Thank You
for Joining With Us 🙏

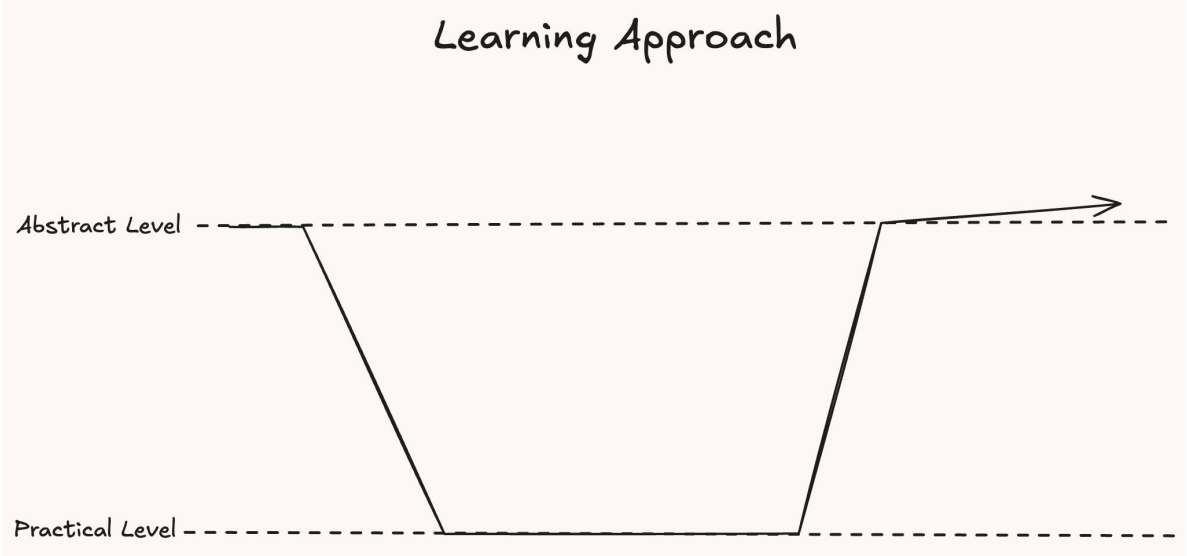
The Goal of the Course

- Techniques to design a system (specially for highly concurrent systems)
- Process of system design.
- Revise, summary knowledge.
- Sharing knowledge between participants.

Notes

- Some content in this course maybe wrong. But I try my best.
- Please feel free to:
  - Feedback
  - Ask
  - Share your knowledge, opinions in the class.
  - Request a specific design.
- You can share your knowledge to others, but please don’t share this class resource.

Learning Approach



Syllabus

1. System Design: In-depth Understanding
2. Design Principles & Estimation
3. Database
4. Caching
5. Communication
6. Microservices & Diagramming
7. Data Structure and Algorithm & Corresponding Case Studies
8. Design URL Shortener system (Bitly)
9. Design a News Feed System (Threads)
10. Design Messaging Platform (Discord)
11. Design a Food Delivery system (DoorDash)
12. Design Digital Wallet (ShopeePay)
13. Design Flash Sale system (Shopify)
14. Mock Interview

System Design

In-depth Understanding

“Stop thinking, and end your problems.”
- Lao Tzu

Outline

1. Understand “System Design”
2. Understand the Problem
3. Design Mindset
4. Practices

1. What is “System Design”?

1.1. What is “System Design”?

- System Design (SD) is a process of defining the structure and operation of a system to meet specific requirement.
- **System Design = Problem Solving + Computer Science**
- **System Design Interview != System Design in Reality**
  - System Design in Reality focus more on constraint resources (time, cost, human) and unknown harmful effects

$$\text{Solution Ideality} = \frac{\text{Benefits (Dimensions: A, B, C, ...)}}{\underbrace{\text{Resources Required}}_{\text{(Time, Cost, Humans)}} + \underbrace{\text{Harmful Effects}}_{\text{(Known + Unknown)}}}$$

