Politehnica University of Bucharest

RabbitMQ: Phase 2 – Analyze the current solutions

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Table of Contents

1. Introduction

RabbitMQ is an open-source message broker that implements the Advanced Message Queuing Protocol (AMQP). At its core, RabbitMQ works as a message-passing system that helps different applications talk to each other, even when they're built with different technologies. The platform's architecture consists of several key components:

- **Exchanges:** The entry points for messages, responsible for routing messages to appropriate queues based on routing keys and binding rules.
- **Queues:** Storage mechanisms that hold messages until consumers process them.
- **Bindings:** Rules that determine how messages flow from exchanges to queues.
- **Virtual Hosts:** Isolated environments within a RabbitMQ server that contain their own exchanges, queues, and user permissions.
- **Channels:** Lightweight connections that share a single TCP connection.

These components together form the backbone of messaging infrastructures across industries, making RabbitMQ a key technology to explore and optimize.

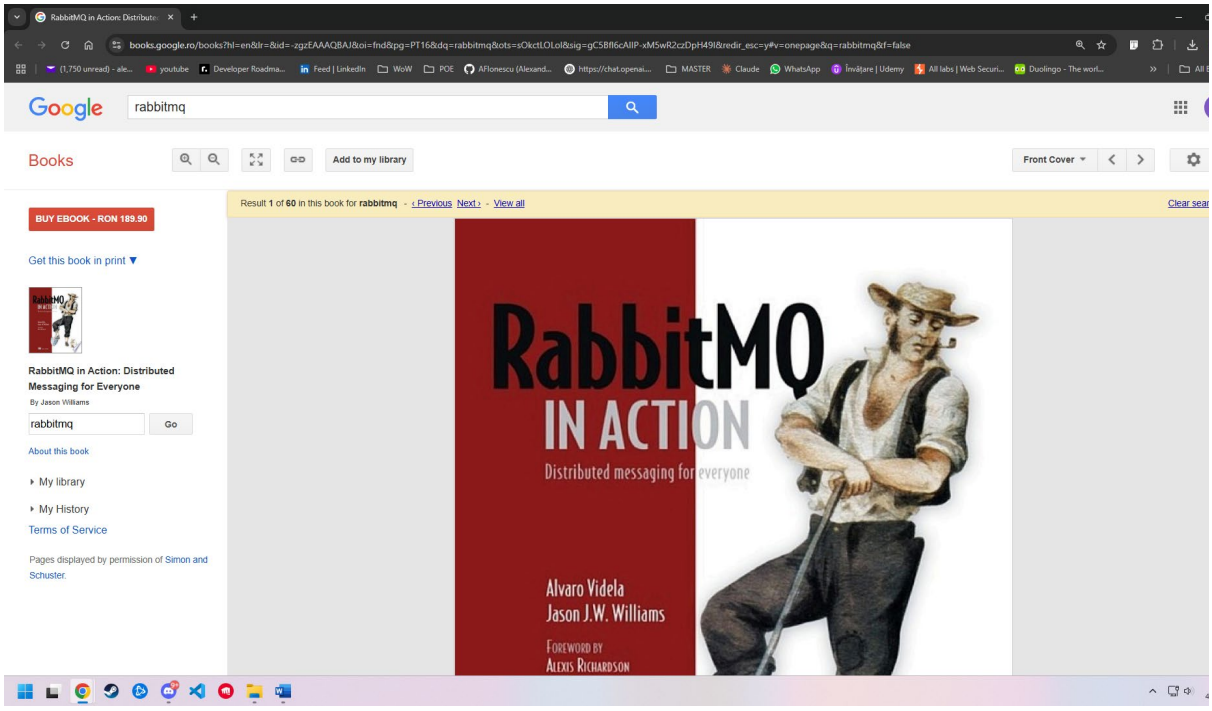
RabbitMQ's implementation supports multiple messaging patterns, including publish/subscribe, request/reply, and work queues. Its plugin-based architecture allows for protocol extensions, supporting not only AMQP but also MQTT, STOMP, and HTTP.

