EXPLOITING HYPERTEXT VALUATION LINKS FOR BUSINESS DECISION MAKING: A PORTFOLIO MANAGEMENT ILLUSTRATION

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Abstract

In this paper we discuss the application of hypertext valuation links to decision support for business problems. Valuation links enable us to relate hypertext link traversal to computation in a way that affects the contents of a hypertext node while retaining the "browsing metaphor" of hypertext. This helps to support quantitative or qualitative reasoning about business problems when described in terms of hypertext nodes that are computational in nature. We illustrate these ideas in the domain of securities analysis and portfolio management, where a "buy side" portfolio manager may need to clarify his understanding of the basis of a "sell side" securities analyst's recommendations about securities that are candidates for inclusion in a portfolio.

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1 INTRODUCTION

Hypertext-based systems are rapidly emerging as a viable alternative to the traditional standard for information retrieval and applications interfaces. Hypertext has generally been applied in areas that do not require decision making or problem solving. These include: 1) efficient text search and retrieval in large on-line document or data bases ; 2) collaborative electronic auditing ; 3) databases and model management ; and 4) software engineering. We believe that there is potential to apply hypertext to a broad spectrum of problem solving and decision making contexts in business. To date, however, there has been little research on the use of hypertext as a tool for decision support except for [12] and [3].

In this paper, we explore the applicability of hypertext in a variety of roles, including decision support, in the area of securities analysis and portfolio management. A securities analyst must also attempt to relate sometimes conflicting information from a variety of sources in an effort to develop a buy or sell opinion for a stock. As Jacoby et al. [11] have suggested, the amount of information that must be brought to bear in security analysis decision making is huge. Thus, there is a premium on decision support approaches that not only make available the varied sources of information underlying the decision, but also help the users to understand how an expert analyst structured the information leading up to the final recommendation.

Our approach to the support of the securities analysis process for portfolio management is based on the application of a new hypertext concept: *hypertext valuation link*. This new type of link enables us to relate hypertext link traversal to computation in a way that affects the contents of a hypertext node while retaining the browsing metaphor of hypertext.

This is useful because it can support quantitative or qualitative reasoning about business problems that are described in terms of hypertext nodes that are computational in nature. We now discuss computational power of hypertext, and the new concepts that make this possible.

2 HYPERTEXT FOR BUSINESS DECISION SUPPORT

Our view of the applicability of hypertext to business problem solving follows from results obtained in recent research.

Minch [12] identified a number of decision making characteristics and procedural concerns that are associated with business decision making and are addressable by hypertext systems. These include:

- breaking down the problem solving or decision making process into a set of primitive actions as previously defined by Simon [14], including problem definition and data search, identification of decision alternatives, and selection of an appropriate solution;
- making multiple criteria decision, where "fuzzy" or changing objectives require significant flexibility in decision support;
- maintaining the ability to flexibly switch from subproblem to subproblem as decision making requires;
- solving problems using a more diffuse or non-linear approach, instead of a traditional linear and sequential one.

3 COMPUTATIONAL HYPERTEXT

Next, let's take a closer look at computational hypertext, and the set of concepts that form the basis of our motivation for a new kind of hypertext link that can be applied in business problem solving settings. The term computational hypertext [13] refers to the ability of a hypertext system to perform computations through a programming environment that is integrated into it. Examples of systems that include computational hypertext capabilities are KMS [1], HyperCard and Maluar [10].

3.1 Hypertext Basics: Nodes and Links

The basic building blocks of hypertext applications are nodes and links. Hypertext nodes are the storage locations of chunks of information related to a document, and are alternatively called *frames* or *notecards* [1] [9]. Generally, node types differ according to the storage function that they perform. For example, plain text, a graphical image, an audio track or an executable program can all be stored in nodes. Hypertext links, on the other hand, represent connections between nodes, based on a relationship that is defined by the system or by the user. Links offer the user a mechanism by which to navigate through a hypertext document, and to discover relationships that are not evident when hypertext is unavailable. The link traversal operation is also referred to as "browsing" in some contexts.

