UML- a Brief Look

UML grew out of great variety of ways

  Design and develop object-oriented models and designs

By mid 1990s

  Number of credible approaches reduced to three

  Work further developed and refined

By 1997 version 1.1 of UML

  Submitted and accepted by Object Management Group - OMG

    OMG body that defines standards in many areas of computer science

  Current version is 2.1.2

UML and the Process

UML designed to be independent of any sw development process

Its designers use three views that work best in conjunction with UML

- Use case driven
- Architecture centric
- Iterative and Incremental

UML views development of software system as series of cycles

  The series ends with release of version of system to customers

    These may be inside or outside of the company

Within the unified process

  Each cycle contains four phases

- Inception

  Goal – establish viability of proposed system

  Define scope of the system

  Outline candidate architecture

  Identify critical risks

    Determine when and how they will be addressed

  Start to make case that project should be done

- Elaboration

  Goal – establish ability to build system given all constraints

  Capture majority of remaining functional requirements

Expand candidate architecture into full architectural baseline

Finalize business case for project

Elaborate on plans for next phase

- Construction

  Goal – build a system capable of operating successfully in beta customer site

  Build system iteratively and incrementally

  Make certain visibility always evident in executable form

- Transition

  Goal – roll out fully functional system to customer

  Correct any defects

  Modify system to correct any previous unidentified problems

Within process

We identify five workflows that cut across all four phases

Each workflow is set of activities project people perform

- Requirements

  Establish requirements for system

  These are high-level functional requirements

  For system being modeled

  These give the *what* of the design not the *how*

  Allows people to agree on

  Capabilities of system

  Conditions to which it must conform

- Analysis

  Build analysis model

  Used to refine and structure

  Functional requirements captured earlier

- Design

  Build design model

  Describes the physical realization

  From requirements and analysis models

- Implementation

  Build implementation model

  Describes how requirements packaged into software components

- Test

    Build test model

    Describes how system integration and systems test

    Will exercise components from implementation model

Class
Use Case
Component
Communication

State Chart
Timing
Sequence
Activity

Object
Package
Composite Structure
Interaction
Deployment

UML Diagrams

UML uses diagrams and models

As a first step towards expressing

Static and dynamic relationships amongst objects

While an important part of the standard

Authors do not see such diagrams as the main thrust of the approach

Rather a philosophy of a *Model Driven Architecture* (MDA)

In which UML is used as a programming language is more common.

High level goal is to create an environment in which tool vendors

Can develop models that can work with a wide variety of other MDA tools

On the user side

Designers who work with UML range from

Those who are putting together a 'back of the envelop' sketch

To those who utilize it as a formal (high level) design and programming language

Current standard recognizes thirteen different classes of drawings

As a design evolves

These different perspectives offer a rich set of tools

Whereby we can formulate and analyze potential solutions

Such tools enable one to model several different aspects of a design

It's rare that all of the types are used in a single design.

UML diagrams and models reflect

Static and *dynamic* relationships

Amongst classes and class instances

Static relationships

Will give us the architecture of our design

Dynamic relationships

Will give us behaviour of our system

At runtime

We will introduce and use the static aspects of UML models

Use Case Diagrams

The first diagram that we'll look at is the *Use Case*

Use cases widely employed

As a mechanism for capturing user requirements

In a form that can be used to drive the rest of the development process

Once agreed to by the customer

Use cases become basis for all further

- Analysis
- Design
- Construction
- Testing
- Deployment

of the software system

At each phase in the process

Results are validated against the requirements

Embodied in the use cases

Use case scenarios form the basis for the functional tests

That verify the software does what it is supposed to do

Use case

Gives outside view of the system

Describes the public interface for the module or system

Answers the questions

What is the behavior that the user sees?

What is the behavior the user expects?

