IT Event Management in the Municipal Public Sector: An Automated Architecture Based on ITIL 4 and Fuzzy Inference

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Abstract. *The digital transformation in Brazilian municipalities has resulted in heterogeneous and frequently fragmented electronic service environments, with limited levels of integrated monitoring, compromising the continuity and reliability of digital public services. In this context, the absence of automated IT Event Management mechanisms increases incident detection and response times, negatively affecting compliance with Service Level Agreements (SLAs) and the operational efficiency of IT teams. This work proposes an open-source architecture that integrates Zabbix for event detection, a Python-based Fuzzy Inference Engine for contextual classification based on impact and urgency, and GLPI for ticket lifecycle management, in alignment with ITIL 4 Event Management guidelines. Fuzzy logic is employed to replace rigid thresholds with continuous criticality assessment, incorporating mechanisms for event duplication control. The proposed artifact is grounded in ITIL 4 service management, fuzzy set theory, and the Design Science Research (DSR) approach, adopting the six-step model proposed by [Peffers et al. 2007]. Methodologically, the study followed the DSR cycle, encompassing problem identification, objective definition, BPMN-based process modeling, prototype development, and demonstration in a municipal environment, with the analysis supported by historical MTTD and MTTR metrics collected prior to the artifact deployment. The demonstration indicates the feasibility of automated event classification and ticket handling, improving prioritisation consistency and reducing manual intervention in early incident handling stages. As a contribution, this work presents an integrated and modular IT Event Management model based on open-source solutions, with potential for replication in complex institutional contexts within public administration.*

1. Introduction

IT Event Management has become a strategic challenge. Digital infrastructures are increasingly complex, and the demand for high availability continues to grow. The intensification of digital transformation and the interdependence among critical systems increase the need for automated monitoring solutions capable of proactively detecting, classifying, and responding to events, thereby minimizing operational impacts and service downtime costs [Mora et al. 2014, Das 2019].

According to the Digital Government Map 2022, only 2.8% of the 5,568 Brazilian municipalities have populations exceeding 200,000 inhabitants. These 155 municipalities account for 59% of the national Gross Domestic Product (GDP) and 46.8% of the population, and they exhibit the fastest pace of digital evolution between 2014 and 2019. The report also indicates that demand for digital services increased in 94% of municipalities after the COVID-19 pandemic, while 18% of them rated system integration and data openness as "poor" or "very poor" [Secretaria de Governo Digital 2022].

In public administration, the organic expansion of IT infrastructures, combined with slow procurement processes and the absence of consolidated management plans, compromises service continuity [Araújo 2020]. Many municipalities still lack clear digital governance strategies [Przeybilovicz et al. 2018], reinforcing the need for integrated solutions for IT Event Monitoring and Management.

Although the literature highlights the benefits of the ITIL 4 framework for service efficiency and quality [Silva et al. 2020], recent reviews indicate the absence of a unified architecture covering the entire lifecycle of alert and incident management from detection to ticket creation particularly with respect to the integration of monitoring, intelligent criticality classification, and ticket management [Yu et al. 2024]. This gap becomes even more relevant in the municipal context, where resources are limited and demand for digital services continues to grow.

Given this scenario, this paper aims to evaluate the technical feasibility of automating the IT Event Monitoring and Management (EMM) workflow, in accordance with ITIL 4 practices, through the integration of monitoring tools, an adaptive criticality classification mechanism, and a ticket management system, within the context of municipal public administration.

Accordingly, the research question guiding this study is: *"How can the EMM workflow be automated in order to integrate detection, adaptive criticality classification, and ticket management in municipal public organizations, while preserving governance, traceability, and operational flexibility?"*

This study is positioned as a contribution consistent with the category "Reflections and Provocations", as it presents an integrated socio-technical proposition grounded in a functional pilot and oriented toward the discussion of organizational and technological challenges in public-sector Information Systems. In addition, the paper is aligned with the tracks "Organizational Information Processes and Systems Management" and "Information Systems Challenges Applied to Domains (Health, Agriculture, Government, Education, among others)", since it addresses both the structuring of organizational processes and the application of Information Systems to the government domain.

