
Business process flexibility through the exploration of stimuli

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Abstract: For organisations to survive and flourish in a changing environment, their business processes need to be flexible. Ashby's law of requisite variety applied to business processes postulates that a robust process needs to exhibit as much as variety in its responses as there are stimuli in its environment. An essential aspect of the design of a business process is to know to what stimuli it needs to respond to. In this paper, stimuli to the requirements of Business Process Flexibility (BPF) are examined. A classification framework is proposed to characterise the environmental stimuli. Using this framework, business process designers can visualise variations of the stimuli affecting the process. They can then consider if the Business Process Support (BPS) system would adequately manage the variations in the stimuli. The use of the framework is illustrated with the example of a university train ticket purchasing process.

Keywords: Business Process Flexibility; BPF; requisite variety; process management.

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1 Introduction

Business processes can be seen as mechanisms for responding to the demands for product and services placed upon organisations by their environment. As the environment constantly changes and evolves, the level and types of demands placed by the environment on the organisation also regularly change and shift. Business processes, therefore, need to exhibit flexibility in order to match the challenges presented by these ongoing variations in demand.

According to the 'Law of Requisite Variety',¹ proposed by Ashby (1956), the survival of a system depends on the matching of its responses to the variations in its environment. A business process having requisite variety will exhibit flexible behaviour to its customers² because it will provide adequate responses to their changing expectations. Conversely, a process that lacks requisite variety will appear inflexible to its users, as its range of responses will be limited and potentially inadequate. The complex business environments faced by contemporary organisations contain many variations in its stakeholders' or customers' expectations. Processes need to be flexible to match this variety.

However, a given business process is designed by and for the organisation that owns it. Its range of responses depend on the understanding by the organisation of itself and its environment, that is, its repertoire of interpretations of the environment. The paradox is that effective business processes (i.e. processes that produce the results expected by the organisation) can only be designed when the range of interpretations in the repertoire is limited to a manageable number. On the other hand, to begin with, this range needs to be sufficient for dealing with the commonly occurring variations in the environmental demand.

Unfortunately, organisations have a natural tendency to prematurely reduce this variation (Weick, 1979). Designing processes with a high range of responses requires a large repertoire of interpretations of the environment, or what Carr (2006) refers to as 'keeping an open mind'. However, Carr also suggests that keeping an

open mind is no easy task. The inability to keep an open mind, often results in blindness to possibility for potential changes and improvements (Carr, 2006). Organisations thus tend to design business processes that lack the flexibility in responses expected by their stakeholders.

In this paper, we present BPF, a framework for BPF. This framework is useful for anticipating, interpreting and documenting the variety of stimulus potentially faced by a business process. The Process Support (BPS) framework can be used for enlarging the design horizons or 'keeping an open mind', in order for it to visualise and build flexible business processes. We illustrate the framework with the real example of a university's train ticket purchasing process. The process defines how university employees obtain train tickets for business travel. A recent redesign of the process made it quite inflexible from the point of view of its customers, that is, the university employees. Paradoxically, the redesign coincided with the introduction of an IT system that was supposed to add flexibility to the process. The example shows how a seemingly flexible IT system can result in an inflexible business process because some of the stimuli in the environment of the process may not have been considered.

This paper is organised as follows. In Section 2, we describe the theoretical background of the BPF framework, that is, Ashby's and Weick's theories. In Section 3, we present the framework itself. In Section 4, we illustrate the framework with the university's process. In Section 5, we relate the framework with prior work.

2 Organisational and business process flexibility

Flexibility is necessary for maintaining the fit with a changing environment without losing identity (Regev et al., 2007). In other words, flexibility is the ability to adapt to a changing environment. The key point in flexibility, therefore, is to know when and what to change and when and what not to change. This judgment is made difficult by what Weick (1979) calls equivocality,

'the richness and multiplicity of meanings that can be superimposed on a situation that organisations must manage'. We call this richness and multiplicity of meanings the organisations 'repertoire of interpretations'. Weick suggests that organisations have three main processes, enactment, selection and retention. With enactment, an organisation acts on its environment. With selection, an organisation selects from among the various interpretations of this environment. Selection reduces the equivocality of the environment; its resulting interpretations act as constraints on subsequent enactments. With retention, the organisation remembers its enactments and selections. It uses this memory for further enactments and selections.

