Rule Based Business Process Compliance

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Abstract. In this paper we report on the development and evaluation of a business process compliance checker, based on the compliance-by-design methodology proposed by Governatori and Sadiq [9].
For a screencast see `http://www.youtube.com/watch?v=gFmDQJNai_4`

1 Introduction

Regulatory compliance is the set of activities an enterprise does to ensure that its core business does not violate relevant regulations, in the jurisdictions in which the business is situated, governing the (industry) sectors where the enterprise operates.

The activities an organisation does to achieve its business objectives can be understood as business processes, and consequently they can be represented by business process models. On the other hand a normative document (e.g., a code, a bill, an act) can be understood as a set of clauses, and these clauses can be represented in an appropriate formal language. Based on this [5] proposed that *business process compliance* is a relationship between the formal representation of a process model and the formal representation of a relevant regulation.

To gain compliance different strategies can be devised. [16] classifies approaches to compliance as *detective*, *corrective* and *preventative*.

Detective measures are intended to identify "after-the-fact" un-compliant situations. There are two main approaches: (a) *retrospective reporting* through manual audits by consultants or through IT forensics and Business Intelligence tools; (b) *automated detections* generating audit reports against hard-coded checks performed on the requisite system. Unlike the first approach, automated detection reduces the assessment time and consequently also the time of un-compliance remediation/mitigation.

Corrective measures are intended to limit the extent of any consequence caused by un-compliant situations. For example, situations that can arise from the introduction of a new norm impacting upon the business, to the organisation coming under surveillance and scrutiny by a control authority or to an enforceable undertaking.

The two approaches above suffer from lack of *sustainability*, caused by the extreme interest of companies in continuous improvements of the quality of services, and for changing legislations and compliance requirements. Indeed, even with automated detection means, the hard coded checking of repositories can quickly grow to a very large scale making it extremely difficult to evolve and maintain. To obviate these problem [17,13] propose a *preventative focus* based on the idea of *compliance-by-design*.

The key aspect of the compliance-by-design methodology is to supplement business process models with additional information to ensure that a business process is compliant with relevant normative frameworks before the deployment of the process itself.

2 BPCC Architecture

In this section we first introduce the architecture of BPCC, a business process compliance checker based on the business process compliance methodology proposed by Governatori and Sadiq [9].

As we have already discussed to check whether a business process is compliant with a relevant regulation, we need an annotated business process model and the formal representation of the regulation. The annotations are attached to the tasks of the process, and it can be used to record the data, resources and other information related to the single tasks in a process.

For the formal representation of the regulation we use FCL [4,8]. FCL is a simple, efficient, flexible rule based logic. FCL has been obtained from the combination of defeasible logic (for the efficient and natural treatment of exceptions, which are a common feature in normative reasoning) [1] and a deontic logic of violations [6]. In FCL a norm is represented by a rule

$$a_1, \dots, a_n \Rightarrow c$$

Where $a_1, \dots, a_n$ are the conditions of applicability of the norm/rule and c is the *normative effect* of the norm/rule. FCL distinguishes two normative effects: the first is that of introducing a definition for a new term. For example the rule

$$customer(x), spending(x) > 1000 \Rightarrow premium\_customer(x)$$

specifies that, typically, a premium customer is a customer who has spent over 1000 dollars. The second normative effect is that of triggering obligations and other deontic notions. The deontic notions covered by FCL are obligations[1], permissions, and reparation chains. For obligations FCL supports both maintenance obligations and achievement obligations, and for achievement obligations both pre-emptive and non-pre-emptive obligations (see [8] for full details). A reparation chair is an expression $O_1 c_1 \otimes O_2 c \otimes \cdots \otimes O_n c_n$, where each O_i is an obligation, and each c_i is the content of the obligation (modelled by a literal). The meaning of a reparation chain is that we have that c_1 is obligatory, but if the obligation of c_1 is violated, i.e., we have $\neg c_1$, then the violation is compensated by c_2 (which is then obligatory). But if even $O_2 c_2$ is violated, then this violation is compensated by c_3 which, after the violation of c_2, becomes obligatory, and so on.

