Applied Expert Systems, E. Turban and P.R. Watkins (Editors)

DEVELOPING CONSOLIDATED FINANCIAL STATEMENTS USING A PROTOTYPE EXPERT SYSTEM

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1. INTRODUCTION

Accountants face a number of judgmental tasks where the questions rarely result in yes or no or black or white responses. Tasks such as these can be addressed using expert systems. The purpose of this paper is to discuss an accounting-based prototype expert system that has been developed to address such a judgmental task.

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TABLE 2
Output of FINSTA--An Aggregated Accounting Statement for Table 1.

Original Number	Title	Dollars
1	Cash	4,048,773
2,3	Special-Deposits and Working--Funds	243,661
4,5	Prepaid Insurance and Other Prepaid Items	379,238
6,7,8,9	Receivables	18,021,847
10,11	Fuel Stock and Plant Materials, Supplies and Merchandise	8,395,121
12	Miscellaneous Current and Accrued Assets	61,032
13,14	Other Investments and Temporary Facilities	1,776,291
15	Net Electric Plant In-Service	327,802,559
16	Electric Plant Construction In-Progress	21,609,430
17,18	Net Steam Plant In-Service and Steam Plant Construction In-Progress	10,700,121
19,20	Net Nonutility Property and Nonutility Property Additions	2,249,256
21,22	Unamortized Discount--Series-D Bonds and Refunding-Cost Series-G Bonds	383,376
23,25	Deferred-Debits Federal--Income Tax and Deferred--Debits Sewer--Use Tax	1,002,837
24	Deferred-Debits Miscellaneous	321,644

1.1. Plan Of This Paper

This paper proceeds as follows. The second section briefly describes some accounting-based expert systems. The third section describes the importance of consolidating financial statements to yield aggregated accounts. The fourth, fifth and sixth sections summarize the judgmental issues in implemented FINSTA. The seventh section discusses some of the limitations and extensions of the system. The eighth section summarizes the paper and some of the contributions of FINSTA.

2. ACCOUNTING-BASED EXPERT SYSTEMS

There are at least two accounting expert systems (AES's) that have been developed for commercial use that have been reported in the literature or at research symposiums. Peat Marwick is currently testing an AES to analyze bank loans (Willingham and Wright [1]). Coopers and Lybrand has implemented a system for tax accrual planning (Shpilberg and Graham [2]). Other AES's are prototype systems, such as the AES developed in this paper including TAXADVISOR (Michaelsen [3]), AUDITOR (Dungan and Chandler [4]) and EDP AUDITOR (Hansen and Messier [5]). TAXADVISOR, designed for use in estate planning, was developed using EMYCIN. AUDITOR, designed for audit-

ing the allowance for bad debts account, was developed using AL/X. EDP AUDITOR, designed for use in auditing EDP systems, was developed using AL/X.

AES prototypes provide a useful tool in accounting research and in accounting practice. Accounting research can use AES prototypes to understand the judgments and heuristics used in a specific decision, to determine the feasibility of developing an AES in a specific area, and to categorize the knowledge in a specific judgmental area: if you can't program a decision making process, it is likely that it is not understood. Accounting practice can use AES to either replace or supplement decision makers.

3. CONSOLIDATION OF ACCOUNTS

Consolidation of accounts is done in order to provide a parsimonious financial statement that is meaningful to users, meet regulation constraints, conform to generally accepted accounting principles (GAAP) and yet does not disclose too much "strategic" information. First, sometimes it is thought that users of financial information should be provided with all available information. However, in his classic paper, Ackoff [6] noted this can lead to an over-abundance of irrelevant information. Second, these statements must reflect the disclosure constraints of regulation as promulgated by the Securities and Exchange Commission (SEC). For example, the SEC requires disclosure of all expenses that are greater than or equal to one percent of sales in the Form 10-K. Third, consolidated statements must conform to GAAP. For example, this means that balance sheet should reflect the liquid nature of the assets and the liabilities. Fourth, as noted in Porter [7] financial statement information can be used to analyze the strategies of a competitor. As a result, firms do not wish to disclose information that can be used to the competitive advantage of their competitors--for example, most firms probably would prefer not to disclose research and development expenditures.

3.1. Approaches to Consolidation

However, there is no generally accepted framework of knowledge for consolidation of financial statement information by aggregating accounts. Accordingly, multiple sources of knowledge are used to develop consolidated financial statements:

1. Theoretical Findings
2. Accounting/Auditing Heuristics
3. Legal Requirements

The limited theoretical work on aggregation in financial statements has suggested some judgmental heuristics. For example, Lev's [8] entropy-based

analysis suggested aggregating accounts whose dollar balances are a small percentage of the total dollar balance of the set of accounts, with other accounts.

