Analiza și Modelarea Sistemelor Software - Lab 5

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Timing Diagrams

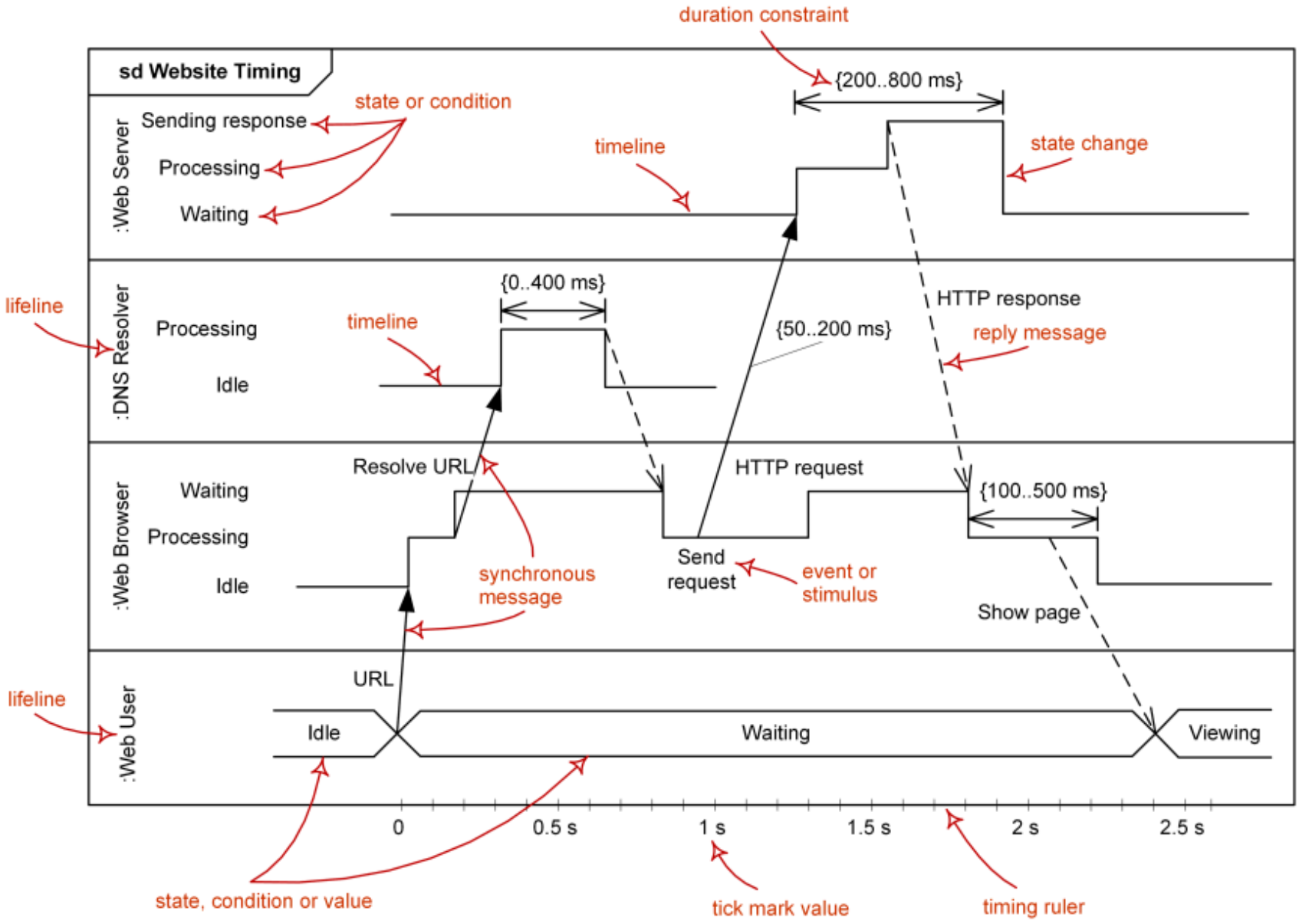
Timing Diagrams — Quick Refresher

- Show **state changes over time** for multiple lifelines
- Emphasize **temporal constraints**, **durations**, and **deadlines**
- Useful for:
  - embedded systems
  - robotics
  - real-time software
  - safety-critical controllers

Key Elements:

- Lifelines
- States / Value changes
- Timing constraints
- Duration and time markers
- Messages and asynchronous events

Timing diagram example



Exercise Overview

You will create a **Timing Diagram** for a multi-sensor **Collision Avoidance System** (CAS) used by a drone.

The system integrates multiple periodic and event-driven signals, strict deadlines, and interrupt conditions.

System Components (Lifelines)

- **FPS** — Front Proximity Sensor
- **ALT** — Downward Altimeter
- **VPU** — Vision Processing Unit
- **APC** — Autopilot Control Module
- **MC** — Motor Controller

Your diagram must include all five.

Normal Timing Behavior

- **FPS:** emits distance reading every **50 ms**
- **ALT:** emits altitude reading every **50 ms**
- **VPU:** emits obstacle classification every **150 ms**
- **APC:** computes flight-plan update every **100 ms**

These periodic events continue unless interrupted.

