

Title: - AI-Driven Software Architecture Decision System

Research Proposal (CI7000 Project Dissertation)

Kingston University

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AI-Driven Software Architecture Decision System:

Recommending Scalable Architectures & Design Patterns for Modern Web Applications

1. Introduction

In today's fast-evolving digital landscape, the need for building scalable, maintainable, and performance-driven web applications has become paramount. Every application whether a simple blog or a large-scale enterprise platform requires a foundational architectural design that aligns with its specific business and technical needs. However, selecting the right software architecture and design pattern remains a challenging task for many developers, especially those working without direct architectural expertise.

The project aims to address this challenge by creating an AI-powered, web-based decision support system that helps developers and technical teams determine the most suitable software architecture and relevant design patterns for their projects. The platform will guide users through a structured questionnaire to gather project-specific details such as scalability goals, user base, performance requirements, and security constraints and then provide recommendations based on rule-based AI logic derived from well-established software engineering practices.

This system will not only serve as a recommendation tool but will also function as an educational platform, offering explanations for the suggested architectural styles, design pattern examples, and real-world case studies from industry leaders like Amazon, Netflix, and Twitter. Unlike static blogs or theoretical documentation, this interactive tool aims to offer contextual, actionable insights that adapt to varying user needs and project types.

By bridging the gap between theory and practical application, this project offers an innovative solution to a widely faced problem equipping developers with intelligent, accessible, and explainable architectural guidance from the outset of the software development process.

1.1 Motivation

Software development today is no longer about just writing code it is about building scalable, secure, and efficient systems that can withstand changing user demands, technological advancements, and growing business needs. In such a dynamic environment, software architecture plays a pivotal role in defining the system's success or failure.

Incorrect architecture decisions can lead to project failures, increased technical debt, scalability bottlenecks, and high maintenance costs. According to a report by IBM (2019), poor architectural decisions can increase software development and maintenance costs by up to 50% in large systems.

Moreover, with the increasing adoption of Cloud Computing, Distributed Systems, and API-driven architectures the complexity of selecting an appropriate architecture has grown significantly.

Modern developers, especially those working in startups, small teams, or freelance projects, often face difficulty in making architectural decisions due to lack of guidance, experience, or access to expert architects.

This motivates the need for an intelligent, automated system that can guide developers in selecting the right software architecture for their projects.

1.2 Background

Software architecture can be defined as the fundamental organization of a software system, represented through its components, relationships among components, and the principles guiding its design and evolution (Bass et al., 2012).

Traditionally, architecture decisions are made by experienced software architects after in-depth analysis of project requirements, budget, user expectations, and technical constraints.

However, in real-world scenarios, especially in small teams or startups — such expert guidance is often missing. Developers rely on blogs, YouTube tutorials, or generalized design principles without considering project-specific needs.

For instance:

- A simple blog website with few visitors does not require a complex Microservices Architecture.
- A high-traffic e-commerce platform may suffer heavily if built using a Monolithic approach.

1.3 Real-world Case Studies & Failures

There are many real-world examples that show the importance of correct architecture selection:

Twitter's Monolithic Problem:

Twitter initially operated with a monolithic architecture built on Ruby on Rails. As their user base expanded, performance bottlenecks and scalability issues started impacting their service reliability. They eventually migrated to a Microservices Architecture to improve scalability and fault isolation.

(Source: Twitter Engineering Blog)

Amazon's SOA Success:

Amazon moved from a monolithic architecture to a Service-Oriented Architecture (SOA) early in its evolution, enabling independent services to handle specific business functions. This helped Amazon scale its infrastructure globally.

1.4 Importance of AI in Architecture Decisions

Artificial Intelligence (AI) is already transforming many areas of software engineering including code generation, automated testing, project management tools, and more.

AI-powered recommendation systems are commonly used in platforms like:

- Amazon (Product Recommendations)
- Netflix (Movie Suggestions)
- Spotify (Personalized Playlists)

However, the application of AI in the domain of Software Architecture Decision Support remains underutilized.

