# Cyclic Process Model Transformation

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**Abstract:**
Process analysis usually focuses only on single and selected processes. It is either existent processes that are recorded and analysed or reference processes that are implemented. So far no evident effort has been put into generalising specific process aspects into patterns and comparing those patterns with regard to their efficiency and effectiveness. This article focuses on the combination of dynamic and holistic analytical elements in enterprise architectures. Our goal is to outline an approach to analyse the development of business processes in a cyclical matter and demonstrate this approach based on an existent modelling language. We want to show that organisational learning can derive from the systematic analysis of past and existent processes from which patterns of successful problem solving can be deducted.

## 1. Introduction

Since the rise of business process orientation, a plethora of modelling techniques and methods have been developed that can be used to visualise, optimise and simulate business processes. A lot of knowledge has been cumulated in those modelling and analysis sessions. Yet there is no structured way to facilitate this knowledge for learning. Models are generated, analysed, applied and then often forgotten. A broad knowledge base to design better processes lies fallow. There is often only a particularistic approach on analysing business processes, even though steps have been made to integrate different processes into an overarching model (Scheer and Nüttgens 2000, Mertins and Jochem 2000).

Processes are often seen as static snapshots of activities within an organisation. There is no approach that focuses on the emergent process development and regards business processes as fluent objects that adapt to necessities with their own logic. According to the dimensions laid out above one can identify four different process analysis approaches (Table 1):

| | Particularistic | Holistic |
|---|---|---|
| Static | One process at a moment | Consolidated organisation model |
| Dynamic | Different instances of the same process observed over time | Different process classes observed over time |

**Table 1: Process analysis approaches**

This paper focuses on the fourth approach, combining dynamic and holistic analytical elements. Our goal is to outline an approach to analyse the development of business processes in a cyclical manner and demonstrate this approach based on an existing modelling language. In that way we want to show that organisational learning can derive from the systematic analysis of past and existent processes from which patterns of successful problem solving can be deducted.

## 2. Processes, models and organisational learning

This section deals with the link between process models and organisational learning. A knowledge based approach will serve as a theoretical umbrella and prepare the ground for the description of the cyclic transformation model.

### 2.1. Processes and models as knowledge sources

Organizations store their experience with the efficient solution of problems in standard operating procedures and routines (Argyris and Schön 1978; Levitt and March 1988; Walsh and Ungson 1991). Those processes can arise from two different sources. First they can be introduced into the organization with an external focus. Such approaches can be based on reference process adoption (Becker et al. 2003) or on the influence of business process re-engineering, i.e through consulting companies. Those top-down approaches follow a well-defined design aim. The other source of business processes is emergence which is not led by an overall design but results from the actions and interaction of members in the organization (Davenport 1993; Bititci and Muir 1997). They tend to be ad hoc solutions, which are manifested and institutionalized into “quasi” formal processes.

According to the knowledge based approach (Duncan and Weiss 1979), the aforementioned processes can be considered as memory resources. They are subject to change imposed from different immanent and exogenous influences (Lyles and Schwenk 1992). While exogenous effects such as changing environmental inputs and conditions force organizations to adapt their decision and resource allocation routines, immanent effects come from ad hoc adaption of the process due to changed internal conditions, i.e. a modified power constellation, new cooperative agreements, etc. (Weick 1979) We can therefore conclude that active processes contain both, components of design and components of emergence.

Modelling of business processes should lead to an idealistic, simplified and similar mapping of a subject, system or other part of the world and hence reduce the complexity of the organisation system, concealing the internal dynamics. Here a process flow (or business process flow in the managerial context) includes rules as regulation for a certain proceeding (Knolmayer et al. 2000). These rules determine the sub-processes and tasks/functions within a process and allow the existence of a logically coherent chain. The processes include a combination of material or immaterial input objects, which are transformed into an output object according to the given process rules (Schwickert and Fischer 1996). The procurement of the needed material input or information objects often correspondents with other well defined processes. Thus, this input can be easily specified because the characteristic of the required objects remain nearly unchanged for different process flows. Process models do not show a large variance from the reference process.

In contrast, knowledge as process input cannot be predetermined and described easily. It is bound to the person – the acting employee – and to the environmental situation the process is embedded in. Neither the quality and quantity of a knowledge demand nor the time of its use can be forecasted (Gronau and Weber 2004). This knowledge feature leads to variation in the resulting models from used reference business processes or to missing sufficiently structured process models.

