

# HOME LOAN MORTGAGE APPROVAL EXPERT SYSTEM USING CLIPS

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## ABSTRACT

This paper presents the works of designing an expert system that aims to assist the bank agents in approving home loan mortgage. There are many criteria to be considered when deciding whether to approve or reject an application of home loan. CLIPS language is used as a tool for designing this expert system. The expert system takes simple answers from the users and generates the final output according to the rules.

**Keywords:** *Expert Systems, CLIPS, Home Loan Mortgage Approval*

## 1. INTRODUCTION

The finance domain has been a hot topic for Expert System development in the past few decades. Expert systems such as Fineva, Port-man and SEAC etc has covered most of the finance domain including performance evaluation, investment portfolio management, loan approval rating, etc. In this study, five expert systems involve in finance domain are evaluated.

According to our knowledge, there are very less people designed expert systems for home loan mortgage approval. Much of the focus is on big firms and banks, while the subject of home loan approval or investment is rarely mentioned. So in this work, we will present a thorough study on the related work involving expert system used in the finance domain in Section 2, which include the technical detail, and the advantages and challenges of each system, followed by the Problem Statement and Motivation of our study in Section 3.

An overview of the meaning of expert system is discussed in Section 4. The proposed methodology is further explored in Section 5 and Section 6 will conclude our study.

## 2. RELATED WORKS

### 2.1 FINEVA- an expert system for financial analysis of firms

#### Objective:

FINEVA assesses corporate performance and viability by evaluating the financial status and the quality of the firm as shown in Figure 1 (Matsatsinis, Doumpos, & Zopounidis, 1997; Nedović & Devedžić, 2002). FINEVA uses the decision table to efficiently acquire knowledge from experts and decision table for graphical representation of the acquired knowledge

#### Technical detail:

Financial ratio can be divided into three groups (profitability ratio, solvency ratio and managerial performance ratio)

- Profitability ratio: examine industrial profitability (profitability of total assets), financial profitability (stockholder's equity), gross profit to total assets ratio and profit margin.
- Solvency ratio: analyze short-term debt, long-term debt capacity, global debt capacity, general liquidity and direct liquidity

- Managerial performance ratio: evaluate interest expenses, general and administrative expenses, mean receiving period of account receivable and mean payment period of account payable.

Qualitative criteria: evaluate managers' work experience, firm's market position, technical structure-facilities, organization personnel, firm's special advantages, and market flexibility.

Each one of these criteria is modeled using five-point criteria: not satisfactory, medium, satisfactory, very satisfactory and perfect.

The knowledge-base through production rules and meta-rules

- Total 1693 rules
- 13000 possible combination of evaluation criteria
- Two major set rules – Financial ratio and qualitative evaluation
- First of these sets is divided into three subsets of production rules including a set of profitability rules, a set of solvency rules (including liquidity rules), and a set of managerial performance rules. Each of these subsets is further divided into smaller and more specific subset of production rules as shown in Figure 8.
- Meta rules control and guide the inference process to specific sets of production rules or even the modification of production rules. In other word, it represents special cases using heuristics,

The inference engine employs both the forward- and the backward-chaining method to draw conclusions about the performance of the examined companies.

- Forward-chaining: guide inference process to a set of rules (meta-reasoning)
- Backward-chaining: derive conclusion

#### **Advantages:**

- reduce the time needed to reach the final estimation

- inference strategy closely reflects human-expert logic and decision making in the domain (using heuristic)

#### **Challenges:**

- Do not provide an estimation needed to draw a conclusion
- The accuracy of the conclusion reached depends on the amount of the available data
- Expensive
- Required long hours of training for employee to familiarize with the system

### **2.2 PORT-MAN- an expert system for portfolio management in banks**

Port-Man expert system has been developed by Chan et al. (1989) at the La Trobe University in Bundoora, Australia. Port-Man is a banking advisory system designed to assist bank officers to give advice on personal investment in a bank

#### **Objective:**

- Select a range of bank products that will satisfy the criteria for investment
- Rank selected products according to the rates of return of the investment and risk levels
- Take into consideration various side-effects for the investor, such as tax variation or pension adjustment
- Provide justification of how a product is selected

#### **Technical detail:**

1. Consultation divided into 4 stages:

i. Information acquisition

System acquires personal information about the investor, including searching for personal record in database, updating record etc through a set of questions about investment objectives and criteria

ii. Product selection

System searches for feasible products for the investment using tree search algorithm. Products are divided into different groups according to the product features. The product groups form a tree, with the most general group as the root node and

the more specific sub-product groups as the successor nodes. Search in a depth-first manner.

If match, the system continues its search at this node and at the successor nodes. If not match, system prunes the branch from that node and backtracks to another unvisited branch of the most recent predecessor node. If undecided, system requests for more information

### iii. Choice refinement

The system considers the various side-effects that the products may have for the investors through warning messages. The system may also recommend the period of investment for some of the selected products. Product ranking also takes place at this stage according to rate of return and risk level.

### iv. Explanation

System answer the how or why a product is selected by recording every decision and justification when it traverses along the product tree.

