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Microservices Architecture Versus Monolithic Architecture: Technical Trade-offs and Economic Analysis of Modularising Human Resources Systems

Gao Zhihao[1],Liu Ziqi[2,*]

[1]School of Economics and Management, Quanzhou University of Information Engineering, Fujian, China,362000, China

[2]School of Business of Belarusian State University,Belarus,Minsk, Oboynaya Street 7,220004, Belarus

KEYWORDS

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Monolithic architecture;
Economic trade-offs modularisation;

ABSTRACT

This paper analyses the technical trade-offs between microservices and monolithic architectures for human resource systems from an economic perspective on human resource management. The research reveals that architectural selection is fundamentally an economic decision concerning modularity, requiring a balance between transaction costs, innovation option value, and asset specificity. It provides an architecture selection framework grounded in economic principles for enterprises of varying scales.

INTRODUCTION

As enterprises deepen their digital transformation journeys, human resource management systems have evolved from traditional back-office support tools into core assets that enhance organisational effectiveness and drive strategic objectives.

1.Research Background and Theoretical Framework

1.1.Research Problem and Perspective

This paper adopts a human resource management economics perspective to construct an analytical framework, defining technological architecture selection as an economic trade-off between long-term costs and benefits.

The research focuses on the impact of system modularity on transaction costs, innovation option value, and asset specificity. Theoretical analysis reveals that for large organisations with complex operations, the initial high investment in microservices architecture can be justified by reducing future change costs and creating more ‘physical options.

Conversely, for small and medium-sized enterprises with stable operations, selecting a monolithic architecture with low initial costs represents a more economical choice. This research provides human resource managers and technology decision-makers with an economics-based assessment tool designed to guide forward-looking decisions[1].

1.2.Background: The Evolving Demands on HR Systems

Against the backdrop of current human resource management systems evolving from record-keeping systems to participatory systems and even intelligent systems, these systems must possess the capability to rapidly respond to emerging demands such as remote working and flexible benefits. The rise of microservices architecture offers a new pathway for system modernisation.

Concurrently, enterprises face the decision of whether to refactor existing systems or adopt microservices directly when building new ones. Existing discussions predominantly focus on technical implementation, lacking a systematic analysis of the long-term cost structures and

* Corresponding author. E-mail address:gaozhihao@qzuie.edu.cn

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value creation mechanisms associated with architectural choices from an economic perspective. This is precisely the issue addressed by this research.

1.3.Core Concepts: Defining the Architectural Paradigms

Within software engineering, monolithic architecture and microservices architecture represent two fundamentally distinct design paradigms.

Monolithic architectures typically integrate all functional modules of an application within a single process for development, deployment, and scaling. Their lifecycle cost model features relatively low initial development costs, but as system complexity increases, maintenance and functional modification costs exhibit non-linear growth. Microservices architecture advocates constructing applications as a collection of small services, each built around specific business capabilities and capable of independent deployment and scaling.

However, while this architecture delivers flexibility, it also introduces inherent complexities of distributed systems, such as additional costs related to network latency, data consistency, and operational monitoring.

1.4.Theoretical Lens: Modularity and Economic Theories

Modularity theory provides a crucial opportunity to understand the differences between these two architectures. In software engineering, modularity pursues the design principles of high cohesion and low coupling.

Drawing from Baldwin and Clark's discussion in Design Rules, the value of modularity in economics lies in its creation of ‘option value’. This allows individual modules within a system to be independently experimented with, iterated upon, or even replaced without undermining the system's foundations, significantly enhancing its capacity to navigate uncertainty[2].

From the perspective of human resource management and economics, relevant theories offer profound insights into architectural choices. Transaction cost economics indicates that architectural decisions directly influence coordination and communication costs among internal human resource teams, technical development teams, and operations teams. Microservices architecture, by defining clear API contracts, holds promise for reducing internal transaction costs arising from ambiguous module boundaries.

