Fun, Friendly Computer Science

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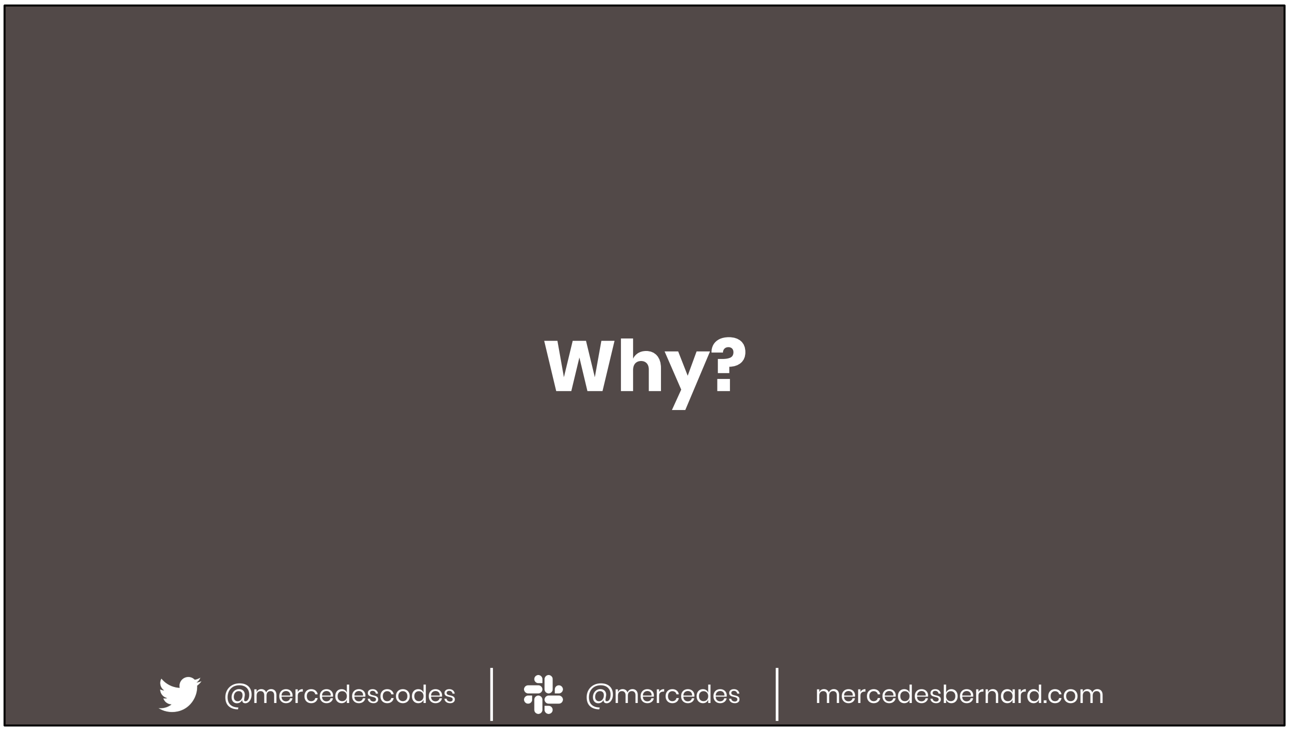
Hello! Today we're here to talk about Fun, Friendly Computer Science. This talk is going to be computer science quick hits. We're going to cover 11 topics in about 55 minutes. So because we don't have very much time, this talk will mainly focus on fundamental and introductory object-oriented programming concepts. But there's a whole world of other CS things to learn if you want to explore more.

If you have some familiarity with loops, array, and classes, you'll be able to follow along with this talk!

My name is Mercedes Bernard. My pronouns are she/her. And I'm a senior software engineer and engineering manager with a digital consultancy in Chicago called Tandem.



Why?

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My background is in traditional, CS. I have a BS in CS. But the longer I'm in this industry, the more I realize that there is a lot that I learned that I never use. If you came into software from a non-traditional path, you may never have had the chance to learn this stuff. But you'll still be interviewed on it.

My goal with this talk is to show you that these topics that are used in interviews and sometimes used for gatekeeping aren't intimidating and also aren't really that important because a) you probably already know it and just don't have the words to explain it and b) you really don't use it very often.

You'll walk away from this talk with a high level understanding of a bunch of different topics as well as metaphors that you can use to explain them and examples that you can refer to later if you need them.

If you already know everything in this talk, that's great! But you'll probably still find something useful in explaining this to those you mentor or teach.

mercedesbernard.com/speaking/fun-friendly-cs

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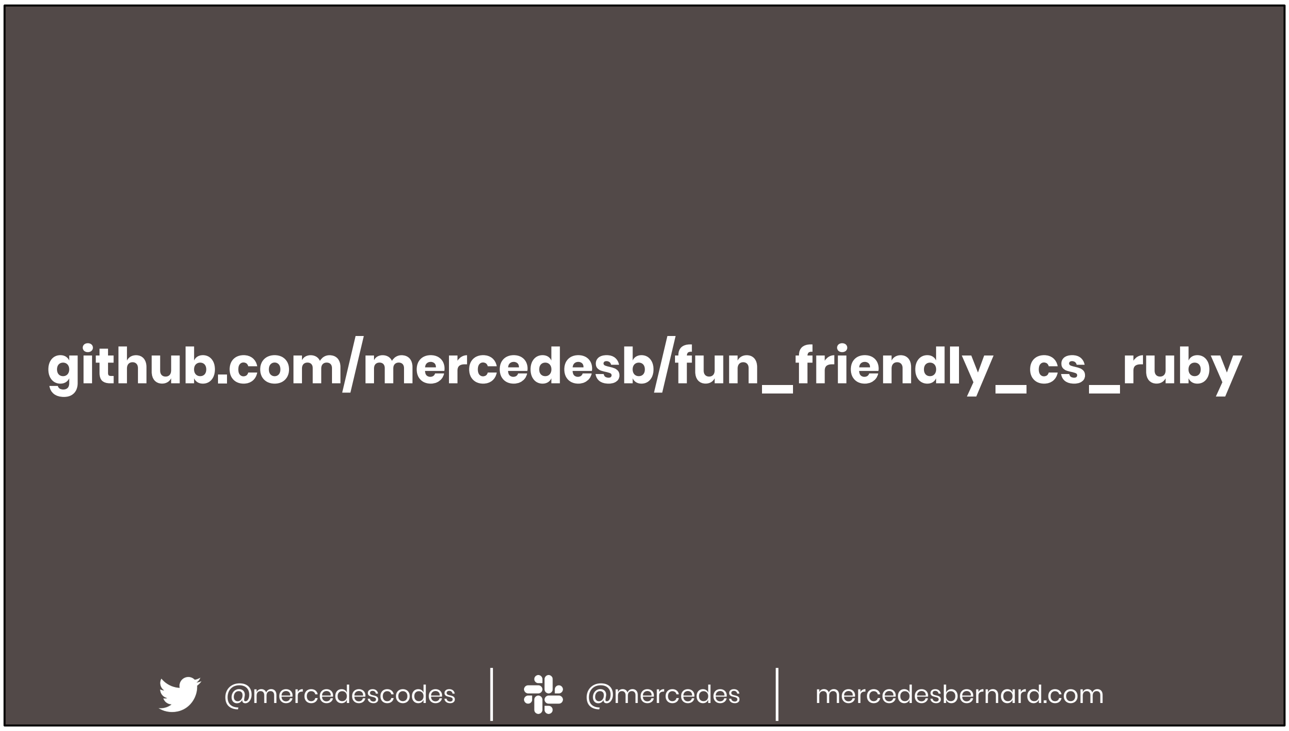
If you are someone who likes to reference slides or speaker notes while I'm talking, I've posted the slides for this talk here. I also tweeted out a link right before I got started so you can also find it on my Twitter profile.



github.com/mercedesb/fun_friendly_cs_ruby

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There will be code samples in this talk and you can find them all in this repo. Be sure to check out the commits because each commit corresponds to one of the topics we'll cover here today.

All of the code you'll see today is written in vanilla js. This was an intentional choice. JS is not exactly known for being object oriented but I wanted to show that CS is more a way of thinking than it is a specific language or framework. There are some languages that are more functional in nature where you would have to force OO behavior, but anything is possible in code.

Vanilla JS also seemed the most accessible of my language options as opposed to .NET or Ruby. Most folks have dabbled a little and even if you only know a framework, you'll still be able to get by. If you've never used JS before, a lot of the syntax is easy to follow.

Test files are probably the most useful and where you should start to understand what the example is trying to show. But not everything has tests because in some cases, like set theory, the tests were no more valuable than the code.

Agenda

1. Concepts

- Big O notation
- Set theory
- Recursion

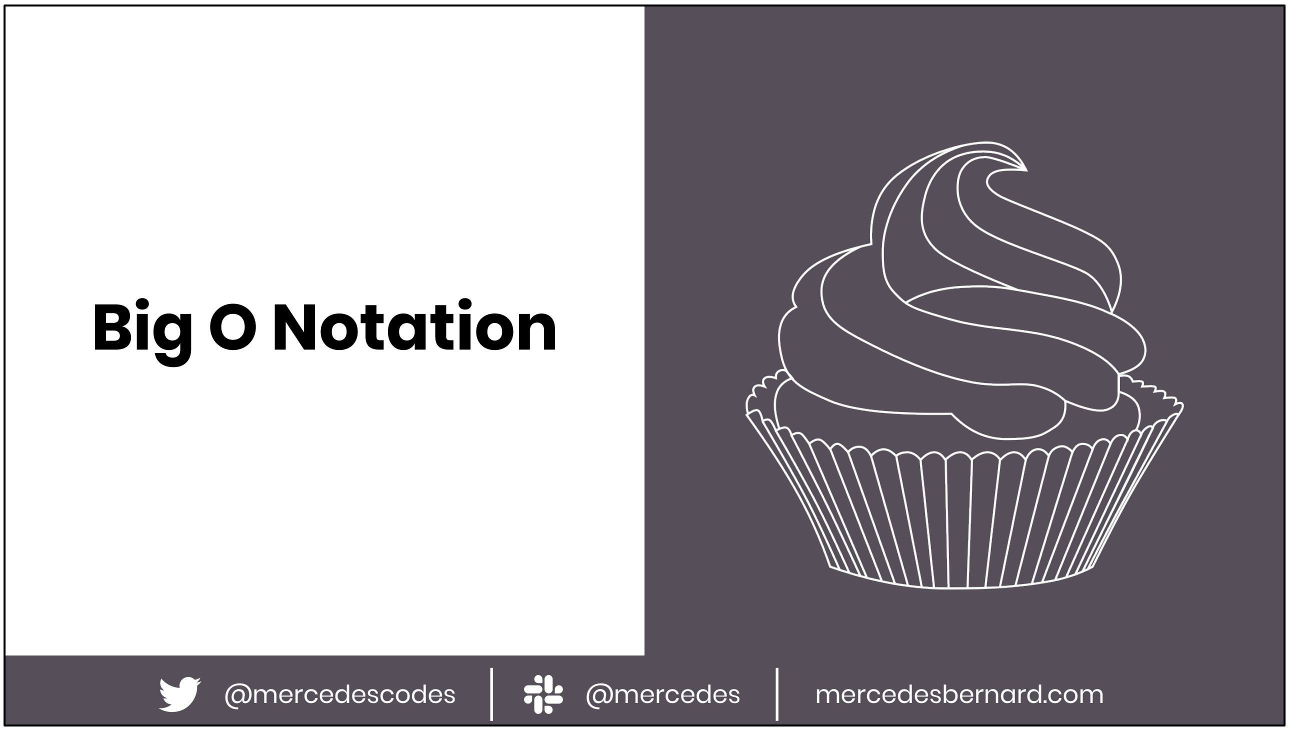
2. Data structures

- Linked list
- Stack
- Queue
- Tree

3. Principles of OO programming

- Encapsulation
- Abstraction
- Inheritance
- Polymorphism

Concepts



Big O Notation

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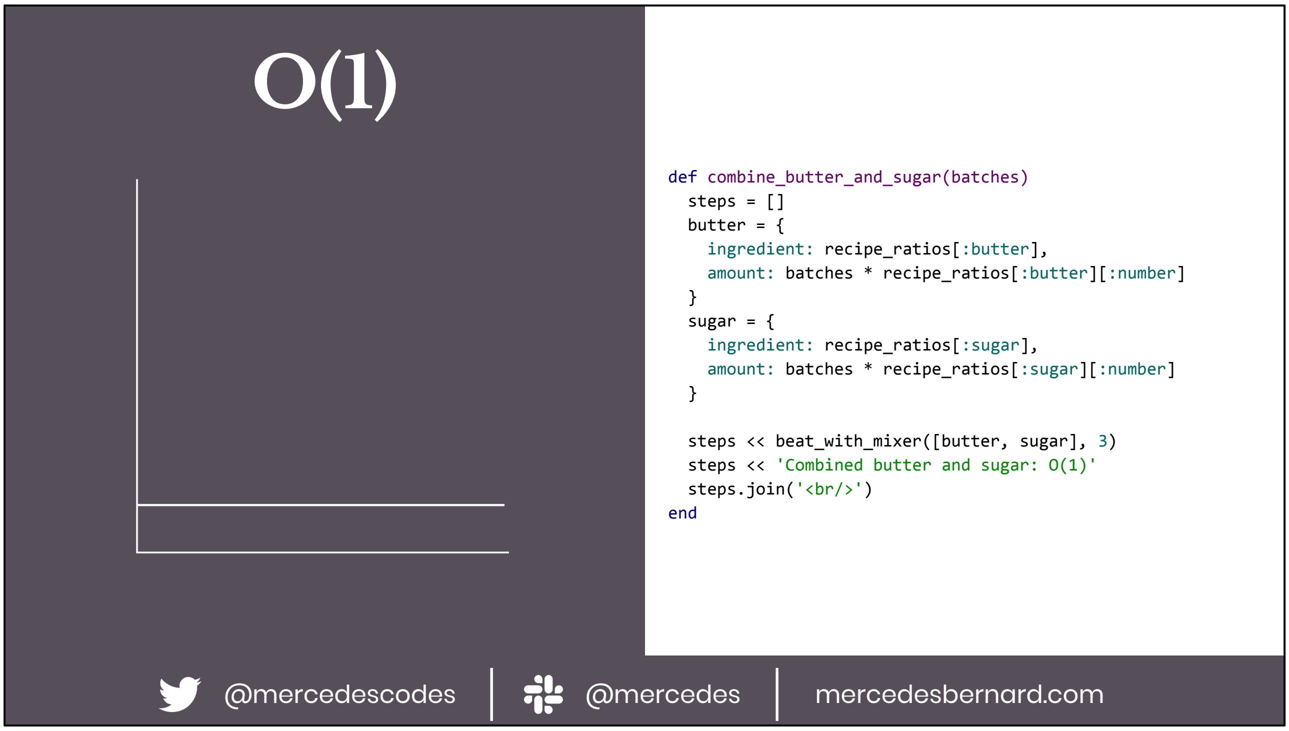
Cooking with ratios is when you don't memorize recipes but instead memorize the ratios of ingredients. The amount of ingredients you need changes *in proportion* to how much of the food you want to make. For example, cupcakes follow a 4:3:2:1 ratio.

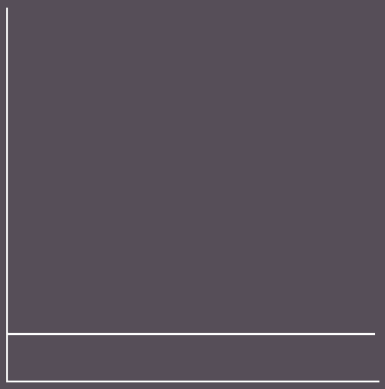
Big O Notation measures relative complexity of a function or algorithm. Most often this is measuring running time but it could also be used to measure memory consumption, stack depth, and other resources. We're going to focus on running time since in an interview, that's what they're usually asking about. The actual input size is unimportant because we want to measure the proportional complexity of the logic.

