Measuring, Analyzing and Managing Process Complexity (Extended Abstract)

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Abstract

Business Process Management (BPM) is pivotal in improving organizational operations, yet struggles with the inherent complexity of business processes that can escalate costs and reduce efficiency and adaptability. This dissertation thoroughly investigates process complexity from three distinct perspectives: measuring, analyzing, and managing it. It introduces novel metrics based on graph entropy that capture multiple dimensions such as size, variation, and distance, augmenting it with the data perspective, enhancing understanding of process complexity. Innovative event log filtering techniques and log-delta analysis tools are developed to facilitate deeper insights and examine the impact of complexity on business performance. Furthermore, it advances managing complexity by integrating modern technological strategies, including a process scripting language and using Large Language Models in BPM. These contributions provide substantial implications for academia and practitioners, offering tools and strategies to manage process complexity effectively, thereby optimizing workflows and boosting operational performance.

Keywords

Process complexity, Process mining, Process automation

1. Introduction

Business Process Management (BPM) focuses on optimizing organizational work, aiming to ensure consistent outcomes and capitalize on opportunities for improvement [1]. Central to BPM is managing the inherent complexity of business processes in order to enhance operational efficiency and competitiveness. Complexity in business processes manifests in various executions, leading to increased costs, reduced efficiency, and decreased adaptability, negatively impacting an organization's growth potential. Event logs play a crucial role in this context, serving as repositories of data that capture the detailed executions and intricate dynamics of business processes. However, existing research uses perceptual and model-based metrics to assess complexity of business processes, while event log complexity is mainly represented by simplistic count-based approaches. Moreover, analyzing event logs requires sophisticated techniques and effort to extract meaningful insights. Additionally, process automation emerges as a powerful tool in mitigating complexity, utilizing modern technology to streamline operations, reduce errors, and enhance process consistency.

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This dissertation delves into process complexity from three angles: *measuring*, *analyzing*, and *managing*. Measuring complexity involves developing metrics that capture the multifaceted nature of business processes, utilizing event logs that provide empirical data on process executions. Analyzing complexity uses these metrics to evaluate the impact on process performance and explores event log filtering techniques and tools like log-delta analysis to gain deeper insights. Managing complexity includes employing process automation and innovative technologies like Large Language Models .

2. Background

Complexity in organizations manifests in various forms and can be classified into *organizational*, *technological* and *textual* complexity [2]. These complexities are often addressed through metrics developed by organizational sciences, software engineering, and linguistics. Process complexity is related to all three of complexity types. Process models help to understand intricate business processes, logs capture dynamic data during process execution, and textual complexity arises from documentation and communication within an organization. As processes change over time due to both external and internal factors, leading to changes in the operational paths and potential outcomes, so does process complexity, showing interesting patterns [3, 4]. Effective management of this dynamic complexity requires balancing standardization, which simplifies processes by reducing variability, and flexibility, allowing organizations to adapt to new challenges and maintain efficiency in face of evolving conditions, and often involve automation of processes.

2.1. Model complexity

Process complexity refers to the difficulty in analyzing, understanding, or explaining a process, influenced by factors like the intricacy of activity interfaces, transitions, and data structures [5]. Typically, the complexity of a business process model is quantified by the number of elements and their interrelations, impacting understandability. Automated discovery of process models, for instance, often yields *spaghetti* models that, despite capturing a broad spectrum of behaviors, are of limited practical value due to their complexity.

2.2. Event log complexity

Event logs record state changes during business process execution, facilitating deep insights into process performance and compliance, and are essential input for process mining. Process mining algorithms have led to the development of basic complexity measures, originating from fields like computer science and management science. Complexity measures are divided into four categories: *size* measures focus on countable log attributes like the number of events and sequence lengths [6]; *variation* measures analyze process behavior variations using methods like the Lempel–Ziv algorithm to assess event log compression [7]; *distance* measures include concepts such as affinity and edit distances between event sequences to evaluate complexity [6, 7]; and *graph entropy* measures, introduced in this dissertation, apply sequence and variant entropy to quantify complexity taking all above aspects into consideration.

