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Research Article

A Comparative Analysis of Programming Languages Used in Microservices

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Abstract:

The rise of microservice architecture has revolutionised software development, enabling greater scalability, flexibility, and modularity. However, the effectiveness of microservices largely depends on the choice of programming language, which influences performance, ease of maintenance, and the system's capacity to handle increased workloads. This paper addresses the critical challenge of selecting an appropriate programming language for microservices by conducting a comparative analysis of four widely used languages: Java, Python, Go, and Node.js. The problem at hand is the lack of clarity on which programming language best suits different microservices environments. Each language offers distinct advantages and trade-offs in terms of performance, scalability, and developer productivity. To address this, we performed a systematic evaluation using a range of comparative measures, including benchmarks on performance, scalability under varying loads, and security features. Our analysis draws on a comprehensive review of literature, industry reports, and case studies to assess the strengths and limitations of each language. The results of this analysis provide valuable insights into the appropriateness of these languages for various microservice contexts. Java excels in performance and robustness; Python offers ease of use and rapid development; Go stands out for its efficiency and scalability; and Node.js is favoured for its asynchronous capabilities and fast development cycles. These findings underscore the importance of balancing efficiency with usability and provide practical recommendations for developers and organisations in selecting the most suitable language for their microservices projects.

1. Introduction

1.1 Background

Microservices, or microservice architecture, refers to apps that are divided into smaller, independent services. These services may be deployed separately, connected in a flexible manner, and interacted with utilising lightweight methods. [1].
Microservices, an architectural paradigm, decompose applications into discrete and autonomous services that interact via APIs. You have the ability to independently build, implement, and grow each service. Adopting microservices architecture may enhance scalability and resource allocation, simplify update management and maintenance, and expedite the development process by enabling independent teams to work on distinct services. Occurring at the same time the microservices architecture has revolutionized software development by breaking down monolithic programs into smaller, autonomous

services, enabling separate development, deployment, and scalability [2]. Each microservice generally manages a distinct business function and interacts with other services via lightweight protocols such as HTTP or message queues. The use of modularity not only improves the capacity to scale and withstand challenges, but also makes it easier to continuously deliver and deploy [3].

1.2 Importance of Programming Languages in Microservices

Choosing a programming language for microservices is not only a technical decision, but also a strategic one. Factors including the performance of the language, its ability to handle concurrency, the maturity of the ecosystem, and the availability of competent developers are important considerations in this decision process [4]. The choice of programming language can have a significant impact on the overall effectiveness and success of the architecture in a microservices environment. In this context, services need to communicate efficiently, be able to scale on demand, and be maintained by multiple teams..

One of the main benefits of microservices is the ability to use the most appropriate tool for a given task. The monolithic design allows you to freely choose the programming language that best suits the needs, efficiency, and complexity of each service. It also allows you to leverage your team's current expertise, frameworks, and libraries while exploring new technologies and paradigms. In addition, microservices allow each service to be independently scaled, updated, and monitored, thereby improving the scalability, stability, and fault tolerance of your application [5].

However, microservices also bring some issues that must be considered when choosing a programming language. A major obstacle is the increased complexity and overhead of monitoring multiple services, dependencies, and communication protocols. It is important to ensure the consistency, compatibility, and security of services while ensuring that they can smoothly handle errors, outages, and delays. It is important to implement best practices and tools to log, track, evaluate, and resolve service issues in different environments. In addition, microservices may introduce some compromises and limitations in terms of data consistency, transactions, and network performance.

When choosing a programming language, it is important to remember that microservices can present some challenges. Dealing with multiple services, dependencies, and communication protocols becomes more complex and cumbersome, which is a significant issue. Ensuring the reliability, security, and fault tolerance of services is critical. It is also important to include best practices and tools for testing, debugging, tracing, and logging services in many scenarios. In addition, using microservices can bring many trade-offs and limitations in terms of network performance, transactions, and data consistency. Choosing the optimal programming language for microservices may be a challenging endeavor, since each language has distinct advantages, disadvantages, and compromises. When choosing a service, it is important to consider the scope and functionality of the service, the performance and efficiency of the language, the compatibility and interoperability of the language, and the learning curve and productivity of the language. Python is a good choice for data science and machine learning services, but Java is better suited for enterprises and web services. C++ and Rust are programming languages that are known for achieving high performance by providing developers with low-level control and optimization capabilities. JavaScript is a general-purpose programming language that can be used on many operating systems and is compatible with a variety of communication protocols and file types. Kotlin and Typescript are modern and expressive programming languages with concise syntax, but Perl and Haskell are more mature languages with powerful features. In the realm of microservices, the logical structure is of utmost importance, including the delineation of boundaries and the construction of services that excel at performing a single task. This approach is independent of any specific technology and allows for the selection of the most suitable tool for each service without any reliance on other tools [6]. Hence, the selection of the technology stack is contingent upon the specific functionality of the microservice, rather than the specified architectural pattern.

