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Enterprise Architecture in the Construction Management Software using the Business Model Canvas

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Abstract: Indonesia's construction industry has boomed over the past decade, acting as a powerful engine for the nation's economic growth. However, this success story comes with a growing list of challenges. Construction projects are becoming increasingly intricate, demanding not only efficiency and quality but also enhanced safety and a minimized environmental footprint. To tackle these complexities, the industry is undergoing a crucial transformation towards "smart construction." This approach leverages the power of information and communication technology (ICT) throughout the entire project lifecycle, from planning and design to execution and maintenance. By integrating ICT tools like Building Information Modeling (BIM) and cloud-based project management platforms, smart construction streamlines processes, minimizes errors, and optimizes resource allocation, ultimately leading to improved efficiency, enhanced worker safety, and a reduction in environmental impact. A key pillar of smart construction lies in the integration of enterprise architecture (EA) within construction management software. EA provides a structured framework for aligning IT systems with construction businesses' specific goals and objectives. This ensures that software development and management are adaptable to evolving industry needs and foster continuous innovation. This research delves into the application of EA within the construction management software industry, specifically focusing on the TOGAF Architecture Development Method (ADM). By exploring EA through this established framework, the research aims to shed light on how the construction industry in Indonesia can leverage technology to its fullest potential. This will ensure continued growth within the sector and contribute to a lasting positive impact on the nation's economy.

Keywords: Archimate, Business Model Canvas, Construction Management Software, Enterprise Architecture

INTRODUCTION

Based on the Mordor Intelligence report entitled Indonesia Construction Industry Size & Share Analysis – Growth Trends & Forecasts (2024 – 2029) (Mordor Intelligence, 2024), the Indonesian construction market is currently booming and is projected to reach almost $408 billion in 2029, compared to estimates $284 billion by 2024. This annual growth of 7.5% is due to significant government investment in infrastructure projects such as roads, bridges, airports, including the construction of Indonesia's new capital city in East Kalimantan. These projects are government programs aimed at improving connectivity, reducing transportation costs, and increasing overall and equitable economic development across the region.

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The market itself is very busy, with both local and foreign companies competing to get a share of this huge potential. To address challenges, such as high costs and financing issues, the US and Indonesian governments recently partnered on a $649 million investment to increase infrastructure financing, particularly for transportation and logistics. In addition, the Indonesian government is also taking steps to stimulate the real estate market and support the growing demand for data centers. Even with the large number of well-established Indonesian businesses, there is still much space for expansion. Due to the market's fragmentation and the government's enormous infrastructure investment plan, there are chances for new competitors, both domestic and foreign. It is anticipated that this rivalry would spur more industry innovation and efficiency.

The management of complex construction projects involving various parties requires support in the form of reliable and adequate information technology. Of the many information technologies used in construction projects, one solution that can be applied in this industry is construction management software. Construction management software is a software system designed to manage and control the costs, progress, and overall workflow of a construction project in an integrated manner (Chen, 2022). This solution uses big data technology to collect, analyze, and process various types of information in projects while providing efficient and effective support for decision-making. The decision-making in question can take the form of investment, design stages, construction process control, and other aspects of construction project management. What is also important is that when the concept of Industrial Revolution 4.0 is implemented, most of the work environment must be automated and operated with IoT or Internet of Things, and Big Data, all processed in real-time using cloud computing (Ali et al., 2021).

Enterprise architecture (The Open Group, 2024) is an architecture that integrates various information systems in an organization. This enterprise architecture can be applied in the construction industry to integrate various activity tools used by various parties involved in construction projects. By implementing enterprise architecture, the construction project management process can become more integrated and efficient. This can increase the productivity and effectiveness of construction projects, as well as reduce the risk of errors.

