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Designing a marketplace system to assist incubators in higher education in fostering technopreneurship

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ABSTRACT

Technology-based startups play a vital role in boosting the Indonesian economy. However, many face sustainability challenges due to misalignment with market needs and a lack of comprehensive understanding of business processes. This condition demands the application of academic theories related to increasing productivity and highlights the need for innovative solutions. Universities can significantly support the development of these startups by leveraging business incubators to enhance competitiveness in the digital era. This research aims to propose a marketplace system architecture incorporating a business incubator unit (BIU), integrating scientific knowledge with societal business interests and talents in a university. The system is developed by the enterprise architecture (EA) methodology with the the open group architecture framework (TOGAF). This approach ensures a systematic design process that aligns with best practices. This study results in several strategic artefacts that provide guidance for creating a practical environment for entrepreneurs and translating theoretical insights into actionable business strategies. The artefacts can be rigorously tested and applied in real-world business incubator settings. The proposed system addresses critical challenges startup businesses face, such as enhancing business understanding and providing a fair foundation before entering the competitive market.

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1. INTRODUCTION

Technology innovation, encompassing product and process aspects in various research fields, has positively and significantly impacted the economic and business sectors [1], [2]. Various innovative technological works drive the strengthening of digitalisation across various aspects, with even information technology (IT) being capable of transforming how humans work and conduct their social lives [3]. For organisations, IT represents a new derivative of sustainable competitive advantage as it can creatively integrate IT and non-IT components into their innovative products or processes to strengthen their business models [4]-[6].

In Indonesia, the growth of internet usage has been remarkable. Internet users rose from approximately 132.7 million in early 2018 [7] to 204.7 million by 2022 [8]. With a population of 277.7 million as of January 2022 [9], the internet penetration rate reached 73.7% [8], indicating a strong foundation for digital transformation. This growth is not only critical for profit-oriented businesses but also for educational institutions, particularly universities, which serve as key laboratories for science and technology development [10]. Students increasingly expect universities to align with the technological advancements they encounter in the workforce or entrepreneurial ventures, including technopreneurship strategies [11].

As the digital landscape evolves, there is a growing recognition of universities' crucial role in preparing students to navigate and excel in this dynamic environment. Universities are more than just centers of academic learning. They are incubators of innovation and entrepreneurship. However, transitioning from academic knowledge to real-world application, particularly in entrepreneurship, poses several challenges. While technological infrastructure is expanding, integrating these advancements into educational frameworks, especially in fostering entrepreneurship, remains uneven and underdeveloped [12]. This gap is particularly evident in the context of Indonesia's socio-economic goals and global competitiveness. The challenges include poverty and unemployment, which are highlighted in the United Nations Sustainable Development Goals (SDGs) [13], specifically SDG 1 (no poverty), SDG 4 (quality education), and SDG 8 (decent work and economic growth). The Indonesian government's vision for 2045 aims to address these issues [14], a key component of this vision is the promotion of entrepreneurship, particularly technopreneurship, as a means to stimulate innovation, create jobs, and drive economic growth [15]-[17], However, the country's entrepreneurship ranking remains low, indicating substantial gaps in entrepreneurial activity and success rates. This suggests that significant challenges and barriers prevent the effective realization of entrepreneurial potential. Developing a robust entrepreneurial ecosystem is crucial, as it can catalyze economic transformation, enabling the country to harness the creativity and innovation of its people to tackle pressing socio-economic issues.

Ideally, Higher Education Institutions (HEIs) can design business incubator units (BIUs) as forums for academics to develop economic and business knowledge practices and to increase awareness that academics are no longer "*an isolated island of knowledge*" [18]. All academics must transform into economic actors [19], who can actively participate in the economic and business ecosystem and become part of the innovation creation and new businesses that add greater value to their social environment [11]. Research on university digital transformation issues has been extensively discussed to meet these criteria. Assessment aspects include [10], [20] and IT framework [11], [21]-[23]. This study explores how an integrated marketplace (IM) system can be designed to effectively support BIUs in fostering technopreneurship within HEIs in alignment with Indonesia's 2045 vision. The proposed solution involves developing an enterprise architecture (EA) that utilizes the the open group architecture framework (TOGAF) with the situation-objective-strategy-tactics-action-control (SOSTAC) model. This approach aims to provide a holistic and integrated platform that enhances the quality and quantity of entrepreneurship by aligning IT strategy with university business models. The platform facilitates the creation and growth of startups within universities, leveraging technology to add value and expand beyond domestic markets to global opportunities.

2. METHOD

Figure 1 illustrates the methodology for designing the system architecture of a marketplace integrated with BIUs, which involves several key phases. The process begins with stakeholder identification and engagement to gather insights and align the system's objectives with the needs of students, faculty, and industry partners. This foundational step ensures that the architecture addresses relevant requirements and expectations. Next, the adoption of the pioneering idea of BIUs as a university startup in alignment with the model proposed by [3], [4], [17], [24]. This is followed by a thorough micro and macro environmental analysis using the SOSTAC framework, which helps identify opportunities and threats within the external and internal environments [25].

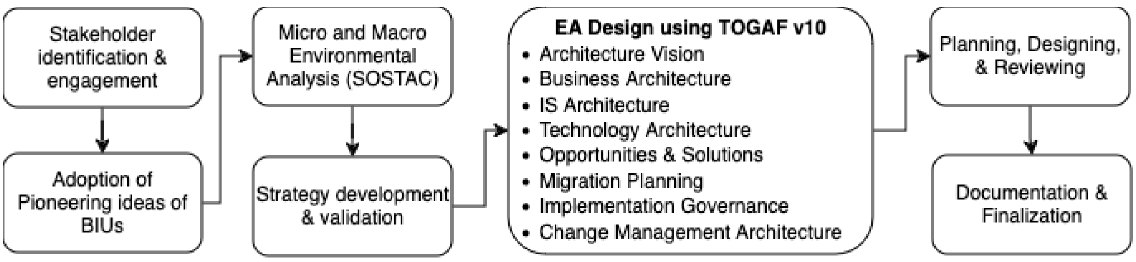

Figure 1. Research method

Strategy development and validation then occur, where the formulated strategies are aligned with the objectives of the BIUs and validated against stakeholder requirements. This step ensures that the strategy is robust and relevant. Subsequently, the EA design using TOGAF v10 is carried out. This involves detailing various architectural layers and ensuring alignment between business and IT strategies. The TOGAF guides this design process through its phases (architecture vision to change management architecture). The architecture design is iteratively refined in the planning, designing, and reviewing phase, ensuring continuous alignment with the strategic goals of the BIUs and HEI. Finally, the methodology includes documenting and finalizing the system architecture. This step involves thoroughly documenting the architecture and finalizing the design, providing a comprehensive blueprint for future implementation.

3. RESULTS AND DISCUSSION

In the following subsections, we will briefly outline the key components of the marketplace architecture. Figure 2 shows an overview of the detailed descriptions. We will examine the system architecture, the role of the BIU, the integration of academic and business elements, user interface (UI) design, and the employed technology stack. Each component addresses the needs of individuals and organisations aiming to develop or integrate their business unit incubators with an online marketplace.

