# QUALITATIVE DECISION EXPLANATION FOR INFORMATION TECHNOLOGY INVESTMENT

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# Qualitative Decision Explanation for Information Technology Investment

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**Abstract**

Many business decisions involve issues that are not amenable to quantitative measures and analysis. One such domain of decisions is large-scale investments in information technology. Traditional capital budgeting methods have not proven effective.

In this paper, we present an alternative paradigm for qualitative decision analysis, embodied in the artificial intelligence program: VOTE. We describe the technology investment domain in general, and how VOTE models goals and agents in this domain. We apply the VOTE model to a specific decision taken from a study of a major information technology investment decision.

**Keywords:** qualitative reasoning, decision-making, explanation, artificial intelligence, natural language generation, information technology.

# 1 Introduction

Managers must frequently decide whether to invest in a new information technology initiative. This decision takes place in a complicated organizational setting; it includes a number of organizations and individuals and has a high potential for conflict among different goals. Textbooks have long advocated capital budgeting techniques like net present value analysis or approaches like cost benefit analysis for making this decision [3]. Exclusively financial approaches have been criticized for their failure to capture intangibles and for the estimates they require of costs, savings (or revenues) and discount rate. A recent survey suggests that simple techniques like payback period or a cost benefit ratio are used more than discounted cash flow models in evaluating information systems investments [34].

Dissatisfied with the decision criteria omitted by purely financial approaches, Lucas and Moore [16] proposed a scoring model adapted from the R&D project selection literature for use in choosing information systems project alternatives. More recently, Schniederjans and Wilson [27] have proposed using the analytic hierarchy process and goal programming for information system project selection. Agarwal, Tanniru and Dacruz [2] have developed a knowledge-based support system for making resource allocations that combines quantitative and qualitative judgments. Dos Santos [24] has suggested a financial model for making decisions based on options theory; he argues that an investment in information technology (IT) today may be justified because of what it allows the firm to do in the future. The organization is in effect buying an option on a future return.

None of these approaches, however, solve the problems created by a complex organizational setting and the presence of large numbers of often conflicting goals. The purpose of this paper is to characterize the rich domain that surrounds the decision to invest in a new IT project and to show how an artificial intelligence program called VOTE [32, 33] can be applied to supporting these investment decisions. VOTE explicitly considers different constituencies and conflicting goals in making its recommendations.

The remainder of this paper is organized as follows. We first discuss qualitative decision making and the VOTE program. Second, we describe the technology investment domain in general, and how VOTE models goals and agents in this domain. Third, we apply the VOTE model to a specific decision taken from a study of a major information technology investment decision. We conclude with a discussion of future work. We also include two appendices that provide additional details of the VOTE program.

# 2 Qualitative Decision Making and VOTE

We may view decision-making as a process, as depicted in the flow chart in Figure 1. We can describe the constituent elements.

**Identify problem.** The agent must recognize that a decision must be made. The term "problem" here denotes any goal that initiates the decision process. An opportunity could just as well trigger the task of decision making. Thus, either losing your job or winning the lottery might well require you to make decisions.

**Identify alternatives.** Once the problem has been identified, the agent must determine what alternative actions are possible. The process underlying the selection of alternatives is by no means simple. Case-based reasoning [30] provides a computational approach to this task.

**Choose usual action.** Many common situations in life may have a standard response that finesses the issue of choice. An agent may always order the same thing for lunch, or always wear the same pair of shoes. Following this branch in effect avoids making a decision. From the perspective of computational effort, choosing the usual action is very efficient.

**Evaluate alternatives.** Assuming that there is more than one reasonable alternative, the agent must evaluate the options. The process of evaluation may rely on factors including consequences and likelihoods of outcomes, preferences, and past experience.

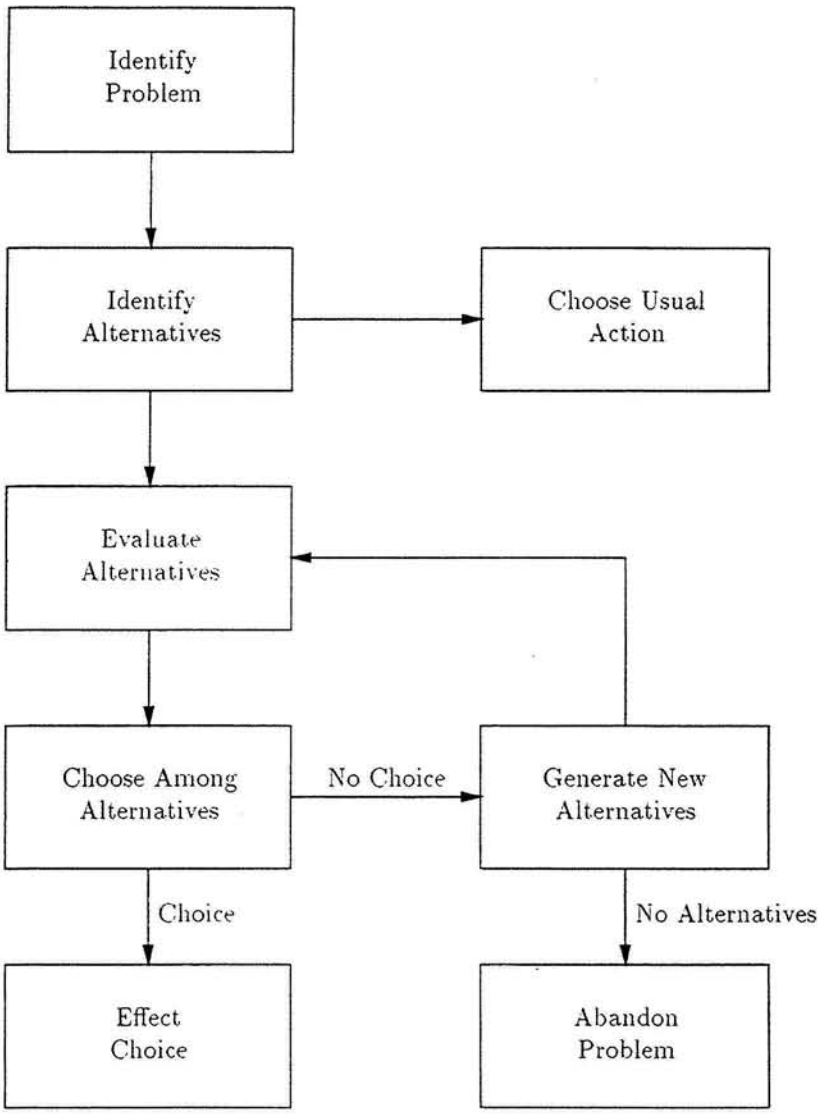


Figure 1: Decision Making Process

**Choose among alternatives.** Implicit in the evaluation process is a metric by which the choices may be ranked. If there is only one ranking possible, then the choice with the highest ranking is selected. If more than one ranking is possible, then there must be additional ways of choosing among the rankings.

**Effect choice.** Once a choice has been made, it needs to be put into action. This step may be the execution of a plan, that is, the agent can perform an action which will achieve the goals of the choice. If that action is unexpected or has adverse consequenses for others, the agent may be expected to provide an explanation for the decision. Decisions involving adopted goals are likely to need explanations.

**Generate new alternatives.** In some cases, the best alternative may not be good enough. That is, the ranking process may suggest a course of action that is unacceptable. In this case, the agent may wish to try again by generating new alternatives. These will then be evaluated as before.

**Abandon problem.** If there is no satisfactory alternative, the agent may choose to abandon the original problem. In fact, abandonment could be considered as simply another alternative that is available for most, if not all, decision problems. Failure to reach a decision may also require an explanation.

The process of decision making is reflected in the VOTE program. VOTE is written in T [28], an object-oriented dialect of LISP, and comprises over 14,000 lines of code, and over 9,000 lines of data. VOTE reflects approximately 1.5 man-years of effort for both the decision making modules, and the underlying object-oriented database system.

VOTE is a qualitative decision-making program that simulates Congressional roll call voting [30, 32, 33]. The input to the program is a specific bill and member of Congress. The program then decides to vote for or against the given bill based on the issue implications of the bill and the program's knowledge of that particular member's ideology, voting record, and constituencies. The program produces natural language output describing both the vote and the underlying rationale.

Below is an example of the VOTE program simulating Congressman Louis Stokes voting on a bill banning the desecration of the American flag. User input is underlined.

```
> (vote 'stokes 'hr-2978)
* Member:          Louis Stokes
* Bill:            Flag Desecration
 — intermediate output deleted —
* English rationale:
```

> *Louis Stokes is opposed to bill HR-2978, the flag desecration bill. He believes that provisions of this bill are not constitutional. He strongly supports the principle of the United States Constitution and the Bill of Rights. However, Stokes realizes that members of the Democratic party are opposed to the right of burning the American flag in protest.*

We note that the natural language output is not canned text, but is generated automatically by the program. The program can also produce French output.

VOTE is an artificial intelligence program that attempts to model human cognitive processes. VOTE is based on the following fundamental assumptions.

- *Agents have goals.* Agents or actors in the world have lots of needs, wants, and desires that they wish to attain. Politicians want to get elected. Managers want to make money. VOTE's model of goals is derived from the artificial intelligence knowledge representations of Schank and Abelson [25].
- *Agents have relationships with other agents.* Intelligent agents do not act alone in the world. The VOTE model suggests that relationships provide a way for agents to adopt new goals [29]. If your friend wants you to do a favor, you generally comply.