This study aligns with II GranDSI-BR 2026–2036 [Sociedade Brasileira de Computação 2025], as the proposal directly addresses the challenge of interoperability between organizational and technical systems by integrating monitoring, event processing, and service management within an integrated architecture. By addressing recurring limitations in municipal environments, such as budgetary constraints, asset heterogeneity, and reliance on manual processes, the study contributes to advancing the maturity of Information Systems governance in the public sector, an aspect widely discussed in the national literature on IS applied to public administration

[Boscarioli et al. 2017].

The main contribution of this study, in the field of Information Systems, lies in the proposition and initial demonstration of an integrated architecture for IT Event Monitoring and Management that articulates, in a coordinated manner, operational monitoring, BPMN-based process structuring, fuzzy inference for contextual criticality classification, idempotency control, and ticket automation aligned with ITIL 4 practices. Unlike approaches that address these elements separately, the proposed model combines them into an end-to-end workflow aimed at improving traceability, interoperability, and operational consistency in municipal public administration.

To properly situate the empirical scope of this research, it is important to highlight that the study focuses on a pilot evaluation, aimed at verifying the technical feasibility of the proposed architecture in a segregated environment with real assets. At this stage, the objective is not to present a conclusive statistical evaluation, but to define the initial operational context and characterize the conditions under which the model was implemented and observed.

2. Theoretical Background

This section presents the concepts, methods, and references that underpin the proposal, highlighting consolidated approaches and solutions for automated IT Event Management.

2.1. IT Event Monitoring and Management in ITIL 4

ITIL 4 consolidates a set of best practices for IT service management, integrating people, processes, and technologies to improve operational efficiency, service quality, and value delivery [Axelos 2019]. Among the practices defined by the framework, EMM plays a central role by enabling the detection, analysis, and response to occurrences that may compromise service availability or performance.

The adoption of automation mechanisms within this practice reduces reliance on manual intervention and contributes to shorter incident response times, which is particularly relevant in complex institutional environments such as public administration. Recent studies indicate that automating Event Management fosters greater operational predictability, standardized responses, and improved failure response capabilities across organizations of different sizes [Silva et al. 2020, Costa et al. 2022, Sengik and Lunardi 2023, Topin et al. 2017].

2.2. Performance Indicators and ITU Recommendations

Reports from the International Telecommunication Union (ITU) define monitoring as a continuous cycle that encompasses the systematic collection of performance indicators, such as packet loss, latency, and availability, and the consolidation of this data to support evidence-based decisions [ITU-T 2018, ITU-T 2022].

In the proposed model, these key performance indicators (KPIs) underpin the impact parameter, while metrics associated with the response time of the operational environment support the urgency variable. This approach allows for the replacement of fixed and arbitrary thresholds with dynamic, adaptive values that are sensitive to the real operational context, ensuring greater objectivity, transparency, and comparability in the processes of prioritizing events in IT environments.

2.3. Criticality Inference Using Fuzzy Logic

Fuzzy Logic (FL), introduced by [Zadeh 1965], constitutes a mathematical approach capable of representing and processing uncertainty through the concept of degrees of membership, overcoming limitations inherent in traditional Boolean logic (true/false). The theoretical development and practical consolidation of this approach were further developed by subsequent works, such as those of [Zimmermann 2001], who systematized its fundamentals and applications, and [Cox 1994], with an emphasis on the implementation of systems based on Fuzzy rules.

Unlike binary classifications (OK/Problem), FL allows an element to simultaneously belong to different linguistic sets with distinct intensities, represented by continuous values in the interval [0,1]. This characteristic makes the approach particularly suitable for problems involving subjectivity and contextual variability, such as risk analysis and prioritization of events and incidents in IT environments [Markowski et al. 2009, Olano et al. 2025, Tomak and Polat 2022].