This measurement is language/hardware/time agnostic and is relative to the code's input size.

We also talk about it according to worst case scenario. Sometimes in different sort and search algorithms you get lucky and the collection is nearly sorted or the object is near the beginning of your iteration but when we're talking about complexity, we want to plan for the worst case scenario.



O(1)



```
def combine_butter_and_sugar(batches)
  steps = []
  butter = {
    ingredient: recipe_ratios[:butter],
    amount: batches * recipe_ratios[:butter][:number]
  }
  sugar = {
    ingredient: recipe_ratios[:sugar],
    amount: batches * recipe_ratios[:sugar][:number]
  }

  steps << beat_with_mixer([butter, sugar], 3)
  steps << 'Combined butter and sugar: O(1)'
  steps.join('<br/>')
end
```

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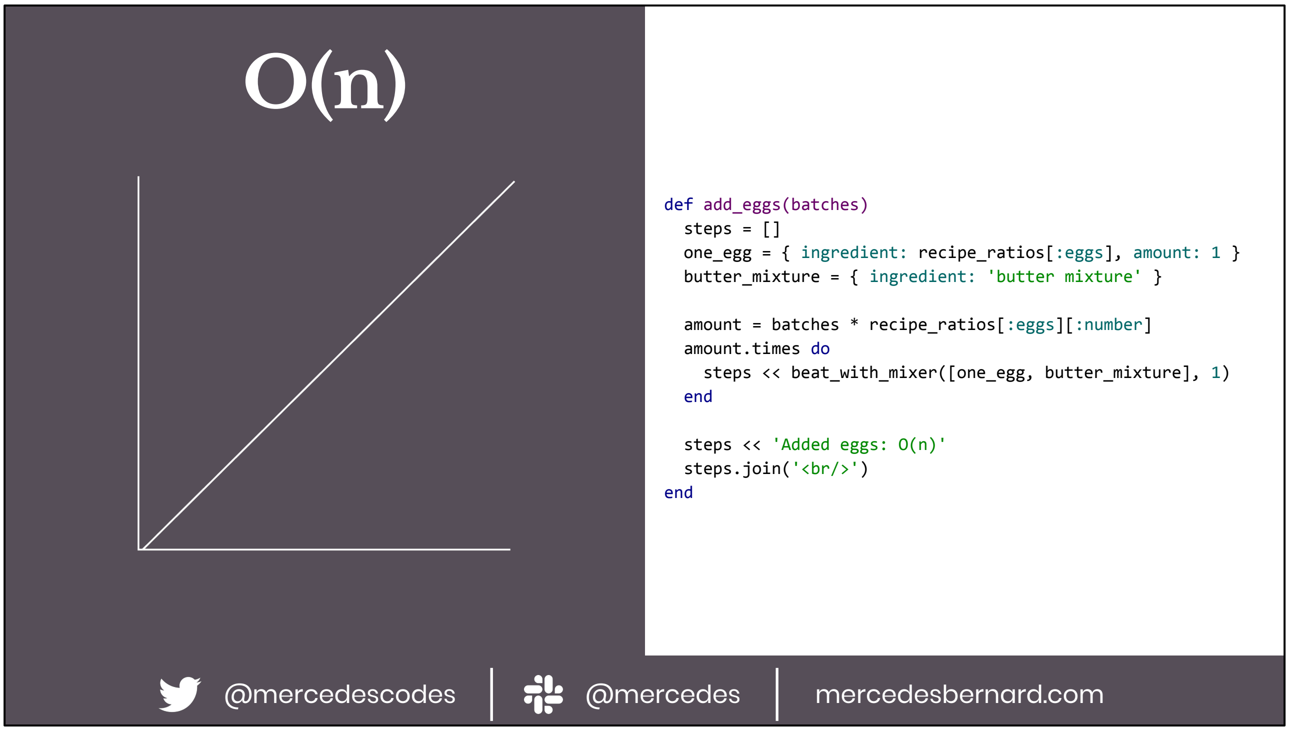
O(1) = Constant running time regardless of input size



O(n)

```ruby
def add_eggs(batches)
  steps = []
  one_egg = { ingredient: recipe_ratios[:eggs], amount: 1 }
  butter_mixture = { ingredient: 'butter mixture' }

  amount = batches * recipe_ratios[:eggs][:number]
  amount.times do
    steps << beat_with_mixer([one_egg, butter_mixture], 1)
  end

  steps << 'Added eggs: O(n)'
  steps.join('<br/>')
end
```

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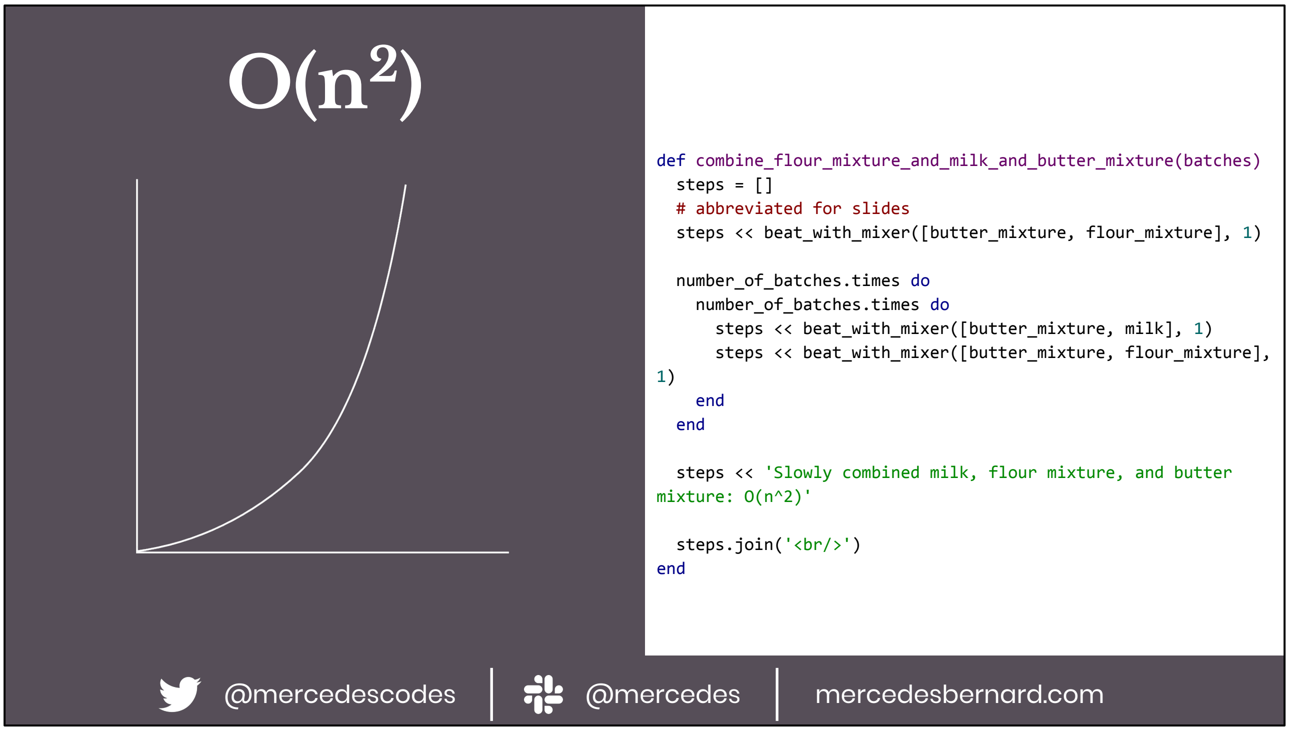
O(n) = Running time proportional to input size and running time increases linearly



O(n^2)

```
def combine_flour_mixture_and_milk_and_butter_mixture(batches)
  steps = []
  # abbreviated for slides
  steps << beat_with_mixer([butter_mixture, flour_mixture], 1)

  number_of_batches.times do
    number_of_batches.times do
      steps << beat_with_mixer([butter_mixture, milk], 1)
      steps << beat_with_mixer([butter_mixture, flour_mixture],
1)
    end
  end

  steps << 'Slowly combined milk, flour mixture, and butter
mixture: O(n^2)'

  steps.join('<br/>')
end
```

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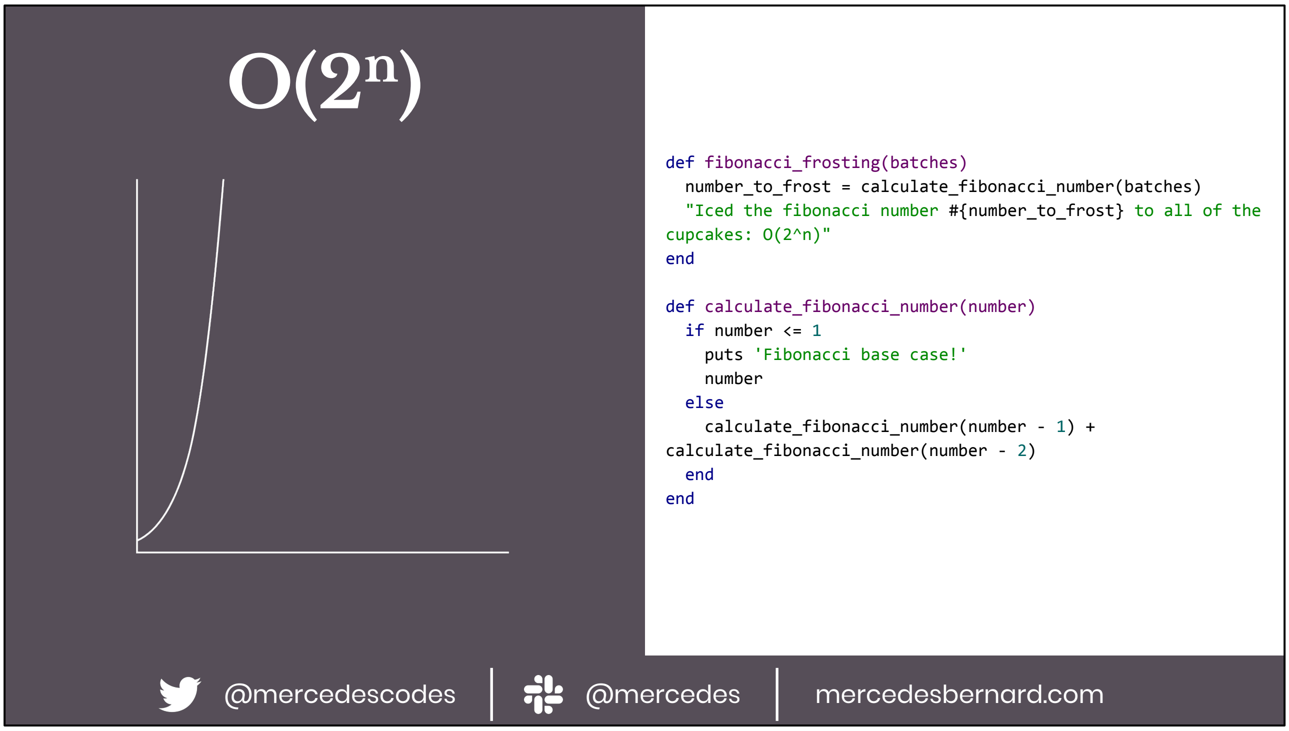
O(n^2) = Running time proportional to the square of the input size. This is common in nested iterations.



$O(2^n)$

```
def fibonacci_frosting(batches)
  number_to_frost = calculate_fibonacci_number(batches)
  "Iced the fibonacci number #{number_to_frost} to all of the
cupcakes: O(2^n)"
end

def calculate_fibonacci_number(number)
  if number <= 1
    puts 'Fibonacci base case!'
    number
  else
    calculate_fibonacci_number(number - 1) +
calculate_fibonacci_number(number - 2)
  end
end
```

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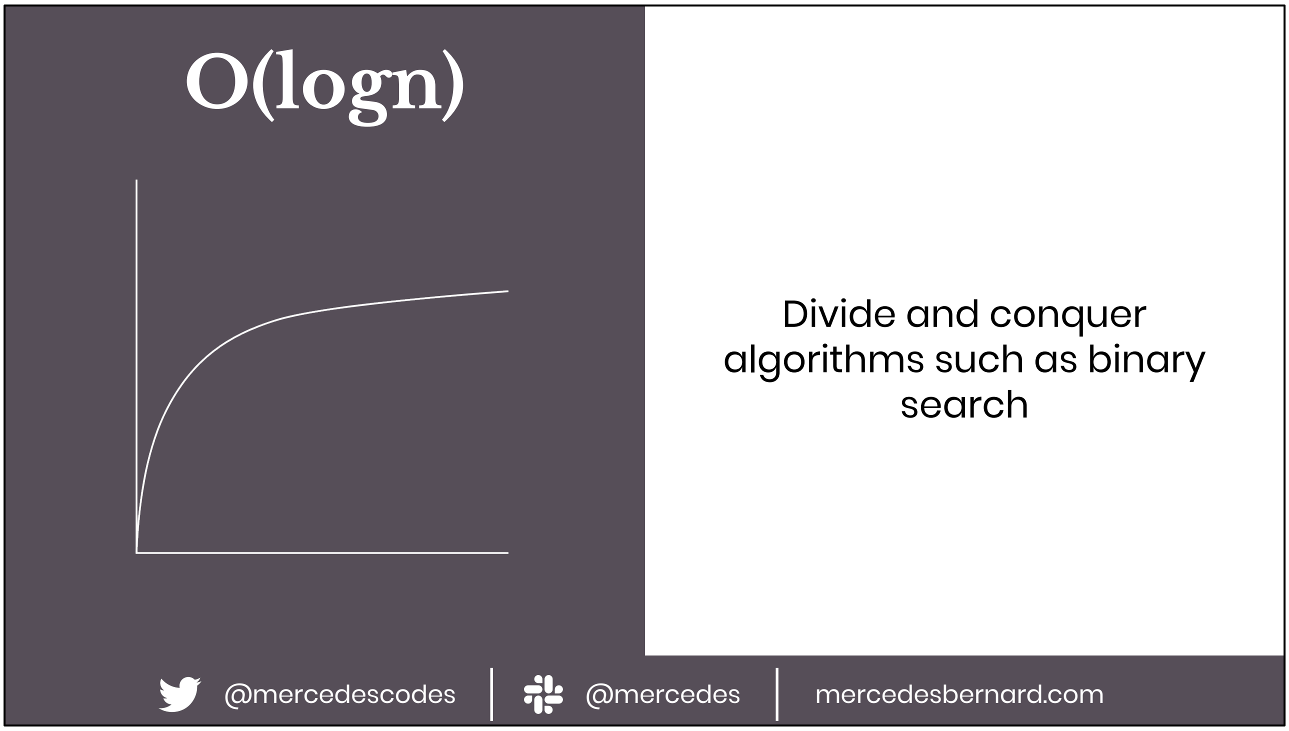
O(2^n) = Running time grows exponentially with the size of the input. For example, calculating Fibonacci recursively



O(logn)

Divide and conquer algorithms such as binary search

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O(log n) = This is kinda the opposite of O(2^n).

