1. Introduction to System Design Interviews

System design interviews assess your ability to design scalable, maintainable, and efficient systems. They test how well you can handle real-world engineering challenges that involve distributed systems, scalability, reliability, and trade-offs.

What Interviewers Evaluate:

- Structured thinking and clarity of communication
- Handling ambiguity through questions
- Awareness of scalability, fault tolerance, and performance
- Ability to justify trade-offs (cost, latency, consistency)
- Familiarity with system components and data flow

The goal isn't a perfect design — it's to show your thought process, how you make informed engineering decisions, and how you adapt under constraints.

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2. Step-by-Step Framework

1️⃣Clarify Requirements

Ask clarifying questions:

- What are functional vs non-functional requirements?
- What's the scale (users, requests/sec, data size)?
- What are the latency and availability expectations?

2️⃣Define Scope

Avoid over-engineering. Focus on core use cases and ignore optional features.

3️⃣Sketch a High-Level Architecture

Start with big blocks:
Client → Load Balancer → Application Servers → Database → Cache → CDN (if needed)

4️⃣Identify Core Components

Define how each part fits in:

- API Gateway: Entry point for clients
- Application Layer: Contains business logic
- Database Layer: Manages persistent data
- Cache: Improves response times
- Queue: Handles asynchronous tasks

5️⃣Design Data Model

Define entities, relationships, and query patterns. Choose between SQL or NoSQL based on use case.

6️⃣Handle Bottlenecks and Scaling

Think about:

- Vertical vs horizontal scaling
- Database replication/sharding
- Load balancing and caching

7️⃣Discuss Trade-offs

Explain pros/cons of design decisions:

- SQL vs NoSQL
- Strong vs eventual consistency
- Monolith vs microservices

8️⃣Wrap-Up

End with a summary:

- How your design meets requirements
- Bottlenecks and future improvements
- Monitoring and observability plans

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3. Core System Components

Client Layer

User interface or external service sending requests (web, mobile, API).

Load Balancer

Distributes incoming traffic across multiple servers to prevent overload.

Application Servers

Process requests, enforce business logic, and communicate with backend systems.

Database Layer

Stores persistent data. Choose:

- SQL (PostgreSQL, MySQL) for transactions
- NoSQL (MongoDB, Cassandra) for flexibility or high write throughput

Cache

Stores frequently accessed data in memory (e.g., Redis, Memcached) to reduce latency and DB load.

CDN

Delivers static assets (images, videos) quickly from edge locations.

Queue System

Handles asynchronous or delayed tasks (Kafka, RabbitMQ, AWS SQS).

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4. Backend-Focused Design Principles

Microservices

Break the system into small, independent services that communicate through REST, gRPC, or message queues.

Database Sharding

Split large datasets across multiple shards (horizontal partitioning) to handle high traffic.

Replication

Maintain multiple copies of data for fault tolerance and faster reads.

Caching

Reduce latency and improve performance by storing computed or frequently accessed results.

Message Queues

Enable asynchronous processing:

- Kafka for event streaming
- RabbitMQ for reliable delivery

Monitoring & Logging

Use:

- Prometheus / Datadog for metrics (latency, error rate, uptime)
- ELK stack (Elasticsearch, Logstash, Kibana) for centralized logging

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5. Example Designs

A. URL Shortener

Goal: Convert long URLs into short unique links.

Approach:

- Use hashing or base62 encoding to create short IDs
- Store mapping in a NoSQL database (high read/write)
- Cache popular URLs for instant lookup
- Handle collisions and rate limiting

Focus Areas: Hashing, caching, scalability

B. Chat Application

Goal: Enable real-time communication between users.

Approach:

- Use WebSocket connections for real-time message delivery
- Store messages in a persistent store (Cassandra, DynamoDB)
- Use message queues to handle delivery reliability
- Partition users or chat rooms for scalability

Focus Areas: Real-time updates, message persistence, partitioning

C. Notification System

Goal: Deliver notifications (push, SMS, email) reliably.

Approach:

- Producers publish events to Kafka
- Consumers process messages and deliver notifications
- Use retry and dead-letter queues for failures
- Track delivery metrics and retries

Focus Areas: Event streaming, asynchronous design, reliability

6. System Design Checklist

- ✅ Clarify scope and assumptions
- ✅ Identify main system components
- ✅ Choose appropriate data stores
- ✅ Handle scaling (load balancing, caching, sharding)
- ✅ Discuss trade-offs (latency, consistency, cost)
- ✅ Include monitoring, logging, and alerting
- ✅ Summarize your design and future improvements

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7. Pro Tips

- Think aloud — your reasoning matters more than final architecture
- Prioritize bottlenecks over completeness
- Mention real metrics: latency goals, throughput, data size
- Always include failure handling and monitoring
- End strong: summarize trade-offs and how your design evolves at scale

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📘 Conclusion

System design is less about drawing diagrams and more about communicating trade-offs. A great candidate shows structured thinking, flexibility, and awareness of real-world challenges.

"The best system design answers sound like engineering conversations, not rehearsed scripts."