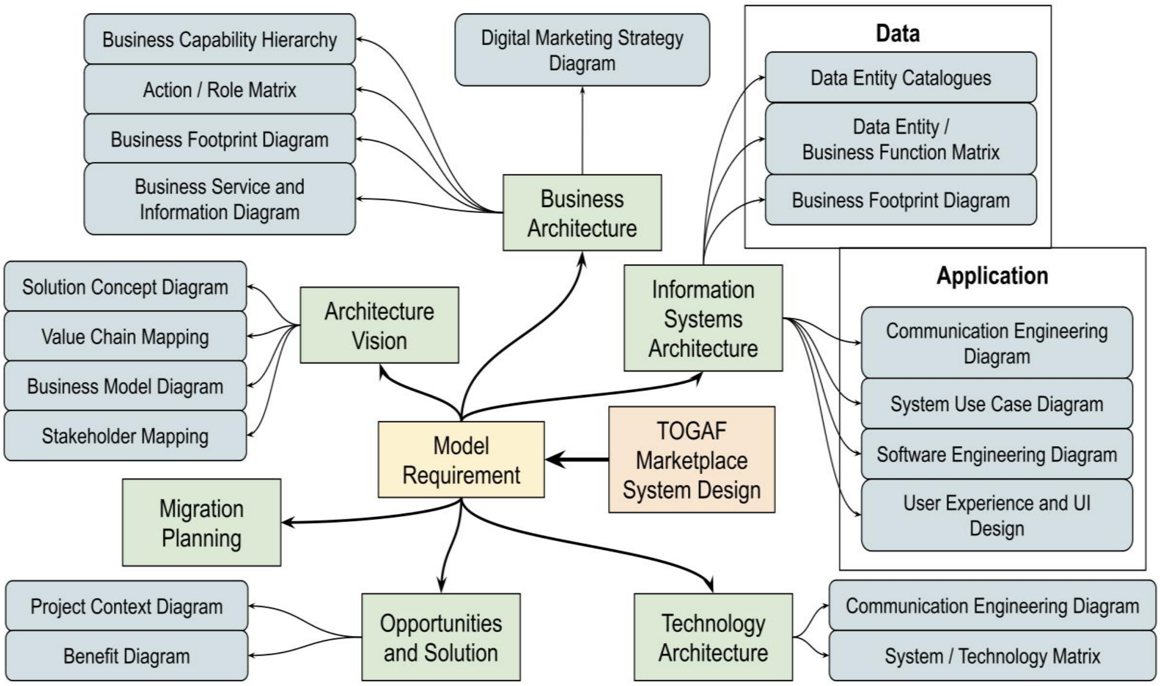

Figure 2. Marketplace TOGAF architecture overview

3.1. Architecture vision

The architecture vision outlines the high-level blueprint for the proposed marketplace system, serving as the foundational guide for its development and implementation. The architecture vision outlines the high-level blueprint for the proposed marketplace system, serving as the foundational guide for its development and implementation. This vision encapsulates the system's strategic objectives and planned outcomes, ensuring alignment with the overarching goals. The goals include: 1) a marketplace platform that is safe, educational, and friendly for sellers by providing ease and flexibility to develop their business from scratch to a professionally managed state; 2) a marketplace platform that is safe and friendly for buyers by offering measurable quality assurance, easy transactions, and post-purchase services; 3) a marketplace platform integrated with products/services from business incubators; 4) to become a marketplace platform that can accommodate and market various forms of creations and downstream products from university BIU services; and 5) a marketplace platform that can redistribute its profits to stakeholders.

3.1.1. Stakeholder mapping

The primary stakeholders in this IM encompass the business incubator team, which acts as the system and service administrators. Subsequently, application users are the main consumers engaged in the buying and selling processes, with the opportunity to accelerate their businesses through learning and funding within the business incubator. Enhancing the quality of identifying the right services for external customers, such as buyers and investors, is paramount. This priority is underscored by a survey result on HEIs [21], which indicates relatively lower satisfaction scores in this area, as shown in Figure 3 for Question 8, “The ability of HEI in classifying the external entity (customers) on each service”.

The university’s leadership, including the rector, deans, internal regulators, and external regulators, play pivotal roles in shaping the regulations applied to the IM. Trainers and investors serve as essential partners in the business development of participants within the incubator. Meanwhile, the campus data centre integrates campus community data into the system and facilitates automatic registration. The specific roles of each stakeholder are outlined in Table 1.

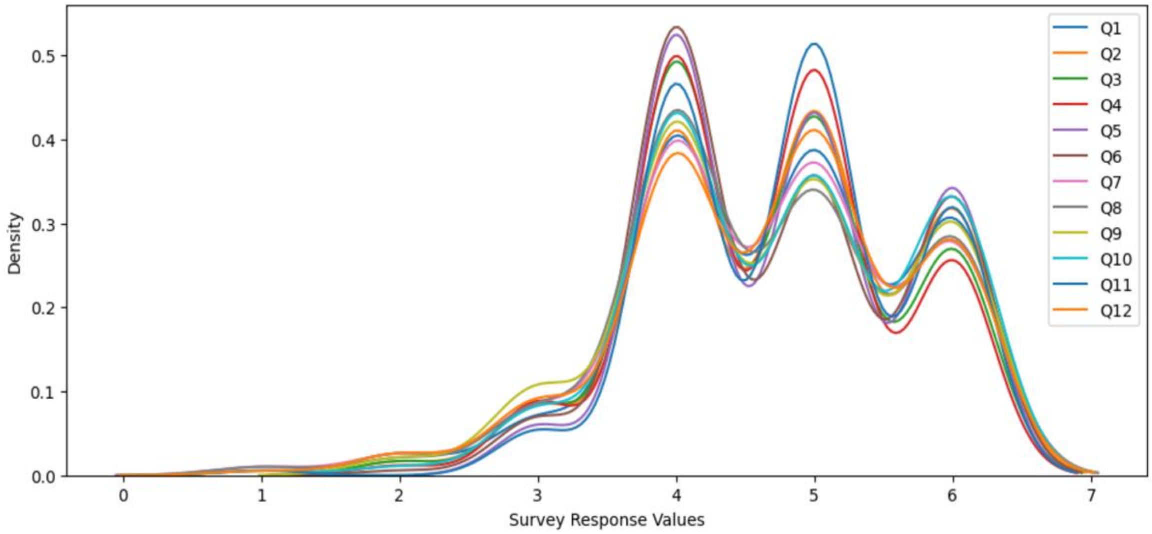

Figure 3. Distribution analysis of survey responses

Table 1. Stakeholders mapping

Actor	Organisational roles
Rector	Leading the planning, regulatory formulation, decision-making, and implementation of activities at the university level
Dean	Leading the planning, regulatory formulation, decision-making, and implementation of activities at the faculty level
BIU team	Managing the sustainability of the organisation, including products and services. Communicating every organisational need with stakeholders
Trainer	Facilitating the learning process for participants in the business incubator. Assisting in formulating the BIU curriculum development
Users	Utilising the organisation’s products and services, acting as a provider of feedback for the organisation’s products and services. Indirectly contributing to the content development for organisation’s products and services. Indirectly participating in the marketing products and services to public
Univ. data Centre	Managing student, faculty, and staff data, who are the primary users of products and services. Administering various internal university applications. Overseeing single sign-on integration for student, faculty, and staff
Internal regulator	Drafting, establishing, coordinating, and overseeing internal regulations for the organisation
External regulator	Drafting, establishing, coordinating, and overseeing external regulations that impact the organisation
Investor	Providing funding for participants in BIU. Conducting screening and supervision funding use by participants in the BIU

3.1.2. Value chain

The value chain delineates each business activity associated with a product/service, from the initial process to its end-user utilisation. It serves as a framework for identifying and concentrating on the inherent value in each activity, thereby enhancing the overall effectiveness and efficiency of the entire process. Figure 4 shows the association between business activity and its product/service.

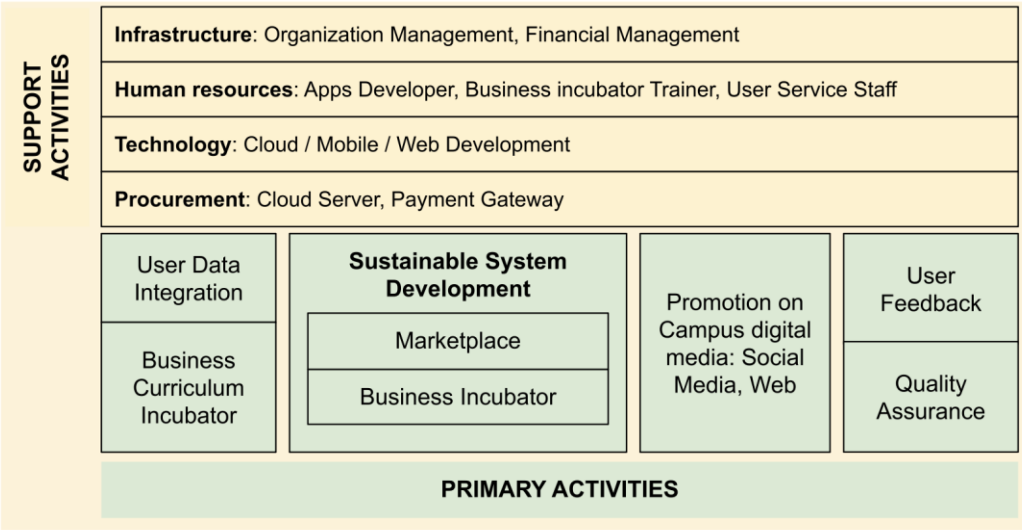

Figure 4. Association between each business activity with a product/service

3.1.3. Solution and concept

An overview of the proposed solution in this IM entails integrating the marketplace system with the BIU. The marketplace is the medium for implementing every venture developed within the BIU. For sellers, this integration significantly aids business development by connecting the learning and funding processes within the business incubator with the sales implementation in the marketplace. This distinctive feature characterises the campus-based IM. The abstraction of this solution is depicted in Figure 5.