The reduction of equivocality by selection creates a simplified interpretation of the enterprise and its environment. This reduced equivocality is necessary for effective action (i.e. design of business processes) but it has the drawback of potentially leading to oversimplified interpretations. As an example, consider the relationships of an organisation with its customers. Any customer represents an opportunity for doing business but also a potential threat to stable, predefined business processes. Indeed, organisations can never trust their customers completely. They may default on payments. They may request unreasonable rebates or product features etc., To protect themselves from 'capricious' customers, organisations define strict business processes (Regev et al., 2005). They then 'select' these processes and usually tend to see them as 'normal' or inevitable. This leads them to listen less, and be less responsive to variety in customers' requests.

Weick suggests that organisations, in order to be able to react and adapt to its environment, need to conform to the 'Law of Requisite Variety' (Ashby, 1956). This law specifies that to successfully regulate a system, (that is, for it to survive in a changing environment by maintaining its essential variables within accepted bounds (Regev and Wegmann, 2005), the system needs to have as much variety in its responses to the environment as there are stimuli in its environment. A system that does not have requisite variety will ultimately fail as it will sometime undoubtedly encounter stimuli that it cannot respond to.

It is therefore important to embark on the requirements definition project for a business process with a relatively large repertoire of diverse interpretations. This high diversity is reduced through the process of defining the requirements (Gause and Weinberg, 1989) so that an effective business process can be created. Ideally, the final requirements for a business process should exhibit as much variety as its environment. The requirements specifications project aims at reducing the initial diversity of interpretations to the requisite variety level (see Figure 1). Creating the requirements with low diversity to begin with (Figure 2) is not likely to produce requisite variety.

Based on the above discussion, we propose a framework for examining BPF based on four aspects (Figure 3): the characteristics of the stimuli, the business process that responds to these stimuli along with a

contingency plan for its participants, the requirements in terms of strategies and tactics to embed flexibility in the process and the organisation's interpretations of the stimuli that justify these requirements.

Figure 1 Reduction of the diversity of interpretations during a project

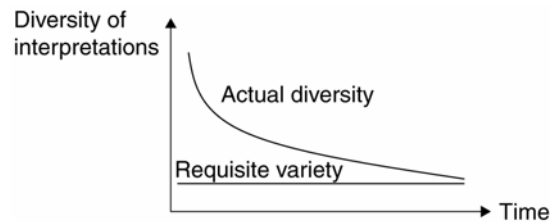


Figure 2 Low diversity of interpretations throughout a project (see online version for colours)

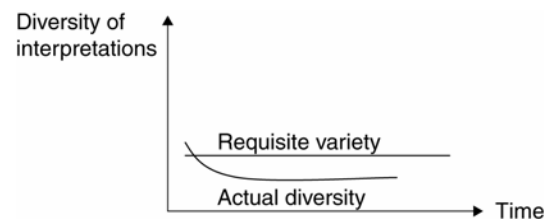
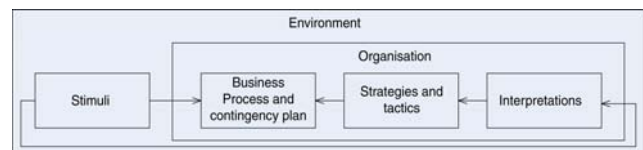


Figure 3 A model for studying business process flexibility (see online version for colours)



Ideally, all four aspects of flexibility should work in consonance. The requirements for the business process and the contingency plan should be defined to meet the different stimuli, whereas, the interpretations of the organisation should support the requirements and plan. Practically, sometimes the link between these aspects of flexibility is not explicit. In the next section, we propose the BPF framework that attempts to harmonise the four perspectives.

3 Designing flexible business processes

As we have seen, the design of requisite BPF requires an understanding of the diversity of the stimuli requiring a response from the business process. In this section, we explore the characteristics of the stimuli and their general relationship to BPF. We provide a taxonomy of stimuli to BPF in Table 1. The BPF stimuli are explained in terms of the model presented in Figure 3. We then illustrate this taxonomy by using the example of an order fulfilment process for computers in Table 2.

Often, process designers attempt to design business processes that would ideally provide the required flexibility with no human intervention, that is, with Business Process Support (BPS) systems (Andersson et al., 2004). However, this is not always possible due to the impossibility of embedding a sufficient variety of

responses within the BPS (see e.g. Bernstein, 2000). This is due to two limitations:

- The intrinsic limitation of response variety that an automated system such as a BPS can exhibit.
- The limited variety of interpretations by the designers leading to limited requirements for the BPS system.