2. Use frame for knowledge representation. Production with similar features are group together.
3. Use production rule for control knowledge of product selection. Rules are group together and attach to appropriate frame. The control becomes modular and local to the frames

Six classes of frame

#### i. Customer frames

Contain personal record of each investor including personal fact and history of previous consultation

#### ii. Target frames

Record particular investment objectives, required product features, justification, and investment criteria. Also has a set of attached rules to guide system search along production tree

#### iii. Product frames

Product classified into groups which form a hierarchical tree. Product frame is a node in the hierarchical tree. Describe the common feature of product group. Has a set of attached rules to guide search for sub-product groups

#### iv. Variable frames

Frame to control and record how value is derived. Store rule required, if-needed function, value derived and context of parameter.

#### v. Control frames

Contains a list of tasks to be performed. A task is an action to be taken by the system and consists of a function that is to be executed. The name of the function is held in the control slot of the frame

#### vi. Objective frames

Link together. Define the purpose for the goal and contain the name of the variable frame or previous objective frame from where the goal originated

4. Have XL, an expert system provides both syntactic and functional level manipulations of frames and rules. indexes rules by means of two master control frames (MCF-s) called the LHS-frame and RHS-frame

- i. LHS-frame: comprise of the antecedent (condition) of a rule
- ii. RHS-frame: comprise of the consequent (conclusion) of a rule

#### Advantages:

- Solve non-consistency of the advice given by bank officers
- Speed up consultation process
- Standardize the experience of bank's financial consultants
- Allows the user to change any previous input or investment criteria
- MCFs allow the rules to be grouped together by means of one expand statement
- Maintenance can be automated
- Allows the user to examine the current chain of reasoning during the consultation and how the system has arrived at the solution
- Help the bank consultants to feedback their experience and to make recommendations to the system

#### Challenges:

- Troublesome to replace old product frame

- Required a lot of searching if rule base is large
- Required training for employee to familiarize with products
- Expensive

### **2.3 INVEX - an expert system in the field of investment management.**

INVEX is an expert system proposed by Vraneš, Stanojević, Stevanović, and Lučin (1996) that focus on investment management and advisory.

#### **How it works:**

1. Inputs in MS-Excel from customer about preferences and intentions builds up his profile
2. The preferences and intentions are translated using production rules into the weights assigned to the different objectives in the multicriteria analysis knowledge source.
3. INVEX divides the investments into five groups according to the values of dynamic parameters.
4. It automatically accepts the investments from the group VERY GOOD for the multicriteria decision making(MCDM) and rejects those from the group VERY BAD.
5. For group GOOD, MEDIUM and BAD, a group-specific sensitivity analysis (GSSA) is performed and ask user whether to accept or reject the investments.

#### **Technical Details:**

INVEX uses four dynamic indicators of project desirability:

- i. Relative net present value of investment(v);
- ii. Return on investment(r);
- iii. Payback period(p);
- iv. Period of achieving the critical breakeven point in the exploitation of investment when the net flow becomes positive(c);

Five groups: VERY GOOD - A, GOOD - B, MEDIUM - C, BAD - D, VERY BAD – E

- Blackboard-based Expert System Toolkit (BEST) allows its users to combine different methods or paradigms according to the type of partial problem at hand, where each knowledge source is a single paradigm program.
- With BEST, the decision-makers are provided with the 'what-if' capability; that is, the capability to change initial data or partial result, or to provide feedback and then allow them to revise their decisions based upon these changes.
- For the purpose of project analysis, a stage-by-stage integrated graphical approach is adopted, which uses standard tables based on an integrated documentation system.
- Excel spreadsheet is used as a front-end interface.
- Both BEST and Excel run under Windows 3.1, with intrinsic gateways among the applications (DDE- Dynamic Data Exchange protocol). The summary tables for the alternative projects and project designs are communicated (through standard DDE) to the BEST-based intelligent server in the background which provides value beyond automation.
- INVEX uses human expert knowledge for heuristic investment classification and ranking, blended with conventional multicriteria analysis and risk assessment methods. Different methodologies are used for different analysis and different programming paradigms are respected for implementing the corresponding knowledge sources. Intermediate data and partial results and decisions are communicated among knowledge sources through a shared data repository, called a blackboard.
- Multicriteria decision-making (MCDM). Investments from the group VERY GOOD are accepted for MCDM, while investments from the group VERY BAD are rejected.
- Group-specific sensitivity analysis (GSSA). For the investments from the group GOOD, MEDIUM and BAD, a GSSA is performed and then a user is asked whether to accept or reject each of these investments.
- Noticed that the criteria of determining which investment belongs to which group are not precisely determined, therefore fuzzy set

theory is used to describe the criteria and determine to which of the five groups each investment belongs. Each criterion is represented by one fuzzy set, as well as each group. An investment can belong to many groups simultaneously but with different membership grade values, thus making boundaries between the groups fuzzy.

