Towards Goal-oriented Analysis and Redesign of BPMN Models

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Abstract: The Business Process Management lifecycle involves identifying, analysing and evolving the design of an organisation's tasks. Modelling plays a key role in those activities to capture the processes but also the related goals representing the rationale behind them. While some mappings have been defined between such models, they lack guidelines to support analysis or (re)design activities in order to improve processes in an evolving organisation. The purpose of this paper is to propose a two-staged guidance: (1) a lightweight approach leaving the goal model implicit but using goal reasoning techniques; and (2) an heavier approach where an explicit goal model is explicitly built and mapped to support the redesign process. Our work is experimented on a running case study inspired from a logistics system. Although still in progress, we were able to uncover interesting problems and to suggest relevant redesigns.

1 INTRODUCTION

A business process consists of a set of activities that are performed in coordination in an organisational and technical environment. These activities jointly realise a business goal (Weske, 2012). Organisations need to make sure that their business processes are correctly defined and kept aligned with their strategic goals. This is achieved through Business process Management (BPM), a disciplined approach to identify, design, execute, document, measure, monitor, and control both automated and non-automated business processes to achieve consistent, targeted results (ABPMP, 2011).

A typical BPM lifecycle is depicted in Figure 1. The focus of this paper is on first two steps: the process analysis and process redesign. In those steps, existing processes are first analysed and then modified in order to address a number of weaknesses resulting from possible evolutions of the organisation's goals, internal capabilities or changes in the environment.

Standard notations to capture business processes are known to be widely available and adopted by companies, especially the Business Process Modelling Notation (BPMN) (OMG, 2011) is known by 64% of companies and 40% are using model-oriented tooling according a recent survey (Harmon, 2016). However, the same survey also reveals that companies have not yet reached a high level of BPM maturity given one third of the companies seeing it as a rather static top-down process. There is also little update in the documentation nor monitoring in more that half of the companies.

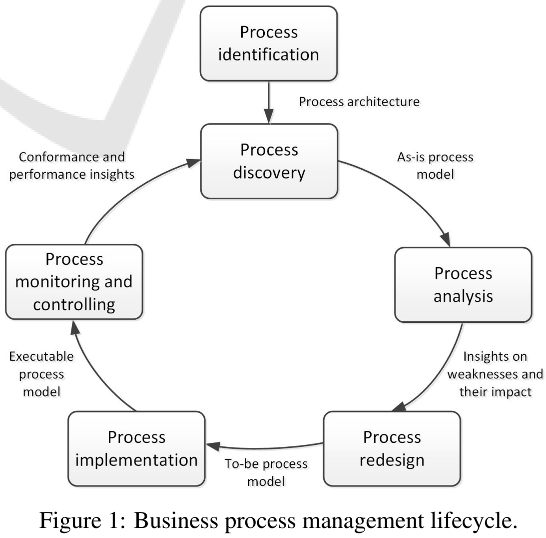

Figure 1: Business process management lifecycle.

The benefits of capturing goals along with business processes are well known: it helps focusing on the relevant activities, exploring alternatives, assessing how well a process operates and understanding its impact on the whole organisation (Kueng and

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Kawalek, 1997). However popular notations like BPMN provide little explicit support for goals and are rather focusing on the operational side.

For strategic goal modelling, different architecture enterprise frameworks are available. While the Zachman framework (Zachman, 2003) only provides the ability to list goals and to work with tables, TOGAF (The Open Group, 2009) can reference them in composite diagrams enabling some graphical modelling of business alignment. Archimate (The Open Group, 2017) provides a more elaborated modelling where goals can be organised hierarchically with positive and negative contributions from more specific (e.g. IT) goals w.r.t. higher level (strategic) goals. More elaborated goal models are also proposed in the field of requirements engineering, e.g. i* (Yu and Mylopoulos, 1997), KAOS (van Lamsweerde, 2009) or URN (International Telecommunication Union, 2012). Those can be used for dealing with business process alignment. However generally companies mostly focus on generic types of goals like cost reduction, customer satisfaction, responsiveness or specific risk management (e.g. governmental or financial regulations). As a result, BPM must still address many challenges related to the management of the misalignment between business and IT, the derivation of IT goals from business goals, the reengineering processes and the adaptation to rapidly evolving business processes (Alotaibi and Liu, 2017).

