

# AN EXPERT SYSTEM FOR DISBURSEMENT OF HOME LOANS

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**Abstract**— the disbursement of home loans is a very challenging process as many aspects are involved in its decision making process. This also includes the attitude and behavior of the customers and loan officials in providing fair and unbiased decisions. Researchers have recently found that expert systems perform very well for this complex problem when compared to more traditional statistical approaches. This paper presents an Expert System that would aid in the disbursement of Home Loans (accepting and rejecting home loan applicants). The system makes decisions and provides suggestions similar to those of a Loan Officer (Human Expert). The system will use a goal driven approach along with knowledge engineering in order to make a uniform, well informed decision. The system was verified and validated for its correctness and efficiency by running a series of tests and comparing the results to the decisions, the human experts have taken in the past.

**Index Terms**— expert systems; home loans; decisions; banking; goal driven systems.

## I. INTRODUCTION

In the banking industry the disbursement of loans is a very challenging process. Banks offer loans to their customers, which through interest rates benefit the banks. The process of applying for a loan differ from the type of loan being asked. In this paper applicants for housing loans have been discussed. There is a high risk involved in giving out home loans without proper assessment of the customers and the collateral. Banks all over the world face major financial crises due to home loan defaults. The major reason for this kind of crises lies in the evaluation process. The evaluation process involves decision making which varies from one loan applicant to another. With each new applicant, new facts and data need to be interpreted in an effective manner. This is a long process as the expert in this domain (loan officers) need to interpret and work efficiently with the large amounts of data provided. The process might get confusing and difficult and also incurs human resource costs and an inordinate amount of time investment also leading to customer dissatisfaction. Also, a loan officer although an expert in this domain is ultimately only human causing them to go off course due to any personal likes or dislikes, which could lead to unfair decisions.

Thus in order to accelerate the evaluation process, improve its effectiveness and decrease the amounts of risk involved we propose to build an expert system that is capable of providing uniformity and non-influential evaluations for disbursement of home loans. An expert system that will be able to efficiently

and quickly interpret large amounts of data and will provide uniform and unbiased results. This involves two major tasks,

- Understanding the problem and acquiring the relevant knowledge within the specific domain.
- Organizing the data in a hierarchal structure and formulation of problem-solving rules.

Therefore, the expert system we have developed would essentially be able to carry out the following tasks:

- Enable customers to input their details and requirements.
- Store all customer details in a database for further use.
- Evaluate facts and fire rules accordingly.
- Make a well informed decision based on all factors involved.
- Give appropriate advice in case of loan rejections.

The scope has been restricted to a relevant size and complexity of expertise and transfer this to the computer program so as to obtain results close to what a human expert would take. However, exceptions to these cases are not possible to include. It is a proof of concept that the solution works and can be expanded to other areas of expertise and businesses. While many studies have been done in this area, the significant contribution we aspire is to possibly make this a relatively low cost solution – done by students using free tools. Thus if the solution can consistently evaluate loan applications, the first basic checks can be automated thus fulfilling the aspired goal. A fallout of this could enable the bank filter online applications from aspiring loan seekers and communicate the eligibility status thus reducing the time spent by the loan evaluation officers.

## II. RELATED WORK

There are two categories in which work in this field has been carried out. One where a computer captures the domain expert in his field of expertise and the other where a review has been carried out on the advantages and flaws of existing expert systems. In the financial world many of the models are mathematical attributing to only the quantitative aspect as opposed to the qualitative one [6]. It is important to have a good understanding of both aspects while developing a system as only then it can be considered to be complete and accurate and with the use of expert systems it has become possible to capture both these aspects. Our system incorporates both these

aspects through the use of a decision tree for the qualitative aspect, mathematical formulae for the quantitative aspect and inputs these into the expert system in order to obtain the results.

Listed below are few of the expert systems in the financial world:

#### 1) Expert System in Banking: The British Scene

This paper analyses the use of expert systems in British banking industry with an aim to find out how this technology is performing and it's affecting the industry. It reviews Information Technology in banking and describes briefly the British banking sector and how the research was conducted; it also gives major findings of the project.

