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IBM Research Report

Structural Analysis of a Business Enterprise

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Abstract

We introduce the concept of structural analysis of a business enterprise. The practice of enterprise structural analysis amounts to the construction of an enterprise model using business entities defined in an enterprise ontology or enterprise architecture and creating specific views of the enterprise based on relationships among the entities. As we demonstrate through a simple yet illustrative example of a hypothetical coffee shop business, these views can provide many insights and points of analysis. Structural analysis provides an interactive, analytical environment for a user to view an enterprise from multiple perspectives, an approach not unlike On-Line Analytical Processing (OLAP) but for analyzing the qualitative or structural aspects of the enterprise.

1 Introduction

Consider a business enterprise engaged in some economic activities for the purpose of making a profit for its owners. An important job of the owners, or professional managers acting on their behalf, is to develop a design of the enterprise, which typically entails the definition of product or service offerings, processes, roles, and reporting structures. It also outlines the resources (humans, machines, or financial resources) the enterprise needs, the information that must be stored and processed, the markets and customers that will be served, and the governance

relationships the enterprise will use to manage the operation. Enterprise design must be considered at the beginning of the venture, when the enterprise is initially established, as well as throughout the growth of an enterprise as needs and goals change. Typically, in the beginning the enterprise is small in size (in terms of volume and variety of offerings) and the design is relatively simple. In most cases the initial design of an enterprise arises fairly intuitively and there is seldom a need for advanced or formal analysis. However, as the enterprise grows and adapts to its environment, decisions on its design can become increasingly complex. As the organization evolves over time, the enterprise design will have to be revisited and adjusted to suit future plans and opportunities. When the enterprise becomes large, the number of entities comprising the organization and the volume of activities it is engaged in become correspondingly large and complex. Changing the enterprise design is then highly non-trivial. At the same time, the stakes are high, as poor decisions on enterprise design will have highly detrimental effects on the execution of the business strategy. Indeed, a weak enterprise design may even lead to an inferior business strategy and inefficient operations.

In this paper, we present a technique for analyzing an enterprise design. In particular, we focus on the situation where the enterprise has been in operation for some time and the design needs to be updated. This is typical of a large company who has been successful but has to consider updating its design due to competitive pressure, new market, political, or legal environment, disruptive technologies, or new demands from customers. This will also be the case when there is a merger or acquisition between two sizable enterprises. In many instances, it is desirable for the post-merger company to have a single, coherent enterprise design to take advantage of the combined strength. Our proposed technique for analyzing an enterprise design revolves around the concept of *structural analysis*: identifying and analyzing relationships among the entities that comprise an enterprise. Several techniques exist for modeling organizational entities; organizational charts specify relationships among people, process models define activities performed by the enterprise, data models define relationships among information assets,

and in particular UML-type models provide an object-based view. The area of enterprise architecture provides a framework for a formal description of the internal organization of operations. It provides the broadest view of an enterprise among all the common techniques, but is focused on a somewhat static depiction to support information system design and integration. We propose a variation or extension of existing business architecture modeling techniques. Building on an enterprise ontology to represent all entities found in an enterprise, our proposed approach identifies linkages and relationships among these entities and use the relationships to perform analyses that are useful for a number of purposes, well beyond information system development.

Similar to On-Line Analytical Processing (OLAP), structural analysis provides an interactive, analytical environment for a user to view the linkages among enterprise entities in many ways. While OLAP provides the capability of having a dashboard for quantitative data relevant to the enterprise (e.g., sales and inventory data), the proposed structural analysis technique provides an equivalent capability in analyzing the qualitative or structural data relevant to the enterprise. The goal of structural analysis is to allow the analyst to "slice and dice" information about the structure of relationships among entities in and enterprise to discover opportunities for improving organizational design and operations. As with OLAP, structural analysis provides the ability to drill-down on a specific qualitative dimension of an enterprise and to quickly switch among various views, where each view may contain different combinations of dimensions and relationships. Such abilities in OLAP have proved to be very useful in the management of an enterprise and we expect the same with structural analysis.

The remainder of this paper proceeds as follows. In Section 2 we review related research and contemporary thinking on the broad topic of business analysis, to which the proposed structural analysis technique belongs. In Section 3 we present the basics of the structural analysis technique. We also introduce a simple yet illustrative example of a business enterprise, a hypothetical coffee shop. In Section 4, we use the coffee shop example to demonstrate the

application of structural analysis. We discuss how valuable insights can be drawn by using the structural analysis technique, much beyond what is useful in information system development. Section 5 contains a discussion on synergies of structural analysis with existing technologies commonly found in an enterprise. Section 6 concludes the paper and discusses opportunities for future research.

2 Related Research

In the last two decades, quantitative analysis of and for a business enterprise has advanced significantly, together with rapid progress in information technology. We have witnessed the creation of entire categories of application software related to business quantitative analysis, most notable of which are business intelligence and advanced planning and scheduling, which is now generally known as supply chain management, and revenue management.

Business intelligence systems make use of online analytical processing (OLAP) and database technologies to provide an interactive environment for the business analyst to perform monitoring, reporting, diagnostic, and pattern exploration, helping them generate insight from large amounts of raw data. (See, e.g., Negash and Gray 2003.) Supply chain management systems utilize mathematical modeling and statistical analysis to predict demand for products or services, to calculate quantitative decisions, such as how much inventory to stock at what locations, and to simulate parts of the supply chain so that reasonably accurate what-if analysis can be done. (See, e.g., An and Fromm 2005, Stadtler and Kilger 2004.) The overall goal of a supply chain management system is to minimize total cost of supplying the product or service to the end customer, under a set of business constraints. Revenue management systems employ mathematical modeling and statistical analysis to calculate product or service pricing and promotion decisions, considering the available supply and predicting the reactions of the end customer to changes in prices and promotions. (See, e.g., Talluri and van Ryzin 2004.) The goal of revenue management systems is to maximize the total revenue generated by a given amount of

product or service supply. Augmenting such enterprise applications is the ubiquitous spreadsheet, which allows ad-hoc data analysis driven completely by the requirements of the situation at hand.

On the other hand, it appears that qualitative analysis of and for a business enterprise has been almost solely focused on business processes and information systems supporting the business processes. In fact, the focus on business processes arises partly because of the desire to develop information systems to automate them. Descriptive modeling techniques, such as graphical and textual modeling languages, have been developed to formally represent data flows and process flows (see, e.g., Kamath et al. 2003). Workflow, a combination of data flow, process flow, the task performing resources and their roles, are typically analyzed by using Petri nets (see, e.g., van der Aalst and van Hee 2004). Properties such as reachability (to ensure that a desirable state can be reached from a selected state) and deadlocking (to ensure that the system will not enter into a deadlocked state from a selected state) can be derived from a Petri net model. Our proposed structural analysis complements these business process models by expanding the focus to other entities within the enterprise that are related to processes.

To facilitate the development of enterprise-wide information systems, reference models for business enterprises (see, e.g., Biemans 1990, Scheer 1994) and governments (see, e.g., US Federal Government 2007) have been developed. A reference model generally follows a functional decomposition of a business enterprise, sometimes specified in a formal language (e.g., as in Biemans 1990). These reference models contain valuable information on what a business enterprise performs (or should perform ideally) on a regular basis, but little analysis has been devised using these models beyond having them as reference information for a human expert. Putting such a reference model in a structural analysis environment enables an enterprise designer to use the reference model as a template and modify it to suit the objectives of the enterprise in question. Continuing with the organization-process alignment example mentioned in Section 1, the designer can immediately see the effects of changing a particular part of the organization chart on process management.

