MODULE-8

Research Methods and Professional Practice

Literature Review

TOPIC: Application of Microservices architecture in the development of web applications
INDUSTRY: Semiconductor

Introduction:

Microservices architecture is a design pattern for software that structures an application as a group of loosely coupled services. Each service is independent and carries out a single function. Using well-defined APIs, services can communicate with one another. In recent years, microservices architecture has gained popularity due to its numerous benefits, which include agility, resilience and scalability.

The semiconductor industry is widely recognized for its rapid technological advances and intricate fabrication procedures. In this constantly changing environment, web applications play a crucial role in a number of areas, including process management, supply chain optimization, quality control, and data analytics. Adoption of contemporary software architecture paradigms is now required to satisfy the evolving demands of the industry. One such concept is micro-services architecture, that provides agility, scaling, and maintainability. This literature review investigates the application of micro-services architecture in the web applications development in semiconductor industry, focusing on its prospective benefits, challenges, and future research opportunities.

Research Design and Methodology:

This paper is based on a literature review of microservices architecture and web applications in the semiconductor industry. A methodical approach was utilized to conduct this literature review. Articles published were researched using academic databases including IEEE Xplore, Google Scholar. Keywords like "micro-services," "micro-services architecture," "web applications," "semiconductor industry," "software development", and “Security Microservices” were used in various combinations to identify pertinent literature. Articles, conference papers, and publications that addressed the application of microservices architecture in the semiconductor industry were reviewed.

Key discussions:

Microservices architecture aligns itself well to the development of web applications in the semiconductor industry because it makes web applications easier to scale, flexible and agile.

Micro-services design is a software development strategy that organizes an application as a set of small independently deployable services. Each service concentrates on a particular business capability and interacts with other services using lightweight protocols such as HTTP. This modular approach facilitates adaptability, scalability, and maintenance simplicity.

In the semiconductor industry, microservices architecture has a variety of specific applications, including:

- Applications for electronic design automation (EDA) are used for the development and simulation of semiconductor circuits. Microservices design can be used to develop more robust and user-friendly EDA applications.
- Product Lifecycle development: Microservices design can be used to break down the development of complex semiconductor products into smaller, more manageable tasks.
- Manufacturing: Microservices design can be used to manage the intricate semiconductor manufacturing process.
- Supply Chain Management: The microservices' real-time data integration capabilities facilitate the tracking and management of the semiconductor supply chain.
- Quality Assurance: Micro-services enable the collection and evaluation of quality-related data,

assisting in defect prevention and detection.

- Sales and marketing: Microservices as a framework can be used to personalize customer sales and marketing experiences.
- Microservices architecture can be utilized to provide more responsive and efficient customer support.

(N. Alshuqayran et Al, 2016)

Microservices Architecture-

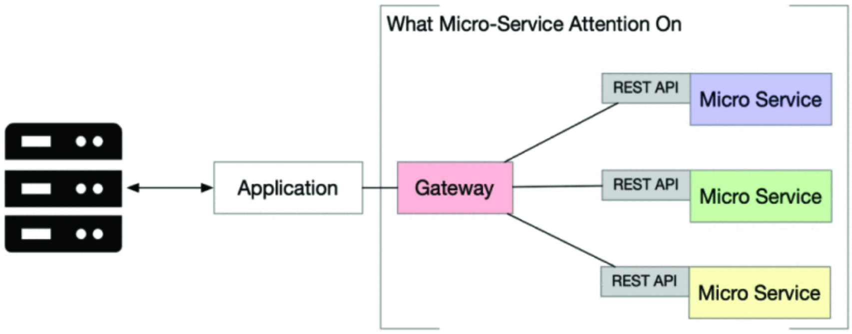

Fig.: Architecture of Microservices

(Y. Gong et all, 2020)

Strengths & Limitations:

The strengths and limitations of microservices architecture include

- **Strengths**:
  - Scalability: The architecture of microservices can be horizontally scaled by adding additional instances of individual functions. Semiconductor companies frequently manage enormous datasets and intricate simulations. Independent scalability of microservices enables efficient resource allocation.
  - Resiliency: Microservices architecture is resistant to failures due to the fact that individual functions can fail without influencing the application as a whole.
  - Agility: Microservices architecture facilitates the development and deployment of new capabilities and features.
  - Technology selection: Microservices can be built with a variety of frameworks and programming languages, giving developers greater latitude to accommodate the semiconductor industry's diverse requirements.
  - CI/CD (Continuous Integration and Deployment): Micro-services facilitate automation, making it simpler to implement CI/CD pipelines for quicker and more secure software releases.
  - Fault toleration: Isolating services reduces the impact of failures, thereby enhancing system resilience.
  - It promotes a modular and decentralized architecture, making maintenance, development and updates simpler.

- **Limitations**:

- Complexity: Microservices architectures are typically more difficult to develop and execute than conventional monolithic architectures. Managing multiple services and their interactions in large-scale applications can be difficult.
- Examination: It can be more difficult to assess microservices-based applications than monolithic applications.
- Ensuring data consistency across microservices can be difficult and requires careful planning, necessitating cautious database design and implementation.
- Migrating from a monolithic architecture to micro-services can involve significant infrastructure and development expenses.
- Observability: Due to the distributed nature of microservices-based applications, it can be challenging to witness and monitor them.
- Microservices architecture can enhance the application's operational overhead, such as the need to monitor and manage multiple services.
- Enhanced security risks
- Complicated debugging: Debugging across distributed micro-services can be time-consuming; therefore, robust monitoring and recording mechanisms are required

(Alshuqayran et al 2016)

EDA (electronic design automation) benefitting with Microservices architecture:

Due to the microservices adaptability and scalability, microservices architecture is increasingly becoming popular across a variety of industries, including Semiconductor applications like EDA. Here's how an approach based on microservices can benefit EDA:

- EDA includes a vast array of tools and functionalities, including schematic design, simulation, layout, and verification. By decomposing these functionalities into microservices, each service is able to concentrate on a particular aspect of EDA. This modularity makes it simpler to build, uphold, and update individual components without impacting the system as a whole.
- Microservices can be designed with well-defined APIs, making it simpler to integrate them within EDA environment (other tools and services). This facilitates **interoperability** and the creation of custom workflows.
- If a single microservice encounters a problem or fails, it can be isolating and resolved without influencing the entire EDA system - system's **fault tolerance and reliability**.
- Microservices enables teams to work independently on individual services, resulting in faster updates and functionality additions.
- Microservices can be individually scaled to accommodate fluctuating demand. Certain EDA jobs, such as simulation and verification, may necessitate substantial computational resources. With microservices, specific services can be horizontally scaled to manage increased workloads without affecting other services.
- **Diverse technologies**: EDA tools frequently require various technologies and programming languages. Microservices enable you to select the most suitable technology stack for each service, making it simpler to take advantage of the most recent software development advancements.
- **Elasticity** - EDA workloads can vary significantly - Microservices can be provisioned and decommissioned dynamically based on demand, allowing for effective resource utilization and cost savings.
- Microservices are capable of having their own **security measures** and access controls. This permits the implementation of granular security measures to safeguard confidential engineering data and intellectual property.

(Laung et al, 2009)
(T. Prasandy et al, 2020)

Security of EDA (with Microservices):

Given the complexity and criticality of EDA workflows, securing a microservices-based Electronic Design Automation (EDA) system presents a number of challenges and opportunities. Here is a summary of the challenges and opportunities:

