# System Design

For a Senior Software Engineer role, interviewers often focus on assessing a candidate’s ability to design scalable, efficient, and robust systems. Here are some common system design questions that you might encounter:

**1. Scalable System Architecture**

* **Design a URL shortening service (e.g., Bitly)**  
  *How would you design a service that takes a long URL and shortens it, allowing users to retrieve the original URL using the shortened version?*
* **Design a social media news feed (e.g., Facebook)**  
  *How would you design the backend system to fetch and display a personalized news feed efficiently?*
* **Design a messaging system (e.g., WhatsApp)**  
  *How would you handle user-to-user messaging, message queues, notifications, and data storage?*
* **Design a web crawler**  
  *How would you design a system that can crawl billions of web pages efficiently, respecting the robots.txt file and handling distributed workloads?*
* **Design an online booking system (e.g., for flights or hotels)**  
  *How would you handle user requests, prevent double bookings, and ensure availability across multiple services?*

**2. Database and Storage Design**

* **Design a distributed database**  
  *How would you build a distributed database that ensures data consistency and availability? Discuss replication, sharding, and partitioning.*
* **Design a time-series data storage system**  
  *How would you store and efficiently query time-series data, such as metrics from IoT devices or logs?*
* **Design a system to handle large file uploads (e.g., Google Drive)**  
  *How would you handle concurrent uploads, large file chunking, and resuming failed uploads?*
* **Design a log aggregation system (e.g., ELK Stack)**  
  *How would you handle collecting, processing, and storing logs from different microservices for analysis?*

**3. High Availability and Fault Tolerance**

* **Design a system to handle millions of concurrent users (e.g., Twitter or Instagram during peak events)**  
  *How would you ensure the system remains highly available and performant under heavy load?*
* **Design a content delivery network (CDN)**  
  *How would you optimize for caching, load balancing, and serving content closer to the end-users?*
* **Design a multi-region architecture for disaster recovery**  
  *How would you replicate data and ensure that your system is resilient to regional failures?*

**4. Microservices and APIs**

* **Design an e-commerce checkout process**  
  *How would you design the system to handle inventory, payments, and order fulfillment?*
* **Design a notification system (e.g., email, SMS, push notifications)**  
  *How would you handle sending notifications to millions of users in real-time?*
* **Design an API rate limiter**  
  *How would you prevent abuse of your APIs while allowing legitimate users to access your services?*

**5. Data Processing and Real-Time Analytics**

* **Design a real-time analytics dashboard (e.g., for monitoring website traffic)**  
  *How would you handle real-time data ingestion, processing, and visualization?*
* **Design a recommendation system (e.g., for Amazon or Netflix)**  
  *How would you use collaborative filtering, content-based filtering, or a hybrid approach to generate recommendations?*
* **Design a system for processing streams of data (e.g., stock market data)**  
  *How would you build a real-time streaming system that ingests and processes data with low latency?*

**6. Scalability and Performance Optimization**

* **How would you optimize database performance for high read/write traffic?**  
  *Discuss techniques like caching, denormalization, and indexing.*
* **How would you scale a monolithic application into microservices?**  
  *Discuss strategies for breaking down a monolith, handling service communication, and ensuring data consistency.*
* **How would you optimize the performance of a web application under heavy load?**  
  *Discuss load balancing, horizontal scaling, caching strategies, and database optimizations.*

**7. Security and Privacy**

* **Design a secure authentication system**  
  *How would you handle user authentication, session management, and data encryption?*
* **How would you secure an API against common vulnerabilities (e.g., SQL injection, XSS)?**  
  *Discuss strategies like input validation, using HTTPS, and implementing rate limiting.*
* **How would you ensure data privacy and compliance (e.g., GDPR)?**  
  *How would you handle sensitive user data, implement data retention policies, and ensure compliance?*

**Key Concepts to Review:**

1. **System Scalability:** Vertical vs. horizontal scaling, load balancing, caching.
2. **Databases:** SQL vs. NoSQL, indexing, sharding, replication, consistency models.
3. **Microservices Architecture:** Service discovery, API gateways, service mesh.
4. **Message Queues & Event-Driven Systems:** Kafka, RabbitMQ, Pub/Sub models.
5. **Security:** Encryption (in transit and at rest), authentication (OAuth, JWT), secure APIs.
6. **Design Patterns:** CQRS, Event Sourcing, Circuit Breaker, Retry Patterns.
7. **Cloud Infrastructure:** AWS, GCP, Azure components, containerization (Docker), Kubernetes.

Focus on explaining your **thought process**, understanding the **trade-offs**, and considering **edge cases** during the interview.

Alright, let's infuse some creativity into system design questions while still targeting the core competencies a senior software engineer needs. These questions are designed to not only assess technical expertise but also explore innovative thinking, adaptability, and problem-solving in unique and sometimes fun scenarios. Imagine these as a mix of real-world challenges and slightly out-of-the-box systems that require creative thinking.

**1. Event-Based Systems with Real-World Constraints**

* **Design a "Smart City" Traffic Management System**  
  Imagine you’re building a system to optimize traffic flow in a city using IoT sensors on traffic lights, vehicles, and pedestrians. How would you manage real-time data streams, prioritize emergency vehicles, and optimize routes during peak hours or events like parades?
* **Design a "Digital Nomad Hub" Platform**  
  You're creating a platform where digital nomads can find co-working spaces, events, local activities, and connect with others in real-time. How would you build a recommendation engine for personalized suggestions while maintaining user privacy?

**2. Social Impact & Creative Systems**

* **Design a Crisis Communication Platform**  
  Imagine a system for handling disaster alerts (e.g., earthquakes, hurricanes) that can reach millions of people via SMS, emails, and push notifications. How would you ensure reliable delivery, prioritize high-risk areas, and handle bandwidth limitations in disaster zones?
* **Design a "Memory Bank" for Digital Legacy**  
  Imagine a system where users can store messages, videos, and content to be delivered to loved ones after they pass away. How would you ensure data security, handle ethical concerns, and allow users to set rules for releasing this information?

**3. Cutting-Edge Technology Integration**

* **Design a Personalized AI Cooking Assistant**  
  You're building an AI system that can analyze users’ pantry items, dietary preferences, and past meal history to suggest recipes. It needs to handle voice commands, integrate with smart kitchen appliances, and order missing ingredients. How would you design the system to optimize the experience while keeping it responsive?
* **Design a Virtual Reality Workspace Platform**  
  Create a system where remote teams can collaborate in a shared VR workspace with real-time document editing, video conferencing, and spatial audio. How would you ensure low-latency communication, data synchronization, and seamless integration with external services like Google Drive or Jira?

