Design and Development Of Formal Multi-agent Information Management System

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Abstract: *In this paper, we present multi-agent information management system, composed of multiple agents .The system is designed for user to access information , update new information and share these information to the other users. A DBA (database agent) provide a common way to access information .It manages the database connection for whole system. Information management system is based on BDI architecture , represents the system more near to the human behaviour. JADE is used to implement the system. Agents communicate with each other by using protocols provided by the JADE.*

Keywords: Multi-agent system, Formal methods, Formal architecture, Information Management System, BDI architecture.

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1. Introduction

Information system proposed here is the demanding need of user to easy and fast access and sharing of information today. This is a large system involving interaction of different people with conflicting goals. Multi-agent systems are suitable for such domains. In Multi-agent applications are designed and developed in term of autonomous software entities (agents) that flexibly achieve their objectives by interacting with one another in term of high level protocols and language [1].

An Agent is a self-contained program capable of controlling its own decision-making and acting, based on its perception of its environment, in pursuit of one or more objectives [2].

We proposed here an approach for Information management system based on Belief, desire intention BDI agent model. We adopt BDI modeling technique to define the system because in our system each agent is autonomous in a sense that they can make decisions on the bases of knowledge base in the time of need without user involvement and exactly show the mental attitude of human by making decisions on the time of need.

Our major objective is to formally specify the system to fulfill the correctness property of the system Along with implementation of system that will provide an easy and flexible system for sharing information.

There are different agent programming platforms (e.g. JADE and JACK [3, 4]) and standalone programming languages (e.g. AgentSpeak (L) [5] and 3APL [8]) are present for the implementation of multi agent systems. We use JADE platform for the implementation of our system. JADE is Java based, FIPA compliant agent environment allow us to develop BDI based agent systems.

Section 2 represents Background study, section 3 BDI methodology; section 4 represents problem statement, section 5 objectives, section 6 application of formal methods, section 7 multi-agent architecture, section 7.1 implementation, section 8 conclusion and future work.

2. Background study

Agent technology is one of the most promising technologies for the distributed systems. This technology offers advantages for complex systems that are difficult to manage. Agent technology claims a great offer to provide solution of complexity of large systems by autonomous agents. Although there is no common agreement has been made yet on the definition of agent but we can say that "agents are software or hardware entities that act on the behalf of user and they can make decisions of control at any time".

Its characterization includes reactivity, autonomy, co-operation, reasoning ability and knowledge based. A Multi-agent system can be defined as loosely coupled network of problem solvers (agents) that work together to solve problems that are beyond the individual capabilities or knowledge of each problem solver.

The paper [9] considers four essential building blocks of agent system: agent (the processing entities) interactions (i.e. the elements for structuring internal interaction between entities), organization (i.e., elements for structuring sets of entities within the multi-agent system), and finally the environment that is defined as "the domain-dependent elements for structuring external interactions between entities".

This multi agent approach gives us idea to develop a system based on modularity. The main feature of the modularity is decentralization .Agents coordinate and cooperates with each other to accomplish tasks .They depends on each other but too little extent. It doesn't mean that if we remove one agent then it will affect other agents. Each agent has its own thread of control and does not need data to become active.

3. BDI Methodology

There have been many approaches of Agent Oriented Software Engineering proposed .Each approach has its merits and demerits. Among different architectures proposed to give formal support to agent-based system, an approach is BDI .The BDI approach is based on the philosophical work of[10] and the theoretical and practical work of Rao and [11]and others (for example, [12] and[13]).

BDI is agent architecture for describing agent behaviors [14] based on the theory of action in humans by [10]. The BDI logics allow the formal modeling of BDI architecture that proves the correctness of BDIbased agents' actions.

We proposed here an approach for Information management system based on Belief, desire intention BDI agent model because it is the most suitable model for our system. We adopt BDI modeling technique to define the system because each agent in the system works exactly like mental attitude of human. The principles of the architecture of the BDI agent were established in the mid-1980s [10]. In BDI terms

Belief represent the real world knowledge. The belief represents the state of the real world, such as variables, database or different symbols .Goal is also an important part of system. Intentions are those goal which are focused for long future. [16].