- *Agents have limited resources.* In general, agents are not able to satisfy all goals due to resource limitations. There is never enough time or money to do everything. In the words of the twentieth century British philosopher, Mick Jagger, "You can't always get what you want."
- *Goals vary in importance.* In resolving goal conflicts that arise from resource limitations, agents must rank goals by importance to determine which trade-offs to make. For example, a business person may not be willing to break the law to make more money.[1]
- *Decisions require explanations.* Once an agent understands the goals, relationships, resource limitations, and importance rankings, there is still a need to produce an explanation for the resulting decision. Different decision strategies are tied to distinct explanations [31].
- *Decision making is a process.* It is possible to decompose the process of making a decision into discrete steps, each of which are reflected in the serial computer program. VOTE provides a demonstration of the computational feasibility of this approach.

Decision making requires both structure and content. The goal-based decision model provides the structure. Detailed information about the domain of Congressional voting provides the content. The VOTE program relies on a set of interrelated databases, including issues (over 200 currently in the database), constituency groups (150), bills (42), members (67), and decision strategies (16). Multiple decision strategies are required since the explanation of the decision depends on the strategy employed. It is not enough to use one simple strategy of summing the weights of the conflicting issues and relationships.

The purpose of VOTE is not to predict individual voting decisions, but rather to demonstrate the computational feasibility of a particular model of decision making. Having said that, we observe empirically that VOTE's accuracy rate on thousands of predictions exceeds 75%.

The purpose of the program is to decide between two alternatives — a vote for or against a bill. Moreover the program must be able to justify its decision. We return to the Stokes/Flag Burning example, and look at the detailed protocol.

```
> (vote 'stokes 'hr-2978)
Extracting stances from voting record of Louis Stokes...done.
* Member:        Louis Stokes
* Bill:          Flag Desecration
* Bill banning the desecration of the American flag.
Inferring stances from relations of Louis Stokes...done.
```

The first step for the program is to determine what set of positions are held by this Congressman. There are three basic sources: the member's personal credo, his voting record, and his constituents. For the latter two, the program must infer stances from the BILL database, in the case of the voting record, and from the GROUP database, in the case of the constituent relationships.

The next step is to compare the issue implications of the bill with the various stances held by the Congressman and his constituents, that is, the groups with whom he has a positive relationship.

```
Considering implications of vote FOR HR-2978
     #{Stance (11) [B:PRO] PATRIOTISM (BILL:HR-2978)}
     #{Stance (12) [B:CON] FLAG-BURNING (BILL:HR-2978)}
Sorting stances based on EQUITY order...done.
Stances FOR: (((CON C GROUP:DEMOCRATS FLAG-BURNING)))
```

A member's preferences are expressed as **stances**, which comprise an **issue**, a **side** (pro or con), and a level of **importance** (A, B, or C, where A is high and C is low). For example, a member who strongly supports affirmative action while opposing gun control might have preference stances such as the following.

[1] Admittedly, not a compelling example.

```
(PRO A MEMBER:MEMBER.2319 AFFIRMATIVE-ACTION)
(CON B MEMBER:MEMBER.2319 GUN-CONTROL)
```

While VOTE prints stances as lists, the program actually uses a more detailed object-oriented representation. Constituency groups have similar sets of preference stances to represent their issue agendas. Stances from constituency groups are adopted by members with a level of importance relative to the priority of the underlying relationship. Most issues also have normative stances. Norms reflect popular opinion for a given issue.

As a Democrat, Stokes should support this bill which opposes flag burning. Note that at this point the matching is partial. Stances match on issue and side, but not on level. The issue of patriotism does not strike a chord with Stokes or his constituents. We next look at the other side.

```
Considering implications of vote AGN HR-2978
Matching member stances with bill stances:
     #{Stance (14) [B:PRO] FREE-SPEECH (BILL:HR-2978)}
     #{Stance (15) [B:PRO] CONSTITUTION (BILL:HR-2978)}
Sorting stances based on EQUITY order...done.
Stances AGN: (((PRO A GROUP:ACLU CONSTITUTION)
               (PRO B BILL:HR-5345 CONSTITUTION)
               (PRO B GROUP:COUNTRY CONSTITUTION)))
```

The issue of free speech is not of particular concern in itself, but the issue of the Constitution triggers Stokes's relationship with the ACLU, a previous vote in support of the Constitution and the belief that the good of the country is at stake in Constitutional matters.

VOTE now considers various decision strategies. The purpose of the strategies is not merely to arrive at a decision, but also to produce an explanation or justification of that decision.

```
  Trying decision strategy: Popular decision...failed.
  Trying decision strategy: Non-partisan decision...failed.
  Trying decision strategy: Not constitutional...success.

Found a consensus AGN this bill.
The most important stances are all on the AGN of this bill:
   Group:          ((AGN ((PRO A GROUP:ACLU CONSTITUTION))))
   Record:         ((AGN ((PRO B BILL:HR-5345 CONSTITUTION))))
   Norm:           ((AGN ((PRO B ISSUE:ISSUE.2591 CONSTITUTION))))

There are constitutional grounds for opposing this bill:
              (((PRO A GROUP:ACLU CONSTITUTION)
                (PRO B BILL:HR-5345 CONSTITUTION)
                (PRO B GROUP:COUNTRY CONSTITUTION)))
  Adding current vote to DECISION database...done.
```

The strategy based on the issue of constitutionality fires. This strategy requires that there is both a consensus of stances opposing the bill, and that the issue of constitutionality is at stake. VOTE arrives at the following decision, as given earlier.

> *Louis Stokes opposes bill HR-2978, the flag desecration bill. He believes that provisions of this bill are not constitutional. He is unwavering in his support of the principle of the United States Constitution and the Bill of Rights. However, Stokes understands that members of the Democratic party oppose the right of burning the American flag in protest.*

The basic structure of VOTE is given in Figure 2. The rectangles indicate the declarative databases for bills, members, groups, issues, and decisions. The oval strategy database contains procedural representations of the decision strategies. Note that though the decisions are derived

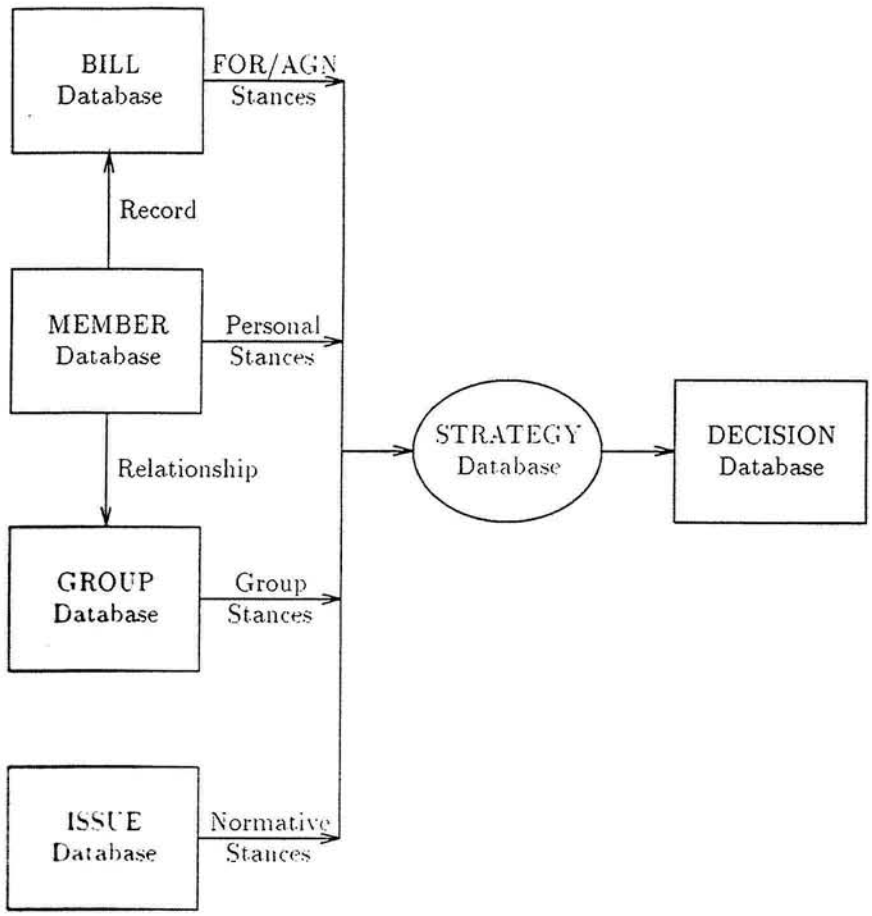


Figure 2: VOTE Architecture

from the other databases, they are themselves stored in a database. This permits VOTE to detect the need to revise decisions based on new information.

The original VOTE databases contained information relevant to the Congressional roll call voting domain. By replacing the contents of the databases with information in another domain, we can apply VOTE to new problems.

**BILL:** past and present decisions described in terms of their projected issue consequences.

**MEMBER:** the individuals whose decisions are being simulated. Each agent is represented by past decisions, ongoing relationships, and an issue agenda.

**GROUP:** the generic organizations, departments, or constituencies with whom the decision makers have relationships. Each group has a default issue agenda.

**ISSUE:** the detailed representation of the issues or goals relevant to the domain.

**STRATEGY:** specific decision strategies and associated explanations.

In the next section, we describe our initial efforts at applying VOTE to a domain very different from the Congressional roll call voting domain.