#### **Advantages:**

- to guide the project analyst and investment decision-maker in their choice among alternative projects and project designs.
- allows exploration of the knowledge base using alternative reasoning strategies (hypothesis reasoning).
- facilitates a rapid response to unforeseen changes allowing the implication of changes in hypothesis to be reflected immediately by logical propagation
- knows how to deal with imprecise, unreliable and uncertain data and/ or knowledge
- provides a flexible, systematically organized and accessible repository for the shared knowledge of various aspects of the decision-making process.

#### **Challenges:**

- Large sums of money are involved
- The decision has to be taken under uncertain conditions
- The decision taken is not easily reversed once taken.
- The multiparadigm method adopted is somewhat complex.

### **2.4 SEAC - An Expert System for Loan Granting**

SEAC is an expert system proposed by Pinson (1987) that focus on loan granting and risk analysis on firm.

#### **How it works:**

1. It asks for minimum data from the customers at the beginning and asks questions if the information is needed in the reasoning process.
2. Starting with the importance and the values of the chosen applicant's

characteristics, it evaluates the quality of each function of the firm. Functions taken into account by SEAC include: the commercial function, the production and operations function, the human resources function, and the financial function.

3. It evaluates the overall soundness of the firm by yielding an overall loan risk value.

SEAC is composed of three components:

1. A rule base which represents the heuristics, rules of thumb of the domain experts.
2. A semantic network which encompasses all the selected facts representing the applicant firm and its environment.
3. An inference engine, which models the reasoning process.

#### **Technical Details:**

1. One of the SEAC's original features is its multilevel processing structure driven by meta-rules. The different tasks communicate through the database. The meta-rules insert them in an agenda that maintains a priority queue of tasks to be performed.
2. Working memory and rule base are the two components of the domain knowledge. Working memory encompasses the applicant firm, industry, economic facts, and assertions. Rule base contains the loan officer's reasoning heuristics. The formalism chosen to represent knowledge depends upon the choice of the inference engine.
3. SNARK is chosen to be utilized as it is a one order inference engine that uses first-order logic to represent knowledge. Its forward reasoning process is well suited to handle the loan granting problem which can be formulated as follows: given the applicant's characteristics, the industry and the bank policy data, what kind of diagnosis can be done and what level of risk can be inferred?
4. The working memory contains two types of knowledge:
  - a. The empirical knowledge of the applicant firm also called descriptive knowledge.
  - b. The knowledge devoted to reasoning also called strategic knowledge, in other words, how should the empirical knowledge be used.

5. The domain knowledge is encoded as production rules which take the following form:
  - a. IF conjunction of conditions
  - b. THEN conjunction of actions
6. The formalism used is the first-order logic. Rules are parameterized by formal variables, which can be instantiated by the objects in the working memory. Within this formalism, all the objects need not be named in the premises of the rule.

#### **Advantages:**

- To guide officers in decision making for loan.
- To shorten the length of time taken of granting a loan

#### **Challenges:**

- Uncertainty handling for weighting the rules.
- Definition of various kind of rules and the interaction among the rules
- It would be better if the system could suggest how much can be loaned given the applicant's data

### **2.5 DEVEX – an expert system for currency exchange advising**

DEVEX is an expert system for currency exchange advising that developed by using EXSYS Professional tool (Nedović & Devedžić, 2002).

#### **Objective:**

It is intended to help people of home business banks who work on various tasks connected with foreign business transactions of concrete bank.

#### **How it works:**

1. It will prepare and process for order of payment to foreign countries arrived. If several orders for payment to foreign countries have arrived, and the bank has limited resources to cover all the order, then the orders will either covered or delayed.
2. It evaluates the assessment of the priorities for payments based on final set of

financial and non-financial criteria-parameters. Each of the criteria will be modeled using an integer number from 0 to 10.

#### **Technical details:**

1. Two knowledge, knowledge of accounting and knowledge of legal regulations are required
2. Accounting knowledge could identify that what accounts will be booked, what accounts have demand or debt balance status and also from what account the payment can be made and in what situation the payment can be made.
3. Legal regulations knowledge can be used in identify that the problem such as whether a payment in cash is possible and when, on what basis the resources can be kept, whether the firms have registered for payment transactions and also the amount of the transactions
4. For certain transactions, documentation would be needed by depending the method of performing the transactions. If the bank possesses the preferred currency, only the payment order and the order for compensation are needed. If not, the additional orders for conversion must exist.

DEVEX consists of:

1. a rule base which consists of 320 rules.
2. an inference engine that draw the conclusion concerning the priorities for payments

Above are the example of criteria for determining the priorities of the payments in DEVEX. The criteria are divided into financial criteria and non-financial criteria. Figure 1 is the example of production rules that calculate the value of parameter c2 shown in criteria.

