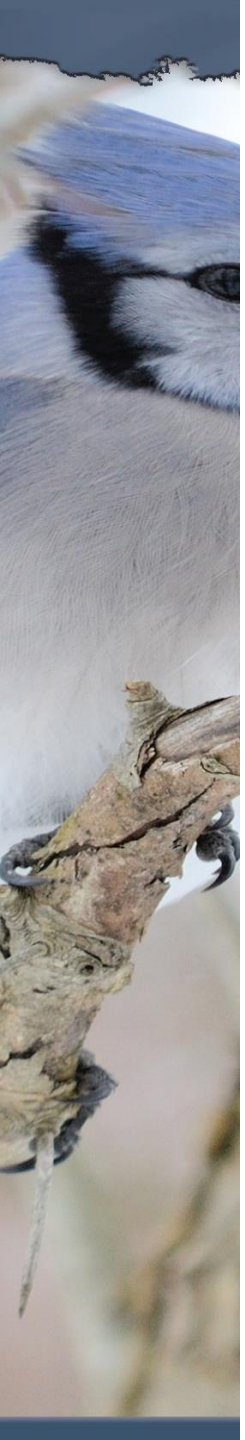
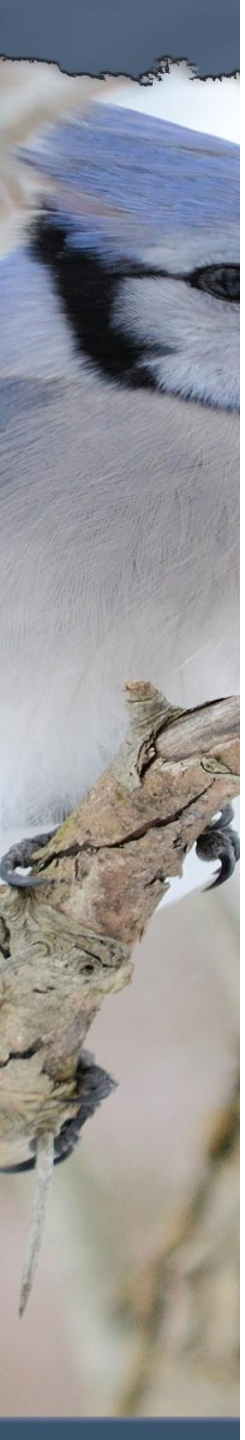


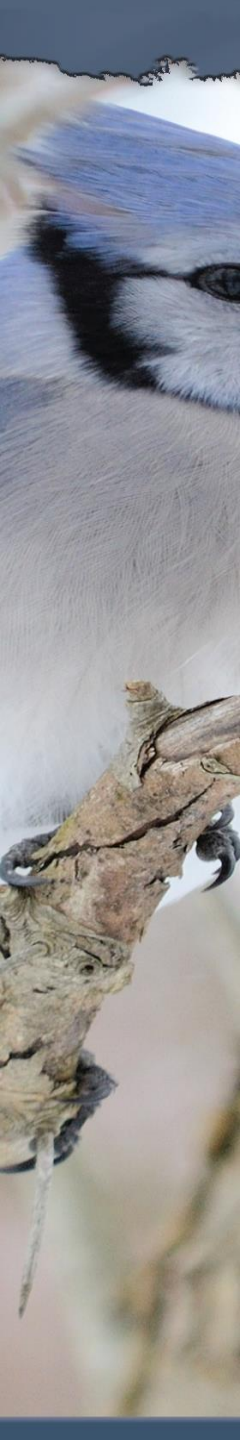
Further abstraction techniques

Abstract classes and interfaces



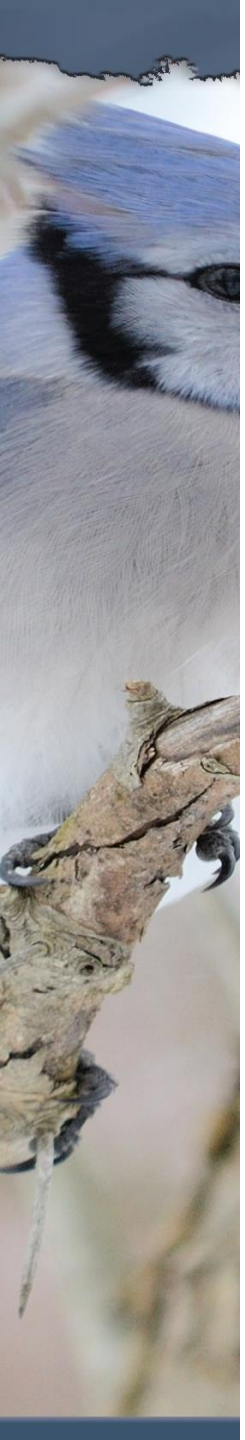
Main concepts to be covered

- Abstract classes
- Interfaces
- Multiple inheritance



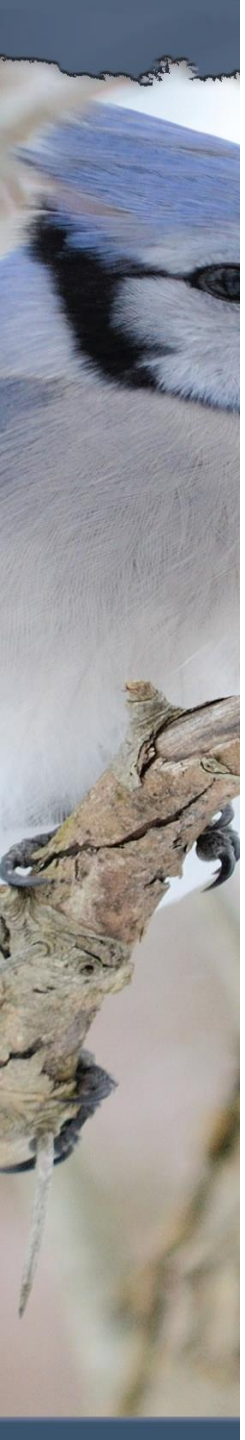
Simulations

- Programs regularly used to simulate real-world activities:
  - city traffic;
  - the weather;
  - nuclear processes;
  - stock market fluctuations;
  - environmental impacts;
  - space flight.



