

Fuzzy Logic based Expert System for Students' Performance Evaluation in Data Grid Environment

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Abstract— In the current competitive era, every school, colleges and institutes strongly focus on improvement of the students' performance by applying fair evaluation methods. Performance of students is difficult to assess before the final results are declared. Major factors that affect on performance are the attendance of students in their theory and laboratory sessions, the exam grades they obtained in internal exams and the exam grades they obtained during term work evaluation. Assessing students' performance is an area in which strict rules often do not represent the realistic situation. Fuzzy logic provides a way of representing the behavior of systems which are either too complex or too imprecise. Also, university is a very large domain and students' data are generally stored in various distributed and heterogeneous data repositories which may span across different organizations and administrative domains. Such distributed data repositories can be integrated within data grid environment by implementing data grid middleware. Therefore, we have developed a fuzzy logic based expert system which assists the process of decision making of students' performance evaluation within data grid environment. The system will utilize the fuzzy logic theory and develop the decision making process based on fuzzy rules to assess whether a student gets very poor, poor, good, average or excellent performance.

Index Terms— Fuzzy Logic, Expert Systems, Data Grid, OGSA-DAI, Agent, Multi-agent Systems, Fuzzy Logic

1 INTRODUCTION

In the current competitive era, every school, colleges and institutes strongly focus on improvement of the students' performance by applying fair evaluation methods. There are several factors are needed to be considered which affect the performance. Major factors that affect on performance are the attendance of students in their theory and laboratory sessions, the exam grades they obtained in internal exams and the exam grades they obtained during term work evaluation. It is possible to analyze these factors qualitatively such as poor, very good, average, excellent etc. Even though quantitative figures are available such as 55% attendance in theory session, 80% marks in internal exam, 70% marks in the term work evaluation; it cannot directly be used for performance assessment. Suppose in the grading process of students' performance, the borderline between a good performance and a bad performance is 50%. Suppose the student got 49% during the grading process. Can this performance considered as a bad? Or if it is 50%, can it consider as a good? So, assessing students' performance is the area in which strict rules often do not represent the real situation.

Also, can two students have the same final exam grade, one of which has been present in the majority of the sessions and the other only in half of the sessions? These are the criteria according to which the teachers can realistically assess students in order to evaluate their performance. There are two main reasons why above classical logic systems cannot deal with problems in which knowledge is approximate. They do not provide a means for representing the meaning of propositions expressed in a natural language when it is imprecise, and they do not provide a mechanism for inference in the cases where knowledge is represented symbolically along with its meaning [3].

As we can clearly see from the above discussion, developing a system for students' performance evaluation based on strict and rigid rules would not be a truthful evaluation process. Therefore, we need systems that will deal with knowledge, which is rather imprecise or incomplete as human routinely and subconsciously place things into classes whose meaning and significance are not well defined. Fuzzy logic provides a way of representing the behavior of systems which are either too complex or too imprecise.

Moreover, university is a very large domain and students' data are generally stored in various distributed and heterogeneous data repositories which may span across different organizations and administrative domains. Such data repositories can be integrated within data grid environment by implementing data grid middleware. Therefore, we have developed a fuzzy logic based expert system which assists the process of decision making of students' performance evaluation within data grid environment. The system accomplishes decision making process to assess students' performance. The implemented experimental system leverages of OGSA-DAI (Open Grid Services Architecture - Data Access and Integration) workflow execution functionality and out-of-the-box activities for data access, inte-

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gration, transformation and delivery.

2 OGSA-DAI (OPEN GRID SERVICES ARCHITECTURE DATA ACCESS AND INTEGRATION): A DATA GRID MIDDLEWARE

To establish a data grid environment, a data grid middleware technology named OGSA-DAI (Open Grid Services Architecture - Data Access and Integration) has been used. The OGSA-DAI has been studied and set of mechanisms have been identified to use data grid services. Open Grid Services Architecture - Data Access and Integration (OGSADAI) is a project that develops middleware solution to assist with access and integration of data from separate data resources via the data grid [2].