We now turn to a closer inspection of link types in hypertext. At this time there is no definitive taxonomy for hypertext links, though it might be useful to have one to untangle the varied definitions of hypertext links that occur in the literature. For example, Nielsen [13] differentiates between *explicit links* and *implicit links.* Explicit links are static links that have a fixed source and a fixed destination. These are the most common types of links. Implicit links are not explicitly defined; instead, they follow from the properties of the system. An example is the glossary look-up capability in Intermedia.

Computed nodes [13] are nodes that are generated by a system. Computed links [13] are determined by the system while the user is interacting with it. For example, the Glasgow Online system determines the actual destination of links pointing to train schedules according to the actual time of link traversal to provide the relevant information. Another term for this type of link is a *dynamic link.*

Byers [5] discusses three different kinds of hypertext links: *thesaurus, static* and *dynamic links.* Thesaurus links map out semantic relations between pairs of terms in a set of index terms. The links remain unchanged as new terms are added to a database, and they are often used in on-line searches of large commercial databases. Static links, however, attach index terms to hypertext nodes, the locations of text, graphics, tables and so on, that hypertext attempts to link together. The terms occur as words in text at the node, and hypertext represents these as being linked to another node. In practice this is done via highlighting the word or through an icon. The third kind of link, a dynamic link, is created when a new link is forged between existing nodes and then stored for future use. According to Byers, dynamic links could be added by users when there was some reason to maintain a link.

3.2 Hypertext Valuation Links

Link traversal affects a user's perception of a hypertext document, though in general it has no impact upon node contents. Instead, the interaction between the structure of nodes and their content has been minimized to formalize hypertext functionality [6] [17]. Even at the level of hypertext querying facilities, however, although the need for interaction between structure and content has been recognized, the content search and structure search are kept separate. Our present interest centers on relating link traversal to computation in a way that affects node contents by using a new kind of link which we call *valuation link*. We believe that the power obtained from such an approach will shift the usage of hypertext from its current and limited role of text retrieval to a more general one which includes decision support and construction of intelligent interfaces. GUIDE [8] provides a useful example here. It includes a facility called a command button, which establishes a relationship between link traversal and computation. However, the effects of the computation do not affect the hyperdocument. Instead, an external program is called.

Valuation links and *valuation nodes*, which we introduce here for the first time, provide simple extensions to hypertext that satisfy the demands of dynamic information environments. Valuation nodes contain expressions (which can range from simple mathematical expression to elaborate computer programs) that the hypertext is able to evaluate. The one constraint is that the expression shall return upon evaluation a single value. In the case of Maluar [10], since the system is implemented in Lisp, any lisp expression can be included in such a node. Valuation links provide the ability to transmit information between hypertext nodes. Normally, the target of a valuation link is a valuation node. We explain the mechanism via the example of Figure 1 which shows two valuation links, a textual node and two valuation nodes. Upon traversal of **link 1**, valuation **node 2** is evaluated and the value 39

