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WSEAS Transactions on COMPUTERS, Issue 3, Vol.2, 2003

WSEAS TRANSACTIONS on COMPUTERS

Issue 3, Volume 2, July 2003
ISSN 1109-2750 http://www.wseas.org

segment and a maximum individual error of 10. The choice was done based on acquiring an acceptable compression ratio (2.2531), while keeping the quality of the reconstructed compressed image acceptable for use. Method 1 gave better results in the terms of calculated statistics; better DPP, NCC, EMS, SNR and maximum error.

One major advantage of Method 1 over JPEG is the ability to control the maximum individual error. This is clearly evident from Table 1 as the maximum individual error of Method 1 was 10 (specified maximum individual error), while that of JPEG was 34 (using quality of 75). To reduce the error in JPEG to 10 quality 93 was used and then compression ratio of only 2.5 was obtained.

An application where the errors of the reconstructed compressed image needed to be directly controlled and the quality of textured areas preserved is an ideal one for using this method. In medical imaging, for example, an error reaching a value of 34 may result in misinterpretation of the medical diagnosis obtained from the image.

Another advantage is that this method preserves the quality of the most difficult parts of the image that cannot be compressed, as they are stored without any change (only some pre-processing and post-processing operations to store the original values in a byte format).

It was observed that compression ratios obtained from the three options on the same input image were not the same (for fixed optional inputs); one of the three compression ratios is better than the remaining two with little difference in the other statistics. As a different image was tested, it was found that the best compression was not generated by the same option that generated the previous best compression. The possibility of one method producing a better compression than the remaining two is related directly to the structure or shape of the input image. For example, for the Lena image the column option gave slightly better results than the others because of vertical uniform areas. This can be considered as an advantage for Method 1.

Also, The compression ratio obtained from Method 1 can be made better by packing the degrees of each two consecutive segments into one byte instead of one byte each. Also, Huffman coding or other lossless compression techniques could be used on the compressed file for further compression.

Method 1 is the basic building block for more advanced methods. Method 1 operates in a blind fashion as it will always deal with the compression of the segments made up by a fixed number of pixels. This way of compression has its disadvantage as either the segment will be compressed or the original pixels are stored (non-compressible segment). This Method is not flexible as in most cases, crossing a sharp edge, for example, results in the original pixels being stored.

Note that Method 1 is not as fast as JPEG, but could be improved by using parallel processing. This is possible as the method lends itself readily to parallel processing since it is row or column-based. However, time to reconstruct the image is very fast.

Finally, with the consideration of Method1 simple and fixed approach, on average it gave acceptable compression ratios greater than 2. The other suggested methods of Chebyshev image compression (Methods 2 and 3) are expected to achieve better results. Future publications will report results of these two new methods.

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MACS: Multi-agent charter system

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Abstract: - Multi-agent systems (MAS) could be (and already are) applied in different areas. In LARIS - Laboratory for robotics and intelligent systems, FESB, University of Split, a number or experiments investigating multi-agent system capabilities are currently in progress. A yacht charter system can be realized as e-commerce system connecting charter providers and costumers. Present-day market provides standard solutions in a form of a database with different querying tools (http://www.croatia-yachtcharter.com, http://www.croatia-yachtcharter.com, http://www.vip-yachting.com, http://www.kingcharters.com). Multi-agent system lends possibility for a charter system improvement and automation.

Key-Words: - Multi-agent system, charter system model, agent behaviour

1 Introduction

During the past years a growing number of scientists have started to do research in the field of agent systems [2], [4], [8]. Application domain of the agent systems is incredibly large. Agents can be used to retrieve information on the Internet, to filter user mail and so on. An agent releasing humans from certain activities is usually called a personal assistant. Assistant agents reduce work and time required for a human to perform a task [1]. Electronic commerce (e-commerce) is also a domain where assistant agents are proved to be very useful [2]. The tourist industry is an excellent example of the trend toward personalized services and a complex market mechanism [9]. These facts routed as toward development and design of the yacht charter rent system as multi-agent system presented in this paper. The considered system can be observed as a tourist e-commerce system where a charter provider companies lease yachts to the costumers. Process of a design included obtaining the system knowledge from an expert and defining ontology and behaviours of agents throwing up MACS. Selection of software packets used in the process of development was based on previous experiments [3].