Hence, we can identify two flexibility levels

- 1 predesigned flexibility where a certain amount of flexibility is built into the BPS system
- 2 the just-in-time responses provided by people, process participants and the process manager, that is, the contingency plan.

In the case of variations in stimuli that can be anticipated and predefined, the designer of the process can build-in the flexible response at the level of the process itself.

This requires that all variations are identified crisply as mutually exclusive and collectively exhaustive. Thus, predefined selection/decision points in the process can be used to steer the process in line with the contingency. Flexibility is thus resolved within the process itself. However, in the case where variation in the stimuli is either ambiguous, or is totally unexpected, the requisite flexibility cannot be anticipated and therefore built into the process. In these cases, process flexibility can be achieved by passing the responsibility for interpreting the variation and designing the response to an intelligent and innovative decision-maker above the process, the process manager.

Kumar and Narasipuram (2006) proposed a taxonomy of stimuli for BPF and explained the stimuli in terms of their description, the number of paths for process fulfilment (that is, the paths from process triggering, execution to completion) and the responsibility for responding to the stimuli.

Table 1 A taxonomy for business process flexibility

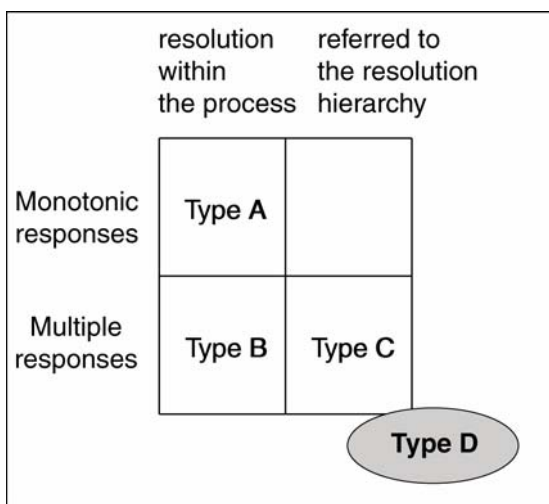
<i>Type of Stimuli</i>	<i>Response responsibility (process participant/manager)</i>	<i>Requirements for business process</i>	<i>Interpretations</i>
Type A: Constant unchanging stimuli.	BPS system, with the help of process participants, is responsible for the responses. No reference to the process manager is required because the response set is fixed. No variations in the stimulus are envisaged.	Requirements define a process model with no optional paths. No contingency plan.	One interpretation only.
Type B: Variable stimuli <i>within</i> expected variations and <i>with</i> contingency plans.	Process participants select the appropriate responses from the contingency plan with the help of the BPS system that implements the corresponding requirements.	The requirements define a process model with multiple paths. No new paths can be added. Contingency plan addresses stimuli.	Multiple crisp interpretations exist.
Type C: Variable stimuli <i>within</i> expected variations but <i>without</i> contingency plan.	Process manager is responsible to be sensitive to the stimulus variations, interpret and classify the stimuli and identify the associated response; otherwise, process actors will wait in eternity or take ineffective decisions such as down grading the stimuli to Type B.	New paths can be added to the process model. Implicit contingency plan exists.	Multiple ambiguous interpretations exist, but resolved by the process management hierarchy.
Type D: Variable stimuli <i>outside</i> expected variations and <i>without</i> contingency plan.	Process participants and manager need to invent appropriate responses to stimuli with no contingency plan and little or no help from the BPS system.	New paths can be added to the process model. No contingency plan exists. Contingency plan making is by necessity decentralised to the process actors.	Multiple ambiguous interpretations may exist, but none recognisable by the process management hierarchy.

Table 2 Taxonomy of stimulus and responses in the case of order fulfilment process of an order for a computer

<i>Type of BPF Stimulus</i>	<i>Response</i>	<i>Response responsibility</i>
Type A: Constant	Selling computers with fixed configurations through the company's website or at a sales outlet	BPS system, sales people
Type B: Uncertain but crisply predefined contingencies	Responding to customers' questions about different configurations according to a knowledge base	BPS system, sales people
Type C: Ambiguous contingencies	Responding to questions for which answers do not appear in knowledge base but the sales people or the sales manager can respond	Sales people, sales manager
Type D: Surprises	Responding to questions that have not been asked before and for which the sales people or sales manager have no answers	Sales people, sales manager, engineer

A process is considered flexible if it does not have a monotonic response; that is, the ‘case’ or ‘the flow-object’, depending on contingencies can potentially take more than two paths through the process execution. Secondly, process flexibility also entails a consideration of the process role that is responsible for responding to the diversity of the stimuli. At one level, the responsibility for responding to the stimuli exists within the process, with the process actors (either human or computers). At another level, the process actors may not be capable nor authorised to respond to the stimuli and consequently the resolution of the response is referred to a higher level in the resolution hierarchy. These dimensions enable us to propose a classification scheme that can help in analysing BPF. Consequently, we identify four types of stimuli as illustrated in Figure 4 and explained in the text below.