In the proposed model, the variables "impact" and "urgency," derived from operational metrics of the monitored environment, are used as input to a Fuzzy Inference Engine (FIE) implemented in Python. This mechanism applies a set of "IF-THEN" linguistic rules to combine the degrees of relevance associated with each variable, producing a continuous criticality value as output. The result of the inference process is subsequently defuzzified, generating a criticality level with greater granularity and adherence to the operational context, suitable for supporting automated decisions in event management.

2.4. The Multi-Criteria Matrix

Prioritization of IT events and incidents typically combines multiple criteria, primarily impact and urgency, according to ITIL 4 [Axelos 2019]. The most common form is the 5x5 matrix: each axis receives levels from 1 to 5, and the intersection of the 25 cells is mapped to priorities (P1 to P5) by a table. This model is simple and operational, but uses fixed thresholds; therefore, borderline cases (in the transition between categories) may experience priority jumps with small variations (example: impact changing from P3 to P4), which reduces sensitivity in uncertain contexts or with noisy measurements [Olano et al. 2025, Tomak and Polat 2022].

Recent literature has explored the application of multi-criteria methods combined with FL (field-based analysis) to refine the prioritization matrix, allowing for smoother transitions between levels and greater adherence to the real-world context of the operation [Pascarella et al. 2021, Olano et al. 2025]. By assigning degrees of relevance to the input variables, the multi-criteria FL model offers more adaptive and robust decisions, overcoming limitations inherent in purely categorical models. This approach is based on consolidated principles of multi-criteria decision-making [Keeney and Raiffa 1993], allowing not only the integration of specialized knowledge but also alignment with international best practices in incident management.

2.5. Related Studies

Recent literature presents relevant contributions in different dimensions of IT event and incident management. In the area of process modeling, studies such as those by [Aguilar-Alonso et al. 2020] and [Tavantzis et al. 2023] highlight the use of BPMN and

Decision Model and Notation (DMN) for formalizing flows and decisions. In the dimension of monitoring and detection, [Nguyen et al. 2024] demonstrates advances in the intelligent analysis of event flows. In the field of prioritization under uncertainty, [Olano et al. 2025] and [Tomak and Polat 2022] reinforce the potential of fuzzy logic and multi-criteria methods to support more context-sensitive decisions. [Liu et al. 2023] contribute to the automation associated with ticket handling, while [Dzemydienė et al. 2023] and [Al-Ashmoery et al. 2024] discuss the fundamentals of governance, standardization, and modernization of ITSM.

Despite these advancements, such contributions remain predominantly segmented, failing to integrate, into a single end-to-end architecture aligned with ITIL 4, BPMN-based workflow, continuous operational monitoring, fuzzy inference, idempotence control, and ticket automation. In this sense, the aim of this article is to advance precisely the coordinated articulation of these elements.

3. Methodology

This study was conducted based on the Design Science Research (DSR) approach, used in Information Systems research that seeks to conceive, demonstrate, and evaluate technological artifacts. According to [Peffers et al. 2007], the DSR cycle comprises six stages: (*i*) problem identification and motivation; (*ii*) definition of solution objectives; (*iii*) design and development; (*iv*) demonstration; (*v*) evaluation; and (*vi*) communication. In this research, these stages were operationalized as follows: problem identification focused on the lack of integrated and automated solutions for IT Event Management in municipal public administration; objective definition established automation, open-source integration, fuzzy-based classification, and alignment with ITIL 4 as design goals; design and development resulted in the BPMN-based workflow and in the integrated architecture composed of Zabbix, the Fuzzy Inference Engine, and GLPI; demonstration was performed in a segregated pilot environment fed by real events from a municipal infrastructure asset; evaluation was conducted qualitatively, supported by workflow execution and by the historical MTTD/MTTR baseline; and communication is expressed in this research through the systematization of the artifact, the method, and the results.

