Scenario Planning for Enterprise Risk Management

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Abstract

We present Scenario Planning Advisor (SPA), that takes as input the relevant news and social media trends that characterize the current situation, as well as the domain knowledge and generates multiple plans explaining the observations and projecting future states. The resulting plans are clustered and summarized to generate the scenarios for use in scenario planning for enterprise risk management.

1 Introduction and Motivation

Scenario planning is a commonly used method for strategic planning [Schoemaker, 1995]. Scenario planning involves analyzing the relationship between forces such as social, technical, economic, environmental, and political trends in order to explain the current situation in addition to providing insights about the future. A major benefit to scenario planning is that it helps businesses or policy-makers learn about the possible alternative futures and anticipate them. While the expected scenarios are interesting for verification purposes, surprising scenarios to the users (e.g., policy-makers) are the most important and significant [Peterson et al., 2003].

Risk management is a set of principles that focus on the outcome for risk-taking [Stulz, 1996]. A variety of methods and standards for risk management under different assumptions have been developed [Avanesov, 2009]. We address scenario planning for risk management, the problem of generating scenarios with a significant focus on identifying the extreme yet possible risks that are not usually considered in daily operations. Our approach is different from previous work in that we reason about emerging risks based on observations from the news and social media trends, and produce scenarios that both describe the current situation and project the future possible effects of these observations. Furthermore, each scenario we produce highlights the potential *leading indicators*, the set of facts that are likely to lead to a scenario, the *scenario and emerging risk*, the combined set of consequences or effects in that scenario, in addition to the *business implications*, a subset of potential effects of that scenario that the users (e.g., policy-makers, businesses) care about.

For example, given an observation of a high inflation rate in a certain country, economic decline followed by a decrease in government spending can be the consequences or the effects in a scenario, while decreased client investment in the company offerings is an example of a business implication. Furthermore, an increase in the price of a commodity can be an example of a leading indicator for such a scenario.

The main idea of the approach in SPA is to view the scenario planning problem for enterprise risk management as a problem that can be translated to an AI planning problem [Sohrabi, Riabov, and Udrea, 2017a]. An intermediate step is a plan recognition problem, where the set of given business implications forms the set of possible goals, and the observations are selected from the news and social media trends. The domain knowledge is acquired from the domain expert via a graphical tool and is then automatically translated to an AI planing domain. AI planning is in turn used to address the plan recognition problem [Ramírez and Geffner, 2009; Sohrabi, Riabov, and Udrea, 2016; 2017b]. Top-k planning is used to generate multiple plans that can be grouped into a scenario [Sohrabi et al., 2016]. The set of plans is then clustered and summarized to generate the scenarios.

2 Key Ideas Implemented in SPA

2.1 Planning Formulation

The scenario planning for enterprise risk management problem is defined akin to a plan recognition problem, where the set of observations is selected from news and social media, the set of possible goals is a set of business implications, and the domain knowledge is captured by the domain experts. We define the solution to the problem as a set of scenarios, where each scenario is a collection of executable plans that explain the observations and considers the possible cascading effects of the actions to identify potential future outcomes.

2.2 Data Transformation

SPA continuously monitors multiple real-world sources (e.g., news channels, social media posts) to identify the set of observations. To this end, several text analytics are implemented to find the information relevant for a particular domain in the vast amount of information available to crawl. We define a set of predefined relevant news sources, topics, and organizations in order to refine and filter the information. Users/analysts can also add a set of keywords that is important for a particular domain. Analysts then review the generated results and select the observations that are the most relevant and important for them. Note that SPA can deal with unreliable observations (i.e., noisy and missing observation) as it exploits previous work on plan recognition as planning that addresses unreliable observations [Sohrabi, Riabov, and Udrea, 2016].

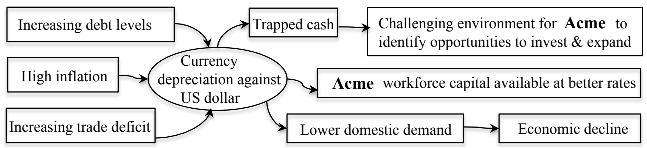

Figure 1: Part of the Mind Map for the currency depreciation.