Indeed, the subject of reference models has grown into a more comprehensive area of enterprise architecture that encompasses not only information and processes, but also other aspects, such as the business objectives and organizational structure, necessary for the existence of an enterprise throughout its life cycle (Bernus et al. 2003). McDavid (1999) represents an early attempt to formally define a business – an "architecture" of a business. Concepts relevant to a business were classified into three sub-domains: drivers of the business, business boundaries, and business delivery system. Subsequent works have factor a business differently, defining different sets of entities in an enterprise. For example, Whittle and Myrick (2004) uses the value stream (consisting of work flows, business use cases, and events) as the main building block of an enterprise. Ross et al. (2006) observes four common elements in representations of enterprise architecture: core business processes, shared data driving core processes, key linking and automation technologies, and key customers. Our structural analysis approach focuses on utilizing the relationships among the different elements of an enterprise architecture to uncover insights beyond information system design and integration.

Rackham (2005) develops a component business model (CBM) framework, in which activities in an enterprise are grouped together by certain criteria to form "business components". A business component is an autonomous part serving specific functions to the rest of the enterprise and/or to external customers. In this framework, "industry maps" serve as a type of reference model for an enterprise of that industry. Such a framework and its reference models have been applied to help develop enterprise and system architectures (see, e.g., Flaxer et al. 2005). For analysis purposes, CBM has been used as an organizing framework (e.g., for expert opinion collection) and as a visualization tool (e.g., for identifying performance improvement areas). At a more basic level, business activities and processes can be viewed on a CBM map. The proposed structural analysis expands such a view to include a more comprehensive set of entities and covers a significantly larger scope of application.

3 Fundamentals of Structural Analysis

We first define the types of entities and their basic relationships that can be used to represent an enterprise. These modeling elements are based on an *enterprise ontology* developed by Uschold et al. (1998). We then apply this set of general entities and relationships to a hypothetical coffee shop, through which we demonstrate the rich set of analyses that can be performed.

3.1 Defining the Ontology of Structural Analysis Entities

For any modeling technique, it is necessary to define the set of elements that will be used in the definition of models. In this context, the purpose of adopting an enterprise ontology is to obtain a comprehensive collection of terms and definitions relevant to business enterprises, from which we can define the modeling elements of the structural analysis technique. At a meta-ontological level, the ontology defines a *business entity* as a fundamental thing (not unlike a class in an object-oriented view) that belongs to or interacts with the enterprise being modeled and a *relationship* (or association) as the way two or more entities can be interact with each other in an enterprise. Uschold et al. (1998) categorize business entities and relationships into four groups, which we adopt in our conceptual model: *activities and processes*, *organization*, *strategy*, and *marketing*[1]. In Uschold's model the activities and processes category captures anything that involves actual "doing" or action within the enterprise. The organization category captures entities and relationships involved in the organizational structure of an enterprise, the strategy category captures anything related to the purpose and objectives associated with the enterprise, and the marketing category captures entities and relationships associated with sales and customers.

The motivation for using the enterprise ontology is threefold. First, a well-defined enterprise ontology is robust, flexible, and encompassing. Second, the formal nature of the

[1] Uschold et al. (1998) also discuss a category of *time* related terms in the enterprise ontology that is out of the scope of our present study.

ontology provides an ideal foundation for developing an enterprise modeling framework. Third, the granularity of the ontology is at a low enough level that other common views of the enterprise can be derived by aggregating business entities and relationships. These characteristics allow for many enterprises to be modeled using the same basic conceptual framework, and they also make it easy to translate between views of the enterprise created using the ontology and context specific representations, such as organization charts, business process models, and system models. The practice of enterprise structural analysis amounts to the construction of an enterprise model using the entities defined below and creating specific views of the enterprise based on relationships among two or more entities. As we will demonstrate in section 4, these views can provide deep insights on the constraints and opportunities embedded within the enterprise structure.

Based on Uschold's business ontology, we define a set of specific business entities that will be used as the basis for enterprise structural analysis. We adopt the four basic categories of enterprise entities from Uschold's ontology, *activity-related entities* (which can comprise processes), *organizational entities*, *strategic entities*, and *marketing entities*, and introduce *resource-related entities* as a separate category[2].

An *activity* is something done by the enterprise and it may have preconditions, produce effects or output, have one or more doers, be composed of sub-activities, have an owner, possess one or more performance metrics, it may consume resources, and utilize machines or systems. Activities are the fundamental business entities that represent actions taken by the enterprise. Activities can be composed of sub-activities and therefore are hierarchical in nature and can be combined with other business entities to represent business processes. Instances of activity entities can be specified for any task or process performed by the enterprise, such as operations and administration. We also include non-human resources as a type of activity entity, since the main purpose of resources is for consumption of support of performing activities. Consistent

[2] Uschold et al. (1998) include resources in the activity category of business entities in their enterprise ontology, however we feel a separate category is warranted for richer analytical views of an organization.

with usual business terminology, we call a collection of related activities, such as those performed in a sequence, a process.

Resources are business entities that can be used or consumed during the performance of an activity. Resources typically have a quantifiable measure of the amount available for use and an activity typically has a specification of how much of a resource it requires. The amount of a resource available is reduced as it is consumed by an activity and increased as it is replenished by the enterprise. We define three specific types of resources: materials, financial resources, and information artifacts. It is possible for multiple activities to use the same resource and for multiple resources to be used by a single activity. Additionally, the output of an activity that is used as an input for a subsequent activity is also considered a resource.

The *organizational entity* category is comprised of two types of entities: actors and organizational units. Actors are business entities that play a role that entails some notion of doing or cognition within the enterprise. Actors can be people, machines or systems and they have roles that are associated with specific activities. For example, a person can have the generic role of "performer" and is responsible for performing a specific activity in the enterprise. Organizational units are business entities that contain one or more actors for managing the performance of activities. Examples of organizational units in general are business units, departments, and corporations. Organizational units typically have specific purposes and allocated resources. For high-level processes, an organizational unit could be considered an actor.

Strategic entities capture the objectives and measurements of the enterprise. Objectives include explicit goals and targets set by the enterprise, while measurements that are associated with assessing the enterprise's progress towards its objectives. Strategic entities are typically associated with activities at a detailed level but are important considerations at the enterprise level. For our structural analysis example, we have chosen arguably the most common and critical objectives: sales goal (in terms of revenue), and customer satisfaction level as a longer

term objective and to balance out the obvious shortcomings of using an immediate revenue objective. For measurements, we chose to use three classes: critical success factors, risk factors, and key performance indicators (KPI's). The first two classes can be measurements in 0-1 form indicating whether an activity is a critical success factor or a risk factor or not, or preferably in a more refined scale form, such as 1-5, indicating its level of severity as a critical success factor of risk factor. KPI's are general metrics such as those related human productivity or cost of performing an activity.