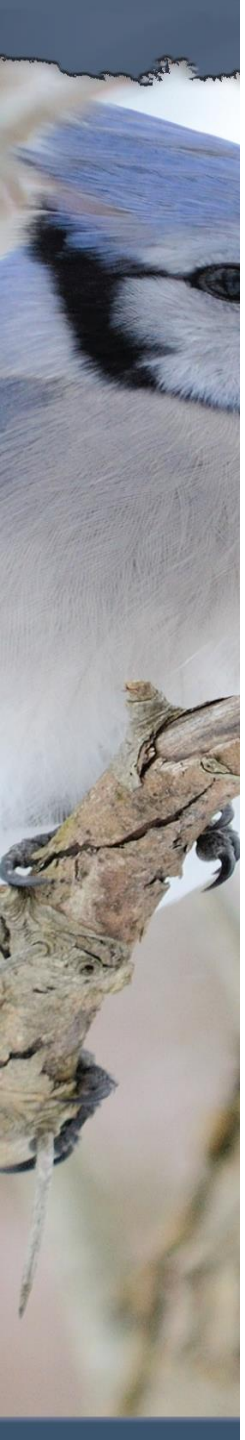
Simulations

- They are often only partial simulations.
- They often involve simplifications.
  - Greater detail has the potential to provide greater accuracy.
  - Greater detail typically requires more resource:
    - Processing power;
    - Simulation time.



Benefits of simulations

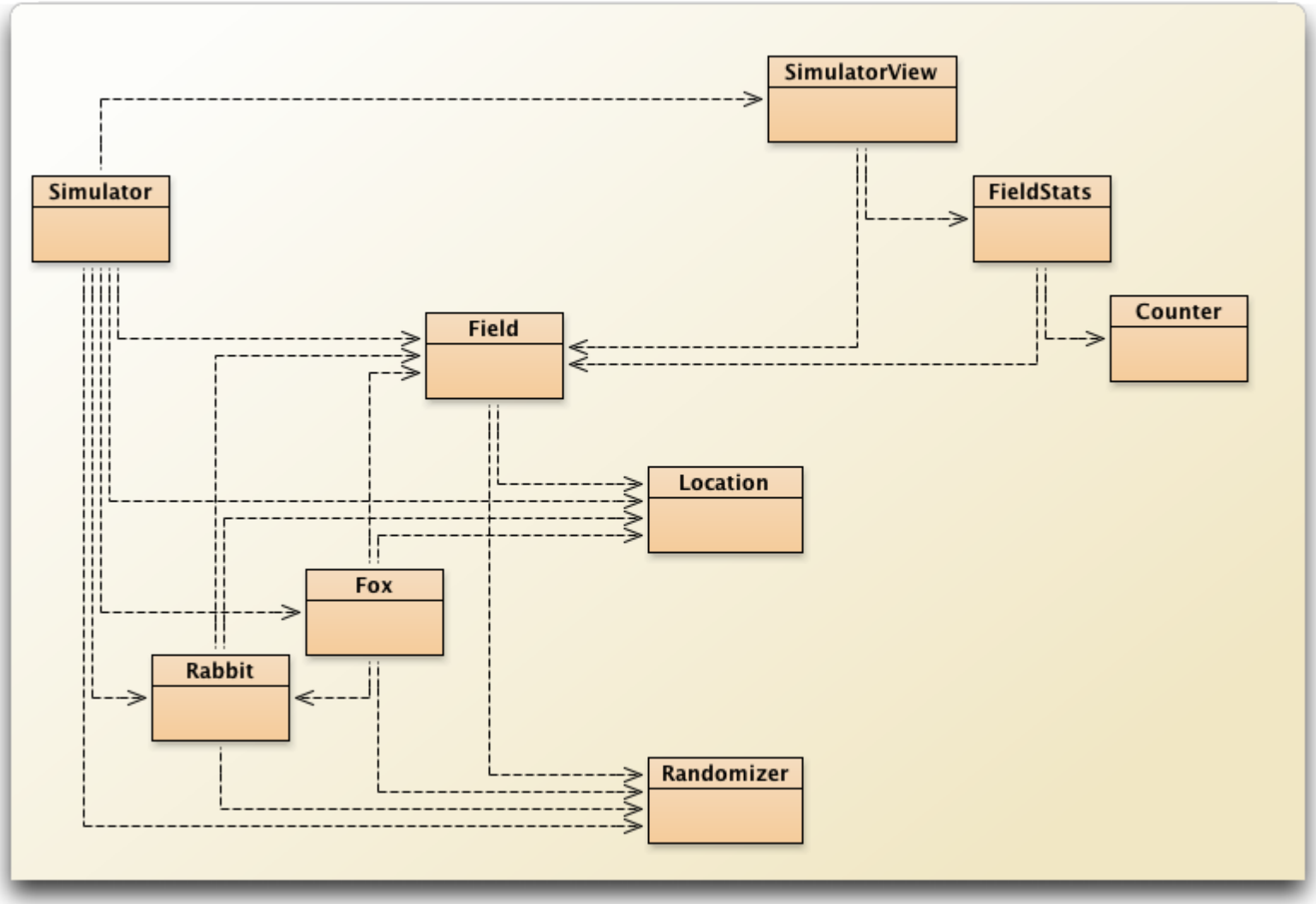
- Support useful prediction.
  - E.g., the weather.
- Allow experimentation.
  - Safer, cheaper, quicker.
- Our example:
  - ‘How will the wildlife be affected if we cut a highway through the middle of this national park?’