Event: Obstacle Detected (FPS)

When FPS detects an object within **2.0 m**:

1. Sends **CloseObstacle** to APC immediately
2. APC must respond within **25 ms** with **Brake** to MC
3. MC performs braking maneuver for **200 ms**
4. MC signals **BrakeComplete** when done

MC braking may be interrupted later by emergency events.

Event: Rapid Altitude Drop (ALT)

If ALT senses a drop $>$ **0.5 m within 100 ms**:

1. ALT sends **RapidDrop** to APC
2. APC must send **Ascend** to MC within **40 ms**
3. MC applies upward thrust for **300 ms**

APC's internal update cycle continues during this.

Event: Vision Override (VPU)

If VPU classifies an obstacle as **Critical**:

1. APC overrides all previous commands
2. Sends **EmergencyStop** to MC within **15 ms**
3. APC broadcasts **CriticalObstacle** to FPS, ALT, and VPU
4. MC halts any action (braking or ascending) immediately

This takes precedence over all other behaviors.

Interaction Rules

- FPS, ALT, and VPU continue periodic outputs at their frequencies
- Motor actions (**Braking**, **Ascending**) last assigned durations
- **EmergencyStop interrupts any motor maneuver**
- APC deadlines must be shown (25 ms, 40 ms, 15 ms)
- Students must show overlapping timing (e.g., Critical detected during braking)

Student Task

Create a **UML Timing Diagram** showing:

- All five lifelines
- State/value timelines for each component
- Periodic readings (50 ms, 150 ms, 100 ms)
- Event-driven transitions:
  - `CloseObstacle`
  - `RapidDrop`
  - `Brake`, `Ascend`, `EmergencyStop`
  - `CriticalObstacle`
- Duration constraints:
  - Braking: **200 ms**
  - Ascending: **300 ms**
- APC deadlines: **25 ms, 40 ms, 15 ms**
- At least **one interrupt case**
- Time markers (t0, t1, t2...)

Tips

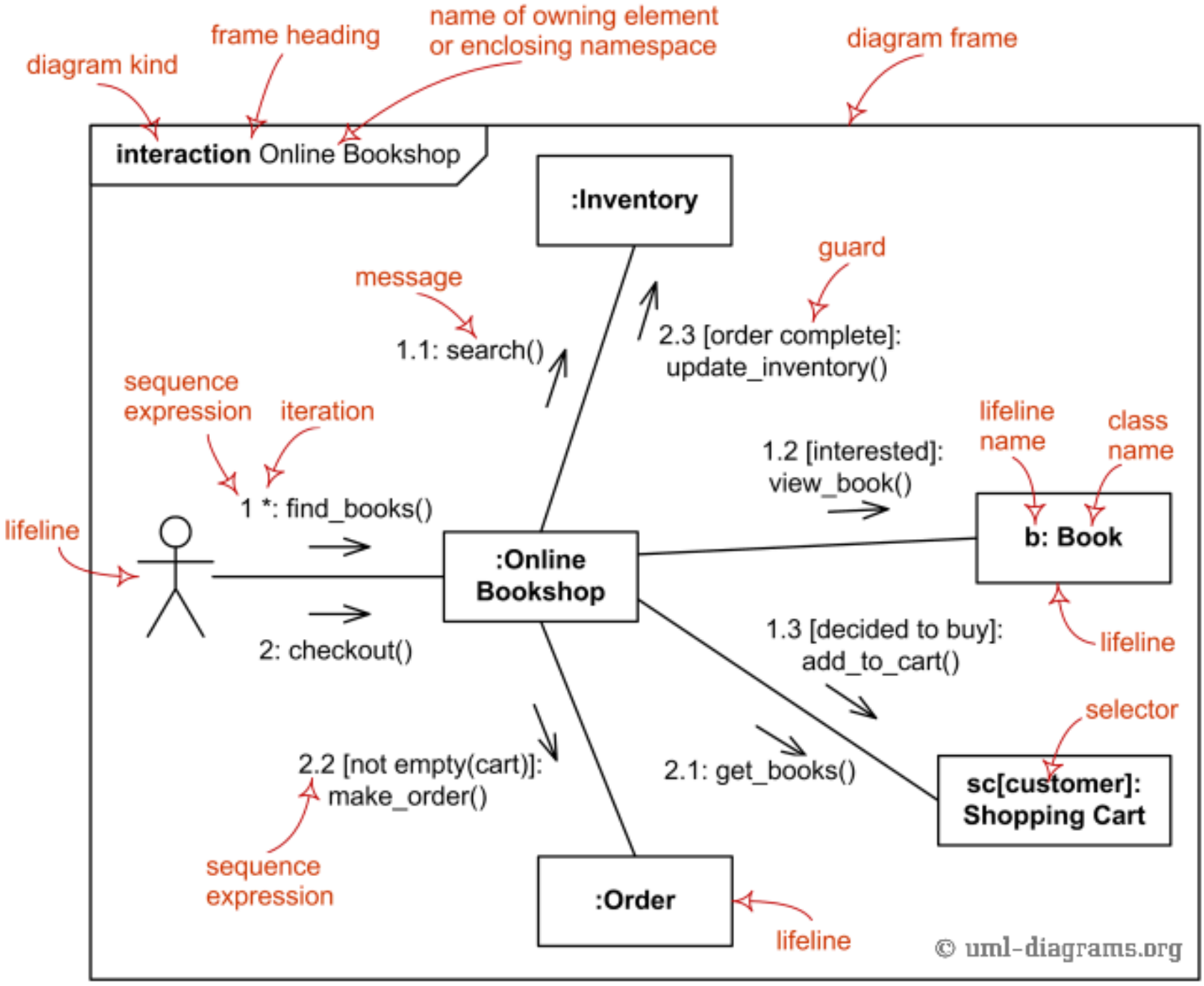
- Start by placing time axis and the five lifelines
- Add periodic outputs first
- Insert event-driven triggers
- Represent deadlines clearly
- Use timing marks (t0, t1...) for clarity
- Ensure emergency paths override other states cleanly

