CESE4015 Software Systems

Unified Modeling Language: An Introduction

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Embedded Systems Group

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Learning objectives

- At the end of the course, you should be able to:
  - Understand:
    - The purpose of UML (unified modeling language)
    - Three categories of UML diagrams:
      - Structural, behavioral, and interactional.
  - Apply basic UML diagrams to model software systems.

- Assessment:
  - Modeling assignments using UML diagrams. [Group of two]
  - Reflection document on UML-based modeling. [Individual]

Agenda for UML

- Week 6 Lecture#1 (17/12):
  - Background of UML
  - Use Case and Component diagrams
- Week 6 Lecture#2 (19/12):
  - Class and Sequence diagrams
  - Time: 13:45~14:45pm @Lecture Hall Boole Building 36.
- Week 6 Lab (19/12):
  - Modeling with UML diagrams
  - Time: 15:00~17:45pm @ PC Hall 2 Building 35.

Acknowledgements

- Slides materials are built from different sources:
  - Slides created by Marty Stepp, CSE403 @ U Washington.
  - *UML Distilled, 3rd edition* by Martin Fowler.
  - *The Unified Modeling Language Reference Manual, 2nd edition* by James Rumbaugh, Ivar Jacobson, and Grady Booch.
  - *Practical UML: A Hands-On Introduction for Developers* by Randy Miller.
  - *IBM Rational Software Architect Documentation:* https://www.ibm.com/docs/en/rational-soft-arch/9.5

- Lab platform:
  - PlantUML: https://plantuml.com/
  - A tutorial will be given by TAs during the lab sessions.
  - In the class, we will work on and cover some examples of the tutorial part as well.

Background

- What is the UML?

  - **UML**: A family of standardized graphical notations that helps in describing and designing software systems at a high level of abstraction.

  - It is a graphical design notation:
    - More clear than natural language and code.
    - Simplifies system design process and avoid a lot of details.
  - Help communicating ideas about a system design.
  - It is language and technology independent.
  - It is a unified/standardized language.

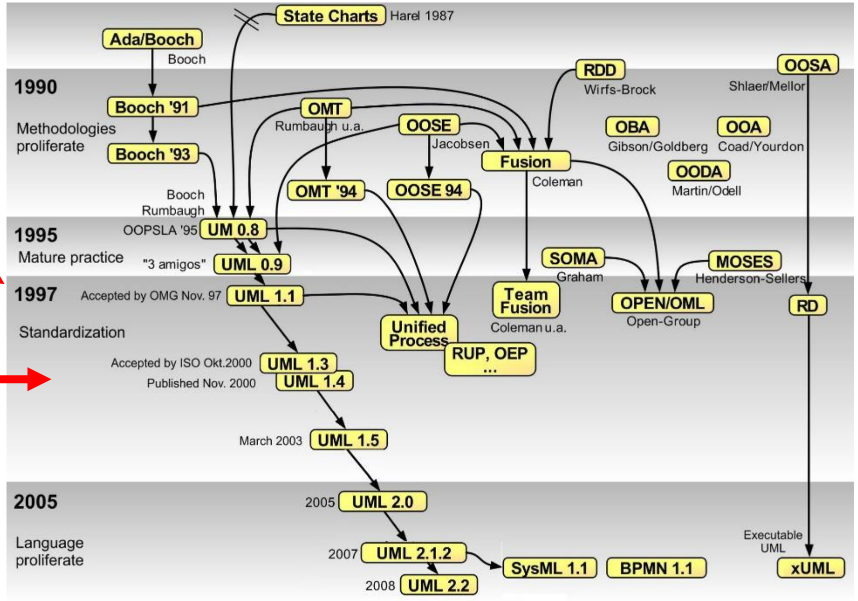
Background (cont.)

- UML is based on many earlier software design approaches:
  - Evolving since 1990s and highly related to object-oriented programming:
    - The Booch method, the Object-modeling Technique (OMT), the Object-oriented Software Engineering (OOSE) and more.

- Driving force:
  - Programming languages do not provide a high enough level of abstraction to facilitate the design.

UML was adopted as a standard by the Object Management Group (OMG)

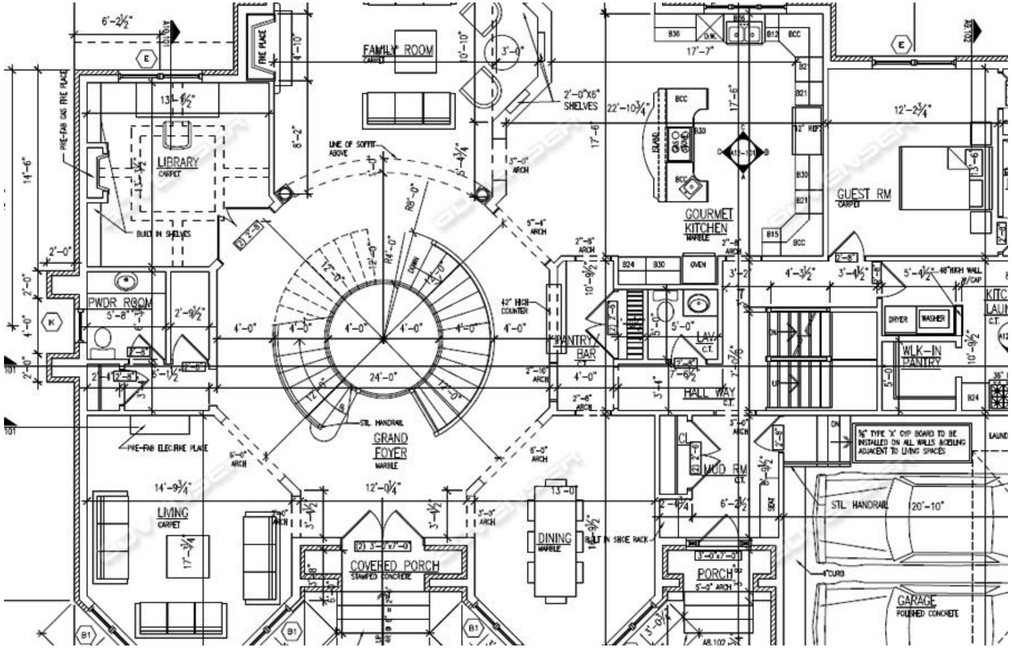
Accepted by IOS as a standard and been periodically revised.



Why bother with the UML?

From the view of building construction:

A unified standard that can be understood by architects and builders.

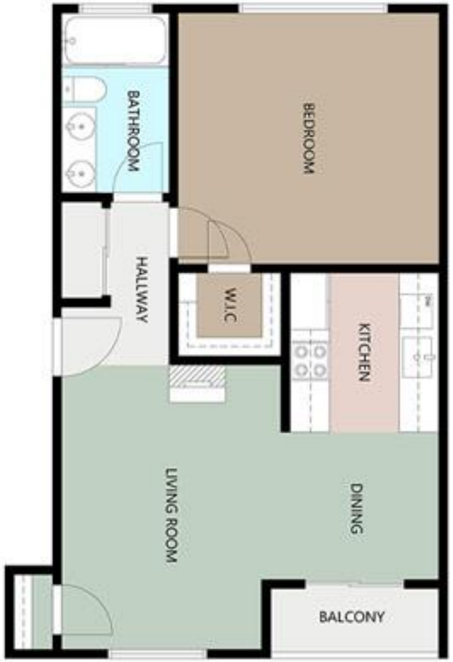


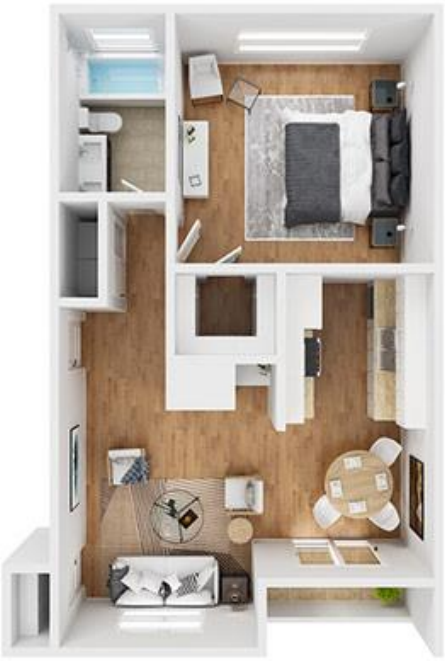
UML is programming language and technology independent and is a unified/standardized language that has been widely used.

Why bother with the UML? (cont.)

From the view of building construction:

Providing different views (and levels of abstraction) of the design based on the needs.





