Enhancing Process-Adaptation Capabilities with Web-Based Corporate Radar Technologies

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ABSTRACT
Dynamic business processes are capable of adapting themselves to internal events but lack the ability to adapt to external events. Corporate radars are capable of mining the Web for external events of interest to produce structured representations of these events but are not capable of adapting themselves based on these events. In this position paper, we advocate and propose a system that integrates these two approaches to enhance the capability of process-adaptation engines, greatly increasing the scope of events they can respond to.

Categories and Subject Descriptors
H.3.5 [Online Information Services]**:** Web-based services

General Terms
Algorithms, Design, Experimentation

Keywords
Dynamic business process, Corporate Radars, Dynamic process adaptation

1. INTRODUCTION
Systems that can automatically adapt an enterprise's business process to changes in the external environment will enable the enterprise to be more agile and responsive to potential risks and opportunities. The creation of such systems requires a mechanism to dynamically adapt business processes and a separate mechanism to provide various types of context–awareness on which adaptation decisions can be based.

The first mechanism can be provided by the WS-BPEL specification and various engines that support its execution. In previous research [2], we have begun to lay the groundwork for dynamic process adaptation. This system employs a process management layer, distinct from the process execution engine, capable of adapting business processes based on service-generated events, such as delivery delays or failures. However, this first generation adaptation system is limited to events generated by the system's services. Hence, there are several important kinds of dynamic adaptation that are beyond its capabilities such as:

1. The ability to react to events that are entirely external to the system, such as changes in a supplier's economic circumstances.
2. The ability to shape the business process based on informed inferences regarding the likely external cause of service-based events.

The second mechanism can be provided by systems that detect and interpret external events of interest to support business decisions. In other previously unrelated work, we have been developing prototype systems that do just that. These "corporate radar" systems [1][4] automatically mine the Web to: 1) detect business-relevant events occurring in the competitive eco-system outside the enterprise; and 2) map those events to a model of the business dynamics in which the user's organization operates to infer the potential implications of these events.

These corporate radar systems suggest techniques that can be used to detect and interpret events for process adaptation, and hence address the limitations with the existing process-adaptation framework described above.

However, corporate radar systems up to now have been designed to populate executive decision-support dashboards or generate news feeds as decision support for human managers. They have not been used to provide guidance to other automated systems such as a process-adaptation engine.

In this paper, we propose a system that combines corporate radars with a business-process adaptation engine, resulting in a context-aware adaptation system. This context-aware adaptation system will be capable of taking a much broader context into account when determining the best process to execute. This broader awareness will enable enterprises to be more agile and responsive to potential threats and opportunities in two important ways:

1. Adapting proactively in response to early detection of external events: Consider a supply chain process where a computer manufacturer has a single supplier for its motherboards. Given the dependence of the manufacturer on this supplier, it is important to become aware of possible disruptions in the supply of motherboards before they happen to proactively adopt the process model. We can use corporate radars to mine the Web for indicators that the supplier will fail to

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deliver. These indicators might include reports of financial trouble, such as filing of bankruptcy, or even natural disasters that might damage the roads (or railways) between the supplier's distribution center and the manufacturer. Hence, a corporate radar can enable a business process adaptation framework to proactively adapt to these detected events by looking for a new supplier and head off economic disaster.

2. Interpreting service behavior in terms of external context: Consider a supply chain process where a computer manufacturer has placed an order for parts from various suppliers. Due to a shortage in silicon production, the memory supplier service is unable to fulfill the order in time and sends a delivery event to the process. In our previous work, the cost of the delay would be weighed against the cost of waiting, and a possible outcome of the adaptation engine might be to cancel the existing order and place a new order with someone else. However, if the delay is due to shortage of raw materials, it is unlikely that another supplier will be able to deliver the required parts in the desired time. We can use corporate radars to mine the Web for indicators of shortages of raw material that can factor into the decision making, thereby reducing the hassle of changing the supplier if it is unlikely that it will improve the chances of timely execution of the process.

