



# DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

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## Experiment 3

**Student Name:** Dikshay Sharma

**UID:** 23BCS11096

**Branch:** CSE

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

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**Subject Name:** System Design

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**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.



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- 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

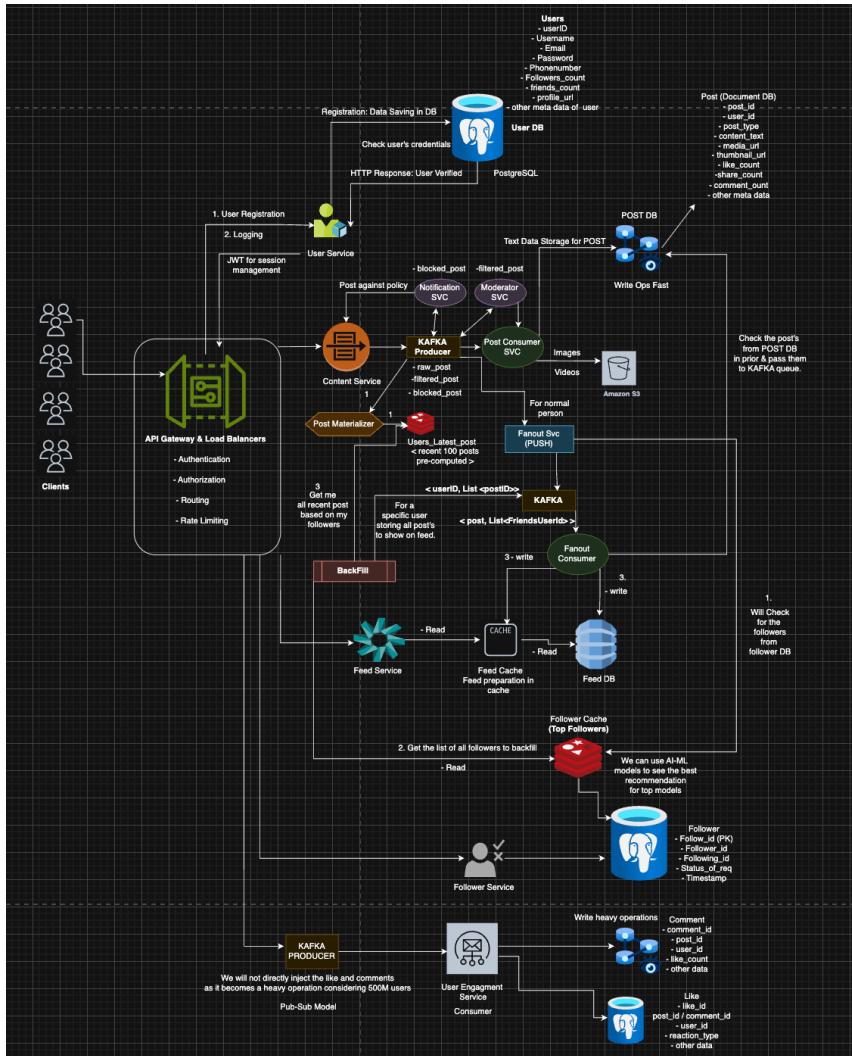
- When a user posts content, the post is pushed to followers' feeds asynchronously using Kafka.
- Suitable for users with limited followers.

### 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**.