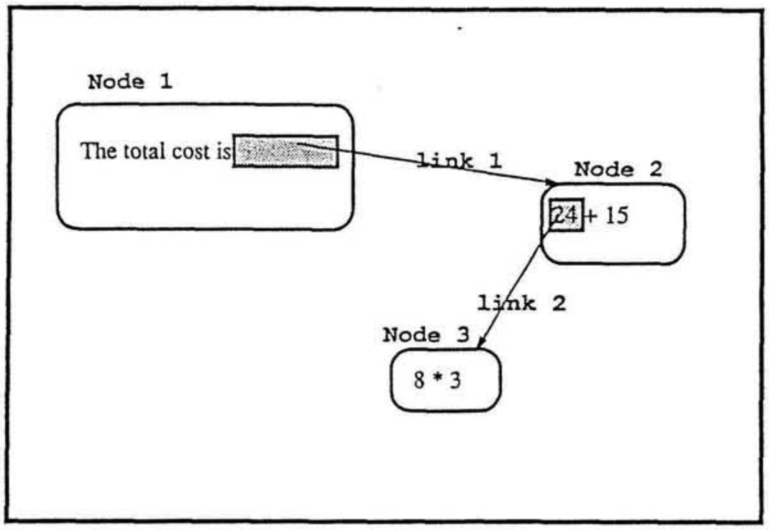

Figure 1: Valuation nodes and valuation links

is returned via **link 1** and pasted in the grayed area of **node 1**. If **node 3** is edited and the number 3 changed to 1, the hypertext automatically traverses link **1** and link **2** updating the grayed areas in both to 8 and 23 respectively. Thus, valuation nodes provide the power to perform local computations and valuation links enhance this power by propagating changes through the hypertext. In order to reduce computation time, specialized algorithms need to be deployed to effectively support computations over the hypertext network. (The reader should refer to Bieber and Isakowitz [4] for additional details on valuation links and valuation nodes.)

Decision support systems need to provide the user with mechanisms to support cross-referencing of heterogeneous information (data, programs, reports, graphs, tables, etc.), as well as tools for performing computations and combining their results. For example, a user of a decision support system (DSS) should be able to perform the following sequence of events with ease: extract information from a database, use that information to evaluate constraints using a spreadsheet model, solve the constraint problem using a linear program and summarize his conclusions in a report which he creates using a word processor. Furthermore, the paths leading to a particular decision should be documented in the DSS since the system was used as an aid to reach that decision. Traditional hypertext is able to document all textual cross-referencing. When it comes to establishing the connections between the different computational steps and automatically streamline these, we need the power of dynamic hypertext. This power can be effectively delivered via the new constructs.

4 ILLUSTRATION DOMAIN: PORTFOLIO MANAGEMENT DECISION SUPPORT

We next discuss how hypertext can support securities analysis in portfolio management. We focus on how the hypertext valuation link concept can be exploited. *Security analysis* is the study of the set of factors that account for variations in the market valuation of a firm's equity. *Portfolio management*, on the other hand, deals with the process of constructing and managing portfolios of financial instruments so as to maximize return in a world of efficient markets.

4.1 Security Analysis and Portfolio Management

Although security analysis activities conducted in the financial community act as a force toward more efficient pricing, investors and portfolio managers are still interested in detecting investment opportunities where the market at large has set a price for a security that is inconsistent with the underlying value of a firm's assets and its future growth opportunities. When a portfolio manager believes that the market has undervalued the security, it will be included in a portfolio with the expectation that the security will deliver returns at higher than the expected rate on the market. Overall, this perspective suggests that portfolio managers believe that investing is still an art, rather than the science that modern finance theory makes it out to be. Yet a troublesome fact remains in this industry: portfolio managers rarely outperform the indicators of market performance as a whole.

Prior research has shown that security analysts track factors that are specific to the firm, as well as factors that are indicative of the firm's ability to compete in its markets against other firms in its industry [2] [16] [7]. Other research has considered the security analyst's use of information [11] [15] and decision making strategies. The overall picture that emerges from this research is that security analysis requires expertise. This includes exceptional information processing capacity; the ability to discern an appropriate subset of relevant firm, market and industry factors; and the willingness to attend to background factors that may not be of importance now, but are potentially crucial.

4.2 The "Buy Side - Sell Side" Conflict: A Conceptual Model

Today, most investment firms employ specialists in security analysis on the "sell side" of the firm. Their primary responsibility is to track multiple securities and to offer opinions to portfolio managers or retail brokers in the "buy side" of an investment management firm, or to sell their research to other firms or individuals in the market. The buy side of the firm is where customer account and portfolio management activities take place. Portfolio managers utilize re-commendations obtained from the sell side analysts, as well as outside vendors, in an attempt to earn better-than-market returns on funds that are under management for their clients. Portfolio managers also act as independent evaluators of the securities they select for investment. They are responsible for managing the investment portfolios of one or more clients who have different investment performance parameters and tolerances for risk.