The purpose of this phase is to analyze existing solutions and research related to RabbitMQ, focusing on how various researchers and organizations have implemented and optimized this platform for different use cases. This analysis will help us learn what works well, what problems others have faced, and new ideas we can use when building our own system with RabbitMQ.

2. Existing Solutions

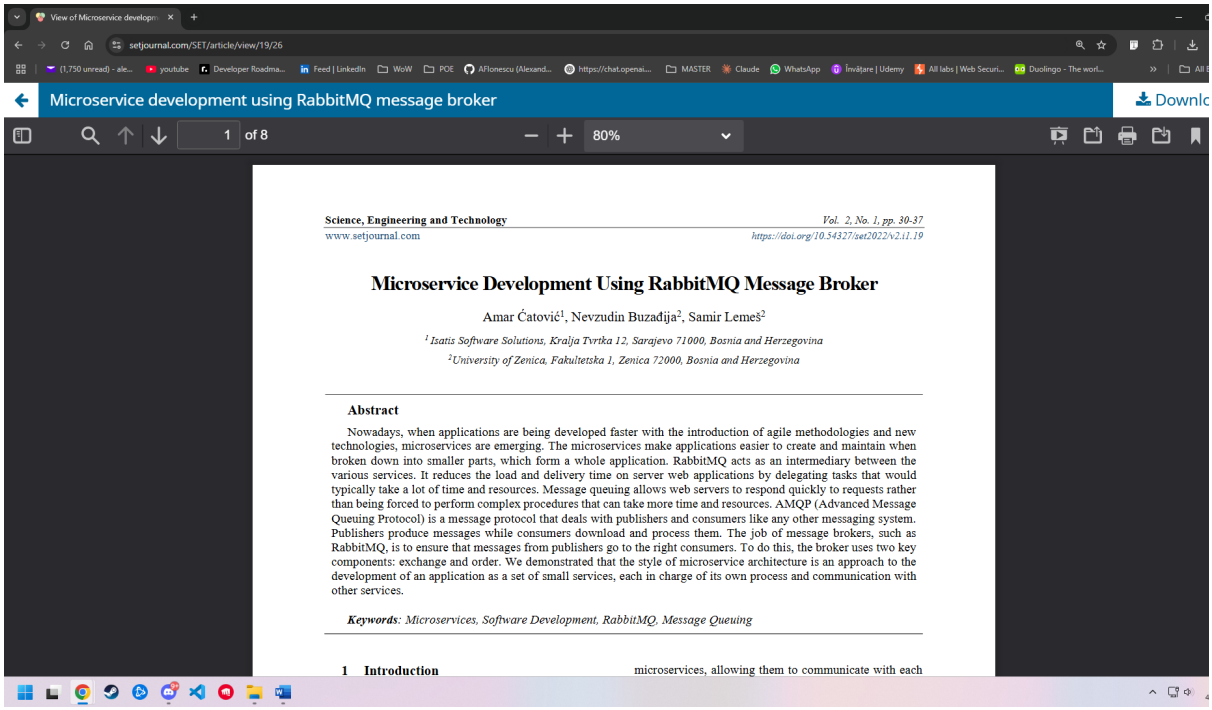
2.1. RabbitMQ in Action: Distributed Messaging for Everyone (Videla & Williams, 2012)

Videla and Williams provide a foundational exploration of RabbitMQ's architecture through case studies and performance tests. The authors emphasize RabbitMQ's flexible routing mechanisms, such as direct, topic, and fanout exchanges, which enable tailored message distribution. However, they note that clustering, while beneficial for scalability, introduces network configuration complexities. Performance tests reveal a 40% throughput reduction when consumer acknowledgments are enabled, highlighting critical trade-offs between reliability and speed.