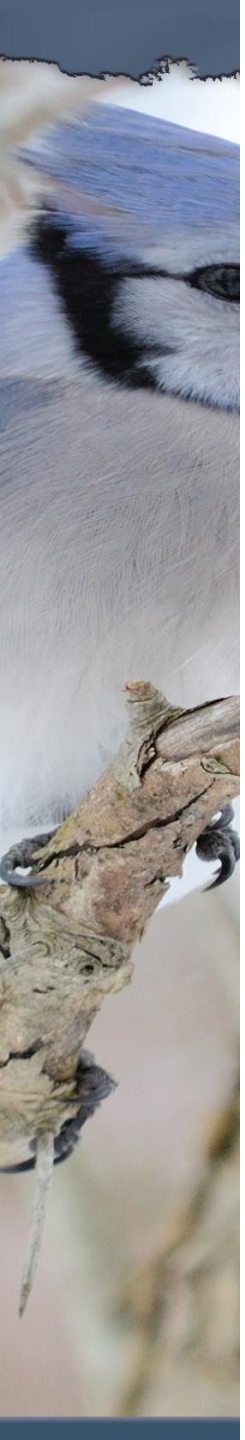


Predator-prey simulations

- There is often a delicate balance between species.
  - A lot of prey means a lot of food.
  - A lot of food encourages higher predator numbers.
  - More predators eat more prey.
  - Less prey means less food.
  - Less food means ...

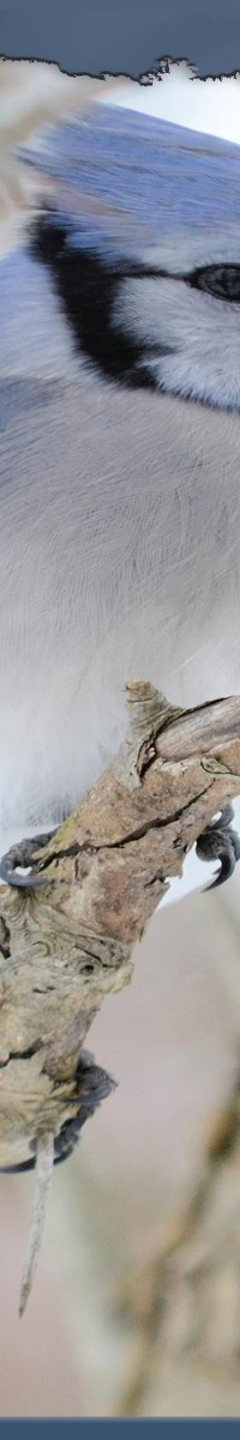
The foxes-and-rabbits project





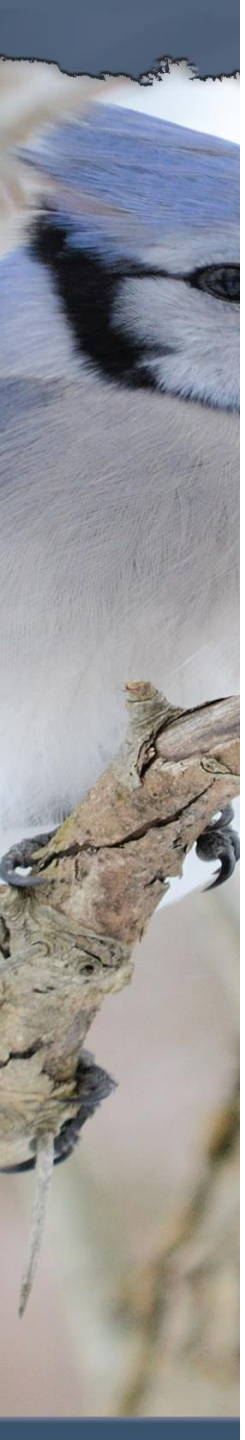
Oppgave!

- Åpne *foxes-and-rabbits-v1*-prosjektet.
- Finn ut hvordan du kan simulere 50 steg.
- Simulér 50 steg.
- Noter hvor mange kaniner og rever du har.
- Forsøk å resette simuleringen og kjør de 50 første stegene på nytt. Får du samme antall rever og kaniner som sist?



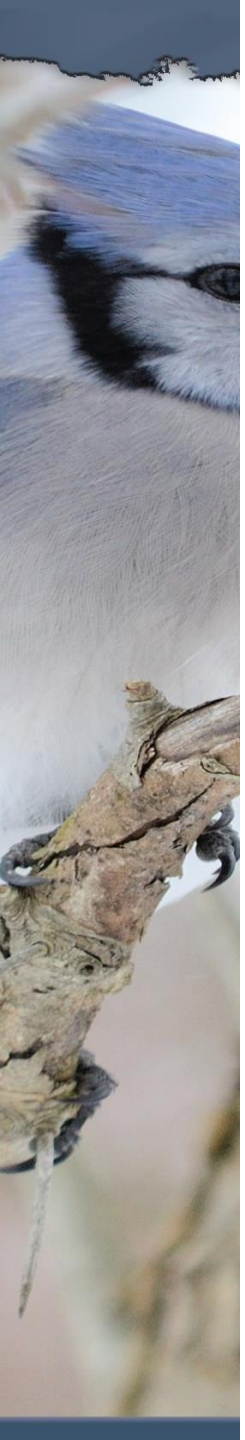
Regression testing

- Kap 9.4: “Regression testing involves rerunning tests that have previously passed, to ensure that the new version still passes them.”