The committed plans and procedures are called Intentions. Computationally, intentions may simply be a set of executing threads in a process that achieve the goals (desires) of the system.

In our system there are different agents having different responsibilities interact with external users and can interact with other agents within the system to accomplish their tasks and to achieve goals.

By using this model system extensibility at any stage is possible without any obstacle. Updating beliefs and deliberation demands only little changes in the model. Extension does not means to change the whole internal architecture but it means to enhance some new features by making local changing in the code to maintain backward compatibility.

4. Problem Statement

The problem is to design and develop a formal multi-agent information management system for the students of Department of Computer Science & IT. Multi-agent based system provides them a distributed and concurrent problem solving, but have the additional advantage of sophisticated pattern of interactions. And a formal system ensures system correctness.

5. Objectives

The first and foremost objective of this approach is to provide the users with a state of the art multiplatform agent based Information Management System. An agent based distributed system which works on computers as well as on mobile devices and provides students with information regarding their class schedules, examination date sheets, results, fee submission dates, university bus timings and routes, and all other notification.

The second objective is the automated creation of statistical reports related to number of students graduating each year, number of student admissions, students attendances, teacher to student ratio, computer laboratory to student ratio, reports consisting of graphs e.g. pie-chart, bar graphs etc. These reports would get a measurement of the quality of education, and therefore would greatly help to uplift the quality of education.

The third objective is to purpose a system that is exactly an image of human mental attitude .For this purpose we use BDI methodology in which belief, desire, and intentions are the elements showing mental states and work almost like human.

The forth objective is to provide a formal architecture for this information management system. Formal architecture plays a significant role towards the safety of the system by significantly reducing the number of possible errors.

6. Application of Formal Methods

It is an application of formal methods for the development of multi-agent based information management system. Formal methods based on pure mathematics and very important for the application of software that is subject to reasoning. To specify a system by formal methods and model checking describes behaviour of the system that will be shown by in implementation. Verification of the system by this way shows the satisfaction or violation of specifications.

Formal methods are already applied in different areas. The process of verification can be done by automated theorem proven or by model checking. Implementation is needed to satisfy the specification which is a multi step process and can be done by more constructive specifications. When we treat the system description with formal semantics then we can think the behaviour of the system.

7. Multi-Agent architecture

A formal Information Management system is distributed in nature. System is managed by different agents. In this system each entity is implemented by agent. Agents are responsible to receive information from other agents within the system and information from external users by user agents as well.

Agents can also make any decision at runtime to achieve their goals. We can say that Formal information management system is a Multi agent system in which functional agents corporate and coordinate with each other to accomplish system functionality.

They are autonomous in a sense that they can collect information from the environment and cane makes decision on its behalf. Each agent is named according to their functionality.

In this section we describe the distributive architecture of our information management system consists of multiple agents.

Figure 1 and Figure 2 shows the overall architecture of the system, which is constituted of functional agents.

All agents are connected to JADE layer which provide all services for interaction and coordination between agents within the system and outward the system

Here we give short description of each agent.

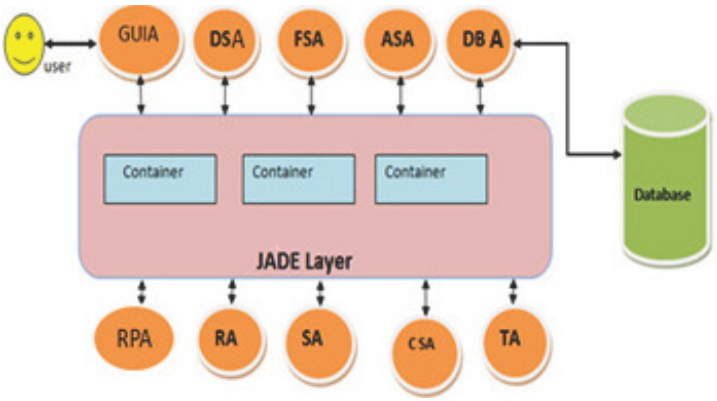

Figure 1. Multi agent Architecture of Information Management system

Abbreviations	Description
GUIA	Graphical User Interface Agent
ASA	Admission Schedule Agent
RA	Result Agent
RPA	Report Agent
TA	Teacher Agent
SA	Student Agent
CSA	Class Schedule Agent
FSA	Fee Structure Agent
DSA	Date Sheet Agent
DBA	Database Agent

Figure 2. Agent in Architecture

GUIA: Graphical user interface agent will provide the interface which is a way of direct interaction of users with the system. It is a common way of retrieving, storing and sharing information in the system. Users get access to the database to store latest knowledge for the visitors.