The aim of this position paper is to propose some improvement over the current state of practice. Starting from the assumption that a BPMN model is available, we propose to drive the improvement by a goal-oriented process. We explore two non exclusive approaches: a lightweight approach based on generic goals that can be inferred implicitly and a more in-depth approach based on the construction of an explicit goal model and enabling more powerful goal-based redesign tactics. Those approaches are discussed based on a running example which is a logistics system operating between UK and Europe.

This paper is structured as follows. Section 2 will remind some background on modelling with processes (using BPMN as widely adopted method) and goals (using KAOS as a representative variant). Section 3 details the redesign approach based on an implicit goal model while Section 4 explores the approach based on the construction of an explicit goal model. Section 5 discusses our work in the light of some related work. Finally, Section 6 concludes by identifying our roadmap to further expand this work.

2 BACKGROUND

This section reminds about the structure of a BPMN and of goal models by presenting their specific meta-models and illustrating them on our case study which is first introduce in textual form.

2.1 Case Study in Logistics

We consider a use case from the logistic domain, describing the process of shipping goods from the UK to continental Europe. In this process, a truck needs to cross the Strait of Dover, usually using an Euro Tunnel shuttle but in case of too high delay the ferry can be considered as an alternative.

In the shipment process, a transport plan is first prepared and is sent to the truck driver. The driver then heads toward the check-in point at the Euro Tunnel. A monitoring can detect some delay and decide to divert the truck route to take a ferry. Once arrived at destination a local dispatch is organised.

2.2 Process Modelling

This paper will rely on the widely used BPMN notation to model processes. BPMN is a specification (currently in version 2) for the high-level representation of business processes (OMG, 2011). It provides a notation that can easily be understood both by business analysts and technical developers. Figure 2 shows a simplified view of the BPMN meta-model.

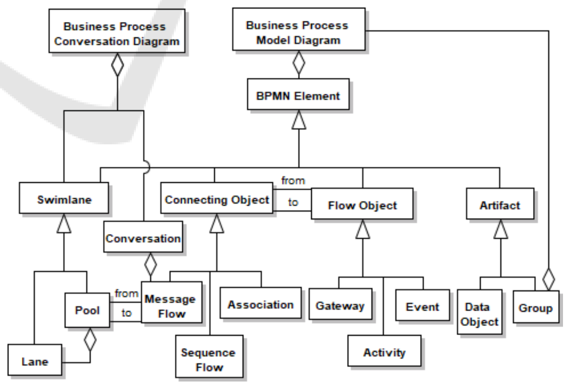

Figure 2: Simplified BPMN meta-model.

The main concepts to define the behaviour of a business process are Flow objects. There are three types of Flow objects: Events, Activities and Gateways. They can be connected to each other with Sequence Flows, Message Flows or Associations. Those elements can also be grouped inside Pools and Lanes. Finally a more abstract view can be given by grouping inter-pool messages using Conversations inside a dedicated diagram. Figure 3 illustrates a possible delivery process for our case study.

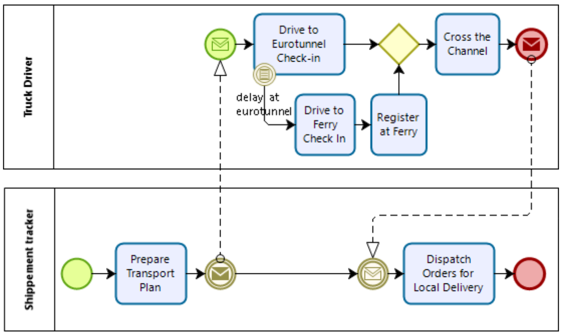

Figure 3: Ideal transport process.

2.3 Goal Modelling

Goal modelling was elaborated in the field of requirements engineering with different method variants discussed in the introduction. In the scope of this paper, we will use KAOS as support. The developed approach can however be transposed to other variants because all notations share many common features around the concepts of goal, refinement, agent and responsibility for achieving the goal and operations/tasks that directly relate to the process dimension.