However, it simultaneously introduces new costs associated with service invocation and governance. The theory of real options treats technological investments as ‘options’ that create future growth opportunities. The modular nature of microservices significantly reduces the cost and risk of experimenting with new technologies or business models for independent functional modules such as recruitment, performance management, and learning development, thereby enhancing an organisation's innovation option value.

Furthermore, the theory of asset specificity indicates that within monolithic architectures, HR business logic becomes deeply intertwined with specific technology stacks, creating high asset specificity.

This results in substantial costs for future technological transformation or system upgrades. In contrast, microservices architecture permits technological heterogeneity, effectively reducing this specificity and enabling the selection of the most suitable technical tools for different HR scenarios.

2.Economic Analysis and Decision Model for Architecture Selection

2.1.Economic Trade-off Model

Building upon these theories, we have constructed an economic trade-off model for evaluating HR system architecture choices. This model unfolds across two dimensions: cost and value.

Within the cost dimension, the initial development cost must first be considered.

Typically, monolithic architectures incur lower costs here than microservices, as the latter necessitate meticulous service decomposition and the establishment of complex distributed infrastructure.

Secondly, coordination and communication costs arise: teams within monolithic architectures are highly interdependent, leading to substantial communication expenses; whereas microservices enable team autonomy, though cross-service coordination relies on rigorous contract management, shifting the cost structure.

System operations and monitoring costs are also significant factors: monolithic architectures are relatively simpler to maintain, while microservices demand a mature DevOps culture and robust monitoring systems. Finally, and critically,

change and iteration costs: as monolithic architectures scale, the friction associated with changes increases dramatically; whereas microservices substantially reduce the cost of localised changes, though cross-service modifications may still present challenges.

On the value dimension, agility and time-to-market are paramount. Microservices architecture typically outperforms monolithic structures due to its independent deployment capabilities. System scalability is another key advantage, with microservices enabling granular scaling for high-load services like payroll processing.

Technical resilience and innovation option value form the core of this model. A microservices architecture creates independent experimental options for each HR functional module, whose aggregate value equals the sum of the potential gains from each module's independent innovation multiplied by its probability of success. In contrast, the option value within a monolithic architecture is bundled and difficult to execute.

Furthermore, system stability and fault tolerance must be considered: monolithic architectures carry single points of failure risk, whereas microservices enable fault isolation, though overall fault diagnosis complexity increases[3].

Taking all these factors into account, corporate decision-making should strive to maximise the net present value across the entire system lifecycle. A simplified net present value model may be expressed as the sum of future net revenues discounted at an appropriate rate.

The core advantage of microservices architecture lies in its value components—particularly the value of innovation options—which appreciates significantly over time and with increasing business uncertainty.

Concurrently, its change cost growth curve remains markedly flatter than that of monolithic architectures, potentially rendering it more economically viable from a long-term perspective[4].

Evaluation Dimensions	**Monolithic Architecture**	**Microservices Architecture**	**Economic Interpretation**
Initial Investment Costs	Low	High	Microservices necessitate upfront investment in distributed infrastructure, containerisation, and service meshes, entailing significant fixed costs.
Coordination and Communication Costs	High internal coupling, high communication overhead	Team autonomy, but high governance costs for API contracts	Transaction costs shift from internally ambiguous boundaries to externally defined interfaces, altering cost structures.
Cost Curve of Change	Non-linear escalation with system scale	Low localised change costs, overall controllability	Microservices reduce internal system friction through modularity, stabilising marginal change costs.
Innovation Option Value	Low (option constraints, high execution costs)	High (each service as an independent option)	Microservices create real options, enabling low-risk experimen

			tation and rapid iteration on specific HR functions (e.g., recruitment, performance management).
Technological Flexibility and Asset Specificity	High (deep binding to specific technology stacks)	Low (supports technical heterogeneity)	Microservices reduce the asset specificity of technology stacks, mitigating future risks of technological lock-in and switching costs.
Optimal Application Scenarios	Suitable for stable operations, small scale, rapid validation requirements	The HR function leaps from the operational to the strategic level	The core decision lies in aligning the organisation's current developmental stage with its level of uncertainty to maximise net present value.