Repeatedly poses the question

What? until the external view of the system has been satisfactorily captured

The use case diagram

Intended to present the main components of the system

How the user interacts with those components

Like many of the diagrams we'll work with

Use case diagram can be hierarchical in nature

From top level drawing, one can expand each use case

- Into sub use cases as necessary

Components

Diagram comprises three components

- The *system*
- The *actor(s)*
- The *use case(s)*

System

- Meaning of system is self evident
- It’s expressed in the diagram as a box
  - We’ll often leave this off the diagram

Actors

- An actor represents
  - “A coherent set of roles users of use cases play when interacting with these use cases."
    - Booch 1999, pp. 221

- Represent any one or any thing that might be using the system
  - Human
  - Hardware device
  - Another system
- Drawn as simple stick figures
- Viewed as being outside of the system

Use Cases – Graphical View

- Use cases represented as a solid oval
- Identify the various behaviors of the system or ways it might be used
- They encapsulate the events or actions
  - That must occur to implement the intended behavior of the system
- Are stated or expressed from the point of view of the user
- Accompanying each use case
  - Is a textual component fully describing it
- Use case diagrams can be a very powerful tool

During the early stages of a project

When trying to identify, define, and capture the requirements for system

As we construct the diagram

We place the actor that executes the use case on the left hand side

Supporting actors appear on the right hand side

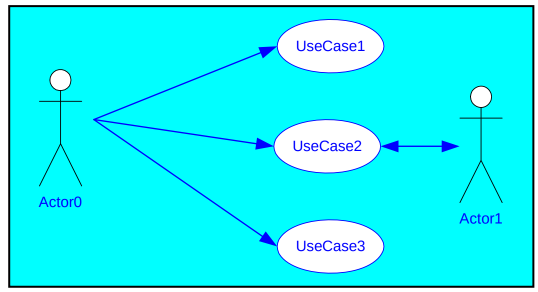
Not restricted to human users

Actor can be a computer or other system as well

Set of use cases appears in the center of the drawing

With arrows indicating the actors involved in the use case

A generic use case diagram given as



System comprises three use cases

Actor0 is using the system

Appears on the left hand side

Actor1 is supporting UseCase2

Placed on the right hand side

It's important to remember to keep things simple

When putting the use case diagram together

If system being designed shows twenty five to fifty use cases

On the top level drawing

Time to rethink the design

Use Cases – Textual View

Use case diagram

Captures a graphical representation of the public interface

To the module or system

Useful to be able to visualize the relationships between

Use cases in a requirement

Show the static relationship between use cases

Equally important to analyze what a use case means

In terms of the functionality the system must deliver

Associated with each use case is a textual description

Called the *use case specification*

Such a description can be decomposed into two pieces

Normal activity of the use case

How e*xceptional conditions* are to be handled

Use case specification describes

What actions the actor is to perform

How the system is expected to respond

Gives set of sequences of actions, including variants

System performs

That yields an observable result

Of value to an actor

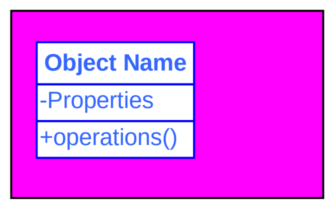
When OO analyst-designers talk about the use cases related to a system

Mean the combination

UML use case diagrams

Use case specifications

Class Diagram – Objects and Tasks



Class diagram presents the various kinds of objects in the system

Permits capturing the relationships amongst them

Called *associations*.

Notation for a class is a rectangle

Simple version with just name

Often used during exploratory phases of modeling

When primary concern is

Structural relationships between classes

Rather than with their attributes and operations

Later when more detail needed

Rectangle subdivided into three areas

- Top area gives the *name* of the class or object
- Middle section identifies all of the *properties* of the object

Will generally be declared inside the module implementation

Thereby hidden from the casual user

- Third pane identifies the *operations* object is intended to perform

These establish the external behavior of the object

Provide the public interface to the object.

For us

Object diagram or class diagram

Reflects exactly the characteristics we need

To express a task - we have

Function which implements the task

Data which task utilizes

Intertask Relationships

We can define number of different relationships

Among tasks

Such relationships can be

Static

Dynamic

Both

Static relationships

Will give us the architecture of our design

Dynamic relationships

Will give us behaviour of our system

At runtime

Static Relationships

We'll start with static relationships

Relationships

Containment

Containment conveys the idea

One object is made up of several others

Implements a whole – part relationship

Under UML we can express two different forms of containment

- Aggregation
- Composition.

