# EXPERIMENT - 1

**Student Name:** Hiten Mehta
**UID:** 23BCS14058
**Branch:** BE-CSE
**Section/Group:** KRG-2A
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**Subject Code:** 23CSH-314

## 1. Aim:

To design and analyze a **URL Shortener System** that converts long URLs into short, unique URLs while ensuring high availability, scalability, low latency, and efficient redirection. The system also supports optional custom URLs, expiration dates, and user authentication.

## 2. Objective:

- To understand functional and non-functional requirements of a large-scale distributed system.
- To design RESTful APIs for URL creation and redirection.
- To identify core entities such as User, Short URL, and Long URL.
- To analyze CAP theorem trade-offs and apply eventual consistency.
- To design high-level and low-level architecture for a scalable URL shortener.
- To study multiple approaches for short URL generation and compare their performance.

## 3. Tools Used:

**Python** - Backend logic implementation and URL generation algorithms.
**Flask** - Lightweight web framework for developing RESTful APIs.
**Draw.io** - Designing system architecture diagrams (HLD & LLD).

## 4. System Requirements:

### A. Functional Requirements

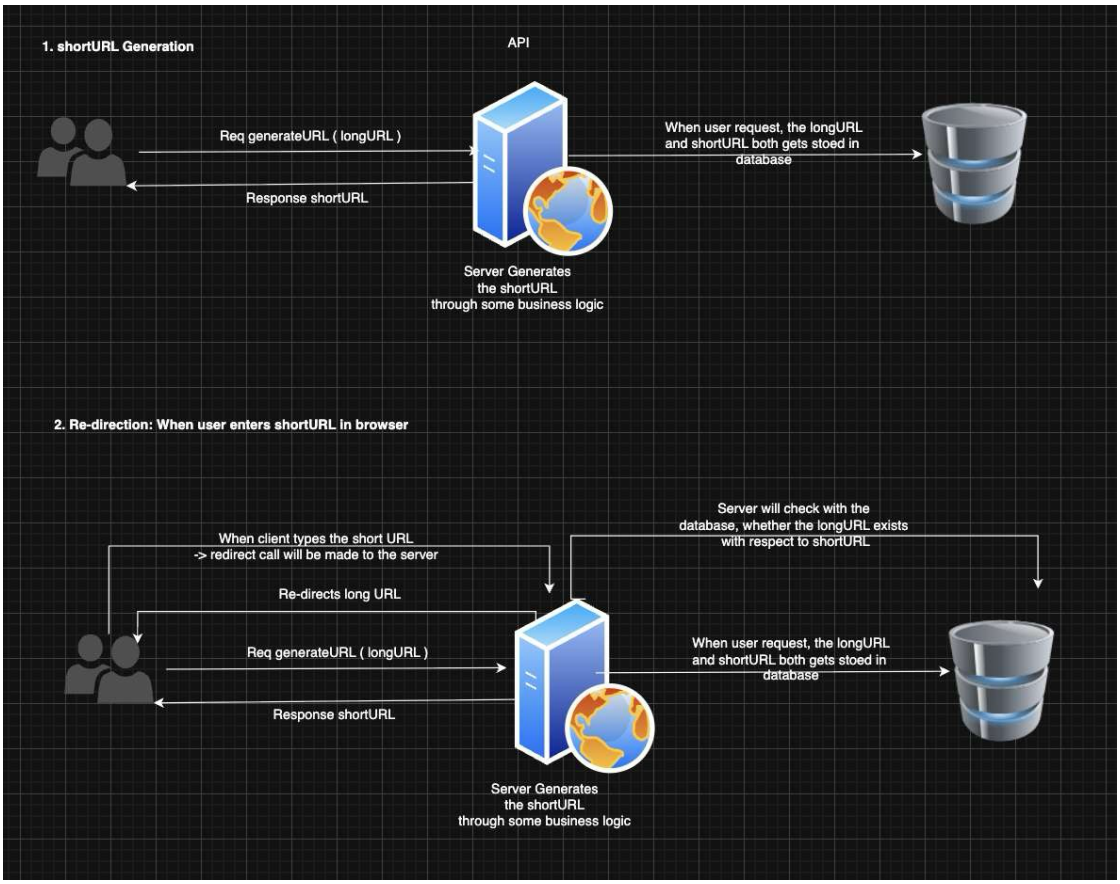
- Create a short URL from a given long URL.

- Support optional custom short URLs.
- Support default and user-defined expiration dates.
- Redirect users from short URL to the original long URL.
- Provide REST APIs for URL creation and redirection.
- Support user registration and login using REST APIs.

### B. Non-Functional Requirements

- Low latency (≤ 20 ms for URL creation and redirection).
- High scalability (100M daily active users, 1B URLs).
- High availability (24×7).
- Uniqueness of short URLs.
- High availability preferred over strict consistency (Eventual Consistency).

## 5. High Level Design (HLD):



The system follows a **Client–Server–Database architecture**:

- Client sends request to generate or access short URL.
- The server processes business logic and generates a short URL.
- Database stores mappings of short URL and long URL.
- On redirection, the server fetches a long URL and redirects the user.