Business process models can also be used to analyse the given situation and to develop a generalised reference concept based on the analysed models. One important feature of these reference concepts and models is their reusability. Reference models are used as generic conceptual models to formalize recommended practices in the enterprise. Thus, they are often labeled with the term “best practice" models, which claim to capture reusable state-of-the-art practices. The main objective of reference models is to streamline the design of particular models by providing a generic solution (Rosemann 2003). However, the dynamic and context sensitivity of the resource knowledge has to challenge the reusability of these models. Hence other aspects such as emergent process adoption have to be considered.

Those models, being explicit knowledge, can be the source of organisational learning. They were recorded or designed top down and stored in documents and diagrams. They are abstract to a large extent and need to be internalised by the members in order to take effect. Tacit organisational knowledge, on the contrary, is found in the emergent processes. They are inscribed into the direct actions and behaviour of the members of the organisation. The accumulated tacit knowledge cannot be directly gasped and is stored, sometimes unconsciously, in the minds of the members.

### 2.2. Organisational Learning from process models

Applying the knowledge perspective back on organisational learning leads to the definition of a mechanism by which the tacit and the manifest dimension can interact. Hence we refer to the works of Nonaka and Takeuchi (1995) with their model of socialization, externalisation, combination and internalisation. They regard learning as a cycle of transformation of knowledge between the tacit and the explicit (or manifest) dimension. The four transformations stated above have been applied to our model of process model learning. When tacit process models are spread throughout the organisations by direct interaction or by mere observation of other persons, socialisation takes place. This transformation is needed but it cannot be controlled or observed by the organisation. It can therefore only be regarded as unstructured learning.

On the other extreme, an organisation can also learn from other external or internal information sources. In our case those sources would be other reference processes or other abstract process models. It would mean that learning only takes place within the manifest realm. The drawback on this perspective is its abstract nature. The models are only refined, but its link to the individual action and the connection to organisational habits is lost. Hence it is necessary to include two other directions of learning into the framework. The explication is the transformation of tacit elements into a manifest form. Actors document their knowledge about processes and routines and make it shareable and directly accessible for the organisation. The other course of knowledge transfer is internalisation. Information, such as formalised process models, is included into the behaviour of organisation members through individual learning.

If those transformations were cyclically linked, processes such as incremental learning (through socialisation and internalisation) and the abstraction of the incrementally learned process models (through externalisation and combination) could be taken into account. Yet, there is no way to identify efficient processes that emerged from day-to-day business and transfer them to new units.

Anderson's (1996) theory of the Adaptive Character of Thought is an approach to bridge this gap based on cognition. He distinguishes knowledge into three types of memory structures:

- Declarative memory consists of a semantic net of propositions, images and sequences. Applied to the organisational context these are all process elements (roles, resources, tasks and decisions) form a repository which the actual process draws from. In our investigation the can be identified as process patterns.
- Procedural memory is the concrete linking of those objects. It constitutes the map of all processes available in the organisation. Again those processes can be distinguished into manifest and tacit processes. In the cyclic transformation model this memory resource serves as a case base.
- The working memory consists of all processes currently in action in an organisation. They are process instances in our model.

The aforementioned memory sources can be transformed in different ways: generalisation, discrimination and strengthening.

The transformation (learning) process can be described with the OADI-SMM (shared mental models) cycle (Kim 1993). Based on the OADI (Observe, Assess, Design, Implement) cycle two different interlinking cycles can be constructed. The foundation is the OADI-IMM (individual mental models) cycle in the individual actor modifies his mental model through the four mentioned stages. The SMM cycle enhances this procedure with commonly shared models such as beliefs and SOPs. Learning in this SMM cycle employs the same OADI procedure as in the IMM cycle, but as its result, processes change. This change can occur on two levels. On completion of the cycle, the modified process is implemented again. This learning is parallel to the emergent modification process and represents incremental learning activities. At the same time we find abstract process models in the cycle, which can be considered as a part of an organisational repository for possible solutions. This means that not only the concrete processes are a part of the organisational memory, but also potential processes. During different loops of the cycle many potential and concrete processes emerge, which are not accounted for properly in current modelling methodologies. The dynamic development and learning from the previous development steps has to be taken into consideration to increase the quality of process models and their design implications. The following section will outline an approach to achieve this with cyclic model transformation.

## 3. Proposed Model Cycle Approach

After we learned about the potentials offered by business process modelling in enhancing the organisational learning, the next step would be to define a classification system for process models, in order to be able to compare and limit process models of different phases and role memberships.

### 3.1. Classification characteristics for process models

A classification system contains rules for transferring a set of unsorted elements into a new overall system in order to achieve an ordered representation of these elements. Therefore, one needs to define classification parameters such as quanta, characteristics, dimensions, value and principles of classification (Laisiepen et al. 1972, Bailey 1994).

