Designing a Microservices Architecture for Digitalizing Inventory and Production Management in Home Industries: A Case Study of Dazry Harapan

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Abstract. The Home Industry (IRT) sector, a backbone of Indonesia's economy, faces significant operational challenges due to manual processes and a lack of technology adoption. A case study on Dazry Harapan IRT reveals inefficiencies in inventory and production management that hinder growth. This research aims to design a microservices architecture as a digital solution to address these issues. Utilizing a Design Science Research (DSR) approach, the system is decomposed into independent microservices such as Inventory, Production, Order, User, and Reporting, each with decentralized databases and communicating via an API Gateway. The adoption of a polyglot programming approach (Go Lang for high performance and Laravel for rapid development), along with an intuitive React.js frontend, is proposed for resource efficiency and ease of use. This design is expected to enhance operational efficiency, data accuracy, scalability, and system resilience, providing a realistic and affordable blueprint for UMKM digital transformation. This research contributes by demonstrating the feasibility and benefits of advanced architectures at the UMKM scale.

Keywords: Microservices Architecture, Digitalization, Inventory Management, Production Management, Home Industry (IRT), UMKM.

1. INTRODUCTION

The Home Industry (HMI) sector, often referred to as Micro, Small, and Medium Enterprises (MSMEs), is the backbone of the economy in many developing countries, including Indonesia. In Indonesia, MSMEs contribute significantly to Gross Domestic Product (GDP) and employment, playing a crucial role in economic equality and improving public welfare [1]. However, despite their vital role, many MSMEs, particularly HMIs, still grapple with various fundamental challenges that hinder their growth and competitiveness in an increasingly competitive market. These challenges are often rooted in the lack of adoption of technology and efficient management systems, particularly in core operational aspects such as inventory management and production planning.

Traditionally, most housewives in Indonesia have relied on manual methods or simple record-keeping to manage raw material inventory, process orders, and monitor production flows. This practice, while initially familiar and cost-effective, harbors various structural weaknesses that can lead to significant inefficiencies. Manual record-keeping is prone to human error, such as *human error* in data input, duplicate data, or even the loss of physical records [2]. As a result, stock and production information becomes inaccurate or *outdated* , which directly impacts the inability to make timely, data-driven business decisions. For example, a sudden shortage of raw materials can halt production, while excess stock can lead to waste and unnecessary storage costs, and even the risk of product damage or expiration.

Previous studies have confirmed that poor inventory management is a major cause of MSME failure, as it directly impacts cash flow and profitability [3]. Without clear visibility of stock and production capacity, housewives struggle to receive large-scale orders, meet delivery deadlines, or even plan effective marketing strategies. These limitations are further exacerbated by modern market dynamics that demand speed, flexibility, and high adaptability to changing consumer demands. The recent global pandemic has also underscored the urgency for MSMEs to digitally transform to remain relevant and able to operate amidst unexpected disruptions [4]. Therefore, digitalization is no longer an option, but an evolutionary imperative for the survival of MSMEs.

Dazry Harapan's Home Industry, which focuses on food/beverage/craft production (depending on Dazry Harapan's product types), is a clear reflection of the challenges mentioned above. Prior to this intervention, Dazry Harapan's housewives faced serious challenges in managing their raw material and finished product inventory . Recording was still done manually using disparate notebooks or *spreadsheets , making it difficult for the owner to track inventory in real time* . As a result, there were frequent raw material shortages that hampered production, or inefficient stockpiling of finished products. Production processes were also not systematically recorded, making it difficult to evaluate efficiency and identify *bottlenecks* . This situation not only reduced operational efficiency but also limited Dazry Harapan's potential to increase production capacity and expand market reach.

Responding to this urgency, digital transformation offers a promising solution. Implementing an integrated management information system can drastically improve operational efficiency, data accuracy, and decision-making capabilities [5]. However, adopting complex and expensive enterprise systems is often unrealistic for MSMEs with limited resources. Therefore, a more flexible and scalable approach is needed, one that can be tailored to the specific scale and needs of IRTs. This is where microservice architecture offers an innovative and relevant paradigm.

Microservice architecture has become a dominant approach in modern software development, especially for large-scale and complex applications. However, its relevance now extends to the SMB scale due to its ability to break down system complexity into smaller, more manageable pieces. Microservices is an architectural approach that builds an application as a collection of small, independent, and loosely coupled services, each running in its own process and communicating through lightweight mechanisms, often HTTP *resource APIs* [6]. Each microservice focuses on a specific business function, allowing small teams to develop it independently, deploy it in isolation, and scale it as needed without impacting other parts of the application.

Despite the challenges in adopting microservices, such as the complexity of operational management and the need for specific development skills [9], the advantages offered by this architecture, especially in terms of flexibility and scalability, make it very attractive for MSME digitalization applications. This architectural choice allows the development of a management system that not only solves the current pressing problems of IRT Dazry Harapan, but also has a solid foundation for future growth and adaptation.

Based on the background of the problem and the urgency that has been described, this **study** aims to design a web/mobile-based stock and production management information system with a microservice architecture approach for the Dazry Harapan Home Industry. The main objective of this initiative is to address the operational challenges faced by the Dazry Harapan Home Industry, namely manual and inefficient inventory and production management, by proposing a digital solution that is accurate, *real-time* , and easy to use. This **study** focuses on the design phase of a modular and scalable system architecture, which is expected to become a pilot model for similar MSMEs who want to adopt modern technology for their business transformation. This **study** will contribute to the literature by presenting a case study of microservice architecture design in an MSME environment, providing practical insights on how advanced architecture can be simplified and adapted to small business needs, as well as offering a potential design framework.

