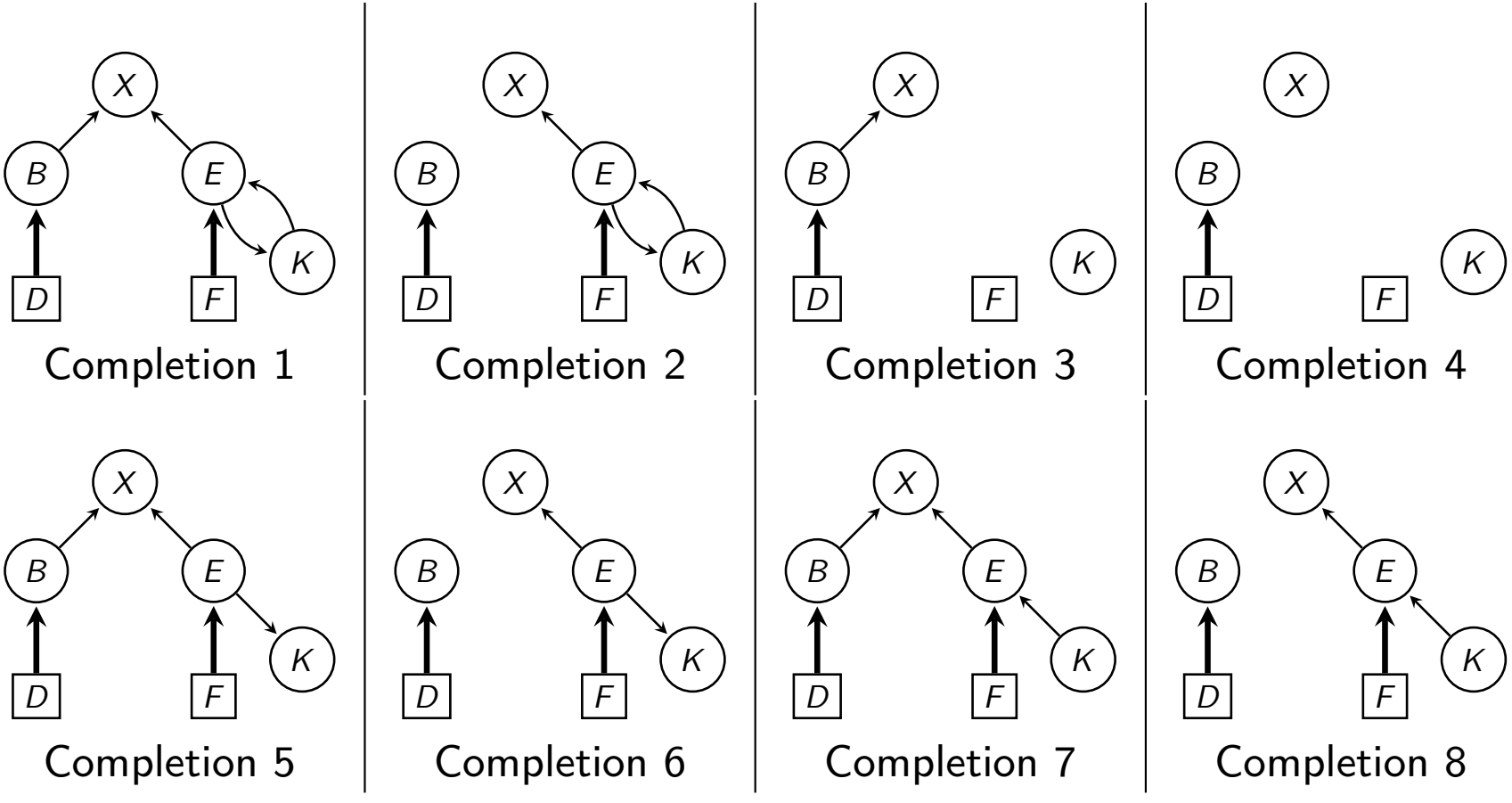
β's turn: support argument for O in α's theory is X