Aggregation

Aggregation which expresses a *whole – part relationship*

In which one object or module

Contains another module

Key characteristic of an aggregation

One or more smaller functions are parts of whole

More complex function decomposed

Into number of smaller functions or modules

Owned module(s) may be *shared* with other modules

Outside of the aggregation

Under such conditions

Rules must be established

To ensure proper management of the shared module

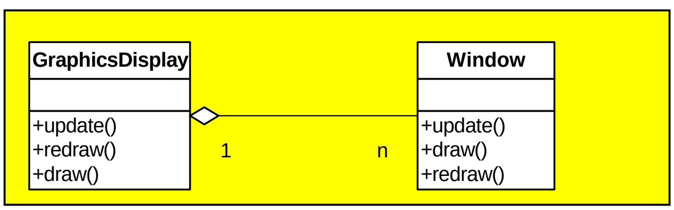


Diagram illustrates design in which

Graphics display implemented as

Aggregate of windows

Windows can exist

Outside of display

UML diagram for the aggregation relationship

Presents both the whole and its parts

Connected via a solid line

Originates at an open diamond on the end associated with the whole

Terminates on the end associated with the part

Composition

The *composition* relationship is similar to aggregation

Notion of ownership of the parts by the whole is much stronger

Elements of the composition

Cannot

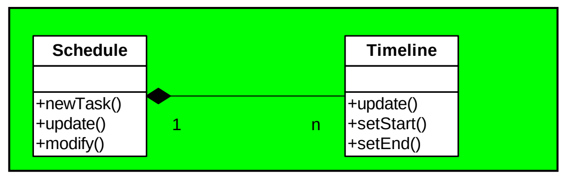
Be part of another object

Exist outside of the whole object

Idea is loosely analogous to local variables in a function

Once one leaves the scope of the function

Local variables disappear



Consider a schedule

Made up of a number of intervals

Without the schedule

Intervals have no meaning

We express such a relationship as given

The schedule is composed of 1 to n intervals

Diagram is similar to that for the aggregation

The connecting line now originates in a solid rather than open diamond

We annotate the relationship as a 1 to n composition

Dynamic Relationships

Dynamic relationships

Provide information about behaviour of system

While performing intended task

Provide information about interaction among tasks

While performing task

As we discussed earlier important considerations include

- Concurrence
- Persistence

Interaction Diagrams

- For our work
  - Understanding and modeling
    - Dynamic behaviour of our system is essential

- Dynamic behaviour
  - Gives us information about the lifetime of a task
  - Tells us when that task is active

  - Models interactions amongst tasks
    - Such interaction takes form of messages

- We've seen message is communication
  - Between two or more tasks
  - Can take several forms
    - Event
    - Rendezvous
    - Message – bad choice of words

- Generally message results in
  - One or more actions
    - Such actions are executable functions within the task
      - Result in change in values of one or more attributes

