ADAPTIVE INFORMATION PROCESSING IN A DOMAIN ONTOLOGY USING RECURSIVE TRANSFER FUNCTIONS TO DETERMINE THE NON-DETERMINISTIC VICINITY OF INTELLIGENT AGENTS

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Abstract: An adaptive walk over a semantic network is possible by describing the domain information in the form of ontology. Leveraging the relationships made between the domain entities by intelligent agents through non-deterministic automation in an object model which is represented in the form of OWL or RDF resource, is the theme of this paper. The successful adaptive walk over a semantic network is with the advent of determining the vicinity of the intelligent agent based on analysing the current service it received, with the prime goal it needs to achieve. The idea of recursive transfer functions is to make the agents travel in the semantic network until the final goal is achieved. The recursive transfer functions takes the current service received from an entity in the semantic network as its parameter and applies the light of the prime goal in order to achieve the next set of possible states. The next set of possible states lie in the similar line of the prime goal to be achieved. The adaptive walk over semantic network aids the agents to act as proxies for human beings there by fulfilling the business needs for the human beings by travelling the vast network of interconnected web resources.

1 INTRODUCTION

Adaptive information processing over a semantic domain network will be a boon for a large number of web information systems. With the advent of Ontologies, and through the idea of leveraging the object model relationships an adaptive walk over the semantic network is discussed. The ability of the intelligent agents to dwell upon the domain ontology is discussed in the light of non-deterministic state automation. The vicinity of next possible set of states for an intelligent agent is decided by the transfer function which analyses the current service received from the semantic entity in the light of the prime goal the agent needs to achieve.

2 KNOWLEDGE REPRESENTATION OF A DOMAIN

2.1 Business Process Execution in Conventional Information Systems

Computerized applications which include both enterprise information systems and web applications assist the human beings in their respective business process. A wealth management system or a hospital management system is needed by the respective business organizations to execute and manage their business process at a faster rate and increase their productivity. But the point to note here is it is still a human being who sits in front of the system and executes the business process. Using an intelligent agent to perform this job is the scope of this paper.

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2.2 Intelligent Agent is not an Aladdin's Genie

Intelligent agents are nothing but software programs which can dwell and feed on a domain network if the semantics of the domain information is understood. But, there exists a similarity between a genie and an intelligent agent.
The high level goals are provided as inputs to an intelligent agent and it becomes the responsibility of the agent to travel through the network keeping the goal in mind. So the onus now falls on the agents when some surprises awaits while progressing the network towards the goal. The important point to note is that an intelligent agent does not write the business rules in a domain, but it should be capable of understanding the consequences of executing a business rule in the light of the prime goal it needs to fulfil for the human being.

2.3 Ontology based Representation of Domain Information

In order for the agents to dwell upon a domain network we need to express the domain information in a way the agent can understand. But knowledge representation had been a holy grail from the time of trying to represent in terms of first order and second order predicate calculus. But now the grail seems to be over with the advent of ONTOLOGY. When domain ontology is derived out of a loosely coupled and highly cohesive object model then that respective ontology can be used by the intelligent agents to achieve the prime goals for the human beings.

2.4 Semantics of Relationships in Ontology

Ontology provides a way to express the kind of relationship between the domain entities. Two entities in a domain can be related through a generalization relationship or an association relationship or through an aggregation or even through depends and a constraint relationship.

Relationships are not just associations between domains entities which help the developer to decide upon the cardinality and navigability. Throwing a high volt light on the relationship we can understand that the relationships actually explain the semantics of the entities in the domain. For example consider the Figure 1. (Note: The same information represented in UML can be represented in OWL).

Each ticket needs to be paid a price. Price can be paid either through cash or through credit card or through debit card. Here the payment generalization gives the semantics of the payment business process. The payment can be either made through cash or through credit or a debit card. That is if an intelligent agent can understand that if the there is no money in the debit then it can use the credit since it is also a type of payment it is nothing but a program which makes a decision making process based on the current service it received.

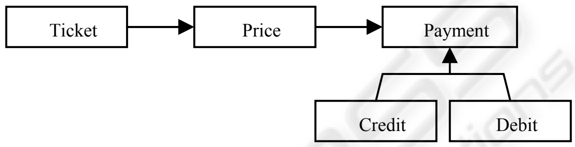

Figure 1: UML representation of Payment module.

