Multilateral Negotiation in Boolean Games with Incomplete Information using Generalized Possibilistic Logic

Sofie De Clercq,
Steven Schockaert, Ann Nowé and Martine De Cock

LogE-meeting, 24 June 2015

UNIVERSITEIT GENT
CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD
CENTER FOR DATA SCIENCE
UNIVERSITY of WASHINGTON | TACOMA
Institute of Technology
FWO VLAANDEREN
Fonds Wetenschappelijk Onderzoek
Research Foundation – Flanders

Overview of the Talk

1. Boolean Games (BGs)
2. Multilateral Negotiation in BGs
3. BGs with Incomplete Information (BGIs)
4. Multilateral Negotiation in BGIs
5. Conclusion and Future Work

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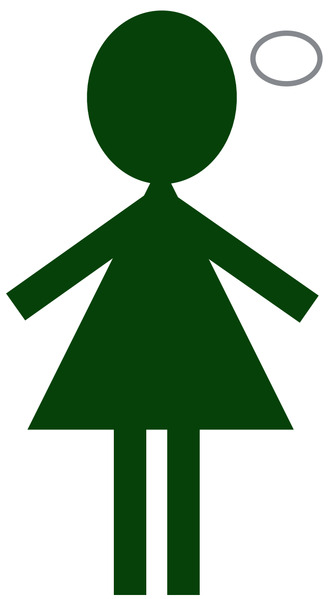
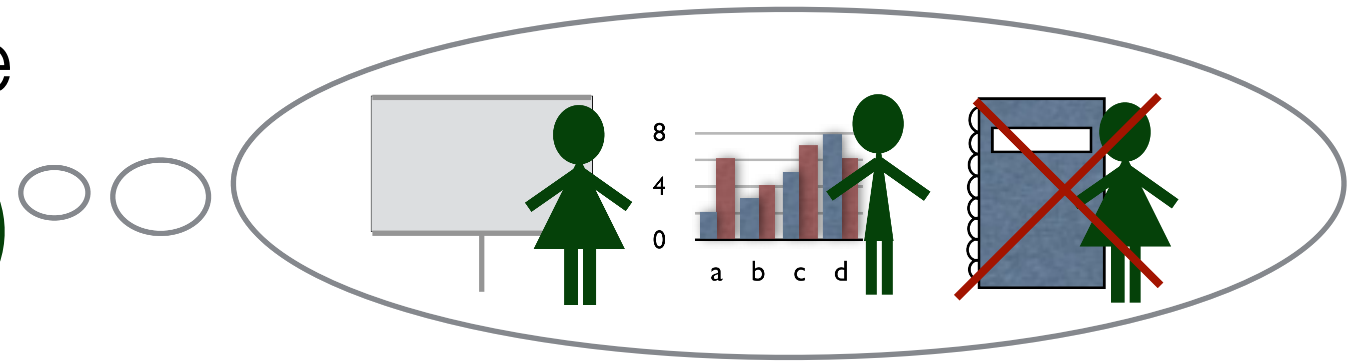
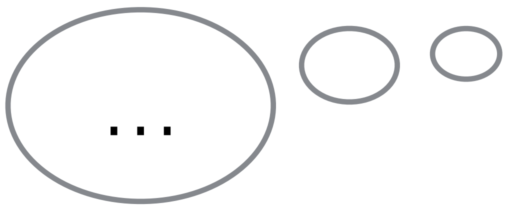
Boolean Games: an Example

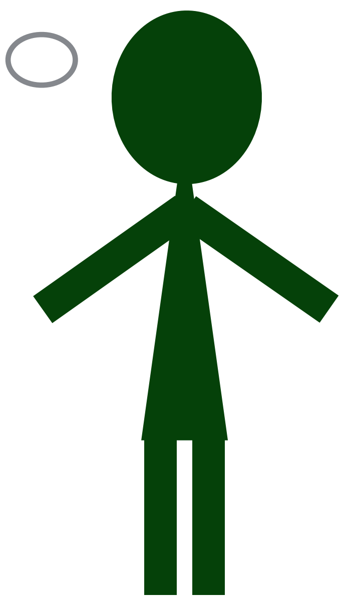
Jane







Tom



d_1 : Jane analyzes the data
r_1 : Jane writes the report
p_1 : Jane presents the results

Boolean Games: an Example

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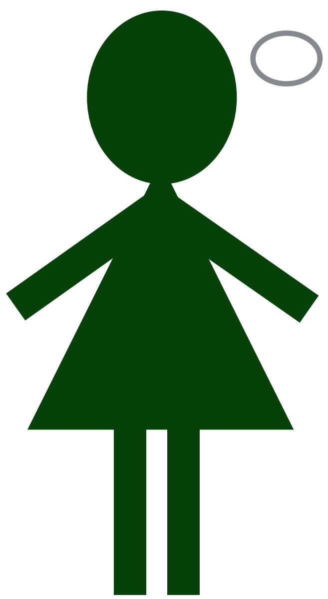