**IF** (average number of the firm's transactions  $\leq 5$

**AND**

the bank's commission acquired from the firm's transactions  $\geq 10.000$ ) **OR**

(average number of the firm's transactions  $\geq 10$

**AND**

the bank's commission acquired from the firm's transactions  $\leq 10.000$ )

Then C2: = 3

**Figure 1: Production rule of DEVEX**

**Advantages:**

- Helpful in people or employees who worked on tasks that involve foreign business transactions of concrete bank
- Foreign exchange transaction deal with a foreign currency and its equivalent value in local currency on the day of exchange

**Challenge:**

- Figure out a more effective way to exchange with daily changes of the currency
- Home bank could work with several different exchange rates but only one could be used in specific transaction
- The way to ensure the bank has sufficient resources if several orders for payments to foreign countries have arrived, they have to know which order need to be covered and which need to be delayed due to its priorities since the system is currently decided by the employees manually

### **3. PROBLEM STATEMENTS AND MOTIVATION**

The traditional loan approval process has many problems including taking a long time to process each applicant. It usually takes days or weeks depending on the type of loans. It also involves a lot of unnecessary delay between departments such as Credit Checking and Income Tax Checking. The transition from each stage should be stream-lined to a logical process to reduce the time needed and improve the loan approval rate.

Another problem with the current loan approval system focus only on big cooperation, such as SEAC. Bank agents also have to undergo training to use the system which is often sophisticated and there are bounds to be error which will invite disastrous consequences to the whole operation. They are usually expensive and required extensive field-testing, which burn a lot of money and time to make it fully operational. They are also often not

user-friendly. The existing system usually cannot reverse its decision once it is taken.

Our proposed solution is to develop a simple user-friendly Home Loan Mortgage Approval System for bank agents, that do not require much training or expertise, and at the same time, increase the home loan approval rate. The system is able to reverse the decision at crucial stages and use a methodology of a rule-based system to determine whether to approve a loan application or not.

### **4. EXPERT SYSTEM**

An expert system consists of the following components each of which is responsible for one of the aspects in the decision-making process (Rynah Rodrigues, 2015):

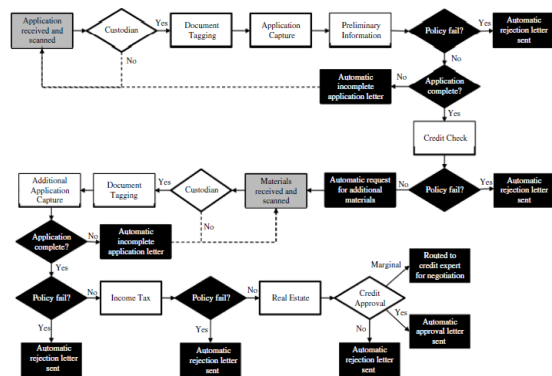
- **Database of Facts:** This holds all the inputs presented by the user. This could be in response to questions prompted by the inference engine as to the existence of particular conditions or the user's current knowledge about the problem at hand.
- **Knowledge Base:** This contains facts and rules. 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

## 5. METHODOLOGY

The development of this home loan mortgage approval expert system is implemented in the CLIPS programming environment (C Language Integrated Production System). This programming tool is designed to facilitate the development of software to model human knowledge or expertise for the finance domain. CLIPS program is used by reason of its flexibility, expandability and low cost. CLIPS supports forward-chaining rules which is suitable for our proposed system.

The rules are used to store the expertise knowledge of a standard home loan approval process, they usually contain a condition statement. When the inference engine is run, all the rules in the rule base check the facts in the fact base and rules whose condition part is matched are executed until no more rules can fire.



**Figure 2: Process flow diagram of Home loan Mortgage**

Figure 2 shows the process flow diagram of the home loan mortgage proposed by Derfler-Rozin, Moore, and Staats (2016). There are usually 17 distinct stages involved in processing a mortgage application for a common bank. After submitted applications were scanned into the information technology system (an activity done by a different group of workers) the application processing group began its work. Each of the stages was considered independent by the bank and this was the level at which activities were assigned.

Each of the 17 stages involved a defined set of activities. For example, at the Custodian stage, operators confirmed that all scans of the materials were legible. At Document Tagging, individuals marked subsections of the document to be

processed at subsequent stages. Then, in stages such as Application Capture or Preliminary Information, individuals entered data from the application into the system.

Our system design followed the above process flow which stream-line the home loan mortgage approval process. It must be noted that our system does not determine the amount of loan approved, rather it only determines whether to approve or reject a home loan application. The expert system developed in this work consists of the user interface for better usability, the explanation facility to explain each stage of the home loan mortgage approval process, the knowledge base that consists of rule usually in conditional statements, and the inference engine which look into rules base and fact base.

