SWE209
Object Oriented Analysis and Design

System Design - 2

Note

- This presentation is based on the slides and content of the course main textbook.
- Bernd Bruegge, Allen H. Dutoit, Object-Oriented Software Engineering: Using UML, Patterns and Java, 3rd Edition, Pearson, 2014
- https://ase.in.tum.de/lehrstuhl_1/component/content/article/43-books/217

Agenda

Big Picture

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UML Deployment Diagrams

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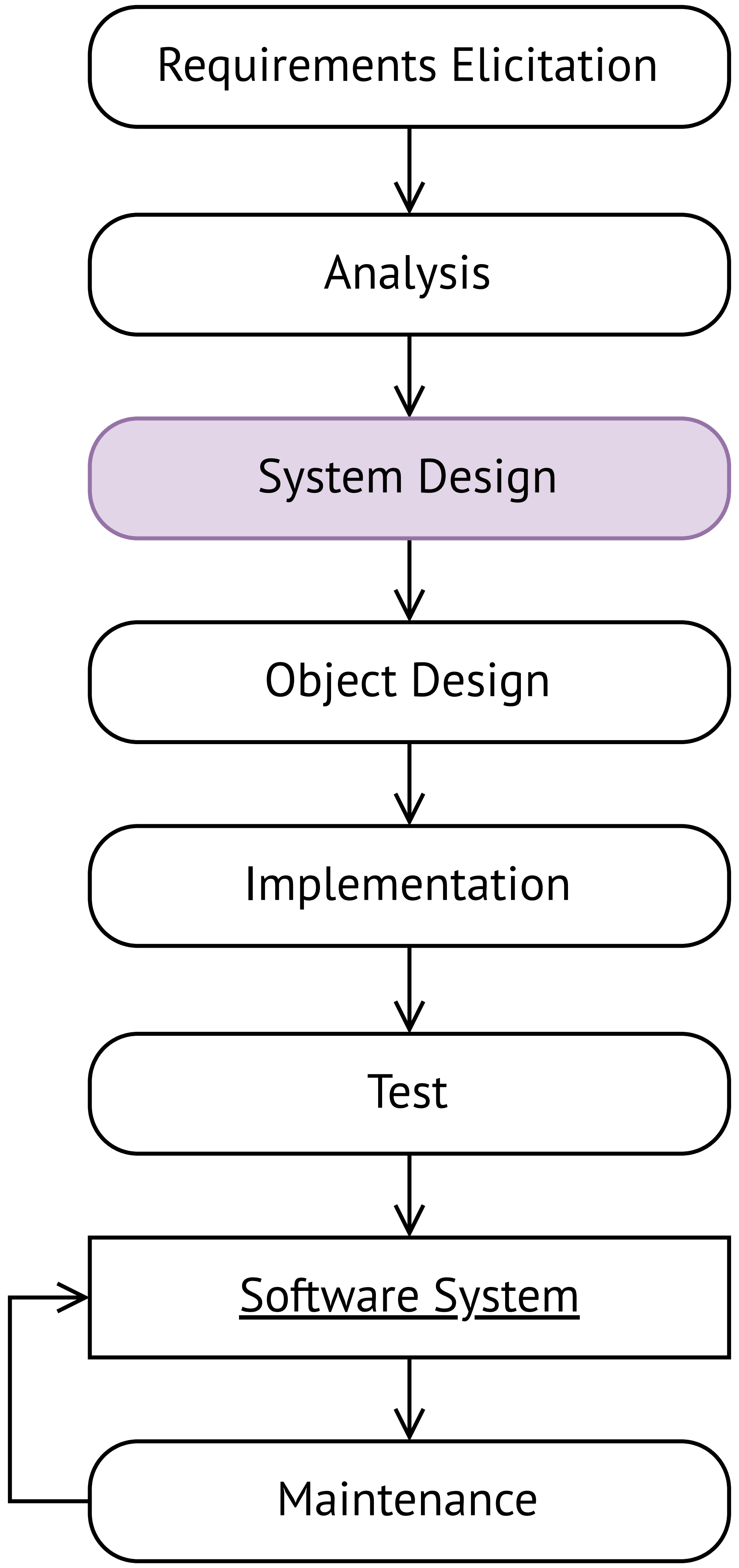
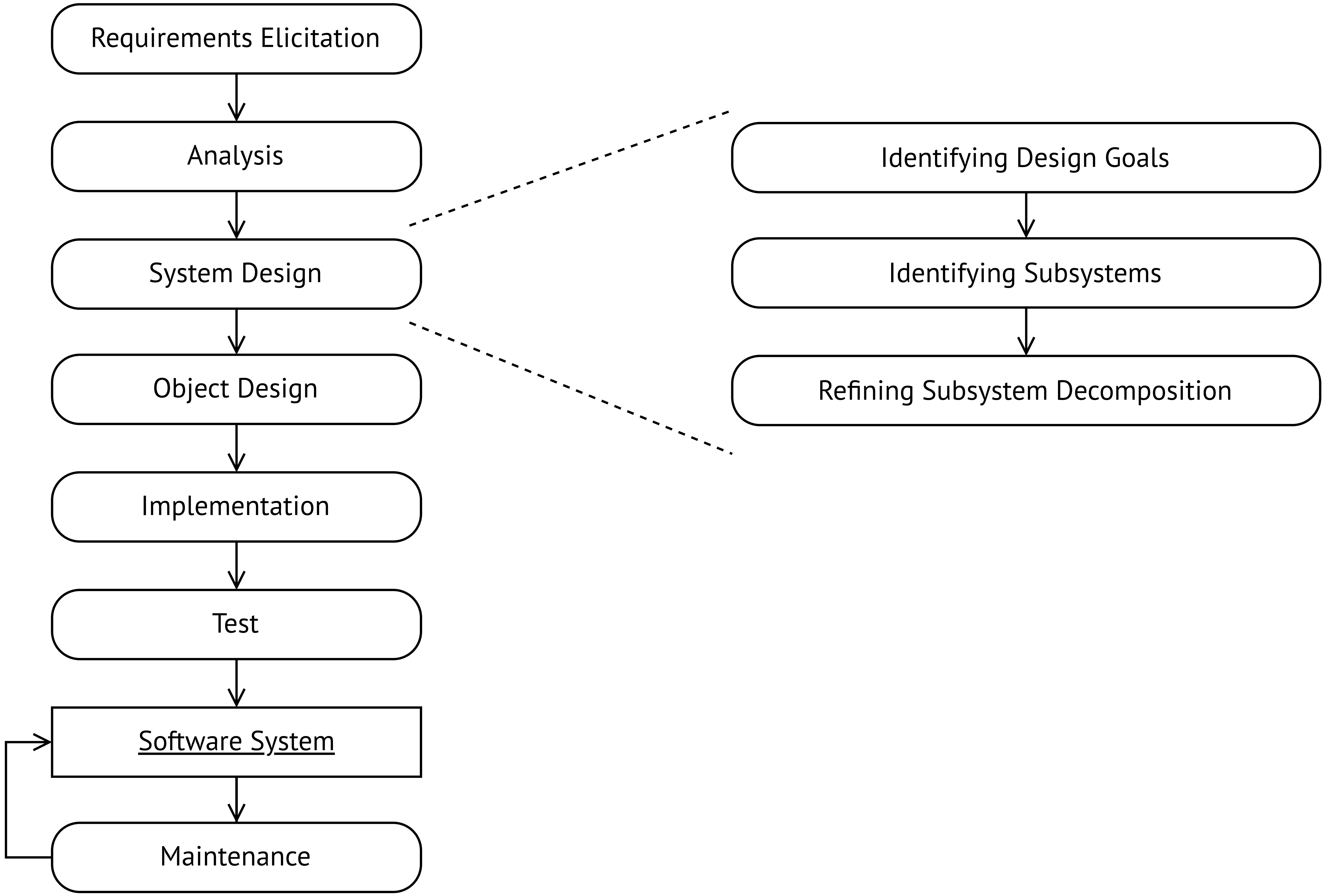
Documenting System Design

