



# Chapter 7 – Design and Implementation

# Topics covered

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- ✧ Object-oriented design using the UML
- ✧ Design patterns
- ✧ Implementation issues
- ✧ Open source development

# Design and implementation



- ✧ Software design and implementation is the stage in the software engineering process at which an executable software system is developed.
- ✧ Software design and implementation activities are invariably inter-leaved.
  - Software design is a creative activity in which you identify software components and their relationships, based on a customer's requirements.
  - Implementation is the process of realizing the design as a program.

# Build or buy



- ✧ In a wide range of domains, it is now possible to buy off-the-shelf systems (COTS) that can be adapted and tailored to the users' requirements.
  - For example, if you want to implement a medical records system, you can buy a package that is already used in hospitals. It can be cheaper and faster to use this approach rather than developing a system in a conventional programming language.
- ✧ When you develop an application in this way, the design process becomes concerned with how to use the configuration features of that system to deliver the system requirements.



# Object-oriented design using the UML

# An object-oriented design process



- ✧ Structured object-oriented design processes involve developing a number of different system models.
- ✧ They require a lot of effort for development and maintenance of these models and, for small systems, this may not be cost-effective.
- ✧ However, for large systems developed by different groups design models are an important communication mechanism.

# Process stages



- ✧ There are a variety of different object-oriented design processes that depend on the organization using the process.
- ✧ Common activities in these processes include:
  - Define the context and modes of use of the system;
  - Design the system architecture;
  - Identify the principal system objects;
  - Develop design models;
  - Specify object interfaces.
- ✧ Process illustrated here using a design for a wilderness weather station.

# System context and interactions



- ✧ Understanding the relationships between the software that is being designed and its external environment is essential for deciding how to provide the required system functionality and how to structure the system to communicate with its environment.
- ✧ Understanding of the context also lets you establish the boundaries of the system. Setting the system boundaries helps you decide what features are implemented in the system being designed and what features are in other associated systems.