The classification goal and the classification set have already been discussed above. The amount of partial and entire process models have to be prepared by the classification system in order to make a systematic model reuse possible. We apply the term model reuse in different ways. A model may be the basis for new process occurrences or models are the basis for process analysis. In the context of this work, two characteristics of process models are important: abstraction and institutionalisation.

The level of abstraction describes whether the model represents a process schema or a process instance. A (cognitive) schema is an internal data structure, which generalise experiences. It represents typically expected facts resp. relationships in a particular domain of the reality. A schema with empty element fields is a conceptual structure that describes entities of a particular category in an abstract way (Schnotz 1994). A process instance is a specific occurrence of a process (at a particular point of time). All elements in this model are well-defined. Process schema and process instances can be differentiated although there could be a smooth transition, that is when only particular elements or element types are kept abstract. For a precise classification we define several abstraction levels. These may be based on the relative part of an abstract model elements or on the set of abstract element types (see Figure 1).

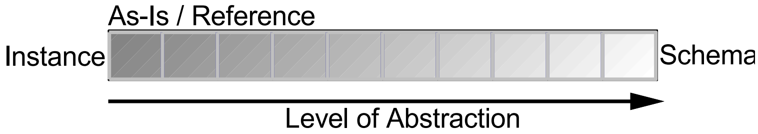


**Figure 1: Level of Abstraction**

The institutionalisation describes the official justification of a process model within an organisation. One extreme is formed by reference models, which are provided by the process manager that in turn suggests and schedule the required resources for a process execution. The other extreme is formed by as-is process models. These may include unpredicted and unplanned process changes as compared with the initial reference process. These changes are often caused by context-specific influencing factors. Therefore, these as-is process instance models have no absolute reference character any longer.

To make the distinction of as-is and reference models measurable, there are two approaches. In case of two comparable process instances, the relative degree of the change can be calculated. Process patterns can use the representativeness. This depends on the size of the case base. The more frequent a certain process pattern can be identified in the case base, the larger is the representativeness of this pattern and the usability as a draft for future process runs. Whether this representativeness is valid for e.g. individual work procedures, departments or the entire organization can also be differentiated (see Figure 2).

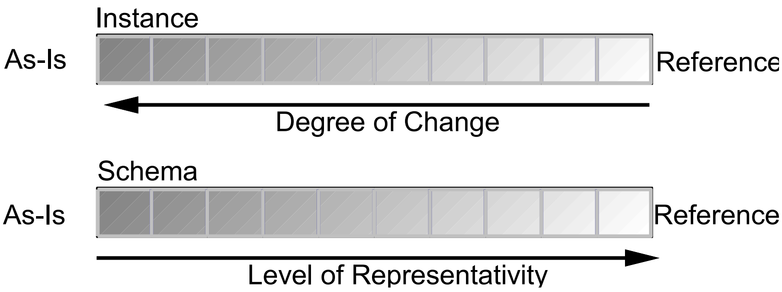


**Figure 2: Degree of change and level of representativeness**

These two process model characteristics allow us to differentiate four extreme types of process models: as-is process instances, as-is process schemata, reference process schemata and reference process instances (see Figure 3).

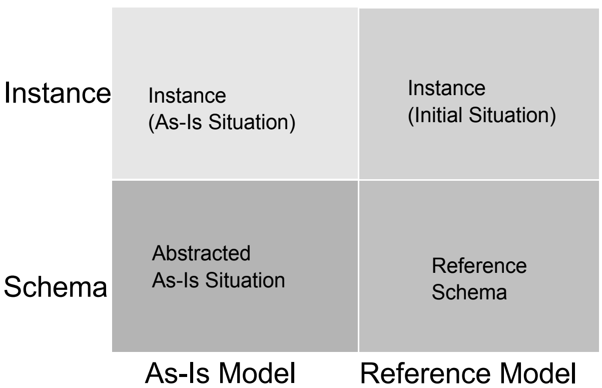


**Figure 3: Model types**

3.2. Model transformation

The four introduced model types are related to each other. Each model type has a particular role/function within the organisation process management. By working with these model, models of a different type are used as pre-condition or created as result.