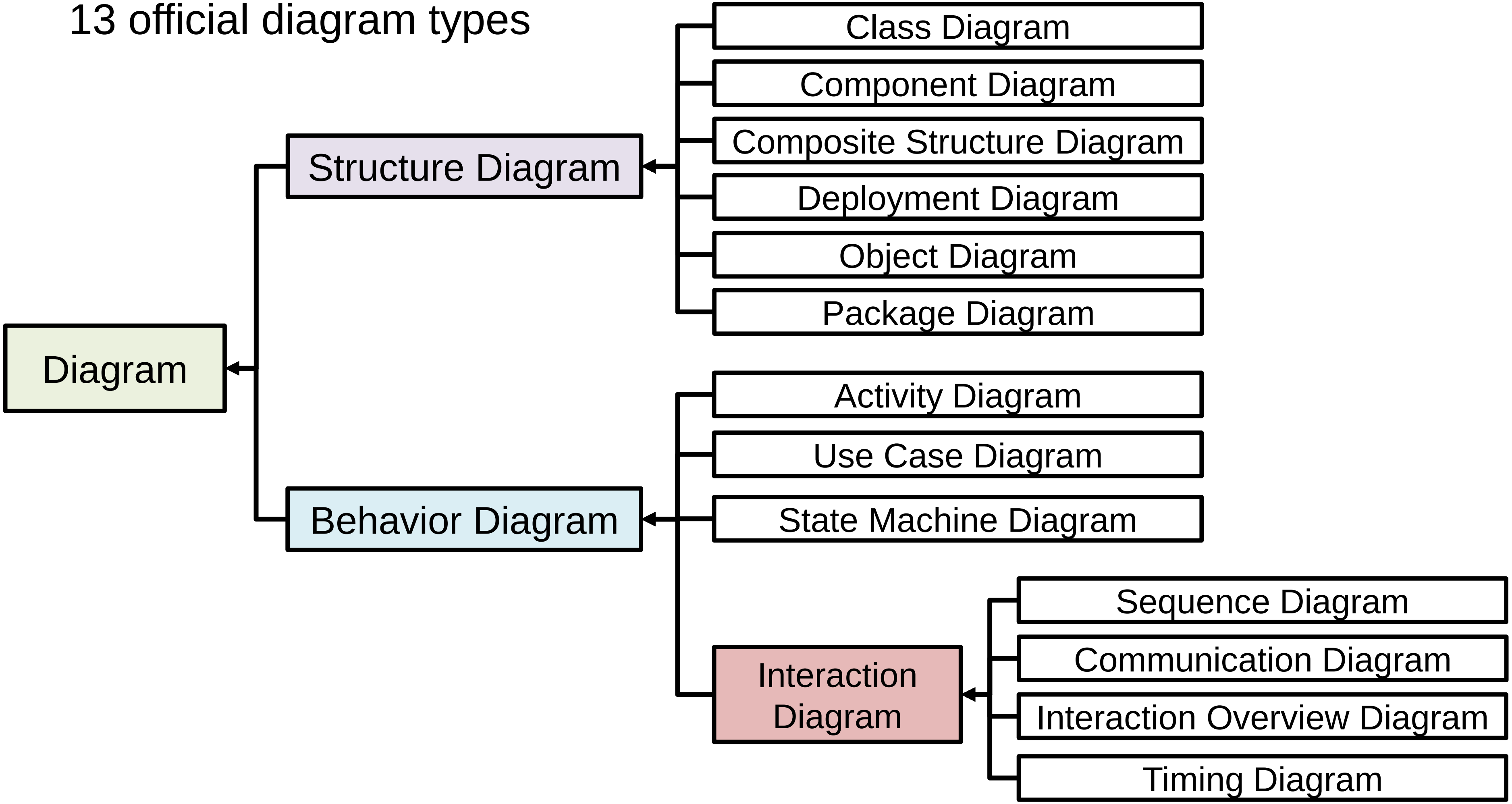
Why bother with the UML? (cont.)

- Ways of using the UML:
  - Three modes [1]:
    - UML as **sketch**:
      - Use UML to help communicate high-level aspects of a system.
    - UML as **forward engineering**:
      - Draw a complete UML diagram before you write codes. The design covers sufficient design decisions for the programmer to code up.
    - UML as **reverse engineering**:
      - Build UML diagrams from existing code in order to help understand it.

[1] UML Distilled, 3rd edition by Martin Fowler

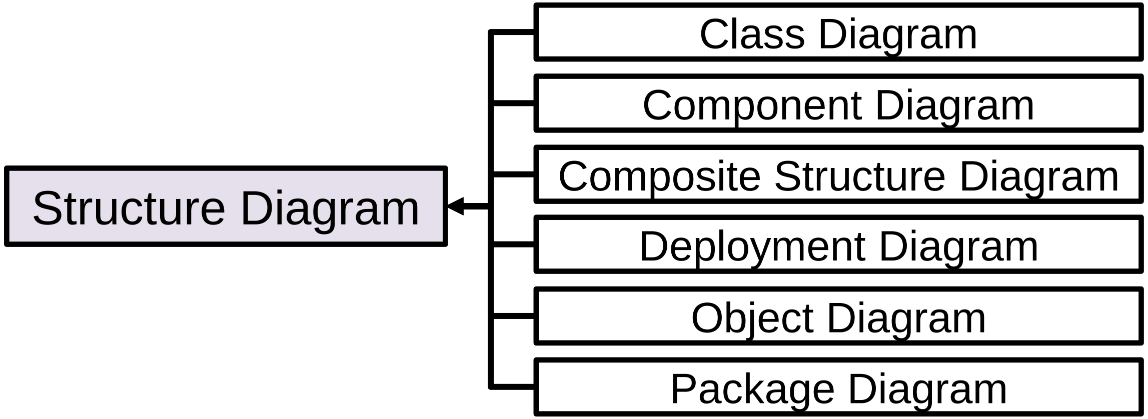
Overview of UML Diagrams

13 official diagram types



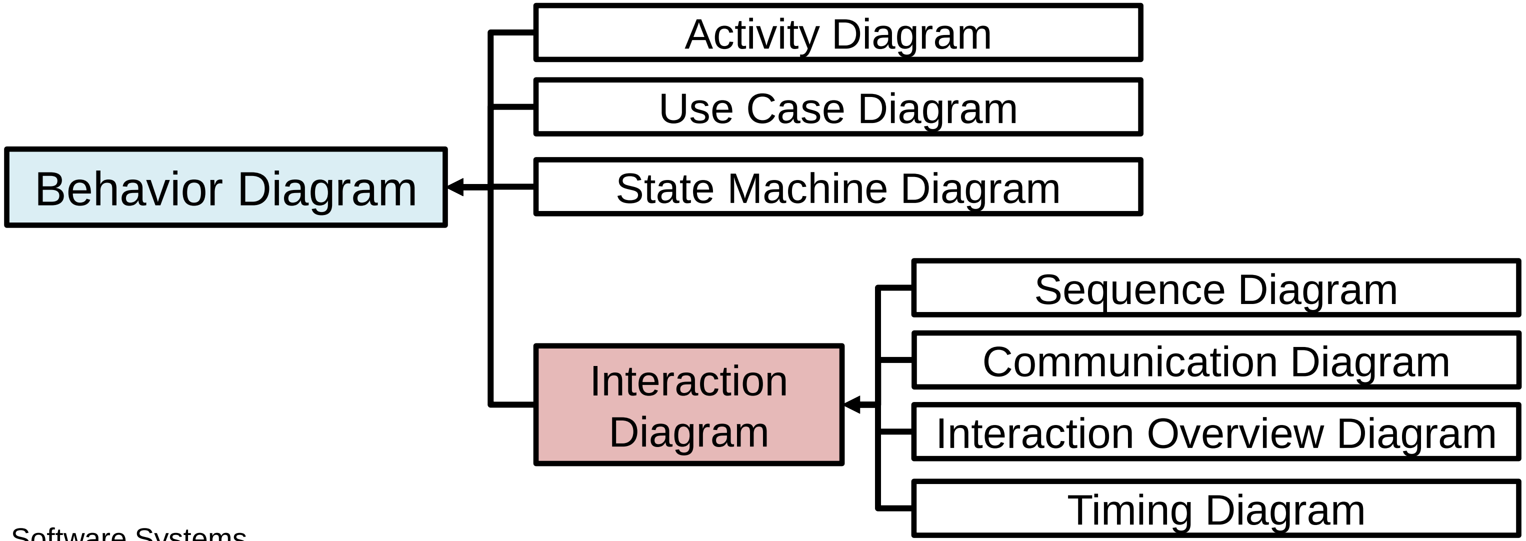
Overview of UML Diagrams (cont.)

- Three types of diagrams:
  - Structural diagrams:
    - Emphasizes the static structure of the system and the things that must be presented in the system, including objects, attributes, operations, components, and relationships.
    - Used extensively in documenting the architecture of the software systems.



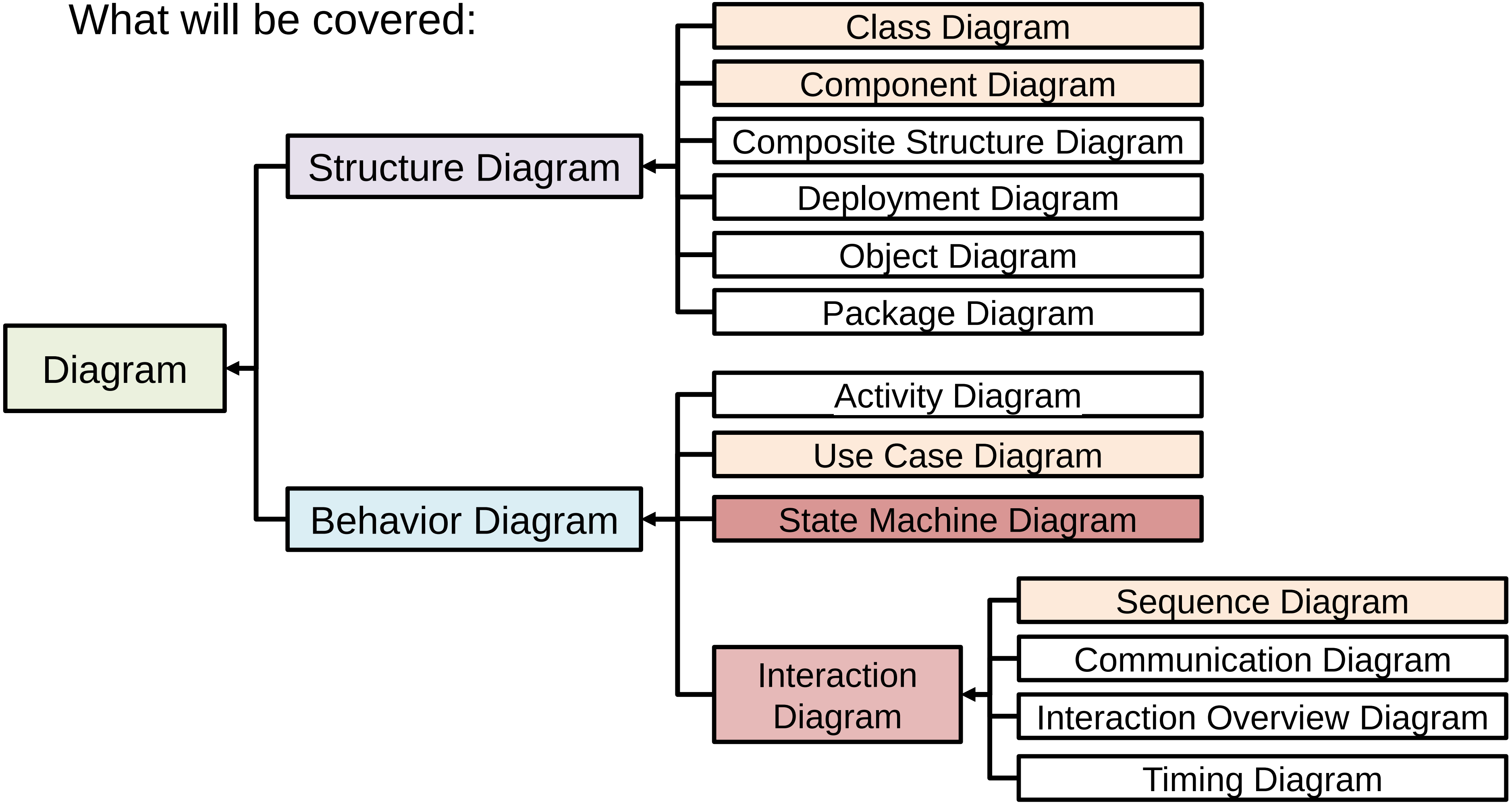
Overview of UML Diagrams (cont.)