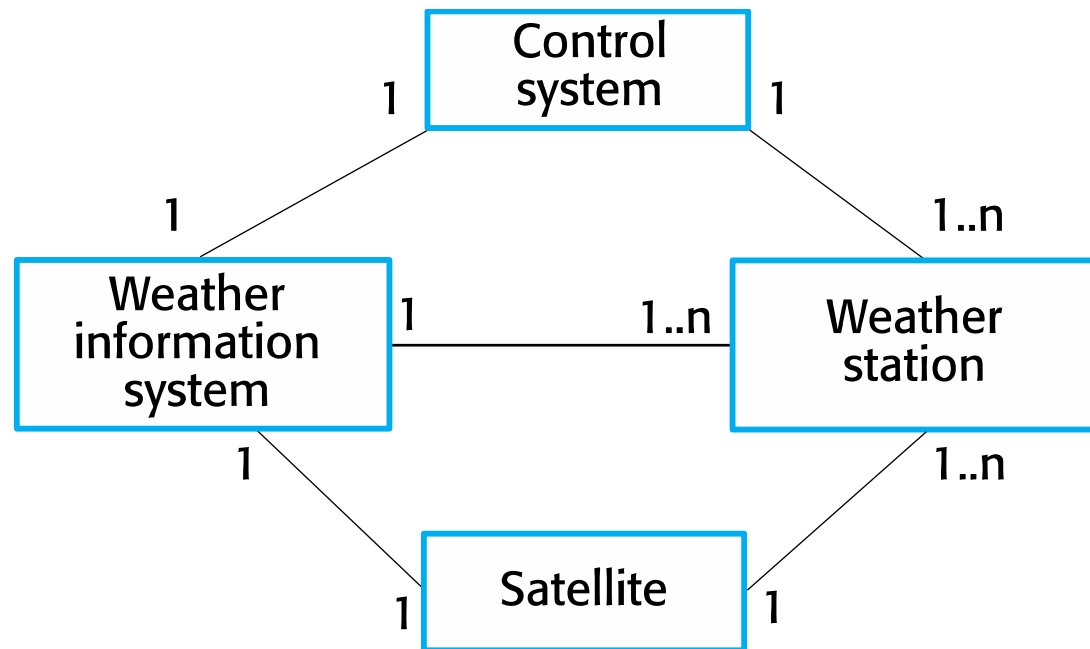
# Context and interaction models

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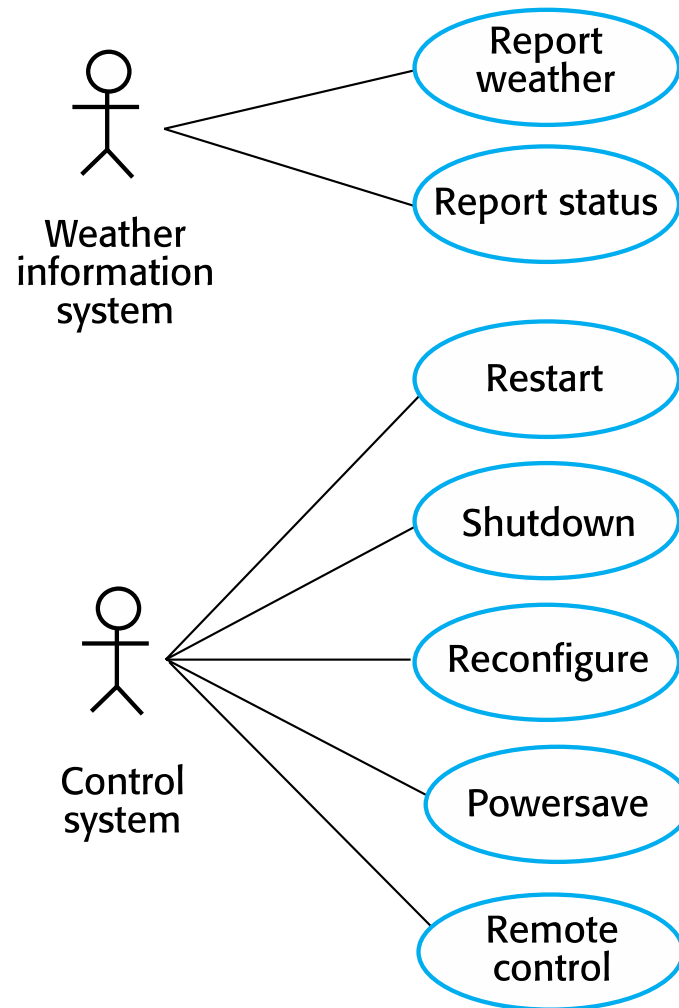


- ✧ A system context model is a structural model that demonstrates the other systems in the environment of the system being developed.
- ✧ An interaction model is a dynamic model that shows how the system interacts with its environment as it is used.

# System context for the weather station



# Weather station use cases



# Use case description—Report weather



System	Weather station
Use case	Report weather
Actors	Weather information system, Weather station
Description	The weather station sends a summary of the weather data that has been collected from the instruments in the collection period to the weather information system. The data sent are the maximum, minimum, and average ground and air temperatures; the maximum, minimum, and average air pressures; the maximum, minimum, and average wind speeds; the total rainfall; and the wind direction as sampled at five-minute intervals.
Stimulus	The weather information system establishes a satellite communication link with the weather station and requests transmission of the data.
Response	The summarized data is sent to the weather information system.
Comments	Weather stations are usually asked to report once per hour but this frequency may differ from one station to another and may be modified in the future.