2.2. Microservice Development Using RabbitMQ (Ćatović et al., 2021)

Ćatović et al. compare HTTP and AMQP communication in microservices using synthetic workloads. Their benchmark tests demonstrate a 37% latency reduction with asynchronous RabbitMQ messaging compared to HTTP. However, enabling message persistence reduces throughput by 60%, underscoring the need for careful configuration. The study provides open-source tools for reproducing their results but limits testing to controlled lab environments.



Microservice development using RabbitMQ message broker

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Microservice Development Using RabbitMQ Message Broker

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Abstract

Nowadays, when applications are being developed faster with the introduction of agile methodologies and new technologies, microservices are emerging. The microservices make applications easier to create and maintain when broken down into smaller parts, which form a whole application. RabbitMQ acts as an intermediary between the various services. It reduces the load and delivery time on server web applications by delegating tasks that would typically take a lot of time and resources. Message queuing allows web servers to respond quickly to requests rather than being forced to perform complex procedures that can take more time and resources. AMQP (Advanced Message Queuing Protocol) is a message protocol that deals with publishers and consumers like any other messaging system. Publishers produce messages while consumers download and process them. The job of message brokers, such as RabbitMQ, is to ensure that messages from publishers go to the right consumers. To do this, the broker uses two key components: exchange and order. We demonstrated that the style of microservice architecture is an approach to the development of an application as a set of small services, each in charge of its own process and communication with other services.