Marketing entities relate to the product or service offerings of the enterprise. There are three major types of marketing entities: product entities, pricing entities, and customer entities. A product is the output of one or more activities and is either sold to a customer or exchanged with another party for resources. Price schedule captures a menu of the product or service offerings of the enterprise, applicable over a specific time span. Promotions associated with products define the nature of the promotion and the applicable time span. Customer entities are external to the enterprise, which interact with the enterprise through the exchange of goods, services, and resources (financial, material, or informational). Market segments are collections of customers with certain similarities for marketing or other purposes as deemed appropriate by the management of the enterprise. Vendors are suppliers of resources, actors, activities, or products to the enterprise. Competitors are suppliers of similar products to those of the enterprise, to the same or similar customers.

Similar to object-oriented modeling using the UML standard, the diagram in Fig. 1 presents the entities, the hierarchical associations, and the relationships among entities within an enterprise as they will be applied in structural analysis. Relationships arise as the business entities within an enterprise interact. For example, an activity can be associated with resources, actors, measurements, or products. The entities and their relationships provide structural information that can provide insights on the operations, organization and performance of an enterprise. A basic, but well-defined a set of business entities for an enterprise and the

corresponding set of essential relationships allows the analyst to construct different, possibly complex, representations through the derived associations. In this vein we will demonstrate that structural analysis is useful in a fairly wide range of business scenarios, from business design to real-time performance monitoring.

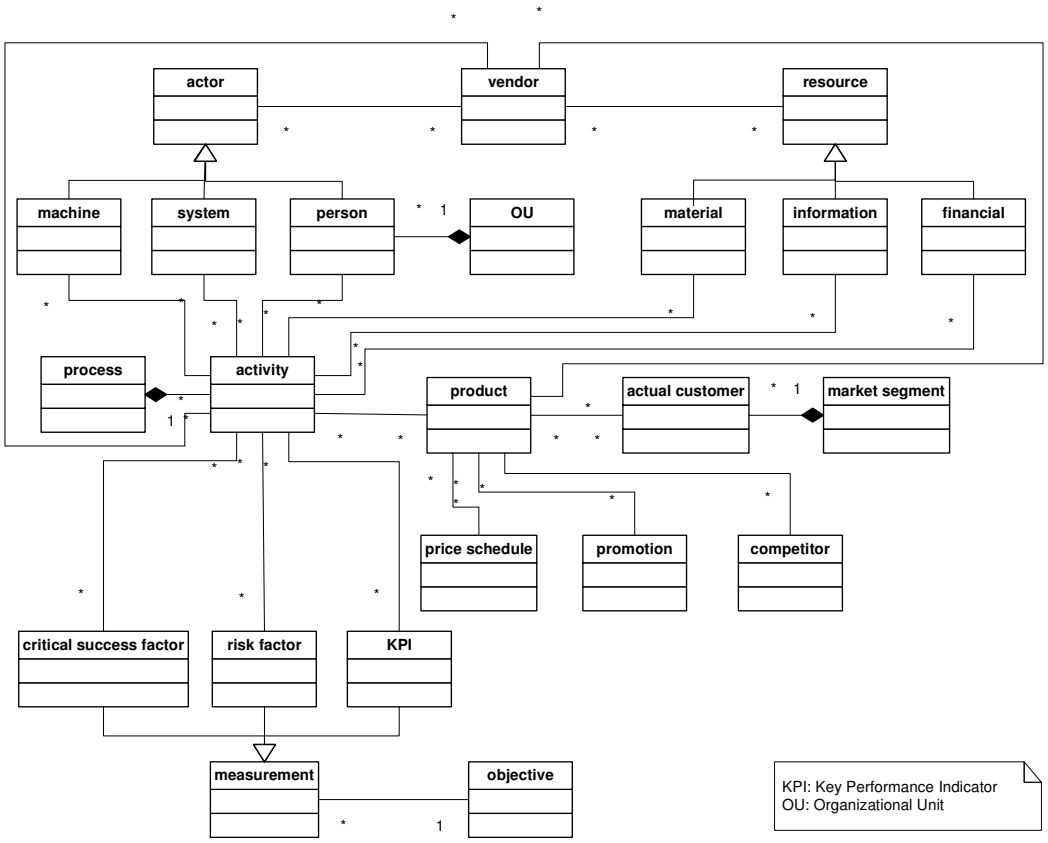

Figure 1. Entities and Their Basic Relationships in Structural Analysis

3.2 A Hypothetical Coffee Shop Enterprise

To demonstrate the structural analysis approach, we model a hypothetical enterprise – a small coffee shop – using the business entities defined previously. For this hypothetical coffee shop enterprise, we will assume it sells three products – a cup of coffee, an espresso drink, and a piece of pastry. We assume there are six key processes performed by the shop: a customer order process, a coffee production process, a cash management process, a payroll process, a material

procurement process, and a recruiting process. Each process consists of a number of individual activities, which are performed by actors and require resources.

Using the entity structure outlined previously, we can also define other important business entities that can be used to analyze our hypothetical coffee shop. Examples of basic activities performed by the coffee include taking an order, receiving a payment, grinding coffee beans, brewing coffee, and calculating payroll. An exhaustive list of activities would capture all the entities that can be combined to comprise the six key processes, such as coffee production or order processing in our example. Example material resources include coffee beans, water, milk, and pastries. Financial resources include lines of credit and cash. Information artifacts include customer orders and recipes. Actor roles for people in the coffee shop example include store manager, barista, cashier, and accountant; machines include coffee grinders, coffee brewers, and cash registers; and systems include an order management system, an inventory and payroll system, and a finance system. Organizational structures could include management team, day shift workers, night shift workers, and the entire coffee shop organization. Strategic entities include weekly sales goals, customer satisfaction goals, risk factors, and critical success factors.

In our coffee shop example, we can define associations to denote general relationships between entities. For example, the activity *grind coffee beans* is associated with a person - barista, a machine - coffee grinder, material resources - coffee beans and electricity, and an organizational structure - day shift. For purposes of exposition, we restrict ourselves to a few associations which have an obvious interpretation. For example, activities can have a precedence relationship among each other and relate to specific products and materials. To summarize, our coffee shop operates six processes using its resources and actors as follows.

1. Customer order processing. The cashier receives a customer order. Depending on the particular order, the cashier pours a cup of coffee (coffee is made in batch in a separate process described below) and/or prepares a piece of pastry (puts it in a bag), and/or the barista makes an espresso drink from espresso grounds. Then the customer tenders

payment to the cashier who also delivers the order to the customer. Espresso grounds are assumed to be purchased from a vendor. Pastry is also purchased from a vendor. We use the term "ready pastry" to denote the pastry in a bag, ready to be delivered to a customer (the finished product). We make the simplifying assumptions that the shop never runs out of coffee beans, coffee grounds for cups of coffee or espresso drinks, brewed coffee, or pastry. Otherwise, the processes will have the additional complication of checking whether the required material is adequate before proceeding.