It documents three major bank applications of expert system:

1. Portfolio management and evaluation
2. Financial planning.
3. Credit evaluation

The research project objective was to find out how extensive expert system technology is being used in aggregate banking sector, and how it is affecting banking organizations. At the preliminary stage, this research has found that expert systems have significant effects on the functions of banking organizations and in particular on their decision making processes. But many questions have not been answered in greater depth; for example how can expert systems deliver competitive edge to the organizations. What are the relationships between expert system and decision making i.e. quality, consistency, structure etc [7]?

#### 2) Expert System in UK banking

This paper identifies the advantages of ES in banking sector as; automation of routine decision making tasks, which frees managers to pursue more challenging problems; separation of decision making skills from human decision makers, allowing novice managers to employ the same knowledge to judgement as recognized experts; and better co-ordination and control of the decision making process so that changes in business strategy can be quickly and efficiently communicated throughout large organizations. The bank also introduced an AI system to crack down on credit fraud. Fraud 2000 uses artificial intelligence to block fraudulent purchases at point of sale. They mention that ES technology should be widely used in retail banks and build societies. Banks have an urgent need to manage their expertise. They need to make expertise available at branch level, to make it cheap and accessible to ensure uniformity in decision making at all levels of organization [8].

#### 3) Expert Systems For Banking Credit Decisions

The major contribution of this research is to propose an expert system for evaluating and supporting credit decisions on the banking sector (ESESCDB). The system can help the human experts in explaining why a particular decision is made. It can evaluate the credit-worthiness of applicant companies or individuals, with recommend for a credit line be accepted, rejected, reduced or revised. The system aids a credit officer in the risk assessment and completion of a loan package [2].

#### 4) Countrywide Loan-Underwriting Expert System

It is the first use of expert systems in business. It is a rule-based expert system used in mortgage processing. The system

was developed to increase the production capacity and productivity of countrywide branches, improve the consistency of underwriting, and reduce the cost of originating a loan [1].

### III. EXPERT SYSTEMS.

A system is said to be an Expert System if it is able to reproduce the way in which Human experts make decisions. It aids the human expert to make decisions rapidly and accurately. It makes use of if-else rules and logical reasoning making it declarative programming as opposed to procedural programming.

Procedural programming involves telling the computer what to do and how to do it. It requires a specific set of inputs and known set of steps in order to obtain a solution. On the contrary, a declarative program describes what the computer should do, but eliminates much of the instructions involved as to how to do it. It is more flexible, capable of providing possible solutions even in the presence of poorly conditioned inputs. Executed by some runtime system it understands how to fill in the blanks and use declarative information in providing a solutions. As it includes only important details it is much easier to understand [3].

An expert system consists of the following components each of which is responsible for one of the aspects in the decision making process [4]:

- Database of Facts: This holds all the inputs presented by the user. This could be in response to questions prompted by the inference engine as to the existence of particular conditions or the user's current knowledge about the problem at hand.
- Knowledge Base: This contains facts and rules. It is not just mere data or information that is present but it consists of interrelationships, consequences and predictions of the data and information. This kind of knowledge is obtained from experts of that domain and knowledge engineering is used to convert that knowledge into facts and rules.
- Inference Engine: This connects the Knowledge base and the database of facts in order to infer rules and draw conclusions from it. There are two ways in which the reasoning can be carried out. The way in which the rules are used is the distinguishing factor.
  - Forward Chaining: This uses a data driven approach. Here, the data is compared with the facts and rules and the conclusion is drawn from it. It uses the evidence present to determine the goal. It follows the if –then structure.
  - Backward Chaining: This uses a goal driven approach. Here, the goal is determined first and then data required to satisfy the goal is searched for. If present then the goal has been approved else disapproved. It follows the then-if structure.
- Explanation Mechanism: This is an important feature of expert systems. It explains how the system has reached a decision and can also allow users to find out why it has asked a particular

question. Because it is 'rule based', the system is able to provide the user with an explanation of which rules were used during the inference process. This allows the user to make a judgement on the reliability of the decision.

- **User Interface:** This is used to interact with the user. It allows the users to input data, view the final result etc.

#### IV. DESIGNING

There are many steps involved in the designing process. It is important to understand how the process for requesting the loan is evaluated, the data that needs to be collected in order to carry out the evaluation, the exceptions to these cases and the limitations of the expert systems.

