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# Hybrid Process Technologies in the Financial Sector: The Case of BRFKredit

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## Abstract

- (a) **Situation faced:** Exformatics, a Danish adaptive case-management vendor, wanted to leverage declarative process tools to support the flexible processes found at BRFKredit. However, switching from the more common flow-based notations to a declarative notation brought new challenges in terms of understandability. We undertook the project described in this chapter to investigate and address these challenges.
- (b) **Action taken:** We started our investigation by having several full-day and half-day meetings to discuss BRFKredit's requirements. Based on these requirements, we proposed and developed a prototype hybrid process-modelling approach with which models are defined declaratively, but the possible behavior of the model can be viewed and investigated using flow-based notions. The prototype was then presented to BRFKredit for feedback.
- (c) **Results achieved:** Our investigation helped to clarify the requirements for making declarative process models understandable to end users at BRFKredit and showed how a hybrid approach could be used to satisfy these requirements. Based on these insights, we developed tools to enhance our existing declarative modelling framework with flow-based visualizations.

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- (d) **Lessons learned:** Different stakeholders have different needs and preferred levels of abstraction when process models are used as tools for communication. However, one model that seems to fit most situations is a simple no-branches sequential swimlane diagram that was extracted automatically from a more detailed declarative model. These observations enabled Exformatics to enhance its declarative modelling framework to make it more attractive to end-users.

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## 1 Introduction

This chapter describes an investigation by Exformatics A/S, a Danish vendor of adaptive case-management (ACM) solutions, into the feasibility of applying its declarative workflow modelling and execution engine in the financial sector. This investigation was carried out in collaboration with the Process and System Models Group of the IT University of Copenhagen and BRFkredit, a Danish mortgage credit institution.

In order to accommodate the diverse requirements of BRFkredit's process models, Exformatics extended its declarative modelling tools to derive from any model representative traces and other relevant flow-based visualizations. Through this extension, the tools now support a hybrid modelling approach in which processes are modelled declaratively based on their underlying business rules, but the behavior supported by the model can be visualized in more familiar flow-based notations, both in full and as representative traces. The new hybrid's features and the broader perspectives of the technology were well received by BRFkredit, but a more thorough evaluation with more users and case studies is needed before any firm conclusions on their use in practice can be drawn.

Exformatics A/S has a customer base of approximately forty organizations, both Danish and international and both private and public. Exformatics' core product is a case-handling system for knowledge workers like lawyers who work with intellectual property protection or real estate management, engineers and project managers who design and construct large power plants, marketing employees who plan campaigns for broadcasting, and case workers in areas like human resources, political hearings, and workforce-related political issues.

Exformatics believes in the need for formal workflow modelling notation as a way to

- strengthen communication of requirements from client organizations
- strengthen communication within client organizations post-deployment
- expedite development
- enable run-time system updates

However, for its current clientele of knowledge workers, Exformatics has found flow-based modelling notations insufficiently flexible. The cases Exformatics' clients handle are in some ways uniform, yet never actually equal. They typically follow a common set of rules, but the details of each individual case invariably differs a great deal. Hence, Exformatics co-developed and adopted a declarative workflow modelling notation, DCR Graphs, originally conceived at the Process and Systems Models Group of the IT University of Copenhagen, which is headed by Thomas Hildebrandt.

Exformatics has invested considerable resources into bringing DCR Graphs from an academic vision to a practical, marketable product in the form of a process-Execution Engine and Workflow-Modelling Toolkit (Marquard et al. 2015). The former has been deployed in Exformatics' solutions, most notably with a complete model of the workflow of the Danish foundation, Dreyers Fond (Debois et al. 2014).

However, the use of formal workflow modelling has, from the perspective of the customer, been an implementation detail, a technical "trick" Exformatics uses to speed implementation. Exformatics' vision is that (suitably authorized) expert end users should be able to update or even create models themselves, with the Exformatics Process-Execution Engine automatically reflecting such updates. With that vision in mind, Exformatics has been looking for a mature process-intensive, knowledge-worker-heavy company, preferably in the financial sector, with which to experiment with the possible future directions of Exformatics' Workflow-Modelling Toolkit.

Such a company was found in Danish mortgage credit institution BRFKredit. In late 2014, a formal collaboration was established among Exformatics A/S, IT University of Copenhagen, BRFKredit, and Visuel IT within the purview of and financially supported by the Copenhagen Fintech Innovation and Research Network (CFIR).