2. Coffee production. Coffee is periodically made in a batch by the barista. Coffee grounds for cups of coffee are made from coffee beans immediately before making the coffee (in the same process). Coffee beans are procured from vendors.
3. Cash management. This process relates to managing cash and other payments in the store. It includes initializing the cash register (e.g., at the beginning of a shift) by the cashier; reconciling cash, check, and credit card payments in the cash register by the cashier; making the corresponding entries in the accounting journal by the cashier; depositing the cash, checks, and credit card slips with the bank by the store manager; and reconciling the accounting journal with the bank statement by the accountant.
4. Payroll. The store manager collects hours worked from the cashier and the barista; the accountant calculates pay; the owner delivers the paychecks.
5. Material procurement. The store manager checks material stock (including all materials such as coffee, espresso, pastry, pastry bags, etc.); places an order for any necessary materials; receives the ordered materials; the accountant makes a payment to the vendor.
6. Recruiting. This process is for recruiting employees who work in the store. The manager places a job advertisement; the manager and the owner select candidates from the job applications received; the manager and the owner interview the selected candidates; the owner makes an offer if there is a suitable candidate; if the offer is accepted, the manager signs on the new employee. If there is no suitable candidates for interview, the manager

goes back to place another job advertisement. If there is no candidate to make an offer to after interviews, the manager and owner go back to select another candidate for interview. If the job offer is rejected and there is a second suitable candidate after interviews, the owner makes an offer to the second candidate. If the job offer is rejected and there is no second suitable candidate, the manager and owner go back to select another set of candidates for interview.

These processes are obviously simplified versions of their real-life counterparts, but are still representative and will serve well to illustrate structural analysis. The first three processes belong to a higher level process called store operations and the last three belong to one called administrative process. Table 1 outlines the coffee shop example according to our proposed business enterprise entity structure. In Table 1, we use regular font to represent general entities in our framework, and italics to represent specific instances of the entities developed for our coffee shop example.

Table 1. Coffee Shop Business Entities

Activity-related Entities	Resource-related Entities	Organizational Entities	Strategic Entities	Marketing Entities
Processes & Activities ***Store Operations*** *Coffee Production* *Customer Order Processing* *Cash Management* ***Administration*** *Payroll* *Procurement* *Recruiting*	**Resources** **Material** *Milk* *Coffee Beans* *Sugar* *Syrups* *Cups* *Napkins* *Water* *Electricity* *Coffee Grounds* *Brewed Coffee* *Espresso Grounds* *Pastry* **Financial** *Payment* *Line of Credit* *Cash in Savings* **Information** *Customer Order* *Time Sheet* *Materials Order* *Coffee Recipe* *Espresso Recipe* *Schedule* *Receipt* *Paycheck*	**Actors** **People** *Store Owner* *Barista* *Cashier* *Accountant* *Manager* *Customer* **Machines** *Coffee Grinder* *Coffee Brewer* *Espresso Machine* *Refrigerator* **Systems** *Order Processing* *Payroll & Inventory Management* *Finance* **Organizational Units** *Management* *Day Shift* *Night Shift* *Accounting*	**Objectives** *Sales Goal* *Customer Satisfaction* **Measurements** Critical Success Factors Risk Factors Key Performance Indicators	**Products** *Finished Cup of Coffee* *Finished Espresso Drink* *Ready Pastry* **Pricing** Price Schedule Promotions **Customers** Actual Customers Market Segments *Loyal Customers* *Morning Customers* *Espresso Drinkers* *Leisure Customers* *Beverage Customers* **Vendors** *Food Service Supplier* *Bank* **Competitors** *Specialty Coffee Shop* *Full Service Restaurant* *Fast Food Restaurant*

To demonstrate the structural analysis technique, we have implemented the coffee shop example using a common, PC-based relational database system. Structural analysis was

performed by calculating different relationships among the entities of the coffee shop through data queries in the database system. We show in Section 4 that structural analysis, despite its rather straightforward computation, has a broad range of applications. We also note that structural analysis will require a substantial amount of data for a business enterprise of significant size.

4 Applications of Structural Analysis

Structural analysis follows a bottom-up approach, which involves generating multiple different views of the enterprise derived from basic data on the business entities and their relationships introduced in the previous section. It provides analysts and management a means of dynamically evaluating the structure and performance of an enterprise. For example, using enterprise structural analysis, the business process view, the resource view, the asset view, component view, or the organizational chart view can all be established and compared (see Figure 2). Enterprise structural analysis can be viewed as a form of OLAP for the structural data of an enterprise.

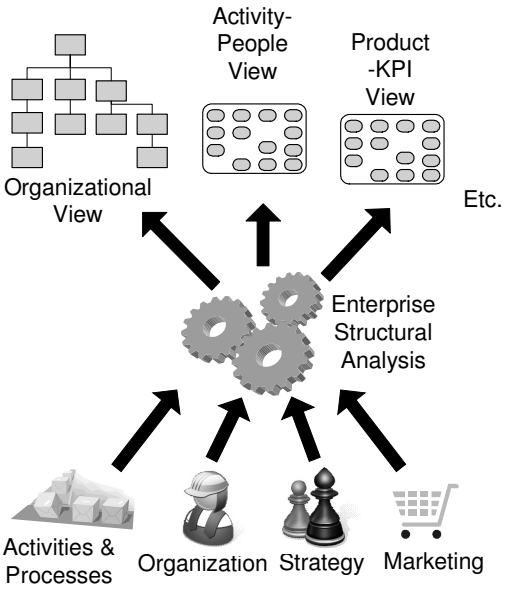

Figure 2. Conceptual Illustration of Structural Analysis

Despite its conceptual simplicity, there are a number of potential applications of structural analysis, mainly in organization and business process design or redesign. It will be useful whether a new organization or process is formulated, say, for a new business, or an existing organization or process is redesigned during a business process reengineering effort. To systematically investigate the potential applications, we explore the space of structural analysis, as defined by the five categories of business entities and their relationships (discussed in Section 3.1 and depicted in Fig. 1 and Table 1). This space is rather large, and we classify the different regions in it by the number of entity categories involved in the analysis. In the following, we discuss examples of how and why structural analysis is useful in the basic regions. For each example, we provide a short general discussion of a potential business application of structural analysis, followed by an illustration using the coffee shop example described above. The list of application examples is by no means exhaustive. We believe that, similar to OLAP, structural analysis will find many more uses beyond what are discussed here once it is easily available to users.

4.1 Applications Using a Single Entity Category

First, we discuss applications which involve a single entity category.

Aggregation-disaggregation analysis. An obvious application within a single entity category is aggregation-disaggregation analysis, essentially examining a tree of the entities in that category. Organizational charts, process charts, bill of materials, product family charts are common examples that every enterprise uses. These are well known and we do not discuss further. Even in the strategic entity category, a hierarchical structure (in the form of vision-goal-objective) has been proposed (Business Rules Group 2007).

Market analysis. In enterprises where customers are identified to some degree (e.g., by gender, age group, postal zip code, phone number, or name), knowing who buys what products is basic market information that helps identify business opportunities, increases promotion effectiveness, aids managing the product portfolio, among other uses. A product-customer view, or at a more

aggregate level a product-market segment view, provides insight on where our products have gone to. Obvious gaps in the customers or segments identified provide hints on potential business opportunities. A product-pricing view helps depict the positioning of the product portfolio in terms of selling price. A customer-pricing view gives insight on the preferred price points of different customers or market segments. Similarly, a product-promotion view and a customer-promotion view give the market coverage of our current (or past) promotions, helping identify gaps or overlaps of current or past promotions.