**4. Environmental & Sustainable Systems**

* **Design a Carbon Footprint Tracker for Consumers**  
  Build a platform where users can track their carbon footprint based on their purchases, travel, and energy usage. How would you gather data from various sources, ensure data accuracy, and provide actionable insights to users on reducing their carbon impact?
* **Design a "Smart Farming" System**  
  Imagine building a system that uses IoT sensors, drones, and machine learning to optimize crop yield, monitor soil health, and predict weather impacts. How would you design a scalable architecture to support data from thousands of farms globally?

**5. Gaming & Entertainment**

* **Design a Real-Time Battle Royale Game Backend**  
  Imagine you're building the backend for a battle royale game where up to 100 players can join a match, interact, and battle in real time. How would you handle low-latency communication, cheat prevention, and dynamic scaling as more players join or leave?
* **Design a Music Discovery Platform with AI DJs**  
  Build a music streaming service that uses AI to act as a DJ, creating personalized playlists based on the listener's mood, activity (e.g., working out), and location (e.g., traveling). How would you handle real-time audio streaming, personalization, and copyright compliance?

**6. Healthcare & Wellness Systems**

* **Design a Mental Health Support Chatbot**  
  You're building a chatbot that can provide mental health support, recommend self-care activities, and connect users to licensed therapists if needed. How would you ensure privacy, handle sensitive conversations, and use NLP to detect signs of distress?
* **Design a Remote Health Monitoring System**  
  Build a system for elderly patients that uses wearable devices to monitor vital signs and detect emergencies. It needs to alert caregivers and doctors while ensuring data privacy and compliance with healthcare regulations. How would you handle real-time alerts, data storage, and predictive analytics?

**7. Unconventional Fun & Creative Scenarios**

* **Design a "Digital Time Capsule" Platform**  
  Imagine a platform where users can store messages, photos, and videos to be sent to themselves or others in the future (e.g., 10 years later). How would you handle secure data storage, ensure delivery on a future date, and address potential changes in technology?
* **Design a "Virtual Pet Adoption" System with AI-Powered Pets**  
  Build a system where users can adopt AI pets that grow, learn, and interact with their environment based on user inputs. The system needs to simulate lifelike behaviors, handle real-time interactions, and store each pet's unique "life history." How would you design this to be both scalable and engaging?

**What Interviewers Look For:**

1. **Creative Problem Solving**: How you approach unconventional challenges, whether it’s designing for edge cases, scalability, or innovative integrations.
2. **Scalability & Resilience**: Designing systems that can handle real-world constraints like traffic spikes, large data volumes, and fault tolerance.
3. **Security & Privacy**: Ensuring user data is protected, especially in sensitive domains like healthcare, finance, or personal communication.
4. **Data Management & Real-Time Processing**: Efficient handling of streaming data, analytics, and event-driven architectures.
5. **Adaptability**: How you can apply foundational system design principles to newer fields like IoT, AI, and VR.

These creative and real-world-inspired scenarios challenge you to think beyond the textbook and design systems that could be implemented in today’s rapidly evolving tech landscape.

When it comes to **system design interviews for frontend developers**, especially those with expertise in **Angular**, the focus shifts from traditional backend-heavy system design questions (like database schemas or distributed systems) to problems centered on **architecting scalable and maintainable frontend applications**. These questions test your ability to design an efficient UI system, handle data flows, optimize performance, and structure your Angular applications for scalability.

Below are some **system design questions** that you might encounter in interviews for a frontend developer role with a focus on **Angular**:

**1. Design an Authentication System for a Single Page Application (SPA)**

* **Scenario**: You are tasked with designing an authentication system for an Angular SPA that supports login, registration, password reset, and role-based access control.
* **Things to consider**:
  + How would you handle **token-based authentication** (e.g., JWT)?
  + Where would you store the tokens (localStorage, sessionStorage, cookies)?
  + How would you implement **route guards** for protected routes?
  + How would you refresh tokens securely?
  + How would you design a service to manage user sessions?

**2. Design a Dashboard for a Data-Heavy Application**

* **Scenario**: You need to design a dashboard using Angular that displays multiple widgets (charts, tables, etc.) with real-time data updates.
* **Things to consider**:
  + How would you **structure components** to make them reusable and maintainable?
  + How would you use **RxJS for handling real-time data streams**?
  + How would you optimize performance to handle large datasets (using virtual scrolling, pagination, etc.)?
  + How would you implement a **state management solution** (e.g., NgRx, Akita) for handling shared data between widgets?
  + How would you ensure the dashboard is responsive and works well on different devices?

**3. Design a File Upload Component with Progress Indicator**

* **Scenario**: Build a file upload component that supports drag-and-drop functionality, shows a progress bar, and allows multiple file uploads.
* **Things to consider**:
  + How would you handle large file uploads efficiently (chunking, resumable uploads)?
  + How would you design the component to be reusable in different parts of the application?
  + How would you handle error states and retry logic?
  + How would you show the progress bar using Angular animations?

**4. Design a Notification System for an Angular Application**

* **Scenario**: You are asked to design a notification system where users receive real-time notifications (like messages, alerts, etc.) with a badge counter.
* **Things to consider**:
  + How would you handle **real-time notifications** using WebSocket or Server-Sent Events (SSE)?
  + How would you manage notifications on the frontend (service, component structure)?
  + How would you persist notifications and badge counts across sessions?
  + How would you ensure notifications are **accessible and mobile-friendly**?

**5. Design a Dynamic Form Builder in Angular**

* **Scenario**: Create a form builder that allows users to drag and drop fields (text, dropdown, checkbox, etc.) and save form configurations.
* **Things to consider**:
  + How would you use Angular’s **Reactive Forms** to handle dynamic form controls?
  + How would you structure the data model for saving and retrieving form configurations?
  + How would you handle form validations for dynamically added fields?
  + How would you optimize performance when dealing with large, complex forms?

