Negotiation Frames

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main

Motivation

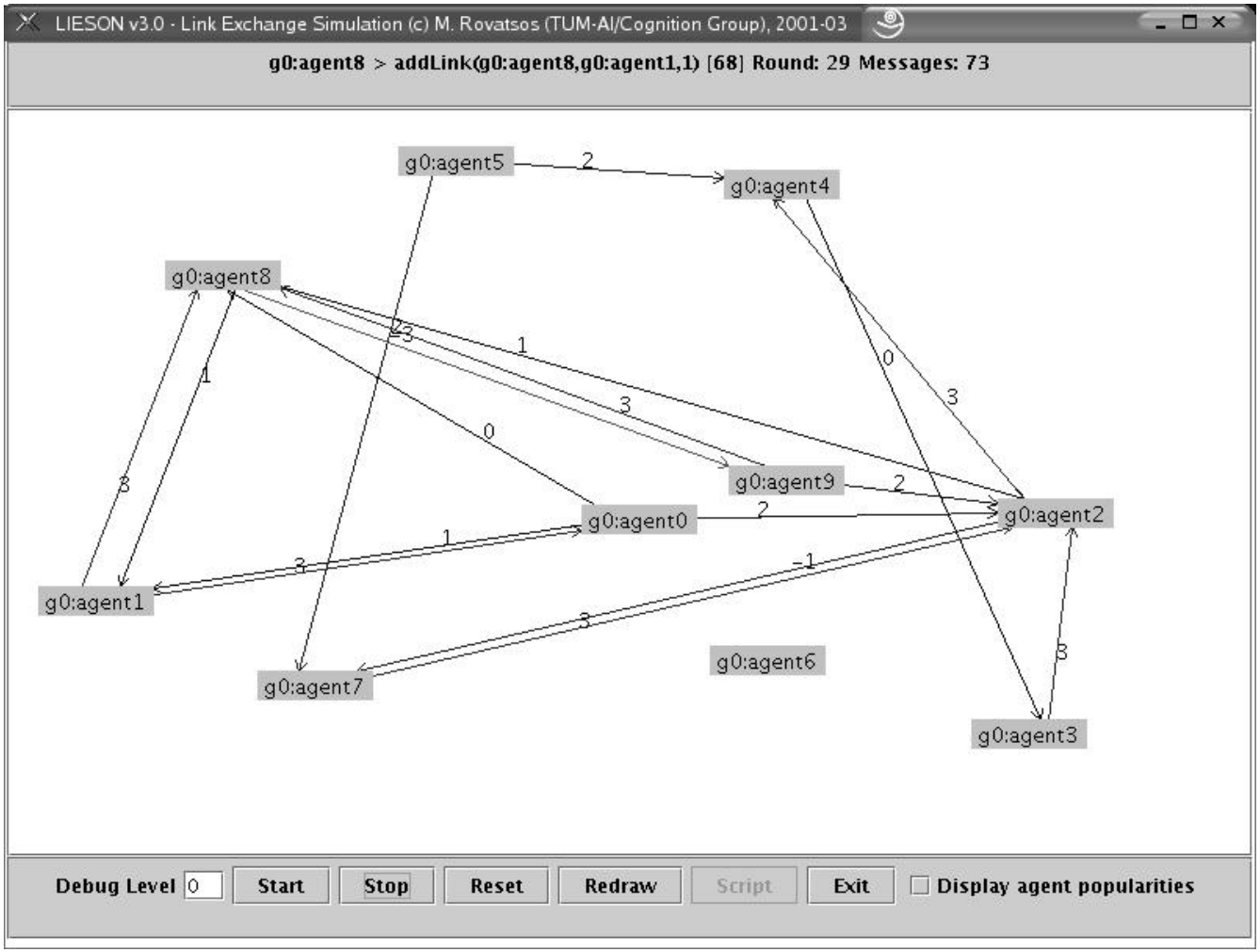
- Frame learning and generalisation techniques provide foundation for frame-based strategic communication management
- Combination of
  - (hierarchical) reinforcement learning
  - case-based reasoning and cluster validation techniques
  - deliberative, knowledge-based reasoning
  - content-rich agent communication
- But how can it be used in practice?

Outline of this talk

- Application scenario: Link Exchange Simulation
- Simple negotiation frames with m^{2}inffra
- Advanced negotiation frames
- Conclusion

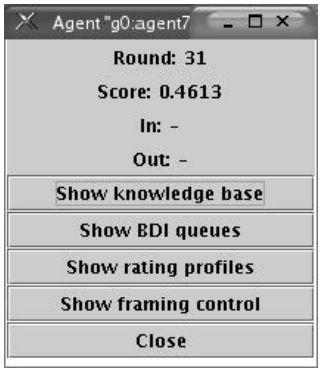
LIESON system overview

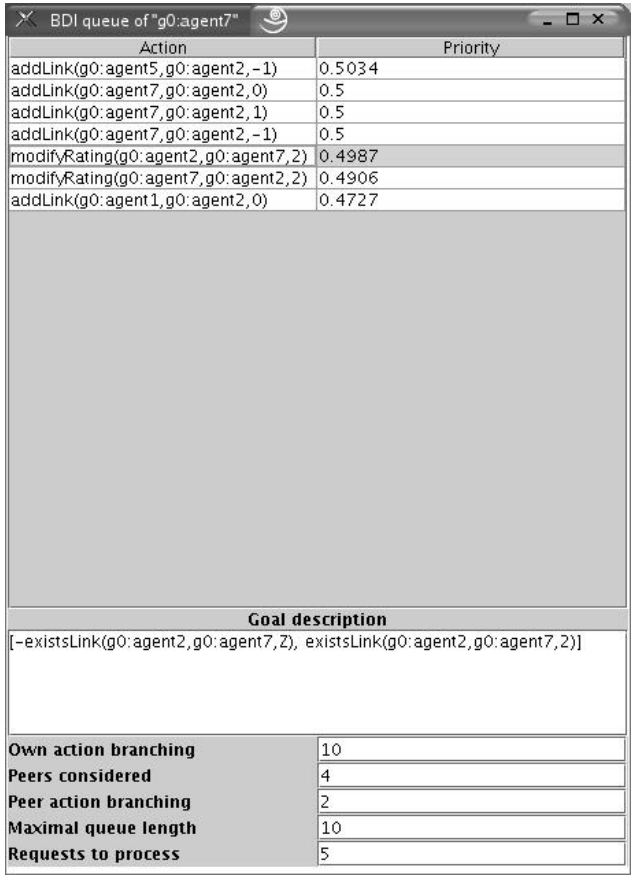
- LI*ESON*– *LI*nk *E*xchange *S*imulati*ON* System
- System objective: increase linkage transparency on the WWW using automated link exchange
- Link ratings express approval/disapproval of target site
- Web surfer behaviour (i.e. site popularity) rating-dependent
- Includes implementation of BDI-like agents with m^{2}inffra engine
  - Entirely self-interested agents
  - Maximisation of dissemination of own opinion
  - Highly boundedly rational agents
- BDI reasoning = goal selection according to projected utility (planning process trivial)
- BDI choices overruled by m^{2}inffra

