Sequence Diagrams | Unified Modeling Language (UML)

Unified Modelling Language (UML) is a modeling language in the field of software engineering that aims to set standard ways to visualize the design of a system. UML guides the creation of multiple types of diagrams such as interaction, structure, and behavior diagrams. A **sequence diagram** is the most commonly used **interaction** diagram.

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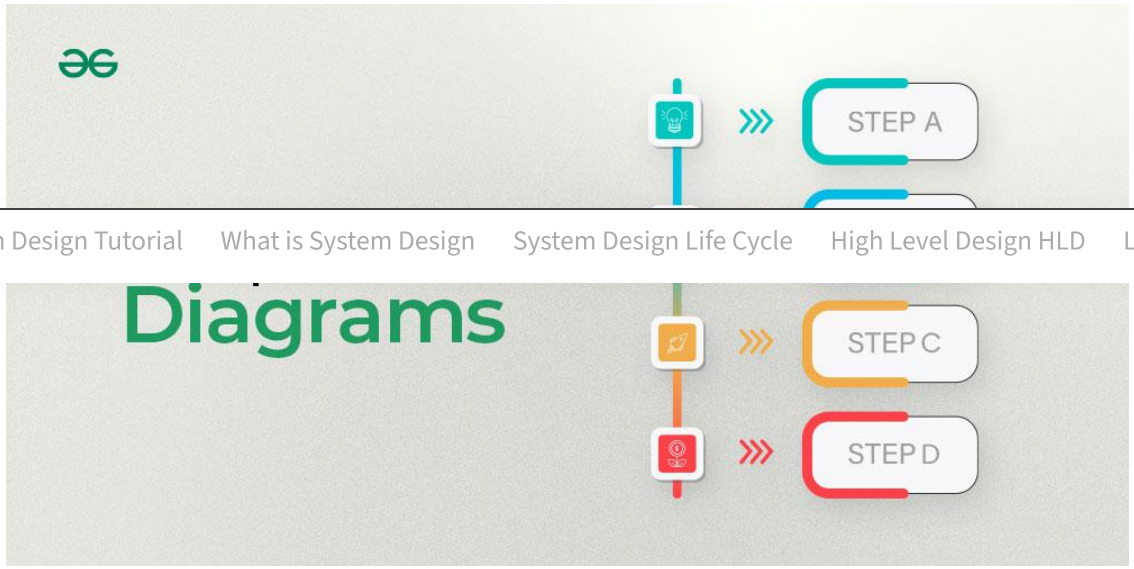

Interaction diagram

An interaction diagram is used to show the **interactive behavior** of a system. Since visualizing the interactions in a system can be difficult, we use different types of interaction diagrams to capture various features and aspects of interaction in a system.

- A sequence diagram simply depicts the interaction between the objects in a sequential order i.e. the order in which these interactions occur.
- We can also use the terms event diagrams or event scenarios to refer to a sequence diagram.
- Sequence diagrams describe how and in what order the objects in a system function.
- These diagrams are widely used by businessmen and software developers to document and understand requirements for new and existing systems.

Important Topics for the Sequence Diagrams

1. Sequence Diagram Notation

1.1. Actors

An actor in a UML diagram represents a type of role where it interacts with the system and its objects. It is important to note here that an actor is always outside the scope of the system we aim to model using the UML diagram.

Notation symbol for actor

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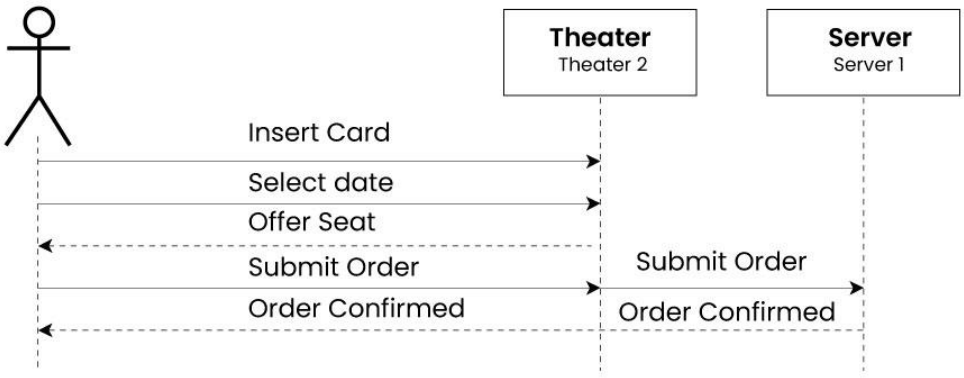
We use actors to depict various roles including human users and other external subjects. We represent an actor in a UML diagram using a stick person notation. We can have multiple actors in a sequence diagram.

For example:

Here the user in seat reservation system is shown as an actor where it exists outside the system and is not a part of the system.