**6. Design a Modular Angular Application**

* **Scenario**: Your company’s product is growing, and you want to refactor your Angular application into a modular structure to enable easier feature releases.
* **Things to consider**:
  + How would you organize your **Angular modules** (e.g., feature modules, shared modules, core modules)?
  + How would you handle **lazy loading** to optimize the initial load time?
  + How would you manage cross-module communication?
  + How would you structure **route guards and services** in a modular app?

**7. Design a Multi-Language Support System**

* **Scenario**: You are tasked with implementing internationalization (i18n) for an existing Angular application to support multiple languages.
* **Things to consider**:
  + How would you use Angular’s built-in **i18n** capabilities or libraries like ngx-translate?
  + How would you manage language files and translations?
  + How would you implement dynamic language switching without reloading the page?
  + How would you ensure that **date, currency, and number formats** are localized?

**8. Design a Performance-Optimized Angular Application**

* **Scenario**: Your application is experiencing slow load times, and you need to optimize its performance.
* **Things to consider**:
  + How would you implement **lazy loading** and **preloading strategies**?
  + How would you optimize the use of Angular’s **change detection** (OnPush strategy)?
  + How would you use **Angular CLI’s build optimizations** (e.g., Ahead-of-Time compilation, tree shaking)?
  + How would you reduce the initial bundle size (e.g., code splitting, optimizing third-party libraries)?
  + How would you handle **caching strategies** using service workers?

**9. Design a Themeable Angular Application**

* **Scenario**: Implement a theme switcher that allows users to switch between light, dark, and high-contrast themes.
* **Things to consider**:
  + How would you use **CSS variables** and **Angular styling** to implement theme switching?
  + How would you persist the user’s theme preference?
  + How would you handle theme-related issues with third-party libraries?
  + How would you ensure accessibility with different themes (contrast, color blindness)?

**10. Design a Chat Application**

* **Scenario**: Build a chat application where users can send messages in real-time, with features like typing indicators, read receipts, and offline support.
* **Things to consider**:
  + How would you use WebSockets for **real-time communication**?
  + How would you implement a **message queue** to handle message ordering and reliability?
  + How would you handle offline mode and **message synchronization** once the user is back online?
  + How would you optimize for mobile devices and handle responsive design?

**Key Concepts to Focus on for Frontend System Design Interviews:**

* **Component Architecture**: Designing reusable, maintainable, and scalable Angular components.
* **State Management**: Using NgRx, services, or other patterns to manage state across your application.
* **Performance Optimization**: Techniques like lazy loading, OnPush change detection, memoization, and efficient RxJS usage.
* **Asynchronous Programming**: Mastering RxJS streams, promises, and handling complex async workflows.
* **Modular Design**: Structuring your Angular applications into feature modules, shared modules, and core modules.
* **User Experience (UX)**: Handling accessibility (a11y), responsive design, and optimizing for mobile devices.
* **Security**: Preventing XSS, CSRF, and ensuring secure storage of sensitive data in SPAs.

By mastering these topics, you’ll be well-prepared to tackle system design questions in a frontend context, especially those focused on Angular applications.

# Leet Code Problems

LeetCode is a popular platform used by many companies to assess candidates' problem-solving skills in coding interviews. Here are some of the most famous LeetCode problems that interviewers frequently ask, especially for senior software engineering roles:

**1. Array & Hashing**

* **Two Sum** (#1)  
  *Given an array of integers nums and an integer target, return indices of the two numbers such that they add up to target.*
* **Product of Array Except Self** (#238)  
  *Given an integer array nums, return an array output such that output[i] is equal to the product of all the elements of nums except nums[i].*
* **Longest Consecutive Sequence** (#128)  
  *Given an unsorted array of integers, find the length of the longest consecutive elements sequence.*
* **Contains Duplicate** (#217)  
  *Check if the given array contains any duplicates.*

**2. Two Pointers**

* **Trapping Rain Water** (#42)  
  *Given n non-negative integers representing the height of walls, find the amount of water that can be trapped after raining.*
* **Container With Most Water** (#11)  
  *Given n vertical lines on the x-axis, find two lines that together with the x-axis form a container that holds the most water.*
* **3Sum** (#15)  
  *Given an integer array nums, return all the triplets [nums[i], nums[j], nums[k]] such that they sum to zero.*
* **Valid Palindrome** (#125)  
  *Determine if a string is a palindrome, considering only alphanumeric characters and ignoring cases.*

**3. Binary Search**

* **Binary Search** (#704)  
  *Implement a binary search algorithm on a sorted array.*
* **Search in Rotated Sorted Array** (#33)  
  *Given a rotated sorted array, find the target value if it exists.*
* **Median of Two Sorted Arrays** (#4)  
  *Find the median of two sorted arrays of different lengths.*
* **Find Minimum in Rotated Sorted Array** (#153)  
  *Find the minimum element in a rotated sorted array without duplicates.*

**4. Dynamic Programming**

* **Climbing Stairs** (#70)  
  *You are climbing a staircase. It takes n steps to reach the top. Each time you can climb 1 or 2 steps. How many distinct ways can you reach the top?*
* **Longest Increasing Subsequence** (#300)  
  *Find the length of the longest increasing subsequence in an array.*
* **Coin Change** (#322)  
  *Given an array of coins and an amount, find the minimum number of coins needed to make up that amount.*
* **House Robber** (#198)  
  *Given an array of non-negative integers representing the amount of money in each house, determine the maximum amount of money you can rob without robbing two adjacent houses.*

**5. Linked Lists**

* **Reverse Linked List** (#206)  
  *Reverse a singly linked list.*
* **Merge Two Sorted Lists** (#21)  
  *Merge two sorted linked lists into one sorted linked list.*
* **Linked List Cycle** (#141)  
  *Detect if a linked list has a cycle.*
* **Remove Nth Node From End of List** (#19)  
  *Remove the N-th node from the end of a linked list.*

**6. Trees & Graphs**

* **Binary Tree Inorder Traversal** (#94)  
  *Perform an inorder traversal of a binary tree.*
* **Validate Binary Search Tree** (#98)  
  *Determine if a given binary tree is a valid binary search tree.*
* **Lowest Common Ancestor of a Binary Tree** (#236)  
  *Find the lowest common ancestor of two nodes in a binary tree.*
* **Course Schedule** (#207)  
  *There are n courses, labeled from 0 to n-1, with some courses having prerequisites. Determine if you can finish all courses.*
* **Word Ladder** (#127)  
  *Given two words (beginWord and endWord) and a dictionary, find the shortest transformation sequence from beginWord to endWord.*