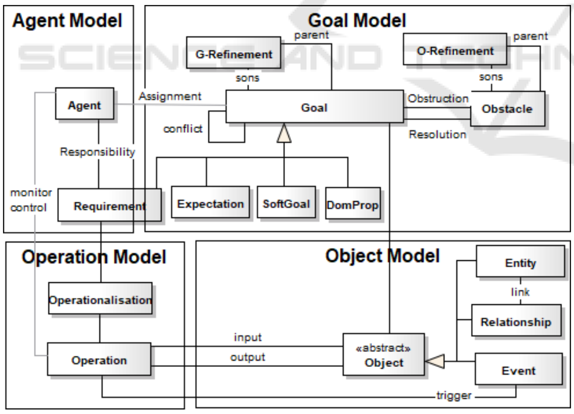

Figure 4: Goal meta-model (KAOS variant).

Although the goal part is central, a KAOS model is actually structured on the following four sub-models depicted in Figure 4.

- The **goal model** structures functional and non-functional goals of the considered system. It also helps identify potential conflicts and obstacles related to goals and reason about their resolution. It is graphically represented as a goal tree.
- The **object model** captures all the concepts involved in goal specifications. Its representation is aligned with UML class diagrams and allows structuring entities, relations, events and agents.
- The **agent model** identifies the agents of both the system and the environment as well as their interfaces and responsibilities. They can be shown as part of goal trees or in more specific diagrams.
- The **operations model** describes how agents functionally cooperate to ensure the fulfilment of the requirements assigned to them and hence the system goals. A simplified form of business process model is proposed by default but more elaborated notations like BPMN can come into play.

In KAOS, different abstraction levels to express goals can range from high-level strategic goals like "Achieve[Timely Dispatch of Orders from UK to EU]" down to operational goals such as "Achieve[Transport through Eurotunnel]" depicted as blue parallelograms in Figure 5. High-level goals can be progressively refined into more concrete and operational ones through relationships linking a parent goal to several sub-goals, with different fulfilment conditions using either ”AND-refinement” (all sub-goals need to be satisfied) or ”OR-refinement” (a single sub-goal is enough, i.e. possible alternatives like Achieve[Transport through Ferry] as alternative to Eurotunnel). The "WHY" and "HOW" questions can be used to conveniently navigate to parent and sub-goals, respectively. This results in a goal tree structure. The goal decomposition stops when reaching a goal controllable by an agent (i.e. a yellow hexagon), i.e. answering the "WHO" question about responsibility assignment. These goals are either requirements on the software or expectations on agent behaviours and are respectively depicted as blue and yellow parallelograms with thick borders. Domain properties or regulation can also be taken into account to justify a refinement, like the maximal speed on a road or the minimal time to cross the Eurotunnel.

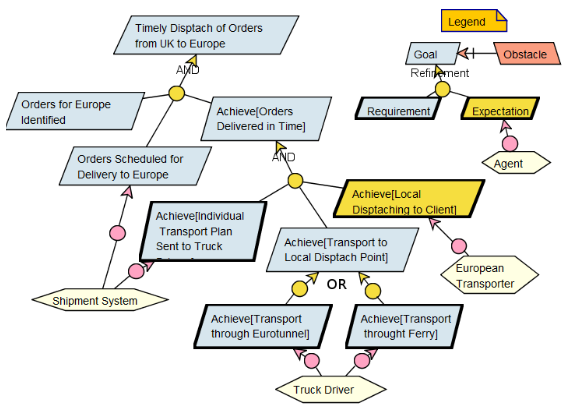

Figure 5: Ideal transport process (with KAOS syntax).

3 IMPLICIT GOAL ANALYSIS

Although processes typically aim at achieving some functional goal, standard BPMN models do not include explicit information about this rationale. The situation is even worse for non-functional goals/requirements (NFR). In this first and deliberately lightweight approach, we choose not to build an explicit goal model but try to guess existing goals, challenge about missing goals and perform redesign directly in the BPMN model. The meta-process is illustrated in Figure 6 and is currently fully manual.

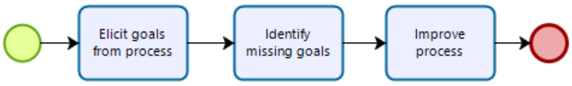

Figure 6: Redesign approach using implicit goal model.