β's Proposal without Control



- X is not accepted in each completion (*e.g.* Completion 1)

β's Proposal with Control



- X is accepted in each completion

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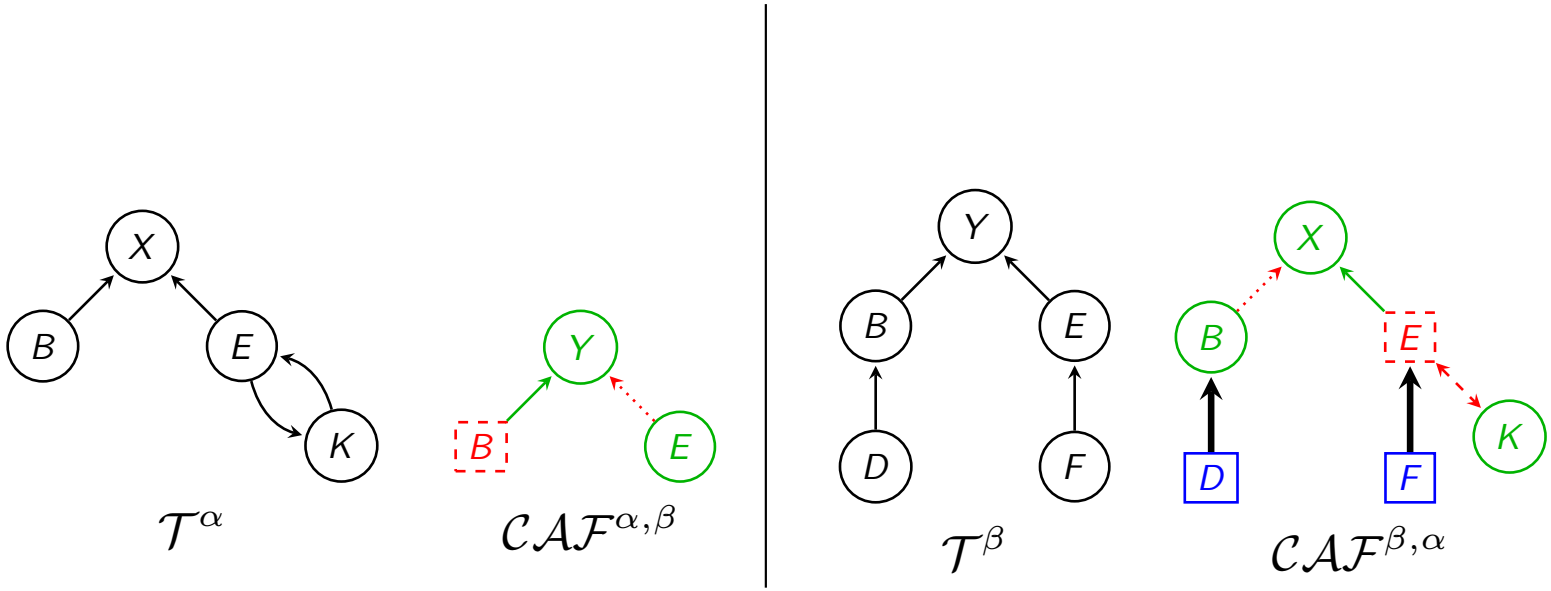
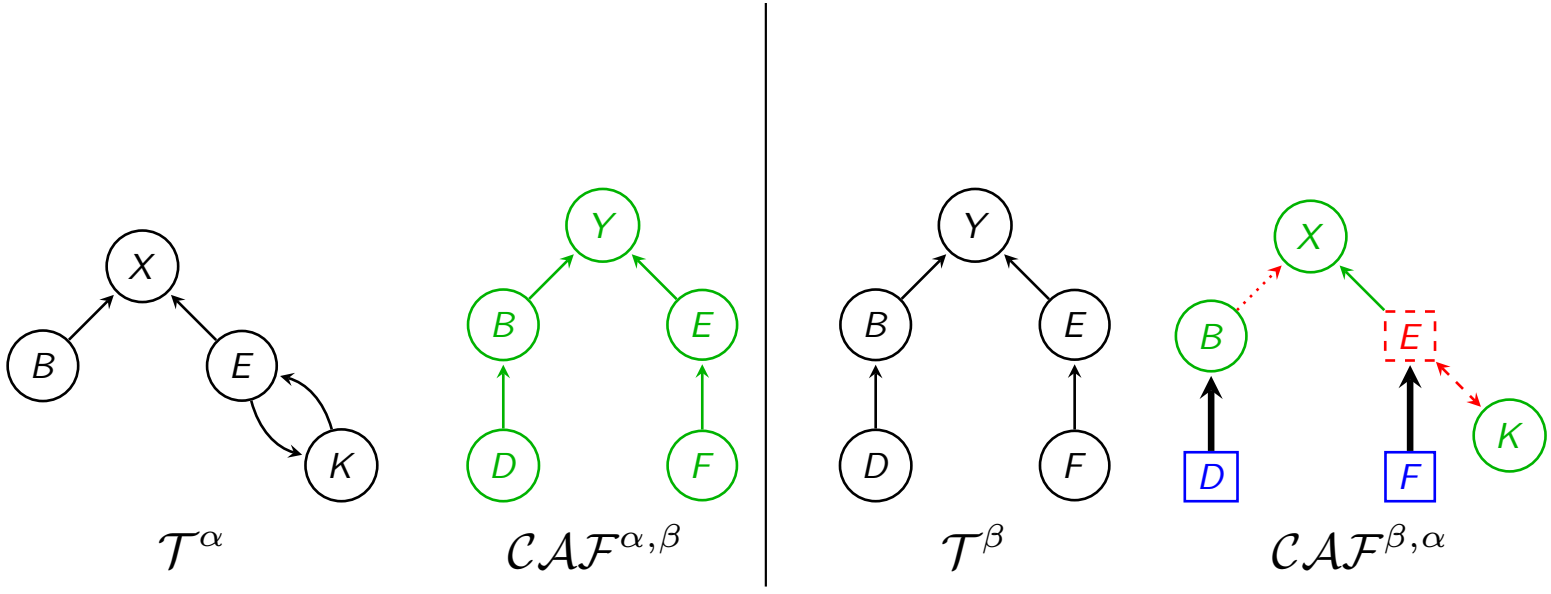
Acceptance Strategy