Creating microservices architecture involves several steps, from designing the system to implementing and deploying the services. Microservices offer a reliable platform for business expansion, leveraging language diversity. However, adding diverse languages can increase operational overhead. Standardizing the technology stack based on business needs is crucial. Key criteria include high observability, automation support, a consumer-first approach, independent deployment, business domain modeling, decentralization of components, and continuous integration support. Microservice architecture decomposes applications into smaller, autonomous services, enhancing scalability, simplifying updates and maintenance, and allowing for technological diversity to meet individual service requirements. The article

compares Java, Python, Go, and Node.js in microservices, analyzing performance, scalability, and developer productivity. It suggests choosing a language based on efficiency and user-friendliness, highlighting the compromises needed for different project situations.

2. Methods

Comparative analysis is a research tool used by researchers to evaluate and compare different topics in order to get insight into their relative strengths and weaknesses. When used to evaluate programming languages for microservices, it provides a systematic method for determining how well various languages meet the specific requirements of microservice architectures. . This study explores comparative analysis techniques, focusing on their use in evaluating microservice programming languages [7-10]. We will analyze a number of factors, including performance, scalability, developer productivity, ecosystem support, and ease of integration. These criteria are supported by recent research references [11].

In microservices architecture, a software system is decomposed into smaller autonomous services that interact with each other over a network. Choosing a programming language to create these services affects performance, scalability, ease of development, and maintainability. When comparing programming languages for use in microservices, a number of basic properties are often evaluated to determine the language that best suits your needs. The following are typical characteristics or criteria used in such an analysis [12-15]:

Performance

- Speed and Efficiency: How well the language performs in terms of execution speed and resource utilization.
- Latency: The responsiveness of the language in handling requests and processing data.
- Scalability
- Concurrency handling: The language's ability to efficiently handle multiple processes or threads.
- Load balancing: The extent to which the language supports distributing workloads across multiple instances.
- Speed of development
- Ease of use: How quickly developers can write and deploy code in the language.
- Productivity: The extent to which the language supports rapid development through frameworks, libraries, and tools.
- Ecosystem
- Libraries and frameworks: Providing ready-made solutions that accelerate development.
- Community support: The size and activity level of the language's developer community.
- Integration
- Interoperability: Compatibility with other services and systems in a microservices architecture.
- API support: The ease of creating and using APIs.
- Maintainability
- Code readability: How easy it is to read and understand the code.
- Refactoring support: The language is able to change and improve code without introducing bugs.
- Provisioning
- Containerization: How well the language integrates with containerization tools like Docker.
- Orchestration: Compatibility with orchestration platforms like Kubernetes.
- Security
- Integrated security features: Availability of language-specific security mechanisms.
- Vulnerability management: The language's track record and community response to security vulnerabilities.
- Skills and learning curve
- Developer expertise: Availability of qualified developers and the learning curve for new team members.
- Training requirements: Time and resources required to train developers in the language.
- Cost and licensing
- Development costs: Costs associated with using the language, including tools and frameworks.
- Licensing fees: All fees associated with licensing if the language or its tools are not open source.
- It's possible to perform a thorough comparative analysis by evaluating these criteria to select the most suitable programming language for your microservices architecture [16].

To include methodology in the language of choice for work, follow these steps:

- Selection of Programming Languages: Selecting the programming languages to compare is the first step. Popular choices in the microservices domain often include Java, Python, Go, Node.js (JavaScript), and Rust, among others.
- Define evaluation criteria: Define the criteria listed above and make sure they meet the specific needs of microservices. To do this, you need to look at the literature, industry benchmarks, and best practices in microservice design.

- Data collection: Collect data through empirical research, benchmarks, case studies, and expert interviews. For example, you can collect performance data from stress-tested microservices built in different languages and measure developer productivity through surveys or time-to-market analysis.
- Data analysis: Analyze the data using statistical methods or qualitative evaluation techniques. Comparative charts, tables, and matrices are often used to visualize differences and support decision making.