Linguistic representation of charter system knowledge, elicited from an expert, is presented in chapter three. Realization of multi-agent charter system is described in-depth in chapter four where is also given an overview of software packets used in development of MACS. Main emphasis is given on agent behaviour and ontology modelling. Created seller agent acts as an assistant agent performing tasks instead of human and providing information to the user while buyer agent acts as an assistant agent performing tasks instead of charter business employers.

Agents are involved in intensive communication and interoperation, not just for purpose of performing tasks for a user, but also for their own existence.

Demonstrated agents behaviour is typical for multi-agent systems described in the next chapter. Conclusion derived from presented work is laid out in chapter five.

2 Multi-agent system

Multi-agent system (MAS) is not firmly defined, so terms and definitions may vary from author to author. We considered a multi-agent system to be any type of the system composed of multiple autonomous components, i.e. agents. Thus, multi-agent systems can be considered as ensembles of autonomous agents, acting and working independently from each other, each representing an independent locus of control of the whole system [4].

The characteristics of MAS are:

- each agent has incomplete information, or capabilities for solving the problem,
- there is no global system control,
- data is decentralized,
- computation is asynchronous.

Key concept in MAS is agent interoperation [8]. Agents need to share a common agent communication language (ACL) and a common ontology to facilitate interactions and cooperation.

Agent communication language is a language with precisely defined syntax, semantics and pragmatics that is the basis of the communication between agents.
Agents need to share common ontology, because ontology provides the system knowledge basic structure. That basic structure contains a set of concepts and terms for describing a certain domain.
Agents with common ACL and ontology can engage in different types of interoperation depending on an agent behaviour and interaction protocols. Whereas ACL, ontology, interaction protocols are likely to be standardized, agent behaviour and the use of interaction protocols can hardly have the same predestination. Primarily, because each system has it's own specific characteristics an agent needs to fulfil (does agent need to bargain, is there time constraint, etc.).

3 Charter system model

Charter agencies are involved in business of renting boats. Each boat has its price. The price depends on boat characteristics, additional services, boat equipment, term and duration of the lease. Boat can be rented only if it is available at the term that customer has requested it. The boat characteristics include boat type, length, capacity and so on.
Pricing also depends on the market. For example, if the demand is high, prices usually rise, but if the offer is higher than demand, prices usually fall. The goal of a customer is to lease a boat with satisfying characteristics at a lowest possible price. The customer usually wants to rent a boat immediately. If there is no adequate boat with satisfying price the customer usually offers slightly increased price. Charter provider goal is to rent a boat at a highest price to obtain the highest currently market possible profit. But the provider also wants to rent boats as soon as possible to assure capacity fullness. So if there is a demand for a boat, but the price is inadequate, provider sometimes wants to rent that boat at the reduced price.
This is relatively simplified model of a charter system.

4 Building system

For the realization of a multi-agent charter system JADE (Java Agent DEvelopment Framework) agent framework is chosen. JADE is chosen on basis of the following criteria:

- free software under the terms of the GNU Lesser General Public License
- compliance with the Foundation for Intelligent Physical Agents (FIPA) specifications
- possibility for distribution of the agent platform across several hosts

FIPA is a non-profit organization aimed at producing standards for the operation of heterogeneous software agents [5]. JADE satisfies all above stated requirements and provides additional benefits like the platform independence (since it is written in Java), multiple protocol support (Java RMI, HTTP, IIOP) and tools for debugging and deployment phase [6]. Agent management, agent communication language and communicative acts are rudiment of an agent framework. Agent management provides the reference model for the creation, registration, location, communication, migration and retirement of agents. Agent communication language standardization aims to provide a standard set of ACL message structure. Each communicative act has to have a formal basis in the ACL semantics. All of this is taken as it is defined and applied in JADE. The main task was to model ontology and to create agents that embrace the properties of the charter provider and costumer.

4.1 Ontology

Ontology was modelled according to the expert knowledge described in chapter three using PROTEGE-2000. PROTEGE-2000 is an integrated software tool used by the system developers and the domain experts to develop knowledge-based systems [7]. This tool is chosen because it provides the plug in for the JADE. PROTEGE-2000 has a graphical user interface for defining ontology through possible elements in the domain of discourse (terms, actions, concepts...) and exporting ontology to the Java objects.
The agent internal representation of information or a knowledge carried in the content part of ACL message can be realized as Java objects in the JADE. Those Java objects can be obtained using PROTEGE-2000 or written by hand. The charter system ontology is presented in Fig. 1.
The main concepts are the craft with subclass boat and the price list. A boat can be available, rented and favourable. Defined agents actions are to seek, to rent or to lease a boat. Ontology concepts, predicates and actions are generated according to the charter ontology model shortly described in chapter three. According to the model concept boat embraces a boat characteristics like boat type, length or boat capacity.

