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# Work Domain Analysis of a Financial System: An Abstraction Hierarchy for Portfolio Management

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**Abstract**
*In this article, we report on an initial attempt to describe a representative financial system using Work Domain Analysis. Our goal was to ascertain the feasibility of employing a familiar cognitive engineering framework in the treatment of a new domain that is likely to be of increasing importance to our discipline. The target of analysis was a type of mutual fund known as a structured product. Effective management of these products requires close monitoring and effective decision-making by portfolio management teams. Although the abstraction hierarchy has been employed effectively in many other domains, it was not intended to model financial systems. As a result, the traditional template was modified to accommodate the characteristics of the structured product. The number of levels of abstraction was reduced from five to four, and the names of each level were changed to better reflect aspects of the structured product. The resulting work domain representation was used to evaluate the information artifact currently used by mangers of the target portfolio. The comparison revealed gaps in the information provided and highlighted target areas for improving the support provided to portfolio managers.*

**Keywords:** Work Domain Analysis, Abstraction Hierarchy, Financial systems, Portfolio management, Decision-making

## 1. Introduction

Recent events in the financial industries have called into question the quality of decisions made by investors, managers, and executives. Despite the high profile of some of these incidents, relatively little attention has been paid to financial decision-making from a cognitive engineering perspective. The reasons behind this lapse in attention are not entirely clear. However, if Rochlin's (1997) observations are any indication of a possible future state of affairs, we may soon find that our skills are called for in supporting more effective decision-making in this domain.

If this is indeed the case, it is prudent to explore the feasibility of applying cognitive engineering approaches to financial systems. In this article, we report on an initial attempt to describe a representative financial system through Work Domain Analysis

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(Vicente, 1999). We discuss how the financial system compares to previous work domains described using this framework. We also discuss the process of conducting the analysis and constructing the resulting representation. Finally, we examine some of the implications of our findings relative to the information artifacts currently in use at one financial institution.

### 1.1 Work Domain Analysis

Work Domain Analysis (WDA) is a cognitive engineering framework used to model the constraints that limit the actions an agent can take in attempting to satisfy the intended purposes of a system. In a broader perspective, WDA is the first stage of Cognitive Work Analysis (Vicente, 1999). Thus, the WDA is not a sufficient description of work in a complex system, but is rather a necessary component of such a description. The Abstraction Hierarchy (Rasmussen, 1986; AH) framework has been used in a variety of settings as a tool for conducing WDA (e.g., Hajdukiewicz et al., 1998; Dinadis and Vicente, 1999; Jamieson and Vicente, 2001).

### 1.2 Portfolio Management as a Tightly-Coupled Intentional System

Rasmussen et al. (1994) describe a continuum of system characteristics, from causal systems (governed by the laws of nature) at one end of the spectrum to intentional systems (governed by actors' intentions, rules, and practices) at the other. WDA has predominantly been used to model systems characterized by causal constraints, such as process plants (Hajdukiewicz et al., 1999). It is somewhat difficult to place portfolio management on this spectrum because the characteristics of the system reveal a discrepancy in descriptions of the continuum itself. From one perspective, intentional constraints strongly influence portfolio management because a portfolio manager's actions are shaped by the laws which govern investing, by the predetermined goals of the portfolio, and by institutional practices. In this view, portfolio management appears to be very much an intentional system. However, Rasmussen et al. (1994) also describe systems along the intentional/causal spectrum in terms of their degree of coupling to the environment. Causal systems tend to be tightly coupled to their environment whereas intentional systems tend to be loosely coupled. A financial portfolio is, in many respects, strongly coupled to the market (i.e., its environment). For example, the values and risk level of the portfolio's holdings are determined by the market.

Given these two descriptions of system characteristics offered by Rasmussen et al. (1994), it is difficult to place portfolio management at a single position along the intentional/causal spectrum. If we use only the intentional/causal distinction (cf., Hajdukiewicz et al., 1999), we would conclude that portfolio management is highly intentional. Yet its strong coupling to its environment makes portfolio management appear more similar to causal rather than intentional systems. Regardless of how this dilemma is resolved, it is clear that very little research addresses how WDA can be applied to systems with intentional constraints. However, Hajdukiewicz et al. (1999) demonstrated through two brief examples that WDA can be applied to intentional systems. Thus, although a WDA for a financial system is a novel contribution to the literature, the system characteristics (coupled or intentional) did not dissuade us from using the framework.