There have been many previous approaches for process adaptation such as petri-nets [5], Event Condition Action (ECA) rules [6] and graph based techniques [7]. In our own work [3], we used Markov Decision Processes to respond to external events. In addition, semantic modeling along with WS-BPEL has also been explored in other projects (e.g., METEOR-S [8], SUPER [9]). To the best of our knowledge, this is the first paper which couples a process adaptation mechanism with a corporate radar that can mine the internet for relevant events.

The sections that follows provides an overview of this context-aware adaptation system which includes a description of the work we have done on process adaptation, corporate radars, and how these two components can be combined. We also provide a motivating example for this system based on current events. We conclude with a discussion of remaining challenges, and future work.

2. System Overview

We give an overview of a context-aware adaptation system by describing the work done on two main components – business process adaptation engine and corporate radars – and describe how these two components are combined. Figure 1 shows the high-level architecture of the system.

2.1 Business Process Adaptation Engine

The business process adaptation engine was presented in our earlier work [2], which combined intelligent adaptation with a WS-BPEL engine. The adaptation engine from our previous work is presented in Figure 3 . The crux of the approach was to model the relevant states and events of the process across various points of its execution. A service manager per service was responsible for controlling the interaction between the service and process engine. In the normal course of execution of the process, the service manager would forward messages from the process engine to the service engine and vice versa. The service manager would also maintain the state of the interaction with service depending on the post-conditions of the operations invoked.

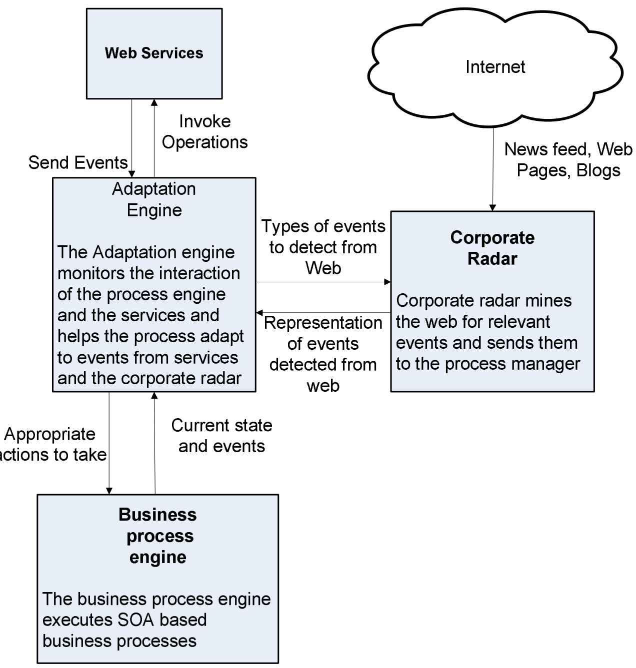

Figure 1. Overall Architecture of Envisioned System

If the process executed normally, the state machine for each service manager would transition effortlessly from the start state to the goal state. If however, there was an unexpected event and exception, the service manager would transition to an error state. In that particular case, the service manager would use its adaptation mechanism to find an optimal path from the error state to the goal state. We characterized the problem as sequential decision-making and used Markov decision processes (MDPs) for decision making. The use of MDPs also allowed us to model the uncertainly of events such as "delays" and allowed us to optimize the adaptation based on expected costs of the events.

We also studied the impact of having dependencies between services and introduced the notion of a process manager, which (as shown in Figure 3) is a separate entity from the service managers and uses the global knowledge of the process to make adaptation decisions based on the local decisions made by service managers. We also investigated various decision making paradigms with three approaches – centralized, de-centralized and hybrid. In centralized approach, the process manager uses a MDP that was constructed by taking a Cartesian product of the service manager MDPs. This approach guaranteed optimality but was exponential with the number of service manager. In the decentralized approach, if a local service manager made a decision to adapt, then all the dependent service managers would have to react accordingly. This approach was computationally less expensive, but it was sub-optimal. Finally, in the hybrid approach, the process manager used polling of service manager local optimal adaptation decisions to deduce the optimal decision for the process. This approach was able to approximate the performance of the centralized approach and had the computation complexity of the de-centralized approach.