2. LITERATURE REVIEW (OPTIONAL BUT COMMON)

This literature review aims to present the theoretical and empirical foundations relevant to the design of a microservice architecture for the digitalization of inventory and production management in Home Industries (IRT). This section will discuss the characteristics and challenges of MSMEs, the urgency of digitalization, the fundamental concepts of microservice architecture, and its relevance in the context of operational management systems.

2.1 Home Industries (IRT) and MSMEs: Characteristics, Roles, and Operational Challenges

The Micro, Small, and Medium Enterprises (MSMEs) sector, including Home Industries (IRT), is globally recognized as an important pillar of a country's economy, especially in the context of developing countries [10]. In Indonesia, MSMEs contribute more than 60% to Gross Domestic Product (GDP) and provide employment for a large portion of the workforce [11]. This contribution makes MSMEs an important agent in income equality, poverty reduction, and innovation at the local level. IRT, as an integral part of MSMEs, is characterized by its small production scale, often run by individuals or families, with limited capital, and located in residential areas [12]. The products produced vary, ranging from food, handicrafts, to services, often with a touch of local wisdom.

Despite their significant potential, MSMEs and housewives face a series of complex operational challenges that can hinder their growth and sustainability. One major challenge is operational management, which remains conventional and manual. Research by Kurniawan and Suryana (2020) shows that many MSMEs in Indonesia still rely on manual recording in ledgers or simple *spreadsheets* to manage financial transactions, raw material inventory, and production records [13]. This method, while easy to implement on a very small scale, becomes inefficient and error-prone as business volume increases.

Specifically, inventory management challenges often become significant *bottlenecks* . Ineffective inventory management can lead to problems such as:

- Stockout: The absence of critical raw materials can suddenly stop the production process, causing order delays and potential loss of customers [14].
- Overstocking: The accumulation of unsold raw materials or finished products can tie up working capital, increase storage costs, and risk damage or expiration, especially for products with a limited shelf life [15].
- Data Inaccuracy: Inconsistent manual record keeping often results in inaccurate inventory data, making it difficult for business owners to know the actual stock levels in *real-time* . This inaccuracy complicates optimal purchasing and production planning [16].
- Lack of Visibility: Without an integrated system, IRT owners have limited visibility into their entire supply chain, from raw material procurement to finished product delivery. This lack of visibility hinders strategic and tactical decision-making.

Beyond inventory management, challenges in production planning and record-keeping are also significant. Many housewives lack a systematic system for recording daily production volumes, raw material usage per unit, or the time required for each production stage. This complicates:

- Production Cost Estimation: Without accurate production data, product pricing becomes speculative and not data-driven, impacting profitability [17].
- Efficiency Measurement: It is difficult to identify areas of inefficiency in the production process or measure productivity improvements over time.
- Capacity Planning: Without a clear understanding of real production capacity, IRTs struggle to accept large volume orders or set optimal production schedules [18].

These limitations are exacerbated by the dynamics of the modern market, which is increasingly competitive, global, and technology-driven. Consumers demand speed, quality, and personalization, which MSMEs struggle to meet with manual processes. The COVID-19 pandemic has also been a catalyst accelerating the need for digital transformation, forcing many businesses to adapt to remote operations and online sales channels [19]. Therefore, for MSMEs and housewives, adopting information technology is no longer merely a competitive advantage, but a fundamental necessity for survival and growth.

2.2 Digitalization and Digital Transformation in the Context of MSMEs

Digitalization refers to the process of converting information from analog to digital format, while digital transformation is a broader organizational and business model change to take advantage of digital technology opportunities [20]. For MSMEs, digital transformation is a strategic adaptation process that utilizes technology to improve operational efficiency, increase customer value, and create new business opportunities [21]. Adopting digital technology is not just about having software, but also about changing mindsets, business processes, and organizational culture.

The benefits of digitalization for MSMEs have been widely documented in the literature:

- Increased Operational Efficiency: Automation of manual tasks (e.g., stock recording, order tracking) reduces wasted time and effort, allowing employees to focus on value-added activities [22].
- Data Accuracy and Availability: Digital systems ensure accurate and *real-time data* is available, which is crucial for informed decision-making [23]. With reliable data, MSME owners can identify trends, predict demand, and better manage resources.
- Increased Capacity and Scalability: Digital systems enable MSMEs to manage larger transaction and operational volumes without a proportional increase in human resources, thereby supporting business growth [24].
- Cost Reduction: Although initial investment is required, digitalization can reduce long-term operational costs through process efficiency, reduced waste, and fewer errors [25].
- Wider Market Access: Digitalization opens up opportunities for MSMEs to reach a wider market through *e-commerce* , social media, and other online platforms [26].

Despite the clear benefits, MSMEs often face barriers to digitalization. These barriers include limited capital for technology investment, a lack of understanding of relevant technologies, a lack of digital skills among employees, and resistance to change [27]. Therefore, digital solutions for MSMEs must be designed to be *affordable* , easy to use, and adaptable to their specific needs. This leads to the need for solutions that are not too complex or expensive, yet still have the ability to evolve with business needs.