Under normal circumstances, a portfolio manager is the final decision maker regarding the content of the portfolios managed. Typically, managing a portfolio involves deciding on an appropriate portfolio mix to balance risk and expected reward, in view of the investment goals of the client. This mix is determined using information from sources that are internal to the firm (such as securities analysis performed by the portfolio manager's staff, re-commendations from the buy side analysts, specific directives from senior management or the firm's equity committee) and from external sources (indicators about a company, an industry or the market in general; value-added securities analyses from competing firms; and the opinions of independent experts.) Although the buy side and the sell side have the same sources of information at their disposal, it is not clear that they would arrive at similar recommendations. In fact, there is a significant asymmetry in the assumptions they employ, the kinds of information to which they have ready access and the basis of their individual decisions, decision biases, and assumptions. This asymmetry gives rise to the potential for conflict in the evaluation of securities which are considered for portfolio investments (Figure 2).

4.3 Securities analysis with valuation links

Securities analysts and portfolio managers decide which stock to buy or sell by a complex process involving different types of intermediate decisions based on analyses of data from a variety of sources. There are at least three types of analyses that can be performed: 1) macroeconomics analysis which provides information about the general state of the economy, 2) fundamental analysis which deals with financial information about the firm under consideration, and 3) technical analysis about the market and its influence on stock prices. Each analyst and each manager uses, formally or informally, some kind of *analysis tree* to organize the decision process. Figure 3 shows a simplified tree where macroeconomic analysis could include sector analysis and international factors and fundamental analysis could include other factors like lawsuits pending, regulatory problems etc. Very often, analysts will disregard parts of the tree, though others might rely on them. For example, technical analysts rely heavily on technical analysis, while excluding macroeconomic and fundamental analysis. Analysts also assign *weights* to the branches of the tree representing their impact on the overall analysis. These weights can be objectively expressed as numeric coefficients when the user casts the analysis in the form of mathematical formulae. Valuation links automatically feed outcomes of lower levels nodes into higher level nodes, where additional steps in the analysis are performed either manually by the user or automatically by the system. In order to enable the latter, the user expresses analysis criteria in a form that the hypertext can evaluate. Data changes at the leaves of the tree automatically propagate upwards through the tree via valuation links.

The tree depicted in Figure 3 is a concise representation of securiites analysis. Some of the nodes in the figure will be further expanded by a securities analyst. We can also assume that a fundamental analyst will include macroeconomic and fundamental analysis,