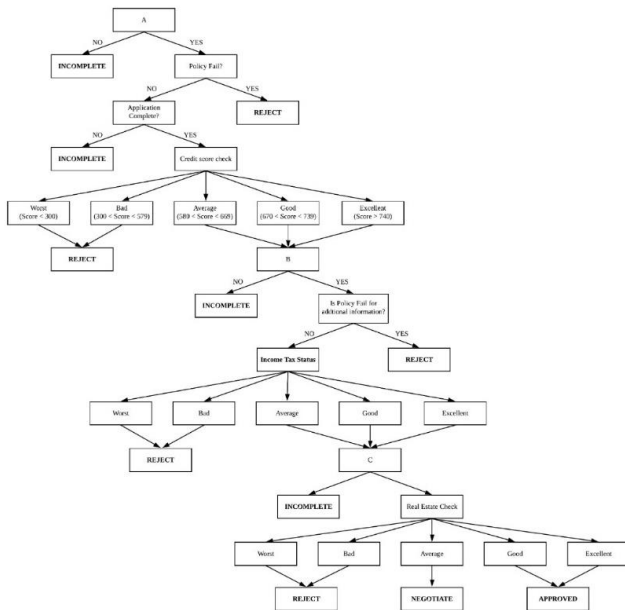
The proposed system will conclude whether to approve an applicant's home loan mortgage based on the conditions outlined. For example, the questions generally involve asking whether the loan applications have been reviewed by Custodian, rate an applicants' credit score, income tax, and real estate appraisal. If the condition is satisfied, an automatic acceptance letter will be generated. If not, it is either advise to credit expert for negotiation or sent an automatic rejection letter to applicants. It consists of around 22 rules.

Some of the techniques involves are Forward-chaining, rule-based system for the document checking, rating system for applicant's credit check, income tax status and real estate appraisal. In the following section, we present the rule and fact for our Home Loan Mortgage Approval System using a decision tree.

### 4.1 Decision Tree

When a loan official assesses an applicant's information, they consciously or unconsciously match it to a certain condition 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 (Rynah Rodrigues, 2015). In this process, we use a decision tree in order to rank condition of the real estate, applicant's credit rating or income tax status as either worst, bad, average, good and excellent. An applicant who falls above average has a good financial reputation and thus stands a higher chance of their loan being accepted. Figure 3 shows the decision tree.





**Figure 3: Decision Tree of proposed system**

The system followed the three main sets of questions represented by A, B, and C, which are:

A: Is the application received, scanned and approved by Custodian?

B: Is the additional material received scanned and approved by Custodian?

C: Is the real estate evaluated by bank's estate agents?

Credit check, income tax status and real estate appraisal is also checked. If at any stage, the applicants falls below average, the system will determine whether to reject or route the applicants to negotiation. The following section is the code of our proposed system using CLIPS.

## 4.2 Code

;; Initialize

(defrule start-up

(initial-fact)

=>

;; Welcome interface

(printout t crlf crlf crlf " Welcome to  
Home Loan Mortgage Approval Expert System"  
crlf)

(printout t crlf crlf crlf " Is the  
application received, scanned and approved by  
Custodian? " crlf)

;; Description

(printout t crlf crlf crlf " \*\*  
Comparison of scanned document to actual  
document to confirm scan is" crlf)

(printout t " of sufficient quality (done  
for both initial and additional data). " crlf)

(printout t crlf crlf crlf "

=====  
=====  
=====  
==" crlf)

(printout t " Enter choice (yes/no) : ")

;; Assert user input as fact

(assert (custodiana (read))))

;; Custodian Stage

(defrule custodiana-yes

(custodiana yes)

=>

(printout t "

=====  
=====  
=====  
==" crlf)

;; Instructions for bank staff

(printout t crlf crlf crlf " Perform  
Document Tagging..." crlf)

(printout t " \*\* Marking of images on  
document scans for subsequent steps (done for  
both" crlf)

(printout t " initial and additional  
data). " crlf)

;; Instructions for bank staff

(printout t crlf crlf " Perform  
Application Capture..." crlf)

(printout t " \*\* Data entry using  
applications (two separate steps each for initial and  
" crlf)

```

        (printout t "      additional application
capture)." crlf)

;; Instructions for bank staff

        (printout t crlf crlf "      Perform Checking
preliminary information ..." crlf)

        (printout t "      ** Additional data entry
from application forms (two separate steps
inputting" crlf)

        (printout t "      data from separate
pages." crlf)

        (printout t crlf crlf "      Is the preliminary
information FAILED to satisfy the bank policy?"
crlf)

        (printout t crlf crlf"
=====
=====
==" crlf)

        (printout t "      Enter choice (yes/no) : ")

        (assert (policy-faila (read))))

;; Continue option

(defrule custodiana-no

        (custodiana no)

=>

        (printout t "
=====
=====
==" crlf)

        (printout t crlf crlf crlf "      Revert back to
checking application....." crlf)

        (printout t "      Do you wish to continue?
"crlf)

        (printout t crlf crlf"
=====
=====
==" crlf)

        (printout t "      Enter choice (yes/no): ")

        (assert (continuea (read))))

```

```

;; Continue check the application

(defrule continuea-yes

        (continuea yes)

=>

        (reset)

        (printout t "
=====
=====
==" crlf)

        (printout t crlf crlf crlf "      Is the
application received, scanned and approved by
Custodian? " crlf)

        (printout t crlf crlf "
=====
=====
==" crlf)

        (printout t "      Enter choice (yes/no): ")

        (assert (custodiana (read))))

;; Not continue, quit the system

(defrule continuea-no

        (continuea no)

=>

        ;; clear all the facts

        (reset)

        ;; remove the initial fact

        (retract 0)

        (printout t "
=====
=====
==" crlf)

        (printout t crlf crlf crlf"      Thank you for
using Home Loan Mortgage Approval System!
Bye!" crlf crlf crlf))

;; first policy fail, reject and quit the system

(defrule policy-faila-yes

        (policy-faila yes)