We believe the hybrid approach lends itself to the corporate-radar based adaptation, because the process manager in addition to polling the service manager can use a reasoning engine for optimal decision-making.

2.2 Corporate Radars

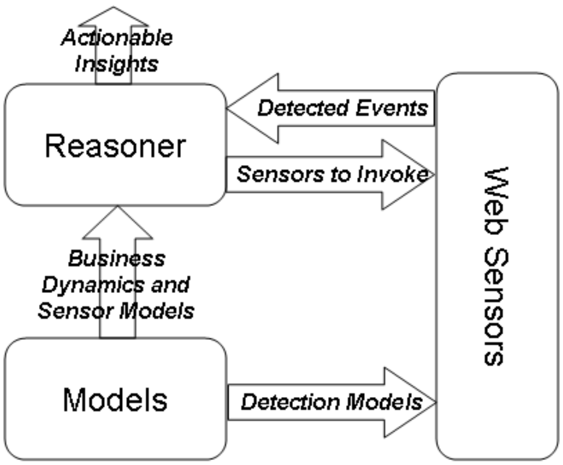

Figure 2. A schematic of the corporate radar platform.

Corporate radars automatically mine the Web to detect business-relevant events occurring in the competitive eco-system *outside* the enterprise and map those events to an organization's business model for generation of actionable insights (i.e. insights that can be acted upon such as when to invest in a technology, how to respond to a competitive threat, etc.). These corporate radars can be built on the platform proposed in [4], which consists of three components: models, reasoners and web-sensors (see Figure 2).

The models provide semantic representations of events and entities that are relevant to decision-makers and their organization (i.e. the business dynamics).For example these models, can include representations of entities like the manufacturers, the products they make, their suppliers, their customers, etc., and can include representations of events like deployments, mergers and acquisitions, price changes, etc. Models are used by the reasoner to guide the detection of relevant events from the Web and to interpret their implications.

The reasoner generates actionable insights from detected external events by applying the implications associated with the corresponding event representations in the business dynamics models. The reasoner also determines the appropriate web sensors to invoke (and hence what events to detect from the Web) based on what events are encoded in the models.

Web-sensors detect relevant unstructured signals on the Web and produce from them structured event descriptions that are consumed by the reasoner to generate actionable insights. The implementation of the sensors depend on the corporate radar being built, but they all require some form of natural language processing as most information on the Web is in the form of unstructured text.

This platform has been used to build corporate radars like the Business Event Advisor [1] and the Technology Investment Radar [4]. The Business Event Advisor provides decision-makers with a more systematic way of detecting, organizing, and interpreting a broad range of external business events in order to help them spot external threats and opportunities that affect their business. For example, using a model of the products made by a decision-makers company and the raw materials used in making these products, the Business Event Advisor can infer that a price increase in one of these raw materials may be due to a shortage and may cut into profit margins. This information can be fed into a business process adaptation framework to acquire as much of the affected raw material as possible in order to weather the shortage.

The Technology Investment Radar enables decision-makers to automatically and systematically track the maturation of technologies that relate to their business and understand when these technologies are mature enough to justify investing in them. For example, using a model of a technology to track, the vendors of the technology, and the technology's maturation cycle (i.e. the stages that the technology advances through as it matures), the Technology Investment Radar can infer that an increase in the number of vendors deploying the technology might mean that the technology is now further along in its maturation cycle. If this technology happens to compete with a more mature technology that is being used in one of your products (e.g. WiMax vs. EV-DO), then this information can be used by a business process adaptation framework to begin placing orders for the new technology and discontinue orders for the old one.