Synthesis and conclusion: This includes analyzing how each language fits into different types of microservices, such as data processing services.

3. Analyses

In the microservices space, several programming languages have become popular choices due to their unique advantages and features. This section briefly introduces the main languages commonly used in microservice architectures:

Java

- Mature ecosystem: Java has a strong ecosystem with a wide range of libraries and frameworks (such as Spring Boot) that make microservice development easier.
- Performance: Java provides high performance, especially through just-in-time (JIT) compilation and advanced garbage collection techniques.
- Scalability: Java's thread-based concurrency model supports the development of scalable and efficient microservices.
- Community support: Java has one of the largest developer communities, which means ample resources and support[10].
- Memory usage: Java applications can be memory intensive, which may require more resources in a cloud environment.
- Startup time: Java applications, especially those running on the JVM, can have longer startup times compared to languages like Go.
- Best use cases
- Java is particularly well suited for enterprise-level microservices that require strong performance, security, and scalability. It is well suited for services that are part of complex systems with high transaction volumes, such as: B. Banking and e-commerce platforms.

Go (Go language)

- Performance: Go is compiled to machine code, resulting in fast execution and low memory footprint, making it ideal for high-performance microservices.
- Concurrency: Go's go routines provide a simple way to handle concurrent tasks, making it easier to create scalable services.• Simplicity: The simplicity and readability of the language shorten the learning curve and make code maintenance easier.
- Startup time: Go applications have fast startup times, which is good for services that need to be responsive and efficient.
- Limited ecosystem: Go has a smaller ecosystem than Java and Python, which may require developers to create more custom solutions.
- Error handling: Go's error handling can be cumbersome and verbose, making the code harder to read.

Go is well suited for building lightweight, high-performance microservices that need to handle high concurrency. It is often used in cloud-native applications, container environments, and systems that require fast startup times, such as: B. API gateways and load balancers.

Python

- Ease of use: Python's simplicity and readability make it a top choice for rapid development and prototyping.
- Rich ecosystem: Python has a rich ecosystem of libraries, including powerful frameworks like Flask and Django,
- Those simplify microservice development.
- Community support: Python has a large and active community that provides a wide range of resources for developers.
- Flexibility: Python's dynamic nature allows for flexible coding, which is beneficial in a rapidly changing environment.
- Performance: Python is an interpreted language, which makes it slower than compiled languages like Java and Go.
- Concurrency: Python's global interpreter lock (GIL) limits the effectiveness of multithreading, although this can be mitigated with asynchronous programming or multiprocessing.

Python is particularly well suited for microservices that require rapid development, efficient data processing, and seamless interaction with machine learning models. It is often used for applications focused on data, RESTful APIs, and services that are not performance-critical.

Node.js (JavaScript/TypeScript)

- Non-blocking I/O: Node.js's event-driven architecture with non-blocking I/O makes it highly efficient for handling concurrent connections.

- JavaScript Ecosystem: The vast ecosystem of JavaScript libraries and frameworks, such as Express.js, accelerates the development of microservices.
- Unified stack: Using JavaScript or TypeScript on both the client and server side simplifies development and
- reduces context switching.
- Community and tools: Node.js has strong community support and a wide range of microservice development tools, including Docker support and cloud integration.
- Single-threaded model: While Node.js handles concurrency well, its single-threaded nature can become a bottleneck for CPU-intensive tasks.
- Callback hell: Asynchronous programming in Node.js can lead to complex and difficult-to-manage code structures, although this can be alleviated with Promises and Async/Await.

Node.js is very effective for building I/O-intensive microservices that manage a large number of concurrent connections, such as: B. Real-time applications, chat services, and lightweight APIs. It is also the first choice for microservices that need to be tightly integrated with front-end development.

C# (.NET Core)

- Performance: C# with .NET Core provides excellent performance, especially for Windows-based environments, and now has strong cross-platform support.
- Integrated Development Environment (IDE): Visual Studio provides a rich development environment and powerful debugging and testing tools.
- Scalability: C# supports strong multithreading and asynchronous programming, which is critical for scalable microservices.
- Mature ecosystem: The .NET ecosystem provides a wide range of libraries, frameworks, and tools to build and deploy microservices.
- Memory usage: Like Java, C# can be memory-intensive, which can increase the cost of cloud deployments.
- Learning curve: For developers coming from dynamically typed languages like Python or JavaScript, C# can have a steeper learning curve.

