Exploring Enterprise Architecture Strategies: Layered, SOA, Microservices, and Cloud Computing Perspectives

Yew Rui Xiang
Faculty of Computing
University Technology Malaysia,
Johor, Malaysia
yewxiang@graduate.utm.my

Sam Chia Yun
Faculty of Computing
University Technology Malaysia,
Johor, Malaysia
samyun@graduate.utm.my

***Abstract*—** In this academic paper, Layered Enterprise Architecture (LEAD), and Service-Oriented Architecture (SOA), Microservices Architecture, Cloud Computing, are compared within the framework of Enterprise Architecture (EA). LEAD stresses a layered approach for agility, and SOA connects technology with business processes, scalability and flexibility are enhanced by Microservices Architecture, cloud computing provides scalability and flexibility through IaaS and PaaS. Because every strategy has different benefits and difficulties, it must be carefully considered in light of organizational requirements.

***Keywords*—** Enterprise Architecture (EA), Layered Enterprise Architecture (LEAD), Service-Oriented Architecture (SOA), Microservices Architecture, Cloud Computing

I. Introduction

Enterprise system architecture is the process of comprehending and articulating the relationships between different components and systems inside an organization [1]. Along with outlining the connections between these elements, it also describes the enterprise's organizational structure, business procedures, and IT infrastructure.

EA is a crucial component of corporate technology frameworks, helping them to align with strategic objectives. Modern complexity is thought to outgrow traditional domain-based EA techniques. As a result, options such as cloud integration, Microservices Architecture, Service-Oriented Architecture, and Layered Enterprise Architecture (LEAD) have been investigated. There are advantages and disadvantages to each of these methods for organizing and managing systems. These frameworks are examined in this analysis, with an emphasis on their tenets, advantages, and disadvantages. Organizations can choose wisely when it comes to EA by being aware of these choices.

Making sure the company runs efficiently to fulfill its mission in the outside world is the aim of enterprise system architecture. In addition to meeting the enterprise's functional requirements, it is made to fulfill various non-functional requirements that are necessary to meet the needs of stakeholders, users, and customers. The components of the enterprise system are given these specifications, after which they are created to satisfy them.

Each aspect of enterprise system management, such as customers, vendors, industry standards, and competitors, has its own architecture within the overall enterprise system architecture framework.

II. Comparative Analysis of Previous Studies

We have meticulously curated a comprehensive selection of insightful articles, each delving into different Enterprise Architectures. Table 1 below provides the detailed analysis and comparison of the author(s), year of publication, citation, proposed EA, and identified weaknesses of the research, allowing for a thorough examination of the literature.

TABLE I. Table Type Styles

Ref	*Author(s), Year, and Citation*	*Proposed Enterprise Architecture*	*Weakness of Research*
[1]	POLOVINA et al., 2020	Layered Enterprise Architecture (LEAD)	Limited exploration of potential drawbacks
[2]	Kistasamy et al., 2010	Service-Oriented Architecture (SOA)	Lacks of case studies or real-world examples
[3]	Abd-Elwahab et al., 2023	Microservices Architecture	Lacks of case studies or real-world examples
[4]	Sajjan & Biradar, 2016	Cloud Computing	Lacks in-depth empirical evidence

a.

Simon Polovina, Mark von Rosing, and Georg Etzel [2] present a comprehensive exploration of Layered Enterprise Architecture (LEAD) as a framework for enhancing Enterprise Architecture (EA) practices. They argue that traditional domain-based approaches to EA, often following a linear waterfall methodology, are inadequate for addressing the complexities of modern enterprises. Instead, it advocates for a layered approach that enables concurrent work within and across multiple domains, fostering agility in EA processes.

The layered approach organizes components into three key layers as shown in Fig. 1. Those layers are mainly about:

- **Business Layer:** Focuses on organizational value, competencies, processes, and services, shaping strategic direction and operational functions.
- **Information Layer:** Manages application systems and data components, supporting business processes and decision-making.

- **Technology Layer:** Includes platform and infrastructure components, providing the technological foundation for business and information systems.

Fig. 1. Overview of the common enterprise layers [2]

In 2010, [3] provided a comprehensive analysis of Service-Oriented Architecture (SOA) within the context of Enterprise Architecture (EA) and organizational alignment between business and IT. Service-Oriented Architecture (SOA) is described as a conceptual business architecture that focuses on making business functionality or application logic available as shared, reusable services on an IT network. These services are modular units of business or application functionality with exposed interfaces, accessible via messages. SOA is portrayed as a methodology that aligns technology with business processes, allowing for the design of architecture as a service. The paper also delves into the conceptual framework of SOA, elucidating its components and principles such as loose coupling, discoverability, and interoperability.