An AI-based system that can analyse project-specific needs and provide architecture recommendations can greatly assist developers especially beginners in making informed decisions.

1.5 Problem Statement

Despite the availability of best practices, architecture pattern catalogues, and research frameworks like ATAM or SAAM there is a gap in real-world tools that:

- Ask project-specific questions.
- Analyse user input.
- Map it to the most suitable architecture and design patterns.
- Provide detailed reasoning and case studies.

This research aims to address this gap by developing an AI-driven Software Architecture Decision Support System.

1.6 Significance of the Study

The outcome of this research is highly significant both academically and practically.

Academic Significance:

- Bridging research frameworks and practical system development.
- Applying AI techniques in a domain lacking automation (architecture selection).

Industry Significance:

- Assisting junior developers, startups, and small businesses in adopting scalable design practices from the start.
- Reducing technical debt and improving project sustainability.

1.7 Architecture Types Comparison Table

Architecture Type	Advantages	Disadvantages	Real-life Usage
Monolithic	Simple Deployment, Easy to Develop	Poor Scalability, Hard to Maintain	Legacy Systems, Small Apps
Microservices	Scalability, Fault Isolation	Complex DevOps, Network Overhead	Netflix, Uber, Amazon
Serverless	No Server Management, Cost-Effective	Limited Control, Cold Start Issues	AWS Lambda Apps
SOA	Loose Coupling, Service Reusability	High Initial Setup Cost	Amazon, Enterprise Systems

Table 1 Architectural Types Comparison

2. Aims and Objectives

Aim:

The primary aim of this research project is to develop an AI-driven Software Architecture Decision Support System that assists developers and businesses in selecting the most appropriate software architecture and relevant design patterns based on their specific project requirements. The system will not only generate architecture recommendations but also provide detailed explanations, justifications, and real-world case studies to support informed decision-making.

Objectives:

To achieve the above aim, the following objectives are defined for the project:

Objective 1:

To conduct a detailed analysis of the factors influencing software architecture selection, including scalability requirements, security concerns, system complexity, expected user traffic, performance expectations, and future maintenance needs.

This objective will ensure a thorough understanding of the core parameters that directly impact architecture decisions in modern web application development.

Objective 2:

To design and develop an interactive, user-friendly web application using React.js for the frontend and Node.js with Express.js for the backend to facilitate user engagement and data collection.

The web platform will allow users to enter their project requirements in a structured and guided manner through an AI-powered questionnaire interface.

Objective 3:

To implement rule-based AI logic for generating architecture recommendations by processing user input parameters and mapping them to suitable software architecture styles and design patterns.

The AI module will analyse project data and suggest architectures like Monolithic, Microservices, Serverless, SOA, along with relevant design patterns like Singleton, Factory, Observer, etc.

Objective 4:

To provide educational content within the platform, including architecture diagrams, design pattern explanations, real-world company case studies (e.g., Netflix, Amazon, Uber), and best practices for architecture design.

This objective focuses on building a learning hub within the application to promote knowledge sharing and skill development.

Objective 5:

To evaluate the performance, usability, and effectiveness of the developed system through testing and performance analysis.

This will involve testing the system with hypothetical project scenarios, collecting feedback from potential users, and refining the system based on evaluation metrics.

3. Initial Literature Review

3.1 Introduction

This section explores the foundational literature that informs the development of an AI-driven software architecture recommendation system. It critically reviews key works on software architecture principles, architectural styles, design patterns, and decision-making frameworks. It also examines how artificial intelligence, particularly rule-based and recommendation systems, has been applied in similar domains. While existing methods offer theoretical frameworks and industry practices for making architectural decisions, they are often too complex, manually intensive, or generalized to be effective for small teams or individual developers. This literature review aims to highlight those gaps and establish the need for an intelligent, user-friendly, and context-aware platform like this project, which combines architectural best practices with AI-driven logic in an interactive and accessible format.

