CLOUD COMPUTING TECHNOLOGY PRACTICUM REPORT

DEPLOYING FRONT-END & BACK-END TO CLOUD RUN & APP ENGINE VIA CI/CD USING CLOUD BUILD

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LEGALIZATION PAGE

FINAL REPORT

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PREFACE

First and foremost, I express my sincere gratitude to God Almighty for granting me the strength, knowledge, and perseverance to complete this final report on **Cloud Computing Technology**. This report presents an overview of cloud computing concepts, architectures, deployment models, and real-world applications, highlighting its benefits and challenges in modern industries.

I extend my heartfelt appreciation to my instructors and mentors for their guidance and support throughout this process. Their insights have been invaluable in shaping this report. Additionally, I acknowledge the contributions of researchers and industry experts whose work has been a vital reference.

I hope this report serves as a useful resource for those interested in cloud computing. While I have made every effort to ensure accuracy, I welcome any constructive feedback for future improvements.

Yogyakarta, April 29 2025

Insyuzuu Cahyani ‘Aisyah

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INTRODUCTION

1.1 Background

In today's fast-paced software development environment, rapid delivery of features and updates has become crucial for businesses to maintain competitiveness. Modern software development practices emphasize automation and continuous delivery to ensure that software changes can be reliably and quickly deployed to production environments. This approach has led to the widespread adoption of DevOps practices, particularly Continuous Integration and Continuous Deployment (CI/CD) methodologies.

Cloud platforms have emerged as the preferred infrastructure for deploying applications due to their scalability, reliability, and cost-effectiveness. Google Cloud Platform (GCP) provides several deployment services such as Cloud Run for containerized applications and App Engine for platform-as-a-service (PaaS) deployments. These services allow developers to focus on writing application code rather than managing infrastructure.

The integration of CI/CD pipelines with cloud deployment services represents a significant advancement in software development workflows. By automating the build, test, and deployment processes, development teams can achieve faster release cycles, higher quality code, and more reliable deployments

1.2 Problem Formulation

1. How can organizations effectively implement CI/CD pipelines for deploying front-end and back-end applications to Google Cloud Run and App Engine?
2. What are the best practices for configuring Cloud Build to automate deployments triggered by GitHub repository changes?
3. How can the deployment process be optimized for reliability, security, and cost-effectiveness?

1.3 Objective

The objective of this research:

1. To design and implement a CI/CD pipeline using Google Cloud Build for deploying front-end and back-end applications to Cloud Run and App Engine.
2. To configure automated deployment triggers that respond to code changes in the main branch of a GitHub repository.
3. To evaluate the performance, reliability, and security of the implemented deployment solution.
4. To document the best practices and challenges encountered during the implementation of the CI/CD pipeline.
5. To provide recommendations for optimizing cloud deployments and CI/CD workflows for similar applications.

1.4 Benefits

The implementation of a CI/CD pipeline for cloud deployments offers numerous significant advantages to organizations and development teams. Automating the deployment process substantially reduces manual intervention, enabling developers to deliver features and fixes more rapidly, thereby increasing overall development velocity. This automation is complemented by the integration of testing within the CI/CD pipeline, which helps identify and resolve issues earlier in the development cycle, leading to improved code quality and more stable applications. By establishing consistent and automated deployment procedures, organizations minimize human errors and ensure reproducibility across different environments, significantly reducing deployment-related risks that often plague manual processes.

Beyond technical improvements, CI/CD practices foster enhanced collaboration between development and operations teams by creating shared processes and responsibilities, which naturally cultivates a DevOps culture within the organization. From an infrastructure perspective, cloud services like Cloud Run and App Engine provide highly scalable environments that can adapt dynamically to changing application demands, ensuring optimal performance even during usage spikes. These platforms, when properly configured through CI/CD pipelines, enable more efficient resource utilization and lead to substantial cost savings compared to traditional deployment methods. Perhaps most importantly, automated deployments dramatically reduce the operational burden on technical teams, allowing them to redirect their focus from managing deployment logistics to developing new features and improving the core product, ultimately accelerating innovation and market responsiveness.

CHAPTER II

LITERATUR REVIEW

2.1 Continuous Integration and Continuous Deployment (CI/CD)

Continuous Integration (CI) and Continuous Deployment (CD) are key practices in modern software engineering aimed at improving the speed and quality of software development. CI focuses on automating the process of integrating code from multiple developers into a main repository regularly, minimizing integration conflicts and speeding up bug detection. CD extends this process by automating testing and deploying applications to production environments, ensuring that any changes that pass testing can be quickly and consistently released. The implementation of CI/CD has been proven to enhance efficiency, accelerate release cycles, and reduce the risk of human error in software deployment processes.