3.1 Eliciting Goals from BPMN

We identified a number of clues that may reflect some design rationale through different means such as analysing the intent behind specific constructs (e.g. the use of parallel tasks, or timers), identifying some BPMN patterns (e.g. feedback loop until a condition is met) and more generally our experience in decoding BPMN diagrams. Table 1 gives a (non-exhaustive) list of such clues. Of course, explicit requirements may also have been documented using notes or in-diagram descriptions.

3.2 Challenging Goals

Once goals have been identified, they can be confirmed and challenged using the questions proposed in the last columns of Table 1. More systematic check-lists, like SQuaRE (ISO, 2011), can also be applied to avoid missing important NFR. Business processes generally focus only on a few of them like performance, reliability while others are less important (e.g. usability is only relevant for ”manual” tasks).

3.3 Improving Business Processes

The use of the above check-lists should trigger a design thinking about the purpose of a specific design and either confirm it or lead to some evolution. Such reasoning even informal will typically uncover some missing goals. At this point, modelling skills come into play but the same table can also provide support to guide enforcing those goals by using it in the reverse way.

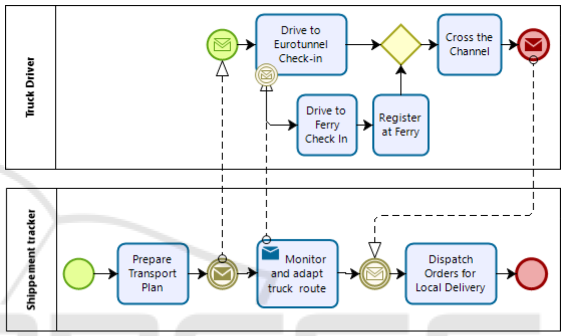

Figure 7: Improved transport process for timing efficiency.

Considering our case, the conditional rule ”delay at Eutotunnel” can be analysed as related to a goal to avoid too much delay. However, in the proposed design, this requirement is placed under the responsibility of the driver and the company will only be informed after the cross of the Strait of Dover. Figure 7 shows a more efficient design where the company is responsible of monitoring Eurotunnel delays and notifying the truck in advance. This design also gives more control to the company.

Table 1: Non-exhaustive list of BPMN rationale indicators.

BPMN	Possibly underlying goal	Challenging question
Single end state	Achievement goal	What is the state reached ?
Final error state	Non-critical requirement	Where/How is the error managed ?
Conditional	Business rule	Does this condition reflects some business property that should be maintained ? How is it maintained more widely ?
Parallel tasks/loops	Scalability requirement	What is the load ? How dynamic is it ? Are enough processing resources available ?
Conditional loop on activity	Reliability requirement	Does the condition reflect some milestone to reach or some key property that should be kept enforced ?
Transaction	ACID property	What are related atomicity, consistency, isolation and durability requirements ?
Timer event	Time-critical requirement	Is the deadline hard ? How is it related to other deadlines ? Why is the activity interrupted or not (if border event)?
Escalation event	Transfer of responsibility	What is the normal operation condition ? Who takes care outside those conditions ?

4 EXPLICIT GOAL ANALYSIS

An explicit goal-based analysis proceeds according to the more complex meta-process described in Figure 8, currently fully manual. It is detailed in the rest of the section and may or not rely on a preexisting goal model, In the later case, the goal model is built.

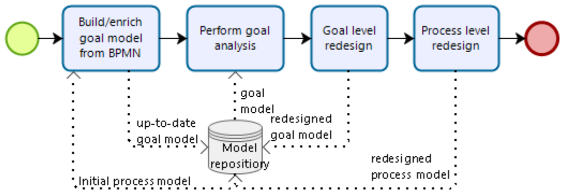

Figure 8: Redesign approach using explicit goal model.

4.1 Build/Enrich Goal Model

The clues detailed in Table 1 remains applicable, especially to identify non-functional goals. However they can be refined in order to provide finer grained rules for the model-to-model translation between business process and goal models. Such mappings have already been studied and taken into consideration to build the consolidated Table 2 which gives our current progress on this task.

In our case study, the three requirements of Figure 5 are directly derived from the process activities of Figure 3. The goal structure can also be derived, e.g. the main milestone (AND refinement) prepare-transport-local dispatch as well as the transportation alternative (OR-refinement) which is actually not totally coherent with the BPMN: this should be a case based AND-refinement as depicted in Figure 9.