Accountants use a number of heuristics to guide their efforts in aggregating information. For example, the materiality of an account is often measured using the rule of thumb that an account is material if it is greater than or equal to 5% of some standard.

Legal requirements primarily include those disclosure requirements promulgated by the Securities and Exchange Commission (SEC), Financial Accounting Standards Board (FASB) and Generally Accepted Auditing Standards (GAAS). These requirements include, for example, disclosure of all expenses that are greater than or equal to 1% of sales in the Form 10-K.

3.2. Implementation of the Consolidation of Financial Statements

FINSTA uses three basic steps to aggregated accounts to develop consolidated financial statements:

1. Determining which accounts should be aggregated,
2. Identifying the sets of accounts that it makes "sense" to aggregate, and
3. Choosing between alternative sets of potential account aggregations.

Each of these steps requires that the system have the knowledge of an accountant. They are implemented using rules and frames. Determining the accounts that should be aggregated involves identifying those accounts that for some reason (e.g., lack of importance or for strategy reasons) should be aggregated with other accounts. Identifying the accounts that can be aggregated is the process of determining which accounts are somewhat similar so that it makes "sense" to aggregate those sets of accounts. Choosing between alternative sets of potential aggregations is the process of choosing between alternative financial reports while meeting the constraints that have been identified in the second step.

4. DETERMINING THE ACCOUNTS THAT SHOULD BE AGGREGATED

Developing a consolidated financial statement where some of the accounts have been aggregated requires determining the "important" accounts. Then the unimportant accounts can be aggregated with other accounts to develop a consolidated financial statement. The development of FINSTA lead to the recognition of three sources of information on which to base the decision to aggregate or not aggregate an account:

1. Account Balance
2. Industry/Company Importance
3. Strategy Security

4.1. Account Balance

Human accountants routinely use the dollar amount of the account to measure the importance of the account. FINSTA also uses this same measure. For those accounts where this measure is below a certain level, FINSTA indicates that they should be aggregated. FINSTA uses a heuristic-based percentage of the total dollar volume. In addition, the total is based on the category totals of the type of assets--for example, current assets. FINSTA uses percentages of the category totals based on the SEC and GAAS percentages.

4.2. Industry/Company Importance

Certain industries require the disclosure of particular accounts either due to regulation by, e.g., the FASB or because of standard industry disclosures. In these cases, those accounts should not be aggregated with other accounts. Alternatively, the company may desire that a particular account is disclosed as a "signal" to the business community or as a measure of its strength or uniqueness.

4.3. Strategy Security

A third approach used by accountants is to determine if there are any potential strategy leaks due to the disclosure of particular accounts. For example, a firm generally would prefer to not disclose research and development expenditures. FINSTA can be used to include this kind of information.

4.4. Example

The accounts from the example that have been chosen for aggregation are summarized in table 3. For purposes of this example, the accounts have been chosen for aggregation based on the number of transactions and the dollar volume of the account.

5. IDENTIFYING SETS OF ACCOUNTS THAT CAN BE AGGREGATED

Next, the human accountant must determine which accounts make "sense" to aggregate with the accounts that have been determined to require aggregation. For example, in table 1, the human accountant would likely decide that it makes "sense" to aggregate the first three items, "Cash," "Special-Deposits," and "Working-Funds," while the accountant would decide that it may not make "sense" to aggregate "Cash" and "Net Electric Plant In-Service". What knowledge would the accountant use to make such a decision?

5.1. Accounting Language Processing

The accountant has a vocabulary of accounting words that describe the accounts and an understanding of the characteristics that define the

accounts. Two primary characteristics are time frame and liquidity. For example, "Cash" is a short-term and highly liquid asset, whereas, "Net Electric Plant

TABLE 3
The accounts to be aggregated.

Category No.	Serial No.	Title
1	2	Special-Deposits
1	4	Prepaid Insurance
1	5	Other Prepaid Assets
1	6	Notes Receivable
1	8	Other Accounts Receivable
1	9	Rents Receivable
1	10	Fuel Stock
1	12	Miscellaneous Current and Accrued Assets
2	13	Other Investments
2	14	Temporary-Facilities
2	18	Steam Plant Construction In-Progress
2	19	Net Nonutility Property
2	20	Nonutility Property Additions
3	21	Unamortized Discount Series-D Bonds
3	25	Deferred-Debits Sewer-Use Tax

(For the purposes of this example, aggregation is based on the magnitude of the dollar and transaction expenses.)