2.3 Knowledge Engineering

We capture the necessary domain knowledge in two forms, Forces Model and Forces Impact. The Forces Model is a description of the causes and effects for a certain force, such as social, technical, economic, and political trends, and is provided by a domain expert who may have little or no AI planning background. Forces Model are captured by a Mind Map (`freemind.sourceforge.net/wiki/`), a graphical tool that encodes concepts and relations. An example of a Mind Map for the currency depreciation force is shown in Figure 1. The concepts with an edge going towards the force, are the possible causes, and the concepts with an outgoing edge from the force, are the possible effects. The effects can cascade to other effects, with a leaf concept of either a business effect, referred to as the business implication in the scenarios, or another force, with its own separate Mind Map that describes it. The Forces Impact describes the potential likelihoods and impact of a cause or an effect. Forces Impact is captured by asking domain experts a series of automatically generated questions based on the Mind Maps. The answers to these questions determine the weight of the edges in the Mind maps. The domain knowledge encoded in the Mind Maps, together with the answers from the questionnaire, is automatically translated into a planning language such as PDDL. To do so we define an action for each cause, as well as each edge in the Mind Map. While the set of actions are fixed, the actions will be grounded based on the Mind Maps.

2.4 Plan Computation

To compute a set of high-quality plans, we use the top-k planning approach proposed in [Sohrabi et al., 2016]. Top-k planning is defined in as the problem of finding k set of plans that have the highest quality. The best known algorithm to compute the set of top-k plans is based on the k shortest paths algorithm called K^* [Aljazzar and Leue, 2011] which also allows use of heuristics search. We use the K^* algorithm together with the LM-cut heuristic [Pommerening and Helmert, 2012] in the SPA system.

2.5 Scenarios Computation

To compute the type of scenarios shown in Figure 2, we perform a set of post-processing steps on the computed set of plans. First, we identify the number of plans out of the top-k plans (e.g., 1000) generated by the planner to consider for scenario generation. We argue that this number is problem-dependent. To calculate the cost cutoff, we calculate the average and the standard deviation of the cost of all plans among the top-k plans. We then consider plans that have a lower cost than the average cost subtracted by the standard deviation. Next, we cluster the resulting plans to create scenarios. To do so we determine the euclidean distance between two plans and compute a dendrogram bottom-up using the complete-linkage clustering method [Defays, 1977] with the mean of all distances between clusters as the aggregate function. The user can specify a minimum and maximum consumable number of scenarios. These settings are used to perform a cut through the dendrogram that yields the number of plans in the specified interval with the optimal Dunn index [Dunn, 1973], a metric for evaluating clustering algorithms that favors tightly compact sets of clusters that are well separated.

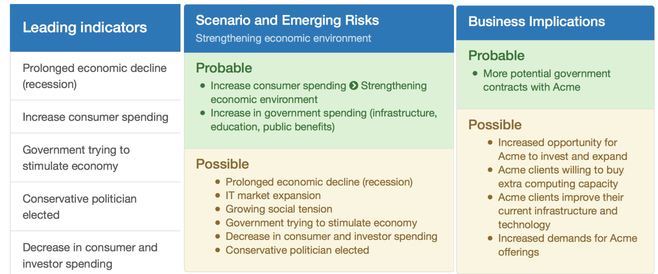

Figure 2: Sample generated scenario

3 User Interface

We perform several tasks to prepare the scenarios for presentation. First, we separate the predicates in each cluster (scenario) into business implications and regular predicates. At the same time, we separate probable and possible predicates in each of these categories by determine the proportion of plans where the predicate is present in the last state from all plans in the scenario. Second, we compute a set of leading indicators. These are predicates that appear early on the plans that are part of one scenario and are also discriminating; these are useful to monitor in order to determine early on whether a scenario is likely to occur. Third, we compute a summary of all plans that are part of the scenario and present this as a graph to the user. This graph serves as an explanatory tool for the predicates that are presented in each scenario and shows how the different Mind Maps are connected with each other through concepts that are shared between them.

4 Summary

We present the SPA system developed by applying plan-recognition-as-planning techniques for scenario planning for enterprise risk management. To this end, we addressed knowledge engineering challenge of encoding the domain knowledge, and designed a system that takes as input news and social media posts, interacts with the business user to obtain observations, and generates scenarios by clustering the generated plans. The SPA system is currently in pilot deployment. The feedback we have received so far have been positive and show that our approach seems promising for this application. To the best of our knowledge, we are the first to apply AI planning in addressing scenario planning for enterprise risk management. We believe that AI planning provides a very natural formulation for the efficient exploration of possible outcomes required for scenario planning.

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