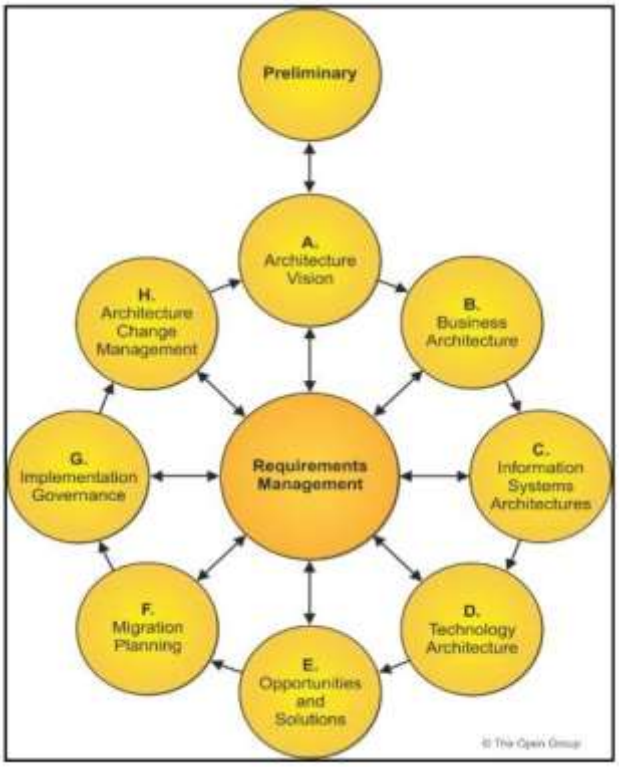

Fig. 1 TOGAF Framework
Source: The Open Group

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As seen in Figure 1, there are eight domains of TOGAF used in completing the enterprise architecture. These eight domains are Architecture Vision, Business Architecture, Information Systems Architecture, Technology Architecture, Opportunities and Solutions, Migration Planning, Implementation Governance, and Architecture Change Management. TOGAF has a comprehensive and complete structure and methodology that supports its implementation (Zahra et al., 2020). TOGAF also involves the process of design, implementation, scheduling and governance of company information architecture, which ultimately helps top management in carrying out data analysis and real-time decision making (Chandra & Legowo, 2022). This research will discuss enterprise architecture analysis, application of enterprise architecture, as well as the benefits and challenges of implementing enterprise architecture in the construction management software industry.

LITERATURE REVIEW

While extensive research exists on Enterprise Architecture (EA) in general, there's a gap in knowledge regarding its application specifically to construction management software. This study aims to complement existing research, not identify shortcomings, by exploring how EA principles can be effectively implemented within construction software.

Table 1. Previous researches related to Enterprise Architecture and Construction Software

Author	Topic	Advantage	Disavantage
(Collin, 2020)	Implementing Project Management Software into a Small Residential Construction Company	The study in this paper explains the benefits of using project management software, which is usually used in the heavy-scale construction industry, is used in small-scale housing companies, and turns out to have many positive impacts on the company.	Focus on the perceived benefits of using project management software and not analyze it from an enterprise architecture and business model canvas perspective.
(Ali et al., 2021)	Agile Project Management Software for Construction and Management Industries	The purpose of this study is to determine how project management software, specifically PlanGrid® and ZenTao®, is implemented in the construction and management sectors while examining the benefits and drawbacks from the perspective of the end user.	The disadvantage is that it does not analyze enterprise architecture and BMC, only the advantages and disadvantages of the two software, based on a literature review relating to experience and learning in project management software and applications.

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(Adwan & Al-Soufi, 2022)	Enterprise architecture-based ISA model development for ICT benchmarking in construction-case study	This paper presents an information systems architecture (ISA) model for the architecture, engineering, and construction sectors in Bahrain, using enterprise architecture. This model serves as an ICT barometer, identifying gaps, levels of duplication, and future investments. This model was tested and evaluated using the TOGAF framework, achieving an average score of 18.5% against 17 comparison countries.	The discussion on enterprise architecture are focused on Preliminary, Architecture Vision, Business Architecture, Info System Architecture, and Architecture Change Management. There is no approach that uses a Business Model Canvas that integrates with Enterprise Architecture.
(Pandowo et al., 2022)	Design and Build Project Cost Control Information Systems for Construction Companies	This paper specifically discusses cost control activities which are very important for the construction business, ensuring project completion on time and the quality of the work produced. The role of information systems is very important for controlling project costs, monitoring progress, and managing data. The method used is Visual Basic and TOGAF in creating an integrated system at PT. Selo Adi Karto, and produced a blueprint for its implementation.	Only discusses designing a company's enterprise architecture using the TOGAF ADM approach, but does not use the Business Model Canvas to complete it.
(Aziz & Ghuzdewan, 2023)	Evaluation of a construction management software: "Progresi"	The paper assesses "Progresi," a project management software for Indonesian construction projects, suggesting improvements such as a formal manual, network planning, and enhanced Gantt charts and tables.	This paper only discusses the features and manual use and does not discuss the enterprise architecture and business model canvas.
(HAMADA, 2023)	Investigate the Efficiency of Project Management Software in Construction Projects	The research objective of this paper is to examine the effectiveness and efficiency of using project management software in construction projects in the commercial cities of Kazakhstan, and understand the various types of software used in these projects and their efficacy.	Only conducting research in qualitative mode through interviews and observations to test how efficient the use of project management software is, but not analyzing from an enterprise architecture perspective.

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METHODS

The research method that will be used to address research issues is the descriptive research approach. The descriptive approach is a process for addressing problems that involve characterizing the state of the topic or target of research—which may be an individual, an organization, a society, or something else entirely—at a certain point in time using data that can be seen or seen as it is (Chandra, 2021).

Descriptive research methods can be carried out in various ways, one of which is literature study. Literature study is a research method carried out by reviewing various existing literature, both books and various other literature such as national journals, international journals, and so on (Hayati, 2022). In this paper, a literature study will be carried out to collect data regarding the concept of enterprise architecture, the application of enterprise architecture in the construction industry, as well as the benefits and challenges of implementing enterprise architecture in the construction industry. Data obtained from literature studies will be used to support the discussion of the paper.