Communication Diagrams

UML Communication Diagrams Refresher

- **Purpose:** Show interactions between objects in a system and their message flows
- **Focus:** Relationships and links, not time sequence
- **Key Concepts:**
  - **Objects/Actors** — represented as rectangles with names
  - **Links** — lines connecting objects
  - **Messages** — arrows along links, optionally numbered to indicate sequence
  - **Sequence numbers** — e.g., `1`, `1.1`, `1.2`, `2` to show nested/parallel interactions
- **Use Cases:**
  - Modeling collaborative behavior
  - Complementary to Sequence Diagrams
  - Useful for analyzing message paths and responsibilities

Communication diagram example



Communication Diagram modelling exercise (summary)

Model two **autonomous warehouse robots** that negotiate access to a **shared loading bay**, using a **UML Communication Diagram**.

Scenario Overview

A distributed system coordinates **autonomous warehouse robots** that negotiate access to a **shared loading bay**.

Key components:

- **Robot A**
- **Robot B**
- **Bay Controller (BC)**
- **Task Scheduler (TS)**
- **Collision Monitor (CM)**
- **Fleet Manager (FM)**

Robots must request access, negotiate conflicts, and handle overrides and safety events.

Normal Behavior

1. Robot A and Robot B each send **AccessRequest** to the Bay Controller (BC).
2. BC queries the Task Scheduler (TS) for priority values.
   - TS returns **priority scores** for each robot.
3. BC grants the bay to the robot with higher priority and sends **AccessGranted**.
4. BC sends **AccessDenied** to the losing robot.

Negotiation Phase

If both robots have **equal priority**:

1. BC initiates a **TieBreak** procedure:
   - BC sends *NegotiationStart* to both robots.
2. Robots exchange **Proposal** and **CounterProposal** messages directly.
3. After exchanging proposals, both robots send **FinalOffer** to BC.
4. BC selects the best offer and grants access accordingly.

Safety Override Behavior

At any time:

- The **Collision Monitor (CM)** may send **ProximityAlert** to:
  - Robot A
  - Robot B
  - Bay Controller (BC)

On receiving **ProximityAlert**:

- BC must immediately send **AbortNegotiation** to both robots.
- BC informs the **Fleet Manager (FM)** with **SafetyEventReport**.
- FM sends **StandDown** to both robots to halt movement.
- After CM clears the danger, FM sends **ResumeOps**.

Additional Constraints

Students must incorporate:

- **Numbered message sequences** typical of communication diagrams.
- **Message ordering** within:
  - Normal access negotiation
  - Tie-break protocol
  - Safety override interrupt sequence
- **Conditional messages** (equality of priority).
- **Loops** for proposal exchanges (Proposal - CounterProposal).
- **Asynchronous safety interrupt** that can occur at any point.

Produce a UML Communication Diagram showing:

1. **Objects / Lifelines**
   - RobotA, RobotB, BC, TS, CM, FM
2. **Links**
   - Show communication paths (e.g., BC - TS, Robot - Robot, etc.)
3. **Message Flows**
   - Access request cycle
   - Priority request to TS
   - Tie-break negotiation if required
   - Safety override sequence
4. **Message Numbering**
   - Use hierarchical numbers (e.g., 1, 1.1, 1.2, 2, 3.1, 3.1.1…)
5. **Conditional & Loop Indicators**
   - Show repeated proposal exchanges
   - Show priority-equality decision branches
6. **Interrupt Modeling**
   - Show how **ProximityAlert** interrupts negotiation
   - Show BC $\rightarrow$ Robot abort sequence
   - Show BC $\rightarrow$ FM reporting
   - Show FM's commands

Expected Complexity

Students must represent:

- Multi-party negotiations
- Conditional tie-breaking
- Direct robot-to-robot communication
- Interrupt-driven behavior
- Message ordering and hierarchy
- Safety-override commands

This typically results in **15–30 messages** and multiple branches.