**7. Backtracking**

* **Subsets** (#78)  
  *Given an integer array nums, return all possible subsets (the power set).*
* **Combination Sum** (#39)  
  *Find all unique combinations in a set of candidates where the chosen numbers sum to a target.*
* **Sudoku Solver** (#37)  
  *Write a program to solve a Sudoku puzzle by filling the empty cells.*
* **N-Queens** (#51)  
  *Place n queens on an n × n chessboard such that no two queens attack each other.*

**8. Heap / Priority Queue**

* **Merge K Sorted Lists** (#23)  
  *Merge k sorted linked lists into one sorted linked list.*
* **Top K Frequent Elements** (#347)  
  *Given an integer array, return the k most frequent elements.*
* **Kth Largest Element in an Array** (#215)  
  *Find the k-th largest element in an unsorted array.*

**9. String Manipulation**

* **Longest Palindromic Substring** (#5)  
  *Given a string, find the longest palindromic substring.*
* **Group Anagrams** (#49)  
  *Group a list of strings into anagrams.*
* **Minimum Window Substring** (#76)  
  *Find the minimum window in s which contains all the characters of t.*
* **Regular Expression Matching** (#10)  
  *Implement regular expression matching with support for '.' and '\*'.*

**10. Bit Manipulation**

* **Single Number** (#136)  
  *Given a non-empty array of integers, every element appears twice except for one. Find that single one using bit manipulation.*
* **Counting Bits** (#338)  
  *Given a non-negative integer num, count the number of 1’s in the binary representation of every number from 0 to num.*

**Tips for Interview Preparation:**

1. **Master Patterns**: Understand the core problem-solving patterns (e.g., sliding window, dynamic programming, divide and conquer).
2. **Practice Mock Interviews**: Simulate the interview environment to improve time management and communication.
3. **Explain Your Thought Process**: Practice explaining your solution clearly to the interviewer, including edge cases and optimizations.
4. **Optimize Solutions**: Focus on writing clean, efficient code, and always look for ways to optimize time and space complexity.

Focusing on these popular problems will help you be well-prepared for coding interviews at top tech companies!

For frontend developers, especially those focusing on Angular, TypeScript, and JavaScript, the coding interview questions often emphasize your ability to work with **data structures**, **algorithms**, and **core frontend concepts** like DOM manipulation, asynchronous programming, and optimization for web performance.

Below are **LeetCode problems and coding challenges** specifically curated for frontend-focused interviews. These questions are designed to test your knowledge of **JavaScript, TypeScript, Angular, and web development concepts**.

**1. Arrays & Strings**

* **Two Sum** (#1)  
  *Classic problem to test your ability to work with arrays and hash maps. Use TypeScript for cleaner type handling.*
* **Valid Parentheses** (#20)  
  *Check if a string containing various types of brackets is valid. Great for practicing stack operations using TypeScript.*
* **Longest Substring Without Repeating Characters** (#3)  
  *Efficiently find the longest substring with all unique characters using the sliding window technique.*
* **Group Anagrams** (#49)  
  *Group words that are anagrams of each other. Useful for practicing object manipulation in JavaScript.*
* **Roman to Integer** (#13)  
  *Convert a Roman numeral string to an integer. Tests your knowledge of string traversal and mappings.*

**2. Two Pointers & Sliding Window**

* **Container With Most Water** (#11)  
  *A common problem using the two-pointer technique to find maximum area. Useful for understanding optimization using pointers.*
* **Longest Palindromic Substring** (#5)  
  *Find the longest palindromic substring in a given string using dynamic programming or expand-around-center technique.*
* **Minimum Window Substring** (#76)  
  *Given two strings, find the smallest substring in the first string that contains all characters of the second. Good for understanding sliding window patterns.*

**3. Data Manipulation & DOM-like Structures**

* **Evaluate Reverse Polish Notation** (#150)  
  *Simulates working with stacks, similar to managing the DOM tree in Angular.*
* **Decode String** (#394)  
  *Given an encoded string, decode it using a stack. Great for practicing recursion and nested structures which are common in component trees.*
* **Flatten Nested List Iterator** (#341)  
  *Flatten a nested list of integers. Think of it like handling nested Angular components or flattening deeply nested JSON data.*

**4. Sorting & Searching**

* **Merge Intervals** (#56)  
  *Given a collection of intervals, merge all overlapping intervals. This is useful in scenarios like scheduling UI events.*
* **Search in Rotated Sorted Array** (#33)  
  *Helps you understand searching and handling edge cases, similar to optimizing Angular components with search filters.*
* **Top K Frequent Elements** (#347)  
  *Tests your understanding of using hash maps and sorting. Useful for efficiently displaying popular content in a UI.*

**5. Dynamic Programming**

* **Climbing Stairs** (#70)  
  *Tests your ability to optimize repetitive calculations, similar to memoizing results in Angular services.*
* **House Robber** (#198)  
  *Tests understanding of dynamic programming in scenarios where previous results affect future choices.*
* **Maximum Subarray** (#53)  
  *Find the contiguous subarray with the maximum sum. Useful for optimizing resource-intensive UI updates.*

**6. Asynchronous Programming & Promises**

* **Promise.all** (Implement your own version)  
  *Test your understanding of JavaScript promises by implementing Promise.all.*
* **Debounce Function**  
  *Implement a debouncing function to limit the rate at which a function can fire. This is crucial for optimizing Angular form validations or search inputs.*
* **Throttling Function**  
  *Implement a throttling function to limit the rate of event handling (like scroll or resize events).*

**7. Frontend-Specific Challenges**

* **Deep Clone a JavaScript Object**  
  *Write a function to deeply clone an object, considering nested properties and arrays. Useful for state management in Angular.*
* **Implement a Simple Event Emitter**  
  *Create an event emitter class that supports on, off, and emit methods. This is similar to Angular’s EventEmitter but from scratch.*
* **Virtual DOM Diffing Algorithm**  
  *Implement a simple virtual DOM diffing algorithm. This can help you understand Angular's change detection mechanism.*
* **Flatten Deeply Nested JSON Object**  
  *Given a deeply nested JSON object, flatten it. Useful for handling complex data structures in Angular apps.*