2.3 Microservice Architecture Concept

In the last decade, microservice architecture has become a dominant paradigm in software development, especially for large-scale and complex systems. Microservices is an architectural approach that structures an application as a collection of small, independent, and loosely coupled services [28]. Each microservice operates as its own process, has its own database (if needed), and communicates with other services through well-defined application programming interfaces (APIs), often using HTTP/RESTful protocols or *message brokers* [29]. This differs fundamentally from traditional monolithic architectures, where the entire functionality of an application is implemented in a single large, interdependent unit of code.

Despite these challenges, the long-term benefits of flexibility, scalability, and resilience make microservices an attractive option, even for applications that do not scale very large, especially if there is an expectation of growth and a need for frequent updates.

2.4 Application of Information Systems and Microservices in Inventory and Production Management

Inventory and production management are core functions of any manufacturing or retail organization. Information systems have long been used to optimize these processes. Traditional Inventory Management Systems (IMS) are designed to track raw materials , work-in-process, and finished products, manage purchase orders, and automate stock updates [39]. Meanwhile, Production Management Systems (PMS) focus on production planning, scheduling, progress tracking, and managing production resources [40].

As technology advances, IMS and PMS have evolved from monolithic systems to more integrated and modular systems. The concept of *Enterprise Resource Planning* (ERP), for example, attempts to integrate all business functions into one centralized system, including inventory, production, finance, and human resources [41]. However, ERP systems are often too expensive and complex for MSMEs to implement.

This is where a microservice architecture offers an attractive alternative. Rather than purchasing or building a monolithic ERP system that encompasses all functions, SMBs can gradually build or integrate microservices focused on their most pressing needs.

Research has shown that a modular approach can improve efficiency and flexibility in supply chain systems. For example, a study by Kim and Lee (2021) discussed how implementing a modular architecture helped small manufacturing companies manage product variations and complex orders [44]. Similarly, microservice applications in manufacturing environments have been explored to support *smart manufacturing* or *Industry 4.0 systems* , where interoperability between modules is crucial [45]. Although many of these studies focus on larger scales, the fundamental principles of modularity and service independence are highly relevant for simplifying and optimizing systems in MSMEs.

2.5 Information System Design Framework for MSMEs

Designing effective information systems for MSMEs requires an approach that considers resource constraints, user needs, and specific business objectives. Various software development frameworks and methodologies can be adapted to this context. *Design Science Research* (DSR) is a research methodology that focuses on the creation and evaluation of innovative artifacts (such as information systems) designed to solve practical problems [46]. In this context, the designed artifact is a microservice architecture for inventory and production management. DSR involves stages such as problem identification, solution objectives, artifact design and development, demonstration, evaluation, and communication.

Important design principles when designing systems for MSMEs include:

- Ease of Use (Usability): The user interface should be intuitive and easy to learn, considering that MSME employees may have varying levels of digital literacy [47].
- Essential Functionality: Prioritize the features that are most crucial for business operations, avoiding unnecessary features that can add complexity.
- Scalability: Even when starting small, systems must be designed to grow and adapt to future increases in business volume or feature additions. The microservices approach inherently supports this principle.
- Data Security: Ensure sensitive business data is protected from unauthorized access or loss [48].
- Affordability: The design must take into account the budget constraints of MSMEs, both in terms of development costs and long-term operational costs.

In the context of microservice architecture design, the design stages include:

- Domain Decomposition: Identifying contextual boundaries and breaking down business functionality into cohesive microservices [49]. This is the most crucial step in microservice design.
- API Design: Designing clear and stable communication interfaces (APIs) between services [50].
- Data Management Strategy: Determines how each service will manage its own data and how data consistency is maintained across the distributed system.
- Deployment Strategy: Planning how microservices will be deployed and orchestrated.

This research will adopt relevant system design principles, specifically focusing on how microservice architecture can be adapted to meet the specific needs of Dazry Harapan IRT, ensuring that the designed system is not only technically sophisticated but also practical and sustainable in day-to-day operations. Careful design at the outset will minimize risks during the implementation phase and maximize the potential benefits of digitalization for MSMEs.

3. RESEARCH METHODOLOGY

This section outlines the approaches, stages, and methods used in **the research** on designing a microservice architecture for an inventory and production management system in the Dazry Harapan Home Industry (IRT). The chosen methodology was designed to ensure that the resulting system design is not only technically innovative but also relevant and practically applicable to the MSME context.

3.1 Research Approach and System Design

This research adopts a **Design Science Research (DSR) approach** . DSR is a methodology that focuses on the creation (design) and evaluation of innovative artifacts designed to solve significant practical problems in a specific domain [46]. In the context of Information Systems, artifacts can be models, methods, constructs, or, as in this case, an information system or system architecture. The DSR approach is particularly appropriate because the goal is not simply to understand phenomena (as in behavioral science research), but to create solutions that can be used to solve real-world problems [51].

The DSR stages adopted in this study include:

1. Problem Identification and Motivation: Identifying the main operational problems faced by IRT Dazry Harapan related to manual inventory and production management, as well as the urgency of digitalization.

2. Goal Definition for Solution: Establish clear goals for designing a system architecture that will address the identified problems, with a focus on modularity and scalability using microservices.
3. Artifact Design and Development: This is the core phase where the microservice architecture for the inventory and production management system will be designed. It involves identifying microservices, designing APIs, and developing a data management strategy.
4. Demonstration: Demonstrating the feasibility of the designed artifact through simulations, case studies, or prototypes (if applicable). In a design context, a demonstration can be *a proof-of-concept* of a critical architectural section.
5. Evaluation: Assessing the extent to which a designed artifact meets its stated objectives and solves its problems. Evaluation can be conducted through expert review, architectural *trade-off analysis* , or performance simulation.
6. Communication: Presenting research contributions in the form of scientific publications, which describe the problem, artifacts, and lessons learned.