BRFKredit is a Danish mortgage credit institution that lends against collateral on owner-occupied homes, commercial properties, and subsidized housing. On the Danish housing market, mortgage loans are not typically taken out from a bank but from specialized credit institutions like BRFKredit, that issue mortgage bonds that pool together many borrowers and investors, thereby spreading the associated risk.

BRFKredit's loans for residential purposes account for the majority of its lending while corporate lending is done for office and business properties, private rentals, and cooperative housing. BRFKredit finances its current lending by continuously issuing covered bonds and mortgage bonds, that is, as tap issues.

BRFKredit A/S is owned by Jyske Bank A/S through the holding company BRFholding A/S. BRFKredit's market share of the total Danish mortgage market is approximately 8%. Jyske Bank/BRFKredit is Denmark's fourth-largest financial institution. BRFKredit has lending of around DKK 213 billion (approx. EUR 28 billion) distributed on around 120,000 mortgage loans that are managed by just over 750 full-time employees.<sup>1</sup>

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<sup>1</sup>BRFKredit in Brief. Accessed August 2015 at <http://www.brf.dk/Investors/About-BRFKredit/Additional-information/BRFKredit-in-brief>

## 2 Situation Faced

Exformatics adopted a declarative notation because of a strong belief in their clients' need for flexibility. Knowledge-worker end users are the experts and should be inhibited in their possible actions only if required by law or business rules. As the academic literature often claims (Pesic and Schonenberg 2007), Exformatics contends that declarative notations are better suited for describing such laws and business rules than imperative or flow-based notations are.

However, declarative notations have been shown to be more challenging for end users to understand than are more common flow-based notations, such as BPMN (Zugal et al. 2014). Hence, the primary objective of the investigation for Exformatics was to determine how the DCR Graph process modelling can be made more accessible to expert end users. A secondary objective was to determine the motivation for and role of manual process modelling in financial institutions and the applicability of DCR Graphs to the same. Another secondary objective was to carry out a practical (yet anecdotal) test of the hypothesis that potentially collaborative simulation can be a useful tool for expert end users' work with process models. Exformatics places a high priority on support for simulation in its tool offerings (Marquard et al. 2015), contending that the ability to simulate and "play through" a process will help users understand the ramifications of a particular declarative model.

### 2.1 The Context of BPM in BRFKredit

Viewed in terms of the BPM Context Framework (Brocke et al. 2016) the focus of BPM initiatives at BRFKredit has been on *exploitation*, that is, using process models primarily to help case workers determine how to handle their cases while remaining compliant.

Both *core processes* and *support processes* are modelled. Examples are process descriptions of loans' lifecycles and models the customer service department use to determine how to respond to customer inquiries. As BRFKredit targets regular consumers with standardized loan options, most processes are highly *repetitive*. Processes are typically *highly knowledge-intensive*, and the case workers are required to have a deep understanding of the mortgage products offered. A *medium level of creativity* is required of the workers: The options for a particular loan can be highly diverse and can depend on a customer's unique situation, but unique cases also tend to be outliers, and many customers fall into common classes for which the best solution has been determined and little creative thought is required. There is a *medium level of interdependence* at play: Many of the processes interact on some level; for example, customer-service processes typically depend on the status of the customer's loan process. The processes at BRFKredit are *highly variable*: Not only is there a significant amount of variability in the products (loans) offered, but the case workers also have considerable flexibility in how they support customers, leading to a high degree of variability how activities are ordered and how they occur.

Most of the processes at BRFkredit are *inter-organizational* in the sense that each department has its own organizational structure, and most processes span many departments. As a mortgage institution, BRFkredit is a *large organization* that falls mostly within the *service industry*, as while the loans can be seen as products, they are not physical products. The culture at BRFkredit is *highly supportive* of BPM practices, with BPM diagrams of important processes adorning the hallways around the case workers' offices, so a *significant amount of the organization's resources* is dedicated to creating and maintaining these diagrams. Finally, the BPM activities at BRFkredit are performed in a *medium-level competitive environment* with a *medium level of uncertainty*.