- Behavioral diagrams:
  - Focuses on the dynamic behavior of the systems and changes to the internal states of objects.
    - Behavior: how data moves; how does the system change in time; how system behaves with different events.
  - Interaction diagrams:
    - Interaction: emphasize the flow of control, showing collaborations among objects; how objects communicate;

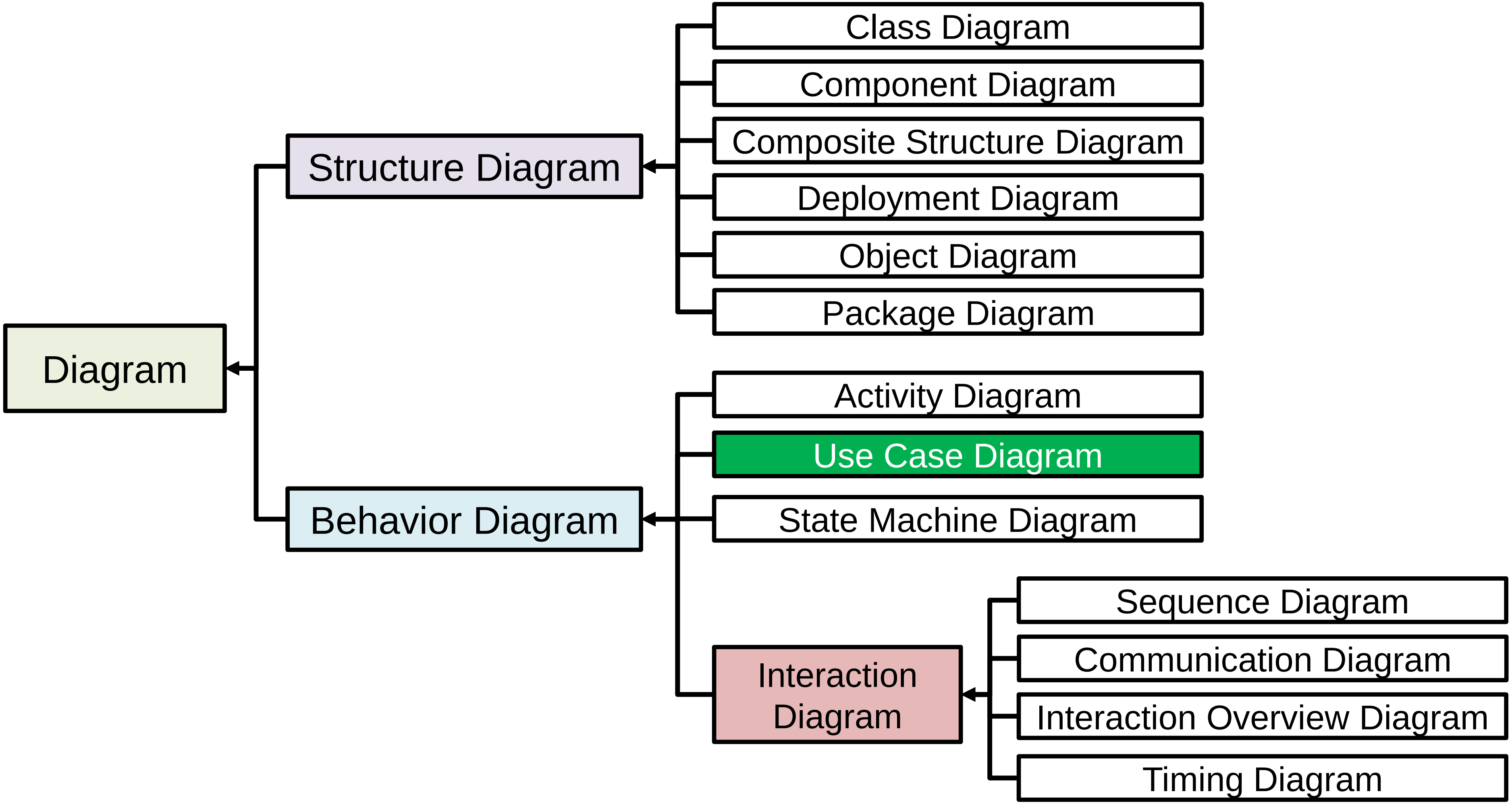


Overview of UML Diagrams (cont.)

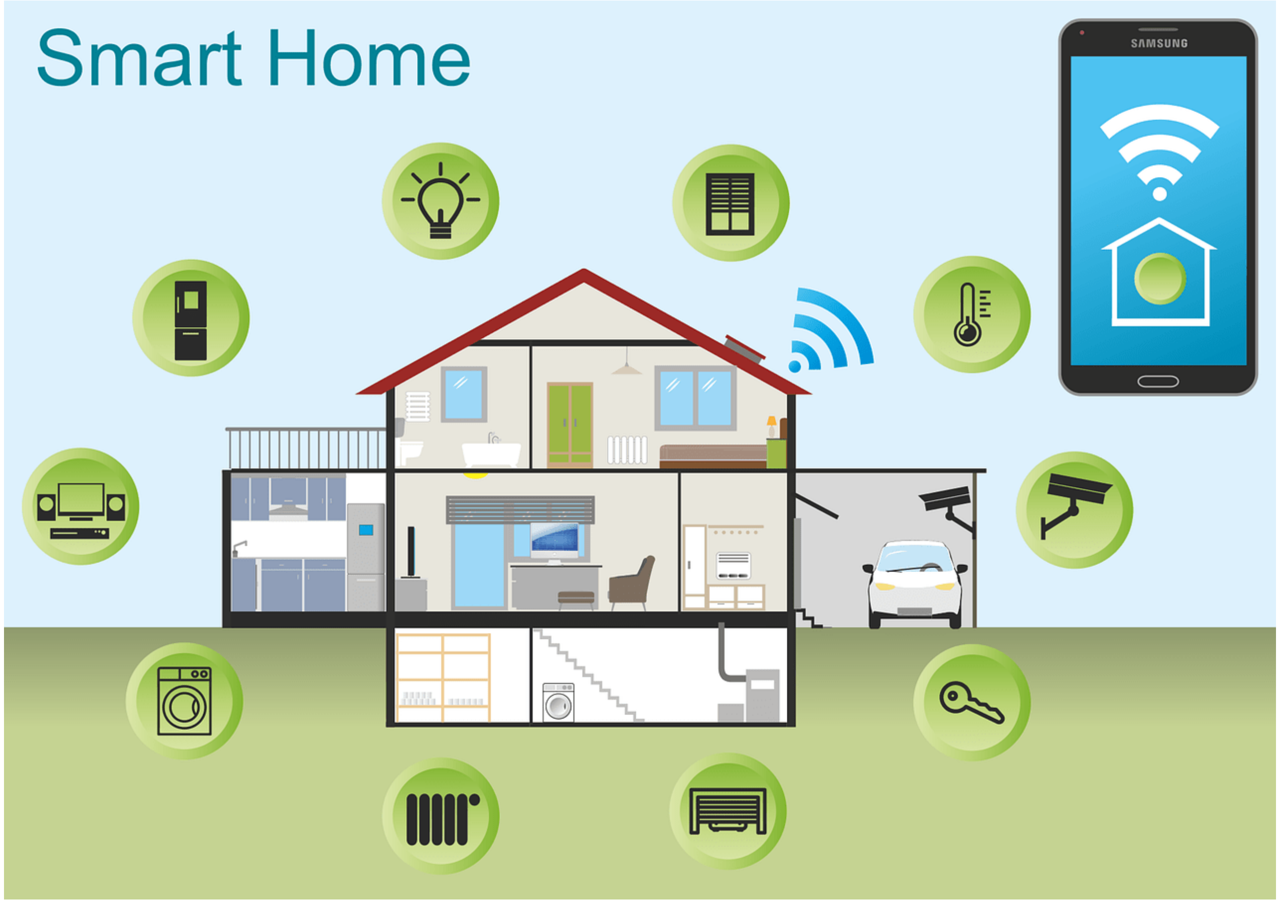
What will be covered:



Use Case Diagram

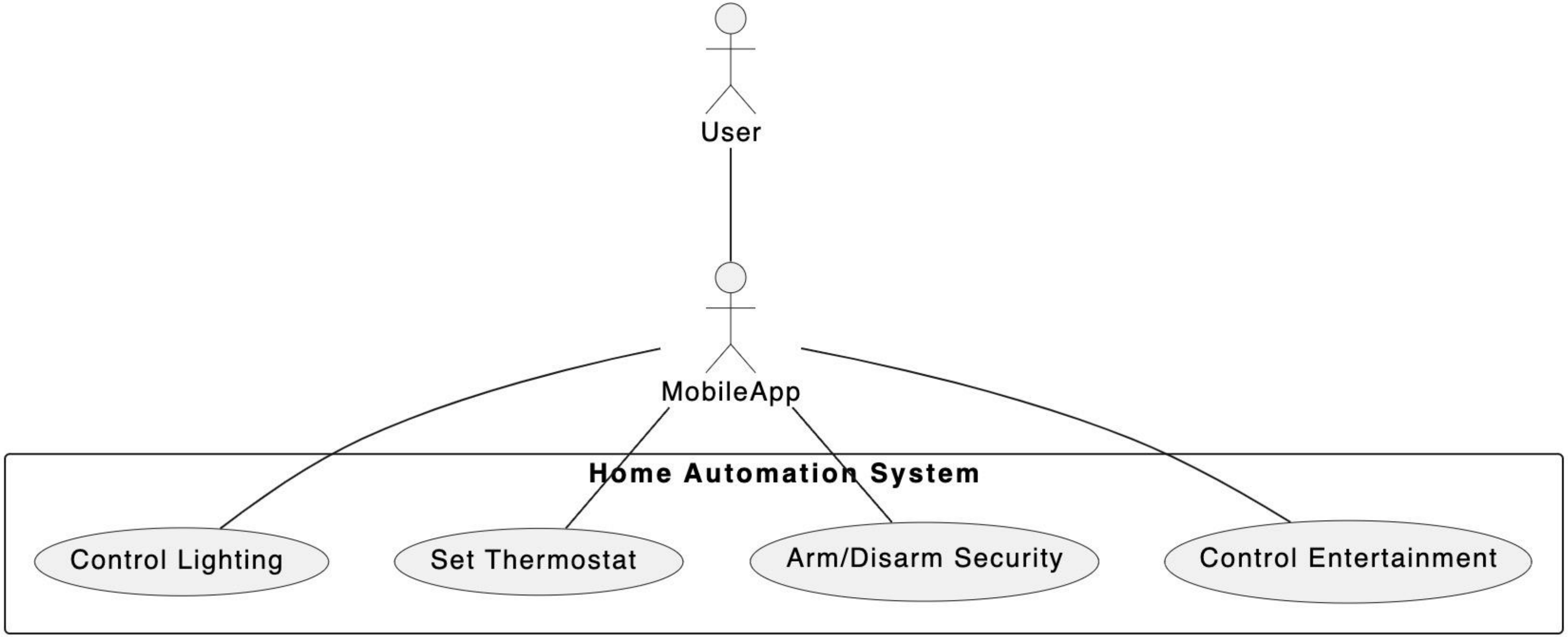


A case study: Home automation system



Use Case Diagram

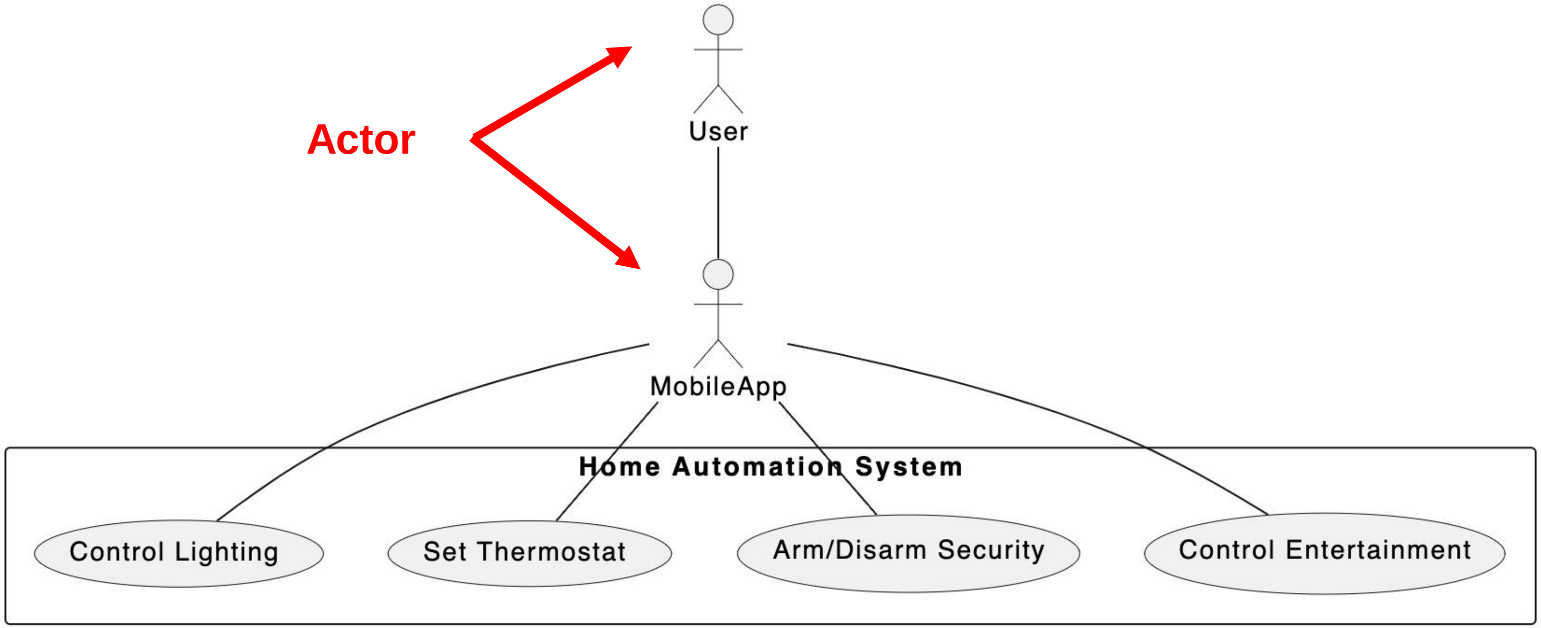
- **Discussion**:
  - What do you see in this diagram?
  - What are the elements in this diagram?
  - What message(s) this diagram may try to deliver?



Use Case Diagram (cont.)

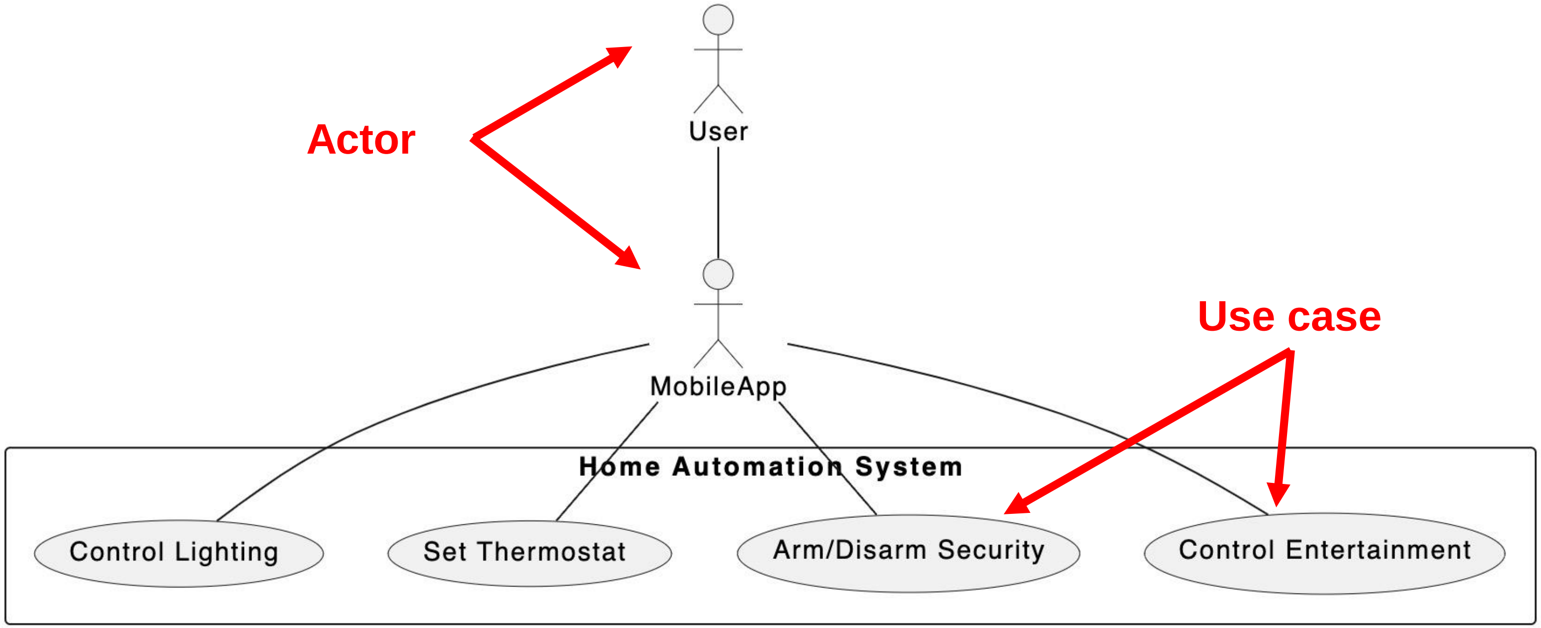
- Common elements in the Use Case Diagram:

- **Actor**: a role that a user plays with respect to the system. Actor could be a user or another system that interacts with the current system.
  - Stick figures that represents external users.
  - Actors must be external objects that produce or consume data.
  - Actor is different from the concept of user – a user can act as different actors.



