

# A Survey on Dynamic Business Processes and Dynamic Business Processes Modelling

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**Keywords:** Dynamic Business Process, Requirements, Environment, Dynamicity, Changing Factors, Running Time.

**Abstract:** Organizations as sets of business processes (BP) that can be analyzed and improved by approaches such as BP modelling. Many books, articles, thesis, and previous research are focus on static BP and workflows but neglect the need of dynamic BP which is very interesting. For that reason, the aim of this paper is to discuss and review various sources related to the topic of dynamic BP definition, requirements and changes can be changed during the time under the effect of various factors. Business is rapidly changing today to meet the requirements of the changing environment or other factors. All those changes of a business must be solved using various approaches because this gap triggered significant research efforts to solving dynamic BP modelling problems and ensuring the processes dynamicity. The main goal motives this work is to survey a group of currently active researchers and investigate some fundamental concepts in this domain related with the concepts is strongly support dynamic BP to can guide to find a representative model can express all proprieties and answer the different questions presented later in the introduction.

## 1 INTRODUCTION

Processes have become an important asset for daily life in organizations because an adequate BP Management (BPM) of an organization (e.g. software development companies) can help achieve organizational objectives.

Organizational environment as companies and enterprises always changing and oblige BP to change during its runtime, for that Over the years, approaches for supporting process change have received much attention from the research community because of the advanced development of hardware and software that are applied at different stages of the design process; the representation issues can be captured in abstract the models can be implemented in program code using various approaches .

In this paper, we will present a literature survey using research papers, theses, articles and books to cover the domain needed for ours research and try to find a definition that represent precisely the concept of dynamic BP

The method of reviewing used is divided into steps that are formulated as questions, the review steps are as follows:

**Question 1:** How can dynamic BP defined and the meaning of dynamic BP modelling?

**Question 2:** During the execution time (run time), which factors have impact on dynamic BP?

**Question 3:** Which process components or elements can be changed at run time?

**Question 4:** What are requirements of dynamic BP that must be known?

**Question 5:** How ensure BP dynamically?

Several research efforts have focused on detailed state of the art that addresses this problem but on static BP not on dynamic. For that reason, we will be base our discussion on that concept of dynamic BP which plays an important role in changing effects nowadays.

This survey organized as follows, we will be starting with the introduction, includes the reviewing method, in the second section we will present dynamic BP and its modelling and give some differences points between dynamic and static BP, after that various factors impact the dynamic BP to change are presented in the third section. Section four describes the components can be change during runtime of the process, the requirements of dynamic BP summarized in section five, after that we will try to find an answer to ensure the dynamicity, finally we will settle our ideas in a conclusion.

## 2 DYNAMIC BP AND DYNAMIC MODELLING

Research on BP (Aris, 2013) is a very active topic in recent years because processes are a dominant factor in workflow management, Modern enterprises and organizations operate in a dynamic environment (Branke, 2012) that is constantly evolving, so it must adapt their processes and establish a framework for modeling and analyzing workflow processes.

The notion of process plays a major role in the definition of information system (IS) management, it has a relevant role related with the concept of information, use of BP can be considered diverse according to the view of the company or the structure of resources used.

Processes are divided into two categories: abstract and executable processes (Oasis,2007) (Konig et al., 2008). These two kinds are specified at different abstraction levels. An abstract process only describes the control-flow while an executable process captures both the control-flow and the data-flow as well as other aspects related to the execution, such as services bound to activities. Thus, an abstract process is a model of its corresponding executable process.

First, we will start with the concept of BP which defined as follows:

**Definition 1.** *A BP is a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer. Or is a set of activities undertaken in a specific objective that can accomplish a specific organizational goal. Some examples of this include taking customer orders and managing bank accounts.* (Brahimi and Bouzidi, 2008) (Mejia et al., 2010).