## 2.2 Related Work

The direction taken in this project relates closely to the recently initiated work on hybrid business process modelling notations and technologies that seeks to combine the strengths of the flow- and constraint-based process modelling paradigms (Reijers et al. 2013). A common approach in this field is to provide hybrid modelling notations that combine both flow- and constraint-based elements (De Giacomo et al. 2015; Sadiq et al. 2001; van der Aalst et al. 2009; Westergaard and Slaats 2013). Our approach, on the other hand, uses the two paradigms separately: a constraint-based notation is used to model the process, whereas a flow-based notation is used to gain insight into the behavior supported by the models. This approach relates closely to recent work (De Smedt et al. 2015; Prescher et al. 2014) on mapping from the declarative Declare (Pesic and Schonenberg 2007) notation to Petri nets; however, contrary to the work presented here, these techniques are not being used in commercial tools or being applied to industrial case studies.

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## 3 Action Taken

The investigation took the form of a sequence of full- and half-day meetings in early spring 2015 in which BRFkredit's needs for process modelling and the required extensions to the DCR Graphs tools to meet those needs were discussed. The present case study reports only on the conclusion of these discussions.

The objective of process modelling at BRFkredit is to communicate within the company. The constructed models are then used by stakeholders that include the IT department, which uses process descriptions as partial requirements specifications for IT systems that support new and updated financial products; caseworkers, who use process models as roadmaps for their daily work; and management (at multiple levels), who use process models as abstracted views of "what goes on in the company."

For BRFkredit, process modelling has enough value as a communication tool alone to merit allocating resources to its construction and maintenance. However, BRFkredit reported that its use of such models faces two major challenges:

Different stakeholders use different process-model notations, and the level of abstraction that is appropriate for a model depends on the stakeholder who uses it.

We treat each of these challenges in turn.

### 3.1 Different Stakeholders Use Different Notations

Attempts to introduce a small subset of BPMN as a standard modelling notation used everywhere in BRFkredit have not been successful. Most departments, including IT, find that notation unhelpful, not because those stakeholders are adverse to process modelling but because some departments have produced their own extensive and comprehensive models of their processes for internal consumption.

These models appear to have two primary commonalities across departments<sup>2</sup>: First, the models are trace models—that is, each model describes a single “happy-path”—the most common variant of a particular process—of the process in question—and typically include little or no possibility to choose between activities or reordering them. Second, the models heavily emphasize roles, whether occupied by humans or IT systems. Diagrams are invariably some form of swim-lane diagrams that are typically produced in PowerPoint.

The emphasis on single traces over branching models is in line with recent research on the understandability of process models (Haisjackl et al. 2013; Zugal et al. 2011). It appears that, for the majority of stakeholders, understandability far outweighs precision or generality when it comes to models’ usefulness as tools for communication. For discussion and communication, a representation of a single “happy path” is far more helpful than a branching model like BPMN, as the greater precision afforded by the branching model sours discussion by bringing in irrelevant detail.

Where detail is required—when process models are used as requirements-specification for IT or when process model are used as roadmaps for caseworkers—BRFkredit simply produces more single-trace models. For example, the processes for granting various kinds of mortgages have grown to more than a thousand. BRFkredit mentions that this approach is burdensome when internal processes change, such as in response to changes in business requirements or the regulatory climate. It is likely that the large number of processes can profitably be represented as minor variations on a small number of core processes.

In a large company like BRFkredit, difficulties in agreeing on notation go beyond process notation. For example, a seemingly simple and precise notion like “client” means different things to different departments: For the sales department, the client is a person who might be interested in obtaining a mortgage, while for the Loan Monitoring department, the client is someone who has an active loan with BRFkredit, and so forth.

The differences in (ad hoc) model notations and terminology have the unfortunate consequence that two diagrams, one depicting a process as seen by IT and one

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<sup>2</sup>For confidentiality reasons, we cannot include actual examples of the various customized models.

as seen by sales, may result in the observer's failing to realize that the two diagrams depict aspects of the same process.

### 3.2 The Level of Abstraction Appropriate for a Model Depends on the Stakeholder Who Uses It

This challenge is most easily explained by example. For instance:

- Caseworkers need process descriptions that show only the process variant on which they are working on and need not know details about the underlying IT processes.
- Sometimes managers need process descriptions that are precise about interactions between departments but do not contain details about what goes on inside departments.
- At other times managers need process descriptions that describe only the part of processes that pertain to particular (financial) products or product lines.
- IT needs process descriptions that contain every possible process variant and full detail on the process's interaction with IT systems, but IT does not care at all about human interactions (e.g., prospective client meetings).