Big O Uses

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Interviews
Comparing the performance of 2 possible solutions
Having a shared language

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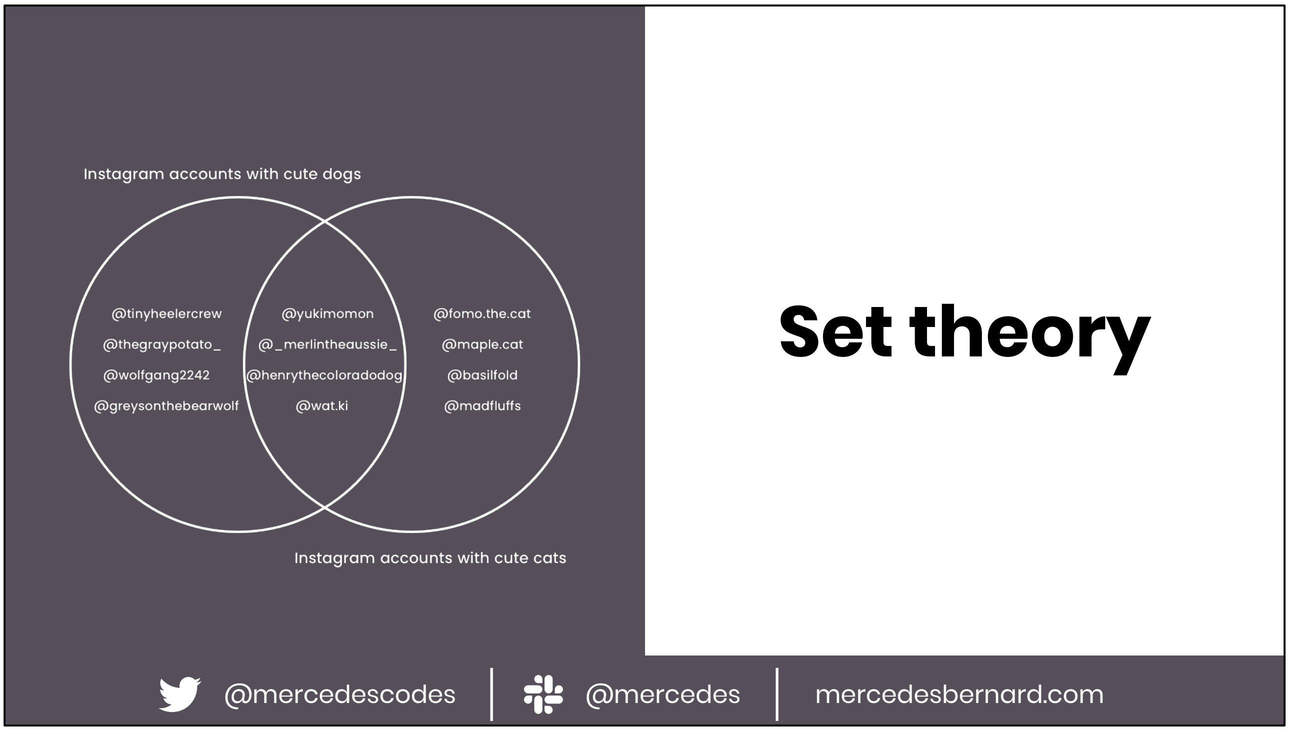

Set theory

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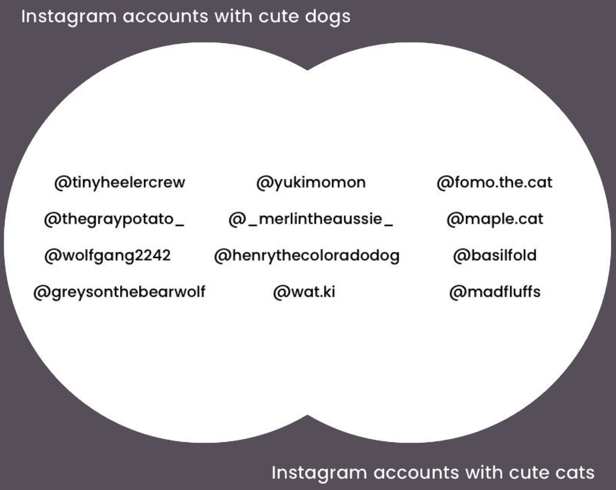
Venn diagrams are a great way to think about set theory. A set is a data structure similar to arrays or lists but it is an unordered collection of objects with no duplicates.

Sets are more interesting for what we can do on them. These operations form the basis of set theory.

Union: X ∪ Y

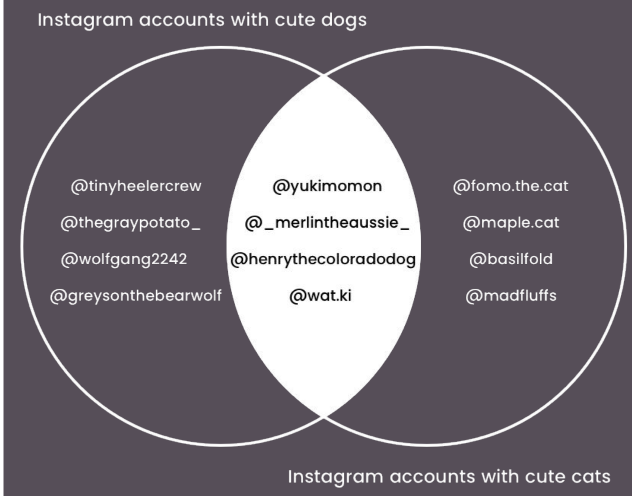
All of the cute accounts



Union - X ∪ Y The stuff that exists in X OR Y

Intersection: X ∩ Y

Accounts featuring cute dogs and cats



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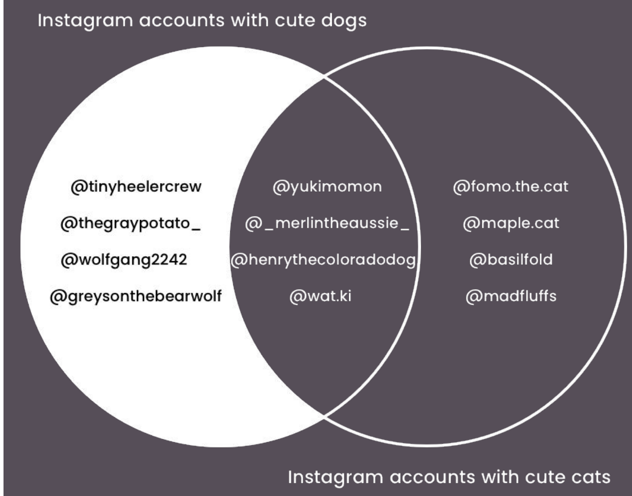
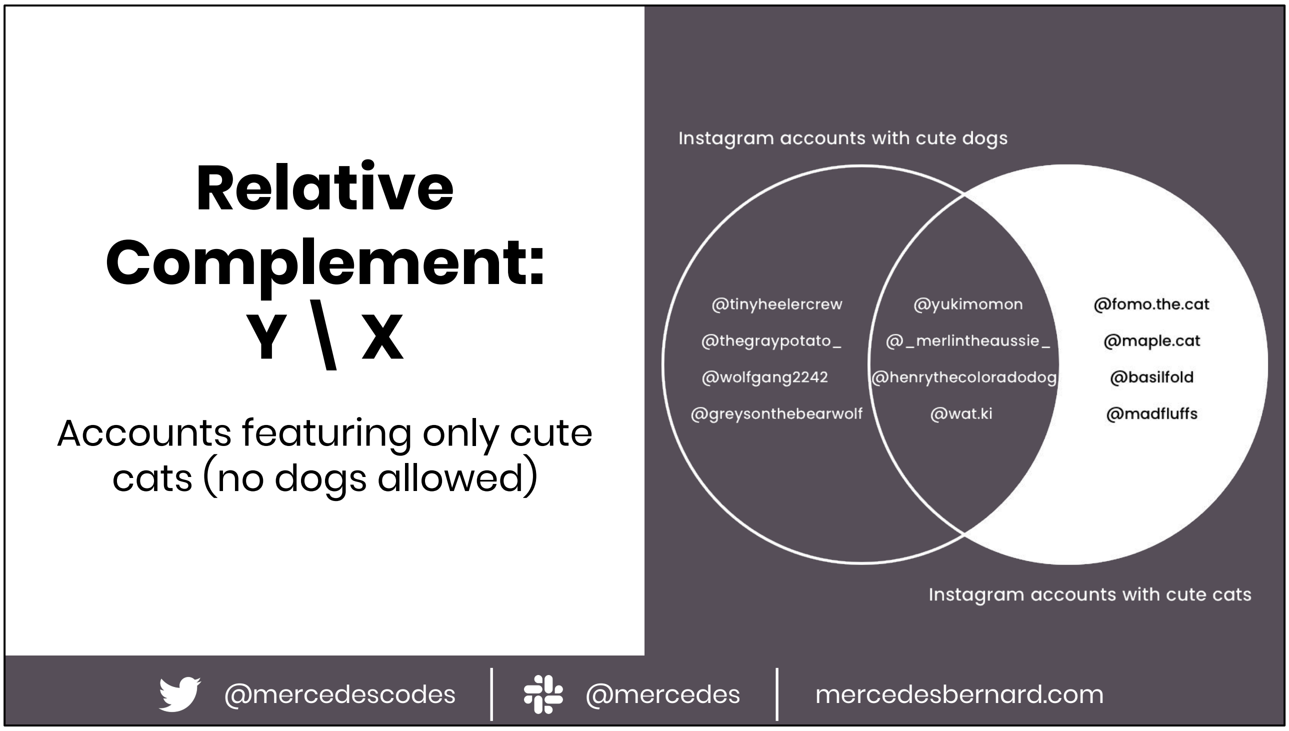
Intersection X ∩ Y - The stuff that exists in X AND Y

Difference: X - Y

Accounts featuring only cute dogs (no cats allowed)

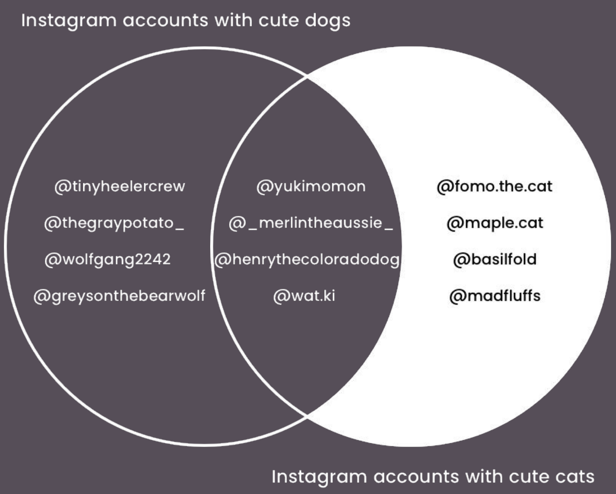


Difference - X - Y The stuff that only exists in X

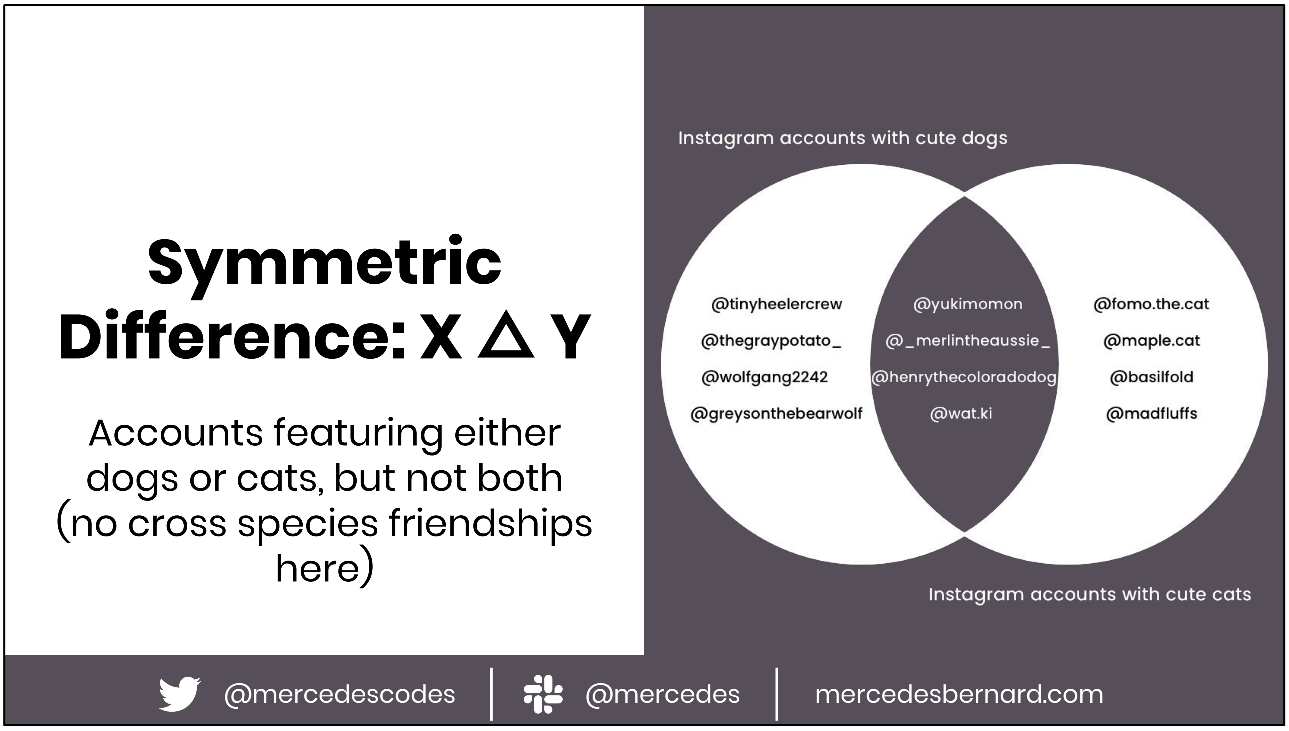


Relative Complement: Y \ X

Accounts featuring only cute cats (no dogs allowed)



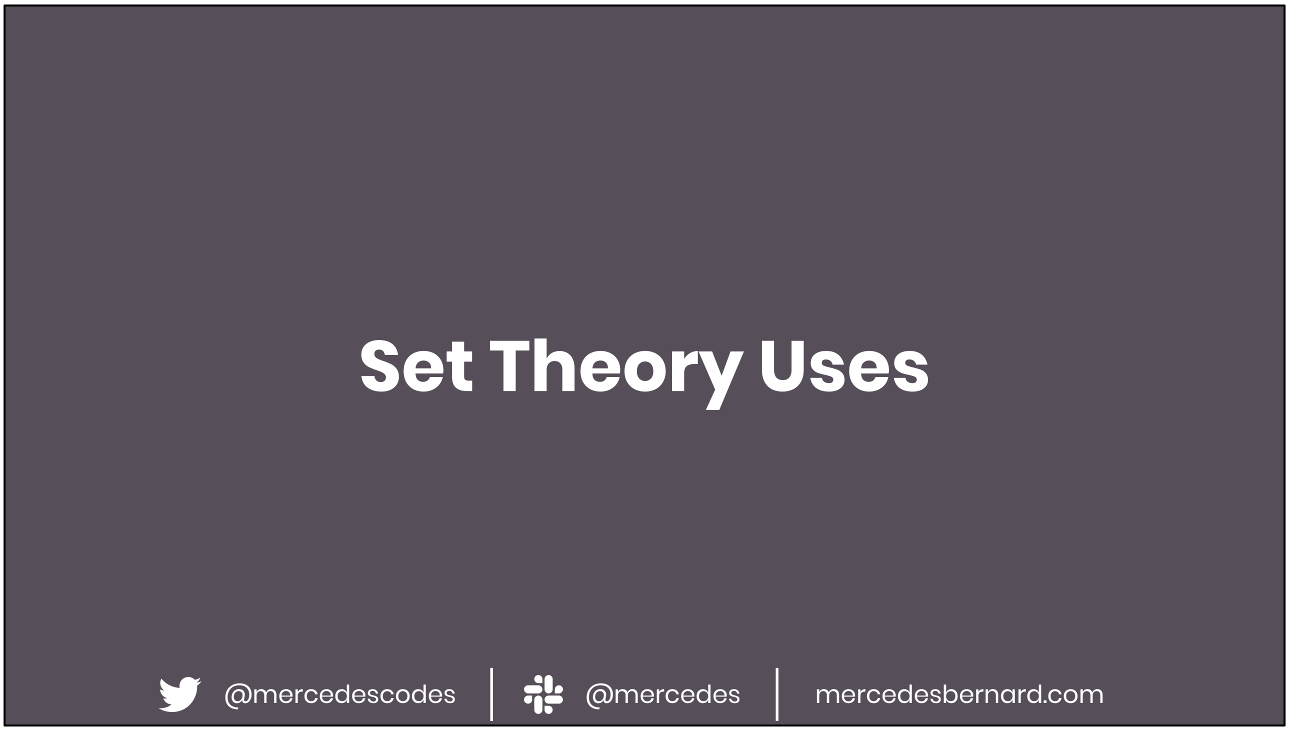
Relative complement Y \ X (same as Y - X) The stuff that only exists in Y



Symmetric Difference: X △ Y

Accounts featuring either dogs or cats, but not both (no cross species friendships here)

Symmetric difference (disjunctive union) X △ Y
Same as (X ∖ Y) ∪ (Y ∖ X).
The stuff that exists in only X and the stuff that exists in only Y but none of the stuff that exists in both



Set Theory Uses

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Set theory is the foundation of relational databases
Website filters

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- ~~Set theory~~
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Recursion

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Russian nesting dolls are a great metaphor for recursion, because each doll is the same except for its size. The dolls continue to open until you get to the smallest child which does not open. When you reach the smallest child, your reverse the process, closing each doll one by one in reverse order.