It is worth noticing that FCL allows deontic expression (but not reparation chains) to appear in the body of rules, thus we can have rules like:

$$restaurant, [\mathrm{P}]sell\_alcohol \Rightarrow [\mathrm{OM}]show\_license \otimes [\mathrm{OAPNP}]pay\_fine.$$

The rule above means that if a restaurant has a license to sell alcohol (i.e, it is permitted to sell it, $[\mathrm{P}]sell\_alcohol$), then it has a maintenance obligation to expose the license ($[\mathrm{OM}]show\_license$), if it does not then it has to pay the fine ($[\mathrm{OAPNP}]pay\_fine$). The obligation to pay the fine is non-pre-emptive (this means it cannot be paid before the violation). For full description of FCL and its feature see [4,8].

[1] Note the obligations allow us to capture prohibitions; a prohibition is an obligation plus negation, for example the prohibition to smoke can be understood as the obligation not to smoke.

Finally, FCL is agnostic about the nature of the literals it uses. They can represent tasks (activities executed in a process) or propositions representing state variables.

Compliance is not just about the tasks to be executed in a process but also on what the tasks do, the way they change the data and the state of artifacts related to the process, and the resources linked to the process. Accordingly, process models must be enriched with such information. [17] proposes to enrich process models with semantic annotations. Each task in a process model can have attached to it a set of semantic annotations. In our approach the semantic annotations are literals in the language of FCL, representing the effects of the tasks. The approach can be used to model business process data compliance [10]

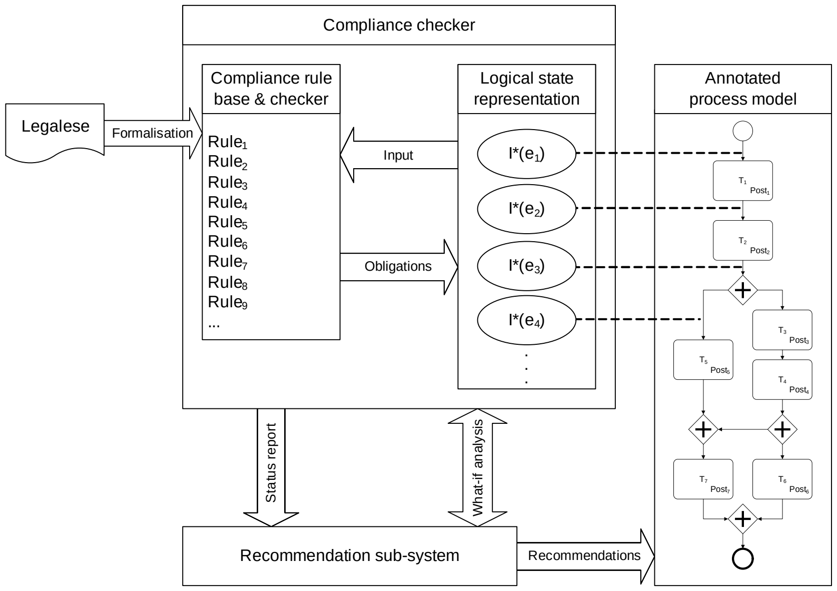

Compliance checker
Compliance rule base & checker
Logical state representation
Annotated process model
Legalese
Formalisation
Rule1 Rule2 Rule3 Rule4 Rule5 Rule6 Rule7 Rule8 Rule9 ...
Input
Obligations
l*(e1) l*(e2) l*(e3) l*(e4)
T1 Post1 T2 Post2 T3 Post3 T4 Post4 T5 Post5 T6 Post6 T7 Post7
Status report
What-if analysis
Recommendation sub-system
Recommendations