The project was funded by the UK e-Science core program and is working closely with the Global Grid Forum Data Access

and Integration Services (GGF DAIS) work group [1]. OGSA-DAI is a database centric middleware solution which mainly provides the data virtualization services.

3 AGENT-BASED INTERFACE TO DATA GRID SERVICES

Configuration and deployment of data grid is a complex and lengthy task. Therefore, data grid services should be offered with minimum user intervention. To facilitate the access of data grid middleware services, we have implemented different collaborative agents those are working together to provide the core, user & knowledge level services to the users.

Users are interacting with agents in order to access OGSA-DAI services. Agents are autonomous, adaptive and cooperative by nature and emerging as dynamic, flexible and extensible mediators for facilitating grid services in a data grid environment [4, 6]. Agents are working proactively with minimum user intervention and offer various data grid services to its users [7].

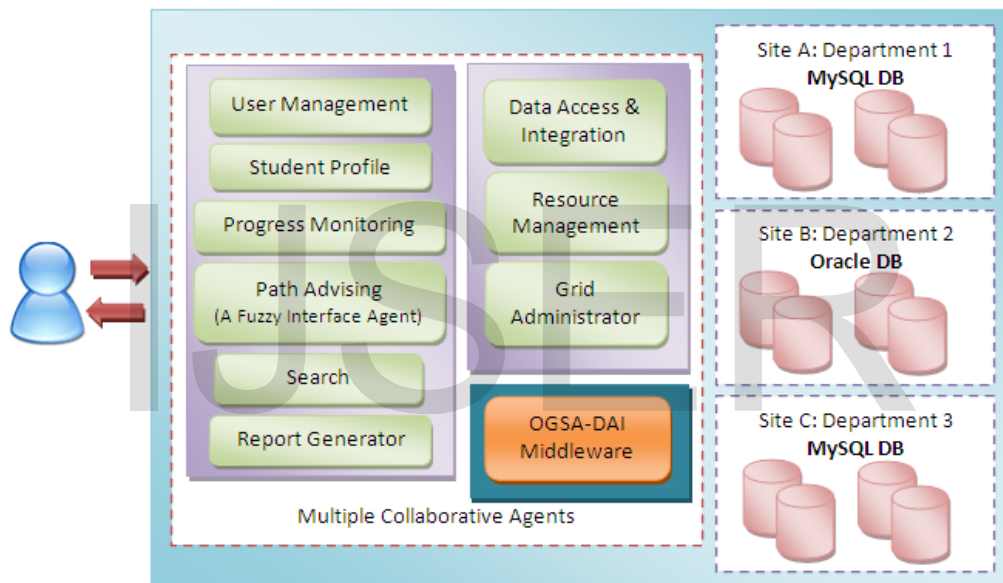


Figure 1: An Architectural View of a Fuzzy Logic based Expert System for Students' Performance Evaluation in Data Grid Environment

4 AN ARCHITECTURAL VIEW OF A FUZZY LOGIC BASED EXPERT SYSTEM FOR STUDENTS' PERFORMANCE EVALUATION IN DATA GRID ENVIRONMENT

In a university, there are several different departments existing and they may manage their students' data individually and in disparate form. The system is able to integrate these distributed and heterogeneous data repositories in the data grid environment. As discussed earlier, a data grid is realized through OGSA-DAI, a data grid middleware. As configuration of the data grid is a complex and tedious tasks, data grid formation should be performed with minimum human intervention. Agents are the sophisticated software entities that work proactively on behalf of its users. So, we have developed an agent-based interface to provide data grid services to users. The multi-

agent system provides a scalable environment to integrate this

data grid to perform the knowledge extraction and delivery process and hides the heterogeneity of the database nodes from the users and handles the data access and integration in an efficient manner. Once the data grid is formed, we have integrated a knowledge-based component by realizing fuzzy logic. This system performs knowledge extraction and delivery of data or information retrieved from data grid which helps students and teachers to evaluate students' performance and assist them in the decision making process at a certain level.