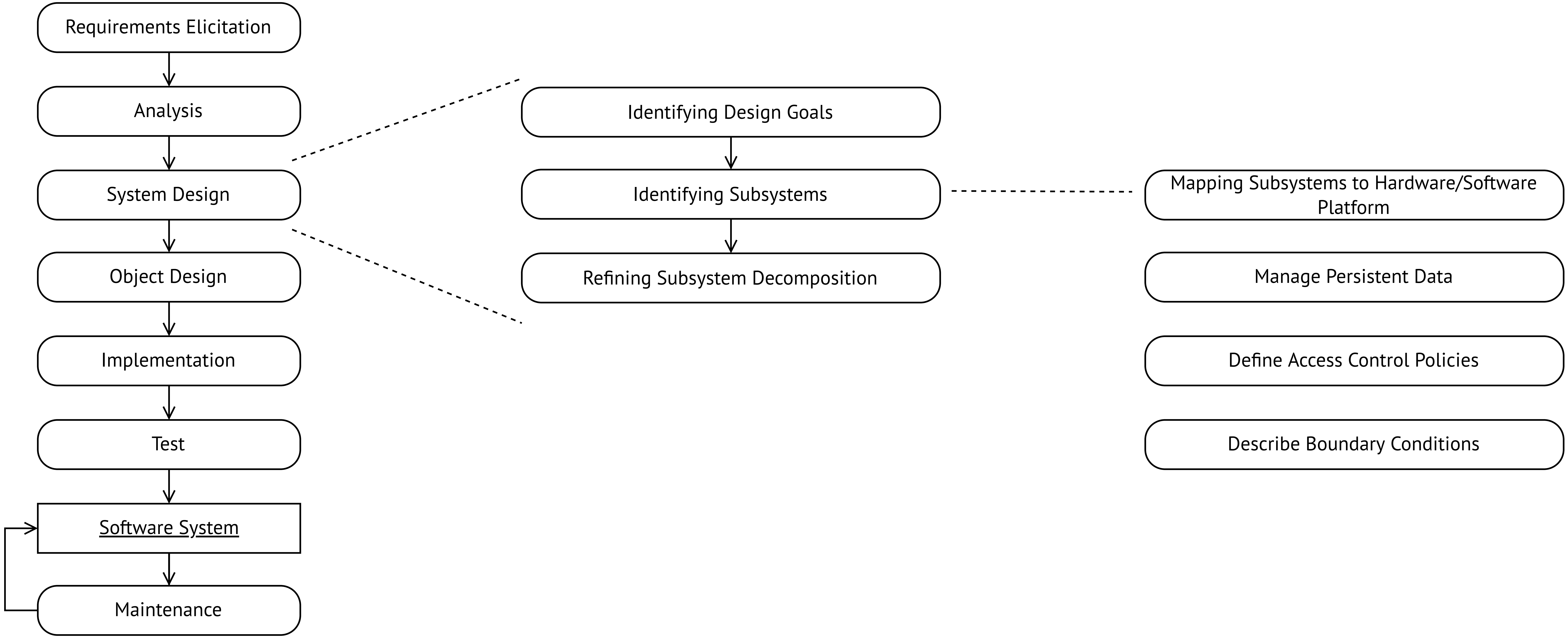
Big Picture


Requirements Elicitation
Analysis
System Design
Object Design
Implementation
Test
Software System
Maintenance

