GENIUS - Negotiation Environment for Heterogeneous Agents

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ABSTRACT

In this demo, we present GENIUS, a tool that facilitates research in the area of bilateral multi-issue negotiation. It implements an open architecture allowing easy development and integration of existing negotiating agents. GENIUS can be used to simulate individual negotiation sessions as well as tournaments between negotiating agents in various negotiation scenarios. It allows the specification of negotiation domains and preference profiles by means of a graphical user interface. A number of negotiating agent implementations as well as negotiation scenarios have been collected in GENIUS. GENIUS can be used in experiments with human negotiators that negotiate against automated agents or other humans. An analytical toolbox integrated in GENIUS calculates optimal solutions, such as the Pareto efficient frontier, Nash product and others. This toolbox may be used to visualize a negotiation process and creates an extensive log.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence – *intelligent agents, multi-agent systems.*

General Terms

Algorithms, Measurement, Performance, Design, Economics, Experimentation, Human Factors, Theory.

Keywords

Automated Multi-Issue Negotiation, Negotiation Strategy, Testbed, Negotiation.

1. INTRODUCTION

This demo presents software for bilateral multi-issue closed negotiations, called GENIUS (**G**eneric **E**nvironment for **N**egotiation with **I**ntelligent multi-purpose **U**sage **S**imulation). The software implements an open architecture for heterogeneous agents, as proposed in [1]. The negotiation environment, user manuals, a number of implemented negotiation agents and negotiation scenarios including domains and preference profiles can be downloaded from http://mmi.tudelft.nl/negotiation.

GENIUS is designed as a research tool to facilitate the design of negotiation strategies and algorithms. The open architecture [1] of the environment allows organizing tournaments between heterogeneous automated agents in various negotiation setups. The environment provides a graphical user interface (GUI) for a human negotiator and, therefore, it can also be used as a training tool for humans. In addition, the environment can be used to teach the design of negotiation strategies.

The core functionality of the system includes:

- specification of negotiation domains and preference profiles;
- simulation of bilateral negotiation between agents;
- analysis of the negotiation outcomes [3] and negotiation dynamics.

GENIUS unifies the representation of negotiation results and, therefore, simplifies comparison between them, which is often hard to do in ad hoc implementations. An analytical toolbox integrated in GENIUS allows the comparison of negotiation results with several standard optimal solutions. By means of running tournaments between negotiating agents a winner can be determined given a negotiation scenario. In addition, GENIUS allows the comparison of results of human and automated negotiators. Interaction protocols are implemented in the negotiation environment as a separate component to allow the use of a variety of protocols. The current version of the negotiation environment supports the alternating offer protocol [2].

The software has been developed using widely-accepted standards such as *design patterns* to integrate various components of the architecture. The software supports the development of new negotiating agents as well as integration of existing agent implementations through a simple API (e.g., in [1] we demonstrated how an existing agent can be integrated into the system using the *Adaptor* design pattern). This approach minimizes programming effort required to (re-)integrate and maintain code of a negotiation agent. The *XML* file format is used system-wide to specify the negotiation domain, preference profiles, and export results of simulations for detailed analysis. The use of XML simplifies the task of maintaining the persistent information in the system, allows extending the original information structures of the system with new concepts with no impact on the existing code, and integration with other systems.

The software environment consists of two main modules:

- Scenario Editor, a GUI-based editor that allows to create, store, and modify a negotiation domain and preferences of the negotiating parties;
- Simulator, a tool used to simulate and analyze negotiation between the software agents and allows humans to negotiate with others or with software agents.

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In addition, the system is supplied with a number of examples of negotiation domains and preference profiles in a repository.

The software is implemented in Java 5.0 and can be run on any platform that supports Java. The current version of the system is used as a stand-alone application that runs on a single computer. Currently we are developing a Web-based platform for GENIUS to enable distributed human-human and human-software negotiations and to allow researchers to participate in negotiation tournaments of software agents through a widely accessible Web-interface.

2. NEGOTIATION SCENARIO

The Scenario Editor of GENIUS is used to create and modify negotiation domains and preference profiles. A negotiation domain is a specification of the objectives and issues to be resolved by means of negotiation. An objective may branche into sub-objectives and issues providing a tree-like structure to the domain. The leafs of such a tree representing the domain of negotiation must be the issues that need to be agreed upon. Various types of issues are allowed, including discrete enumerated value sets, integer-valued sets, real-valued sets, as well as a special type of issue used to represent a price associated with the negotiation object. For every issue the user can associate a range of values with a short description and a cost.

