TAGA: Agent meets Semantic Web

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Travel Agent Game in Agentcities (TAGA) is designed and implemented to demonstrate agent and semantic web technology working together. It is developed on the foundation of FIPA technology and the Agentcities infrastructure, which provides the stable communication environment where messages expressed in semantic web languages can be exchanged. The agents and services use FIPA-supported languages, protocols and service interfaces to create the travel market framework. This market is the combination of auctions and varying markets including service registries, service brokerage, wholesalers, peer-to-peer transactions and bilateral negotiation. TAGA provides a test-bed for experimenting with agents, semantic web and web services as well as a rich and interesting scenario to test and challenge agent technology.

1 Introduction

Semantic Web defines and links web data in both human readable and machine understandable form. "Human readable" refers to the traditional text/image web documents intended for machine display and human consumption. "Machine understandable" means that data has been explicitly prepared for reasoning and reuseing across various agents. In this definition, intelligent agents, the consumers of the semantic web content, play very important roles in the semantic web.

However, today's agent is not designed for the web environment. While the agent uses common knowledge base, the billons web pages on the World-Wide-Web are unlikely to be saved in a single knowledge base. The multiple agents share ontologies with each other. The web sites owned by different peoples and organizations are unlikely to agree on same ontology. Thus without prior knowledge of the content or the ontologies used in the web pages, the agents may not know what the web page is talking about, or even worse, they have variant understanding about the same web page. Agents run at the same home platform or federated platforms, which are considered to be safe and trustable. Web is neither safe place (hacker, DOS attack, etc.) nor trustable (fake identity, snoop, Non-paying-buyer, etc.), hence requiring the ability to decide who can trust and evaluates the credibility of the information sources.

Travel Agent Game in Agentcities (TAGA) demonstrates that agent and semantic web can fit together. The TAGA framework uses a distributed peer-to-peer approach based on standard agent languages, protocols and infrastructure components (FIPA, Agentcities [2]). It exploits the emerging standards for representing ontologies, knowledge and services (RDF, OWL, OWL-S) and web infrastructure (e.g., Sun's Java Web Start). To demonstrate the heterogeneous agent interoperability, several FIPA platform implementations are currently used within TAGA, including Jade and AAP.

2. TAGA Game and Agents

Inspired by TAC [3], TAGA was designed as a general framework for running agent-based market simulations and games. The first use of TAGA was to build a travel competition along the lines that used in the classic TAC. In this competition, customers travel from City A to City B and spend several days before flying back. A travel package includes a round-trip flight ticket, corresponding hotel accommodations and tickets to entertainment events. A travel agent (an entrant to the game) competes with other travel agents in making contracts with customers and purchasing the limited travel services from the travel service agents. The customer agent selects the travel agent with the best travel itinerary. The objective of the travel agent is to acquire more customers, fulfill their travel packages, and maximize the profit.

As shown in Figure 1, the collaboration and competition among six types of agents, who play different roles, simulate the real world travel market:

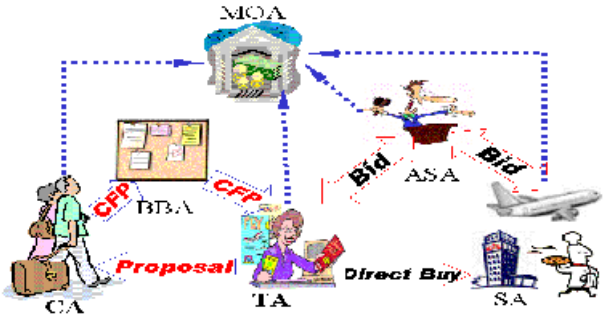

Figure 1: TAGA Architecture

The *Auction Service Agent* (ASA) operates all of the auctions markets in TAGA. The auction types currently include English and Dutch auctions as well as other dynamic markets similar to Priceline and Hotwire.

A *Service* Agent (SA) offers travel related service units such as airline tickets, lodging and entertainment tickets. Each class of travel related service has multiple providers with different service quality level and with limited service units;

A *Travel Agent* (TA) is a business that helps customers acquire travel service units and organizes travel plan. The units can be bought either directly from the service agents, or through an auction server.