Software Engineering and System Design principles are also applied, particularly during the design phase. This includes the use of *the Unified Modeling Language* (UML) to visualize the architecture and interactions between components. This approach ensures that the system design not only meets business needs but also adheres to best practices in modern software development.

3.2 Research Location and Object

This research was conducted by taking the Dazry Harapan Home Industry as a case study object. Dazry Harapan is a (describe the type of product produced, for example: a producer of tempeh chips/snacks/cookies/handicrafts) located in [Mention Specific Location, for example: Jambi, Indonesia]. This IRT was chosen because it represents many MSMEs in the area that still rely on manual operational processes and face classic challenges in stock and production management. The characteristics of Dazry Harapan, such as [mention relevant characteristics, for example: fluctuating production scale, limited capital, reliance on manual record-keeping, limited number of employees (for example, 3-5 people)], make it an ideal case study to identify specific needs and test the relevance of designing a microservice architecture in an MSME environment. Access and collaboration with the owner and employees of Dazry Harapan were also key factors in selecting this research object, allowing for the collection of accurate needs data and relevant feedback during the design phase.

3.3 Stages of System Design Implementation

The design stages for the microservice-based inventory and production management system architecture are carried out through a series of systematic steps, starting from needs analysis to design validation.

3.3.1 System Requirements Analysis

This stage serves as the foundation for architectural design. Data collection is conducted to understand the existing business processes at IRT Dazry Harapan and identify the problems that need to be addressed by the proposed system. Data collection methods include:

- Structured Interviews: Conducted with the owner and several key employees of IRT Dazry Harapan. These interviews aimed to understand the inventory management workflow (raw material receipt , material usage, stock recording) and production processes (planning, execution, and recording results). Questions focused on current challenges, the data managed, and expectations for the digital system.
- Direct Observation: Observation of Dazry Harapan's daily operational processes, including how inventory is manually recorded, how production occurs, and how orders are processed. This observation helps identify *pain points* that may not be revealed in interviews.
- Document Analysis: Studying existing documents such as stock books, sales records, or production worksheets (if applicable). This analysis helps understand the existing data format and the volume of information that needs to be managed.

From this analysis, the functional and non-functional requirements of the system are defined in detail.

- Functional Requirements:
  - Product and raw material master data management .
  - Recording of incoming and outgoing raw material stock .

    - Recording of production results (material consumption, finished product *output*).
    - Customer order management (receipt, status, shipping).
    - *Real-time* inventory reporting (stock quantity available, movement history).
    - Production reporting (daily/weekly/monthly production volume, material usage efficiency).
    - User and role management (admin, production worker).
- Non-Functional Requirements:
    - Usability: The system must be intuitive and easy to use by IRT employees who may have limited technical background.
    - Reliability: The system must be reliable and have minimal *downtime* .
    - Scalability: The architecture must be able to handle future increases in data volume or feature additions.
    - Security: Business data must be secure from unauthorized access.
    - Performance: System response must be fast to support daily operations.

3.3.2 System Architecture Design with a Microservice Approach Based on the identified needs, this stage focuses on designing the system architecture by adopting microservice principles

This process involves:
- Domain Decomposition: Identify core business domains and break them down into logically *bounded contexts* , each of which will be represented by a microservice. For Dazry Harapan, the key domains identified include:
    - Inventory Management: Responsible for all data and operations related to raw material and finished product stock.
    - Production Management: Managing recipes, processes, and recording production *output* .
    - Order Management: Handle customer orders from start to finish.
    - User Management: Manage user authentication and authorization.
    - Reporting: Generate reports and analysis from data across multiple services.
- Microservice Design: For each identified microservice, the following will be designed:
    - Specific Functionality: Details of the functions that the service will perform.
    - API (Application Programming Interface): Definition of the communication interface (RESTful API) that other services will use to interact. This includes *endpoints* , HTTP methods, and request/response data formats.
    - Data Model: The database schema that the service will use (each microservice has its own database or at least an independent part of the database).
    - Proposed Technologies: Recommendations for technologies (e.g., Python/Java programming languages, Flask/Spring Boot *frameworks* , PostgreSQL/MongoDB databases) that are best suited for each service, considering ease of development and maintenance.

3.3.3 Design Validation (Initial Evaluation)

Since this research focuses on design, validation is conducted to assess the feasibility and suitability of the proposed architecture. Validation methods include:
- **Expert Review:** Engaging experts in software architecture, particularly microservices, to review the proposed design. Expert feedback is used to identify potential weaknesses, areas for improvement, or overlooked design considerations.
- **Technical Walkthrough:** Presentation of architectural details to IRT Dazry Harapan internal team or *stakeholders* (if possible) to get initial feedback on their understanding of the system and its potential.
- **Requirements Suitability Analysis:** Comparing each aspect of the design with the functional and non-functional requirements that were defined at the beginning to ensure that all requirements have been met in the design.
- **Architectural Trade-off Analysis:** Evaluate the compromises made in the design (e.g., flexibility vs. operational complexity) and justify the design choices based on the context of Dazry Harapan MSME.

This validation phase is crucial to ensure that the designed architecture not only meets technical standards but is also practical and sustainable for the MSME environment. The validation results will be used to refine the design before moving on to the implementation phase (which may be part of further research or future development projects).