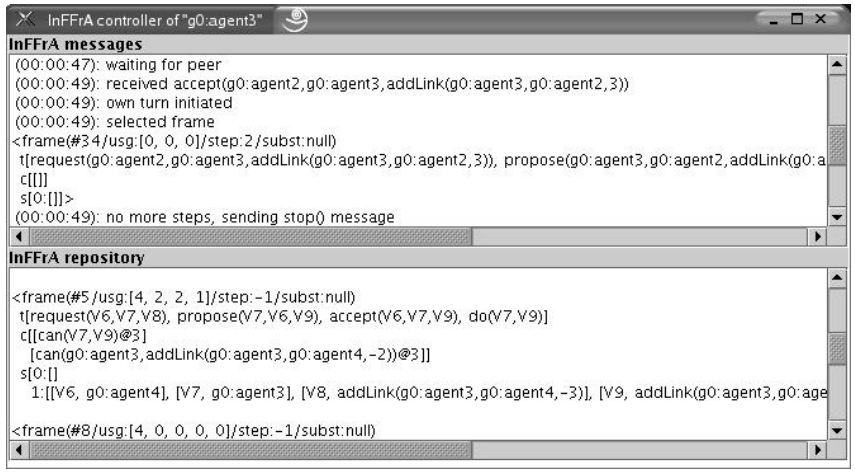


Agent popularity

Agent	Popularity	Simple Popularity
g0:agent6	0.1	0.1
g0:agent5	0.1	0.1
g0:agent4	0.8638	0.2958
g0:agent3	0.4825	0.15
g0:agent2	0.8173	0.5758
g0:agent1	0.3517	0.2682
g0:agent0	0.3658	0.1993
g0:agent9	0.1018	0.1006
g0:agent8	0.3822	0.3486
g0:agent7	0.2953	0.2124


Agent "g0:agent7
Round: 31
Score: 0.4613
In: -
Out: -
Show knowledge base
Show BDI queues
Show rating profiles
Show framing control
Close


BDI queue of "g0:agent7"
Action
Priority
addLink(g0:agent5,g0:agent2,-1) 0.5034
addLink(g0:agent7,g0:agent2,0) 0.5
addLink(g0:agent7,g0:agent2,1) 0.5
addLink(g0:agent7,g0:agent2,-1) 0.5
modifyRating(g0:agent2,g0:agent7,2) 0.4987
modifyRating(g0:agent7,g0:agent2,2) 0.4906
addLink(g0:agent1,g0:agent2,0) 0.4727
Goal description
[-existsLink(g0:agent2,g0:agent7,Z), existsLink(g0:agent2,g0:agent7,2)]
Own action branching 10
Peers considered 4
Peer action branching 2
Maximal queue length 10
Requests to process 5


InFFrA controller of "g0:agent3"
InFFrA messages
(00:00:47): waiting for peer
(00:00:49): received accept(g0:agent2,g0:agent3,addLink(g0:agent3,g0:agent2,3))
(00:00:49): own turn initiated
(00:00:49): selected frame
<frame(#34/usg:[0, 0, 0]/step:2/subst:null)
t[request(g0:agent2,g0:agent3,addLink(g0:agent3,g0:agent2,3)), propose(g0:agent3,g0:agent2,addLink(g0:a
c[[]]
s[0:[]]>
(00:00:49): no more steps, sending stop() message
InFFrA repository
<frame(#5/usg:[4, 2, 2, 1]/step:-1/subst:null)
t[request(V6,V7,V8), propose(V7,V6,V9), accept(V6,V7,V9), do(V7,V9)]
c[[can(V7,V9)@3]
[can(g0:agent3,addLink(g0:agent3,g0:agent4,-2))@3]]
s[0:[]
1:[[V6, g0:agent4], [V7, g0:agent3], [V8, addLink(g0:agent3,g0:agent4,-3)], [V9, addLink(g0:agent3,g0:age
<frame(#8/usg:[4, 0, 0, 0, 0]/step:-1/subst:null)