**8. Tree & Graph Traversal (DOM-like Structures)**

* **Maximum Depth of Binary Tree** (#104)  
  *Similar to traversing and calculating the depth of nested Angular components.*
* **Invert Binary Tree** (#226)  
  *Invert a binary tree, which is similar to manipulating nested Angular elements.*
* **Clone Graph** (#133)  
  *Clone a graph using BFS or DFS. Useful for scenarios where you need to clone deeply nested structures.*

**9. HTML, CSS & Browser API Questions**

* **Implement a Modal Component from Scratch**  
  *Create a simple modal component with close functionality using HTML, CSS, and vanilla JavaScript.*
* **CSS Grid vs. Flexbox**  
  *Explain the differences between CSS Grid and Flexbox and when to use each in Angular applications.*
* **Lazy Loading Images**  
  *Implement a lazy loading feature for images using Intersection Observer API.*

**10. Angular & TypeScript Specific Questions**

* **RxJS Operators**  
  *Explain the difference between mergeMap, switchMap, concatMap, and exhaustMap. Demonstrate with examples.*
* **Angular Lifecycle Hooks**  
  *Explain the sequence of Angular lifecycle hooks and their use cases.*
* **Dependency Injection**  
  *Explain Angular's dependency injection system and how to use @Injectable, providers, and hierarchical injectors.*
* **Change Detection Strategies**  
  *Explain the difference between OnPush and default change detection. Demonstrate how to optimize components using these strategies.*

**Tips for Frontend Interviews:**

1. **Understand JavaScript Fundamentals**: Master concepts like closures, event loop, this keyword, promises, and async/await.
2. **Focus on Angular Concepts**: Be prepared to explain Angular-specific topics like change detection, RxJS patterns, and component communication.
3. **TypeScript Proficiency**: Understand interfaces, type unions, generics, and decorators to write efficient, type-safe code.
4. **Optimize for Performance**: Know how to optimize Angular apps using lazy loading, route guards, OnPush change detection, and efficient RxJS patterns.
5. **Practice UI Challenges**: Implement common components like modals, infinite scroll, and debounced search bars to showcase your frontend skills.

Practicing these problems will help you prepare for frontend interviews, especially those focused on Angular, TypeScript, and JavaScript.

Here are some common and basic LeetCode problems that are frequently asked in coding interviews:

1. **Two Sum**  
   Problem: Given an array of integers, return the indices of the two numbers such that they add up to a specific target.
   * **Difficulty**: Easy
2. **Reverse Linked List**  
   Problem: Reverse a singly linked list.
   * **Difficulty**: Easy
3. **Merge Two Sorted Lists**  
   Problem: Merge two sorted linked lists into one sorted list.
   * **Difficulty**: Easy
4. **Valid Parentheses**  
   Problem: Given a string containing just the characters '(', ')', '{', '}', '[' and ']', determine if the input string is valid.
   * **Difficulty**: Easy
5. **Maximum Subarray (Kadane's Algorithm)**  
   Problem: Find the contiguous subarray (containing at least one number) which has the largest sum and return its sum.
   * **Difficulty**: Easy
6. **Longest Substring Without Repeating Characters**  
   Problem: Given a string, find the length of the longest substring without repeating characters.
   * **Difficulty**: Medium
7. **Climbing Stairs**  
   Problem: You are climbing a staircase. Each time you can either climb 1 or 2 steps. How many distinct ways can you climb to the top?
   * **Difficulty**: Easy
8. **Palindrome Number**  
   Problem: Determine whether an integer is a palindrome. An integer is a palindrome when it reads the same backward as forward.
   * **Difficulty**: Easy
9. **Single Number**  
   Problem: Given a non-empty array of integers, every element appears twice except for one. Find that single one.
   * **Difficulty**: Easy
10. **Intersection of Two Arrays**  
    Problem: Given two arrays, find their intersection.
    * **Difficulty**: Easy
11. **Linked List Cycle**  
    Problem: Given a linked list, determine if it has a cycle in it.
    * **Difficulty**: Easy
12. **Best Time to Buy and Sell Stock**  
    Problem: Given an array where the i-th element is the price of a given stock on day i, find the maximum profit you can achieve.
    * **Difficulty**: Easy
13. **Find Missing Number**  
    Problem: Given an array containing n distinct numbers taken from 1 to n+1, find the one that is missing from the array.
    * **Difficulty**: Easy
14. **First Unique Character in a String**  
    Problem: Given a string, find the first non-repeating character in it and return its index.
    * **Difficulty**: Easy
15. **Count and Say**  
    Problem: The count-and-say sequence is a sequence of digit strings defined by the following rules: 1. 1 is the first number. 2. To generate the next number in the sequence, say the digits of the current number, counting the number of digits in groups of the same digit.
    * **Difficulty**: Easy

Here are some intermediate-to-advanced LeetCode problems that are often asked in coding interviews:

1. **Three Sum**  
   Problem: Given an array of integers, return all unique triplets in the array which give the sum of zero.
   * **Difficulty**: Medium
2. **Longest Palindromic Substring**  
   Problem: Given a string, find the longest substring that is a palindrome.
   * **Difficulty**: Medium
3. **Group Anagrams**  
   Problem: Given an array of strings, group the anagrams together.
   * **Difficulty**: Medium
4. **Add Two Numbers**  
   Problem: Add two numbers represented by two linked lists, where each node contains a single digit.
   * **Difficulty**: Medium
5. **Valid Sudoku**  
   Problem: Determine if a 9x9 Sudoku board is valid. Only the filled cells need to be validated.
   * **Difficulty**: Medium
6. **Word Search**  
   Problem: Given a 2D board and a word, check if the word exists in the grid.
   * **Difficulty**: Medium
7. **Reverse Words in a String**  
   Problem: Given an input string, reverse the order of the words without reversing the characters within the words.
   * **Difficulty**: Medium
8. **Find Peak Element**  
   Problem: A peak element is an element that is greater than or equal to its neighbors. Find any peak element in an array.
   * **Difficulty**: Medium
9. **Search in Rotated Sorted Array**  
   Problem: Given a rotated sorted array, find the target element. You must write a solution with a time complexity of O(log n).
   * **Difficulty**: Medium
10. **Maximum Product Subarray**  
    Problem: Given an integer array, find the contiguous subarray within the array that has the largest product.
    * **Difficulty**: Medium
11. **Binary Tree Level Order Traversal**  
    Problem: Given a binary tree, return the level order traversal of its nodes' values.
    * **Difficulty**: Medium
12. **Coin Change**  
    Problem: You are given an integer array coins representing coins of different denominations and an integer amount representing a total amount of money. Return the fewest number of coins that you need to make up that amount.
    * **Difficulty**: Medium
13. **Permutations**  
    Problem: Given an array of distinct integers, return all the possible permutations.
    * **Difficulty**: Medium
14. **Container With Most Water**  
    Problem: Given n non-negative integers representing the height of a vertical line at each index, find two lines that together with the x-axis form a container such that the container contains the most water.
    * **Difficulty**: Medium
15. **Kth Smallest Element in a Sorted Matrix**  
    Problem: Given an n x n matrix where each of the rows and columns are sorted in ascending order, find the kth smallest element in the matrix.
    * **Difficulty**: Medium