3.2 Importance of Software Architecture

Software architecture is considered the blueprint of a software system. It provides guidelines for the system's structural organization, component interactions, data flows, and deployment strategies (Bass et al., 2012).

Good architecture ensures:

- Scalability
- Maintainability
- Reliability
- Performance
- Security

On the other hand, poor architectural choices lead to technical debt, frequent failures, and increased development costs.

Clements et al. (2010) emphasize that a well-documented architecture not only guides developers but also helps in future system evolution and maintenance.

3.3 Architecture Styles & Patterns in Practice

Modern software systems employ various architectural styles, each suited for specific scenarios:

Common Architecture Styles:

- Monolithic Architecture
- Microservices Architecture
- Service-Oriented Architecture (SOA)
- Serverless Architecture
- Layered Architecture
- Event-Driven Architecture

Each style comes with its advantages, limitations, and real-world applicability.

3.4 Real-world Adoption Examples:

Company	Architecture Type	Reason for Adoption
Netflix	Microservices	Handle massive user traffic, improve scalability
Amazon	SOA / Microservices	Decoupled services for independent deployment
Uber	Event-Driven + Microservices	Real-time tracking, fault isolation
Twitter	Migrated from Monolithic to Microservices	Overcome performance bottlenecks

Table 2 Real-world Adoption Examples

These industry examples demonstrate that architecture is not "one-size-fits-all" — it depends on project-specific requirements.

3.5 Role of Design Patterns

Design Patterns, popularized by Gamma et al. (1994), offer reusable solutions to recurring design problems. Patterns like:

- Singleton
- Factory
- Observer
- Decorator
- MVC (Model-View-Controller)

help developers create systems that are more flexible, maintainable, and scalable.

3.6 Architecture Evaluation Frameworks

Several frameworks have been proposed to assist in architecture evaluation:

Framework	Key Feature	Limitation
ATAM (Architecture Trade-off Analysis Method)	Structured architecture evaluation process	Complex, time-consuming
SAAM (Software Architecture Analysis Method)	Scenarios-based analysis	Limited automation
CBAM (Cost Benefit Analysis Method)	Focus on economic factors	Suitable for large enterprises only

Table 3 Architecture Evaluation Frameworks

While these frameworks are academically robust, their practical adoption is low among small teams and startups due to their complexity and manual nature.

3.7 AI in Decision Support Systems

AI-based decision support systems (DSS) have seen rapid growth in domains like:

- Product Recommendation (Amazon)
- Movie Recommendation (Netflix)
- Music Recommendation (Spotify)

Jannach et al. (2021) highlight that AI-driven recommender systems use a combination of rule-based systems, machine learning, and user profiling to generate suggestions.

However, in the field of Software Architecture the use of AI for automated recommendation and guidance is still under-researched and underdeveloped.

3.8 Gap Identification

Based on the literature reviewed, the following research gaps are identified:

1. Lack of Practical Tools:

Most architecture evaluation frameworks are theoretical and designed for large organizations.

2. Absence of AI-Driven Recommendation Systems:

There is a lack of intelligent systems that can collect project requirements, analyse them, and provide architecture recommendations dynamically.

3. Insufficient Educational Platforms:

New developers or startups often struggle with architecture choices due to the absence of structured learning platforms that offer real-world examples, design patterns, and decision justifications.

3.9 Justification for Proposed Research

This research aims to fill these gaps by developing this product — a web-based platform that will:

- Provide an AI-powered architecture recommendation engine.
- Offer educational content about different architecture styles and design patterns.
- Present real-world case studies from industry leaders.
- Serve both as a decision-support tool and a learning platform.