## 6. Low Level Design (LLD):

**Approach :** Counter-Based

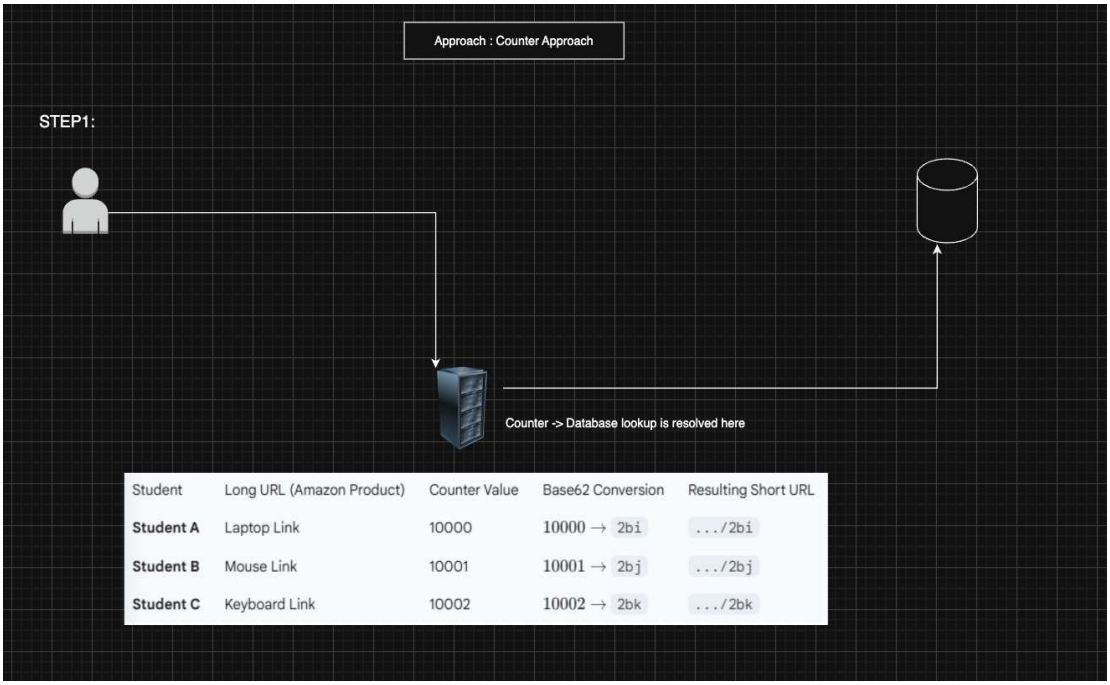
• Uses an auto-increment counter.

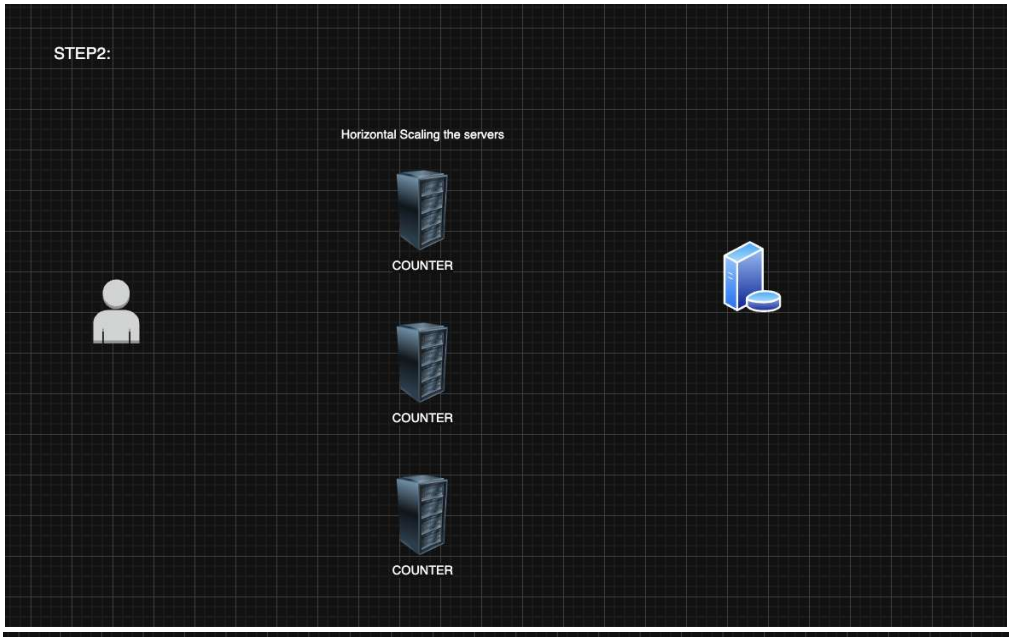
• Counter value converted to Base62 for a short URL.