CHALENGES	OPPORTUNITIES
1) Service to Service Communication: Difficulty can be encountered when securing communication between microservices (inter-service communication), as multiple services must communicate securely.	Implementing mutual TLS (mTLS) and appropriate authentication mechanisms between services can provide solid data in transit security.
2) **Data Security**: Protecting sensitive design data is of the utmost importance. Microservices can confound data security due to the frequent sharing of data between services.	Implement encryption at rest and access controls to protect sensitive data. For sensitive data, implement tokenization or homomorphic encryption.
3) **API Security**: Microservices expose APIs, which must be protected from unauthorized access and exploitation.	APIs that are effectively designed can facilitate secure access control. Control access with API gateways and powerful authentication mechanisms.
4) **Authentication and Authorization:** Implementing uniform authentication and authorization methods across microservices can be difficult.	Utilize IAM and RBAC solutions for consistent access control.
5) **Incident Response:** In a microservices environment, dealing to security incidents necessitates coordination between various services.	Develop and evaluate a customized incident response plan for a microservices architecture, including procedures for detecting and isolating compromised services.

(Jakob et. Al, 2023)
(Wajjakkara et. Al, 2020)

In addition to the above Security risks, other web security risks provided by OWASP TOP 10 also apply to Microservices based web applications-

A01:2021-Broken Access Control
A02:2021-Cryptographic Failures
A03:2021-Injection
A04:2021-Insecure Design
A05:2021-Security Misconfiguration
A06:2021-Vulnerable and Outdated Components
A07:2021-Identification and Authentication Failures
A08:2021-Software and Data Integrity Failures
A09:2021-Security Logging and Monitoring Failures

A10:2021-Server-Side Request Forgery (SSRF)

(Nuno et. Al, 2021)
(OWASP Top Ten, N.D.)

Relevance & Value:

Microservices architecture is applicable and advantageous for the design of web applications in the semiconductor industry due to the following factors:

- In the semiconductor industry, micro-services framework is well-suited for the development of complex web applications. This is because semiconductor web applications are typically large and complex, and must be able to scale up and down rapidly to meet the industry's fluctuating demands.
- Microservices architecture can also speed up the development and deployment of new features and problem fixes for semiconductor companies. This is crucial because the semiconductor industry is in a constant state of evolution, and semiconductor companies must be able to respond rapidly to market changes.
- In addition, micro-services architecture can assist semiconductor companies in making their web applications more resilient. This is significant because semiconductor web applications are frequently vital to the operations of semiconductor companies, and any downtime can have a substantial influence on their business.

Due to the semiconductor industry's dependence on data-intensive processes and its demand for rapid innovation, the application of micro-services design is highly relevant. In semiconductor manufacturing, supply chain management, and quality control, microservices have the potential to improve competitiveness, agility, and efficiency. Understanding the benefits and drawbacks of micro-services in this context is crucial for industry professionals and developers seeking to optimize software infrastructure.
(T. Prasandy et al, 2020)
(Y. Gong et al, 2020)

Gaps:

In spite the fact that microservices architecture provides a number of benefits for web development in the semiconductor industry, there are still a number of gaps in the literature and industry knowledge. For instance, more research is needed on how to manage the level of complexity in microservices applications, ensure their security and dependability, and monitor and troubleshoot them.

Numerous publications discuss the theoretical benefits and difficulties of micro-services, but lack empirical validation from practical semiconductor applications.

The semiconductor industry handles classified intellectual property and confidential data. A thorough analysis of the security implications of microservices is required.

Integration of legacy systems: Integrating micro-services with existing monolithic systems is a complex project, and research on effective strategies and best practices is required.

(T. Prasandy et Al, 2020)

Conclusion:

Due to Microservices adaptability, scalability, and resilience, microservices architecture is a suitable strategy for building web applications in the semiconductor industry. Using microservices architecture, semiconductor companies are developing a range of web applications, such as customer portals, product catalogues, supply chain management systems, and manufacturing execution systems.

Microservices architecture presents some challenges, such as managing the multifaceted nature of distributed systems and ensuring data integrity.

Future research should concentrate on empirical studies, security concerns, and techniques for integrating micro-services with legacy systems in order to further improve the sector's competitiveness and efficacy.

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