**BAKU HIGHER OIL SCHOOL**

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**Cloud Computing and Blockchain**

**S4 Project Final Report**

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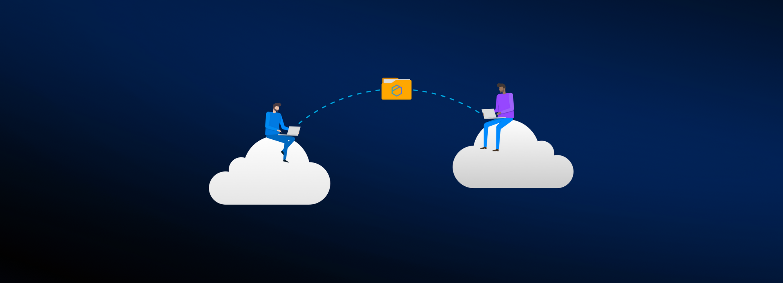
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# Introduction

Cloud computing is the on-demand, pay-as-you-go delivery of IT services over the Internet. Instead of purchasing, owning, and maintaining physical data centers and servers, renting computing power, storage, and databases from a cloud provider on an as-needed basis is possible. Cloud computing is in fact a mechanism or model for enabling convenient, easy, on demand network access to a shared pool of devices that are configurable. Another important feature of cloud computing is the minimum efforts and management cloud model provides rapid services.

People rely heavily on cloud services in their daily lives, e.g., for storing data, writing documents, managing businesses, and playing games online. Cloud computing also provides the infrastructure that has powered key digital trends such as mobile computing, the Internet of Things, big data, and artificial intelligence, thereby accelerating industry dynamics, disrupting existing business models, and fueling the digital transformation.

In regard to the benefits of cloud computing, some of them can be described as follows:

1. **Scalability**

The inherent scalability of cloud computing is one of its main advantages. Being able to simply (and quickly) scale an IT solution, for example, can have a significant and immediate impact on company. In the past, scaling an environment on-demand was impossible since businesses were limited by the size and processing capability of their hardware.

With the cloud, this constraint is no longer an issue. The cloud has completely transformed how businesses handle their technical resources.

1. **Innovation**

Business growth is inextricably linked to innovation. Using old technology might limit an organization's capacity to experiment with new solutions as well as deploy them on a large scale.

Combating back-end performance difficulties, particularly in the area of web applications, can be a serious challenge. Using the cloud as a foundation for innovation can result in better performance, reduced costs, and more agility. In the world of IoT product development, for example, companies are accelerating innovation at a rate that can only be achieved with cloud computing. The IoT industry has been able to develop, produce, and launch new products that are changing the world thanks to cloud computing – and this is true across the entire digital ecosystem.

1. **Cost-effective**

One of the key reasons why cloud computing is significant for businesses is its cost-effectiveness. While cloud migration can be costly, the best way to address the pricing issue isn't to consider how much money you'll save by migrating. Instead, consider how much your company is currently spending on IT services against how much it will be spending on the cloud.

Due to the wide range of project/solution requirements, calculating the true cost of ownership for a cloud solution can be tricky. For an approximate estimate, it's advisable to use a cloud partner.

1. **Flexibility**

One of the most frequently claimed reasons for cloud computing's importance in the business world is its flexibility. The cloud provides more flexibility in terms of infrastructure. However, cloud computing's intrinsic future-proofing architecture is often referred to as flexibility.

Technology is a constantly changing field where adaptation is not only necessary for survival but also for corporate growth. Business expansion used to be a costly process that required devoting a significant amount of people and financial resources to a single project. Now fast forward to today, and businesses have the technical ability to scale up and down as the market demands. The flexibility of cloud computing technology allows for this on-demand flexibility of growing capacities.

The operational flexibility of cloud computing can be achieved at a substantially lower cost.

Still, cloud computing not only provides a vast number of benefits and opportunities; it also comes with several challenges and concerns, e.g., regarding protecting customers’ data. Therefore, there is a dire need for more secure and low complexity cloud provision.