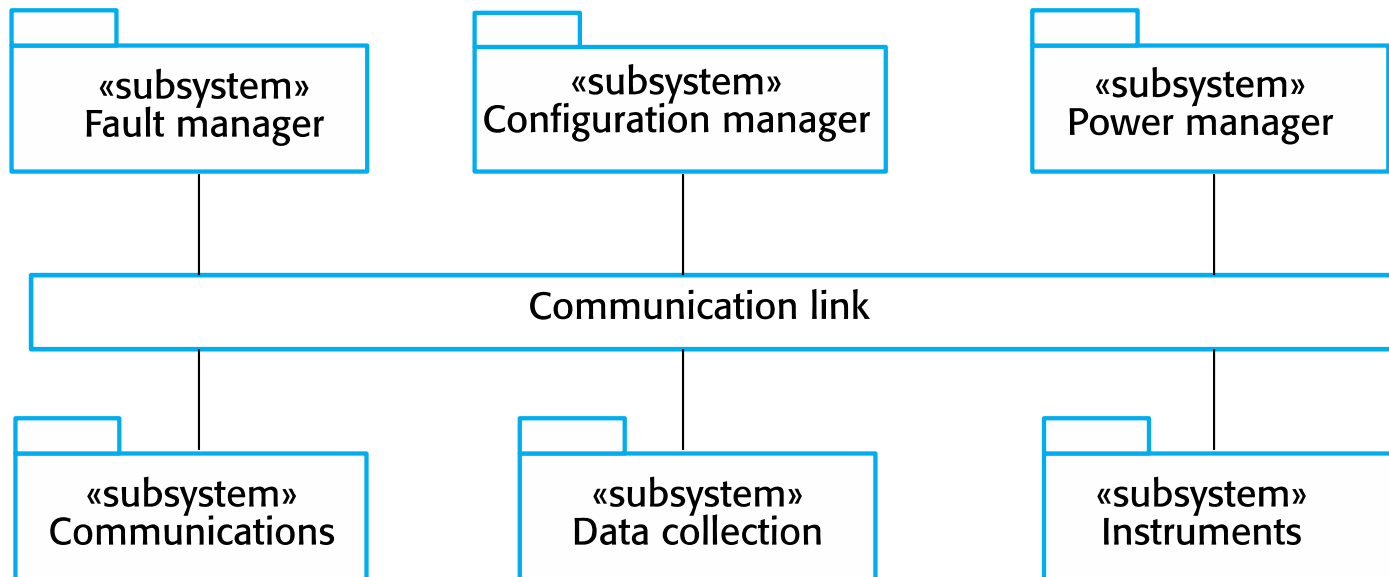
# Architectural design

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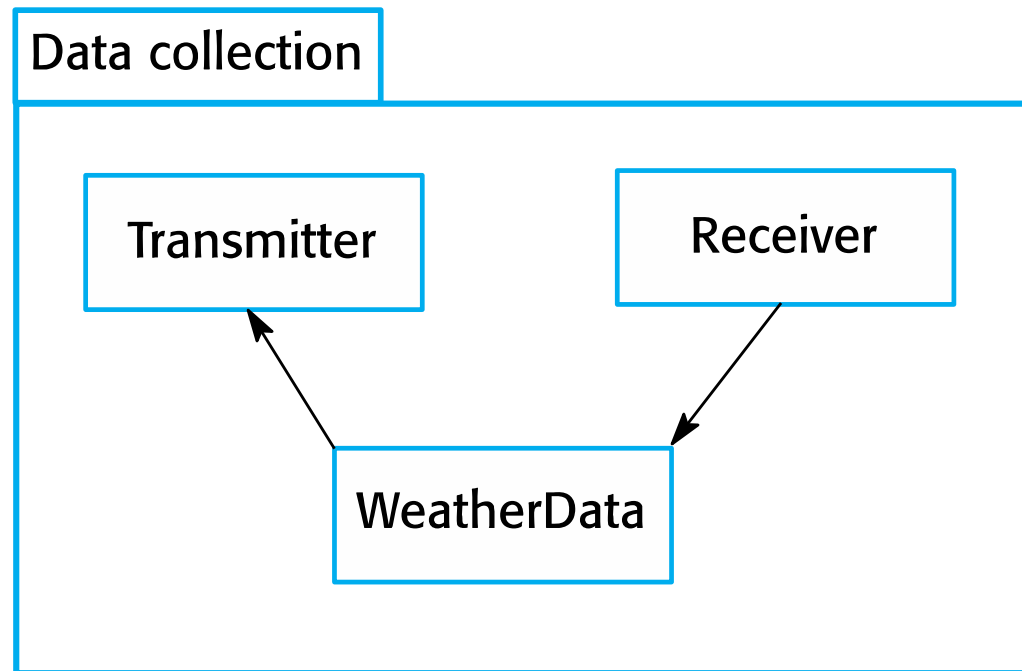


