Goal Decomposition and Scenario Analysis in Business Process Reengineering

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Abstract This paper presents experiences in applying the goal decomposition and scenario analysis model in the context of Business Process Reengineering (BPR). The relationships of goals, scenarios, as well as the understanding and description of business processes are discussed. Different methods of goal refinement, and the application of scenarios to support this process of refining goals and roles are reviewed. A case study is presented which serves to exemplify and validate the process of using scenarios in refining business process descriptions. We tried deriving full scenarios for business processes, but obtaining them from the organization's prescriptive goals was difficult. Explanatory scenarios that justify descriptive goals are easier to obtain but are fragmentary. We conclude that both types of scenario and goal analysis are necessary for effective BPR. The need for technology support for this process is discussed and attention is given to future anticipated research in this area.

1 Introduction

Business Process Reengineering (BPR) attempts to avoid the penchant of automating existing processes or tasks in organizations in order to achieve efficiencies, and it attempts to question the reasons why specific processes and activities are linked together in support of a particular business entity [Smith93]. BPR models an organization's behavior so that we may better understand how to modify that behavior, and then develop the requirements for the needed automation to support that changed behavior. Hammer and Champy [Hammer93] suggest that BPR requires "discontinuous thinking" (abandoning outdated rules and business operations) or starting from a "clean slate" in order to achieve dramatic improvements in performance. BPR usually involves the automation of some activities in the overall process, or the redistribution of process-related responsibilities from people to software systems (or even physical devices). The requirements for a software system that support a reengineered process therefore, must be understood in the context of the goals of the BPR project.

A less radical approach than Hammer and Champy's [Hammer93] 'clean slate' philosophy is to identify local inefficiencies in business processes, and recommend interventions to remove or mitigate them. In such cases of incremental automation, the requirements for systems still arise out of a process analysis and can only be understood as a response to an organizational need. Most system development falls somewhere on a spectrum between 'clean slate' and 'incremental improvement.' Smith and McKeen [Smith93] use the term *business re-engineering* to refer to the 'clean slate' philosophy, and the term *process re-engineering* refers to incremental automation. We will use these two terms in the remainder of this paper.

A critical factor in successful projects appears to be that developers not only understand what they are developing, but *why* [Conklin90, Potts94a]. In the context of business

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reengineering and process reengineering, the issues of 'why' are critical to understanding current processes and identifying inefficiencies in those processes so that they may be improved. Our approach centers on describing the activities of an organization so that needs for improvement may be identified. This approach suggests the need for a mechanism to describe the organization's behavior (not the organization's structure), as a precursor to the specification of the software to automate some of the behavior of the organization.

To describe this behavior, we are using operational concept definitions, not specifications. A specification is a description of behavior that should be able to generate all possible or valid behaviors. Specification languages are very valuable for describing software systems because they describe in detail and with minimal ambiguity the behavior of a mechanistic system. Researchers in the 1970's explored the use of special purpose specification languages for describing business processes as formally as possible [Hammer77], but businesses are not mechanistic systems and current opinion about the usefulness of business process specifications is divided. Another shortcoming of the specification approach is that a specification language provides a means of expression but does not tell the user what to say. The successful use of a specification language therefore depends on the application of an analysis method.

Operational concept definitions (OCD) are an alternative to specifications. An OCD describes business processes in terms of scenarios, critical incidents, or examples of the problems an organization must solve. Whereas, specifications abstract away from the concrete, OCDs describe the organization through a collection of concrete examples. Although this makes them easy to understand, and a good source of information system requirements [Benner92], there is the danger that a random collection of scenarios may not actively represent what the organization does or needs. It is essential, therefore, to populate OCDs with representative cases and relate them to goals of the organization.

In the rest of this paper, we discuss the relationships between goals and scenarios, as well as the understanding and description of business processes. We review different methods of goal refinement, and the application of scenarios to support this process of refining goals and roles. A recently conducted case study is presented. The case study serves to exemplify and validate the process of using scenarios in refining business process descriptions. Additionally, the case study will aid in determining the requirements for a suite of tools we are developing to support goal decomposition and scenario refinement. The last section of the paper explores the needs for technology to support our process and discusses further research we anticipate conducting in this area.