2.3 Integration Approach

Using corporate radar along with business processes, created using WS-BPEL [3], can prove beneficial for business intelligence. The corporate radar can be used to track a wide range of news sources to provide structured events as inputs to the process. The process uses these events to move into a specific branch of execution, which in turn gives directions to the radar on what additional kinds of events to look for. This interaction provides a feedback mechanism with the process serving as a guide and the radar fetching the necessary information. Additionally, the radar can use its semantic models to reason about the strength of the events detected as either strong signals or weak ones. The strength of a signal is based on the participants involved in an event (e.g. a Fortune 500 company performing an event yields a stronger signal than a start-up), the type of source an event is detected from (e.g. mainstream sources like the Wall Street Journal are given more weight than personal blogs), and the number of sources an event is detected from.

We will now briefly describe two constructs provided by WS-BPEL for event handling that logically lend it to be integrated with a corporate radar – scope and event handlers. WS-BPEL provides a construct called scope, which allows users to group activities with the same fault and event [3]. In the proposed system, the "scope" construct can be leveraged to correlate activities related to specific event. To exemplify if a corporate rival fires employees, a scope related to employee hiring should be activated rather than a scope related to office supplies. Hence, the scope construct can help focus the impact of events mined by the radar to specific sections of the process.

Each scope can be associated with a set of "Event Handlers". Event handlers allow the business process to accept parallel receipt of messages along with the normal flow of control thus allowing asynchronous execution [3]. In the proposed system, event handlers are a vital component since they allow the process to continue its normal execution without having to wait for events to be detected by the radar. On detection of an event, the radar can generate an appropriate message for the process engine, which will route it to the corresponding scope.

The radar and the process engine have complimentary capabilities. The process engine provides an execution environment for invoking complex processes and also provides a framework that allows a process to react to events. The radar has the capability to mine the Web for relevant events. When the radar is combined with the process engine, it enables a new set of capabilities for both. Now, the business process engine has the ability to find relevant events on the Web, which it could not do without the radar. At the same time, the radar has the ability to identify a set of non-trivial sequence of events to look for a capability that it lacked without the process engine.

3. Motivating Scenario

We illustrate the advantages of this system by analyzing the recent collapse of Independent National Mortgage Corporation (IndyMac) bank. Corporate rivalries are part of the economic ecosystem and big corporations always seek early signals of rival collapse to take preemptive measures that maximize profit. A rival bank of IndyMac bank, let's say Ultimate Banking Corporation, creates a long running BPEL process namely 'Rival Monitoring Process' integrated with a corporate radar. The Rival Monitoring Process configures the corporate radar to track the following 4 events related to a list of corporate rivals. Some of these execution branches are modeled in Figure 4.

- Government Involvement in IndyMac functioning
- Selling off of assets
- Layoffs
- Shutdown of operations

Government involvement in IndyMac functioning

The radar detects a strong signal: a senator has requested federal authorities to seize the functioning of IndyMac bank. The radar will utilize its semantic models to pass the information to the process, which invokes the following Web Service:

- Consumer banking Web service informs of a possible surge in disgruntled customers.
- HR Department service suggests an increase in staff hiring to handle new customers.
- The Public relation division service suggests an aggressive advertising campaign warning IndyMac customers of possible trouble time.

Layoffs

The radar feeds the process news about IndyMac selling off its retail mortgage business and laying off 55% of its workforce. The Rival Monitoring Process invokes the HR Department service, informing them of a potential workforce pool.

Selling off of assets

The radar detects a strong signal related to auction IndyMac assets. It passes the information to the process, which invokes the financial department service to investigate what assets are available in the market at low rates.

Shutting down of operations

The radar detects news stories regarding IndyMac shutting down headquarters and federal seizure of the bank. The Rival Monitoring Process informs management about the same. Figure 4 illustrates some of the above mentioned execution branches.

