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M3 (a) – Object State

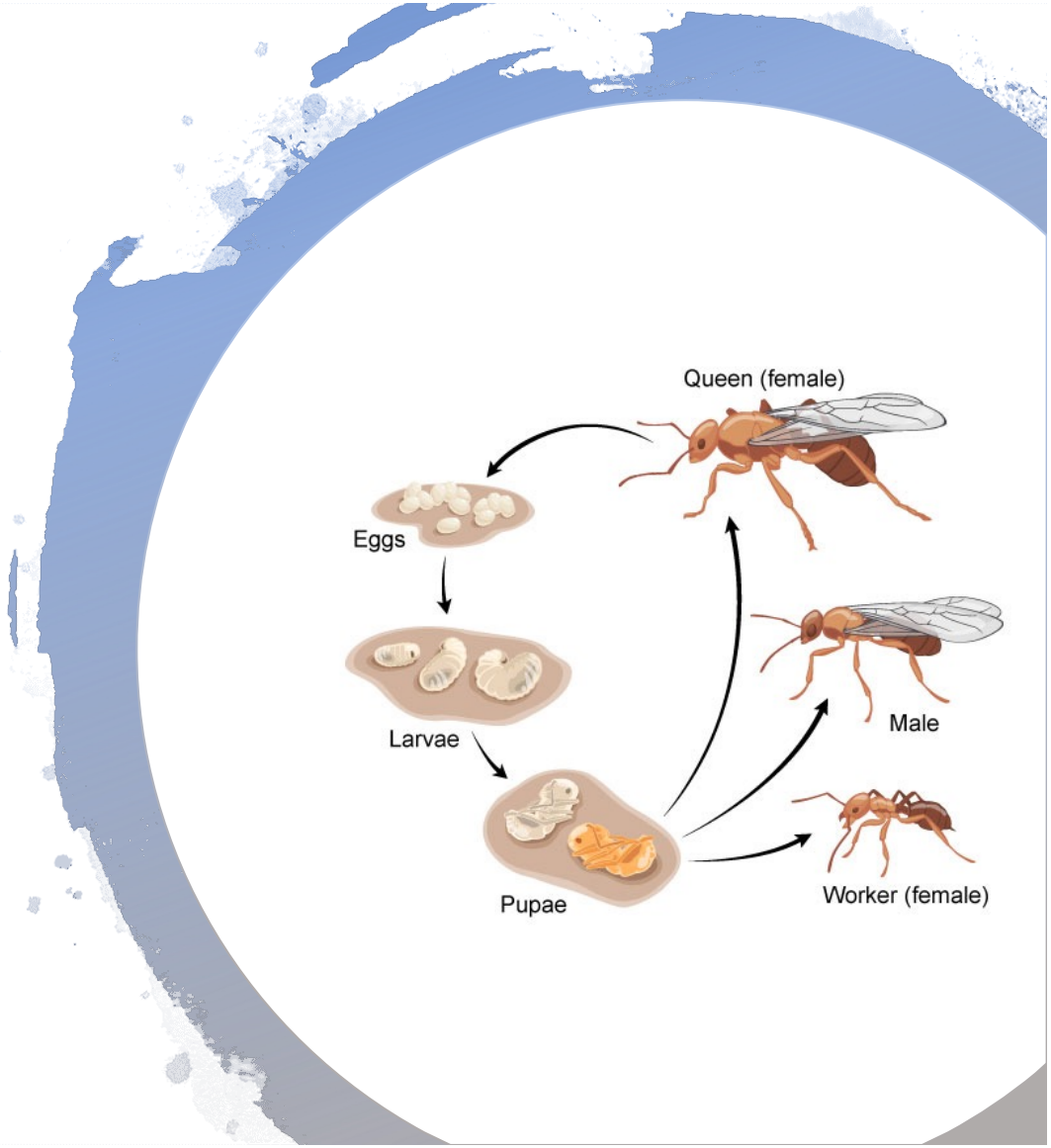


Image Source: https://askabiologist.asu.edu/individual-life-cycle

Objective

- Programming mechanism:

Null references, optional types

- Concepts and Principles:

Object life cycle

- Design techniques:

State Diagram

- Design Patterns and Antipatterns:

NULL OBJECT

Object at Run-time

```
public final class Card
{
    private final Rank aRank;
    private final Suit aSuit;
}
```

{*ACE*, *TWO*, *THREE*, *FOUR*, *FIVE*, *SIX*, *SEVEN*, *EIGHT*, *NINE*, *TEN*, *JACK*, *QUEEN*, *KING*}

{*CLUBS*, *DIAMONDS*, *HEARTS*, *SPADES*}

13x4 possible state

Object at Run-time

Abstract State is needed

```
public class Student {
    // Representation of a word in its original form
    // as in one sentence.
    private final String firstName;
}
```

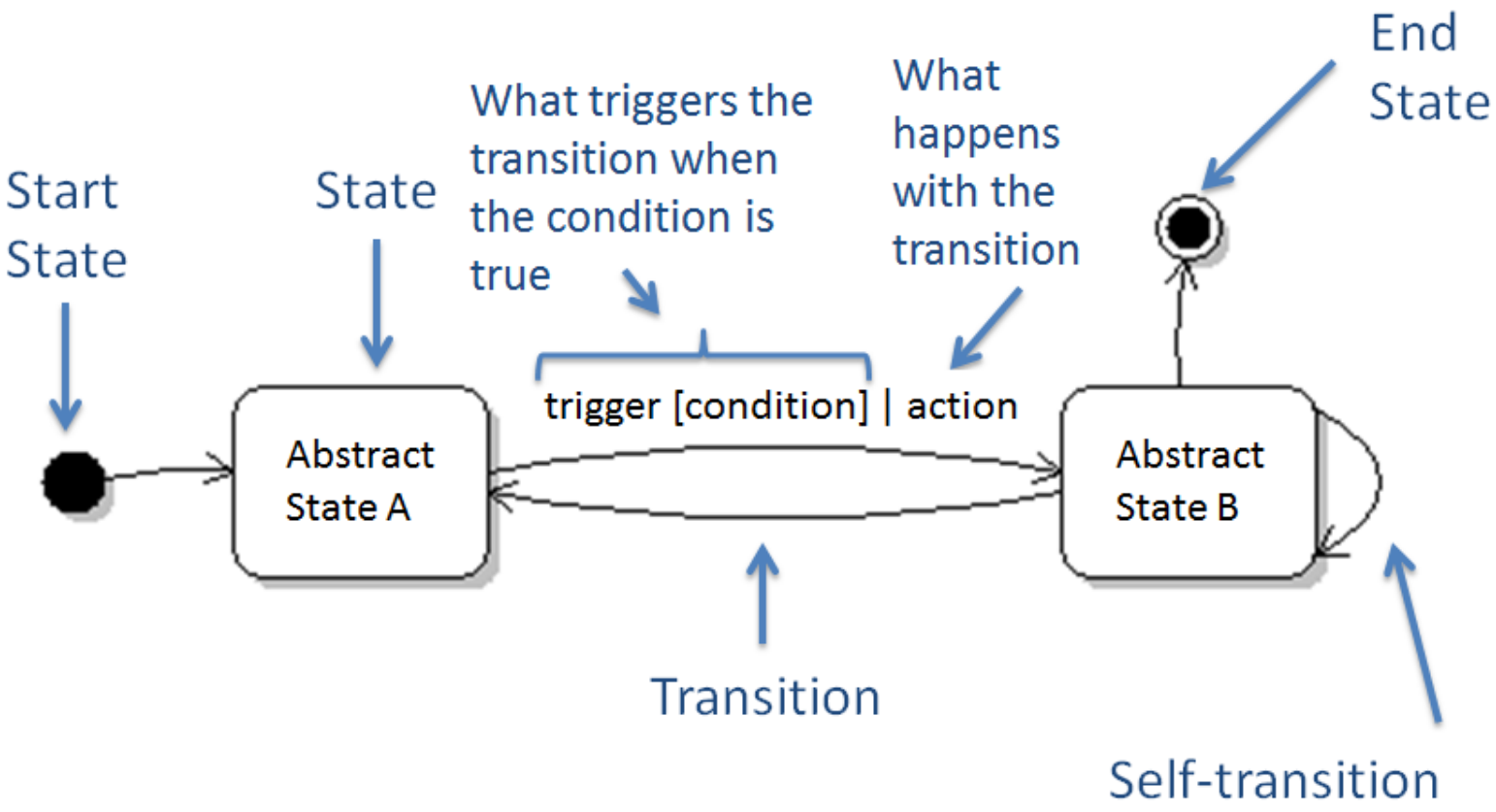
Possible state of the object
(2^31 – 1) X 2^16 !