# 3 Information Technology Investment Domain

The purpose of this paper is to discuss a new approach to making decisions about investments in technology. This decision takes place in a complex domain consisting of a number of different

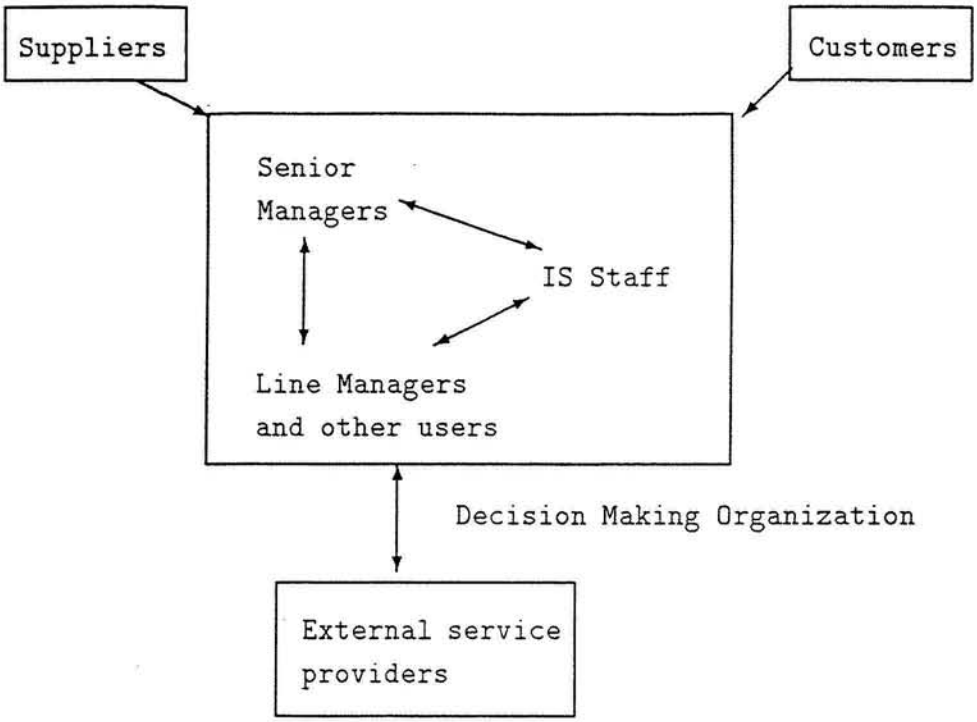


Figure 3: The Decision Domain

organizations and actors. We shall attempt to map this new domain onto the VOTE model of decision making.

## 3.1 Organizations

There may be four or more types of organizations involved in a proposal for a new investment in information technology. See Figure 3.

The first is the organization making the investment: it expects to obtain the most benefits from developing a system. There are still many applications of technology that only involve the developing organization. However, at least some new projects are likely to involve other firms.

The second organization involved is an external service provider. Today, many investments in technology involve outside firms. For example, Frito-Lay had a supplier design and build hand-held computers for its trucks; UPS equipped its drivers with custom-designed pen computers which customers use to sign for packages. Many systems today involve communications among different parties so that various communications service providers are included in a new IT project.

The third organization that is often represented in a new technology project is the customer. Firms are developing systems which provide better customer service and are frequently providing customers with direct access to their computer systems. Most mail order firms use order entry and inventory systems to make it easy for the customer to order from them. American Hospital Supply, now a part of Baxter Health Care, is credited with developing the first order entry system in which customers used American's terminals to enter orders for hospital supplies dirctly into American's computer systems.

A fourth organization that may be involved in new technology is a supplier. Firms like Ford make extensive use of Electronic Data Interchange (EDI) to improve the quality and efficiency of transactions with suppliers. For firms using just-in-time (JIT) production, suppliers may actually have access to the manufacture's production planning and control system in order to

anticipate needed deliveries.

For a large IT initiative, there may be a number of instances of these four types of organizations. For example, a system to support customers might involve tens or hundreds of customer organizations. EDI systems might extend to 50 or more suppliers. A national or international network could involve ten or more suppliers of services and equipment. Thus, the domain for the IT investment decision is potentially large and complex.

## 3.2 Players

Within the organization making the decision, there are three major groups of players.

Managers are responsible for the overall direction of the firm; they determine its goals and strategy. Managers also have to allocate scarce funds to different candidates for investment. These same managers should be involved in the design and implemetation of the IT project as well.

Users are individuals in the organization who work directly with the new technology. This group of users may be very localized, for example, the order entry clerks in a mail order business who work with the company's order entry system. Users may also ecompass almost everyone in the organization. For example, DEC's world-wide electronic mail system has tens of thousands of users including DEC's chairman.

The last group of players is the information services staff. The extent of involvement of this group depends on how the firm is organized and on the scope of the IT initiative. Today, there are many investment decisions made by general managers and users without any input from a technological expert, particularly in decentralized companies. As the cope and cost of the IT project increase, it is likely that members of the information services staff will be involved in developing a project proposal.

## 3.3 Relationships

There are a variety of relationships among the various organizations and individuals described above. The company that wants to develop EDI links with its suppliers has a great deal of power and leverage because it is the customer. The firm that wants its customers to install terminals or PCs connected to an order entry system has a different problem since it cannot risk alienating customers. External service providers, in general, are eager to have one's business and are likely to be very helpful in developing a proposal for a new IT project.

On the individual level, senior managers, line managers and other users and the IS staff all interact in the organization contemplating an IT investment. These interactions are not always smooth as the three parties often have different viewpoints and goals. Managers are typically concerned with market share and financial performance measures such as stock price, return on assets, sales and profitability.

Line managers and other users often have very specific goals such as processing all orders that arrive by a certain time so that shipments are made the same day. There may be specific quality goals as well, for example, allowing only a certain number of errors per thousand items shipped. Each user subunit may have different goals and criteria for evaluation by management.

The IT staff is a support group in most organizations; its goal should be to develop and operate technology to help the firm meet its objectives. Unfortunately, there is a long history of conflict between the information services staff and others in the organization. Often information services groups develop goals that are not necessarily compatible with the objectives of the organization. Sometimes IS staff members loose contact with management and users and become very unresponsive to their constituents.

## 3.4 Goals

Each of the organizations and groups described above has different goals. Sometimes a group's professed goals may not be the goals that others perceive. For example, an IS department may

state that its goal is to provide user service and high levels of satisfaction. However, the actions of this group may lead to users perceiving that the IS staff wants to develop new and better technology for its own sake or that it is "building an empire."

Goals often change over time, making it difficult for members of the organization to know exactly how to act. For example, during the 1980s there was a surge of corporate takeovers and leveraged buyouts, often financed with junk bonds. The goal was growth and synergy from diverse businesses. Today, many firms have a goal of reducing debt by selling peripheral businesses and returning to their area of core competence.

As stated earlier, decision making requires both structure and content. In adapting the VOTE program to the domain of business decisions, we must provide new content to replace the knowledge of Congressional voting. In other words, we need to identify the business goals that may play a role in arriving at or justifying an IT investment decision.

Typically, the primary goal used to evaluate an IT investment opportunity is its anticipated contribution to the firm's financial performance [8]. Firms routinely use such quantative criteria as net present value, internal rate of return, return on investment, cost/benefit ratio, payoff period, expected value, and opportunity cost to measure the attractiveness of investment opportunities [35]. If all significant consequences of an investment could be accurately reflected in these quantitative measures, then no other decision criteria would be needed. Investments could be chosen on the basis of a relatively straightforward optimization of the quantitative criteria.

Given the complexity and uncertainty surrounding IT investment decisions, however, firms generally concede that many important costs and benefits cannot be quantified [5]. To evaluate investment opportunities in terms of their overall impact on financial performance, firms must consider qualitative as well as quantitative consequences of investment decisions [35, 5, 7]. By themselves, optimization techniques do not provide a sufficient mechanism for evaluating these investment decisions. Instead, decision makers must analyze and justify an IT investment on the basis of its alignment with the firm's broad spectrum of economic, political, and social goals. Because this alignment is viewed as critical, firms typically establish planning and policy groups or other decision control mechanisms to ensure a linkage between the firm's overall business goals and its investments in IT [5].

Proper analysis and justification of an IT investment decision requires that the firm's overall business goals be identified, and that the instrumental relationships between goals be defined. We have identified over 130 qualitative and quantitative business goals that are relevant to IT investment decisions. (See Appendix A.) In addition, we have structured these IT investment goals into a chain, patterned after the chain of causality which Porter [21] developed to explain the sequence of conditions and events that leads to a firm's financial success. Each link in the goal chain depicts how one goal is instrumental to achieving another. For example, the goal of reducing paperwork may provide a means of achieving increased productivity, which may lead to reduced costs, and so on. By navigating through the goal chain, the specific consequences of an IT investment can be assessed within the context of the firm's overall set of business goals. Thus, the goal chain provides VOTE with an integrative framework of goals for analyzing and justifying IT investment decisions.

As discussed earlier, we assume that the goal of protecting or improving financial performance is the primary motivating force behind a firm's decision to invest in IT. Accordingly, financial performance is positioned at the apex of the goal chain. The question now becomes: How can a firm achieve superior and sustainable financial performance? To answer this question, we must identify those business goals that are instrumental to achieving financial performance goals. In other words, we must take one step along the goal chain. By doing so we find that a firm's profitibility is a function of the attractiveness of industry structure and the relative position of the firm within the industry [21].

Porter [21] has identified five forces that can damage an industry's structure and erode long-term industry average profitibility. These forces are the threat of new entrants, the threat of substitute products and services, bargaining power of suppliers, bargaining power of buyers, and rivalry among existing competitors. If firms within an industry are interested in counteracting these forces, they can enlist the help of IT to pursue this goal [5]. For example, IT can be

used to create entry barriers, differentiate products and services, improve cost-effectiveness and quality, and increase the selection and alter the switching costs of buyers and suppliers.

Within an industry, profit differences between firms depend on their relative positioning. An attractive relative position may be manifested in terms of market share advantages, accelerated growth, or a superior balance sheet. In order to achieve a desirable position, a firm must possess a sustainable competitive advantage [21, 4]. There are two basic types of competitive advantage.