Modeling is a key element of process control and ownership that allows the detailed description of a BP and which can then be mapped to illustrates pictorially, through graphs and charts, how certain processes flow into others. As we mentioned in our previous work (Khawla and Molnár, 2017) that the modelling of BP is divided in two kinds of models: static and dynamic modeling summarized below:

Static modeling simplifies a representation of BP at a point in time. As such, they ignore dynamic behavior, which may change over time as a result of resource competition, interactions or other sources of uncertainty. In fact, static models are very useful in understanding and representing the structural features of BP and can be valuable means of communication. However, BP often display complex interactions (Billington and Weber, 2003) (Rosenberg, 2010) that can only be understood by unfolding behavior through time.

Dynamic modeling is that it enables the outcome of a changed process to be evaluated prior to it being implemented into the physical environment.

In this section, we will focus research efforts on the definition of dynamic BP and its modelling.

Generally, dynamic BP definitions refer to changes within the *external* and *internal* environment, and the consequences can be traced through adding, deleting, replacing components representing activities (Russell et al, 2006).

We can conclude from the table below (Table 1) which shows various sources related to the definition the concept of dynamic BP:

**Definition 2.** *Dynamic BP is the process that can change some BP activities during run time (at certain points) under various conditions not predefined in the beginning, it can react and adapt from internal or external environment changes, it is flexible and agile in its environment to express the concept of BP dynamicity. All properties of dynamic BP concept (Adaptive, Variable, flexible, Ad hoc and dynamic) are related and used together with various relation degrees in order to respond to different scenarios*

**Definition 3.** *Dynamic BP modeling is the representation of a BP, the model includes activities, components, functionalities, resources, individuals (participant) that need to be understood before modelling, so the result of modelling exercise could be implemented and simulated.*

After reviewing the table (Table 1), we obtained the answer needed for our first question, next section we will try to answer our other questions.

## 3 CHANGING FACTORS IMPACT THE DYNAMIC BP

There are various reasons that require process change, including requirements derived from new business strategies, new policies, new laws and new applications (Papazoglou et al., 2002) (Ryuf et al., 2008), changing market conditions and application environments (Wang et al., 2012) (Papazoglou et al. 2011) (Andrikopoulos et al., 2012), problems with the original process, and BPs reengineering and process enhancement needs (Van and Papazoglou, 2011).

Enterprises either commercial businesses or government organizations are faced with a range of challenges recently. These challenges and deferent factors impact their components during BP execution (runtime), these factors where summarized from various research in that domain:

Table 1: Definitions related with dynamic BP and dynamic BP modelling.

Reference (s)	Definitions related with dynamic BP and dynamic BP modelling
(Hayes and Lavery, 1991)	Four main concepts are popular for defining the ability of a BP to adapt to the changing environment. those are: dynamicity, flexibility, agility and adaptability.
(Dadam and Reichert, 2009)	Not all authors define the concept of dynamic process clearly, Ad hoc processes are always used together with flexible and dynamic processes and it is mostly used with adaptive processes, but it is never used with variable processes. Variable processes are always used together with flexible and dynamic process and it is mostly used with adaptive process. Adaptive processes are always used together with dynamic process and it is mostly used with flexible processes. Flexible process is always used together with dynamic processes.
(Patel and Hlupic, 2001)	In order to create a dynamic model of a process, it is necessary to understand its functionality; the nature of dynamic modelling enables the representation of resources, timeframes and the functionality of the individual activities contained within the process. Dynamic modelling enables a closer representation of the physical BP environment including people and equipment, resources and their movements are also taken into consideration within the dynamic model.
(Pucher, 2010)	Dynamic BP is a variant of agile process and enables a business user to make changes in the process at runtime
(Kalibatiene et al., 2015)	Dynamic BP is not defined strictly at the beginning of its execution and it changes under new conditions at runtime.
(Trinkunas, 2015)	Dynamic BP can implement a BP model whose components (a set of conditions, a set of activities, a content of activity, a set of activity sequences, a set of decision nodes, the participants) may vary and, if necessary, change with low latency at runtime due to changes of the context).
(Vasilecas et al, 2016)	The dynamics of BP is characterized by a variety of terms: ad-hoc (there is no predefined definition), adaptive (the ability of workflow to react to exceptional circumstances), dynamic (must have flexible and adaptive execution), flexible (ability of a process to adapt to the changes in the environment or to its changing requirement) and variable process (adapted as a response to evolution in internal and external environment).
(Kalibatiene et al, 2016)	Dynamic BP where content and the sequence of activities depends on the context of the environment and can be changed at runtime. In contrast to dynamic BP, static BP has a strict specification, i.e. the content and sequence of activities are defined before BP instance execution and cannot be changed at runtime
(Vasilecas et al, 2017)	The concept of dynamic BP can be perceived as group of states that a collection of BP activities might change at certain point in time due to the changes occurring in the BP context, therefore, a sequence of activity execution cannot be predefined in advance