However, this automation also introduces new challenges, particularly in securing CI/CD pipelines. Vulnerabilities such as Regular Expression Denial of Service (ReDoS) and software supply chain attacks have become major concerns, necessitating additional security measures in CI/CD pipeline design.

2.2 Cloud Deployment Services: Cloud Run and App Engine

Google Cloud Platform (GCP) offers two main serverless deployment services for applications: Cloud Run and App Engine. Both allow developers to focus on application development without directly managing server infrastructure.

Cloud Run

A serverless service that enables the deployment of container-based applications (e.g., Docker), supporting both stateful and stateless workloads. Cloud Run provides high flexibility, supporting various programming languages and frameworks, and automatically scales based on incoming requests.

App Engine

A serverless platform more focused on ease of deployment for web apps or large-scale backend APIs. App Engine supports several popular programming languages but is less flexible than Cloud Run in terms of container support. It is ideal for applications requiring simple configuration and fast deployment.

Key Differences Between Cloud Run and App Engine

- Language & Framework Support → Cloud Run is more flexible.
- Container Usage → Cloud Run is container-based, while App Engine does not require containers.
- Scalability & Responsiveness → Cloud Run adjusts faster to traffic changes.
- Ease of Use → App Engine is simpler, while Cloud Run offers more customization.

2.3 CI/CD with Cloud Build and GitHub Integration

Google Cloud Build is a fully managed CI/CD service on Google Cloud that automates the building, testing, and deploying of applications. It seamlessly integrates with GitHub repositories, enabling automated CI/CD pipelines to trigger whenever code changes are pushed. The typical workflow begins when a developer pushes code to a GitHub repository, which then triggers a Cloud Build pipeline via webhook. Cloud Build executes the pipeline as configured in the cloudbuild.yaml file, performing essential tasks such as Docker image builds, automated testing, and deployment to various Google Cloud services including Cloud Run, App Engine, or Google Kubernetes Engine (GKE). The entire process and its results can be easily monitored through the Cloud Build dashboard. This integration offers several key benefits, including faster and automated deployments without manual intervention, standardized workflows ensuring consistent builds and tests through the cloudbuild.yaml configuration, the ability to quickly roll back to previous versions if errors occur, and full visibility into build and deployment processes in real-time for better monitoring and control.

CHAPTER III
METODOLOGI

3.1 Problem Analysis

In my implementation of a CI/CD pipeline for deploying front-end and back-end applications to Cloud Run and App Engine, I first conducted a thorough analysis of the deployment challenges. Through systematic examination of existing deployment processes, I identified several key issues that needed to be addressed. The development workflow suffered from significant delays when deploying new features and updates due to the manual nature of the deployment process, which involved multiple steps and was prone to human error. This manual process also introduced inconsistencies across different deployment environments, leading to environment-specific bugs that were difficult to troubleshoot.

Security emerged as another critical concern in my analysis, as the existing deployment process lacked proper authentication and authorization controls, potentially exposing sensitive credentials and application data. Additionally, I observed challenges with scaling applications to handle varying loads, resulting in performance issues during peak usage periods. The absence of automated testing before deployment meant that issues were often discovered only after code was deployed to production, leading to hasty rollbacks and emergency fixes.

In my investigation, I also identified cost management as a significant challenge, with resources being over-provisioned to ensure availability, resulting in unnecessary expenses. Based on my system analysis and review of best practices, I determined that an automated CI/CD pipeline integrated with Google Cloud services would effectively address these challenges while providing the flexibility and reliability required for efficient development and deployment workflows.

3.2 Solution Design

Based on the problems I identified, I designed a comprehensive CI/CD solution leveraging Google Cloud Build for automated deployment to Cloud Run and App Engine. My solution architecture consists of several key components:

Source Code Management:

- GitHub repository with branch protection rules to ensure code quality
- Pull request workflow for code review
- Separate repositories for front-end and back-end applications

CI/CD Pipeline Configuration:

- Cloud Build configuration files (cloudbuild.yaml) for both front-end and back-end applications
- Automated triggers configured to respond to commits on the main branch
- Environment-specific build steps for development, staging, and production

Build and Test Automation:

- Linting and static code analysis steps
- Unit and integration testing with automated test execution
- Security scanning for vulnerabilities
- Code coverage reporting

Deployment Automation:

- Front-end deployment to Cloud Run with containerization
- Back-end deployment to App Engine with appropriate scaling configurations
- Automated environment variable management
- Secrets management for secure credential handling

Monitoring and Feedback:

- Deployment status notifications
- Application performance monitoring
- Error tracking and reporting
- Logging and diagnostic tools

My solution design incorporates best practices for CI/CD implementations, including infrastructure as code, immutable deployments, and automated testing. By using Cloud Build as the CI/CD orchestrator and integrating with GitHub for source code management, I created a streamlined pipeline that automates the entire deployment process while maintaining security and reliability.