1. **Reduce Costs.** A firm may be able to produce goods and services at a lower cost than competitors.
2. **Product Differentiation.** A firm may be able to differentiate its products and services in the marketplace and command a premium price that exceeds the cost of differentiation.

Competitive advantage, in turn, depends on how a firm configures and executes its basic business activities, such as manufacturing products, processing customer orders, and making service calls. If a firm can perform its activities in unique ways, then it may be able to achieve low relative cost or to create buyer value and hence achieve differentiation. In particular, the goal of securing a competitive advantage can be attained through innovative uses of IT to improve the performance of a firm's essential activities.

Researchers have observed numerous ways in which IT can be used to reduce costs:

- IT has been used extensively as a vehicle for improving productivity. Some of the earliest applications of IT were used to monitor and control the pace of work, and this trend persists [10, 6].
- IT has also been used to decrease productivity losses in manufacturing due to machine downtime, poor quality, and production inflexibility [5]. Scheduling and coordinating functions within firms have been improved with IT, thereby increasing the efficiency of such functions as production, distribution, and service [6, 5].
- Firms often look for ways to automate existing functions with IT and to reduce the flow of paperwork [17, 5].
- Proponents of reengineering claim that innovative uses of IT can eliminate the need for many work tasks, thereby enabling dramatic gains in efficiency [6, 11, 7].
- The efficiency of physical asset utilization can also be enhanced by IT [17].
- IT can improve the efficiency and effectiveness of decision making. Knowledge embedded within decision support systems and expert systems can simultaneously improve decision quality and reduce the skills required of users [17]. Advocates of "informating" suggest that putting accurate, detailed real-time information into the hands of decision makers can reduce operational costs [36].
- Procurement costs can be lowered by establishing electronic linkages to suppliers. Firms exploit these connections to reduce supplier search costs and inventory costs [17, 5].

Researchers have also discovered numerous ways that IT can be used to effect differentiation:

- In businesses where time-based competition is prevalent, IT applications can reduce process cycle time, product delivery time, service response time, and product development time [6, 7, 26].
- The reliability, accuracy, security, and overall quality of products and services can be improved with IT [6, 7].
- IT can be used to improve the interface with customers, particularly if effective electronic ties are established. For example, IT applications can simplify order placing, increase customer control over service, perform activities such as inventory management on behalf of the customer, or provide value-added information to support sales, service, or product operation [13, 17].

- The creation of new products and entry into new markets can be facilitated by IT. For instance, IT can enable information-based alliances between companies [5], allow firms to create information-based products and services [19, 15], and support the mass customization of products and services [7].

While IT investments may reduce costs and increase differentiation, they will not necessarily result in competitive advantage. If a firm hopes to achieve competitive advantage as a result of its IT investments, it must successfully exploit IT in ways that its rivals have not. Of utmost importance is a firm's ability to envision creative, strategic applications of IT [15]. In addition, the proper timing of investment decisions, the effectiveness of organizational learning, and the ability to protect IT innovations against imitation by rivals are all required for a firm to stay ahead of its competition [23, 22]. Thus, goals such as innovation and trade secret protection are reflected in the goal chain as potential determinants of competitive advantage.

As outlined above, the goal chain is composed of economic goals related to IT investments. Firms also pursue a multitude of political and social goals, which are often related to economic goals. In response to coercive pressure exerted by powerful institutional actors, for example, firms may adopt inefficient technological innovations [9, 1]. In these situations firms are motivated by the goal of achieving legitimacy in the eyes of the institutions, which is necessary to insure an inflow of resources to the firm [20]. In addition, managers have been known to use IT resources to pursue their own political goals, such as systematically controlling workers, protecting their managerial turf, or redistributing power within the firm [18, 17]. Not surprisingly, managers often justify their political agendas in terms of the firm's economic goals [17]. Finally, firm's often pursue such social goals as improving job satisfaction, job security, and patterns of social interaction, which they hope will lead to lower turnover rates or increased productivity [14, 17]. An unfortunate, though not necessarily inevitable, consequence of many IT investments is that economic goals (e.g., eliminating manual labor) may conflict with social goals (e.g., improving job security). The relationships and conflicts among economic, political, and social goals are reflected in the goal chain.

As stated above, we have identified over 130 business goals that may play a role in arriving at or justifying a decision. Here are some examples, together with their norms and justifications. A complete list of goals appears in Appendix A.

**Reengineering.** For this first issue only, we list both the internal symbolic representation, as well as the derived English language output.

```
Norm:          ((PRO B ISSUE:ISSUE.160 REENGINEERING))
PRO Stances:   (((PRO B ISSUE:REENGINEERING CUSTOMER-DRIVEN)
                 (PRO B ISSUE:REENGINEERING REDUCE-LEVELS-OF-MANAGEMENT)
                 (PRO B ISSUE:REENGINEERING RIGHT-SIZING)
                 (PRO B ISSUE:REENGINEERING MANUAL-PROCESSES)
                 (PRO B ISSUE:REENGINEERING CHANGE-ORG-STRUCTURE)))
```

*A normal stockholder is eager to support reengineering company operations. Support of reengineering company operations is important for changing the organizational structure, being customer driven, reducing levels of management, right sizing, in addition to automating manual processes.*

**Low Cost Producer.** *Managers approve of being the low cost producer. Support of being the low cost producer is always part of increased competitive advantage. It reinforces reducing costs. It is important for increased profits, increased volume, increased revenues, achieving an attractive industry position versus rivals, and increased market share. Support of being the low cost producer is compatible with increased productivity.*

**Automating Manual Processes** *The majority of investors are eager to show their support for automating manual processes. Support of automating manual*

*processes is important for increased efficiency, increased profits, as well as increased productivity. Opposition to automating manual processes is important for job security.*

Below, we list a few of the groups with their associated issue agendas.

**Information Systems Managers.** For this first group, we list both the internal symbolic representation of goals, as well as the derived English language output.

```
Stances:  (((PRO B GROUP:IS-MANAGEMENT USER-SATISFACTION)
            (PRO B GROUP:IS-MANAGEMENT RESPONSIVE-TO-USERS)
            (PRO B GROUP:IS-MANAGEMENT IS-INFRASTRUCTURE)
            (PRO B GROUP:IS-MANAGEMENT HIGH-IMPACT-SYSTEMS)
            (PRO B GROUP:IS-MANAGEMENT EXCITING-TECHNOLOGY)
            (PRO B GROUP:IS-MANAGEMENT EXPENSES)
            (PRO B GROUP:IS-MANAGEMENT HARDWARE)
            (PRO B GROUP:IS-MANAGEMENT SOFTWARE)
            (PRO B GROUP:IS-MANAGEMENT NETWORK)
            (PRO B GROUP:IS-MANAGEMENT DATA-STORAGE)
            (PRO B GROUP:IS-MANAGEMENT BACKUP)
            (PRO B GROUP:IS-MANAGEMENT CONNECTIVITY)
            (PRO B GROUP:IS-MANAGEMENT INNOVATION)
            (PRO B GROUP:IS-MANAGEMENT SYSTEM-RESPONSE-TIME)
            (PRO B GROUP:IS-MANAGEMENT USER-INTERFACES)
            (PRO B GROUP:IS-MANAGEMENT MANUAL-PROCESSES)
            (PRO B GROUP:IS-MANAGEMENT SYSTEM-PERFORMANCE)
            (PRO B GROUP:IS-MANAGEMENT REENGINEERING)
            (PRO B GROUP:IS-MANAGEMENT SYSTEM-SECURITY)))
```

*Information systems management strongly supports increasing system security, system performance, reengineering, user satisfaction, responding to users, improving the IS infrastructure, developing high-impact IS systems, using exciting technology, increased expenses, contributing to the hardware architecture plan, contributing to the software architecture plan, contributing to the network architecture, improving data storage, system backup, increasing system connectivity, increased innovation, improving system response time, improving user interfaces, and automating manual processes.*

**Line Management and other Users.** *Line management is an opponent of increased bureaucracy, and hierarchy reduction. It strongly supports decreasing the chance of failure, pleasing senior management, increasing the pace of work, accomplishing the basic mission, maximizing performance measures, reducing costs, reducing cycle times, increasing capacity, improving control, capturing data for analysis, quality, coordinating work, increasing responsiveness to customers, taking over customer processes as a service, reducing uncertainty, improving communications, complying with legal and regulatory requirements, increasing profits, increasing efficiency, reducing paperwork, reducing process response time, increasing production or service flexibility, tracking information, improving work scheduling, reducing delivery time to customers, increasing customer satisfaction, productivity, increasing inventory turnover, improving system backup, enhancing system availability, improving information systems performance, right sizing, in addition to creating effective incentive systems.*

**Senior Management.** *Senior management is unwavering in its support of increasing profits. It strongly opposes increasing supplier switching costs, increased risk, increases in the tax rate, increased taxes, increased expenses, and increased regulation. It is strongly in favor of increased market share, increased product*

*or service quality, increasing productivity, increased revenues, increased sales, increased cash flow, increased competitive advantage, reducing costs, increasing the quality of decision making, increased earnings, increased growth, being the low cost producer, product differentiation, right sizing, being customer driven, reducing cycle times, maximum net present value from investment, fair and just executive pay, increased technological advances, improving service, increased shareholder return on investment, increased stock price, good cost benefit ratio, short payoff period, increased internal rate of return, reducing opportunity costs, automating manual processes, changing the organizational structure, reducing levels of management, improving communications, complying with legal and regulatory requirements, reengineering company operations, responding to the competition, pleasing senior management, increasing span of control, centralizing decision making, decentralizing decision making, creating information-based alliances, creating barriers to potential entrants, increased shareholder value, achieving an attractive industry position versus rivals, reengineering, increasing buyer switching costs, and increasing profit margins. Senior management is opposed to increased bureaucracy. Senior management approves of safety, niche marketing, globalization, and increased innovation.*

### 3.5 Goal Conflicts

Given at least three constituencies, the possibility of four types of organizations being involved, and the large number of goals described above, it is easy to find conflicting goals when evaluating an IT investment opportunity. In fact, it is this failure to take conflicting goals into account that is one of the major shortcomings of capital budgeting approaches to the decision to invest in IT.