During problem identification and motivation, it was observed that, in the context of public administration, there is a lack of integrated and automated solutions for IT Event Management, which compromises timely detection, accurate classification, and effective response to incidents [Silva et al. 2020, Sengik and Lunardi 2023]. Recent literature indicates that alert and incident management remains largely manual and lacks a uniform architecture integrating the entire lifecycle from monitoring to resolution [Yu et al. 2024].

Based on this diagnosis, the objectives of the artifact were defined as follows: (*i*) automate the EMM workflow; (*ii*) integrate open-source tools for monitoring, intermediate processing, and ITSM; (*iii*) increase the granularity of event classification using FL; and (*iv*) align the proposed workflow with ITIL 4 recommendations [Axelos 2019].

The design and development of the artifact were modeled using BPMN 2.0 [Object Management Group 2013], specifying interactions among three main components: (*i*) a monitoring tool (Zabbix), responsible for real-time monitoring and event dispatch; (*ii*) a Fuzzy Inference Engine (FIE), which receives events and applies a criticality matrix based on membership functions and linguistic rules grounded in FL [Zadeh 1965, Cox 1994, Zimmermann 2001] and fuzzy risk models [Markowski et al. 2009, Tomak and Polat 2022]; and (*iii*) an ITSM platform (GLPI), accessed via REST API, responsible for creating or updating tickets according to the calculated priority. To prevent duplicate records, the FIE maintains a control mechanism based on the history of processed events, discarding subsequent repetitions.

The artifact was demonstrated in a segregated pilot environment, fed in real time by events originating from an operational infrastructure asset belonging to a municipal health department. A scenario involving connectivity interruption and subsequent restoration was fully handled by the automated workflow, allowing verification of continuous ticket creation and closure without exposing sensitive information from the production infrastructure.

The evaluation phase was conducted qualitatively and comparatively, contrasting the performance of the automated workflow with the previous scenario of manual records. While in the previous model incident detection depended on failures perceptible to users, the proposed artifact allows tickets to be opened immediately after the event is generated by the monitoring system. Although the current focus is on technical feasibility, detailed quantitative measurement of operational indicators (such as the exact time savings) is a planned step for future evolution cycles of the artifact.

At this stage, the study does not claim a statistically supported before-and-after comparison. Historical MTTD and MTTR values are used only as a pre-implementation baseline, while the pilot demonstrates technical feasibility and end-to-end automation.

To support the comparative analysis of the proposed artifact, an operational baseline was defined for the 90 days preceding its implementation (July 15 to October 15, 2025). During this period, 209 incident records were examined, of which 160 contained complete and consistent temporal information for metric calculation, while 49 were excluded due to data quality limitations. The valid set showed an average MTTD of 19.08 hours and an average MTTR of 4.92 days. These values characterize a predominantly reactive operational context dependent on human intervention and are used as an exploratory baseline for the pilot evaluation, without statistical generalization.

Finally, the communication stage consisted of systematizing the proposed model, operational workflow, and initial evidence obtained, enabling replication, extension, and evaluation in other organizational contexts.

4. The IT Event Monitoring and Management Model

The proposed model[1] is structured into five stages: event collection, correlation, classification, prioritization, and handling. Metrics, logs, and other operational data are collected and correlated to generate events that reflect the operational state of the environment. These events are then classified as informational, alerts, or exceptions and, when required, submitted to the Fuzzy Multicriteria Matrix (FMCM), which assesses impact and urgency to define priority contextually. Finally, the flow is directed according to the assigned criticality, including registration, ticket opening, escalation, and corrective actions, when applicable. A safe color palette was adopted to improve legibility and accessibility while preserving BPMN semantics [Brewer 1994].