User interacting with seat reservation system



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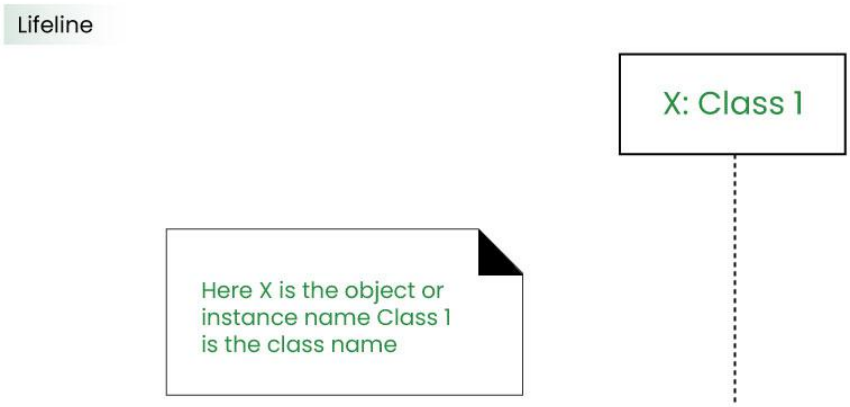
1.2. Lifelines

A lifeline is a named element which depicts an individual participant in a sequence diagram. So basically each instance in a sequence diagram is represented by a lifeline. Lifeline elements are located at the top in a sequence diagram. The standard in UML for naming a lifeline follows the following format:

Instance Name : Class Name



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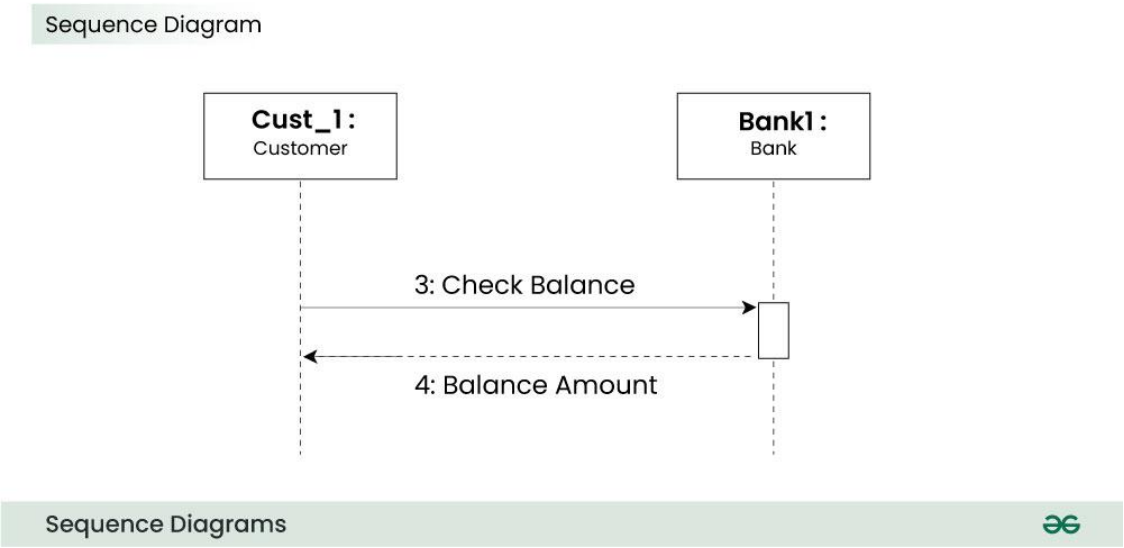
We display a lifeline in a rectangle called **head** with its name and type. The head is located on top of a vertical dashed line (referred to as the stem) as shown above.

- If we want to model an unnamed instance, we follow the same pattern except now the portion of lifeline's name is left blank.
- **Difference between a lifeline and an actor**

- A lifeline always portrays an object internal to the system whereas actors are used to depict objects external to the system.

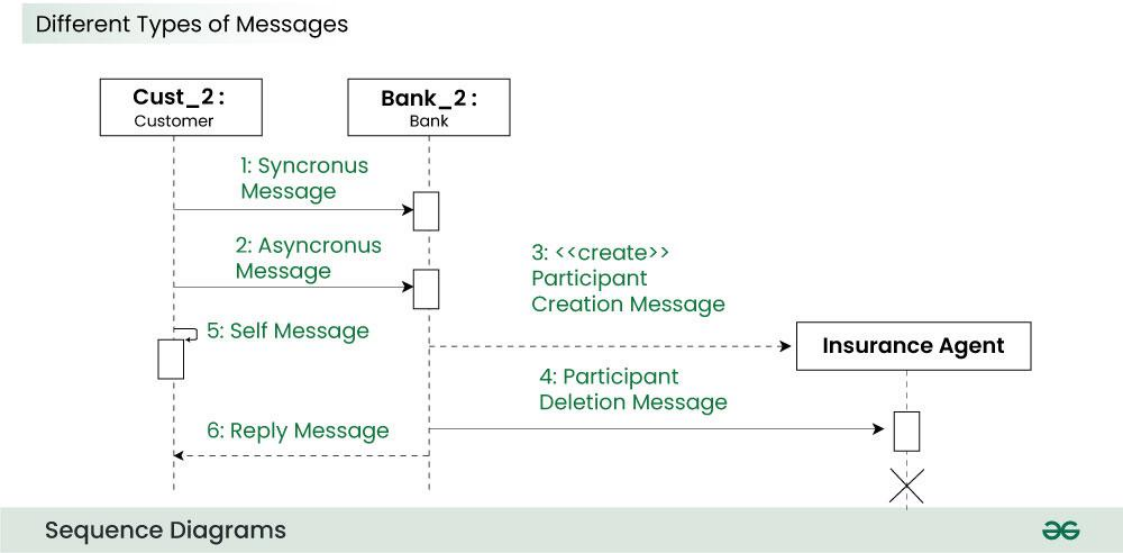
The following is an example of a sequence diagram:



1.3. Messages

Communication between objects is depicted using messages. The messages appear in a sequential order on the lifeline.