Architecture vs Design

1.2. Architecture vs Design

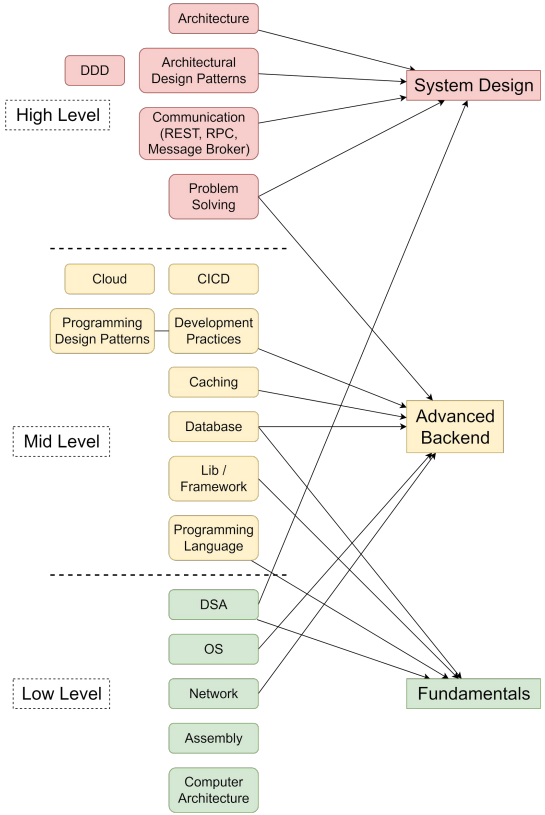
	Architecture	Design
Abstract Level	**Highest Level** **Strategy**	**High Level** **Tactic**
Goal	● Ensure the system meet functional & non-functional requirements ● Guide overall direction of development.	● Ensure the system meet functional & non-functional requirements ● Detail plan to implement
Scope	● **Focus more on non-functional requirements** ● Architectural styles ● Communication styles (sync, async) ● Global	● **Focus on specific functions/problems** ● DSA, logic and technology to solve the problems ● More localized

“Architecture is a overall design.”

Which knowledge is used in designing system?

(Kiến thức gì phục vụ cho quá trình thiết kế hệ thống?)

1.3. Knowledge Mapping



Which ones are fundamentals?
Which ones are important?

(Kiến thức nào là nền tảng?
Kiến thức nào là quan trọng?)

1.4. Knowledge Classification

- Fundamentals:
  - Problem Solving
  - DSA
  - OS
  - Network
  - Concurrent programming
  - Computer Science
- Importance:
  - **Scale out**
  - **Database**
  - **Caching**
  - Communication

- Strategy:
  - **Quan trọng học trước**, nền tảng tích lũy dần.
  - Nếu mắc ở trong “quan trọng"
    → xuống tìm hiểu và chắc nền tảng **liên quan**

What does the interviewer want from interviewees in SD Interview?

(Nhà tuyển dụng muốn gì trong System Design Interview?)

1.5. You need to show off in the SD interview?

- **Problem Solving**
  - How do you clarify the problem?
  - How do you analyze the problem and solutions?
- **Solid fundamental knowledge**
  - Computer Science
- **Communication skills**
  - Proactive
  - Presentation
- Nice to have: Product mindset