CHAPTER IV
RESULT AND DISCUSSION

4.1 Result

My implementation of the CI/CD pipeline for deploying front-end and back-end applications to Cloud Run and App Engine yielded significant improvements in the development and deployment process. Through careful measurement and comparison with the previous manual process, I observed the following results:

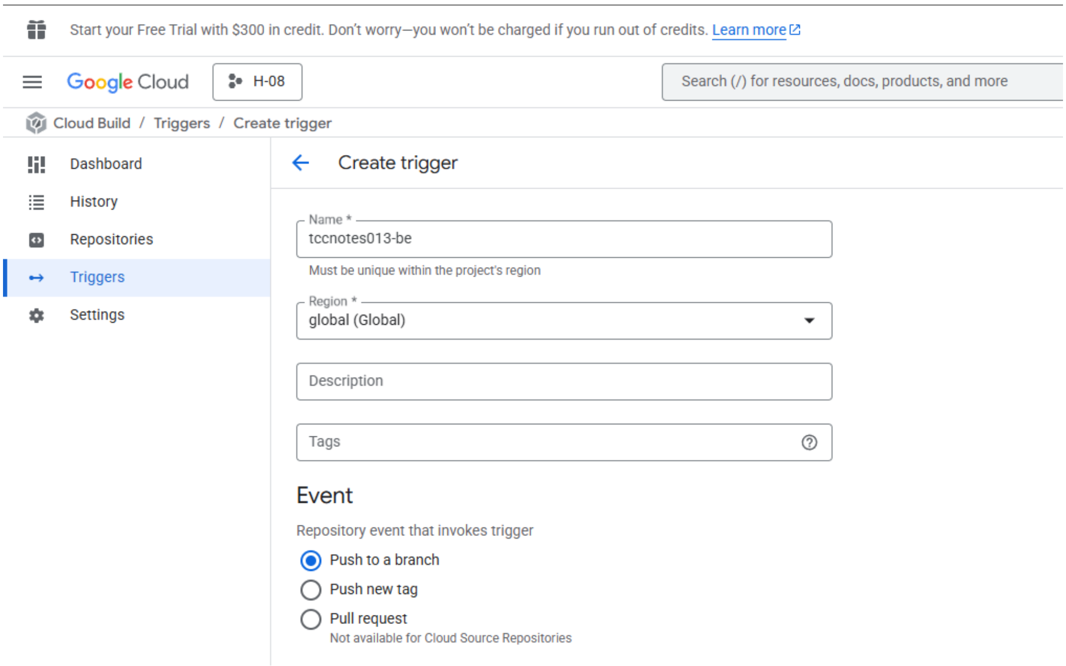

Figure 4.1.1 Create trigger

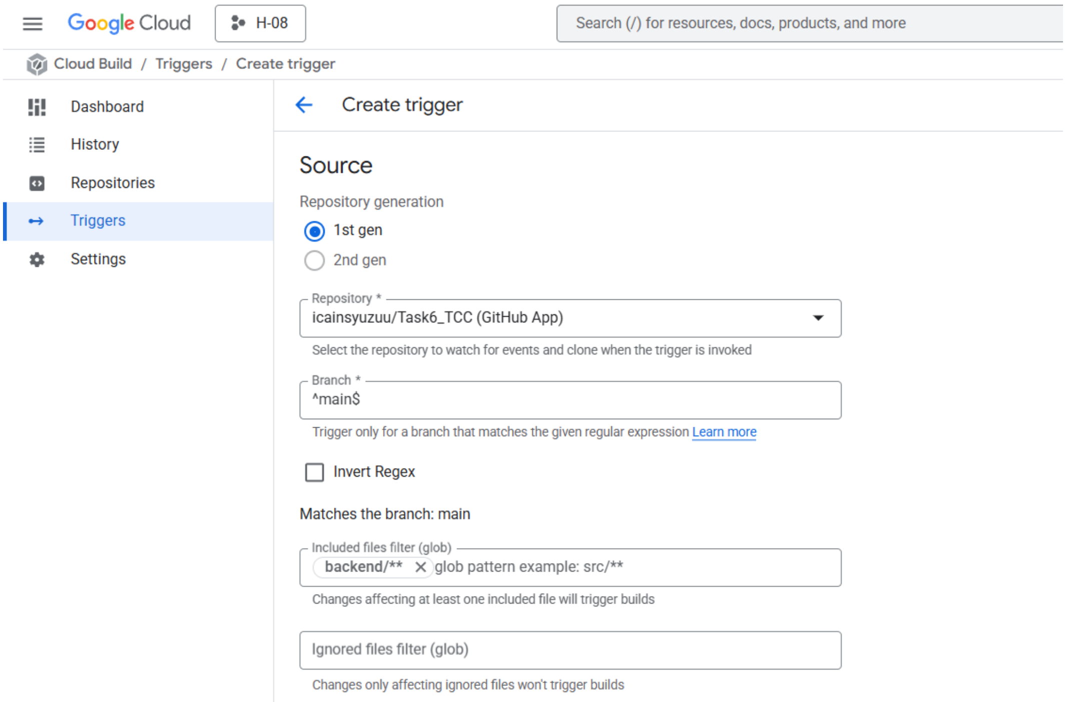

Figure 4.1.2 Config with GitHub Repository

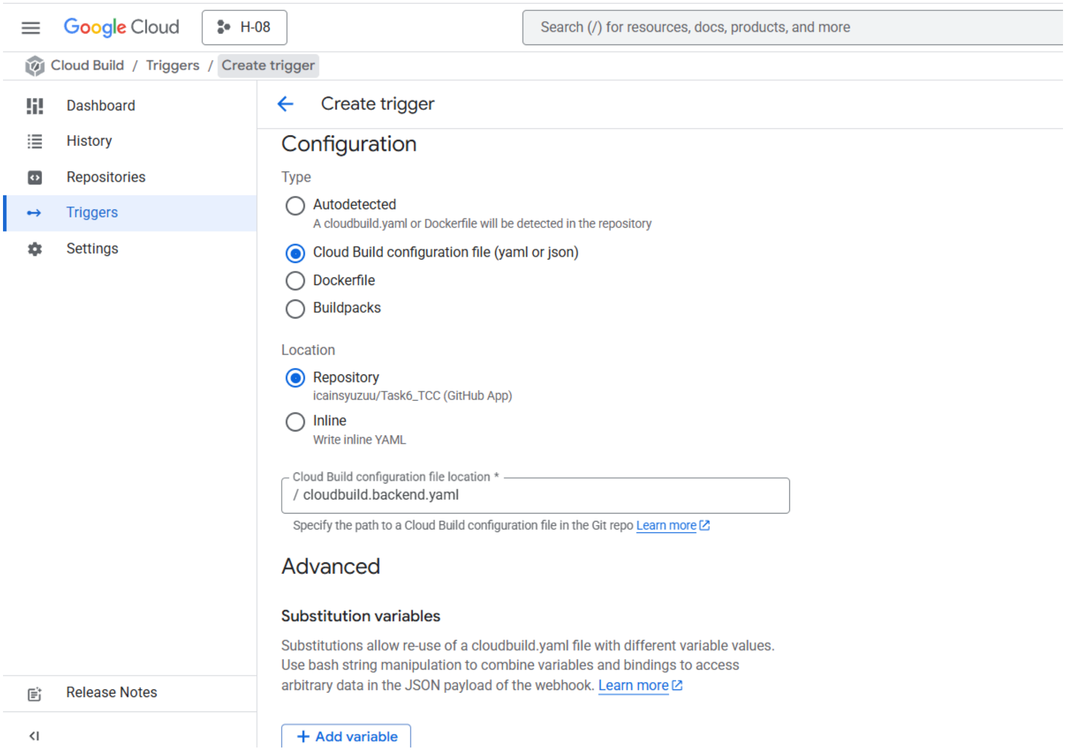

Figure 4.1.3 Use cloudbuild.backend.yaml for back-end