2 Goals

Business processes and the operations that roles perform are *operationalizations* of goals. While the processes, organizational structures, and operations of a system will evolve continually, goals remain more stable. An efficient enterprise and an effective use of information technology depends on a close correspondence between goal structure and role responsibilities; if the goal structure of the enterprise is incompatible with its physical structure (including the automated components) there will be much inefficient and unnecessary communication of information across subsystem boundaries.

2.1 Semantic Classification of Goals

Goals may be classified in several ways. Dardenne et. al. [Dardenne93] present a goal refinement method which offers a way of modeling concepts acquired during requirements elicitation. Their goal classification scheme differentiates among types of goals according to the conditions that are the target of the goals. In this scheme, goals are of three types: achievement, maintenance and avoidance goals. An achievement goal is satisfied when a target condition is attained. A maintenance goal is satisfied as long as its target condition remains true. An avoidance goal is satisfied for as long as its target condition remains

false. This classification is useful when it comes to operationalizing the goals as actions the system must perform [Dardenne93].

Sutcliffe and Maiden [Sutcliffe93] present a model in which goals are classified according to the desired system states. Goals are classified into six classes: positive state, negative state, alternative state, exception-repair, feedback, and mixed state. These six classes are expressed in terms of a policy-goal model which consists of three levels: policy level, functional goal level and domain goal level. Policy goals describe what should be done. At the functional goal level, goals express information about what may be done to achieve policy level goals. At the domain goal level, goal descriptions are refined in order to give consideration to management implications, operational implications, and opportunities for automated support. The decomposition model facilitates the structuring of the problem space by refining policies to identify the functions necessary for achievement [Sutcliffe93].

Yu and Mylopoulous [Yu94] present a modeling framework composed of goals, rules, and methods to support the systematic analysis and design of business processes. The two main components of their framework are an Actor Dependency model and an Issue Argumentation model. These two models allow one to distinguish between process goals and design goals. The Actor Dependency model provides a representation of an organization as a network of interdependencies among actors. The Issue Argumentation model serves to support reasoning during the design process. It captures the design argumentation and the relative merits of each alternative with regard to relevant issues of concern [Yu94].

2.2 Pragmatic Classification of Goals

While semantic classification schemes are valuable for elucidating the formal relationships among goals, once they are identified, they do not suggest strategies for identifying goals during business reengineering and process reengineering. A pragmatic classification of goals differentiates *prescriptive* and *descriptive* goals. A prescriptive goal is offered by a stakeholder to account for organizational structures and processes that *should* be observed. These goals typically come from strategic management or are codified in the organization's written procedures. A descriptive goal, in contrast, emerges from an analysis of actual processes. These goals are most often found in the transcripts of interviews with operational staff or observational records. Descriptive goals usually lie buried in the current operational processes of the organization. Without prompting, stakeholders seldom reflect on these goals, being aware only of the operationalizations of the goals in the form of actions they regularly perform. Our observations lead us to believe that management stakeholders lean towards expressing goals as prescriptive, while stakeholders in support positions tend to describe goals in a descriptive fashion.

Another distinction among classes of goals, glossed over by research into the semantics of goals, is that between *objective* goals and *adverbial* goals. Objective goals refer to the object of the business. For example, a university parking space allocation system may need to satisfy the goal of assigning all requests for parking before the start of the year. The object of the goal is parking space allocation - precisely what the stakeholders think the purpose of the system to be. Elucidating objective goals is the aim of much recent research in requirements engineering. An adverbial goal, on the other hand, is a meta-level goal that refers to the manner of achieving an objective goal. For example, the parking allocation department may have the goal of responding to all customer queries courteously. Adverbial goals are an important part of all businesses, and in some service industries the boundary between objective and adverbial goals is not clear-cut. We find the distinction useful, however, because it translates directly into different strategies for elucidating goals and using them in the requirements specification process. For example, adverbial goals are seldom refined into system requirements, but they affect how the requirements themselves are evaluated and refined. Adverbial goals often serve as the rationale for the non-functional requirements (e.g. performance, reliability, and usability requirements). In this paper, we concentrate on objective goals and functional requirements.

