Learning from Context to Improve Business Processes

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Why Context Matters

Have you lately been standing in a check-in line during a national holiday and wondered why the airline staff could not handle the queue more efficiently? While we assume our day to day operations run smoothly, they are actually subject to frequent variations. The main source of these variations is our environment, which introduces changing conditions. If we insist on keeping our processes as if nothing has changed, we may get poor performance or even worse. Changing environmental conditions may include the season, and how it affects the check-in process; the falling commodity prices; or expected or unexpected local or global events (e.g., a drop in the national interest rate, a new president). You may want to change your shipment processes as fuel prices go up and transportation becomes very costly. Differing exchange rates of foreign currencies may affect the way you select your suppliers.

Failing to adapt your processes to changes in the environment can lead to poor performance in terms of service, time, or cost. In some cases, the results of not being able to respond to changes or to unexpected events in the environment may be even worse. In a recent example, a German bank lost € 300 Million in a scheduled swap transaction to Lehman Brothers hours after the American investment bank had announced bankruptcy. The imminent threat caused by the financial crisis meltdown was apparently not on the radar screen of the bank's management, and the process was carried out as if nothing had happened. All these examples show how environmental conditions affect processes. But it does not stop there. Variations in business processes can also be the result of different subjects or cases being addressed. For example, selling to a regular and well-known customer is not the same as selling to a one-time customer who may not be trusted. Or consider patient treatment processes in a hospital, where each case – and thus process – is different.

What do all these examples imply? Business processes should be designed to be able to respond both to different cases to be handled and to different environmental conditions. A general term, addressing both the events and conditions in the environment and the specific properties of cases handled by the process, is the *context* of the process.

In their 2007 report on Magic Quadrants for Business Process Management Suites, Gartner highlighted the requirements of business processes that are "externally facing" and "highly susceptible to disruption from external forces" [1]. So how do we manage such business processes today? On the one hand, business process modeling is an increasingly popular method to capture and document the various processes of an organization. On the other hand, while day to day operations show a large degree of variability, we currently design process models in complete isolation from their environment and in a static, prescriptive manner. Whether an activity is executed in a given context or not is difficult to express in contemporary process modeling languages such as UML, EPC, or BPMN. At most, contextual variables are captured through textual annotations or decision points, which have the drawback of making process models overly verbose. As a result, process modelers are lacking the analytical capabilities to determine preparedness for specific events in the process context. Impact assessments in the form of "What do we have to do in the case of x?" become impossible.

Researchers at Queensland University of Technology, Australia, Stanford University, USA, and Haifa University, Israel, are currently investigating how context-awareness can become an integral part of business process modeling [2-4]. The main objective is to better understand the variables that drive context-dependent process change. These variables potentially cover a wide

spectrum, such as weather, time, location, resource prices, business partners, or strategies. They can also represent macroeconomic factors, e.g., competitive environment, trends in the financial markets, regulatory environment, and trade policies. In addition, every specific case has its own contextual variables, such as properties of the customer, asset, purchase order, location, etc. These specific variables are termed the *case context*.

Once a comprehensive understanding of contextual variables is achieved, they can be incorporated into process modeling and utilized in order to establish an ongoing improvement of key performance indicators, such as cost, time, and level of service. Ultimately, the intention is to increase, through context-awareness, the key process metric known as process agility, process flexibility, or responsiveness to change. Being aware of contextual variables and understanding their potential effect on the process will enable the incorporation of environmental variability into the process and continuously adapt it to various contextual conditions.

Learn from Past Disruptions

Understanding business processes as an integral part of its contextual environment means increasing the boundaries and complexity of the system under analysis. Before reinventing the wheel and designing approaches for such complex systems, it is useful to learn from current practices, both in BPM and in related disciplines. The most promising approach is to learn comprehensively from the insights that other disciplines have already obtained in scenarios similar to the one that we consider. By way of example, how can BPM benefit from latest insights in biology (*selection* and *evolution*) and cognitive science (*learning model*) to deal better with contingencies in the business environment and to continuously improve process performance?

Business processes, just like any organizational procedures, adhere to similar principles like systems or organisms. In biology, the evolution of species takes place by survival of the fittest. Key to this phenomenon is variation and selection. The *variation* of heritable traits occurs naturally in populations of organisms, resulting in a variety of phenotypes. *Natural selection* is the process by which the individuals that are more adjusted to the environment have more chances of surviving and producing more offspring, and therefore they eventually become more abundant in the population. As in biology, business processes do not always occur exactly according to plan. Instead, they have variations in the order and type of activities performed that result in different organizational outcomes. Eventually, businesses adjust to their environments by selecting to operationalize the business process variants that have the best outcomes.