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## 2. Developing an Abstraction Hierarchy for Portfolio Management

Structured interviews with a financial analyst (working as part of a portfolio management team) served as the primary source of information for this research. Supplementary information was drawn from textbooks, a financial prospectus, and several informal interviews with professionals working in the business and finance industry. The following section describes the work domain of portfolio management in more detail and discusses the changes made to the abstraction hierarchy to accommodate the new domain.

### 2.1 Portfolio Management Work Domain

Within the sphere of portfolio management, the target of our analysis was a type of mutual fund known as a structured product. Effective management of these trusts requires close monitoring and effective decision-making by portfolio management teams. The structured product which was modeled contained both a fixed portfolio and a managed portfolio. All funds in the fixed portfolio are locked into a forward agreement with an investment agency, while funds in the managed portfolio are used to purchase shares and/or options. Each portfolio management team is steered by an asset mix committee made up of senior partners. This committee is responsible for making high-level decisions about the composition of the trust.

The actions of the portfolio management team are restricted by several categories of constraints. The most concrete of these constraints are those introduced by the market itself. Although the market might be viewed as an intentional system from a global perspective, from the perspective of the portfolio, the market introduces many immutable constraints on action. These include interest rates and commodity prices. Less concrete limits on action are imposed by legal constraints. Numerous laws govern the make-up of the portfolio and the transactions undertaken to manipulate it. While these laws can be broken, there are serious consequences for doing so. Finally, the practices of the financial institution also direct the actions of the portfolio managers. These practices may be either explicit or implicit, and they allow for more or less flexibility in management strategies.

### 2.2 Modifications to the Abstraction Hierarchy

The AH was conceived as a framework to describe how experts reason about faults in physical systems (Rasmussen, 1986). In its original and most commonly employed form, it consists of five levels of abstraction. As researchers have expanded the range of domains in which the AH has been employed, they have sometimes made modifications to these levels (e.g., Hadjukiewicz et al., 1998; Sharp and Helmicki, 1998). In describing the structured product, an AH consisting of four layers instead of five was chosen and the traditional names of each level were revised to better reflect their content. Aside from the name change, the content of the top three abstraction levels was generally the same as the corresponding levels of the traditional template.

Starting from the top of the AH, the ‘Functional Purpose’ level became simply ‘Purposes’. Nodes situated at this level describe the main objectives of the structured product. The second level, traditionally referred to as the ‘Abstract Function’, was renamed ‘Balances’. The nodes at this level describe how value and risk flow through the product. The third level of the AH was renamed from ‘Generalized Function’ to

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'Processes'. Nodes at this level describe the processes that the system must undergo to bring about the flow of elements that are described at the Balances level. The changes made at the fourth level of abstraction include both a name change and a description change. The 'Physical Function' moniker was dropped because a portfolio is not primarily a physical system. The label 'Enabler' was substituted to describe the means-ends link between the third and fourth levels of abstraction, and invites the use of both physical artifacts and non-physical entities to describe this level of the work domain. The last level of a traditional AH, the 'Physical Form' level, was omitted because four levels of abstraction fully described the constraints on decisions made by the managers.

## 3. An Abstraction Hierarchy for Portfolio Management

Figure 1 provides an overview of the AH for portfolio management. At the Purposes level of abstraction are the two objectives; 1) to return the original issue price of each unit to unitholders (after its termination date), and 2) to make monthly payouts to unitholders above those of a conventional equity mutual fund. The ability to meet both of these objectives is an indication of the structured product's performance.