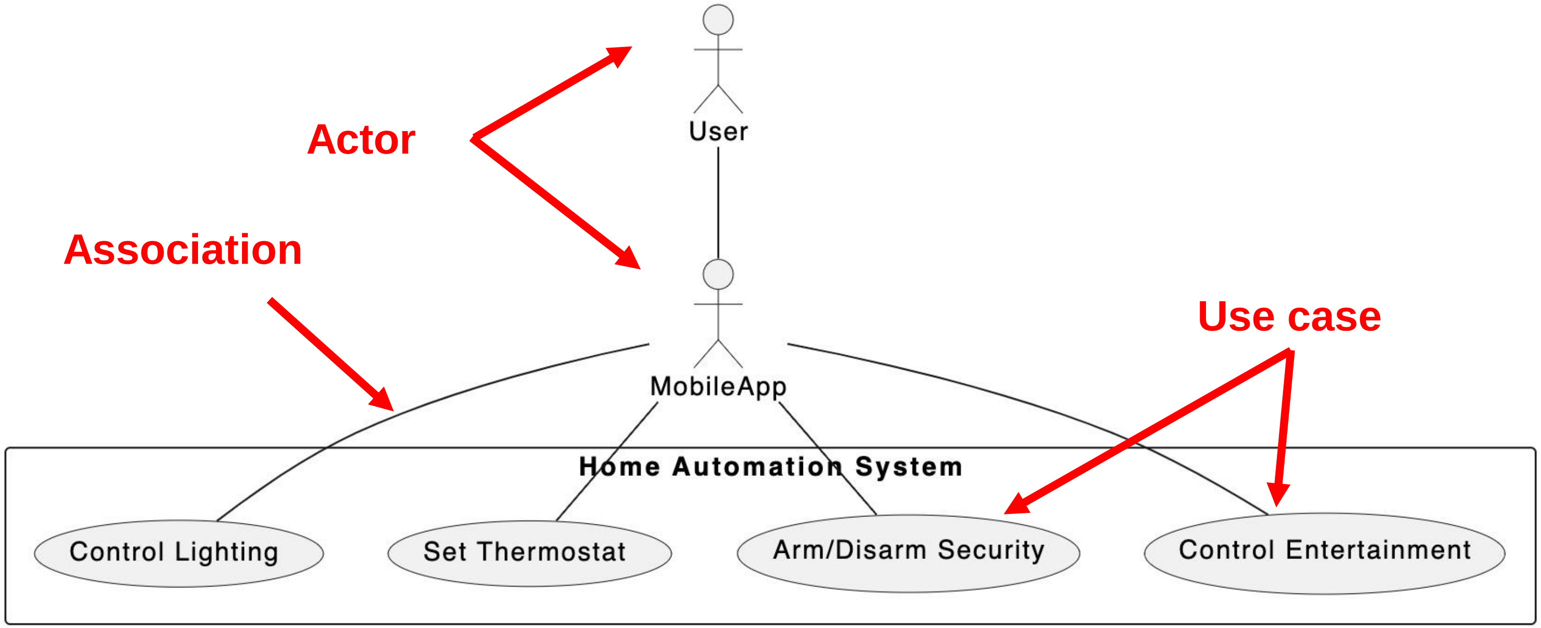
Use Case Diagram (cont.)

- Common elements in the Use Case Diagram:
  - **Use case:** is a summary of scenarios that describes the typical interaction between the users of a system and the system itself.
    - Horizontally shaped ovals
    - Represent different uses/interactions that a user might have.
    - Typically represents system function.



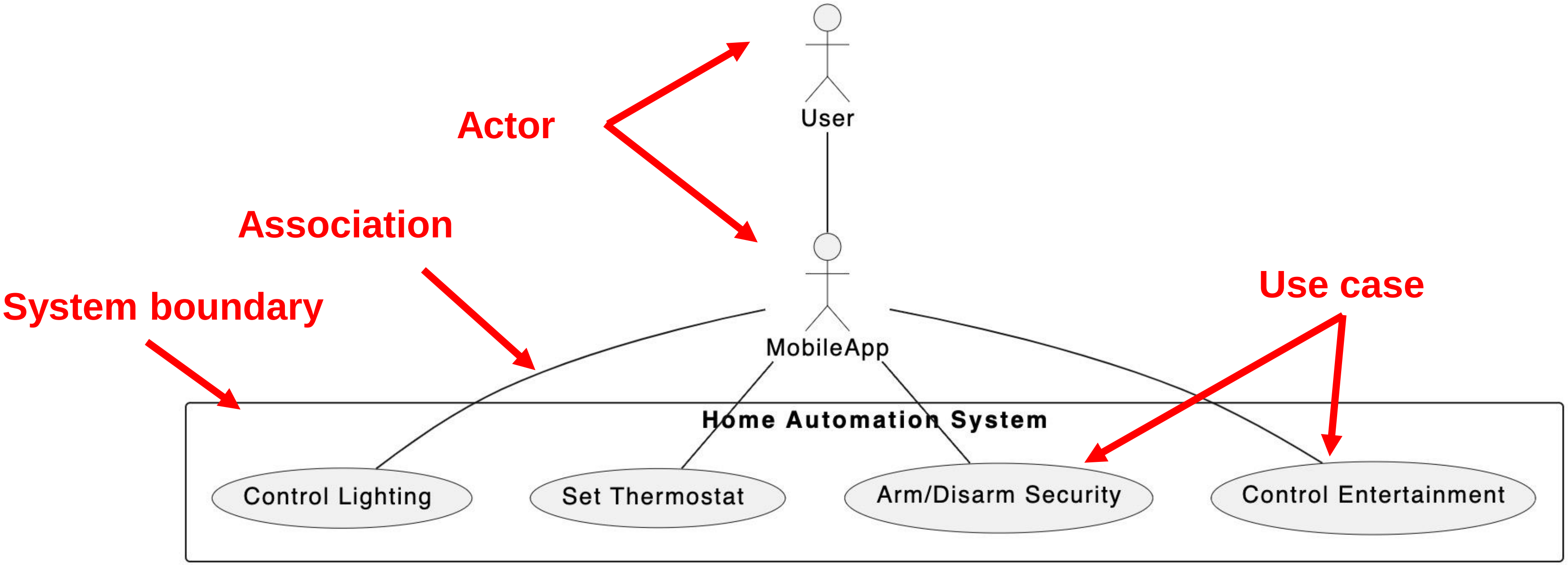
Use Case Diagram (cont.)

- Common elements in the Use Case Diagram:
  - **Association**: communication between an actor and a use case.
    - A solid line between actor and use case. **[No arrow!]**

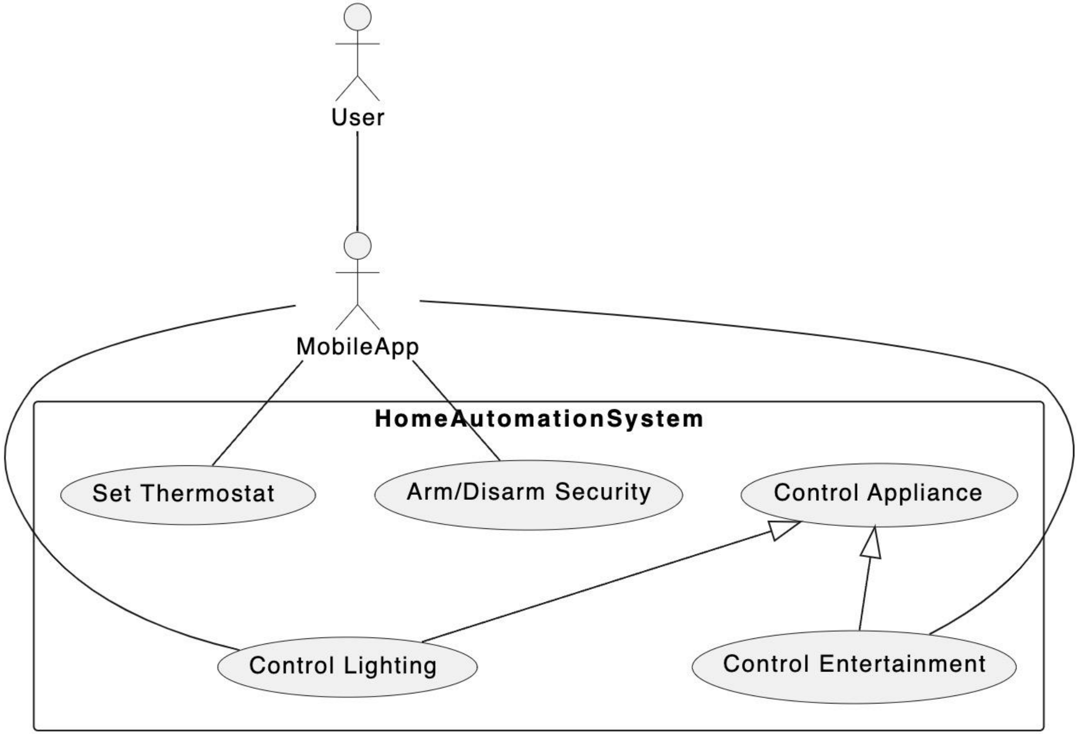


Use Case Diagram (cont.)

- Common elements in the Use Case Diagram:
  - **System boundary:** a rectangle that separates the system from the external actors.
    - All use cases outside the boundary box are outside the scope of the system.
    - For large and complex systems, each module may be the system boundary.