In-Service," is a long-term asset with very little liquidity. Because those characteristics are different it may not make "sense" to aggregate those particular assets in a consolidated financial statement. FINSTA uses an approach to natural language processing that meets the specific needs of this problem domain.

5.2. Accounting Vocabulary Representation in FINSTA

In each title there is a concept represented by a set of "keywords" and less important words. Accounting vocabulary representation in FINSTA is implemented as follows. To determine the characteristics of an account title, the concept must be found. This is done as follows. First, given an account title, the "importance level" (called the hierarchical level) of each word is determined. Level 1 is treated as the most important and Level 8, the least important--for example, "Net (Level 6), Electric (Level 4), Plant (Level 1), and In-Service (Level 2)." Such hierarchical levels are assigned to the words so the significance of the words in determining the characteristics of the account title are not equal.

FINSTA uses the hierarchical levels found in a table referred to as "Hierarchical Levels of Accounting Words" (see table 3). This table, in the form of a list, is given to FINSTA as a priori knowledge.

Not every word in the table has a unique level. For example, the word "Plant" in "Net Electric Plant In-Service" is a keyword defining the account as a fixed asset. However, the "Plant" in "Plant Materials, Supplies and Merchandise" does not represent the concept for that title. Instead, "Supplies" defines the concept

for that account. The latter is identified by the fact that there is another level 1 word in the title.

This table is not the only table that could be constructed for an AES or a human accountant to represent accounting language. Because this table was designed to meet the needs of this application, it reflects the asset side of the balance sheet, general accounting knowledge and selected electric power industry knowledge required for this application.

Levels were designed to group conceptually similar accounting words that the system would encounter. As a result, there is no strict ordering of importance of the particular levels. Level 1 includes the set of concept describing keywords that FINSTA recognizes. Level 2 summarizes the state of plant assets. Level 3 defines the descriptors associated with receivables. Level 4 reflects the industry-specific descriptors. Level 5 includes the set of descriptors that are not keywords, but are the same as keywords (e.g., Plant Asset as opposed to Plant Supplies).

TABLE 4

Hierarchy levels of accounting (Level 1 is the highest)

Level 1

plant*, property, investments, equipment, cash, special-deposits, working-funds, receivables, stock, supplies, merchandise, materials, prepaid, current, accrued, unamortized discount refunding-cost, temporary-facilities, deferred-debits, inventory

Level 2

In-service, in-progress

Level 3

notes, accounts, rent, bonds

Level 4

Electric, steam, fuel, nonutility, construction, customers, insurance, series-d, series-g, tax

Level 5

plant* (if there are no other components that are Level 1)

Level 6

net

Level 7

other, items, additions, miscellaneous, assets

Level 8

(all other words that do not appear in Levels 1 through 7)

*Note. "plant" is in Levels 1 and 5.

Level 6 summarizes the descriptors deriving from the depreciation or amortization of assets. Level 7 includes the miscellaneous asset descriptors. Level 5, 6, and 7 words generally are not required to derive the "concept" of the particular accounting descriptor.

Second, given that FINSTA has found the concept in a given title, it uses the concept as represented by the appropriate Level 1 word to determine the characteristics associated with the title. The characteristics provide accounting "meaning" of the account to FINSTA. The characteristics are based on the two dimensions of time frame and liquidity. These dimensions typically are used by accountants to develop financial statements. Generally, the time frame determines the category in which the asset is included (e.g., Current or Long-term). In addition, the liquidity determines the order of appearance within a category. Table 4 shows the set of characteristics for time frame and table 5 shows the characteristics of liquidity. Table 6 summarizes FINSTA's knowledge of the assets.

TABLE 5

Vocabulary set of accounting words for time frame

A1. Current (short term)

cash, special-deposits, working-funds, receivable, stock, supplies, merchandise, materials, prepaid, current, accrued, inventory

A2. Long term

investments, plant, property, equipment, temporary-facilities

A3. Deferrals

unamortized-discount, deferred-debits, refunding costs

5.3. Development Of Potential Aggregation Tuples

To develop the potential aggregation sets (tuples), the human accountant may use the accounts that require aggregation and find those accounts that it makes sense to aggregate with them. First, accounts with the same A (table 5) and B (table 6) numbers are grouped together as "original tuples." For example, in table 8, assets (15, 16, 17, 18) constitute an original tuple since they have the same A number 2 and B number 10. These tuples represent one type of potential aggregation of accounts: the set of accounts that have the same time frame and liquidity.

