



### Experiment 3

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**Branch:** CSE

**Semester:** 6th

**Subject Name:** System Design

**UID:** 23BCS14207

**Section/Group:** KRG 1-B

**Date of Performance:** 26/01/2026

**Subject Code:** 23CSH-314

**1. Aim:** To design and analyze a **scalable Social Media platform** similar to **Facebook / Instagram** that allows users to register, create posts, follow other users, like and comment on posts, and view personalized feeds while ensuring **high availability, scalability, consistency trade-offs, and low latency**.

#### **2. Objective:**

- To identify functional and non-functional requirements of a social media system.
- To design a microservices-based scalable architecture for a large-scale social platform.
- To understand CAP theorem trade-offs in social media systems.
- To design a High-Level Design (HLD) for user management, post creation, feed generation, likes, and comments.
- To understand the role of Kafka, caching, fan-out strategy, and object storage (S3) in real-time systems.
- To analyze how high availability is prioritized over strict consistency in social platforms.

#### **3. Tools Used:**

- **Draw.io** – Designing system architecture (HLD).
- **PostgreSQL** – Relational database for user and follower data.
- **Document DB (NoSQL)** – Post, comment, and feed storage.
- **Apache Kafka** – Event streaming and asynchronous processing.
- **Redis** – Caching feeds and follower data.
- **Amazon S3** – Media storage for images and videos.

#### **4. System Requirements:**

##### **A. Functional Requirements:**

- 1) User should be able to register and login to the application.
- 2) User should be able to create posts (text / image / video).
- 3) User should be able to follow other users or send friend requests.
- 4) User should be able to like and comment on posts.



- 5) User should be able to view feed consisting of posts from users they follow.
- 6) System should support real-time user engagement (likes, comments).

## **B. Non-Functional Requirements:**

### **1) Scalability**

- Target Scale: 500 Million Daily Active Users (DAU)
  - System must handle millions of concurrent users.

### **2) Availability & Consistency**

- High Availability is prioritized over Strong Consistency
  - Reason:
    - If the platform is unavailable, the system becomes useless.
    - Slight delay in post propagation (eventual consistency) is acceptable.

Example:

If Instagram is down for 1 hour → Critical issue

If a post reaches followers after 500 ms → Acceptable

**Hence:**

**Availability >>> Consistency**

### **3) Latency**

- Post publishing latency  $\leq 500$  ms
  - Feed loading latency should be minimal for smooth user experience.

### **4) Reliability**

- System should tolerate failures and recover automatically.

## **5. High Level Design (HLD):**

The system follows a microservices-based architecture:

### **API Gateway**

- Handles routing, authentication, authorization, and rate limiting.

### **User Service**



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- Manages user registration, login, JWT-based authentication, and profiles.

## **Follower Service**

- Manages follow / unfollow relationships between users.

## **Content Service**

- Handles post creation, validation, and metadata management.

## **Media Service**

- Uploads and stores images/videos in Amazon S3.

## **Feed Service**

- Generates personalized user feeds using fan-out strategy and caching.

## **User Engagement Service**

- Handles likes and comments using Kafka (Pub-Sub model).

## **Kafka**

- Asynchronous processing of post events, likes, comments, and feed updates.

## **Cache (Redis)**

- Stores frequently accessed feeds and top followers for fast access.

## **6. Feed Generation Strategy:**

### **Fan-Out on Write**

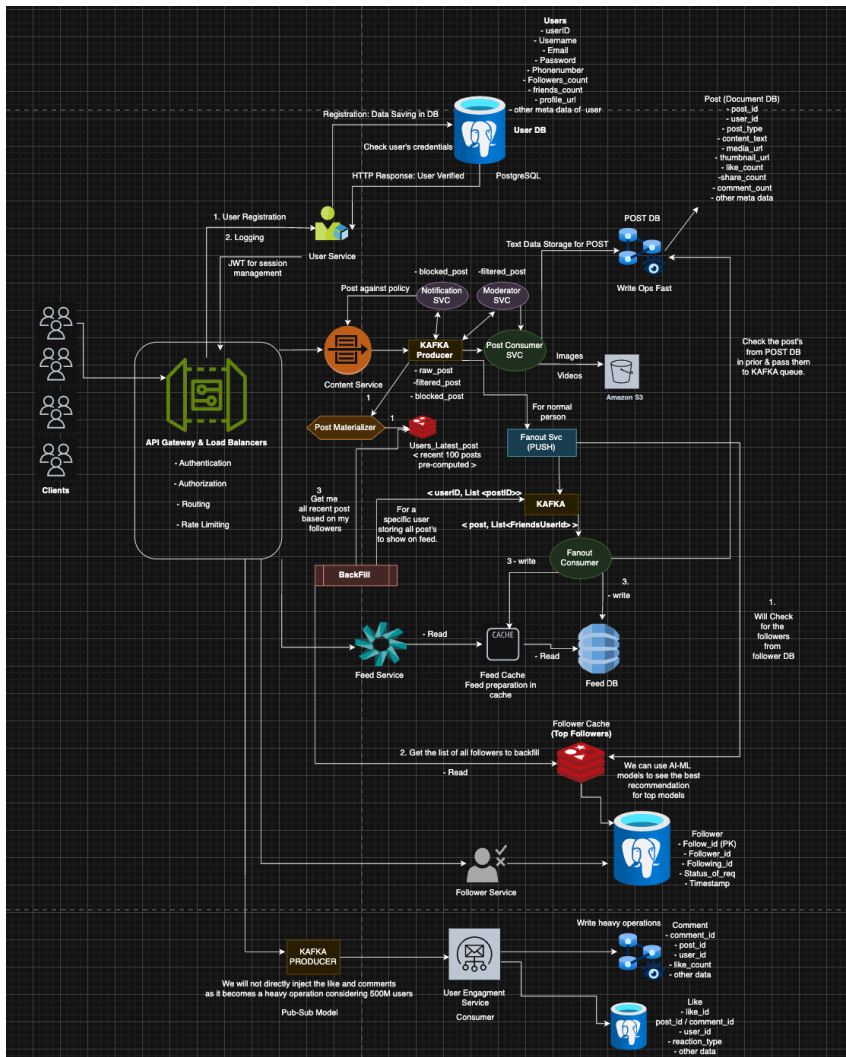
- When a user posts content, the post is pushed to followers' feeds asynchronously using Kafka.
- Suitable for users with limited followers.

### **Fan-Out on Read**

- For celebrities with millions of followers, feed is generated at read time to avoid heavy writes.

### **Hybrid Approach**

- System intelligently chooses between fan-out on write and read.



## 7. Scalability Solution:

- Horizontal scaling of microservices.
- API Gateway acts as load balancer.
- Kafka decouples services and smoothens traffic spikes.
- Redis caching reduces database load.
- Object storage (S3) handles heavy media traffic efficiently.

## 8. Learning Outcomes (What I Have Learnt):

- Learned how real-world social media platforms are designed.
- Understood **functional vs non-functional** requirements clearly.
- Gained strong understanding of **CAP theorem trade-offs**.
- Learned how **Kafka, caching, and fan-out strategies** are used at scale.
- Understood why **availability is more important than consistency** in social systems.
- Learned how to design **low-latency, highly scalable distributed systems**.