1. Reference process schemata are the base for new process instances. These are created by instantiation. Abstract objects are replaced by specific objects. This complies an interpretative usage of declarative memory (see section 2.2).
2. Reference process instances are the basis for the documentation of process changes. New models are created by comparing the reference model to the current reality. These models describe the current situation of particular process runs. From a process manager's point of view it is a combination of production rules (see section 2.2). Different models or partial models are (re-)combined.
3. As-is process instances are the base for creating new process schemata. Elements, element types or partial process models are abstracted. From a process manager's point of view it is a proceduralisation of knowledge. Knowledge about a specific procedure is stored context-non-specific (depending on the abstraction level) in the case base. Declarative knowledge is encoded into rules (see section 2.2) and creates process schemata as well as schemata without a noticeable process structure but with a description of other kinds of patterns (e.g. relationship between person and knowledge). This schematisation can be realised computer-based. Any kind of abstraction level and decomposition of process models is possible.
4. As-is process schemata are the base for model refinement. Process schemata are analysed and optimised. Re-occurring patterns are searched for and checked, whether this pattern is a success factor or a barrier. From a process manager's point of view it is the generalisation, discrimination, amplification of process knowledge (see section 2.2). It is a knowledge optimisation resp. model optimisation. The command variable is the representativeness a process schema could get.

After four transformation activities, the cycle is run through (see Figure 4). Of special importance are the entrance points to this cycle. One entrance point is the adoption of external reference models, which are already abstracted. They claim a high degree of representativeness resp. generality and become reference process schemata. Another point of entrance is the process capture in the context of a system analysis. A specific system situation is captured and the documentation becomes a as-is process instance.

Reference process instances and as-is process schemata are no adequate entrance points. Their usage always implies the hidden creation of a reference process schema or a as-is process instance and their schematisation as well as instantiation.

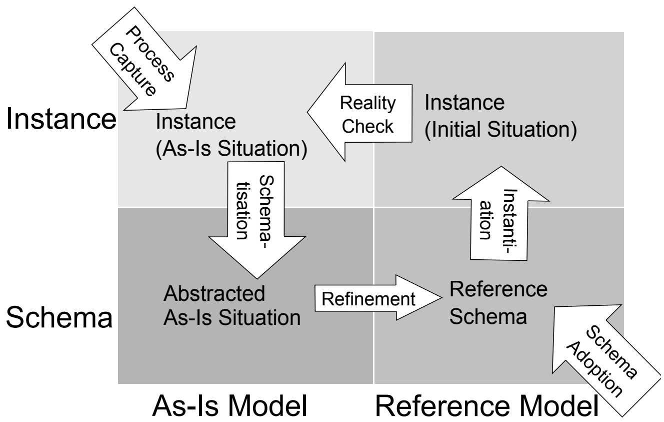


**Figure 4: Cyclic transformation**

## 3.3. The Knowledge Cycle (K-Cycle)

The K-cycle denotes the cycling run-through of model transformations. Schemata are continuously tested and optimised by the use of the case base of past process runs (see Figure 5)

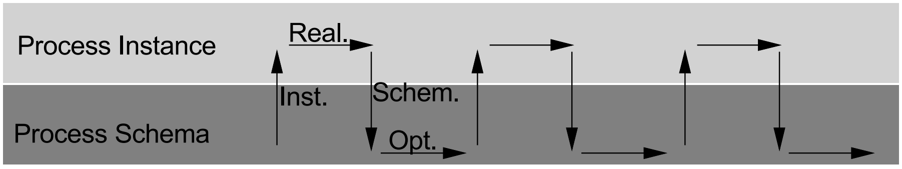


**Figure 5: Model Transformation Cycle**

Knowing and understanding the level of abstraction, change and representativeness is important for the selection of process model as base for model optimisation. Thus, the model is also qualified for a particular process management task. As-is process instance models with only few changes to the reference model will cause a higher representativeness after schematisation. Just as models used for the analysis should have a comparable level of abstraction.

The usage history of a model or partial model can be observed in the classification system. The cycle will become visible but there are also branches going outside of the cycle when the model is the base for more than one reference process instances or when multiple schemata of different abstraction levels are created. And there will be branches going inside when the analysis is based on many schemata or when a process instance is updated by further partial process models (see Figure 6).

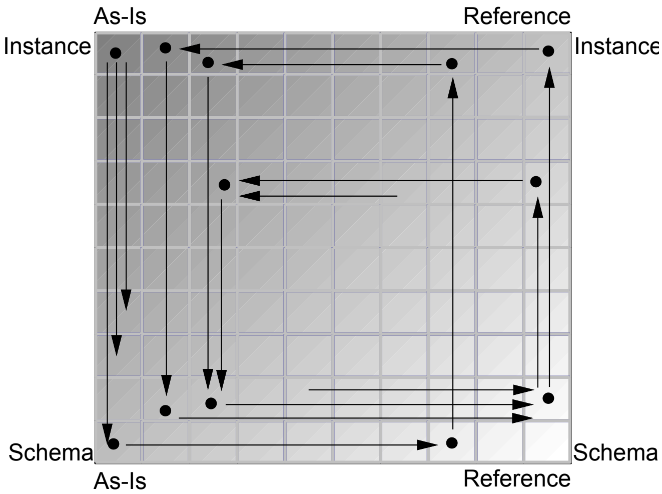


**Figure 6: Continuous cycle**

## 4. Application of Method

The following section gives an overview of how the above explained concept can be applied into a reality-based scenario. First we will introduce the Knowledge Modeling Description Language (KMDL), a semi-formal knowledge activities modelling method, which was selected over other methods because of its capability to visualize informal relationships between process participants along the chain of tasks (Gronau and Weber 2004). After a brief theoretical background we will show some excerpts of KMDL models taken from a reality-based scenario. These models will be transformed into a conversion map by running through the proposed K-Cycle phases.