- UML explicitly supports five kinds of actions
  - Call and Return

    Call action invokes method on object

    Return returns value in response to call
  - Create and Destroy

    Create action creates object

    Destroy does opposite

- Send

  Sends signal to object

These actions shown in following diagrams

The dashed line emanating from each object or class

Called lifeline

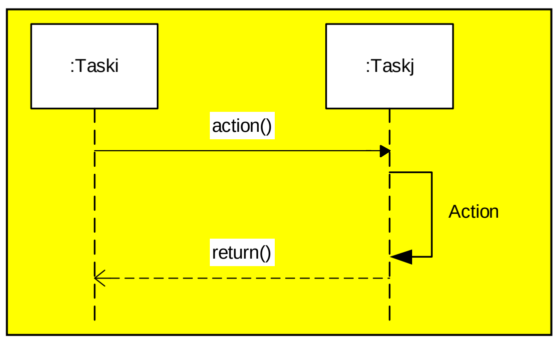
Call and Return

Express call action

Solid arrow from calling object to receiving object

Express return action

Dashed arrow from receiving object to calling object



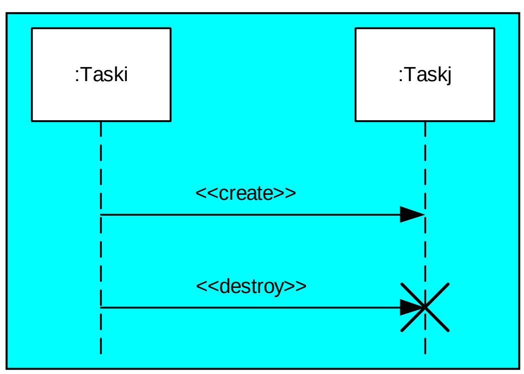
Create and Destroy

Express create action

Solid arrow from creating object to created class instance

Express destroy action

Solid arrow from destroying object to destroyed class instance



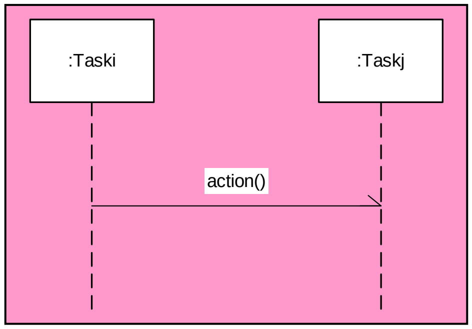
Send

Express send action

Solid arrow with half arrow head

From sending task to receiving task

Sender does not expect response



Sequence Diagrams

Purpose of sequence diagram

Express time ordering of message exchange

Between objects

Have 4 key elements

- Objects

  Appear along top margin

  For our implementation these will be the tasks

- Lifeline

  Described earlier

- Focus of control

  Thin rectangular box

  Straddles task's lifeline

  Indicates time during which object

  In control of flow

  Executing method or

  Creating another task

- Messages

Show actions objects perform

Each other

Self

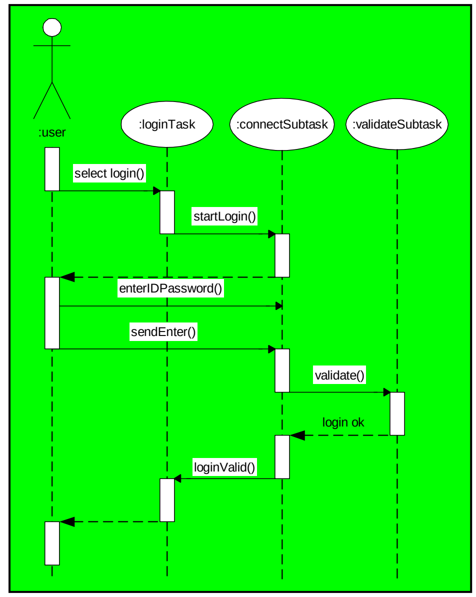


Diagram gives sequence diagram

Logging into system

Observe that the loginTask has spawned

loginSubtask

As the sequence proceeds

The *validateSubtask* spawned and

Confirms login parameters

Fork and Join

When we work in multitasking system

Common sequence

Parent process or task to start

Spawn several child tasks

These do the real work

Child tasks complete

Child tasks terminate

Parent class terminates

The process of splitting flow of control into two or more flows

Called *fork*

Each flow operates independently of the others

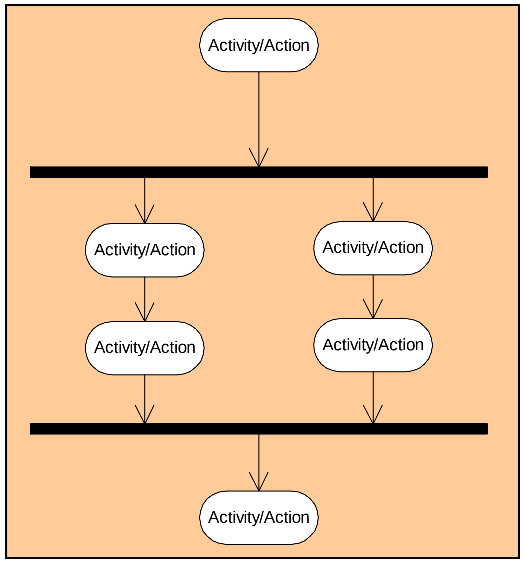
Synchronization of multiple flows into one

Called *join*

We model control flow behaviour of processes and tasks

Using Fork and Join diagram

Such diagram reflected as follows



Forks and joins represented by thick black rectangle

Called *synchronization bar*

Fork occurs after first activity or action completes

Following action

Task spawns subtasks

Suspends itself until subtasks complete

Once all subtasks have completed

Join occurs

Original task resumes its activities

Branch and Merge

Another form of flow of control is *branch*

The thread of execution is determined

By value of some control variable

Such a structure permits one to model

Alternate threads of execution

A *merge* brings the flow back together again

Each is represented by the diamond symbol

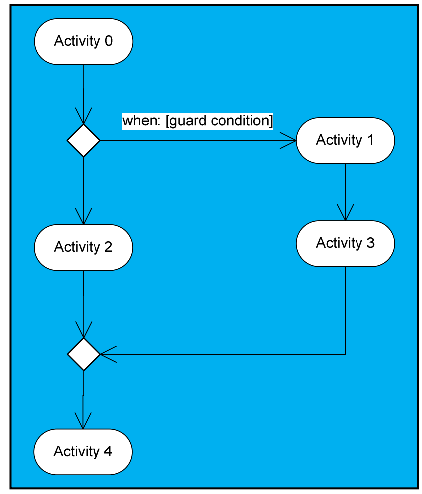
That is commonly found in the familiar flow chart