Apart from literature studies, research methods are also carried out through secondary data collection. Secondary data, which is existing data collected by previous institutions or organizations, tends to be easier and faster to do (Syafnidawaty, 2020). In this paper, secondary data collection was carried out by observing and analyzing one of the construction management software programs already on the market to understand the pattern of the construction management process. In general, the research flow diagram can be shown in Figure 2, where the process begins with a literature study, collecting secondary data through observing one of the construction management software, designing business architecture, designing information system architecture, designing information technology architecture, and discussions to get conclusions from the study.

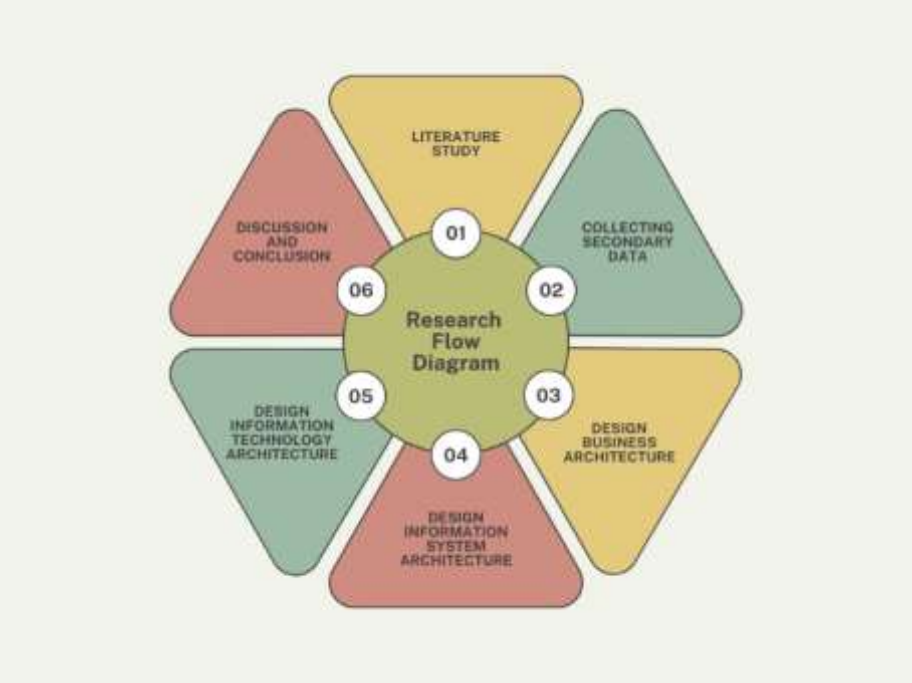

Fig. 2 Research Flow Diagram
Source: researcher property

Enterprise Architecture

According to The Open Group Architecture Framework (TOGAF) (The Open Group, 2022). Enterprise Architecture is a way to describe, define and plan a company organization. Enterprise Architecture covers all aspects of an organization, including business processes, information systems, and technology infrastructure. The goals to be achieved with this enterprise architecture are: increasing organizational efficiency and effectiveness, increasing organizational competitiveness, and increasing

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organizational readiness to face change. According to TOGAF, enterprise architecture itself is divided into 4 (four) domains, namely: business architecture, application architecture, data architecture, and technology architecture.

Business Model Canvas

Also from TOGAF, the Business Model Canvas (BMC) is a visual tool used to describe the business model of an organization. Another definition, BMC is a business management framework created to design how business strategies will be implemented (Macha-Huamán et al., 2023). BMC consists of 9 (nine) blocks that describe how an organization creates, delivers, and captures value for its customers, namely:

1. Value Propositions, is the selling value of products, services, or benefits that an organization offers to its customers. The value proposition must be unique and attractive to customers in order to differentiate the organization from its competitors.
2. Customer Segments, are customer segments served by the organization according to similar needs and desires. Organizations need to understand their customer segments to be able to develop the right value proposition.
3. Customer Relationships, are the relationships that an organization builds with its customers. Organizations can build different customer relationships, such as transactional relationships, personal relationships, or community relationships.
4. Channels, are the channels that organizations use to reach their customers. Organizations need to choose the right distribution channels for their customer segments.
5. Key Activities, are the main activities carried out by an organization to run its business. These activities can be production activities, sales activities, or marketing activities.
6. Key Resources, are the resources an organization needs to run its business. Resources can be physical resources, human resources, or intellectual resources.
7. Key Partnerships, are partnerships built by organizations to run their business. These key partnerships can help organizations improve efficiency, effectiveness, or innovation.
8. Cost Structures, is the cost structure that must be incurred or budgeted.
9. Revenue stream, is the organization's source of income. An organization needs to have more than one source of income to reduce risk.
10.

Archimate

Based on the definition from TOGAF(The Open Group, 2022), ArchiMate®(The Open Group, 2020) is an architectural modeling language used to describe, document, and communicate about enterprise architecture. ArchiMate® provides a comprehensive framework for describing various aspects of enterprise architecture, including business processes, information systems, and technology infrastructure.