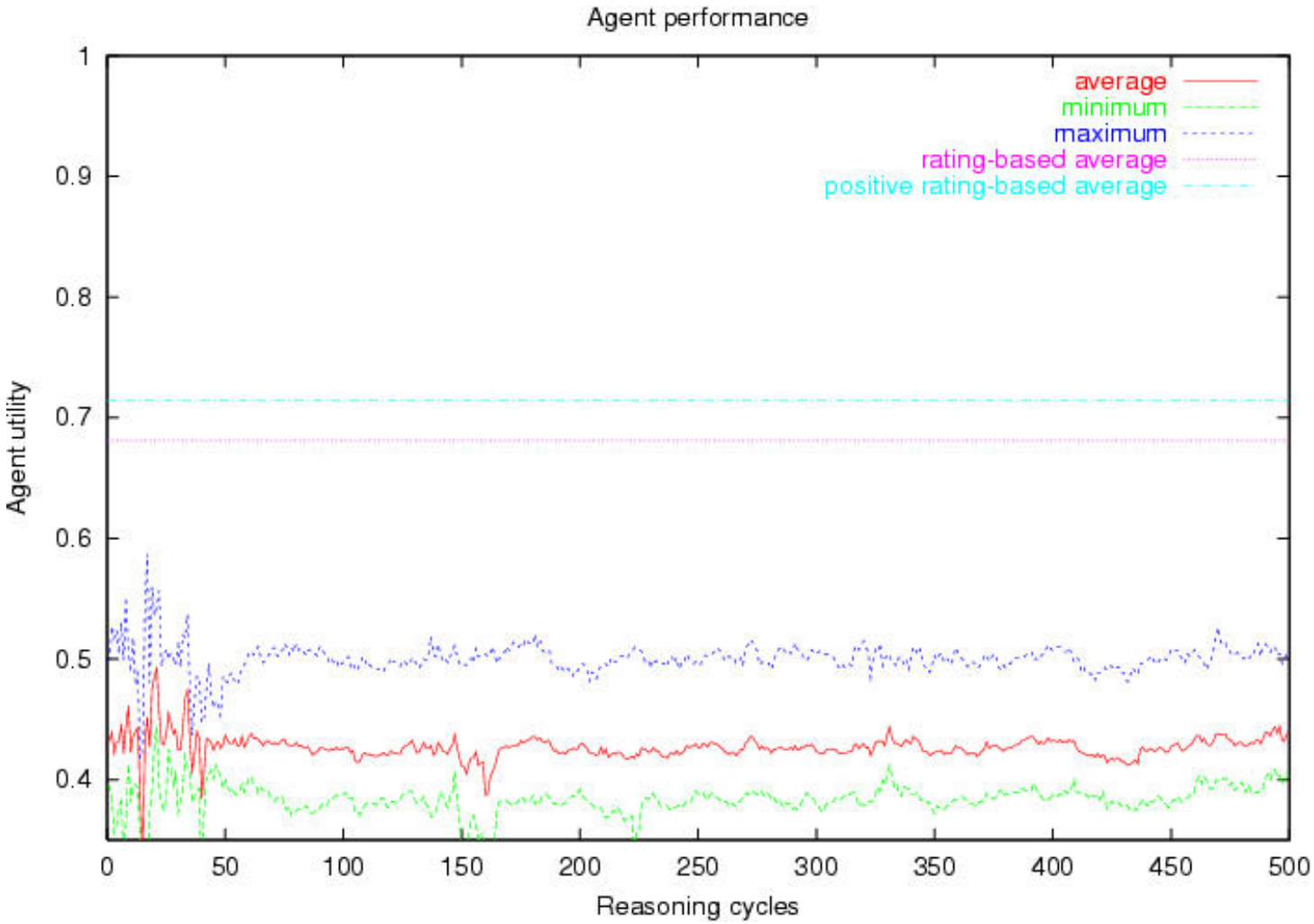
Proposal-based negotiation frames

- First series of experiments as proof-of-concept implementation
- Simple frames allowed for making proposals, counter-proposals, and compromise offers:
  - $\langle \texttt{request}(A, B, X) \rightarrow \texttt{accept}(B, A, X) \rightarrow \texttt{confirm}(A, B, X) \rightarrow \texttt{do}(B, X) \rangle$
  - $\langle \texttt{request}(A, B, X) \rightarrow \texttt{reject}(B, A, X) \rangle$
  - $\langle \texttt{request}(A, B, X) \rightarrow \texttt{propose}(B, A, Y) \rightarrow \texttt{accept}(A, B, Y) \rightarrow \texttt{do}(B, Y) \rangle$
  - $\langle \texttt{request}(A, B, X) \rightarrow \texttt{propose-also}(B, A, Y) \rightarrow \texttt{accept}(A, B, Y) \rightarrow \texttt{do}(B, X) \rightarrow \texttt{do}(A, Y) \rangle$
- State abstractions of the form $\{\uparrow|\downarrow\}(\{I, R\}, \{I, R, T\}, \{+, -, ?\})$
- Example: a_1 and a_2 talk about $\texttt{do}(a_1, deleteLink(a_1, a_3))$, a_2 is the responder, a_2 likes a_3's site) $\Rightarrow$ add $\downarrow(I, T, +)$ to state

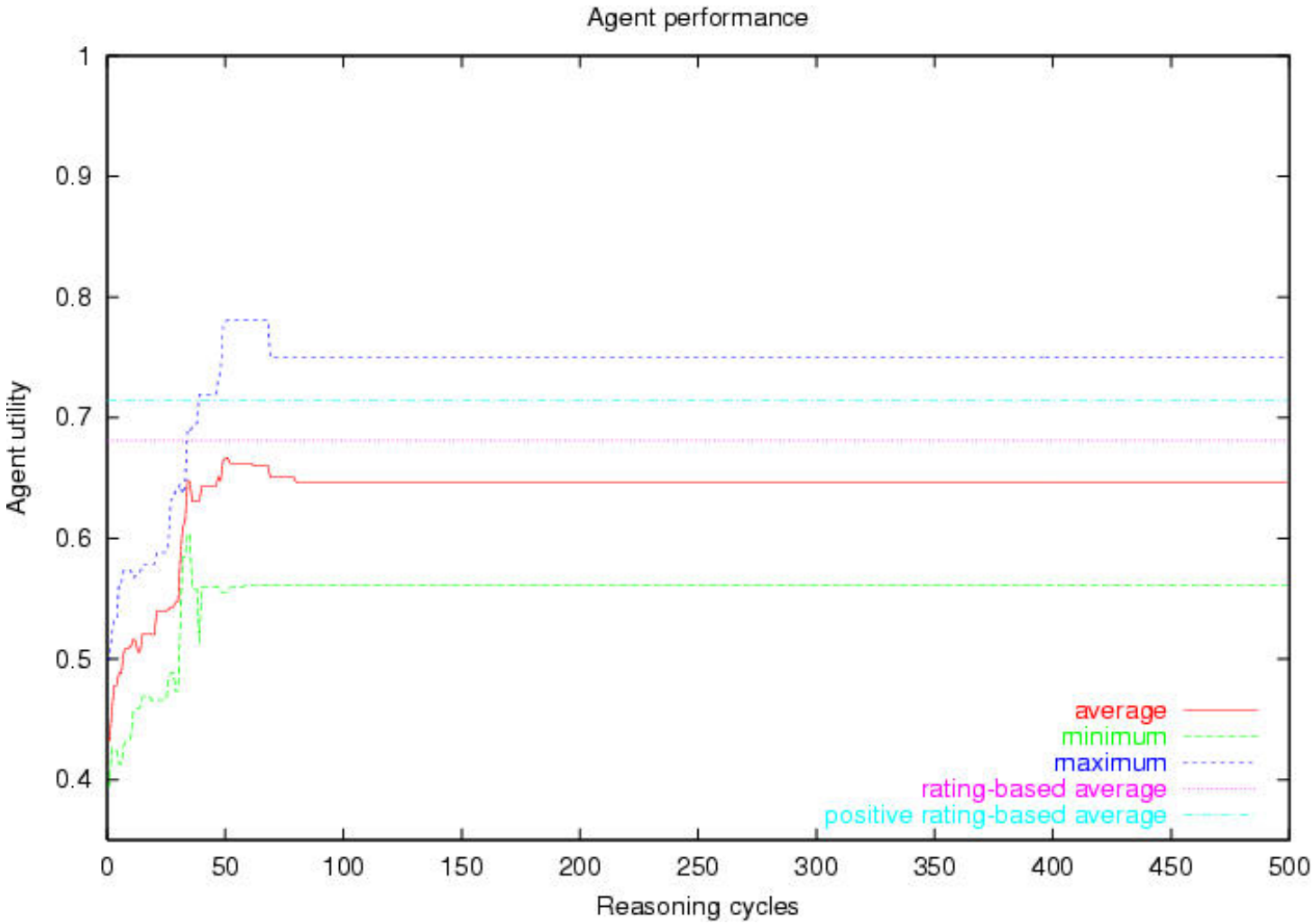
Experimental setup

- Compared utility performance of m^{2}inffra to
  - BDI agents with simple communication
  - BDI agents without communication
  - random agents
- Utility function with interesting properties:
  - Empty/fully connected linkage networks yield highly suboptimal utility distribution
  - Interesting utilities range between rating-based and "politically correct" linkage
- Fixed rating profile
  - two antagonistic "groups" (in-ward cohesion, out-group distinction)
  - agents with higher index are more popular within their group
  - "bridge" between the two groups

