Conversational AI for Framed Autonomy in AI-augmented Business Process Management

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Abstract

AI-augmented Business Process Management Systems (ABPMSs) represent an emerging category of process-aware information systems driven by AI technology. These systems autonomously manage the execution flow of business processes (BPs) within predefined frames, encompassing procedural and declarative specifications, which may sometimes conflict. Despite operating autonomously within these boundaries, ABPMSs require dynamic conversations with human agents. These conversations not only respond to user queries but also initiate discussions to inform them of BP progression and provide recommendations for performance improvement. This research proposal aims to leverage *Conversational AI* to support the ABPMS's *framed autonomy*, functioning as a Decision Support System (DSS). This involves explaining system's choices and suggesting actions when constraints are violated. This technique enables intelligent, context-aware interactions with ABPMSs, fostering user trust. Our findings indicate that Conversational AI has the potential to significantly enhance the interpretability and usability of ABPMSs, thereby facilitating improved decision-making and process optimization.

Keywords

AI-augmented Business Process Management, Conversational AI, LLM, Decision Support

1. Context and Motivation

In the era of Industry 4.0, the increased availability of event data tracing the execution of Business Processes (BPs), combined with recent advancements in Artificial Intelligence (AI), is laying the ground for a new generation of AI-augmented Business Process Management Systems (ABPMSs), capable of autonomously unfolding and adapting the BP execution flows. A recent research manifesto [1] defines the vision for ABPMSs, extending the traditional BPMS lifecycle in two ways. Firstly, traditional lifecycle phases (e.g., modeling, analysis, execution, monitoring) are iteratively enhanced with AI capabilities. Secondly, the lifecycle includes additional AI-dependent tasks, including adaptation, explanation, and continuous improvement.

A crucial aspect of this transition is the evolution of BP modeling to the broader concept of *process framing*, which involves establishing multiple constraints including procedural rules, best practices, and norms to guide the BP's execution [2]. In this regards, an ABPMS is expected to exhibit *framed autonomy*, i.e., making independent decisions about the execution within the boundaries of the established frame. Unlike conventional BPMSs where framed autonomy

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rigidly adheres to the prescriptive interpretation and enactment of a predefined BP model, ABPMSs must simultaneously take into account multiple (potentially conflicting) constraints regulating strict and/or flexible aspects of a BP execution in a procedural or declarative way. Among these constraints, there could be a partial BP execution that needs to be completed, violating the frame with the minimum cost.

Regarding autonomy within the frame, an ABPMS can proactively reframe itself as it acquires new knowledge during adaptation, improvement, or explanation phases. Alternatively, it can be restricted by the designer, determining which parts of the frame it can modify independently and which require human intervention. Furthermore, the ABPMS's autonomy depends on its knowledge of the environment: the more information it has about the process' context and constraints, the more it can make informed decisions and act accordingly. Besides, the ABPMS should ask its human agent for additional information whenever needed.

Indeed, despite the autonomous nature of ABPMSs, human involvement remains essential [3], particularly for maintaining trust and a sense of control within the workforce, a known barrier to the adoption of automated technologies in Information Systems [4]. To address these concerns while minimizing human effort, an ABPMS should be *conversationally actionable*, engaging with users through natural language when the constraints of the frame cannot be met. Effective communication with humans is crucial for the ABPMS not only for responding to queries but also for initiating conversations about the BP progression, making recommendations for interventions, and discussing with them the benefits and drawbacks of actions.

This research proposal explores how *Conversational AI* can support the framed autonomy of ABPMSs. The conversational interface should function as a Decision Support System (DSS), providing explanations for the ABPMS's choices and suggestions when constraints are violated. Additionally, Conversational AI can facilitate *what-if BP analysis*, explaining the implications of violating particular constraints and helping to find the optimal trade-off that minimizes violation costs while allowing the process to progress.

Differently from traditional user interfaces (UIs) for DSSs, a Conversational AI-based interface in ABPMSs enables intelligent and insightful interactions with users. To better illustrate this, we examine a healthcare scenario involving the treatment of hip fractures [5]. The frame includes procedural clinical guidelines and declarative constraints representing basic medical knowledge. During the process enactment, violations of these constraints may occur, and the ABPMS must find the near-optimal frame, namely the right trade-off for such violations, through intelligent interactions with clinicians to discuss with them the nature and severity of the violations.