Recursion is the process in which a function calls itself directly or indirectly. And the function that is doing this calling of itself is called a recursive function. Everything that you do recursively you can also do in a loop.

When writing a recursive function, we don't want it to continue calling itself infinitely so we have to set up a condition where it exists the nesting and returns a finite value. This is called the base case. The smallest doll in Russian nesting dolls is like the base case.

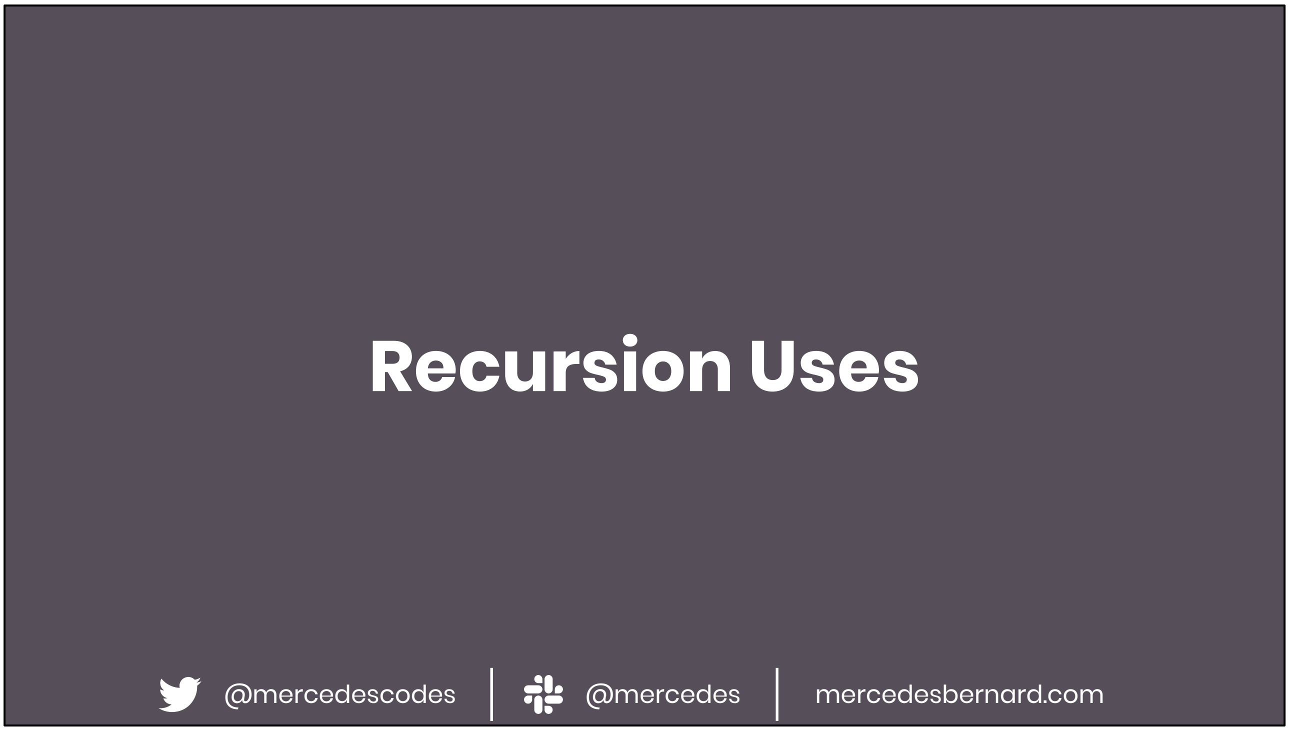
When you're writing a recursive function, the base case is usually the easiest place to start.

```
def count
  count_nested_dolls(big_doll)
end

def count_nested_dolls(doll)
  child = doll.open

  # base case
  return 1 unless child

  count_nested_dolls(child) + 1
end
```



Recursion Uses

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Navigation paths on a website

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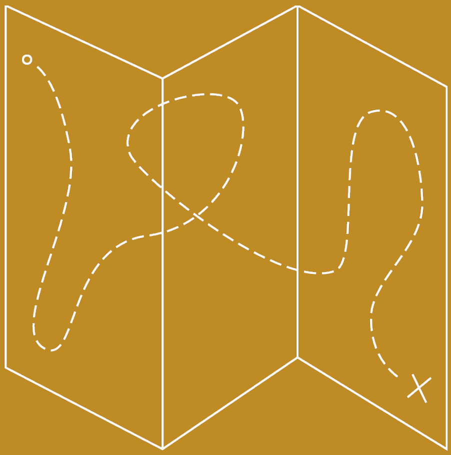
Data Structures



Linked List

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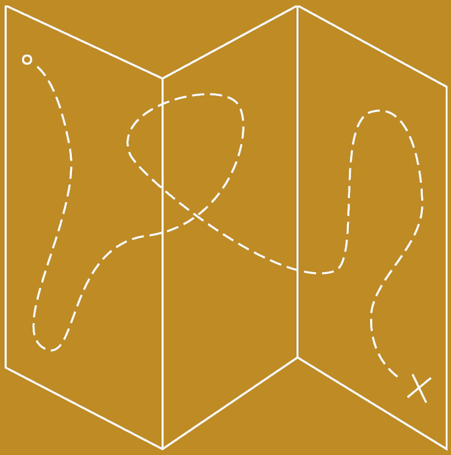
When you are following a scavenger hunt, you start with the first clue and must follow each clue sequentially one at a time. Because you have no way of knowing where the nth clue is when you start, you must follow the hunt from clue to clue to clue.

A scavenger hunt is a good metaphor for a linked list. A linked list is a data structure characterized by sequential data access and no random access. This is unlike arrays. In arrays, because all of the data is stored in contiguous locations in memory, you can do simple addition and subtraction to find the memory location of the data at the nth node. For example, array[3] is just 3 memory
locations from array[0]. Linked lists on the other hand, do not need contiguous memory allocated. Each node in a linked list points to where the next node is located.

Because of the memory allocation, a linked list will have no wasted space because it can grow and shrink dynamically whereas traditionally an array always needs to be allocated to maximum size (or copied to a new array if it needs to grow). We tend to forget this when working with Javascript since JS Arrays behave more like ArrayList.

However, because a linked list node needs to store its data and a reference to the next node, it does take up a bit more space than an array of the same data.

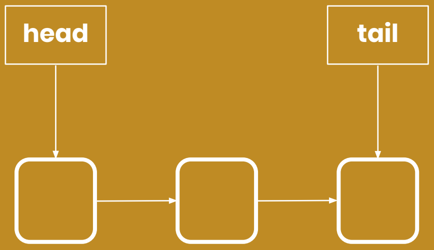
Linked lists have fast insertion and deletion if its at the head or tail. But to insert into the middle of a linked list is O(n) because we need to **loop through the list** to the place we want to insert, update the previous nodes pointer to the inserted node and update the inserted nodes pointer to the next node.



```
def add(data)
  new_node = LinkedList::Node.create(data: data)
  if head.nil?
    self.head = new_node
  else
    tail.update(next: new_node)
  end

  self.tail = new_node

  save
  reload
  new_node
end
```



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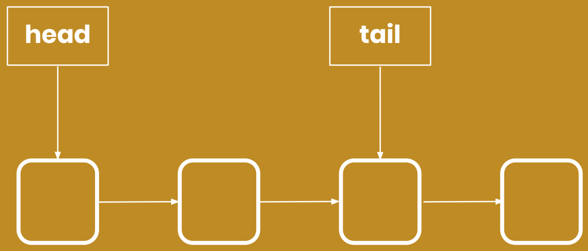

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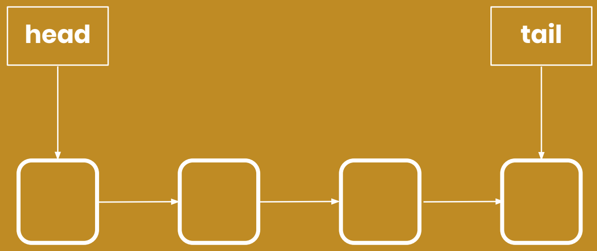
```



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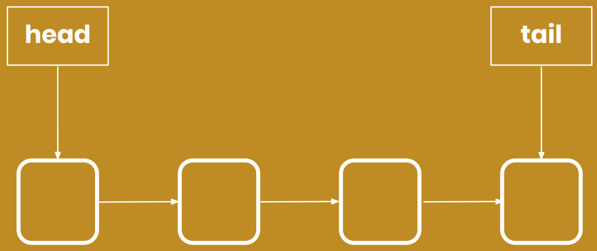
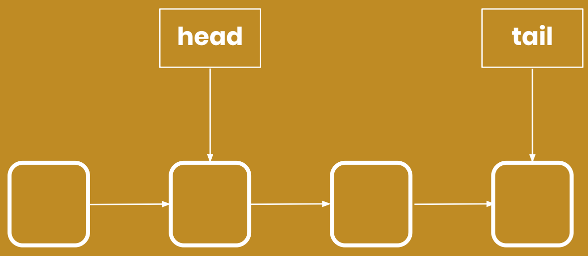
```



```
def remove
  return head if head.nil?

  removed = head
  update(head: head.next)
  removed.update(next: nil)
  removed
end
```



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def remove
  return head if head.nil?

  removed = head
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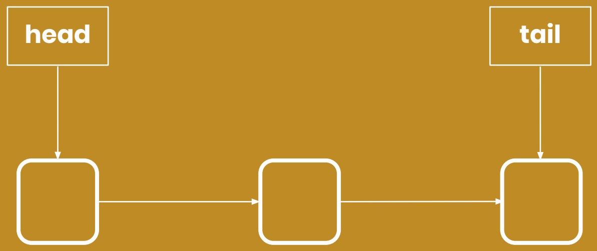
```



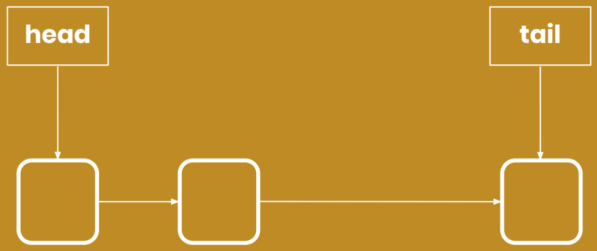
```
def insert(data, index)
  return nil if index.negative?

  new_node = LinkedList::Node.create(data: data)

  if index.zero?
    new_node.next = head
    update(head: new_node)
  else
    current = head
    previous = nil
    i = 0

    while !current.nil? && i < index
      previous = current
      current = current.next
      i += 1
    end

    if !current.nil? # found where to insert the new node
      previous.update(next: new_node)
      new_node.update(next: current)
    elsif previous == tail
      add(data)
    end
  end
  new_node
end
```



```ruby
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```

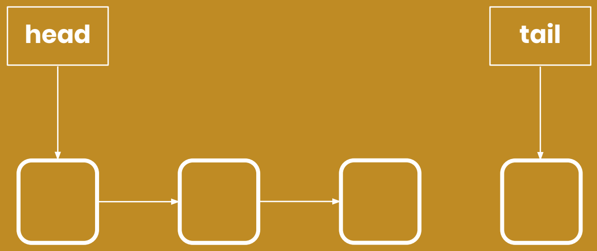

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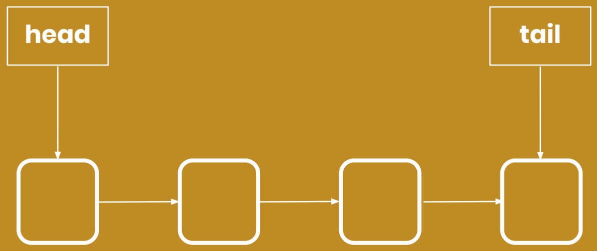
```



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    elsif previous == tail
      add(data)
    end
  end
  new_node
end
```

Linked List Uses

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When you don't know the size of the data ahead of time and you don't need efficient random access.

Implementing your own stack or queue… but would you really? Probably not since most languages and frameworks have these data structures built for you already. We don't want to reinvent the wheel.

Blockchain

Doubly linked list
Playlist

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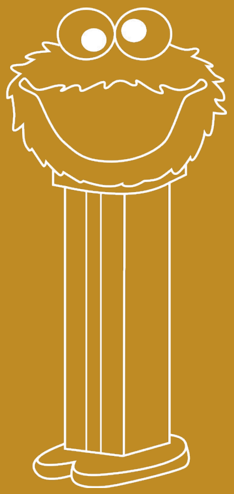
Stack



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A PEZ dispenser is wonderful visualization of a stack. When you fill it with candy, you are pushing the candy from the top down and when you eat the candy, you pop a piece of the top of the literal stack of pieces one at a time.