[1]Available at: `https://figshare.com/s/8db82d4ea8320b3175d3`

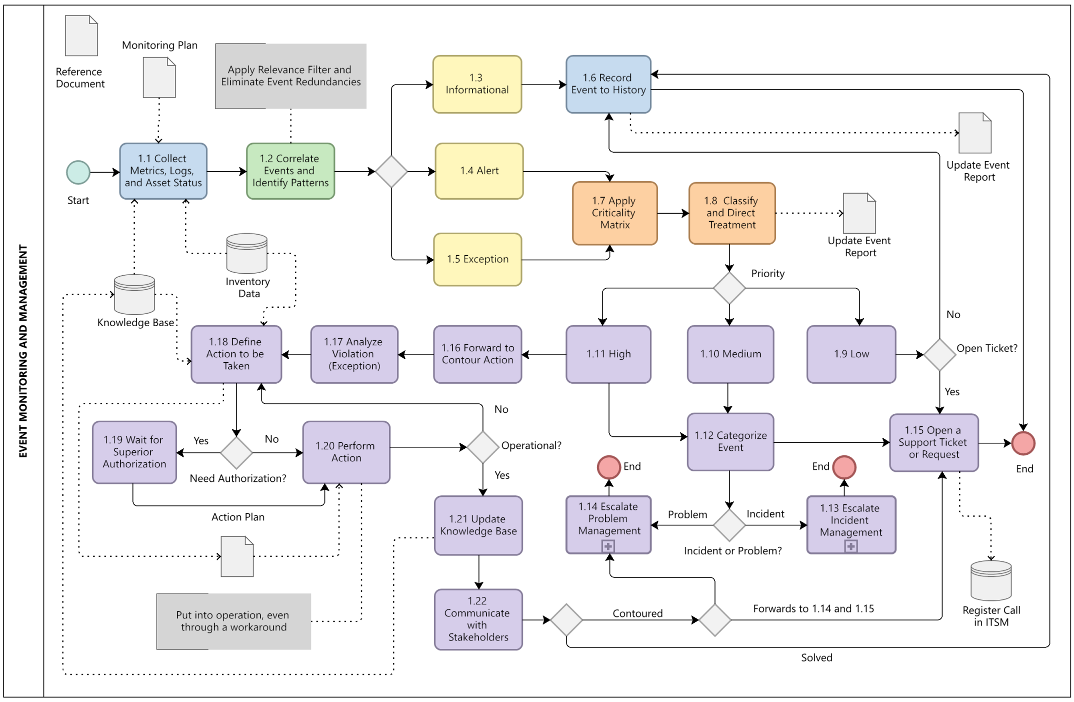

Figure 1. BPMN representation of the proposed EMM model. ***Color legend:*** **Light blue – data collection and event registration; Light green – event correlation and pattern identification; Light yellow – event type classification (informational, alert, exception); Light orange – criticality assessment and prioritization; Light purple – decision and treatment actions.**

5. Automation of IT Event Management

The proposed model integrates three modules (Zabbix, FIE and GLPI) through RESTful APIs to automate the IT event and incident lifecycle. This architecture supports continuous monitoring, contextual classification, and automated response, while preserving modularity and enabling future integrations.

5.1. Integrated System Architecture

The operational cycle begins with continuous monitoring of IT assets, responsible for detecting relevant events such as failures, state changes, or performance degradation. Detected events are automatically forwarded to the FIE via HTTP POST requests using a Python-based REST API, where criticality is assessed through a fuzzy matrix based on impact and urgency variables. After classification and duplication check (local event-ID registry), a new HTTP POST request is sent to the GLPI REST API, which automatically creates a ticket already categorized according to the assigned criticality level.

Communication among modules occurs exclusively through REST APIs with JSON payloads, token-based authentication, and traffic restricted to the internal network, ensuring data confidentiality and integrity.

5.2. Monitoring Module: Zabbix

Zabbix performs continuous metric collection and event detection for infrastructure assets and applications. Within the proposed architecture, detected events trigger automated actions that forward essential information to the FIE through webhooks and REST-based interfaces, enabling workflow automation and adaptation of monitoring behavior to model requirements without tight coupling among components.