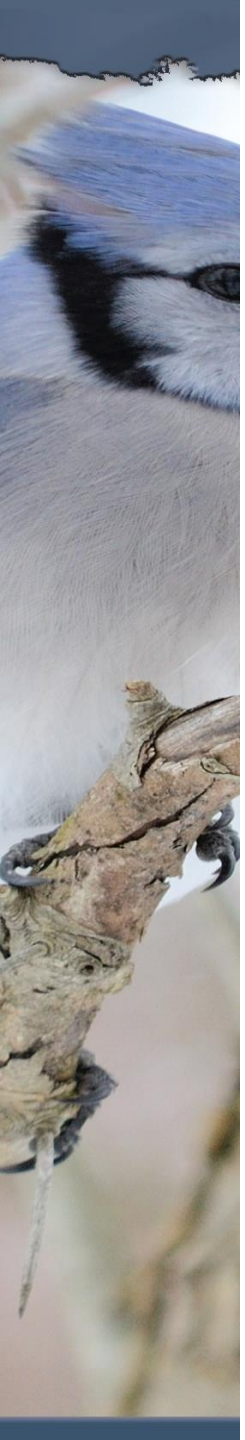
Main classes of interest

- **`Fox`**
  - Simple model of a type of predator.
- **`Rabbit`**
  - Simple model of a type of prey.
- **`Simulator`**
  - Manages the overall simulation task.
  - Holds a collection of foxes and rabbits.



Modeling the environment

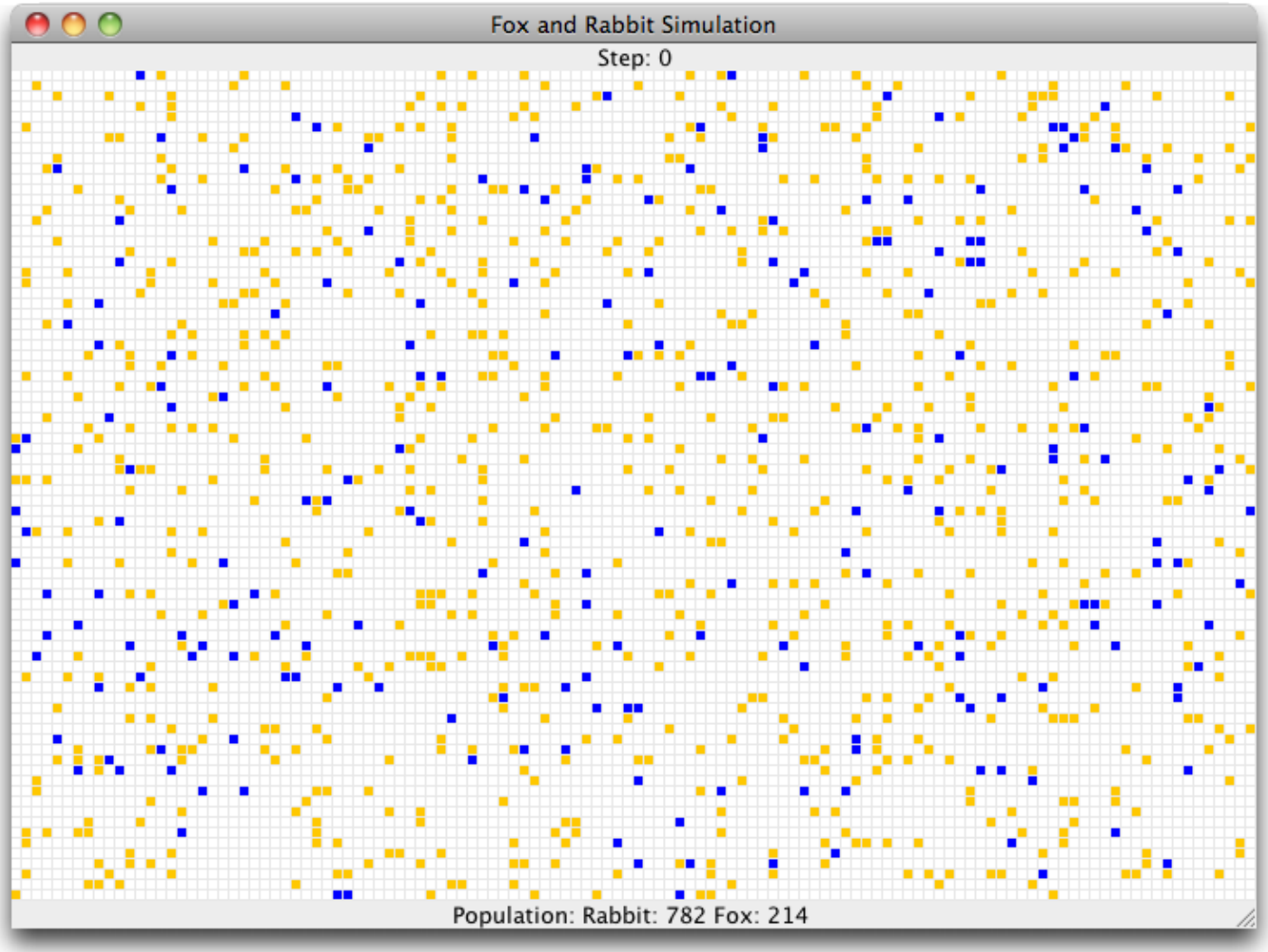
- **`Field`**
  - Represents a 2D field.
- **`Location`**
  - Represents a 2D position in the environment.

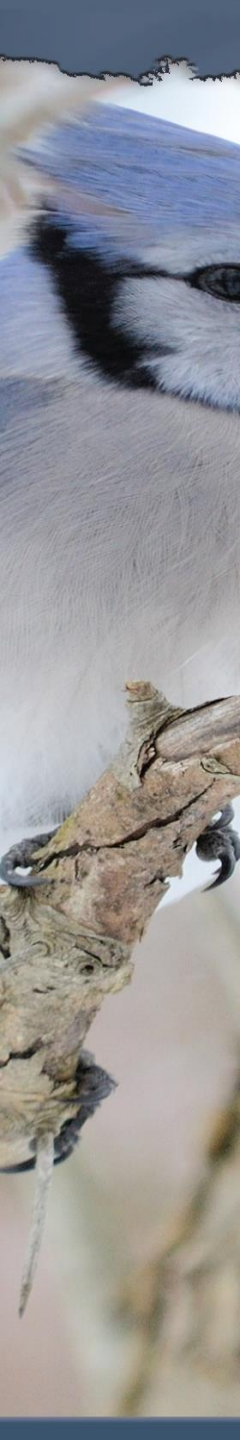


Monitoring the simulation

- **`SimulatorView`**
  - Presents a view of the environment.
- **`FieldStats`, `Counter`**
  - Maintain statistics.
- **`Randomizer`**
  - Supports reproducibility.