RESULTS AND DISCUSSION

Results of Secondary Data Collection and Analysis

The results of observations and analysis carried out on one of the construction management software, namely Procore® (Collin, 2020), a mobile apps and web-based construction management software originating from the United States, show the relationship between users and principals in providing features that support the construction management process flow and how the principal build architecture to support construction management software services to users.

Business Architecture

The business architecture for construction management software is depicted using a business model canvas as follows in Figure 3.

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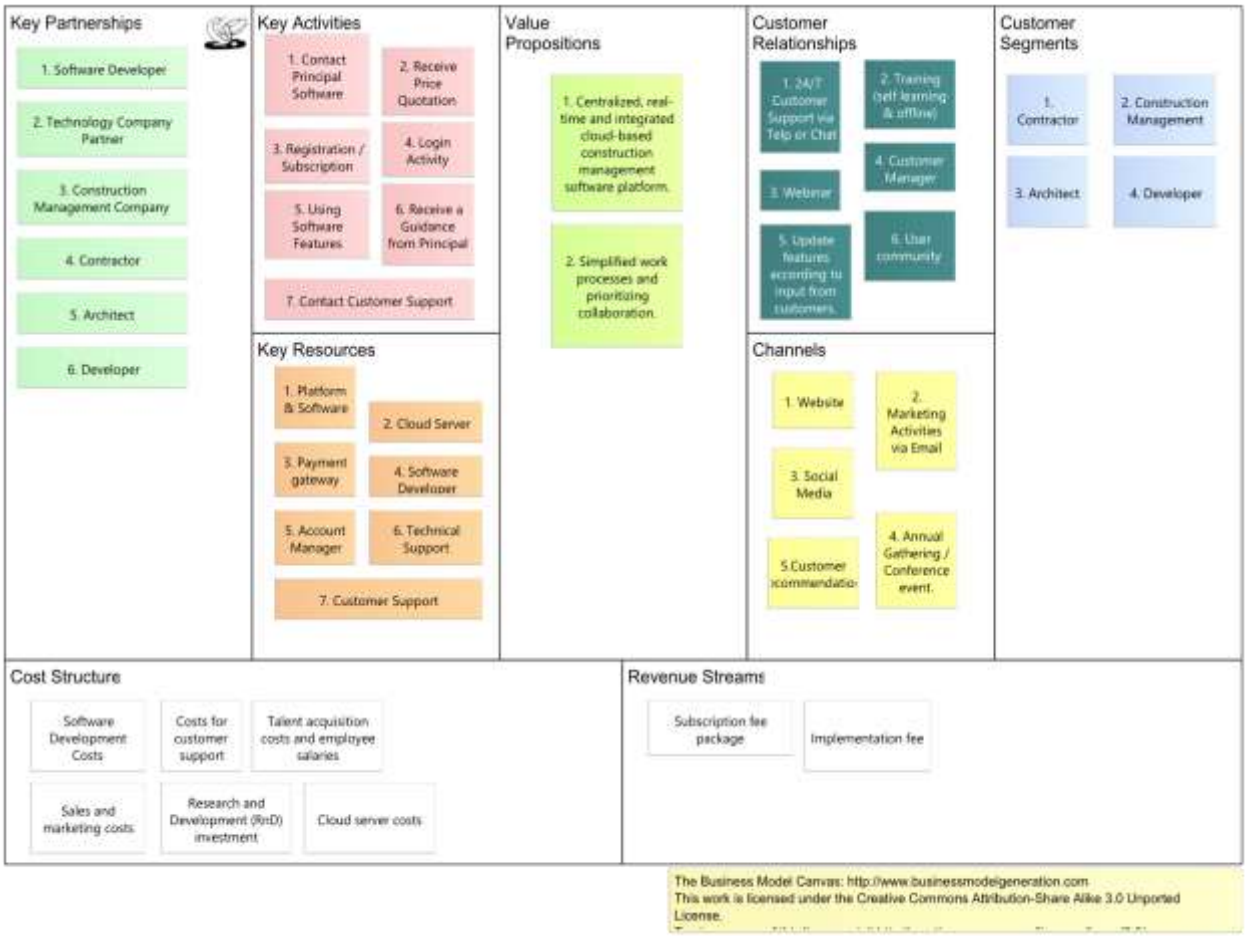

Fig. 3 Business Model Canvas Construction Management Software
Source: researcher property

1. Value Propositions of construction management software are as a centralized, real-time, and integrated web and cloud-based construction management software platform.
2. Customer Segments for construction management software are Contractors, Construction Management, Architects, and Developers.
3. Customer Relationships for construction management software, are customer support via telephone or chat 24 (twenty four) hours 7 (seven) days a week, training either offline or independently through special training pages, webinars, customer managers who specifically handle customer requests or complaints in certain areas, feature updates regularly periodically according to customer needs or input, and customer or user communities as a place to share and exchange information.
4. Channels for construction management software are websites, marketing via email, social media, annual gatherings or conferences, and recommendations from old customers.
5. Key Activities for construction management software are, prospective customers contacting the software principal, receiving a price offer, registering, logging in, using features, getting instructions or directions from the principal, and contacting customer support.
6. Key Resources for construction management software, are platforms and software, cloud servers, payment gateways, software developers, account managers, technical support, and customer support.

