The Bargaining Game

A case study in Prolog Programming
This is also your assignment
Join the **Tournament**!

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The Bargaining Game 3.3 (2004)

1. Seller is given (a) cost;
2. Buyer is given (a) utility;
3. Both players know: cost ∈ [MinC, MaxC], utility ∈ [MinU, MaxU], Cost_per_iteration, MaxDays.
4. The seller doesn't know the buyer's utility;
5. The buyer doesn't know the seller's cost;
6. Either play can terminate the bargain at any time by bidding "0"
7. The players make alternate bids, starting with the seller;
8. When both players bid for the same price, a sale is agreed;
9. Bargaining terminates when any player decides to stop, or maximum day has been reached;
10. Past bargaining is forgotten;
11. The history is given to the player (in reverse order), e.g.:
    [+106, -106, +192, -53, +215]
    [+0, -100, +200, -100, +250, -100, +300]

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Design of the mediator

- Ask: what information is relevant?
- Minimum information:
  - mediator(Seller, Buyer, ParamFile, Logfile, NoI)
- For convenience:
  - mediator(Seller, Buyer, ParamFile, Logfile, NoI, SellerProfits, BuyerProfits)

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Predicate mediator/7 (simplified)

```
mediator(Seller, Buyer, Param, Logfile, NoI, SProfits, BProfits ) :-
    mediator_retract_all( mediator_log(_, _, _, _, _) ),
    concat_strings( 'buyers/', Buyer, BFile ), consult( BFile ),
    concat_strings( 'sellers/', Seller, SFile ), consult( SFile ),
    consult(Param ),
    negotiation( NoI ),
    mediator_writes_to_log_file( Seller, Buyer, Logfile, NoI ),
    summarize_results(Seller, Buyer, NoI, SProfits, BProfits ).
```

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Design of negotiate/?

- Assume: buyer, seller & parameters loaded
- negotiate(NoI) or
  negotiation(NoI, SellerProfit, BuyerProfit)?
  - NoI in '0,000, hence used *assert* & *retract*
  - mediator_log(iteration(25), seller(142, 8, 9), buyer(252, 10, 101), History, sales_agreed(151)).
  - History: [+151, -151, ..., +452, -100, +454]

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Simplified negotiation/1

```
negotiation( 0 ).
negotiation( NoI ) :-
    NoI > 0, N1 is NoI - 1, negotiation( N1 ),
    /* generate random Cost, Utility, DTB and DTS */
    negotiate( Cost, Utility, DTB, DTS, [ ], History, Result ),
    profits(Cost, Utility, Result, SellerProfit, BuyerProfit ), !,
    assert( mediator_log( ... ) ),
    mediator_reports_one_negotiation( ... ).
```

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Predicate negotiate/7

```
negotiate( _, _, _, _, History, History, sales_agreed(AgreedPrice) ) :-
    sales_agreed( History, AgreedPrice ), !.
negotiate( Cost, Util, DTB, DTS, [ ], History, Result ) :-
    DTS > 0, DTS1 is DTS - 1, seller( Cost, DTS, [ ], AskingPrice ),
    negotiate( Cost, Util, DTB, DTS1, [+AskingPrice], History, Result ).
negotiate( Cost, Util, DTB, DTS, [-P | BidSF], History, Result ) :-
    DTS > 0, DTS1 is DTS - 1, seller( Cost, DTS, [-P | BidSF], AskP ),
    negotiate( Cost, Util, DTB, DTS1, [+AskP, -P | BidSF], History, Result ).
negotiate( Cost, Util, DTB, DTS, [+P | BidSF], History, Result ) :-
    DTB > 0, DTB1 is DTB - 1, buyer( Util, DTB, [+P | BidSF], BidP ),
    negotiate( Cost, Util, DTB1, DTS, [-BidP, +P | BidSF], History, Result ).
negotiate( _, _, 0, 0, BidHistory, BidHistory, timeout(both) ).
negotiate( _, _, 0, _, BidHistory, BidHistory, timeout(buyer) ).
negotiate( _, _, _, 0, BidHistory, BidHistory, timeout(seller) ).
```


Selected predicates

- sales_agreed([-P, +P | _], P).
- sales_agreed([+P, -P | _], P).