2.3 Goal Structure

Goals are high-level objectives that require refinement before they give rise to system requirements or constraints. The two refinement processes that accomplish this are operationalization and responsibility assignment. Operationalization is the process of refining goals so that the resulting subgoals have an operational definition. This means that the goals are defined in sufficient detail for their achievement to be a matter of objective measurement. It is not generally possible to refine a goal into a set of operationalized subgoals in one step. Not only are many goals sufficiently abstract that they must be decomposed through several levels of subgoals before they can be operationalized, but many goals potentially conflict with other goals. In cases of goal conflict, the refinement process involves providing more detailed and qualified definitions of the goals that reflect exceptions and priorities.

Responsibility assignment allocates some operationalized goals to organization components (including automated systems). Information system requirements therefore emerge from an analysis of operationalized goals.

2.4 Goal Refinement

The literature on goal refinement assumes a relatively orderly or rational organization of goals [Benner92, Dardenne93] provided that the analyst knows enough about the domain. It should always be straightforward to decompose a goal into its subgoals. While this is true of prescriptive goals, in part because they have usually been written down and organized in advance, descriptive goals present more problems to the analyst. There are often large gaps in the descriptive goal structure that emerges from an analysis of stakeholder input.

Because a rational organization of goals cannot be taken for granted, we regard the refinement of goals as a type of discovery or inquiry process throughout which the analyst repeatedly asks questions of certain types. For example, to refine an achievement goal [Dardenne93] the analyst asks what constituent conditions must be attained for the target condition to become true. By resolving these questions it becomes possible to refine, operationalize and reorganize the goals. The goal refinement strategy depends most of all on asking 'what if' questions and using *scenarios* to explain the rationale for goals (especially the operationalization of goals).

3 Scenarios

From our studies of existing projects [Lubars93] we have concluded that concrete scenarios are essential to an understanding of the operational concept of a system, and that scenarios therefore play a major role in deriving goals and thus, the requirements for the system. There are at least two types of scenarios which may affect the derivation of requirements, which we call *process* scenarios and *explanatory* scenarios. Both types are closely related to the goal structure of the organization.

3.1 Process scenarios

In process scenarios, the analyst and user walk through a detailed process from beginning to end to investigate the opportunities for improvements or to investigate the impacts of a proposed system on their current processes. In a process scenario, the analyst asks the question: "what do we actually do?" or, alternatively: "how would the proposed system handle the following case?"

Goals and process scenarios are closely related. Process scenarios result from the aggregation of phases, or *episodes*, each of which is a short sequence of goal-related activities to achieve or thwart a goal [Potts94b]. We are investigating the identification of episodes (and therefore scenario discovery) through the analysis of maintenance goals (which are usually refined into activities that periodically, or sporadically, check the state of

some system state variables) and avoidance goals (which are usually refined into tests that are performed before or after potentially goal-violating actions). Process scenarios require a thorough understanding of the organization's goals or global understanding of the operations in a process. They are therefore most useful for business reengineering.

Because scenarios usually explicate the interactions among several organization components (including existing or proposed systems) it is important to highlight which actors perform the constituent actions in the scenario. We refer to these actors as *roles*. Ideally, the actions performed by the role in a scenario should reflect a rational assignment of responsibilities for the achievement of operationalized goals.

Table 1 shows a process scenario from a group meeting scheduling system [Potts94b]. This scenario represents an end-to-end sequence of activities performed by several roles to achieve the goal of scheduling a meeting.

3.2 Explanatory scenarios

In explanatory scenarios, the analyst and users may describe current operations or desired features of the system by referring to concrete incidents. Unlike process scenarios, which refer to end-to-end, purposive transactions in the organization, explanatory scenarios are fragmentary illustrations of details. We find that they are particularly illuminating when an organizational member has to explain an inefficiency to an analyst who is not familiar with the business process.