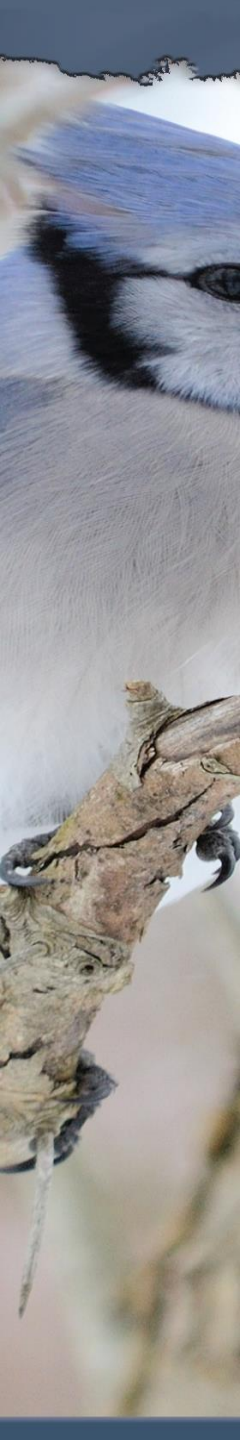
Example of the visualization





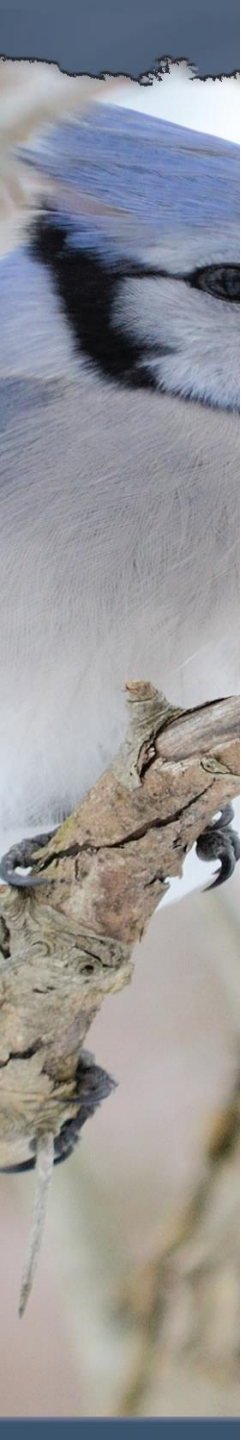
A Rabbit's state

```
public class Rabbit
{
    Static fields omitted.

    // Individual characteristics (instance fields).

    // The rabbit's age.
    private int age;
    // Whether the rabbit is alive or not.
    private boolean alive;
    // The rabbit's position
    private Location location;
    // The field occupied
    private Field field;

    Methods omitted.
}
```



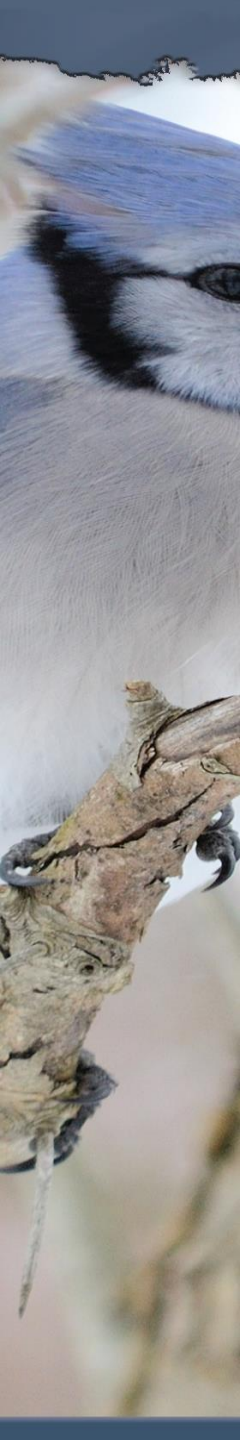
A Rabbit's behavior

- Managed from the **`run`** method.
- Age incremented at each simulation 'step'.
  - A rabbit could die at this point.
- Rabbits that are old enough might breed at each step.
  - New rabbits could be born at this point.



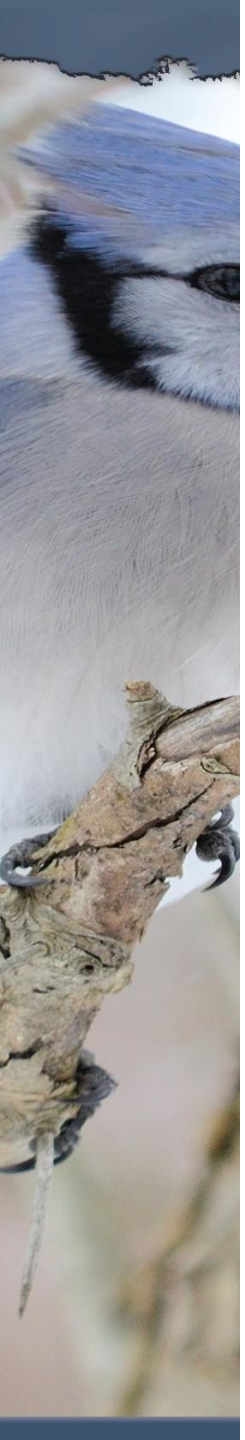
Rabbit simplifications

- Rabbits do not have different genders.
  - In effect, all are female.
- The same rabbit could breed at every step.
- All rabbits die at the same age.
- Others?