- We represent messages using arrows.
- Lifelines and messages form the core of a sequence diagram.



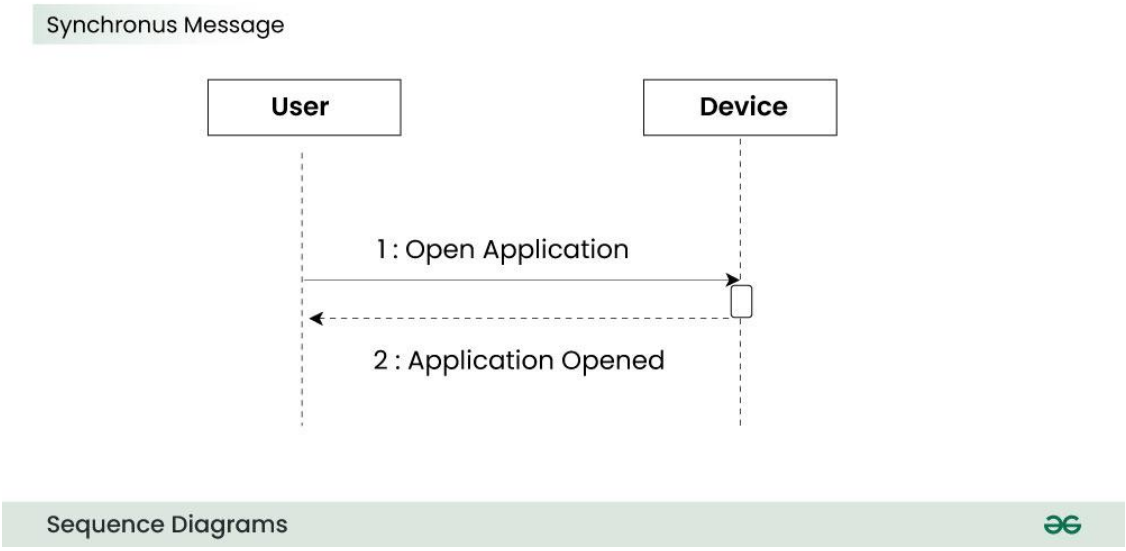
Messages can be broadly classified into the following categories:

Synchronous messages

A synchronous message waits for a reply before the interaction can move forward. The sender waits until the receiver has completed the processing of

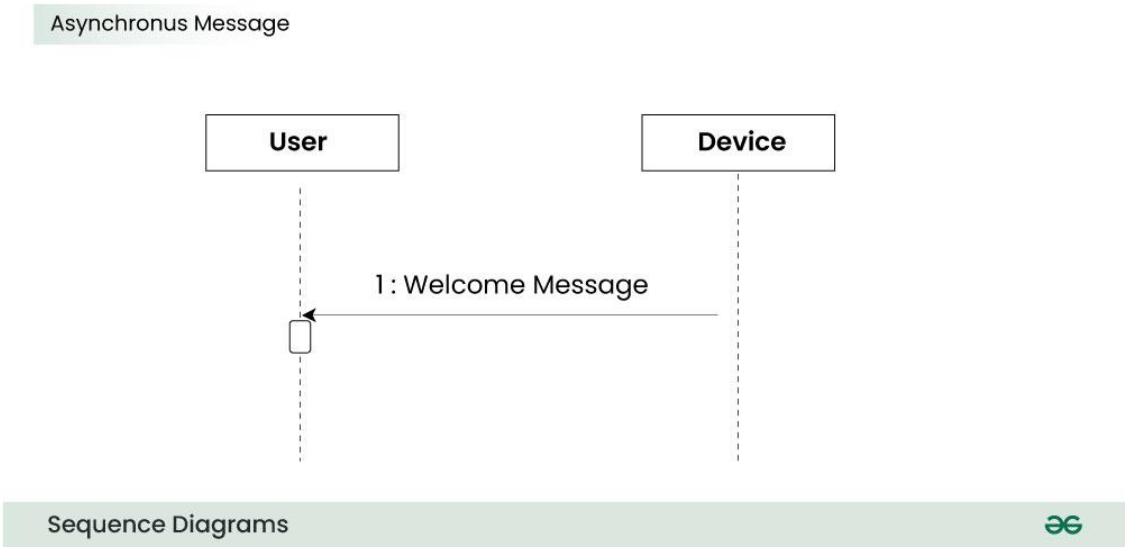
the message. The caller continues only when it knows that the receiver has processed the previous message i.e. it receives a reply message.

- A large number of calls in object oriented programming are synchronous.
- We use a **solid arrow head** to represent a synchronous message.



Asynchronous Messages

An asynchronous message does not wait for a reply from the receiver. The interaction moves forward irrespective of the receiver processing the previous message or not. We use a **lined arrow head** to represent an asynchronous message.