State Diagram

- Abstract States

- Transitions between states

State Diagram



State diagram of `Card`

```
public class Card
{
     private final Rank aRank;
     private final Suit aSuit;

     public Card(Rank pRank, Suit pSuit)
     {
          aRank = pRank;
          aSuit = pSuit;
     }

     public Rank getRank()
     {
          return aRank;
     }

     ……
}
```

State diagram of `Deck`

```
public class Deck
{
    final List<Card> aCard = new ArrayList<>();

    public Deck()
    {
        shuffle();
    }

    public Card draw()
    {
        assert !isEmpty();
        return aCard.remove(aCards.size()-1);
    }

    /**
     * Reinitialize the deck with all 52 cards and shuffles them.
     */
    public void shuffle()
    {
        ……
    }

    ……
}
```

Activity 1: *Sketch* the state diagram of `Course`

```
public class Course {

    private String         aID; // e.g. “COMP 303”
    private boolean        aIsActive;
    private int            aCap;
    private List<Student>  aEnrollment;
    private CourseSchedule aSchedule;
```

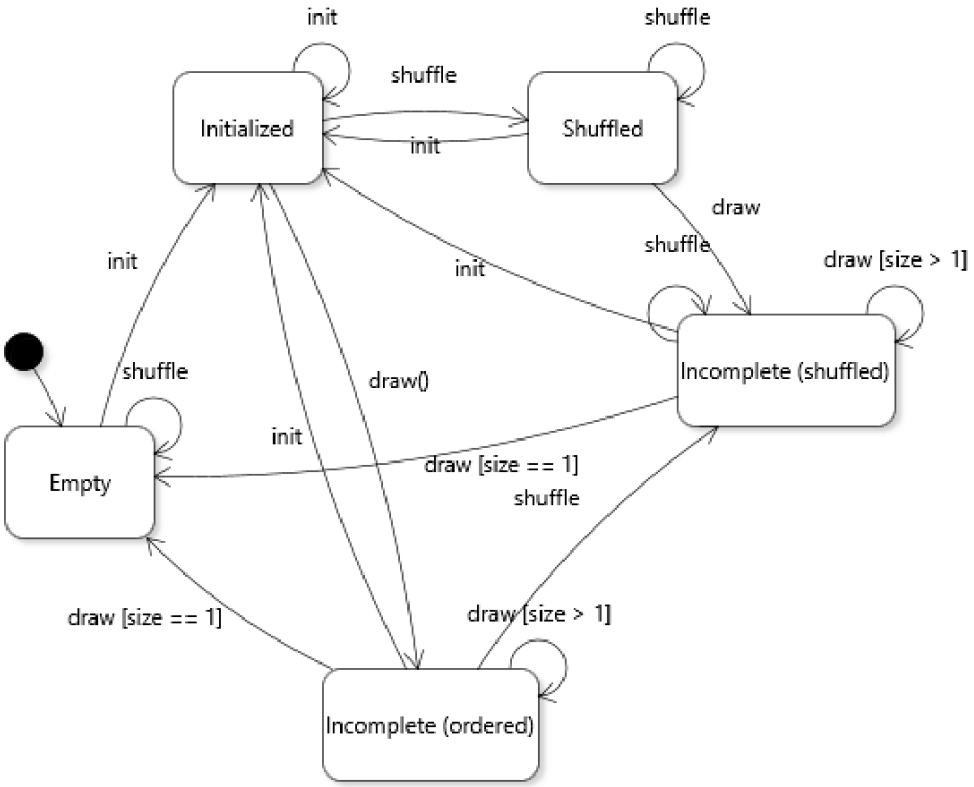
What might be useful states of a Course object?

How a Course object would transit from one state to another?