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7. Key Partnerships, for construction management software, are software developers from 3rd parties, technology company partners, construction management companies, contractors, architects, and developers.
8. Cost Structures of construction management software, are software development costs, customer support costs, talent acquisition costs and employee salaries, sales and marketing costs, research and development investments, and cloud server costs.
9. Revenue Streams for construction management software, are subscription packages that are adjusted to the volume of construction work from customers and implementation costs.
10.

Application Architecture

The application architecture in construction management software is divided into 5 (five) components, starting from applications for management, suppliers/partners, core processes, back office, and customers, as seen in Figure 4.

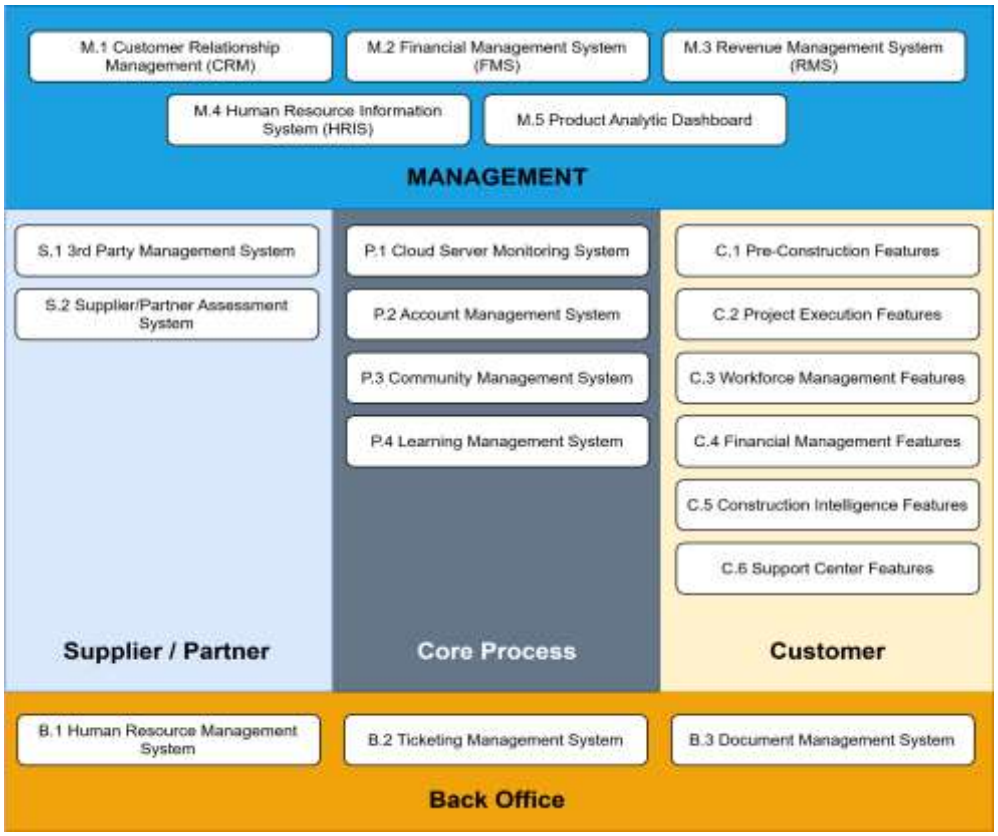

Fig. 4 Application Architecture
Source: researcher property

1. Management Application

   Is an application needed by the principal management of construction management software in carrying out activities within the organization, including those related to customers, namely:

   a. M.1 Customer Relationship Management (CRM), is an application that organizations use to manage customer data, track customer interactions, and improve relationships with customers.
   b. M.2 Financial Management System (FMS), is an application used by organizations to manage company financial activities, such as cash flow management, accounting, budgeting, taxes, and financial risk.

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c. M.3 Revenue Management System (RMS), is an application used to manage revenue and help companies maximize revenue by using data and analytics to predict demand, adjust prices, and manage availability.
d. M.4 Human Resource Information System (HRIS), is an application that stores and manages company partner data, such as contact information, work history, and performance assessed from regular assessments.
e. M.5 Product Analytic Dashboard, is an application used to collect, analyze, and display data about how users interact with products or features. From this dashboard, organizations will understand how products or features are used, identify areas that need improvement, and make better decisions about product development.

2. Supplier/Partner Application

Is an application used by organizations to monitor and make assessments of suppliers or partners. The application is in the form of:

a. S.1 3rd Party Management System, is an application used to manage organizational relationships with third parties, such as vendors, suppliers, and business partners. The features in this application are contract management, order management, payment management, and SLA management.
b. S.2 Supplier/Partner Assessment System, is an application that helps organizations to manage various aspects of relationships with third parties, such as due diligence, onboarding, performance management, and risk management.