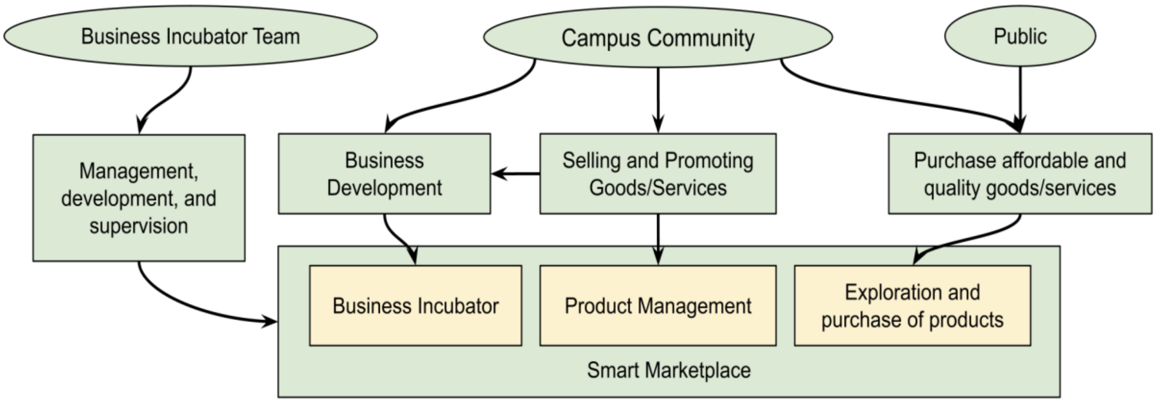

Figure 5. Overview of the proposed solution of the marketplace system integrated with the BIU

3.1.4. Business model

The business model implemented in the IM is anchored in the value of fostering new entrepreneurs with quality products and sustainable growth emerging from the campus. It emphasises how the ease of buying and selling processes contribute to the well-being of the campus community. The sociopreneurship principle is at the forefront, with the primary expected benefits being the growth of businesses for each seller and the improved welfare of the campus community. Administrative fees for each transaction process with appropriate nominal values to generate revenue will be applied. Optimising features and user experience (UX) on the application for both sellers and buyers is a key factor in achieving IM's business value. Integration with internal unit products, such as departments, is expected to stimulate greater engagement from each unit with various products resulting from their research. The system's business model diagram is represented in Figure 6.

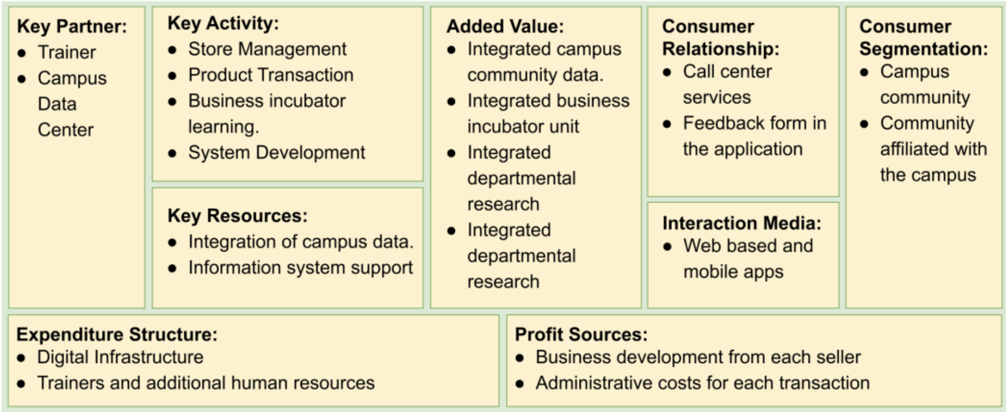

Figure 6. Business model

3.2. Business architechture

The IM's business architecture provides a reference for all stakeholders, especially the business incubator team, to aid in system development, governance implementation, and evaluation of business processes. In the Architecture Vision phase, it emphasizes the key functions of the marketplace and BIU. This includes focusing on online transactions and bank integration to enhance user interactions and productivity.

3.2.1. Business capability hierarchy

The IM encompasses three primary functionalities: the marketplace, business incubator, and account management. The Marketplace function has two key capabilities: selling and purchasing goods and services. The BIU function entails two primary capabilities: learning and funding. Meanwhile, the account management function ensures that campus and non-campus users can utilise the system. Elaborating on the capabilities from high to low levels aids in prioritisation and task allocation. Figure 7 illustrates the hierarchy of capabilities for each business process, ranging from high to medium levels.

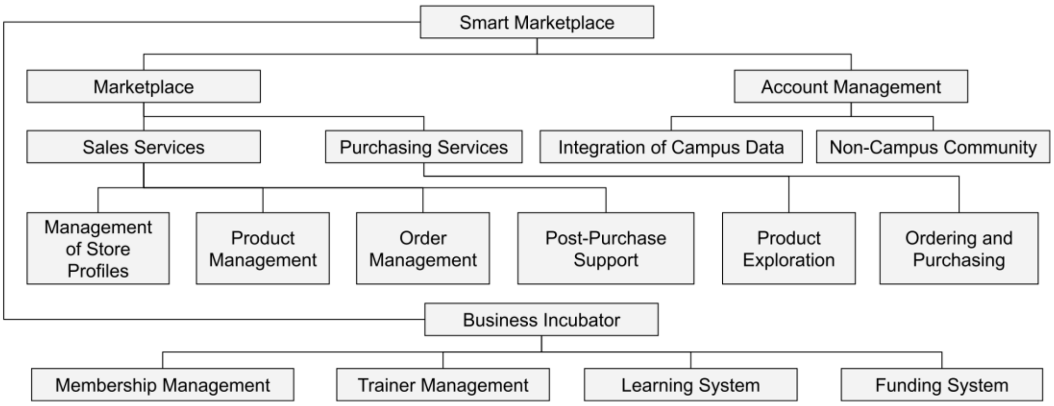

Figure 7. Business capability hierarchy

3.2.2. Action role matrix

This provides the relationship between role types and the corresponding authorities. The IM comprises six role types, where each user can hold more than one role. For instance, a campus member can be both a buyer, seller, and business incubator member. In general, every buyer is a seller at the most basic level. In the IM, two features are accessible to the public: the product exploration feature and the business incubator materials feature, intended to enhance engagement from potential external stakeholders. Table 2 lists the relationship between roles and authorities.

Table 2. Action/role matrix

Action/role	1	2	3	4	5	6	7
Integration of campus members data					✓		
Registration of non-campus members	✓						
Managing store profiles					✓		
Managing product catalogues					✓		
Product exploration	✓	✓	✓	✓	✓	✓	
Ordering and purchasing products			✓			✓	
Management of product orders				✓			
Post-purchase management				✓			
Completing the requirements to become a member of the business incubator				✓			
Accessing business incubator materials	✓	✓	✓	✓	✓	✓	
Completing business incubator assessments		✓					
Reviewing business incubator assessments					✓	✓	
Managing business incubator materials					✓	✓	
Providing funding information						✓	✓
Accessing funding information		✓				✓	✓
Submitting a funding request		✓					
Conducting funding assessments						✓	✓
Monitoring funding							✓
Updating a profile		✓	✓	✓	✓	✓	✓
Managing trainers					✓		

1=Public 2=Member 3=Buyer 4=Seller 5=Admin 6=Trainer 7=Investor

3.2.3. Business footprint

The IM's goals, business functions, service offerings, and supporting technologies should be organised in a hierarchical structure to clearly illustrate each component's role in fulfilling company objectives. This structure provides a basis for evaluating how effectively each element contributes to the overall mission. Such an approach ensures alignment and allows for focused analysis of priority areas within the organisation.

Figure 8 depicts evidence that the community data integration service plays a pivotal role in the overall functions, thus requiring prioritisation for early-stage implementation. On the technological front, the development of mobile and web applications holds a key role in the primary services and functions of the application. Therefore, it necessitates priority in preparation and provisioning regarding human resources and the technology employed.