- ✧ Once interactions between the system and its environment have been understood, you use this information for designing the system architecture.
- ✧ You identify the major components that make up the system and their interactions, and then may organize the components using an architectural pattern such as a layered or client-server model.
- ✧ The weather station is composed of independent subsystems that communicate by broadcasting messages on a common infrastructure.

# High-level architecture of the weather station



# Architecture of data collection system



# Object class identification



- ✧ Identifying object classes is often a difficult part of object oriented design.
- ✧ There is no 'magic formula' for object identification. It relies on the skill, experience and domain knowledge of system designers.
- ✧ Object identification is an iterative process. You are unlikely to get it right first time.



# Approaches to identification

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- ✧ Use a grammatical approach based on a natural language description of the system.
- ✧ Base the identification on tangible things in the application domain.
- ✧ Use a behavioural approach and identify objects based on what participates in what behaviour.
- ✧ Use a scenario-based analysis. The objects, attributes and methods in each scenario are identified.

# Weather station object classes



- ✧ Object class identification in the weather station system may be based on the tangible hardware and data in the system:
  - Ground thermometer, Anemometer, Barometer
    - Application domain objects that are 'hardware' objects related to the instruments in the system.
  - Weather station
    - The basic interface of the weather station to its environment. It therefore reflects the interactions identified in the use-case model.
  - Weather data
    - Encapsulates the summarized data from the instruments.

# Weather station object classes



reportWeather ( )  
reportStatus ( )  
powerSave (instruments)  
remoteControl (commands)  
reconfigure (commands)  
restart (instruments)  
shutdown (instruments)

groundTemperatures  
windSpeeds  
windDirections  
pressures  
rainfall

collect ( )  
summarize ( )

## Ground thermometer

gt\_Ident  
temperature

## Anemometer

an\_Ident  
windSpeed  
windDirection

## Barometer

bar\_Ident  
pressure  
height

# Design models

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- ✧ Design models show the objects and object classes and relationships between these entities.
- ✧ There are two kinds of design model:
  - Structural models describe the static structure of the system in terms of object classes and relationships.
  - Dynamic models describe the dynamic interactions between objects.

# Examples of design models

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- ✧ Subsystem models that show logical groupings of objects into coherent subsystems.
- ✧ Sequence models that show the sequence of object interactions.
- ✧ State machine models that show how individual objects change their state in response to events.
- ✧ Other models include use-case models, aggregation models, generalisation models, etc.

# Subsystem models



- ✧ Shows how the design is organised into logically related groups of objects.
- ✧ In the UML, these are shown using packages - an encapsulation construct. This is a logical model. The actual organisation of objects in the system may be different.