Introduction



Introduction

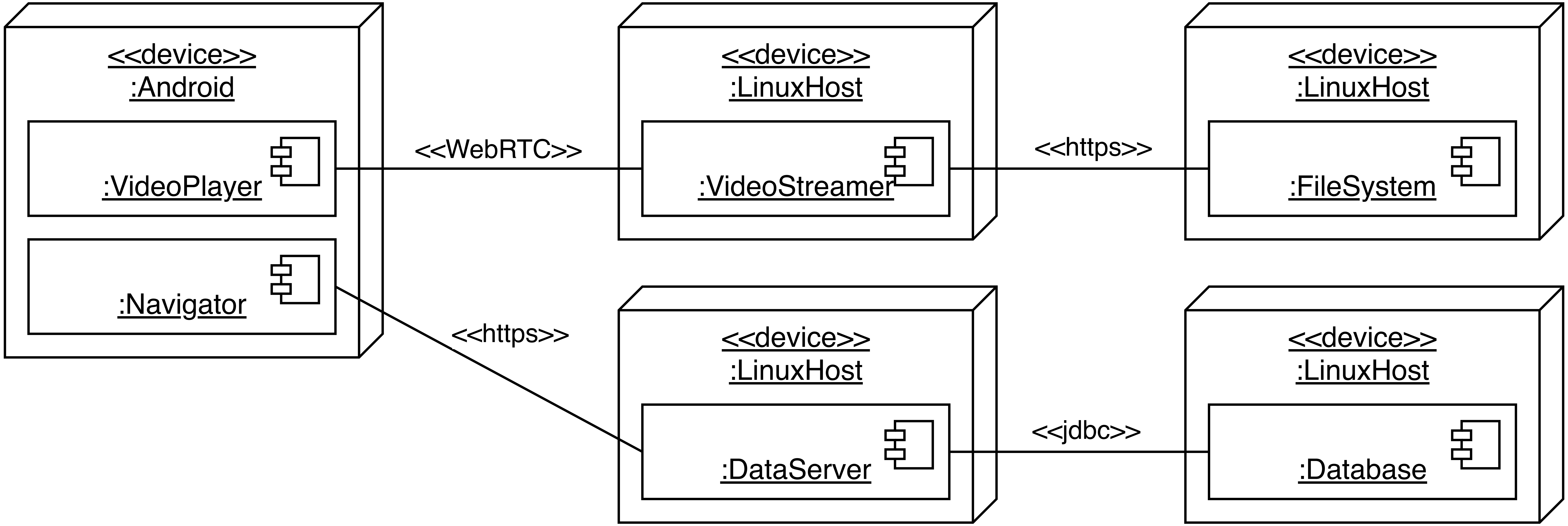


UML Deployment Diagrams

UML Deployment Diagrams

- UML deployment diagrams include components and nodes.
- Components → Self-contained entities that provide services to other components or actors.
- Node → Physical device or an execution environment in which components are executed.
- System → Interacting run-time components that can be distributed among several nodes.

UML Deployment Diagrams



System Design Activities

System Design Activities

- Additional system design activities
    - Map Subsystems to Hardware/Software Platform
    - Manage Persistent Data
    - Define Access Control Policies
    - Describe Boundary Conditions

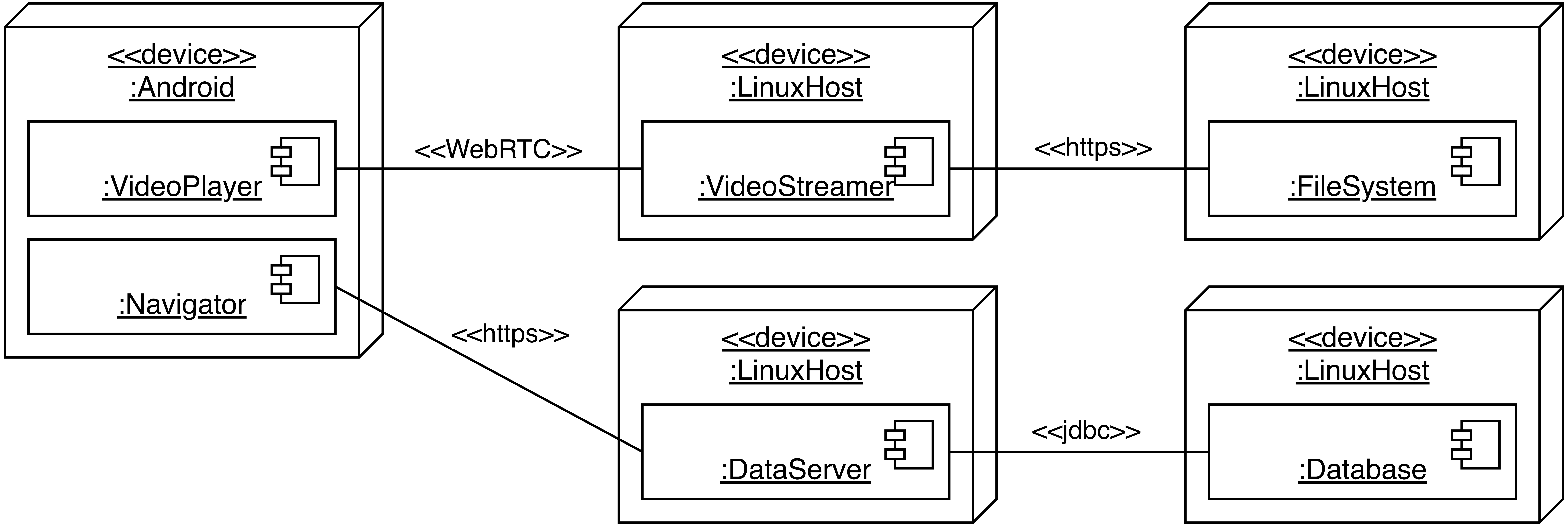
Map Subsystems to Hardware/Software Platform

- Will the software;
  - Run on just a single computer?
  - Run on more than one computer?
- Determine which subsystem will run on which device.
- Determine how subsystems will connect?
- Get help from UML deployment diagrams.