As an example, a proposal for a new system to allow customers to order electronically might result in staff increases and added expenses for technology when senior management is focusing on overall cost and overhead reduction. A pharmaceuticals company had the objectives of doubling sales in four years with no increases in staff. At the same time, it wanted to have more information systems to support marketing and sales without investing additional funds or increasing the size of the information services department.

An approach to deciding whether or not to invest in a new IT project based purely on financial criteria is likely to be unsatisfactory given the entities involved and their conflicting goals. We propose a new qualitative approach to this decision problem based on system which explicitly considers different and conflicting goals in recommending an outcome.

## 4 Burlington Northern: The ARES Decision

> In July 1990, Burlington Northern's senior executives were deciding whether to invest in ARES (Advanced Railroad Electronics System), an automated railroad control system. ARES, expected to cost $350 million, would radically change how railroad operations were planned and controlled. The potential implications of this investment were so extensive that they affected virtually all parts of the BN organization. Nine years had passed since BN managers had begun to consider whether automated control technology could be applied to the railroad. Yet managers were still divided about whether the ARES project should be continued. [12]

This case presents a complex set of quantitative and qualitative factors that must be assessed.

ARES was expected to save $190 million in reduced labor costs - hence, job security may be a concern to the operations staff. Also, Jim Dagnon (Senior VP - Labor Relations) noted that conductors are not too enthusiastic about ARES, since it will reduce their job responsibilities.

Opportunity cost appears as a justification on both sides of this decision. Since BN has limited investment funds available, then investing in ARES may preclude other investment

opportunities, such as the MIS upgrades that Brock Storm (VP - Info Sys) says are needed to support potential strategic changes.

Greenwood (COO) and Lewis (VP - Strategic Planning) both are concerned that a massive reorganization would be required to take advantage of the benefits of ARES, and they are concerned about the cost and feasibility of such a reorganization.

Reducing debt is an urgent concern to BN, largely because they have a higher debt-to-capital-ratio than is typical in the railroad industry. Grinstein (CEO) and Bell (CFO) have both made it clear that reducing debt is a top corporate priority. Using current income to finance ARES as opposed to retiring debt is thus a major concern to senior management.

It is evident that senior management is very concerned about the financial risks (and to a lesser extent the technical risks) associated with the project. For example, Greenwood thinks that the total costs of the project could be considerably larger than the $350 million estimate when the costs of reorganization are factored in. Brock Storm pointed out the notoriously poor record of estimating the costs of IT projects, and suggested that the costs and time required for development could well exceed estimates. Other managers were concerned that ARES may not be compatible with another information system, ATCS, currently under development.

It is also evident that the managers are concerned with the uncertainty surrounding the benefits of ARES. Senior management had a feeling that they could get 80% of the benefits for 20% of the costs, but they had no evidence. They were also skeptical of the estimates of the price gains possible by improving service reliability. They were so concerned about the level of uncertainty that they hired SRI international to audit the cost/benefit study and perform additional analysis.

Still, there are additional arguments on the positive side. ARES will provide a sophisticated communications network that transmits almost real-time information to track train locations, thereby improving business control and the reliability of delivery schedules.

Since the underlying technology had not been used before in the railroad industry, ARES represents an innovative application of IT. Assuming the application is successful, BN may attract market share from the other rail carriers and maybe even from the trucking industry. Grinstein believes that it may lead to a competitive advantage for BN.

Finally, Dagnon believes that ARES may lead to an overall improvement in employee satisfaction. This is based on the safety improvements offered by ARES, as well as the fact that unscheduled work will be reduced.

We have represented this case using the VOTE model. We note that this simulation is quite limited, even by VOTE's standards, for several reasons.

- We do not have specific representations for the individual decision makers' personal preferences.
- We do not have a "voting record" of past choices for the decision makers.
- The case does not fully present the reasons for opposing this decision.

Below is natural language output for VOTE's representation of the choice, to fund or not to fund ARES.

> *Support of investing $340 million in ARES upholds improving the reliability of the product or service, increased innovation, increased competitive advantage, increased market share, improving work scheduling, capturing data for analysis, increased volume, improving service, increased capacity with no additional resources, reducing costs, increasing efficiency, improving accuracy and reducing errors, reducing cycle times, workplace safety, increased prices, reducing the cost of not investing, product differentiation, improving control of the business, improving communications, as well as providing information to track processes. It is consistent with increased employee satisfaction.*
>
> *Opposition to ARES stands completely against increased debt, increased expenses, as well as increased risk. It is an essential element of reducing uncertainty. It stands firmly against changing the organizational structure. Opposition to ARES*

*upholds increased cash flow, decreasing the chance of failure, and reducing opportunity costs. Opposition to ARES is compatible with job security, increasing skill content of jobs, and increased earnings.*

Next, we present the output of VOTE simulating the decisions of various BN executives.

- Gerald Grinstein, CEO.

  *Gerald Grinstein endorses investing $340 million in ARES. He believes that sincere people have trouble balancing the tradeoffs presented by this plan. He readily endorses improving communications. Grinstein is strongly in favor of product differentiation. Grinstein is strongly in favor of reducing the cost of not investing. He believes in reducing cycle times. He strongly supports reducing costs. Grinstein readily endorses improving service. Grinstein is eager to show his support for increased market share. He believes in increased competitive advantage. He supports workplace safety. Grinstein approves of increased innovation. Still, Grinstein appreciates that senior management is eager to support decreased risk. It is strongly in favor of reducing costs. It strongly supports increased earnings. Senior management is strongly in favor of increased cash flow. Senior management cares deeply about reducing opportunity costs.*

- Jim Dagnon, Senior VP for Labor Relations.

  *Jim Dagnon favors investing $340 million in ARES. He believes that sincere people have trouble balancing the tradeoffs presented by this plan. He stands for workplace safety. Dagnon is a defender of increased employee satisfaction. Dagnon is committed to increased market share. He stands for increased competitive advantage. He believes in reducing cycle times. Dagnon is eager to support reducing costs. Dagnon strongly supports improving service. He is a defender of improving communications. He readily endorses product differentiation. Dagnon is committed to reducing the cost of not investing. Dagnon is in favor of increased innovation. Still, he realizes that employees are a defender of increasing skill content of jobs. They readily endorse job security. Senior management readily endorses reducing opportunity costs. It strongly supports decreased risk. It is strongly in favor of reducing costs. Senior management believes in increased earnings. Senior management believes in increased cash flow.*

- Joe Galassi, executive vice president, Operations.

  *Joe Galassi is in favor of investing $340 million in ARES. He believes that the consensus of opinion supports this measure. He is a defender of improving communications. Galassi readily endorses improving control of the business. Galassi believes in reducing cycle times. He stands for increasing efficiency. He is eager to show his support for reducing costs. Galassi is eager to support increased capacity with no additional resources. Galassi strongly supports capturing data for analysis. He believes in improving work scheduling. He stands for providing information to track processes. Galassi is eager to show his support for increased innovation. Even so, Galassi understands that line management readily endorses decreasing the chance of failure. It cares deeply about reducing uncertainty.*

- John Smith, typical employee.

  *John Smith favors investing $340 million in ARES. He believes that the consensus of opinion supports this measure. He cares deeply about increased employee satisfaction. Smith feels strongly in favor of workplace safety. Still, Smith understands that employees feel strongly in favor of increasing skill content of jobs. They believe in job security.*

An annotated, detailed transcript of VOTE processing an ARES decision appears as Appendix B.

# 5 Future Work and Conclusion

VOTE provides an explicit computational model of qualitative reasoning based on a decision maker's goals and relationships. The program includes the ability to produce a natural language explanation of the decision. VOTE originally operated in the domain of Congressional roll call voting. We have begun to apply VOTE to business decisions, particularly in the domain of information technology investment.

Our preliminary efforts demonstrate the feasibility of this approach, which may provide a mechanism for revealing hidden assumptions or even alternatives in simulated decisions.

Much work remains. Topics of future research includes the following.

**Language generation.** The natural language generation routines in VOTE were designed for political discourse. In applying VOTE to business domains, the generation programs need to be modified to produce idiomatic business output.

**Business decision strategies.** VOTE's decision strategies determine both the choice criteria and the explanation for the resulting decision. These strategies were tailored for roll call voting and need to be adapted and extended for business decisions.

**Integrating quantitative data.** In spite of the pervasive utility of qualitative decision making, business decisions clearly require use of quantitative data. Costs, revenues, profits, and other business issues must be subject to quantitative analysis.

**Case-based Reasoning.** A key component of human decision making is the ability to reason based on prior experience. Case-based reasoning [30] provides a way to apply past cases to new decisions. By creating a library of past business cases with appropriate issue-based indices, we can increase the depth and robustness of VOTE's business decision making. A new decision may then be analyzed and explained in terms of past cases.

**Empirical verification.** Given that this work claims to be a cognitive model of decision making, we would like to apply the VOTE business program to real world problems. Ideally, we would obtain subjects who themselves make significant business decisions and use VOTE to model their first-hand experiences.