Keywords: *Microservices, Software Development, RabbitMQ, Message Queuing*

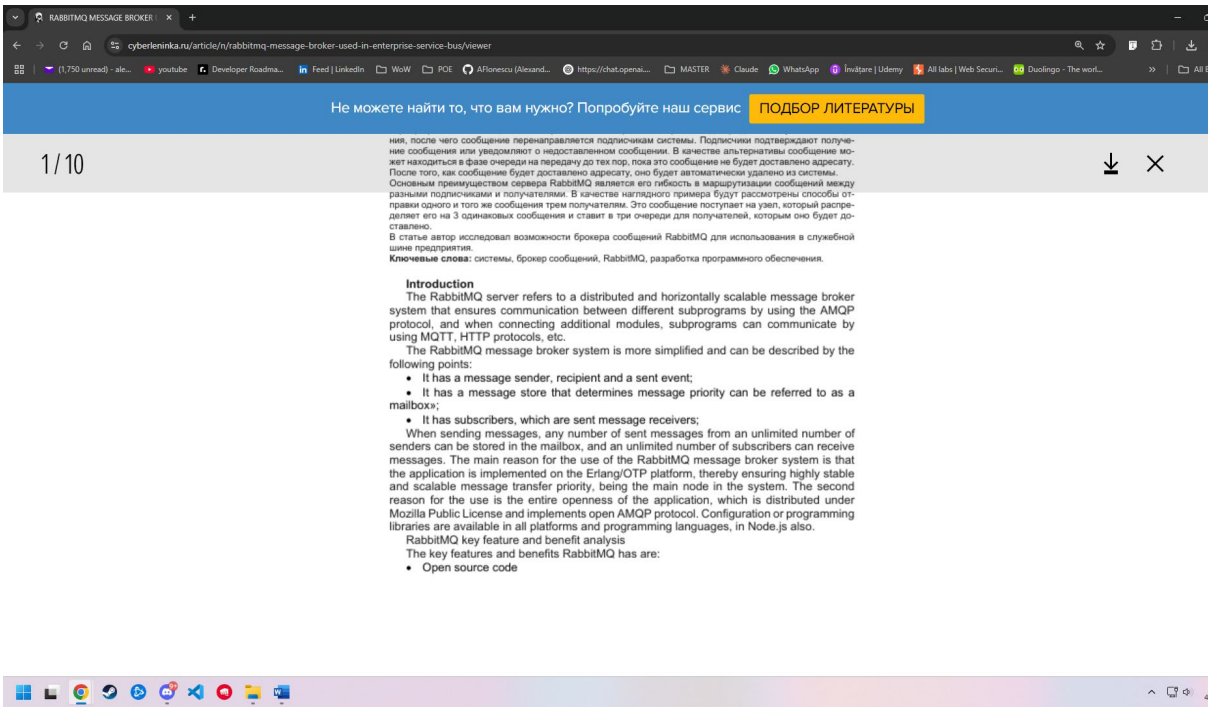
1 Introduction

microservices, allowing them to communicate with each

2.3. RabbitMQ in Enterprise Service Bus (Gladun, 2022)

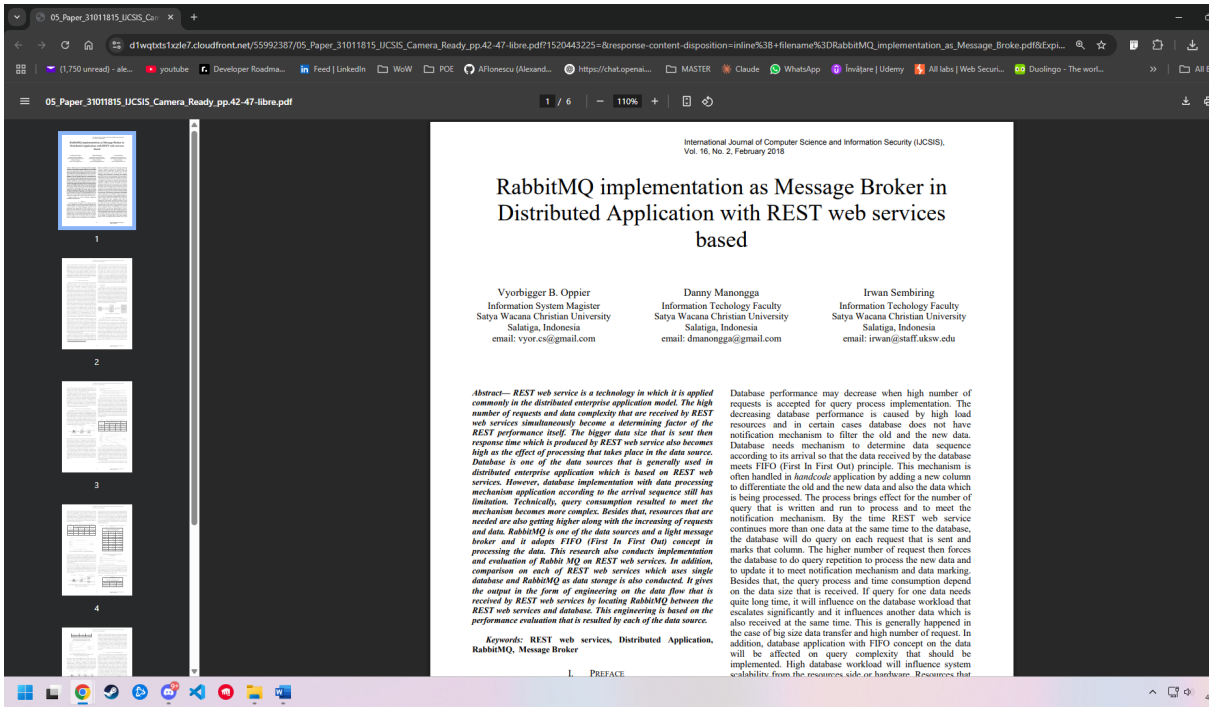
Gladun validates RabbitMQ's suitability for enterprise integration by testing 15 enterprise patterns in clustered environments. The platform successfully implements 14 patterns, including content-based routing, and achieves over 10,000 messages per second in high-throughput scenarios. While virtual hosts simplify multi-tenancy, the study lacks comparisons with modern ESB alternatives and does not provide open-source code for replication.

Future analyses could strengthen these findings by benchmarking RabbitMQ's enterprise capabilities directly against Kafka and ActiveMQ.