A preference profile specifies personal preferences regarding possible outcomes of a negotiation. The current version supports linear additive utility functions [3]. The profile is used to convert any offer in that domain to a value indicating how the user would rate that offer, the so called utility value. A profile is also called a utility space.

A weight, which is assigned to every issue, indicates the importance of that issue. A human user can move sliders to change the weights or enter their values by hand, which are automatically normalized by the editor. In the issue editor the user can give every value an evaluation. The evaluation values are positive integers starting with 1. The evaluation values are normalized for each issue to ensure they are in the range [0;1].

3. NEGOTIAION SIMULATOR

A simulator is used to run negotiation sessions as well as tournaments. To setup a negotiation session the following parameters have to be determined by the user: negotiating agents, negotiation domain, preference profiles for each party, and, if appropriate, a deadline. The user can use agents, negotiation domains, and preference profiles from the GENIUS repository.

A tournament is a typical experimental setup for negotiating agents that allows to analyse the behaviour and effectiveness of an agent compared to that of others. GENIUS allows selecting multiple negotiation domains and preferences profiles for a tournament. The negotiating agents used in a tournament can be parameterized to study the sensitivity of a strategy to a selected parameter. Every session can be repeated a number of times to build a representative sample of negotiation results for a statistical analysis in case of non-deterministic negotiation strategies.

The progress of a negotiation session as well as of a tournament can be observed in real-time in the analytical toolbox of GENIUS. The toolbox visualizes the negotiation space by plotting the coordinates of the utility values of the negotiating parties. The negotiation progress is visualized by means of connecting offers made by the parties as two lines, the so called the "negotiation dance" [3]. The analytical toolbox (see Figure 1) presents optimal

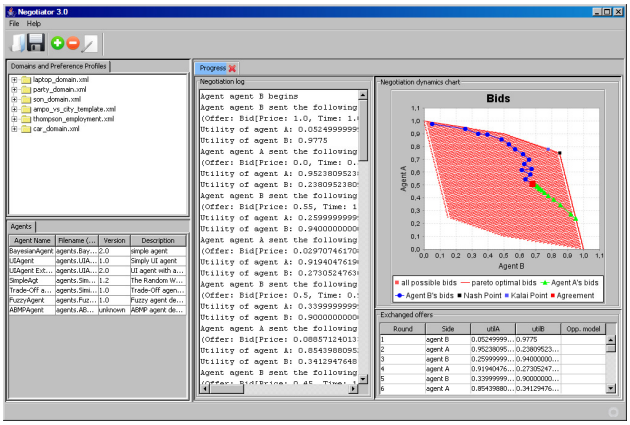

Figure 1 - GENIUS user interface (analytical toolbox)

solutions [3], such as the Pareto efficient frontier, Nash product and Kalai-Smorodinsky solution for benchmarking of the negotiation outcome.

The results of the analysis can help researchers to improve their agents. The output of the analytical toolbox is presented by means of visualization. GENIUS saves the details of the negotiation session in an XML file. The transcript contains the following:

- details of the negotiation session setup, names of the agents, negotiation domain and preference profiles, which agent started the negotiation;
- negotiation outcome and utilities of the agents;
- all offers exchanged in the negotiation and their utilities with respect to the preferences of the agents.

The XML transcript of the negotiations can be imported into software, such as: MS Excel or Mathematica for further analysis.

4. USER INTERFACE FOR HUMAN NEGOTIATOR

GENIUS has two GUIs for human negotiators. The first GUI presents only the last offer of the opponent and asks the user to select the next action: accept opponent's offer, stop negotiation without agreement or send a counter-offer. The counter-offer is filled in through drop-down boxes showing alternatives per issue. The GUI automatically calculates utilities and costs of the offers for the opponent's and user's own offers according to the user's preference profile.

The second GUI for a human negotiation extends the first one using a table showing the history of offers exchanged during the session and their utilities. In addition, using time lines the user can see a plot of the utilities of the offers received from the opponent and a plot of the utilities of the offers made by the user. The GUIs for the human negotiators are not part of the systems core and, therefore, can be easily modified, extended and combined in a simulation.

5. REFERENCES

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