4.2 Goal Analysis and Redesign

Goal analysis and redesign are considered together. They are performed using standard techniques from goal-oriented requirements engineering (GORE). Some useful techniques are:

- analysis techniques for identifying incomplete goal refinements that could result from the previous goal elicitation phase.
- different goal refinement tactics and patterns to produce correct refinements.
- analysis techniques to identify correct agent assignment w.r.t. their monitor and control capabilities to fulfil their responsibilities.
- obstacle analysis to make sure goals are not overidealistic with respect to adverse events. This can also be identified by analysing process KPIs, i.e. level of goal satisfaction.
- obstacle resolution techniques such as avoidance, mitigation, goal deidealisation.

Those techniques are fully detailed in GORE literature with can be explored through (van Lamsweerde, 2009). Considering our case study, an example of problem revealed by the BPMN model at the goal level is that the shipment tracker is in charge of monitoring the status of the Eurotunnel. This design is not very efficient because monitoring is best performed by a dedicated software agent such as a CEP (Complex Event Processing) software agent. In the goal

Table 2: Model-to-model mapping between business process model (BPMN) and goal model (KAOS).

BPMN	KAOS	Comment	Source
Process/Subprocess	goal/sub-goal	to be stated as achieve goal	(de la Vara et al., 2013) (Rebeca Alves, 2013)
Sequence	AND milestone	parent is enclosing business process	(Horita et al., 2014)
XOR split	AND case-based	parent is enclosing business process	(de la Vara et al., 2013) (Horita et al., 2014)
Incoming flow from user/env.	Expectation	Process expects some input otherwise it could block (e.g. on message wait)	(Horita et al., 2014)
Loop with guard	AND refinement	with until pattern in guarded sub-process	(Horita et al., 2014)
Control flow	agent-driven refinement	inside the system (if across corridors) between system and env. (if across pools)	authors' contribution
Escalation	case-based responsibility	see the escalation condition	authors' contribution
Message/timer/ signal/condition (as interrupt event)	OR or case-based AND	check the condition, could also result from obstacle resolution	authors' contribution
Transaction/ compensation	Transaction pattern	Complete final state enforced or initial state should be restored	authors' contribution
Error/Cancellation (as start event)	Obstacle resolution	See obstacle management strategies (e.g. restore state/mitigation)	authors' contribution
Error/Cancellation (as border event)	Obstacle resolution	See obstacle management strategies (e.g. weakening/mitigation)	authors' contribution

model of Figure 9, a new software agent is introduced to detect Eurotunnel delays (but possibly other impacting conditions) and inform the shipment tracker who will can then focus on notifying and tracking the trucks. Other strategic evolution could also be introduced such as the need for an extra activity to prepare border control due to the Brexit (see obstacle in red).

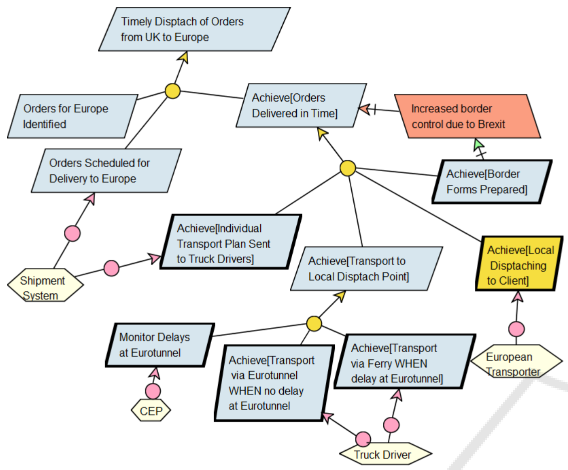

Figure 9: Ideal transport process (with KAOS syntax).

4.3 Process Level Redesign

The BPMN model should then be revised with this goal perspective to reflect the changes in the goal model. This is partly supported by the mapping given in Table 2. More generally this step is following the usual design flow and does not pose much problems.