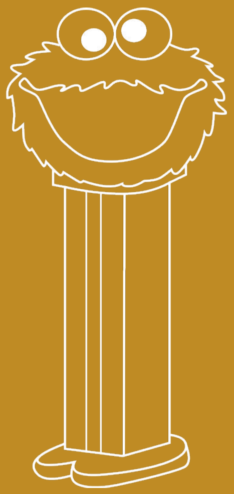
A stack data structure behaves the same way. Stacks are characterized by last in, first out (LIFO) data access. When implemented as a linked list, adding and removing from the stack are O(1).

```
def push(data)
  new_node = LinkedList::Node.create(data: data)

  if head
    new_node.next = head
    new_node.save
  end

  self.head = new_node
  save
  reload
  new_node
end

def pop
  popped = head
  update(head: head.next)
  popped.update(next: nil)
  popped
end
```



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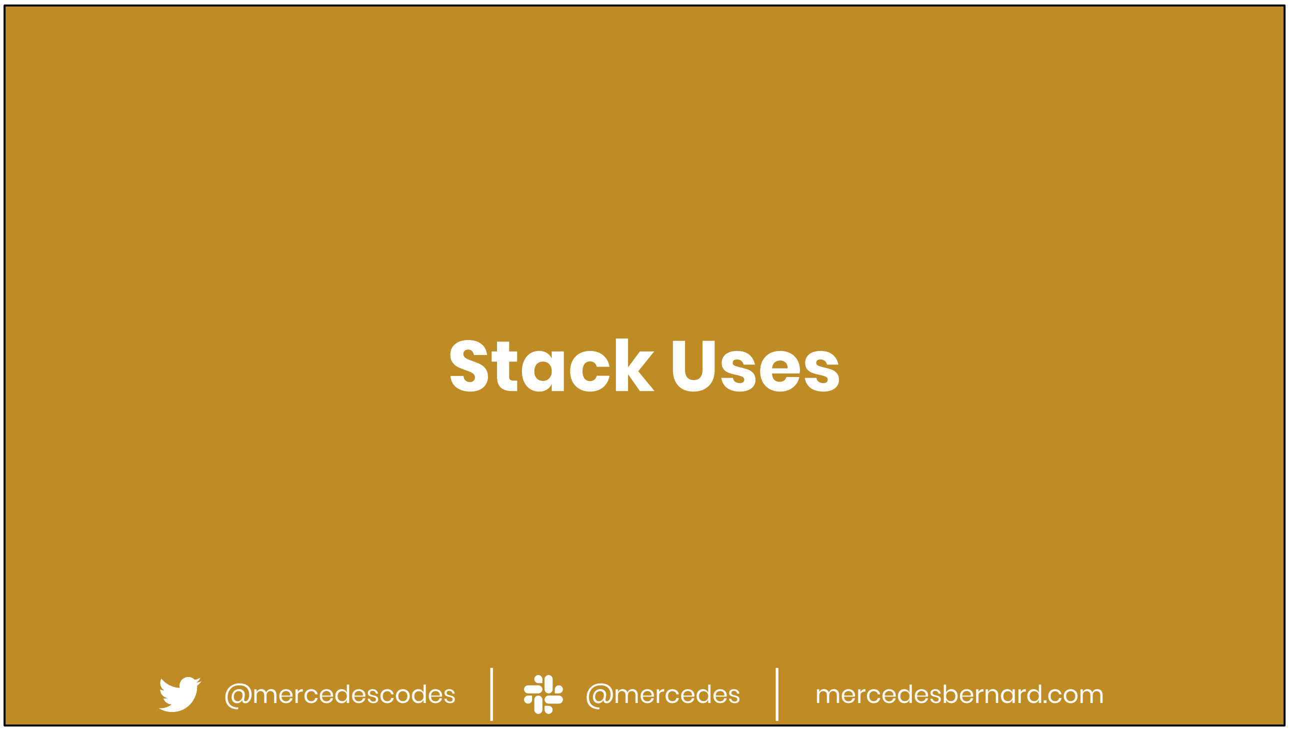

Stack Uses

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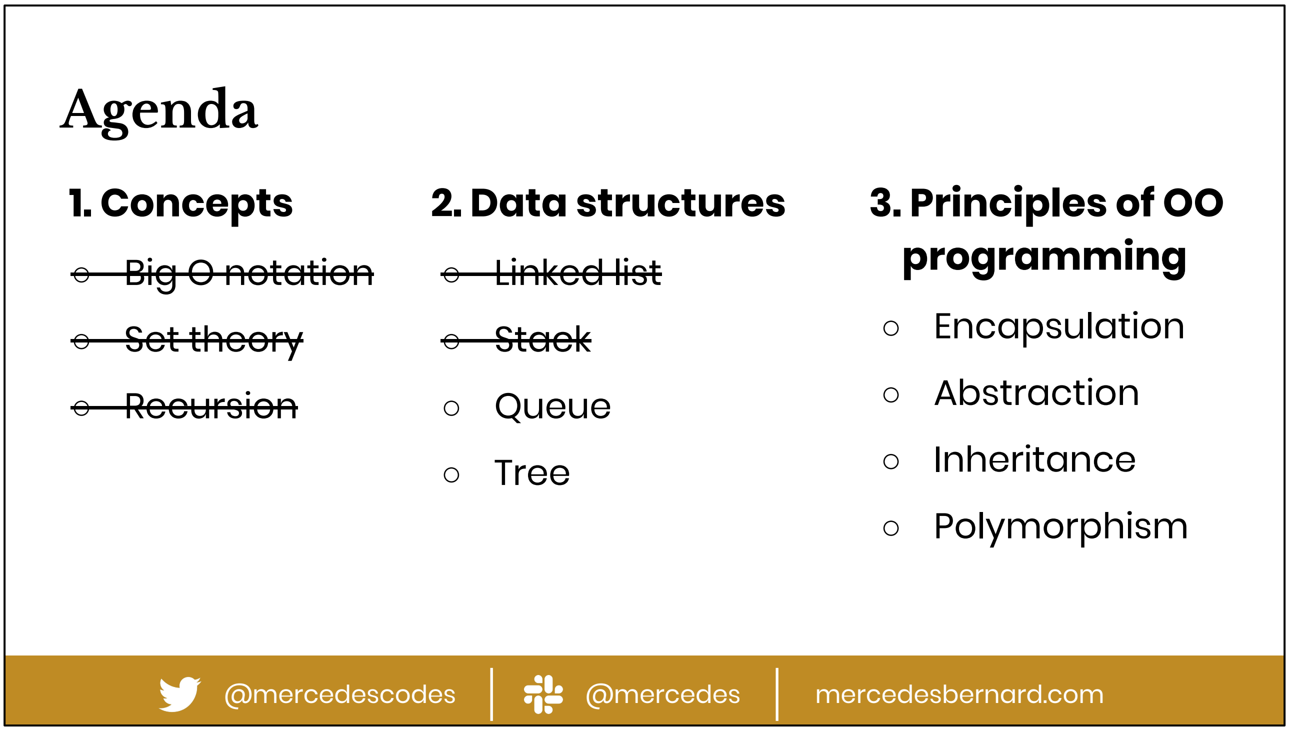
When you want to enforce LIFO data access.
Browser back button
Undo/redo feature
Checking for balanced delimiters in a string (parentheses, quotes, HTML tags, etc)



Agenda

1. Concepts

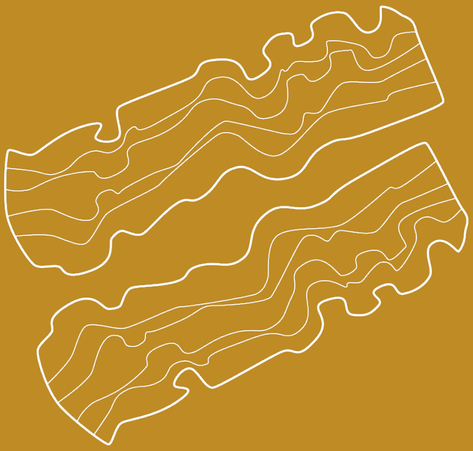
- ~~Big O notation~~
- ~~Set theory~~
- ~~Recursion~~

2. Data structures

- ~~Linked list~~
- ~~Stack~~
- Queue
- Tree

3. Principles of OO programming

- Encapsulation
- Abstraction
- Inheritance
- Polymorphism



Queue

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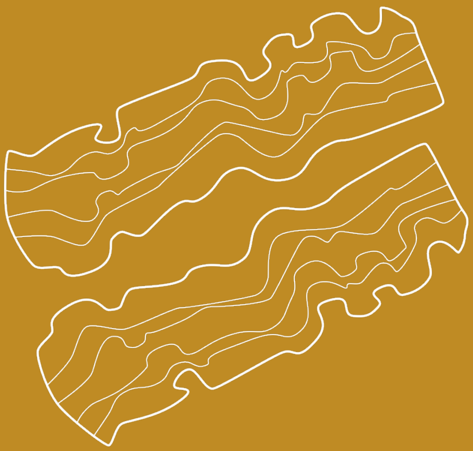
Waiting in line, or as the British call it queuing up, is a literal
visualization of a queue. The first person in line is the first person out of line. And new folks joining the line (should) always join at the back.

A queue data structure behaves the same way. Queues are characterized by first in, first out (FIFO) data access. When implemented as a linked list, enqueuing and dequeuing from the queue are O(1).



```ruby
def enqueue(data)
  new_node = LinkedList::Node.create(data: data)
  if head.nil?
    self.head = new_node
  else
    tail.update(next: new_node)
  end

  self.tail = new_node

  save
  reload
  new_node
end

def dequeue
  dequeued = head
  update(head: head.next)
  dequeued.update(next: nil)
  dequeued
end
```

Queue Uses

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When you want to enforce FIFO data access.
Processing jobs asynchronously but in the order they were scheduled

Agenda

1. Concepts

- ~~Big O notation~~
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Tree

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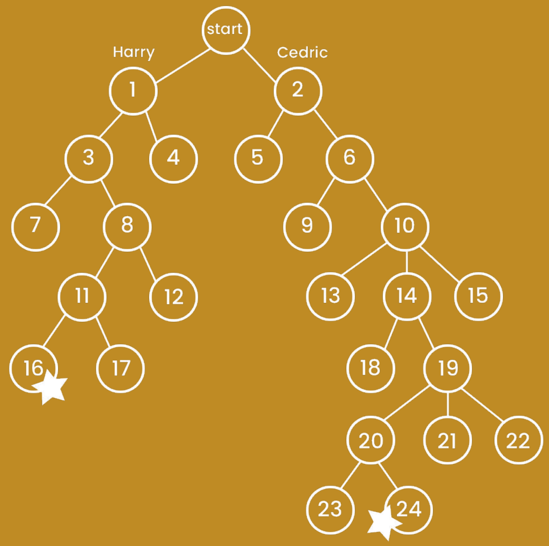
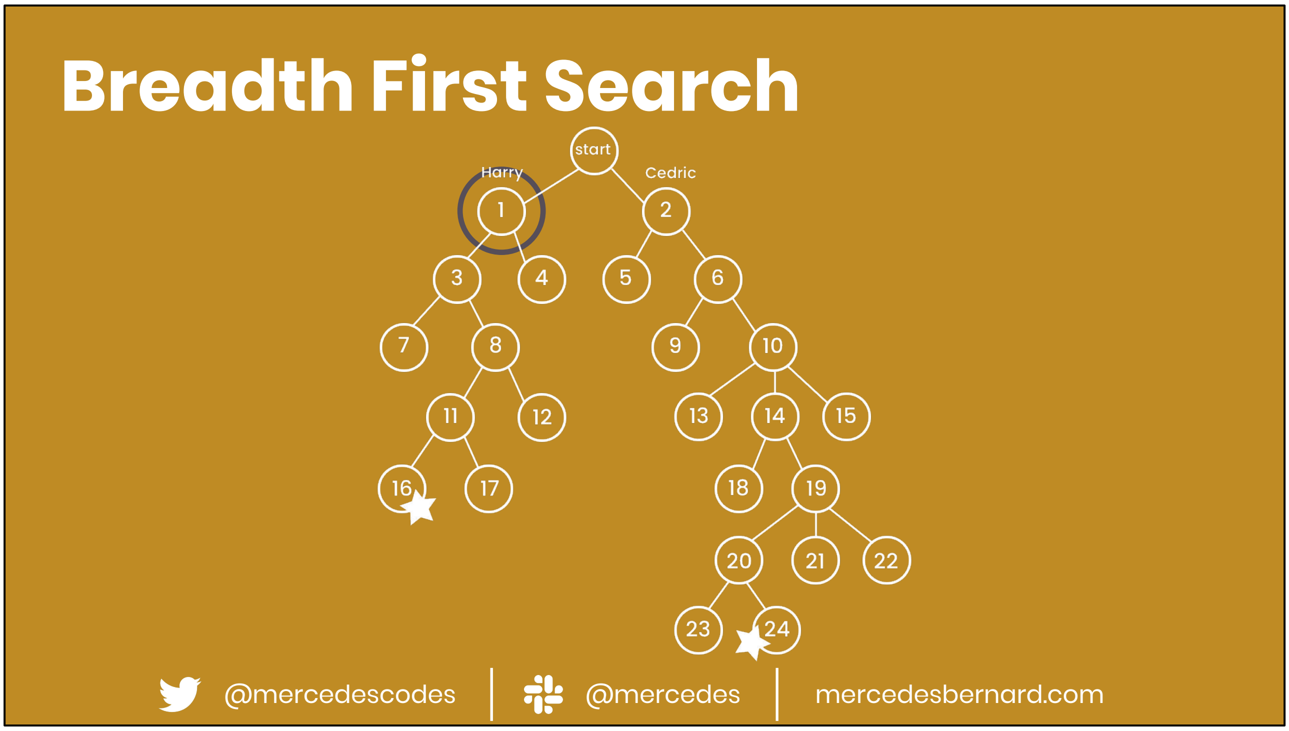
If you're a big Harry Potter fan, you probably enjoyed the end of the fourth book that featured a giant maze full of magical obstacles. The first person to the center of the maze won the Triwizard cup. When you are completing a maze, you are often faced with choices about whether to go left or right or in some cases continue straight down the center path.

Modeling these choices can be done using a tree data structure. Unlike linked lists, stacks, or queues, trees are useful to model hierarchical data. Think file systems or organization charts. In a tree data structure, there is a root node that has 1 to many children (in much the same way that a linked list stores a reference to the next node in the list).

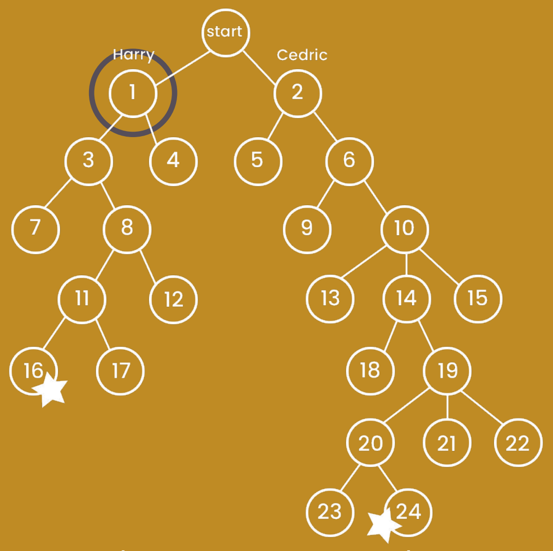
To access other nodes in the tree, you must traverse through the nodes.

Harry Potter & the Triwizard Maze





Breadth First Search



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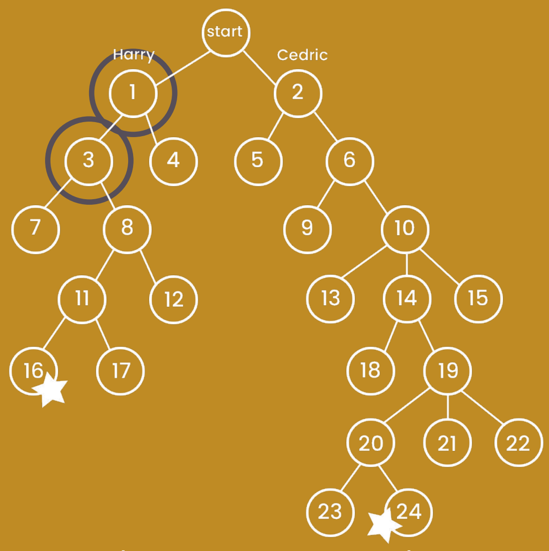
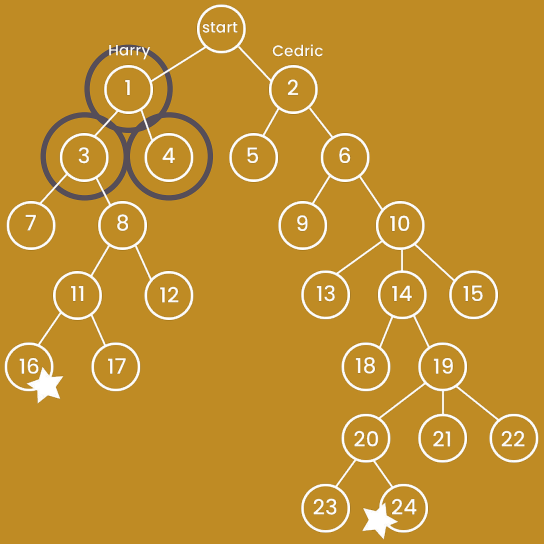
Breadth first search is when you traverse the nodes one level at a time, visiting all the nodes on level 1, then level 2 and so on. In the case of a maze, BFS is the worst way to get to the center quickly.