Table.1. Comparative Analysis of Economic Characteristics in HR System Architecture

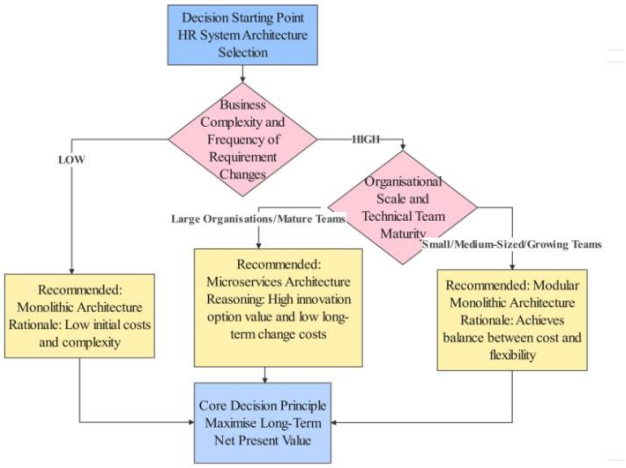

Fig1.HR System Architecture Selection Decision Diagram

2.2.Application Scenarios

Building upon these theories, we have constructed an economic trade-off m

Applying the aforementioned analytical framework to diverse scenarios yields more actionable conclusions. For human resources shared service centres within large conglomerates, the inherent complexity of operations — spanning multiple business models, countries, and high-concurrency environments with fluctuating demands— creates a primary contradiction: the substantial costs of coordination versus the opportunity costs incurred by rigid systems that hinder development. In this context, microservices architecture resolves these issues by decoupling core modules such as personnel management, remuneration, recruitment, and learning. This allows teams across different regions or business units to iterate localised functionalities independently and agilely, while adhering to core data standards. The substantial innovation options value it creates and the long-term change costs it reduces are sufficient to offset the high initial investment, thereby demonstrating significant economic rationality.

For small and medium-sized growth enterprises, whose operations tend to be relatively straightforward, teams compact, and resources constrained, the primary imperative

lies in rapid deployment to validate business models. At this stage, the low initial development costs and reduced coordination complexity inherent in monolithic architectures become decisive factors. Premature adoption of microservices introduces unnecessary distributed system complexity, consuming precious R&D resources. Moreover, the potential innovation option value remains difficult to realise effectively, as the enterprise's developmental direction is still being explored.

2.3.Refactoring Decision

When choosing the path from monolithic to microservices architecture, the decision to refactor should be judged from an economic perspective. It is not a simple question of 'whether to do it,' but rather 'when to do it' most economically. The economic inflection point for refactoring arrives when the marginal change cost of the monolithic system continues to rise and ultimately exceeds the marginal governance cost of a microservices architecture. Investing at this juncture effectively constitutes purchasing a compound option that permits the enterprise to pursue continuous innovation and evolution at lower future costs[5].

2.4.Organisational Alignment (Conway's Law)

Conway's Law classically observes that a system's design architecture replicates the organisation's communication structure. This principle carries profound economic implications within the architectural trade-offs of human resources systems. A tightly coupled monolithic HR system typically corresponds to a traditional HR department structure characterised by functional silos and cumbersome communication processes. Within such an organisational framework, any system-level change necessitates complex cross-departmental coordination, perpetuating exceptionally high internal transaction costs. Conversely, adopting a microservices architecture represents not merely a technical transformation but a strategic investment in organisational design. It necessitates the establishment of cross-functional agile teams aligned with this approach, such as dedicated small feature teams responsible for recruitment operations or compensation management. While the initial restructuring costs of this new organisational model are undoubtedly substantial, once successfully implemented, it significantly reduces subsequent coordination and communication expenses. This enables each team to make rapid decisions and pursue continuous iteration around their independently managed business modules. Therefore, architectural selection fundamentally involves a joint decision between organisational communication costs and technological innovation benefits. When selecting technologies, enterprises must carefully assess whether their existing organisational structure can support a microservices architecture, or whether they are willing to make the necessary investments to build a new organisational structure capable of fully unlocking the value of microservices.