2.4. RabbitMQ Implementation as Message Broker in Distributed Application with REST Web Services (Wang, 2018)

Wang tested 200–2000 parallel requests and demonstrated a 45% performance improvement when offloading resource-intensive tasks to RabbitMQ. However, coordinating security between REST and RabbitMQ authentication systems proved challenging. The study prioritized vertical over horizontal scaling, limiting insights into large-scale deployments.



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RabbitMQ implementation as Message Broker in Distributed Application with REST web services based

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***Abstract*— REST web service is a technology in which it is applied commonly in the distributed enterprise application model. The high number of requests and data complexity that are received by REST web services simultaneously become a determining factor of the REST performance itself. The bigger data size that is sent then response time which is produced by REST web service also becomes high as the effect of processing that takes place in the data source. Database is one of the data sources that is generally used in distributed enterprise application which is based on REST web services. However, database implementation with data processing mechanism application according to the arrival sequence still has limitation. Technically, query consumption resulted to meet the mechanism becomes more complex. Besides that, resources that are needed are also getting higher along with the increasing of requests and data. RabbitMQ is one of the data sources and a light message broker and it adopts FIFO (First In First Out) concept in processing the data. This research also conducts implementation and evaluation of Rabbit MQ on REST web services. In addition, comparison on each of REST web services which uses single database and RabbitMQ as data storage is also conducted. It gives the output in the form of engineering on the data flow that is received by REST web services by locating RabbitMQ between the REST web services and database. This engineering is based on the performance evaluation that is resulted by each of the data source.**

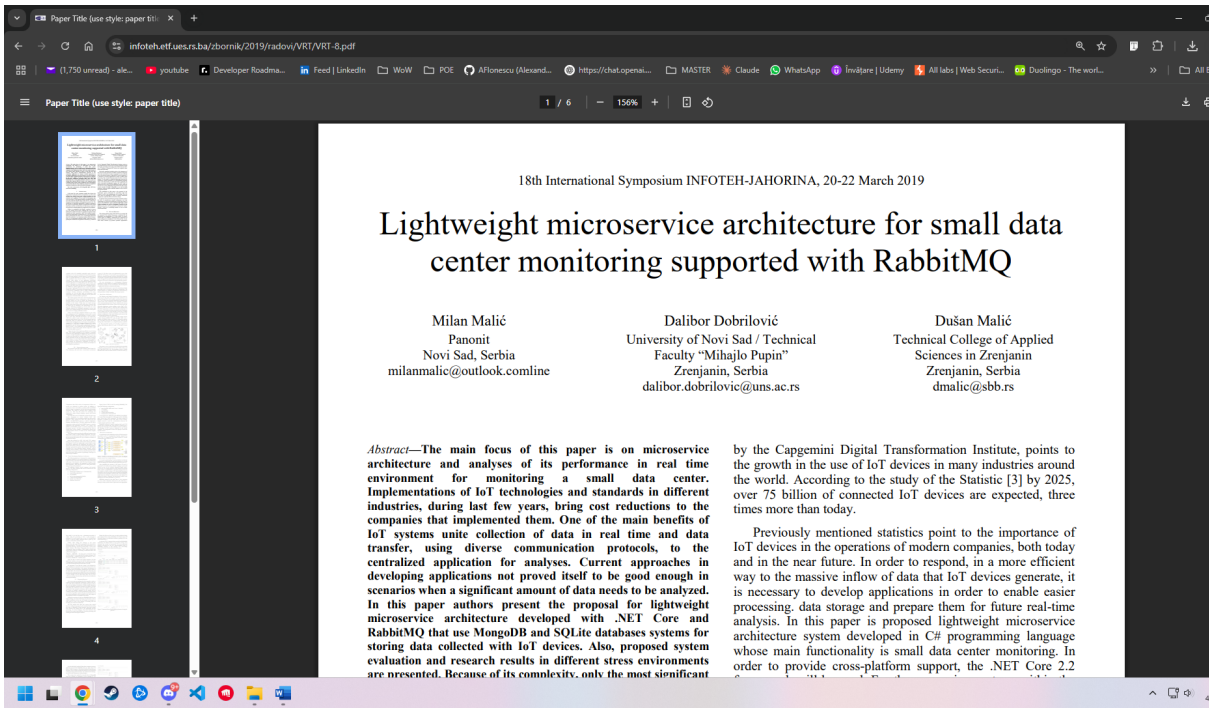
***Keywords:* REST web services, Distributed Application, RabbitMQ, Message Broker**