```

```

=>

(reset)

(retract 0)

(printout t "
=====
=====
==" crlf)

(printout t crlf crlf crlf" Send
Automatic rejection letter!" crlf)

(printout t crlf crlf " Thank you for
using Home Loan Mortgage Approval System!
Bye!" crlf crlf crlf))

;; Application completeness checking stage
(defrule policy-faila-no

(policy-faila no)

=>

(printout t "
=====
=====
==" crlf)

(printout t crlf crlf crlf" Is the
application COMPLETE? " crlf)

(printout t crlf crlf "
=====
=====
==" crlf)

(printout t " Enter choice (yes/no): ")

(assert (application-completea (read))))

;; Credit check stage
(defrule credit-check

(application-completea yes)

=>

(printout t "
=====
=====
==" crlf)

;; Instruction for staff

(printout t crlf crlf crlf" Credit
checking....." crlf)

```

```

(printout t " ** Step 1 a credit check is
requested." crlf)

(printout t " ** Step 2 the data is
entered from the check." crlf)

(printout t crlf crlf " Please rate
applicant credit...." crlf)

;; Rating options

(printout t crlf " 1----Worst (Credit
Score less than 300)" crlf)

(printout t " 2----Bad (Credit Score
300-579)" crlf)

(printout t " 3----Average (Credit
Score 580-669)" crlf)

(printout t " 4----Good (Credit Score
670-739)" crlf)

(printout t " 5----Excellent (Credit
Score above 740)" crlf)

(printout t crlf "
=====
=====
==" crlf)

(printout t " Enter number: ")

;; Store the input as a variable
(bind ?ans (read))

;; if ans greater or equal to 3
(if (>= ?ans 3) then (assert (credit-check-
fail no))))

;; if ans less than 3
(if (< ?ans 3) then (assert (credit-check-
fail yes))))

;; Cannot proceed if incomplete application,
provide option to continue
(defrule incomplete-application

(application-completea no)

=>

(printout t "
=====
=====
==" crlf)

```

```

=====
==" crlf)

    (printout t crlf crlf crlf "    Send
Automatic Incomplete Application letter!" crlf)

    (printout t crlf crlf "    Revert back to
checking application....." crlf)

    (printout t crlf crlf "    Do you wish to
continue? "crlf)

    (printout t crlf crlf"

=====
=====
==" crlf)

    (printout t "    Enter choice (yes/no): ")

    (assert (continuea (read))))

;; Credit fail, reject and quit the system
(defrule credit-check-fail-yes

    (credit-check-fail yes)

    =>

    (printout t "

=====
=====
==" crlf)

    (printout t crlf crlf crlf"    Send
Automatic rejection letter!" crlf)

    (printout t crlf crlf "    Thank you for
using Home Loan Mortgage Approval System!
Bye!" crlf crlf crlf)

;; Credit eligible, proceed checking additional
materials

(defrule credit-check-fail-no

    (credit-check-fail no)

    =>

    (printout t "

=====
=====
==" crlf)

    (printout t crlf crlf crlf"    Credit check
success!" crlf)

    (printout t crlf crlf "    Automatic request
for additional materials..." crlf)

```

```

    (printout t crlf crlf "    Is the additional
materials received, scanned and approved by
Custodian? " crlf)

    (printout t crlf crlf "

=====
=====
==" crlf)

    (printout t "    Enter choice (yes/no): ")

    (assert (custodianb (read))))

;; Custodian stage 2
(defrule custodianb-yes

    (custodianb yes)

    =>

    (printout t "

=====
=====
==" crlf)

    (printout t crlf crlf crlf"    Additional
document is tagged.....done!" crlf)

    (printout t crlf crlf "    Additional
application is capture.....done!"crlf)

    (printout t crlf crlf "    Is the application
complete? (yes/no)" crlf)

    (printout t crlf crlf "

=====
=====
==" crlf)

    (printout t "    Enter choice: ")

    (assert (application-completeb (read))))

;; Cannot proceed if additional materials
incomplete
(defrule custodianb-no

    (custodianb no)

    =>

    (printout t "

=====
=====
==" crlf)

    (printout t crlf crlf crlf"    Revert back to
checking additional materials....." crlf)

```

```

        (printout t crlf crlf "    Do you wish to
continue? (yes/no)"crlf)

        (printout t crlf crlf "
=====
=====
==" crlf)

        (printout t "    Enter choice: ")
        (assert (continueb (read))))

;; Continue checking additional materials
(defrule continueb-yes

    (continueb yes)

    =>

    (reset)

    (printout t "
=====
=====
==" crlf)

        (printout t crlf crlf crlf "    Is the
additional materials received, scanned and
approved by Custodian? (yes/no)" crlf)

        (printout t crlf crlf "
=====
=====
==" crlf)

        (printout t "    Enter choice: ")
        (assert (custodianb (read))))

;; Not continue and quit
(defrule continueb-no

    (continueb no)

    =>

    (reset)

    (retract 0)

    (printout t "
=====
=====
==" crlf)

        (printout t crlf crlf crlf "    Thank you for
using Home Loan Mortgage Approval System!
Bye!" crlf crlf crlf)