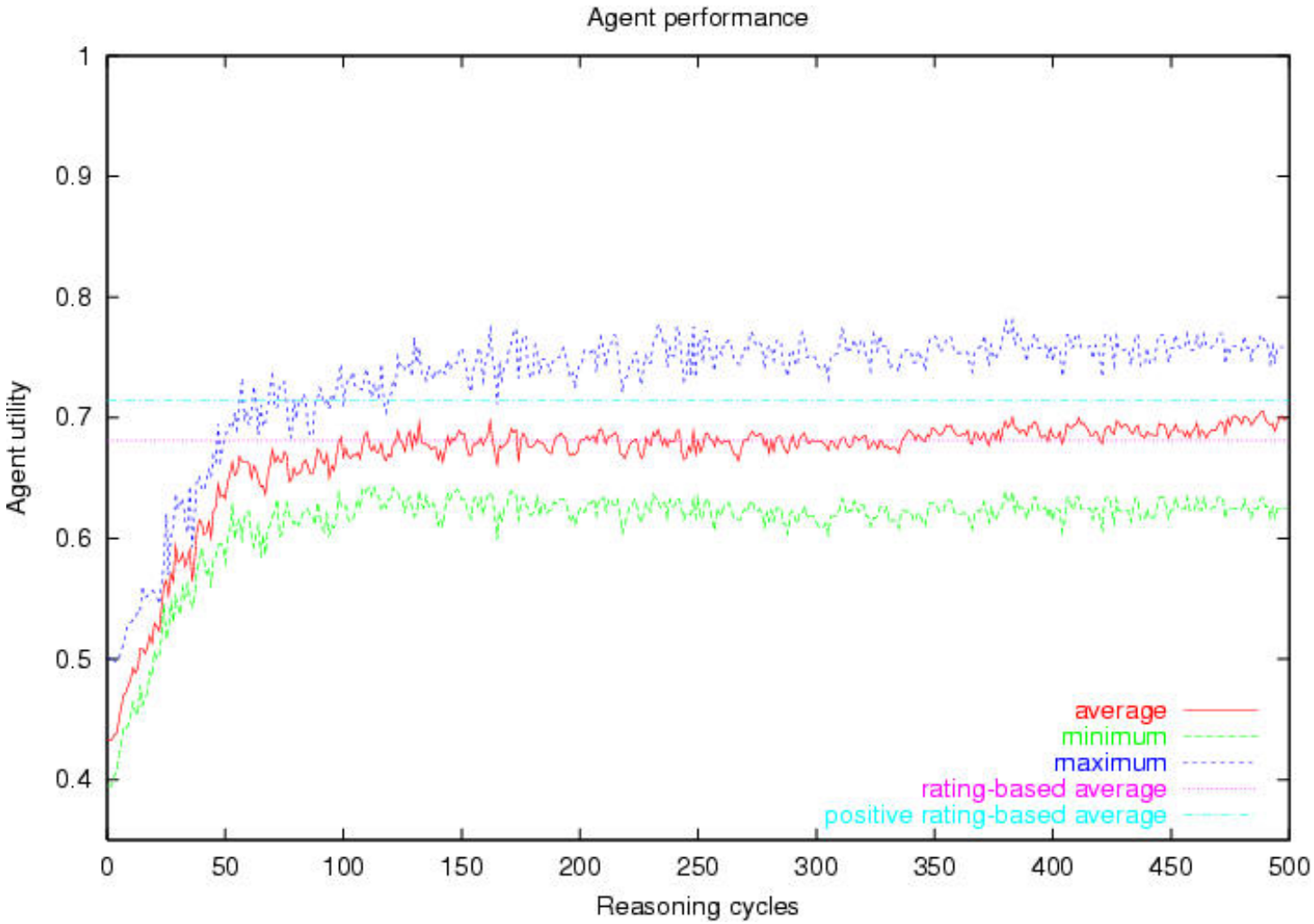
Utility comparison: random agents



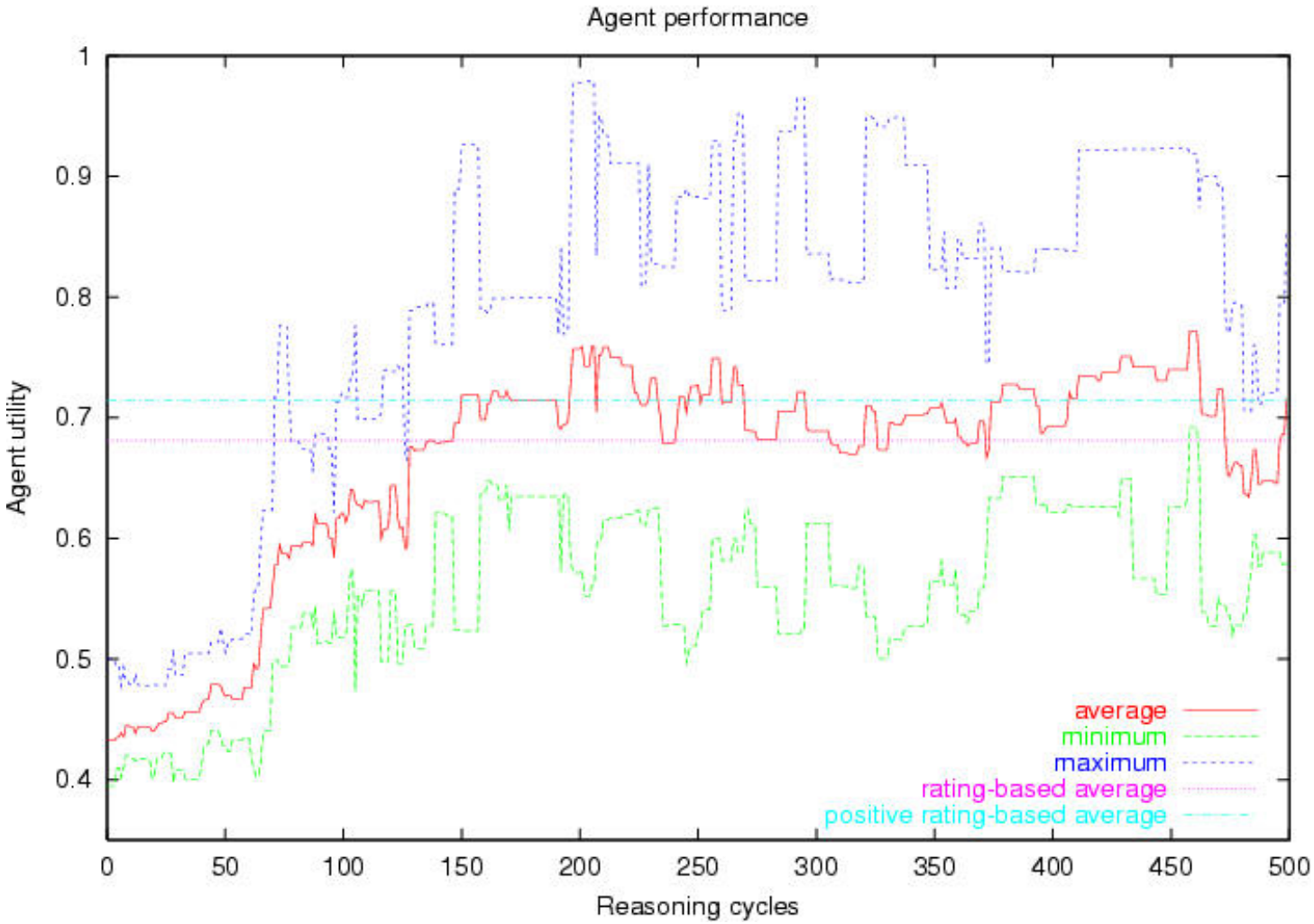
Utility comparison: BDI agents with communication



Utility comparison: BDI agents without communication



Utility comparison: m^{2}inffra agents



Why negotation?