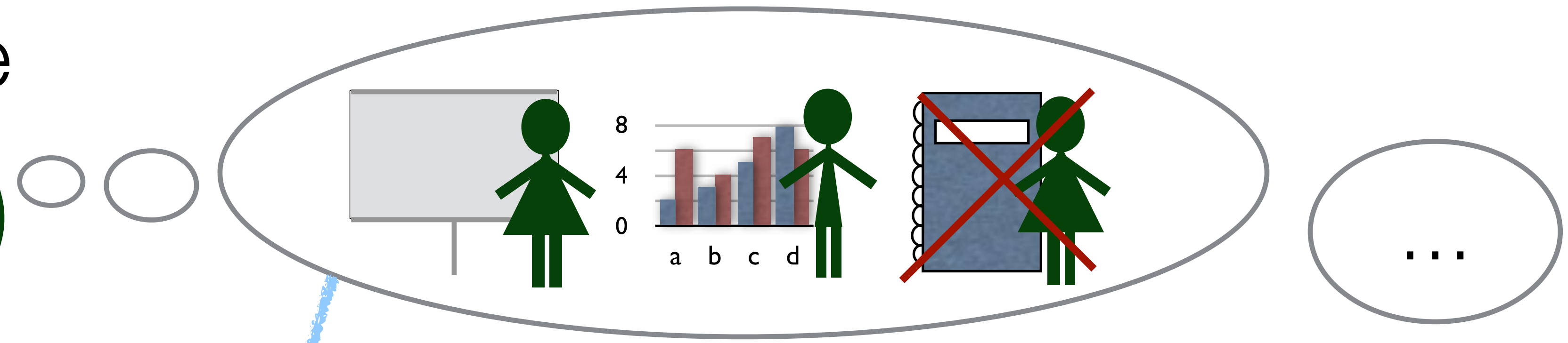

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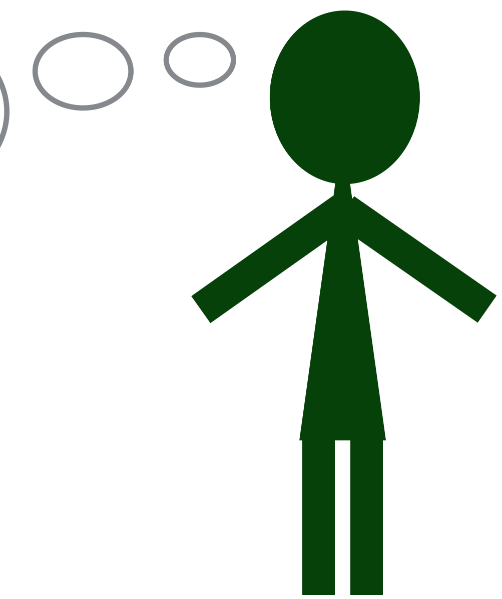

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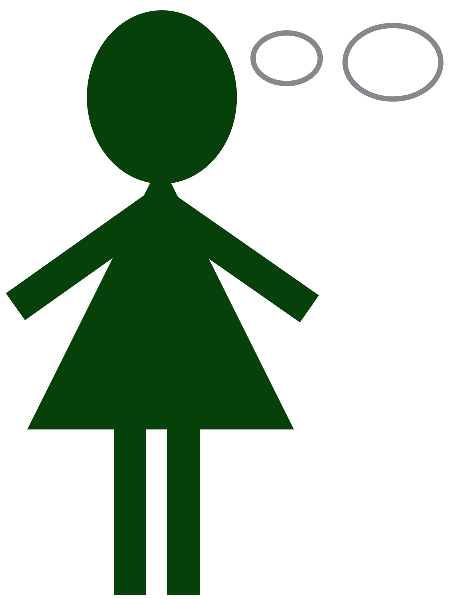

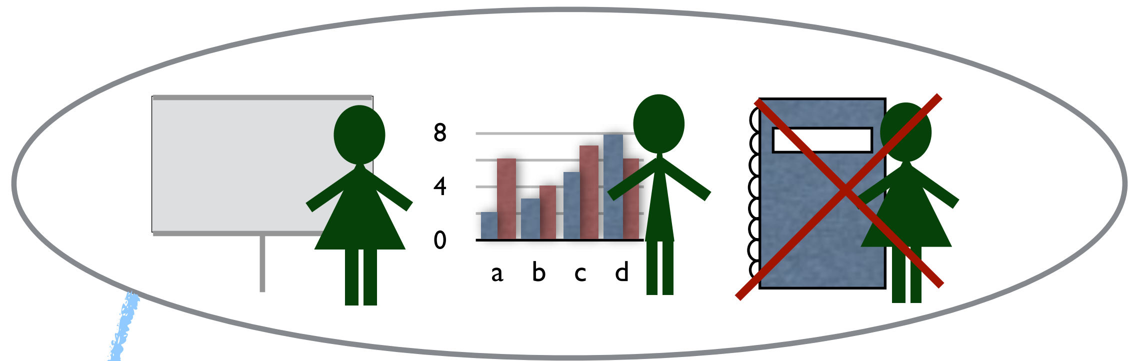

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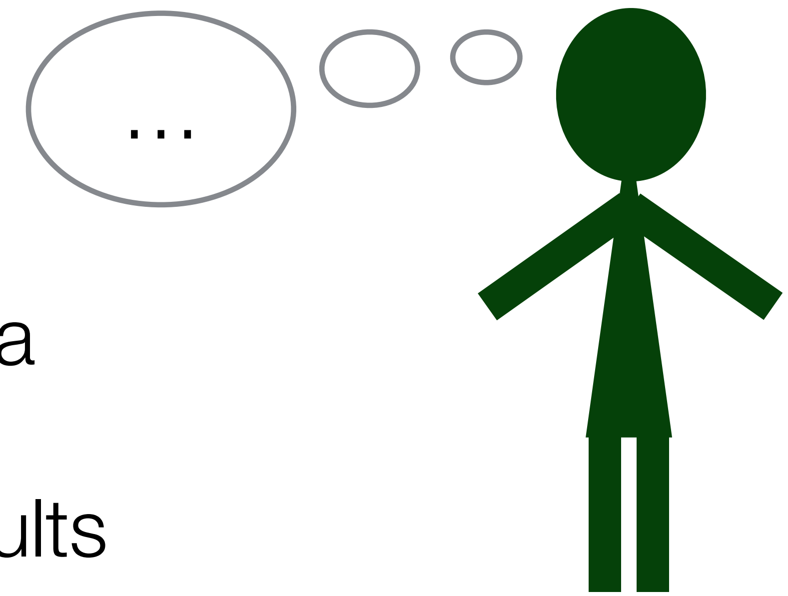

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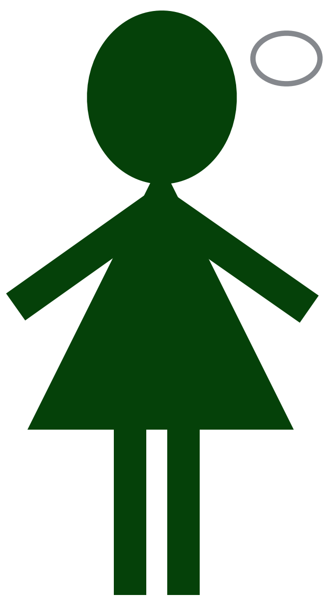