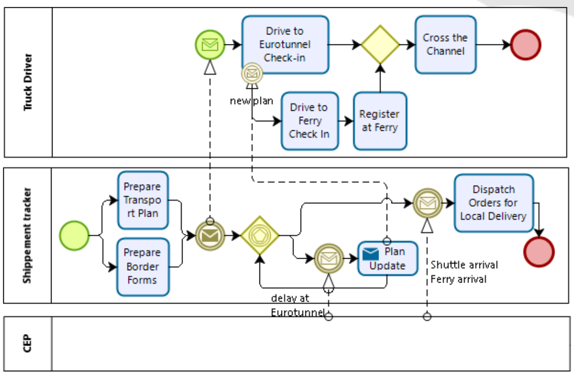

Figure 10: Revised transport process after goal analysis.

Note there is some room left for implementation level decisions as long as the goal is enforced. For example, the new requirement to produce a border form can be enforced as a new activity either parallel or sequential with the existing preparation of the transportation plan. In our case, we selected the former as it is more general. The final revised process is shown in Figure 10. The new lane at the bottom corresponds to the new CEP agent which monitors possible delays and arrival events. The shipment tracker is now in charge of monitoring and reacting to such events through an event-based gateway. The truck driver lane is unchanged except the delay notification is now generated by the CEP and send by the shipment tracker.

5 DISCUSSION AND RELATED WORK

The problem of relating business processes and goals has received quite some attention with several proposed mappings (Koliadis et al., 2006), (Rebeca Alves, 2013), (de la Vara et al., 2013), (Horita et al., 2014). Our approaches build on top of them.

The GoalBPM methodology proposes a bi-directional mapping and satisfaction verification between operational BPMN and goal models both for i* and KAOS in order to ensure their co-evolution (Koliadis et al., 2006; Koliadis and Ghose, 2006). The method also relies on clues to establish the required traceability links but do not provide any heuristics as we do. However, it introduces a consistency check using normal and exceptional trajectories which relates to our notion of obstacle.

Considering more specifically the KAOS approach, the Goal-Oriented Business Process Modelling Notation (GO-BPMN) is a language enhancing standard BPMN with support for the explicit modelling of goals, plans and their relationships (Greenwood and Ghizzioli, 2009). A GO-BPMN model consists of a set of goal hierarchies (similar to KAOS) that must be achieved or maintained. Leaf goals (i.e. requirements) are related to at least one plan describing the activities to be performed. Although it combines goals and processes, GO-BPMN is however focusing more on autonomous run-time adaptation of systems than on supporting a more general redesign process for which it does not define useful tools.

A recent survey also reported that the most commonly used techniques are i* and Key Performance Indicators (KPI) for strategic goals and Business Process Model and Notation (BPMN) for business processes (Carmo et al., 2017). KAOS, used here, is less popular but offers a clear semantics that can be transposed to those more popular notations. The problem of dealing with NFR is also still open and our work only devoted a limited attention to it.

A distinctive characteristic of our approach is the ability to keep the goal analysis implicit in a first attempt to improve the processes and if necessary to perform a deeper analysis and redesign based on an explicit goal model. Some indicators triggering the need to build a goal model are the discovery of undocumented goals through the use of Table 1 or the use of complex redesigns going beyond simple actions like adding some activity of a transfer of responsibility. Note Table 1 supports the analysis process and discovery of goals while Table 2 is more a syntactic instrument to help in the building a goal model if partial or not available.

6 CONCLUSION AND FUTURE WORK

This work considered the problem of the poor attention to goals in business process models and more specifically the widely used BPMN standard which focuses essentially on the "who/when/how" operational dimensions rather than on providing rationales about the "why/who" dimensions. Our proposal is in line with previous work and is structured in two approaches: a lightweight approach that does not try to build an explicit goal model for improving BPMN models and a more powerful one that relies on the construction of such a model. For the implicit goal approach, we proposed support under the form of guidelines derived from goal analysis principles applied to generic process constructs. For the explicit goal approach, we refined existing mappings to build a goal model in order to apply goal analysis techniques on it. Our experiment on a small logistics model shows its applicability and benefits proportional to the considered approach.

Our work is still in progress as we are now evolving the guidelines for the implicit approach under the form of a more consistent knowledge base. For the explicit approach, we are prototyping tool support base on an EMF model-to-model transformation according to the meta-models sketched in Section 2. We also plan to conduct experiments with novice and more experienced modellers to assess our current mappings and to improve them.

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