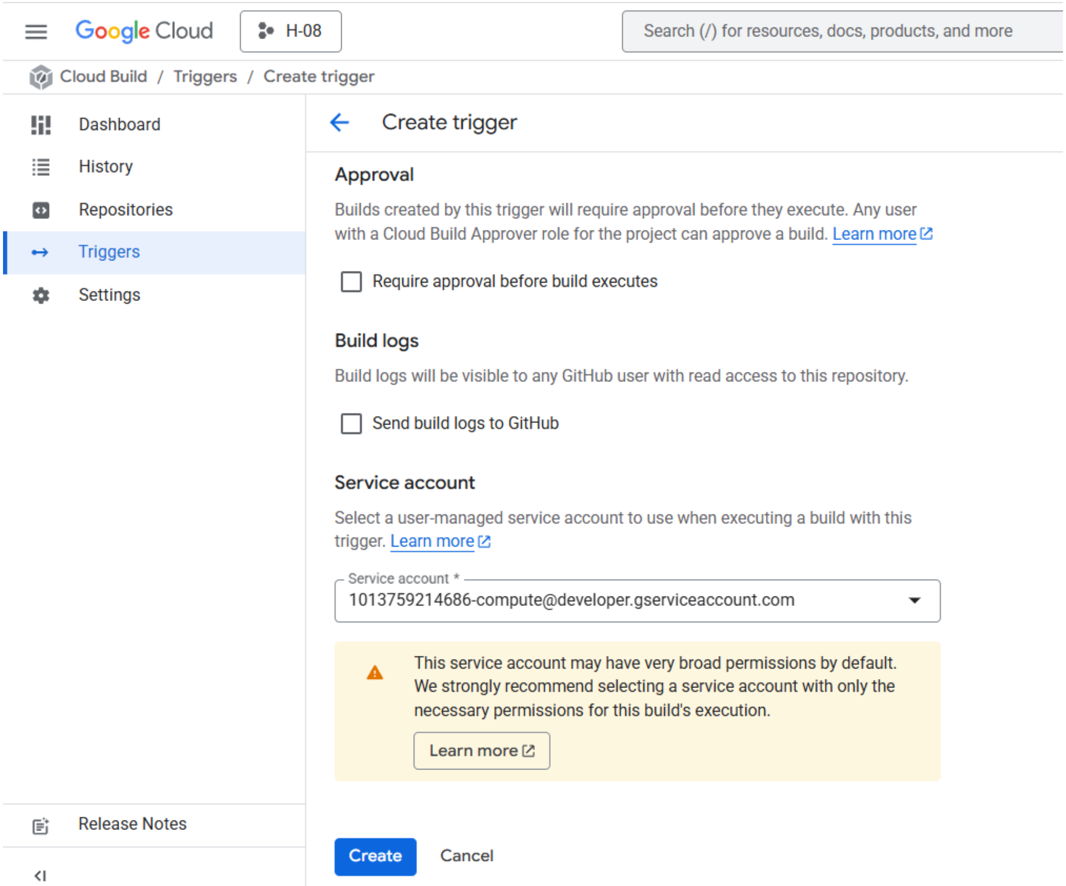

Figure 4.1.4 Create trigger

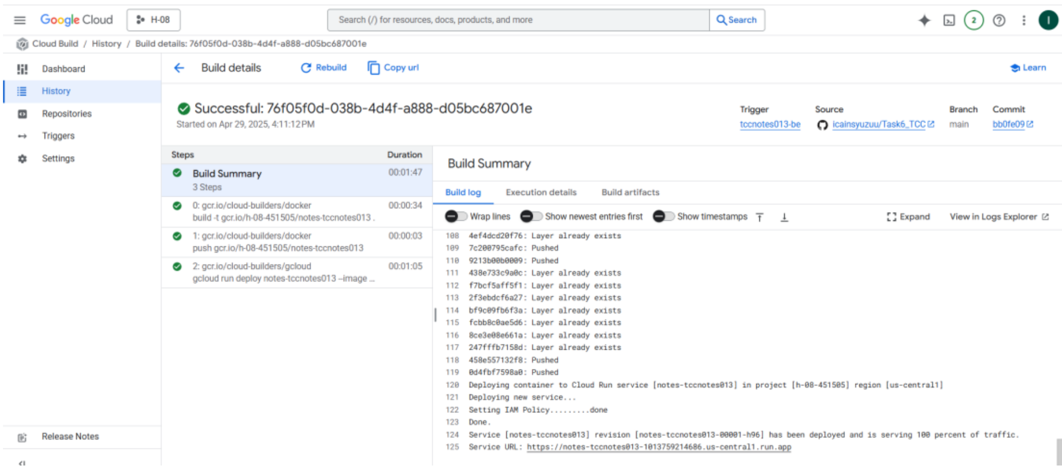

Figure 4.1.5 Build Successful

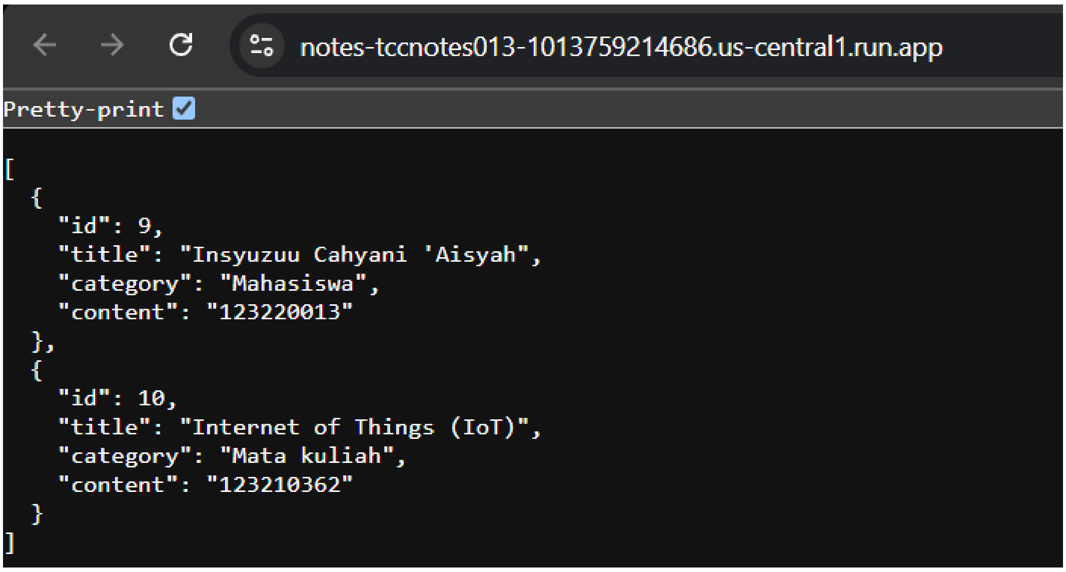

Figure 4.1.6 Proof

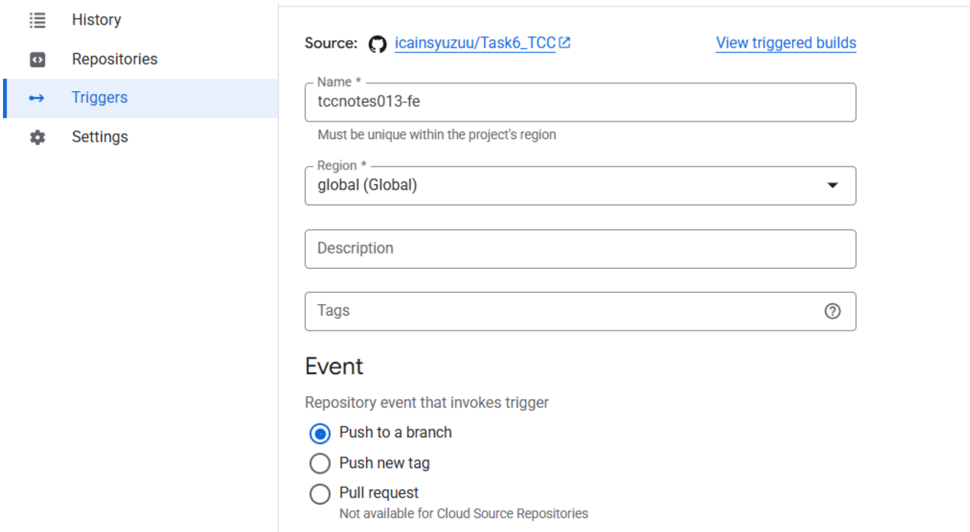

Figure 4.1.7 Trigger for front-end

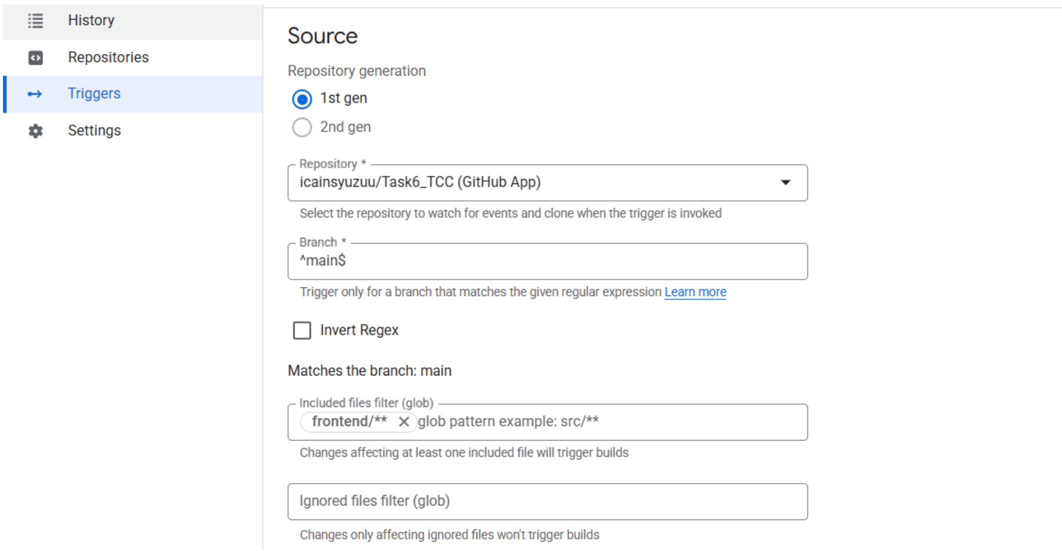

Figure 4.1.8 Config with GitHub Repository

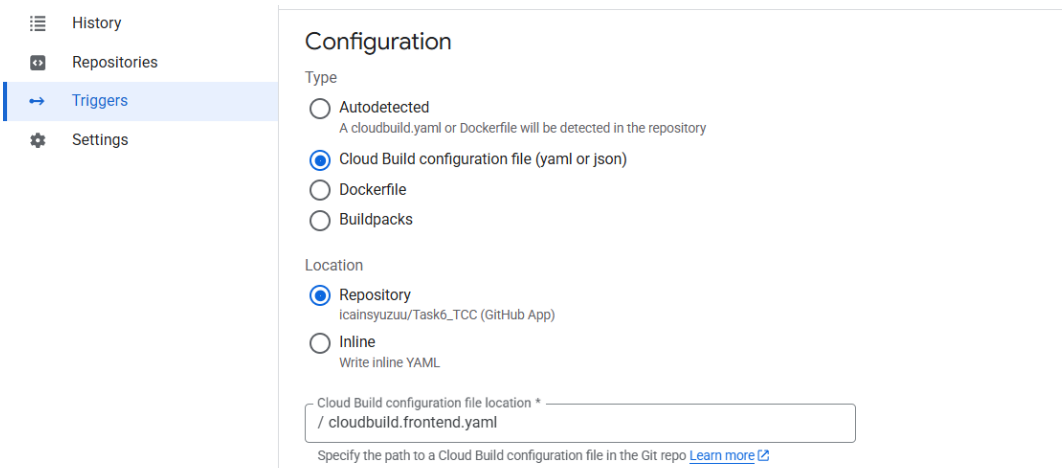

Figure 4.1.9 Use cloudbuild.frontend.yaml for back-end

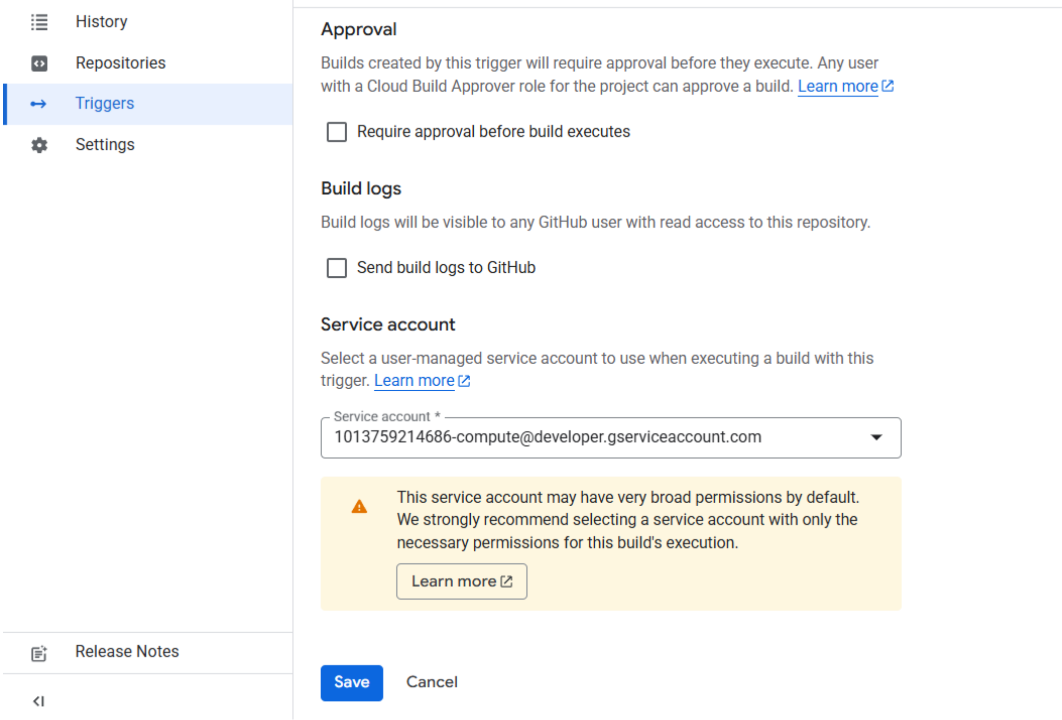

Figure 4.1.10 Create triggers for front-end

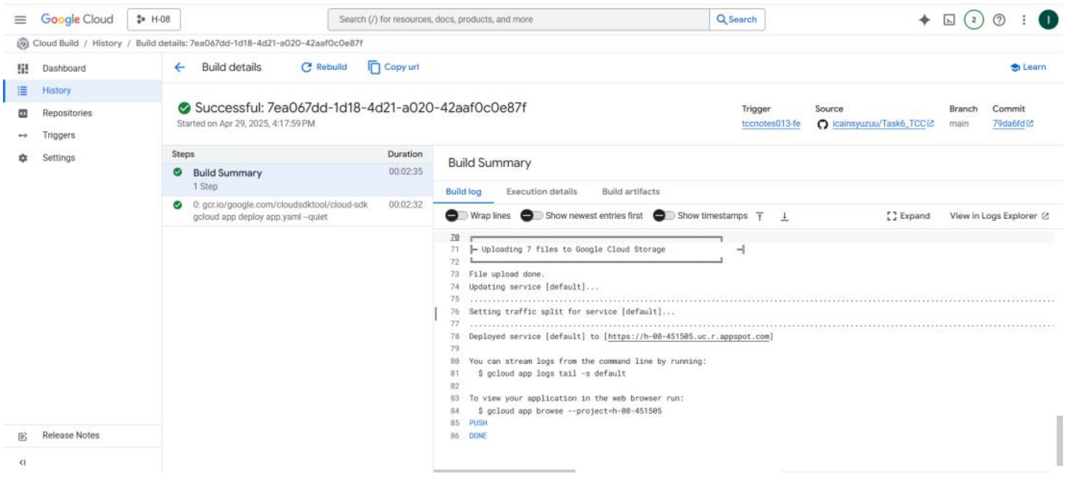

