A Visual Analytics Tool for Multi-Dimensional Resource Insights in Process Mining

Alana Hoogmoed[1,*], Maximilian Schoditsch[1] and Djordje Djurica[1,*]

[1]Vienna University of Economics and Business, Welthandelsplatz 1, 1020 Vienna, Austria

Abstract

Understanding how resources contribute to business process execution is essential for identifying inefficiencies and improving operational performance. However, existing tools often offer fragmented support for resource analysis and lack integrated, interpretable visualizations. This paper introduces a visual resource analytics tool that supports resource-centric analysis across four key dimensions: resource allocation, performance, workload distribution, and capacity utilization. The tool enables practitioners to explore resource behavior through interactive visualizations, comparative metric views, and contextual overlays on process models. By making resource behavior more transparent and analyzable, the tool addresses a critical gap in process mining practice.

Keywords

Visual Analytics, Resource Analysis, Process Mining

1. Introduction

Process mining has emerged as a key technology for analyzing and improving business processes based on event data [1]. While process mining research has made significant progress in analyzing control-flow, the resource perspective, which focuses on how human and non-human resources contribute to process execution, remains comparatively underexplored [2, 3]. This perspective is increasingly critical as organizations seek to optimize resource performance, balance workloads, and proactively manage capacity in dynamic and resource-constrained environments.

Existing process mining tools typically offer only fragmented support for resource analysis, often limited to isolated performance reports, simple utilization charts, or static dashboards that present basic counts or averages. These views frequently focus on single metrics in isolation, such as case completion times or activity throughput, without enabling joint exploration of how different resource dimensions interact. Moreover, most tools lack integrated support for visually connecting resource performance back to process structure, leaving analysts to manually piece together information from multiple screens or reports. Visualizations, when provided, are often treated as secondary by-products of algorithmic implementations, rather than being systematically designed for analytical clarity, cognitive interpretability, or decision support [4]. As a result, analysts face considerable cognitive overhead when trying to analyze resource behavior holistically, especially in high-volume, complex event logs where resource allocation, workload distribution, and performance dynamics intersect in non-trivial ways [5, 6].

As process data grows in scale and complexity, there is an increasing need for user-centric interfaces that not only support flexible exploration but also enable *focused* and *task-oriented* analysis. Recent research in human-centered visual analytics emphasizes the importance of context-sensitive interaction, dynamic filtering, and cognitively effective visual design to improve task accuracy and reduce cognitive load [6, 7]. However, these principles have rarely been systematically applied in tools designed for resource-centric process analysis.

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*Corresponding authors.

alana.hoogmoed@wu.ac.at (A. Hoogmoed); maximilian.schoditsch@s.wu.ac.at (M. Schoditsch); djordje.djurica@wu.ac.at (D. Djurica)

0000-0002-3656-8314 (D. Djurica)

To address this gap, we present a visual analytics tool that supports exploratory, multi-dimensional analysis of resource behavior in business processes. The tool integrates four key dimensions of resource analysis: allocation, performance, workload distribution, and capacity utilization into a unified, interactive interface. Designed with cognitive usability principles in mind [7], the tool enables analysts to explore patterns, compare metrics across resources, and interpret behavior directly in relation to process structure through contextual process model overlays.

This demonstration builds upon our earlier work, which introduced the algorithmic approach and initial prototype for resource behavior analysis [8]. Based on insights gathered through a user evaluation study conducted in that prior project, we derived design requirements and developed this significantly improved, fully interactive version of the tool. The remainder of this demo paper presents the tool's key features and interactive capabilities (Section 2), discusses its current maturity and availability (Sections 3 and 4), and concludes the paper by outlining future development (Section 5).