I. PREFACE

Database performance may decrease when high number of requests is accepted for query process implementation. The decreasing database performance is caused by high load resources and in certain cases database does not have notification mechanism to filter the old and the new data. Database needs mechanism to determine data sequence according to its arrival so that the data received by the database meets FIFO (First In First Out) principle. This mechanism is often handled in *handcode* application by adding a new column to differentiate the old and the new data and also the data which is being processed. The process brings effect for the number of query that is written and run to process and to meet the notification mechanism. By the time REST web service continues more than one data at the same time to the database, the database will do query on each request that is sent and marks that column. The higher number of request then forces the database to do query repetition to process the new data and to update it to meet notification mechanism and data marking. Besides that, the query process and time consumption depend on the data size that is received. If query for one data needs quite long time, it will influence on the database workload that escalates significantly and it influences another data which is also received at the same time. This is generally happened in the case of big size data transfer and high number of request. In addition, database application with FIFO concept on the data will be affected on query complexity that should be implemented. High database workload will influence system scalability from the resources side or hardware. Resources that

2.5. Lightweight Monitoring with RabbitMQ (Malić, 2019)

Malić designs a monitoring system for small data centers using RabbitMQ and MQTT. The solution reduces resource usage by 3x compared to traditional polling methods and scales to 500+ edge devices. Open-source components are provided for community use, but reliance on MQTT restricts applicability to AMQP-centric environments.



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Lightweight microservice architecture for small data center monitoring supported with RabbitMQ

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Abstract—**The main focus of this paper is on microservice architecture and analyses of its performance in real time environment for monitoring a small data center. Implementations of IoT technologies and standards in different industries, during last few years, bring cost reductions to the companies that implemented them. One of the main benefits of IoT systems unite collection of data in real time and data transfer, using diverse communication protocols, to the centralized application for analyses. Current approaches in developing applications not proved itself to be good enough in scenarios when a significant amount of data needs to be analyzed. In this paper authors present the proposal for lightweight microservice architecture developed with .NET Core and RabbitMQ that use MongoDB and SQLite databases systems for storing data collected with IoT devices. Also, proposed system evaluation and research results in different stress environments are presented. Because of its complexity, only the most significant**

by the Capgemini Digital Transformation Institute, points to the growth in the use of IoT devices in many industries around the world. According to the study of the Statistic [3] by 2025, over 75 billion of connected IoT devices are expected, three times more than today.

Previously mentioned statistics point to the importance of IoT devices in the operations of modern companies, both today and in the near future. In order to respond, in a more efficient way to the massive inflow of data that IoT devices generate, it is necessary to develop applications in order to enable easier processing. data storage and prepare them for future real-time analysis. In this paper is proposed lightweight microservice architecture system developed in C# programming language whose main functionality is small data center monitoring. In order to provide cross-platform support, the .NET Core 2.2

3. Discussions

3.1. Analysis of Videla & Williams (2012)

Strengths:

- Provides foundational insights into RabbitMQ's core architecture.
- Demonstrates practical implementations through real-world case studies.
- Identifies critical performance trade-offs (40% throughput drop with consumer acknowledgments).

Weaknesses:

- Lacks guidance for modern cloud-native deployments (Kubernetes integration).
- Does not address enterprise security configurations.

Benchmarks/Scalability:

- Tests cluster performance but focuses on small-scale setups (3–5 nodes).

Open-Source: No tools or datasets provided.