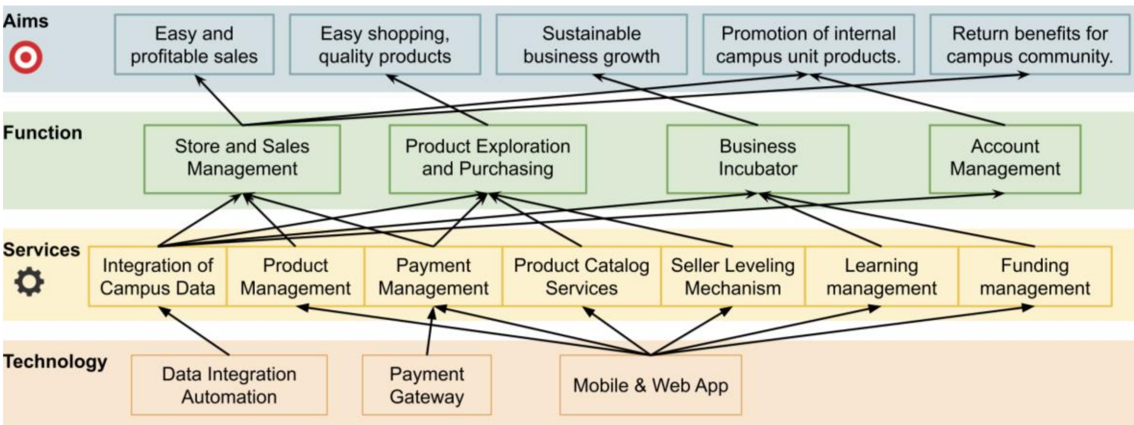

Figure 8. Business footprint

3.2.4. Business service and information

In the IM, information flows when the public registers, whether as campus or non-campus members. Campus members can serve as sellers of goods or service providers (sellers) and buyers of goods or service users (buyers). In contrast, non-campus members can only become buyers after registration. This distinction is established due to the primary focus and goal of the IM, which is to accelerate business and enhance the well-being of the campus community. This limitation is also in place to facilitate control and evaluation of sellers, ultimately improving the quality of services for buyers. Subsequently, sellers will create new information in the form of store data, including the products/services offered to buyers and the public. Buyers, in turn, will generate order and purchase information when deciding to buy goods or use services provided by sellers. Sellers who meet specific criteria can join the business incubator. Sellers can also unlock more features by meeting specific requirements, such as product provision, transaction history, and transaction volume. Sellers who become members of the business incubator generate new information during coaching sessions with business trainers, filling out learning evaluations, and applying for and receiving funding from investors. The flow of information in the application's functions is detailed in Figure 9.

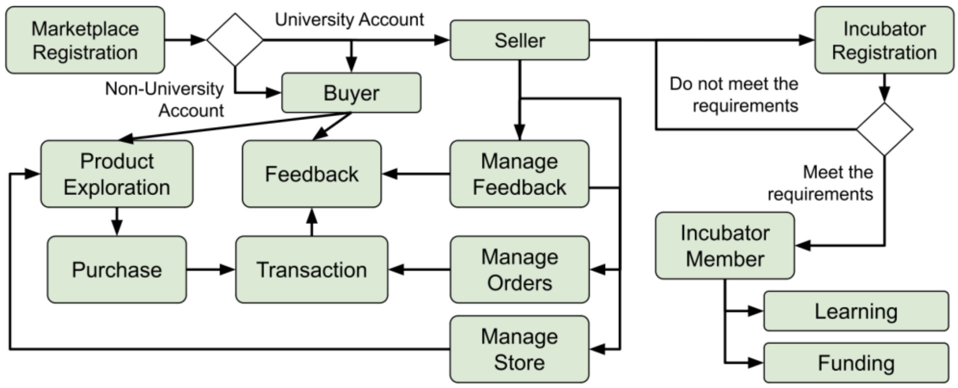

Figure 9. Business service and information diagram

3.2.5. Digital marketing strategy

There are three primary marketing targets that the IM platform must approach with ingenuity: sellers, buyers, and investors. It is crucial to strategize effectively on how to attract new sellers, buyers, and investors, while also enhancing the engagement of existing users with the platform. For instance, encouraging sellers to improve their products, increasing public awareness to attract new buyers, and motivating investors to support sellers. Figure 10 depicts the digital marketing strategy.

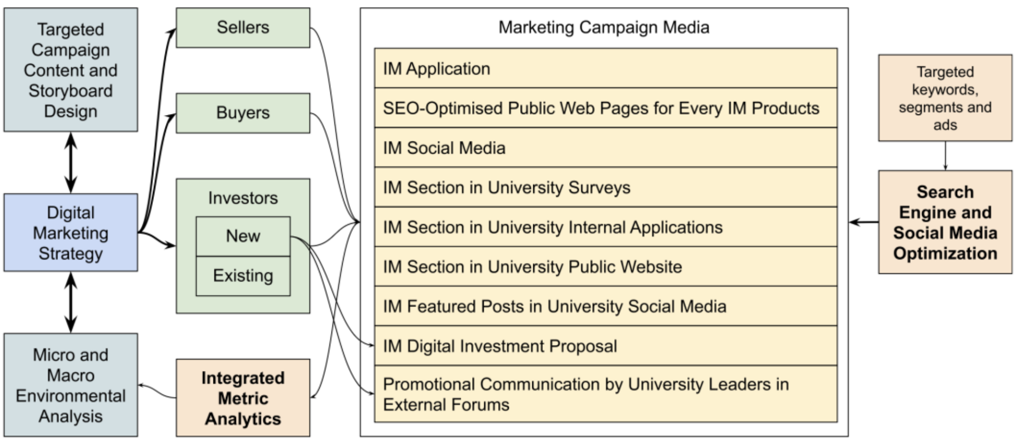

Figure 10. Digital marketing strategy

With the proliferation of digital media offering significant advantages, digital marketing has become the standard strategy for modern products. The digital marketing strategy illustrated in the Figure 10 demonstrates how digital technology can be harnessed to deliver clever marketing campaigns by optimally designing campaigns and selecting media types that respect micro-environmental factors such as target audience groups, behavioural and consumption patterns, and the most used digital media platforms. Additionally, it considers macro-environmental factors such as economic, cultural, and technological conditions and global and national trends. This approach minimises costs while maximising the engagement of the IM platform's target audience.

3.3. Information system architecture

The IM's information system (IS) architecture serves as a reference point for system designers, developers, and IS testers, ensuring that the constructed IS meets essential business functions. It provides a framework that guides developers in setting priorities and organising development stages. This structure allows developers to address each function according to its complexity and level of urgency.

3.3.1. Data entity catalogues

In developing the IS for the IM, data entities have been identified to represent each essential function, including user, store, product, order, rating, learning, learning activities, user level, and funding. Each entity corresponds to a key component within the system, capturing relevant attributes to support functionality. Table 3 provides an overview of all identified entities and their main attributes.

Table 3. Data entity catalogues

ID	Entity	Description	Main attributes
1	User	User data from IS involving (either personal/internal unit), non-campus members, trainers, business incubator teams, and investor	ID user, email, username, full name, user type, buyer, seller, business incubator member, admin team of business incubator, trainer, investor
2	Store	Sales channel for goods and services owned by users who have the authority as sellers	ID store, ID owner, store name, store detail
3	Product	Goods and services products sold in a Store	ID product, product type, unit price (optional), description, available quantity, ID rating
4	Order	Product orders placed by buyers	ID order, ID buyer, order time, payment time, delivery time, received time, order status, on-going, finish, total price
4.1	Order item	Products ordered in a purchase	ID order item, ID order, ID product, purchase quantity
5	Rating	Rating for a product, order, or store	ID rating
5.1	Item rating	Unit value of the user rating	ID rating item, ID rating, ID user, rating value, rating expression
6	Learning	Learning topic from the business incubator	ID learning, label, description
6.1	Learning item	Materials, evaluations, learning process in the business incubator	ID learning item, ID learning, learning item type, label, content
7	Learning activity	Learning activity of the business incubator member in accessing learning materials/providing evaluation feedback on learning process	ID learning activity, ID learning item, ID learner, activity status (not accessed; accessed; already responded), learner response
8	User level	Level of user membership, and requirements for the advancement of the level of user seller and BIU member	ID user level, ID user, membership level, user level requirement
9	Funding	Funding from investor	ID funding, ID investor, amount, appointment time, disbursement time, usage report, ID recipient

3.3.2. Data entity/business function matrix

A matrix has been created to illustrate the relationship between entities and business functions based on the identified IM business process entities. This maps whether the created entities have represented all business functions, providing certainty in the database design and application function processes. Table 4 presents the matrix.