Second, another type of potential aggregation, with greater specificity, is derived from the original tuples by considering their subsets. If a subset contains at least one Level 2, 3, or 4 word in common, then the subset is a potential ag-

TABLE 6
Vocabulary set of accounting words for liquidity

B1.	cash, special-deposits, working funds
B2.	investments
B3.	prepaid
B4.	receivable
B5.	merchandise, inventory
B6.	supplies, stock, materials
B7.	current, accrued
B8.	temporary-facilities
B9.	equipment
B10.	plant
B11.	property
B12.	deferred-debits, refunding-costs, unamortized discount

gregation; otherwise, it is not considered for aggregation. For example, the subset (15, 16) is a potential aggregation tuple since both accounts 15 and 16 contain a common level 4 word "Electric." Subset (15, 16, 17) is not a potential aggregation since there is no common Level 2, 3, 4 word for all the accounts. Table 8 shows the set of potential aggregation tuples for the example.

This second process derives its rationale from using additional information in the development of the potential aggregation tuples. In particular, it allows the grouping of more closely related sets of assets. In addition, this process is frequently used in the development of aggregated financial statements.

6. CHOOSING BETWEEN ALTERNATIVE AGGREGATIONS

Given the set of potential aggregation tuples, the system must choose between the available alternative aggregations. FINSTA uses two heuristic rules to guide the search: (1) minimize the number of accounts that are aggregated, subject to the constraint of aggregating the appropriate accounts. This rule is based on the entropy approach of Lev (1969); and (2) group together similar sized accounts. This rule is based on practical experience and an analysis of the entropy approach.

TABLE 7
FINSTA's Knowledge of the Table 1 Information

A No.	B No.	Serial	Title	Dollars	Transactions
1	1	1	Cash	4,048,773	167,354
1	1	2	Special-Deposits	1,166	87
1	1	3	Working-Funds	242,495	608,959
1	3	4	Prepaid Insurance	369,210	894
1	3	5	Other Prepaid Items	10,028	742
1	4	6	Notes Receivable	53,004	911
1	4	7	Customer Accounts Receivable	17,448,883	17,392,927
1	4	8	Other Accounts Receivable	479,353	74,945
1	4	9	Rents Receivable	40,607	962
1	6	10	Fuel Stock	1,218,478	75
1	6	11	Plant Materials, Supplies and Merchandise	7,176,643	8,056
1	7	12	Miscellaneous Current and Accrued Assets	61,032	1,480
2	2	13	Other Investments	1,758,042	1,358
2	8	14	Temporary-Facilities	18,249	1,040
2	10	15	Net Electrical Plant In-Service	327,802,559	109
2	10	16	Electric Plant Construction In-Progress	21,609,430	723
2	10	17	Net Steam Plant In-Service	10,520,537	15
2	10	18	Steam Plant Construction In-Progress	179,584	76
2	11	19	Net Nonutility Property	2,167,063	201
2	11	20	Nonutility Property Additions	82,193	842
3	12	21	Unamortized Discount Series -D Bonds	41,501	80
3	12	22	Refunding-Cost Series-G Bonds	341,875	120
3	12	23	Deferred-Debits Federal-Income Tax	990,800	89
3	12	24	Deferred-Debits Miscellaneous	321,644	1,655
3	12	25	Deferred-Debits Sewer-Use Tax	12,037	895

The choice between alternative aggregations works as follows. First partition the set of tuples in table 8 into groups of tuples so no elements in one group ever appear in other groups. For table 8, the groups are partitioned as follows (here [] represents a group): [(1,2,3), (1,2), (1,3), (2,3)], [(4,5)], [(6,7,8,9), (7,8)], [(10,11)], [(15,16,17,18,), (15,16), (15,17), (16,18), (17,18)], [(19,18)], [(21,22,23,24,25), (21,22), (23,25)]. After partitioning, an optimal solution may be obtained for each group. Since few tuples are in each group, the number of possible solutions will be relatively small. The set of optimal solutions for all the

TABLE 8
The set of potentially tuples for aggregation.
(The elements in the tuples are the Serial Numbers in Table 1.)