Negotiation is a form of interaction in which a group of agents with conflicting interests and a desire to cooperate, try to come to a mutually acceptable agreement on the division of scarce resources. (Rahwan et al. 2004)

- LIESON experiments show that agent really only exchange proposals
- limited strategic options if no information about *reasons* is available
- ideal for domain in which "Web traffic" is a scarce resource

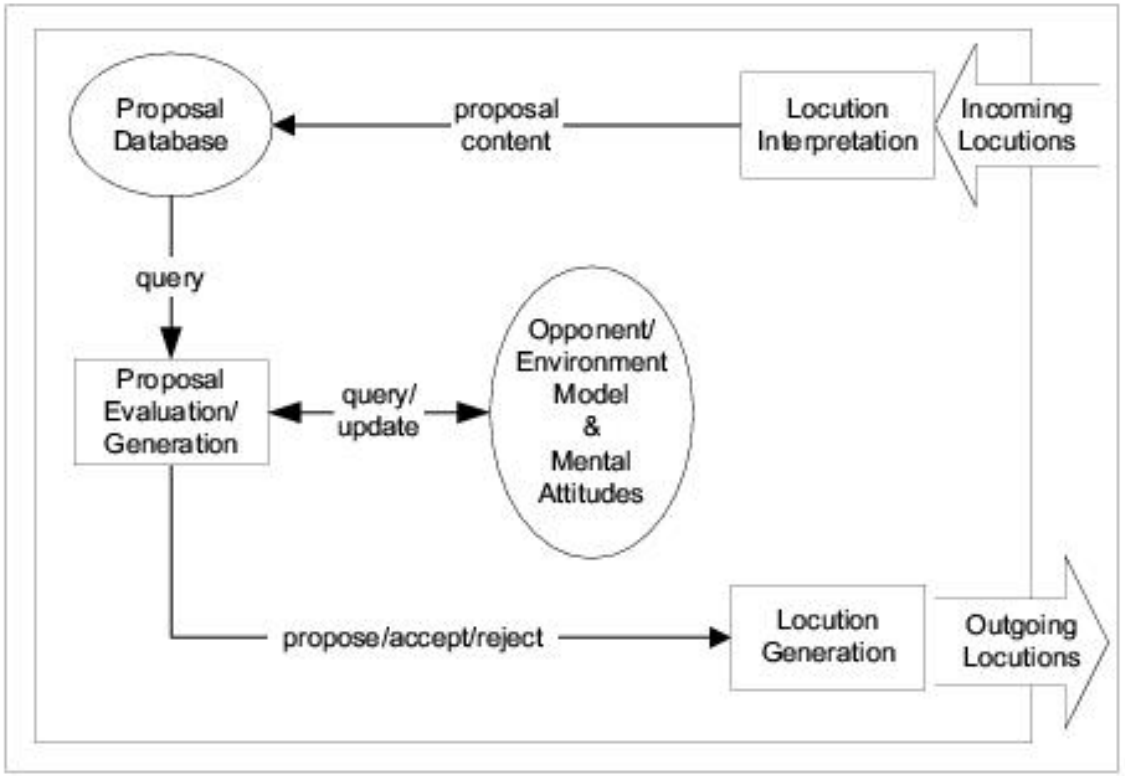
Different types of Automated Negotiation

- Game-theoretic approaches (formulation of games, quest for optimal strategies and equilibria)
- Heuristic-based approaches (use "good enough" rules of thumb rather than optimality criteria)

All based on direct exchange of *proposals*, i.e. all information is available in advance

- preferences are *proper* and *fixed*
- no influence on mental attitudes during negotation