3.10 Summary of Findings

Finding	Implication for Research
Architecture decisions are critical for project success	There is a need for guided architecture selection tools
AI-based recommender systems are proven in other domains	Their application in software architecture remains unexplored
Existing frameworks are manual and complex	Automation and simplification are required for small teams/startups

4. Ethics Relevance & Progress

4.1 Ethical Relevance in Software Architecture Decision Systems

Ethical considerations are an integral part of any research or system development process, especially when dealing with AI-driven tools and user-interactive platforms. While this project does not involve sensitive personal data or human participants, the ethical responsibility of creating transparent, secure, and responsible software solutions remains crucial.

This project, being a decision-support system, has certain ethical expectations to meet particularly in areas of data privacy, transparency of recommendations, and user trust.

As highlighted by Floridi et al. (2018), AI systems should operate on principles of fairness, explainability, privacy, and accountability all of which are highly relevant for this project.

4.2 Ethical Considerations Addressed in This Project

1. Data Privacy & Confidentiality:

- The system will not collect any sensitive personal data except user email and contact information.
- Project-related inputs (like system type, expected traffic, scalability needs) will be entered voluntarily by the user.
- No user-identifiable information will be stored.

2. Transparency of AI Recommendations:

- The recommendation engine will clearly display the reasons behind suggesting a particular architecture or design pattern.
- Factors considered (scalability, performance, security) will be explained within the system interface.
- This ensures users understand that the system provides guidance not absolute decisions.

3. No Algorithmic Bias:

- AI recommendations will be based on universally accepted software architecture principles and research-backed design patterns.
- There will be no commercial bias or influence from third-party vendors.

4.3 Ethical Progress & Future Compliance

- The project complies with Kingston University's ethical guidelines.
- In the future, if the system evolves to store user data for personalized experiences compliance with GDPR (General Data Protection Regulation) and Data Protection Act 2018 (UK) will be ensured.

The platform will also include a disclaimer page informing users of the nature of data collected, its purpose, and the non-storage of sensitive information.

5. Technologies & Resources

5.1 Overview

The proposed system will be developed as a functional web-based application that uses a modern technology stack to ensure scalability, flexibility, and ease of development.

The technology choices reflect industry standards and practical relevance for building real-world decision-support systems.

Selection of tools and technologies is based on the following factors:

- Open-source availability
- Community support
- Scalability and performance
- Ease of learning and development
- Industry-wide adoption

5.2 Frontend Technologies

Chosen Technology: React.js with Tailwind CSS

React.js is a widely used JavaScript library for building dynamic and responsive user interfaces. It provides a component-based architecture that enables reusability and better management of large-scale projects.

Relevance in Industry:

- Used by global tech companies like Facebook, Instagram, Airbnb.
- Over 10 million developers actively use React (State of JS Survey, 2023).
- Excellent support for Single Page Applications (SPA) and component-driven design.

Alternatives Considered:

- Angular: Rich framework but comes with a steeper learning curve.
- Vue.js: Lightweight but limited industry dominance compared to React.js.

Final Choice Justification:

React.js is chosen due to its flexibility, faster learning curve, large community, and easier integration with backend APIs.

5.3 Backend Technologies

Chosen Technology: Node.js with Express.js

Node.js is a JavaScript runtime that enables server-side programming, while Express.js provides a minimal and fast web framework for building APIs.

Relevance:

- Non-blocking I/O model ideal for handling multiple API requests.
- Unified technology stack (JavaScript across frontend & backend).
- Industry usage in platforms like Netflix, PayPal, LinkedIn.

Alternatives Considered:

- Django (Python): Excellent framework but would break the unified JavaScript stack.
- Spring Boot (Java): Enterprise-level heavy framework not required for a lightweight decision-support tool.

5.4 Database

Chosen Technology: MongoDB

MongoDB is a NoSQL document-oriented database that stores data in JSON-like format, making it highly flexible for projects with varying data structures.

Relevance:

- Highly scalable and cloud friendly.
- Easy to integrate with Node.js using Mongoose ORM.
- Used by companies like Uber, eBay, and Forbes.