3. Core Process Application

It is an application that is the core of the entire process in construction management software. These applications are:

a. P.1 Cloud Server Monitoring System, is an application used to monitor the performance and health of cloud servers so that they continue to run smoothly and meet SLA (Service Level Agreement) requirements.
b. P.2 Account Management System, is an application that organizations use to manage customer accounts.
c. P.3 Community Management System, is an application used by organizations to manage online communities, including management of content, users, activities, and analytics.
d. P.4 Learning Management System, is an application provided by an organization for customer needs in terms of online learning. The features of this application are content management, user management, activity management, and data analysis.

4. Back Office Application

Is an application that supports activities or process activities in construction management software, namely:

a. B.1 Human Resource Management System, is an application that covers all aspects of human resource management in the organization. These include human resource planning, recruitment, selection, training and development, compensation and benefits, performance, and employee relations.
b. B.2 Ticketing Management System, is an application used by organizations to manage customer requests, such as questions, complaints or problems faced with construction management software. The features in this application include ticket creation, ticket assignment, ticket tracking, ticket response, and data analysis.
c. B.3 Document Management System, is an application used by organizations to manage digital documents, such as: storing, organizing, and tracking digital documents.

5. Customer Application

Is an application needed by customers to manage their construction management process activities by utilizing all the features of construction management software. These applications are:

a. C.1 Pre-Construction Features, is an application used by users to manage designs, cost estimates, tenders, and budgets in construction management.

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b. C.2 Project Execution Features, is an application used by users to manage project activities, budget use, quality and safety, design reviews, etc. during the project.
c. C.3 Workforce Management Features, is an application used by users to manage human resources in construction projects and monitor their productivity in real time.
d. C.4 Financial Management Features, is an application used by users to manage financial activities on construction projects, including monitoring cost usage, billing management, and analytical data.
e. C.5 Construction Intelligence Features, is an application that users need to view project conditions in the form of reports and visual dashboards.
f. C.6 Support Center Features, is an application that users use to view documentation on how to use features and onboarding for new users.

Information Architecture

Information architecture for construction management software is made in 5 large parts as seen in Figure 5, namely: Management, Supplier / Partners, Support, Core Process, and Customer.