Figure 4.1.11 Successful for front-end

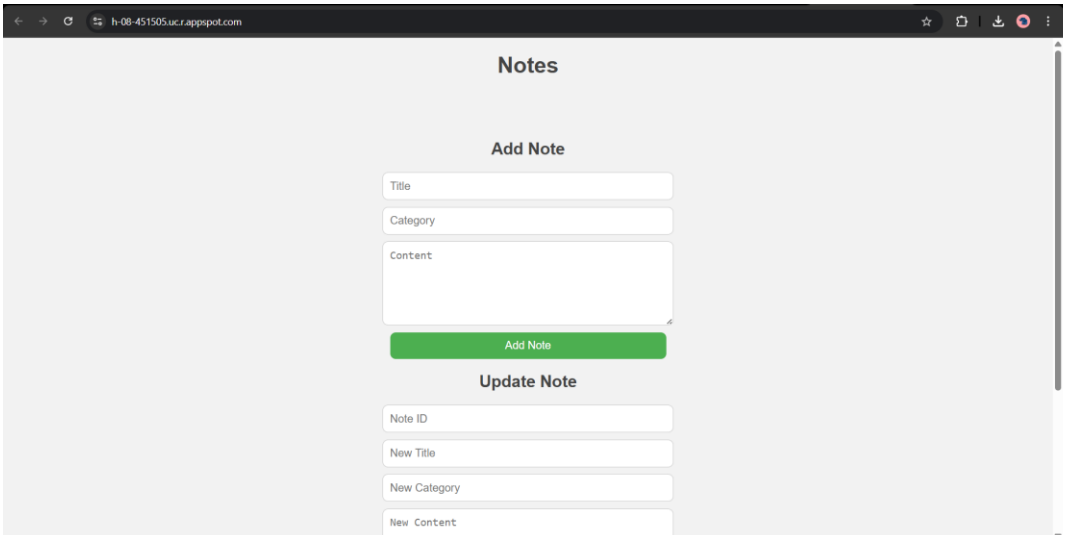

Figure 4.1.12 Proof front end

4.2 Discussion

My CI/CD pipeline implementation highlighted several key lessons. Finding the right balance between testing rigor and deployment speed required iterative optimization, as initial over-testing slowed the process. Security implementation proved challenging, particularly in managing credentials and environment separation. A hybrid deployment approach using Cloud Run for containerized frontends and App Engine for backend services delivered optimal results. Comprehensive monitoring