Figure 4 Dimensions of the taxonomy



3.1 Type A (no variety)

The underlying assumption in Type A, flexibility is that there are no variations in the stimuli to the process. For the given stimuli, a fixed response is defined. No contingency planning is done, and no other interpretations and their associated strategies and/or tactics are allowed. The process has a monotonic response. While in real life, such situations are rare; sometimes the system designer, due to inadequate requirements analysis, assumes that there are no variations in stimuli and associated responses (see Figure 2). This leads to the absence of recognition of the role of process manager. This could be the reason why the traditional system development methodologies seldom recognise the role of a process manager.

3.2 Type B (planned expected variety)

A fixed set of potential stimuli are identified, each associated with a certain probability of occurrence. The interpretations of the stimuli are crisp and can be done within the process by the process actors. Each interpretation of the stimuli has an associated definite response. Thus, there is no need for intervention by a higher level process manager or supervisor.

3.3 Type C (unplanned expected variety)

There are ambiguities in identifying and interpreting the potential stimuli. The complexity and scale of variations in the stimuli are not clear or the probability of occurrence of some stimuli is considered low. Multiple interpretations of the stimuli exist. The interpretation of the stimuli and therefore the assignment of an associated response are thus impossible within the process and have to be referred up to a higher level. No explicit contingency plan for interpreting the stimuli is defined, but once an interpretation is made the associated response can be identified. The process requirements may not reflect the potential diversity of stimuli; but when unexpected stimuli occur, the resolution hierarchy can interpret and categorise the response into one of the predefined response categories.

3.4 Type D (surprise – or unplanned unexpected variety)

The potential stimuli have not been imagined at all and come as a complete surprise to both the process actors and the resolution hierarchy. No contingency plan and no requirements are defined. Depending on the situation, the process participants and manager may not be in a position to assess and react to the contingency. No interpretation exists within the organisation for the stimuli or the organisation interprets that no such stimuli are possible.

4 University train ticket purchasing process example

The example with which we illustrate the BPF framework is part of a university employee travel management process for a European University. The process we consider defines how employees obtain train tickets when they need to travel regarding of their work, for example, to a conference or a meeting. The process involves the train company providing the tickets, the university employees who use the tickets and the university administration (represented by secretaries and the travel manager responsible for the overall process). The example is based on interviews with university employees (faculty, department secretaries and travel manager) and train company officials. However, it only describes the authors' interpretations of the process and not an official view of the organisations involved.

Our analysis was prompted by a recent change in the process. Whereas the old process was considered by the university employees to be very flexible, the new process turned out to be much less so.

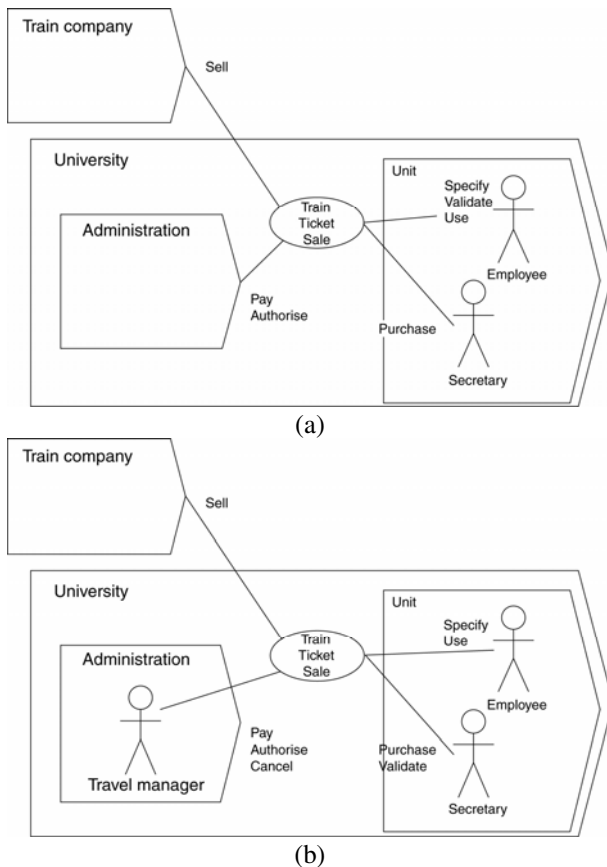
The new process may seem normal to some readers as it is a standard process in many European organisations. However, the users in the university have been accustomed to greater flexibility and want to regain it. Hence, this example may not be transferable to other organisations but it is still useful in illustrating the framework.