The first efforts at modeling the IT investment decision using the structure of VOTE look very promising. Conventional approaches that stress financial criteria can overlook important considerations in the investment decision. The approach taken by VOTE helps the organization include differing goals and objectives and consider the different positions of those involved in the decision. VOTE makes it possible to expand quantitative criteria like net present value to include important qualitative factors in a decision. A qualitative approach to decisions on IT investment more closely mirrors the reality of the decision. Such an approach should result in better decisions and in participants who are comfortable with the outcome.

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# Appendix A: Issues

Below we list the summary contents of the ISSUE database. Each entry has the following features.

- An index number.
- A name.
- An optional type, e.g., `QUANTITY`
- An optional normative value, e.g., `+B` indicates a PRO stance with importance B, suggesting that most people are in favor of this issue.
- An optional list of symbolic synonyms for this issue.

We do not claim that this is an exhaustive list. However, the number of issues given here suggests that business decisions can be quite complex. Also, most of the issues are not readily quantifiable, and thus are not amenable to traditional quantitative analysis. The traditional economic tenet of maximizing profits requires considerable elaboration.

```
0   Accomplish basic mission                +B(BASIC-MISSION)
1   Accuracy                                +B
2   Alliance                                +B
3   Attractive industry position            +B(ATTRACTIVE-POSITION)
4   Bureaucracy                             -B
5   Buyer switching costs                   +B(BUYER-SWITCHING-COSTS)
6   Cannibalization                         -B(CANNIBALISM)
7   Capturing data for analysis             +C(CAPTURE-DATA)
8   Cash flow                    QUANTITY   +B(CASH-FLOW)
9   Cash on hand                 QUANTITY   +B(CASH-ON-HAND)
10  Centralize decision making                (CENTRALIZE)
11  Change organizational structure         -C(CHANGE-ORG-STRUCTURE
12  Closer ties to customer                 +C(TIES-TO-CUSTOMERS)
13  Communications                          +B
```

| | | | |
|---|---|---|---|
| 14 | Compensation | QUANTITY | +C(PAY WAGES SALARY) |
| 15 | Competitive advantage | | +B(COMPETITIVE-ADVANTAGE) |
| 16 | Control | | +B |
| 17 | Coordinate work | | +B(COORDINATE-WORK) |
| 18 | Cost benefit ratio | | +B(COST-BENEFIT) |
| 19 | Cost reduction | | +B(REDUCE-COSTS) |
| 20 | Customer control | | +B(CUSTOMER-CONTROL) |
| 21 | Customer driven | | +B(CUSTOMER-DRIVEN) |
| 22 | Customer interface | | +B(CUSTOMER-INTERFACE) |
| 23 | Customer satisfaction | | +C(CUSTOMER-SATISFACTION) |
| 24 | Customization | | +B |
| 25 | Data storage | | +B(DATA-STORAGE) |
| 26 | Debt | QUANTITY | -C(DEBT) |
| 27 | Decentralize decision making | | (DECENTRALIZE) |
| 28 | Decision Making | | +B(DECISION-MAKING) |
| 29 | Delivery time | | +B(DELIVERY-TIME) |
| 30 | Develop high-impact IS systems | | +C(HIGH-IMPACT-SYSTEMS) |
| 31 | Dividends | QUANTITY | +B |
| 32 | Dow Jones Industrial Average | STATISTIC | +B(DJIA) |
| 33 | Earnings | QUANTITY | +B(EARNINGS) |
| 34 | Earnings per share | RATIO | +B(EARNINGS-PER-SHARE) |
| 35 | Efficiency | | +B |
| 36 | Employee satisfaction | | +B(EMPLOYEE-SATISFACTION) |
| 37 | Employee stock ownership plan | PLAN | (ESOP) |
| 38 | Entry barriers | | +B(ENTRY-BARRIERS) |
| 39 | Equity base | | +B(EQUITY-BASE EQUITY) |
| 40 | Executive compensation | | -C(EXECUTIVE-COMPENSATION) |
| 41 | Expenses | QUANTITY | -B(COSTS) |
| 42 | Failure | | +B |
| 43 | Flexibility | | +B |
| 44 | Globalization | | +B(GLOBAL) |
| 45 | Growth | PERCENTAGE | +B |
| 46 | Hardware architecture | | +B(HARDWARE) |
| 47 | IS infrastructure | | +B(IS-INFRASTRUCTURE) |
| 48 | Incentive system | | +B(INCENTIVES) |
| 49 | Increase span of control | | +C(SPAN-OF-CONTROL) |
| 50 | Increased capacity | | +B(INCREASED-CAPACITY) |
| 51 | Inflation | RATE | -B |
| 52 | Innovation | | +C |
| 53 | Insider trading | PLAN | -B(INSIDER-TRADING) |
| 54 | Interest rates | RATE | -B(INTEREST-RATES) |
| 55 | Internal rate of return | RATE | +B(IROR INTERNAL-RATE-OF-RETURN) |
| 56 | Inventory turnover | RATE | +B(INVENTORY-TURNOVER) |
| 57 | Job security | | +C(JOB-SECURITY) |
| 58 | Job skilling | | +B(JOB-SKILLING) |
| 59 | Legal and regulatory requirements | | +C(LEGAL-REQUIREMENTS) |
| 60 | Leverage | RATIO | +B(LEVERAGE) |
| 61 | Liquidity | VALUE | +C |
| 62 | Low cost producer | | +C(LOW-COST-PRODUCER) |
| 63 | Management desire | | +C(MANAGEMENT-DESIRE) |
| 64 | Manual processes | | +B(MANUAL-PROCESSES) |
| 65 | Market Share | PERCENTAGE | +C(MARKET-SHARE) |
| 66 | Marketing | | +B |
| 67 | Maximize NPV | QUANTITY | +B(MAXIMIZE-NPV) |

```
68  Maximize performance measures          +B(PERFORMANCE-MEASURES)
69  Merger                          PLAN
70  Network architecture                   +B(NETWORK)
71  New markets                            +B(NEW-MARKETS NEW-MARKET)
72  New product                            +B(NEW-PRODUCT)
73  Niche marketing                        +C(NICHE-MARKETING)
74  Opportunity cost                       +B(OPPORTUNITY-COST)
75  Outstanding shares              QUANTITY   (OUTSTANDING-SHARES)
76  Paperwork                              +B
77  Payoff period                   DURATION +B(PAYOFF-PERIOD)
78  Price/Earnings Ratio            RATIO    +B(P/E)
79  Prices                          MONEY
80  Process response time           DURATION +B(PROCESS-RESPONSE-TIME)
81  Product development time        DURATION +B(PRODUCT-DEVELOPMENT-TIME)
82  Product differentiation                +B(PRODUCT-DIFFERENTIATION)
83  Product quality                        +B(PRODUCT-QUALITY
84  Product reliability                    +B(RELIABILITY PRODUCT-RELIABILITY)
85  Productivity                           +B
86  Profit margins                         +B(PROFIT-MARGINS)
87  Profit sharing                  PLAN     +B(PROFIT-SHARING)
88  Profits                         QUANTITY +A
89  Program trading                        -C(PROGRAM-TRADING)
90  Reduce cycle times                     +B(REDUCE-CYCLE-TIMES
91  Reduced levels of management           +B(REDUCE-LEVELS-OF-MANAGEMENT)
92  Reengineering                          +B(REENGINEERING)
93  Regulations                            -B
94  Respond to competitor                  +B(RESPOND-TO-COMPETITOR)
95  Responsive to user needs               +B(RESPONSIVE-TO-USERS)
96  Responsiveness to customers            +B(RESPONSIVE-TO-CUSTOMERS)
97  Revenues                        MONEY    +B
98  Right sizing                           +B(RIGHT-SIZING)
99  Risk                            VALUE    -B
100 Sales                           MONEY    +B
101 Securities regulations          RULES    +C(SECURITIES-REGULATIONS)
102 Security                        VALUE    +B
103 Service                                  +B
104 Shareholder return on investment PERCENT+A(RETURN-ON-INVESTMENT)
105 Shareholder value                        +B(SHAREHOLDER-VALUE)
106 Simplify order placing                   +B(ORDER-PLACING)
107 Social Responsibility           VALUE    +C(SOCIAL-RESPONSIBILITY)
108 Software architecture                    +B(SOFTWARE)
109 Status information                       +B(STATUS-INFORMATION)
110 Stock Price                     MONEY    +B(STOCK-PRICE PRICE)
111 Stock buyback                   PLAN     +B(STOCK-BUYBACK)
112 Stock dividend                  MONEY    +B(STOCK-DIVIDEND)
113 Stock split                     PLAN     +B(STOCK-SPLIT)
114 Supplier switching costs        MONEY    -B(SUPPLIER-SWITCHING-COSTS)
115 Supplier ties                            +B(SUPPLIER-TIES)
116 System availability                      +B(AVAILABILITY)
117 System backup                            +B(BACKUP SYSTEM-BACKUP)
118 System connectivity                        (CONNECTIVITY)
119 System performance                       +B(SYSTEM-PERFORMANCE)
120 System response time                     +B(SYSTEM-RESPONSE-TIME)
121 System security                          +B(SYSTEM-SECURITY)
```

```
122 Takeover                          PLAN
123 Taking over customer processes            +C(CUSTOMER-FUNCTIONS)
124 Tax Rate                          PERCENTAGE-B(TAX-RATE)
125 Taxes                             QUANTITY  -B
126 Technological advances                      +B(TECHNOLOGICAL-ADVANCES)
127 Tracking information                        +B(TRACKING-INFORMATION)
128 Trade secrets                               +C(TRADE-SECRETS)
129 Uncertainty                                 +B
130 Use exciting technology                     +C(EXCITING-TECHNOLOGY)
131 User interfaces                             +B(INTERFACES USER-INTERFACES)
132 User satisfaction                           +B(USER-SATISFACTION)
133 Volume                            QUANTITY  +B
134 Work pace                                   +B(WORK-PACE)
135 Work scheduling                             +B(WORK-SCHEDULING)
136 Workplace safety                            +B(WORKPLACE-SAFETY
SAFETY)
```

# Appendix B: Annotated Transcript

Below we present an annotated transcript of VOTE simulating the decision of Jim Dagnon, the Senior VP for Labor Relations. Dagnon must be sensitive both to the concerns of senior management, and to those of the employees.

```
> (vote 'dagnon 'ares)

Extracting stances based on voting record of Jim Dagnon...done.

*
* Decision:      @13
* Agent:         Jim Dagnon
* Option:        Burlington Northern ARES Decision
* ARES will give Operations better control over its assets.
* We will schedule locomotives and cars more precisely, and get more
* efficiency and utilization of locomotives and tracks.  ARES will
* also enable us to service our customers better by offering more
* reliable and predictable deliveries.
*
  Inferring stances from relations of Jim Dagnon...done.

**************************************************************************
*                  Analyzing alternative positions                       *
**************************************************************************
```

At this point, VOTE has inferred the basic set of preferences for Dagnon. In this case, there is no voting record, so all the major stances come from Dagnon's constituencies of senior management and the employees.