Various aspects come into play when deciding on a programming language for microservices, including performance requirements, developer skills, and respective application scenarios. Java and C# are the best choices for efficient enterprise-level services, while Go is well suited for lightweight, highly concurrent services. Python is suitable for rapid development and handling data processing tasks, but Node.js is well suited for real-time applications and services involving intensive input/output processes. A thorough understanding of the pros and cons of each programming language can help developers and architects make informed decisions to meet the goals and constraints of their projects.

To create a comprehensive comparison table of Go, Java, Python, Node.js, and C# in terms of security, features and learning curve, cost, and licensing in a microservices environment, I would normally look up relevant articles and extract specific information. However, since I cannot personally retrieve or check an article, I can provide a general table based on generally accepted characteristics and research of these languages.

Use research to synthesize data and identify the most appropriate programming language for a specific microservice situation. The conclusion should contain practical recommendations, such as recommending a specific programming language for services that require high speed or highlighting the advantages of a certain language for rapid development. Comparative analysis is an effective method for evaluating programming languages in the context of microservices. Through careful criteria selection and comprehensive data collection and analysis, researchers and engineers can make informed judgments to meet the unique needs of their projects. This approach not only highlights the strengths and weaknesses of each language, but also provides a structure for negotiating trade-offs based on the different needs of microservices [17].

The comparative analysis reveals that each programming language offers unique advantages and trade-offs when used in a microservices architecture.

- Java: Best for large-scale, enterprise-grade microservices where stability, performance, and a mature ecosystem are critical.
- Python: Great for rapid development and prototyping, especially for microservices with low performance requirements. However, performance limitations should be considered.
- Go: Best choice for performance-critical microservices that require efficient concurrent processing and low latency.
- Node.js: Great for I/O-intensive microservices where non-blocking operations are essential, making it suitable for real-time applications.

The choice of programming language should be based on the exact requirements of the microservice to be developed. If you need a performance-critical service, we recommend using Go or Java. Python vs. Node.js offers significant advantages for rapid development and deployment. Number 18 is enclosed in square brackets.

The choice of programming language is a crucial factor when designing microservices architecture. While there is no universally better language, developers and architects can make an informed choice by understanding the pros and cons of each language. Java, Python, Go, and Node.js are all suitable for use in a microservices ecosystem. The decision of which language to use depends on the individual requirements of the application, such as: B. Performance requirements, scalability, and developer experience. The number 25 is enclosed in square brackets. Figure 1 is steps involved in the creation of microservice architecture and figure 2 is the method for selecting a microservice's programming language.

Table 1 presents a comparison of popular programming languages commonly utilized in microservices based on key attributes and table 2 presents a comparison of the programming languages used in microservices depending on the use of big data. Go's performance advantages may lead to its increasing popularity in the next microservices development trend, but Python and Node.js are more popular due to their ease of use and ability to quick development. Continual assessment of programming languages will continue to be crucial in order to maintain an efficient, scalable, and maintainable architecture as the microservices landscape progresses.

Below is a comparative table that evaluates prominent programming languages often used in microservices, depending on important characteristics.

- Go: Known for its simplicity and efficiency, making it suitable for microservices that need to handle concurrency well.
- Java: A mature language with strong security features and a large ecosystem, but with a high learning curve.
- Python: Popular for its ease of use, but may not be the best choice for performance-critical microservices.
- Node.js: Great for handling I/O-intensive services, but requires special attention to security due to its reliance on external packages.
- C#: Well integrated into Microsoft's ecosystem, powerful in enterprise environments, and has good support for secure coding practices.

4.Programming Languages Used in Microservices for Big Data

Big data refers to the large amounts of structured and unstructured data that pours into enterprises every day. Traditional monolithic architectures often struggle to meet the scalability and flexibility required to manage and process such large data sets. To this end, microservices architecture has emerged as a solution that breaks down applications into smaller, independent services that can be