But how do businesses acquire process variations, and how can they advance from variant practice to context-based process support? Consider the following example from the airlines industry. The airline market is highly competitive. In order to succeed, airline companies need to make unique selling propositions, such as fast service, low operational cost, a streamlined workforce, or in the example discussed below, excellent customer service and shorter point-to-point travel time. In order to do so, these companies need to create regulations and work processes for improving their service, as well as to follow staff work practices. With data on actual work practices being available, the airline companies can improve customer service by providing their employees (e.g., check-in clerks) with context-based process management systems. To illustrate this, we discuss the following hypothetic scenario.

Air Panda and Grizzly Airways both have daily flights from San Francisco to Israel. The Air Panda flight leaves at 7:45 am, and the Grizzly Airways flight leaves at 16:15. Air Panda created a business process model for its normal flight process, which, in simple terms, can be expressed as shown in Figure 1.

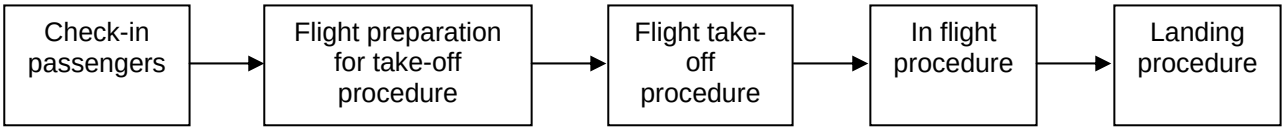

Figure 1. Flight Operations

The thorough process design phase considered possible disturbances that necessitate changes to the process model. For example, if during the "flight preparation for take-off procedure" a faulty part were detected, all attempts would be made to fix it by the ground crew, and if this were not possible, the faulty parts would be shipped for repair, a replacement part would be shipped to the airport, and the passenger-handling procedure would be initiated. The passenger-handling procedure that was conceived during design time was as shown in Figure 2.

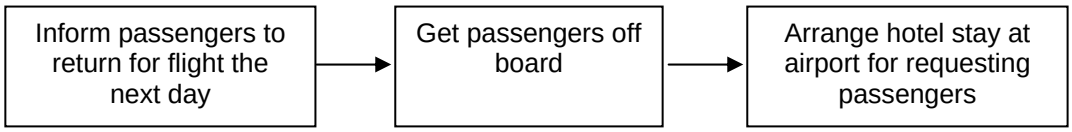

Figure 2. Passenger Handling – Technical Delay

However, when the process model was executed in normal business operation, some passengers were always in urgent need to get to their destination early and could not accept the 24-hour delay. They went to Air Panda's check in counter and tried to convince the clerks to get them on an earlier flight or refund their money. Most clerks could take the heat, but Luck Jones felt sorry for the passengers. She knew that Grizzly Airways had the earliest next flight to Israel, and her friend Amanda Kelp was working at Grizzly Airway's check in counter. She arranged with Amanda to book flights for the poor passengers, when that was possible. Amanda did the same, when Grizzly Airways flights were cancelled. Lucy and Amanda started to refer complaining passengers on a regular basis. The company was informed about this deviation when its records showed that passengers from cancelled flight were not booked on flights for the following day. In addition, the company received letters from grateful passengers, describing the events that took place. The company evaluated the costs and benefits of this process variant and later decided to introduce this context-dependent (the context being "angry patients") process variant into their collection of business process models.

This example demonstrates several principles that added value to the company, First, as already done in organizations nowadays, a thorough business process design phase that considered disturbance contexts yielded variant business processes that fitted with varying external conditions (normal operation vs. technical problems detected during "flight preparation for take-off procedure." Second, the company learned from user's deviations from the company's standard process model and thus evolved their process by adopting for certain case contexts (e.g., complaining passengers) the variant process that yielded better outcomes (customer satisfaction without extra cost). This user-based optimization became one of the standards of the organization. Thus, before learning from the experience of Lucy Jones, work practices were constrained by rigid system implementation, resulting in increased point-to-point travel time and lower customer satisfaction. Learning-based process adaptation improved customers' experience by adapting the system to the operational context of users, decreasing cycle times, and contributing to customer satisfaction.

What is learning and how could businesses learn to improve their processes automatically?

According to Franklin and Ferkin [5], humans and other organisms continually and cyclically sense their environment, and act upon it in pursuit of their goals. In this pursuit, cognition is the endless cycle of selecting what to do next (actions). Humans learn to perform new tasks and improve their behavior. The learning mechanism involves perception, memory, and attention. Perception assigns meaning to the sensed environment. Procedural memory stores the procedures for executing behaviors. Episodic memory records events that had happened (the what, the where, and the when). Since the number of inputs from the perceived, sensed environment and from the episodic memory could be very large, attention is a focusing mechanism that provides relevant, current information to the action selection process.