Map Subsystems to Hardware/Software Platform

- Decide additional software for the system.
  - Map them to appropriate devices.
- Decide virtual machine usage.
  - On which device virtual machine(s) will be placed?
  - How many virtual machines will be used?
  - Which components will be mapped to which virtual machines?

Map Subsystems to Hardware/Software Platform



Manage Persistent Data

- Systems commonly use persistent data.
- Three sub activities:
    - Identify Persistent Data
    - Decide Storage Management Strategy
    - Decide Storage Location
- Performed concurrent with the previous activity.

Manage Persistent Data

Identify Persistent Data

- Identify which data must be persistent.
- Obvious candidates → Entity objects
- Not all entity objects must be persistent.
- Persistent objects are not limited to entity objects.

Manage Persistent Data

Identify Persistent Data

- How can we identify persistent objects?
    - Examine the classes that must survive during shutdown.
- The system must be able to restore these long-lived objects by retrieving their attributes from storage during system initialization.

Manage Persistent Data

Decide Storage Management Strategy

- Decide how persistent objects should be stored.
  - Should the objects be retrieved quickly?
  - Must the system perform complex queries to retrieve these objects?
  - Do objects require a lot of memory or disk space?

Manage Persistent Data

Decide Storage Management Strategy

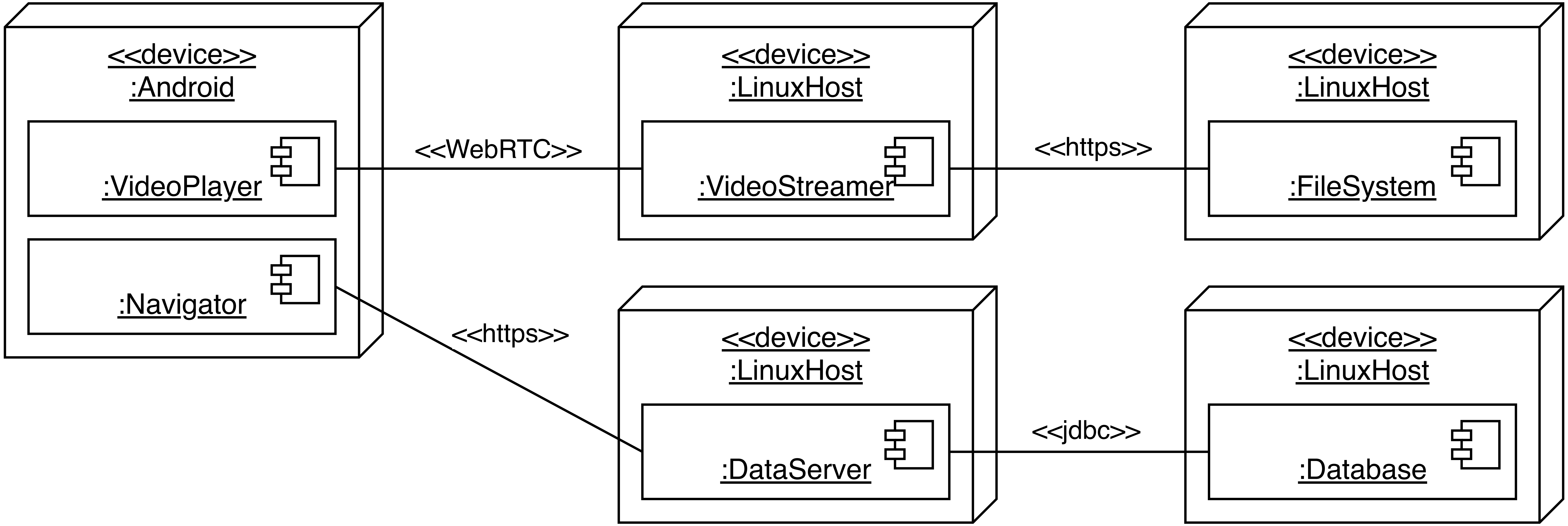
- Main options for storage management:
  - Classical File Structure
    - Binary file, CSV files, XML files, etc.
  - Database Management System
    - Relational, NoSQL, etc.