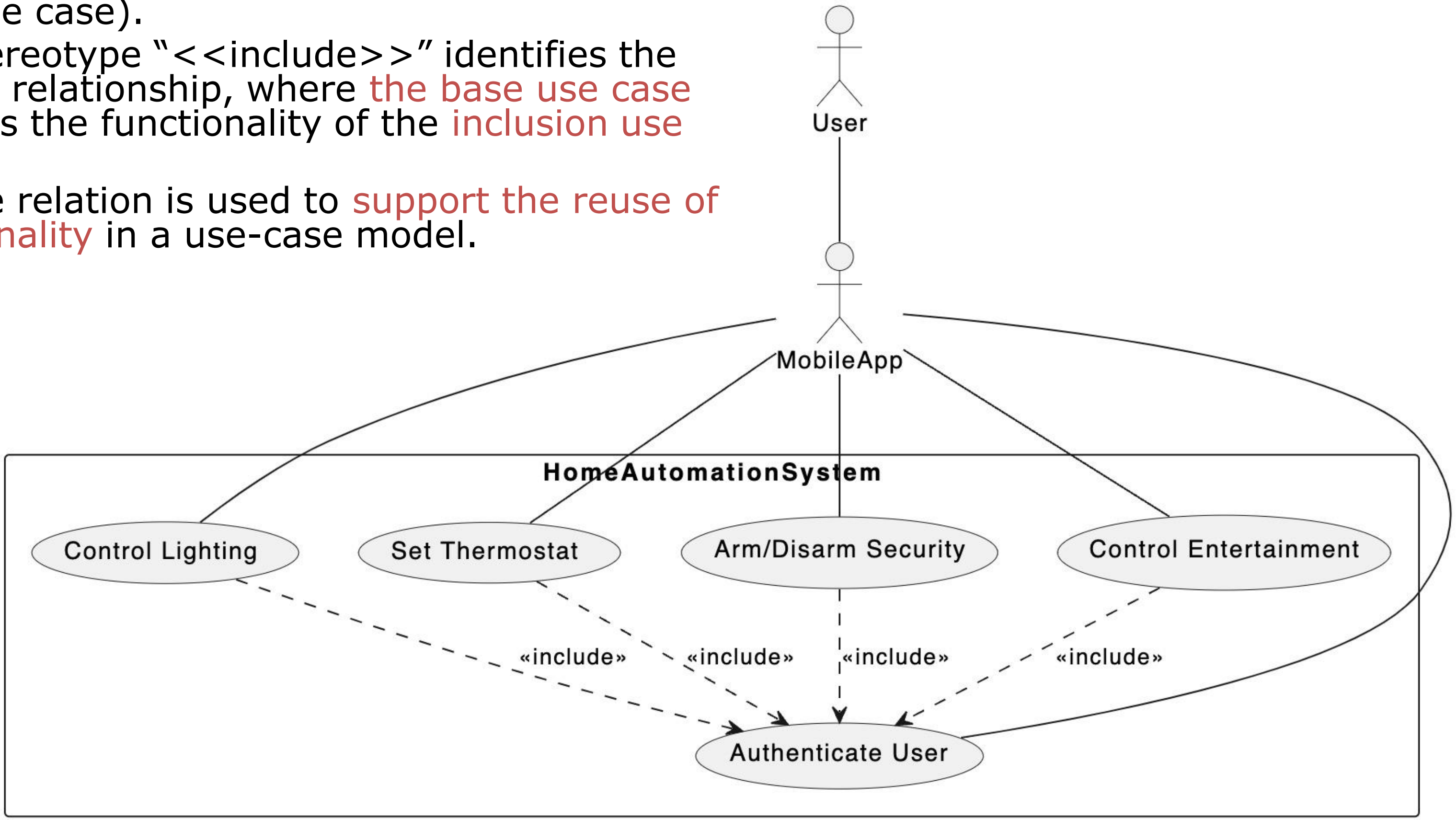
Use Case Relationship



- **Generalization**: indicates one use case is a special kind of another.
  - Indicates a **parent-child relationship** between use cases.
  - The child use case is connected at the base of the arrow, while the tip of the arrow is connected to the parent use case.
  - Generalization is used when we find **two or more use cases that have commonalities** in behavior, structure, and purpose.

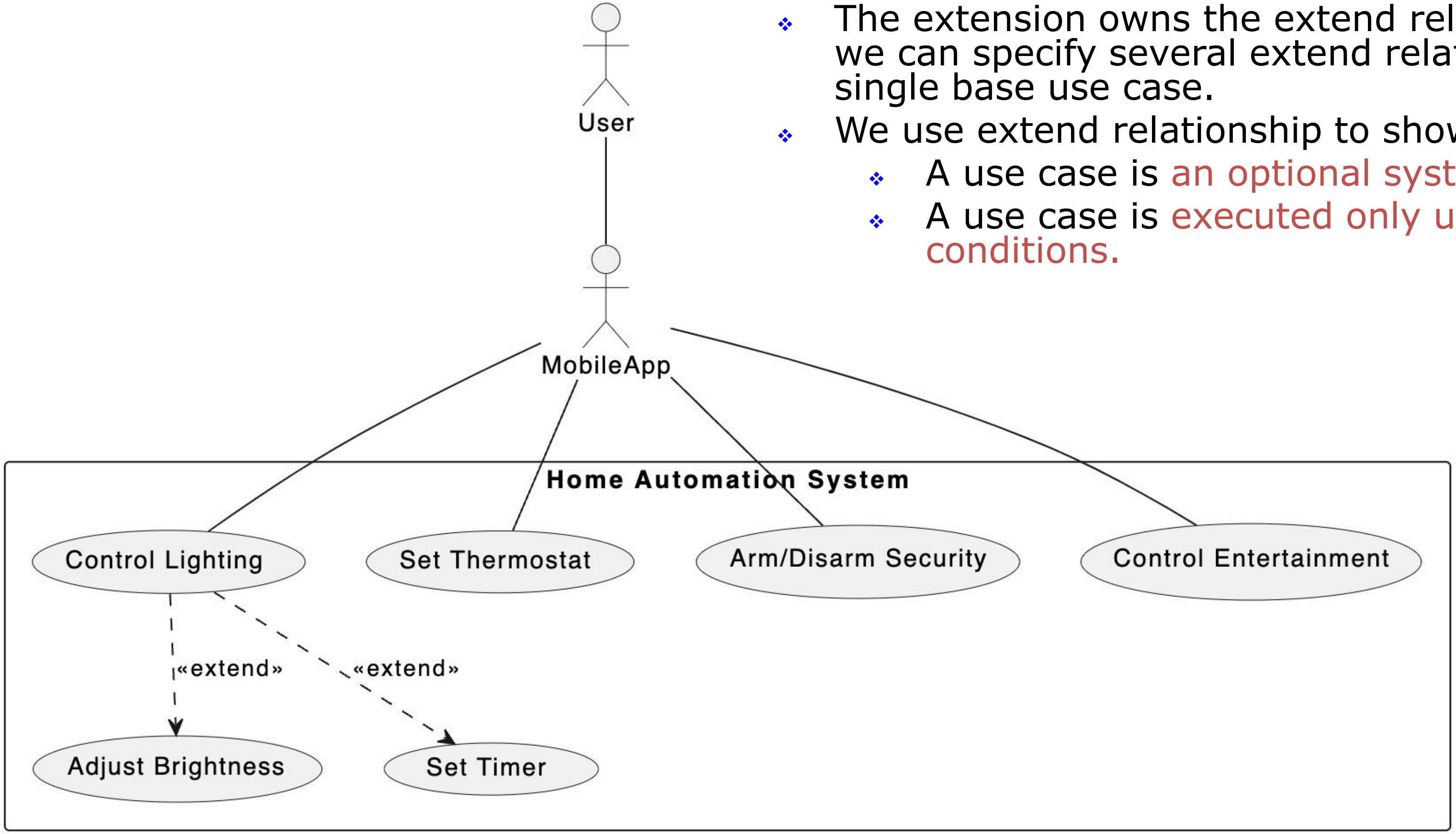
Use Case Relationship (cont.)

- **Include**: indicates one use case (the base use case) is using the functionality of another use case (the inclusion use case).
  - The stereotype "<<include>>" identifies the include relationship, where the base use case includes the functionality of the inclusion use case.
  - Include relation is used to support the reuse of functionality in a use-case model.



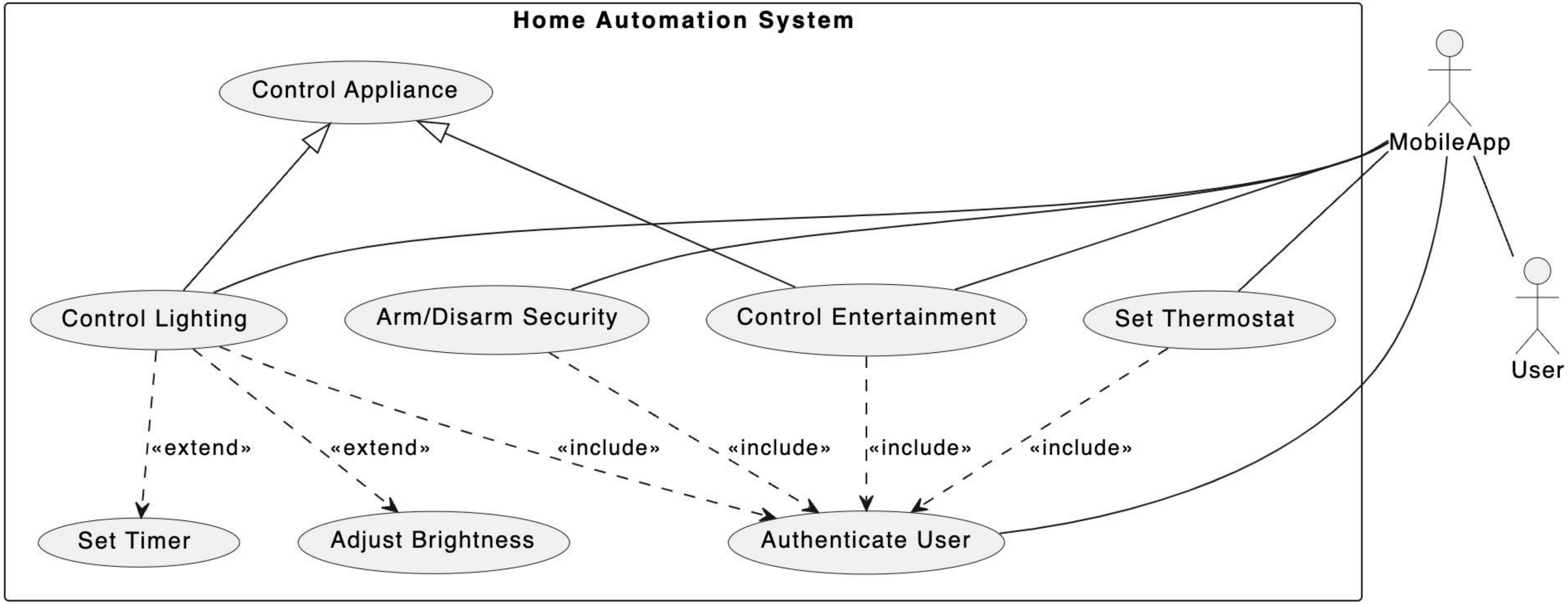
Use Case Relationship (cont.)