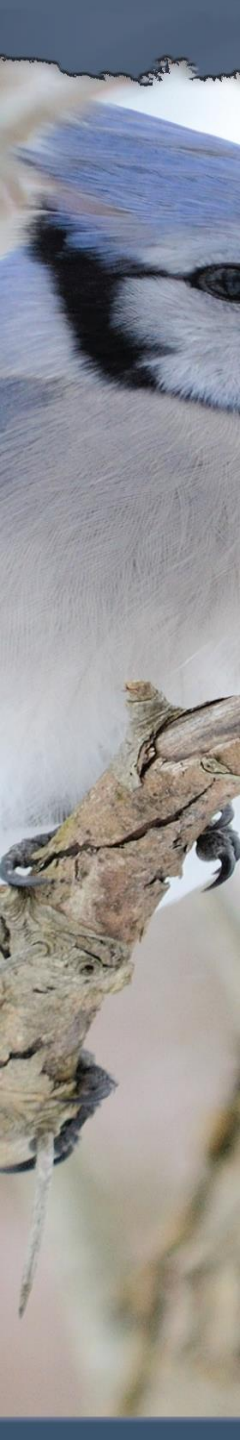
A Fox's state

```
public class Fox
{
    Static fields omitted

    // The fox's age.
    private int age;
    // Whether the fox is alive or not.
    private boolean alive;
    // The fox's position
    private Location location;
    // The field occupied
    private Field field;
    // The fox's food level, which is increased
    // by eating rabbits.
    private int foodLevel;

    Methods omitted.
}
```



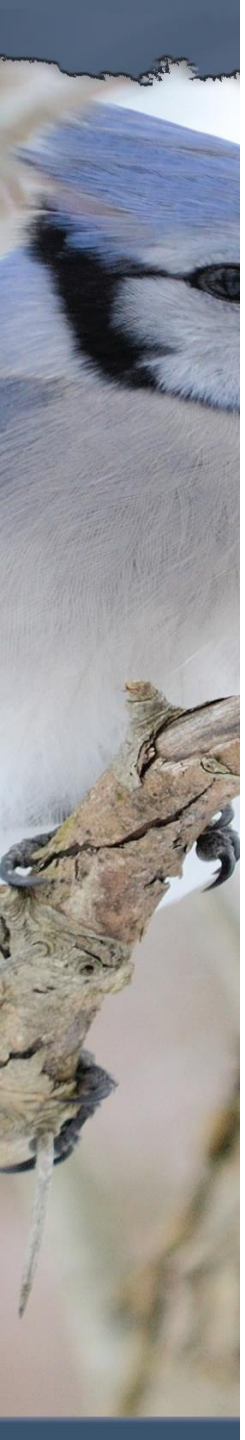
A Fox's behavior

- Managed from the **`hunt`** method.
- Foxes also age and breed.
- They become hungry.
- They hunt for food in adjacent locations.



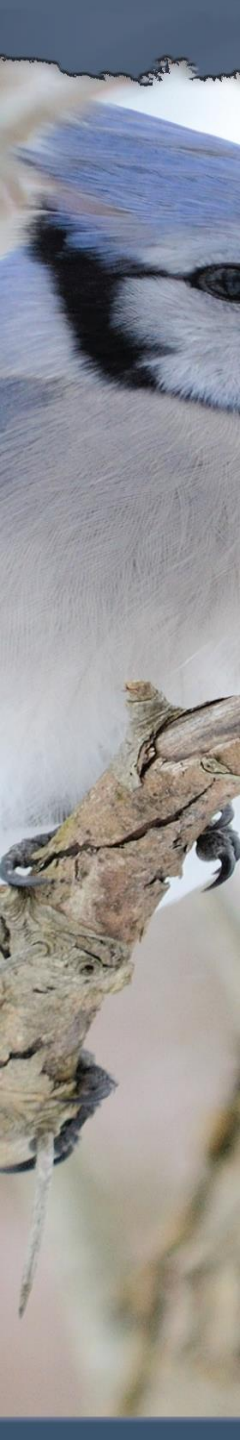
Configuration of foxes

- Similar simplifications to rabbits.
- Hunting and eating could be modeled in many different ways.
  - Should food level be additive?
  - Is a hungry fox more or less likely to hunt?
- Are simplifications ever acceptable?



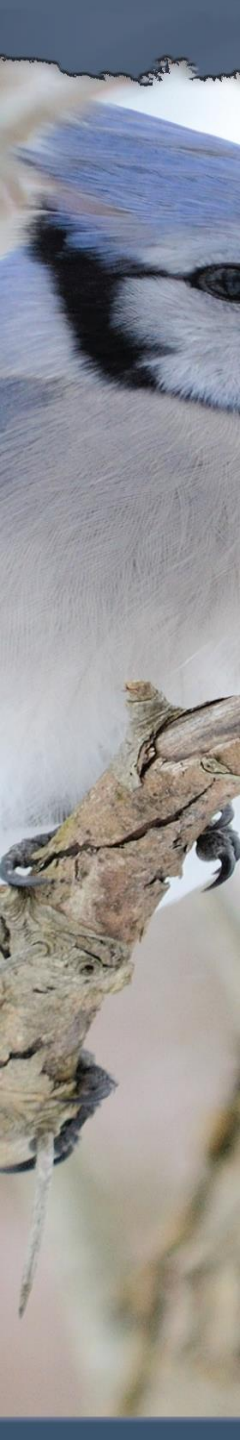
The Simulator class

- Three key components:
  - Setup in the constructor.
  - The **`populate`** method.
    - Each animal is given a random starting age.
  - The **`simulateOneStep`** method.
    - Iterates over separate populations of foxes and rabbits.
    - Two **`Field`** objects are used: **`field`** and **`updatedField`**.