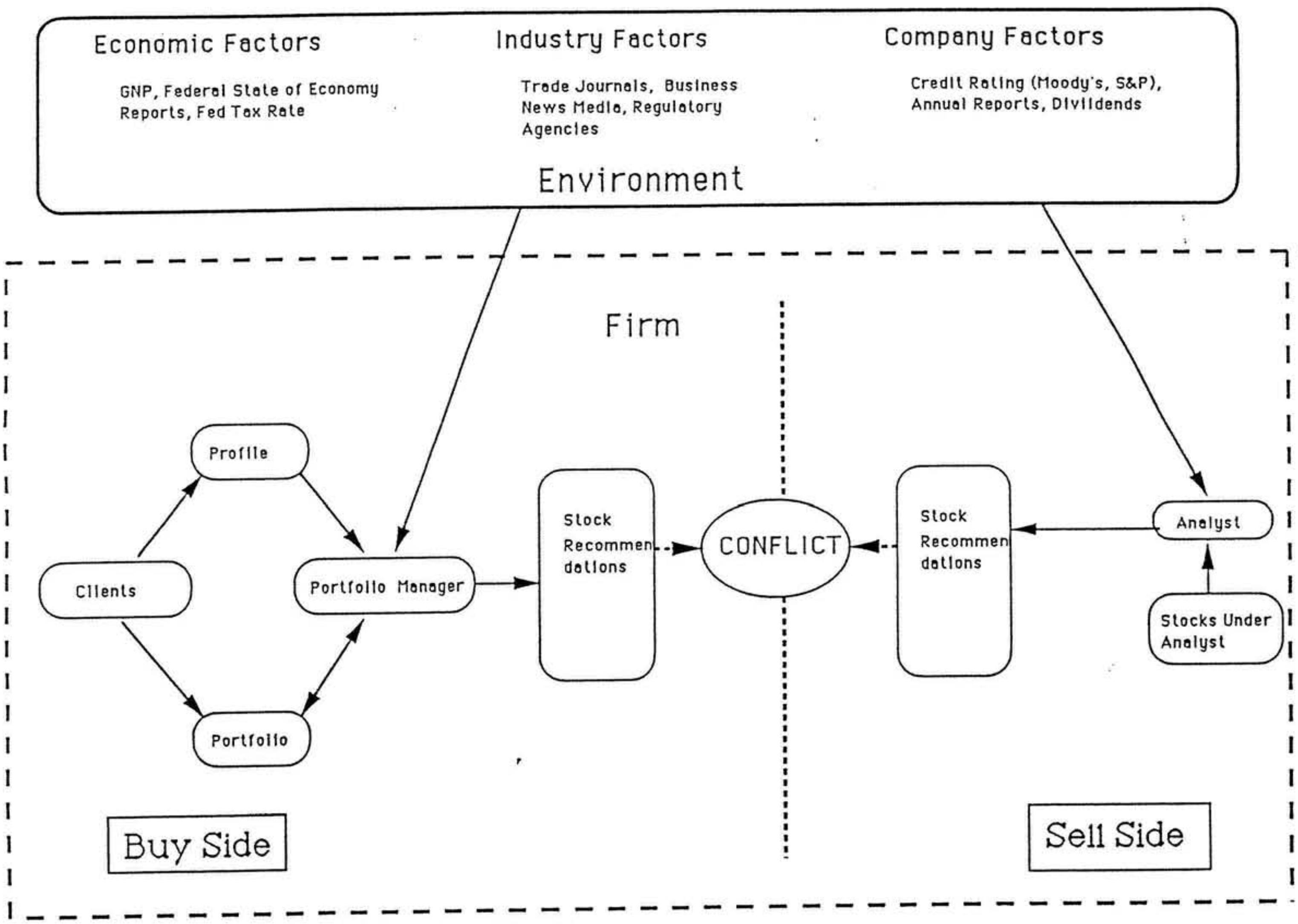

Figure 2: Conceptual Model of Decision Process in Portfolio Management

while excluding technical analysis.

Over and above the expected differences among the analysis trees of different users due to personal inclinations, we expect fundamental differences to exist between the trees of analysts and portfolio managers. *First,* the expert analyst who specializes in an industry will construct a tree which is *deeper in some branches*, e.g., the nodes below the fundamental analysis node in the tree ought to represent a level of knowledge that surpasses that of the asset manager. *Second,* the expert analyst's tree will show *appropriate breath*, in the sense that only *relevant* information will be present. A *third* point relates to the weights each of them assigns to the different techniques. The analyst's weights will be more refined reflecting his confidence, knowledge, depth of experience and judgment. For example he might use his own insights to justify placing greater importance on liquidity and funds flow than on return on assets, and no importance at all on other metrics that represent the operational performance of a firm. *Fourth,* by using his understanding of the industry, the economy and the specific company, the analyst may be able to establish *cross-references* between different branches of the tree. For example, he might realize that changes in prime rate may affect the liquidity of firms in the manufacturing sector. He will record this cross-reference with new nodes in the tree, of which the manager will have no knowledge.

Valuation links can automatically detect changes in the tree and determine their repercussion. This works well both for trees which are deep and for trees which are broad. If factors that determine the relative strength of each type of analysis are reconsidered thereby adjusting the weights of the tree's branches, valuation links will reflect the full impact of such revisions. Furthermore, valuation links support the identification of joint changes in different portions of the tree provided the user has established the proper relationships. Since the trees of analysts and managers differ in terms of *depth, breath, sensitivity* and *cross-references,* it should be clear that the two types of trees will react in a qualitatively different way to data changes. Thus, valuation links allow the hypertext to effectively represent differences in expertise and knowledge among its users.