The views to support market analysis mentioned are fairly standard practice in marketing and examples from our coffee shop are omitted.

Pareto analysis of resources and actors. Pareto analysis (also called ABC analysis) of products to rank products in terms of contribution to revenue, profit, or units sold is common practice for manufacturers. Utilizing the mapping between products and resources or actors provided by structural analysis, we can extend standard Pareto analysis to find the resources or activities associated with products of the highest rank in revenue or profit. These resources or actors are critical to the enterprise. These represent the highest priority for improvement or investment considerations. It might also be worthwhile to have contingency plans in case of unforeseen changes or emergencies, such as back-up plans or alternative vendor arrangements. Alternatively, we can rank resources or actors in terms of their usage by the number of products or number of customers. Even though they may not contribute to the highest fraction of revenue or profit, the resources or actors contributing to the largest number of products or customers may still be very important to the enterprise. They enable the enterprise to have a broad set of offerings that help secure for the enterprise a place in the market.

In the coffee shop example, once the highly ranked products are identified, a product-people view (similar to Fig. 5), a product-material resource view (Fig. 11), a product-machine view (similar to Fig. 13), or a product-system view (similar to Fig. 15) can be generated to identify the resources used to make these products. For structural Pareto analysis based on

number of products, we obtain data from the product-people and product-machine views (Fig. 5 and Fig. 13 respectively) and plot histograms of people and machine, sorted by the number of products covered. The histograms are shown in Fig. 3 and Fig. 4 respectively. Similar plots can be done for systems and material resources using data from the product-system view (Fig. 15) and the product-material resource view (Fig. 11). It is also possible to plot a weighted histogram taking into account the number of activities performed by the people or the machines for each product covered.

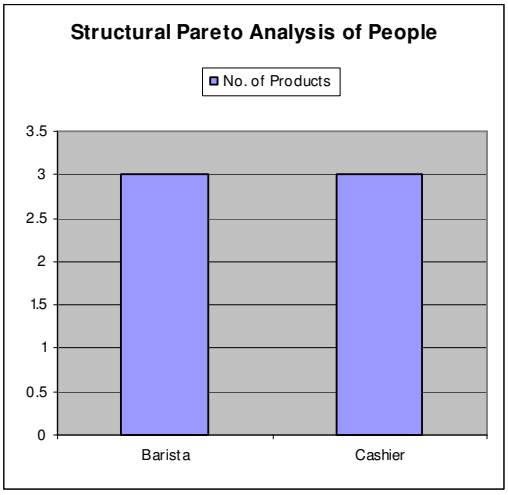

Figure 3. Structural Pareto Analysis of People

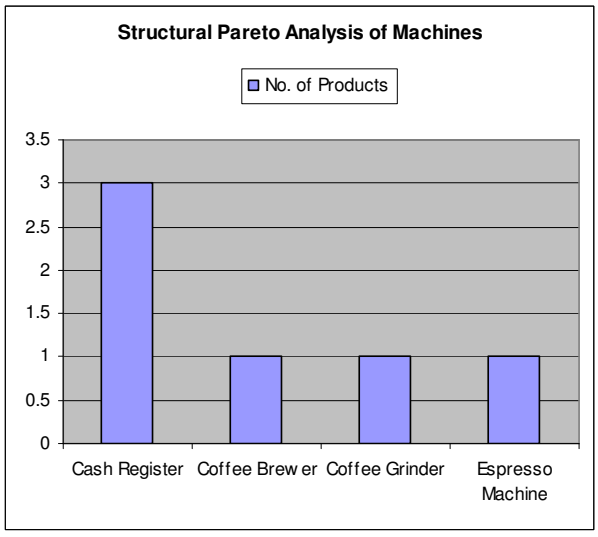

Figure 4. Structural Pareto Analysis of Machines

Pareto analysis of resources and actors also provides insights on resource reuse among the product or service offerings. Do many products have unique resource or actor requirements? If so, there may be cost saving opportunities to consolidate resources or actors by modifications to the resource or the product design. In addition, new product candidates can be introduced in a what-if analysis to see the potential impact of the new offerings from a structural standpoint. The cost or time to market for new offerings which require many new types of resources or actors is likely to be larger than new offerings which require mostly existing types of resources or actors. Note that resources here include physical materials, financial resources, and information, and actors include both people and machines (physical machinery or computer systems).

4.2 Cross-Entity-Category Applications

In this section we discuss applications which involve two entity categories. These applications make use of the direct and derived relationships between a pair of entity categories.

4.2.1 Applications Associated with Activity-Related Entities

Process management. In a large enterprise where business processes and products are complex, the management of a single product or a single business process often requires a number of people and possibly a number of different departments or organizations within the enterprise. Frequently there are numerous "handoffs" of a process, a product, or a customer to different stakeholders. Ultimately who is responsible for the process, product, or customer? Is there any built-in conflict of interest of the different stakeholders due to their measurements, say? These are important issues to consider when designing a process, but so far little research has addressed them.

Using the coffee shop example introduced in Section 3.1, Fig. 5 shows a product-people view, indicating who is directly involved in producing the three products. (Note that in all of the following product-related views, only the entities directly related to the product are computed.

Entities that contribute indirectly to the product are not included, but are easily computed if needed. For example, the store manager performs activities that contribute indirectly to all the products but is not shown in Fig. 5.) The number in a cell indicates how many activities of that product require the person. Fig. 6 shows a product-organization view, indicating which organization within the enterprise is directly involved in producing the products. The number in a cell indicates how many activities of that product require people from that organization. In this case both products happen to be made by the same organization called DayShift. Fig. 7 shows an activity-people view, indicating who is performing the different activities. The last column shows the total number of people required by that activity. Fig. 8 shows an activity-organization view, indicating which organization within the enterprise is performing the different activities. The number in a cell indicates how many people of that organization are required by that activity.

ResourceName	Barista	Cashier
Finished Cup of Coffee	2	3
Finished Espresso Drink	1	2
Ready Pastry		3

Figure 5. Product-People View (showing Number of Activities)

ResourceName	DayShift
Finished Cup of Coffee	5
Finished Espresso Drink	3
Ready Pastry	3

Figure 6. Product-Organization View (showing Number of Activities)

ActivityName	Accountant	Barista	Cashier	Manager	Owner	Total Of Res
Brew Coffee		1				1
Calculate Pay	1					1
Check Current Coffee Stock		1				1
Check Materials stock				1		1
Collect Hours Worked		1	1	1		3
Deliver Paycheck					1	1
Deposit cash, checks, credit card payments				1		1
Grind Beans		1				1
Initialize Cash Register			1			1
Interview Candidates				1	1	2
Make Espresso Drink		1				1
Make Offer					1	1
Make Payment	1					1
Place Job Advertisement				1		1
Place Order				1		1
Pour Coffee			1			1
Prepare Pastry			1			1
Receive Material				1		1
Receive Order			1			1
Reconcile accounting journal with bank stat	1					1
Reconcile cash, checks, credit card payment			1			1
Select Candidates from Applications				1	1	2
Sign On New Employee				1		1
Tender Payment			1			1
UPdate Accounting Journal			1			1