3.3 Scenarios in BPR

In moving from systems requirements analysis to business process reengineering, the question arises: do the types of scenarios that we have described occur when stakeholders describe current processes? And how are the scenarios related to the goal structure of the organization and its operationalization in role responsibilities and actions?

No.	Role	Action
1	Initiator	Request meeting of a specific type, with meeting info. (e.g. agenda/ purpose and date range)
2	Scheduler	Add default (active/ important) participants, etc.
3	Initiator	Determine 3 participants
4	Initiator	Identify 1 presenter as active participant
5	Initiator	Identify initiator's boss as important participant
6	Initiator	Send request for preferences
7	Scheduler	Send appropriate e-mail messages to participants (incl.. additional requests to boss and presenter)
8	Ordinary Participant	Respond with exclusion and preference set
9	Active Participant	Respond with exclusion and preference sets and equipment requirements
10	Scheduler	Request required equipment
11	Important Participant	Respond with exclusion and preference sets and possibly location preference
12	Scheduler	Schedule meeting based on responses, policies and room availability
13	Scheduler	Send confirmation message to all participants and meeting initiator

Table 1: Process scenario script for No Conflicts scenario in Meeting Scheduling System.

Dardenne [Dardenne93] has found that scenarios are not common in users' dialogues with analysts in the case of a library information system. Looking at Dardenne's data, it appears that when scenarios do occur, they tend to be explanatory scenarios. This agrees with our experience [Lubars93b] that process scenarios must be investigated by means of a deliberate, inquiry process. Whereas, explanatory scenarios are offered more spontaneously.

Often the scenarios whose exploration yields the best insights into the proposed system are those that revolve around the operational definition of roles and their responsibilities [Potts94b]. This conclusion, taken together with our interpretation of Dardenne's results, suggests that explanatory scenarios are more likely to be useful when analyzing descriptive goals, and process scenarios are more likely to be useful when analyzing prescriptive goals. We must be careful, therefore, in moving our ideas about goals and scenarios to practical BPR interventions, because the rational approaches that work best on artificial laboratory exercises may not be the ones that are amenable to the data gathered from real stakeholders.

4 Case Study

We now describe a case study involving a College Financial Services Office (FSO) which employs four full time employees, two part time student assistants, and requires the integral involvement of three College administrators. The FSO is responsible for all of the College's finances. Six stakeholders participated in initial interviews (two College administrators and four FSO employees), and these information gathering sessions provided us with an understanding of the organizational structure, the lines of communication within the organization, and the business processes that the FSO is responsible for.

4.1 Goal Structures

The FSO administration provided a set of very high-level goals which were prescriptive in nature and emphasized deliverables. Upon speaking with the actual FSO employees, it was obvious that no one outside the administration was aware of the existence of these prescriptive organizational goals and objectives. This led us to believe that these goals were not representative of the perceived goals of all stakeholders. The prescriptive goals were analyzed using a top-down approach in order to develop a goal hierarchy. This goal hierarchy was then compared to the goal hierarchy which resulted from a bottom-up analysis of the goals from the perspective of the FSO employees. These goals, from the bottom-up analysis were much more concrete, process/task oriented, and *descriptive* in nature.

4.2 Initial Goal Identification

By analyzing the list of process inefficiencies which we identified in our initial analysis of the FSO business processes, we were able to identify some of the organizational goals using the bottom-up approach. We examined each process inefficiency, asking *"What goal is prevented from being satisfied by this inefficiency?"* We initially chose this approach, because it was structured, methodical, and would enable us to identify scenarios that satisfy the system goals. It is important to recognize, however, that this approach in no way provides a 'complete' set of goals. The goals identified in this manner proved to be very high level and did not offer a direct correspondence to our set of prescriptive goals. Thus, the results of this analysis were not extremely useful for the consideration of information system requirements. For purposes of our BPR effort which concentrated on the *current* business processes, we chose to focus our analysis on the descriptive goals.