A *Bulletin Board Agent* (BBA) provides a mechanism through which helps customer agents can find and engage one or more travel agents.

A *Customer Agent* (CA) represents an individual customer who has particular travel constraints and preferences. Its goal is

to engage one or more TAs, negotiate with them over travel packages, and select one to try to purchase.

The *Market Oversight Agent* (MOA) monitors the simulation and updates the financial model after each reported transaction and finally announces the winning TA when the game is over.

The basic cycle of the TAGA game has the following stages:

- To start the game, the MOA creates tables and inserts data into the database, thus creating the game. The TAs register at the BBA, therefore subscribing to new customer informing services. The SAs register at the ASAs as auction seller;
- A customer-generating agent creates a new customer with particular travel constraints and preferences chosen from a certain distribution and sends to the BBA in the form of a Call-For-Proposal) message;
- The BBA forwards the CA's CFP message to each of the TAs that has registered with it. Each TA independently considers the CA's CFP and decides whether and how to respond;
- Once deciding to propose a travel package, the TA contacts the necessary ASAs and SAs and assembles a travel itinerary. Note that the TA is free to implement a complex strategy using both aggregate markets (ASAs) as well as direct negotiation with SAs. The proposal to the CA includes the travel itinerary, a set of travel service units, the total price and the penalty to be suffered by the TA if failing to complete the transaction;
- The CA negotiates with the TAs, ultimately selecting one from which to purchase an itinerary based on its constraints, preferences and purchasing strategy;
- Once having a commitment from the CA, the TA attempts to purchase the service units in the itinerary from the ASAs and SAs. There are two possible outcomes: the TA acquires the units and completes the transaction, resulting in a satisfied CA and a profit or loss for the TA, or the TA is unable or unwilling to purchase all of the units, resulting in an aborted transaction and the invocation of the penalty (which can involve both a monetary and a reputation component);
- All transactions are reported to the MOA, who is responsible for verify them based on report from multiple parties. The MOA also controls the finance records and transfers money from buyer to seller;
- The game runs continuously. The transactions and finance records are published at TAGA web site in real time. The TA who has most money is the current winner of the game.

The travel agent implemented in JADE can be downloaded from TAGA web site and run to instantiate a new TA agent. The GUI interface allows the user to set operating parameters. By modifying or extending the java code, the TA can support complex trading and auction strategies. A set of web based monitoring services allows one to see the status of a game, examine messages being sent or lookup the reputation of agents.

3. Discussion

TAGA framework uses a distributed peer-to-peer approach based on standard agent languages, protocols and infrastructure components (FIPA, Agentcities), emerging standards for representing ontologies, knowledge and services (OWL, OWL-S) and web infrastructure (e.g., Sun's Java Web Start). The OWL language is used as agent language for message passing and interaction. F-OWL, an OWL inference engine, is used to extract hidden knowledge via resolution.

We see two contributions in our work. First, TAGA provides a rich environment to explore aspects of multi-agent systems and semantic web technologies. We are using TAGA as a test-bed for research on the use of the semantic web languages (e.g., RDF and OWL) as content languages and as service description languages (OWL-S). Future work is planned in adding more sophisticated negotiation and ontology mapping to our TAGA environment. Second, TAGA provides a rich framework for exploring agent-based approaches to ecommerce like applications. Our current framework allows users to create their own agents (perhaps based on our initial prototype) to represent a TA, SA and to include it in a running game where the agents make decisions about price and purchase strategies based on complex strategies and market conditions and compete with other system provided and user defined agents. We hope that this might be a useful teaching and learning tool.

4. Conclusion and future work

TAGA presents a vision of agents working in the semantic web environment. Research involves the fields of web services, the semantic web languages, and agent systems.

For the TAGA system, there is much to be improved. We are working to increase the integration of TAGA and emerging Agentcities components and infrastructure and will include agents running on handheld devices using LEAP [1]. We are also working to enhance the ontology sharing and mapping. Co-ordination between the distributed services, i.e. making complex distributed decisions and planning in the agents, is not covered yet and should be considered in the future.

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