Reconciling differences in terminology in a large organization is a problem beyond the scope of process modelling, so we focus on notation.

### 3.3 Regarding Differences in Notations

We contend that the differences in the process notations employed at BRFKredit do not arise from any inherent difference in the preference for modelling notations but from the absence of a single notation that is suitable for all stakeholders. BPMN is apparently not it, not for want of flexibility but simply because of its plethora of symbols and less than intuitive semantics.

Recall the observation that most of the ad-hoc diagrams with which we have been presented present only a single trace with precise distinction between roles. That notation is, then, apparently the appropriate notation for the majority of stakeholders. As such, we envision a mechanism for presenting process models in terms of a small number of representative traces. This idea fits well with the idea of declarative or constraint-based process modelling: A declarative model is a concise representation of a typically large number of admissible traces with semantics that allow us to compute efficiently whether a trace is admissible (Pesic and Schonenberg 2007). If BRFKredit's processes were represented as a single or, more realistically, a small number of general processes, one could extract from these models representative traces that "represent" the process in internal communications.

This idea begets the question: Which traces? Among all the possible traces admitted by our hypothesized general model, how do we find an appropriate set of representative traces?

We contend that, in a given process model, we can name activities whose execution is the objective of the process. In the case of BRFkredit, the objective of, say, an instance of a mortgage application process is the evaluation of that application. Variants of that process arise as different opportunities present themselves for reaching that goal. For instance, in one variant the value of the property that secures the mortgage can be appraised statistically, without a visual inspection. Another variant arises when the property is in an insufficiently uniform neighborhood, so the process model's constraints forbid the statistical appraisal.

In summary, at least in this instance, the process's objective can be defined as the execution of a particular activity (e.g., "assess loan application"), and the process's variants can be identified by which activities are executed in pursuit of that objective (e.g., "statistical appraisal" or "on-site appraisal").

This approach yields a method for identifying relevant traces: Domain experts, who must be consulted anyway when one is constructing the model, help to figure out which activities characterize the process's objective and the key activities that identify (collections of) process variants.

### 3.4 Regarding Differences in the Appropriateness of Abstractions

For the single-trace model representatives suggested above, determining the appropriateness of an abstraction is simply a matter of projecting the trace in question, that is, leaving out activities that are unwarranted at the desired level of abstraction.

**Example 1** Caseworkers need process descriptions that show only the process variant on which they are working and need not know details about the underlying IT processes. Proposed solution: Given a complete trace, remove all activities that do not directly involve the caseworker.

**Example 2** Sometimes managers need process descriptions that are precise about the interactions between departments but do not contain details about what goes on inside departments. Proposed solution: Given a complete trace, remove all activities that are not adjacent to an activity of a different department.

**Example 3** At other times managers need process descriptions that describe only the part of the processes that pertain to particular (financial) products or product lines. Proposed solution: Look for a trace that concludes in, say, "assess additional loan application" to fulfil this requirement in part.

**Example 4** IT needs process descriptions that contain every possible process variant and full detail on interactions with IT systems but does not care at all

about human interactions (e.g., prospective client meetings). Proposed solution: In this case, where we do need branching structure, the picture is less clear. For IT, process descriptions often play a role as part of a requirements specification, so the process model must describe all of (and only) the desired system’s behavior. However, we may assume minimal sophistication with formal models and so use the general DCR model as the appropriate model.

For DCR graphs, the possibilities for semantically well-founded projection has been well studied, so getting rid of “human interactions” in amounts to employing one of the known sound projection methods (Hildebrandt et al. 2011).

### 4 Results Achieved

To present the ideas of Sect. 3 to BRFKredit staff, Exformatics extended its existing workflow modelling tool with a proof-of-concept analysis tool that (a) presents projected traces and (b) generates minimal traces that are executing or not executing given activities.

The tool presupposes a single DCR Graph-based process model that encompasses a family of processes, including a particular class of mortgage loan application processes. For confidentiality reasons, we cannot report on an actual model here, but we constructed a fictional and somewhat simplified process that is heavily inspired by the actual processes at BRFKredit. This DCR Graph model is presented in Fig. 1 and can be found as a public graph (BPM 2015 BRF Example) at <http://dcrgraphs.net>. Boxes indicate activities and arrows indicate constraints.

