An object-oriented design process

- Structured 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 essential communication mechanism.

Process stages

- Highlights key activities without being tied to any proprietary process such as the RUP.
  - 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.

Weather system description

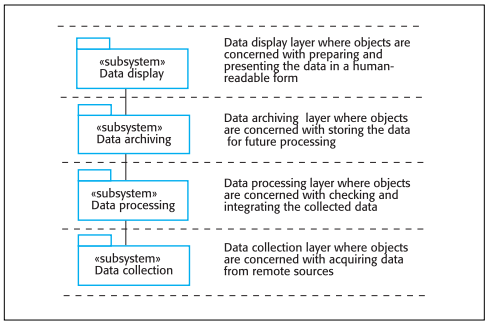
A weather mapping system is required to generate weather maps on a regular basis using data collected from remote, unattended weather stations and other data sources such as weather observers, balloons and satellites. Weather stations transmit their data to the area computer in response to a request from that machine.

The area computer system validates the collected data and integrates it with the data from different sources. The integrated data is archived and, using data from this archive and a digitised map database a set of local weather maps is created. Maps may be printed for distribution on a special-purpose map printer or may be displayed in a number of different formats.

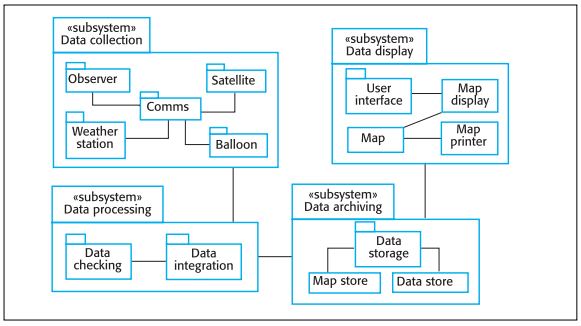
System context and models of use

- Develop an understanding of the relationships between the software being designed and its external environment
- System context
  - A static model that describes other systems in the environment. Use a subsystem model to show other systems. Following slide shows the systems around the weather station system.
- Model of system use
  - A dynamic model that describes how the system interacts with its environment. Use use-cases to show interactions

Layered architecture



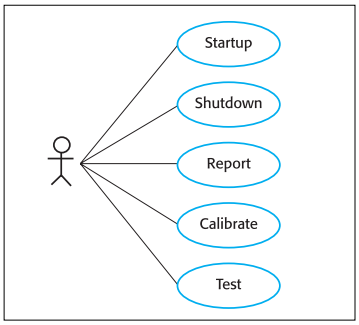
Subsystems in the weather mapping system



Use-case models

- Use-case models are used to represent each interaction with the system.
- A use-case model shows the system features as ellipses and the interacting entity as a stick figure.

Use-cases for the weather station



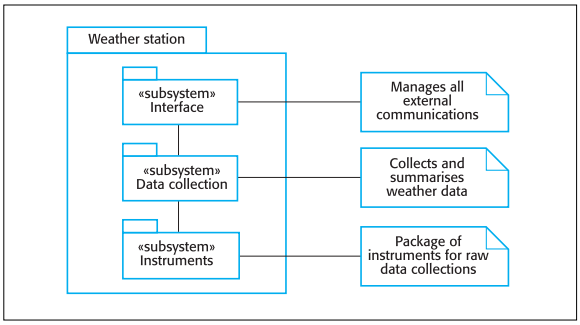
Use-case description

System	Weather station
Use-case	Report
Actors	Weather data collection system, Weather station
Data	The weather station sends a summary of the weather data that has been collected from the instruments in the collection period to the weather data collection 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 5 minute intervals.
Stimulus	The weather data collection system establishes a modem link with the weather station and requests transmission of the data.
Response	The summarised data is sent to the weather data collection system
Comments	Weather stations are usually asked to report once per hour but this frequency may differ from one station to the other and may be modified in future.

Architectural design

- Once interactions between the system and its environment have been understood, you use this information for designing the system architecture.
- A layered architecture as discussed in Chapter 11 is appropriate for the weather station
  - Interface layer for handling communications;
  - Data collection layer for managing instruments;
  - Instruments layer for collecting data.
- There should normally be no more than 7 entities in an architectural model.

Weather station architecture



Object identification

- Identifying objects (or object classes) is the most 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.

