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```
public class Interval {
   private int left, right;

   public Interval(int left, int right) {
      this.left = left; this.right = right;
   }

   public void translate(int shift) {
      this.left += shift; this.right += shift;
   }

   public String toString() {
      return "(" + left + "," + right + ")";
   }
}
```

What is the value of `a.toString()` at the end of this code snippet?

```
Interval a = new Interval(1, 5);
Interval b = a;
b.translate(3);
b = new Interval(2, 4);
```

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```
public class Interval {
   private int left, right;

   public Interval(int left, int right) {
      this.left = left; this.right = right;
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   public String toString() {
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}
```
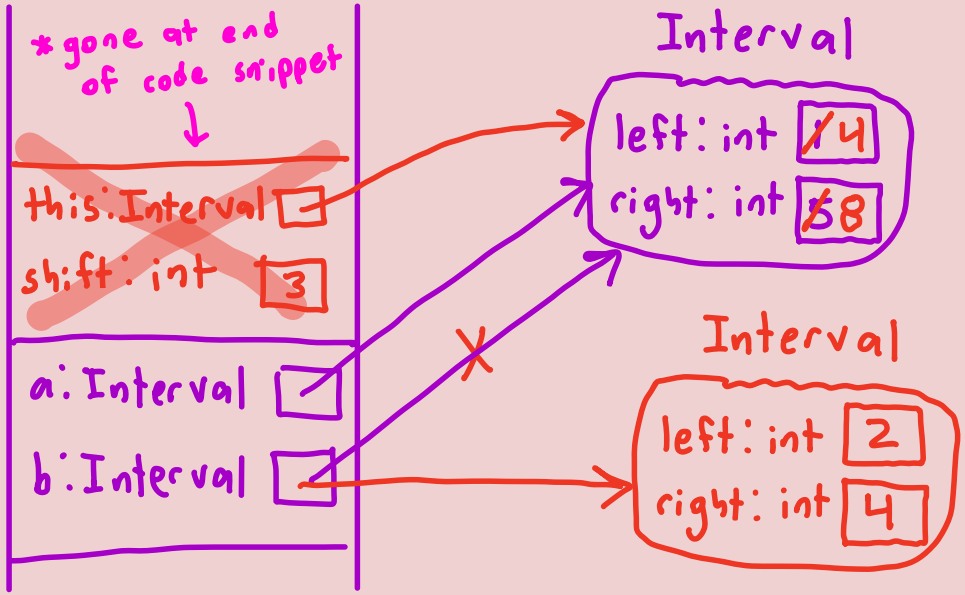

```
Interval a = new Interval(1, 5);
Interval b = a;
b.translate(3);
b = new Interval(2, 4);
```

visible through a

"(4,8)"



Lecture 9: Interfaces and Polymorphism

CS 2110

February 19, 2026

Today's Learning Outcomes

39. Implement an interface using a given state representation according to its specifications.

40. Compare and contrast *static types* and *dynamic types*.

41. Identify three scenarios where subtype substitution is permitted.

42. Explain the benefits of leveraging *polymorphism* in object-oriented code.

43. Describe the principle of dynamic dispatch and the compile-time reference rule.

Real-World Interfaces

2014 Toyota Prius C
Matt's Car

2023 Volkswagen ID.4
Matt's Rental Car

These cars are built and run very differently.

Should Matt have been worried?

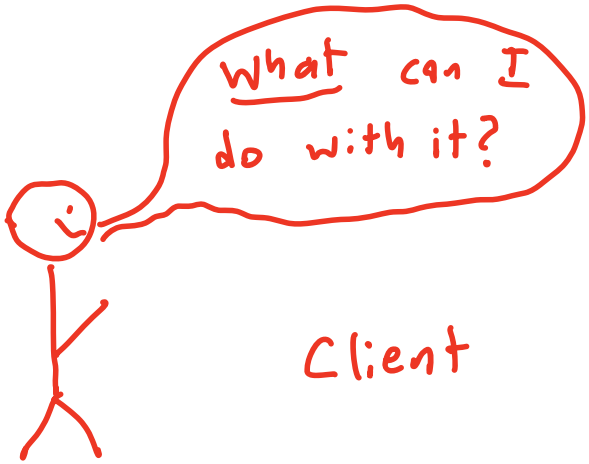
No. The way the driver interacts with the cars is nearly the same; they offer drivers the same interface (set of exposed features)

Other real-world interfaces:

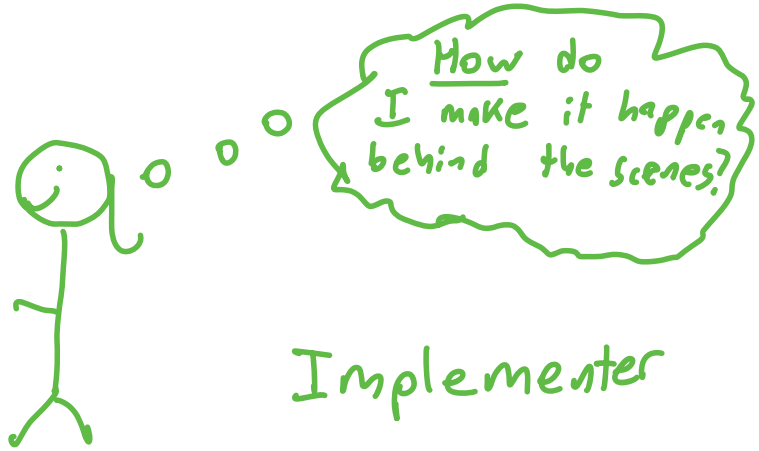
- Power grid: just plug into outlet of right shape
- Data cables, file formats, etc.