### 4.1. Knowledge Modeling and Description Language (KMDL)

The development of KMDL was triggered by the limitations of conventional modelling methods in visualizing knowledge processes and activities, especially in informal relationships. Aiming to address this problem, KMDL builds its core elements based on the differentiation of knowledge by Polanyi (1966) into tacit and explicit knowledge as well as the SECI-Model (see section 2.2) by Nonaka and Takeuchi (1995). Modelling with KMDL is primarily intended as an instrument to visualize knowledge intensive business processes (see section 2.1). The course of tasks within the processes is represented in the process view. Each tasks is assigned to certain departments or organisational units, called Role. This view also allows alternative routes in cases of exceptions through the OR, XOR and AND operators. In case an information system is utilized to perform a task, the type of the IS should also be mentioned. Figure 7 shows an example of a process view.

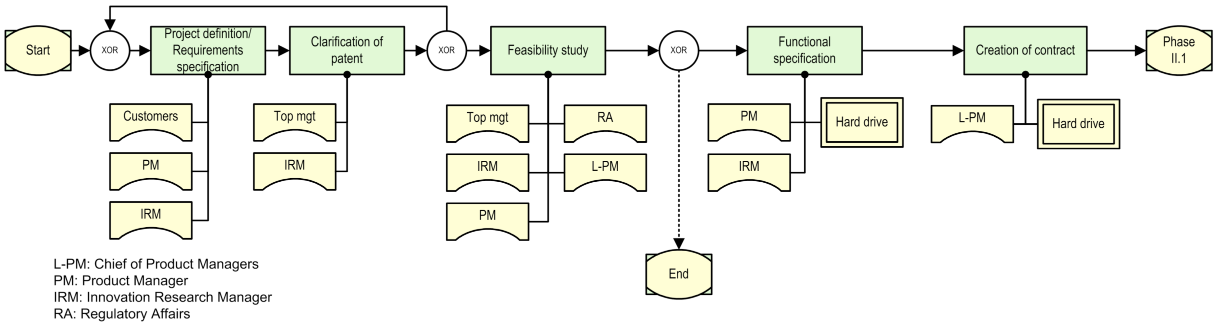


**Figure 7: Exemplary process view**

Each task within the process view can be elaborated into specific activities, which are to be found in the activity view. This view shows the types of knowledge conversion occurring within each task and thus, the knowledge flow. Since knowledge is person-bound and context dependent, the performers of the knowledge activities are individuals. Figure 8 shows the objects of the process and activity view.