```

```

;; Check the additional material fulfill policy
(defrule policy-failb-checking1

    (application-completeb yes)

    =>

    (printout t "
=====
=====
==" crlf)

        (printout t crlf crlf crlf "    Is the
additional information FAILED to satisfy the bank
policy?" crlf)

        (printout t crlf crlf "
=====
=====
==" crlf)

        (printout t "    Enter choice (yes/no): ")
        (assert (policy-failb (read))))

;; Send Incomplete application letter
(defrule policy-failb-checking2

    (application-completeb no)

    =>

    (printout t "
=====
=====
==" crlf)

        (printout t crlf crlf crlf "    Send
Automatic Incomplete Application letter!" crlf)

        (printout t crlf crlf "    Revert back to
checking additional application....." crlf)

        (printout t crlf crlf "    Do you wish to
continue?"crlf)

        (printout t crlf crlf "
=====
=====
==" crlf)

        (printout t "    Enter choice (yes/no): ")
        (assert (continueb (read))))

;; materials not eligible, reject and quit the system

```

```

(defrule policy-failb-yes
  (policy-failb yes)
  =>
  (reset)
  (retract 0)
  (printout t "
=====
=====
==" crlf)

  (printout t crlf crlf crlf"      Send
Automatic rejection letter!" crlf)

  (printout t crlf crlf "      Thank you for
using Home Loan Mortgage Approval System!
Bye!" crlf crlf crlf))

;; Income tax stage
(defrule policy-failb-no
  (policy-failb no)
  =>
  (printout t "
=====
=====
==" crlf)

  ;; Instructions for staff
  (printout t crlf crlf crlf"      Checking
Income tax....." crlf)

  (printout t "      ** Step 1 tax verification
is requested" crlf)

  (printout t "      ** Step 2 the data is
entered from the verification." crlf)

  ;; Rating status
  (printout t crlf crlf "      Please rate
Applicant Income Tax Status...." crlf)

  (printout t crlf "      1----Worst" crlf)
  (printout t "      2----Bad" crlf)
  (printout t "      3----Average" crlf)
  (printout t "      4----Good" crlf)
  (printout t "      5----Excellent" crlf)

```

```

(printout t crlf "
=====
=====
==" crlf)

(printout t "      Enter number: ")
(bind ?ans (read))
(if (>= ?ans 3) then (assert (incometax-fail
no)))
(if (< ?ans 3) then (assert (incometax-fail
yes))))

;; Bad income tax status, reject and quit system
(defrule incometax-fail-yes
  (incometax-fail yes)
  =>
  (reset)
  (retract 0)
  (printout t "
=====
=====
==" crlf)

  (printout t crlf crlf crlf "      Send
Automatic rejection letter!" crlf)

  (printout t crlf crlf "      Thank you for
using Home Loan Mortgage Approval System!
Bye!" crlf))

;; Check appraisal of the home
(defrule incometax-fail-no
  (incometax-fail no)
  =>
  (printout t "
=====
=====
==" crlf)

  (printout t crlf crlf crlf"      Income tax
status...Success!" crlf)

  (printout t crlf crlf "      Is the Real Estate
evaluated by bank's estate agent?(yes/no)" crlf)

  (printout t crlf crlf "
=====
=====
==" crlf)

```

```

=====
==" crlf)

    (printout t "    Enter choice:")

    (assert (realestate-check (read))))

;; Evaluate Appraisal stage

(defrule realestate-check-yes

    (realestate-check yes)

    =>

    (printout t "
=====
=====
==" crlf)

    ;; Instructions for staff

    (printout t crlf crlf crlf "    Evaluating
real estate appraisal....." crlf)

    (printout t "    ** Step 1 a real estate
appraisal is requested" crlf)

    (printout t "    ** Step 2 the data is
entered from the appraisal." crlf)

    ;; Ranking

    (printout t crlf crlf "    Please Rank Real
Estate evaluated by bank's estate agent...."crlf)

    (printout t crlf "    1----Worst (Not
recommend as collateral)" crlf)

    (printout t "    2----Bad (Required
extensive renovation)" crlf)

    (printout t "    3----Average (Required
average renovation)" crlf)

    (printout t "    4----Good (In Good
Condition, recommend as collateral)" crlf)

    (printout t "    5----Excellent (In
Excellent Condition, recommend as collateral)" crlf)

    (printout t crlf "
=====
=====
==" crlf)

    (printout t "    Enter number: ")

    (bind ?ans (read))