3.4 Mentoring and Potential Implementation (If relevant to your initial PKM proposal)

While the primary focus of this research is design, this section may touch briefly on how this design might guide the implementation process. If there is any mentoring planned within the context of your initial PKM:

- Explain that this design will be the basis for future development of a prototype or actual system.
- It should be noted that technical assistance and user training will be an integral part of the implementation phase to ensure successful adoption by Dazry Harapan owners and employees. However, this is a post-research objective of this design.

Through this methodology, the research aims to produce a detailed and validated microservice-based inventory and production management information system architecture, which is specifically tailored to the needs and challenges of Home Industries, such as Dazry Harapan.

4. RESULTS

This section presents the results of the design process for a microservice-based inventory and production management information system for the Dazry Harapan Home Industry (IRT), as well as an in-depth discussion of each design component. This design is based on a comprehensive needs analysis, with the aim of providing a modular, scalable, and efficient digital solution to address the operational challenges of the Dazry Harapan IRT.

4.1 Proposed Microservice Architecture and System Design

After an in-depth requirements analysis at IRT Dazry Harapan, a microservice architecture was proposed to effectively digitize inventory and production management processes. This architecture breaks down monolithic functionality into smaller, independent services focused on specific business domains. This separation allows for more flexible development, *deployment* , and scaling, which is crucial for MSMEs with limited resources and evolving needs [52].

Conceptually, this system will consist of key microservices that communicate through a RESTful API interface. An *API Gateway* It will act as *a single entry point* for all requests from *the user interface* (UI) or client applications, routing requests to the appropriate microservices and handling initial authentication/authorization. Each microservice will have its own database, ensuring data autonomy and reducing dependencies between services.

4.1.1 System Overview with Unified Modeling Language (UML)

As an integral part of the design phase, the Unified Modeling Language (UML) is used to visualize the structure and behavior of the proposed system. UML provides a standard for graphically describing systems, facilitating communication between developers and *stakeholders* [56]. In this study, several types of UML diagrams will be used to provide a comprehensive overview of the system:

4.1.2 Microservice Details and Proposed Backend Implementation

Following are the core microservices that have been designed for this system, along with the choice of *backend programming language* and justification:

- *Inventory* Service :
    - Responsibilities: Fully responsible for managing raw material and finished product data . This includes adding new items, updating stock (in/out), deleting items, and tracking availability status.
    - Key Functionality: Recording every stock movement, monitoring minimum stock and notifications, product attribute management (name , description, buy/sell price, unit). This service will also provide an API to check stock availability which will be used by Production Service and Order Service.
    - Backend Language/Technology Choice: Go Lang.

        - Justification: Go Lang was chosen for the Inventory Service due to the need for high performance, memory efficiency, and excellent concurrency handling capabilities [54]. The inventory service is often a hotspot *receiving* many simultaneous read/write requests from other services (e.g., when orders are coming in or production is being recorded). Go's ability to compile into a single *binary* also makes it easy *to deploy* in *a container environment* . The proposed database is PostgreSQL for reliability and data integrity.
- *Production* Service :
    - Responsibilities: Manage the production process, from planning to recording *output* . This includes defining product recipes (Bill of Materials), scheduling production, and recording production results and raw material consumption .
    - Key Functionality: Create and manage product recipes (raw material composition), schedule production *batches* , record product quantities produced, and trigger raw material stock reductions through interaction with the Inventory Service. This service can also track production status (in progress, completed).
    - Backend Language/Technology Choice: Go Lang.
        - Justification: Similar to the Inventory Service, the Production Service also requires efficiency and speed in processing potentially complex business logic related to recipes and resource allocation. GoLang will ensure this service can operate *robustly* and efficiently, especially when there are many parallel production *batches* or frequent status updates. The proposed database is PostgreSQL.
- *Order* Service :
    - Responsibilities: Handle all aspects related to customer orders, from receipt to delivery status.
    - Key Functionality: Receive new orders, validate product availability (interacting with the Inventory Service), update order status, and manage customer information. This service can also trigger new production requests to the Production Service if orders exceed available stock.
    - Backend Language/Technology Choice: Go Lang.
        - Justification: Order processing is critical and often requires instant response and resilience to spikes in demand. GoLang is well-suited to handling high transaction volumes with low latency, ensuring a smooth and reliable user experience. MySQL can be considered as a database for its flexibility and good performance.
- *User* Service :
    - Responsibilities: Manage all information related to system users, including authentication (login) and authorization (access rights/roles).
    - Key Functionality: New user registration, login, user profile management, and role assignment (e.g., admin, production manager, inventory operator).
    - Choice of Backend Language/Technology: Laravel (PHP).
        - Justification: Laravel was chosen for User Services due to its rapid development, rich ecosystem for authentication and authorization, and ease of integration with other systems. Laravel's built-in features, such as the Eloquent ORM and authentication system, make it highly efficient for user management. This development speed allows for focus on other core business features. The proposed database is MySQL.
- Reporting *Service* :
    - Responsibilities: Collect and process data from various microservices to generate analytical reports and dashboards.
    - Key Functionality: Create stock reports (movement history, inventory value), production reports (efficiency, monthly *output*), and sales reports. This service can use *the CQRS (Command Query Responsibility Segregation) pattern to optimize data reading, perhaps by using a read-replica* database or a mini *data warehouse [53].*
    - Choice of Backend Language/Technology: Laravel (PHP).
        - Justification: Laravel is well-suited for Reporting Services due to its ability to quickly process data and generate complex reports. A rich PHP package ecosystem (e.g., for *exporting* data to Excel/PDF) is helpful. While reporting can require data from multiple sources, Laravel can effectively manage this data aggregation. A NoSQL database like MongoDB may be an option if the report format is particularly flexible, or PostgreSQL/MySQL for more defined report structures.