When a customer applies for a home loan a wide array of factors need to be taken into consideration. This involves the practicability of the bank to provide the loan amount and capacity of the customer to repay the loan accreted with interest within the stipulated time period. The process of evaluation includes three phases.

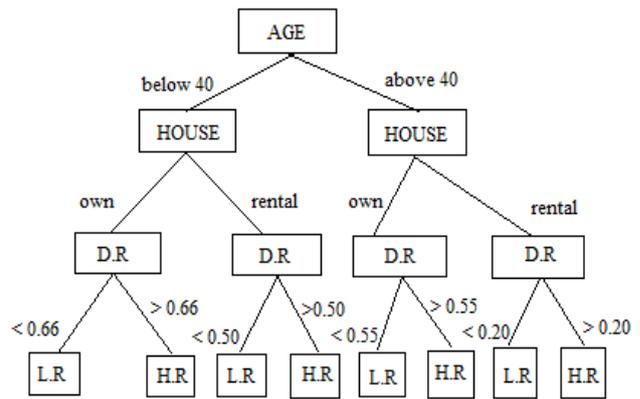
1. This phase involves an eclectic collection of home loan applicant's personal information and data.
2. This phase involves evaluation of the home loan applicant's data in order to determine their eligibility.
3. This phase involves document verification, site visitation and area assessment. Phase 3 however, is beyond the scope of this paper as it would require human intervention.

Once the problem at hand and the requirements that are needed to attain the solution has been thoroughly understood, it now becomes easy to determine whether to carry out the evaluation using a data driven or a goal driven approach. In our case we have chosen the goal driven approach. The goal is to grant a home loan and we go backward seeking data that would satisfy the goal. If all the data required to satisfy the goal is present we grant the home loan else it is rejected. Through this approach we are able to obtain all the possible solutions that would be available at our disposal, giving the customers an option as to their preferences and convenience.

##### A. PROFILING APPLICANTS.

When a loan official assesses an applicant's information, they consciously or unconsciously match it to a certain profiling pattern in order to decide whether to grant the loan or not. In order to emulate this process of human intelligence a method termed as 'Profiling System' has been adopted [9]. In this process we use a decision tree in order to classify applicants as high risk and low risk. An applicant who falls in the low risk category has a good financial reputation and thus stands a higher chance of their loan being accepted.

Fig.1 represents a small illustrative sample of the decision tree where few of the attributes have been presented in order to get an idea of the process. The original decision tree for the problem set includes many more attributes like sex, profession, dependents etc providing many more profiling patterns which is quite large in comparison.



**Key:-**  
D.R : Default Ratio (No. of defaults/No. of loans)  
H.R : High Risk  
L.R : Low Risk

Fig 1. Decision Tree

In the above tree, based on the applicant's age and whether or not they live in an owned or rented place their default ratios vary and thus result in classifying them as high or low risk candidates.

##### B. FACTS & RULES.

Before we begin to write down the rules, it is important to determine all the facts that are concerned with the structure of the problem. This can be done by looking through all the data that has been collected in Phase I. The following presents the various facts in reference to housing loans. Here every fact has been substituted with a single word in order to ease the process of rule writing.

Note:- Here are some of the banking jargons used to formulate the Facts below.

- a. **Loan amount:** This is the amount of loan the customer i.e the loan applicant wishes to acquire from the bank.
- b. **Collateral:** This is the loan applicant's assets that can be seized on failure to repay the loan amount.
- c. **Equated monthly installment:** This includes the monthly installments the loan applicant makes in order to repay the loan which is an aggregation of the interest rates on the loan amount as well.
- d. **Joint-borrower:** This person can be considered as the secondary loan applicant who aids the primary loan applicant in repaying the loan.
- e. **Take-home:** This is the amount of income a person makes monthly after deduction of taxes, insurances etc.
- f. **Financial reputation:** This includes the qualitative aspect of the loan applicant. This includes profiling of the applicant, making the applicant high or low risk candidate as discussed in the decision tree above.
- g. **Credit Rating:** This presents the CIBIL score of the applicant which is based on the applicant's ongoing loans if any, past loan or credit card defaults etc.