Bottom-up Approach to Goal Identification. In order to identify a more concrete set of 'process' goals, we reviewed the scenario fragments elicited from the stakeholders. For each scenario we asked, *"What goal does this scenario fragment either support or*

satisfy?" and/or *"What goal does this scenario fragment prevent the achievement of?"* We then constructed a goal hierarchy using the representation scheme presented in [Benner92]. This is a bottom-up approach to goal identification. As such, it is less structured and by no means offers a complete set of goals. It does, however, raise exceptional cases which may not have been apparent in the prescriptive goal set. This goal hierarchy is shown in Figure 1. Goals identified in this fashion are defined primarily by the current organizational procedures. The goal Avoid AccountsUndesignated (see '2' in Figure 1) was derived upon examination of the following natural language scenario:

> ***Scenario 1: Accounts Undesignated.*** *Professor salaries are not always paid completely by State funds. When we do not know which account or contracts will be used to pay a Professor's entire salary, we put the professor on a dummy number (undesignated account). We are not supposed to use dummy numbers so we try to move them off of undesignated accounts as soon as possible.*

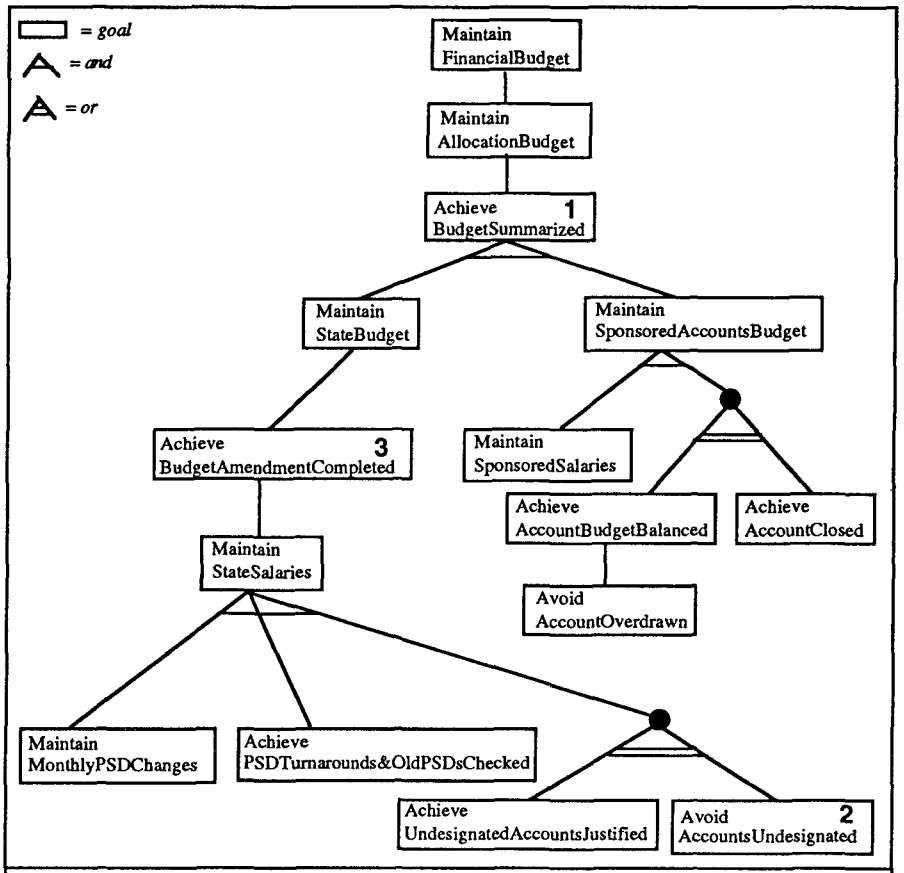

Fig. 1. Goal Hierarchy for FSO Sponsored and State Accounts.
This hierarchy was constructed using a bottom-up approach.

Top-down Approach to Goal Identification. The goal hierarchy in Figure 2 is based on the given set of prescriptive goals. These goals were systematically decomposed into subgoals. The scenario transcripts were then reviewed in an effort to identify supporting and/or non-supporting scenario fragments as in the bottom-up approach. Scenarios were identified for three of the prescriptive goals (1. Achieve ConsolidatedReport, 2.