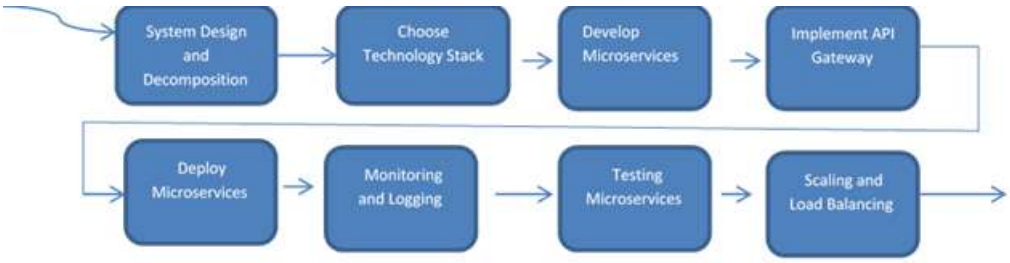

Figure 1. *Steps involved in the creation of microservice architecture*

Figure 2. *Method for selecting a microservice's programming language*

Table 1. *Comparison of popular programming languages commonly utilized in microservices based on key attributes.*

Criteria	Java	Python	Go	Node.js (JavaScript)	Rust
Performance	High performance for enterprise-grade applications, though JVM overhead can be high.	Moderate; limited by GIL, better for I/O-bound tasks.	Very high; efficient concurrency with go routines.	Good for I/O-bound tasks, slower for CPU-bound.	Very high; near C/C++ performance with memory safety.
Scalability	Excellent, supported by robust frameworks and multi-threading.	Moderate; scaling can be challenging due to GIL, but works well with async.	Excellent; designed for high concurrency and large-scale services.	High; suitable for real-time services but requires careful state management.	Excellent; ideal for high-performance, low-latency services.
Ease of	Moderate; verbose syntax	High; simple syntax,	High; clean syntax,	High; easy to use with a	Moderate; steep learning

Development	but extensive tools.	fast development cycles.	moderate learning curve	rich ecosystem.	curve but excellent tooling.
Ecosystem and Libraries	Very rich; mature ecosystem with numerous libraries.	Very rich; extensive libraries, particularly for data science.	Growing; strong standard library, emerging frameworks.	Very rich; npm offers vast libraries and tools.	Growing; fewer libraries than others, but high quality.
Community Support	Large and active; extensive documentation and third-party support.	Very large; one of the largest and most active communities.	Growing; vibrant community focused on performance and simplicity.	Very large; one of the largest developer communities.	Passionate and growing; highly engaged community.
Suitability for Microservices	Backend services, API gateways, and large enterprise applications.	Data processing, machine learning, and quick prototyping.	Real-time communications, network services, high concurrency tasks.	Real-time data processing, API development, and I/O-bound services.	Performance-critical microservices, such as real-time analytics and low-latency systems.
Security	- Mature language with extensive security features. - JVM security policies add extra layers.	- Flexible but less strict typing. - Needs careful handling for secure coding.	- Strong concurrency model reduces risk of race conditions. - Static typing helps in catching bugs early.	- Asynchronous event-driven architecture may introduce security challenges. - Relies heavily on npm packages.	- Robust security frameworks. - Windows platform security integration.
Skillset and Learning Curve	- Steeper learning curve due to complexity. - Requires knowledge of JVM and ecosystem.	- Easy to learn, especially for beginners. - Extensive community and resources.	- Simple syntax, easy to learn. - Ideal for developers familiar with C-like syntax.	- JavaScript familiarity is beneficial. - Asynchronous programming can be complex.	- Intermediate learning curve. - Familiarity with .NET framework required.
Cost	- Open-source but enterprise support might be costly. - Higher resource consumption than Go.	- Open-source, free to use. - Potentially higher costs due to slower performance in some use cases.	- Open-source, no licensing costs. - Efficient resource usage lowers infrastructure costs.	- Open-source, free to use. - Highly efficient in I/O-bound operations, lowering cost in those scenarios.	- Open-source under .NET Core; licensing costs for enterprise support (Windows Server).
Licensing	- Open-source (GPL) with commercial options. - Oracle's commercial licensing may apply in certain cases.	- Open-source (PSF license). - Few licensing concerns, permissive license.	- Open-source (BSD-style license). - No major licensing issues.	- Open-source (MIT License). - Some concerns with npm package licenses	- Open-source (.NET Core under MIT license). - Enterprise licensing for full .NET framework

Table 2. *Comparison of the programming languages used in microservices depending on the use of big data.*