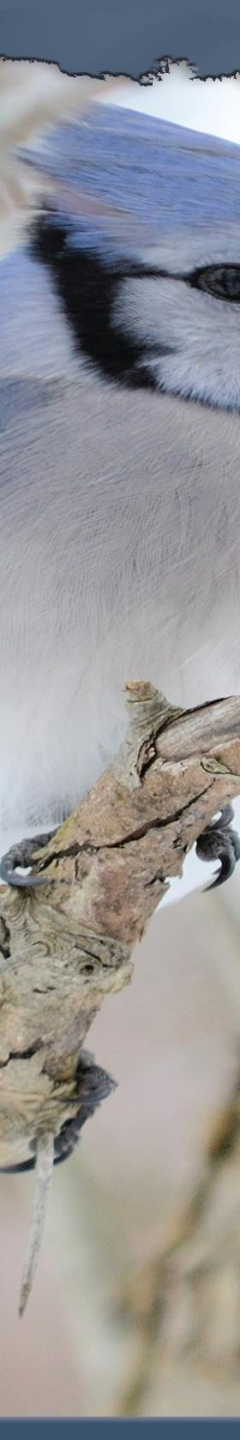
The update step

```
for(Iterator<Rabbit> it = rabbits.iterator();
        it.hasNext(); ) {
    Rabbit rabbit = it.next();
    rabbit.run(newRabbits);
    if(! rabbit.isAlive()) {
        it.remove();
    }
}
…
for(Iterator<Fox> it = foxes.iterator();
        it.hasNext(); ) {
    Fox fox = it.next();
    fox.hunt(newFoxes);
    if(! fox.isAlive()) {
        it.remove();
    }
}
```



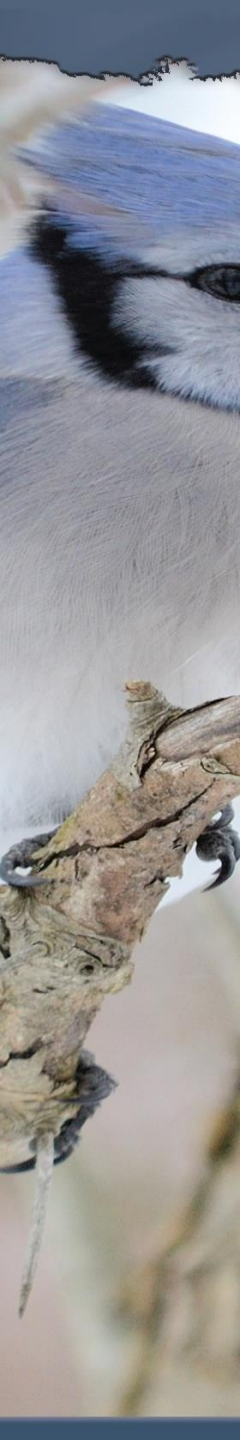
Iterator

- Fra forrige semester: Iterere over en samling av elementer der vi kanskje skal endre samlingen underveis… (Kap 4.12.2)



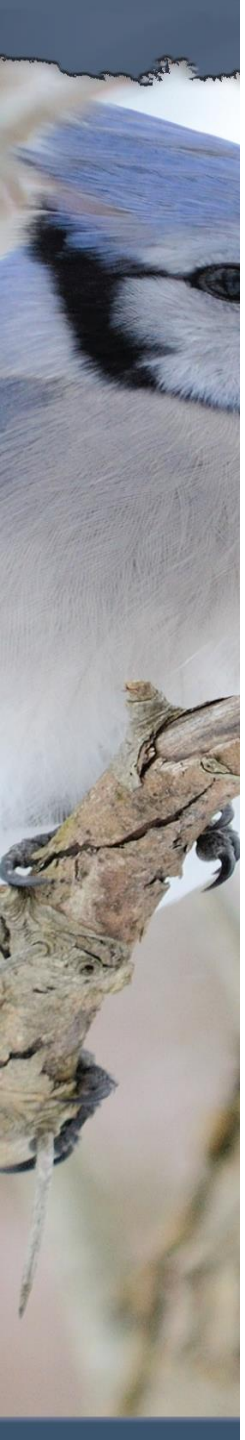
Room for improvement

- **`Fox`** and **`Rabbit`** have strong similarities but do not have a common superclass.
- The update step involves similar-looking code.
- The **`Simulator`** is tightly coupled to specific classes.
  - It 'knows' a lot about the behavior of foxes and rabbits.



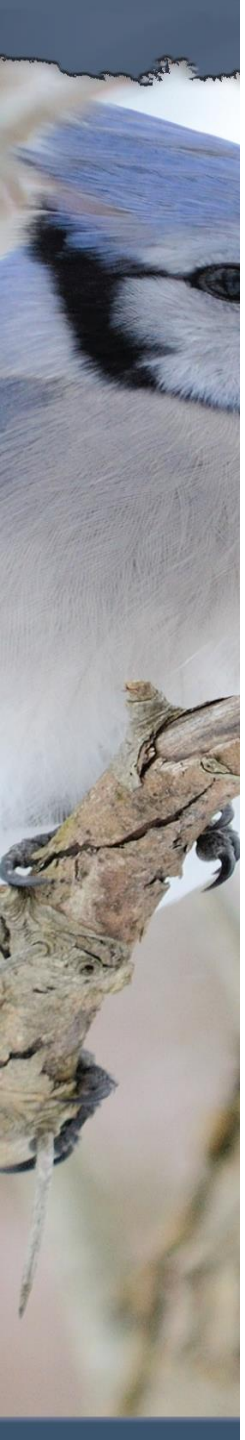
The Animal superclass

- Place common fields in **`Animal`**:
  - **`age`**, **`alive`**, **`location`**
- Method renaming to support information hiding:
  - **`run`** and **`hunt`** become **`act`**.
- **`Simulator`** can now be significantly decoupled.