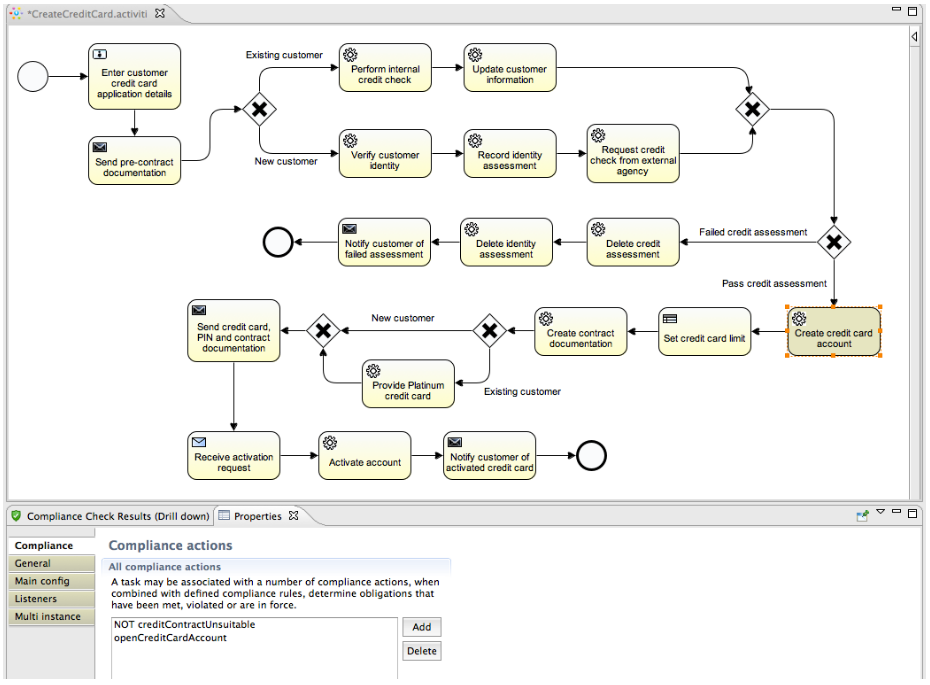
Fig. 1. Architecture of BPCC

Figure 1 depicts the architecture of BPCC. Given an annotated process and the formalisation of the relevant regulation, we can use the algorithm propose in [7,8] to determine whether the annotated process model is compliant. The process runs as follows:

– Generate an execution trace of the process.
– Traverse the trace:
  - for each task in the trace, cumulate the effects of the task using an update semantics (i.e., if an effect in the current task conflicts with previous annotation, update using the effects of the current tasks).
  - use the set of cumulated effects to determine which obligations enter into force at the current tasks. This is done by a call to an FCL reasoner.
  - add the obligations obtained from the previous step to the set of obligations carried over from the previous task.

    - determine which obligations have been fulfilled, violated, or are pending; and if there are violated obligation check whether they have been compensated.
- repeat for all traces.

A process is compliant if and only if all traces are compliant (all obligations have been fulfilled or if violated they have been compensated). A process is weakly compliant if there is at least one trace that is compliant.


*CreateCreditCard.activiti
Enter customer credit card application details
Send pre-contract documentation
Existing customer
New customer
Perform internal credit check
Update customer information
Verify customer identity
Record identity assessment
Request credit check from external agency
Failed credit assessment
Pass credit assessment
Notify customer of failed assessment
Delete identity assessment
Delete credit assessment
Send credit card, PIN and contract documentation
New customer
Create contract documentation
Set credit card limit
Create credit card account
Provide Platinum credit card
Existing customer
Receive activation request
Activate account
Notify customer of activated credit card
Compliance Check Results (Drill down)
Properties
Compliance
General
Main config
Listeners
Multi instance
Add
Delete