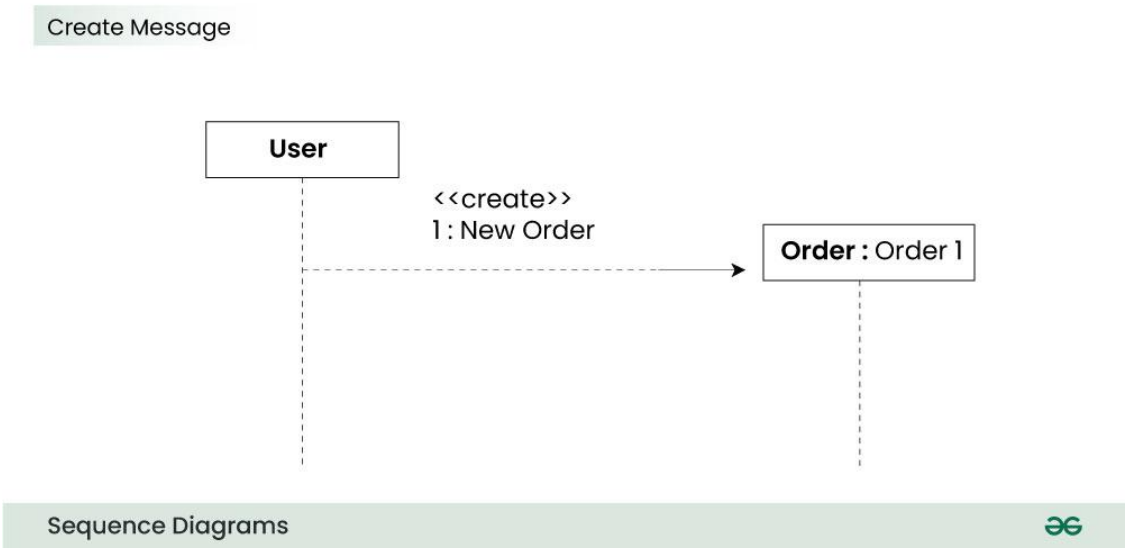
1.4. Create message

We use a Create message to instantiate a new object in the sequence diagram. There are situations when a particular message call requires the

creation of an object. It is represented with a dotted arrow and create word labelled on it to specify that it is the create Message symbol.

For example:

The creation of a new order on a e-commerce website would require a new object of Order class to be created.



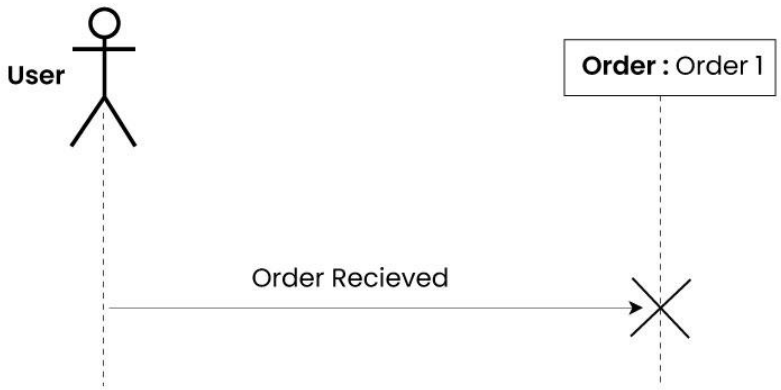
1.5. Delete Message

We use a Delete Message to delete an object. When an object is deallocated memory or is destroyed within the system we use the Delete Message symbol. It destroys the occurrence of the object in the system.It is represented by an arrow terminating with a x.

For example:

In the scenario below when the order is received by the user, the object of order class can be destroyed.

Delete Image



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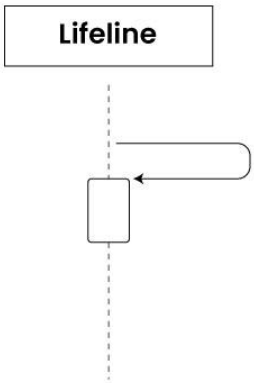
1.6. Self Message

Certain scenarios might arise where the object needs to send a message to itself. Such messages are called Self Messages and are represented with a **U shaped arrow**.

Self Image

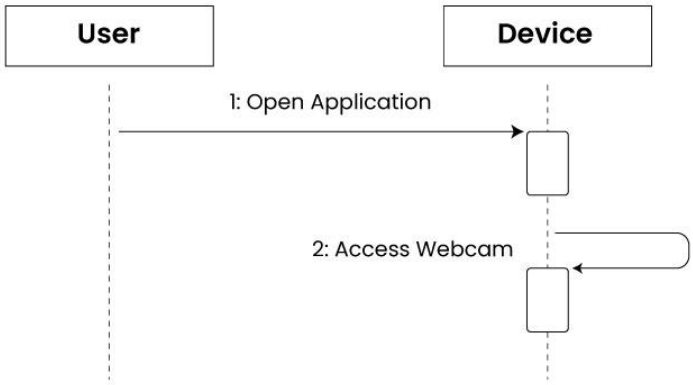


Sequence Diagrams

Another example:

Consider a scenario where the device wants to access its webcam. Such a scenario is represented using a self message.