In fact, the success of enterprises depends increasingly on their ability to react to changing conditions of operation in their environment in a quick and flexible way (Adam, 2010) (Sheng, 2015), for that reason, we can say that the environment and its nature exert internal and external impact on the BP during the execution time.

Changes of the environment, like new government regulations, stock price change, or internal changes like business volatility, desire to remain competitive, that motivate companies to change BP components quickly, i.e., BP components must be adopted in response to changes of internal and external environment, named as a context at runtime.

In (Yu, 2015) the author examines the impact of internal changes on BPs and the capability of

processes to adapt themselves to the changing environment; the externally initiated alterations are not considered.

Dynamics is dependent on internal (Business strategy, organizations infrastructure, IT) and external (market, regulating acts by government, changes in technologies) drivers (Lankhorst, 2009).

Resources too are able to impact changes on the workflow that may cause a problem if resources are limited and could not finish the execution of workflow on time so the process may be blocked, might be the type of resources have the capability to change on dynamic characteristic of BP.

Resources that appears on workflow structures are as follows: sequential, parallel, choice and loop patterns. Although in (Lankhorst, 2009) considers only sequential and parallel patterns.

In reference (Salman and Madani, 2002) too, we have found offline stage which determines the required resources to execute a workflow while minimizing the cost and meeting the user specified deadline. The second one is an online stage which reacts to structural changes that can take place at runtime like adding tasks during execution.

The author in (Jain, 2008) examines the impact of internal changes on BP and the capability of the processes to adapt themselves to the changing environment; the externally initiated alterations are not considered.

In (Van et al., 2016), the author postulate that processes should be capable for dynamic adaptation to different scenarios, although the method for adaptation cannot be exhibited in detail.

Next section we will search for the components that are impacted during the execution time.

#### 4 PROCESS COMPONENTS CAN BE CHANGE AT RUN TIME

In this section we will investigate the processes components can be changed under the impact of different factor, after that we collect some important components at the execution time (i.e. at runtime, before runtime and after runtime).

*Activity:* as we know that the activities are the main components of BP and it have the responsibility to handle different events of BP that may be running in cases, namely defined or non-defined (formed at runtime). These activities are those ones which are affected during changes; an activity can be modified a new activity can be added or existing one can be removed.

Some previous works implement as dynamic BP tools (DYPROTO) (Wörzberger and Heer, 2011) which can insert new activities, delete old activities or dynamically implement activity loop, another tool mentioned in (Zeng et al., 2002) able to adapt flexibly to the changing business environment and can determine the sequence of activities at BP runtime. But these solutions don't meet the dynamic BP requirements.