Maintain UndesignatedSalaryExpenditures, and 3. Achieve BudgetSummarized). These scenarios/goals correspond to goals 1, 2, and 3 in Figure 1. The top-down approach requires an initial set of prescriptive goals. In our case study, these goals displayed a definite emphasis on deliverables. The following scenario was identified for the goal Avoid UndesignatedSalaryExpenditures:

> ***Scenario 2: Undesignated Salary Expenditures.*** *Often times, when Winter quarter rolls around, a lot of professors still have their research assistants on a dummy number (undesignated account). That is not supposed to be the case. You are supposed to know which accounts will be used to support all employees all year long.*

4.3 Analysis

Our analysis exhibits that employing solely a bottom-up approach to goal identification fails to provide a sufficiently high-level view in order to reorganize/restructure the organization. Similarly, simply employing a top-down approach, limits one's understanding of the actual current processes in an organization. However, a top-down approach coupled with a bottom-up approach offers a more complete view of an organization and its processes. Both views augment each other and result in the identification of multiple viewpoints which can then be resolved. It is interesting to note in conventional systems analysis, one speaks with the *real* users in order to get a *descriptive* view of the system and one speaks with people at a more elevated level (in our case the administration) in order to get a *prescriptive* view of the system. Both views are desired and this case study further illustrates that.

Viewpoint Resolution. Our analysis did not yield conflicting viewpoints which leads us to believe that in cases where there exists a well defined task differentiation, and roles do not overlap, there is less opportunity for viewpoint conflict. Further study may allow for examination of whether or not the existence of multiple viewpoints is affected by how structured the organization is. Every goal shown in Figure 1 has at least one supporting scenario. For example, Scenario 1 which was presented in the previous section. In contrast, only four of the goals shown in Figure 2 have supporting scenarios. This is partly due to the fact that the goals in Figure 1 were identified by examining the entire set of available scenario fragments. Thus, intuitively, we know that every goal in Figure 1 should indeed have at least one supporting scenario.

Contrasting both of the goal hierarchies gives rise to the issues of synonym identification and goal relationships. What is referred to as the "Allocation Budget" by the FSO employees (shown in Figure 1), is referred to as the "Monthly Consolidated Report" by the administration. If we were to resolve this 'viewpoint conflict', it is apparent that we would be able to identify a few more supporting scenarios for the prescriptive goals in Figure 2. Some of the scenarios which support the Maintain AllocationBudget goal in Figure 1 would also support the Achieve MonthlyConsolidatedReport goal in Figure 2. Thus, synonym identification may be useful in facilitating viewpoint resolution. In comparing the goal relationships for both of the goal hierarchies, we see that only the 3 to 2 relationship between goals is maintained.

Our analysis has shown that prescriptive and descriptive goal hierarchies are lacking in levels of correspondence. In our experience, it is difficult to obtain a factual goal hierarchy due to the large gap between goals and actual operations. Viewpoint contradictions do not occur because the roles are highly compartmentalized. However, gaps do occur due to different viewpoints (as noted in the synonym example). This gives rise to the need to consider schema integration and the merging of different viewpoints. Similar findings have been uncovered by operations management researchers. Their investigations have focused on the relationships of organizational goals and operational strategies. The findings have shown that organizational goals are often not reflected in operational strategies. An example that has been found is that the organizational goal of improving quality is not operationalized since the reward system at the operations level remains focused at productivity without regard to quality [McCracken90].