**FACTS**

- OK (Grant loan)
  - COLLAT (Collateral for the loan is sufficient)
  - APP (value on the collateral is greater than loan amount)
  - INC (60% take-home of applicant is greater than equated monthly instalment)
  - PYMT (applicant is able to pay the loan)
  - JBPYMT (applicant + joint-borrower is able to pay the loan)
  - JBINC (60% take-home of applicant + joint-borrower is greater than equated monthly instalment)
  - REP (applicant has a good financial reputation)
  - RATING (applicant has a good credit rating and applicant falls under the low risk category.)
  - BAL (40 times take-home is greater than loan amount)
  - JBBAL (40 times take-home of loan applicant + joint-borrower is greater than loan amount)
- A combination of facts above are used in order to determine if the applicant is illegible for the loan. Rules are formulated accordingly [5].

**RULES**

1. **if** (APP)  
**then** (COLLAT)
2. **if** (RATING)  
**then** (REP)
3. **if** (INC)  
**then** (PYMT)
4. **if** (JBINC)  
**then** (JBPYMT)
5. **if** (COLLAT) **and** (PYMT) **and** (REP)  
**then** (OK)
6. **if** (BAL) **and** (COLLAT) **and** (PYMT)  
**then** OK
7. **if** (COLLAT) **and** (JBBAL) **and** (JBPYMT)  
**then** OK
8. **if** (COLLAT) **and** (BAL) **and** (JBPYMT)  
**then** (OK)

Fig 2. shows the different possible solutions to granting the home loan. It is possible for an applicant to have more than one solution in order to be eligible for the disbursement of the loan.