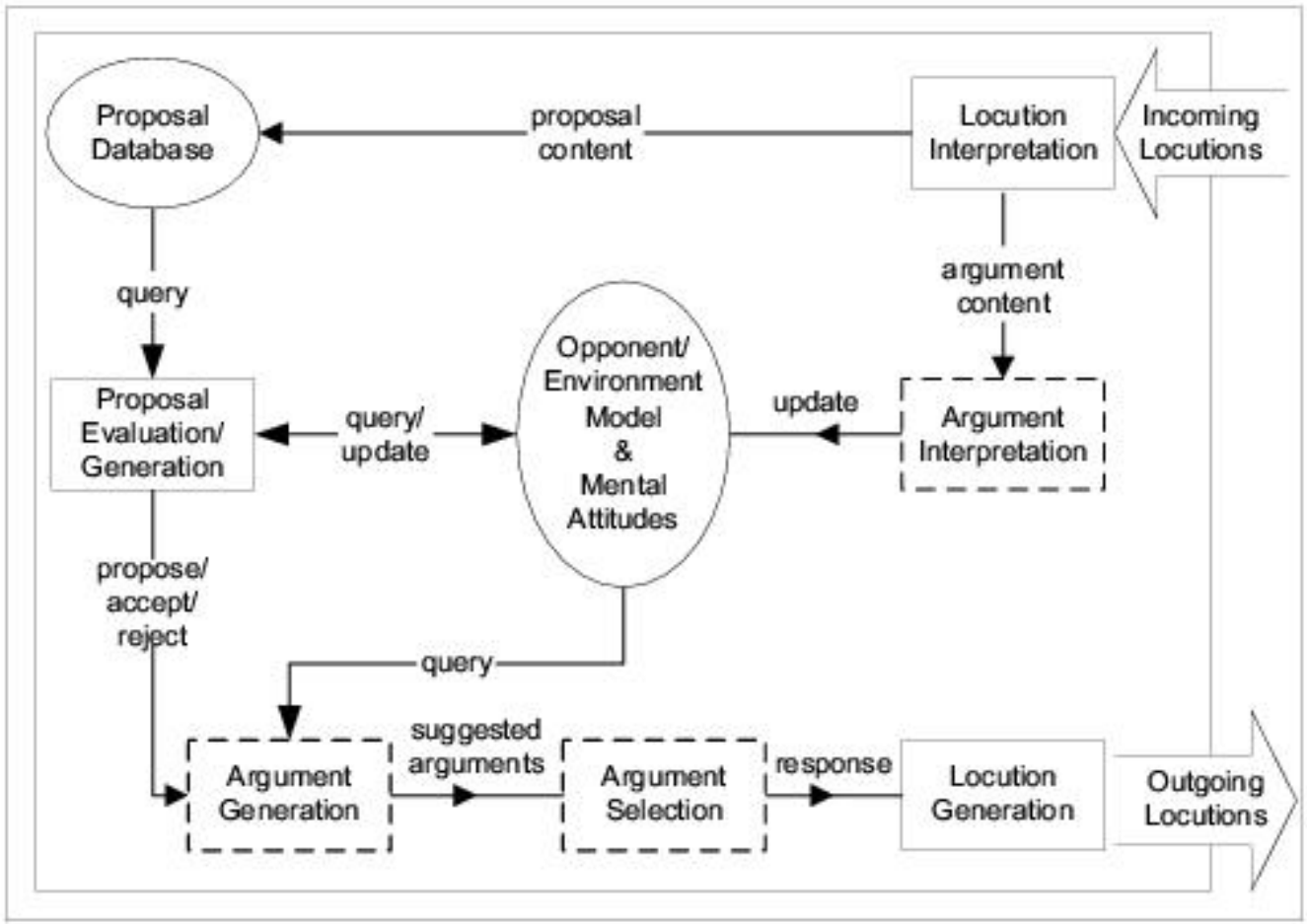
General negotiation agent design



Argumentation-based negotiation (ABN)

- ABN approaches are based on the idea of exchanging information (arguments) *during* negotiation
- External elements:
  - Agent communication language and domain language
  - Negotiation protocols (rules for admission, termination, withdrawal, proposal validity, commitment rules, outcome determination)
  - Information stores (in particular: commitment stores)
- Elements of ABN agents:
  - locution interpretation and generation
  - proposal evaluation/generation
  - argument interpretation, generation, selection

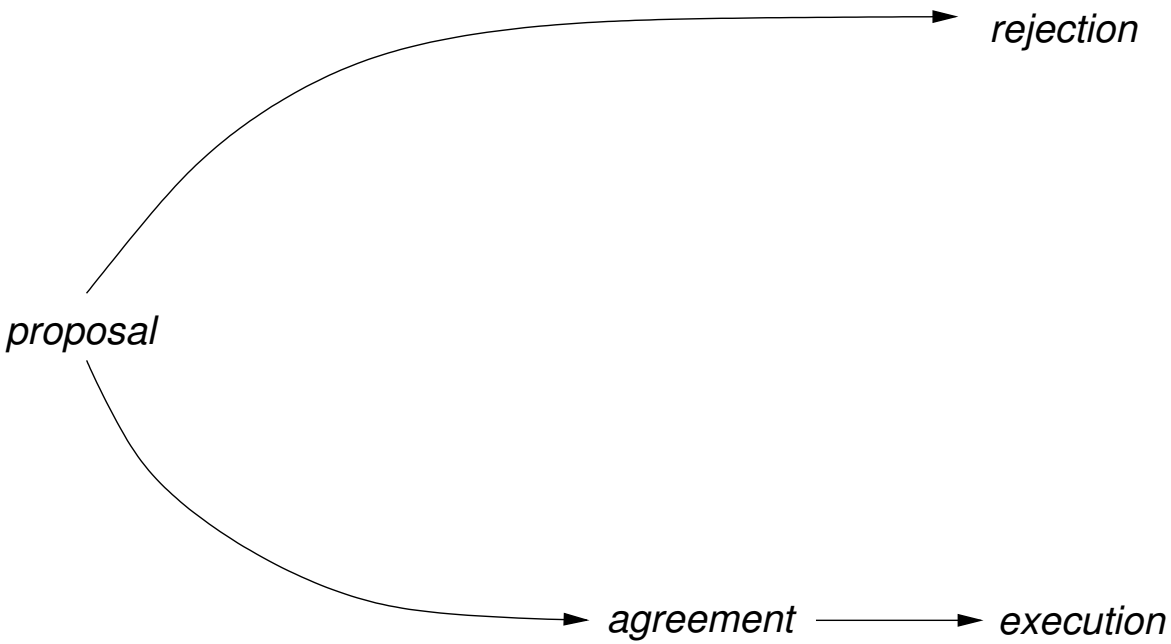
ABN agent design



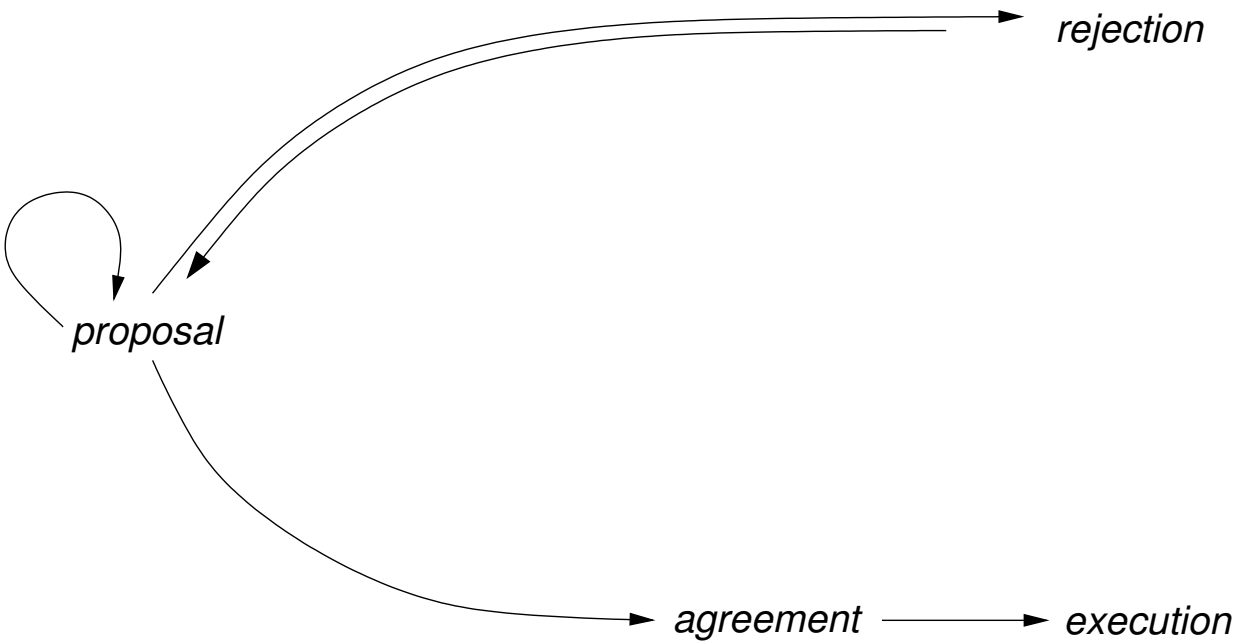
Interest-based negotiation (IBN)