3 MODELING THE VICINITY OF AN INTELLIGENT AGENT

3.1 Goal Description through XMI in a Semantic Network

Any business domain can be modelled and represented in the form of semantic network through ontology. The requirements that are filtered out as the primary use cases can be considered as primary goals of the concerned domain. So each primary goal has sequence of steps to be completed before the final goal is achieved. The intermediate steps are represented as steps of the use case during the inception and analysis phase. When the same use case is represented in the form of a XMI it stands as a goal description repository for the agents.

Consider the semantic network described in the figure below

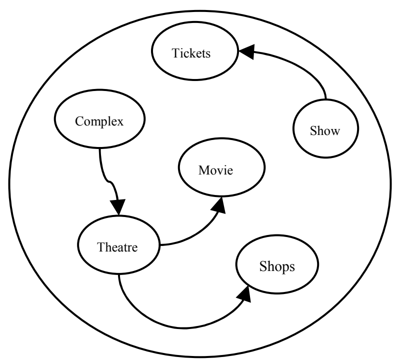

Figure 2: Semantic Network of Online Ticket Purchase System.

The above semantic network is a derived out of a online ticket booking system for a movie. Each entity in the semantic network is capable of offering a service in the domain of online ticket purchase. The type of relationship existing between the entities is described through the ontology written in the form of OWL.

The primary use cases of the domain gets filtered out into a finite set of goals over the respective semantic network. Let us define,

F = {G1, G2, G3…Gn}

Where F is the set of finite goals possible in the network

3.2 Meta Model of Human Mind in Goal Progression

In this section we actually analyze the working of the human mind before actually modelling the intelligent agent.

Consider a human being who serves as an agent for booking tickets in the above mentioned FIG.1 Booking tickets for the respective show and for the respective movie is the primary goal of that guy. The person has a map in his mind for achieving this goal. He/she starts walking in the network as per the map defines the successful ticket booking process.

The path taken by the guy gets disrupted whenever he/she encounters a negative service form one of the entities present in the path. For example when the person receives a service from the entity Ticket as “No tickets available for the requested show” it is considered as a negative service in the light of the prime goal to be achieved.

Whenever a negative service is encountered the walk towards the goal gets altered in a non deterministic manner. For example when the negative service is received from the ticket entity the mind brings alternative maps for “Another movie”, or “Dating out with a girl friend” which actually lie in the line of the prime goal which is to relax out the mind.

3.3 Non Deterministic Vicinity of the Intelligent Agent based on the Current Service Received

Analogous to the human mind described above each intelligent agent that dwells upon the semantic network has a walk table. Each entry of the walk table corresponds to the path that has to be taken for each goal which is actually retrieved from the XMI definition as described.

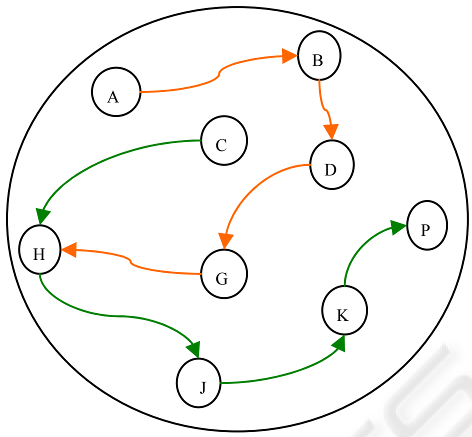

Figure 3: Goal path definition for a Semantic network.

For example the walk table of an intelligent agent for the semantic network in FIG is as follows

Table 1: Walk Table for an agent goal repository.

Prime Goals	Prime Walk Map
G1	A – B – D – G – H
G2	C – H – J – K – P

In case of an intelligent agent the vicinity of an intelligent is determined in a non deterministic manner with respect to the next set of semantic entities. The intelligent agent travels in the semantic network until the final goal is achieved.

The recursive transfer function that enables the agent to travel in the semantic network until the final goal is achieved can be described as follows,

T (f) = {Walk stops, Prime goal = achieved
SL [T (Q X ∑)], Prime Goal! = achieved

In the above recursive transfer function Q is the set of all semantic entities capable of providing a service in the semantic network.

Q = {q1, q2, q3 …. qn} where q1, q2 are the semantic service entities present in the network.