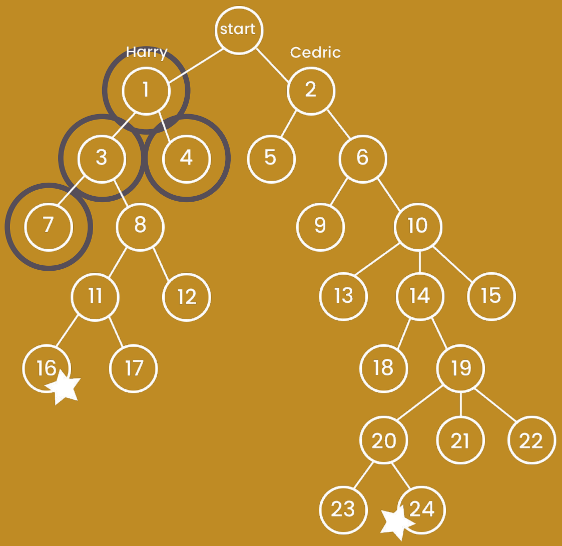
Breadth First Search



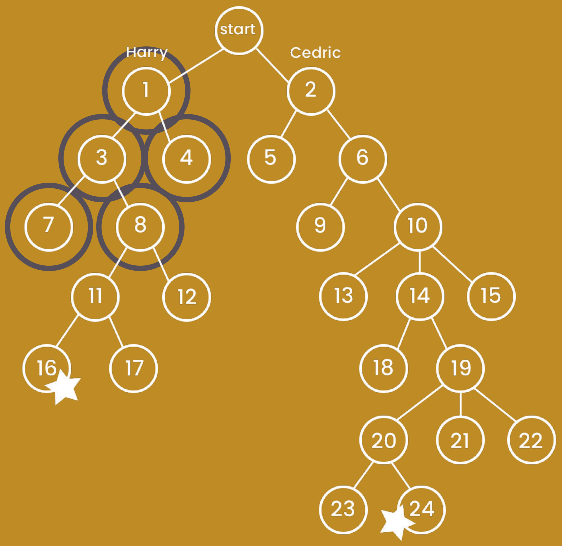
Breadth First Search



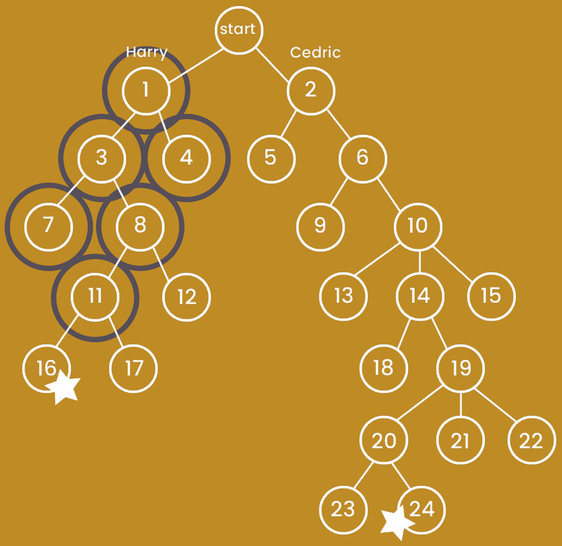
Breadth First Search



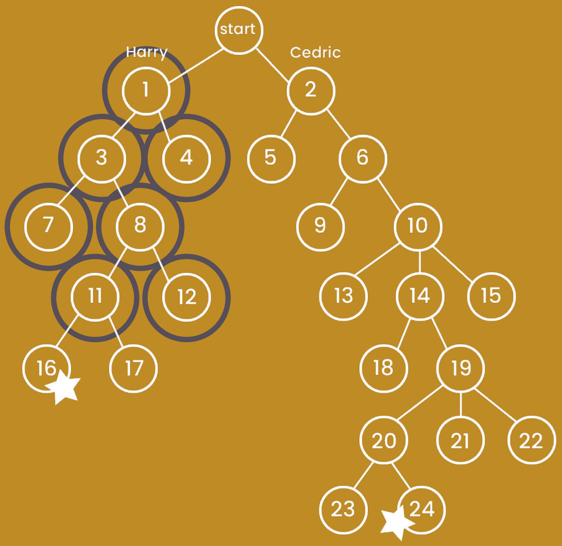
Breadth First Search



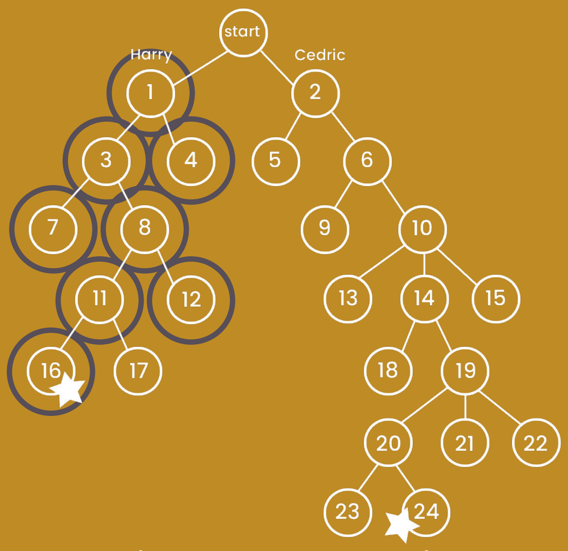
Breadth First Search



Breadth First Search



Breadth First Search



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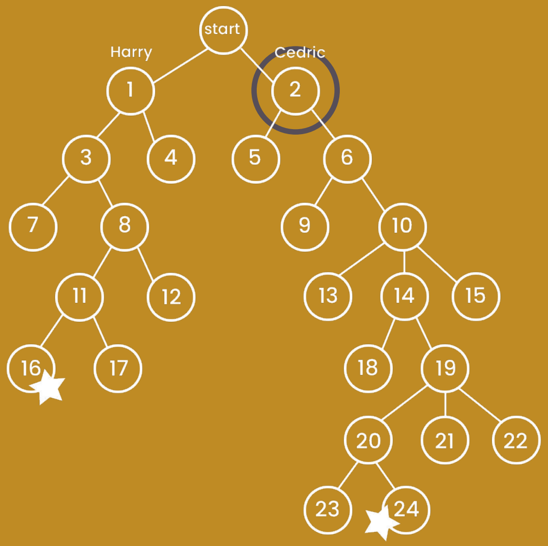
Depth First Search



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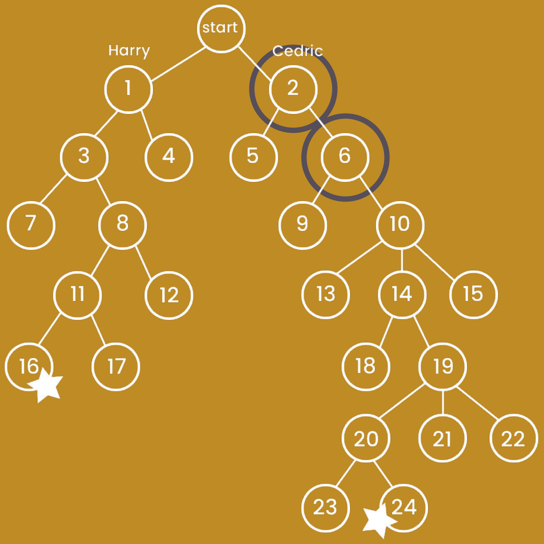
Depth first search is when you traverse the nodes as deep as possible from one side of the tree to the other. In a maze, DFS is the best way to get to the center quickly but you can see here that the villain in the book laid a trap for Harry in the center of the maze and purposefully set up the maze so that even Cedric's best route would be worse than Harry's worst route.

Depth First Search



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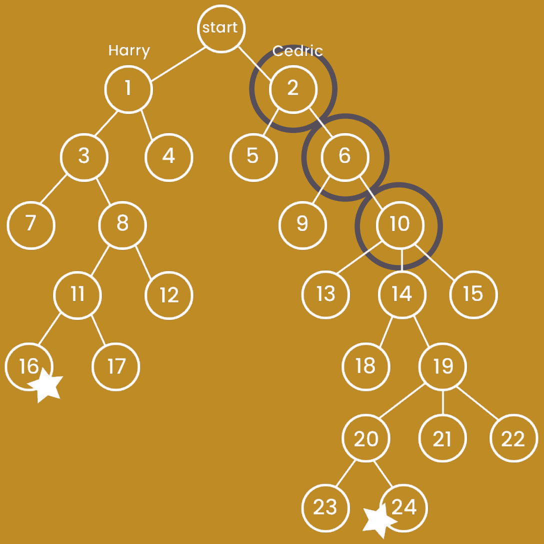
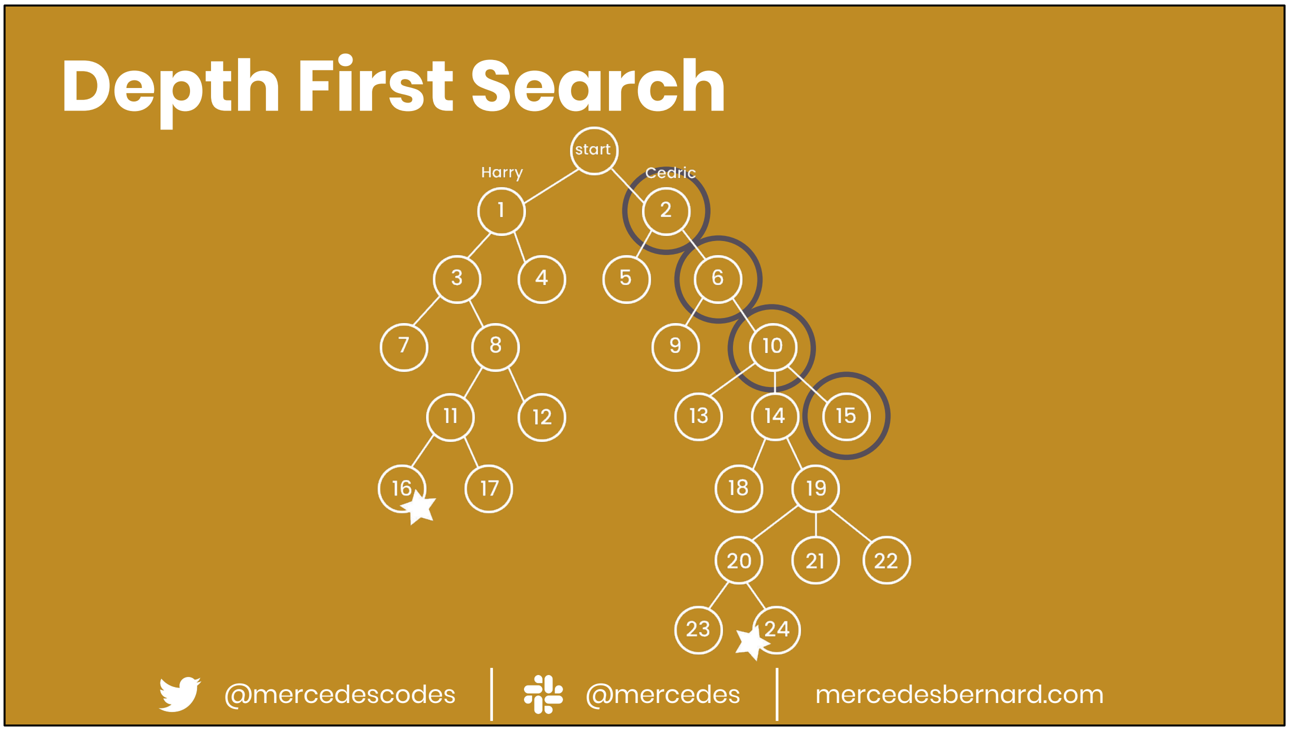
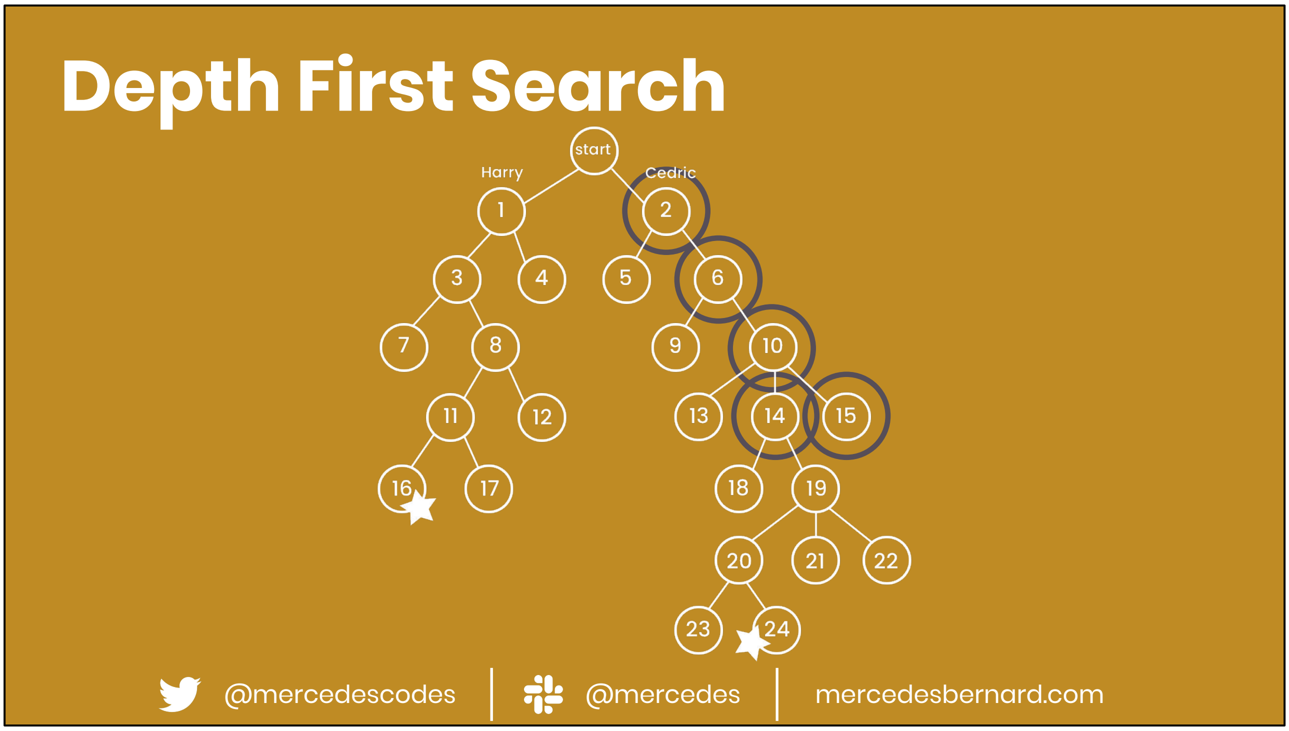
Depth First Search

