An Expert System for Financial Management Consultation.

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1. Introduction

This paper describes our experiences with an expert system that integrates different sorts of expertise for *financial management consultation* and incorporates *Constraint Satisfaction Paradigm* (CSP) and *Best-first Search* (BFS) techniques to guide the consultation task to improve the performance of the inference engine in the previous work expert system [1]. The task of financial consultation is achived based on the analysis of the enterprise's historical and financial information concerning its market characteristics, which determines a selection of *management policies* that are most beneficial to a customer, within an agreed set of standards. See figure 1.

We begin the paper by specifying the overview of the expert system then present the Knowledge Structure and Inference Structure. In the former we describe the heuristics functions to avoid combinatorial explosion in the finding of feasible management policies. In the latter we describe the inference algorithm developed. We will handle a mechanism called the *constraint solver* [2], which propagate the *financial index values* in the financial consultation constraints. Finally we present conclusions and future work.

2. FIMCOES expert system overview

The entire expert system works on the assumption that the user will have sufficiently detailed information to answer all the questions raised by it. The expert system accepts the *financial indices equations* that represent the constraints for the constraint solver and the answers from the user as its input. And through the inference engine each biased financial index is rectifyed with the selection of adequate management policies that repair its constraint violations and minimize the total outstanding deviation.

3. Knowledge structure

In order to perform the financial analysis required, we built a model of the system that adequately captured its salient features. See figure 2. Domain knowledge base is the representation of the *public accountant knowledge* throughout the management policies, which are considered as *rules* invoked as needed. The rules themselves are applied to the financial analysis according to the *financial index intervals propagation* through the *equation base.*

Financial knowledge database:

Main and detailed Management Policies: are the highest level of abstraction of the public accountant. It includes detailed control questionnaires. 'No' and 'Yes' answers in the questionnaires indicate strong and weak spots

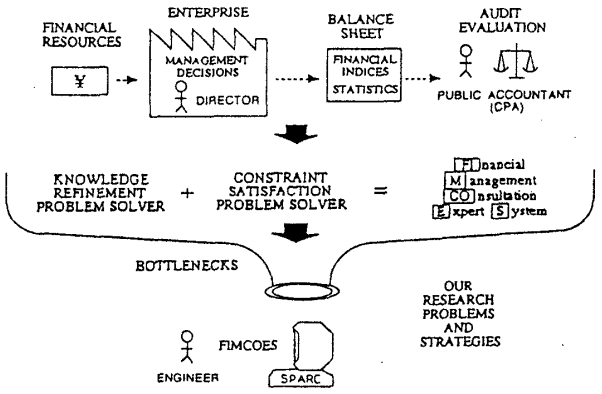

Figure1: Financial Management Consultation Problem

in internal control of the enterprise. Denoted as:
management ← financial indices condition(grade of effect in indices); grade of necessity, questionnaire.

We call the *interaction net of management policies* (INMP), the graph made by connecting *managements* as nodes, when their *financial indices condition* intersect more than 50%.

Financial Indices: these ratios can be taken and derived from common accounting business publications. Their accounting equations constitute what we call the *equation base* and their average standard maximum and minimum values form what we cite as the *financial index normal range interval* (NRI). By comparing key financial indices of an enterprise with those of similar firms in the industry, so FIMCOES can detect impending financial difficulties. The equation base is represented by a *constraint net graph* (CNG) of the constraints. The financial indices are denoted as: *index; grade of operationality, depth in the CNG, NRI*

Company financial information: is the balance sheet of the company, taken from *real data of Japanesse companies.* Denoted by *index(value).*

Searching control strategies:

Financial indices and their relationship to business management decisions form the main framework of the financial management consultation process.

History of the reasoning: to control and identify FIMCOES responsibility for its conclusions from the premises. It will be difficult to know what management policy will be added to the FIMCOES *final recommendation.*

Heuristics: we use them to capture the way in which the public accountant selects and searchs the management policies, forming a *treatment of financial 'health'* for the company.