For instance, if a patient has a high body temperature, he cannot immediately undergo surgery but an X-ray check must be performed. In this case, the ABPMS should converse with the doctor to determine whether to book an X-ray check. However, the doctor, leveraging his expertise, may decide to proceed with the surgery to prevent further damage to the patient's hip mobility in cases of extremely severe fractures. Another example involves the patient showing post-operative delirium. The ABPMS notifies the doctor, who requests a what-if analysis to explore the consequences of delaying physiotherapy. The ABPMS might explain that delaying physiotherapy could slow down recovery but help prevent complications from delirium, whereas starting physiotherapy could worsen the delirium. Hence, the doctor might choose to violate the conventional guideline of initiating physiotherapy within 24 hours, opting to wait an additional 12 hours to monitor and reassess the patient's condition before making a final decision.

This healthcare scenario exemplifies how Conversational AI can enable the effective collaboration between the ABPMS and the doctors in a trustworthy manner to manage violations of the initial constraints by dynamically aligning the execution to the novel frame. Thus, building on the previous considerations, the following research questions (RQs) can be drawn:

RQ1: *What conversational techniques have been developed to enable actionable conversations?*
RQ2: *How can Conversational AI support framed autonomy in ABPMSs?*
RQ3: *How does Conversational AI impact human trust and influence the adoption of ABPMSs?*

2. Related Work

In recent years, there has been significant interest in DSSs due to their ability to aid humans in making high-quality decisions based on domain-specific information [6]. Since the foundational work in [7], various studies have focused on developing recommendation services to guide decision-making during process execution by suggesting possible next steps. Other research has employed Markov Decision Processes to determine optimal decisions based on probability distributions of all potential ones [8, 9]. Novel advancements in AI models have fostered the evolution of DSSs, allowing for the prediction of decisions and explanation of factors influencing them [10, 11]. Additionally, emerging Large Language Models (LLMs) technologies have been explored to improve DSSs by transforming business questions and hypotheses written in natural language into executable specifications that generate relevant reports for stakeholders [12, 13].

A related area to this research proposal is *What-if analysis*, which involves building digital process twins of the BP (i.e., simulation models) to evaluate the outcomes of their execution based on the specified constraints [14]. Conversational approaches for assisting this analysis have focused on enabling the specification of what-if simulation scenarios through natural language, facilitating the comparison of the BP performance against a standard reference [15, 16].

Moreover, *Prescriptive process monitoring* focuses on optimizing BPs by recommending interventions in real-time to prevent negative outcomes or address poorly performing cases [17] and explored the combination of conversational methodologies with recommendation systems [18].

Unlike the existing literature, this research proposal aims to leverage of Conversational AI to assist the framed autonomy of ABPMSs by providing a holistic approach that includes process-aware decision support, monitoring, and what-if analysis, thereby enhancing their functionality and trustworthiness.

3. Methodology

In this section, we examine in detail the RQs and explain how conversational AI can address them. We present the results achieved, highlight open challenges, and propose potential solutions.

3.1. RQ1: What conversational techniques have been developed to enable actionable conversations?

RQ1 requires an extensive and structured review of the state-of-the-art approaches facilitating actionable conversations to back framed autonomy in ABPMSs. Thus, we developed a survey

Table 1
Research challenges identified in [19].

BPM Area	Identifier	Research Challenge
Descriptive Process Analytics	RC1	*Unambiguous BP Discovery*
	RC2	*BP model semantics explanations*
	RC3	*From natural language to BP and vice versa*
	RC4	*Conversational interfaces for PM*
Predictive Process Analytics	RC5	*Conversational what-if analysis*
	RC6	*Explainable predictive process monitoring*
Prescriptive Process Optimization	RC7	*LLM-driven process redesign*
	RC8	*Multi-disciplinary integration for prescriptive process monitoring*
Augmented Process Execution	RC9	*Trustworthy conversational corrections*
	RC10	*Conversational RPA*
	RC11	*Cognitive automation*

[19] applying a rigorous and reproducible search protocol across recognized academic databases inspired by [20], and we categorized the findings following the BPM taxonomy drawn in [12].

In *Descriptive Process Analytics*, Natural Language Processing and neural architectures proved effective in extracting process models from natural language descriptions [21], and expressing BP models in natural language [22]. Conversational interfaces can also enhance understanding and accessibility of process mining findings [23]. *Predictive Process Analytics* employed conversational interfaces for what-if analysis of digital process twins [15] and predictive process monitoring [24]. In *Prescriptive Process Optimization*, the focus was on supporting automated process optimization [25] and prescriptive process monitoring, providing real-time recommendations through natural language [18]. Finally, *Augmented Process Execution* used conversational agents for smooth interactions [26] and to assist Robotic Process Automation [27].