Abstraction Barriers

Interfaces present an abstraction barrier between implementer and client of a system



Interface



API (application programming interface) view

- method signatures and specifications

source-code view of class

- state representation
- invariants
- method bodies

Interfaces in Java

- New Java construct that is an alternative to a class.

- Assigns a new type name to a collection of guaranteed behaviors without committing to how these behaviors are implemented
  - contains only (public) method signatures and specs
  - no fields
  - no method bodies

  } "behind the scenes" details

Type that models a contract between clients + implementers

Coding Demo: Account interface

Implementing an Interface

Interfaces don't have state (no fields), so can't be constructed.

Classes provide blueprints for objects that can be constructed.

We link a class to an interface using the "implements" keyword:

```
public class CheckingAccount implements Account {
    ...
}
```

To fulfill its end of the Account contract, CheckingAccount must provide method bodies for all Account methods that meet their spec. (but can also define other methods, too)

Coding Demo: `CheckingAccount` class

Specifications and @Override

The @Override annotation signifies that a class's method definition is based on declaration from "higher up" (e.g., in an interface it implements)

- must match signature exactly *
- must conform to the specifications

} contract

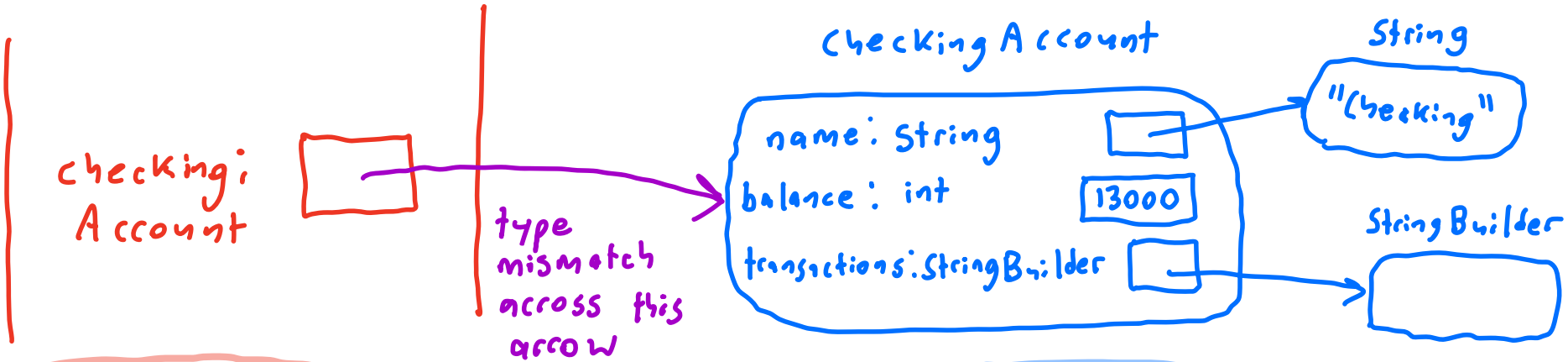
If the higher specs match exactly, no need for new JavaDoc. @Override "pulls down" spec.

If the class definition refines spec (adds new post-conditions) then new complete documentation is needed.

Coding Demo: Client Code with Interfaces

Dynamic vs. Static Types

```
Account checking = new CheckingAccount("Checking", 13000);
```



static type (Account)

- describes variable
- tells compiler how it should "view" object ref'd by checking

dynamic type (CheckingAccount)

- describes object
- which blueprint was used at runtime to build this object

The Compile Time Reference Rule

A variable's static type dictates the compiler's view of the object it references.

- Compiler can't "see" dynamic types

The compiler is responsible for enforcing type safety of our programs.

⟹ CTRR We can only call instance methods that exist for the static type of the target.

MOST IMPORTANT RULE OF THE COURSE!!!!!

Subtype Relationships

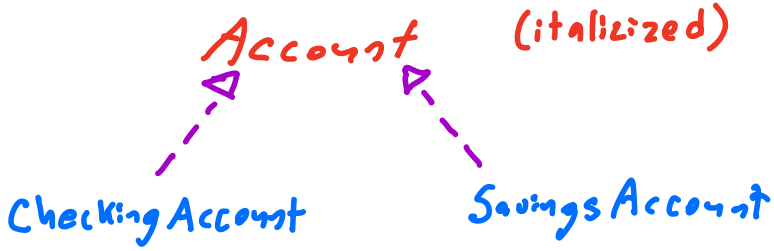
We say CheckingAccount is a subtype of Account since it's a more specific descriptor.