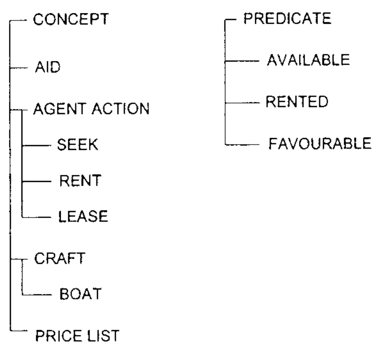

Fig. 1. Charter ontology

4.2 Jade Agents

Standard JADE agents [6] are the Agent Management System (AMS) agent and the Directory Facilitator (DF) agent. AMS supervises the entire platform controlling access and use of the platform. DF agent provides a yellow page service. The Message Transport System is the software component controlling all exchange of messages within the platform and between the existing platform and remote platforms. Beside the standard JADE agents two more agents were used. Agents we have developed are the seller agent, representing boat, and the buyer agent, representing costumer. As we stated one of the two main tasks was to model those two agents. To model an agent means mainly to model the agent behaviour in the interactions with other agents. Behaviour is a finite state machine that continually maps perceptual input to the action output [8].

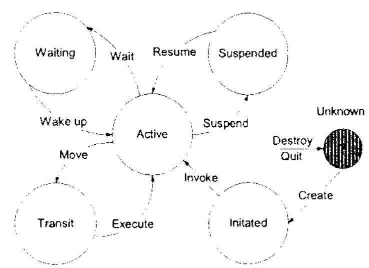

Fig. 2. Agent life-cycle

The agent entire life-cycle (period from the beginning of the agent execution till the end) can also be viewed as a finite state machine (Fig. 2.).
Besides the agent life-cycle (essential behaviour) agent can be supplemented with the task-oriented behaviour. The JADE agent is allowed to execute task-oriented behaviour only when it is in active state. JADE provides predefined classes that can be used to model the wanted behaviour. For our agents JADE classes for the simple behaviour were adequate. Those classes are OneShotBehaviour class used for atomic tasks (for example, the agent sends just one message) and CyclicBehaviour used for repeating, cyclic tasks (for example, the agent is continuously waiting for an incoming ACL messages from the other agents) [7].
The seller agent task is to rent (or sell) all available terms of a boat it represents. After launching the agent registers with DF agent as a seller agent. HandleRequestBehaviour, HandleTraziBehaviour and HandleInformBehaviour are behaviours that the agent embraces. All stated behaviours are cyclic since the agent needs to continuously sell all available boat renting terms. The agent assignment is finished when it has sold the terms. Behaviours are executed concurrently. An internal scheduler automatically manages behaviours placed in the queue in the round-robin non-pre-emptive way.

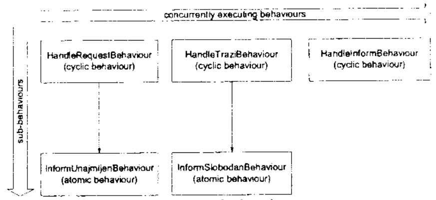

Fig. 3. Seller agent behaviour structure

The buyer agent assignment is to lease a desirable boat at the wanted term and price. After launching the agent registers with DF as a buyer agent. The buyer agent assignment could be produced with the similar behaviour structure like seller agent structure shown in figure 3.
The agent behaviours are described minutely in [10].

4.2.1 User Agent communication

MACS is created to provide the service for renting boats to the both costumer and charter provider. Communication between the human and multi-agent system is carried out via the graphical user interface (GUI) developed for the seller and for the buyer agent. Each boat has an agent representing that particular boat and each costumer has an agent representing him. Agent representing boat has to be initiated with the information bounded to that particular boat. In the upper part of the GUI charter provider sets the boat type, capacity, skipper and pricing. If the provider wants to enable the discount it sets a percentage of available discount or zero for none. In the lower part of the GUI charter provider can obtain the information from the agent like its current state, sold terms and the gained price. If the discount is enabled it provides the agent a possibility to engage in negotiation with agents acting on behalf of the customer.