Table 4. Data entity/business function matrix

Entity/business function	1	2	3	4	5	6	7	8	9
Marketplace registration	✓							✓	
Managing product and store	✓	✓	✓						
Exploration, order, and product transaction	✓	✓	✓	✓	✓				
Business incubator registration	✓							✓	
Advancement of seller and business incubator member levels	✓							✓	
Business incubator learning	✓					✓	✓		
Business incubator funding	✓							✓	✓
Business intelligence	✓	✓	✓	✓	✓	✓	✓	✓	✓

3.3.3. Data migration mapping

The IM IS is a new system built based on the existing data structure, namely the campus community data. Therefore, data migration mapping is required between the data sources used, namely campus community data and internal campus unit data, with the goal of the application components, namely account management and product management features. Migration technology involves data transformation, data interoperability, and data quality assurance. The data migration process in the IM is depicted in Figure 11.

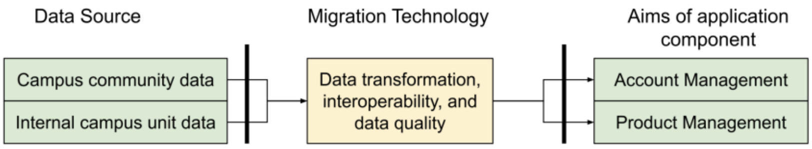

Figure 11. Data migration mapping

3.3.4. Application communication diagram

The IM IS comprises internal and external applications. The primary communication methods between these applications are web services and pub-sub. Figure 12 depicts relationships between systems to facilitate system planning and resource allocation for each required application.

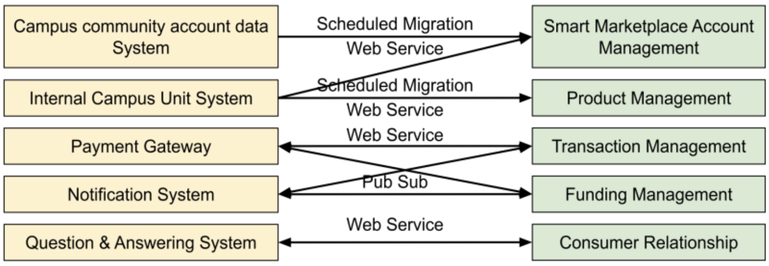

Figure 12. Application communication diagram

System use case diagram: registration and the marketplace system are two fundamental components of the IM used by three main actors: the public, buyers, and sellers. Use cases representing these components take priority in development as they form the initial stage for the functioning of the business incubator component. Figure 13 represents the overall high-level abstraction of use cases for the IM.

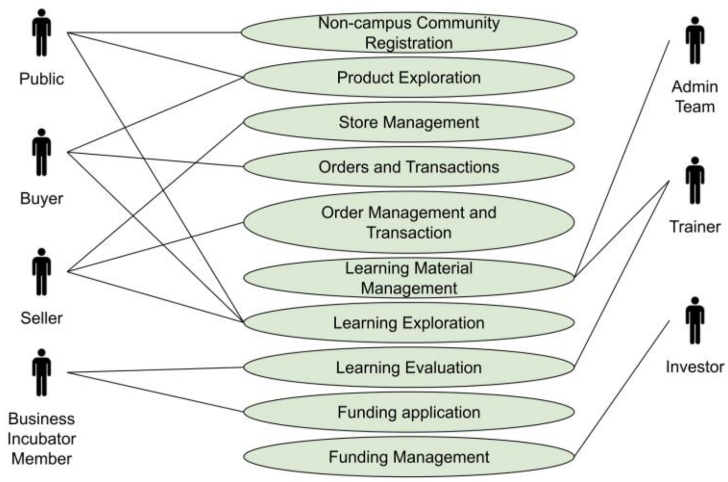

Figure 13. System use case diagram

3.3.5. Software engineering diagram

In developing the IM IS, developers have structured the system into three primary components: account management, marketplace, and business incubator systems. Each component is responsible for distinct functions within the overall system. Figure 14 illustrates these components and their connections with external services such as payment gateways and bank APIs.

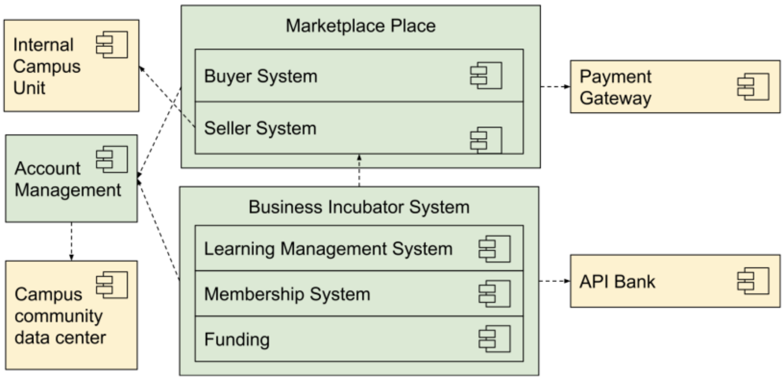

Figure 14. Software engineering diagram

3.3.6. User experience and user interface diagram

UX and UI play a crucial role in the IM as they determine the engagement and productivity of the primary application users, namely sellers and buyers. The UX process must be based on a solid analysis of what users need, what makes users satisfied, and what improves audience engagement, particularly for external customers such as buyers and investors. Implementing a UX designed as a UI supported by the right technologies will enhance engagement for both internal and external users. This is evidenced by the correlation matrix from the previous HEI survey, specifically the strong correlation between the ability of HEI to classify the internal entity (users) on each service and the ability of HEI to classify the external entity (customers) on each service, illustrated in Figure 15.

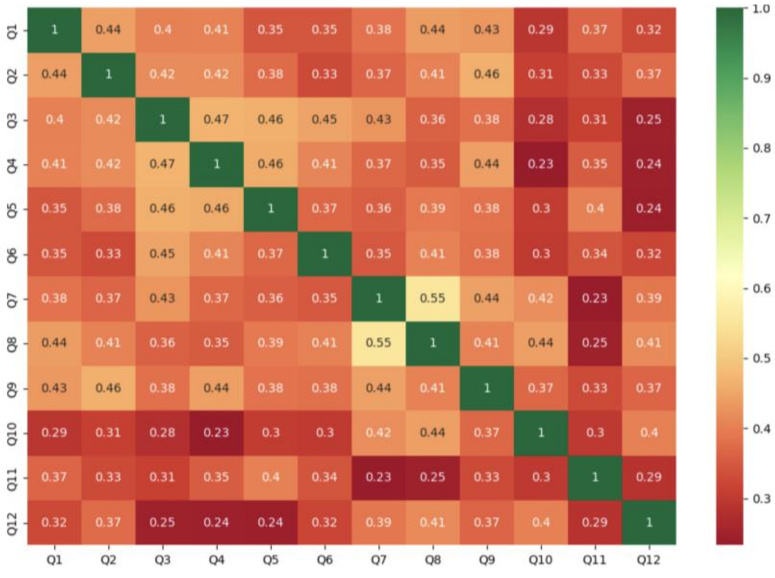

Figure 15. Correlation matrix

The initial UX/UI design helps analyse each user's stage, allowing for the preparation of subsequent update steps. This analyse enables the team to anticipate user needs and refine features that enhance the overall experience. Furthermore, with a clear understanding of user progression, developers can prioritize updates that align closely with user expectations and improve usability over time. The IM's UX/UI is detailed in Figure 16. Disclaimer: the UX/UI images in this article are presented in *Bahasa*. They are intended for illustrative purposes to support the discussed concepts.