Self Image



Sequence Diagrams

1.7. Reply Message

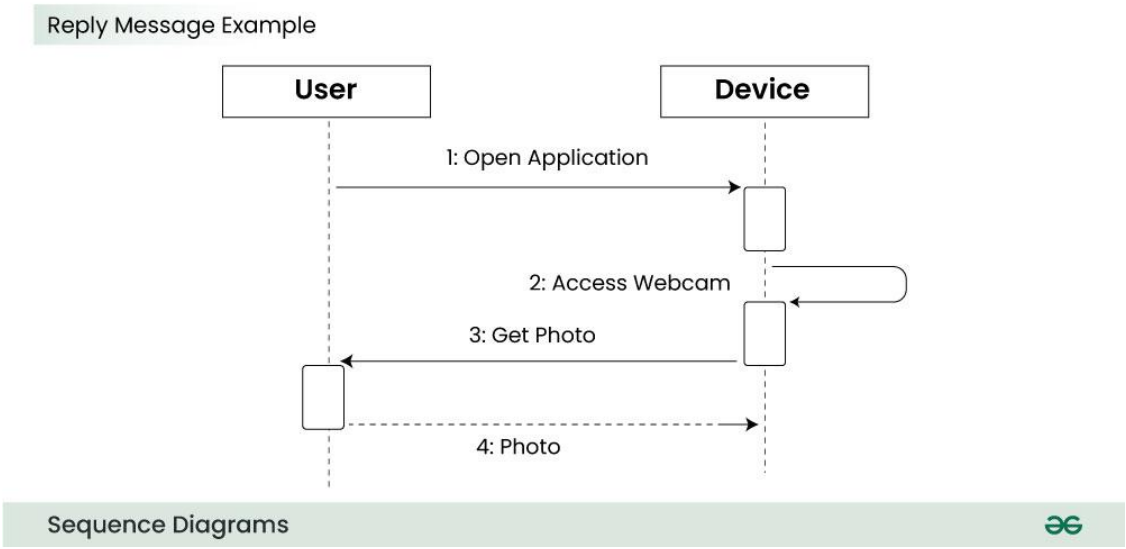
Reply messages are used to show the message being sent from the receiver to the sender. We represent a return/reply message using an **open arrow head with a dotted line**. The interaction moves forward only when a reply message is sent by the receiver.

Reply Message

Sequence Diagrams

For example:

> *Consider the scenario where the device requests a photo from the user. Here the message which shows the photo being sent is a reply message.*