Tournament

```
neg_game( SellersList, BuyersList, Exp_Para, NoI ) :-
    neg_game( SellersList, BuyersList, Exp_Para, NoI, [ ] ).
neg_game( SellersList, BuyersList, Exp_Para, NoI, Parameters ) :-
    'neg_game: delete'( logfile(Logfile), Parameters, OtherParameters ), !,
    tell(Logfile),
    neg_game( SellersList, BuyersList, Exp_Para, NoI, OtherParameters ),
    told.
neg_game( SellersList, BuyersList, Exp_Para, NoI, Parameters ) :-
    ( 'neg_game: delete'( seed(Seed), Parameters, _) ;
     'mediator: random'(1, 10000, Seed) ), !,
    'neg_game: experiments'( SellersList, BuyersList, Exp_Para, NoI, Seed ).
```


Running Experiments (Simplified)

```
'neg: experiments'( Sellers, Buyers, Exp_Param, NoI, Seed ) :-
    neg_game_signature(Signature),
    'neg: writelist'([nl, Signature, nl]),
    findall( (Seller-SellerProfit, Buyer-BuyerProfit),
            'neg: match_one_pair'( Sellers, Buyers,
                    Exp_Param, NoI,
                    Seed, Seller, Buyer, SellerProfit, BuyerProfit ),
            Results),
    'neg: summarize_results'( Results, Sellers, Buyers, NoI ).
```


Match one pair

```
'neg: match_one_pair'( SellersList, BuyersList, Param_file, NoI,
        Seed, Sellerfile, Buyerfile, SellerProfit, BuyerProfit ) :-
    member( Seller, SellersList),      /* rely on backtracking */
    member( Buyer, BuyersList),
    mediator(seed(Seed)),              /* reset the seed */
    mediator( Seller, Buyer, Param_file, nologfile, NoI,
            SellerProfit, BuyerProfit ).
```


Jacob-Seller (dgjaco_s)

- Accepts bids that are above the cost by a predefined margin,
- Or when it judges (based on the bids history) that the buyer has reached its limit.
- Start offer: cost plus a predefined premium
- General rule: This offer is reduced linearly until 4th final day. It then offers cost plus a target profit (parameter to the program) for one move. The penultimate move makes an obvious drop in price to tempt the buyer. A minimum profit is demanded in the final offer.

Stacey-Seller (rpstac_s)

- Complex seller: 18 rules for various situations
- Drive hard bargains by various sensible means.
- When the bid is above cost, the bid is accepted if
  (i) the last two bids are 50% above cost;
  (ii) the last three bids are 25% above cost; or
  (iii) the last four bids are 15% above cost.
- Final 2 days' strategies fine tuned with 7 rules
  - depending on its predetermined margin thresholds
  - and the buyer's latest offer.
- General rule: reduce offer by 7.5% of the cost per round, as long as the offer is above cost.

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Bargaining

Research Frontier

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Bubinstein's Two players alternative offering game

Player 1: How about 70% for me 30% for you?

t = 0, Player 1's pay off is 70%

Player 1: No, how about 50-50?

t = 2, Player 1's pay off is $50\% \times e^{-0.1 \times 2} = 41\%$

- If neither players have any incentive to compromise, this can go on for ever
- Payoff drops over time – incentive to compromise
- A's Payoff = $x_A \exp(-r_A t\Delta)$ Let r_1 be 0.1, Δ be 1

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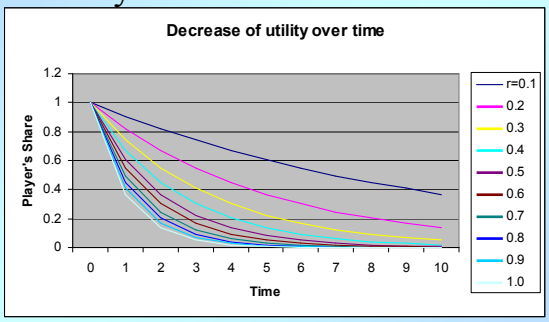
Payoff decreases over time



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Evolutionary Computation for Bargaining

- Conventional methods find strategies mathematically
  - However, it is laborious
  - It also assumes perfect rationality
- Co-evolution is an *alternative approximation* method to find game theoretical solutions
  - Perfect rationality assumption relaxed
  - Relatively quick for approximate solutions
  - Relatively easy to modify for new models
- Genetic Programming with incentive / constraints
  - Constraints helped to focus the search in promising spaces

See http://www.bracil.net/finance/bargain for details

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