When changes alter the workflow, i.e. BPs during the run time which is seen as the composition of a set of basic operations (general flow structures including sequential, parallel, choice and loop patterns) that must be performed on a given input data set to produce the expected result. So, these modifications can provide as data too and make some changes on it as well. For solving that problem cloud computing

has emerged as a new technology which offers a new model of service provisioning for workflows applications. It provides on demand network access to a shared pool of computing *resources* that can be elastically provisioned and released. Then, the elastic nature of cloud environment enables such dynamic workflow to be enacted more efficiently since it facilitates the changing of resource quantities at runtime

The challenges impact the *architecture* of enterprises, for that reason, it should be able to focus their attention on all those impacts, The proposal is to extend the BP modeling approaches with an organization and planning level according to Zachman Framework (Zachman , 1987) thereby an “analysis season” is created beside the “design season” and “operational season” (Bell et al., 2008). In our previous work (Khawla and Molnár, 2017), we propose an approach where the data and business structure (operational level and design level) is expanded with an analysis phase (organizational and strategic planning level) to observe and to detect business events that enforce changes in process flow, documents and document flow. The impact of business events influences both the structure of the workflow and the structure of document types.

Next, the *process context* where the set of external factors and set of internal factors. and conditions changes too. Challenges related to the development of a new promising paradigm for BP modelling is to support explicit definition of the ‘context related knowledge’ that should be identified. For example, in health process activities are selected according to the user's context, which describes user's health state. When a user's context changes, like blood pressure or temperature, necessary activities, Moreover, in many cases, it is difficult or impossible to predict all possible changes of a context and predefine possible sequences of activities. Contrary to DBP static processes have predefined sequence of activities and could be adopted only in predefined places of a process instance, like variation points

Authors argue that any information reflecting changing in circumstances during the execution of a BP can be considered as contextual information. The context is thus defined as “the collection of implicit assumptions that is required to activate accurate assignments in the BP model at the process instance level”. In (Saidani and Nurcan, 2007), the role-driven BP modeling approach (RBPM) presented in (Saidani and Nurcan, 2006) was extended to support context awareness.

## 5 DYNAMIC BP REQUIREMENT

Most recently, the rapidly changing business environment and thereby originated adaptivity requirement against business IS led to the agile business approach as a management science philosophy. In this section we will have a look at the dynamic BP requirements.

Dynamic BP have no predefined sequences of activities, it formed at runtime: so every subsequent should selected according to the external and internal context and predefined rules, Therefore, every subsequent instance may differ from the other instance of the same BP, if there is no activity for further execution at a dynamic BP runtime we should terminate the execution of a dynamic BP instance or to define a new activity and concerning rules for a dynamic BP instance execution.

- *Context-based* (Hallerbach et al., 2008) *Dynamicity*: BP must support changes due to any process context which defined with a set of external (variables and rules) (Bui at al., 2013) and internal (state of system and resources users) factors and dynamic BP should react with that context changes (Saidani and Nurcan, 2007).
- *Rule-based* (Kalibatiene et al., 2015) *Dynamicity* i.e. it must define new business rules, change/delete existing business rules at BP

runtime. Where dynamic BP should be reacting to those changes formulated in business rules at runtime of the business rules at process instance. Every next activity in the sequence within dynamic BP should be selected according to the predefined rules.

- *The Low Latency*: dynamic BP execution should support dynamic BP instance change, according to role of the process, at any time, with very low latency compared with duration of the process.
- *Analyzing of Historical Data of Instance*: Before selecting the next activity, the historical data (stored in a log file) of instances execution (can be a good practice which is suitable instance from the historical data for repeated execution, or as bad practice should not be executed ) of the same dynamic BP should be analyzed and the selected next activity should not cause execution of an unacceptable sequence of activities, in addition time, cost, values should be calculated and stored for each executed dynamic BP instance. This requirement describes that before executing any dynamic BP instance.
- BP should *support changes* to any process component (a set of conditions, activity, activity sequences, decision nodes and participants).

The table below (Table 2) summarize requirements and their role:

Table 2: Dynamic BP requirements and its roles.