Shape, arrow

Description automatically generated**Simple and Secure Storage Service - S4** is a service to distribute user’s data among user-specified cloud providers in a secure fashion. The available cloud providers’ list depends on the project managers and is evolving. The cloud provided by S4 is one of the safest places on the internet. Sync, backup and share of files from anywhere, anytime – with military-grade encryption and zero-knowledge privacy are supposed to be some of the main benefits of the project to its users.

Logo of S4

This paper describes the main points regarding the development and deployment of S4 project.

# Technical Specification Report

A technical specification document defines the requirements for a project, product, or system. A specification is the information on technical design, development, and procedures related to the requirements it outlines. This document provides information to developers and other stakeholders on business requirements, internal standards, and best practices.

## List of Requirements

Requirements identify the product's business needs and purposes at a high level. They also clarify the features, functionality, behaviors and performance that stakeholders expect. Below you will find list of requirements.

1. Registration
2. Login
3. User Profile Settings
4. User System Settings
5. Dashboards
6. Subscription Plans
7. Request Forms
8. Cloud and on premise support

## User and System Requirements

*1. Registration -* Users will be able to create personal accounts by following ways (UR):

a. By providing username, email and password (SR)

b. By using one of the oAuth options(e.g twitter, facebook, github) (SR)

* Username and passwords will be checked by predefined policies (FR)
* All sensitive data will be stored in hash format (NFR)

*2. Login -* User will be able to login to portal with credentials registered in registration stage. (UR):

a. User will be able to login with username/email and password (SR)

* User will be informed about successful / unsuccessful login attempts. (FR)
* User will be redirected to home page after successful login within 2 seconds (FR)
* User will be get notification emails about fraud attempts if there is more than 5 failed login attempts (FR)

*3. User Profile Settings* - User will be able to change all profile information stored. (UR)

a. New user profile details should be checked by proper policies in backend. (SR)

* User will be allowed to customize their profile and modify username, email and password. (FR)
* Option to upload profile picture (FR)
* Profile deletion, suspension, activation mechanism will be available in profile settings.(FR)

4. *User System Settings* - User will be able to manage billing and alert&notification settings (UR)

a. Proper billing mechanism will be configured to make transactions(SR)

* User will be able to add and remove credit cards for making purchases. (FR)
* Transaction process will be managed by third party providers (FR)
* User will be able to create notifications for budgeting, resource usage and instance state alerts. (FR)
* User can see user activity in system settings page. (FR)
* Option to export user activity information as well known media formats (csv, json) (NFR)

*5. Dashboards* - User will be able to monitor instance states, resource usage, billing statuses from dashboards. (UR)

a. Prometheus will export logs and Grafana will provide monitoring dashboards in UI. (SR)

* User will see hourly, daily, weekly, monthly monitoring logs in dashboards. (FR)
* Billing dashboards will provide clear understanding of current, past and possible future costs. (FR)
* Grafana dashboards will be exported from standalone server (NFR)

*6. Subscription Plans* - User can select one of the provided subscription plans. (UR)

a. Resource quotas will be measured by subscription plans in backend. (SR)

* User should choose one of the possible subscription plans. (FR)
* User can upgrade or downgrade plan whenever he/she wants. (FR)

*7. Request Forms* - User must fulfill request form in order to create new instance (UR)

a. Request form will be analyzed and proper resources will be allocated in storage providers (SR)

* Option to upload request form as a well known media formats (e.g. json, hcl, xml). (FR)
* Option to fulfill form in web UI as html form. (FR)
* Request form will be matched with chosen subscription plan. (FR)
* Request plans will be saved and prompted afterwards. (NFR)

*8. Cloud and on premise support* - User will be able to choose where to store data, whether in cloud or on premise infrastructure.

a. Chosen database solution will be provisioned in cloud or on premise. (SR)

b. Special security policies will be applied for better security principles in backend when provisioning new database instances. (SR)

* User should be able to provision new instance, suspend it and terminate it. (FR)
* User will be suggested about the most supported types of instances based on chosen availability zones (or provided hardware vendor in on premise infrastructure) (NFR)

# Cloud Environment

Project environment has been set up in Google Cloud Platform. Google Cloud Platform (GCP), offered by Google, is a suite of cloud computing services that runs on the same infrastructure that Google uses internally for its end-user products, such as Google Search, Gmail, Google Drive, and YouTube. Main Cloud Services that are used in S4 are following:

- Artifact Registry

- Cloud SQL

- Cloud Run

# 3.1 Artifact Registry

As the evolution of Container Registry, Artifact Registry is a single place for your organization to manage container images and language packages (such as Maven and npm). It is fully integrated with Google Cloud’s tooling and runtimes and comes with support for native artifact protocols. This makes it simple to integrate it with your CI/CD tooling to set up automated pipelines. Core Artifact Registry features include:

* 1. Secure and Consistent
  2. Artifact build process can be easily automated with CI/CD
  3. It supports Native Artifact
  4. Vulnerability Scanning insights
  5. In case of critical vulnerabilities, Artifact Registry can prevent artifact pulls for better security

# 3.2 Cloud SQL

Cloud SQL is fully managed relational database service for MySQL, PostgreSQL, and SQL Server. Run the same relational databases you know with their rich extension collections, configuration flags and developer ecosystem, but without the hassle of self management.

Its core features:

1.Secure and compliant

Data encryption at rest and in transit. Private connectivity with Virtual Private Cloud and user-controlled network access with firewall protection. Compliant with SSAE 16, ISO 27001, PCI DSS, and HIPAA.

2.Scale as you go

Scale your instances effortlessly with a single API call whether you start with simple testing or you need a highly available database in production.

3.Set up in minutes

Standard connection drivers and built-in migrational tools allow you to create and connect to your first database in just a few minutes.

S4 also use Cloud SQL to provision and provide database instances for end users.

# 3.3 Cloud Run

Cloud Run is a managed compute platform that enables you to run containers that are invocable via requests or events. Cloud Run is serverless: it abstracts away all infrastructure management. With the help of Cloud Run applications can be deployed to highly scalable environments which are managed by Google Cloud.

Cloud Run main features include:

1.Container to production in seconds

Write code your way by deploying any code or container that listens for requests or events. Build applications in your favorite language, with your favorite dependencies and tools, and deploy them in seconds.

2. Fully managed

Cloud Run abstracts away all infrastructure management by automatically scaling up and down from zero almost instantaneously—depending on traffic. Cloud Run only charges you for the exact resources you use.

3. Enhanced developer experience

Cloud Run makes app development and deployment simpler and faster. And it’s fully integrated with Cloud Code, Cloud Build, Cloud Monitoring, and Cloud Logging for an enhanced end-to-end developer experience.

4. Any language, any library, any binary

Use the programming language of your choice, any language or operating system libraries, or even bring your own binaries.

5. Leverage container workflows and standards

Containers have become a standard to package and deploy code and its dependencies. Cloud Run pairs great with the container ecosystem: Cloud Build, Cloud Code, Artifact Registry, and Docker.

6. Pay‐per‐use

Only pay when your code is running, billed to the nearest 100 milliseconds.

Cloud Run can minimize the effort spent on deployment process and provide seamlessly perfect working websites, REST APIs, etc.

# 3.4 Overview

S4 application has been developed as cloud native, therefore there are more deployment options that can be utilized. Currently, S4-app has been deployed to Cloud Run, with following parameters:

Graphical user interface, text, application, email

Description automatically generated

Figure - 1

Cloud Run also provides autoscaling, which is one of the main features of Serverless Architecture.

Graphical user interface, text, application, email

Description automatically generated

Figure - 2

Currently, all traffic is routed directly to service, but traffic can easily be controlled by Cloud IAM or other Authentication Methods. (S4 itself also has Authentication Authorization mechanism).

Following document illustrates kNative Yaml that is used by Cloud Run, which define desired state of the application service:

apiVersion: serving.knative.dev/v1

kind: Service

metadata:

name: s4-app

namespace: '601285205640'

selfLink: /apis/serving.knative.dev/v1/namespaces/601285205640/services/s4-app

uid: b6f12860-5920-42cf-b65f-42cc3974a549

resourceVersion: AAXdgaPKZeI

generation: 8

creationTimestamp: '2022-04-24T18:14:38.119704Z'

labels:

cloud.googleapis.com/location: us-central1

annotations:

run.googleapis.com/client-name: cloud-console

serving.knative.dev/creator: kamrankarimov674@gmail.com

serving.knative.dev/lastModifier: kamrankarimov674@gmail.com

client.knative.dev/user-image: us-docker.pkg.dev/vital-wavelet-346108/s4-registry/s4-app@sha256:310ada0e819325d6566f66f0636b3a7b254a822bda9168a0bb21704904d06450

run.googleapis.com/ingress: all

run.googleapis.com/ingress-status: all

spec:

template:

metadata:

name: s4-app-00006-yar

annotations:

run.googleapis.com/client-name: cloud-console

autoscaling.knative.dev/minScale: '1'

autoscaling.knative.dev/maxScale: '5'

spec:

containerConcurrency: 80

timeoutSeconds: 300

serviceAccountName: 601285205640-compute@developer.gserviceaccount.com

containers:

- image: us-docker.pkg.dev/vital-wavelet-346108/s4-registry/s4-app@sha256:310ada0e819325d6566f66f0636b3a7b254a822bda9168a0bb21704904d06450

ports:

- name: http1

containerPort: 8080

resources:

limits:

cpu: 1000m

memory: 512Mi

traffic:

- percent: 100

latestRevision: true

status:

observedGeneration: 8

conditions:

- type: Ready

status: Unknown

reason: UpdatingIngressTrafficAllowed

message: Updating ingress traffic allowed.

lastTransitionTime: '2022-04-25T21:55:52.023522Z'

- type: ConfigurationsReady

status: 'True'

lastTransitionTime: '2022-04-25T19:02:23.663117Z'

- type: RoutesReady

status: Unknown

reason: UpdatingIngressTrafficAllowed

message: Updating ingress traffic allowed.

lastTransitionTime: '2022-04-25T21:55:52.023522Z'

latestReadyRevisionName: s4-app-00006-yar

latestCreatedRevisionName: s4-app-00006-yar

traffic:

- revisionName: s4-app-00006-yar

percent: 100

latestRevision: true

url: https://s4-app-dtpokso7oq-uc.a.run.app

address:

url: https://s4-app-dtpokso7oq-uc.a.run.app

Performance monitoring dashboards:  
A screenshot of a computer

Description automatically generated

Figure - 3

S4 store its data in Postgres SQL, which is also one of the database types that Cloud SQL provides, therefore Cloud SQL Postgres instance has been created for it.

Following picture describes summary of currently running Cloud SQL instance

Graphical user interface, table

Description automatically generated

Figure - 4

At the time 26 April, 08:57 am, 2022, there are 9 users that have been authenticated to S4, and they have created total number of 3 databases instances.

Graphical user interface, application

Description automatically generated

Figure - 5

Table

Description automatically generated

Figure - 6

S4 project container images are stored in Artifact Registry:

Graphical user interface, text, application, email

Description automatically generated

Figure - 7

Note that Artifact Registry Vulnerability Scanning feature has found vulnerabilities in container image.

# Implementation of Cryptography

In the website HTTPS is used instead of HTTP, which is much more secure.

Apart from this, SHA256 is used.

Text

Description automatically generated

Figure - 8

# Testing

Text

Description automatically generated

Figure - 9

The script checks whether the website’s registration page is available or not through obtaining HTTP status code. Here is the script written in bash.

Text

Description automatically generated

Figure - 10

**Performance Testing**

Text

Description automatically generated

Figure - 11

**Penetration testing**

The following depicts the result of whatweb command which reveals the server information and IP address.

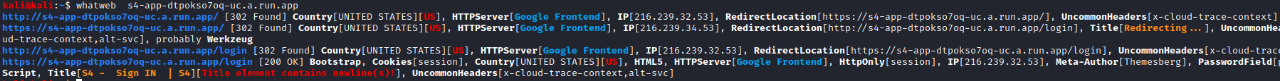


Figure - 12

The below dig command usage reveals the IP and ns records of the application which then can be used.

Text

Description automatically generated

Figure - 13

Text

Description automatically generated

Figure - 14

# Links

* <https://github.com/app-generator/flask-volt-dashboard>
* <https://cloud.google.com/>
* <https://cloud.google.com/sql>
* <https://cloud.google.com/artifact-registry>
* <https://cloud.google.com/run>

# References

* <https://sam-solutions.us/why-cloud-computing-is-important-for-business/>
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