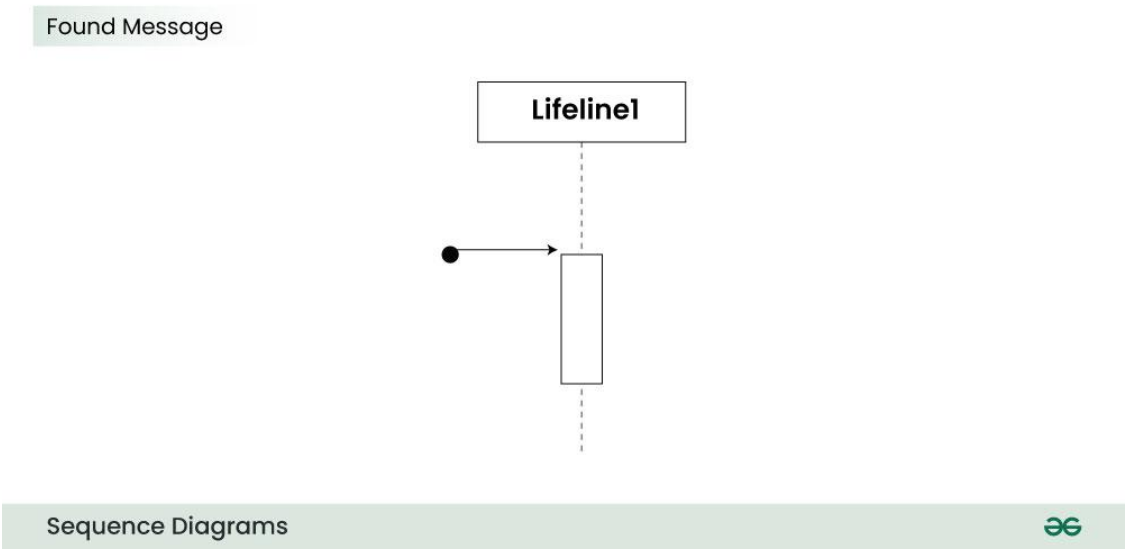


1.8. Found Message

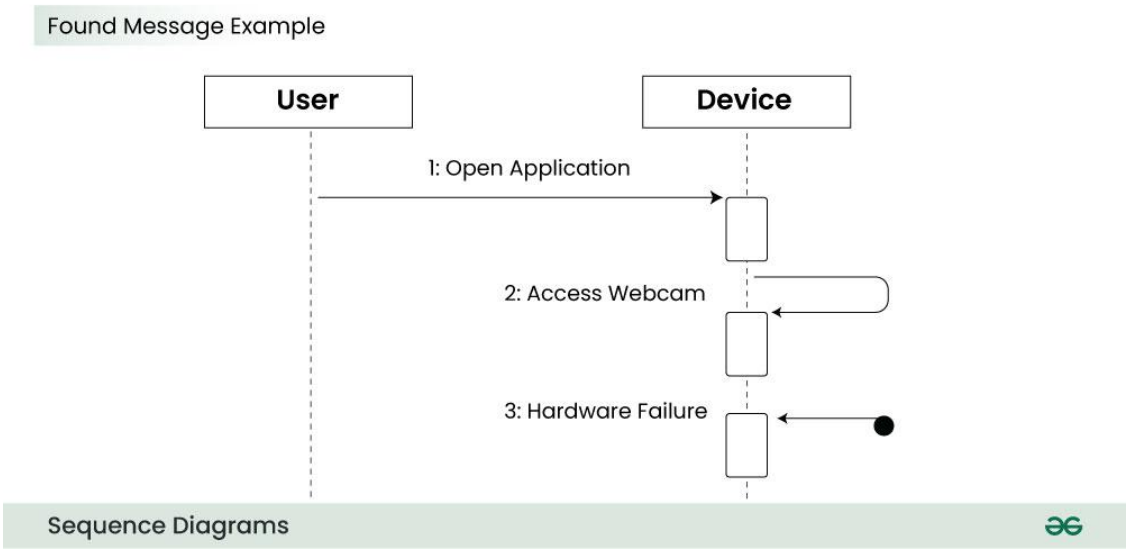
A Found message is used to represent a scenario where an unknown source sends the message. It is represented using an **arrow directed towards a lifeline** from an end point.

For example:

Consider the scenario of a hardware failure.



It can be due to multiple reasons and we are not certain as to what caused the hardware failure.

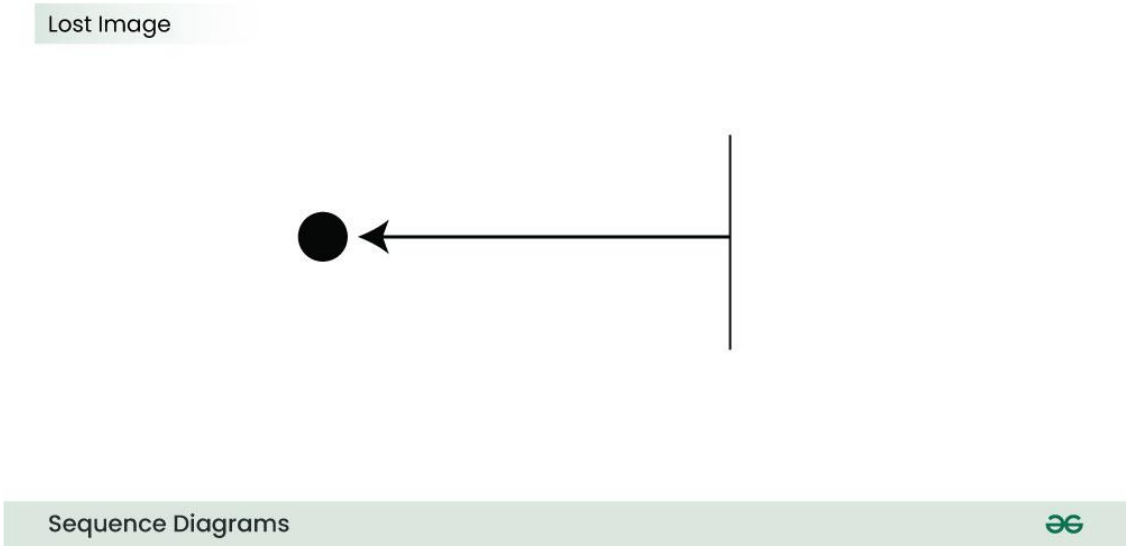


1.9. Lost Message

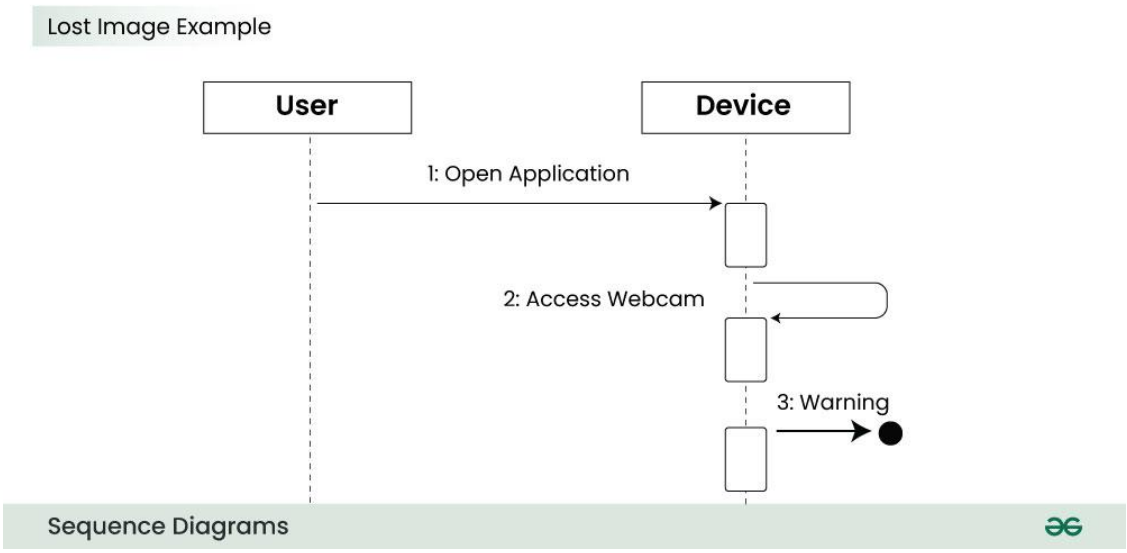
A Lost message is used to represent a scenario where the recipient is not known to the system. It is represented using an arrow directed towards an end point from a lifeline.