Manage Persistent Data

Decide Storage Location

- Where to store the data?
- Concurrent with/part of
    - Mapping subsystems to hardware/software platform activity

Manage Persistent Data



Define Access Control Policies

- Modern software systems → Multi-user systems
- Which actors can access and perform which operations on which objects?
  - Permissions, access rights
- Policies → Determine permissions, access rights
- Mechanisms → Manage the access to the objects and functionalities of the system.

Define Access Control Policies

- Four sub activities
  - Prepare access matrix
  - Choose access control approach
  - Choose authentication mechanism
  - Choose encryption

Define Access Control Policies

Prepare Access Matrix

Objects Actors	Corporation	LocalBranch	Account

Teller			postSmallDebit()
			postSmallCredit()
			examineBalance()

Manager		examineBranchStats()	postSmallDebit()
			postSmallCredit()
			postLargeDebit()
			postLargeCredit()
			examineBalance()
			examineHistory()

Analyst	examineGlobalStats()	examineBranchStats()	

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Define Access Control Policies

Choose Access Control Approach

- Realization of access matrix:
    - Access Control List (ACL)
    - Role-Based Access Control (RBAC)

Define Access Control Policies

Choose Authentication Mechanism

- Authentication → Identify actor
- Authentication mechanisms:
    - Single-factor authentication (SFA)
        - User name and password
        - Find user name
        - Check whether passwords match
        - Passwords are transmitted and stored encrypted

Define Access Control Policies

Choose Authentication Mechanism

- Two-factor authentication (2FA)
  - SFA + Ask verification of the user using a device the user owns (smartphone, smart card etc.)
- Multi-factor authentication (MFA)
  - 2FA + Ask verification of the user using personal property (fingerprint, voice, etc.)
  - 2FA + Biometric verification

Define Access Control Policies

Choose Encryption

- Encryption of password → password hashing
  - Cryptographic hash algorithms
    - MD5
    - SHA-1, SHA-2, SHA-3
    - BLAKE, BLAKE2, BLAKE3

Describe Boundary Conditions

- Decide how the system is started, initialized, and shut down.
- Define how we deal with major failures.
- Examine each subsystem and each persistent object, and determine boundary use cases.
- Perform this activity under three titles:
    - Configuration, start-up and shutdown, exception handling

Describe Boundary Conditions

- Configuration
    - For each persistent object, examine in which use cases it is created or destroyed (or archived).
    - For objects that are not created or destroyed in any of the common use cases, add a use case invoked by a system administrator.
- Start-up and shutdown
    - For each component, add three use cases to start, shutdown, and configure the component.