```

```

    (if (> ?ans 3) then (assert (approve-credit
yes))))

    (if (= ?ans 3) then (assert (approve-credit
marginal))))

    (if (< ?ans 3) then (assert (approve-credit
no))))

;; Cannot proceed if no appraisal, provide option to
continue

(defrule realestate-check-no

    (realestate-check no)

    =>

    (printout t "
=====
=====
==" crlf)

    (printout t crlf crlf crlf "    Revert back to
checking real estate....." crlf)

    (printout t crlf crlf "    Do you wish to
continue?"crlf)

    (printout t crlf crlf "
=====
=====
==" crlf)

    (printout t "    Enter choice (yes/no): ")

    (assert (continuec (read))))

;; continue checking appraisal

(defrule continuec-yes

    (continuec yes)

    =>

    (reset)

    (printout t crlf crlf crlf "    Real Estate
evaluated by bank's estate agent?" crlf)

    (printout t crlf crlf "
=====
=====
==" crlf)

    (printout t "    Enter choice (yes/no): ")

    (assert (realestate-check (read))))

```

```

;; Not continue, quit
(defrule continuec-no
  (continuec no)
  =>
  (reset)
  (retract 0)
  (printout t "
=====
=====
==" crlf)

  (printout t crlf crlf crlf"      Thank you for
using Home Loan Mortgage Approval System!
Bye!" crlf))

;; Good appraisal credit, approve loan
(defrule approve-credit-yes
  (approve-credit yes)
  =>
  (reset)
  (retract 0)
  (printout t "
=====
=====
==" crlf)

  (printout t crlf crlf crlf"      Action: Sent
Automatic Approval letter!" crlf)

  (printout t crlf crlf "      Thank you for
using Home Loan Mortgage Approval System!
Bye!" crlf crlf crlf))

;; Bad appraisal credit, reject
(defrule approve-credit-no
  (approve-credit no)
  =>
  (reset)
  (retract 0)
  (printout t "
=====
=====

```

```

=====
==" crlf)

  (printout t crlf crlf crlf"      Action: Sent
Automatic Rejection letter!" crlf)

  (printout t crlf crlf "      Thank you for
using Home Loan Mortgage Approval System!
Bye!" crlf crlf crlf))

;; average credit, send to negotiation with credit
expert

(defrule approve-credit-marginal
  (approve-credit marginal)
  =>
  (reset)
  (retract 0)
  (printout t "
=====
=====
==" crlf)

  (printout t crlf crlf crlf"      Action: Route
to credit expert for negotiation!" crlf)

  (printout t crlf crlf "      Thank you for
using Home Loan Mortgage Approval System!
Bye!" crlf crlf crlf))

```

### 4.3 User Interface

In home loan mortgage approval expert system, it provides the communication between users. The user interface is represented as a menu and feedback for which displays the corresponding information to the user. At first, a main menu is displayed on the screen and it will ask user to answer the following questions as shown in Figure 4.

In the main screen as shown in Figure 5, the question ‘Is the application received, scanned and approved by Custodian?’ is asked and users are required to answer with a simple input, yes or no. When users input, the next action or questions will be triggered based on the input given.

Each of the input rows will be surrounded by ‘=’ symbol in order to highlight the region and increase the visibility for that region that required important inputs. The sentence in the system are also well-constructed to prevent all the word being densely packed together as it will make the user difficult to



read through all the sentences or even the word completely.

```
CLIPS> (reset)
CLIPS> (run)

Welcome to Home Loan Mortgage Approval Expert System

Is the application received, scanned and approved by Custodian?

** Comparison of scanned document to actual document to confirm scan is
of sufficient quality (done for both initial and additional data).

=====
Enter choice (yes/no) : ☐
```

**Figure 4: Main menu of the system**

```
Is the application received, scanned and approved by Custodian?

** Comparison of scanned document to actual document to confirm scan is
of sufficient quality (done for both initial and additional data).

=====
Enter choice (yes/no) : yes
=====

Perform Document Tagging...
** Marking of images on document scans for subsequent steps (done for both
initial and additional data).

Perform Application Capture...
** Data entry using applications (two separate steps each for initial and
additional application capture).

Perform Checking preliminary information...
** Additional data entry from application forms (two separate steps inputting
data from separate pages).

Is the preliminary information FAILED to satisfy the bank policy?

=====
Enter choice (yes/no) : yes
=====

Send Automatic rejection letter!

Thank you for using Home Loan Mortgage Approval System! Bye!
```

**Figure 5: Sample flow of the system**

## 6. CONCLUSION

Our proposed system of Home Loan Mortgage Approval System using expert system, written in CLIPS is proven to be one of its kind, as there are yet to have an expert system that focuses on home loan approval. Our system is generally more informative and user-friendly, which mean no training is required. It must be noted that our system does not determine the amount of loan approved, rather it only determines whether to approve or reject a home loan application. Our target user for this system is the home loan officers in banks. The cost of development of this system is low and it is based on the expert knowledge of the home loan mortgage approval process proposed by Derfler-Rozin et al. (2016). Future work will involve determining how much loan is approved for an applicant, accessed the risk of applicants and develop a more interactive GUI

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