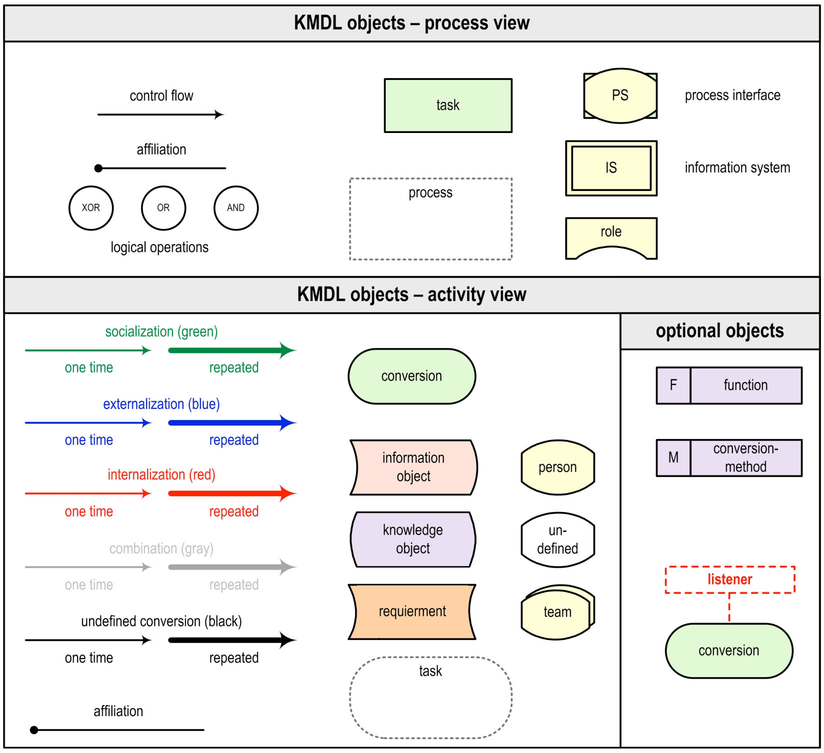


**Figure 8: Objects of the process and activity view**

## 4.2. Feasibility Analysis: a Reality-based Scenario

The following KMDL models are excerpts from an innovation process captured in a small enterprise that builds video solutions for mobile applications. The following models describe how products go through a feasibility analysis within an innovation process in the company. Using the KMDL procedural model we gathered information about the course of action within this event by interviewing the process participants bearing various roles and responsibilities. For the publication purpose the names of the participants are anonymised. The integration of K-Cycle occurs within the activity view, since it enables the visualization of knowledge exchange processes from a knowledge bearer to another.

### 4.2.1. As-is process instance models

As explained in section 3 the as-is process instance model serves as a means to describe the detailed possibilities of occurrence within a process. A process instance is a concrete specification of a process class, which builds a real ongoing process, in this case of a feasibility analysis process. During the first interview rounds we captured some scenarios of how the feasibility analysis for new products and features is being generally performed. Its varying implementations depend on various factors, for instance the provider of the suggestions, the type of suggested product or feature, the criticality of implementation, etc. Figure 9 shows the first process instance alternative model.

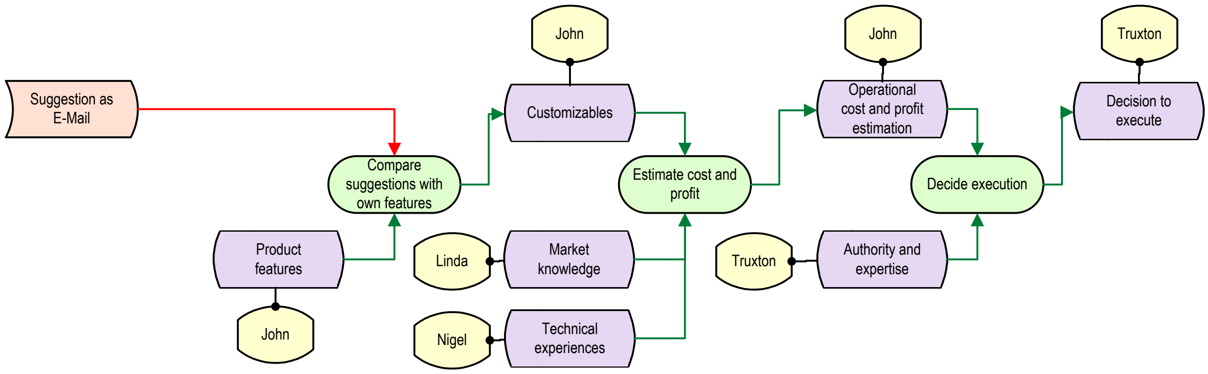


**Figure 9: As-is process instance model 1**

Within this process instance model suggestions come from one of the employee of the company as an E-Mail. This suggestion is processed by John Brown, who is the product manager, by comparing it with already existing products and features. In order to do this, Brown needs to be familiar with the company's product features. The comparison yields the result of which customizing possibilities might be undertaken. Since the suggestion came from someone who is rather familiar with the situation and competence of the company, Brown only talks to Linda Bray from Marketing and Nigel White from Product Development informally during lunch and asks their opinion based on their knowledge and experiences on market and technique. The discussion results in the operational cost and profit estimation, which Brown shares with Truxton Spangler, one of the executives. With his authority and expertise in running the company Spangler decides on whether to execute production of the suggested product or to save it for later.

