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# **A Multi-Layered Framework for Developing a Web-Based Intelligent Corporate Bond Rating Agent**

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## **Abstract**

*This paper describes a Web-based Intelligent Corporate Bond Rating Agent. It is designed to include a real-time dimension in a corporate bond rating information system. By incorporating qualitative variables, the agent also provides a means of supplementing conventional rating approaches. Timely information capabilities of the Web-based Intelligent Corporate Bond Rating Agent would be a benefit for the capital market considering the nonmonotonic nature of rating information systems.*

## **Introduction**

Corporate bond rating system demands quick adjustment to new data or information. As new data or information arrive in the domain, the rating information system should update its knowledge base, as quickly as possible, to maintain the accuracy of its rating evaluation. Information updates, transforms, replaces, or changes knowledge. Therefore, once new pieces of information are received, old knowledge may be no longer true, which is best described by the “*nonmonotonic* attribute” of information. This implies that for the bond rating information system, timely information (i.e., a fast rating release) is desired to the extent that the response time of the rating system to new information is minimized.

To date little research in the corporate bond rating area has dealt with the subject of timeliness. In addition, most past researchers used only financial variables as their measurement. As a result, they excluded some important qualitative consideration. In this paper, we describe the design of the Web-based Intelligent Corporate Bond Rating Agent. The bond rating agent includes a real-time dimension in the corporate bond rating information system and provides a means to supplement conventional rating approaches.

## **Prior Research**

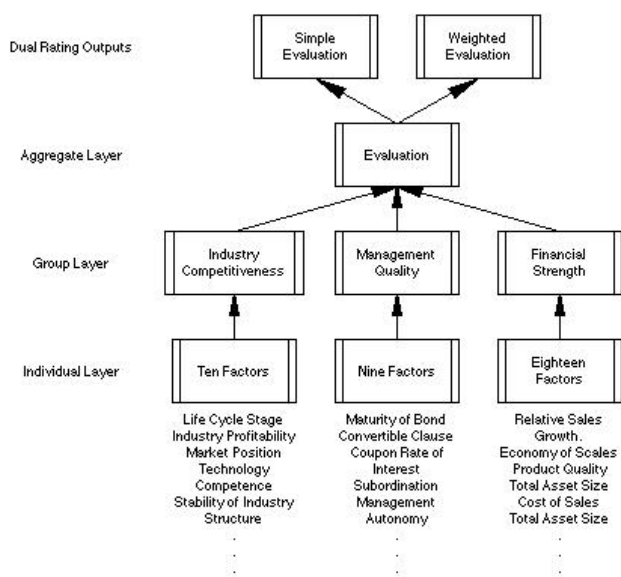
The corporate bond rating situation poses a typical classification problem; transformation of domain information and data (inputs) into rating symbols (outputs) through interpretation of experts (processes). In the past, statistical techniques such as multiple regression analysis, multivariate discriminant analysis were dominant categorization tools. Recently artificial neural networks (ANNs) have gained popularity (Dutta, et al., 1988; Surkan, et al., 1990; Kim, et al., 1993; and Nour, 1994).

Despite much effort of past bond researchers, comparing one research result with another is fairly difficult, due to the diverse algorithms used and/or incompatibility in measurement variables. Further, as mentioned earlier, the timeliness dimension was seldom incorporated in the past literature. This is largely because the prior research is built on the fundamental assumption that the amount of information does not change much over time.

In addition, most researchers excluded the qualitative side of corporate bond rating system by incorporating only financial variables. The supposition of the past research is that financial results of a firm cover all the relevant factors that rating information systems should consider. This past approach can be criticized due to technological breakthroughs that make the traditional accounting and financial processes difficult to access the true value of a firm (Dos Santos, 1991). The prior approaches do not suitably represent knowledge, “the chief ingredient of new economy” (Losee, 1994). Due to the importance of the timeliness attribute of information, response time lags to new information is now directly linked to loss of competitiveness (Dos Santos, 1991).

## **Expert System of the Web Agent**

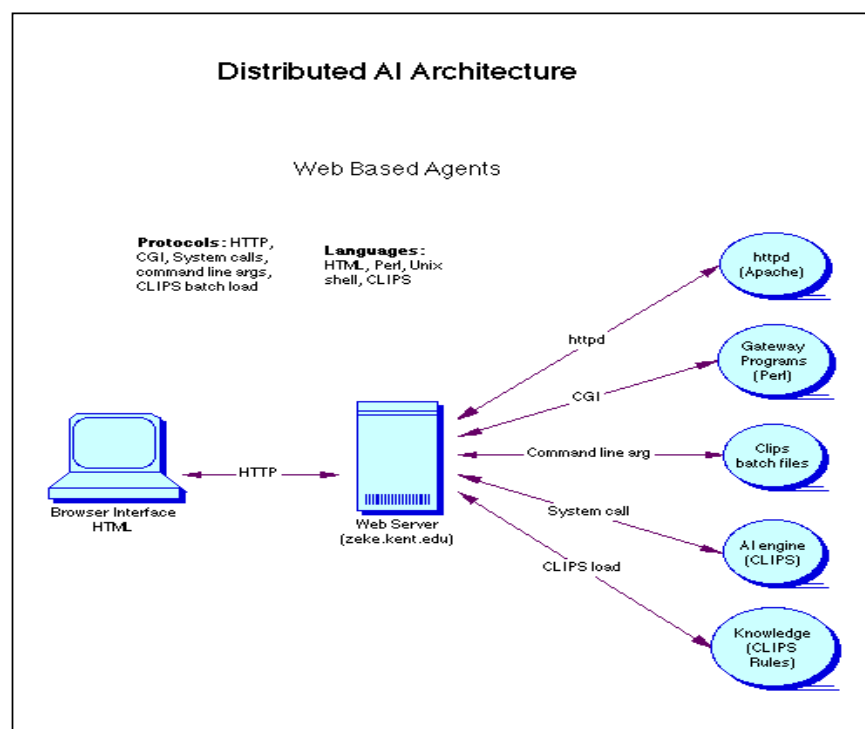
This Web-based intelligent expert system provides a tool to evaluate the creditworthiness of a corporate bond issuer *instantly over any geographical area*, based on three groups of variables (industry, management and financial) in a multi-layered framework. Two groups of qualitative variables, industry and management, are added to supplement the conventional bond rating approaches. The framework for the KBS (knowledge base system) of the bond rating agent is organized into three layers -- individual, group, and aggregate layers. This multi-layered expert framework, adopted from Suh and Madey (1997), is shown in Figure 1. CLIPS (C Language Integrated Production System) is used to capture the knowledge bases of the experts. CLIPS is a multi-paradigm programming language that supports rule-based, object-oriented programming environment.



