Argumentation-Based Negotiation

AN APPLICATION TO COOPERATIVE DISTRIBUTED PROBLEM SOLVING IN OPERATIONAL CONTROL CENTRES

SMA/PRODEI (10-11-2011)
António Castro
• Motivation and Background:
  – Negotiation
  – Multi-agent Systems
• Operational Control Centres
• GQ-Negotiation Protocol
• Example of an ABN in AOCC
• A PhD Dissertation Proposal
Motivation and Background: Negotiation
Negotiation is **essential** in settings where autonomous agents have conflicting interests and a desire to cooperate

Rahwan et al, 2004
A powerful paradigm to be used not only to reach agreements regarding more commons scenarios like buying and selling of goods but also as a problem resolution technique.
• Goal is to determine the optimal strategy by analysing the interaction as a game between identical participants and seeking its equilibrium

• Assumes participants behave according assumptions of rational-choice theory:
  – Agents have unbounded computational resources
  – Space of outcomes is completely known

In most realistic environments we have bounded-rationality, i.e., limited processing and communication capabilities as well as resource or time constraints.
Heuristic-based Approaches

• Various heuristic decision functions are used for evaluating and generating offers or proposals
• Relaxed assumptions about agent’s rationality and resources
• Fits better (most of) the realistic environments
• Agent’s utilities or preferences (usually) are assumed to be completely characterized apriori and fixed (like in previous approach).

1. Usually leads to sub-optimal outcomes
2. Difficult to predict how the system and constituent agents will behave:
   – The models need extensive evaluation through simulations and empirical analysis
Argumentation-based Approaches

- Agents exchange additional information *arguing* about their beliefs during negotiation process.
- In addition to accepting or rejecting a proposal:
  - an agent can offer a critique, a justification,....
  - Make a threat or promise a reward
  - Change the negotiation object (new attributes or dimensions)
- Agent’s utilities and preferences might change during negotiation.
- A more human-like negotiation approach.

These models are typically more complex than the game-theoretic and heuristic ones.
Motivation and Background: 
Agents, Multi-Agent Systems and Environments
• A powerful paradigm to represent an organization and their individuals.

• In LIACC/NIADR we use MAS and Negotiation in different domains, like:
  – Partner selection in B2B E-commerce (Q-Negotiation).
  – Problem resolution in an AOCC (GQ-Negotiation)
• **Competitive Environment:**
  – Agents are selfish and compete with each other (e-commerce)

• **Cooperative Environment:**
  – Agents do not have full knowledge/expertize to reach their goals, so, they need the cooperation of others.

• **Distributed Environment:**
  – Physical
  – Functional (different expertise)
  – Spatial (local views)
Operational Control Centres
Flight 103 enters the Porto airspace and declares that needs to land immediately due to lack of fuel. It has fuel for only 10 minutes.

At the same time there are 6 other aircrafts approaching the airport, each one with a specific level of fuel.

What is the best solution to solve this unexpected event?
Flight 103 with a schedule ETA in Lisbon at 11:00 did not departure yet from Rio due to an aircraft malfunction. The new ETD is 20:00 and the new ETA is 12:30.

It has 230 passengers on board with the following connections:

- 20 to flight 231 – ETD 12:15
- 34 to flight 350 – ETD 12:00
- 60 to flight 412 – ETD 12:45

What is the best solution to solve this unexpected event?
Aircraft Malfunction => Flight Departure Delay
- Swap the aircraft
- Delay flight for the necessary time
- Cancel flight and redirect passengers other flights
- Rent an aircraft and crew from another company

Enroute Air Traffic Delay => Flight Arrival Delay
- Use reserve crew to replace delayed one at dep.
- Swap crew at departure.
- Delay connection flights (if possible)
- Redirect passengers with connections to others flights
Generic Q-Negotiation Protocol
• Multi-Attribute:
  – Each with a set of preferred values and domains

• Qualitative Feedback:
  – Organizer agent classifies the values of each attribute and gives feedback

• Several Rounds

• Inter-agents negotiation:
  – Respondent agents negotiate in each round to be able to complete their knowledge and present a proposal

• Learning:
  – Agents adapt their strategy during proposal formulation

• Multiple agent types and roles:
  – Organizer, Respondent. Initiator, Participants.

• Suitable for competitive and cooperative environments
Event_time: 18-09-2009 12:39
Event_type: AC
Resource_Affected: CS-TTG
Resource_Type: A319
ETR: 110
Flt_date: 18-09-2009
Flt_Nbr: 686
STD: 13:20
STA: 15:50
ETA: 16:10
From: LIS
To: LUX
Dep_Delay: 20
Bus_Pax: 1
Econ_Pax: 128
Schd_Trip_Time: 02:30
Est_Trip_Time: 02:50
Schd_AC_Cost: 1084
Schd_Crew_Cost: 1745
Schd_Pax_Cost: 0

GQ-Negotiation

ACTION, RESOURCE, RES_TYPE, DELAY, COST
NEAREST, 24164.6, NB, 10, 1900

ACTION, DELAY TT, COST
KEEP, 20, 2000

ACTION, RESOURCE, RES_TYPE, DELAY, COST
DELAY, CS-TTG, A319, 20, 1300

\[ E_{T_{cc}} = \alpha \left( \frac{dc}{C_{cc, pref}} \right) + (1-\alpha) \left( \frac{cc}{C_{cc, pref}} \right) \]

\[ E_{T_{round}} = \frac{\alpha \left( \frac{da}{D_{a, max}} \right) + \beta \left( \frac{dc}{D_{c, max}} \right) + \gamma \left( \frac{dt}{D_{t, max}} \right) + \delta \left( \frac{ca}{C_{a, max}} + \frac{cc}{C_{c, max}} + \frac{pc}{P_{c, max}} \right)}{\alpha + \beta + \gamma + \delta} \]
ABN – An Example in AOCC
Negotiation

Argument Interpretation

Argument Generation

Argument Selection
• Different types of arguments:
  – An appeal to prevailing practice
  – A counter example
  – An appeal to past promise
  – An appeal to self-interest
  – A promise of future reward
  – A threat
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1) PROPOSE: KEEP, 20,000, (APPEAL_SELF: VIP PAX)
2) INFORM: (APPEAL_CURRENT: MIN COSTS)
3) INFORM: (THREAT: VIP WILL NEVER FLY IN THIS COMPANY)
4) INFORM: (ARG_ACCEPTED)
A PhD Dissertation Proposal
Cooperative Distributed Problem Solving in Operational Control Centres

An Argumentation-Based Negotiation Approach

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Co-supervisor
António Castro (LIACC/TAP Portugal)
The definition of a methodology and negotiation protocol that includes the ABN components as a way of solving problems in operational control centres
- Argument **Interpretation**
  - Dealing with arguments from multiple sources

- Argument **Generation** (how?)
  - Dealing with multiple issues
  - Learning with the past (e.g., CBR)
  - Using context information
  - Using profile information

- Argument **Selection** (how?)
  - Based on agent utility
  - Based on argument strength
  - Based on the counterparts’ reply
The research necessary for this PhD proposal has the cooperation of TAP Portugal


• Thank you very much!
• Questions?

Links e E-mails

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