Steps in Designing System

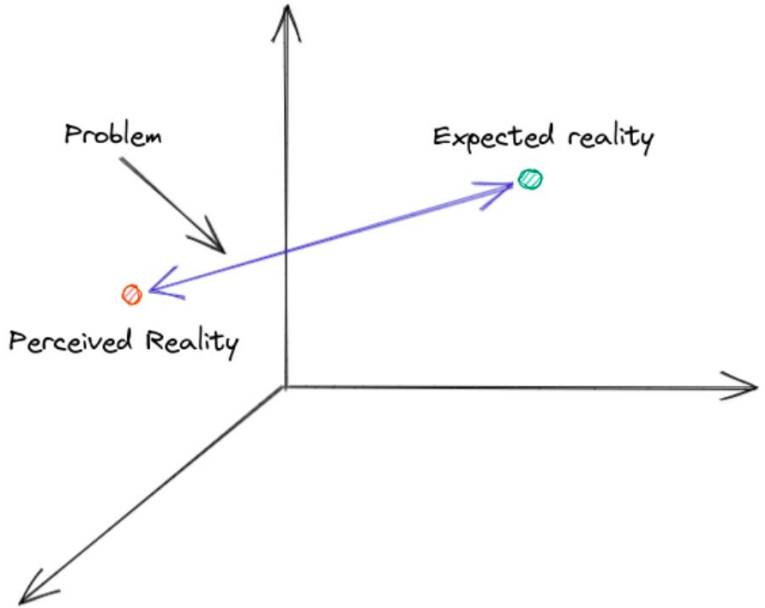
1.6. Steps in Designing System

1. Understand the Problem and Define Scope
2. Estimation
3. High-Level Design
    - API Design: this make sure you understand how the function works
    - Data Model: a summary of info from step 1, 2
    - High-level Design: a draft solution
4. Deep Dive (Low-Level Design)
    - For example: storage space, concurrency issue, …
    - Note:
        - There is no final design
        - Low-level decision may affect to the high-level design

Principle 1: Understand the **Problem** First.
Do not jump to solutions first!

2. What is the definition of problem?

2.1. The Definition of “Problem”



Problem is gaps between perceived reality and expectation for stakeholders.

2.2. How to Understand the Problem?

- Expected:
  - Find ultimate goals (requirements)
    - Functional requirements
    - Non-functional requirements
  - Stakeholders
  - Timeline
- Reality:
  - Existing system
    - Ack constraints (team expertise, costs, …)
    - Note: SD interview usually requires to build a system from scratch
      → this is usually be skipped
  - Clear assumptions
    - **Principle 2: Distinguish between opinion/assumptions and fact**
      → Avoid to get lost or psychological manipulation

2.1. Functional Requirements

2.3. Functional Requirements

- Functional Requirements define what the system should do or interact with users.
- In other word, functional requirements are your purpose/features.
- A system may have many functional requirements, but in the interview, **focus at most 3** requirement to solve

How to find key requirements?

2.3.1. Tips to find key requirements

- (1) The function **solves customer's problem directly**.
- (2) The function **helps biz make money directly**.
- For example: Airbnb System
    - (1): Searching homestay by location
    - (2): Booking a homestay

Exercise 1

- Find functional requirements of a Dating system (Tinder)
  - Creating a profile
  - Generating a feed based on the user location, filter conditions
  - Chatting
  - Subscription

2.3.2. Questioning Guideline to Functional Requirements

- To describe a feature, **the statement must include Actor, Activity, Work Object**
  - Ex: A patient can schedule an appointment with a doctor
    - Actor: patient, doctor
    - Activity: schedule
    - Work Object: an appointment
- The data flow, domain story
- **The most important information, features → most frequency query → data access pattern**
- Flexibility: configure radius, price filter, …
- Type: In-house / SaaS
- UX:
  - Real-time?
  - Edge case?
  - Delivery Guarantee (notification)
  - …

2.2. Non-functional requirement

2.4.1. Non-functional Requirement

- Non-functional requirements are the properties of a system that influence its operation and user experience
- Are not directly tied to specific functionality
- Which non-functional requirements do you know?

2.4.1. Non-functional requirement

Term	Type	Definition
Performance	Operational	How efficiently the software executes its tasks
Availability	Operational	How long the system will need to be available
Reliability	Operational	Ensures consistent operation even in unexpected conditions. If the system fails, will it cost the company large sums of money?
Scalability	Operational	allows the system to adapt to increasing workloads.
Maintainability	Structural	Allows for easy modifications and updates.
Security	Cross-Cutting	Shielding the system and its sensitive data from attackers. Ex: Does the data need to be encrypted in the database?