**Figure 1. A Multi-layered Framework of KBS**

classes -- AAA (extremely strong), AA (very strong), A (strong), BBB (adequate), BB (speculative), B (speculative and uncertain), CCC (poor) -- depending on 64 combinations of evaluation values (4 values for each group and 3 group factors:  $4 \times 4 \times 4 = 64$ ). The aggregate layer then presents the user with a rating class and its explanation. This is a simple-weighted result that is based on combination of the group sums. The agent also provides an additional function at the aggregate layer. That is, the user can assign different significance (weight) to the group sums to do simulation. Following are the individual variables in the groups.

- Industry competitiveness—life cycle stage of industry, profitability of industry, market position of firm, technology competitiveness, stability of industry structure, price competitiveness of firm, niche market possibility, research and development state, business cycle, flexibility.
- Management quality—maturity of bond, convertible clause, subordination, coupon rate of interest, management autonomy, management succession, creative culture, balance of policy, compatibility of management.
- Financial strength—relative sales growth, sales growth rate, economy of scales, product quality, improvement of product quality, total asset size, ratio of sales to net income, cost of sales, appropriateness of accounting procedure, ratio of sales to interest payment, appropriateness of investment, cash flow/total debt, quick ratio, liquidity ratio, inventory turnover, sales turnover, equity/debt, trend of equity to debt.



**Figure 2. Architecture of Web-based Bond Rating Agent**

## Architecture of the Intelligent Rating Agent

Figure 2 shows the architecture of the intelligent corporate bond rating agent that has three major components: a) a user's interface, b) a gateway that provides connectivity between the user and the corporate bond rating expert, and c) the rating expert system that is organized in the multi-layered framework explained earlier. Detailed description of how the multi-layered knowledge base system works is also found in the following Layers and Variable section. Figure 2 also specifies the protocols and languages that the intelligent bond rating agent employs. For example, the protocols that the intelligent bond rating agent uses are HTTP, CGI, System calls, etc. Languages being used are HTML, PERL, UNIX shell scripts, and CLIPS.

## Layers and Variables

The individual layer receives a user's response. Each response to an individual layer is weighted and then is summed at the group layer. The sum of a user's responses will be translated into one of four classes-- superior, good, average, or poor. This information feeds into the aggregate layer where the previous information is classified into 7 different bond rating

classes -- AAA (extremely strong), AA (very strong), A (strong), BBB (adequate), BB (speculative), B (speculative and uncertain), CCC (poor) -- depending on 64 combinations of evaluation values (4 values for each group and 3 group factors:  $4 \times 4 \times 4 = 64$ ). The aggregate layer then presents the user with a rating class and its explanation. This is a simple-weighted result that is based on combination of the group sums. The agent also provides an additional function at the aggregate layer. That is, the user can assign different significance (weight) to the group sums to do simulation. Following are the individual variables in the groups.

## Variable Significance

At the aggregate layer, the user can simulate his/her weighting factors using different subjective attachments to the group sum. First, the expert system asks the user's relative significance of each group factor (i.e., industry: management: finance = 20%: 30%: 50%). And then an aggregate score is provided. The maximum aggregate score is 100. For example, if an aggregate score is 82, the user may assume some range of values for rating, together with a simple-weighted result.

- To run the program, go to <http://zeke.kent.edu/~lee/Jess30/bond.cgi>.

## Limitations/Conclusions

The fundamental assumption of this study is that the intrinsic value of information in financial analysis is nonmonotonic. As nonmonotonicity applies to the rating information system, so it does to the program coding. Therefore, the problem of truth maintenance arises. A periodic review should be exercised to maintain the correctness of the autoepistemic-reasoning base of the experts.

The concepts of fuzzy logic and ANNs are not explicitly incorporated in the program. But the agent tries to resolve decision ambiguity by assigning different significant attachments at the aggregate level. Due to the rule-based feature of CLIPS, the knowledge base of the agent can be easily expanded to cover knowledge limitation of the experts and to apply it to related fields such as municipal bond rating or sovereign rating areas. Besides, deployment of this Web technology in some other time-demanding financial applications (i.e. asset pricing, bankruptcy prediction) would be a benefit for the capital market.

In conclusion, this prototype provides instant responses to new information over any geographical area. By using Web technology, it also explores a way of reducing possible temporal difference between the true period of information belongings and rating evaluation based upon that information.

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