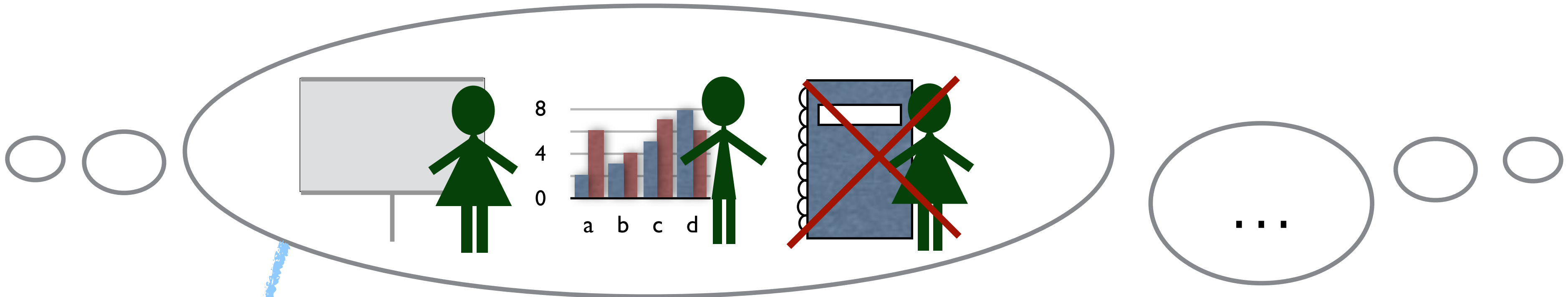

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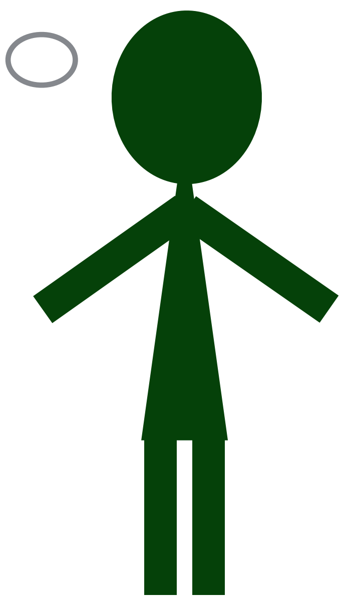

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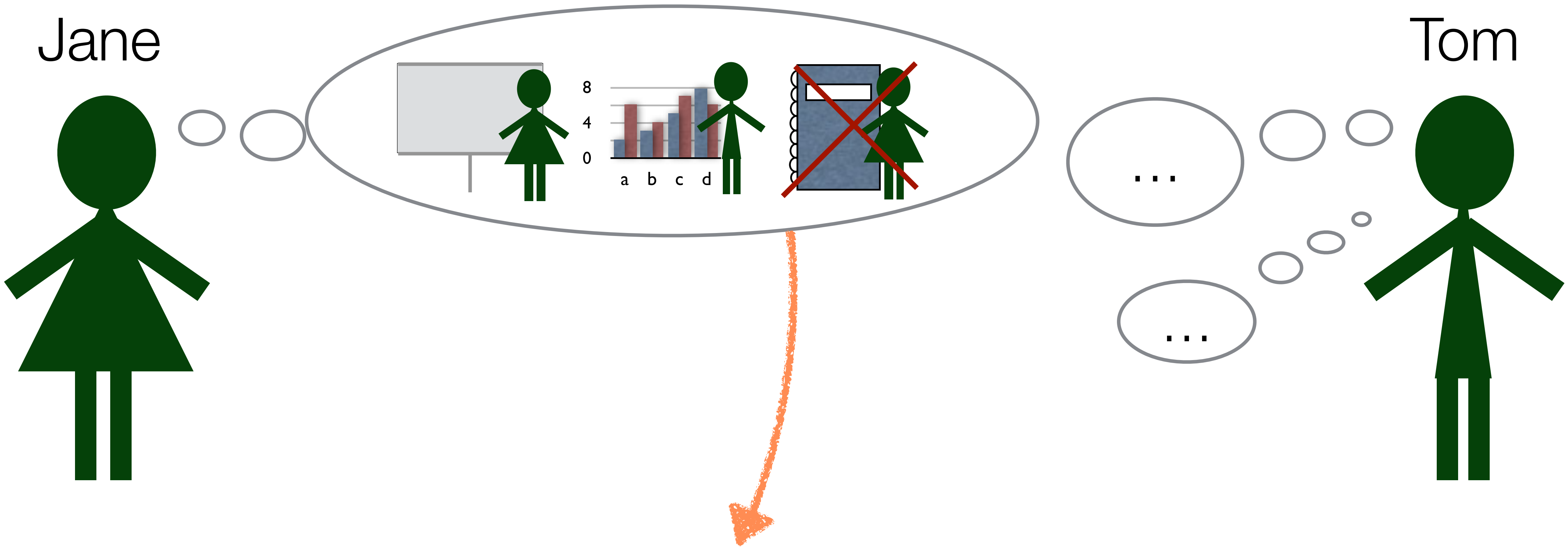
induced utility: $u_1(\{d_1, r_1, p_2\}) = 0$