- **Extend**: specify that one use case (extension) extends the behavior of another use case (base).
  - The extension owns the extend relationship, and we can specify several extend relationships for a single base use case.
  - We use extend relationship to show:
    - A use case is an optional system behavior.
    - A use case is executed only under certain conditions.



Use Case Diagram (cont.)

Put everything together:



Use Case Diagram (cont.)

- What is the Use Case Diagram?

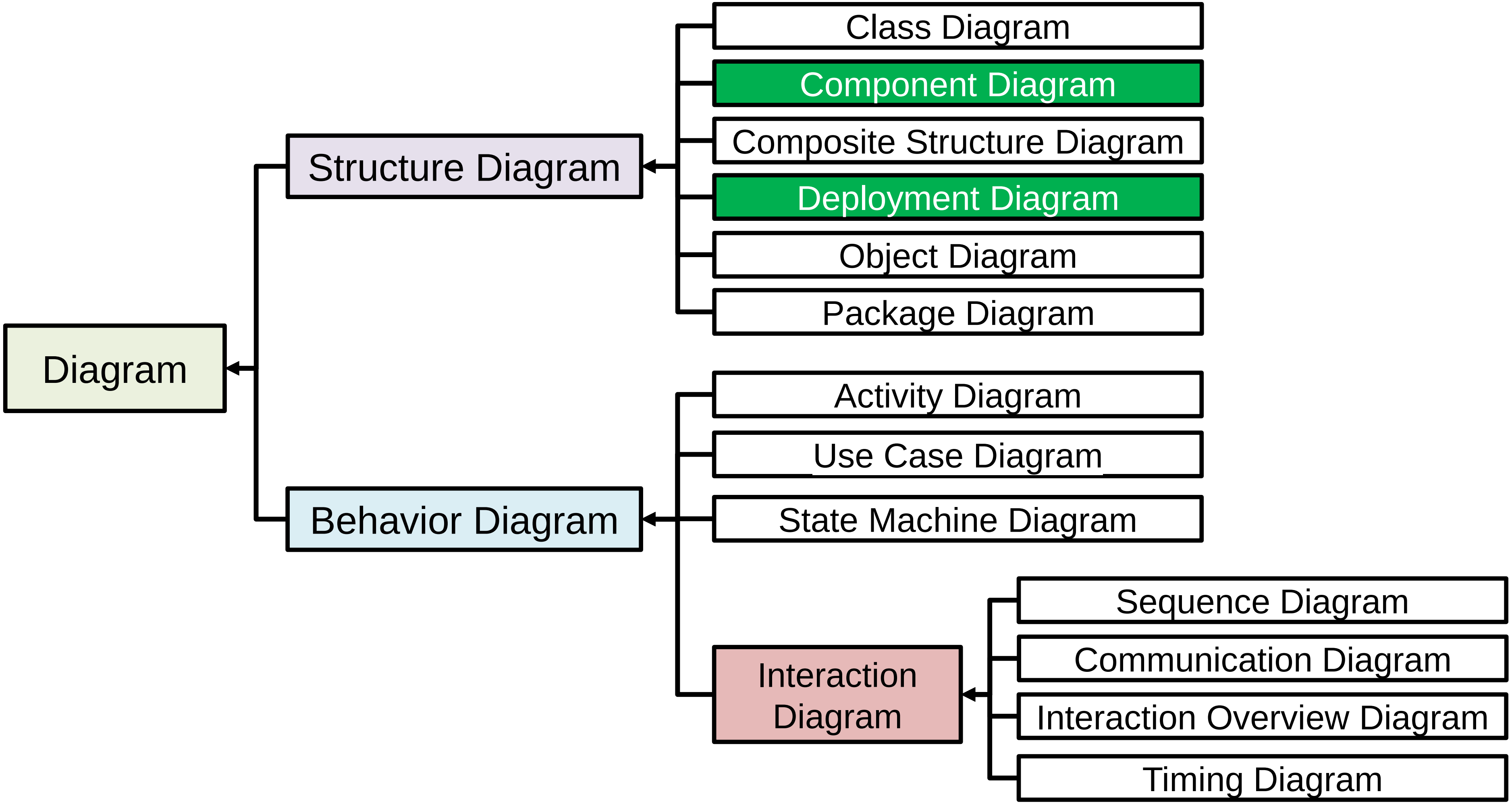
▪ **Use Case Diagram:** a collection of actors, use cases, and their associations that describes what a system does from the standpoint of an external observer.

  - It presents the users of the system and their interactions with the system.
  - Show high-level overview of relationship between use cases, actors, and the system.
  - Does not provide a lot of details.

Use Case Diagram (cont.)

- When to use the Use Case Diagram?
  - To represent the system-user interactions.
  - To define and organize the functional requirements of a system.
  - Is typically used in the early phase in system design.

Component and Deployment Diagrams



Component Diagram

- What is the Component Diagram?

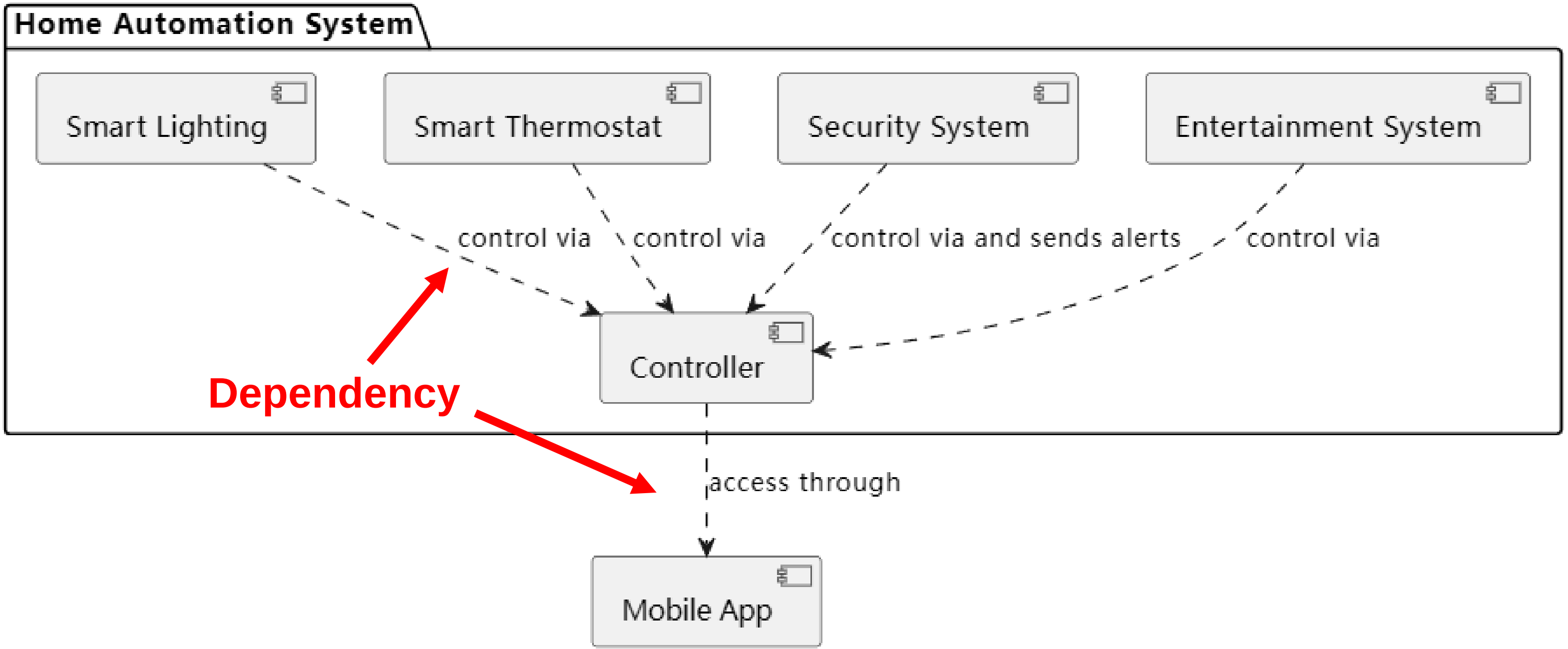
▪ **Component Diagram:** divides a complex system into multiple components and shows the inter-relationships between the components.

▪ The term ‘**component**’: a module of classes that represents independent system or subsystem with the ability to interface with the rest of a more complex system.