Design Constructor

- A constructor should fully initialize the object
  - The class invariant should hold
  - Shouldn't need to call other methods to “finish” initialization

State diagram of **Deck** *without fully initialization*



Design Field

- Has a value that retains meaning throughout the object's life
- Its state must persist between public method invocations

General Principle

- Minimize the state space of object to what is absolutely necessary
  - It’s impossible to put the object in an invalid of useless state
  - There’s no unnecessary state information

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Nullability (absence of value)

```
Card card = null;
```

A variable is temporarily un-initialized and will be initialized in a different state.

A variable is incorrectly initialized. The code of initiation is not executed properly.

As a flag that represents the absence of a useful value

Special use.

```
Card.Rank rank = card.getRank();
```

Avoid *null* values when designing classes!

Avoid *null* values when designing classes?

```
public class Course {

    private String aID;
    private boolean aIsActive;
    private int aCap;
    private List<Student> aEnrollment;
    private CourseSchedule aSchedule;

    public Course(String pID, int pCap) {
        aID = pID;
        aCap = pCap;
        aEnrollment = new ArrayList<>();
        aIsActive = false;
    }
```

It might be a valid state when the class is created but not scheduled.

What about `Schedule`?

Avoid *null* values when designing classes?

- Sometimes it’s necessary to model absence of value

Activity 2:

- Discuss your design of the extension of class Card where one instance can also represent a ”Joker”. (Textbook Chatper2 - Exercise#4)

  Note: Joker is special card with no rank and no suit.

- How did you handle the fields of Rank and Suit for “Joker”?

Image source: https://upload.wikimedia.org/wikipedia/commons/6/6f/Joker_Card_Image.jpg

```
public class Card
{
   private Rank aRank;
   private Suit aSuit;
   private boolean aIsJoker;
```

Arbitrary (valid) value for rank and suit?

Add special value for Rank and Suit enums?

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java.util.Optional<T>

- A container object which may or may not contain a non-null value.
- If a value is present, isPresent() will return true and get() will return the value.

```
public class Card
{
   private Optional<Rank> aRank;
   private Optional<Suit> aSuit;
   private boolean aIsJoker;
```

```java
public Card(Rank pRank, Suit pSuit)
{
  assert pRank != null && pSuit != null;
  aRank =  Optional.of(pRank);
  aSuit = Optional.of(pSuit);
}

public Card()
{
  aIsJoker = true;
  aRank = Optional.empty();
  aSuit = Optional.empty();
}
```

What about getter methods?

- Return Optional<T> types

- Up-wrap Optional and return T

Go back to the `Course` class

```
public class Course {

    ……

    public Course(String pID, int pCap) {
        aID = pID;
        aCap = pCap;
        aEnrollment = new ArrayList<>();
        aIsActive = false;
        aSchedule = Optional.empty();
    }

    public void setSchedule(CourseSchedule pSchedule) {
        aSchedule =  Optional.of(pSchedule);
    }

    public Optional<CourseSchedule> getSchedule(){
        return aSchedule;
    }
```

Client code of the `Course` class

```
private static void printSchedule(Course pCourse) {
    if(pCourse.getSchedule().isPresent()) {
        CourseSchedule schedule = pCourse.getSchedule().get();
        System.out.println(schedule);
    } else {
        System.out.println("Schedule unavailable.");
    }

}
```

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`Null` Object Pattern

- Use polymorphism to handle absence
- Create a subtype to act as a null version of the class, make it singleton
- *Special Case* Pattern, representing absence, unknown, etc.

```
public class Deck
{
    private final List<Card> aCard = new ArrayList<>();

    private Comparator<Card> aComparator;

    public Card draw()
    {
        assert !isEmpty();
        return aCard.remove(aCards.size()-1);
    }


    public void sort()
    {
        Collections.sort(aCards, aComparator);

    }

    ……
}
```

How to compare the Card objects is unknown when we initialize a Deck object

```java
public class NullComparator implements Comparator<Card>
{
    @Override
    public int compare(Card o1, Card o2) {return 0;}
}
```

Another Example

```
public interface CardSource extends Cloneable
{

   Card draw();

   boolean isEmpty();

}
```

```
public interface CardSource extends Cloneable
{
   public static CardSource NULL = new CardSource() {
      @Override
      public Card draw() {
         assert isEmpty();
         return null;
      }

      @Override
      public boolean isEmpty() {
         return true;
      }
   };

   Card draw();
   boolean isEmpty();
}
```

Recap - Objective

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- Design techniques:

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