Next, VOTE matches these preferences with the consequences of deciding for or against (AGN) this plan.

```
**************************************************************************
* Vote FOR ARES                                                          *
**************************************************************************
```

```
  Considering implications of vote FOR ARES
Matching agent stances with option stances:
     #{Stance (14) [C:PRO] EMPLOYEE-SATISFACTION (OPTION:ARES)}
     #{Stance (15) [B:PRO] MARKET-SHARE (OPTION:ARES)}
     #{Stance (16) [B:PRO] COMPETITIVE-ADVANTAGE (OPTION:ARES)}
     #{Stance (17) [B:PRO] INNOVATION (OPTION:ARES)}
     #{Stance (18) [B:PRO] RELIABILITY (OPTION:ARES)}
     #{Stance (19) [B:PRO] TRACKING-INFORMATION (OPTION:ARES)}
     #{Stance (20) [B:PRO] COMMUNICATIONS (OPTION:ARES)}
     #{Stance (21) [B:PRO] CONTROL (OPTION:ARES)}
     #{Stance (22) [B:PRO] PRODUCT-DIFFERENTIATION (OPTION:ARES)}
     #{Stance (23) [B:PRO] OPPORTUNITY-COST (OPTION:ARES)}
     #{Stance (24) [B:PRO] PRICES (OPTION:ARES)}
     #{Stance (25) [B:PRO] SAFETY (OPTION:ARES)}
     #{Stance (26) [B:PRO] CYCLE-TIMES (OPTION:ARES)}
     #{Stance (27) [B:PRO] ACCURACY (OPTION:ARES)}
     #{Stance (28) [B:PRO] EFFICIENCY (OPTION:ARES)}
     #{Stance (29) [B:PRO] REDUCE-COSTS (OPTION:ARES)}
     #{Stance (30) [B:PRO] CAPACITY (OPTION:ARES)}
     #{Stance (31) [B:PRO] SERVICE (OPTION:ARES)}
     #{Stance (32) [B:PRO] VOLUME (OPTION:ARES)}
     #{Stance (2) [B:PRO] DATA (OPTION:ARES)}
     #{Stance (1) [B:PRO] WORK-SCHEDULING (OPTION:ARES)}
Sorting stances based on EQUITY order...done.
Stances FOR: (((PRO B GROUP:EMPLOYEES WORKPLACE-SAFETY)
                      (PRO B GROUP:EMPLOYEES EMPLOYEE-SATISFACTION)
                      (PRO B GROUP:SENIOR-MANAGEMENT MARKET-SHARE)
                      (PRO B
                           GROUP:SENIOR-MANAGEMENT
                           COMPETITIVE-ADVANTAGE)
                      (PRO B GROUP:SENIOR-MANAGEMENT CYCLE-TIMES)
                      (PRO B GROUP:SENIOR-MANAGEMENT REDUCE-COSTS)
                      (PRO B GROUP:SENIOR-MANAGEMENT SERVICE)
                      (PRO B
                           GROUP:SENIOR-MANAGEMENT
                           COMMUNICATIONS)
                      (PRO B
                           GROUP:SENIOR-MANAGEMENT
                           PRODUCT-DIFFERENTIATION)
                      (PRO B
                           GROUP:SENIOR-MANAGEMENT
                           OPPORTUNITY-COST)
                      (PRO C
                           GROUP:SENIOR-MANAGEMENT
                           WORKPLACE-SAFETY)
                      (PRO C GROUP:SENIOR-MANAGEMENT INNOVATION)))
************************************************************************
* Vote AGN ARES                                                        *
************************************************************************
```

```
  Considering implications of vote`AGN ARES
Matching agent stances with option stances:
     #{Stance (35) [A:CON] DEBT (OPTION:ARES)}
     #{Stance (36) [B:CON] CHANGE-ORG-STRUCTURE (OPTION:ARES)}
     #{Stance (37) [B:PRO] OPPORTUNITY-COST (OPTION:ARES)}
     #{Stance (38) [C:PRO] JOB-SKILLING (OPTION:ARES)}
     #{Stance (39) [C:PRO] JOB-SECURITY (OPTION:ARES)}
     #{Stance (40) [B:PRO] FAILURE (OPTION:ARES)}
     #{Stance (41) [A:PRO] UNCERTAINTY (OPTION:ARES)}
     #{Stance (42) [A:CON] RISK (OPTION:ARES)}
     #{Stance (43) [A:CON] EXPENSES (OPTION:ARES)}
     #{Stance (4) [C:PRO] EARNINGS (OPTION:ARES)}
     #{Stance (3) [B:PRO] CASH-FLOW (OPTION:ARES)}
Sorting stances based on EQUITY order...done.
Stances AGN: (((PRO B GROUP:EMPLOYEES JOB-SKILLING)
                      (PRO B GROUP:EMPLOYEES JOB-SECURITY)
                      (PRO B
                           GROUP:SENIOR-MANAGEMENT
                           OPPORTUNITY-COST)
                      (CON B GROUP:SENIOR-MANAGEMENT RISK)
                      (CON B GROUP:SENIOR-MANAGEMENT EXPENSES)
                      (PRO B GROUP:SENIOR-MANAGEMENT EARNINGS)
                      (PRO B GROUP:SENIOR-MANAGEMENT CASH-FLOW)))
```

There are many reasons on both sides of this decision. VOTE now applies its decision strategies to determine its choice.

```
**********************************************************************
*                    Applying decision strategies                    *
**********************************************************************
  Trying decision strategy: Popular decision...failed.
  Trying decision strategy: Non-partisan decision...failed.
  Trying decision strategy: Unimportant Bill...failed.
  Trying decision strategy: Minimize adverse effects...failed.
  Trying decision strategy: Inconsistent constituency...success.

   Found a consensus FOR this plan.
   The most important stances are all FOR this plan:
     Group:          ((FOR ((PRO B GROUP:EMPLOYEES WORKPLACE-SAFETY)
                            (PRO B
                                 GROUP:EMPLOYEES
                                 EMPLOYEE-SATISFACTION))))
```

```
Norm:          ((FOR ((PRO B ISSUE:ISSUE.395 WORKPLACE-SAFETY)
                      (PRO B
                           ISSUE:ISSUE.126
                           EMPLOYEE-SATISFACTION)
                      (PRO B
                           ISSUE:ISSUE.287
                           COMPETITIVE-ADVANTAGE)
                      (PRO B
                           ISSUE:ISSUE.114
                           REDUCE-CYCLE-TIMES)
                      (PRO B ISSUE:ISSUE.295 REDUCE-COSTS)
                      (PRO B ISSUE:ISSUE.294 SERVICE)
                      (PRO B ISSUE:ISSUE.98 COMMUNICATIONS)
                      (PRO B
                           ISSUE:ISSUE.109
                           PRODUCT-DIFFERENTIATION)
                      (PRO B ISSUE:ISSUE.188 OPPORTUNITY-COST))))

  The same group has stances on both sides of this plan:
  (#{Stance (48) [B:PRO] OPPORTUNITY-COST (GROUP:SENIOR-MANAGEMENT)})
 Adding current vote to DECISION database...done.
```