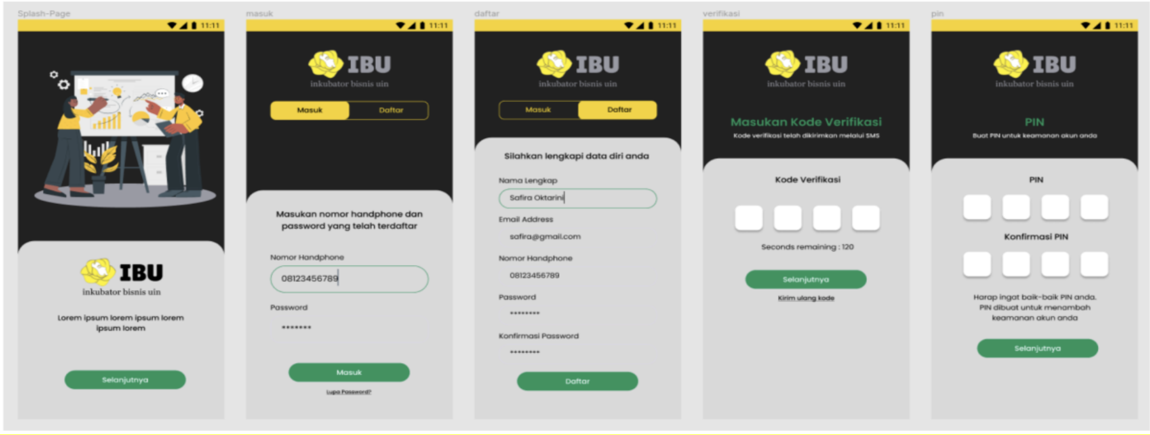

Figure 16. UX/UI

3.4. Technology architecture

Technology architecture was created to accommodate all the needs of IS architecture. The main architecture used is Client-Server Architecture, where users utilise smartphone-based applications (Android and iOS) and browsers connected to a server for centralised cloud-based information access. Internal cloud infrastructure is an internal cloud infrastructure whose development stages and placement locations are directly managed by the marketplace software developer team. This architecture has four main components: account service, marketplace service, incubator service, and business intelligence service. In addition, information security technological architectures act as containers that encapsulate every internal structure. They ensure that the input and output of external systems comply with information security standards, thus safeguarding the entire ecosystem. The technology components used in the cloud are scalable, meaning computing resources and data storage can expand as user loads increase. This allows organisations to minimise computing and storage resources when the application is published and the number of active users is still small.

3.4.1. Communication engineering

The IM's internal developers build internal cloud infrastructure and client applications. This internal cloud connects the system, linking client applications to various IM services and external services such as campus single sign-on, payment gateways, and bank APIs. Figure 17 depicts the cross-network relationships of each component.

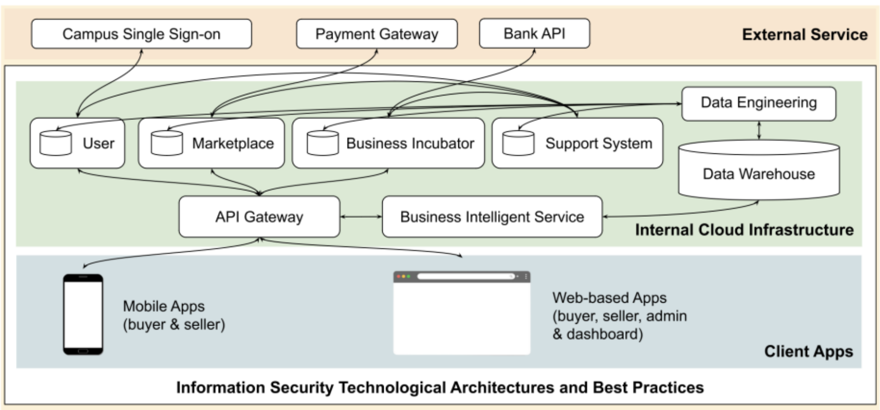

Figure 17. Communications engineering diagram

3.4.2. System/technology matrix

Various technologies have been selected to build the IM, employing open-source technologies for internal development. These open-source technologies are chosen for their flexibility in development, cost-effectiveness in provisioning, and ability to collaborate well with the research environment on campus. The key technologies in system development include application development frameworks, databases, infrastructure, and data analytics. We separated the technology matrix into three categories: internal infrastructure (cloud), external services, and client applications. All technology-category matrices are shown in Tables 5-7 respectively.

Table 5. Internal infrastructure

No	Services	Components	Software
1	Marketplace	Database, caching, dynamic public web page, mobile and web backend, microservices, and scalability	PostgreSQL, PostGIS, and Redis, NextJS, GraphQL, and Docker Stack
2	Business incubator	Database, caching, mobile and web backend, microservices, and scalability	
3	Learning management systems		
4	User management	Database, microservices, and scalability	Docker Stack
5	API gateway	API gateway app	KrakenD
6	Supporting systems	Web backend	Python
7	Data warehouse	Database	PostgreSQL and PostGIS
8	Migration and data transformation	GraphQL backend and data warehouse migration service	Hasura, Apache, and Airflow
9	File services	Object storage management	MinIO
10	Business intelligent services	Business intelligence backend	Python and GraphQL
11	Cloud integration	Web server and containerization	Nginx and Docker

Table 6. External services

No	Components	Description	Software
1	Centralized campus login (single sign-on)	University provides a single sign-on API for applications requiring authentication of campus academic community accounts.	RESTful API
2	Payment gateway	A third-party financial transaction service provider within the system.	host-to-host RESTful API
3	Banking API	API to access the primary bank account of the marketplace used for distributing buyer profits and investor funding	host-to-host API

Table 7. Client applications

No	Component	Description	Software
1	Mobile-based application	Developed using multiplatform mobile application development technology to enable a single development to be released for various platforms such as Android and iOS.	React Native, Play Store Developer Portal, and iOS Developer Portal
2	Web-based application	It is utilized to maximize search engine optimization (SEO) for published products and for data visualization for business intelligence modules.	Next JS and D3.js

3.4.3. Information security technology

Information security is paramount and is built upon various technologies and best practices derived from the open web application security project (OWASP) guidelines. These practices ensure robust protection against common threats and vulnerabilities, such as structured query language (SQL) injection, cross-site scripting (XSS), and other attack vectors. The security architecture incorporates multiple layers of defense, including secure coding practices, rigorous access controls, encryption of sensitive data, and regular security audits. Furthermore, the system employs advanced firewalls, intrusion detection systems (IDS), and continuous monitoring to safeguard against potential breaches and ensure the integrity and confidentiality of the data. The entire information security components are described in Table 8.

Table 8. System and technology matrix

No	Architecture component	Description	Software	Hardware
1	Application firewall	Protects applications from common web threats.	Cloudflare	
2	Data encryption	Ensures data is encrypted both in transit and at rest.	OpenSSL	
3	User authentication	Manages user identities and access control	Auth0	
4	Backup server	Provides backup and recovery for critical data	MinIO	Backup server
5	IDS	Monitors network for malicious activity	Snort	
6	Information availability	Ensures system uptime and availability		Uninterruptible power supply (UPS)

3.5. Opportunity and solution

Implementing the construction of the IM is carried out gradually, considering the existing opportunities and solutions. Before the construction implementation, it is necessary to identify the urgency of each feature and part of the system so that crucial business processes can be initiated in the early stages of system development. The IM cloud infrastructure is the first component in the system development implementation. This phase includes selecting virtual server services, initial virtual server configuration, installing basic technologies like containerisation, and configuring domains and networks. The next step is to build a user management system that allows for integrating campus data for user information, designing and implementing databases for users, and login mechanisms for use in the client application. Subsequently, supporting systems will be initiated for various IM modules such as file management, notifications, ratings, AI, and pubsub. Once the user management system is completed, the development team will build the back and frontend marketplace system in parallel. The mobile frontend application will be prioritised as it contains the basic functions of the marketplace system. The development process is described in Figure 18.

The prioritisation of development features can be based on their impact and significant benefits on the objectives. Features in various categories, such as microservice offerings, are considered a priority for development as they significantly impact the objectives. The impact and benefits of these features on the objectives can be visualised in Figure 19.