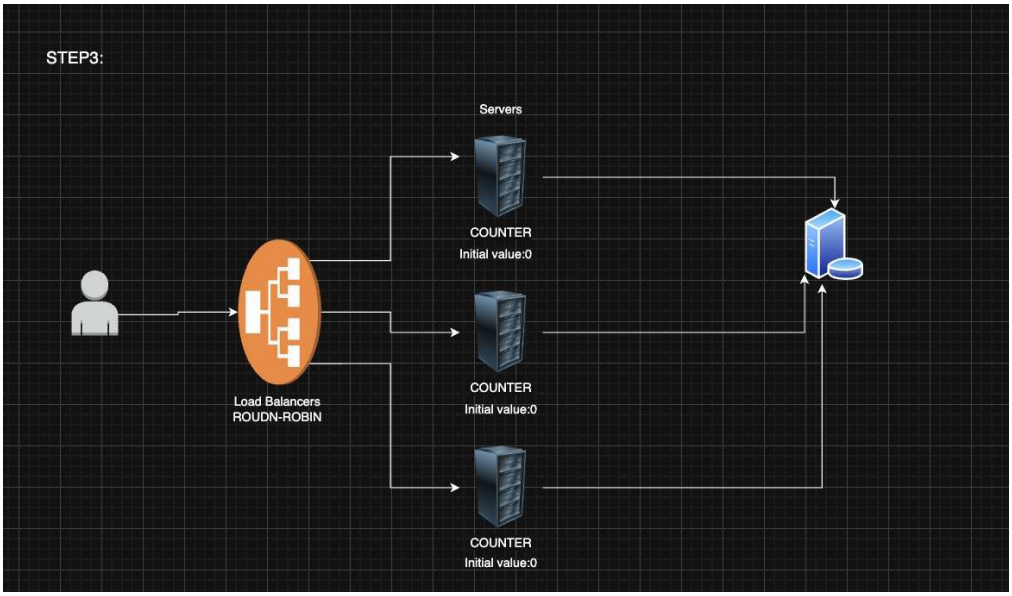
**Example** :

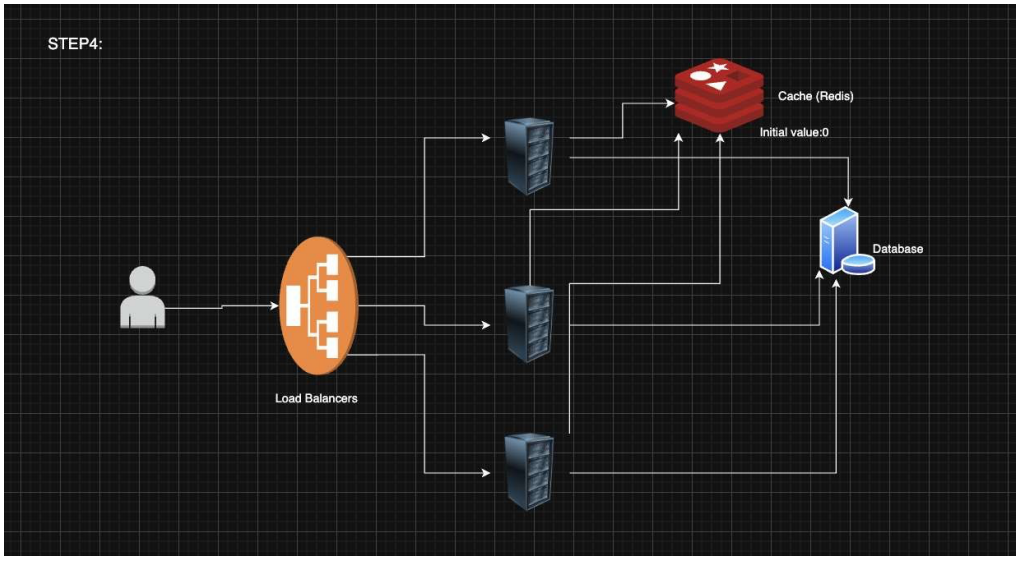
Counter: 10000 → Base62: 2bi → Short URL

• Issue: Single counter causes scalability issues.




STEP2:
Horizontal Scaling the servers
COUNTER
COUNTER
COUNTER


STEP3:
Servers
COUNTER
Initial value:0
COUNTER
Initial value:0
COUNTER
Initial value:0
Load Balancers
ROUDN-ROBIN


STEP4:
Cache (Redis)
Initial value:0
Database
Load Balancers

## 7. Scalability Solution:

- Horizontal scaling of application servers.
- Use of Load Balancer (Round Robin).
- Centralized counter stored in Redis cache.
- Redis ensures fast access and atomic increments.
- Database stores final URL mappings.

## 8. Learning Outcomes:

- Gained an understanding of how to design scalable, real-world systems.
- Learned the principles and best practices of REST API design.
- Developed knowledge of the CAP theorem and the concept of eventual consistency.
- Explored different URL shortening techniques along with their trade-offs.
- Understood the role of horizontal scaling, caching, and load balancing in system performance.
- Learned the importance of building systems with low latency and high availability.