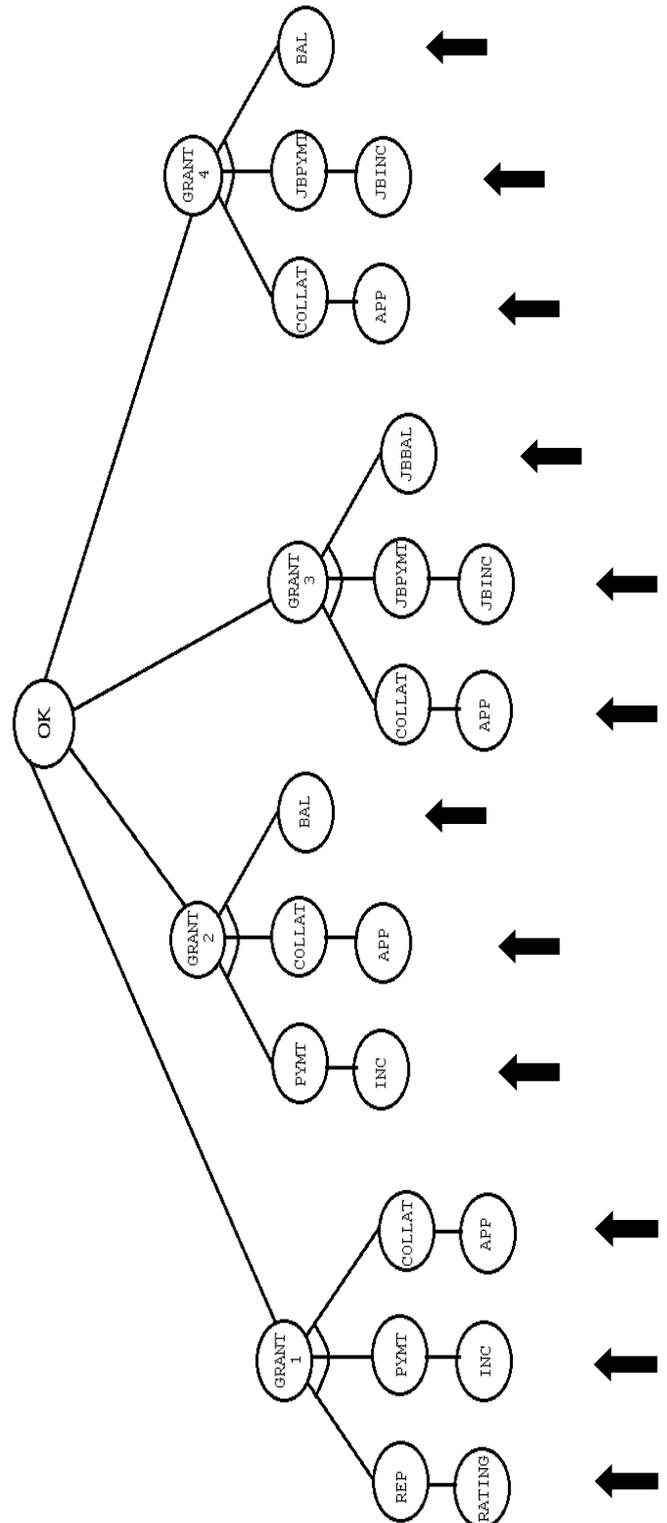


Fig 2. Backward Chaining for Home Loan

**I. IMPLEMENTATION**

The implementation of the project is a two part process which includes Knowledge Acquisition and Software Design.

### A. KNOWLEDGE ACQUISITION

This process includes three major aspects which are Document Analysis, Knowledge Elicitation from Experts and Validating and Verifying the Knowledge from the domain Experts [2] and [3].

#### 1) Document Analysis:

Disbursement of home loans are assessed based on the credit worthiness of an individual. Accepting or rejecting a loan is calculated from the financial history and current assets and liabilities of the applicants. Three criteria need to be studied in order to make sure that the expert system that is being developed includes all the aspects pertaining to home loans:

- The Client Study Analysis: This contains the client five C's Merit Creditworthiness (characters, capacity, circumstances, capital, and collateral).
- Loan Study Analysis: This contains the personal interviews and the field visits. It also includes consideration of the feasibility and risks involved for the banks in providing the respective housing loans.
- The Collaterals: The last one is the collaterals, it is classified to eight kinds the Bank guarantee, real Estate, deposit account, promissory notes, holding company guarantee, storage of the product, personal guarantee and over Draft Guarantee.

It is important to study the above three criteria well so that it aids in developing a system that will provide most accurate results and will consider all possible solutions.

#### 2) Knowledge Elicitation from Experts:

The process of collecting information about a domain for use in a rule-based system is called knowledge engineering. The information obtained from the experts included:

- Requirements: Looking at the problems the system needs to solve is the first step. However, this is an ongoing process as many problems and solutions to those problems might not be fully understood until later in the process. It can give us a clear understanding as to what the exact problems are and brainstorming solutions in this aspect became much easier. Experts help us understand the directions in which they approach a problem, their difficulties and their limits. Getting a better understanding of these criteria help develop a system that resembles a way in which human experts take decisions and also make an attempt to overcome their limitations.
- Principles: This gives an understanding of the entire loan processing. From the time the applicant requests for a loan, the steps and procedures that the expert is expected to carry out in order to come to a decision as to grant or reject the loan was recorded. This helps to create a mental model for proper structuring of the algorithm to be used.
- Resources: This gives an insight to all the parameters and details that need to be collected. All the required formulae for calculations, the rates of interest and the criteria for deciding the period for the repayment of the loan.
- Frontiers: Every domain has its dark corners and dead ends. Understanding the need to out where the tough bits, ambiguities, and limits of human understanding is highly crucial. Understanding cases in which expectations are

made and areas where the system could fail to operate in should also be understood.

#### 3) Validating and Verifying the Knowledge from the domain Experts:

The extracted and elicited knowledge have been validated, verified, and updated with the domain experts and they also provided other knowledge to complete it, the experts' contribution appeared in different aspects of the system. Additional books and references and guidance from the internet also aid this process.

### B. SOFTWARE DESIGN

The application is developed using Eclipse Kepler which is an integrated development environment (IDE), Java Swing for the frontend and MySQL database server. JESS rule language was used to implement the application. JESS is an interpreter for the JESS rule-language and its syntax is similar to that of LISP. JESS is dynamic and java centric, so it automatically gives you access to all of Java's powerful API's for networking, graphics and so on [3].

The MySQL database server keeps a record of all the bank customers, each customer having a unique identity. When a customer applies for a home loan, that customer needs to have an account with the bank else the loan will not be granted. A validation message is displayed as in Fig 3. The database server maintains another record of all the details of the home loans that customers apply for along with the status of the loan (grant or reject).



Fig 3. Validation error.

The application acquires all the details it needs from the customers and then carries out the computations as required using the various rules and finally prints a report. The report prints the information provided by the customer and also provides the customer with details concerned with the status of the loan and recommendations in case of rejections. Fig 4. and Fig 5. presents two case scenarios.