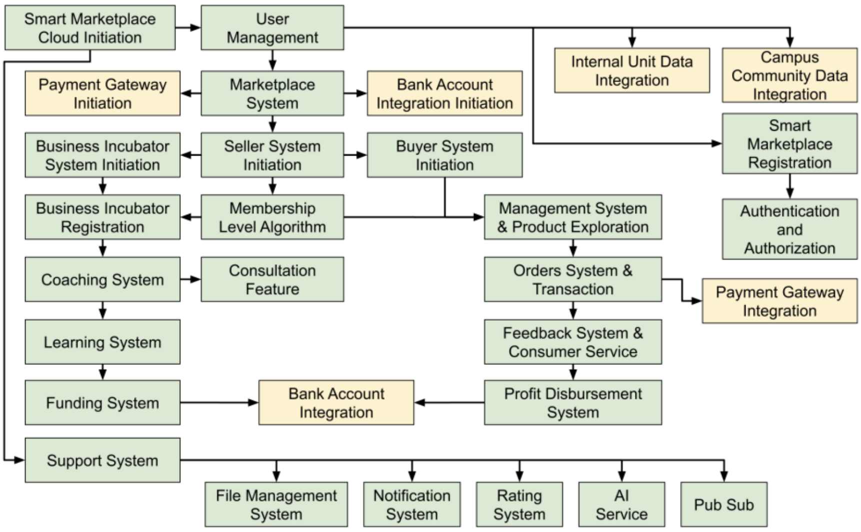

Figure 18. Project context diagram

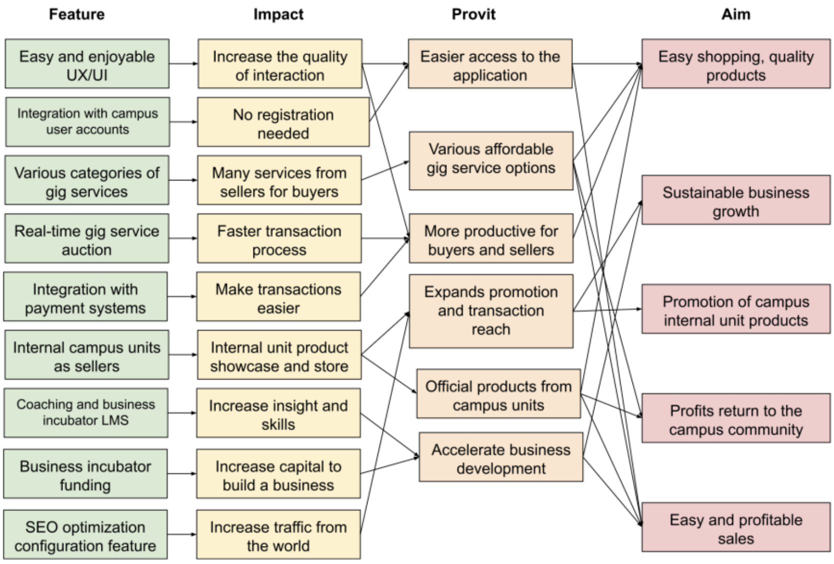

Figure 19. Benefit diagram

3.6. Migration planning

The migration and implementation process of the IM will be built gradually over a three-year duration, with parallel development for each feature. This approach allows the system's minimum viable product to be implemented in the first year. The selection of stages and tasks in each phase is based on the benefits diagram and project context diagram, with additional considerations such as the complexity of the technologies used. the first stage focuses on the basic implementation of the IM, where sellers can open a store and manage products, buyers can explore and order products, both parties can transact directly, and sellers can become members of the business incubator. The second stage focuses on the availability of the learning management system (LMS) for the incubator and the integration and implementation of payment options for buyers using a payment gateway. The third stage, system finalisation, focuses on integrating the funding mechanism for investors through the bank's API. The entire process is detailed in Table 9.

Table 9. Architecture definition increments

Task	Phase 1: basic features	Phase 2: LMS and payment	Phase 3: funding system
Faculty data integration	Integration of faculty data and non-faculty registration data	Refinement of data integration process	
Cloud infrastructure	Basic container-based application	Scalable container managing platform	Cloud infrastructure monitoring system
Membership management	Registration of faculty and non-faculty, initial implementation of levelling procedure	Advanced implementation of levelling procedure with payment mechanism	Final implementation of levelling procedure with funding mechanism
Support system	File storage, Pub/Sub, and rating system	Notification system and basic AI support	Refinement of AI support
Marketplace system	Store and product management, Product exploration, ordering, and inter-party transactions	Marketplace-mediated transactions, rating system, consumer comments, and feedback	Refinement of transaction mechanisms and UX/UI
Business incubator system	Membership mechanisms, coaching system, and LMS initialization	LMS refinement and funding system initialization	Refinement and integration of banking services for funding system

3.7. Implementation governance

In implementing system development, governance and control mechanisms must complete each stage according to the target timeframe. Breaking down the target of completing tasks into subtasks and sub-deadlines is done to enable evaluations within shorter timeframes. The SCRUM method ensures that the system is built according to requirements. Table 10 lists the overall governance.

Table 10. Implementation governance

Activity	Governance	Control and monitoring
Faculty Data Integration	Establishing time-bound objectives, creating documentation for integration formats, ensuring the presence of formal agreement documents	Periodic evaluation, data migration monitoring system
System Development	Adopting SCRUM for planning, control, and evaluation during system development iterations	Daily SCRUM, sprint retrospective, monitoring system for application code repository
Development of the curriculum and procurement of trainers	Creating a trainer data management, preparing agreement formats, certificates, and standard operating procedures (SOP) for trainers, developing curriculum templates with learning outcomes	Periodic evaluation of learning outcomes, monitoring system for coaching processes
Procurement of investor	Creating a trainer data management, preparing formats for agreements, legal documents, and SOPs for investors	Periodic evaluation and reporting system
Payment Gateway Integration	Coordinating and resolving legal matters with external financial services and regulators	Periodic evaluation, transaction monitoring system
Bank Account Integration	Coordinating and resolving legal matters with external financial services and regulators	Periodic evaluation Transaction monitoring system

3.8. Architecture change management

As the implementation of the IM progresses, opportunities for architectural changes may arise due to the need to address constraints or opportunities for development. For instance, a strategy is needed to handle the architectural change requirements if new technology can expedite development. The handling strategies for each architectural change requirement are shown in Table 11.

Table 11. Change management architecture

Changes	Strategy
Fundamental policy changes from external/internal regulators. Example: policies prohibiting the integration of community data	Reverting functions to a more basic form that is not affected by the policy. Designing the software development architecture in a modular, interface-based manner to allow for interchangeable application-building technologies
Significant changes in the version of application-building technology, application support technology, and business process function models within the application. Example: Version changes in application component libraries, database upgrades, AI model updates	Designing the software development architecture in a modular, interface-based manner to allow for interchangeable application-building technologies. Providing infrastructure for the development and testing of code to be deployed to production, thereby facilitating easier migration without disrupting the existing system

3.9. Discussion

The TOGAF framework's architectural design, complemented by the SOSTAC model, offers a comprehensive methodology for developing an IM system within higher education institutions. The SOSTAC model provides a structured approach to digital marketing strategy, ensuring the system's development aligns with situational analysis, setting clear objectives, and devising strategies, tactics, actions, and controls. The key finding from this study is that combining these frameworks allows for a detailed and strategic planning process that not only focuses on technical architecture but also considers marketing and operational aspects. This holistic approach is crucial for supporting BIUs in fostering technopreneurship.

Previous research has underscored the value of EA frameworks like TOGAF in organizing and managing complex systems (references). However, this study highlights a unique challenge in the practical application of TOGAF, particularly in choosing appropriate output forms that enhance rather than hinder communication among stakeholders. The strength of this research lies in its focus on the practical implications of architectural documentation, which has often been underexplored in existing literature. Nonetheless, a significant limitation is the theoretical nature of the findings, as the proposed solutions for managing EA documents have yet to be empirically tested. Additionally, the discussion points to the potential benefits of utilizing web and mobile technologies for interactive and accessible EA exploration, which requires further validation.

This study primarily aims to refine the use of the TOGAF within the context of higher education by addressing the practical challenges associated with architectural documentation. The importance of this work lies in its potential to improve the accessibility and interactivity of EA documents, making it easier for stakeholders to navigate and understand complex architectural relationships. Future research should focus on empirically testing the proposed solutions, such as the use of web and mobile platforms for interactive exploration and the integration of script-based documents with version control systems like Git. Moreover, investigating the impact of different output forms on stakeholders' understanding and decision-making processes could provide valuable insights into optimizing EA practices. Further studies should also explore the potential correlation between technology procurement, as represented in architectural outputs, and the achievement of institutional key performance indicators (KPIs).