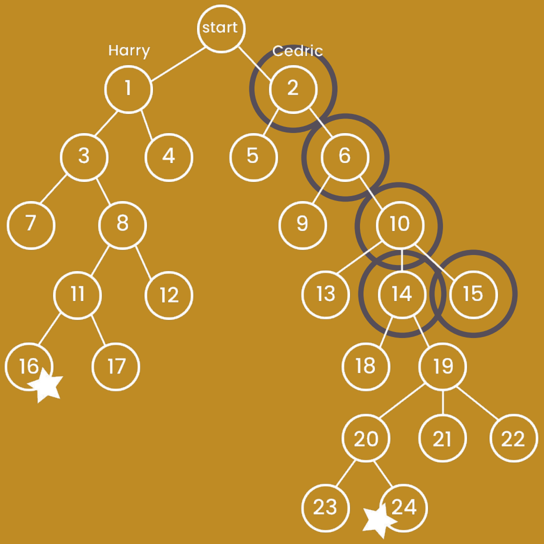


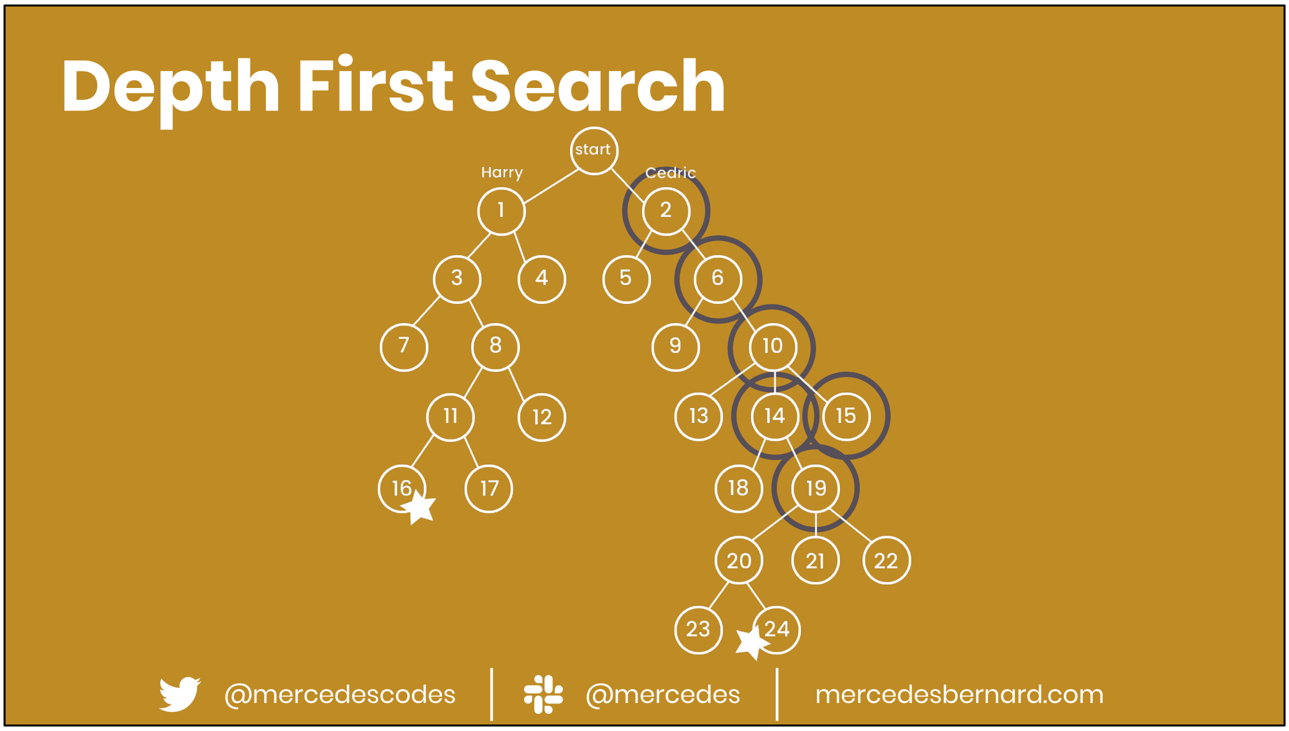


Depth First Search

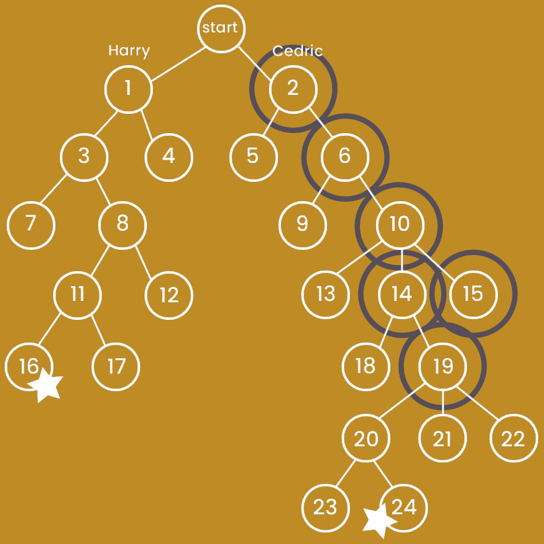


Depth First Search

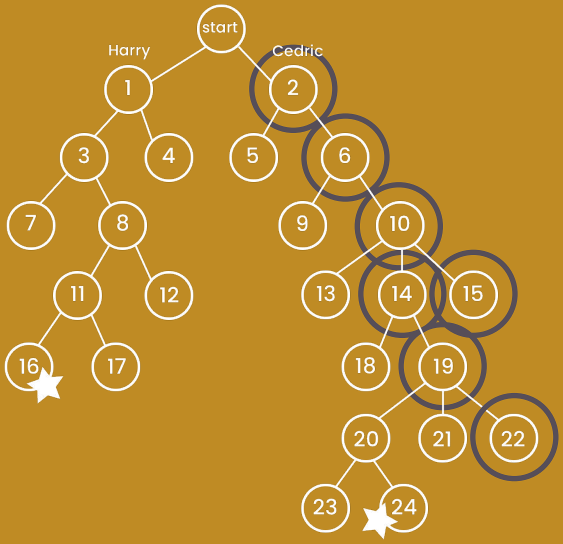


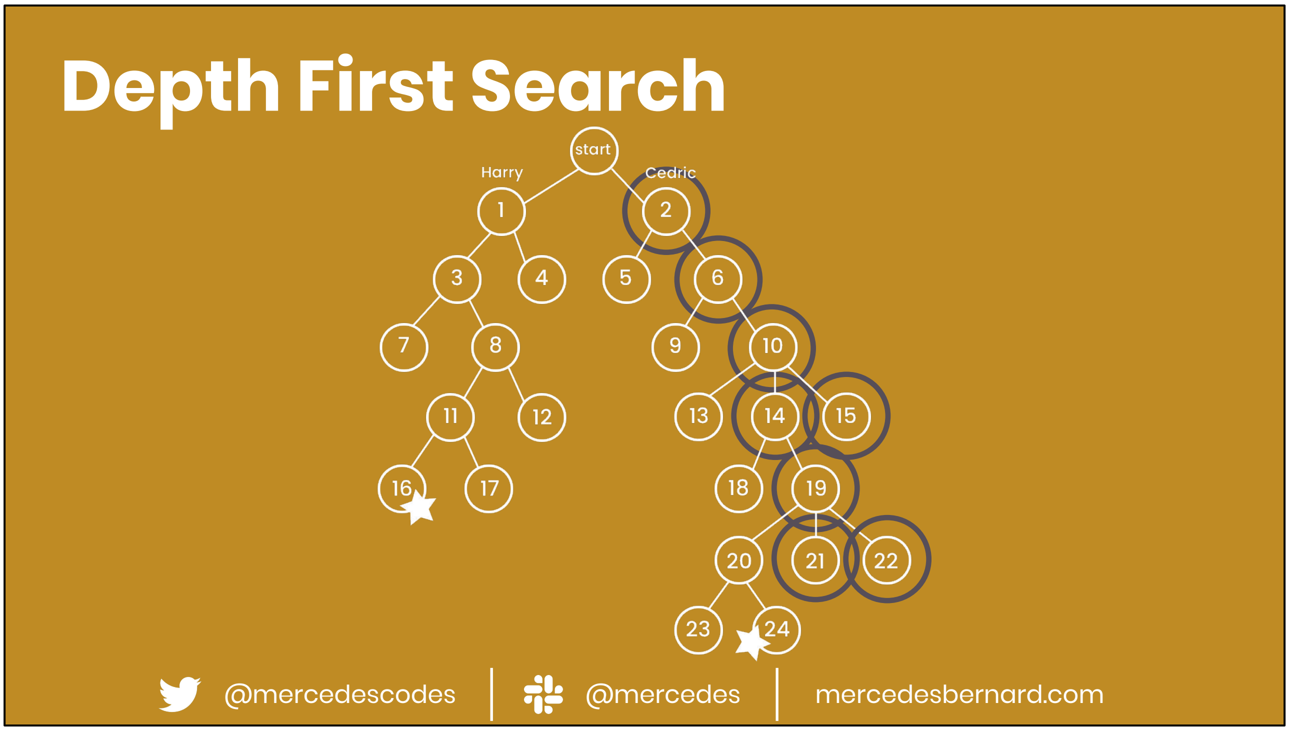


Depth First Search



Depth First Search





Depth First Search

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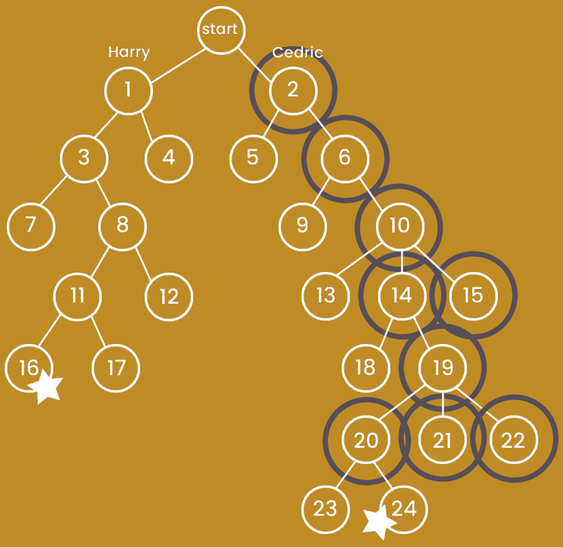
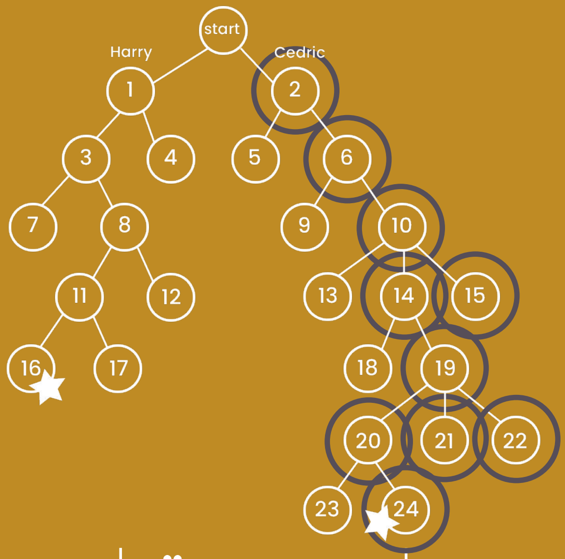
Depth First Search



Depth First Search



Tree Uses

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There are many many types of trees that are out of scope for this talk but the most common you'll hear about are binary trees (of which there are also many types). Binary trees are trees where the nodes have at most 2 children.

Binary trees on their own aren't super useful but there are many types of binary trees that have further constraints making them more useful. For example, a binary search tree.

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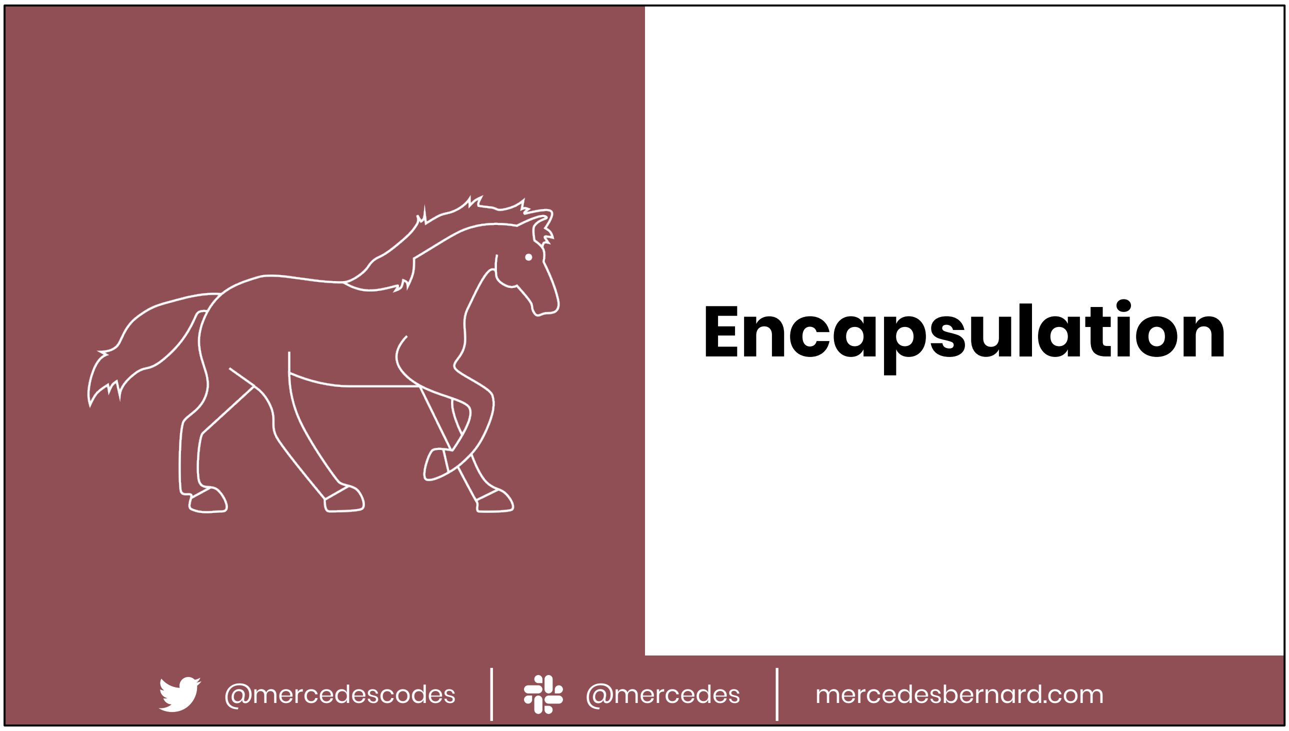
- ~~Tree~~

3. Principles of OO programming

- Encapsulation
- Abstraction
- Inheritance
- Polymorphism

Principles



Encapsulation

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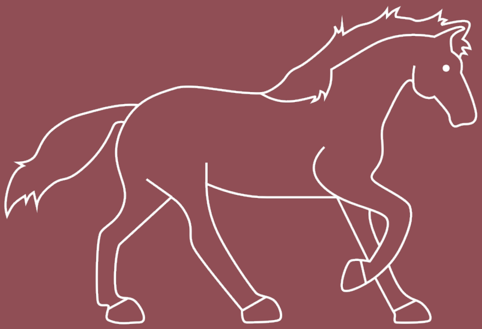
Let's pretend that we're going to code a video game where the user had to move the horse. A horse has 4 gaits, a walk, trot, gallup, or canter.

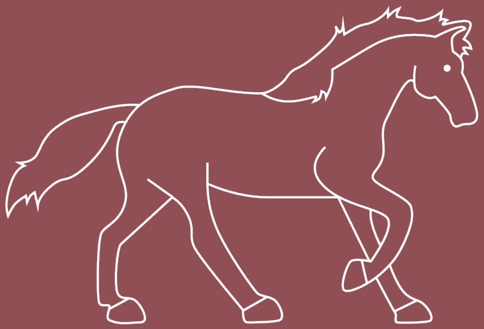
Walking: 4 beat pace, left hind leg, left front leg, right hind leg, right front leg
Trot: 2 beat pace, left hind leg + right front leg, right hind leg + left front leg
Canter: 3 beat pace, left hind leg, right hind leg + left front leg, right front leg
Gallop: 4 beat pace, left hind leg, right hind leg, left front leg, right front leg

So everytime the horse needs to move, we don't want the object telling the horse to move to tell it which leg to move and how quickly. This is incredibly error prone and could result in the horse ending up in a broken state. They could have too many legs in the air or they could be moving at the wrong pace. Instead, we'd define 4 methods, one for each gait, so the horse can handle moving its own legs at the appropriate pace. Those 4 methods that *encapsulate* the state of each leg while it's moving.