$u_1(\{p_1, d_2, r_2\}) = 1$

Prioritized Goal Bases



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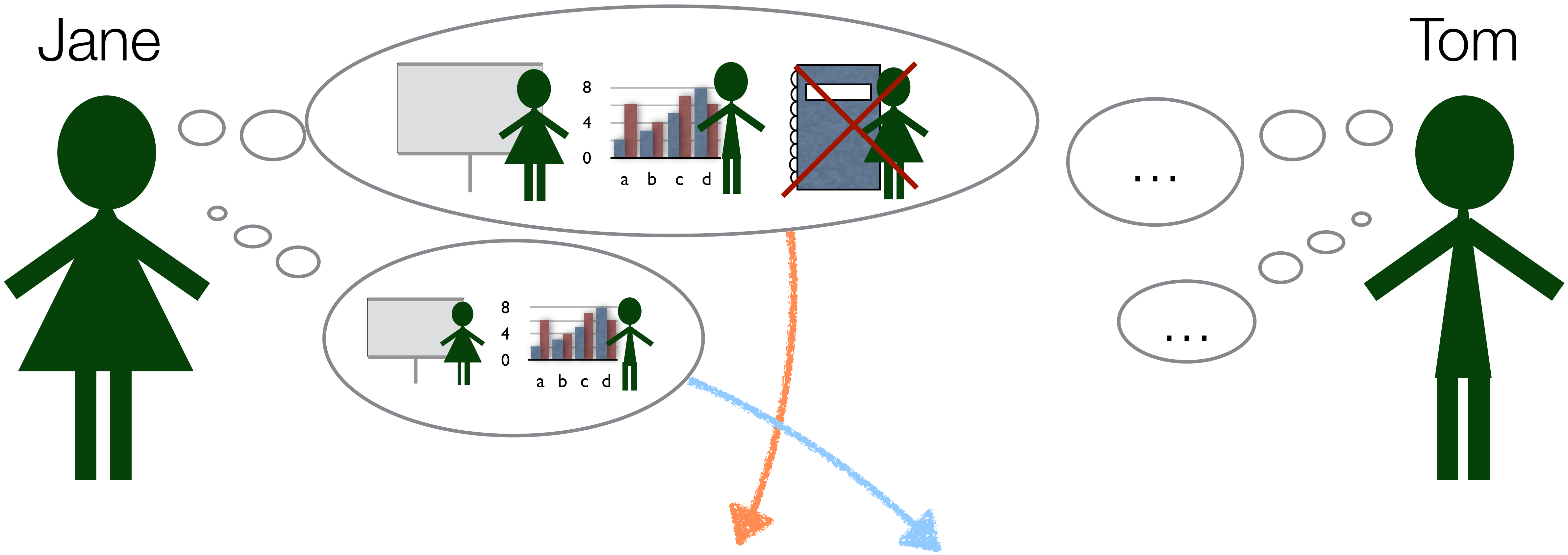

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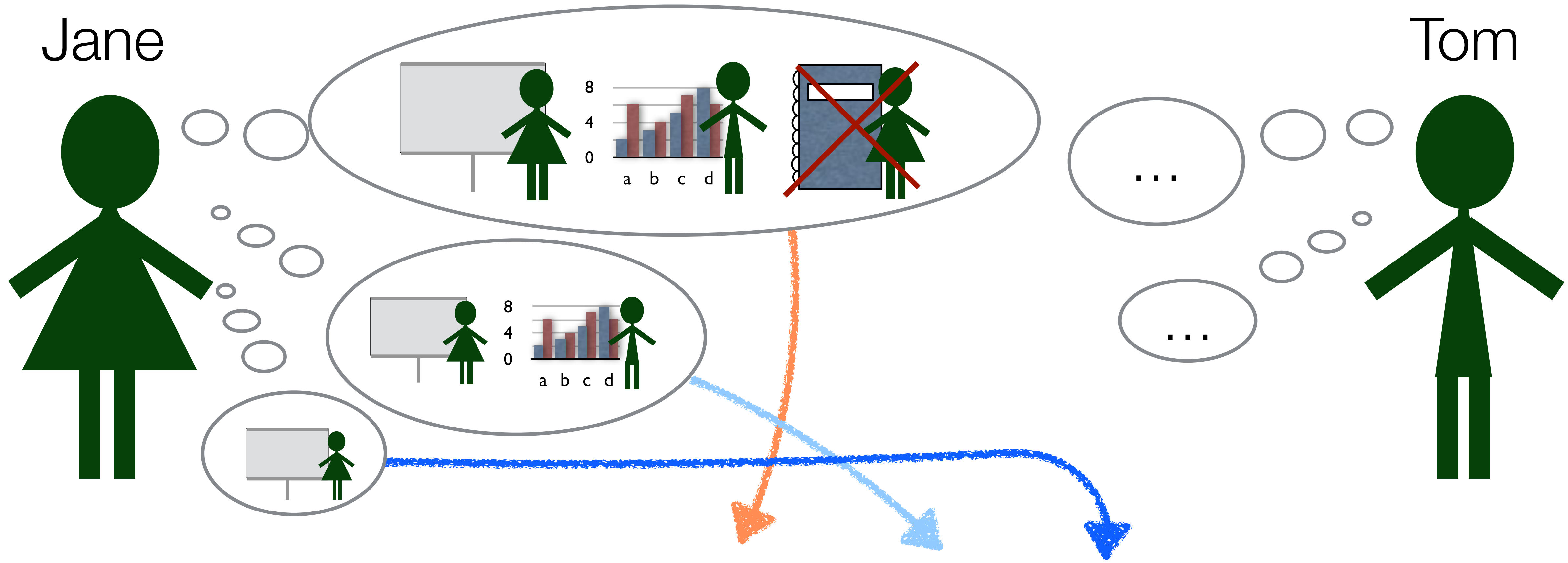

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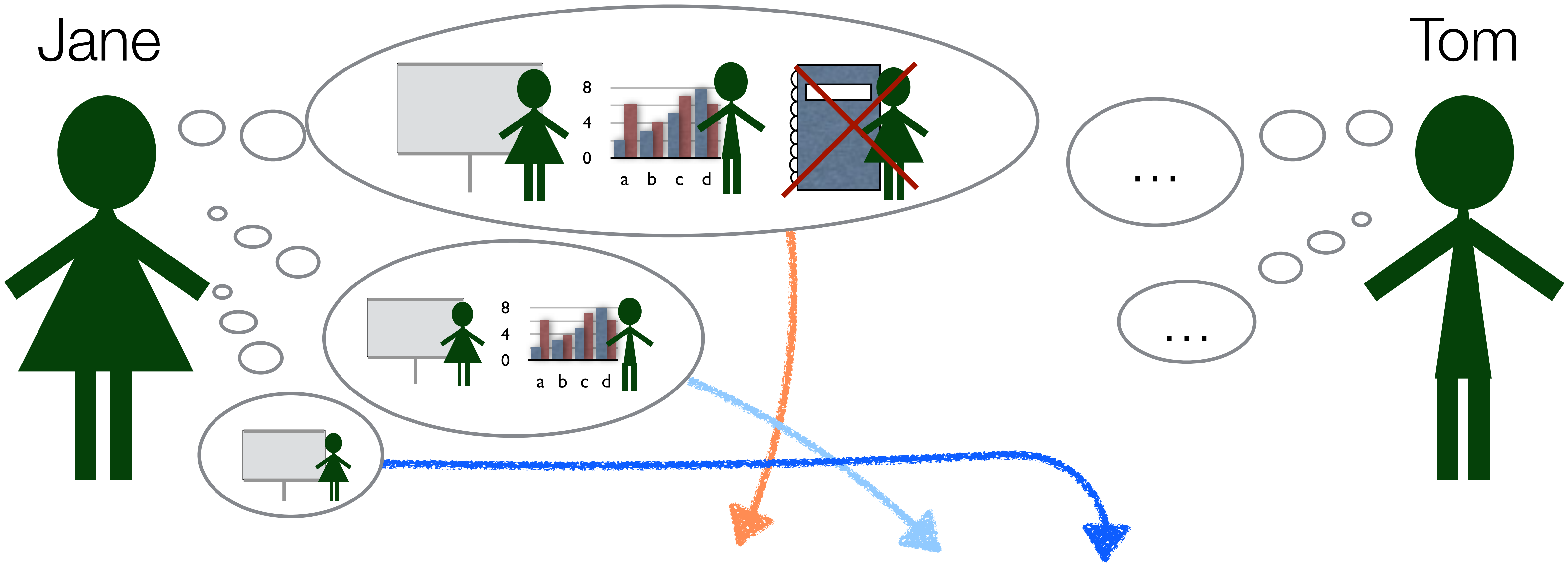