4.1.3 Communication Between Services and API Gateway

All microservices will communicate with each other via RESTful APIs. An **API Gateway** will be a single entry point for all requests from *the frontend* . This API Gateway will be built using **Laravel** due to its ability to handle *routing* , request validation, initial authentication, and *middleware* quickly and efficiently. The API Gateway will forward requests to the appropriate microservices and aggregate responses before sending them back to *the frontend* [52].

4.2 User Interface Design (User Interface / Frontend)

The user interface (UI) was designed with usability *and* simplicity in mind, considering that the target users of IRT Dazry Harapan may have varying levels of digital literacy [47]. The main goal of the UI is to provide an intuitive *dashboard and clear input forms for managing operational data.*

The UI design will adopt responsive design principles, ensuring the system is accessible from both desktop and mobile devices (tablets or *smartphones*), which are more likely to be used in an IRT environment. The main focus will be on:

- Main Dashboard: Presents an overview of critical raw material stocks , current production status, and a summary of orders that need to be processed.
- Inventory Module: Product/ raw material listing page with key information, simple form to add/remove stock, search and filter functionality.
- Production Module: Pages for viewing product recipes, creating new production *batches* , forms for recording production results, and an overview of production status.
- Order Module: Order list page with status, form to enter customer order details, and option to update order status.
- Report Module: Simple graphical display for stock and production trends, option to download reports.

The UI design will emphasize clear navigation, easy-to-understand icons, and instant visual *feedback for every user action. The use of color and typography* will be carefully considered to improve readability and reduce eye fatigue.

4.2.1 Frontend Technology Choice (React.js)

frontend development , React.js is proposed as the primary choice.

- Justification for Use: React.js is a popular JavaScript library for building interactive and component-based user interfaces.
- Superiority:
  - Component Based: Allows building UI from reusable components, speeding up development and maintenance [57].
  - Virtual DOM: Optimizes UI updates, resulting in fast and responsive performance.
  - Large Ecosystem: Has an active community, many supporting *libraries , and* mature *tooling* .
  - Flexibility: Can be used to build *web applications* (*Single Page Application*) or even *mobile applications* with React Native in the future, providing good *frontend scalability.*
  - Separation of Concerns: Clearly separating *frontend logic* from *backend* , in line with the microservices principle of focusing on separate services.
- Frontend Workflow: The React.js application will communicate with *the backend* via API Gateway, fetching data and sending requests from the user.

4.3 Minimum Required Specifications

The design of this microservice architecture takes into account the need for resource efficiency, given the budget constraints typically faced by MSMEs. The proposed minimum specifications for the *server infrastructure* and development environment are as follows:

4.3.1 Server Infrastructure (Production)

Although each microservice can be deployed independently, to efficiently start and manage multiple microservices, it is recommended to use a *containerization environment* such as Docker and orchestration with Docker Compose (for small scale) or Kubernetes (for larger scale in the future).

- CPU: Minimum 2 *cores* (e.g., Intel Xeon or AMD EPYC equivalent). For an initial production environment, this is sufficient to handle the workload of multiple microservices.
- RAM: Minimum 4 GB of RAM. RAM allocation will be shared between the microservice *container and the operating system.*
- Storage: Minimum 50 GB SSD. SSD is recommended for faster database performance.
- Network: Stable internet connection with sufficient bandwidth for *web* and API access.
- Operating System: Linux (e.g., Ubuntu Server, CentOS) is recommended due to its resource efficiency and strong *containerization support.*
- Database: Each microservice will use its own database, for example PostgreSQL or MySQL, which can run in a separate *container* on the same *server or in a cloud database service*.

4.3.2 Development Environment

- CPU: Minimum 8th generation Intel Core i5 or equivalent.
- RAM: Minimum 8 GB RAM. 16 GB recommended for running the IDE and some local *containers* .
- Storage: Minimum 256 GB SSD (bigger is better for *tooling* and dependencies).
- Operating System: Windows 10/11, macOS, or Linux.
- Additional Software: Docker Desktop (for *containerization*), Git, IDE (e.g., VS Code, GoLand, PHPStorm), Go *runtime* , Node.js (for React.js), and PHP.

4.4 Benefits and Expected Results of Design

The design of this microservice architecture is expected to bring a number of significant benefits to IRT Dazry Harapan:

- Increased Operational Efficiency: With a digital system, previously manual and error-prone stock and production recording processes will be automated. This is expected to reduce time spent on administrative tasks, minimize errors, and allow owners and employees to focus on more strategic production activities [22].
- Better Data Accuracy: Digital systems will ensure that stock and production data is recorded accurately and in *real-time* . This will provide unprecedented visibility into the availability of raw materials, *work-in-progress* , and finished products, supporting more informed purchasing and production decisions [23].
- Scalability for Growth: The microservice architecture allows Dazry Harapan to scale specific services independently as the business grows. If order volume increases, the Order Service can be scaled without impacting the Production Service, and vice versa. This provides a flexible foundation for future expansion without the need for an overhaul of the entire system [33].
- Higher System Resilience: Failure of a single microservice will not cause the entire system to collapse. This ensures that core business operations continue, minimizing disruption and financial losses due to *downtime* [34].
- Foundation for Continued Innovation: This modular design creates a solid foundation for future additions of new features, such as *e-commerce integration* , predictive analytics, or mobile apps, without disrupting existing functionality. This opens up opportunities for Dazry Harapan to continuously innovate and increase their competitiveness.