For example:

Consider a scenario where a warning is generated.



The warning might be generated for the user or other software/object that the lifeline is interacting with. Since the destination is not known before hand, we use the Lost Message symbol.

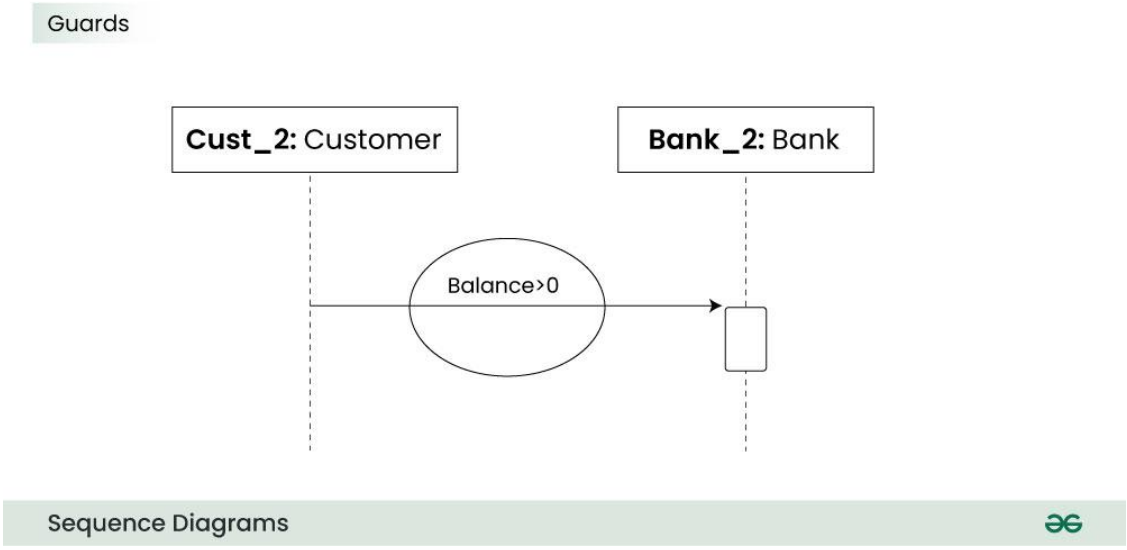


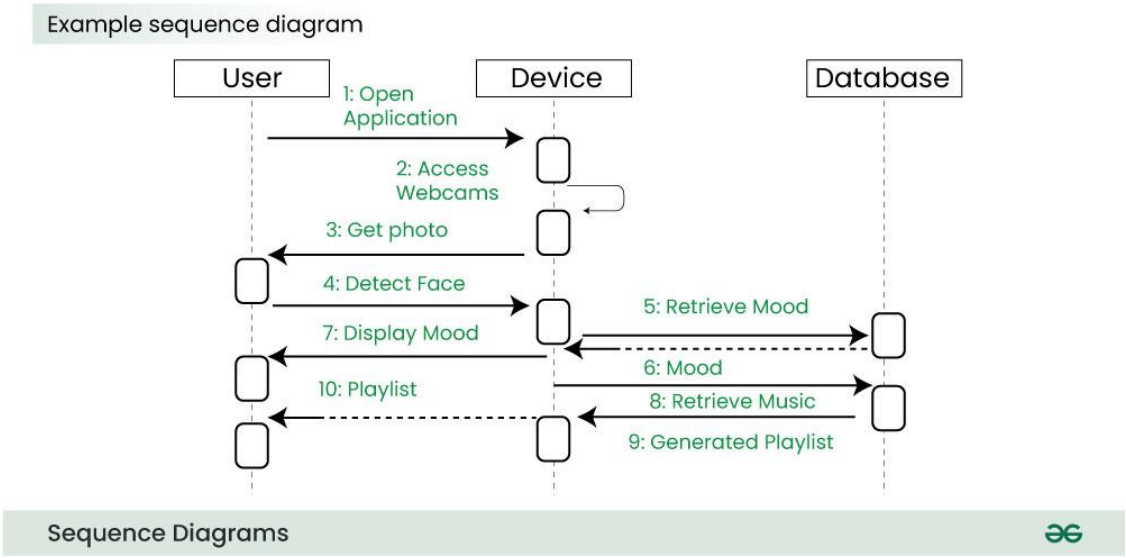
1.10. Guards

To model conditions we use guards in UML. They are used when we need to restrict the flow of messages on the pretext of a condition being met. Guards play an important role in letting software developers know the constraints attached to a system or a particular process.

For example:

> *In order to be able to withdraw cash, having a balance greater than zero is a condition that must be met as shown below.*





The above sequence diagram depicts the sequence diagram for an emotion based music player:

1. Firstly the application is opened by the user.
2. The device then gets access to the web cam.
3. The webcam captures the image of the user.
4. The device uses algorithms to detect the face and predict the mood.
5. It then requests database for dictionary of possible moods.
6. The mood is retrieved from the database.
7. The mood is displayed to the user.
8. The music is requested from the database.
9. The playlist is generated and finally shown to the user.