We examine in turn, the old process, the current one and the process we wish to have, and our interpretation of the reasons for the loss of this flexibility.

4.1 The old process

The university used to have a flexible, paper based system for train travel for its employees (see Figure 5 (a)). Employees only have to obtain a generic ticket from their secretary. The employee wrote his or her name, departure location and destination on the ticket and stamped it in a machine at the train station before boarding the train so that the date would appear on it. This is called 'validate' in Figure 5 (a), as the ticket was then considered as used and payable. The ticket could be used for boarding local buses and trams in addition to the train to arrive to a specific location in a city. The ticket was paid for only when it was used and returned to the secretary.

Figure 5 University ticket purchasing, modelled with SEAM



Source: Wegmann (2008).

The old process had a safeguard against the misuse of tickets. Whenever a ticket was given to an employee, the secretary wrote its serial number in a paper file and associated with the employee's name. If the employee failed to return the ticket, either used or blank, he or she had to pay for it from their own pocket. If the ticket was returned used, it was paid for. If it was returned blank it could be reused by the same employee or by some other employee.

The process was very flexible for employees because if the travel was cancelled they returned the unused ticket to their secretary or used it for another journey. If the travel

plan was modified, say they took the train from the university premise rather than from home, they simply changed the departure location or destination before using the pass.

4.2 The current process

A newly introduced IT solution changed the process completely (see Figure 5 (b)). Employees must now give their travel plan and date to their secretary prior to their departure. The secretary uses a BPS system to order a ticket. The system produces a pdf file that contains an electronic ticket. It contains the travel plan in both human and machine readable forms. The pdf file must be printed and presented to the train controllers. The ticket is invoiced as soon as the pdf file is created (validated in Figure 5 (b)) and can only be used by the employee who requested it for the travel plan that is written on it for the specified day. Any changes are not allowed. If the ticket is cancelled, a well justified request (e.g. sickness, meeting cancelled) needs to be filed by the secretary to receive a refund. For employees this is a much less flexible process.

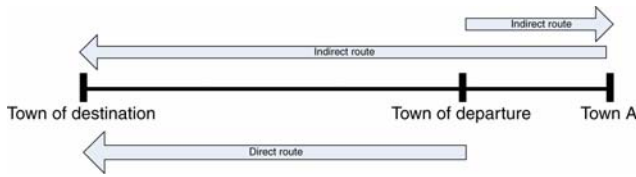
The new process requires employees to purchase tickets in advance of their trip, usually at least one day before. In the case of long trips, the return ticket also needs to be purchased several days in ahead. However, employees may be unsure of their travel plans up to the last minute before boarding a train.

We cite three main reasons for this,

- Employees may be unsure whether they want to travel or not. This uncertainty can sometimes last until a few minutes before the trip.
- When they do decide to travel, employees may have an alternate mode of transport available, that is, a personal car. This may depend on changing conditions such as spouse availability to bring the employee to the airport during the week end for example.
- The constraint imposed by the train company on users to purchase a different, more expensive ticket if the user takes an indirect route to go from her town of departure to her town of destination (see Figure 6). This is the case even if the indirect route is the one recommended by the ticket purchasing system. For some departure/destination pairs, half the scheduled trains take an indirect route. This prevents train users from knowing in advance which train they will be able to board and purchase the corresponding ticket ahead of time.

The BPS system in itself is considered as very flexible by the train company. It enables train users to purchase tickets through a variety of channels, such as the web, mobile phone with MMS. The IT system has provisions for use in organisations with the possibility to grant access to the system to different people and to allocate ticket purchases to different cost centres. However, it was not designed to be integrated in the university business process. The IT system is in fact much too flexible for the needs of the university requiring an inflexible process.