5.3. Intelligent Classification Module: Fuzzy Inference Engine

The Fuzzy Inference Engine (FIE) acts as the intermediary classification component of the model, receiving detected events, validating essential information, and enriching them with contextual metadata from *mapa-decisao.yaml*, which maps assets and event types to fuzzy impact and urgency parameters. Based on these parameters, the FIE applies a fuzzy multi-criteria matrix to determine event criticality and automatically direct it to the appropriate ITSM treatment, supporting flexible adaptation without source-code modification and ensuring standardized, proportional responses.

The core of the FIE is the fuzzy inference mechanism grounded in fuzzy set theory, which treats impact and urgency as linguistic variables associated with different degrees of membership [Zimmermann 2001]. Instead of rigid thresholds, FL converts numerical impact and urgency values into linguistic variables (Low, Medium, or High) using membership functions whose degrees typically range from 0 to 0.9, with 1 being the theoretical limit representing maximum membership [Cox 1994, Zimmermann 2001].

Using these variables, the FIE applies IF–THEN inference rules to combine impact and urgency and determine event criticality, an approach widely used in IT event prioritization [Markowski et al. 2009, Tomak and Polat 2022]. For example, rules such as "if impact is high and urgency is high, then criticality is high", "if impact is medium and urgency is high, then criticality is medium", and "if impact is low and urgency is low, then criticality is low" illustrate the inference mechanism adopted in the model, impact and urgency are externally parameterized according to the asset-event context through the decision map, which allows adaptation without modifying the source code. The inference result is then converted into a continuous numerical value through centroid defuzzification [Ross 2010], and subsequently discretized into linguistic levels compatible with GLPI priority fields. The entire process is executed transparently, with logging of inputs, applied rules, and results, ensuring auditability of the decision-making process.

Integration with GLPI occurs automatically, allowing the FIE to create, update, or close tickets according to assigned criticality and event evolution. This mechanism standardizes the workflow, reduces subjectivity, and prevents duplicate tickets for previously processed events, ensuring consistency in automated event management.

5.4. Ticket Management Module: GLPI

In the proposed model, GLPI acts as the ITSM system responsible for registering, tracking, and ensuring traceability throughout the incident lifecycle. Integrated with the FIE through an authenticated REST API, it automatically receives classified events and creates, updates, or closes tickets according to the evolution of monitored events and the criticality assigned. Idempotency mechanisms prevent duplicate records, while GLPI histories and FIE logs preserve traceability, contributing to transparency and governance in IT Event Management.

6. Discussion of Results

The pilot implementation of the EMM model demonstrated the technical feasibility of the proposed automation and its operational relevance. The integration of monitoring, fuzzy inference, and ticket management enabled automated incident handling in alignment with ITIL 4 best practices.

In the previous scenario, ticket opening and prioritization depended on human analysis, making the process susceptible to delays and subjectivity. In the controlled pilot environment, a documented case showed that the corresponding GLPI ticket was opened approximately 2 seconds after event registration in Zabbix, indicating low latency in the proposed automated flow. For transparency and verifiability, the visual records of this case were made available in a supplementary digital repository[2]. At this stage, the evaluation remained qualitative, with systematic collection of quantitative metrics planned for subsequent operational cycles, in line with studies that associate automation with improved operational performance and service-level achievement [Yu et al. 2024].

Regarding prioritization, the use of Fuzzy inference proved suitable for overcoming limitations of approaches based on fixed severities, by incorporating impact and urgency in a contextualized way. The resulting classification generates continuous levels of criticality, reducing abrupt decisions in borderline cases and increasing the granularity of the decision-making process, in line with evidence reported in the literature on adaptive event prioritization [Zadeh 1965, Zimmermann 2001, Markowski et al. 2009].