With a multi-user hypertext, the trees of analysts and asset managers offer additional synergies. *Conflicts among the views of the buy and sell side of the firm can not only be*

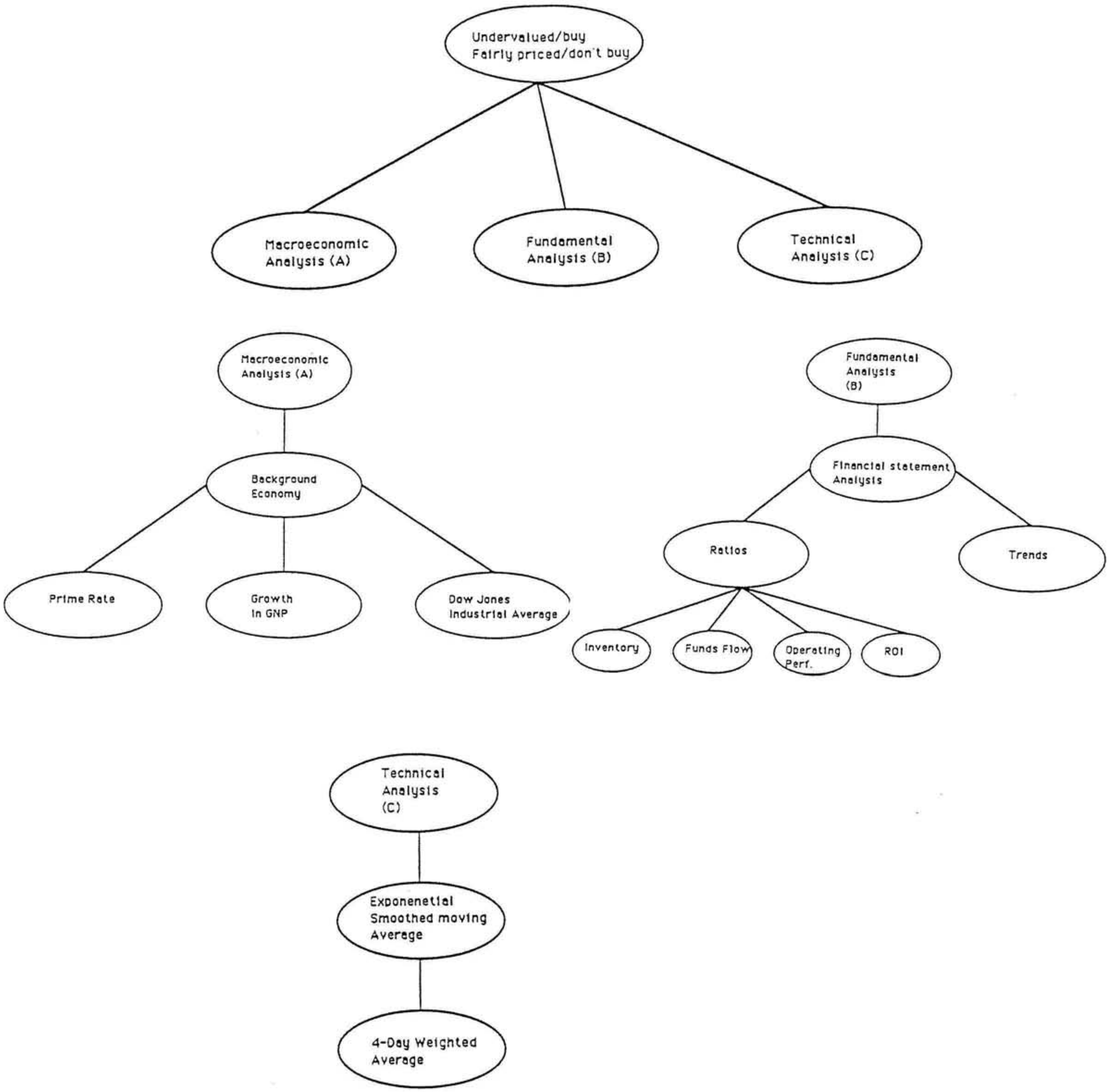

Figure 3: A general view of the securities analysis.

detected, but also analyzed in detail. The asset management process is improved by having decisions well-documented and changes in them highlighted, and by offering the tools to compare among different decision criteria. A portfolio manager might access an analyst's tree about a security under consideration and then use it to study differences in the analysis that led to divergent decisions. Hence the asset manager can learn from the analyst and potentially incorporate new decision elements into his own tree.