Revised (decoupled) iteration

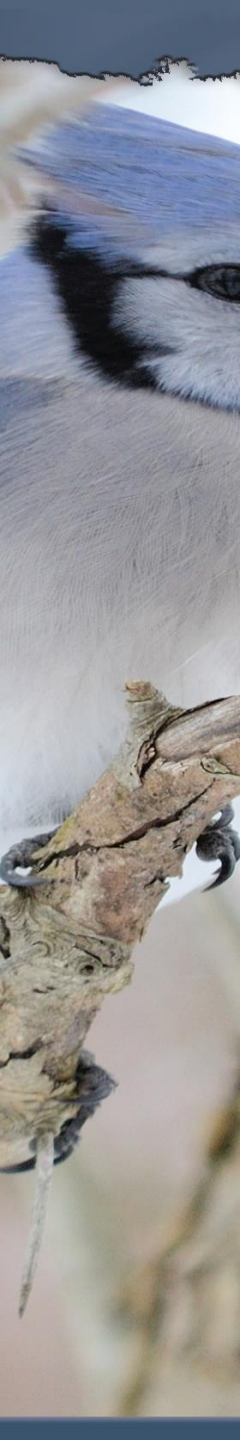
```
for(Iterator<Animal> it = animals.iterator();
        it.hasNext(); ) {
    Animal animal = iter.next();
    animal.act(newAnimals);
    // Remove dead animals from simulation
    if(! animal.isAlive()) {
        it.remove();
    }
}
```



The `act` method of Animal

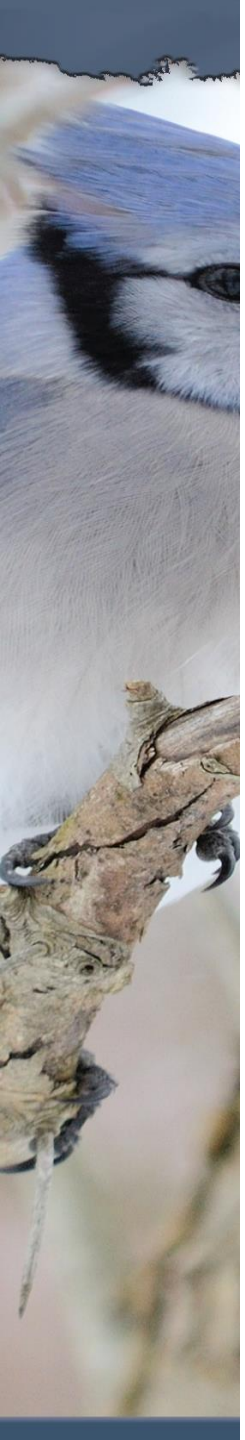
- Static type checking requires an **`act`** method in **`Animal`**.
- There is no obvious shared implementation.
- Define **`act`** as abstract:

```
abstract public void act(List<Animal> newAnimals);
```



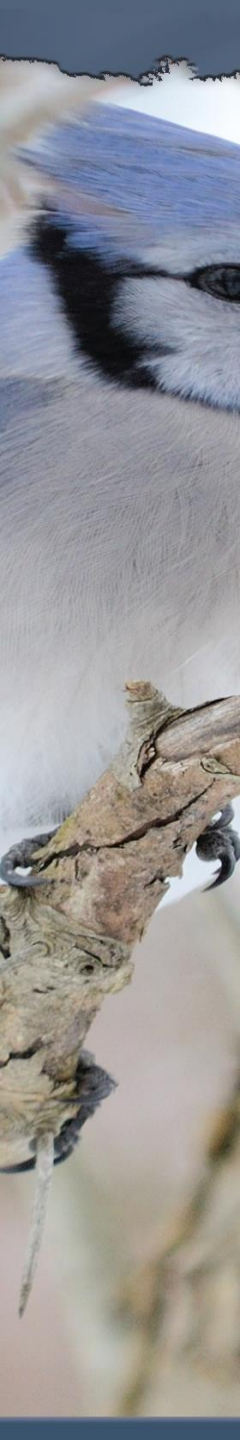
Abstract classes and methods

- Abstract methods have **`abstract`** in the signature.
- Abstract methods have no body.
- Abstract methods make the class abstract.
- *Abstract classes cannot be instantiated.*
- Concrete subclasses complete the implementation.



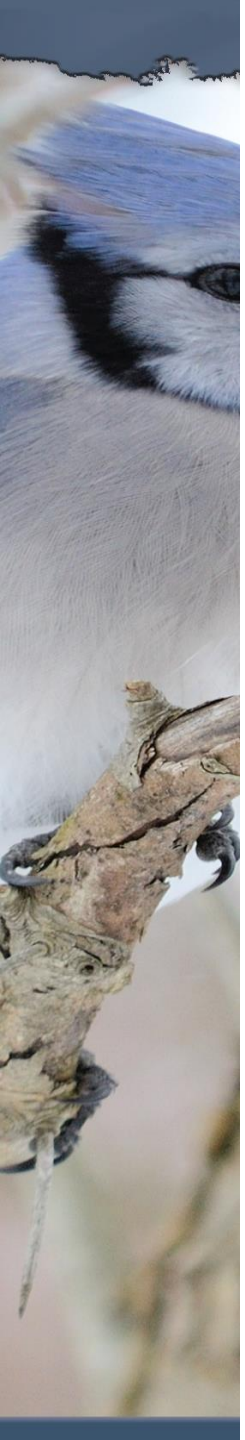
The Animal class

```
public abstract class Animal
{
    fields omitted

    /**
     * Make this animal act - that is: make it do
     * whatever it wants/needs to do.
     */
    abstract public void act(List<Animal> newAnimals);

    other methods omitted
}
```



Review

- Abstract methods allow static type checking without requiring implementation.
- Abstract classes function as incomplete superclasses.
  - No instances.
- Abstract classes support polymorphism.



Øving

- Skjer på Fjerdingen (sjekk TimeEdit).

- Nå: Kahoot☺