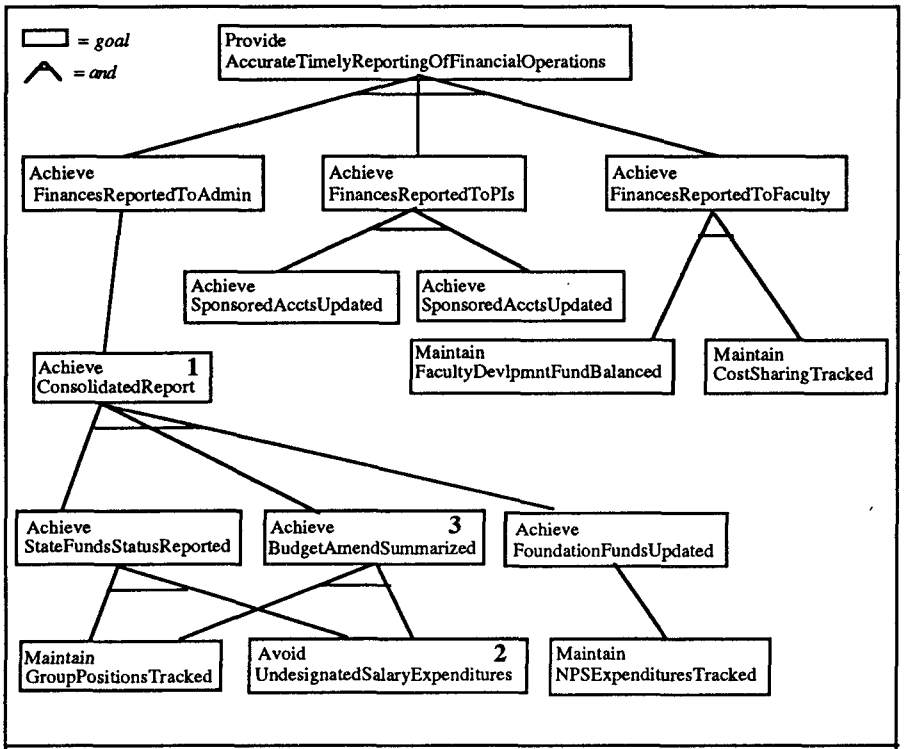

Fig. 2. Goal Hierarchy for FSO prescriptive goal set.
This hierarchy was constructed using a top-down approach.

Explanatory scenarios. The context interviews yielded much information, some of which was expressed as scenario fragments or subscenarios. The initial elicitation of scenarios was unguided. Each stakeholder was asked to explain the business processes that he/she is currently responsible for. Often times, they voluntarily expressed their processes as scenarios to illustrate a process goal or to demonstrate exceptional cases. As previously described, we used these scenario fragments for the identification of goals. Each of the goals identified in this fashion had at least one corresponding scenario (either supporting or non-supporting). The scenarios were also used to try to identify similarities and relationships between the goals in both of the goal hierarchies (as described above). Scenarios were beneficial in terms of identifying ways of redesigning the system as well as for the identification of exceptional cases.

Scenarios As Design Rationale Artifacts. Although our analysis has mainly provided requirements for a new system, the scenarios and goals provide an explanation of why we need the new system. Our goals and scenarios constitute part of the rationale for the new system.

5 Conclusions

Our initial premise of conducting the case study was based on the evaluation of scenarios to support identification of requirements and improvements of the business processes of the organization we studied. We anticipated using methods and techniques to identify *process* scenarios that describe the end to end business processes. As the case study progressed,

though, we found that the initial efforts of defining the organization's goals, both prescriptive and descriptive, focused our work on understanding the relationships between these two sets of objectives. We found that when we identified our initial *prescriptive* goals, and then tried to identify the supporting scenarios that the goal refinement process broke down. We had to revert to *descriptive* goals related to the activities at the operations level. We were able to identify explanatory scenarios which supported those operations, but we were unable to elicit process scenarios that described complete sequences that supported the prescriptive goals, and their subgoals.

The above findings have prompted us to rethink the goal refinement process and to try to understand the relationships between refinement of goals and scenarios. Our future work will concentrate in part on this question, and in particular these results will influence our plans for building tools to support this process. We are developing tools that will allow us to support the process of goal refinement, scenario depiction, and the discussion and resolution of issues, and in particular we will support the process with "synchrony weakening" technologies that will support the continuous dialogue we have found necessary to support the process of identification of goals (both prescriptive and descriptive), and the determination of scenarios that describe the activities supporting the attainment of those goals.

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