2.4.2. Questioning for Non-functional Requirements

- Load
  - The number of users, active users
  - DAU (Daily Active Users)
  - The number of Action / user / day on average
- Throughput
  - QPS, TPS
- Storage
  - Save history? How long is the retention?
  - Size of source data, message
  - Growth prediction: the number of customers grow 20% per year
  - Compression is allowed?

2.4.3. How to find key non-functional requirements

- (1) What **hurts the user experience**?
- (2) What **prevents the business growth**?
- Example:
  - (1)
    - Airbnb: users need to find homestay quickly → Performance
    - Bank: Reliability
  - (2)
    - E-commerce: the system stores and handles a lot of products, merchants, payment methods → Scalability
- **SD interview mostly focus on: Scalability, Performance, Availability, Reliability**

2.4.4. Discover the Existing system

- Existing system:
  - What does existing infrastructure look like?
- Constraints
  - What are the budget limitations?
  - When is the deadline?

Exercise 2

- Find non-functional requirements of a Food Delivery system (DoorDash)
  - Scalability
  - Availability
  - Performance

Exercise 3

- Find non-functional requirements of a Trading Engine (Binance)
  - Availability
  - Reliability
  - Security
  - Latency

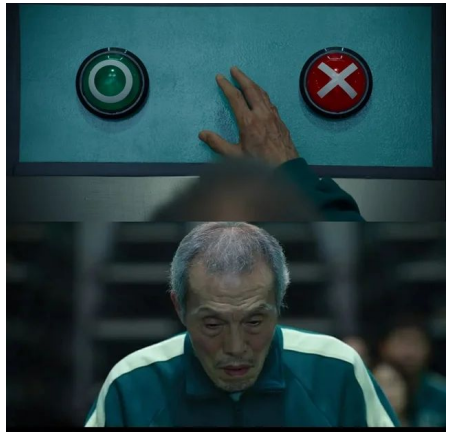
3. Design Mindset

3.1. Design Mindset

- **Principle 3: Trade-off**
  - Be fully aware of limitations of each solution
- **Ability to answer “Why?”**

3.2. Trade-off

- What is “Trade-off”?
  - When you have **multiple solutions** but it is **hard** to choose a solution.
- What factor affect to the final decision?
  - **The order of non-functional requirements (Know what you need)**



3.1. Design Mindset

- **Principle 3: Trade-off**
  - Be fully aware of limitations of each solution
- **Ability to answer “Why?”**
- **The order of non-functional requirements**
  - Scalability (for both tech and biz)
  - Reliability
  - (Security)
  - Performance
  - Availability
  - Note: this order may be changed slightly in the life cycle of a system.

How to Evaluate a Design?

(Làm sao đánh giá được 1 design tốt khi chưa implement?)

3.2. Evaluate a Design

- Necessary Conditions
  - Meet both functional and non-functional requirements
  - Satisfy constraints (timeline, cost, team expertise)
  - Document and explain clearly
- Sufficient Conditions
  - **Strong evidences**
    - **Asking why → find fundamentals to prove the design**
    - For example, requirement: find X from 34 to 88
      - In B+Tree, leaf nodes are sorted. Time complexity to find one end of the range is O(Log(N)). → Time complexity of the finding process: ~ O(Log(N) + M)
      - It's hard to find other data structure with lower time complexity
  - **Scalability**

Recap

- System Design = Real Problem Solving + Computer Science Knowledge
- Problem is gaps between perceived reality and expectation for stakeholders.
- Asking why → find fundamentals to prove the design and clarify the assumptions.

Homework

- Read more, think more of CAP theorem
- Think of principles / techniques for Scalability, Performance, Availability

References

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Thank you 🙏