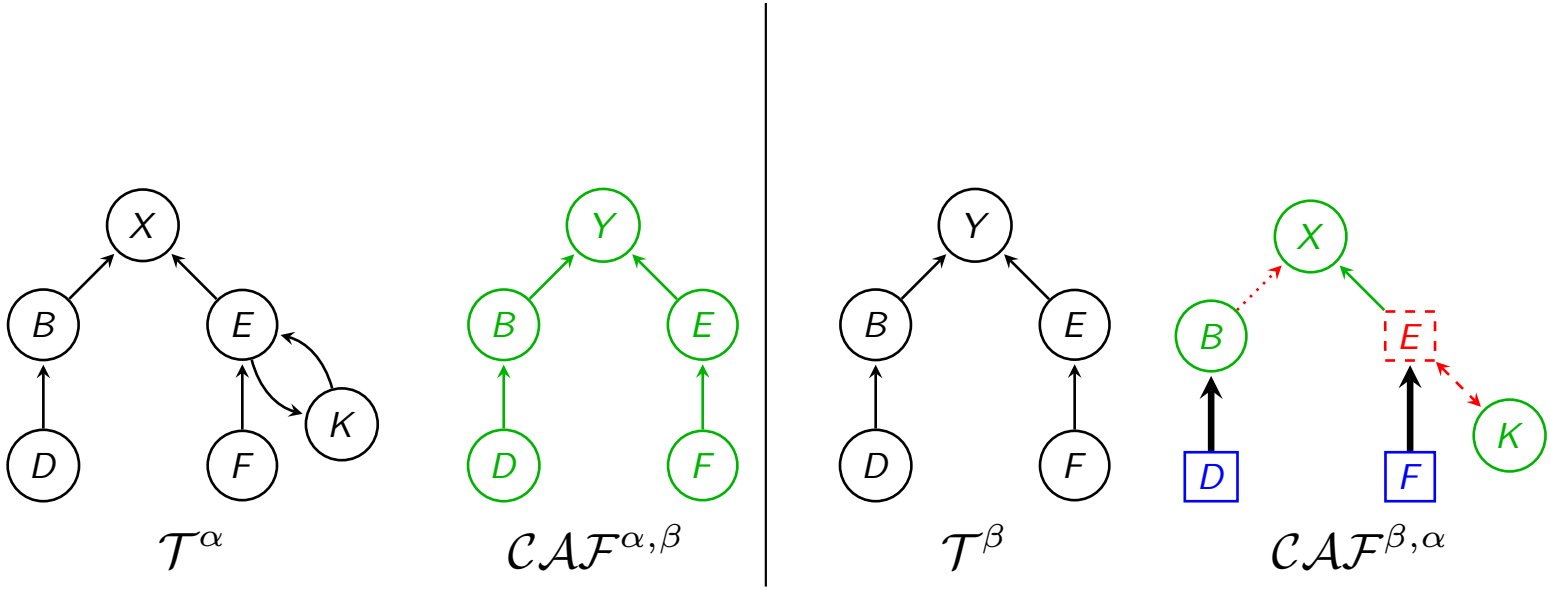
β's turn: proposal is offer O, supported by argument X, defended by D and F