ASA: agent that maintains information about admissions of all programs in computer science department. Admission criteria, opening and closing dates, new offered programs; all information will be managed by this agent. Students can get information and teachers are allowed to update latest information and they can remove information if needed.

DSA: Datesheet of all programs will be managed by this agent. Timing, dates, venue for each class, semester and discipline will be managed by date sheet agent. Any updation will be made by this agent in the time of need According to user query agent provide the datesheet of those programs and also offer him to get easy access to the datesheet of other programs as well.

FSA: It will manage fee structure of all programs .Under each program, there can be semesters that are more than one in a year and in each program there may be shifts of evening and morning. Fee structure of all programs, semester, and shifts will be updated by this agent. Agent keep sensing that if department offers a new course it will be the duty of this agent to make an alert to admin to specify fee structure of that course for the visitors.

TA: All teachers will create their accounts by making registration through this agent. Information about students, their name, id, designation will be managed by this agent. Registration is necessary for all teachers to get access of this system.

SA: All students will create their accounts by making registration through this agent. Information about students, their name, id, discipline all are managed by this agent. Registration is necessary for all students to get access of this system.

RPA: This Agent will create automated statistical reports related to number of students graduating each year, number of student admissions, student attendances, teacher to student ratio, computer laboratory to student ratio, reports consisting of graphs

charts etc. This agent will automatically sense the information from other agents to generate reports.

As the theory of Rao and Georgeff [15] represents in BDI Belief Desire and Intentions are the mental attitude representing world state. So according to state transitions beliefs would also be change and that will need some extension in the model to cope with this change. Beliefs are the real world model or we can say in counting language this is the database knowledge that are dynamic in nature and update consistently, here the autonomy of the agents will work to keep update the record and maintain correct data.

Desires are the goals that are aimed to get. Or we can say desires are the way that we pass through belief to action. Our main goal is here to provide correct and updated information to the users according to their needs and keep all agents up to date .And generate reports at the time of need by sensing required information from different agents. These goals can be extending in future.

Intentions: Achievement of goals directly affects our intention. Every agent should keep data update and consistent. Report agent plans are defined in such a way that it can sense and adopt new change in related agent. Agent can say No to sensor at any time for changing caused by any unforeseen event. Here fig 3 and 4 given below, representing system in terms of belief desire and intention.

Here in figure 4 BDI based architecture is presenting, in which working of each agent has shown.

Each agent has to interact with database agent to get access to the database for latest information or to update new information. For this purpose agent send a request to relative agent, that agent then send query to database agent according to the need, Database agent response accordingly. Reports are created from the latest updated data from database.

7.1 Implementation

Agents need to communicate with each other to accomplish a task. For this communication rather than developing the core infrastructure, it is more convenient to build multi-agent system on top of an agentoriented middleware that provides the domain-independent infrastructure that allow the developers to produce the key business logic. JADE is the most widespread agent-oriented middleware use today. JADE is completely distributed middleware system with flexible infrastructure allowing easy extension with add-on modules.

Belief	**Information of:** Class schedules Date sheets Results Admission schedules Fee structures Teachers Students.
Desire	Up to date data of Class schedules, Date sheets Results, Admission schedules, Fee structures to the user.
Intention	Generate reports from updated data.

Figure 3. representing belief, desire and intention in the system

8. Conclusion and Future work

Here in this paper we propose a modular information management system .Which is highly flexible for dynamic environment of this system .It provide high level of abstraction from underlying knowledge of interaction. Implementation is easy by the facility of wide range of libraries provided by JADE.