Structured products are fundamentally concerned with moving money from one investment vehicle to another. Consequently, the Balances level focuses on describing the movement of income through the system. In order to meet the two main objectives of the trust, the flow of income within both the fixed and the managed portfolios must balance. To highlight this requirement, the abstraction hierarchy separates into six branches. The three offshoots on the left in Figure 1 describe the source, transfer, and sink of income flowing through the fixed portfolio. The three larger offshoots on the right describe the source, transfer and sink of income flowing through the managed portfolio. Figure 2 shows a detailed view of the 'Income Transfer' branch of the managed portfolio.

The third level of the AH describes the Processes which cause money to flow though the system. Under the 'Income Transfer' branch of the managed portfolio (shown in Figure 2) are the various processes that generate income for the trust. Each process is an attempt to realize a positive return on invested assets by exploiting the stock market's tendency to mis-price securities. For example, portfolio managers may purchase undervalued shares, and then wait for the stock market to correct itself. If this occurs, they can earn a profit by selling the shares at a higher value than they paid. Portfolio managers also make extensive use of call and put options. Options not only allow portfolio managers to exploit mis-priced securities, they also allow them to hedge (i.e., reduce the risk of) their investments. If correctly monitored and controlled, call and put option writing should generate enough income to pay most of the monthly distribution to unitholders.

The Enablers level is made up of objects or entities that are necessary for the Processes to be carried out. For instance, the sale of a cash-covered put option requires that the fund company has a buyer (counterparty), the money to pay for the option (this is necessary in case it becomes profitable for the counterparty to exercise their right to sell), and a termination date on which the option expires. The nodes at this level are distinct because they each have a specific value, or boundary attached to them. For example, each security has a dividend distribution rate and a market value price in dollars per share.

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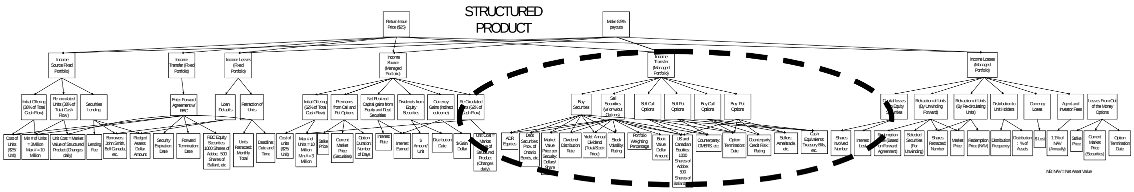