Figure 7. Activity-People View

ActivityName	Accounting	DayShift	Management
Brew Coffee		1	
Calculate Pay	1		
Check Current Coffee Stock		1	
Check Materials stock			1
Collect Hours Worked		2	1
Deliver Paycheck			1
Deposit cash, checks, credit c			1
Grind Beans		1	
Initialize Cash Register		1	
Interview Candidates			2
Make Espresso Drink		1	
Make Offer			1
Make Payment	1		
Place Job Advertisement			1
Place Order			1
Pour Coffee		1	
Prepare Pastry		1	
Receive Material			1
Receive Order		1	
Reconcile accounting journal	1		
Reconcile cash, checks, credit		1	
Select Candidates from Appli			2
Sign On New Employee			1
Tender Payment		1	
UPdate Accounting Journal		1	

Figure 8. Activity-Organization View (showing Number of People)

Outsourcing analysis. Business process outsourcing represents an important opportunity for a manufacturing or a service enterprise. When a business process is outsourced, its associated actors and resources will no longer be under the control of the enterprise. Are there any undesirable consequences? For example, is a resource to be outsourced needed by other in-house business processes? When the enterprise is large and complex, such a simple question is not easy to answer. After a business process with its associated resources and people is outsourced, do the remaining resources and people get utilized productively? Will a customer notice any difference? Structural analysis provides activity-resource and activity-actor views that show precisely what gets outsourced and helps highlight undesirable consequences, if any. Some of the consequences may not be obvious if one has to traverse two or three links between activities and resources / actors in order to see them.

In the coffee shop example, there are four business processes, each of which can be a candidate for outsourcing. Each process consists of a number of activities, all of which are shown in Fig. 7. Fig. 9 shows a process-people view that indicates who are involved in each process across the row. (The number in the cell indicates how many activities require that person and the "Total" column shows the total across a row.) If a process uses an exclusive set of people that are not used by any other process, it may be a better candidate for outsourcing than a process that shares many people with other processes. In this example, it can be seen easily from Fig. 9 that there is no process that uses an exclusive set of people. If one is considering the outsourcing of the payroll process, say, then from Fig. 9 we can see that it will reduce the effort of every person except the store manager. In particular, the owner will have no activity left to perform (besides intangible activities connected to owning the shop) and the accountant will have only one activity in procurement left to perform. The owner may consider outsourcing payroll as an advantage since he can enjoy life more. The other issue is whether we can fill the time of the accountant productively or have the possibility of reducing the paid hours of the accountant. In reality, for a more complex enterprise such information will be highly useful in analyzing outsourcing.

Similarly, Fig. 10 shows a process-machine view that indicates what machines are required in each process across the row.

ParentActivity	ActivityName	Total	Accountant	Barista	Cashier	Manager	Owner
Act-3	Coffee Production	3		3			
Act-30	Cash Management	5	1		3	1	
Act-4	Customer Order Processing	5		1	4		
Act-40	Recruiting	7				4	3
Act-5	Payroll	5	1	1	1	1	1
Act-6	Procurement	4	1			3	

Figure 9. Process-People View (showing Number of Activities)

ParentActivity	ActivityName	Total	Cash Registe	Coffee Brew	Coffee Grinc	Espresso Ma	Refrigerator
Act-3	Coffee Production	2		1	1		
Act-30	Cash Management	2	2				
Act-4	Customer Order Processing	3	1	1		1	
Act-6	Procurement	1					1

Figure 10. Process-Machine View (showing Number of Activities)

Sometimes an enterprise is interested in outsourcing the production of entire products. In this case it will be useful to see whether any product uses an exclusive set of people or machines. In the coffee shop example, Fig. 5 shows a product-people view that indicates who are involved directly in making a product across the row. It can easily be seen that no product in this example uses an exclusive set of people. Similarly, Fig. 13 shows a product-machine view that indicates what machines are required for making a product across the row.

4.2.2 Applications Associated with Resource-Related & Organizational Entities

Resource-related and organizational entities are all physical assets of the enterprise. The usual concerns with them, such as how well they are utilized or how bad it would be should some become unavailable, apply to both entity categories. Hence we treat them together in this sub-section.

Reuse analysis. In software development or product manufacturing, a lot of emphasis is placed on the reuse of parts or components due to a number of advantages such as cost, time to market,

and reliability. In product manufacturing, the degree of reuse of a selected part can be analyzed using the bills of materials of the products made by the company. If we extend the concept of reuse to a general resource that includes parts, financial resources, machines, and people, a similar analysis to that of the bills of materials needs to be carried out. Structural analysis provides an easy way to view the mapping of resources to activities, actors to activities, resources to products, actors to products showing the extent of reuse of resources and actors across activities or across products.

In the coffee shop example, Fig. 5 shows a product-people view that shows the degree of reuse of a person among products down a column. Fig. 7 shows an activity-people view that indicates the degree of reuse of a person among activities down a column. Fig. 11 shows a product-material resource view that indicates the degree of reuse of a material among products down a column. (The number in the cell indicates how many activities use that material for the product.) Fig. 12 shows an activity-material resource view that indicates the degree of reuse of a material among activities down a column.

ResourceName	Brewed Coffe	Coffee Bean	Coffee Filter	Coffee Groun	Cups	Electricity	Espresso Groun	Milk	Pastry	Pastry Bag	Water
Finished Cup of Coffe	1	1	1	2	1	4					1
Finished Espresso Drir					1	3	1	1			1
Ready Pastry						2			1	1	

Figure 11. Product-Material Resource View (showing Number of Activities)

ActivityName	Brewed Coffe	Coffee Bean	Coffee Filter	Coffee Groun	Cups	Electricity	Milk	Water	Espresso Groun	Pastry	Pastry Bags
Brew Coffee	1		1	1		1		1			
Grind Beans		1		1		1					
Initialize Cash Regist						1					
Make Espresso Drink					1	1	1	1	1		
Pour Coffee					1						
Prepare Pastry										1	1
Receive Order						1					
Tender Payment						1					

Figure 12. Activity-Material Resource View

Additional insights on reuse can be obtained through a structural Pareto analysis. This is discussed further below. One disadvantage of heavy reuse is the risk of a critical resource not being available or having a failure. This leads us to the next application.

Risk analysis. There are several types of risks faced an enterprise. A standard classification of risks (IRM et al. 2002) suggests four broad categories: financial, operational, strategic, and hazard risks. Although some risks could be result in positive benefits for an enterprise, most risk management personnel are concerned with negative risks. In particular, operational risks include potential impacts on a supply chain when some resource cannot be obtained or when some actor is not functional.

For example, in a manufacturing plant, if a machine fails, what processes and ultimately what final products will be impacted? In a labor-intensive service firm, what processes, customers, and performance measures will be impacted if one person calls in sick or leaves the company? Even more fundamentally, what business processes or activities will be impacted if we run out of cash one day? Due to recent political and economic volatilities, business continuity and contingency planning has gained more attention. Structural analysis shows all processes, customers, and performance measures related to a selected resource or actor. This helps identify risks, a first step in any risk management program.