Encapsulation is when you hide an object's state from other objects. You create a public interface (a method) for other objects to interact with your object and mutate its state.



```
def canter(steps)
  time = 0
  distance_traveled = 0

  steps.times do
    @back_left_leg_position = LegPosition::UP
    @back_left_leg_position = LegPosition::DOWN

    @back_right_leg_position = LegPosition::UP
    @front_left_leg_position = LegPosition::UP
    @back_right_leg_position = LegPosition::DOWN
    @front_left_leg_position = LegPosition::DOWN

    @front_right_leg_position = LegPosition::UP
    @front_right_leg_position = LegPosition::DOWN

    time += 0.27; # 3.667 steps / second
    distance_traveled += 6; # 22 ft / second
  end

  { steps: steps, time: time, distance_traveled:
distance_traveled }
end
```



```
giddy_up = Encapsulation::Horse.new
number_of_steps = # read from input
giddy_up.canter(number_of_steps)
```

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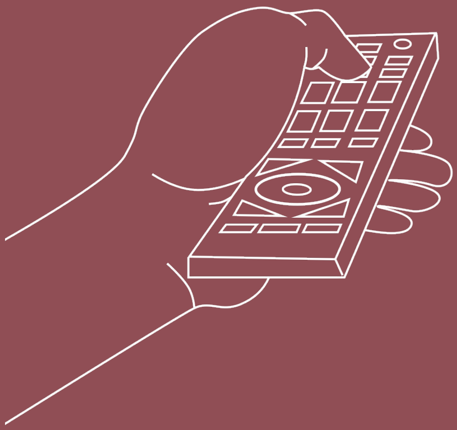
Abstraction



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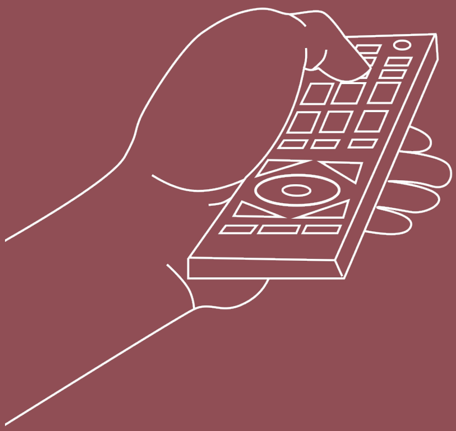
When you push a button on a remote control, something happens on your TV. The volume goes up, the channel changes, etc. There are few, finite things you can do with a remote. And you don't need to know how it works in order to make your change happen. For example, you don't need to know how infrared light works, how the binary is encoded or decoded, or how the microprocessor in your TV carries out the action.

This is an *abstraction*. You push a button and a thing happens. And you have only a few buttons to choose from.

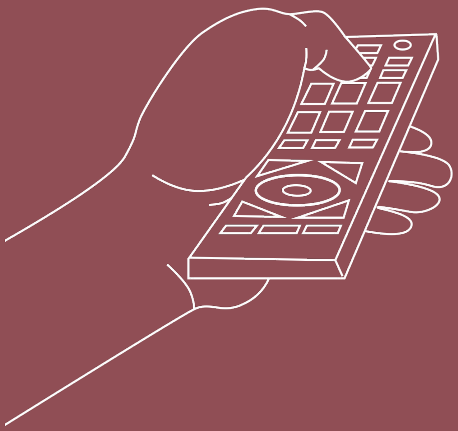
Abstraction is an extension of encapsulation. Abstraction refers to hiding all the internal implementation details of a class and providing very few, clear mechanisms for other objects in the code to interact with each other.

You can create different abstractions… think the knobs on a TV from a 50s that required you to get up to change the channel

```
tv = Abstraction::Television.create
remote =
Abstraction::RemoteControl.create(television: tv)
remote.power
remote.turn_up_volume
remote.turn_up_volume
remote.turn_down_volume
```



```
class Abstraction::RemoteControl < ApplicationRecord
  # abbreviated for slides

  def turn_up_volume
    handle_button_click(Button::VOLUME_UP)
  end

  private

  def handle_button_click(button)
    encoded_data = encode_button_press_into_binary(button)
    send_binary_data_as_infrared_light(encoded_data)
  end

  def send_binary_data_as_infrared_light(binary_data)
    infrared_light = convert_binary_to_infrared_light(binary_data)
    television.handle_remote_control_click(infrared_light)
  end

  def encode_button_press_into_binary(button)
    # ... button data is encoded into binary and returned
  end

  def convert_binary_to_infrared_light(binary_data)
    # ... binary data is converted and returned
  end
end
```



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Inheritance

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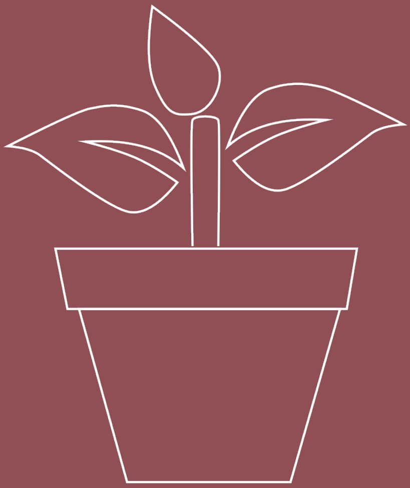
All garden plants need sun, soil, and water to survive. And if you want to learn how to garden, you'll be reading about the plant's care instructions that describe how to help your plant stay healthy and thrive.

If we were going to code up an app that displayed each plant's care instructions, we can use inheritance to share the code accesses each plant's needs and prints them out in a human understandable format.

Inheritance supports reusability in programming. A child class (or sub class) can inherit all of the fields/methods/properties from another class (called the base or super class) and then implement its own that differ or are in addition to what exists in the base class.

```ruby
class Inheritance::Plant
  attr_reader :name, :light_needs, :water_needs, :soil_needs,
:sun, :wet

  # abbreviated for slides

  def shade
    !sun
  end

  def dry
    !wet
  end

  def planting_instructions
    "Planting instructions: #{soil_needs}"
  end

  def care_instructions
    "Sunlight needs: #{light_needs}<br/>Watering instructions:
#{water_needs}"
  end

  def learn_how_to_garden

"#{name}<br/>#{planting_instructions}<br/>#{care_instructions}"
  end
end
```

```ruby
class Inheritance::Geranium < Inheritance::Plant
  def initialize
    @name = 'Geranium'
    @sun = true
    @wet = false
    @light_needs = '4 - 6 hours of direct sunlight
per day.'
    @soil_needs = 'Plant in a pot with soil-less
potting mixture and good drainage.'
    @water_needs = 'Water thoroughly and allow to
soil to completely dry between waterings.'
  end
end
```



```
plants = [Inheritance::Geranium.new,
Inheritance::Coleus.new, Inheritance::Begonia.new]
plants.map { |p| p.learn_how_to_garden }
```

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Polymorphism

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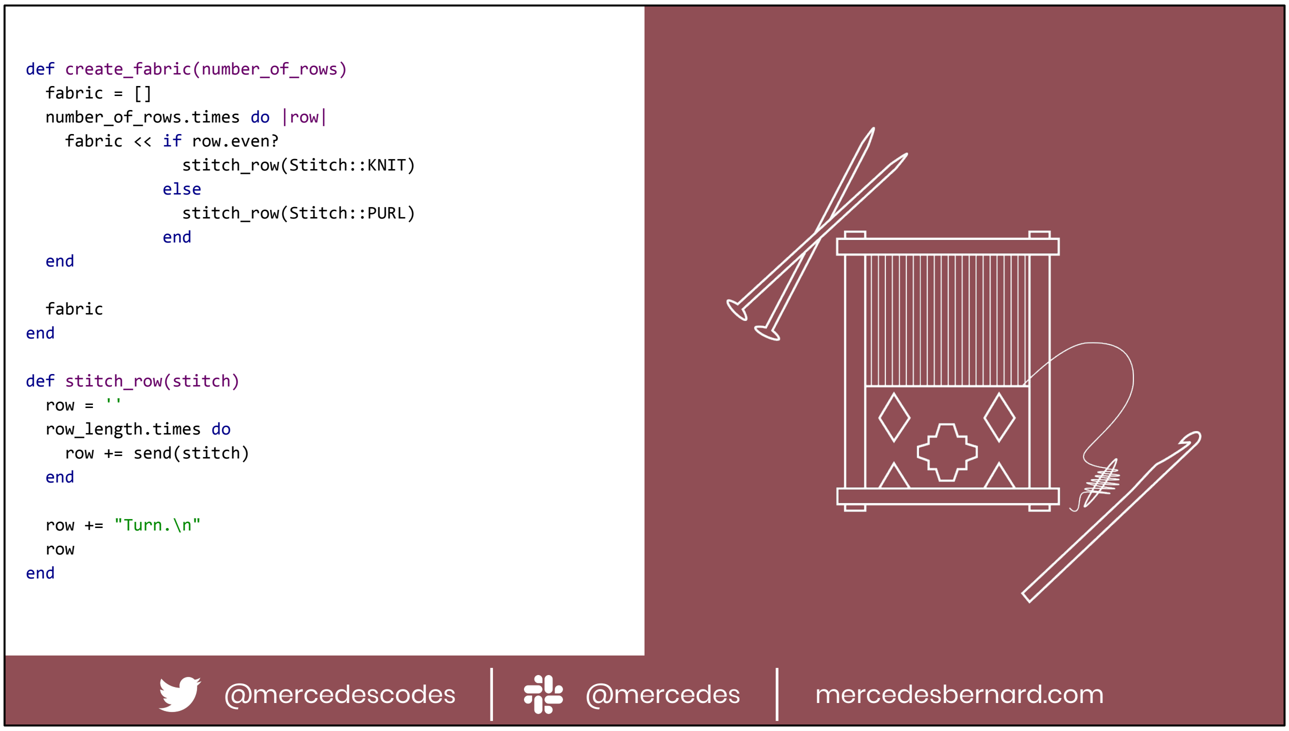
If you are an avid crafter, you may know multiple different crafts in which you could create a fabric. And depending on the type or style of fabric you want, you would use a different craft. But at the end of the day, you want to do the same thing: create fabric. If we were to model that programmatically, we would take advantage of polymorphism.

Polymorphism is an object oriented concept where you can use multiple classes in exactly the same way so that their concrete class doesn't matter. Inheritance is one way to achieve polymorphism. But other ways can include duck typing (defining the same method signature on multiple classes) or using interfaces (if you are using a statically typed language that supports them).



```
def create_fabric(number_of_rows)
  fabric = []
  number_of_rows.times do |row|
    fabric << if row.even?
                stitch_row(Stitch::KNIT)
              else
                stitch_row(Stitch::PURL)
              end
  end

  fabric
end

def stitch_row(stitch)
  row = ''
  row_length.times do
    row += send(stitch)
  end

  row += "Turn.\n"
  row
end
```

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In this code example, we use duck typing to achieve polymorphism where each yarn craft class defines a `createFabric` method, allowing us to use them all exactly the same way without caring about which concrete class we're using at that moment.

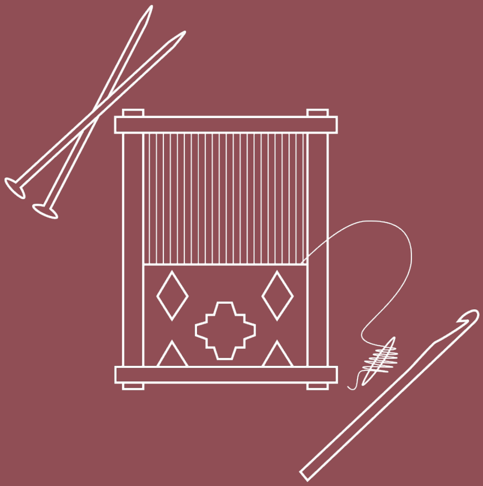
```ruby
def create_fabric(number_of_rows)
  fabric = []
  number_of_rows.times do |row|
    fabric << weave_row(row)
  end

  fabric
end

def weave_row(row_number)
  row = ''

  # start with Over when even, start with Under when odd
  row_length.times do |stitch_number|
    row += if (row_number.even? && stitch_number.even?) ||
(row_number.odd? && stitch_number.odd?)
              weave_weft_over_warp
            else
              weave_weft_under_warp
            end
  end

  row += "Turn.\n"
  row
end
```



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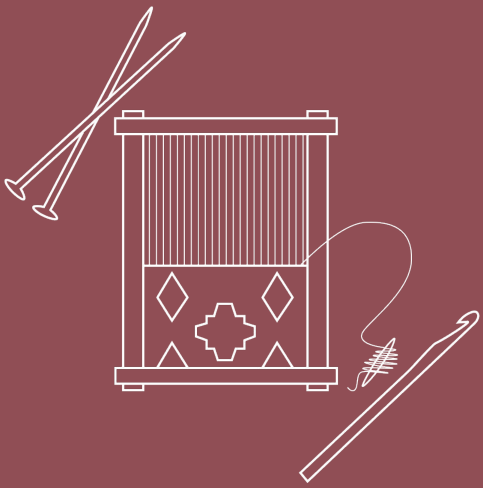
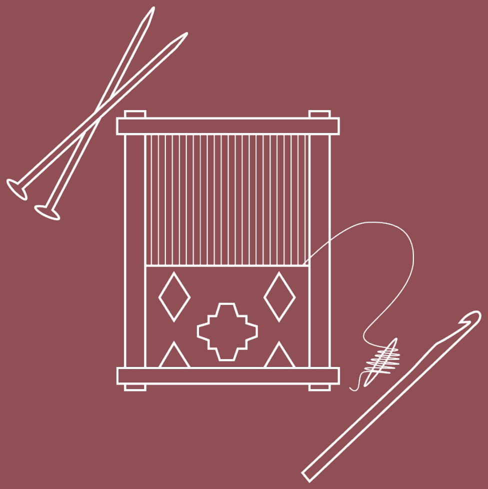
```ruby
def create_fabric(number_of_rows)
  fabric = []
  number_of_rows.times do
    fabric << stitch_row
  end

  fabric
end

def stitch_row
  row = ''
  row_length.times do
    row += single_crochet
  end

  row += "Turn.\n"
  row
end
```



```
craft = # read from input
row_length = # read from input
number_of_rows = # read from input

yarn_craft = if craft == 'knit'
              Polymorphism::Knitting
            elsif craft == 'crochet'
              Polymorphism::Crocheting
            elsif craft == 'weave'
              Polymorphism::Weaving
                end

chosen_craft = yarn_craft.new(row_length)
fabric = chosen_craft.create_fabric(number_of_rows)
```



Agenda

1. Concepts

- ~~Big O notation~~
- ~~Set theory~~
- ~~Recursion~~

2. Data structures

- ~~Linked list~~
- ~~Stack~~
- ~~Queue~~
- ~~Tree~~

3. Principles of OO programming

- ~~Encapsulation~~
- ~~Abstraction~~
- ~~Inheritance~~
- ~~Polymorphism~~

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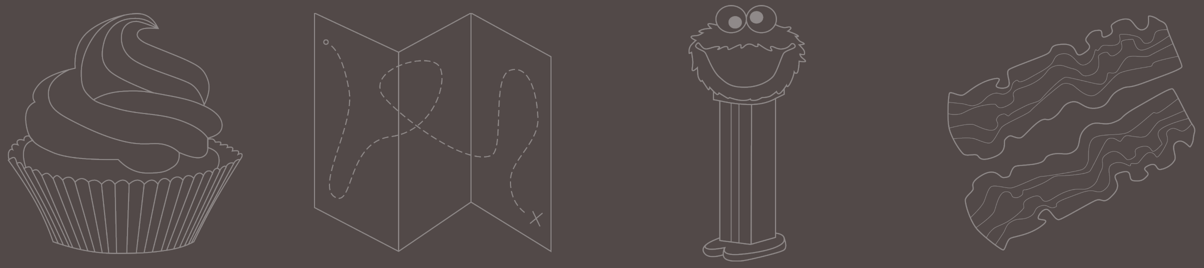

Thank you

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