The radar continues to track stories related to other corporate rivals and passing on the information to Rival Monitoring Process. From the scenario mentioned above it's easy to identify that the radar provides capabilities for continuously monitoring information of interest, analyzing this information, and producing structured representations of this information using its semantic models. The Rival Monitoring Process configures the Radar in beginning to look for specific events and it executes operations on appropriate Web service according to the detected events.

The events detected by the radar and the actions taken by Ultimate Bank Process are captured in Table 1 below.

Table 1. Events captured by Radar and execution performed

Events Captured by the Radar	Services invoked by Rival Monitoring Process
Government Involvement in IndyMac	• Consumer banking • HR Department • Public relation
Sale of assets	• Financial Department
Layoffs	• HR Department
IndyMac shut down	• Management

4. Challenges and Future Work

In this paper, an approach for combining web-based corporate radar technologies with a business process adaptation engine is presented to create the next generation of adaptive business processes. Such a system will be able to automatically adapt an enterprise's business process to changes in the external environment, and hence enable the enterprise to be more agile and responsive to potential risks and opportunities.

Several challenges and issues, however, remain that require further investigation. These challenges and issues include:

- **Broadening the eco-system of the adaptation engine:** In our previous work, the adaptation engine was created as a closed system, where model of all states, costs, and events was created before the process started execution. Being able to leverage a broader range of events that the corporate radar may detect is an open challenge. Taking full benefit of the combined approach will require dynamic updating of the model (e.g. costs of actions may have to be changed, new events may have to introduced, etc.). In the future, we will evaluate if MDPs are still the ideal modeling paradigm for adaptation decision making, whether some extensions may allows us to still use MDPs or if some other modeling paradigm is needed.

- **Providing greater automation in radar technology:** Radar technology has been created to present information for human consumption. It aims to provide enhanced insight for human decision-makers, delivered via custom dashboards, email alerts, or other communications channels. In the business process adaptation context, there is greater demand for accuracy in detection of events due to the promise of automation. There are several challenges in natural language processing and knowledge engineering which need to be addressed to improve the reliability of such systems.

- **Validating the proposed system:** We presented an example based on real current events to motivate the value of combining corporate radars with a business process adaptation engine. However, a rigorous, empirical evaluation is needed to fully assess the utility of our proposed solution. We are currently working towards this end by applying our solution to the financial services and supply chain management domains to assess whether it can improve the agility and responsiveness of enterprises to potential risks and opportunities.

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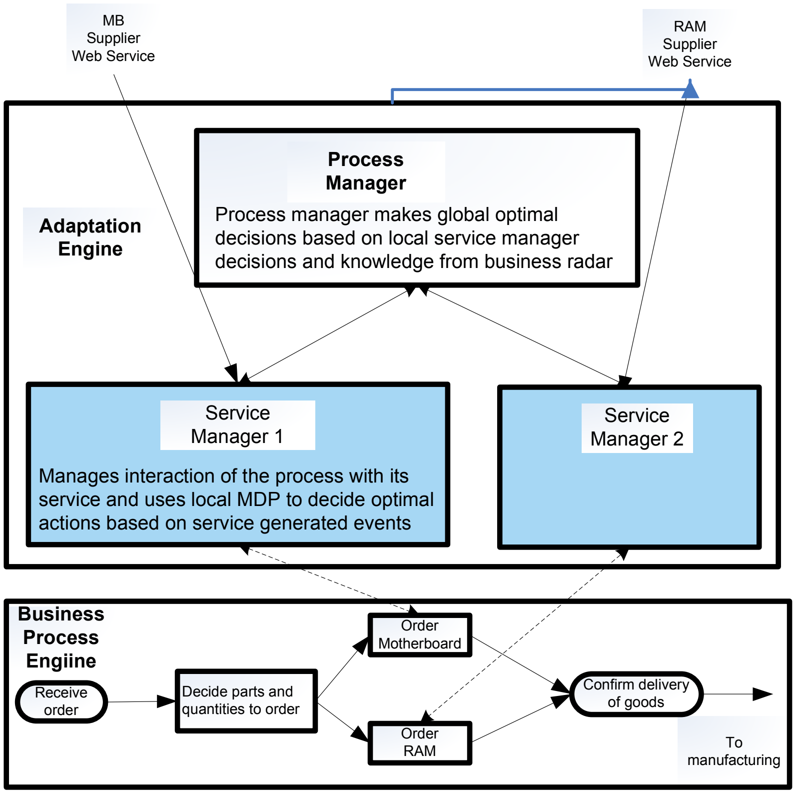