2.3. Process automation

Process automation is essential in modern business management, leveraging information technology to optimize and streamline operations through the configuration of IT systems to support tasks, assign responsibilities, and perform automated cross-checks. Central to this is the use of Process-Aware Information Systems (PAISs), which can be domain-specific, such as ERP and CRM systems , or domain-agnostic, like Issue Tracking systems and Document Management Systems. A central tool in this sphere is the Business Process Management System (BPMS), which aids in the design, execution, and monitoring of business processes [1]. BPMS not only automates traditional manual tasks, thus enhancing efficiency and productivity, but also ensures precise process execution which is crucial in a compliance-focused business environment. Task automation within a BPMS involves a careful selection of tasks for automation, integrating primarily manual tasks with technology, and creating a hybrid system that combines human intuition with machine efficiency. Other technologies, such as Robotic Process Automation (RPA), further contribute to process automation by operating on the user interface, similarly to human workers.

3. Approach

This dissertation, consisting of seven contributions, tackles the complexity of business processes from three perspectives—measuring, analyzing, and managing—guided by the following research questions:

- **RQ1.** How can process complexity be measured based on event logs?
- **RQ2.** How can process complexity and its impact on process characteristics be analyzed?
  - **RQ2.1.** How can process complexity be analyzed?
  - **RQ2.2.** How can impact of complexity on process performance be analyzed?
- **RQ3.** How can modern technology help tackle process complexity?
  - **RQ3.1.** How can complexity of business processes be reduced?
  - **RQ3.2.** How can complex processes be handled?

Utilizing algorithm engineering [8] as the main research method, it employs a systematic approach that combines experimental evaluations on both synthetic and real-world data with formal analysis to develop efficient, real-world applicable algorithms. Algorithm engineering is the method of choice for all the contributions listed below, except for the last one, which follows an exploratory approach.

This dissertation addresses **RQ1** by exploring process complexity measures in event logs. First, an entropy-based complexity metric is introduced [9]. This metric allows for direct comparison between logs of different business processes and accounts for all three perspectives of event log complexity: size, variation and distance. Then, the correlation between log complexity metrics and the quality of process models derived through process mining is studied. The proposed metric is then further enhanced by incorporating event data [10]. This enables a more nuanced measurement of event log complexity, providing insights that are inaccessible with traditional metrics, which focus only on the control flow.

Next, **RQ2** is addressed by the analysis of process complexity. An advanced multi-range event log filtering technique is introduced, allowing for more control on which behavior is included in the filtered event log [11]. Building upon that, a novel log-delta analysis tool is developed, which allows filtering on more parameters and enables side-by-side comparison of sub-logs [12]. Then, the connection between the complexity of business processes and their time performance is studied by developing explanatory regression models [13].

Finally, **RQ3** is explored by presenting strategies for managing business process complexity through innovative automation techniques. This includes the development of a process scripting language designed to simplify automating complex business processes [14] and the exploration of Large Language Models (LLMs) in Business Process Management [15]. The latter proposes the use of advanced natural language processing techniques to manage process complexity, promoting more sophisticated and effective BPM strategies.

4. Conclusion

Complexity in business processes is critical for operational performance and agility, and understanding this complexity is crucial as business environments evolve. This dissertation studies complexity of business processes from three perspectives: measuring, analyzing and managing it. It significantly advances research on process complexity and process mining, proposing and evaluating new quantitative complexity measures for event logs and applying them to explain time performance of business processes. The research provides a strong foundation for evidence-based complexity measurement alongside existing perceptual and model complexity measures, also equipping practitioners with tools to monitor the complexity and its effects on the business process, allowing for more thorough consideration of standardization and optimization strategies. Additionally, it introduces advanced event log filtering techniques to ensure comprehensive data analysis and novel interactive tools for precise control in analyzing process behaviors, giving the practitioners a more complete view of the processes, which is especially relevant for evaluating conformance and compliance. Furthermore, the work underscores the importance of automation in BPM by proposing a new scripting language to enhance process modeling and automation, which gives the practitioners a readily available tool for creating executable process models, as well as suggesting the integration of Large Language Models for automation of tasks along the BPM lifecycle, paving the way for conversational and natural language-based automation of BPM tasks.

Future work could enhance existing complexity measures by complementing event log complexity measures with other perspectives, such as perceptual and model complexity measures, to investigate potential synergies and discrepancies between them. Incorporating data complexity, which currently relies on domain knowledge, could be standardized. Exploring the relationships between process complexity and other characteristics like the accuracy of predictive process monitoring or the average throughput time offers a fertile ground for research, potentially employing simulations within tools like InterLog for what-if analyses. Additionally, further investigation of the applications of Large Language Models in BPM could lead to innovative strategies for managing process complexity.

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