The program found a strategy that works. VOTE now adds the outcome to its decision database and produces a natural language explanation.

```
**********************************************************************
*                          Decision @13                              *
**********************************************************************

  Status:          ("Active")
  Isa-depth:       ("")
  Symbol:          (DECISION.177)
  Option:          #{Option (49) Burlington Northern ARES Decision}
  Agent:           #{Agent (50) Jim Dagnon}
  For-stances:     (((PRO B GROUP:EMPLOYEES WORKPLACE-SAFETY)
                     (PRO B GROUP:EMPLOYEES EMPLOYEE-SATISFACTION)
                     (PRO B GROUP:SENIOR-MANAGEMENT MARKET-SHARE)
                     (PRO B
                          GROUP:SENIOR-MANAGEMENT
                          COMPETITIVE-ADVANTAGE)
                     (PRO B GROUP:SENIOR-MANAGEMENT CYCLE-TIMES)
                     (PRO B GROUP:SENIOR-MANAGEMENT REDUCE-COSTS)
                     (PRO B GROUP:SENIOR-MANAGEMENT SERVICE)
                     (PRO B GROUP:SENIOR-MANAGEMENT COMMUNICATIONS)
                     (PRO B
                          GROUP:SENIOR-MANAGEMENT
                          PRODUCT-DIFFERENTIATION)
                     (PRO B
                          GROUP:SENIOR-MANAGEMENT
                          OPPORTUNITY-COST)
                     (PRO C
                          GROUP:SENIOR-MANAGEMENT
                          WORKPLACE-SAFETY)
                     (PRO C GROUP:SENIOR-MANAGEMENT INNOVATION)))
```

```
Agn-stances:     (((PRO B GROUP:EMPLOYEES JOB-SKILLING)
                   (PRO B GROUP:EMPLOYEES JOB-SECURITY)
                   (PRO B
                        GROUP:SENIOR-MANAGEMENT
                        OPPORTUNITY-COST)
                   (CON B GROUP:SENIOR-MANAGEMENT RISK)
                   (CON B GROUP:SENIOR-MANAGEMENT EXPENSES)
                   (PRO B GROUP:SENIOR-MANAGEMENT EARNINGS)
                   (PRO B GROUP:SENIOR-MANAGEMENT CASH-FLOW)))
Number-for:      (12)
Number-agn:      (7)
Group-for:       (((PRO B GROUP:EMPLOYEES WORKPLACE-SAFETY)
                   (PRO B GROUP:EMPLOYEES EMPLOYEE-SATISFACTION)
                   (PRO B GROUP:SENIOR-MANAGEMENT MARKET-SHARE)
                   (PRO B
                        GROUP:SENIOR-MANAGEMENT
                        COMPETITIVE-ADVANTAGE)
                   (PRO B GROUP:SENIOR-MANAGEMENT CYCLE-TIMES)
                   (PRO B GROUP:SENIOR-MANAGEMENT REDUCE-COSTS)
                   (PRO B GROUP:SENIOR-MANAGEMENT SERVICE)
                   (PRO B GROUP:SENIOR-MANAGEMENT COMMUNICATIONS)
                   (PRO B
                        GROUP:SENIOR-MANAGEMENT
                        PRODUCT-DIFFERENTIATION)
                   (PRO B
                        GROUP:SENIOR-MANAGEMENT
                        OPPORTUNITY-COST)
                   (PRO C
                        GROUP:SENIOR-MANAGEMENT
                        WORKPLACE-SAFETY)
                   (PRO C GROUP:SENIOR-MANAGEMENT INNOVATION)))
Group-agn:       (((PRO B GROUP:EMPLOYEES JOB-SKILLING)
                   (PRO B GROUP:EMPLOYEES JOB-SECURITY)
                   (PRO B
                        GROUP:SENIOR-MANAGEMENT
                        OPPORTUNITY-COST)
                   (CON B GROUP:SENIOR-MANAGEMENT RISK)
                   (CON B GROUP:SENIOR-MANAGEMENT EXPENSES)
                   (PRO B GROUP:SENIOR-MANAGEMENT EARNINGS)
                   (PRO B GROUP:SENIOR-MANAGEMENT CASH-FLOW)))
For-norms:       (((PRO B ISSUE:ISSUE.395 WORKPLACE-SAFETY)
                   (PRO B ISSUE:ISSUE.126 EMPLOYEE-SATISFACTION)
                   (PRO C ISSUE:ISSUE.101 MARKET-SHARE)
                   (PRO B ISSUE:ISSUE.287 COMPETITIVE-ADVANTAGE)
                   (PRO B ISSUE:ISSUE.114 REDUCE-CYCLE-TIMES)
                   (PRO B ISSUE:ISSUE.295 REDUCE-COSTS)
                   (PRO B ISSUE:ISSUE.294 SERVICE)
                   (PRO B ISSUE:ISSUE.98 COMMUNICATIONS)
                   (PRO B
                        ISSUE:ISSUE.109
                        PRODUCT-DIFFERENTIATION)
                   (PRO B ISSUE:ISSUE.188 OPPORTUNITY-COST)
                   (PRO C ISSUE:ISSUE.292 INNOVATION)))
```

```
Agn-norms:      (((PRO B ISSUE:ISSUE.250 JOB-SKILLING)
                  (PRO C ISSUE:ISSUE.382 JOB-SECURITY)
                  (PRO B ISSUE:ISSUE.188 OPPORTUNITY-COST)
                  (CON B ISSUE:ISSUE.139 RISK)
                  (CON B ISSUE:ISSUE.283 EXPENSES)
                  (PRO B ISSUE:ISSUE.134 EARNINGS)
                  (PRO B ISSUE:ISSUE.284 CASH-FLOW)))
Agn-bnorms:     (((PRO B ISSUE:ISSUE.284 CASH-FLOW)
                  (PRO B ISSUE:ISSUE.134 EARNINGS)
                  (CON B ISSUE:ISSUE.283 EXPENSES)
                  (CON B ISSUE:ISSUE.139 RISK)
                  (PRO B ISSUE:ISSUE.96 UNCERTAINTY)
                  (PRO B ISSUE:ISSUE.303 FAILURE)
                  (PRO C ISSUE:ISSUE.382 JOB-SECURITY)
                  (PRO B ISSUE:ISSUE.250 JOB-SKILLING)
                  (PRO B ISSUE:ISSUE.188 OPPORTUNITY-COST)
                  (CON C ISSUE:ISSUE.128 CHANGE-ORG-STRUCTURE)
                  (CON C ISSUE:ISSUE.847 DEBT)))
Split-group:    (((PRO B
                       GROUP:SENIOR-MANAGEMENT
                       OPPORTUNITY-COST)))
Mi-stance:      ((FOR ((PRO B GROUP:EMPLOYEES WORKPLACE-SAFETY)
                       (PRO B
                            GROUP:EMPLOYEES
                            EMPLOYEE-SATISFACTION))))
Mi-group:       ((FOR ((PRO B GROUP:EMPLOYEES WORKPLACE-SAFETY)
                       (PRO B
                            GROUP:EMPLOYEES
                            EMPLOYEE-SATISFACTION))))
Mi-norm:        ((FOR ((PRO B ISSUE:ISSUE.395 WORKPLACE-SAFETY)
                       (PRO B
                            ISSUE:ISSUE.126
                            EMPLOYEE-SATISFACTION)
                       (PRO B
                            ISSUE:ISSUE.287
                            COMPETITIVE-ADVANTAGE)
                       (PRO B
                            ISSUE:ISSUE.114
                            REDUCE-CYCLE-TIMES)
                       (PRO B ISSUE:ISSUE.295 REDUCE-COSTS)
                       (PRO B ISSUE:ISSUE.294 SERVICE)
                       (PRO B ISSUE:ISSUE.98 COMMUNICATIONS)
                       (PRO B
                            ISSUE:ISSUE.109
                            PRODUCT-DIFFERENTIATION)
                       (PRO B ISSUE:ISSUE.188 OPPORTUNITY-COST))))
Strategy:       #{Strategy (55) Inconsistent constituency}
Result:         (FOR)
```

```
   Reason:          ((((PRO B GROUP:EMPLOYEES WORKPLACE-SAFETY)
                       (PRO C
                            GROUP:SENIOR-MANAGEMENT
                            WORKPLACE-SAFETY))
                      ((PRO B GROUP:EMPLOYEES EMPLOYEE-SATISFACTION))
                      ((PRO B GROUP:SENIOR-MANAGEMENT MARKET-SHARE))
                      ((PRO B
                            GROUP:SENIOR-MANAGEMENT
                            COMPETITIVE-ADVANTAGE))
                      ((PRO B GROUP:SENIOR-MANAGEMENT CYCLE-TIMES))
                      ((PRO B GROUP:SENIOR-MANAGEMENT REDUCE-COSTS))
                      ((PRO B GROUP:SENIOR-MANAGEMENT SERVICE))
                      ((PRO B
                            GROUP:SENIOR-MANAGEMENT
                            COMMUNICATIONS))
                      ((PRO B
                            GROUP:SENIOR-MANAGEMENT
                            PRODUCT-DIFFERENTIATION))
                      ((PRO B
                            GROUP:SENIOR-MANAGEMENT
                            OPPORTUNITY-COST))
                      ((PRO C GROUP:SENIOR-MANAGEMENT INNOVATION))))
   Downside:        ((((PRO B GROUP:EMPLOYEES JOB-SKILLING))
                      ((PRO B GROUP:EMPLOYEES JOB-SECURITY))
                      ((PRO B
                            GROUP:SENIOR-MANAGEMENT
                            OPPORTUNITY-COST))
                      ((CON B GROUP:SENIOR-MANAGEMENT RISK))
                      ((CON B GROUP:SENIOR-MANAGEMENT EXPENSES))
                      ((PRO B GROUP:SENIOR-MANAGEMENT EARNINGS))
                      ((PRO B GROUP:SENIOR-MANAGEMENT CASH-FLOW))))
**********************************************************************
* English rationale:                                                 *
**********************************************************************
```

*Jim Dagnon favors investing $340 million in ARES. He believes that sincere people have trouble balancing the tradeoffs presented by this plan. He stands for workplace safety. Dagnon is a defender of increased employee satisfaction. Dagnon is committed to increased market share. He stands for increased competitive advantage. He believes in reducing cycle times. Dagnon is eager to support reducing costs. Dagnon strongly supports improving service. He is a defender of improving communications. He readily endorses product differentiation. Dagnon is committed to reducing the cost of not investing. Dagnon is in favor of increased innovation. Still, he realizes that employees are a defender of increasing skill content of jobs. They readily endorse job security. Senior management readily endorses reducing opportunity costs. It strongly supports decreased risk. It is strongly in favor of reducing costs. Senior management believes in increased earnings. Senior management believes in increased cash flow.*

```
**********************************************************************
*                        End of Decision @13                         *
**********************************************************************
#{Decision (13) [FOR:ARES] Dagnon (() : ()) }
```