Figure 3. Interactions of the business process engine with Web services with the help of the adaptation framework.

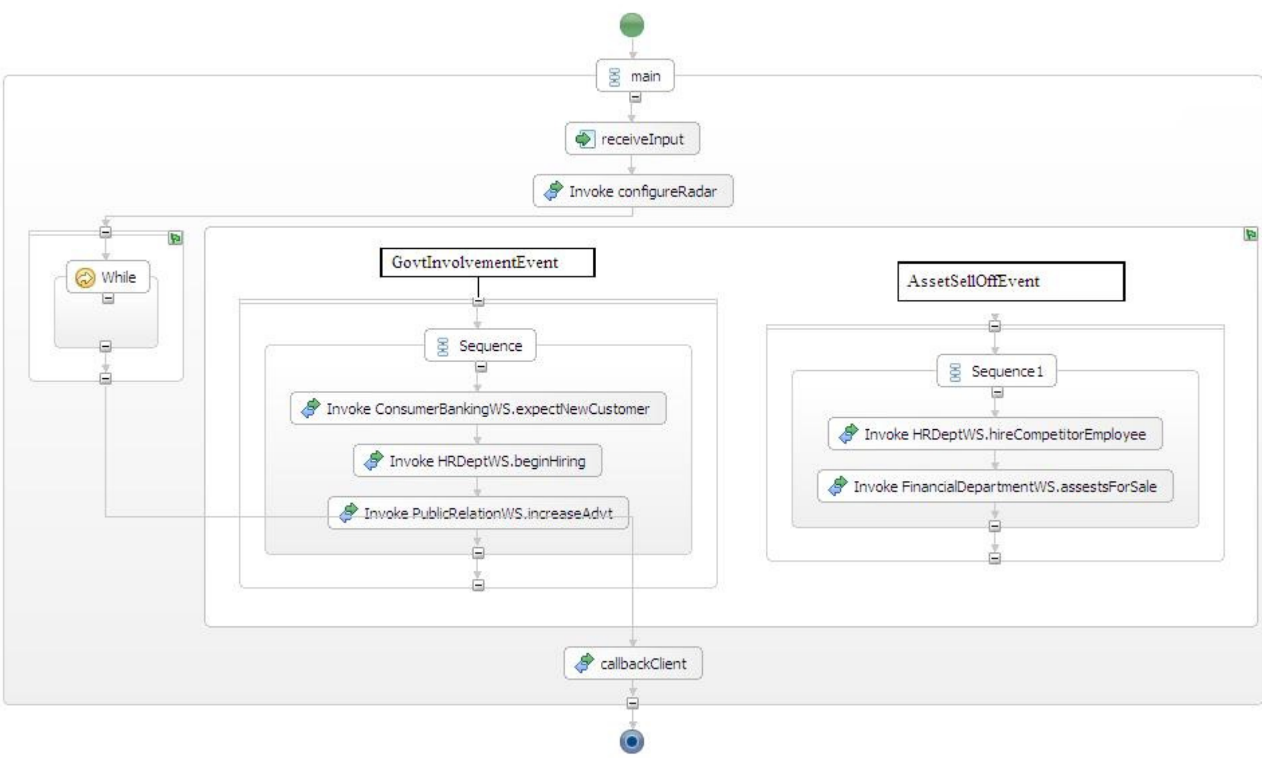

Figure 4. Rival Monitoring Process