- Special form of ABN (Rahwan, Sonenberg and Dignum 2003)
- Main idea: acquiring and use information about other's goals beliefs and goals
- Process characterised by iterations of
  - *challenge*: a request for reasons behind other's proposal/refusal
  - *justification*: providing the rationale for previous standpoint
  - *attack*: refutation of other's beliefs/presentation of alternatives
- Operational model (our contribution):
  - If attack successful, the other agent will make a concession regarding previous rejection
  - If set of "open rejected issues" is empty, acceptance is likely $\Rightarrow$ set of agreed terms is new proposal

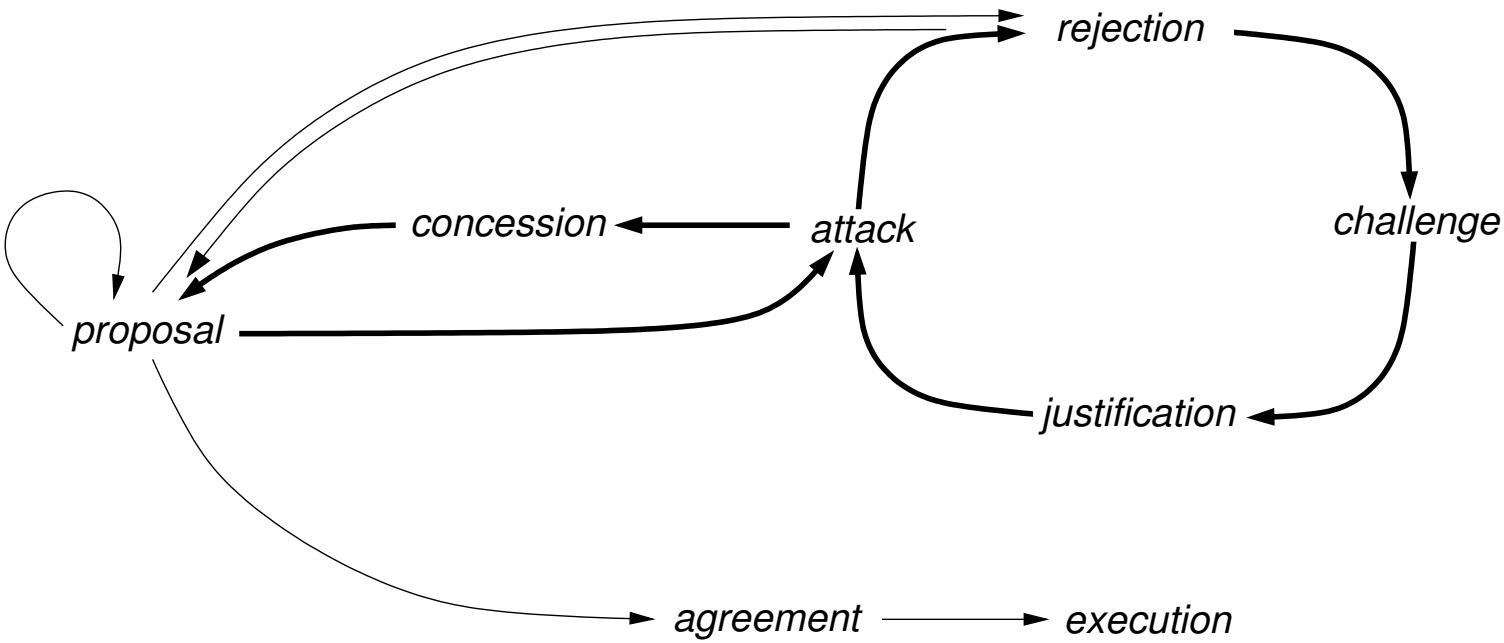
Proposal-based negotiation process



Repeated proposal-based negotiation process



Ineterest-based negotiation process



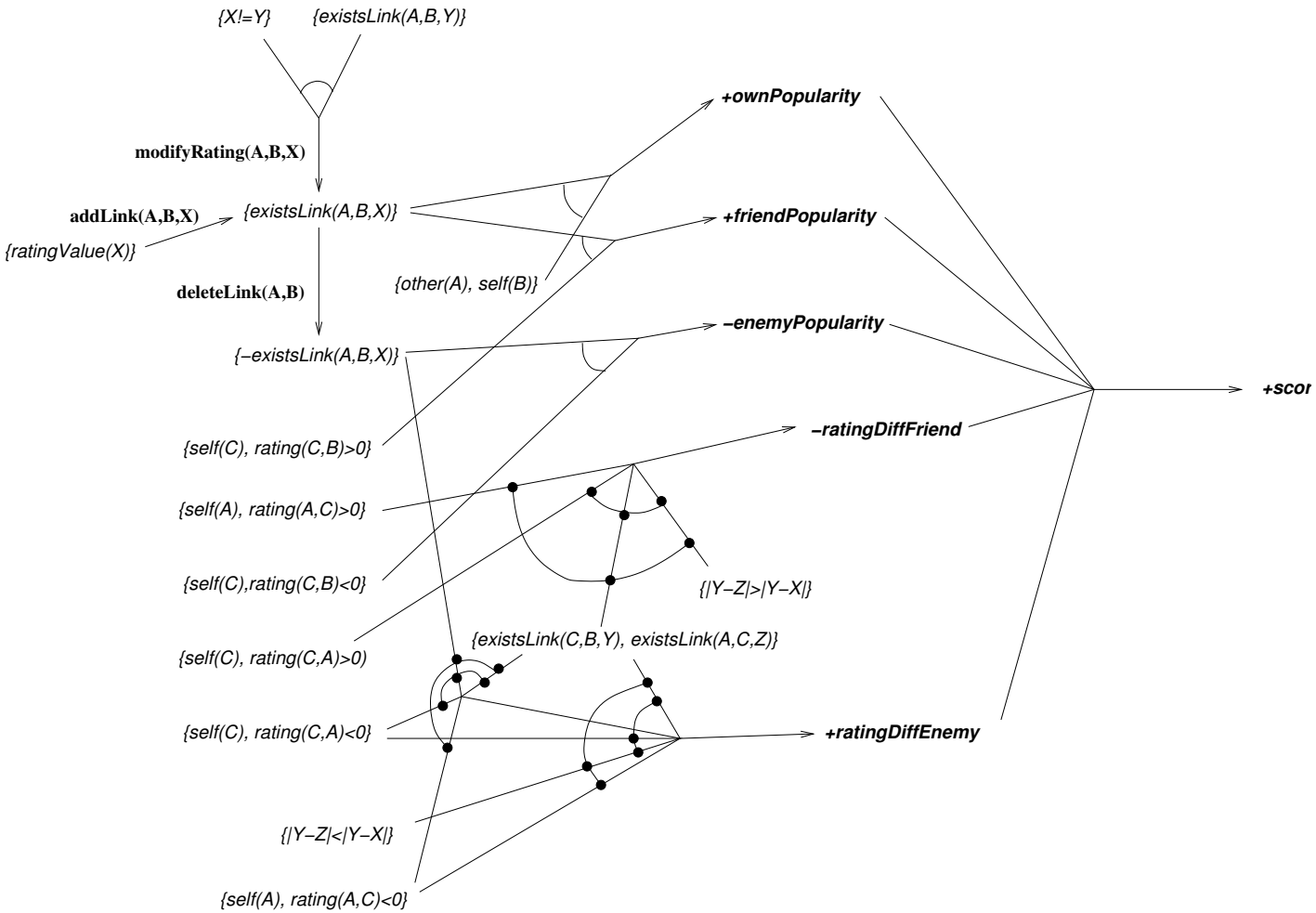
IBN frames in m^{2}inffra

- Objective: utilise IBN theory in m^{2}inffra
- Case study in development of InFFrA architectures
- Requirements:
  - Develop a meta-model of the entire IBN process
  - Add interest-based reasoning to sub-social inference processes
  - Capture negotiation moves in the form of frames
  - Ensure they are linked through conditions
  - Develop online frame construction mechanism
  - Adapt Q-update rule to suit negotiation moves

Adapting reasoning mechanisms

- Formal apparatus to talk about goals and ways of achieving them
- Based on relation $achieves(V, V')$ where V, V' sets of logical facts and actions
- Can be used to derive: $achieved(V)$, $achievable(V)$, $threat(\varphi, V)$, $instr(v, v')$ (if $achieves(V, V'), v \in V, v' \in V'$)
- Basic idea: a proposal is accepted if it is *instrumental* for a goal, rejected if it is a *threat* to a goal
- Assumption: only goals that are *achievable* and have not yet been *achieved* can be pursued
- NOTE: these are communicative conventions, need not reflect agents' internal beliefs or desires

Goal graphs


{X!=Y}
{existsLink(A,B,Y)}
modifyRating(A,B,X)
addLink(A,B,X)
{existsLink(A,B,X)}
{ratingValue(X)}
deleteLink(A,B)
{other(A), self(B)}
{−existsLink(A,B,X)}
+ownPopularity
+friendPopularity
−enemyPopularity
−ratingDiffFriend
+ratingDiffEnemy
+scor
{self(C), rating(C,B)>0}
{self(A), rating(A,C)>0}
{self(C),rating(C,B)<0}
{|Y−Z|>|Y−X|}
{existsLink(C,B,Y), existsLink(A,C,Z)}
{self(C), rating(C,A)>0}
{self(C), rating(C,A)<0}
{|Y−Z|<|Y−X|}
{self(A), rating(A,C)<0}

Goal graphs and challenges

- Assumptions:
  - all agents have the same goal graph structure (but concrete actions and facts depend on knowledge base!)
  - internal ratings are identical to displayed ratings ("suspension of disbelief")
  - if no justification can be given for rejection, the agent must accept a proposal
- During negotiation agents seek to identify each other's goals and beliefs
- Two types of challenges can be used: asking for the *purpose* of a proposal (or a rejection), and asking for the *justification* for pursuing a goal
- These correspond to tracing $instr$- and $threat$-edges *forwards* and *backwards* in the goal graph

Goal graphs and attacks

- Let ϕ is the issue talked about (a fact or a plan/action)
- An attack to a *purpose* g claimed for ϕ can be any of the following assertions from the counter-party:
  - $achieved(g)$