Programming Language	Strengths	Weaknesses	Suitability for Big Data Microservices	Popular Frameworks/Tools
Java	- Mature ecosystem (e.g., Spring Boot) - Strong static typing - JVM platform independence - High performance for large-scale apps	- Verbose code - Longer startup times	- Well-suited for data-intensive microservices - Ideal for enterprise-level big data processing	- Spring Boot - Apache Hadoop - Apache Kafka
Python	- Simple and readable syntax - Extensive libraries for data processing (e.g., Pandas, NumPy) - Strong community support	- Slower execution speed - Global Interpreter Lock (GIL) limits multi-threading	- Excellent for data analysis, ETL tasks, and AI/ML integration - Less ideal for performance-critical tasks	- Flask, Django - Apache Spark (PySpark) - Dask
Scala	- Interoperable with Java - Functional programming support - High performance in concurrent processing	- Steeper learning curve - Less widespread adoption compared to Java and Python	- Ideal for high-performance big data microservices - Strong support for distributed data processing	- Apache Spark - Akka - Play Framework
Go (Golang)	- High performance and efficiency - Concurrency support with goroutines - Compiled language with fast execution	- Limited libraries for data processing - Less expressive for complex data manipulation	- Best for performance-critical, lightweight microservices - Suitable for distributed systems and real-time data processing	- Go-Micro - Gorilla - gRPC
Node.js (JavaScript)	- Non-blocking I/O for handling multiple connections - Large ecosystem of libraries - Rapid development and deployment	- Single-threaded nature limits CPU-bound tasks - Potential performance issues for large-scale data processing	- Suitable for I/O-bound microservices - Useful for real-time data processing with WebSockets	- Express - NestJS - Koa
Rust	- High performance - Memory safety without garbage collection - Concurrency support	- Steeper learning curve - Smaller ecosystem compared to others	- Suitable for performance-critical microservices - Ideal for handling large-scale, low-latency data processing	- Actix - Rocket - Tokio
C++	- High performance and fine-grained control - Low-level memory management - Extensive optimization opportunities	- Complexity in development - High potential for bugs if not managed properly	- Best for microservices where performance is critical - Suitable for systems-level programming in big data environments	- gRPC - Apache Kafka (client libraries) - Boost

deployed and scaled individually. The choice of programming language for these microservices is crucial, especially in big data where performance, concurrency, and data processing capabilities are critical.

This section compares several popular programming languages used in microservices tailored for big data environments. Each language is examined for its strengths, weaknesses, and suitability, taking into account factors such as performance, ecosystem, usability, and community support.

Key Takeaways:

- Java and Scala are good choices for big data microservices that require strong performance and scalability, especially in enterprise environments.
- Python is favored for its simplicity and wide range of data processing libraries, making it ideal for data analysis and machine learning tasks in microservices.
- Go is suitable for performance-critical microservices, especially distributed systems.
- Node.js excels in real-time data processing scenarios, especially I/O-intensive microservices.
- Rust and C++ are the best choices for microservices where maximum performance and low-level control are critical, although they have a steeper learning curve and complexity. Selecting the right programming language for microservices in big data depends on the specific requirements of the task, including performance, scalability, and ease of development [18-21].

5. Result

The study found that Go is best suited for high-performance microservices that require low latency and efficient concurrency. Java, on the other hand, is well suited for demanding, large-scale, enterprise-grade microservices with strong support for distributed systems. Python is well suited for data-focused microservices, while Node.js is best suited for microservices that require real-time processing and are constrained by input/output operations. Rust is well suited for systems that require both fast performance and memory safety, but requires a more rigorous learning process. Thanks to Go's lightweight go routines and Java's well-optimized JVM, Both Go and Java are highly scalable and offer strong support in distributed environments. Java provides a well-developed environment with strong community support, comprehensive documentation, and a wide range of tools and libraries. Go prioritizes development speed and maintainability, reducing runtime errors and facilitating long-term management[22]. Java and Python have broad and mature communities, but Go and Node.js have strong communities. Go is primarily focused on cloud-native programming, while Node.js targets full-stack and real-time application development[23].