*Figure 1. Abstraction Hierarchy Overview with Figure 2 Focus Noted.*

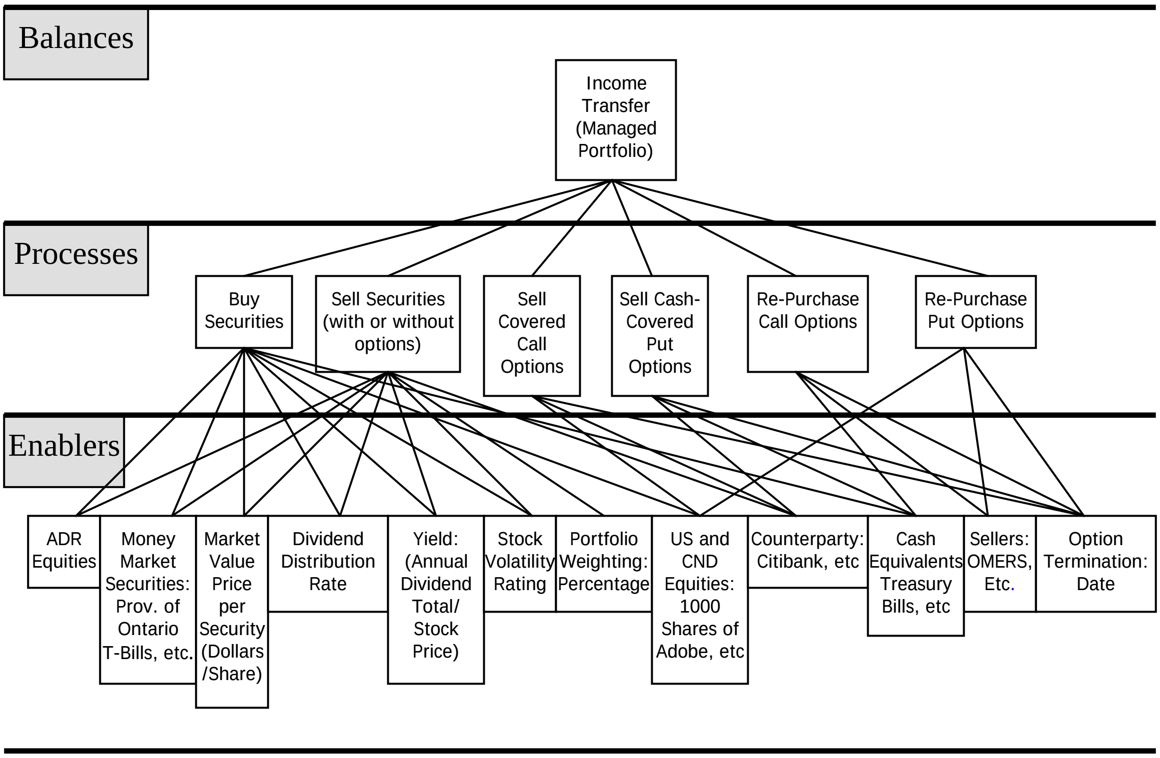


*Figure 2. Abstraction Hierarchy Close Up of Income Transfer (Managed Portfolio).*

## 4. Discussion

In addition to establishing the feasibility of constructing a WDA for a financial system, the information gathered from this modeling effort highlighted two opportunities for improving the decision support available to the portfolio management team.

### 4.1 Information Requirements for Different Stakeholders

Members of the portfolio management team require information which corresponds to distinct levels of the abstraction hierarchy (Hajdukiewicz et al., 1998). For instance, the asset mix committee requires information on the overall health of the structured product. This information is contained at the Purposes and Balances levels of the AH. Other members of the portfolio management team are responsible for adding details and carrying out the specifications of the asset mix committee, and as a result, make decisions which correspond to the two lower levels of the AH. Knowledge of the distinct information requirements of each user could contribute to the design of

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interfaces or decision support systems customized to the role of the user. In addition to providing support for each role, the AH can also clarify how different roles relate to each other and how information must pass between stakeholders. Understanding these relationships is necessary to encourage communication and collaboration between team members (Hadjukiewicz et al., 1998).

### 4.2 Limitations Revealed in Existing Information System

We used the AH for the structured product to evaluate the current monitoring and decision support tool (Vicente 1990, 1999) used by the portfolio management team. Specifically, we cross-checked the information provided by the tool with the constraints contained in the AH. This comparison revealed that the spreadsheet used to track the performance of the structured product provides an incomplete view of the work domain. The spreadsheet effectively communicates information on how well the trust is performing in terms of its two Purposes. It also provides a large amount of information at the Processes and Enablers levels (e.g., on the equities and options that make up the securities component of the managed portfolio). However, very little information is provided at the Balances level. The constraints at the Balances level are key because an imbalance in any of the components signals a potential problem in the flow of funds through the structured product. Moreover, Vicente (2002) reviewed several empirical studies that show that interfaces lacking content at intermediate levels of abstraction lead to decrements in problem-solving performance.

Thus, through a content comparison of the work domain representation and the information system that is currently used by portfolio managers, we were able to identify areas where decision-making is not effectively supported. This knowledge can be used to modify the current information system or to design a more effective replacement.

## 5. Future Work

In this feasibility study, Work Domain Analysis was successfully applied to portfolio management. The abstraction hierarchy shown in Figure 1 proved to be a suitable model from which to draw information requirements for system design. The results may be used to develop an interface (Vicente and Rasmussen, 1992) or a decision support system (Bisantz and Vicente, 1994) for members of the portfolio management team.

On a broader level, this study serves as an existence proof for the assertion that existing cognitive engineering methods can be brought to bear on issues of increasing concern to the finance industry. Even as the management of accounts, portfolios, and funds becomes increasingly automated (Rochlin, 1997), the need to support effective human decision-making will likely grow.

## 6. Acknowledgements

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