4.2.2 Agent execution

The agent behaviour structure has already been described in chapter 4.2. Here will be discussed the agent execution from the programming point of view as software with execution steps (the software agent is still a peace of software exhibiting agent features). Figure 4. and the figure 5. depict the seller and the buyer agent activity diagram. After activation the seller agent is registered with the DF agent. After registration with the DF the seller agent waits for the buyer agents requests as it usually occurs in the real charter system. Received requests are checked for the term availability.

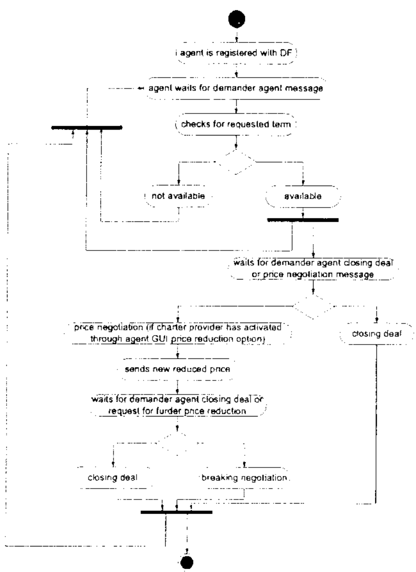

Fig. 4. Seller agent execution steps

Seller agent ends communication with the buyer agent if the requested term is not available (already sold). On the contrary, if the requested term is available seller agent notifies the buyer agent. Seller agent then waits for the buyer agent to close the deal. Buyer agent can also start negotiation with the seller agent on the price reduction (Fig. 4.).

The buyer agent first step after activation is also registration with the DF. After that, request is called upon the DF for the information on all currently active seller agents. Buyer agent then queries all seller agents for the desired term availability. Beside the term seller agent answer retains all the other boat significant information (boat type, capacity, skipper, pricing).

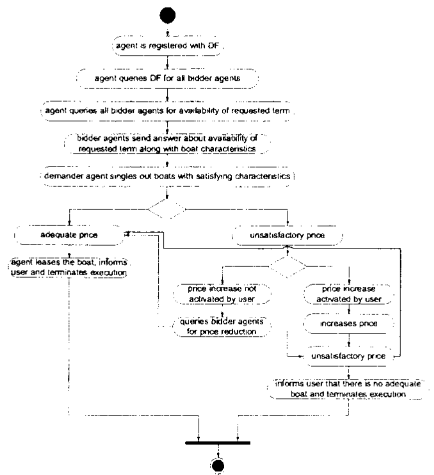

Fig. 5. Buyer agent execution steps

Buyer agent singles out only boats with the satisfying characteristics. If pricing is adequate the buyer agent leases the boat, informs the user and terminates execution since it has fulfilled the task. If seller agent price is higher than the price offered by the buyer agent there are two possible scenarios. Buyer agent can query the seller agent for the price reduction. Newly obtained price from the seller agent is considered. If it is not satisfying the buyer agent informs the user and terminates execution. If the price is adequate, the boat is leased, the user is informed and agent execution is terminated. If user has activated the buyer agent price increase option then buyer can increase offered price. Seller agent price is revalorised. The boat is leased if supplied and demanded price match. Otherwise communication with the seller agent is terminated. In both cases, the user is informed and agent execution is terminated (Fig. 5.).

5 Conclusion

Modelled experimental charter system was successfully realized like the multi-agent system. This implies that the other tourist e-commerce systems currently realized like databases with different querying tools can also use agents to replace or to improve services provided to the user (http://www.croatia.hr/accommodation).

During the system development it became visible that main work is defining ontology and modelling agent task-oriented behaviour since the agent management, communication and acting are very close to standardization and are incorporated in the agent framework. Although some behaviour protocols are in process of the standardization majority of the special purpose multi-agent systems will probably need experts for defining agent behaviour and the domain specific concepts and terms. The benefits obtained in the multi-agent systems (charter service provided to the user is raised to the higher level reducing the user work and time effort) make such effort worth a while. Future work is intended on improving the charter system model and providing agents more complex negotiation and altogether behaviour. It is also intended to realize another tourist e-commerce system (private accommodations renting) like multi-agent system.

Acknowledgments

This work is supported by the Ministry of Science and Technology of the Republic of Croatia under grant No. 0023008 "Intelligent Agents in Modelling and Control of Complex Systems".

Especially thanks to Ana Puović for her contribution to project realization.

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