As a result of this first research effort, we identified the challenges reported in Table 1, which were crucial in defining the problems that this proposal addresses for achieving ABPMSs framed autonomy and in determining the techniques that could be employed to tackle these issues.

3.2. RQ2: How can Conversational AI support framed autonomy in ABPMSs?

RQ2 explores the application of Conversational AI techniques to support framed autonomy in ABPMSs. Building on the previous example, Conversational AI in the ABPMS vision should function as a DSS, providing real-time decision support, interactive what-if scenario evaluation, and proactive process adjustments based on monitoring information. It should detect exogenous actions violating the frame and converse with human agents to reframe accordingly, adhering to a human-in-the-loop approach where the final decision rests with the human [28].

A promising solution involves leveraging LLMs [29], which can create conversational interfaces that interpret and respond to natural language queries, thereby democratizing access to complex technologies to a broader audience. We have already experimented with integrating LLMs. In [30], we implemented a conversational process-aware DSS using LLMs for answering BP-related questions, combining fine-tuning to incorporate domain-specific knowledge and *Retrieval-Augmented Generation* to embed the contextual knowledge for grounded answers. Additionally, we explored conversational Process Mining analysis over object-centric event logs following the OCEL 2.0 format, combining LLMs with a preliminary preprocessing step for extracting relevant information from the log.

Future work includes extending these techniques to fully leverage what-if analysis for anticipating the consequences of frame violations in ABPMSs. For instance, the integration with prescriptive process monitoring can provide more accurate what-if scenarios, improving the quality of natural language responses. Moreover, LLMs suffer from poor explainability and hallucinations [31]: we posit that integrating Symbolic AI reasoners can enhance the reliability and transparency of the conversational DSS, making its reasoning more human-understandable. Another avenue involves implementing techniques for continuous process monitoring that utilize real-time data streams to detect frame deviations and proactively propose adjustments.

3.3. RQ3: How does Conversational AI impact human trust and influence the adoption of ABPMSs?

RQ3 investigates how Conversational AI can boost human trust in ABPMSs, thereby encouraging their wider adoption. Indeed, it plays a crucial role in framed autonomy since, instead of merely presenting actions to select for the human agent as in traditional UIs, it supports decision-making intelligently by providing useful insights into the choices. Nevertheless, the ABPMS's decisions in sensitive contexts, e.g., in our healthcare example, might not be trusted by patients who fear for their health and safety. Thus, the human agent (e.g., a doctor) remains essential for trust. Additionally, users of ABPMSs themselves may not trust the system's decisions.

For this reason, in [32], inspired by established principles for trustworthy AI, we explored factors that foster human trust in these systems. We developed and validated a classification framework to assess the trustworthiness of ABPMSs, linking specific trust principles to each step of the system. Adopting this framework can lead to the implementation of more transparent, reliable, and accountable ABPMSs, capable of handling modern BP complexities.

Future research will address the lack of standardized metrics for evaluating the trustworthiness of ABPMSs and the impact Conversational AI has on them. A potential solution is to develop comprehensive metrics that include both qualitative and quantitative aspects, such as user satisfaction surveys, adherence to ethical guidelines, and performance benchmarks. Moreover, users may distrust ABPMS decisions if they do not understand the reasoning behind them. Implementing explainable AI to provide clear and understandable explanations for decisions is crucial, along with user-friendly interfaces that visualize decision pathways. Furthermore, the dynamics of human-AI collaboration in decision-making processes, particularly in high-stakes environments, are not well understood. Hence, we plan to conduct empirical studies to explore human and conversational DSS interactions in various scenarios. Insights from these studies will inform the design of interaction protocols with the ABPMS to improve efficiency and trust.

4. Outlook

Our research proposal investigates the application of Conversational AI to support framed autonomy in ABPMSs. This research endeavor will improve decision support, what-if analysis, and real-time monitoring within ABPMSs. Indeed, our initial results show a promising boost in the system's ability to provide intelligent, context-aware answers and foster human trust.

Thus, enhancing the framed autonomy and trustworthiness of ABPMSs, we hope to lay the ground for their broader adoption and more effective application across various industries.

References

[1] M. Dumas, F. Fournier, L. Limonad, A. Marrella, et al., AI-Augmented Business Process Management Systems: A Research Manifesto, ACM Transactions on Management Information Systems 14 (2023) 1–19.

[2] M. Montali, Constraints for Process Framing in AI-Augmented BPM, in: 20th Int. Conf. on Business Process Management (BPM'22 Workshops), volume 460, Springer, 2022, pp. 5–12.