goal:

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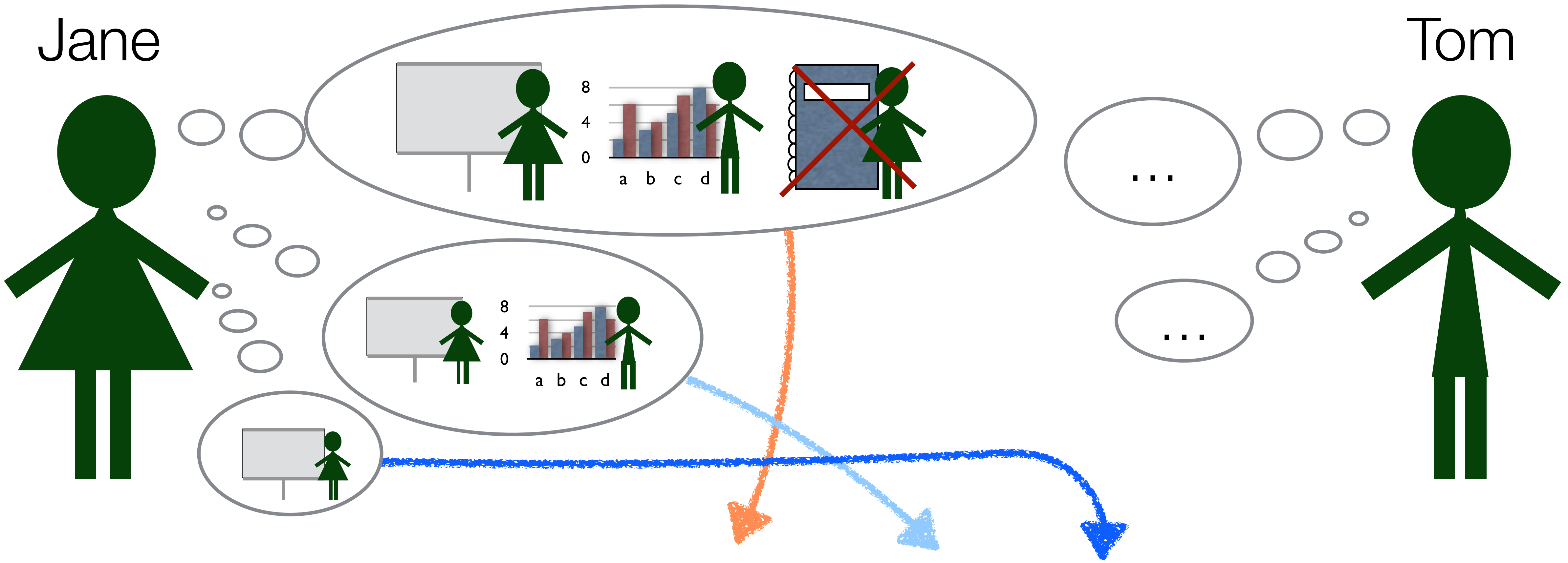

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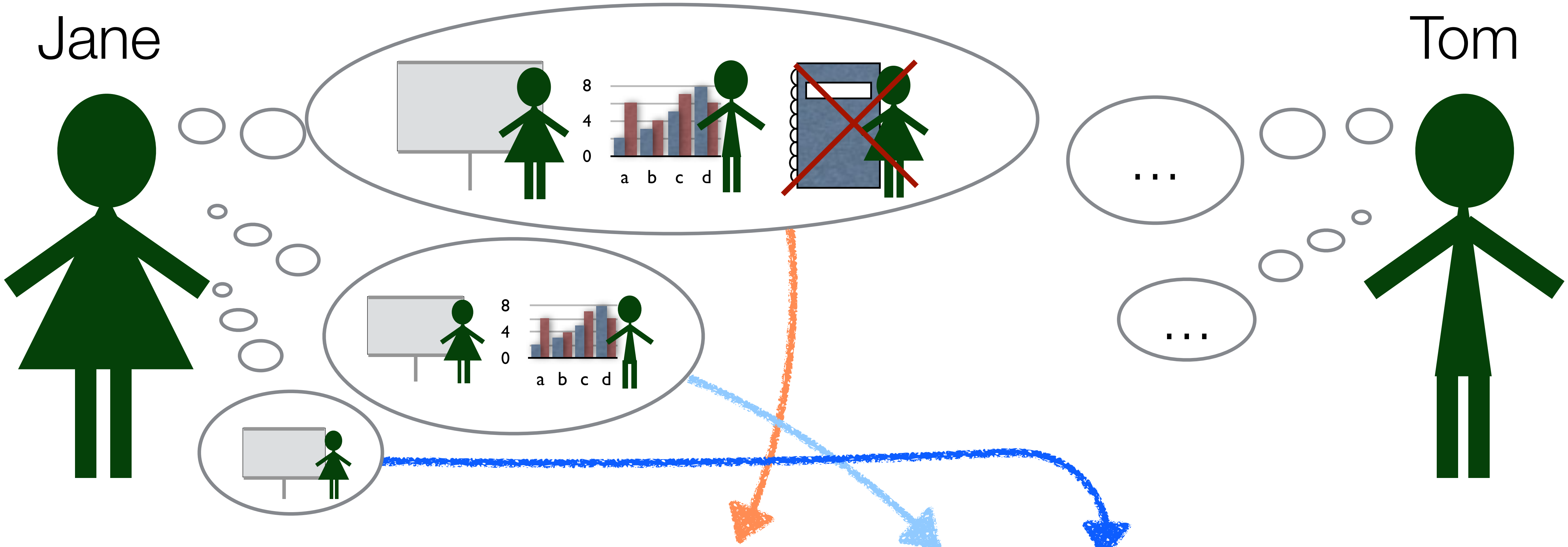