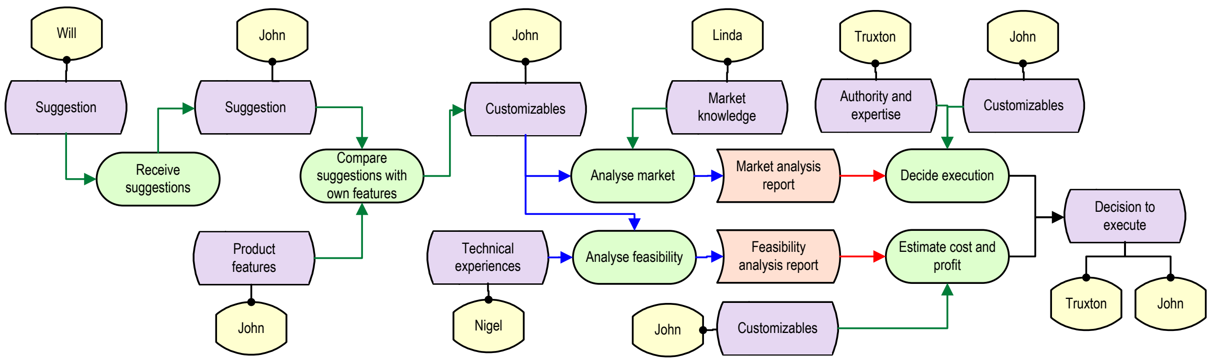


**Figure 10: As-is process instance model 2**

In another interview we captured the second scenario of the process (see Figure 10). A suggestion comes from Will Andrews, a customer through an informal discussion with John Brown on the telephone. Brown writes this down and compares this suggestion with the existing products and features and arrives at some possible customizing activities. Since this product suggested is something new, Brown tells Bray and White to do some market and technical feasibility analysis on this suggestion. The results of the analysis were written down as reports. Brown estimates the cost and profit based on the technical feasibility while Spangler takes a look at the market analysis report. Brown and Spangler agree upon whether or not the suggestion should be followed up.

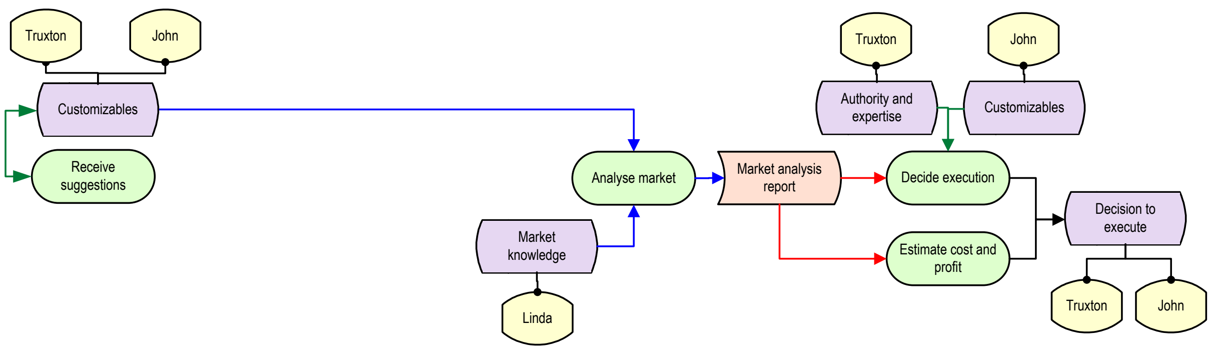


**Figure 11: As-is process instance model 3**

The third scenario is captured in Figure 11. Spangler shares his idea of a new product with Brown, who discusses the market chances for this suggestion with Bray. She writes down the analysis into a report, which becomes the basis for the cost and profit estimation and the decision to execute, which is met by Spangler according to a prior discussion with Brown.

#### 4.2.2. As-is process schema model

The next step is to build a generalised model based on the three different specific scenarios. Since the process schema model does not include specific input and output objects we represent the knowledge and information objects within this process schema model as exchangeable objects. Within this model (see Figure 12) we conclude that all suggestions are received and documented before they are compared with the products and features already existing in the company. This comparison serves to decide whether a radical innovation (developing from scratch) or incremental innovation (building on existing structures or customizing) should be performed. The decision provides the foundation for the market and technical feasibility analysis in order to estimate the cost and profit obtained when executing the innovation process.

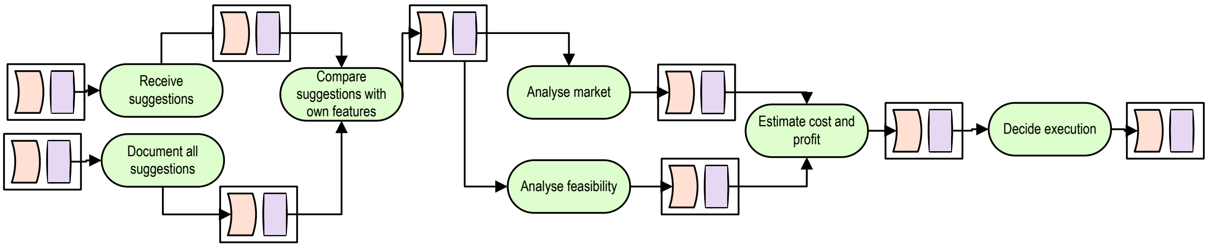


**Figure 12: As-is process schema model**

#### 4.2.3. Reference process schema model

We analysed the as-is process schema model and identified some needs for adjustments (see Figure 13). The activity "document all suggestions" has not been consequently performed since some suggestions come only as informal discussion point or already in a written form in an E-Mail. Based on the captured process object models this externalisation of knowledge is not significant. The technical feasibility analysis has also been left out in some cases, since some suggestions come from actors with product knowledge. This means that the suggestions have undergone a technical feasibility at a certain extent. In order to estimate cost and profit, however, a documentation of the market analysis is necessary, which in turn, affects the decision of execution.