As it can be observed in Fig 4. that the Loan Acceptance Criteria posits three possible solutions giving the loan applicant the freedom to choose any one of the three

options in this case. For instance the loan applicant can choose to repay the loan individually or can share the repayment with the joint-borrower making the application quite flexible. Similarly in Fig 5. where the loan applicant has been rejected for the loan, the Loan Rejection Criteria provides a reason as to why the loan was rejected and provides the loan applicant with possible solutions helping the applicant take an appropriate decision. The recommendations have been acquired by iterative mathematical process based on the information provided.



Fig 4. Loan Accepted

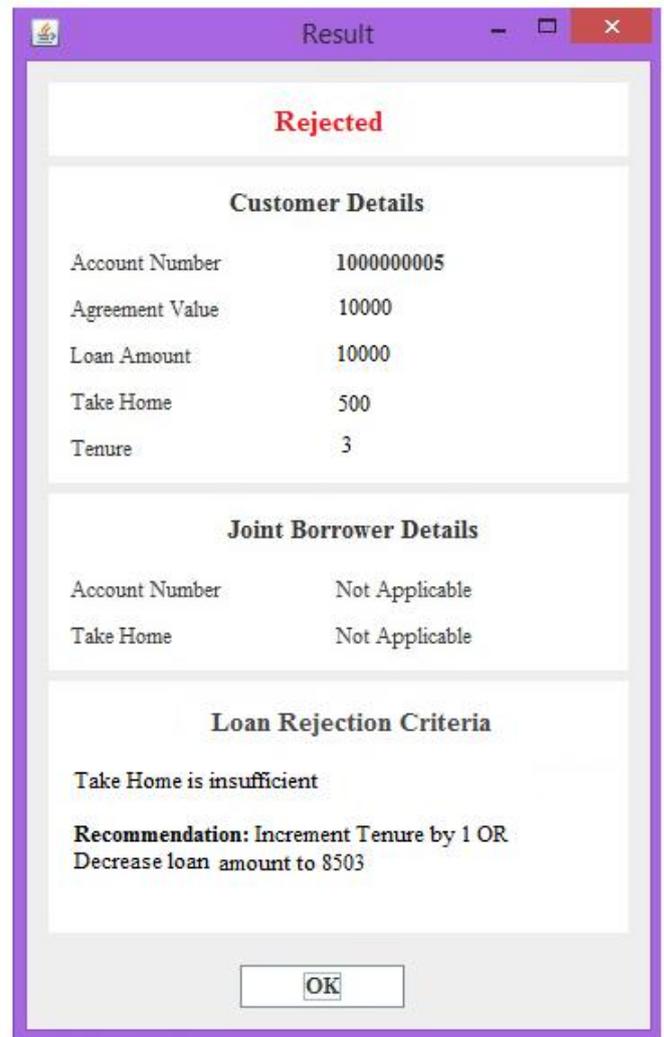


Fig 5. Loan Rejected

## V. RESULT

The ideas proposed above have been implemented and verified by a series of tests that were carried out. Past applicants who had applied for home loans were considered. Their information was used as input to the system and the system's output was compared to the decision taken by the loan officers in the past. In most cases the results were identical. Those that were not, in some cases provided alternative solutions enabling rejected candidates an opportunity to apply for the loan. In some cases the loan applicants were rejected by the system which were approved by the loan officer. In these cases though the system disagreed with the expert, it was found that the system had better assessments since the loans in reality were defaulted by the applicants.

## VI. CONCLUSION

The major contribution of this research is to propose an expert system for evaluating and supporting decisions for disbursement of home loans. This application is designed not only to justify the chosen decision, but also to make recommendations to the process. The system can help the

human experts as well as loan applicants in explaining why a particular decision is made. It can evaluate the credit-worthiness of applicants. The system can help home loan applicants by expediting the loan application process providing the customers with a well-informed unbiased decision. It also provides applicants with recommendations enabling them to make decisions according to their preferences and convenience. It can also aid a loan officer in the risk assessment and completion of a loan process. It can help in training new employees, to improve productivity and it also enhances customer satisfaction.

## VII. ACKNOWLEDGMENT

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