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constraint: $\delta = (p_1 \leftrightarrow \neg p_2) \wedge (d_1 \leftrightarrow \neg d_2) \wedge (r_1 \vee r_2)$

induced utility: $u_1(\{p_1, d_1, r_2\}) = 0.33$

$u_2(\{p_1, d_2, r_1\}) = 0.67$

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  "When the utilities of some agents in a coalition C change, then the lowest utility among the new utilities of the agents in C can never be higher than the lowest among the old utilities of the agents in C."

  $$(0.5, 0.5) > (1, 0),\ (0.5, 0.5) > (0.4, 0.4),\ (0.5, 0.5) > (0.8, 0.2)$$

An Intuitive Negotiation Rule

‘Silver Rule’ or **‘Reprocity of Ethic’**:

One should not treat others in ways that one would not like to be treated.

Negotiation Rule:

If I do not accept on offer of utility k, I should not lower another agent’s utility to k or less in order to improve my own.

Example Protocol

Goals

$\Gamma_1 = \{p_1 \wedge d_2 \wedge \neg r_1; p_1 \wedge d_2; p_1\}$

$\Gamma_2 = \{p_2 \wedge \neg(d_2 \wedge r_2); \neg(d_2 \wedge r_2) \wedge r_1; \neg(d_2 \wedge r_2)\}$

Protocol

1: $\{p_1, d_2, r_2\}$? $u_1 = 1, u_2 = 0$

2: $\{r_1, p_1, d_2\}$? $u_1 = 0.67, u_2 = 0.67$

1: accept.

Characterization and Properties

- The negotiation protocol always ends in a finite number of steps.
- The agreement outcome is discrimin optimal, i.e. fair and efficient.

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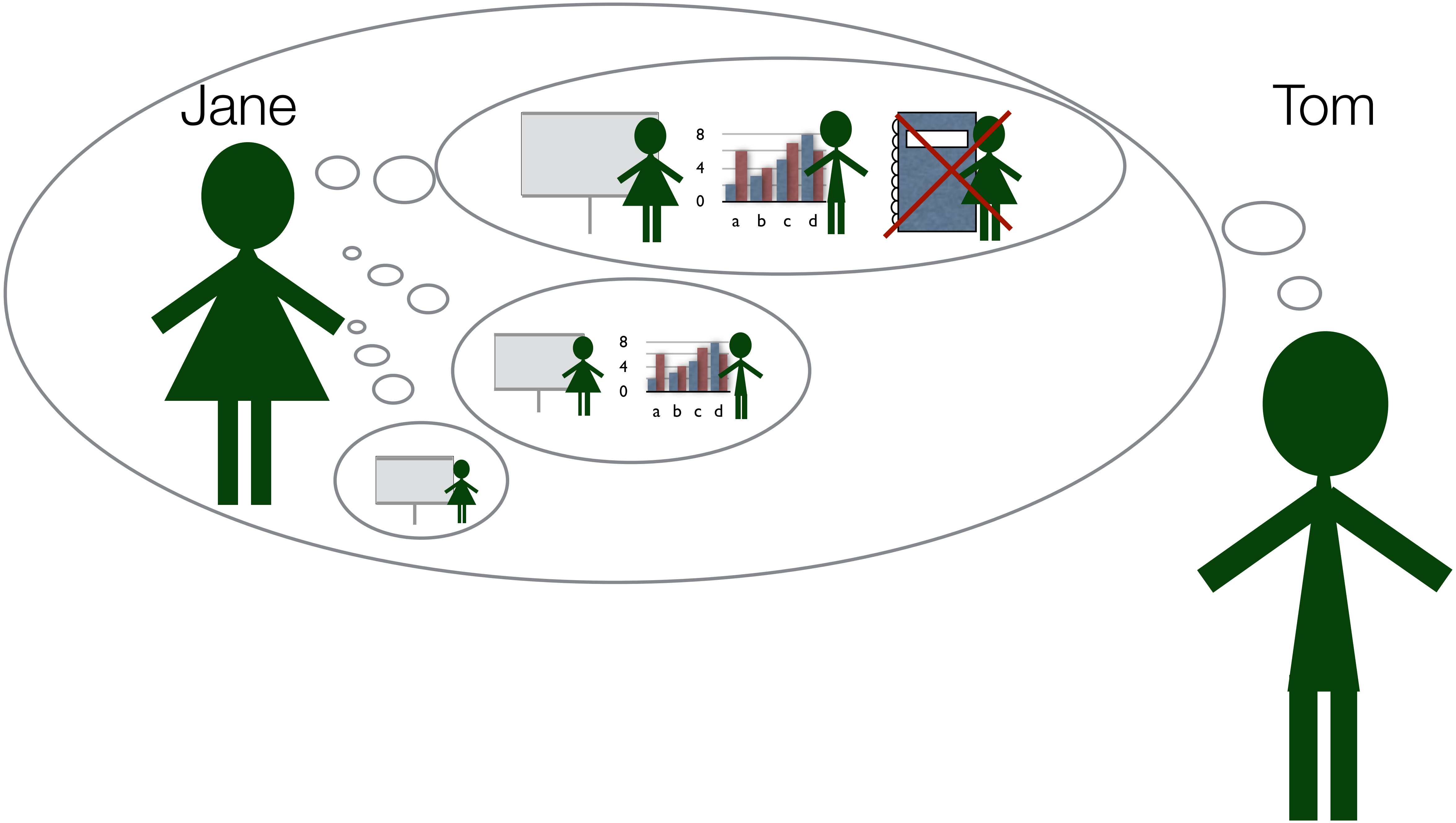
Incomplete Information