Our system is flexible in a way that it can embed new agents without affecting other agents that is a need of dynamic nature of systems. For future we planned for learning capability of our agents and handling of incomplete information.

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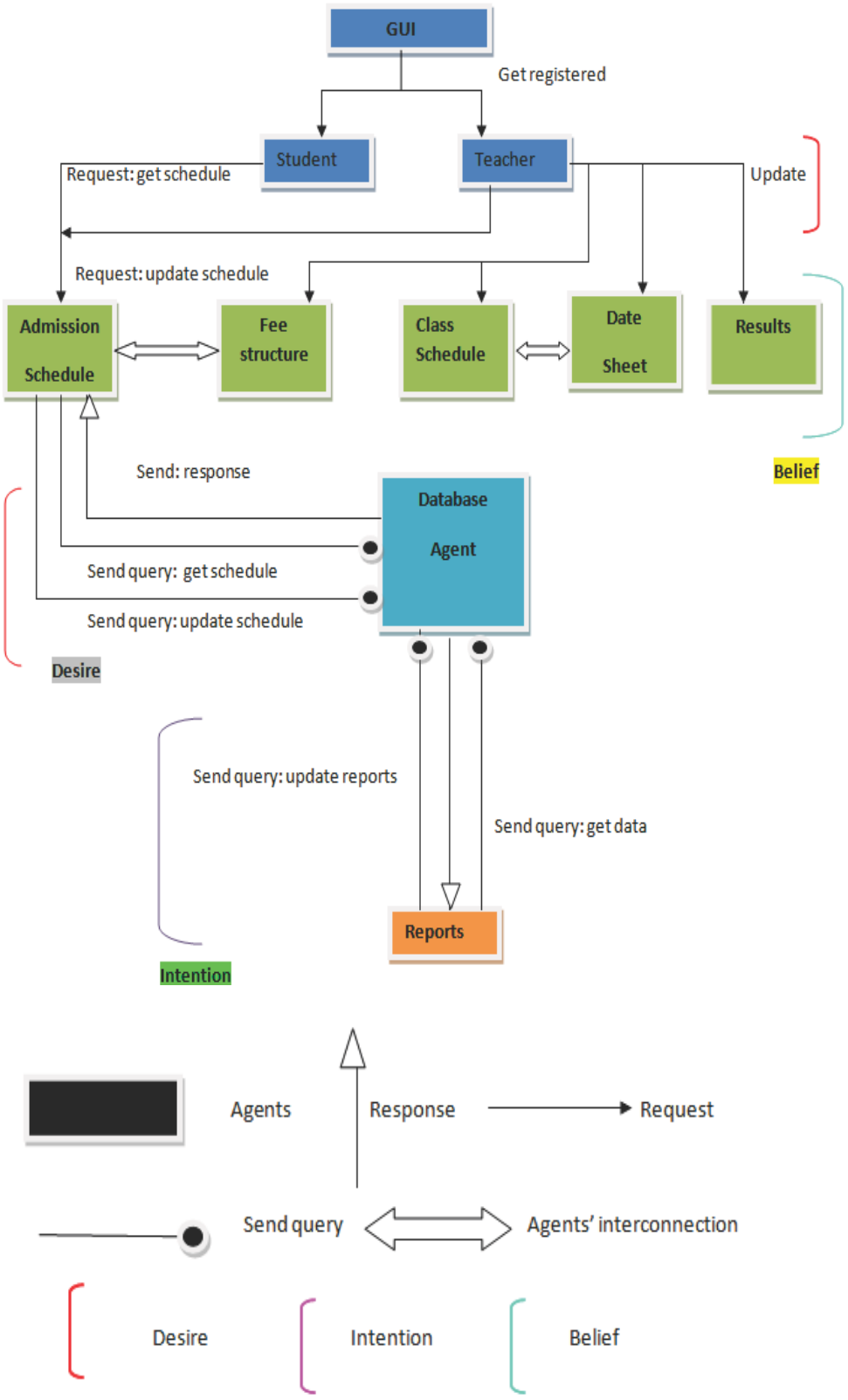

Figure 4. BDI based architecture

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