All CheckingAccounts are Accounts

Not all Accounts are CheckingAccounts

Notation: CheckingAccount <: Account

Type Hierarchy



Implementing an interface establishes a subtype relationship.

In "type mismatched" variable assignments

dynamic type <: static type

Subtype Substitution

Often, we can use a subtype in place of its supertype.

(Hint: real-world example)

Cat <: Animal

1. Assignment — If S <: T, we can assign an S object reference to a variable with static type T

"An Animal variable can store a Cat"

---

2. Parameters — If S <: T, we can pass an S object reference as an argument to serve as a T parameter

"If a method expected to get an Animal, it's happy to get a Cat"

---

3. Return value — If S <: T and f() has return type T, it can return an S object reference.

"If a method promises to return an Animal, it's allowed to return a Cat"

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Suppose that B <: A. Which line of code will compile if it is inserted "// HERE"?

Tip: plug in "real-world types" A = Animal B = Bear

```
static A foo(B b) { ... }

static B bar(A a) { ... }

public static void main(...) {
  A a = new A();
  B b = new B();
  // HERE
}
```

no: foo needs a B

A x = foo(a); ✗ **(A)**

no: foo might return a different A

B x = foo(b); ✗ **(B)**

supertype is fine subtype is fine

A x = bar(b); ✓ **(C)**

None of Them **(D)**

Polymorphism

When we write code, we'd like it to handle as many use cases as possible.

- Avoids code duplication
- Improves readibility, maintainability

Poly (many) morphic (shape) code is able to naturally handle multiple types of data with the same code lines.

Interfaces enable subtype polymorphism.

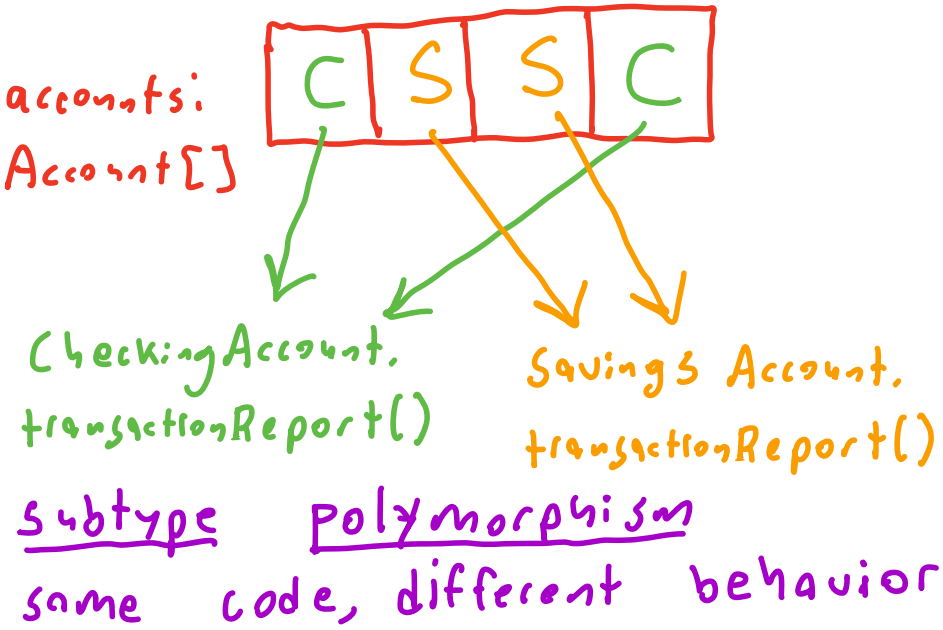
(Other varieties coming soon...)

Coding Demo: Many Accounts

Dynamic Dispatch

The dynamic type of an object determines which "version" of a method gets invoked on it.

(more to say about this next lecture...)




```
Account[] accounts;

// initialize and interact with accounts

for (int i = 0; i < accounts.length; i++) {
    accounts[i].transactionReport();
}
```

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Given these type declarations (top), what happens when we try to run the following client code (bottom)?

```
interface Phone {
   void  makeCall();
   void  sendText(); }

class Pixel implements Phone {
  void  makeCall() { … }
  void  sendText() { … }
  void  takePicture() { … } }
```

```
Phone myPixel = new Pixel();
myPixel.takePicture();
```

Compile Time Reference Rule!

- Compiler Error (Line 1) **(A)**
- Compiler Error (Line 2) **(B)**
- Runtime Error **(C)**
- Runs OK (Dynamic Dispatch) **(D)**

Dynamic vs Static Types: Big Ideas

The static type of a variable determines which behaviors can be called on that variable.

(Compile Time Reference Rule)

The dynamic type of an object determines how that behavior is actually carried out.

(Dynamic Dispatch)