Acceptance Strategy



α updates its CAF: uncertainty decreases

Acceptance Strategy

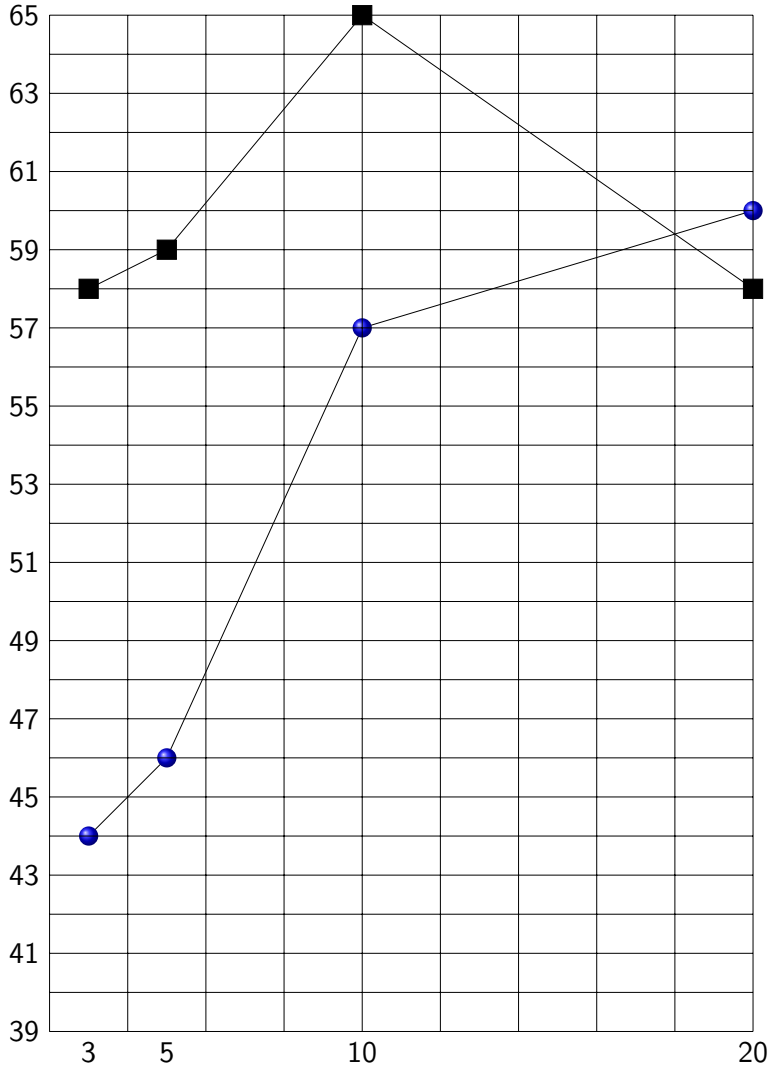


α updates its own theory. X is now accepted: **agreement**

Experimental Protocol

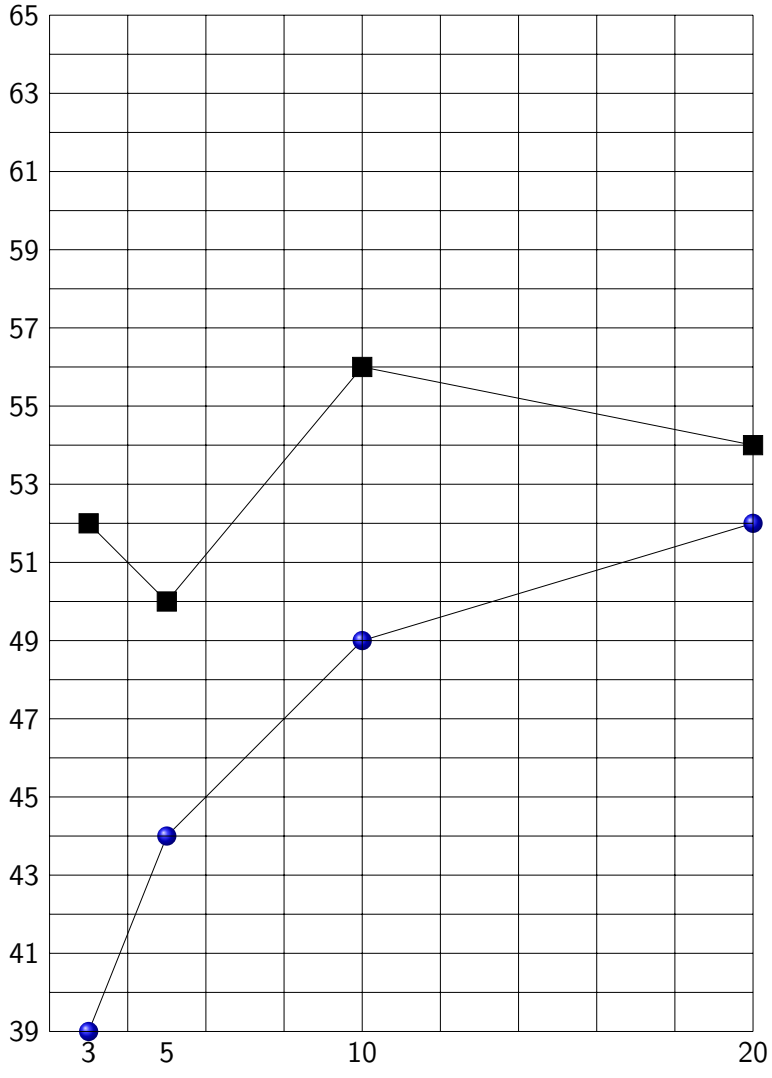
- Java/Jade prototype
- Random generation of agents' theories and CAFs
- We measure the percentage of agreements depending on
  - number of control arguments
  - density of control attacks
  - density of attacks in individual theories
- Total: 15600 negotiations