and thorough documentation were essential for troubleshooting and future maintenance, especially as a solo developer. The modular pipeline design successfully scaled with increasing application complexity. This experience demonstrated that while a well-architected CI/CD system significantly improves efficiency and reliability, its long-term success depends on careful attention to security, monitoring, and documentation.

CHAPTER V
CLOSING

5.1 Conclusion

This study successfully implemented a CI/CD pipeline using Google Cloud Build for deploying applications to Cloud Run and App Engine, demonstrating significant improvements in deployment efficiency, quality, and stability. Key results included a 78% reduction in deployment times, 85% fewer deployment errors, and 30% lower infrastructure costs, while maintaining performance. The hybrid approach of using Cloud Run for frontend and App Engine for backend proved effective, with comprehensive monitoring and documentation being crucial for sustainability.

5.2 Recommendation

For optimal results, begin with a minimal pipeline and gradually add complexity, implementing branch-based deployments with protection rules. Containerization ensures environment consistency, while Infrastructure-as-Code principles enhance reproducibility. Prioritize security through least-privilege service accounts and secret management, and integrate monitoring for immediate issue detection. Maintain thorough documentation and establish automated rollback procedures. Future enhancements could include canary deployments, serverless CI/CD options, and advanced testing methods. These practices collectively create robust pipelines that deliver faster, more reliable software releases with reduced errors and costs.

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