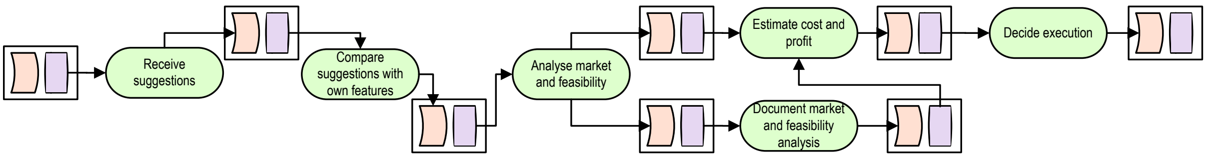


**Figure 13: Reference process schema model**

#### 4.2.4. Reference process instance model

The above model was built based on the success factors identified in single process objects. It serves as a reference model that shows how the process "should" be implemented. Companies can use this reference process class model as a "blueprint" for strategically planning and optimizing the company infrastructure and objectives. Nevertheless, it is not sufficient for the day-to-day operation within the process. The process schema model has to be specified into concrete activities with real actors and real environments. Figure 14 shows some excerpts of some possible reference process instance models derived from the reference process schema model.

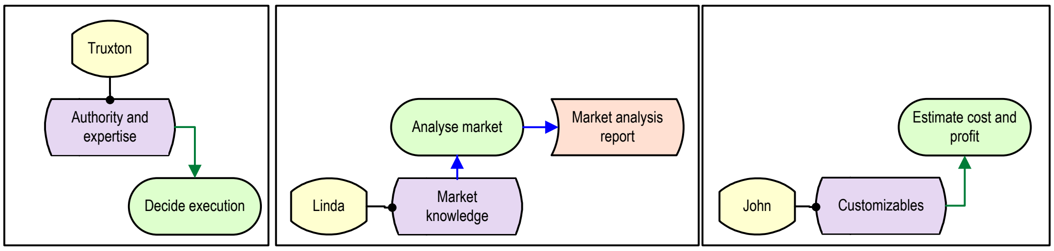


**Figure 14: Reference process instance models**

In receiving suggestions, the role of John Brown as a product manager is indispensable due to his knowledge about product features and his capability to derive on the customizing potentials, as we can see from all the scenarios. Truxton Spangler as decision maker can also be found repeatedly. Linda Bray is another key person for the market feasibility analysis. Based on these scenarios the reference process schema model can be broken down into elements that consist of parts of the process that appear frequently. Reference process instance models can also be derived from other points of view, for example: the commonly used methods, the type of knowledge conversions, the frequency of activities, etc. This concept might serve as a foundation for a computer based best practice pattern recognition system.

## 5. Conclusion

In the practices of business process modelling and organizational design, often only certain and obvious aspects of the process are being captured and used for further strategic improvement planning. The emerging models cannot be sustained for future usage since a systematic learning using these process models is not imposable.

Knowledge Cycle aims to enable the learning process within an organisation based on its own process models. Successful process models can be recognized through the identification of particular patterns. These patterns account for the specific elements of the process model so that by consequently undergoing the model transformation companies can learn from their own “mistakes” and “successes”.

Elements that are hidden or cannot be easily captured by using conventional modelling approaches but are significant for the process can also be identified. Companies can decide on further measures to be taken in order to institutionalise and enforce their implementation as well as to provide the necessary infrastructures and resources. Important process building blocks also imply the supplementary competence of the company. These competences can be integrated into the success patterns in order to produce an effective reference process.

The ongoing cycle of the model transformation provides a basis for a Continuous Improvement Process (CIP) and thus, a dynamically functioning quality management. The company will be able to organize itself according to its own proven measures, on which the top management can base their decision regarding the vision and mission of the company.

One of the further research needs for this concept is the integration of the business process re-engineering concept into the classification system. Within this paper we assume that changes happen gradually and during the transformation process itself, which means that improvement measures can be taken progressively. In some cases this is not worth the effort, for example when the entire personal management has to be replaced or when the company decides to merge or change its direction of growth. A radical business process re-engineering can provide a better solution, which is why the aspect of a total re-engineering should be integrated in the future.

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