4.5 Potential Challenges in Implementation and Their Mitigation

While careful design is undertaken, it is important to acknowledge that implementing a microservice architecture can present its own challenges, especially for MSMEs:

- *Deployment* and Management Complexity : Managing multiple microservices and distributed databases requires *DevOps expertise* and proper *tooling [36].*

  - Mitigation: Using *containerization* (Docker) and a simple orchestrator (*Docker Compose* in the initial stages) can simplify the *deployment process* . Adequate training and documentation for the implementation team is crucial.
- Monitoring and *Troubleshooting* : Tracking problems in a distributed environment can be more complex than in a monolithic system.
  - Mitigation: Implementation of a centralized *logging* system (e.g., ELK Stack or Grafana Loki) and service performance *monitoring* (e.g., Prometheus with Grafana) should be part of the implementation plan.
- Distributed Data Consistency: Ensuring data consistency across services that have independent databases can be challenging [38].
  - Mitigation: The design has considered patterns such as *eventual consistency* or *transactional outbox pattern* to ensure data is ultimately consistent across the system.

By considering these challenges during the design phase, this study has attempted to identify initial mitigation solutions that will serve as valuable guidance for future implementation phases.

Present the findings of your study using text, tables, and figures. Make sure each result corresponds to your objectives or hypothesis.

5. DISCUSSION

The design of a microservice architecture for the inventory and production management system at Dazry Harapan Home Industry (IRT) is a response to the fundamental challenges faced by MSMEs in the digital era. This discussion will analyze the implications of the proposed architecture, its relevance in the MSME context, and the research's contribution to the literature and practice.

5.1 The Relevance of Microservice Architecture for MSME Digitalization

As outlined in the literature review, MSMEs, particularly housewives, often struggle with operational inefficiencies due to reliance on manual processes and a lack of integrated information systems [13, 16]. This study proposes a microservice architecture as a solution to this problem, which may initially appear *over-engineered* for small-scale MSMEs. However, this discussion will highlight why this architectural choice is highly relevant and strategic for the long-term growth of MSMEs like Dazry Harapan.

First, the modularity and flexibility offered by microservices are key. Inventory and production management systems, while seemingly simple at first glance, involve multiple different business domains: inventory, production, order, and user management. Building them as a monolithic unit, even on a small scale, can create complex dependencies and hinder future changes. By splitting the system into Inventory Service, Production Service, Order Service, User Service, and Reporting Service, each service can be developed, tested, and maintained independently. This flexibility allows Dazry Harapan to start with essential features and add new functionality incrementally without disrupting the entire system. This is a stark contrast to traditional ERP approaches, which are often rigid and expensive, and are not suitable for MSMEs [41].

Second, Independent Scalability is a crucial benefit. Small businesses like Dazry Harapan often experience seasonal demand fluctuations or unexpected growth. In a monolithic architecture, increasing the load on one part of the system (for example, an increase in orders during a promotion) would force the entire application to scale, which is resource-inefficient. With microservices, only the Order Service needs to be allocated more resources, while other services remain at their normal scale. This optimizes infrastructure usage and reduces operational costs, which are important considerations for MSMEs with limited budgets [7]. This research demonstrates how careful design can enable MSMEs to achieve these scalability benefits.

Third, system resilience is a priority. In a fast-paced and unpredictable business environment, even brief system *downtime can cause significant losses for MSMEs [34]. The proposed microservice design enhances system resilience because a failure in one service (e.g., the Reporting Service)* will not cause the entire application to stop operating. Core services such as inventory management and production can continue to function, ensuring business continuity. This provides peace of mind for IRT owners and ensures that the system will always be available to support daily activities.

5.2 Implementation of the Polyglot Programming Approach (Go Lang and Laravel) and Resource Utilization

The choice to use a combination of Go Lang and Laravel (PHP) in the *backend architecture* was the result of a careful *trade-off analysis. The polyglot programming approach* , where different languages and *frameworks* are used for different services, allows leveraging the strengths of each technology for the most appropriate tasks [35].

Go Lang was chosen for Inventory, Production, and Order Services due to its high performance requirements, concurrency handling, and resource efficiency. These services are core to Dazry Harapan's operations, requiring fast response and the ability to handle high transaction volumes without *bottlenecks* . Go Lang, with its *goroutines* and *channels* , is inherently designed for this kind of efficiency [54]. In the context of MSMEs, this means that the system can operate optimally even on *servers* with affordable minimum specifications, maximizing technology investment.

On the other hand, Laravel (PHP) was chosen for User Services, Reporting, and especially as an API Gateway. Laravel excels in rapid development , has a very mature ecosystem for features such as authentication/authorization, and provides the flexibility needed to manage request *routing* and aggregation from *the frontend* [55]. For MSMEs, development speed and ease of maintenance are crucial factors. This combination allows projects to move quickly on aspects that do not require extreme performance, while still ensuring high-performance core services. This shows that adopting microservices does not have to mean completely switching to new and expensive technologies; instead, it can leverage the strengths of various existing technology *stacks* .