Experiment 1: No Ignorance



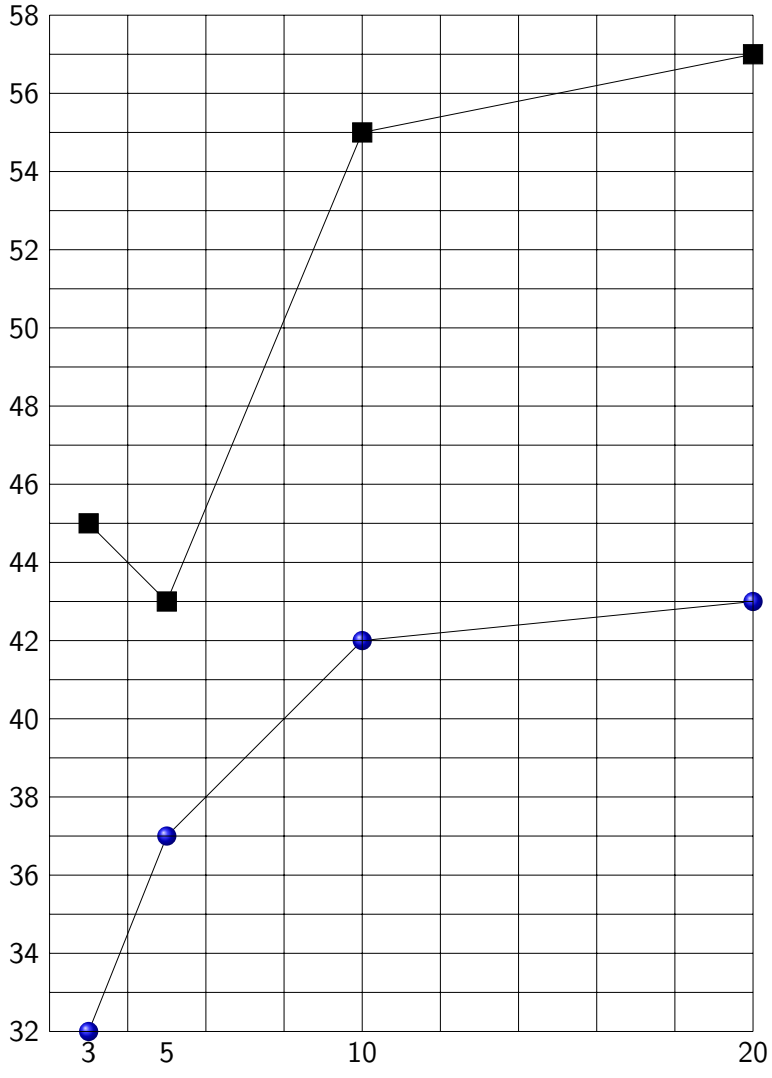
- All arguments from $\mathcal{T}^{\beta}$ belong to $\mathcal{CAF}^{\alpha,\beta}$ (and vice-versa)
- x-axis: density of control attacks
- y-axis: rate of agreement
- Density of attacks: 15%
- ●-curve: 3 control arguments
- ■-curve: 6 control arguments
- With 0 control arguments: 23% of agreement
- Each point gives the average over 600 negotiations

Experiment 1: No Ignorance



- All arguments from $\mathcal{T}^{\beta}$ belong to $\mathcal{CAF}^{\alpha,\beta}$ (and vice-versa)
- x-axis: density of control attacks
- y-axis: rate of agreement
- Density of attacks: 20%
- ●-curve: 3 control arguments
- ■-curve: 6 control arguments
- With 0 control arguments: 16% of agreement
- Each point gives the average over 600 negotiations

Experiment 2: 25% Ignorance



- $\mathcal{T}^{\beta}$ contains 25% of arguments not in $\mathcal{CAF}^{\alpha,\beta}$ (and vice-versa)
- x-axis: density of control attacks
- y-axis: rate of agreement
- Density of attacks: 15%
- ●-curve: 3 control arguments
- ■-curve: 6 control arguments
- Each point gives the average over 600 negotiations

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Summary

- We have proposed a negotation method taking advantage of the recent CAF framework to model the (uncertain) knowledge about the opponent
- The experiment show that control arguments are an important tool to improve the rate of agreement, even in presence of ignorance