Compliance actions

All compliance actions

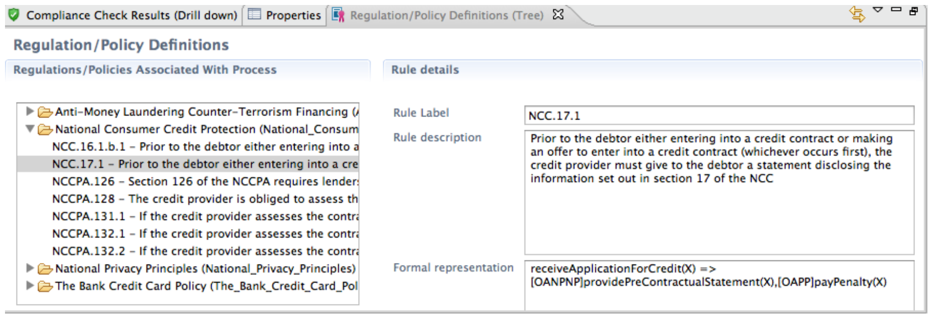
A task may be associated with a number of compliance actions, when combined with defined compliance rules, determine obligations that have been met, violated or are in force.

NOT creditContractUnsuitable
openCreditCardAccount

Fig. 2. An Opening Credit Card Account Process with Annotations in BPCC

3 Implementation and Evaluation

BPCC is implemented on top of Eclipse. For the representation of process models, it uses the Eclipse Activiti BPMN 2.0 plugin, extended with features to allow users to add semantic annotations to the tasks in the process model. BPCC is process model agnostic, this means that while the current implementation is based on BPMN all BPCC needs is to have a description of the process and the annotations for each task. A module of BPCC take the description of the process and generates the execution traces corresponding to the process. After the traces are generated, it implements the algorithm outlined in the previous section, where it uses the SPINdle rule engine [12] for the evaluation of the FCL rules. In case a process is not compliant (or if it is only weakly compliant) BPCC


Compliance Check Results (Drill down)
Properties
Regulation/Policy Definitions (Tree)

Regulation/Policy Definitions

Regulations/Policies Associated With Process

- Anti–Money Laundering Counter–Terrorism Financing (/
- National Consumer Credit Protection (National_Consum
  - NCC.16.1.b.1 – Prior to the debtor either entering into a
  - NCC.17.1 – Prior to the debtor either entering into a cre
  - NCCPA.126 – Section 126 of the NCCPA requires lender:
  - NCCPA.128 – The credit provider is obliged to assess th
  - NCCPA.131.1 – If the credit provider assesses the contr
  - NCCPA.132.1 – If the credit provider assesses the contr
  - NCCPA.132.2 – If the credit provider assesses the contr
- National Privacy Principles (National_Privacy_Principles)
- The Bank Credit Card Policy (The_Bank_Credit_Card_Pol

Rule details

Rule Label: NCC.17.1

Rule description: Prior to the debtor either entering into a credit contract or making an offer to enter into a credit contract (whichever occurs first), the credit provider must give to the debtor a statement disclosing the information set out in section 17 of the NCC

Formal representation:

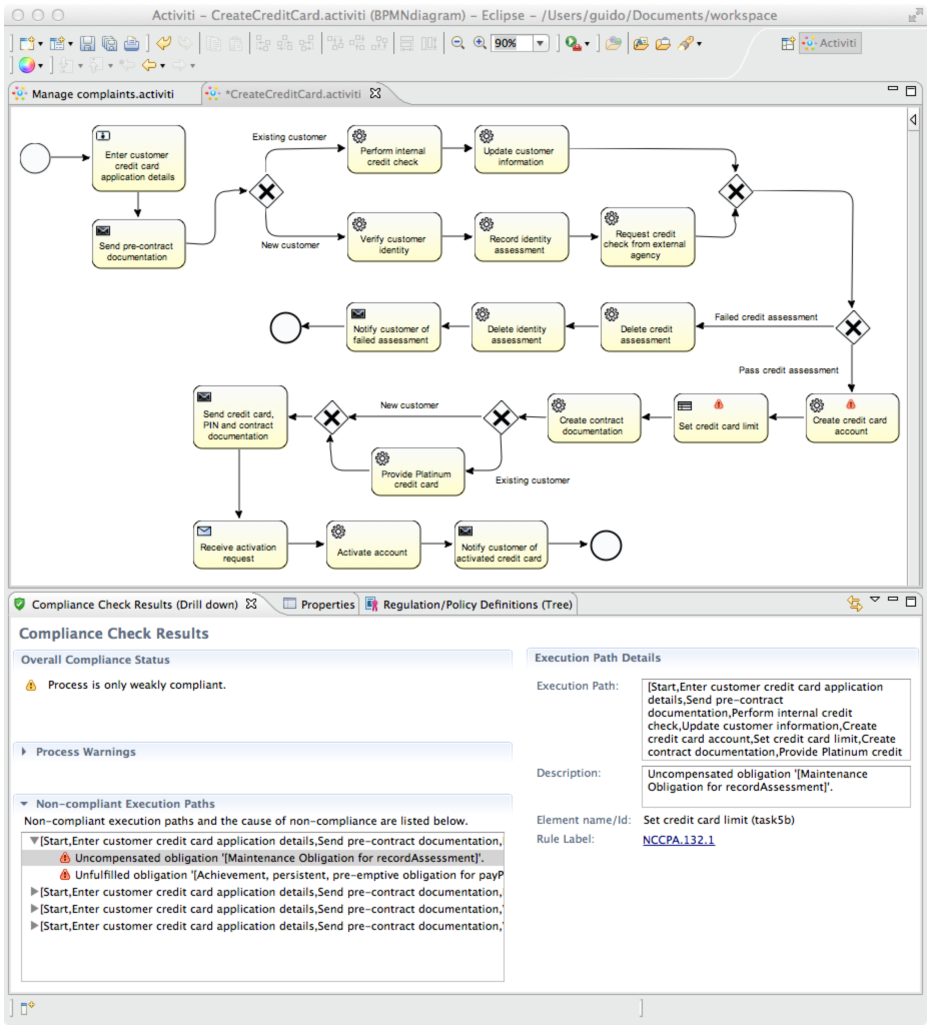
```
receiveApplicationForCredit(X) =>
[OANPNP]providePreContractualStatement(X),[OAPP]payPenalty(X)
```

Fig. 3. Regulations Relevant to the Opening Credit Card Process

reports the traces, tasks, rules and obligations involved in the non compliance issues (see Figure 4).

BPCC was tested against an 2012 Australian Telecommunications Customers Protection Code (C628-2012). The code is effective from September 1st 2012. The code requires telecommunication operators to provide annual attestation of compliance with the code staring from April 1st 2013. The evaluation was carried out in May-June 2012. Specifically, the section of the code on complaint handling has been manually mapped to FCL. The section of the code contains approximately 100 commas, in addition to approximately 120 terms given in the Definitions and Interpretation section of the code. The mapping resulted in 176 FCL rules, containing 223 FCL (atomic) propositions, and 7 instances of the superiority relation. Of the 176 rules 33 were used to capture definitions of terms used in the remaining rules. Mapping the section of the code required all features of FCL: all types of obligations apart punctual obligations were used, reparation chains, permissions, defeasibility to easily capture exceptions, and obligations and permissions in the body of rules.