Sequential flow

Shown by a solid arrow

Individual tasks or activities

Shown using a rounded rectangle



Simple diagram with two alternate paths of execution

For a portion of the overall task

Given in adjacent diagram

Following completion of activities in right hand path

Flow of control merges back to a single path

At each branch point

One can associate a guard condition

To stipulate under what conditions the branch is to be taken

The guard condition

Shown in square brackets on the transition arrow

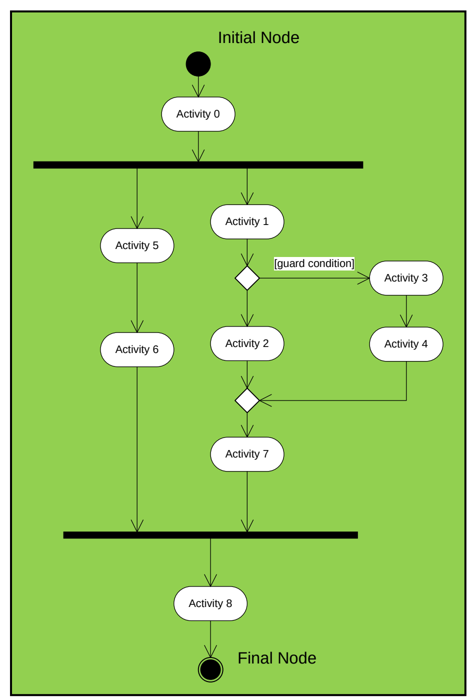
Activity Diagram

An *activity diagram* permits the capture of

All of the procedural actions or flows of control within a task

Such actions may be

- Branch and merge
- Fork and join
- Simple transition from state to state



The initial node in the diagram

Given by a solid black circle

The final node

Solid black circle surrounded by a second circle

Accompanying diagram shows how we might combine

Earlier activities into a larger task

Conversely, one can show how a larger task

Decomposed into its components

Events State Machines and State Chart Diagrams

Events

Any embedded application must interact

With world around it

System will accept inputs and produce outputs

Inputs generally result in some associated action

Actions may or may not lead to an output

Such inputs outputs and actions

Referred to under various names

Under UML umbrella

Inputs and outputs collected under name *events*

Event is any occurrence of interest to the system

Generally to one of the tasks in the system

UML supports 4 kinds of events

- Signal

  Asynchronous exchange between tasks
- Call event

  Synchronous communication involving

  Sending message to another task

  Sending a message to self
- Time event

  Event occurs after specified time interval elapsed
- Change event

  Event occurs after some condition satisfied

State Machines and State Chart Diagrams

We have studied and used state machines

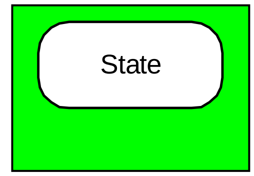
Model and implement behaviour of system in time

We now apply those concepts to design and implementation of

Embedded applications

UML supports and extends

Traditional notion of state machines



A *state* is written as rectangle with rounded corners

Transitions between states

Reflect change in system from one state to another

Expressed as an arrow directed from

Source to destination

Transition occurs when

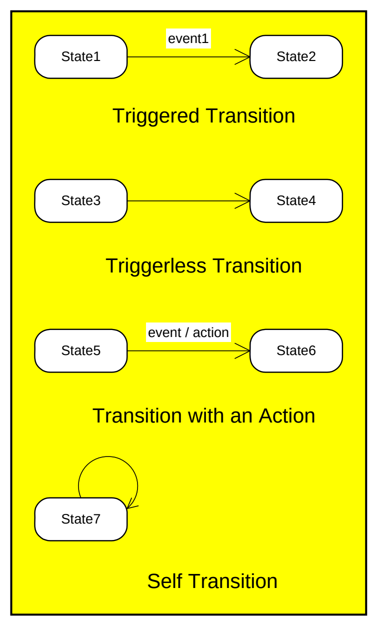
- Event of interest to system occurs
- System has completed some action