Figure 6 Difficulty in predicting which train to take (see online version for colours)



4.3 The 'wished-for' process

In the BPF framework, the business process has to respond to the following variations in stimuli. This is not an exhaustive list as there could be many other variations in stimuli:

- Employees may purchase tickets in advance.
- Employees may need to purchase tickets at the last minute.
- Employees do not know the intricacies of cost centres.
- Employees may make errors when specifying travel plans.
- Some employees may try to abusively purchase tickets for private use.
- The train company has constraints on the kind of tickets that employees can use, for example, the example in Figure 6.
- The train company needs to make sure that every trip is paid for.

The following list gives a few optional solutions that respond to these stimuli by creating some accommodation (Checkland and Scholes, 1990) between their differing demands:

- Let employees order as many tickets as they want but invoice only those that were used. This requires linking the train controller system with the ticket ordering system for an end to end process. This option did not receive the favours of the train company for fear of losing the control over the process.
- Authorise all employees to order tickets and approve them afterwards. For last minute purchases, a deferred approval can be envisioned. This option may not receive the favours of the university secretaries who may fear that they will be overwhelmed by requests to cancel tickets that were wrongly purchased by employees due to erroneous data entry.
- Negotiate an average price for special nominal tickets with no fixed departure and destination (modern generic tickets) that secretaries can preallocate to their cost centres. The advantage is that these tickets can be used without specifying the travel plan ahead of time, reducing the problems of data entry errors. These tickets can be reused if they have not been used, therefore reducing the

need for a cancellation process. The train company can control these generic tickets through the same mechanism we proposed above, linking the train controller system with the ticket ordering system. The BPS system issuing the tickets can automatically allocate the ticket to the preallocated cost centre. The BPS system memorises the status of the ticket (e.g. issued, controlled). If the ticket was not controlled in the train, the system will alert the employee to update the status. This last point may be a thorny problem because it requires trust in the employee. This is, however, not any different than the process that was in place with this paper-based system.

4.4 Analysing the processes with BPF

The BPF analysis shows that each organisation implemented a solution based on its enacted environment without seeking adequate interpretations about the consequences of the new overall process on the work patterns of university employees. The train company built an IT system that dispenses exactly the same tickets that it is selling to all its customers but with a few added functionalities for use in organisations, for example, delegation of access rights, allocation of purchases to cost centres, ticket purchasing statistics. The university built a classic process consisting of a delegation of authority and the centralisation of train ticket purchasing in the hands of secretaries. This added more responsibility to the secretaries and made employees more dependent on their secretaries. This resulted in more roles and centralised decision making in the process and created inflexibility from the point of view of the employees.

In Table 3, we show that in the old process, employees handled their ticket purchases autonomously from type A (fixed travel plans) to type D (surprises in travel plans). The current process, by ignoring types C and D (the possibilities of changes and surprises in travel plans and data entry errors), imposes stringent constraints on employees while creating a burden on secretaries and the travel manager.

A wished-for process could restore some or all of the lost autonomy back to employees, restoring in passing the lost flexibility. Note how in Table 3 the wished-for process involves the BPS system more, and the secretary and travel manager less. This wished-for process could use one or more of the solutions we outlined above or solutions that we have not yet imagined.

Note that this is a process as wished by employees. It may not receive the favours of the university or train company. However, it is a useful starting point from which to examine a future process.

5 Discussion

In the following subsections, we discuss the strengths and weaknesses of BPF and demonstrate how this framework helps to interpret the changes required in business processes.

Table 3 Ticket purchasing process BPF analysis

Type of BPF Stimuli	Old process		Current process		'Wished-for' process	
	Response	Response responsibility	Response	Response responsibility	Response	Response responsibility
Type A: Constant: fixed travel plans ; fixed mode and location of ticket purchase	Employee gets a generic ticket from their secretary and specify their travel plans when boarding a train	Employee, Secretary	Employee specifies travel plans ahead of their travel date. Once a ticket is created it is invoiced with no possible refund	BPS system, Employee, Secretary	Employee gets a generic ticket from BPS system and specifies their travel plans when boarding a train BPS automatically allocates ticket to required cost centre and memorises ticket status for future control	BPS system, Employee,
Type B: Meetings may be cancelled or employees can get sick	Employee reuse ticket or return ticket to secretary if not used Specifying travel plan when boarding train insures adequate response to last minute changes	Employee, Secretary	Process A augmented with refund in limited predefined cases such as meeting cancellation, illness, etc	BPS system, Employee, Secretary	Employee reuses ticket or uses BPS system to cancel ticket if not used Specifying travel plan when boarding train insures adequate response to last minute changes	Employee
Type C: Employees may not be able to plan trip ahead of time	Same as B	Employee	Employee consults secretary and are encouraged to buy their own tickets at train station and then ask for refund	Employee, Secretary	Same as B	BPS system, Employee, Secretary
Type D: Employees may make many data entry errors when purchasing tickets ahead of time	Specifying travel plan when boarding train insures correct data entry	Employee	Erroneous tickets are cancelled through unused ticket cancellation process	Employee, Secretary, Travel Manager	Specifying travel plan when boarding train insures correct data entry	BPS system, Employees