∑ = {Type of service received, Light of prime goal}.

Q * ∑ is the transfer function which decides the possible set of next states.

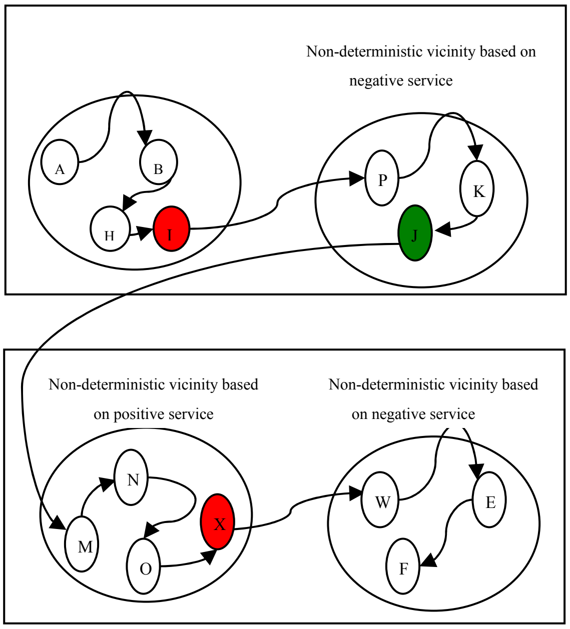

Figure 4: Non-deterministic vicinity of an agent based on current service.

The transfer function T(Q * ∑) is actually used by the heuristic module of the intelligent agent to filter out the most possible successful set of semantic sets based on the walk it had made on the semantic network. This heuristic function module of the intelligent agent is represented by SL (next set of possible states) where

Next set of possible states = Q * ∑

3.4 Importance of the Heuristic Learning Function in an Intelligent Agent

The role of the heuristic function in an intelligent agent can be compared to that of an experienced person who had been working in that domain for a larger period of time and knows the nooks and corners of the domain.

The situation is analogous to an experienced human agent who goes and tries out booking a ticket in theatre which is at the city outskirts when the tickets are filled for the theatre which is present inside the city.

The intelligent agent also pays a similar role. Over acting as proxy for a respective human being over a respective semantic network the agent would be able to know about the behaviour of human mind. So whenever a negative service is received from a Semantic entity like “Ticket” it would rather execute the walk path for “Booking a table for dinner with his girl friend” rather then trying for booking for some tickets in some other movie.

3.5 Association and Generalization Relationship in Determining the Intelligent Agent’s Vicinity

The vicinity of the intelligent agent is determined based on the type of the current service it received from the semantic entity. When the type of service received is positive in the light of the prime goal then the probability of association entities is higher than the probability of generalization entities.

In the above network when the service received from the entity “Payment” is positive (i.e. cash has been paid for ticket) then the next possible set of entities includes “ShowTime”, “Parking Space” which are having an association relationship with the current entity “Ticket”.

Similarly when the service received from the entity payment is negative (i.e. enough money is not available in the debit) then the next possible set of entities may include other modes of payments like “Credit” and “Coupons” which are actually belonging to the super type “Payment”.

The probability of non deterministic vicinity of the agent can be summarized as follows,

Probability (association entities) > Probability (generalization entities) When the current service received is positive in the light of the Prime goal.

Probability (generalization entities) > Probability (association entities) When the current service received is negative in the light of the Prime goal.

3.6 Modelling of Services Offered by Entities in a Semantic Network

Services offered by the entities in the semantic network are highly cohesive with the responsibilities the entities are entitled with. The core of the service oriented architecture decouples the tight linkage between the entities.

When the entities are loosely coupled but highly cohesive the service offered by the entity becomes obvious by their signature definition. Also techniques like CRC cards can be used to decide upon the high level responsibility of the entity from a business point of view.

The basic idea is to create a loosely coupled and highly cohesive object model which is capable exposing its services and getting it leveraged by the intelligent agents.

4 CONCLUSIONS

The aim of this paper is to implement the vision of adaptive information processing towards the business goals with the advent of ontological engineering. With the criteria of a service oriented architecture, the type of service returned back by a semantic entity is compared in the light of the prime goal with which the intelligent agent is progressing in the network. The recursive transfer functions gets agent travelling in the network until the final goal is achieved.

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