[3] V. Muthusamy, M. Unuvar, H. Völzer, J. D. Weisz, Do's and Don'ts for Human and Digital Worker Integration, CoRR abs/2010.07738 (2020). URL: https://arxiv.org/abs/2010.07738. arXiv:2010.07738.

[4] J. D. Lee, K. A. See, Trust in Automation: Designing for Appropriate Reliance, Hum. Factors 46 (2004) 50–80. doi:10.1518/HFES.46.1.50.30392.

[5] A. Alman, F. M. Maggi, M. Montali, F. Patrizi, A. Rivkin, Multi-model Monitoring Framework for Hybrid Process Specifications, in: Advanced Information Systems Engineering - 34th International Conference, CAiSE 2022, Proceedings, volume 13295 of *Lecture Notes in Computer Science*, Springer, 2022, pp. 319–335. doi:10.1007/978-3-031-07472-1_19.

[6] H. Mozannar, D. A. Sontag, Consistent Estimators for Learning to Defer to an Expert, in: Proceedings of the 37th International Conference on Machine Learning, ICML 2020, 13-18 July 2020, Virtual Event, volume 119 of *Proceedings of Machine Learning Research*, PMLR, 2020, pp. 7076–7087. URL: http://proceedings.mlr.press/v119/mozannar20b.html.

[7] H. Schonenberg, B. Weber, B. F. van Dongen, W. M. P. van der Aalst, Supporting Flexible Processes through Recommendations Based on History, in: Business Process Management, 6th International Conference, BPM 2008, Milan, Italy, September 2-4, 2008. Proceedings, volume 5240 of *Lecture Notes in Computer Science*, Springer, 2008, pp. 51–66. doi:10.1007/978-3-540-85758-7_7.

[8] C. C. Bennett, K. K. Hauser, Artificial intelligence framework for simulating clinical decision-making: A Markov decision process approach, Artif. Intell. Medicine 57 (2013) 9–19. doi:10.1016/J.ARTMED.2012.12.003.

[9] S. Voorberg, R. Eshuis, W. van Jaarsveld, G. van Houtum, Decision Support for Declarative Artifact-Centric Process Models, in: Business Process Management Forum - BPM Forum, Vienna, Austria, September 1-6, 2019, Proceedings, volume 360 of *Lecture Notes in Business Information Processing*, Springer, 2019, pp. 36–52. doi:10.1007/978-3-030-26643-1_3.

[10] P. Agarwal, B. Gao, S. Huo, P. Reddy, et al., A process-aware decision support system for business processes, in: KDD '22: The 28th ACM SIGKDD Conference on Knowledge Discovery and Data Mining, Washington, DC, USA, August 14 - 18, 2022, ACM, 2022, pp. 2673–2681. doi:10.1145/3534678.3539088.

[11] R. Ali, A. Hussain, S. Nazir, S. Khan, H. U. Khan, Intelligent Decision Support Systems: An Analysis of Machine Learning and Multicriteria Decision-Making Methods, Applied Sciences 13 (2023) 9–19. doi:10.3390/app132212426.

[12] D. Chapela-Campa, M. Dumas, From process mining to augmented process execution, Softw. Syst. Model. 22 (2023) 1977–1986. doi:10.1007/S10270-023-01132-2.

[13] A. Berti, D. Schuster, W. M. P. van der Aalst, Abstractions, Scenarios, and Prompt Definitions for Process Mining with LLMs: A Case Study, in: J. D. Weerdt, L. Pufahl (Eds.), Business Process Management Workshops - BPM 2023 International Work-

shops, Utrecht, The Netherlands, September 11-15, 2023, Revised Selected Papers, volume 492 of *Lecture Notes in Business Information Processing*, Springer, 2023, pp. 427–439. doi:10.1007/978-3-031-50974-2_32.

[14] K. Rosenthal, B. Ternes, S. Strecker, Business Process Simulation on Procedural Graphical Process Models, Bus. Inf. Syst. Eng. 63 (2021) 569–602. doi:10.1007/S12599-021-00690-3.

[15] D. Barón-Espitia, M. Dumas, O. G. Rojas, Coral: Conversational What-If Process Analysis (Extended Abstract), in: Proceedings of the ICPM Doctoral Consortium and Demo Track 2022 co-located with 4th International Conference on Process Mining (ICPM 2022), Bolzano, Italy, October, 2022, volume 3299 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2022, pp. 118–122. URL: https://ceur-ws.org/Vol-3299/Paper25.pdf.

