

# Curiosity-aware bargaining

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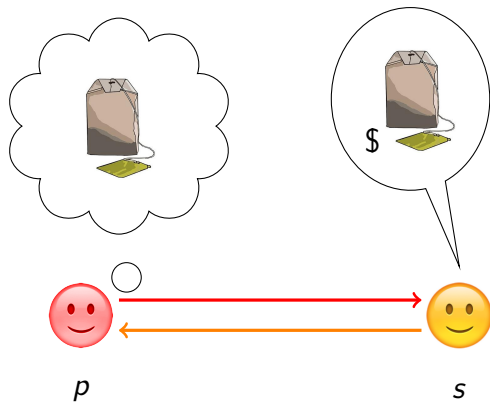


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# Context and motivation

A purchaser  $p$  and a seller  $s$  negotiating for teabags.



# Context and motivation

Very long negotiation, canceled by  $p$ .



$p$



$s$

# Context and motivation

$p$  gets much information on  $s$  for free, used for opponent modeling.

**Opponent modeling** is the exploitation of information obtained through opponent's action to learn some of its aspects.

Deadline  
Utility  
Strategy  
Reserve price



$p$



$s$

# Context and motivation

Purchaser: “**curious**”

Goal of curious agents: get **information** during the negotiation rather than the good.

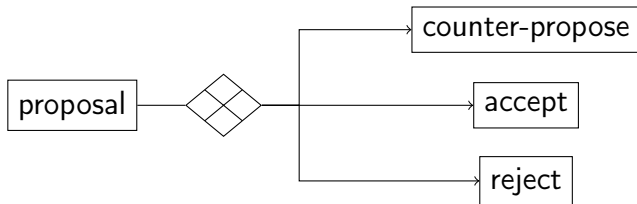
Harmful:

- long negotiations
- many cancellations
- unbalances negotiations



# Bargaining and curious agents

- **Bargaining**: alternate negotiation protocol for **two agents**.
- In this paper: **mono-attribute** negotiation (negotiation on the price only), following the rule of **monotonic concession**.



Bargaining is one of the protocols most vulnerable to curiosity.

# Bargaining and curious agents

Bargaining has three vulnerable points:

- *at the beginning*: if reservation prices of agents are not compatible, negotiation eventually canceled,
- *during the exchange of the proposals*: potentially make small concessions to get information,
- *at the end*: cancellation is not penalized.

Problem: how to make curious agents harmless?



# Bargaining and curious agents

Our proposal: **extend** bargaining (design a new protocol) in order to penalize curious behaviors:

- 1 formalize curiosity by extending standard rationality,
- 2 design a protocol from three extensions of bargaining to reduce the impact of curiosity,
- 3 analyze properties of these extensions,
- 4 study their significance experimentally.





# Curiosity-aware bargaining

Introduction of the **exchanged information** in the definition of bargaining.

Bargaining  $b$  defined as a 6-uplet

- good  $g_b$ ,
  - purchaser  $p$ , seller  $s$ ,
  - outcome  $\pi_b$  (price or  $\perp$  if negotiation canceled)
- + sequences of proposals  $\nu_b^p$  for the purchaser,  $\nu_b^s$  for the seller.

Information is identified with the number of messages sent/received.



# Curiosity-aware bargaining

## Curiosity-aware agents

Extend the rationality of the agents by adding exchanged information (the outcome is still considered in all the cases):

uncurious   info  
 info

curious   info

secretive   info

secretive & curious   info  
 info



# Curiosity-aware bargaining

The utility depends on the step of the negotiation.

→ the reserve price becomes depends on the step of the negotiation.

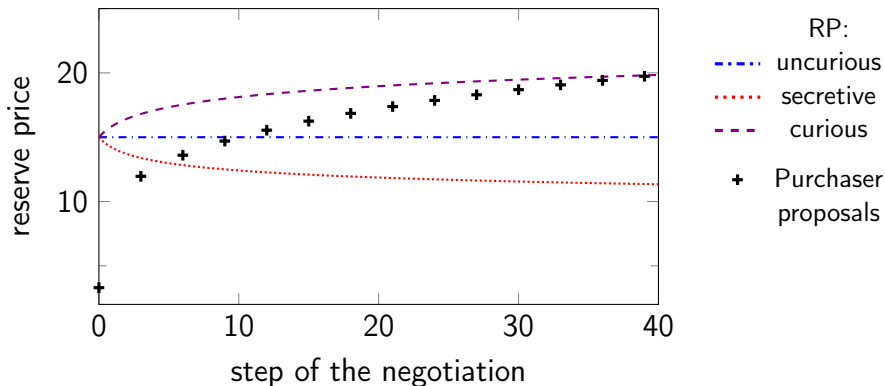


Figure: Reserve price and proposals of a purchaser

# Extensions

Our 3 extensions deal with the 3 points of bargaining prone to curiosity: the **initiation** of the deal, the **length** of the negotiation and the **outcome**.