These problems test knowledge of various algorithms like sorting, searching, dynamic programming, tree traversal, and graph traversal. Solving them requires a deeper understanding of problem-solving techniques and the ability to optimize solutions efficiently.

# Common

Here are some common interview questions that might be asked when interviewing for a **Senior Angular Developer** or **Frontend Architect** role:

**1. Angular & Framework-Specific Questions**

* What are the main differences between AngularJS and Angular?
* Can you explain the concept of Angular modules? How do you organize them in a large project?
* How does Angular's dependency injection system work? Can you give an example?
* What are the main lifecycle hooks in Angular? How would you use ngOnInit vs constructor?
* What is the purpose of ngZone in Angular?
* How do you handle state management in Angular applications? Have you used NgRx, Akita, or any other state management libraries?
* How would you optimize the performance of an Angular application?
* What are Angular guards, and how would you use them to protect routes?
* Can you explain the purpose of ChangeDetectionStrategy.OnPush? When would you use it?
* What is lazy loading in Angular? How do you implement it?
* How do you handle forms in Angular? What’s the difference between template-driven and reactive forms?
* Can you explain how Angular’s ViewEncapsulation works? What are the different types available?
* How would you implement dynamic components in Angular?
* What is the difference between Observable and Promise in Angular?
* How would you debug an Angular application?

**2. Architecture & Design Questions**

* How do you design a scalable and maintainable Angular architecture?
* What strategies would you use to structure a large enterprise-level Angular project?
* How do you handle versioning and compatibility for frontend libraries in your projects?
* What are the best practices for managing global state in a large-scale Angular application?
* How would you ensure code quality in a frontend project? (e.g., code reviews, linters, unit testing)
* How do you ensure your code is optimized for performance in production?
* How do you approach building responsive and accessible web applications?
* Can you describe your experience with micro-frontend architecture?
* What are your strategies for code splitting and reducing the initial load time?
* How would you implement a design system across multiple Angular projects?

**3. Testing & Debugging**

* How do you write unit tests for Angular components, services, and directives?
* How do you test HTTP services in Angular?
* What are the tools you use for end-to-end testing? Have you used Cypress, Protractor, or Playwright?
* How would you debug a memory leak in an Angular application?
* How do you handle browser compatibility issues?

**4. JavaScript/TypeScript & Web Technologies**

* What are the key differences between TypeScript and JavaScript? Why is TypeScript preferred in Angular?
* Can you explain how JavaScript closures work? How have you used them in your projects?
* How do you handle asynchronous operations in JavaScript/TypeScript?
* What are the differences between let, var, and const?
* Can you explain how the event loop and the JavaScript call stack work?
* What are some of the latest ECMAScript features you have used?

**5. CSS & UI/UX**

* How do you handle styling in Angular components?
* What is CSS specificity, and how does it affect your styles?
* How do you implement a responsive design? Have you used any CSS frameworks like Tailwind, Bootstrap, or Material Design?
* How do you handle browser caching for frontend assets?
* What tools and techniques do you use to ensure accessibility (a11y) in your applications?

**6. DevOps & Tooling**

* How do you deploy Angular applications to production?
* What is the difference between ng build and ng serve?
* How do you use Angular CLI for project management?
* Can you explain how you handle continuous integration and deployment (CI/CD) for frontend projects?
* How do you optimize build processes in Angular, like using Webpack or ESBuild?

**7. Behavioral & Experience-Based Questions**

* Can you describe a challenging Angular project you’ve worked on? What were the key takeaways?
* How do you prioritize tasks and manage deadlines on a busy project?
* How do you keep up with the latest trends and updates in frontend development?
* Describe a situation where you had to mentor junior developers.
* How do you handle disagreements in your team about design or technology decisions?

These questions cover a mix of **technical, architectural, and behavioral topics** to gauge your experience and expertise in frontend development, specifically Angular, as well as your ability to handle real-world challenges and work in a team.

Let's add some creativity and challenge to the mix! Here are some unique, thought-provoking, and scenario-based questions designed to really test the skills and mindset of a **Senior Angular Developer or Frontend Architect**:

**1. Creative Angular Challenges**

* Imagine you’re tasked with refactoring a legacy AngularJS project to Angular 16. What’s your game plan to ensure minimal downtime and a smooth transition?
* Your product owner wants to add a complex data visualization chart, but with custom interactions that aren't supported out-of-the-box by any library. How would you approach building this in Angular?
* How would you build a custom directive that applies "dark mode" to a complex Angular component tree with minimal re-rendering?
* If Angular suddenly announced it would be dropping support for decorators, how would you adapt your current projects?
* Suppose Angular introduces a major breaking change in its next version. How would you prepare your team and projects for such updates?

**2. Architectural Design Scenarios**

* You’ve inherited a large Angular monolith project that’s becoming too unwieldy. How would you start breaking it into micro frontends without affecting existing users?
* The backend API your Angular app depends on is notorious for being unreliable. How would you architect a solution that ensures the frontend remains responsive and resilient to downtime?
* You're building a complex Angular application that handles sensitive financial data. What architectural decisions would you prioritize to ensure security and scalability?
* How would you design an Angular application to dynamically switch themes, languages, and layouts on-the-fly, catering to different user preferences?
* Imagine your Angular app needs to support offline usage with real-time data synchronization once back online. How would you architect this using service workers, IndexedDB, or other techniques?