In the coffee shop example, Fig. 5 shows a product-people view, indicating what products are impacted down a column if a person is not available. Fig. 11 shows a product-material resource view that indicates what products are impacted down a column if a material is not available. At a more detailed level, Fig. 7 shows an activity-people view that indicates precisely what activities are impacted down a column if a person is not available. Similarly, Fig. 12 shows an activity-material resource view that indicates precisely what activities are impacted down a column if a material is not available; Fig. 13 shows an product-machine view that indicates the impact of machines on products; Fig. 14 shows an activity-machine view that indicates the impact of machines on activities. Further, Fig. 15 shows a product-system view that indicates what

products are impacted down a column if a system is not available. Fig. 16 shows an activity-system view that indicates precisely what activities are impacted down a column if a system is not available.

ResourceName	Cash Register	Coffee Brewer	Coffee Grinder	Espresso Machine
Finished Cup of Coffee	1	2	1	
Finished Espresso Drink	1			1
Ready Pastry	1			

Figure 13. Product-Machine View (showing Number of Activities)

ActivityName	Total Of Res	Cash Registe	Coffee Brew	Coffee Grinc	Espresso Ma	Refrigerator
Brew Coffee	1		1			
Grind Beans	1			1		
Initialize Cash Register	1	1				
Make Espresso Drink	1				1	
Pour Coffee	1		1			
Receive Material	1					1
Reconcile cash, checks, cr	1	1				
Tender Payment	1	1				

Figure 14. Activity-Machine View

ResourceName	Order Processing
Finished Cup of Coffee	2
Finished Espresso Drink	2
Ready Pastry	1

Figure 15. Product-System View (showing Number of Activities)

ActivityName	Total Of ResourceID	Finance	Inventory and Payroll	Order Processing
Calculate Pay	1		1	
Check Materials stock	1		1	
Collect Hours Worked	1		1	
Make Espresso Drink	1			1
Make Payment	1		1	
Place Order	1		1	
Pour Coffee	1			1
Receive Material	1		1	
Receive Order	1			1
Reconcile accounting journal	1	1		
Update Accounting Journal	1	1		

Figure 16. Activity-System View

Business performance dashboards. Common business performance dashboards show high-level quantitative measures related to products (e.g., number of units sold, amount of revenue generated, amount of gross profit, amount of cost incurred to produce the product) and customers (e.g., number of customers, number of customer orders per customer or per region, amount of revenue per customer or per region). Since structural analysis gives the mapping of products or customers to resources, actors, and activities, the output of a business performance dashboard can be combined with that of structural analysis to show measurements of resources, actors, and activities. For example, one can monitor the volume of products sold in a region together with the volume of the activities used to manufacture the products and with the level of effort of the people or machines used by the products. Such information will be useful in periodic reporting or in real-time monitoring.

In the coffee shop example, say if a traditional performance dashboard tells us that on this day in this shop 500 cups of coffee and 200 espresso drinks were sold, then from the product-people view in Fig. 5 we can deduce the number of times the different people were called on to sell the products though a simple multiplication, as shown in Fig. 17. Similarly, from the sales volume and the product-machine view in Fig. 13 we can deduce the number of times the different machines were used to sell the products, as shown in Fig. 18. (We are counting a machine or a person every time a product is handled, assuming no consolidation across products. If there is consolidation, then this represents the maximum number of times the people or machines are used.)

ResourceName	Barista	Cashier
Finished Cup of Coffee	1000	1500
Finished Espresso Drink	200	400
Ready Pastry		100

Figure 17. Number of Times of People Called On For a Given Day's Sales

ResourceName	Cash Register	Coffee Brewer	Coffee Grinder	Espresso Machine
Finished Cup of Coffee	500	1000	500	
Finished Espresso Drink	200			200
Ready Pastry	200			

Figure 18. Number of Times Machines Used For a Given Day's Sales

4.2.3 Applications Associated with Strategic Entities

Performance diagnostics. Any enterprise, in particular, a commercial enterprise is measured by a number of key performance indicators (KPI's). Senior management staff and other stakeholders of the enterprise, such as shareholders, monitor these KPI's to ensure that the enterprise is running effectively and to identify opportunities for improvement. When one or more of the KPI's are judged to be unsatisfactory, corrective actions will be triggered. In the case of large enterprises, a natural, first step is to find out where are the potential issues that contribute to the inadequate KPI. Structural analysis provides a view of all resources, actors, activities, or products directly related to the KPI in question. This will be very useful for quickly narrowing down our focus to take the next steps of investigation.

In the coffee shop example, there are two KPI's: coffee inventory level and time to serve a customer. Fig. 19 shows an activity-KPI view that indicates what activities are measured by a KPI down a column. If, say, the time to serve a customer is too long, the five activities indicated in the last column in Fig. 19 might have something to do with it. Fig. 20 shows a people-KPI view that indicates which people are measured by a KPI down a column. (The number in a cell indicates the number of activities performed by that person that are measured by the KPI.) Similarly, Fig. 21 shows a machine-KPI view that indicates which machines are measured by a KPI down a column.

ActivityName	CoffeeBeans	CoffeeInventory	EspressoGounc	NumberOfAccountingErrors	PastryInventc	TimeToRecruitEmp	TimeToServeCust
Brew Coffee		1					
Calculate Pay				1			
Collect Hours Worked				1			
Grind Beans	1						
Initialize Cash Register				1			
Interview Candidates						1	
Make Expresso Drink			1				1
Make Offer						1	
Make Payment				1			
Place Job Advertisement						1	
Place Order	1		1		1		
Pour Coffee		1					1
Prepare Pastry					1		1
Receive Material				1			
Receive Order							1
Reconcile accounting journal				1			
Reconcile cash, checks, credit				1			
Select Candidates						1	
Sign On New Employee						1	
Tender Payment							1
UPdate Accounting Journal				1			

Figure 19. Activity-KPI View

ResourceName	CoffeeBean:	CoffeeInvent	EspressoGo	NumberOfAccountingErrors	PastryInventory	TimeToRecruitEmp	TimeToServeCust
Accountant				3			
Barista	1	1	1	1			1
Cashier		1		4	1		4
Manager	1		1	2	1	4	
Owner						3	

Figure 20. People-KPI View (showing Number of Activities)

ResourceName	CoffeeBeans	CoffeeInven	EspressoGound	NumberOfAccountingErrors	TimeToServeCustomer
Cash Register				2	1
Coffee Brewer		2			1
Coffee Grinder	1				
Espresso Machine			1		1
Refrigerator				1	

Figure 21. Machine-KPI View (showing Number of Activities)

Value driver analysis. A common method used in business strategy development is value driver analysis whose goal is to develop a list of the most important factors (i.e., the value drivers) influencing a selected KPI or a certain issue. In this way, appropriate actions can then be taken to improve the KPI or to resolve the issue. Finding the critical value drivers is not a trivial exercise, and most approaches ultimately depend on qualitative reasoning or subjective judgment. Structural analysis helps provide an internal view by identifying the resources, actors, activities,

or products directly related to the KPI. This provides valuable information to support the development of value drivers that are internal to the enterprise.

In the coffee shop example, Figures 19 – 21 are useful for value driver analysis. Further, Fig. 22 shows a product-KPI view that indicates which products are measured by a KPI down a column. (The number in a cell indicates the number of activities for the product that are measured by the KPI.)