Requirements	Role
No predefined sequences of activities	The advantage of implementing this requirement is that we increase dynamicity of a process.
Context-based dynamicity	The advantage of implementing this requirement is that at process instance runtime context can change and process should be adopted to those changes immediately at process instance runtime
Rule-based dynamicity	We believe the main opportunities of using business rules to ensure dynamicity of BP are as follows: each activity in a process is selected according to the defined conditions (expressing constraints of application domain) at BP runtime, and the content of an activity is chosen based on the changing internal and/or external context, and it should be implementing those changes at process instance runtime.
Low latency	The advantage of implementing this requirement is that the change of a context or of business rules influences selection of the next activity immediately after the changes comes in force at process instance changes and allows rising process dynamically
Analyzing of previous activity (historical data)	The analysis of historical data allows determining so called "good" (requires minimum resources and process is reached) and "bad" (use too many resources). During historical data analysis, it can be found what conditions i.e. state of current context and to propose suitable alternative sequence of activities for execution.
Supporting of changes to any process component	Components and their relationships are organized in such a way as to support rule and context-based dynamic BP activity is modelling and simulation. And are also included into the architecture in order to add intelligent functionality.

The representation at business analysis and process level should consider the demands for changes at the data perspective. As the requirement for changes at data perspective can be perceived as modification in the structure of documents, collections of data and database schemas. The intimate interrelationship between documents and BPs can assist to deduce the requirements for changes dynamically.

The traditional linear model that involves design, build independent test, implement and support design, build and test occurs iteratively, and the critical requirements are not system requirements, but BP requirements. A more traditional private sector organizational model should be used; i.e., one that explicitly addresses the importance of BP requirements in defining an Enterprise Resource Planning (ERP) implementation. The role of BP requirements as mentioned in (Blick et al., 2000) is to support of the life-cycle implementation process, support BP functionality which described in the models, and it facilitates analysis and BP configuration management. From the references that where analyzed we can conclude an answer for the dynamic BP requirements and the importance of each one and its role when we implement, therefore that we should observe these requirements when we want to propose an approach or model for dynamic environment and the requirements can guide the selection of activities.

## 6 BP DYNAMICITY

The main opportunities of using business rules to ensure dynamicity of BP lie in the following: each activity in a process is selected according to the defined conditions at BP runtime; choice of activity content; and representing the changing dynamic BP context. However, as presented in the works related to this paper, there is no complete approach or tool for rule- and context-based dynamic BP modelling and simulation i.e. none of the analyzed tools which are widely used for BP modelling and simulation, supports changing business rules during the simulation of dynamic BP. Some approaches, like (Hermosillo et al., 2010), describe BP dynamicity using BP pointcuts, where adaptations can be made, or changes of BP are available in new instances of the BP, but not at the same instance, like in (Xiao et al., 2011).

Process adaptation is a topic that create a lot of interest in the research community, however there is still no integration. In (Hermosillo et al., 2010) the authors presented Complex Event processing for

Context-adaptive processes in pervasive and Heterogeneous Environments (CEVICHE), a framework that intends to facilitate the integration of Complex Event Processing (CEP) into existing BP and to allow these processes to be dynamically adapted to different circumstances and to address four issues: adaptation, dynamicity, integration to BP, and non-dependency to a specific CEP engine.

As part of the CEVICHE framework proposed the Standard Business Process Language (SBPL), an extension of BP Execution Language (BPEL) that allows the user to include the adaptation points and conditions in order to create dynamically adaptable BP.

## 7 CONCLUSION

From our research in that domain we found that there are various approaches and methods for modelling which are suitable for static BP and their execution. The concept of dynamic BP is analyzed and its different definitions which are used to define requirements are presented in our simple survey.

In our future work we will focus on an approach of modeling using hypergraph based on formal and logic-based model to express the different requirements mentioned before and try to control activities of dynamic BP to define the main goal of the process. The model that will be proposed improve the realization of requirements and can be checked using various methods, moreover, can verify consistency of dynamic BP and ensure its dynamicity. We believe that the approach yields are a model that includes all characteristics and properties of dynamic BP and its simulation or implementation.

We hope that this survey will inspire other researchers to take up some of the challenging problems in this field.

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