– Component diagram is useful to:

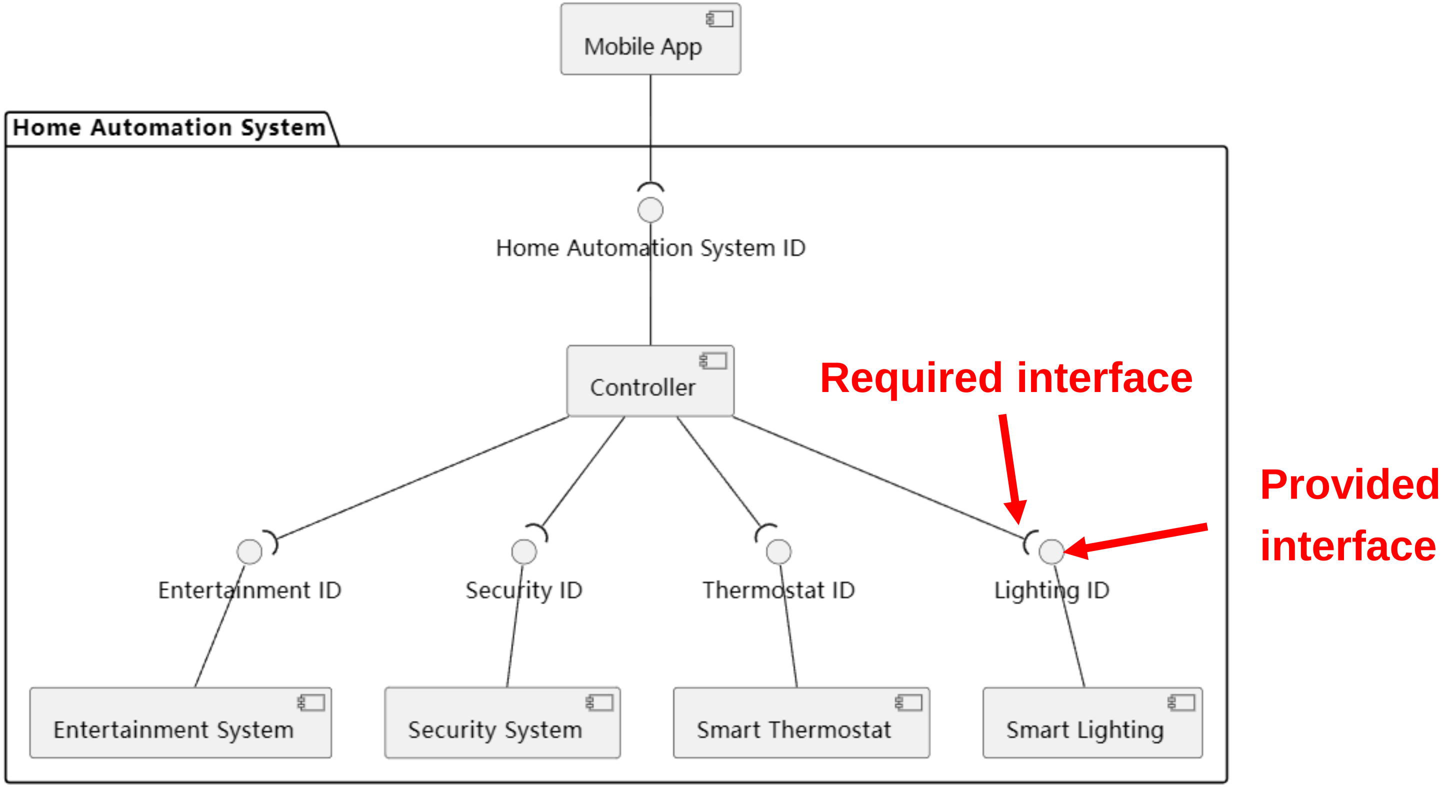
- Show the system’s physical structure.
- Show the system’s static components and their relations .

Component Diagram (cont.)



- **Component:** represents a modular part of a system that encapsulates its contents.
- **Dependency:**
  - Indicates that the functioning of one element depends on the existence of another element. (Thinking about the *#include* statement)

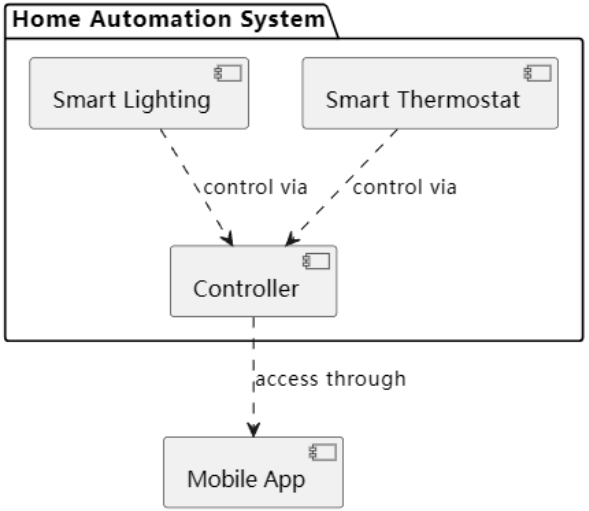
Component Diagram (cont.)

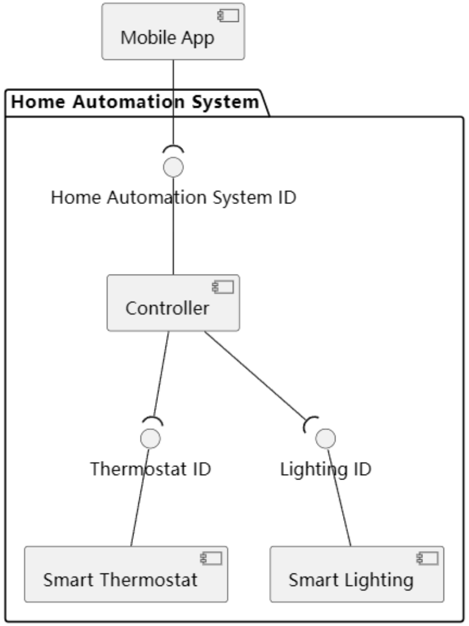


- **Assembly:**
  - **Provided interface**: symbols with a complete circle at the end represent an interface
  - **Required interface**: symbols with a half circle at the end represent an interface that the component requires.

Component Diagram (cont.)

- Differences between dependency and assembly:

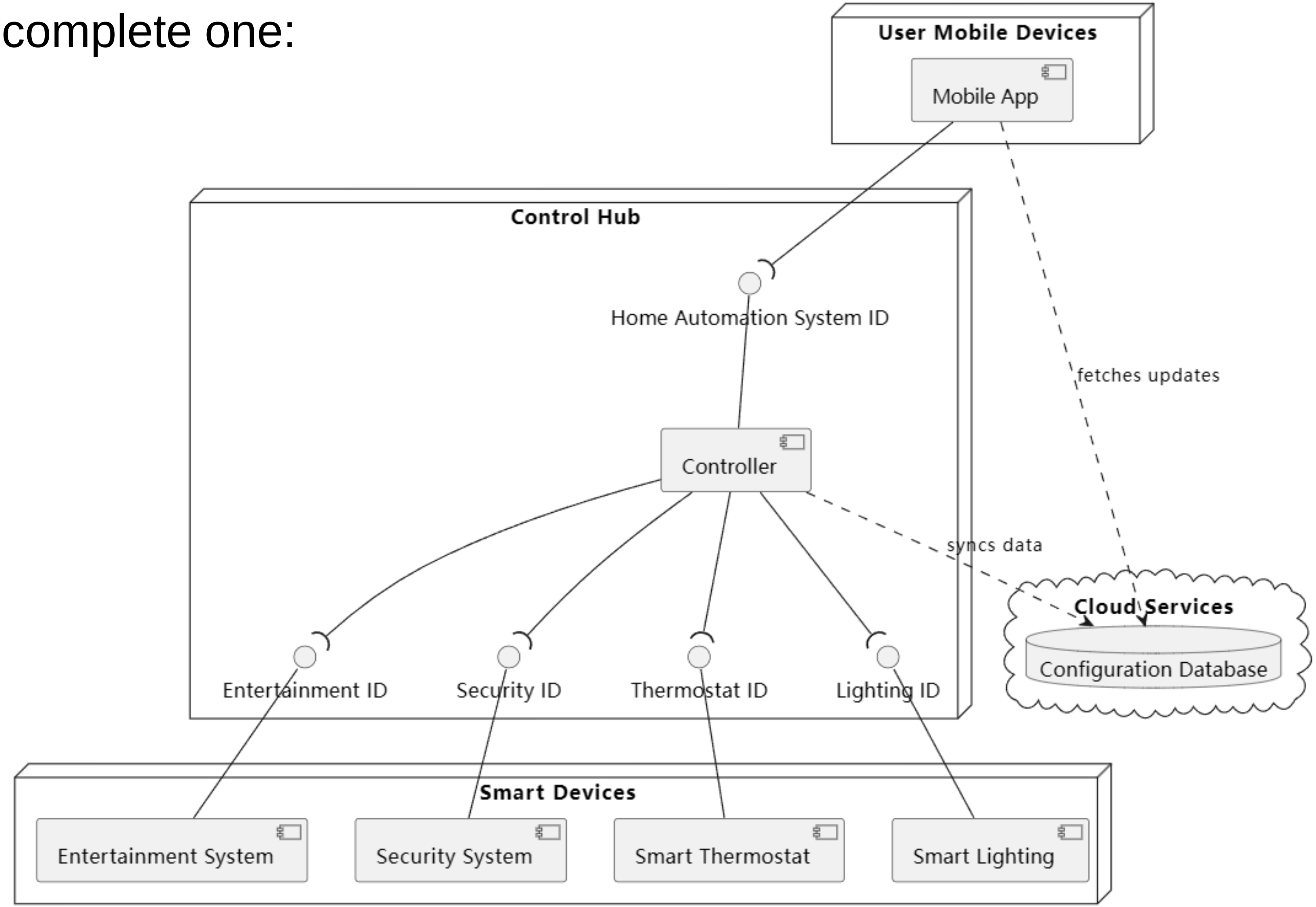




- **Dependency** is a looser, transient relationship where one component uses another.
- **Assembly** is a stronger, structural relationship between required and provided interfaces.
- Dependency between two components expresses a potential assembly relationship between the two corresponding instances in system run-time.
- They are modeling the system at different abstraction

Component with Deployment Diagram (cont.)

- A complete one:


User Mobile Devices
Mobile App
Control Hub
Home Automation System ID
fetches updates
Controller
syncs data
Cloud Services
Configuration Database
Entertainment ID
Security ID
Thermostat ID
Lighting ID
Smart Devices
Entertainment System
Security System
Smart Thermostat
Smart Lighting