The evaluation was carried over in cooperation with an industry partner subject to the code. The industry partner did not have formalised business processes. Thus, we worked with domain experts from the industry partner (who had not been previously exposed to BPM technology, but who were familiar with the industry code) to draw process models for the activities covered by the code. The evaluation was carried out in two steps. In the first part we modelled the processes they were. BPCC was able to identify several areas where the existing processes were not compliant with the new code. In some cases the industry partner was already aware of some of the areas requiring modifications of the existing processes. However, some of the compliance issues discovered by the tools were novel to the business analysts and were identified as genuine non-compliance issues that need to be resolved. In the second part of the experiment, the existing processes were modified to comply with the code based on the issues identified in the first phase. In addition a few new business process models required by the new code were designed. As result we generated and annotated 6 process models. 5 of the 6 models are limited in size and they can be checked for compliance in seconds. The largest process contains 41 tasks, 12 decision points, xor splits, (11 binary, 1 ternary). The shortest path in the model has 6 tasks, while the longest path consists of 33 tasks (with 2 loops), and the


Activiti – CreateCreditCard.activiti (BPMNdiagram) – Eclipse – /Users/guido/Documents/workspace
90%
Activiti
Manage complaints.activiti
*CreateCreditCard.activiti
Enter customer credit card application details
Send pre-contract documentation
Existing customer
New customer
Perform internal credit check
Update customer information
Verify customer identity
Record identity assessment
Request credit check from external agency
Failed credit assessment
Pass credit assessment
Notify customer of failed assessment
Delete identity assessment
Delete credit assessment
Send credit card, PIN and contract documentation
New customer
Create contract documentation
Set credit card limit
Create credit card account
Provide Platinum credit card
Existing customer
Receive activation request
Activate account
Notify customer of activated credit card
Compliance Check Results (Drill down)
Properties
Regulation/Policy Definitions (Tree)

Compliance Check Results

Overall Compliance Status

Process is only weakly compliant.

Process Warnings

Non-compliant Execution Paths

Non-compliant execution paths and the cause of non-compliance are listed below.

```
▼[Start,Enter customer credit card application details,Send pre-contract documentation,
    Uncompensated obligation '[Maintenance Obligation for recordAssessment]'.
    Unfulfilled obligation '[Achievement, persistent, pre-emptive obligation for payP
▶[Start,Enter customer credit card application details,Send pre-contract documentation,
▶[Start,Enter customer credit card application details,Send pre-contract documentation,
▶[Start,Enter customer credit card application details,Send pre-contract documentation,
```

Execution Path Details

Execution Path:	[Start,Enter customer credit card application details,Send pre-contract documentation,Perform internal credit check,Update customer information,Create credit card account,Set credit card limit,Create contract documentation,Provide Platinum credit
Description:	Uncompensated obligation '[Maintenance Obligation for recordAssessment]'.
Element name/Id:	Set credit card limit (task5b)
Rule Label:	NCCPA.132.1

Fig. 4. BPCC report of traces, rules, and tasks responsible for non-compliance

longest path without loop is 22 task long. The time taken to verify compliance for this process amounts approximately to 40 seconds on a MacBook Pro 2.2Ghz Intel Core i7 processor with 8GB of RAM (limited to 4GB in Eclipse).

4 Conclusions

We reported on the development of a tool, BPCC, for checking the compliance of business processes with relevant regulations. The BPCC was successfully tested for real industry scale compliance problems. In the recent years, a few other compliance prototypes have been proposed: MoBuCom [15], Compass [2] and SeaFlows [14]. MoBuCom and Compass are based on Linear Temporal Logic (LTL) and mostly they just address "structural compliance" (i.e., that the tasks are executed in the relative order defined by a constraint model). The use of LTL implies that the model on which these tools are based on is not conceptual relative to the legal domain, and it fails to capture nuances of reasoning with normative constrains such as violations, different types of obligations, violations and their compensation. For example, obligations are represented by temporal operators. This raises the problem of how to represent the distinction between achievement and maintenance obligations. A possible solution is to use always for maintenance and sometimes for achievement, but this leaves no room for the concept of permission (the permission is dual of obligation, and always and sometimes are the dual of each other). In addition using temporal operators to model obligations makes hard to capture data compliance [10], i.e., obligations that refer to literals in the same task. SeaFlow is based on first-order logic, and it is well know that first oder logic is not suitable to capture normative reasoning [11]. On the other hand FCL complies with the guidelines set up in [3] for a rule languages for the representation of legal knowledge and legal reasoning.