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•*Management Policy Grade of Necessity* (GN):

$$\sum_{question} \frac{weight(question) \times answer_{ratio}(question)}{length_{questionnaire}}$$

•*Operationality Ratio:*

$$\frac{operationality_{weight}(index_i)}{CNG_{depth}(index_i)}$$

•*g* for the BFS := *number of intervals biased*

•*h* for the BFS := *total deviation of the intervals biased + GN*

•*Heuristic f* for the BFS := g + h

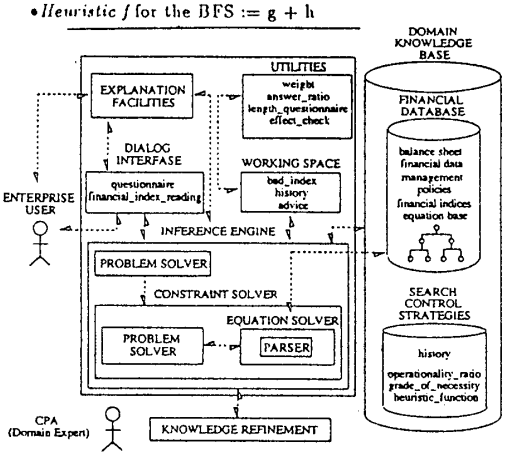

Figure 2: Architecture of the Financial Management Consultation Expert System

4. Inference structure

The basic inference mechanism for accomplishing the consultation task is based on CSP combined with the BFS. The problem-solving under FIMCOES, involves the selection of a sequence of management policies, which will succeed in transforming the *initial state*, given by the balance sheet, into the *goal state*, i.e., all the financial index values under their NRIs.

Inference engine:

1. Constraint solver: is the equation reasoning method.

•*Domain:* is the equation base, i.e., the rules about algebraic relations.

•*Equation solver:* corresponds to the *interval constraint satisfaction problem* (ICSP) *tolerance propagation algorithm* [3]: calculate the *global solution equations* for the *agenda*. Assign *interval values* for the financial indices. For each global solution equation in *Agenda* until *Agenda* is empty: evaluate equation and compare its interval values with the already assigned interval values of the variables in the previous step, if the interval values are equal or a subset eliminate the equation from *Agenda* else modify *Agenda* or end with no solutions.

2. Problem solver: employs the BFS.

Algorithm: repeat the next process until there are not Financial Indices with deviation:

1. Scan Balance Sheet to point out the Financial Indices with deviation in their NRIs responsible for the financial problem of the enterprise.

2. Select $index_i$ with narrowest Interval Value, if there are two indices $i \neq j$ with the same Interval Value length, choose the one with the bigest Operationality Ratio or else random.

3. Search the Management Policies whose *financial indices condition* intersect the $index_i$ and select the *management* with the biggest cardinality intersection.

4. Eliminate the Management Policies that do not rectify the deviation of $index_i$.

5. Place the Management Policies in the OPEN list for the Best-first Search, and add also the *managements* that are contained in their respective Interaction Net of Management Policies.

6. Apply the inference engine to propagate the Interval Values bottom-up. for the *managements* in OPEN, generating the new deviations for Financial Indices in the top of the CNG. Management Policies may introduce new constraints that must be evaluated automatically with the Agenda of the Constraint Solver.

7. Calculate Heuristics and Select the best *management*.

8. Apply the inference engine to propagate the Interval Values, generated by the best *management*, top-down, and update the Financial Indices in the leaves of the CNG.

The reasons why we argue that our present work is more efficient than previous one [1] are because:

• In the previous work the *top-down* propagation was made with estimations about which financial indices and to what degree they will be modified by the propagation, not carrying out the inheritance of the constraints generated by the financial indices values. In the present work this heuristic is not needed due to the CSP that cuts down the searching space.

• The previous work made depth-first search in the financial index space, generating a small set of management policies to test and select for repairing the biased index in question. The present work makes BFS in the management policy space, centering the search to a bigger set of combinations of management policies tested simultaneously in the inference engine as long as the CSP takes care of rectifying deviated indices. In this way the searching is reduced and enforced to be more efficient.

5. Conclusion and future Work

The addition of a constraint solver, results in very positive performance of FIMCOES, i.e., *top-down* and *bottom-up* propagations of indices values throughout the equation base. The heuristic functions adopted contribute to the convergence of the inference engine to generate its recommendations.

A prototype of the system, that runs on Sicstus-Prolog, has been already developed, but it is being redesigned in a different way to improve its efficacy and performance. We will use the benefits of the already designed Constraint Logic Programing Language CAL (ICOT) [2], and examine the Knowledge Refinement Strategies.

References

[1] K. Omachi, "A Knowledge Refinement System in Fixed Task Structure Structure, in the Task Domain of Financial Consultation", B.S. Thesis, 1991.

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[3] Ero Hyvonen, "Constraint reasoning based on interval arithmetic: the tolerance propagation approach". *Artificial Intelligence. Special Volume Constraint-Based Reasoning*. Volume 58. Numbers 1-3. December 1992, pages 71-112.