4. CONCLUSION

The design of the IM system, based on the TOGAF and SOSTAC model, demonstrated that a structured approach to aligning IT strategy with university business models could significantly enhance the support for BIUs, thereby fostering technopreneurship among students and faculty. This finding suggests that the TOGAF and the SOSTAC model offer a comprehensive solution for supporting BIUs in fostering technopreneurship within HEI. The EA includes modules for resource management, mentorship matching, market analysis, and networking. These components are designed to work together seamlessly, providing a holistic support system for aspiring technopreneurs. The alignment of these modules with the university's strategic goals ensures that the system can effectively integrate academic and entrepreneurial activities. The TOGAF allows for a modular design, making the system scalable and adaptable to different universities and varying sizes of BIUs. This flexibility is crucial for accommodating future growth and changes in the technopreneurship landscape. The SOSTAC model's inclusion ensures that the system's design closely aligns with the strategic objectives of fostering entrepreneurship and innovation. By setting clear objectives and strategies, the system is poised to support the university's mission of contributing to socio-economic development through technopreneurship. Although empirical testing has not been conducted, the architectural design theoretically promises to enhance the efficiency of BIUs by providing a structured environment for nurturing startups. The system is expected to streamline processes, reduce administrative burdens, and provide valuable data insights for decision-making. The design phase highlighted potential challenges, such as ensuring user adoption, integrating with existing university systems, and securing continuous funding and support.

This research has successfully developed a mechanism for the IM using the TOGAF. The EA created covers user management by integrating community data, marketplace systems management, and business incubator systems management. Diagrams, matrices, and catalogues were employed to represent the objectives of each stage within the EA. The quest for the most effective EA form was conducted by iterating through each stage of TOGAF, analysing the most advantageous steps, and identifying those that should be avoided. This iterative process ensured a refined approach at each stage. This research integrated community data by linking the campus data centre with the IM application. The TOGAF effectively represented the data integration architecture and multi-system software development. The findings highlight that aligning the goals and outputs of each stage is the most critical aspect of using the TOGAF. Furthermore, carefully selecting the type and form of output significantly enhances the effectiveness of using EA as a reference for all relevant stakeholders. Future studies can explore the long-term impacts of such incubator IMs on technology-based startup success rates and economic growth.

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REFERENCES

[1] M. D. Parrilli, M. Balavac, and D. Radicic, "Business innovation modes and their impact on innovation outputs: Regional variations and the nature of innovation across EU regions," *Research Policy*, vol. 49, no. 8, p. 104047, Oct. 2020, doi: 10.1016/J.RESPOL.2020.104047.

[2] M. Wang, Y. Li, J. Li, and Z. Wang, "Green process innovation, green product innovation and its economic performance improvement paths: A survey and structural model," *Journal of Environmental Management*, vol. 297, p. 113282, Nov. 2021, doi: 10.1016/J.JENVMAN.2021.113282.

[3] OECD, "OECD Science, Technology and Industry Scoreboard," *OECD Science, Technology and Industry Scoreboard 2017*, Nov. 2017, doi: 10.1787/9789264268821-EN.

[4] N. Nan and H. Tanriverdi, "Unifying the Role of IT in Hyperturbulence and Competitive Advantage Via a Multilevel Perspective of IS Strategy," *MIS Quarterly*, vol. 41, no. 3, pp. 937–958, Sep. 2017, doi: 10.25300/MISQ/2017/41.3.12.

[5] H. Bouwman, S. Nikou, and M. de Reuver, "Digitalization, business models, and SMEs: How do business model innovation practices improve performance of digitalizing SMEs?," *Telecommunications Policy*, vol. 43, no. 9, p. 101828, Oct. 2019, doi: 10.1016/J.TELPOL.2019.101828.

[6] C. Reichstein, "Strategic IT management: how companies can benefit from an increasing IT influence," *Journal of Enterprise Information Management*, vol. 32, no. 2, pp. 251–273, Apr. 2019, doi: 10.1108/JEIM-08-2018-0172.

[7] S. Kemp, "Digital 2018: Indonesia," datareportal.com. [Online]. Available: https://datareportal.com/reports/digital-2018-indonesia (Accessed: Jul. 01, 2023).

[8] S. Kemp, "Digital 2022: Indonesia." [Online]. Available: https://datareportal.com/reports/digital-2022-indonesia?rq=Digital%202022%3A%20Indonesia (Accessed: Jul. 01, 2023).

[9] S. Kemp, "Digital in Indonesia: All the Statistics You Need in 2021-DataReportal-Global Digital Insights." [Online]. Available: https://datareportal.com/reports/digital-2021-indonesia (Accessed: Jun. 28, 2024).

[10] G. Rodríguez-Abitia and G. Bribiesca-Correa, "Assessing Digital Transformation in Universities," *Future Internet*, vol. 13, no. 2, p. 52, Feb. 2021, doi: 10.3390/FI13020052.

[11] C. E. Miller, "Leading Digital Transformation in Higher Education: A Toolkit for Technology Leaders," *Technology Leadership for Innovation in Higher Education*, p. 25, Feb. 2019, doi: 10.4018/978-1-5225-7769-0.CH001.

[12] S. Hill, A. Ionescu-Somers, and A. Coduras, "Global Entrepreneurship Monitor (GEM) 2022/2023 Global Report: Adapting to a "New Normal"," *Global Entrepreneurship Monitor (GEM)*, London, 2023.

[13] Department of Economic and Social Affairs, 'Sustainable Development Goals', THE 17 GOALS. [Online]. Available: https://sdgs.un.org/goals (Accessed: Jul. 03, 2023).

[14] The Ministry of National Development Planning/Bappenas Republic of Indonesia, 'The Eight Long-Term National Development Agenda 2025-2045'. Accessed: Jul. 03, 2023. [Online]. Available: https://indonesia2045.go.id/

[15] Y. H. Al-Mamary and M. Alshallaqi, "Impact of autonomy, innovativeness, risk-taking, proactiveness, and competitive aggressiveness on students' intention to start a new venture," *Journal of Innovation and Knowledge*, vol. 7, no. 4, p. 100239, Oct. 2022, doi: 10.1016/J.JIK.2022.100239.

[16] X. Ordeñana, P. Vera-Gilces, J. Zambrano-Vera, and A. Jiménez, "The effect of high-growth and innovative entrepreneurship on economic growth," *Journal of Business Research*, vol. 171, p. 114243, Jan. 2024, doi: 10.1016/J.JBUSRES.2023.114243.

[17] M. Tahir and U. Burki, "Entrepreneurship and economic growth: Evidence from the emerging BRICS economies," *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 9, no. 2, p. 100088, Jun. 2023, doi: 10.1016/J.JOITMC.2023.100088.

[18] M. Klofsten and D. Jones-Evans, "Comparing Academic Entrepreneurship in Europe -The Case of Sweden and Ireland," *Small Business Economics*, vol. 14, no. 4, pp. 299–309, 2000, doi: 10.1023/A:1008184601282.

[19] H. Etzkowitz, "The evolution of the entrepreneurial university," *International Journal of Technology and Globalisation*, vol. 1, no. 1, pp. 64–77, 2004, doi: 10.1504/IJTG.2004.004551.

[20] A. Marks, M. Al-Ali, R. Atassi, A. Z. Abualkishik, and Y. Rezgui, "Digital Transformation in Higher Education: A Framework for Maturity Assessment," *International Journal of Advanced Computer Science and Applications (IJACSA)*, vol. 11, no. 12, 2020.

[21] C. Slamet, A. B. A. Rahman, and M. A. Ramdhani, "Concepts of Strategic Management of Information Technology," *Journal of Physics: Conference Series*, vol. 1175, no. 1, p. 012264, Mar. 2019, doi: 10.1088/1742-6596/1175/1/012264.

[22] S. Bente, U. Bombosch, and S. Langade, *Collaborative enterprise architecture: Enriching EA with lean, agile, and enterprise 2.0 practices* in Collaborative Enterprise Architecture, Wyman Street, Waltham, MA 02451, USA pp. 1–310, Aug. 2012, doi: 10.1016/C2011-0-69682-6.
[23] S. Kotusev, "TOGAF-based Enterprise Architecture Practice: An Exploratory Case Study," *Communications of the Association for Information Systems*, vol. 43, no. 1, p. 20, Sep. 2018, doi: 10.17705/1CAIS.04320.
[24] M. Wright, S. Birley, and S. Mosey, "Entrepreneurship and university technology transfer," *Journal of Technology Transfer*, vol. 29, pp. 235–246, 2004, doi: 10.1023/B:JOTT.0000034121.02507.f3.
[25] D. Chaffey and F. E. Chadwick, "Digital Marketing, 7th ed." in *Pearson Education limited*, 7th ed. London, 2019.

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