ABSTRACT

According to the exponential growth of services available on large distributed networks, transport customers require relevant, interactive and instantaneous information during their travels. Thus, we designed and implemented a multi-agent information system using a special kind of software agents: the Mobile Agents. However, some network errors can occur during the mobile agents moving through the distant network nodes (bottleneck, failure, crash...). For this problem, we define in this paper a mobile agent negotiation process to reassign required mobile agents moving through the distant network nodes according to their current states in their correspondent final routes called Workplans. Furthermore, the complex interactions features of our system exceed the limits of the traditional negotiation systems which impose several restrictions on the type and format of the negotiation messages. Therefore, we designed and implemented a flexible transport ontology which allows an easy handling of the terms and messages for negotiating.

Categories and Subject Descriptors
H.4.0 [Information Systems Applications]: General.

General Terms
Algorithms, Design, Theory.

Keywords
Multi-Agent System, Mobile Agents, Negotiation, Ontology.

1. INTRODUCTION

Giving the mobility character to a software agent will allow him to migrate towards any node on the network which can receive mobile entities. Nodes to be visited by a Mobile Agent (MA) correspond to his route called Workplan. In a recent work [1], we justified the usage of the MA paradigm in a Transport Multimodal Information System (TMIS) in order to collect needed data. The transport field is a special application for the design, the implementation and the optimization of a huge and distributed information system. Therefore, our work can be adopted for similar systems which can represent the same characteristics and constraints of a TMIS. The remainder of this paper is organized as follows: the problem formulation is presented in the next section. Then, the global architecture of the multi-agent system is proposed in section 3. A proposed negotiation protocol is specified in section 4, followed by the proposed flexible transport ontology in section 5. Simulation results are given in section 6 and finally a conclusion is addressed in last section.

2. PROBLEM FORMULATION

The main concern of a TMIS is to satisfy users, respecting the delays of the responses (due dates) and minimizing their total cost; this is a two-step optimization problem [2, 3]: firstly the assignment of an effective set of MAs to all existent network nodes. This assignment builds initial Workplans of the MAs in order to explore, in an optimal manner, the Extended Transport Multimodal Network (ETMN) entirely. The second step corresponds to the best assignment of a sub-set of the ETMN nodes to identified tasks, deducing final Workplans. The selected sub-set of nodes corresponds to the possible providers to the identified tasks. A single identified task corresponds to an independent recognized sub-request which belongs to one or several requests formulated simultaneously by one or different customers through different devices (laptop, PDA...). More precisely, a single task can correspond to a transport service (sub-route, well-known geographical zone...) or to a related service (cultural event, weather forecast...). After the decomposition process, information providers (distant nodes), which propose services to the correspondent identified tasks, are recognized. Indeed, we have partial flexibility; the realization of each task requires a node selected from a set of nodes which propose the same service performing the correspondent task, with different cost, processing time and data size. Finally, nodes must be assigned to tasks in order to satisfy all connected users knowing that a user is satisfied if his request was answered rapidly with a reasonable cost. A possible solution for the problem is an instance of a flexible representation of a chromosome, called Flexible Tasks Assignment Representation (FeTAR). The chromosome is represented by a matrix where rows represent independent tasks (services), composing globally simultaneous requests and columns represent recognized distributed nodes (providers). Each element of the matrix specifies the assignment of a node to a task.

In the next section, we present the proposed global architecture of the TMIS.
3. THE MULTI-AGENT SYSTEM

To resolve the problem described previously, we propose a system based on the coordination of five kinds of software agents:

- Interface Agent (IA): this agent interacts with the user of the system allowing him to choose appropriate form of response to his demand, so this agent manages the request and then displays the correspondent result. Therefore, when a user accesses to the TMIS, an agent IA deals with the formulation of his request and then sends it to an available identifier agent.

- Identifier agent (IdA): this agent manages the decomposition of the requests which were formulated through a same short period of time $E$ ($E$-simultaneous requests). Through a decomposition process, an agent IdA has to recognize possible similarities in order to avoid a redundant search, identifying the potential providers. Finally, the agent IdA transmits cyclically all generated data to available scheduler agents.

- Scheduler Agent (SA): the agent SA has firstly to optimize the number of collector agents before assigning nodes to tasks. The SA agents have to interact in order to share information and negotiate the different parts of assignments for a global optimization. For this problem, we just underline that we propose a solution using the formation of coalitions approach but this is not the topic of this paper. For example, in the case of possible overlapping of the simultaneous requests, concerning SA agents have to gather, forming coalitions, in order to share the assignments about the different identified similarities.