5.1 Strengths of the BPF framework

An objective of the business process modelling is to reduce process ambiguities by defining and documenting unambiguous interpretations and actions. However, the overriding objective of Business Process management (BPM) is to manage the business with unambiguous, ambiguous and unexpected stimuli, all! Our contention is that too often the process designers focus on what is anticipated, specifiable and unambiguous. However, when the process actors are faced with ambiguous or unrecognisable (unanticipated) stimuli, they are at a loss to figure out the appropriate response. Instead of a reactive

stance, a proactive designer would be one who anticipates the possibility of ambiguous or unexpected stimuli (i.e. knows that there are things that he does not know) and designs in 'really flexible' mechanisms that can assess and deal with these stimuli in a dynamic manner. However, before a designer can design unambiguous actions, he or she first needs to recognise where such ambiguities and unexpected possibilities can exist. Moreover, given the variations in human intentions and nature it may not always be possible for the process designer to anticipate ambiguities from the universe of all possible ambiguities. For example, for the majority of disaster relief orgs it was not possible to anticipate the

nature, size and extent of the 2005 Tsunami disaster. Thus, while trying to attain unambiguity and flexibility within Type B processes it is not always attainable. The environment, that is, both nature and humans are perverse enough to throw up situations that the designer of the process never imagined before. As the old saying goes, 'man proposes and god disposes.' The proposed framework alerts the process designers to the possibilities of types C and D. It alerts them 'to know what they do not know', which is the defining characteristic of human self-awareness.

5.2 *Limitations of the BPF framework*

The BPF is essentially the view of a particular observer. The same process management can be viewed from the perspectives of different process participants. This could be done by having several tables, each with a different view but it may not be very effective and relating the different tables may be problematic. Also, when a number of stimuli are present in one row of the table, it may not be easy to describe which responses address which stimuli since there is not necessarily a one to one mapping between stimuli and response (Weinberg and Weinberg, 1988).

5.3 *Process management model*

Process management involves process participants (also referred as process actors) and process manager. 'Process manager' may include a hierarchy of process managers or the resolution hierarchy. A process management model has significant influence on business process flexibility. If a process management model can interpret any stimuli to the process and invoke strategies and tactics to respond with suitable business process plans, we view such a process as a flexible process. A stimulus is considered to be interpretable if either the process participants or any of the process managers in the hierarchy of process managers can understand the stimulus. The classification of the stimuli proposed is based on this view. However, it is possible that a process actor invokes the process manager immediately above the process actor, and if that process manager can not interpret the stimuli, then the stimuli becomes uninterpretable within the two layers – the process actor and the adjacent process manager. Thus the classification of the stimuli in an organisation depends on its BPM model also.

In Types A and B stimuli, the process participants' behaviour is predictable and possible participant responses are well-defined. In Type C, even though process participants' behaviour is not predictable, they are not autonomous, and instead are well-guided by the process manager. Hence, the Type C stimuli for a process actor could be viewed by the process manager as Type B stimuli. In Type D stimuli, process manager also cannot respond as they are 'surprises' and the process participants needed to respond autonomously. If the process deployment does not allow process participants to respond autonomously, the process fails and breakdown occurs.

5.4 *Dimensions of BPF*

Regev et al. (2007) compile a comprehensive set of the possible types of changes in business processes, thereby creating a taxonomy of BPF. BPF has been classified with respect to the types of changes it enables. The classification includes three orthogonal dimensions: the abstraction level of the change (type and instance), the subject of change (functional perspective, operational perspective, behavioural perspective, informational perspective and organisational perspective) and the properties of the change (extent, duration, swiftness and anticipation). We suggest that the characteristics of the stimulus defined above can be used to identify the requirements for BPF identified in Regev et al. (2006).