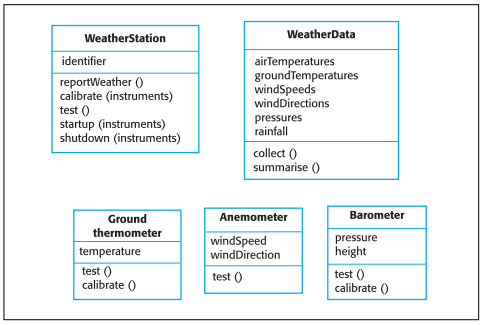
Approaches to identification

- Use a grammatical approach based on a natural language description of the system (used in Hood OOD method).
- 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

- 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 summarised data from the instruments.

Weather station object classes



Further objects and object refinement

- Use domain knowledge to identify more objects and operations
  - Weather stations should have a unique identifier;
  - Weather stations are remotely situated so instrument failures have to be reported automatically. Therefore attributes and operations for self-checking are required.
- Active or passive objects
  - In this case, objects are passive and collect data on request rather than autonomously. This introduces flexibility at the expense of controller processing time.

Design models

- Design models show the objects and object classes and relationships between these entities.
- Static models describe the static structure of the system in terms of object classes and relationships.
- Dynamic models describe the dynamic interactions between objects.

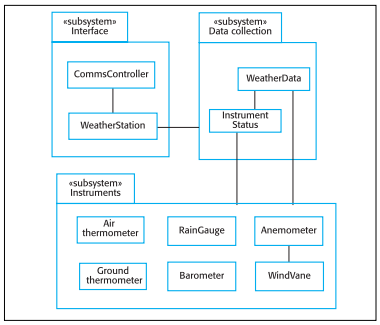
Examples of design models

- Sub-system 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.

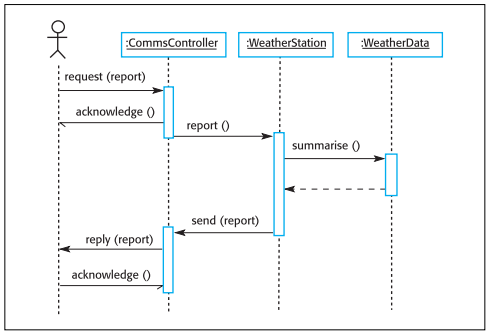
Weather station subsystems



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.

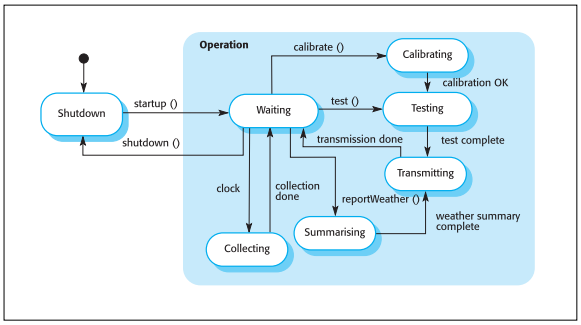
Data collection sequence



Statecharts

- Show how objects respond to different service requests and the state transitions triggered by these requests
  - If object state is Shutdown then it responds to a Startup() message;
  - In the waiting state the object is waiting for further messages;
  - If reportWeather () then system moves to summarising state;
  - If calibrate () the system moves to a calibrating state;
  - A collecting state is entered when a clock signal is received.

Weather station state diagram



Object 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 interface

```
interface WeatherStation {

        public void WeatherStation () ;

        public void startup () ;
        public void startup (Instrument i) ;

        public void shutdown () ;
        public void shutdown (Instrument i) ;

        public void reportWeather ( ) ;

        public void test () ;
        public void test ( Instrument i ) ;

        public void calibrate ( Instrument i) ;

        public int getID () ;

} //WeatherStation
```


Design evolution

- Hiding information inside objects means that changes made to an object do not affect other objects in an unpredictable way.
- Assume pollution monitoring facilities are to be added to weather stations. These sample the air and compute the amount of different pollutants in the atmosphere.
- Pollution readings are transmitted with weather data.

Changes required

- Add an object class called Air quality as part of WeatherStation.
- Add an operation reportAirQuality to WeatherStation. Modify the control software to collect pollution readings.
- Add objects representing pollution monitoring instruments.

Pollution monitoring