**3. Testing & Debugging Brain Teasers**

* You're investigating a sporadic bug that only occurs when users have been on the site for over an hour. How would you go about debugging this in your Angular app?
* Suppose your team discovers a memory leak after a recent deployment. What steps would you take to locate and fix it in an Angular application?
* You wrote a test suite that suddenly fails after a minor version upgrade of Angular. The tests were passing before. How do you identify and fix the issue efficiently?

**4. Out-of-the-Box TypeScript & JavaScript Questions**

* Let’s say you’re working on a team with mixed TypeScript experience. How would you convince them of the benefits of TypeScript without overwhelming them?
* Imagine you need to rewrite a core function that’s been causing performance issues, but you have no documentation and the original developer has left the company. How would you approach refactoring it safely?
* Write a custom TypeScript utility type that extracts only the function properties from a given object type.

**5. User Experience & Design Challenges**

* How would you design an Angular application to be fully accessible, ensuring compliance with WCAG 2.1 AA standards?
* You have a request from the design team to animate every button on the page, but you know this could impact performance. How would you negotiate a balance between performance and design?
* Suppose your client wants to add voice commands to your Angular app. How would you integrate this functionality?

**6. DevOps & Deployment Hypotheticals**

* Your team’s Angular application is experiencing unusually long build times in CI/CD pipelines. How would you diagnose and reduce the build time?
* The CEO wants a feature toggle mechanism to instantly turn features on/off without redeploying the Angular app. How would you implement this?
* Your Angular application needs to be served in multiple regions around the world with minimal latency. How would you design the deployment strategy?

**7. Behavioral & Leadership Challenges**

* Imagine you’re leading a team of developers, and you notice they’re hesitant to refactor code due to fear of breaking things. How would you encourage a culture of continuous improvement?
* A new junior developer joins your team and is overwhelmed with Angular concepts. How would you mentor them to get up to speed?
* You've been assigned to review a critical Angular feature developed by another team. During the review, you find significant performance bottlenecks. How do you communicate this feedback constructively?

**8. Fun & Abstract Questions**

* If you could change one thing about Angular, what would it be and why?
* Describe an Angular project you’re most proud of, but with a twist—explain it as if you were telling a story to someone who knows nothing about software development.
* Let’s pretend you’re a superhero, and your superpower is solving Angular bugs instantly. What’s the most challenging bug you’ve ever fixed, and how did your superpower help you?

These questions go beyond just technical know-how—they assess your **problem-solving skills, creativity, leadership, and ability to handle complex, real-world scenarios**. They’re designed to see how you think on your feet and adapt to the unexpected, which is essential for senior and architect-level roles!

Frontend architecture is a crucial topic in interviews, especially when assessing a candidate's ability to design, maintain, and scale large web applications. Here are some thoughtful questions to evaluate a candidate’s understanding of frontend architecture, organized by key areas:

**1. General Frontend Architecture**

* How would you design the architecture of a large-scale web application?
* What are the key principles you consider when architecting a frontend system?
* How do you decide between a monolithic frontend and a micro-frontend architecture?
* What are the benefits and drawbacks of using a Single Page Application (SPA) vs. Multi-Page Application (MPA)?
* How would you structure the folder hierarchy of a medium-to-large Angular/React/Vue project?

**2. Scalability & Maintainability**

* How would you ensure your application is scalable and easy to maintain as it grows?
* What strategies do you use to manage state in large frontend applications?
* How do you handle dependencies and version management in a frontend project?
* How would you structure your application to support multiple themes or internationalization (i18n)?
* How do you manage code splitting and lazy loading to improve performance?

**3. Performance Optimization**

* What techniques do you use to optimize frontend performance?
* How would you reduce the initial load time of a web application?
* What are some ways to handle performance bottlenecks caused by heavy JavaScript bundles?
* How do you optimize rendering performance in Angular/React/Vue?
* How do you use tools like Lighthouse, Web Vitals, or Chrome DevTools to analyze and improve performance?

**4. Design Patterns & Best Practices**

* What design patterns do you commonly use in frontend development (e.g., MVC, Flux, Observer)?
* How do you handle reusable components in a frontend architecture?
* Can you explain the concept of Dependency Injection, and how it's used in frameworks like Angular?
* What is the difference between a **container component** and a **presentational component**, and when would you use each?
* How do you manage and structure your CSS to avoid conflicts in large projects?

**5. State Management & Data Flow**

* How do you decide between using a state management library (like NgRx, Redux, or MobX) versus local component state?
* How would you handle cross-component communication in an Angular/React application?
* What are some challenges associated with global state management, and how do you mitigate them?
* How would you handle complex forms and validations in a frontend application?

**6. Security & Accessibility**

* What strategies do you use to prevent common frontend security vulnerabilities (e.g., XSS, CSRF)?
* How would you handle sensitive data on the client side?
* How do you ensure that your frontend application is accessible (a11y) to all users?
* What are some best practices for managing user authentication and authorization in a frontend app?

**7. Testing & Quality Assurance**

* How do you approach writing unit, integration, and end-to-end tests for your frontend code?
* What tools do you use for testing components, services, and UI interactions (e.g., Jasmine, Jest, Cypress)?
* How do you set up continuous integration (CI) for testing and deploying a frontend application?
* How would you test a component that depends on an external API?

**8. Build Systems & Tooling**

* How do you optimize build times in a large project (e.g., Webpack, Vite, esbuild)?
* What is your approach to setting up a CI/CD pipeline for frontend applications?
* How do you handle environment-specific configurations in your builds (e.g., dev, staging, production)?
* How do you handle code versioning and branching strategies in a frontend project?

**9. Micro-Frontends & Modularization**

* What are micro-frontends, and when would you choose to use them?
* How do you manage shared dependencies and communication between micro-frontend modules?
* What are some challenges associated with implementing micro-frontends?
* How would you ensure a consistent user experience when using micro-frontends?

**10. Progressive Web Apps (PWA)**

* What are the key benefits of building a Progressive Web App (PWA)?
* How do you enable offline capabilities in a frontend application?
* How would you handle service worker updates and cache management in a PWA?
* How do you optimize a web application to achieve a high Lighthouse PWA score?

**Behavioral & Scenario-Based Questions**

* Can you describe a challenging frontend architecture problem you faced in a previous project and how you solved it?
* Describe a situation where you had to refactor a large portion of a frontend codebase. What was your approach?
* How do you keep up with new frontend technologies and decide which ones to adopt?