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References

1. G. Antoniou, D. Billington, G. Governatori, and M.J. Maher. Representation results for defeasible logic. *ACM Transactions on Computational Logic*, 2(2):255–287, 04 2001.
2. A. Elgammal, O. Türetken, and W.-J. van den Heuvel. Using patterns for the analysis and resolution of compliance violations. *Int. J. Cooperative Inf. Syst.*, 21(1):31–54, 2012.
3. T.F. Gordon, G. Governatori, and A. Rotolo. Rules and norms: Requirements for rule interchange languages in the legal domain. In G. Governatori, J. Hall, and A. Paschke, editors, *RuleML 2009*, lNCS 5858, pp. 282–296. Springer, 2009.
4. G. Governatori. Representing business contracts in RuleML. *International Journal of Cooperative Information Systems*, 14(2-3):181–216, 2005.

5. G. Governatori, Z. Milosevic, and S. Sadiq. Compliance checking between business processes and business contracts. In P.C..K. Hung, ed., *EDOC 2006*, pp. 221–232. IEEE Computing Society, 2006.
6. G. Governatori and A. Rotolo. Logic of violations: A Gentzen system for reasoning with contrary-to-duty obligations. *Australasian Journal of Logic* 4:193–215, 2006.
7. G. Governatori and Antonino Rotolo. An algorithm for business process compliance. In E. Francesconi, G, Sartor, and D. Tiscornia, eds, *Jurix 2008*, pp. 186–191. IOS Press, 2008.
8. G. Governatori and A. Rotolo. A conceptually rich model of business process compliance. In S. Link and A. Ghose, eds, *APCCM 2010*, CRPIT 110, pp. 3–12. ACS, 2010.
9. G. Governatori and S. Sadiq. The journey to business process compliance. In J. Cardoso and W. van der Aalst, eds, *Handbook of Research on BPM*, pp. 426–454. IGI Global, 2009.
10. M. Hashmi, G. Governatori, and M. Thandar Wynn. Business process data compliance. In *RuleML 2012*, LNCS 7438. Springer, 2012.
11. H Herrestad. Norms and formalization. In *ICAIL 1991*, pp 175–184. ACM, 1991.
12. H-.P. Lam and G. Governatori. The making of SPINdle. In G. Governatori, J. Hall, and A. Paschke, eds, *RuleML 2009*, LNCS 5858, pp. 315–322. Springer, 2009.
13. R. Lu, S. Sadiq, and G. Governatori. Compliance aware business process design. In A.H.M. ter Hofstede, B. Benatallah, and H.-Y. Paik, eds, *BPD'07*, LNCS 4928, pp 120–131. Springer, 2007.
14. L.T. Ly, S. Rinderle-Ma, K. Göser, and P. Dadam. On enabling integrated process compliance with semantic constraints in process management systems - requirements, challenges, solutions. *Information Systems Frontiers*, 14(2):195–219, 2012.
15. F.M. Maggi, M. Montali, M. Westergaard, and W.M.P. van der Aalst. Monitoring Business Constraints with Linear Temporal Logic: An Approach Based on Colored Automata. In *BPM 2011*, LNCS 6896, pp. 132–147. Springer, 2011.
16. S. Sadiq and G. Governatori. Managing regulatory compliance in business processes. In J. van Brocke and M. Rosemann, eds, *Handbook of Business Process Management*, volume 2, pp. 157–173. Springer, 2010.
17. S. Sadiq, G. Governatori, and K. Naimiri. Modelling of control objectives for business process compliance. In G. Alonso, P. Dadam, and M. Rosemann, eds, *BPM 2007*, LNCS 4714, pp. 149–164. Springer, 2007.