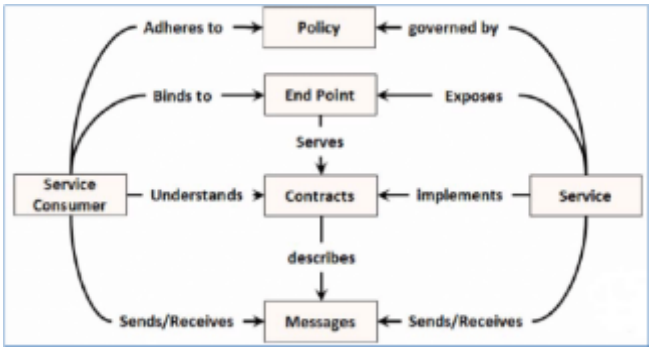

Fig. 2. SOA Components and Relationships [6]

There exists an EA that shares some similarities with SOA which is MicroServices architecture that is discussed in [4]. The authors proposed the use of MicroServices technology to drive digital transformation involves several key steps, including crafting the MicroServices architecture, instituting standardized best practices, integrating supportive tools like DevOps, aligning with the enterprise's cloud roadmap, and facilitating seamless data integration.

At its core, microservices architecture advocates for breaking down complex IT systems into smaller, self-contained units of functionality known as microservices. These microservices are designed to encapsulate specific business capabilities or functions, allowing for greater flexibility, scalability, and resilience across the enterprise ecosystem.

Fig. 3. Uses of EA with MicroServices technologies [4]

Although Microservices architecture and SOA share some similarities but also have significant differences. Microservices architecture and SOA differ in scope, size, technology stack, governance, and organizational culture, with microservices focusing on agility and autonomy while SOA may be better suited for larger enterprise integration scenarios; however, both can be considered enterprise system architectures, with microservices offering scalability, flexibility, resilience, integration, agility, and decentralization within an organization's IT infrastructure.

Cloud computing has emerged as a revolutionary paradigm in the field of information technology, fundamentally altering the way businesses and individuals access, store, and manage data and applications. Sajjan and Biradar [5] introduce cloud environments as basic to build EA which provide better flexibility, availability and scalability. The authors suggest organizations can use cloud computing services to build their IT architecture:

- **Technical Architecture:** Utilize IaaS and PaaS for foundational infrastructure and development platforms.
- **Application Architecture:** Leverage SaaS for readily available applications on-demand.
- **Data Architecture:** Employ IaaS for scalable storage and data processing solutions.

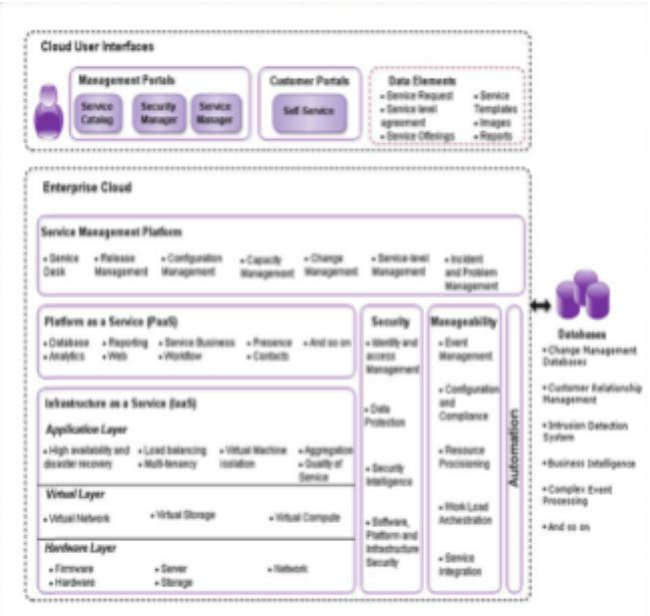

Fig. 4. The architectural stack of private Cloud [5]

III. Advantages and Disadvantages

In this part, based on the Enterprise Architectures (EA) discussed from each selected researcher's results, the advantages as well as the disadvantages will be discussed and analyzed.

A. *Layered Architectures*

The layered design has various benefits, including a distinct division of responsibilities, which aids in understanding, developing, and maintaining the EA. This strategy facilitates the capacity to make modifications and expansions, allowing for changes or improvements to be introduced in one layer without causing disruptions to other layers. This encourages the ability to quickly and gradually build the system. Furthermore, the ability to reuse components inside each layer improves efficiency and minimizes the amount of work required for development. Additionally, the architecture's scalability allows for accommodating increases in data volume, user load, and functionality, both in terms of expanding vertically and horizontally.

Nevertheless, layered architecture does have its disadvantages, including the additional burden of managing numerous levels, which can lead to increased complexity and potentially affect the performance of the system. Interactions among different levels, especially in remote systems, can result in delays and decreased responsiveness. Furthermore, the inflexible framework of layered architectures might impede the ability to adjust to changing demands, requiring significant redesign.

B. *Service-Oriented Architecture (SOA)*

The academic paper in [3] highlights several advantages of SOA in enhancing enterprise practices. An outstanding benefit is its capacity to efficiently integrate technological solutions with company objectives. SOA accomplishes this by establishing a conceptual business framework in which business operations are shown as shared, reusable services on an IT network. SOA enables the encapsulation of business logic into modular services with exposed interfaces, resulting in increased flexibility and agility to respond to evolving business requirements. Furthermore, SOA facilitates the ability of businesses to easily connect disparate systems and applications by promoting interoperability and composability. This compatibility enables cooperation among diverse corporate divisions and external associates, resulting in enhanced effectiveness and ingenuity.

