Comprehensive Project Report: Personalized Study Planner on the Cloud

Course: Introduction to Cloud Computing (CS 4037) **Instructor:** Sir Muhammad Sudais
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Date: November 30, 2025

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1. Project Overview

The **Personalized Study Planner on the Cloud** is a modern, web-based application designed to enhance student productivity by providing a centralized platform for planning, organizing, and tracking academic schedules and resources. Developed as a demonstration of cloud computing principles, the application is entirely hosted on **Microsoft Azure**, leveraging its suite of services to ensure a scalable, secure, and resilient solution. The project serves as a practical case study in cloud architecture design, service integration, and the implementation of enterprise-grade security practices.

2. Project Objectives

The primary objectives of this project were to move beyond theoretical understanding and achieve practical implementation of a cloud-native application:

Objective	Description	Status
Technical Deployment	To design and deploy a full-stack web application using Azure App Service.	Achieved
Service Integration	To utilize and integrate a minimum of five core Azure services (Compute, Storage, Database, Security, Monitoring).	Achieved
Scalability & Resilience	To implement an architecture capable of supporting 100+ concurrent users with a target 99.95% uptime SLA.	Achieved
Security Implementation	To utilize Azure Active Directory (AAD) for secure authentication and implement secrets management via Azure Key Vault.	Achieved
CI/CD Proficiency	To gain practical experience in Continuous Integration/Continuous Deployment (CI/CD) pipelines using Azure DevOps (Future Work).	Planned

3. Project Requirements and Implementation

The project was guided by a set of functional and non-functional requirements, ensuring the application was both feature-rich and robust.

3.1 Functional Requirements

Requirement	Implementation Details	Azure Service Used
Application Hosting	Next.js application deployed as a managed Platform-as-a-Service (PaaS).	Azure App Service
User Authentication	Secure login and session management using enterprise-grade identity.	Azure Active Directory (AAD) via NextAuth.js
Schedule Management	Full CRUD (Create, Read, Update, Delete) functionality for personalized study schedules.	Azure Cosmos DB
Resource Upload	Ability to upload and associate study materials (PDFs, notes, images) with schedules.	Azure Blob Storage
API/Function App	Serverless function for time-triggered events, such as sending daily reminders.	Azure Functions
Secrets Management	Secure storage of sensitive configuration data (e.g., database connection strings).	Azure Key Vault

3.2 Non-Functional Requirements

Requirement	Target	Implementation Strategy
Performance	Handle 100+ concurrent users.	Optimized Next.js SSR/SSG and low-latency Azure Cosmos DB access.
Scalability	Auto-scale based on user load.	Configured auto-scaling rules on Azure App Service to dynamically adjust compute resources.
Availability	Target 99.95% uptime SLA.	Leveraged Azure’ s global infrastructure and App Service’ s high availability features.
Security	Encryption, identity management.	End-to-end encryption, AAD for SSO, and Key Vault for secrets management.
Cost Optimization	Efficient resource utilization.	Utilized PaaS services, auto-scaling to right-size resources, and cost-effective Blob Storage for static assets.

4. Azure Services Used and Architecture

The application is built on a **three-tiered, serverless-augmented architecture** designed for cloud efficiency and scalability.

4.1 Architecture Overview

The system is logically divided into three layers, with serverless components augmenting the application layer:

Layer	Components	Role
Presentation	Next.js (Frontend)	User interface and interaction.
Application	Next.js (API Routes), Azure Functions	Business logic, authentication, and scheduled tasks.
Data	Azure Cosmos DB, Azure Blob Storage	Persistence for structured data (schedules) and unstructured data (resources).

4.2 Core Azure Services

The project successfully integrated the following core Azure services:

- **Azure App Service (Compute):** Provides the fully managed PaaS environment for hosting the Next.js web application, handling deployment, scaling, and monitoring.
- **Azure Functions (Compute/Serverless):** Used for event-driven or time-triggered tasks, such as sending daily study reminders, demonstrating serverless computing.
- **Azure Cosmos DB (Database):** Selected over Azure SQL Database for its multi-model capabilities, global distribution, and low-latency access, ideal for the flexible data structure of user schedules.
- **Azure Blob Storage (Storage):** Utilized for cost-effective, massive-scale storage of student-uploaded study resources (PDFs, notes), with secure access managed via Shared Access Signatures (SAS).
- **Azure Active Directory (Security/Identity):** Integrated via NextAuth.js to provide secure, enterprise-grade Single Sign-On (SSO) authentication for users.

- **Azure Key Vault (Security/Secrets):** Ensures sensitive application secrets, such as database connection strings, are stored securely and not exposed in the source code.
- **Azure Monitor & Application Insights (Monitoring):** Provides real-time telemetry, logging, and performance monitoring for the application, crucial for maintaining the target SLA.

5. Technology Stack

The application utilizes a modern, high-performance technology stack:

- **Frontend Framework: Next.js 16** (React 19, TypeScript) for performance-optimized rendering and routing.
- **Styling: Tailwind CSS 4** for utility-first, rapid, and consistent styling.
- **Authentication: NextAuth.js** for secure and flexible integration with Azure AD.
- **Language: TypeScript** for strong typing, enhancing code quality and maintainability.
- **Database Client:** Dedicated **Cosmos DB Client** for data operations.

6. Key Learnings and Future Work

6.1 Key Learnings

The project provided invaluable hands-on experience in several critical areas of cloud computing:

1. **PaaS vs. IaaS:** Gaining a deep understanding of the benefits of PaaS (Azure App Service) for reduced operational overhead and built-in scaling capabilities.
2. **NoSQL Data Modeling:** Implementing a flexible data model in Azure Cosmos DB, contrasting with traditional relational database approaches.
3. **Identity Management:** Successfully integrating Azure AD for secure authentication, a cornerstone of enterprise cloud applications.
4. **Secrets Management:** Enforcing security best practices by using Azure Key Vault to manage application secrets, preventing hardcoding in the repository.

6.2 Future Work

The following enhancements are planned to further mature the application:

1. **Azure API Management:** Implement API Management to secure, govern, and monitor the backend API endpoints, enabling features like rate limiting and advanced security policies.
2. **Azure DevOps CI/CD:** Establish a complete Continuous Integration/Continuous Deployment pipeline using Azure DevOps to automate testing, building, and deployment workflows, improving development velocity and reliability.
3. **Infrastructure as Code (IaC):** Implement IaC using Terraform or ARM templates to manage and provision all Azure resources, ensuring reproducible and version-controlled infrastructure.
4. **Advanced Features:** Integrate Azure Machine Learning for intelligent study recommendations and predictive analytics based on user study patterns.

References

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