From a governance perspective, the integrated architecture ensures traceability and auditability, as each event generates records in both the FIE and ITSM system, enabling reconstruction of decision and action sequences. These mechanisms align with principles of transparency, control, and objective evidence established by [ISO/IEC 2018]. Additionally, architectural modularity and configurable parameters allow behavior adjustments without source-code changes, supporting replicability, scalability, and adaptation to diverse organizational contexts.

Overall, results observed in this initial phase indicate that combining automated monitoring, fuzzy multi-criteria inference, and ITSM integration constitutes a coherent approach to supporting IT Event Management in complex institutional environments. Although evaluation was exploratory and qualitative, findings reinforce the technical consistency of the model and its adherence to service management best practices, while highlighting potential gains in standardization, traceability, and prioritization quality. These elements provide a foundation for deeper empirical investigations in future cycles, in which quantitative metrics may consolidate analysis of observed operational impacts.

7. Limitations and Future Work

Evaluation of the EMM model was conducted in a pilot environment, which introduces limitations related to internal validity, external validity, and artifact evaluation. Internal validity is constrained by the controlled and segregated setting, which limits direct inference about workflow behavior under full production conditions. External validity is restricted by the focus on a single municipal organization and a limited set of IT assets. Artifact evaluation is also limited, since the current assessment is based on technical

[2]Available at: `https://figshare.com/s/9e4763d0e55cae698175`

feasibility, workflow execution, and exploratory baseline indicators, without yet providing statistically supported post-deployment measurement of operational gains. In addition, adoption in large municipalities depends on mature configuration management and CMDB consolidation, both of which may be affected by business alignment, scope definition, and process rigor, compromising the quality and reliability of ITSM information.

Future work is directed along four main lines: (*i*) incremental refinement of impact and urgency parameterization in alignment with organizational maturity; (*ii*) investigation of mechanisms for progressive adjustment of fuzzy membership functions based on historical Service Desk data to increase prioritization adherence to the operational context; (*iii*) expansion of managerial decision support through consolidated indicators of criticality, event volume, and SLA compliance; and (*iv*) quantitative comparison between pre- and post-deployment performance under comparable operational conditions to assess the model's effects on event handling efficiency and service response time. These directions should consider process maturity, gradual expansion of monitored assets, human resource availability, and institutional constraints, while preserving governance, traceability, and continuous improvement.

8. Conclusion

This study presented an automation model for IT Event Monitoring and Management integrating Zabbix, a Fuzzy Inference Engine, and GLPI. The proposed architecture demonstrated automated handling from event triggering to ticket closure in accordance with ITIL 4 guidelines [Axelos 2019].

Application of Fuzzy Logic, grounded in [Zadeh 1965, Zimmermann 2001, Cox 1994], enabled generation of continuous criticality values subsequently mapped to linguistic levels in a pilot environment. This approach proved more granular than binary threshold-based mechanisms, such as the OK/Problem logic employed by Boolean triggers in Zabbix documentation [Zabbix LLC 2025], supporting prioritization that is more sensitive to operational context.

Overall, the results indicate that the integration between automated monitoring, multi-criteria fuzzy inference, and IT service management can structure a more consistent event management flow aligned with ITIL 4. The proposed model is a viable alternative for modernization initiatives, especially in the public sector, by combining open-source tools and modular integration.

9. Data and Artifact Availability

Datasets, legacy system metric spreadsheets containing MTTD and MTTR values, analysis scripts, diagrams, and other artifacts supporting the proposed (Zabbix, FIE and GLPI) integration model are available in an open digital repository[3],promoting transparency, reproducibility, and future research extensions. During the preparation of this manuscript, the authors used a generative AI tool (ChatGPT, OpenAI) exclusively for grammatical and orthographic revision. All content was critically reviewed by the authors, who take full responsibility for the final text.

[3]Available at: `https://figshare.com/s/bfd647f9379b14c36dfc`

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