  - $threat(\phi, g)$
  - $\neg achievable(g)$
  - $\neg achievable(\phi)$
  - $threat(\phi, g'), achievable(g')$
  - $instr(\phi, g'), achievable(g)$
- An attack to a *justification* ϕ claimed for g can be any of the following:
  - $\neg achieved(\phi)$
  - $threat(\phi, g)$

Online frame construction

- Idea: equip agents only with $\langle \texttt{propose}(A, B, X) \rightarrow \texttt{accept}(B, A, X)$ as a "real" frame and with additional negotiation frames that consist of
  - challenge, attack, concession
  - challenge, attack, counter-attack, concession
- Each of this moves also comes with a *reject* prefix which causes the content to be negated before being challenged (e.g. $\texttt{propose}(a_1, a_2, addLink(a_2, a_1)) \rightarrow \texttt{reject}(a_2, a_1, addLink(a_2, a_1)) \rightarrow \texttt{request} - \texttt{purpose}(a_1, a_2, \neg addLink(a_2, a_1)))$
- "Admissible" proposals must contain achievable and not yet achieved goals (or the respective plans)

Online frame construction (II)

- Rejection or unsolicited challenge causes a framing problem
- Concession effects deletion from "open issues" list
- Line of reasoning: if "open issues" list is empty, proposal will be accepted
- Attack/justification generation according to knowledge of other's goal graph (model only used within a single conversation)
  - select least defeasible arguments (goal graph search)
  - remain truthful (i.e. arguments do only contain facts that can be derived from one's own knowledge base)
  - step between attack and concession/counter-attack (only performed once) mediated by belief revision (perception)
- Useful frame can be constructed by concatenating moves until `accept`/`reject` $\Rightarrow$ desirability criterion need not be changed

Example

- $\texttt{propose}(a, b, modifyRating(b, c, 3)) \rightarrow \texttt{reject}(b, a, modifyRating(b, c, 3))$
- a knows $existsLink(b, c, 1)$, infers $instr(modifyRating(b, c, 3), +friendPopularity)$, attacks with $\texttt{request-purpose}(\neg modifyRating(b, c, 3))$
- b justifies with $\texttt{provide-purpose}(instr(\neg modifyRating(b, c, 3), -ratingDiffFriend))$
- a verifies that $existsLink(a, c, 1)$ and $existsLink(b, c, 1)$ through observation actions
- a says $\texttt{concede}(a, b, \neg modifyRating(b, a, 3))$
- b says $\texttt{propose}(b, a, \{modifyRating(b, c, 3), modifyRating(a, c, 3)\})$
- a cannot find a suitable reason to reject and sends accept

Adaptations to Q-learning mechanism

- Instead of learning framing utility, now learn use of negotiation moves
- Re-framing procedure spawned everytime a new issue is discussed (through rejection or an unsolicited challenge)
- Update rule for Q-learning has to be modified, since entire frames will only be generated temporarily
- Open question: *What should the state abstraction during negotiations be?*

Conclusions

- Discussed simple proposal-based and complex interest-based negotiation frames
- Reassuring results regarding learning algorithms with proposal-based frames
- Advancing into more complex forms of negotiation to explore wider range of communication strategies
- InFFrA approach combines design of protocols, information stores, and agent strategies
- Next step: implementation of IBN frames and experimental validation