# Sequence models

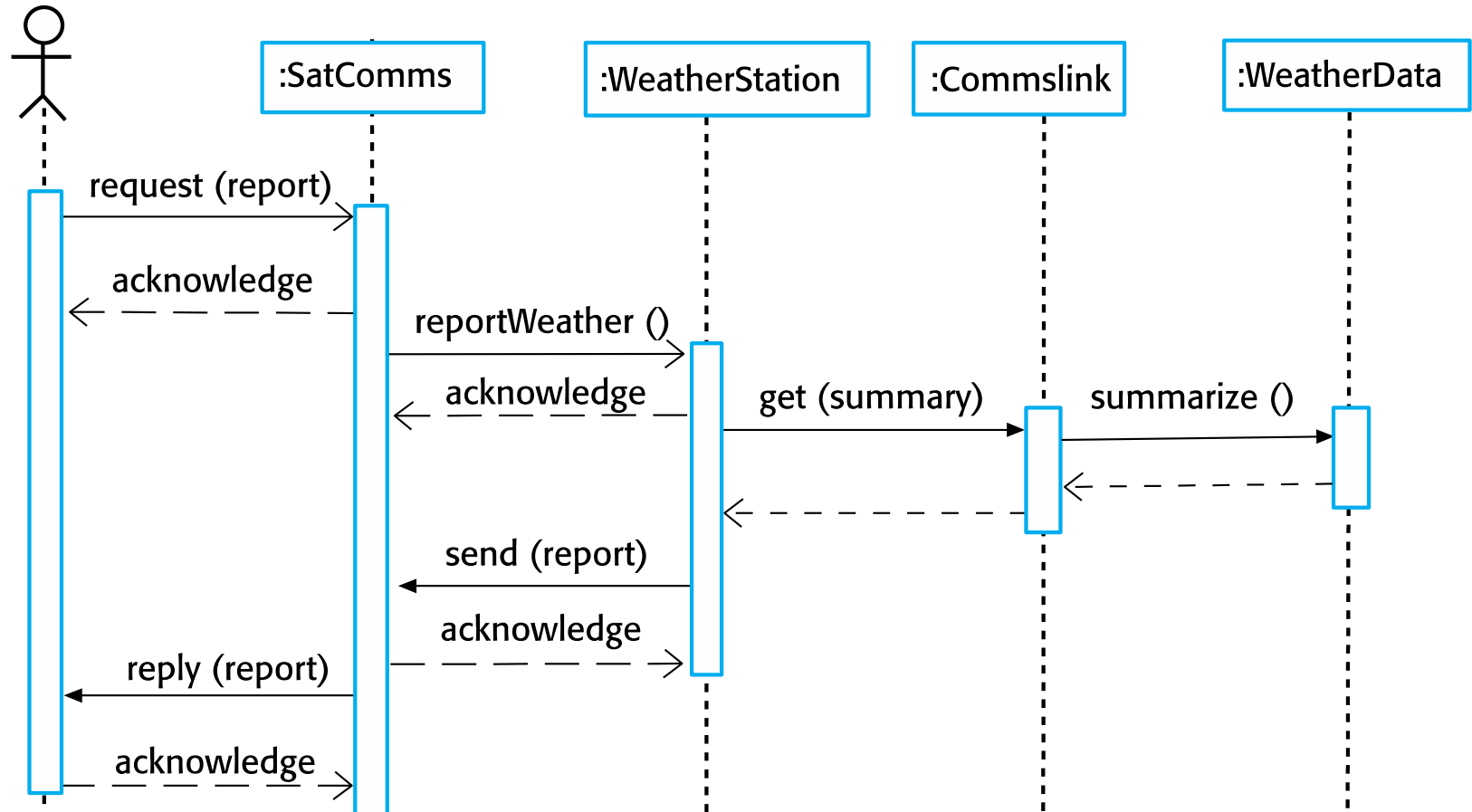


- ✧ Sequence models show the sequence of object interactions that take place
  - Objects are arranged horizontally across the top;
  - Time is represented vertically so models are read top to bottom;
  - Interactions are represented by labelled arrows, Different styles of arrow represent different types of interaction;
  - A thin rectangle in an object lifeline represents the time when the object is the controlling object in the system.