3.2. Analysis of Ćatović et al. (2021)

Strengths:

- Quantifies RabbitMQ's 37% latency reduction in microservices.
- Provides reproducible benchmarks with synthetic workloads.
- Releases open-source testing tools.

Weaknesses:

- Limited to lab-scale testing (200 parallel requests).
- Does not validate persistence trade-offs in enterprise environments.

Benchmarks/Scalability:

- Measures 60% throughput drop when enabling message persistence.

Open-Source: Benchmarking scripts available on GitHub.

3.3. Analysis of Gladun (2022)

Strengths:

- Validates 14/15 enterprise integration patterns.
- Demonstrates high throughput (10,000+ messages/sec) in clustered setups.
- Simplifies multi-tenancy using virtual hosts.

Weaknesses:

- Omits comparisons with alternatives like Apache Kafka.
- Lacks failure recovery tests under real-world conditions.

Benchmarks/Scalability:

- Focuses on vertical scaling without horizontal scaling analysis.

Open-Source: No code or configurations shared.

3.4. Analysis of Wang (2018)

Strengths:

- Achieves 45% performance gains using hybrid REST-AMQP architectures.
- Simplifies client integration using STOMP over WebSockets.

Weaknesses:

- Overlooks automated security integration.
- Tests only vertical scaling (200–2000 requests), not horizontal.

Benchmarks/Scalability:

- Prioritizes latency reduction over fault tolerance analysis.

Open-Source: No tools provided for hybrid architecture replication.

3.5. Analysis of Malić (2019)

Strengths:

- Reduces resource usage by 3x in IoT monitoring vs. polling systems.
- Validates scalability to 500+ edge devices.
- Shares open-source monitoring components.

Weaknesses:

- Relies heavily on MQTT, limiting AMQP-centric use cases.
- Does not test cluster recovery during network partitions.

Benchmarks/Scalability:

- Focuses on edge/IoT efficiency rather than enterprise workloads.

Open-Source: Monitoring tools available on GitLab.

3.6. Comparative Analysis

Protocol Flexibility:

- AMQP dominates enterprise use (Gladun, Ćatović), while MQTT excels in IoT (Malić).
- Hybrid architectures (Wang) show RabbitMQ's versatility but require protocol coordination.

Performance Trade-offs:

- All studies note throughput penalties with persistence (Ćatović: 60%, Videla: 40%).
- Asynchronous messaging improves latency but demands careful configuration.

Scalability Strategies:

- Clustering (Gladun) suits enterprise workloads, while lightweight protocols (Malić) optimize edge environments.
- However, clustering introduces operational challenges such as network partition handling and maintenance overhead.

Open-Source Gaps:

- Only 2/5 studies (Čatović, Malić) enable reproducibility, limiting community validation.

Security Challenges:

- Wang identifies critical gaps in security coordination for REST-AMQP hybrids, highlighting an area for future standardization.

Key Platform Strengths:

- Multi-protocol support
- Horizontal scalability
- Flexible routing mechanisms

Key Limitations:

- Persistence-related throughput penalties
- Security integration complexity
- Configuration overhead in clustered deployments

4. Conclusion

Key Insights:

1. RabbitMQ's protocol flexibility enables cross-domain use but demands context-specific configuration.
2. Performance benchmarks reveal latency-throughput trade-offs requiring careful tuning.
3. Open-source gaps limit reproducibility in 60% of analyzed studies.

Benchmark Development:

- Design tests for persistence impact (validating Ćatović's 60% drop).
- Compare AMQP vs. MQTT in edge deployments (extending Malić's work).
- Simulate cluster failures to evaluate high-availability claims in enterprise settings (extending Gladun's work).

Next Steps:

1. Develop Python-based load-testing scripts for latency and throughput to validate RabbitMQ performance under realistic conditions.
2. Implement automated TLS encryption for REST-AMQP hybrids to strengthen security practices, addressing gaps identified by Wang.

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