



Reflection on compliance monitoring in business processes: Functionalities, application, and tool-support[☆]

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ABSTRACT

Together with Information Systems, we celebrate the journal's 50th anniversary and the 10th anniversary of our joint work on a systematic framework for compliance monitoring functionalities.

1. Retrospective

Our paper defined ten Compliance Monitoring Functionalities (CMFs) as a systematic foundation for operationalizing compliance in process-aware systems. This provided a lens to think about compliance, not just as a binary notion (“violated or not”), but with a runtime verification semantics defined for the first time with five truth values: temporarily violated, temporarily satisfied, permanently violated, permanently satisfied, and violated due to conflicting constraints. The latter means that, within the set of monitored rules, none was permanently violated, but their conjunction did not allow the ongoing process instance to be completed. Moreover, the paper offered a rich concept involving time, data, resources, root-cause explanations, and even proactive detection. At that time, different tools were available and could be compared in terms of functionality. These tools supported the monitoring of rules with different characteristics, such as those related to the data perspective of a process instance, qualitative and quantitative time constraints, and the implementation of reactive and proactive monitoring.

In the paper, researchers from five different universities, who had worked on the topic using various approaches from formal rule representation to tool engineering and applied process management, joined forces. This diversity helped shape a holistic view of compliance checking that balanced conceptual rigor with practical considerations.

2. Today: Ten years after publication

After more than a decade, the compliance monitoring functionalities we singled out appear as fresh as they did in 2014. Proactive monitoring was further developed in later years through more advanced types of monitoring, which began emerging at that time and leveraged machine learning techniques, such as predictive process monitoring, followed by prescriptive process monitoring and process-aware recommender systems. Due to the increasing presence of (typically machine-learning-based) sophisticated, but black-box and potentially unreliable, agents and components within the process lifecycle. Unforeseen courses of interaction often cannot be anticipated and thus call for immediate detection and reaction.

3. Personal reflections on future perspectives

Linh Thao Ly: Since 2015, compliance has gained even greater relevance, though often in new forms. While the original paper focused on rule-based verification against process models and logs, my later professional experience exposed me to regulatory compliance challenges of a different nature, which need to be addressed from different angles and at multiple levels. This contrast has deepened my appreciation for the complexities of implementing compliance in

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practice, where context, interpretation, and the interplay of existing information systems all need to be considered. Revisiting this work now, I see renewed opportunities to bridge these worlds — to combine the analytical precision of compliance checking with the pragmatic insights of real-world governance and regulation. As I return to academia, I look forward to contributing to this ongoing dialogue between theory and practice.

Fabrizio Maria Maggi: Now, after ten years, even industrial process mining products are increasingly recognizing the importance of incorporating declarative rules. In many cases, the *de jure* process is difficult, or even impossible, to model explicitly because domain experts cannot fully anticipate how the process will unfold in certain parts. What they do know, however, are the rules and constraints that must always be satisfied regardless of how the execution varies. Declarative rules provide a natural and powerful way to capture this knowledge, enabling organizations to enforce compliance and flexibility at the same time. As a result, compliance monitoring, once primarily a research-driven application, has become a central driver for the adoption of declarative process mining techniques in industry.

Marco Montali: Despite the technical advancements on conformance and compliance monitoring within process science and neighboring communities, the integration of multiple process dimensions, and the need of providing finer-grained feedback, are inherently difficult to achieve. Thus, further research in foundations and engineering, as well as on-field testing, is needed. It is definitely time to revive and extend the complementary and synergic research network that led to the definition of the monitoring functionalities. Two particularly relevant directions come to my mind. First, given the parallel advancements in monitoring in multiagent systems, there is a unique opportunity for integrating these two parallel lines, considering on the one hand temporal requirements, and on the other (multiagent) norms and commitments. Second, while our compliance monitoring functionalities dealt with different forms of process data, they did not emphasize the need to track the evolution of multiple interrelated objects through the process. This problem, currently known under the term of “object-centric processes” deserves a fresh update to the monitoring functionalities and corresponding techniques.

Stefanie Rinderle-Ma: Our original work has since inspired further research, including our study on predictive compliance monitoring functionalities published in *Information Systems* in 2022 [1] and utilized in an ACM Computing Survey in 2025 [2], as well as on regulatory compliance assessment solution requirements presented at CAiSE 2023 [3]. To me, the article reflects a strong community effort, provides a lasting framework for assessing process compliance approaches, and serves as a foundation for ongoing and future work in the field.

Wil van der Aalst: Upon re-reading the original paper, I realize that most organizations still struggle with it in practice, and unfortunately, not enough has changed. Considering the expanded capabilities of commercial process mining platforms, I would have expected these ideas to be more widely adopted. Instead, compliance features are often reduced to simple query-based checks or simplistic conformance dashboards. The deeper aspects of proactive guidance, multiple-instance reasoning,

or quantifying degrees of compliance are still largely absent. This is surprising. Apparently, there is not enough regulatory pressure. Instead, the focus is on AI. Rereading the paper, I realize that most parts are case-centric. In the background, there is often a case notion or an assumed case-centric process model (e.g., using BPMN). This may be too limiting, considering actual enterprise data with one-to-many and many-to-many relations. For example, to calculate an OTIF (On Time In Full) score, one must consider the relationships between orders, items, and shipments. Today, I would push for object-centricity as a way to get closer to reality [4]. By moving beyond the case-centric view, Object-Centric Process Mining (OCPM) enables us to naturally capture interactions between orders, resources, and data objects—precisely the setting where the CMFs demonstrate their full potential. In other words, it would be great to revisit the original paper from an OCPM perspective.

CRediT authorship contribution statement

Linh Thao Ly: Writing – review & editing, Writing – original draft, Conceptualization. **Fabrizio Maria Maggi:** Writing – review & editing, Writing – original draft, Conceptualization. **Marco Montali:** Writing – review & editing, Writing – original draft, Conceptualization. **Stefanie Rinderle-Ma:** Writing – review & editing, Writing – original draft, Conceptualization. **Wil M.P. van der Aalst:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

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