# Sequence diagram describing data collection



information system



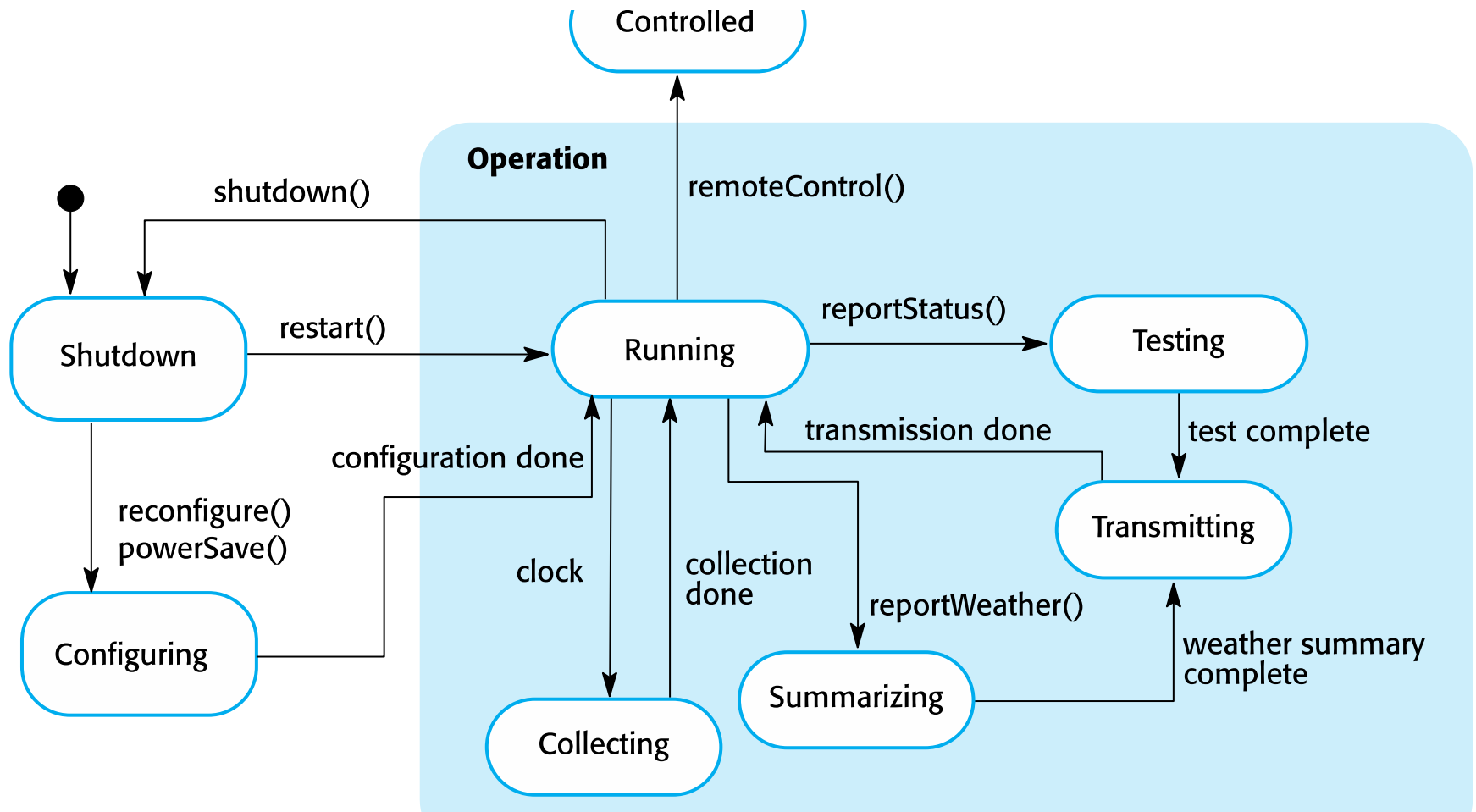


# State diagrams



- ✧ State diagrams are used to show how objects respond to different service requests and the state transitions triggered by these requests.
- ✧ State diagrams are useful high-level models of a system or an object's run-time behavior.
- ✧ You don't usually need a state diagram for all of the objects in the system. Many of the objects in a system are relatively simple and a state model adds unnecessary detail to the design.

# Weather station state diagram



# Interface specification



- ✧ Object interfaces have to be specified so that the objects and other components can be designed in parallel.
- ✧ Designers should avoid designing the interface representation but should hide this in the object itself.
- ✧ Objects may have several interfaces which are viewpoints on the methods provided.
- ✧ The UML uses class diagrams for interface specification but Java may also be used.

# Weather station interfaces



## «interface» Reporting

weatherReport (WS-Ident): Wreport  
statusReport (WS-Ident): Sreport

## «interface» Remote Control

startInstrument(instrument): iStatus  
stopInstrument (instrument): iStatus  
collectData (instrument): iStatus  
provideData (instrument ): string