Alternatives Considered:

- MySQL: Suitable for structured data but less flexible for this project's dynamic storage needs.
- Firebase: Good for real-time data but vendor lock-in with specific pricing models.

5.5 AI Logic Implementation

Approach: Rule-Based Expert System

Given the project's timeframe and complexity constraints, the initial version of AI logic will follow a Rule-Based Expert System approach. This involves creating a knowledge base of architecture styles, decision rules, and mapping criteria.

AI Technology Selection:

The core AI approach will be based on a **Rule-Based Expert System**.

This method is chosen because the architecture recommendation process relies heavily on **known**

best practices, architectural principles, and standardized decision rules, rather than large datasets or dynamic user behaviour learning (which would require Machine Learning).

Working of the Rule-Based System:

- The system will collect structured input from users (e.g., project type, scalability requirements, traffic expectations, security needs).
- These inputs will be matched against a knowledge base of pre-defined architecture decision rules.
- Based on the conditions met, the AI engine will recommend the most suitable architecture and relevant design patterns.
- Justifications for each recommendation will be provided based on well-documented architecture strategies.

Example of Rule Mapping:

- IF expected user traffic is high AND scalability is required → Recommend Microservices Architecture.
- IF project is simple, limited user base, budget constraints → Recommend Monolithic Architecture.

Future Scope:

The system will be designed to accommodate Machine Learning-based decision-making in future iterations.

5.6 Hosting & Deployment

Frontend Hosting: Vercel

- Automatic CI/CD pipeline.
- Optimized for React.js applications.

Backend Hosting: Render / Heroku

- Scalable deployment of Node.js backend services.
- Database hosting through MongoDB Atlas.

5.7 Version Control & Development Tools

Tools Used:

- Git & GitHub for version control and collaboration.
- Visual Studio Code (VS Code) as the primary development IDE.
- Postman for API testing.

- Figma for UI/UX wireframing and prototyping.

5.8 Resource Management Strategy

To ensure code quality and avoid integration conflicts, the project will follow:

- Modular Backend Design - Each feature (Homepage, Learning Hub, Recommendation Engine) will have its separate backend route and logic files.
- Branching Strategy on GitHub - Feature-specific branches merged into the main branch after successful testing.

5.9 Summary of Technologies & Alternatives

Component	Chosen Technology	Alternatives Considered	Final Reason for Selection
Frontend	React.js + Tailwind CSS	Angular, Vue.js	Industry standard, flexibility, component-driven design
Backend	Node.js + Express.js	Django, Spring Boot	Unified JavaScript stack, lightweight
Database	MongoDB	MySQL, Firebase	NoSQL flexibility, scalable
Hosting	Vercel (Frontend), Render (Backend)	Netlify, AWS	Easy deployment, free-tier availability
AI Logic	Rule-Based Expert System	ML-based Model (Future Scope)	Quick implementation within project constraints

Table 4 Summary of Technologies & Alternatives

6. Research Method & Work Plan

6.1 Research Methodology

This project follows a practical and structured research approach aligned with software engineering best practices.

Since the project involves system design, development, testing, and evaluation, a combination of:

- System-based Research
- Agile Development Methodology

Agile Justification:

Agile development methodology is selected for this project due to the dynamic and evolving nature of the system features. This project involves multiple interconnected modules (Questionnaire System, AI Logic Engine, Recommendation Output, Learning Hub), and Agile supports:

- **Incremental Development:** Each feature can be developed, tested, and refined in iterations (Sprints).
- **Continuous Feedback:** Agile allows flexibility to incorporate feedback from early system evaluations and user testing.
- **Risk Management:** Smaller sprints make it easier to identify and resolve issues early, avoiding last-minute surprises.
- **Flexibility:** As the system's scope might evolve (e.g., adding more architecture styles or design patterns), Agile ensures the project can adapt quickly without major rework.