(1, 2, 3)	(1, 2)	(1, 3)
(2, 3)	(4, 5)	(6, 7, 8, 9)
(7, 8)	(10, 11)	(15, 16, 17, 18)
(15, 16)	(15, 17)	(16, 18)
(17, 18)	(19, 20)	(21, 22, 23, 24, 25)
(21, 22)	(23, 25)	

groups gives an optimal solution for the entire problem. To obtain an optimal solution for a group, the following "elimination search" is used. This search is an efficient exhaustive search that constructs a tree of all possible solutions excluding those tuples whose elements have appeared before. The following are the algorithm and an example of its use.

6.1. Elimination Search Algorithm

Construct a tree of all possible solutions. The root of the tree is a dummy node, called "start." Every other node represents a particular tuple, "X" (crossed out) or "N" (No solution).

A1. Place the root "start." For each account to be aggregated that has not been picked up, perform A2 through A3.

A2. Connect all the tuples that satisfy the following to the previous tuple node:

i. the tuple contains the account to be aggregated and

ii. none of the other elements in the tuple has appeared in the partial solution so far.

If there is no such tuple, write "N" in the node.

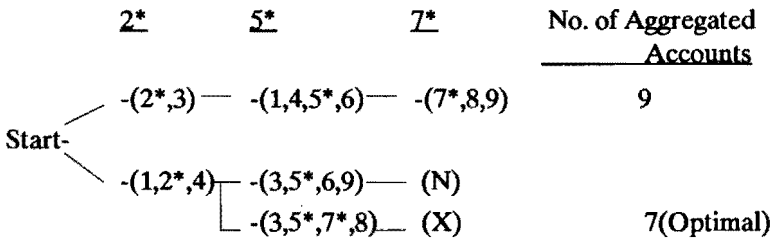
A3. For each tuple in A2, check whether it contains other accounts to be aggregated. If so, cross out the other accounts in the subtree whose root is the tuple.

A4. After all the accounts to be aggregated are picked up in steps A2 and A3, count the number of aggregated accounts for all the solutions. Choose the smallest number solution. If there is a tie, select the one with the smallest difference between the dollar amounts.

6.2. Computational Illustration of Algorithm

Consider the following set of aggregatable tuples in one group (different than the one in table 1): (1,2,4), (1,4,5,6), (2,3), (3,5,6,9), (3,5,7,8), (7,8,9), where the following accounts require aggregation, 2*, 5*, 7*.

The search is as follows.



In order to meet the constraints of aggregating the three accounts, 2, 5 and 7, either four other accounts or six other accounts could be used. The algorithm chose the solution where four other accounts are aggregated.

6.3. Example

Using the information in Table 1 as input, with the accounts in Table 3 requiring aggregation, leads to Table 2. In order to aggregate the 15 accounts in Table 3, only 5 additional accounts were required. However, there was one account, number 12, that should have been aggregated, but was not aggregated. This resulted because no tuples were developed that included account number 12.

7. LIMITATIONS AND EXTENSIONS OF FINSTA

Since FINSTA is a prototype there are necessarily a number of limitations of the system that could be addressed if the system were to be developed for commercial application. However, each of these limitations is easily remedied and does not require further development in this proof of concept.

First, the approach used in this paper is only for the asset portion of the balance sheet. This does not include the income statement or the liability/capital section of the balance sheet. This limitation can be remedied by increasing the scope to include these other areas of financial statements.

Second, as with all natural language like systems, FINSTA has a relatively limited vocabulary. The set of accounting words in the knowledge base can be extended to mitigate this difficulty.

Third, FINSTA does not contain client information. This type of knowledge can improve the match between the financial statements designed by FINSTA and the user's needs. The more specific the information that can be used by the

system, the more likely the financial statements will meet the user's needs. FINSTA can be changed to include client information by interfacing the user with FINSTA or building that information into the knowledge base.

Fourth, FINSTA could be extended to lead to consolidation across companies, rather than just accounts. Although conceptually similar to the aggregation of accounts, there are a number of regulations and rules that require adherence.

8. SUMMARY AND CONTRIBUTIONS OF FINSTA

FINSTA is an AES developed to provide consolidated financial statements The basic contribution is that FINSTA is a computer program that can perform some of the activities of a human accountant. As an example of its capabilities, FINSTA can take table 1 and develop table 2 as the final output. However, FINSTA is an AES that has made five particular contributions. First, FINSTA is the first expert system developed for the design of financial statements. Second, this is one of the first AES designed using Prolog. Third, this is one of the first AES designed using a frame-based knowledge representation. Fourth, this AES provides a first step in the analysis of natural accounting language to aid the solution of the consolidation problem. Fifth, FINSTA summarizes in computer program form much of the current theoretical and practical knowledge of the use of aggregation in accounting.

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