Figure 1 presents the architectural view of students' performance evaluation system. We can see from the figure 1.1 that there are multiple collaborative agents working together as a part of multi-agent system environment. There are mainly three entities of the system. They are distributed & heterogeneous data repositories reside in data grid, data grid middleware and

multiple collaborative agents to configure and manage the data grid.

We can see the database nodes in figure 1 that contain relational data resources (e.g. MySQL, Oracle, SQLServer etc.). These databases are located at different sites. Each site may contain different relational database type and schema. Also, each site contains necessary data to perform evaluation. i.e. attendance, exam marks and termwork evaluation marks of respective student. We have used horizontal fragmentation strategy where students' databases may store at different sites (in different departments), having different data tuples but having similar table schemas. More departments (i.e. database nodes) can be added in the data grid according to requirement with help of agent-based interface. The agents access and integrate the necessary data (attendance, exam marks and termwork evaluation marks) from this database grid through OGSA-DAI and then apply fuzzy set theory and logic to provide knowledge-based assistance. Apart from relational resources (MySQL, Oracle, etc.), XML and file-based data resources may also integrate with necessary modification.

4.1 Domain Specific Multiple Collaborative Agents

We have developed the following domain specific agents: User Management Agent, Student Profile Agent, Progress Monitoring Agent, Path Advising Agent (A fuzzy Interface Agent), Search Agent and Report Generator Agent. The following is the detail of the services offered by each agent. Table 1.1 shows the responsibilities of each agent.

Table 1.1: Domain Specific Multiple Collaborative Agents with their Responsibilities

Agent	Responsibility
User Management Agent	New user registration, Verification and management
Student Profile Agent	Get students' basic details like profile, course announcement etc. from related database grid node, Display all details to student, Interact with data access & integration agent
Progress Monitoring Agent	Calculate the necessary data to measure the student's performance, Interact with data access & integration agent
Path Advising Agent (A Fuzzy Interface Agent)	Perform fuzzification and defuzzification processes, A knowledge-based agent possess decision making capability
Report Generator Agent	Generate the report and charts to show the students' performance, Generates the fuzzy graphs
Search Agent	Search for different requests according to the user's requirements, passes the output to relevant user

4.2 Data Grid Service Agents

The agent-enabled data grid model offered core, data and user level services. Through these services, the client applications and users may get access to digital objects of the data grid environment. The typical agents namely resource management agent, data access & integration agent and grid administrative agent provide the above said services [7]. Table 1.2 shows the responsibilities of each data grid service agents.

Table 1.2: Data Grid Service Agents with their Responsibilities

Agent	Responsibility
Resource Management Agent	Data grid node establishment through user-friendly and automated way, Hides the complexity of development and execution of the configuration script from user, Provides a standardized interface to manage data grid nodes
Data Access & Integration Agent	Interact with OGSA-DAI, Allows data resources to be accessed, manipulated, integrated and federated across the network such as LAN or WAN, Gets the query execution request from user, Executes the workflow on OGSA-DAI server, Make union of query result if necessary, Sends response back to the user
Grid Administrative Agent	Monitors the data grid nodes, shows the active data grid nodes, Automatically switch between original and backup nodes as and when necessary to avoid single point of failure.

5 FUZZY INFERENCE PROCESS THROUGH IMPLEMENTATION OF A FUZZY INTERFACE AGENT

We have developed a fuzzy interface agent (i.e. path advising agent) which implements fuzzy inference process on behalf of users. There are mainly five components in a fuzzy inference process execution. They are Crisp Values, Fuzzification, Fuzzy Inference Engine, Fuzzy Knowledge base and Defuzzification. The fuzzy expert system takes three input parameters for its calculations: Attendance, Internal Exam Marks and Teamwork Marks and generates one output parameter as a result i.e. Performance. The input parameters are supplied by the data access & integration agent. Data access & integration agent takes all these values from distributed and heterogeneous databases that reside in a data grid environment. The fuzzy inference agent matches the input provided by the corresponding rules of the rule base and produces a result fuzzy set. The given output defuzzifies value of the result fuzzy set. Students' performance evaluation with a fuzzy expert system comprised with three steps:

A. Fuzzification of input & output parameters

Fuzzification of input parameters is carried out using input variables and their membership functions of fuzzy sets. We have formed a set of linguistic variables with respect to their input parameters as well as output parameter. Fuzzification of performance is carried out by using three input parameters and their associated membership functions. For each input parameter, we have defined three linguistic values and membership functions. The fuzzy set of all three input parameters (attendance, internal exam evaluation and term work evaluation) and their associated membership functions are given in Table 1.3.

For output variable, we have defined five linguistic values and membership functions. The fuzzy set for output parameter (performance) and its associated membership functions are given in Table 1.4.

Table 1.3: Fuzzy Set for Input Parameters

Linguistic Values	Membership Function	Interval
Poor	Trapezoidal R	(3,5)
Good	Triangular	(3,5,7)
Excellent	Trapezoidal L	(5,7)

Table 1.4: Fuzzy Set for Output Parameter

Linguistic Values	Membership Function	Interval
VeryPoor	Trapezoidal R	(1,3)
Poor	Triangular	(1,3,5)
Average	Triangular	(3,5,7)
Good	Triangular	(5,7,9)
Excellent	Trapezoidal L	(7,9)

B. Determination of fuzzy rules and inference method

Fuzzy rules are the rules determine input and output membership functions that will be used in inference process. The decision, which the fuzzy inference system makes, is derived from the rules. These rules are a set of 'If-Then' statements that are intuitive and easy to understand as they are written in common English declarations. We have derived and framed the following rules for the system to generate an expert advice on students' performance evaluation.

RULE 1: IF Attendance IS poor AND Exam_Evaluation IS poor AND Termwork_Evaluation IS poor THEN Performance IS VeryPoor;

RULE 2: IF Attendance IS poor AND Exam_Evaluation IS poor AND Termwork_Evaluation IS good THEN Performance IS VeryPoor;

RULE 3: IF Attendance IS poor AND Exam_Evaluation IS poor AND Termwork_Evaluation IS excellent THEN Performance IS Poor;

RULE 4: IF Attendance IS poor AND Exam_Evaluation IS good AND Termwork_Evaluation IS poor THEN Performance IS VeryPoor;

RULE 5: IF Attendance IS poor AND Exam_Evaluation IS good AND Termwork_Evaluation IS good THEN Performance IS Average;

RULE 6: IF Attendance IS poor AND Exam_Evaluation IS good AND Termwork_Evaluation IS excellent THEN Performance IS Good;

RULE 7: IF Attendance IS poor AND Exam_Evaluation IS excellent AND Termwork_Evaluation IS poor THEN Performance IS Poor;

RULE 8: IF Attendance IS poor AND Exam_Evaluation IS excellent AND Termwork_Evaluation IS good THEN Performance IS Good;

RULE 9: IF Attendance IS poor AND Exam_Evaluation IS excellent AND Termwork_Evaluation IS excellent THEN Performance IS Good;

RULE 10: IF Attendance IS good AND Exam_Evaluation IS poor AND Termwork_Evaluation IS poor THEN Performance IS VeryPoor;

RULE 11: IF Attendance IS good AND Exam_Evaluation IS poor AND Termwork_Evaluation IS good THEN Performance IS Average;

RULE 12: IF Attendance IS good AND Exam_Evaluation IS poor AND Termwork_Evaluation IS excellent THEN Performance IS Good;

RULE 13: IF Attendance IS good AND Exam_Evaluation IS good AND Termwork_Evaluation IS poor THEN Performance IS Average;

RULE 14: IF Attendance IS good AND Exam_Evaluation IS good AND Termwork_Evaluation IS good THEN Performance IS Good;

RULE 15: IF Attendance IS good AND Exam_Evaluation IS good AND Termwork_Evaluation IS excellent THEN Performance IS Good;