Thus, Agile methodology aligns perfectly with the needs of this modular, feedback-driven system.

6.2 Requirement Gathering & Analysis

The initial phase involves defining functional and non-functional requirements.

Key Activities:

- Conducting research on architecture selection criteria.
- Identifying common project-specific factors like scalability needs, security concerns, user traffic, budget, and performance expectations.
- Designing the user input questionnaire that captures these parameters.
- Defining the knowledge base for the AI rule engine.

Deliverables:

- Requirement Specification Document
- Wireframes for User Interface (UI)

6.3 System Design

The system will follow a modular architecture to ensure that changes in one component do not affect others.

Key Modules:

- Homepage (Overview & Navigation)
- AI Questionnaire Module (User Input)
- AI Recommendation Engine (Rule-based Logic)

- Learning Hub (Educational Resources & Case Studies)
- Architecture Explorer (Optional)

Design Artifacts:

- System Architecture Diagram
- Database Schema Design
- Wireframes (Figma)

6.4 Implementation Plan

Development will follow feature-based sprints:

Sprint 1: Frontend Development

- Homepage
- Navigation
- Questionnaire UI

Sprint 2: Backend API Development

- API Setup with Node.js
- Questionnaire Response Handling
- AI Rule Engine Development

Sprint 3: Integration

- Connecting Frontend with Backend
- AI Recommendations Display Logic

Sprint 4: Learning Hub & Case Studies

- Dynamic Content Management
- Real-world Industry Examples

6.5 Testing Strategy

Quality Assurance is essential to ensure that the system functions as expected.

Testing Techniques:

Testing Type	Purpose
Unit Testing	Backend logic & API endpoint testing
Component Testing	Frontend UI/UX behaviour validation

Testing Type	Purpose
Integration Testing	Frontend & Backend communication check
Performance Testing	Load handling & API response time
Security Testing	Input validation, API protection
Usability Testing	User-friendly experience evaluation

6.6 Evaluation Strategy

Post-development, the system will be evaluated based on:

- Accuracy & relevance of architecture recommendations.
- User feedback on clarity, usability, and helpfulness of the platform.
- Performance metrics like API response time and system stability.

Tools Used:

- Postman for API Testing
- Browser DevTools for UI Testing
- Feedback Collection through Surveys or Direct Interaction

6.7 Work Plan Timeline












Task	May 2025	June & July 2025	August 2025
Requirement Gathering & System Design			
Frontend Development (React UI)			
Backend Development (Node APIs)			
AI Logic Implementation (Rule Engine)			
Integration (Frontend + Backend)			
Testing (Unit, Integration, Usability)			
Evaluation			
Final Report Preparation			

Table 5 Gantt Chart: Research Project Timeline

6.8 Risk Management

Potential Risks & Mitigation:

Risk	Mitigation Strategy
AI Rule Engine Complexity	Start with simple rule-based logic, scale later.
Time Constraints	Follow Agile methodology with strict sprint goals.
Deployment Issues	Use cloud-friendly platforms like Vercel & Render for seamless deployment.
User Feedback Integration Delay	Keep user testing planned in parallel with development sprints.
Scalability Limitations	Modular design ensures easy future upgrades.

Table 6 Potential Risks & Mitigation

6.9 Future Scope

While this project focuses on a rule-based expert system, future improvements can include:

- Machine Learning-based recommendation engine.
- User authentication & personalized architecture suggestions.
- Expansion into other software domains like DevOps patterns, Cloud Architecture, API Design.

7. Conclusion

This proposal presents the development of described project, an AI-driven tool aimed at guiding developers in selecting suitable software architectures and design patterns based on specific project needs. By combining rule-based AI logic with educational resources and real-world case studies, the system addresses the lack of practical, personalized architectural guidance in modern development workflows. The project bridges the gap between theory and practice, offering both a decision-support platform and a learning environment ultimately promoting better software design and reducing architectural errors.

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