[16] M. Li, R. Wang, X. Zhou, Z. Zhu, Y. Wen, R. Tan, ChatTwin: Toward Automated Digital Twin Generation for Data Center via Large Language Models, in: Proceedings of the 10th ACM Int. Conf. on Systems for Energy-Efficient Buildings, Cities, and Transportation, BuildSys '23, Association for Computing Machinery, 2023, p. 208–211.

[17] K. Kubrak, F. Milani, A. Nolte, M. Dumas, Prescriptive process monitoring: *Quo vadis*?, PeerJ Comput. Sci. 8 (2022) e1097. doi:10.7717/PEERJ-CS.1097.

[18] S. Zeltyn, S. Shlomov, A. Yaeli, A. Oved, Prescriptive Process Monitoring in Intelligent Process Automation with Chatbot Orchestration, in: Proceedings of the Workshop on Process Management in the AI Era (PMAI 2022) co-located with 31st International Joint Conference on Artificial Intelligence and the 25th European Conference on Artificial Intelligence (IJCAI-ECAI 2022), Wien, Austria, July 23, 2022, volume 3310 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2022, pp. 49–60. URL: https://ceur-ws.org/Vol-3310/paper5.pdf.

[19] A. Casciani, M. L. Bernardi, M. Cimitile, A. Marrella, Conversational Systems for AI-Augmented Business Process Management, in: 18 Int. Conf. on Research Challenges in Information Science (RCIS'24), volume 513, Springer, 2024, pp. 183–200.

[20] B. Kitchenham, Procedures for performing systematic reviews, Keele, UK, Keele University 33 (2004) 1–26.

[21] H. van der Aa, K. J. Balder, F. M. Maggi, A. Nolte, Say it in your own words: Defining declarative process models using speech recognition, Lecture Notes in Business Information Processing 392 (2020) 51 – 67.

[22] Y. Fontenla-Seco, M. Lama, A. Bugarín, Process-To-Text: A Framework for the Quantitative Description of Processes in Natural Language, Lecture Notes in Computer Science 12641 (2021) 212 – 219.

[23] L. Barbieri, E. Madeira, K. Stroeh, W. van der Aalst, A natural language querying interface for process mining, Journal of Intelligent Information Systems 61 (2023) 113 – 142.

[24] K. Brennig, K. Benkert, B. Löhr, O. Müller, Text-Aware Predictive Process Monitoring of Knowledge-Intensive Processes: Does Control Flow Matter?, in: Int. Conf. on Business Process Management, Springer, 2023, pp. 440–452.

[25] A. Mustansir, K. Shahzad, M. K. Malik, Towards automatic business process redesign: an NLP based approach to extract redesign suggestions, Automated Software Eng. 29 (2022).

[26] L. F. Lins, G. Melo, T. Oliveira, P. Alencar, D. Cowan, PACAs: Process-Aware Conversational Agents, Lecture Notes in Business Information Processing 436 (2022) 312 – 318.

[27] H. van der Aa, H. Leopold, Automatically identifying process automation candidates using natural language processing, Springer, 2022.

[28] F. M. Zanzotto, Viewpoint: Human-in-the-loop Artificial Intelligence, J. Artif. Intell. Res. 64 (2019) 243–252. doi:10.1613/JAIR.1.11345.

[29] W. X. Zhao, K. Zhou, J. Li, T. Tang, et al., A Survey of Large Language Models, CoRR abs/2303.18223 (2023). URL: https://doi.org/10.48550/arXiv.2303.18223. doi:10.48550/ARXIV.2303.18223. arXiv:2303.18223.

[30] A. Casciani, M. L. Bernardi, M. Cimitile, A. Marrella, Conversational Systems for AI-Augmented Business Process Management, Preprint (Version 1) available at Research Square (2024). doi:https://doi.org/10.21203/rs.3.rs-4125790/v1.

[31] Y. Zhang, Y. Li, L. Cui, D. Cai, et al., Siren's Song in the AI Ocean: A Survey on Hallucination in Large Language Models, CoRR abs/2309.01219 (2023). URL: https://doi.org/10.48550/arXiv.2309.01219. doi:10.48550/ARXIV.2309.01219. arXiv:2309.01219.

[32] G. Acitelli, S. Agostinelli, A. Casciani, A. Marrella, The Role of Trust in AI-augmented Business Process Management, in: Artificial Intelligence for Business Process Management (AI4BPM) Workshop - BPM 2024, Kraków, Poland, Springer, 2024.