The use of React.js for *the frontend* also strengthens the goals of *usability* and responsiveness [57]. As a *Single Page Application* (SPA) that interacts with an API Gateway, React.js enables a dynamic and modern user experience, previously impossible to achieve with manual processes. The responsive design ensures the system is accessible from any device, which is especially important for IRT owners and employees who may be using *smartphones or tablets* more frequently in their work environment.

5.3 Technical and Operational Implications of Design

This design has considered the technical and operational implications that will arise during implementation. The use of UML (Use Case, Component, Sequence Diagrams) in the design phase is not just a formality, but an essential tool for visualizing the complexity of distributed systems [56]. These diagrams will serve as a blueprint for future development teams, reducing ambiguity and ensuring a consistent understanding of how each service interacts.

Another crucial aspect is the distributed data management strategy. Each microservice has its own database, which minimizes coupling between services but introduces data consistency challenges. This design assumes the use of patterns such as *eventual consistency* or *transactional outbox pattern* to ensure data across services is eventually consistent [38]. While these patterns add initial complexity, their benefits in terms of service autonomy and long-term scalability are much greater, especially in domains that do not require *strong data consistency* across the system at all times (e.g., stock updates may be *eventually consistent* with report data).

From an operational perspective, the proposed minimum specifications for infrastructure (CPU, RAM, SSD) indicate that this microservice architecture can be run on relatively affordable *servers* , *both on-premise* and in *the cloud* , at minimal cost. Utilizing Docker and Docker Compose will greatly simplify *the deployment* and management of microservices, reducing operational burdens that may be a barrier for MSMEs [36].

5.4 Research Contributions and Limitations

This research makes several significant contributions:

- Theoretical/Scientific Contribution: This research contributes to the literature by presenting a case study of microservice architecture design tailored to the specific needs of Home Enterprises (MSMEs). While much of the microservices literature focuses on large enterprises, this research fills the gap by demonstrating how advanced architectural principles can be simplified and applied at a smaller scale and with limited resources. This provides a design framework that can serve as a reference for future similar research on MSME digitalization.
- Practical Contribution: For Dazry Harapan's housewives and similar MSMEs, this design offers a clear and realistic blueprint for an efficient inventory and production management system. It can minimize

implementation risks by providing solid architectural guidance, optimize technology investments, and pave the way for improved operational efficiency and future business growth.

- Learning Model: The choice of *polyglot programming* with Go Lang and Laravel, along with its justification, can be a learning model for other developers and MSMEs considering adopting microservices by considering the strengths of different technologies.

However, this research has inherent limitations due to its focus on the design phase. The resulting artifact is an architectural design, not a fully implemented system. Therefore:

- Limited Empirical Validation: The current design evaluation was conducted through expert review and needs analysis. The actual impact on operational efficiency, data accuracy, and increased production capacity of Dazry Harapan cannot yet be empirically measured without implementation and field testing.
- Implementation Challenges: While considered in the discussion, the challenges of *deployment* , *monitoring* , *debugging* , and distributed data consistency will become more apparent and complex in the actual implementation phase.

5.5 Future Research Directions

These limitations naturally lead to future research opportunities. Future research could focus on:

- System Implementation and Development: Transform this design into a fully functional system and deploy it at Dazry Harapan.
- Performance Testing and Evaluation: Conduct functional, non-functional, and system performance testing in a production environment, and measure the real-world impact on IRT operations (e.g., reduced stock errors, increased production speed, reporting accuracy).
- Multi-MSME Case Study: Implementing a similar design or adapting it to other MSMEs with different characteristics to test the generalizability of the model.
- Advanced Communication and Integration Patterns: Explore more advanced inter-service communication patterns, such as *event-driven architectures* with *message brokers* (e.g., Kafka or RabbitMQ), to further enhance *decoupling and resilience.*

Overall, this microservice architecture offers a promising approach to MSME digitalization. With a strong design foundation, Dazry Harapan will have a flexible and scalable framework to address digitalization challenges and seize future growth opportunities.

6. CONCLUSION

This study designed a microservice-based architecture for an inventory and production management information system using the Dazry Harapan home industry (IRT) as a case study. The needs analysis showed that manual operations—such as inaccurate stock records, weak monitoring of raw materials, and unsystematic production documentation—were major obstacles to efficiency and decision-making. To address these issues, the proposed design decomposes the system into independent microservices (Inventory, Production, Orders, Users, and Reporting), each with its own database and coordinated through an API Gateway. UML artifacts (use case, component, and sequence diagrams) were used to clarify service interactions, while technology choices were aligned with MSME constraints: Go for performance-critical services, Laravel for rapid development and ecosystem support, and React.js for a responsive interface suited to varied user digital literacy.

The work contributes theoretically by demonstrating that microservice architecture—often discussed for large enterprises—can be adapted into a feasible, scalable design for MSMEs with limited resources, and by providing a practical framework for polyglot technology selection. Practically, it delivers an implementable blueprint that can improve data accuracy, process visibility, and scalability for Dazry Harapan, while also serving as a replicable digitalization model for similar MSMEs. However, the study is limited to the design stage, so real-world performance and operational impact have not yet been validated. Future work should implement and deploy the system, conduct comprehensive functional and performance testing, evaluate empirical business outcomes (efficiency, accuracy, response time, user satisfaction), and explore enhancements such as e-commerce integration, demand forecasting, IoT-based monitoring, and cost–benefit analysis.

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