The research on the selection of programming languages for microservice architectures highlights many important conclusions that emphasise the crucial role this choice plays in the development of microservice-based systems:

- Performance and applicability: The choice of programming language has a significant impact on the performance of microservices. High-performance languages such as C++ or Rust are suitable for computationally intensive tasks, while programming languages such as Go or Node.js are well suited for latency-sensitive applications. Choosing the appropriate language based on service requirements is critical to optimizing performance [24-32].
- Languages with rich library and framework ecosystems enable faster development and integration. For example, Java's Spring Boot and Python's Django provide powerful tools for building and managing microservices, improving development efficiency [33].
- Integration and interoperability: Effective communication between microservices is essential. Languages that support different communication protocols and data formats ensure seamless integration within the architecture. This feature is essential for maintaining interoperability between different services and systems [34].
- Development speed and maintainability: Languages that provide rapid development capabilities and easy maintenance can speed up project schedules and reduce long-term costs. Languages known for their simplicity, such as Python, can speed up development, while strongly typed languages, such as Java, improve maintainability and extensibility [26].
- Scalability and deployment: Scalability is a core feature of microservices, and it is critical to choose a language that supports extensible patterns and integrates well with containerization and orchestration tools. Extensibility functions are a unique feature of languages such as Go and Node.js[28].
- Security considerations: Security is a primary concern in microservice architectures. Languages with built-in security features or strong security libraries can help protect

applications from vulnerabilities and threats [30].

- Skills and team expertise: Using a language that matches the team's existing skills can simplify development and reduce training costs. Conversely, languages with steep learning curves may require additional training, impacting development timelines [31].
- Cost and licensing: Development costs and licensing considerations play an important role in the selection process. Open source languages often offer cost advantages and community support compared to proprietary options[28].
- Emphasis on importance: Choosing the right programming language for microservices is a critical decision that affects performance, development efficiency, scalability, and security. By tailoring language selection to the specific needs of microservices and the capabilities of the development team, companies can improve the effectiveness of their microservices architecture and achieve their strategic goals.

6. Discussion

The choice of microservice programming language is influenced by multiple aspects, including performance, developer efficiency, scalability, and ecosystem support. Using performance-oriented languages such as Golang and Rust can significantly improve high-performance microservices, but developers tend to choose Python and JavaScript for their simplicity and development speed. Java and C# are suitable for large-scale architectures. Programming languages like Golang and Elixir that prioritize scalability and concurrency are conducive to building fault-tolerant and scalable systems. Programming languages with well-developed ecosystems and mature libraries are well suited for a wide range of microservice needs. When choosing a microservice language, it is important to consider project requirements, team skills, and the level of community support. For large projects, choosing a language with strong community support is usually a safer choice [35-38].

The industry expects to adopt programming languages to develop microservices based on individual needs. While Java remains the dominant choice for enterprise solutions, go and Rust are becoming increasingly popular in cloud-native environments. Python is the top choice for data-driven services, but Node.js is often used for real-time event-driven microservices. To overcome performance limitations in demanding applications, companies need to complement Python with other programming languages. The non-blocking, event-driven design of Node.js makes it well suited for services that manage real-time data. The growing trend of language specialization will impact how companies design microservice architectures, improve performance, and strike a balance between development speed and long-term maintainability. Companies may use a polyglot strategy, which involves using many languages within the same organisation to exploit the unique advantages of each language for various categories of tasks.

7. Conclusions

The choice of programming language when developing microservices should depend on the individual needs of the application. Java is a solid choice for building high-performance business-level microservices, while Python is known for its rapid development and ease of use, making it suitable for data-oriented applications. Go offers excellent performance and is well suited for scalable cloud-native applications, as is Node.js. JavaScript is well suited for managing microservices efficiently in real time with limited input/output.

When developing software, it is important to choose a programming language that meets the performance requirements, development speed, and scalability requirements of a microservice architecture. Each language has its own strengths and weaknesses, and the best choice depends on the specific needs of the project. The use of different languages when applying a microservices architecture is worth noting. Each microservice or microservice phase has its own language. While some services use NodeJS, Kotlin, Python, and Go, most services are written in Java, Spring Boot, and MongoDB [35].

There is no better way to choose the ideal technology for a microservice. The tools used to build the other components of the application influence every technology decision made. It also depends on what the development team currently understands. The decision should be consistent with the development team's capabilities, technical requirements, and business goals.

Microservices represent a dynamic and rapidly evolving research area that provides significant opportunities for future research. Key areas of focus include the impact of new programming languages such as Kotlin, Swift, Crystal, or Zig on microservice development, the evolution of microservice architectures, and security in environments with multiple programming languages, techniques for optimizing performance

across different languages, and using AI to select languages for microservices. These areas can help organizations make informed decisions about adopting new technologies, understand the security implications of using multiple languages in a single architecture, develop new security protocols, and explore AI-driven language selection for microservices. These topics have the potential to lead to more efficient and customized microservice architectures.

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