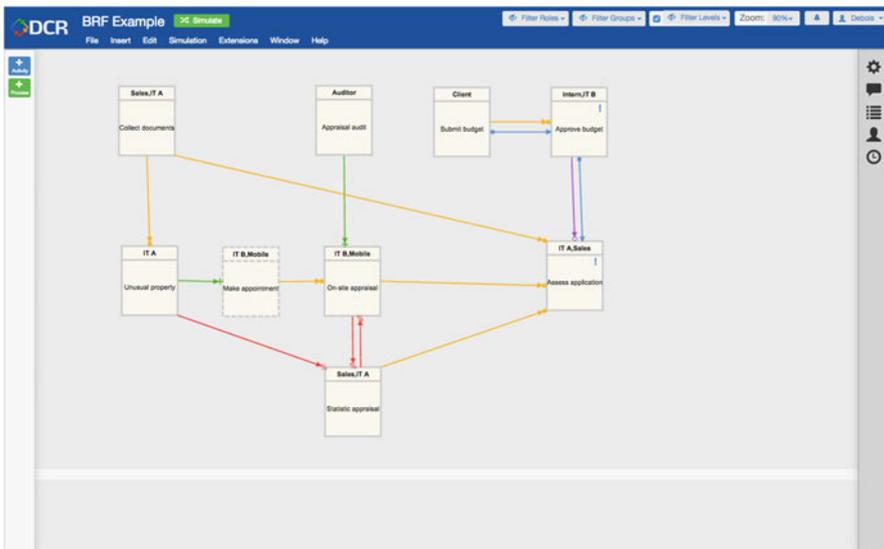


Fig. 1 DCR Graph model of a (simplified) mortgage loan application process.

Each *box* is labelled (in the *middle*) with the name of the activity and (at the *top*) with the roles that participate in the activity. The *arrows* with a *bullet* in the end (*yellow* in the tool) indicate conditions, so we cannot “Assess application” before we have executed, among other processes, “Collect documents.” *Arrows* with a *bullet* at the beginning (*blue* in the tool) indicate required responses, so whenever “Submit budget” is executed—that is, whenever the prospective client updates his or her budget—“Approve budget” must be executed again. The graphic notation for conditions and responses is consistent with the notation for precedence and response constraints used in DECLARE (Pesic and Schonenberg 2007). The *arrows* with % and + at the end (and *red* and *green* in the tool) indicate exclusion and inclusion, respectively; *arrows* with *diamonds* at the end (*purple* in the tool) represent “milestones”; however, it is not necessary to understand these in detail to read the remainder of this report, so we omit further details and refer the reader to previous papers on DCR Graphs [e.g. (Debois et al. 2014; Hildebrandt and Mukkamala 2010)] for more details.

This model is only potentially suitable for the IT stakeholders as a requirements specification for implementation purposes. Accordingly, using Exformatics Workflow Editing Tool’s plug-in infrastructure, we constructed a plug-in that provides perspectives on this model to be used by the other stakeholders (caseworker and management). One such perspective is the full state-space of the DCR Graph model in a flow-graph notation; this representation provides the full detail of the model, including branching structure (decision points), so it can be helpful for implementors, but it is generally far too detailed. The example in Fig. 2 shows the complete (but somewhat overwhelming) picture.

For stakeholders who are interested in representative traces, the prototype tool has a panel for specifying such, as illustrated in Fig. 3.

Figures 4 and 5 show examples of input constraints and the resulting trace.

Starting from the same constraints, we may restrict our attention to different roles. Figures 5 and 6 exemplify such different perspectives of the constraints entered in Fig. 4.

The new tool aims primarily at the *process analysis* stage of the BPM Lifecycle Model (Dumas et al. 2013) by making visible to the user what paths are and are not allowed by the declarative model. However, the tool can also be used as a part of the *process implementation* stage: If the user is interested only in executing particular happy paths that are allowed under the declarative rules, then they can be generated using the tool and used as executable process models instead of the more flexible declarative model.