For disadvantage, SOA has inherent intricacy involved in building and overseeing a service-oriented architecture. Creating and sustaining a thorough SOA architecture necessitates meticulous strategizing, oversight, and collaboration among different areas and individuals involved. Furthermore, achieving the discoverability, loose coupling, and location transparency of services can pose technological difficulties, especially in extensive business settings. Furthermore, the transition to SOA may necessitate substantial organizational modifications and expenditures in infrastructure and technology. Obstacles such as resistance to change, insufficient skills, and cultural hurdles inside the organization might impede the effective adoption and implementation of SOA efforts.

C. *MicroServices Architecture*

The Microservices architecture has numerous benefits that make it an appealing option for enterprises undergoing digital transformation. First and foremost, the modular architecture of the system enables increased flexibility and agility in both development and deployment processes. By decomposing applications into smaller, self-contained services, development teams may work on each service independently, allowing for quicker iteration cycles and decreasing the time it takes to introduce new features and updates to the market. Furthermore, the scalability of Microservices architecture is a notable benefit, as it enables enterprises to independently scale certain services according to demand. This optimizes resource consumption and ensures efficient performance, even during periods of high demand.

While the disadvantage for this EA arises from the augmented intricacy brought about by the dispersed nature of Microservices. Effectively managing and organizing communication among several services can present challenges, including problems related to service discovery, load balancing, and the overhead associated with inter-service communication. Additionally, the implementation of Microservices architecture frequently necessitates substantial modifications to the organizational culture, procedures, and tools, which might provide difficulties in terms of resistance to change and the necessity of enhancing skills or retraining current staff. Moreover, maintaining uniformity and logical connection among numerous autonomously created and implemented services might pose difficulties, potentially resulting in problems concerning the management of different versions, compatibility, and the integrity of data.

D. *Cloud computing*

The incorporation of cloud computing into EA has several benefits, particularly in regards to scalability and flexibility. According to [7], organizations can achieve dynamic scalability of their IT infrastructure to accommodate changing demand without making substantial initial investments in hardware by implementing Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) models. The ability to scale allows firms to promptly adapt to shifting market conditions, ensuring that their IT resources can effectively meet changing operational needs. Furthermore, the integration of enterprise architecture

(EA) with cloud-based systems promotes adaptability by granting enterprises the ability to instantly access a diverse range of services and resources. This facilitates the quick creation, testing, and implementation of new applications and services. The agility mentioned can result in competitive advantages, as organizations are able to innovate at a faster pace and deliver their products and services to the market more quickly than their competitors.

Nevertheless, cloud computing EA integration also presents several possible problems and concerns. A primary issue of concern is the safeguarding of data security and privacy. This is because enterprises are required to rely on third-party cloud providers to handle sensitive information, which increases the likelihood of data breaches or illegal access. To successfully manage these risks, it is crucial to ensure compliance with relevant legislation and standards, such as GDPR or HIPAA. Moreover, relying on external cloud providers can give rise to concerns regarding the availability and dependability of their services. Interruptions or disturbances in cloud services can hinder corporate operations, resulting in decreased productivity and potential financial consequences.

IV. Opinion

Enterprise Architecture (EA) is crucial in determining the technological framework of businesses, directing them towards the attainment of their strategic goals and objectives. It is essential to recognize that all firms have distinct requirements and situations, which demand the implementation of customized enterprise architecture techniques. Layered Architecture offers a systematic method for handling complexity and enabling flexibility, while SOA focuses on aligning technology with business processes, encouraging interoperability and the reuse of services. The Microservices Architecture provides enterprises with flexibility and scalability, making it particularly ideal for those undergoing digital transformation projects. Integrating Cloud Computing into EA offers the advantages of scalability, flexibility, and agility, allowing firms to easily adjust to changing market conditions.

Keeping up with emerging trends and breakthroughs in the field of EA is crucial. With the rapid evolution of technology, emerging concepts like Artificial Intelligence (AI), Internet of Things (IoT), and Blockchain are fundamentally changing the field of EA. These technologies provide novel prospects for refining company processes, enhancing customer experiences, and fostering creativity. Hence, firms must consistently demonstrate adaptability and proactivity in embracing these changes in order to sustain their competitive advantage in the digital age.

V. Conclusion

The present analysis has investigated various concepts related to Enterprise Architecture (EA), including Layered Enterprise Architecture (LEAD), Microservices Architecture, Service-Oriented Architecture (SOA), and cloud computing. With benefits like flexibility, scalability, and agility, each strategy offers a different viewpoint on how to organize and manage enterprise systems.

While choosing an EA framework, organizations should carefully consider their objectives and goals as each method has advantages and disadvantages. In order to modify EA methods to satisfy the expectations of the digital age, it is imperative to stay up to date on developing technologies such as blockchain, IoT, and AI. Organizations may assist their efforts in digital transformation and accomplish their strategic goals by making educated decisions based on their grasp of these frameworks and their implications.

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