- 1 *at the beginning*: the reservation prices (RPs) are declared to a trusted third part. Negotiation begins iff declared RPs match,
- 2 *during the exchange of the proposals*: limit the number of steps,
- 3 *at the end*: in case of a cancellation, both agents get/pay their RPs (the surplus is lost for the agents).



# Properties

## Honesty

Let:

- $b$  be a negotiation between a purchaser  $p$  and a seller  $s$ ,
- $\pi_b^a(k)$  be the reserve price of an agent at the step  $k$  and
- $k_b^{max}$  the step at which the negotiation is stopped (deadline)

## Theorem

*Using the three extensions gives  $p$  (resp.  $s$ ) an incentive to give a reserve price inferior (resp. superior) to  $\pi_b^p(k_b^{max})$  (resp.  $\pi_b^s(k_b^{max})$ ).*



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*“Declaring a reserve price more interesting for the opponent than the real one is costly”*



# Properties

## Agreement

### Theorem

*When the three extensions are used, rejecting an offer or going to a deadline is less interesting for a couple of rational negotiating agents than finding any agreement more advantageous than the declared reserve price, before the deadline is reached.*

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*“Agents have an incentive to reach an agreement”*





# Experiments

Goal: study the effect of our protocol on the welfare of the curious and secretive agents.

First, implement our 3 kinds of agents.

Agent utility functions:

$$\forall b \in \mathcal{B}, u_a(\pi_b, \nu_b^s, \nu_b^p) = \begin{cases} \pi_a^b(0) \cdot \Delta(n) - \pi_b & \text{if agreement} \\ \pi_a^b(0) \cdot (\Delta(n) - 1) & \text{otherwise} \end{cases}$$

where

$$\begin{cases} \Delta(n) = 1 & \text{if } a \text{ is uncurious} \\ \Delta(n) = \frac{1}{\log_n(n + k_b^p)} & \text{if } a \text{ is secretive} \\ \Delta(n) = \log_n(n + k_b^p) & \text{if } a \text{ is curious} \end{cases}$$



# Experiments

- Agents strategy, designed by Faratin et al.<sup>1</sup> depending only on the step of the negotiation,
- the offering at step  $k$  of a purchaser  $p$  is:

$$\gamma_p + \left( \kappa_p + (1 - \kappa_p) \cdot \left( \frac{k}{k_p^{\max}} \right)^{\frac{1}{\beta_p}} \right) \cdot (\gamma_p - \pi_p^b)$$

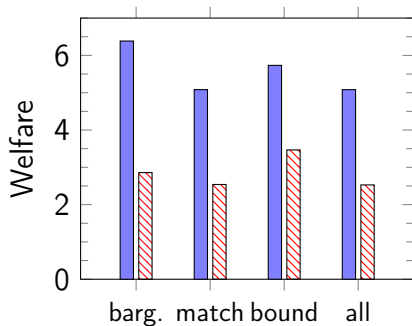
where  $\kappa_p$ ,  $\beta_p$  and  $\gamma_p$  determine the concession rate for agent  $p$ ,  $k_p^{\max}$  is the deadline of the protocol and  $\pi_p^b$  is the RP of  $p$ ,

- proposal accepted if it is better than its new computed proposal, rejected if its new computed proposal is worse than its RP.

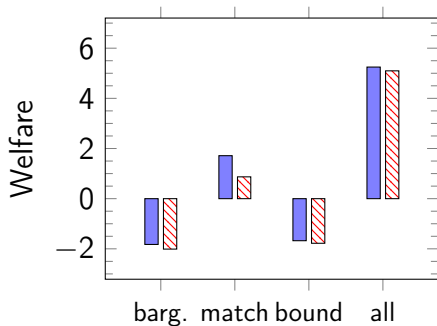
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 <sup>1</sup> Faratin, P.; Jennings, N. R.; Sierra, C. **Robotics and Autonomous Systems** 1998, 24, 159–182.

# Experiments



(a) Welfare of the curious agents



(b) Welfare of the secretive agents



Figure: Welfare of curious & secretive agents with different protocols

# Perspectives & conclusion

## Contributions:

- a **new protocol** (based on of three extensions of bargaining),
- incentive to **look for an agreement**, partially to be **honest** in the declaration of their RP,
- general impact: efficient to **limit the exchanged information**,


## Perspective:

- perspective: extend the protocol to **one-to-many negotiation**  
→ avoid manipulation of the protocol (get incentive to be **perfectly honest**).



# Acknowledgements



 Thank you for your attention!