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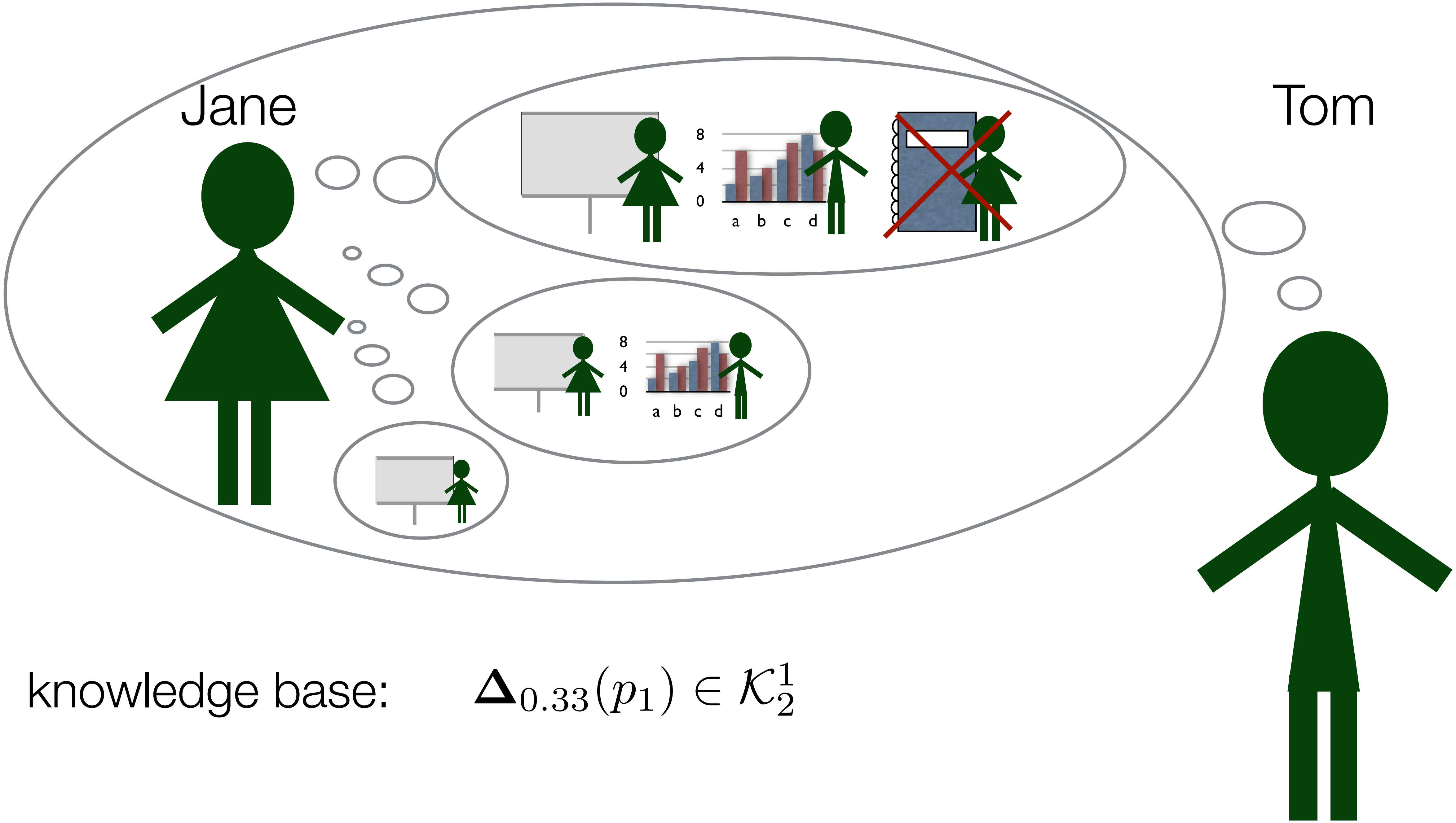
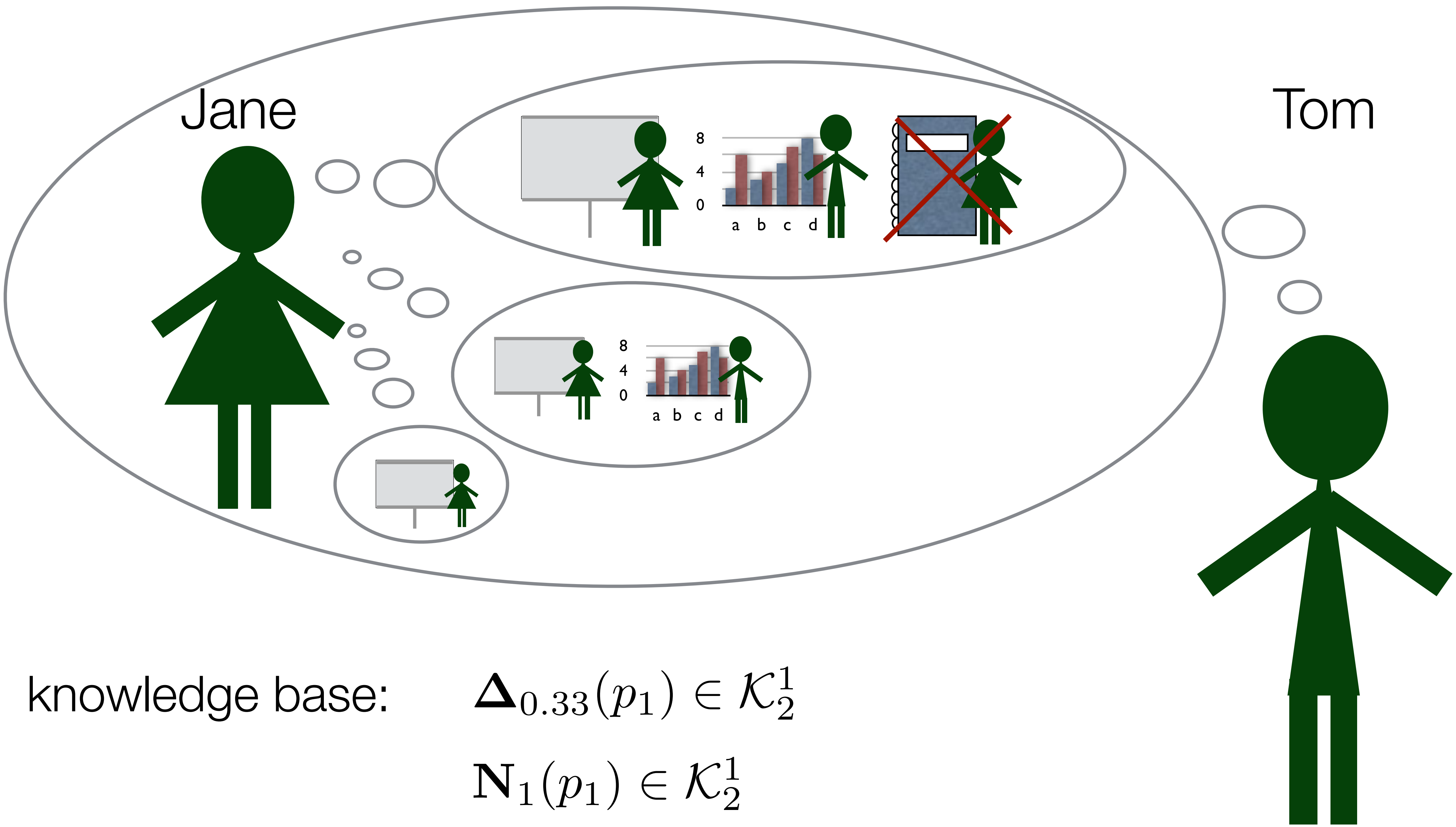