5 Valuation Links and Decisions in Portfolio Management

Valuation links empower hypertext to fulfill a number of roles in the portfolio management decision processes.

1) Hypertext As a Decision Assistant

By recording analyses and decisions with valuation links in hypertext, the asset manager has the ability to study decisions and their outcome in detail. The dual role of valuation links as a computational tool and as a link play a role here. The actual data sources and sub-analyses used at a particular step in the overall securities analysis are all available to the manager by browsing along the valuation links. This allows him to study subcomponents of the analysis. Thus, the manager will be able to revise his own decision strategy by studying the experts' hypertext.

2) Hypertext As a Scout

By automating digital data feeds, the hypertext can inform the manager that an earlier decision should be reconsidered. Each node in the analysis acts as a template stipulating the conditions which validate a prevailing decision. The system acts as a scout for changes.

If a significant change requires a revision, the system will help the asset manager to track the factors that led to the shift. An analysis of these factors can be assisted by empowering the user to navigate the valuation links and thus examine the trails that led to the changes. As a matter of fact, the valuation links themselves could incorporate information about changes and present them to the user. In this way the user can trace the chain of events that led to suggesting a reversal of a decision all the way to the digital data feeds. For example, the hypertext representation of the securities analysts decision tree may change its analysis of a company stock from "fairly priced/don't buy" to "undervalued/buy". The analyst navigates the trail of changes and discovers a substantial increase in the current year estimated earnings of the company. This leads him to investigate this matter further. As it turns out, the previous year's earnings may have been artificially low due to nonrecurring events, hence the additional cashflows are not reflected in the market valuation. The analyst records his new analysis which again supports a "fairly priced/ don't buy" position.

3) Hypertext As An Auditor

As we just explained, the trail of analyses and ensuing decisions are readily traceable through the valuation links utilized at each step. This also offers people who are not directly involved in a "buy"/ "don't buy" decision to be apprised of how it was reached. Through the use of hypertext valuation links, senior management obtains the opportunity to investigate individual asset manager decision quality. On an institutional level it provides a chance to more completely understand and represent the expertise on hand in the firm.

6 Concluding remarks

In this paper we introduced the concept of *valuation links* and demonstrated how they enable hypertext to be applied in decision making for securities portfolio management. We showed that valuation links can be used to detect conflicts between the buy and sell sides, and to analyze the sources of such conflicts. Valuation links can provide benefits by acting in a number of different roles, especially as a decision assistant, a scout and an auditor. We have initial indications that these roles apply well in portfolio management. This leads us to propose their application to other financial areas such as capital budgeting and credit analysis, which are similarly data-intensive and model-based, and require conflict detection and resolution.

The hypertext we envision here will require simple maintenance since digital data links are automatic and other links will constantly be utilized and revised by the users. Although the systems might initially be slow, customized algorithms can be developed to improve the speed.

When comparing hypertext as a tool for decision support one realizes a number of advantages. Although, spreadsheets offer speed they have difficulties in handling information of different types (text, graphs, programs, numbers), and do not provide built in trails which allow annotation and referencing. As opposed to procedural languages hypertext delivers the support for concentrating on the analyses and the decision rather than on algorithms and their implementation. Neural nets have been used to solve business problems wherein the problem structure is not well understood. However, the capacity of neural nets to aid in the detection and resolution of conflicts has not been established.

The work we presented here demonstrates the potential of hypertext in decision making applications. However, traditional hypertext concepts need to be extended to be effective in such domains. Valuation links provide a powerful, yet simple, concept which enables hypertext's roles in decision support.

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