2. Innovations and Main Features

The resource analysis tool introduces a novel technique which addresses key gaps in existing process mining tools by offering a comprehensive, interactive, and visually grounded approach to resource analysis. The following innovations define its core contributions:

Multi-Metric Integration. Traditional process mining tools often focus on isolated behavioral metrics, such as allocation or performance, offering limited support for integrated analysis across multiple dimensions[2, 3]. This fragmentation in research hinders a holistic understanding of resource behavior. Our tool addresses this research gap by integrating four critical resource-related dimensions into a single, unified framework:

- **Resource allocation** captures how resources are distributed across different roles and activities within the process. Analyzing allocation patterns allows analysts to detect specialization, role diversity, and staffing imbalances. For example, critical roles relying on only a few individuals may introduce operational risk, while overly broad role assignments may signal inefficient use of specialized competencies.
- **Resource performance** measures task execution efficiency, operationalized through average case durations (ACD) at both role and activity levels. This allows for comparative assessment of how quickly different resources complete similar tasks. Persistent performance differences may indicate skill gaps, training needs, or potential shortcut behaviors that merit further investigation.
- **Workload distribution** reflects how each resource allocates working time across activities and roles. Imbalances may lead to overburdened staff and burnout risks, while fragmented work patterns can suggest inefficient multitasking, coordination overhead, or scheduling inefficiencies. Visualizing workload shares supports fairness assessment and organizational efficiency.
- **Capacity utilization** evaluates how resource workload aligns with estimated capacity, embedded in the process flow. Sustained high utilization may reveal bottlenecks and resource strain, while chronic underutilization could indicate idle time, process waiting, or staffing misalignments. This perspective enables proactive capacity balancing and workload optimization.

By integrating these four metrics, our tool enables analysts to examine how resources behave, how efficiently they perform tasks, how workload is distributed, and how effectively capacity is utilized across a process.

Visual-First Design. While process mining literature has traditionally treated visualization as a secondary output of algorithmic analysis [4], our tool positions visual design as a core component of this approach. Each of the integrated resource metrics is represented through interactive and cognitively effective visualizations such as heatmaps, bar charts, and Directly-Follows Graphs with overlays. These visualizations are designed in accordance with Moody's Physics of Notation principles [7]. These visualizations enable quick identification of patterns, bottlenecks and other inefficiencies

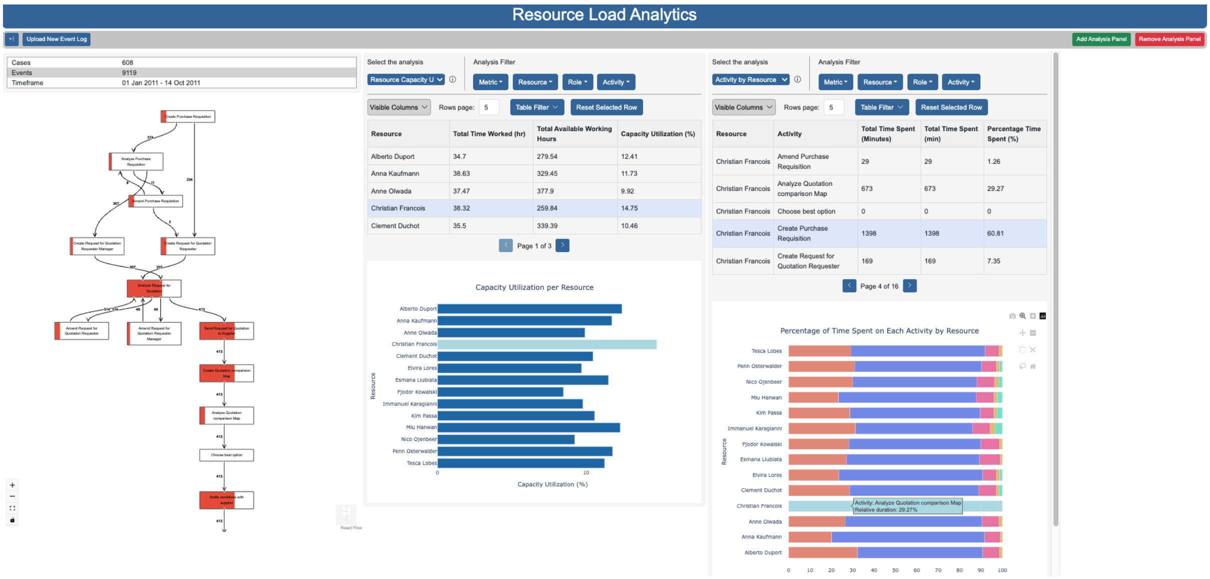

Figure 1: Interface of Visual Resource Analytics Tool.

across multiple resource dimensions while maintaining interoperability for both novice and experienced users.