knowledge base: $\mathbf{\Delta}_{0.33}(p_1) \in \mathcal{K}_2^1$

Incomplete Information



knowledge base: $\mathbf{\Delta}_{0.33}(p_1) \in \mathcal{K}_2^1$

$\mathbf{N}_1(p_1) \in \mathcal{K}_2^1$

Generalized Possibilistic Logic

$$\mathcal{K} \models \mathbf{N}_\lambda(\alpha) \equiv \big(\forall \pi \in Mod(\mathcal{K}), \forall \nu \in \mathcal{V} : (\nu \not\models \alpha) \Rightarrow \pi(\nu) \leq 1 - \lambda\big)$$

$$\mathcal{K} \models \mathbf{\Pi}_\lambda(\alpha) \equiv \big(\exists \pi \in Mod(\mathcal{K}), \exists \nu \in \mathcal{V} : (\nu \models \alpha) \wedge \pi(\nu) \geq \lambda\big)$$

$$\mathcal{K} \models \mathbf{\Delta}_\lambda(\alpha) \equiv \big(\forall \pi \in Mod(\mathcal{K}), \forall \nu \in \mathcal{V} : (\nu \models \alpha) \Rightarrow \pi(\nu) \geq \lambda\big)$$

Models of a GPL knowledge base correspond to utility functions.

$$\Downarrow$$

Any model of Tom's base $\mathcal{K}_2^1$ is considered a possible utility function of Jane, according to Tom.

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$\Downarrow$

Possibilistic Discrimin Optimality

"Intuitively, an outcome v is optimal if for any outcome v′ which dominates v according to the discrimin ordering, the agents who are better off in v′ than in v are not aware that v′ is a valid counteroffer in the sense of the negotiation rule."

An Intuitive Negotiation Rule

Negotiation Rule:

If I do not accept on offer of utility k, I should not lower another agent's utility to k or less in order to improve my own. I only make a counteroffer if I am certain I do not violate this rule.

Example Protocol I

Goals

$$\Gamma_1 = \{p_1 \wedge d_2 \wedge \neg r_1; p_1 \wedge d_2; p_1\}$$
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Knowledge bases

$\mathcal{K}_1^2 = \dots$

$\mathcal{K}_2^1 = \emptyset$ Tom knows nothing about Jane's goals…

Protocol

1: $\{p_1, d_2, r_2\}$? $u_1 = 1, u_2 = 0$

2: accept.

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$$\Gamma_1 = \{p_1 \wedge d_2 \wedge \neg r_1; p_1 \wedge d_2; p_1\}$$
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Knowledge bases

$\mathcal{K}_1^2 = \ldots$

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Protocol

1: $\{p_1, d_2, r_2\}$? $u_1 = 1, u_2 = 0$

2: accept. … and is forced to accept every offer Jane makes.

Example Protocol II

Goals

$$\Gamma_1 = \{p_1 \wedge d_2 \wedge \neg r_1; p_1 \wedge d_2; p_1\}$$
$$\Gamma_2 = \{p_2 \wedge \neg(d_2 \wedge r_2); \neg(d_2 \wedge r_2) \wedge r_1; \neg(d_2 \wedge r_2)\}$$

Knowledge bases

$$\mathcal{K}_1^2 = \ldots$$
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Tom knows Jane's utility is at least 0.67 when Jane presents the results and he analyzes the data…

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… and is able to make a counteroffer.

1: accept.

Characterization and Properties

- The negotiation protocol always ends in a finite number of steps.

- The agreement outcome is possibilistic discrimin optimal, i.e. fair and efficient w.r.t. the agents' knowledge.

- The agreement outcome is not necessarily discrimin optimal, but every discrimin optimal outcome is guaranteed to be accepted.

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Conclusion and Future Work

- Development of first negotiation protocol in BGIs.
- Characterization of agreement outcomes.
- Knowledge leads to more desirable outcomes.
- Order of agents matters
  - $\Rightarrow$ Hierarchic games / power
- Future work: investigate bargaining protocols in "symmetric" BGIs.

Any questions?

contact: SofieR.DeClercq@UGent.be

Generalized Possibilistic Logic

$$\mathbf{\Pi}_\lambda(\alpha) \equiv \neg\mathbf{N}_{inv(\lambda)}(\neg\alpha), \qquad \mathbf{\Delta}_\lambda(\alpha) \equiv \bigwedge_{\nu \in [\![\alpha]\!]} \mathbf{\Pi}_\lambda(\varphi_\nu)$$

- π is a model of $\mathbf{N}_\lambda(\alpha)$ iff $N(\alpha) \geq \lambda$;
- π is a model of $\gamma_1 \wedge \gamma_2$ iff π is a model of γ_1 and π is a model of γ_2;
- π is a model of $\neg\gamma_1$ iff π is not a model of γ_1;

where N is the necessity measure induced by π, i.e. $N(\alpha) = \min_{\nu \not\models \alpha}(1 - \pi(\nu))$.