Organizations could use this model to automatically learn how to improve their behaviors in pursuit of their goals, as shown in Figure 1. Organizations record historical process instances in episodic memory and specify their business process model as procedural memory. Following this, process model determines what actions are selected. Perception parses the data associated with the current process instance, identifying its context, task flow, and outcomes, Attention is focused on successful (i.e., having favorable outcomes) process instances from the episodic memory that have context that is similar to that of the current case; the task flows of successful process instances are used to improve the process model.

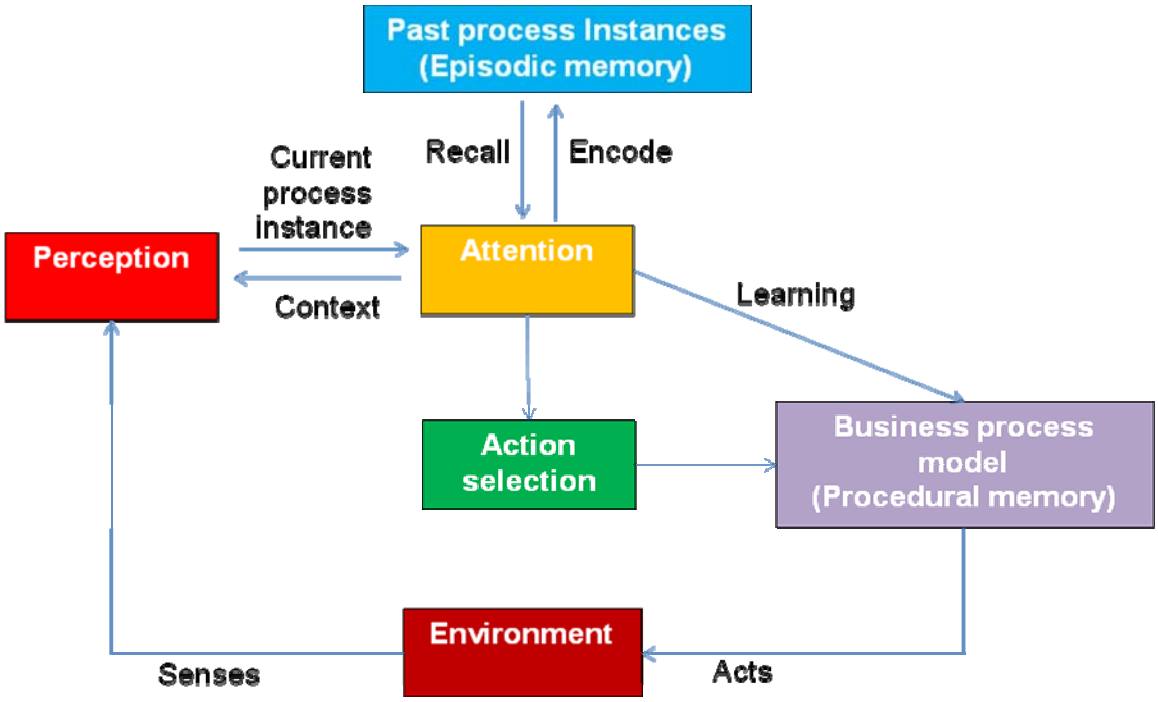

Figure 3. Business process learning as a cognitive model.

The Context-aware Process Management Cycle

The identification of context variables and context-based learning are two essential notions we associate with context-awareness in process design. Ultimately, however, we envisage context-awareness to be a continuous principle that spans all stages of a process lifecycle. This, in turn, suggests that context-awareness should be built into a process management suite from ground up (rather than as a separate component). Considering context needs to be an exercise that runs through each stage of a process management project.

So how much support for context-awareness is already available? Current offerings by enterprise architecture and business application vendors allow incorporating some variability into business processes. Managing process variants and the configuration and customization of off-the-shelf solutions will align best practice scenarios with specific requirements to achieve competitive advantage (academics in information systems research typically refer to this as *internal fit*). However, this type of variability is mostly internal, i.e., it is an intrinsic property of the solution which does not consider the extrinsic variables of environmental change (i.e., the *external fit* with respect to environmental contingencies). In the following, we want to extend this current way of thinking, and the current line of support, by introducing a number of research streams that study concepts and technologies that will enable context-awareness. As you identify, model, optimize, implement, and operate a core process, these techniques will increase your awareness and responsiveness to the opportunities and threats in the environment. Figure 4 shows the parts of the context-awareness puzzle.