Figure 1 illustrates the main interface of the tool, showcasing how multiple resource dimensions are visually represented and interactively explored through integrated views and contextual process model overlays.

Process Model Enhancement. Resource data is embedded directly into the process model by overlaying the metrics onto Directly-Follows Graphs (DFGs). This integration allows analysts to assess resource behavior within the process context, linking capacity or performance issues directly to specific activities and execution paths. This contextual embedding supports localized diagnosis of bottlenecks and inefficiencies.

User-Centric Interaction. Designed for process analysts, the tool is built with a strong focus on usability and analytical flexibility by providing a responsive and intuitive interaction layer. Users can conduct side-by-side comparisons of different metrics (e.g., resource performance vs. workload distribution), leverage hover-based tooltips to access detailed metric values, and apply filters to focus on specific resources, roles, or activities. The DFG view supports zooming and panning for seamless navigation of complex workflows. These interactive features enable both high-level overviews and granular investigations, positioning the tool as a robust platform for resource analysis in process mining.

Together, these features position the tool as a robust and user-friendly analytics platform for resource analysis in process mining, addressing both current limitations in tool support and the increasing need for actionable, visually communicable resource insights in business process management.

3. Maturity of the Tool

The resource analytics tool has reached a stable and fully functional prototype stage. All core functionalities presented in this paper, including metric computation, interactive filtering, visualizations, and model overlays, are fully operational. The tool has been tested extensively using multiple event logs, including a procurement event log provided by Fluxicon[1]. The prototype supports interactive analysis across all four resource dimensions and maintains responsiveness even with mid-sized logs.

The tool follows a modular architecture and supports input in both XES and CSV formats, each requiring event data with the following elements: *Case ID, Start Timestamp, Complete Timestamp, Activity, Resource, and Role.* Ensuring the presence of these attributes is necessary for the consistent computation of all four resource analysis dimensions—allocation, performance, workload distribution, and capacity utilization. We acknowledge, however, that real-world event logs may not always conform to this schema. At present, the tool assumes complete input and does not yet support logs with missing columns. As such, preprocessing (e.g., using tools like pm4py) is required to ensure compatibility. Enhancing the tool's flexibility to handle incomplete data – through schema detection, adaptive visualizations, and user guidance – is planned for future development to broaden applicability and improve robustness.

Currently, the tool is stable for browser-based use with logs up to approximately 10,000 events. For larger-scale logs, performance optimizations are planned as part of ongoing development.

4. Availability

The resource analytics tool is implemented as a web-based application, for which the source code, along with setup instructions and example event logs, can be accessed via Github.[2][3] The application can be deployed locally using standard development stacks and does not require specialized infrastructure. Extensive ReadMe is provided within the GitHub repository.

To support accessibility and reproducibility, a screencast is provided that demonstrates the tool's main functionalities, including how to upload logs, explore metrics across the four analysis areas, and interact with the resulting visualizations.[4]

5. Conclusion

The presented visual analytics tool enables richer and more intuitive analysis of resource behavior in business processes. By integrating multiple resource-related metrics into a single interactive environment, the tool facilitates the detection of bottlenecks, workload imbalances, and capacity issues. Through a visual-first design approach with interactive features, the tool supports both exploratory and targeted analysis. By making resource behavior more transparent, it adds tangible value to both BPM research and practical process analysis.

Beyond the current capabilities, future work will extend the tool's scope from descriptive resource analysis toward *predictive allocation support*, incorporating behavioral dynamics such as learning curves, overload patterns, task switching behavior, and fatigue effects. This would enable the tool to not only visualize resource performance retrospectively, but also anticipate resource suitability for upcoming tasks, supporting more proactive and adaptive resource management decisions.

Declaration on Generative AI

The authors have not employed any Generative AI tools.

[1]https://fluxicon.com/disco/files/Disco-Demo-Logs.zip
[2]https://github.com/maxscho/resource-analytics_backend
[3]https://github.com/maxscho/resource-analytics_frontend
[4]https://drive.google.com/file/d/12s7jzVY2FMWdXkrhPkifNXaaJ7JoE2ZX/view?usp=sharing

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