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## 5 Lessons Learned

During the project we made a number of useful observations on the use of business process models at BRFkredit:

1. BRFkredit uses process modelling primarily as an internal communication tool.

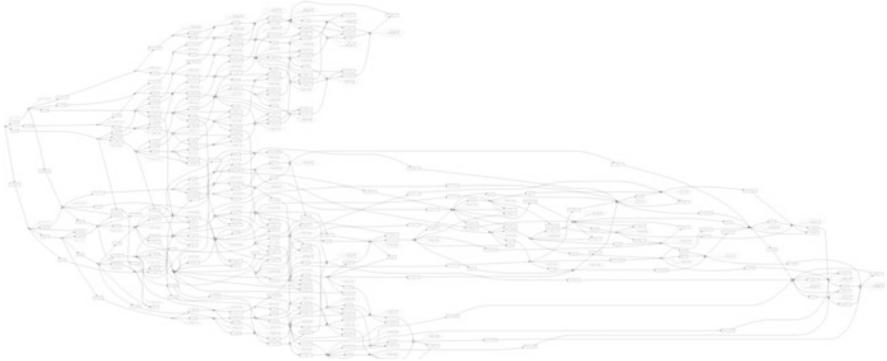


Fig. 2 Flow-graph representation of the model in Fig. 1

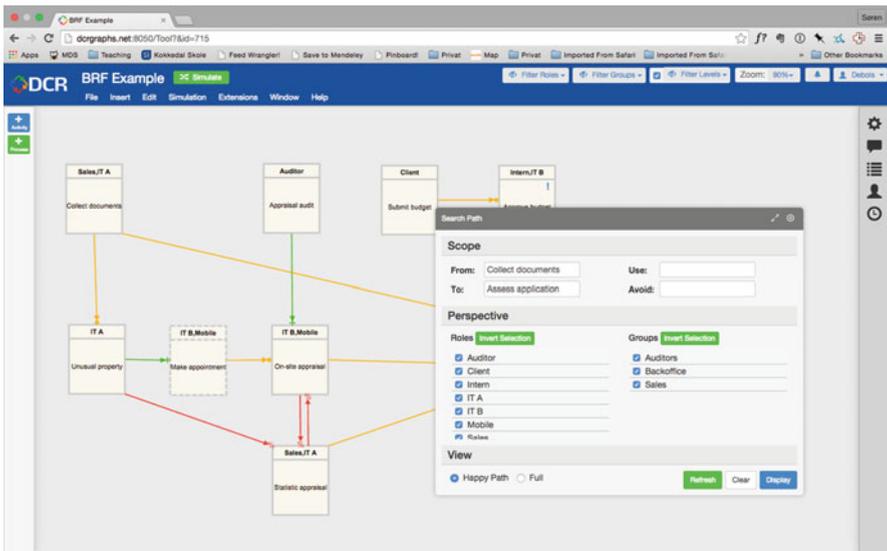


Fig. 3 Pop-up panel for specifying single-trace parameters. One specifies under “Scope” the activity that should be the starting point of the trace, the ending point, and optional activities that must or cannot occur along the way. Under “Perspective,” one may indicate a projection onto specific roles or groups. The tool will then find the shortest trace that satisfies the given constraints (e.g., variants of the loan application process in which the property in question needs an on-site appraisal) by searching through the transition graph

2. Different stakeholders have radically different uses for the resulting process models.
3. Different stakeholders prefer somewhat different process notations.
4. Many stakeholders are content with representing processes as “representative traces.”