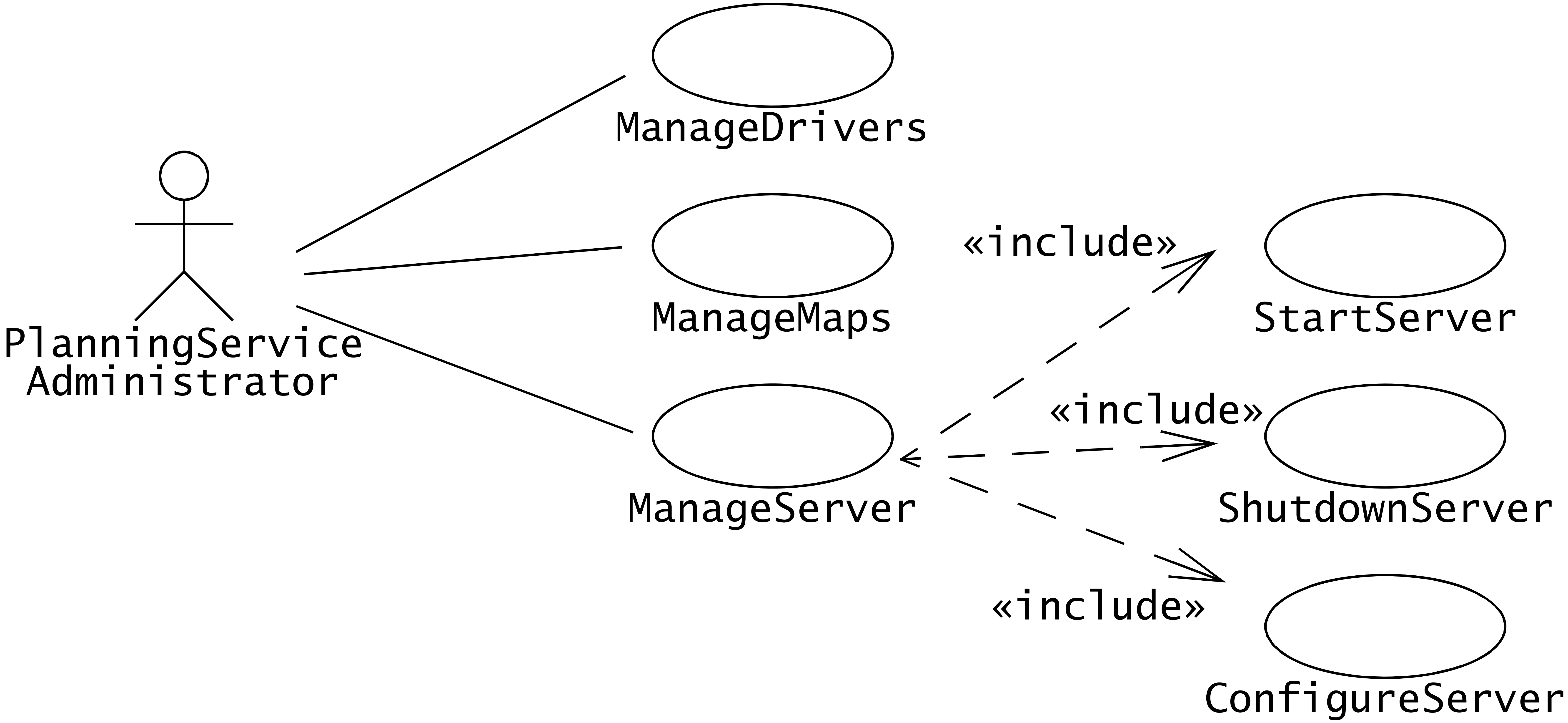
Describe Boundary Conditions

- Exception handling
  - For each type of component failure, decide how the system should react.
  - Add exceptional use cases that extends the relevant common uses cases.

Describe Boundary Conditions

- Exception → An event or error that occurs during the execution of the system.
- Three sources:
  - Hardware failure
  - Changes in the operating environment
  - Software fault
- Exception handling → Mechanism by which a system treats an exception.

Describe Boundary Conditions



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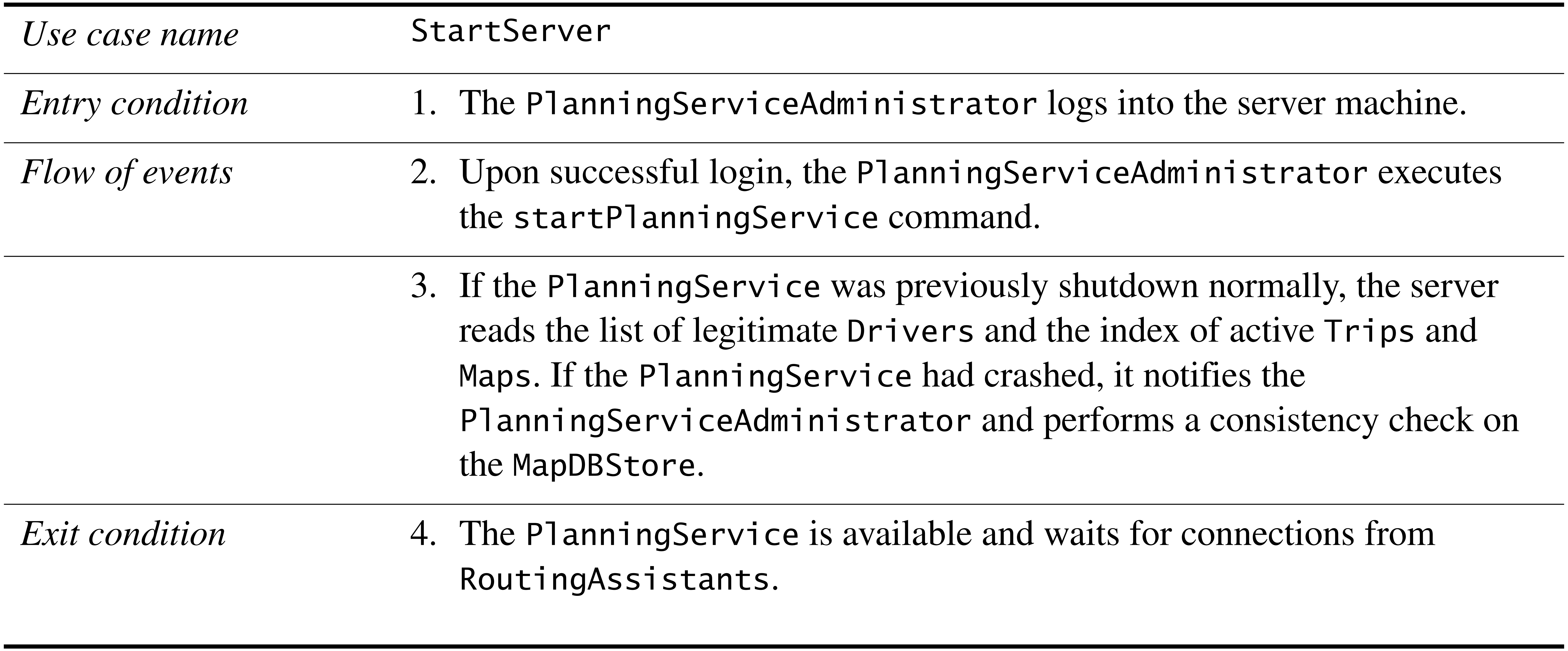
Describe Boundary Conditions