2.5.Three-stage Evolutionary Model

The selection of an HR system architecture is not a static, fixed decision but should be viewed as a dynamic, phased strategic investment process.

To this end, we propose a three-stage evolutionary model to guide enterprises in formulating more forward-looking architectural planning.

During the monolithic initiation phase, business operations typically undergo preliminary validation with relatively straightforward requirements and constrained resources.

The optimal strategy here is to adopt a monolithic architecture for rapid implementation of core HR functions such as employee information management and payroll processing.

The primary objective is to minimise initial investment costs while validating the fundamental business model. It is noteworthy that even at this stage, conscious modular design should be implemented at the programming level.

Within the monolithic system itself, clear boundaries should be established for key business logic such as recruitment and performance management.

This effectively pre-emptively embeds valuable 'options' for potential future decomposition.

When business growth reaches a scale where microservices-based refactoring becomes a decision-making inflection point, operational complexity significantly increases.

Monolithic systems often become difficult to modify, while organisational demand for rapid innovation intensifies. Decision triggers at this stage typically arise when one or more of the following conditions are met:

The marginal cost of modifying the monolithic system exceeds the marginal governance cost of a microservices

architecture; Business growth necessitates rapid, independent experimentation and iteration on specific human resources modules such as learning platforms; or the technical team has expanded sufficiently to support multiple autonomous teams working in parallel. The optimal strategy at this stage is to initiate strategic refactoring, prioritising business value to progressively decouple and transform the most mature, agility-critical functional modules from the monolithic system into independent microservices.

Ultimately, upon completing the microservices transformation, the system enters the microservices governance and value extraction phase. The core task shifts from system construction to efficient governance. Enterprises must establish a mature DevOps culture, a robust API governance framework, and a unified monitoring platform to effectively control and optimise the long-term operational costs of the microservices architecture, thereby maximising its inherent innovation option value[6].

3.Managerial Implications and Practical Recommendations

This study holds significant implications for both human resources managers and technology decision-makers. For human resources managers, it is essential to move beyond viewing technology architecture as purely technical implementation details, instead understanding the economic rationale underpinning its role as a tool for realising human resources strategy. When communicating with technology departments, greater emphasis should be placed on business language such as ‘return on investment, response speed, and operational flexibility’ to jointly evaluate architectural choices.

When selecting HR technology providers, the modernity and modularity of their system architecture should also be a key evaluation criterion.

For technology decision-makers, it is essential to recognise that technology decisions must be closely aligned with the organisation's business strategy and developmental stage, avoiding the pitfall of pursuing technology for technology's sake. Adopt an ‘evolutionary architecture’ mindset. When initially building monolithic systems, consciously design clear interfaces and boundaries for potential future modularisation. This delays major decisions, allowing the natural emergence of the most economically viable refactoring inflection point.

Conclusion

This paper systematically demonstrates that the choice between microservices and monolithic architectures for HR systems is fundamentally an economic trade-off based on modularity.

The core decision lies in prudently evaluating and comparing the long-term cost structures and value creation capabilities of different architectural approaches, where innovation option value plays a particularly critical role in rapidly changing business environments.

For modern HR organisations committed to enhancing agility and innovation capabilities, microservices represent an economically rational choice: strategic upfront investment to secure long-term system evolution capabilities while reducing core change costs. However, this is by no means a universal panacea. Organisations must ground their decisions in their specific scale, operational complexity, and developmental stage, applying economic principles to conduct rigorous evaluations.

This approach enables the selection of technological investments that maximise long-term human resource effectiveness and align most effectively with overarching organisational strategic objectives.

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