  Ready to move to next state

  Called *triggerless* transition
- We may have an action associated with the transition
- We may have a transition to self

We see all four types of transition in

Accompanying figure



Guard Conditions

A guard condition

Boolean expression that must evaluate to true

Before transition can fire

We show a guard condition in square brackets

Near transition arrow

- If guard condition associated with event

  EventName [*guardCondition*]

  If condition evaluates to false

Transition not taken

- If event, guard condition, action
  - *EventName* [*guardCondition*] / *Action*
    - If condition evaluates to false
      - Action not executed and transition not taken

- Guard condition by itself
  - [*guardCondition*]
    - Repeated self transition until met

State Machines and State Chard Diagrams

State machine term that describes

- States an system can enter during life time
- Events to which system can respond
- Possible responses system can make to an event
- Transitions between possible states

State chart diagram

Nothing more than the state diagram we've been using

There are some extensions / modifications under UML

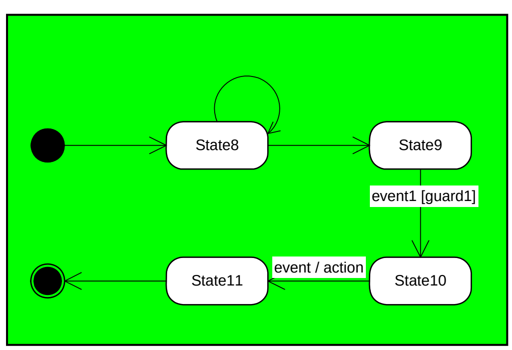
In following diagram

Solid black circle

Represents initial state

Solid circle with surrounding open circle

Represents final state



We also make the following definitions

- *Entry action*

  Action system always performs

    Immediately on entering state

  Appears as *entry / actionName* within state symbol

- Exit action

  Action system always performs

    Immediately before leaving state

  Appears as *exit / actionName* within state symbol

- Deferred event

  Event that is on interest to system

    Handling deferred until system reaches another state

  Appears as *eventName / defer* within state symbol

  Such events get put into queue

    When system changes state

Composite States

States we've looked at so far

  Called simple states

UML extends notion of simple state to include

  Multiple nested states - called *composite states*

These come in several varieties

Sequential States

If the system exists in

  A composite state and

  Only one of the state's substates at a time

    Substates called *sequential substates*

We can have transitions between such substates

As we've seen for full states

Using sequential substates

We can decompose behaviour of state into smaller pieces

History States

When system makes transition into composite state

Assumed that flow of control

Starts in initial substate

However

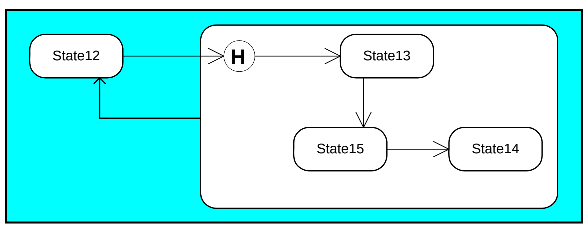
Can use *history substate* to remember

Last state system in before leaving composite state

We see such a state useful when modeling interrupt behaviour

Under interrupt we leave present state

Return to same state following interrupt



Concurrent Substates

A system may be in a composite state

Also in more than one of the substates

Such is a situation in which we may have

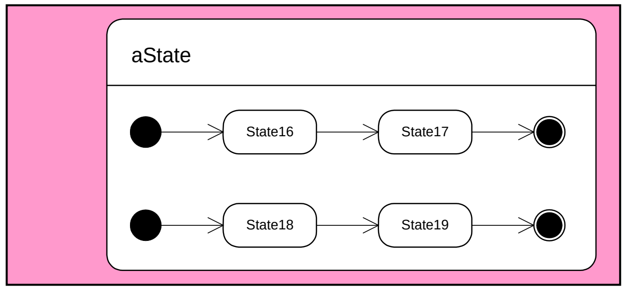
Two or more sets of substates

Representing parallel flows of control

When system enters composite state with concurrent substates

Enters into initial state of both flows

We resynchronize by showing a final state for each flow



Have only touched on some of capabilities

UML diagrams

This will be sufficient for what we'll be doing

Vast amount of literature available

For those who are interested

Let's now try to put what we've learned

To work