RULE 16: IF Attendance IS good AND Exam_Evaluation IS excellent AND Termwork_Evaluation IS poor THEN Performance IS Good;

RULE 17: IF Attendance IS good AND Exam_Evaluation IS excellent AND Termwork_Evaluation IS good THEN Performance IS Good;

RULE 18: IF Attendance IS good AND Exam_Evaluation IS excellent AND Termwork_Evaluation IS excellent THEN Performance IS Excellent;

RULE 19: IF Attendance IS excellent AND Exam_Evaluation IS poor AND Termwork_Evaluation IS poor THEN Performance IS Poor;

RULE 20: IF Attendance IS excellent AND Exam_Evaluation IS poor AND Termwork_Evaluation IS good THEN Performance IS Good;

RULE 21: IF Attendance IS excellent AND Exam_Evaluation IS poor AND Termwork_Evaluation IS excellent THEN Performance IS Good;

RULE 22: IF Attendance IS excellent AND Exam_Evaluation IS good AND Termwork_Evaluation IS poor THEN Performance IS Good;

RULE 23: IF Attendance IS excellent AND Exam_Evaluation IS good AND Termwork_Evaluation IS good THEN Performance IS Good;

RULE 24: IF Attendance IS excellent AND Exam_Evaluation IS good AND Termwork_Evaluation IS excellent THEN Performance IS Excellent;

RULE 25: IF Attendance IS excellent AND Exam_Evaluation IS excellent AND Termwork_Evaluation IS poor THEN Performance IS Good;

RULE 26: IF Attendance IS excellent AND Exam_Evaluation IS excellent AND Termwork_Evaluation IS good THEN Performance IS Excellent;

RULE 27: IF Attendance IS excellent AND Exam_Evaluation IS excellent AND Termwork_Evaluation IS excellent THEN Performance IS Excellent;

$$\mu_c(y) = \max_k [\min[\mu_A(input(i)), \mu_B(input(j))]], k = 1, 2, 3, 4... r.$$

Inference Method: An output fuzzy set is obtained from the input variables and rules by applying the inference procedure. We have used the Mamdami's max-min inference method as it is typically used in modeling human expert knowledge and it is given below [5]:

C. Defuzzification of performance value

Defuzzification is the process of converting a fuzzy number into a crisp value. It is the process of producing a quantifiable result in fuzzy logic based on given fuzzy sets and corresponding membership degrees. Several methods have been developed so far for defuzzification. In our experimental system, we have used Center of Gravity (CoG) Method (also known as CoA - Center of Area) for defuzzification.

6 OUTCOMES OF A SYSTEM

It is observed that, to store the data of students, the different institutes may use different storage systems and data formats

with differences in their schema, access rights, metadata attributes and many more. Therefore, there is a need of the system which provides a single and a virtualized view of such institutional data assets and allows data providers of institutes to retain control of their data. As a result, we have developed a system which operates in a data grid environment and new institution may add as a new database grid node in the system without much modification in code. Also, the system offers scalability and extensibility and implemented a strategy used to avoid a single-point-of-failure. The system evaluates the performance of the students at regular interval, generates the appropriate reports for the same and makes these reports available to the students. The reports are generated on regular interval as a part of a continuous evaluation process and provide a chance for the students to increase their performance rate before the final exams are conducted. The university may accomplish the assessment of their students' performance in a timely and user friendly manner. Also, the performance may disaggregate by institutes, instructor, gender, ethnicity, economic status and disability; have a meaningful impact on the achievement of students throughout their career.

7 CONCLUSION

This research work presented here enhances business intelligence and quickening decision making process by providing knowledge-based component through fuzzy set theory and fuzzy logic that leads to a novel model. A fuzzy logic based expert system evaluates students' performance on regular basis and advise them on their state of progress. The system uses the data grid service agents in order to expose the heterogeneous and distributed databases in grid environment. Moreover, it implements the fuzzy interface agent to realize the knowledge-based component, which assists the users in the decision making process at a certain level.

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