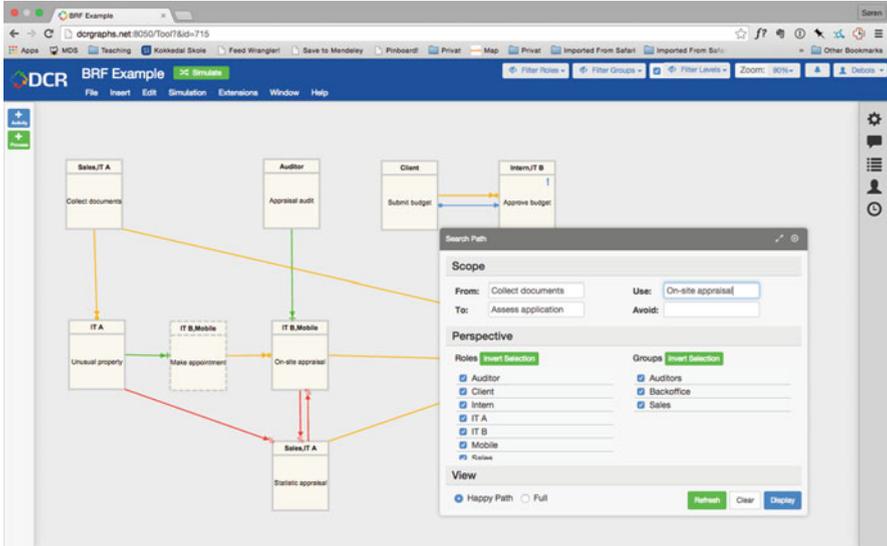


Fig. 4 Specification of a process variant requiring on-site appraisal

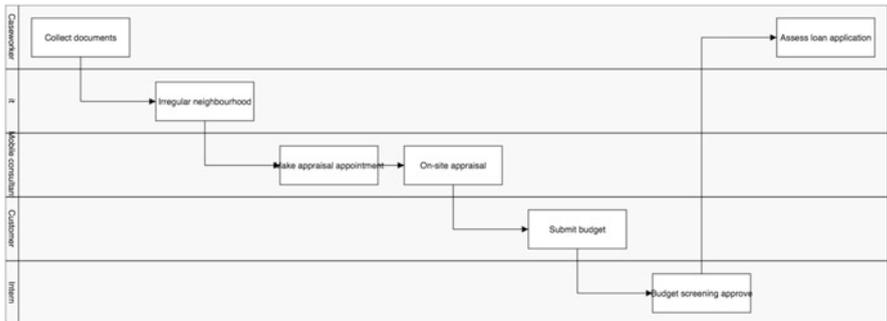
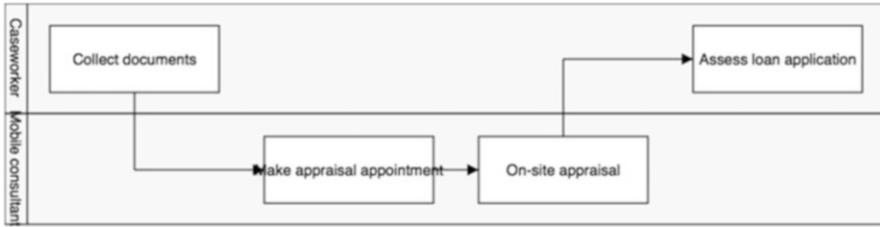


Fig. 5 Trace resulting from the parameters entered in Fig. 4

5. Such representative traces should contain only activities that are relevant to the business case at hand.

We speculate that many of these lessons can be observed at other large organizations as well, particularly in the financial sector.

Driven by these observations, Exformatics A/S extended the plug-in architecture for its Workflow Editing Tool to encompass the proof-of-concept technology reported here as an APP and evolved the proof-of-concept to an important feature of its current offering.



**Fig. 6** Trace resulting from the parameters entered in Fig. 4, but keeping only the “Mobile Consultant” and “Caseworker” roles

In conclusion, this case demonstrates anecdotally a clear need for different visualization of processes for different stakeholders. In addition, the proof-of-concept implementation of the semi-automatic generation of “representative traces” was well received by BRFkredit. Both of these points are likely independent of the concrete case presented here and the notation used, although it is also likely that the possibility of producing the projections depends on the use of a formal declarative model like DCR Graphs. The solution is available at <http://www.dcrgraphs.net>.

Based on these observations we propose that there is a clear opportunity for hybrid process modelling approaches that provide different views of the same process to the various stakeholders of a process. Exformatics has made a first step in this direction by incorporating functionality for the semi-automatic generation of “representative traces” in their declarative modeling tool, but there are many opportunities for improvements, both in terms of tool-development and research.

First of all, the proposed approach needs to be tested on a larger audience, following a rigid experimental methodology, to determine if the hybrid approach taken by Exformatics truly benefits the understandability of declarative models.

Secondly, more encompassing hybrid approaches could be tried: instead of only using flow-based models for the visualization of relevant traces, one could also combine modeling notations directly and produce truly hybrid models. Alternatively, one could adopt a methodology where a flow-based notation is used to capture specific instances of a process that are interesting to individual stakeholders and then use these models to verify the correctness of a general declarative model that captures all possible behaviors, which would be of greater interest to e.g. a programmer who is tasked with developing software that can support all potential uses cases of the process.

It is not clear yet if the notations chosen by Exformatics are those best suited to the hybrid approach. For example, by using purely sequential swimlane diagrams, they extremely limit the local behavior that can be presented to a stakeholder in a single diagram. It would be interesting to experiment with a larger subset of BPMN that also supports constructs such as choice and parallelism.

Finally, it would be interesting to investigate the possible application of hybrid models to other parts of the BPM lifecycle (Dumas et al. 2013), such as process implementation, monitoring and discovery.

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