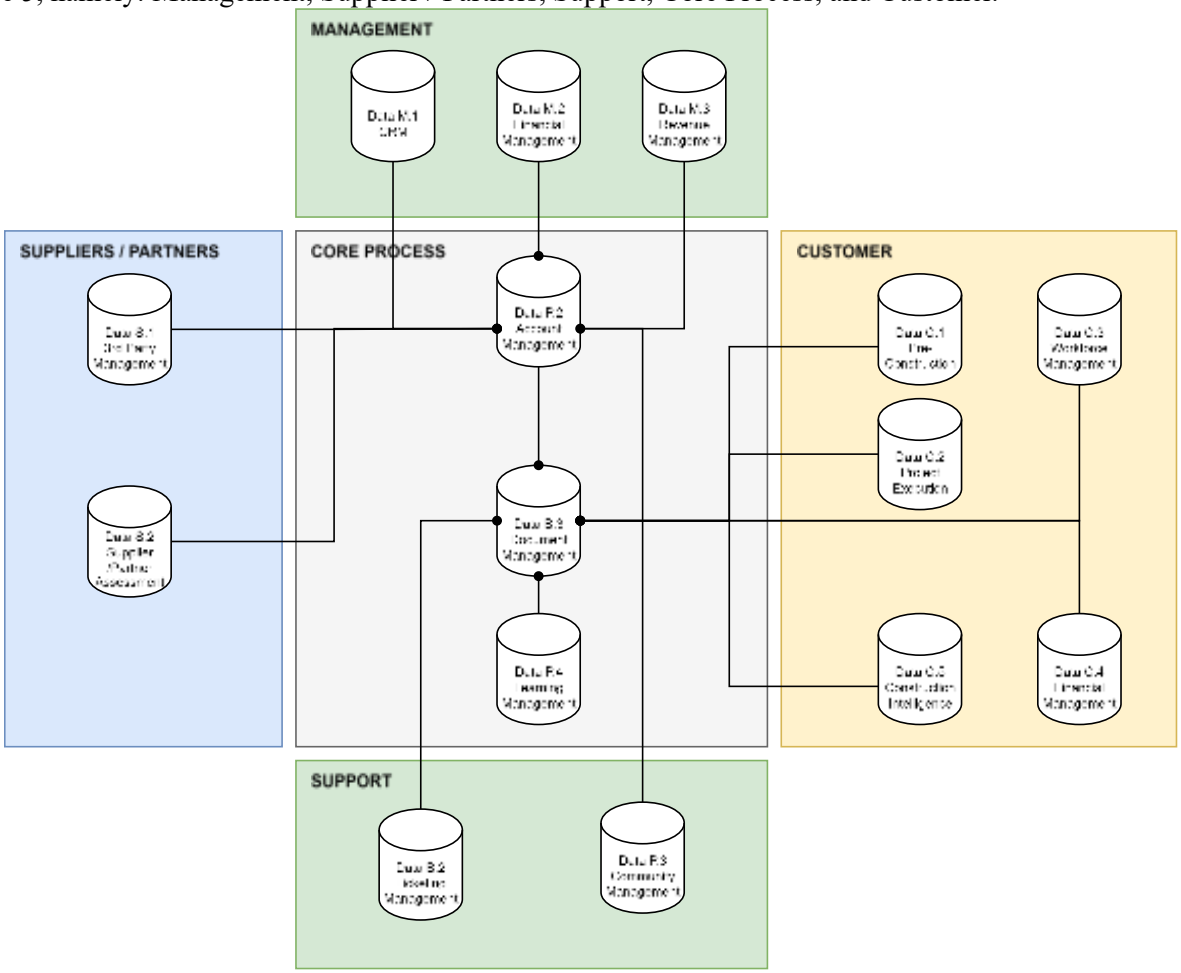

Fig. 5 Construction Management Software Information Architecture
Source: researcher property

1. Management

In this section, there are three databases required by management, namely: CRM data related to customer data, Financial Management related to billing, and Revenue Management related to revenue receipts from customers.

2. Suppliers/Partners

In this section, there are two databases accommodate data related to 3rd party management and supplier/partner assessment.

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3. Support

   In this section, two databases support the core process, namely: Ticketing Management and Community Management.

4. Core Process

   As a core part, of this section there are 3 databases, namely: Account Management which contains user or customer account data as well as supplier/partner databases, Document Management, and Learning Management.

5. Customer

   In the customer section, five databases represent each application module, namely: Pre-Construction which contains bid data, pictures, and photos of project locations, Project Execution which contains ongoing project data such as project progress, budget, and quality and safety, Workforce Management which contains data human resources and productivity, Financial Management which contains purchase order data, absorption of budgets and bills from sub-contractors, and finally Construction Intelligence which contains report data and project analysis.

Technology Architecture

Based on business architecture which is then reduced to application architecture and information architecture, the next step is designing a technology architecture that considers current and future needs. As seen in Figure 6, there are three servers needed to serve application and database needs in construction management software. The type of server used is a cloud server, one of the service providers is AWS® (Amazon Web Service) which they are one of the greatest cloud service providers worldwide. They offer a wide range of services and well-managed securities (Singh, 2021). These three cloud servers will serve fourteen applications and fourteen databases, which are grouped as follows:

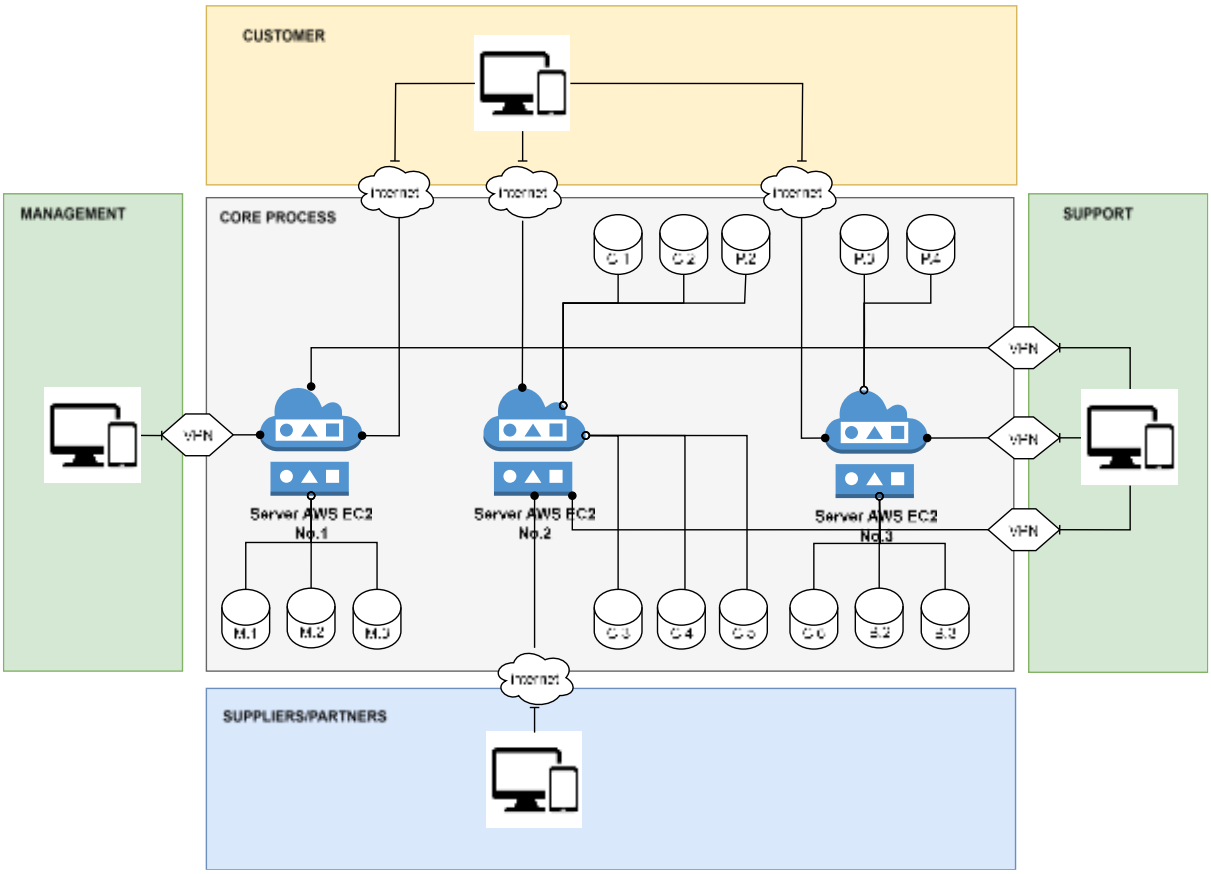

Fig. 6 Construction Management Software Technology Architecture
Source: researcher property

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1. AWS EC2 Server No.1, this server is tasked with serving application needs in the customer relationship management, financial management, and revenue management sections.
2. AWS EC2 Server No.2, this server is tasked with serving application needs in the account management section, and the features that will be used by users are pre-construction, workforce management, financial management, and construction intelligence.
3. AWS EC3 Server No.3, this server is tasked with serving application needs in the training services section, namely: document management, community management, and learning management. Apart from that, there is also a support center section which consists of ticketing management and a support center.

For management and support areas, connect to AWS EC3 No.1 and AWS EC3 No.3 servers via VPN. Meanwhile, in the supplier/partners and customer areas, the connection to AWS EC3 server no.2 is via the Internet.

Opportunities and Solutions

Following the author's prior discussion of the four aspects, an Enterprise Architecture Business Model was produced using ArchiMate® modelling, ranging from Business Architecture, Application Architecture, and Information Architecture to Technology Architecture, as seen in Figure 7.

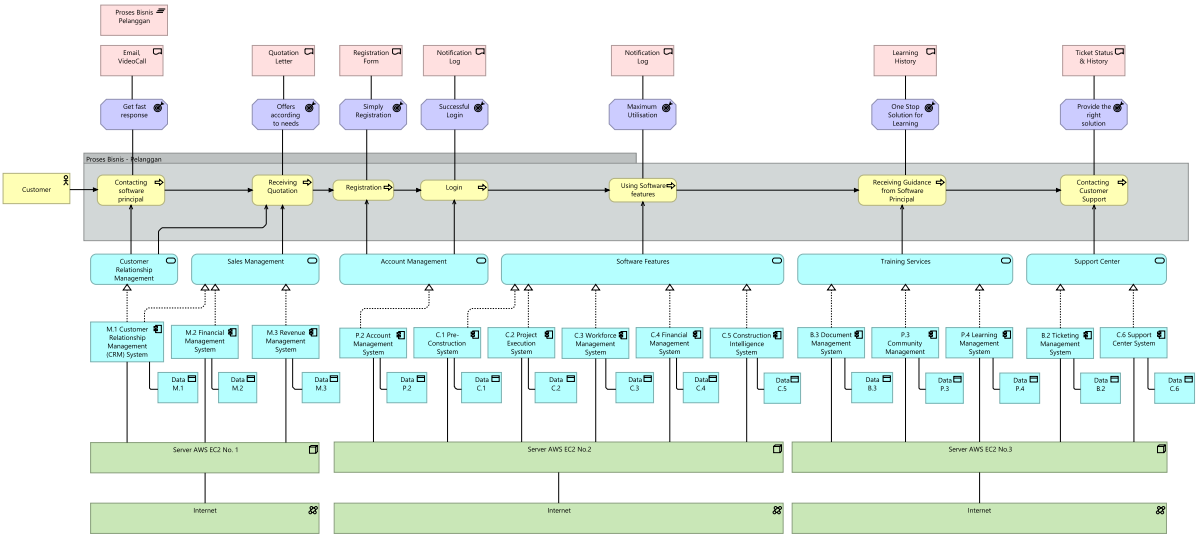

Fig. 7 ArchiMate® Enterprise Architecture Business Model
Source: researcher property

Briefly, the model above shows the customer's journey from starting to use the software to support from the principal, what output is expected from each service, and the mapping of features and servers used for construction management software needs. A model like this is proposed as an innovative idea that has not existed in previous studies or research. However, it is possible to carry out more in-depth research in the future for business processes that are appropriate to the project conditions.

CONCLUSION

Designing an enterprise architecture in construction management software is crucial for meeting the business needs of a construction organization. It involves stakeholders from various departments, including planning, design, construction, and operations and maintenance. The software should support all important business processes, integrate with other information systems for data sharing, and be safe and reliable to protect data and ensure smooth operation. This process should involve stakeholders from various departments in the organization. The proposed enterprise architecture is an innovative idea based on existing knowledge and references, making it flexible and

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adaptable to new technologies and business processes. The use of ArchiMate® diagram as a business model tool could make construction software management in Indonesia more efficient, contributing to the 4.0 revolution and smart construction solutions, especially in the construction industry.

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