Use case name	`StartServer`
Entry condition	1. The `PlanningServiceAdministrator` logs into the server machine.
Flow of events	2. Upon successful login, the `PlanningServiceAdministrator` executes the `startPlanningService` command.
	3. If the `PlanningService` was previously shutdown normally, the server reads the list of legitimate `Drivers` and the index of active `Trips` and `Maps`. If the `PlanningService` had crashed, it notifies the `PlanningServiceAdministrator` and performs a consistency check on the `MapDBStore`.
Exit condition	4. The `PlanningService` is available and waits for connections from `RoutingAssistants`.

Bernd Bruegge, Allen H. Dutoit, Object-Oriented Software Engineering: Using UML, Patterns and Java, 3rd Edition, Pearson, 2014.

Reviewing System Design

Reviewing System Design

- Like analysis, system design is an evolutionary and iterative activity.
- Unlike analysis, there is no external agent to review.
- Need to organize a review process.
- Developers who were not involved in system design may review.
- Developers from another project may review.

Reviewing System Design

- Ensure that the system design model is correct, complete, consistent, realistic, and readable.
- The system design model is;
  - Correct if the analysis model can be mapped to the system design model.
  - Complete if every requirement and every system design issue has been addressed.
  - Consistent if it does not contain any contradictions.

Reviewing System Design

- Realistic if the corresponding system can be implemented.
- Readable if developers not involved in the system design can understand the model.

Documenting System Design

Documenting System Design

- System Design Document → SDD
- Describes;
    - Design goals
    - Subsystem decomposition (UML class diagrams)
    - Hardware/software mapping (with UML deployment diagrams)
    - Data management
    - Access control
    - Boundary conditions

Documenting System Design

- SDD is used to define interfaces between teams of developers
- SDD serves as a reference when architecture-level decisions need to be revisited.
- Audience for the SDD;
  - Project managers
  - System architects (developers who participate in the system design)
  - Developers who design and implement each subsystem

Documenting System Design

1. Introduction
   - 1.1 Purpose
   - 1.2 Design Goals
2. Current Software Architecture
3. Proposed Software Architecture
   - 3.1 Overview
   - 3.2 Subsystem Decomposition
   - 3.3 Hardware/Software Mapping
   - 3.4 Persistent Data Management
   - 3.5 Access Control and Security
   - 3.6 Boundary Conditions
4. Subsystem Services
5. Glossary

Documenting System Design

- SDD is written after the initial system decomposition is done
- System architects should not wait until all system design decisions are made before publishing the document.
- SDD, once published, is baselined and put under configuration management.
- The revision history section of the SDD provides a history of changes.

References

- Bernd Bruegge, Allen H. Dutoit, Object-Oriented Software Engineering: Using UML, Patterns and Java, 3rd Edition, Pearson, 2014.
- Object Management Group, OMG Unified Modeling Language Superstructure, Version 2.2., http://www.omg.org/2009.

Thank you.