2. How to create Sequence Diagrams?

Creating a sequence diagram involves several steps, and it's typically done during the design phase of software development to illustrate how different components or objects interact over time. Here's a step-by-step guide on how to create sequence diagrams:

1. **Identify the Scenario:**
   - Understand the specific scenario or use case that you want to represent in the sequence diagram. This could be a specific interaction between objects or the flow of messages in a particular process.

2. **List the Participants:**
   - Identify the participants (objects or actors) involved in the scenario. Participants can be users, systems, or external entities.

3. **Define Lifelines:**
    - Draw a vertical dashed line for each participant, representing the lifeline of each object over time. The lifeline represents the existence of an object during the interaction.

4. **Arrange Lifelines:**
    - Position the lifelines horizontally in the order of their involvement in the interaction. This helps in visualizing the flow of messages between participants.

5. **Add Activation Bars:**
    - For each message, draw an activation bar on the lifeline of the sending participant. The activation bar represents the duration of time during which the participant is actively processing the message.

6. **Draw Messages:**
    - Use arrows to represent messages between participants. Messages flow horizontally between lifelines, indicating the communication between objects. Different types of messages include synchronous (solid arrow), asynchronous (dashed arrow), and self-messages.

7. **Include Return Messages:**
    - If a participant sends a response message, draw a dashed arrow returning to the original sender to represent the return message.

8. **Indicate Timing and Order:**
    - Use numbers to indicate the order of messages in the sequence. You can also use vertical dashed lines to represent occurrences of events or the passage of time.

9. **Include Conditions and Loops:**
    - Use combined fragments to represent conditions (like if statements) and loops in the interaction. This adds complexity to the sequence diagram and helps in detailing the control flow.

10. **Consider Parallel Execution:**
    - If there are parallel activities happening, represent them by drawing parallel vertical dashed lines and placing the messages accordingly.

11. **Review and Refine:**
    - Review the sequence diagram for clarity and correctness. Ensure that it accurately represents the intended interaction. Refine as needed.

12. **Add Annotations and Comments:**
    - Include any additional information, annotations, or comments that provide context or clarification for elements in the diagram.

13. **Document Assumptions and Constraints:**
    - If there are any assumptions or constraints related to the interaction, document them alongside the diagram.

14. **Tools:**
    - Use a UML modeling tool or diagramming software to create a neat and professional-looking sequence diagram. These tools often provide features for easy editing, collaboration, and documentation.

3. Use cases of Sequence Diagrams

- **System Behavior Visualization:**
    - Sequence diagrams are used to illustrate the dynamic behavior of a system by showing the interactions among various components, objects, or actors over time.
    - They provide a clear and visual representation of the flow of messages and events in a specific scenario.
- **Software Design and Architecture:**
    - During the design phase of software development, sequence diagrams help developers and architects plan and understand how different components and objects will interact to accomplish specific functionalities.
    - They provide a blueprint for the system's behavior.
- **Communication and Collaboration:**
    - Sequence diagrams serve as a communication tool among stakeholders, including developers, designers, project managers, and clients.
    - They help in conveying complex interactions in an easy-to-understand visual format, fostering collaboration and shared understanding.
- **Requirements Clarification:**

- When refining system requirements, sequence diagrams can be used to clarify and specify the expected interactions between system components or between the system and external entities.
- They help ensure a common understanding of system behavior among all stakeholders.

- **Debugging and Troubleshooting:**
  - Developers use sequence diagrams as a debugging tool to identify and analyze issues related to the order and timing of messages during system interactions.
  - It provides a visual representation of the flow of control and helps in locating and resolving problems.

4. Challenges of using Sequence Diagrams

- **Complexity and Size:**
  - As systems grow in complexity, sequence diagrams can become large and intricate. Managing the size of the diagram while still accurately representing the interactions can be challenging, and overly complex diagrams may become difficult to understand.
- **Abstraction Level:**
  - Striking the right balance in terms of abstraction can be challenging. Sequence diagrams need to be detailed enough to convey the necessary information, but too much detail can overwhelm readers. It's important to focus on the most critical interactions without getting bogged down in minutiae.
- **Dynamic Nature:**
  - Sequence diagrams represent dynamic aspects of a system, and as a result, they may change frequently during the development process. Keeping sequence diagrams up-to-date with the evolving system can be a challenge, especially in rapidly changing or agile development environments.
- **Ambiguity in Messages:**
  - Sometimes, it can be challenging to define the exact nature of messages between objects. Ambiguity in message content or meaning may lead to misunderstandings among stakeholders and impact the accuracy of the sequence diagram.

- **Concurrency and Parallelism:**
  - Representing concurrent and parallel processes can be complex. While sequence diagrams have mechanisms to indicate parallel execution, visualizing multiple interactions happening simultaneously can be challenging and may require additional diagrammatic elements.
- **Real-Time Constraints:**
  - Representing real-time constraints and precise timing requirements can be challenging. While sequence diagrams provide a sequential representation, accurately capturing and communicating real-time aspects might require additional documentation or complementary diagrams.

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