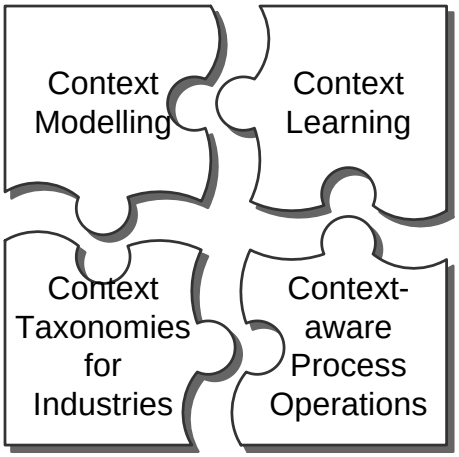

Figure 4. Context-aware Design – The Pieces of a Puzzle

Context-awareness covers different stages of the process design, starting off with context planning and modeling, through context mining and learning, to using industry best practices such as taxonomies of industry-specific context drivers and process reference content for your sector. Some current research streams, e.g., [2, 3, 6] have produced first insights and results. Imagine prototypes that help you in context-based data analysis and decision-making fully integrated into your process modeling environment. These instruments complement each other like the pieces of a puzzle and will eventually form a toolbox from which you may pick to realize a context-aware process design. Table 1 lists each technique and summarizes what it does and when it is appropriate to use.

Table 1. Techniques of Context-awareness

Concept	Description	Applicable To
Context Mining & Learning	Context mining analyzes your application log files and sources of unstructured data for disturbance and case contexts. Based on advanced algorithms and machine learning, the tool may then correlate external events to operational changes and their outcomes. This will help you work out how you respond today and where you lack preparedness for contextual events. To use a graphical example, think of this as the Google Finance[1] of your operations. The website mashes a company's stock price with events and headlines in the news for root cause analysis and decision making.	Process Identification, Process Control & Audit
Context Modeling	Context modeling supports you in modeling cause-effect relationships and performing an impact analysis on your business process repository. This is a key step towards improved contingency planning and more robust business processes. Further research will deal with visualizing externally induced change in your process modeling environment and simulating *what-if* scenarios. The principle	AS-IS and TO-BE Process Modeling

[1] Cf. http://finance.google.com
[2] One of the authors (KP) is on the authoring team for the upcoming version BPMN 2.0.

Concept	Description	Applicable To
	research challenges lie in properly managing complexity and redundancy of your process models. Work is underway to propose context extensions to the industry standard Business Process Modeling Notation[2]. This work may be applied to other prominent notations as well (such as EPC).	
Context Taxonomies for Industries	Import industry-specific context libraries into your enterprise architecture tool chain. Context taxonomies will dramatically speed up your context modeling efforts by providing a standardized vocabulary. This will support you in identifying reference content and industry best practices, such as macroeconomic models [7] and environmental scanning [8] (e.g., PEST).	Process Standardization, Process Benchmarking, Community of Best Practices
Context-aware Process Operations	Continuous monitoring of contextual variables is an integral component of context-awareness in process operations. This comprises the selection, configuration, and installation of sensors (both virtual and physical). It also incorporates the provisioning of near real-time data for decision making through content aggregators and business intelligence software. Ultimately, the research stream of business process flexibility would deal with the flexible reconfiguration of processes in your enterprise applications and workflow management systems in response to environmental contingencies. This can be achieved by process support systems that (1) can substitute the current standard business process model with one selected from a collection of standard business process models that are fit for different contexts and (2) allows users to adapt processes by deviating from the standard business processes. Using process mining, (3) user-devised processes that are fit for new contexts could be discovered and added to the collection of business process models. In addition, (4) existing standard process models could be evolved (optimized) based on successful user-defined process instances for particular contexts.	Process Implementation, Automation, and Operation

Summary & Outlook

With this paper we sought to raise visibility for the next generation of process management. Under the notion of *context-awareness* we described some of the current and future challenges in process management towards true agility and flexibility. We put forward the argument that, in order to bring process modeling, process improvement, and process management to the next level, we have to widen our scope of analysis beyond the internal processes and study, complementarily, the wider contextual environment in which our processes are embedded, and that impact the way we design, change, or execute these processes.

So what are the next steps towards context-awareness in BPM? At first, we need achieve a better understanding of the general context of a business process, and the main types of environmental context factors that force a process to change. Building upon this understanding we can then assess and extend the level of support of current process management methods, techniques, and tools to be more aware of this context. We would start with enabling context-aware process modeling, i.e., an extended approach to more comprehensively capture in the design of a process the environmental stimuli that impact the execution of these processes. Ultimately, we want to arrive at comprehensive support for all stages of a process lifecycle, including, for instance, context-aware process improvement, execution, mining, or, in general, process learning approaches.

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