ResourceName	CoffeeBeans	CoffeeInventory	EspressoGounds	PastryInventory	TimeToServeCustomer
Finished Cup of Coffee	1	2			3
Finished Espresso Drink			1		3
Ready Pastry				1	3

Figure 22. Product-KPI View (showing Number of Activities)

4.3 Applications Involving Three or More Entity Categories

Detailed performance diagnostics or performance diagnostic "drill-downs." We discussed how structural analysis can help in identifying the problematic areas in an enterprise in Section 4.2.3. Continuing with that line of thought, once say the activities, people, or machines are identified with the KPI or KPI's in question, we may want to further discover what products these activities, people, or machine operate on. In our coffee shop example, we can list the products under a selected Activity-KPI combination in Fig. 19, or a selected People-KPI combination in Fig. 20, or a selected Machine-KPI combination in Fig. 21. Alternatively, as a summary view, we can count the number of products associated with a selected Activity-KPI combination in Fig. 19, or a selected People-KPI combination in Fig. 20, or a selected Machine-KPI combination in Fig. 21. These are shown in Fig. 23 – 25. Such views give insights on how extensive the scope of a particular KPI-Activity (or –People or –Machine) combination is, in terms of the number of products impacted. An unsatisfactory KPI associated with many activities (or people or machines) impacting many products is naturally a top candidate for attention. (Note, however,

that activities, people, machines, or KPI's not directly related to a product are not shown in Fig. 23 – 25, in contrast to Fig. 19 – 21.)

ActivityName	CoffeeBeansInventory	CoffeeInventory	EspressoGoundsInventory	PastryInventory	TimeToServeCust
Brew Coffee		1			
Grind Beans	1				
Make Expresso Drink			1		1
Pour Coffee		1			1
Prepare Pastry				1	1
Receive Order					3
Tender Payment					3

Figure 23. Activity-KPI View (showing Number of Products)

ResourceName	CoffeeBeansInventory	CoffeeInventory	EspressoGoundsInventory	PastryInventory	TimeToServeCust
Barista	1	1	1		3
Cashier		1		1	3
Manager	1		1	1	

Figure 24. People-KPI View (showing Number of Products)

ResourceName	CoffeeBeansInventory	CoffeeInventory	EspressoGoundsInventory	NumberOfAccountingErrors	TimeToServeCustomer
Cash Register				3	3
Coffee Brewer		1			1
Coffee Grinder	1				
Espresso Machine			1		1

Figure 25. Machine-KPI View (showing Number of Products)

We should mention that Fig. 20 – 22 earlier actually shows information from three entity categories, but our purpose there is identify a two-way 0-1 relationship without using the information provided in the third category (in the example the Number of Activities in the cells of the three tables).

Detailed risk analysis. We discussed how structural analysis can help identify operational risks in Section 4.2.2, such as the scope of impact of an unavailable resource or actor. To further analyze the severity of an unavailable resource or actor, one way is to calculate the fraction of products purchased by a certain customer or a customer segment that is impacted by the unavailability of a resource or an actor. For example, if a material is used by all of the products

purchased by a customer and the material becomes unavailable, that customer will most certainly not be satisfied. In a service business, many processes involve the direct interaction of employees with customers, and a similar analysis of the fraction of services a customer purchase that is impacted by the unavailability of a person or an organizational unit will be useful. A ranking of resources or actors by this faction for a selected customer segment(s) provides insights on the relative need for risk protection of the resources or actors.

In the coffee shop example, Figure 26 shows the number of products purchased by a customer segment, that requires a certain material directly. Comparing the number of products for each material to the total number of products purchased by the customer shows immediately the scope of potential impact. Figure 27 shows a similar view for people (instead of materials) directly associated with the customer segments. The customer-people view showing number of products will be especially important to service businesses.

CustomerSegment	Brewed Coff	Coffee Bean	Coffee Filte	Coffee Grou	Cups	Electricity	Espresso Gr	Milk	Pastry	Pastry Bags	Water
Beverage Customers	1	1	1	1	2	2	1	1			2
Espresso Drinkers					1	1	1	1			1
Leisure Customers	1	1	1	1	2	3	1	1	1	1	2
Loyal Customers	1	1	1	1	2	3	1	1	1	1	2
Morning Customers	1	1	1	1	1	2			1	1	1

Figure 26. Customer-Material View (showing Number of Products)

CustomerSegment	Barista	Cashier
Beverage Customers	2	2
Espresso Drinkers	1	1
Leisure Customers	2	3
Loyal Customers	2	3
Morning Customers	1	2

Figure 27. Customer-People View (showing Number of Products)

5 Synergies with Existing Enterprise Information Technologies

We discuss the synergies of structural analysis with existing technologies from the viewpoint of a business user. Due to the many potential applications (described in the previous

section), there are a number of target users, including senior management, enterprise architecture designers, business analysts, business process engineers, marketing analysts, strategy and operations specialists, and management consultants.

Business architecture software typically contains many of the data entities in the structural analysis framework. Some BA software tools have the capability of user-defined data entities, which will be useful here. In addition, the user interface might have to be enriched to accommodate the specific output requirements of structural analysis, such as Pareto graphs or a cross-tabular presentation for showing dense relationships between two sets of entities. Most BA software tools today focus on using graphical representations of entities on the screen.

Another obvious synergy is with OLAP based software tools. The latter include important business applications such as business performance dashboards and business intelligence. Databases, be they relational, hierarchical, or universal in nature, now commonly offer OLAP capability as an add-on, making themselves synergistic with structural analysis. Although structural analysis can be done using standard database query languages such as SQL (as we have done in our coffee shop example), OLAP technology will provide more efficient computation for large enterprises and generally a superior user interface.

Because much of the data required by structural analysis are also used by and contained in a typical ERP system, structural analysis is synergistic with ERP systems. In particular, some ERP systems have an open interface to support independent add-ons. One can potentially develop code to directly perform structural analysis of the appropriate data resided in the ERP system.

Structural analysis could and should be used along with other analytical tools for organization or process design or reengineering. For example, process modeling and simulation tools are commonly used and structural analysis complements their capabilities by providing information that could not be obtained easily with these tools alone. Therefore structural analysis

is synergistic with existing organization or process design tools to the user. In fact, much data that already exist in process models can be reused by structural analysis.

6. Concluding Remarks

In this paper, we propose the concept of structural analysis of an enterprise and discuss some of the potential applications of it in a business setting. Using a simplified, hypothetical example of a coffee shop and PC-based relational database software, we developed a proof-of-concept prototype to illustrate our main ideas. We also discuss the synergies of existing technologies with structural analysis as an everyday tool for a business.

We believe that structural analysis will find many more uses than the applications described here. For example, in the above applications we have only used a subset of the entities defined by the enterprise ontology (Uschold et al. 1998); other applications similar to the above can be thought of using entities in the ontology not covered by the above examples.

Many new research issues will surface as new uses are discovered. As part of the basic work on the subject, an obvious research issue is effective visualization of the views provided by structural analysis, other than the tabular forms shown here or in common OLAP based tools. For example, some of the views related to people in the enterprise may be combined with an organization chart to give more intuitive representation.

We mention the potential application of structural analysis in a business performance dashboard. Despite the two simple examples given in Section 3.2, the precise linkage of the results from a typical dashboard to that of structural analysis is not trivial in general. Exactly what information will be useful under what setting (e.g., periodic reporting or real-time monitoring) when we have the possibility of showing very detailed views inside an enterprise is a research issue in itself.

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