However, before we do so, we need to reclarify the understanding of the concept of flexibility and change. Above, we had defined flexibility as the capacity of adapting to variations. We also demonstrated that this capacity, to some extent, can be built into the design of the process itself (Type B stimulus). Thus, in case of Type B stimuli we do not need to change the design of the process. We have a self-adaptive process. The process flexibility is inherent in the process design and manifests itself through the choice of alternate paths for different process cases.

In cases C and D, the flexibility is not completely built into the process design. It requires an intelligent process manager to interpret variations, select or change the design of the process in response to the variation, and execute it. Thus, qualitatively, this change is different than the type B change and includes changes in process design as well as process enactment.

It is possible that in some cases, we may not directly relate the level of stimulus to the type of business process change. It is our conjecture that this problem could be due to two types of ambiguity. Firstly, there is considerable ambiguity in the commonly used terms 'flexibility' and 'change'. For example, it is not clear if the change is with respect to the 'normal' case or is it with respect to the designed process. It can be argued that all changes are only with respect to the 'normal' case. In that case, any variations from the norm, whether anticipated and designed for as a contingency or unanticipated, will be considered a flexibility requirement and hence a change. On the other hand, if the change is with respect to the designed process, the need for flexibility and therefore change arises only in the case of unanticipated change. Secondly, the difference between 'Process type' and 'Process instance' needs clarification. For example, in the case of anticipated and designed variations, each unique path may be considered a process instance. In this situation, the anticipated variation would lead to a designed change as a new process instance. On the other hand, an unanticipated and therefore, not designed for variation may result in changes to the process design (type) itself. Therefore, it is important that such ambiguities in definitions of change be clarified before the levels of stimulus can be substantively related to BPF changes.

6 Related work

The work we presented in this paper is at the confluence of systems thinking, organisational theory, requirements engineering and BPM. We briefly explore each one of these fields in turn.

Ashby's law of requisite variety is studied and applied in the general systems literature (Weinberg and Weinberg, 1988). Weick's ideas are mostly used in organisational theory and strategic thinking; (see e.g. Mintzberg et al., 1998). Engelbart (1992) defined the ABC model of organisational improvement where A activities designate the core competency of the organisation, B activities designate the efforts toward the improvement of A and C activities designate efforts toward the improvement of B activities. One can see a parallel between the BPF ABCD types and the ABC model not only in the names of the types but also in the attempt to improve business processes if we accept they essentially encode A activities.

The concept of stimuli can be related to the requirements engineering concept of stakeholders needs. The BPF framework Type A processes can be compared to essential usecases (Constantine, 1995) and main success scenarios (Cockburn, 2000) where only the achievement of a predefined goal is considered. Moving towards Type B processes is comparable to moving towards fully dressed use cases (Cockburn, 2000) containing a set of alternative paths that match the identified stimuli. Types C and D processes are not supported by the use cases. Brainstorming techniques (Gause and Weinberg, 1989), scenarios (Alexander et al., 2004) and goal-oriented methods (van Lamsweerde, 2001) can be used to explore C and D types stimuli and can be employed to move towards B and A processes. In BPM, most of the work focuses on embedding flexibility within BPS systems using Workflow Management Systems (WfMS), for example, (Ellis et al., 1995; van der Aalst, 2001), etc. Part of the research is geared towards improving BPF by bridging aspects of management and WfMS. Bernstein (2000), for example, proposes a tool that supports dynamic processes along a Continuum that Spans Computer Cooperative supported Work (CSCW) systems (e.g. e-mail) with little process support all the way to strict support with WfMS.

7 Conclusions

We have shown that to design flexible business processes, the adequate stimuli in the environment of the process need to be considered by the designers. We have shown how this happened in the case of the university train ticket purchasing process. Considering the necessary and sufficient set of stimuli is far from easy and necessitates maintaining a variety of interpretations within the organisation. We proposed the BPF framework that classifies business process and their stimuli into 4 types, from the rather theoretical Type A process facing only constant stimuli to the Type D process, facing surprises. For the ticket purchasing process, we were

able to present a synthetic view of the old process, the current process and the process as we wish it would be.

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Notes

- ¹Law of requisite variety states 'Only variety can destroy variety.' Thus, in order to respond to variety (variations) in demand from its environment, the system or the organisation should have the requisite variety of responses built into it.
- ²Here, we are using the term 'customer' in the generic sense as the role that expects and receives the outcome or the deliverable of the business process. The customer can be either an external customer or a customer within the organisation.