- Intelligent Collector agent (ICA): an agent ICA is a mobile software agent who can move intelligently from a node to another through a network in order to collect needed data and finally returns to his home node, noted by H. This special kind of agent is composed of data, code and a state and has an intelligent behavior. When they come back to the system, the agents ICA must transmit collected data to the available fusion agents.

- Fusion Agent (FA): the agents FA have to fusion correctly collected data in order to compose responses to the simultaneous requests. The fusion procedure needs information on behalf of IdA and SA agents and progresses according to the collected data availability.

Some network errors can occur during the mobile agents moving through the distant network nodes (bottleneck, failure, crash...). For this problem, we define in next section a mobile agent negotiation process to reassign required services to available network nodes according to their current states in their correspondent final routes called Workplans.

4. THE NEGOCIATION PROCESS

Some perturbations can occur through the network when ICA agents are following their correspondent final Workplans, according to the generated FeTAR instance. In this case, the ICA agents have to avoid unavailable nodes in their remained final Workplans. In addition, they have to change their itineraries in order to take into account the cancelled tasks which still need assignments because of the perturbations. Therefore, a new assignment process has to occur to find suitable new available providers. To do this, we have to benefit of active ICA agents who are still traveling through the network and to launch new ones otherwise. So ICA agents have to interact with SA agents in order to find suitable solution to the current situation of perturbation. Thus, we propose a negotiation procedure (figure 1) inspired from the well-known contract net protocol between ICA agents, representing the participants of the negotiation, and SA agents who are the initiators. In our proposed solution, we allow a partial agreement of the proposed contract from each ICA agent, to be confirmed partially or totally by the initiator of the negotiation (SA agent). A renegotiation process is necessary while there are still tasks which need to be reassigned. The purpose of this solution is to allow the ICA agents to cooperate and coordinate their actions in order to find globally near-optimal robust schedules according to their priorities, preferences and constraints which depend on their current positions in their correspondent Workplans. Through the negotiation process tours, SA agents must assure reasonable total cost and time.

The complex interactions features of our system exceed the limits of the traditional negotiation systems which impose several restrictions on the type and format of the negotiation messages. Therefore, we designed and implemented a flexible transport ontology which allows an easy handling of the terms and messages for negotiating.

5. TRANSPORT FLEXIBLE ONTOLOGY

We aim to define a proper vocabulary to the whole proposed multi-agent system in order to automate the different kind of exchanges between agents. Therefore, we propose extensible...
ontologies packages (figure 2) which can adapt to all possible kind of interactions. In this paper, we derive our different edges of ontologies from a basic one (level 0) which already defines fundamental features. Thus, in order to keep a flexible ontology aspect, we start our derivations with a Generic Ontology (level 1).

6. SIMULATION

6.1 Global System Communication

For the implementation of our whole system, we use the Java Agent DEvelopment framework (JADE) which includes a proficient support for content languages and ontologies. On the left side window of the JADE Sniffer graphic tool (figure 3), we can see available servers containers on the network, where ICA agents can move in order to collect data according to the adopted contract model.

6.2 Comparison of the MA Paradigm with the classical CS

Many researchers have long discussed the benefits of the MA paradigm and conclude that it might be efficient in some cases [4, 5]. Indeed, the MA paradigm illustrates some efficient utility in several system architectures [5]. In a recent work [1], we justified the usage of MA paradigm in our system, proposing an efficient approach through a multi-agent transport system to optimize the management of services in the transport business domain. Indeed, when we randomly generate several FeTAR instances for the same simulation example, we observe the benefit of the usage of our optimization approach, using MA paradigm instead of the CS one through our system (figure 4).

6.3 Negociation Tours

The proposed negociation process allows the reassignment of the cancelled services. F6, F7 and F9 in figure 5 below represent three different generated FeTAR instances assignments for the same network error scenario, where the number of agreed assigned tasks was respectively 6, 7 and 9 in the priorities of ICA agents. Thanks to our proposed negociation process, cancelled services find new available providers through an agreement between SA agents and ICA agents so the correspondent transport users are satisfied in spite of some network perturbations.

7. CONCLUSION AND PROSPECTS

In this paper, we proposed a flexible ontology intended for the transport area. The usage of this ontology was currently devoted, to the negociation protocol between static decision maker agents and mobile intelligent agents. In a future work, we aim to manage the interactions between several initiators and participants in concurrent negociation processes in case, for example, of simultaneous requests overlapping.

REFERENCES