These questions aim to assess both theoretical knowledge and practical experience in frontend architecture. Tailoring questions to the candidate's specific experience or the technology stack your company uses can help you gain deeper insights into their expertise.

Here are some common questions a senior Node.js developer might ask regarding their project:

1. **Performance Optimization:**
   * How can we optimize the performance of our Node.js application, particularly with respect to handling a high number of concurrent requests?
   * Are we efficiently managing asynchronous operations, or are there places where we can use Promises, async/await, or streams for better performance?
   * How do we handle memory leaks or monitor memory usage effectively?
2. **Scalability:**
   * What strategies are we using to scale the Node.js application? Are we utilizing clustering or a microservices architecture?
   * How are we managing load balancing, and is there any bottleneck in the request-response cycle?
3. **Error Handling and Logging:**
   * Are we handling errors properly across the application, including unhandled promise rejections and uncaught exceptions?
   * What logging framework are we using, and are we capturing sufficient information for debugging and monitoring in production?
4. **Security:**
   * Are we ensuring secure communication with SSL/TLS, and handling sensitive data properly?
   * How are we preventing common security issues such as SQL injection, XSS, CSRF, and man-in-the-middle attacks?
   * Are we using security headers appropriately, and is user authentication/authorization implemented securely (JWT, OAuth, etc.)?
5. **Testing and Quality:**
   * What testing framework are we using, and is it being applied to all layers of the application (unit, integration, e2e)?
   * How are we managing test coverage, and are we using tools like Istanbul or coverage report tools to ensure quality?
   * Are we performing load or stress testing to ensure the application can handle high traffic?
6. **Database Integration:**
   * How are we managing database connections? Are we using connection pooling, and how are we handling database failovers?
   * Are we using ORM/ODM libraries, and if so, are they optimized for performance and ease of use?
7. **Deployment and CI/CD:**
   * Are we following best practices for deploying the application to production, including automated deployment and rollback strategies?
   * How are we managing environment variables securely in different stages (development, staging, production)?
   * Are we using a CI/CD pipeline, and how can we improve the efficiency and reliability of our build and deployment process?
8. **API Design:**
   * Are we following RESTful principles, or is GraphQL a better choice for our use case?
   * How are we ensuring backward compatibility with the API, and do we have a versioning strategy in place?
9. **Code Quality and Maintenance:**
   * How are we maintaining code quality? Are we using tools like ESLint, Prettier, or TSLint?
   * Is our codebase modular and maintainable, or are there areas where we can refactor and improve readability and structure?
   * Are we using a consistent coding standard across the project, and how can we enforce it?
10. **Caching and Performance:**
    * Are we using caching effectively (e.g., Redis or in-memory caching)?
    * How are we handling cache invalidation, and are there scenarios where we might be over-caching?

These are questions that could help a senior Node.js developer ensure that the project is well-structured, scalable, secure, and maintainable.

Here are some creative, out-of-the-box questions a senior Node.js developer might ask when thinking strategically about their project:

1. **Architectural Evolution:**
   * If we were to start over from scratch today, how would we design the Node.js application differently, considering the current trends like serverless or edge computing?
   * How could we adopt a more event-driven architecture, where each microservice or module reacts to specific events in the system?
2. **Concurrency and Parallelism:**
   * Can we use Web Workers or Worker Threads in Node.js to offload CPU-intensive tasks and avoid blocking the event loop?
   * Is there an innovative way to handle concurrency without adding complexity, like using a message queue to distribute tasks asynchronously across multiple instances?
3. **Real-time Communication:**
   * How can we use WebSockets or Server-Sent Events to create more engaging, real-time features in our application, such as live collaboration or instant notifications?
   * Could we integrate something like GraphQL subscriptions to push data to clients in real time instead of traditional polling?
4. **Fault Tolerance and Graceful Recovery:**
   * How can we create a self-healing Node.js system that can automatically detect and recover from failures (e.g., process crashes or memory overload)?
   * What would it look like to implement a "circuit breaker" pattern in Node.js to prevent cascading failures?
5. **Distributed Tracing:**
   * How can we implement distributed tracing to track requests across multiple microservices, ensuring we can spot performance bottlenecks or errors in complex flows?
   * Are we collecting the right metrics from the entire stack to visualize how requests move from one service to another?
6. **AI/ML Integration:**
   * Can we experiment with machine learning models in Node.js to provide real-time predictions or insights? (e.g., recommendation systems, fraud detection)
   * Could we integrate a Node.js service with TensorFlow.js to run simple ML models directly in the app for enhanced user experiences?
7. **Edge and IoT Use Cases:**
   * What would it take to adapt our Node.js project for the edge, running on IoT devices with limited resources, but still needing to handle asynchronous events in real time?
   * How could we use serverless functions or edge computing to reduce latency and improve user experiences for geographically distributed clients?
8. **Code as Config:**
   * How can we make parts of our application configuration-driven, allowing non-developers to control logic (without writing code) for features like routing, caching policies, or UI changes?
   * Is there a way to dynamically inject or change the behavior of a module or service based on environmental factors like traffic, geography, or user preferences?
9. **Unusual Data Sources:**
   * How can we integrate unusual data sources like sensors, wearables, or external APIs in real-time without slowing down the main application?
   * Could we create a Node.js app that listens to an IoT stream of data and performs instant processing, then pushes that data to a UI in real-time?
10. **Blockchain and Smart Contracts:**
    * Can we use Node.js to interact with blockchain networks and smart contracts, adding decentralized features like secure transactions, authentication, or auditing to our application?
    * What would it take to implement a smart contract within our app that automatically executes actions based on specific conditions (e.g., payments, service activation)?
11. **Edge Case Handling:**
    * What’s the most creative way to handle edge cases that seem impossible, like partial data, unpredictable network conditions, or users inputting completely malformed data?
    * Can we develop a Node.js system that’s so robust it adapts to unexpected situations without throwing errors—handling errors gracefully in ways that surprise us?
12. **Artificial Intelligence (AI) for Developer Productivity:**
    * Can we integrate AI-powered tools into our Node.js development pipeline (e.g., using code suggestions or automated refactoring) to reduce time spent on tedious tasks?
    * How about using AI-based testing that predicts the most likely areas of code that need testing based on recent changes or historical patterns?

These questions challenge the status quo and push the boundaries of what might be possible or beneficial with Node.js. They help imagine ways to elevate the project's technical sophistication, user experience, and maintainability.