Object interaction

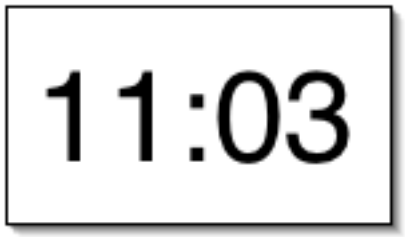
Creating cooperating objects

A digital clock

Abstraction and modularization

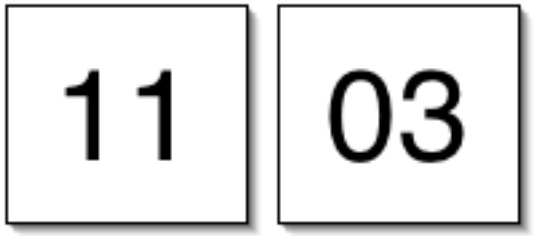
- **Abstraction** is the ability to ignore details of parts to focus attention on a higher level of a problem.
- **Modularization** is the process of dividing a whole into well-defined parts, which can be built and examined separately, and which interact in well-defined ways.

Modularizing the clock display



One four-digit display?

Or two two-digit displays?



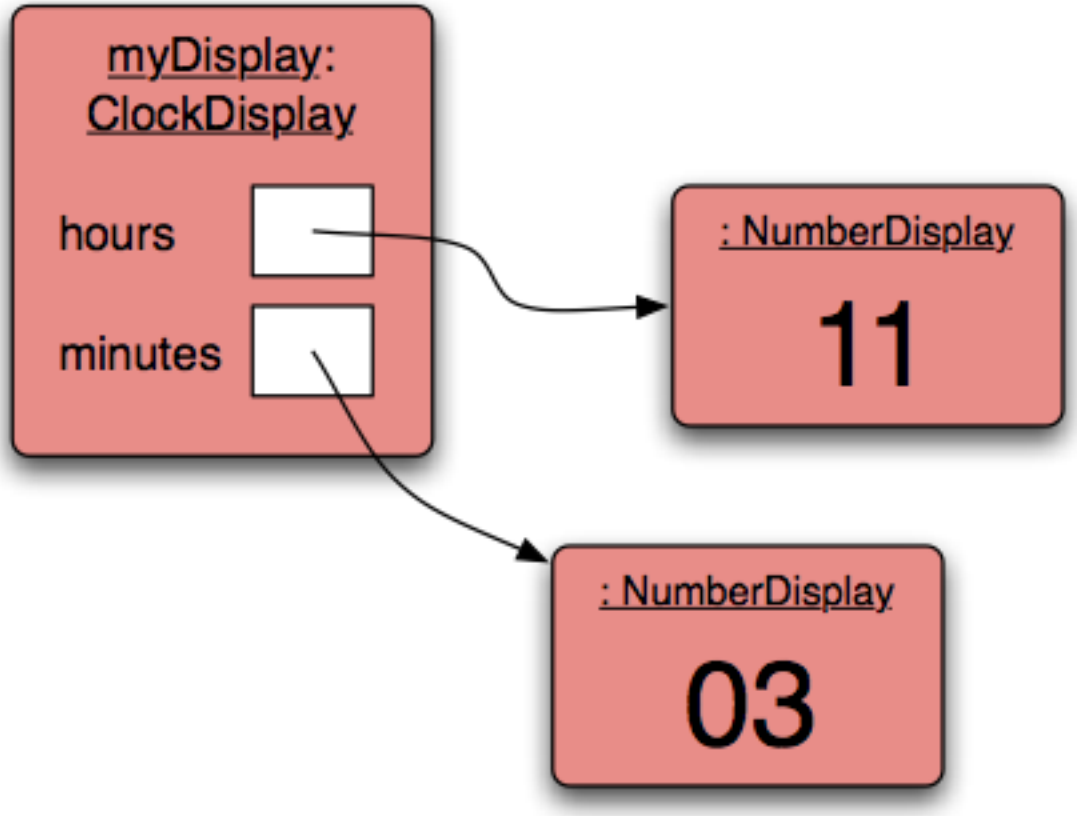
Implementation - NumberDisplay

```
public class NumberDisplay
{
    private int limit;
    private int value;

    Constructor and
    methods omitted.
}
```

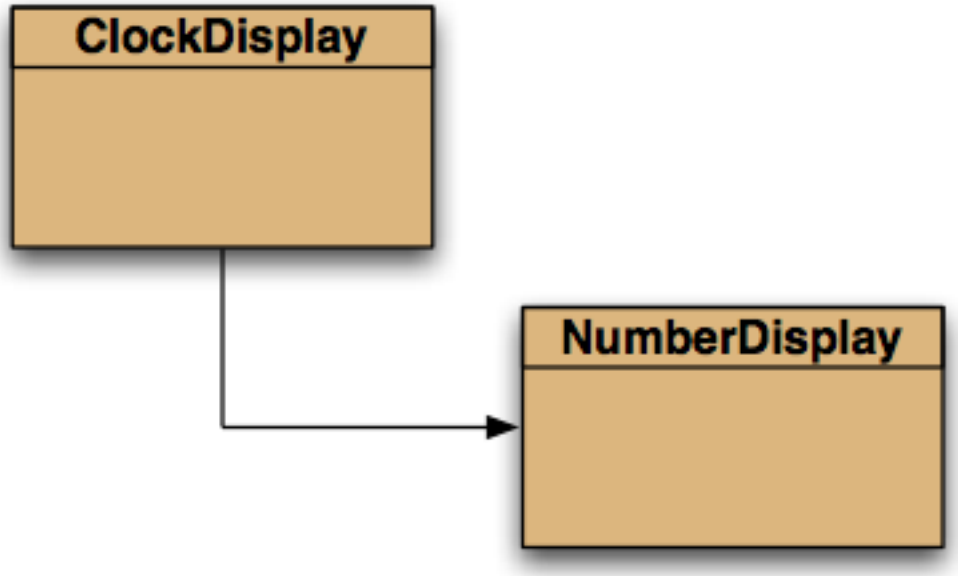
Implementation - ClockDisplay

```
public class ClockDisplay
{
    private NumberDisplay hours;
    private NumberDisplay minutes;

    Constructor and
    methods omitted.
}
```

Object diagram



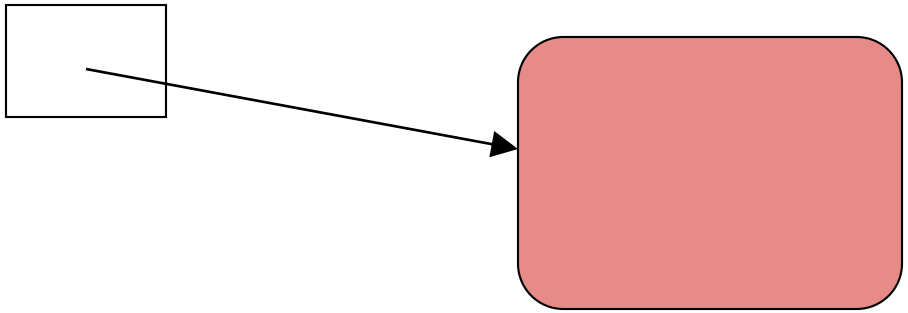
Class diagram



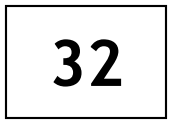
Primitive types vs. object types

```
SomeObject obj;
```

object type



```
int i;
```



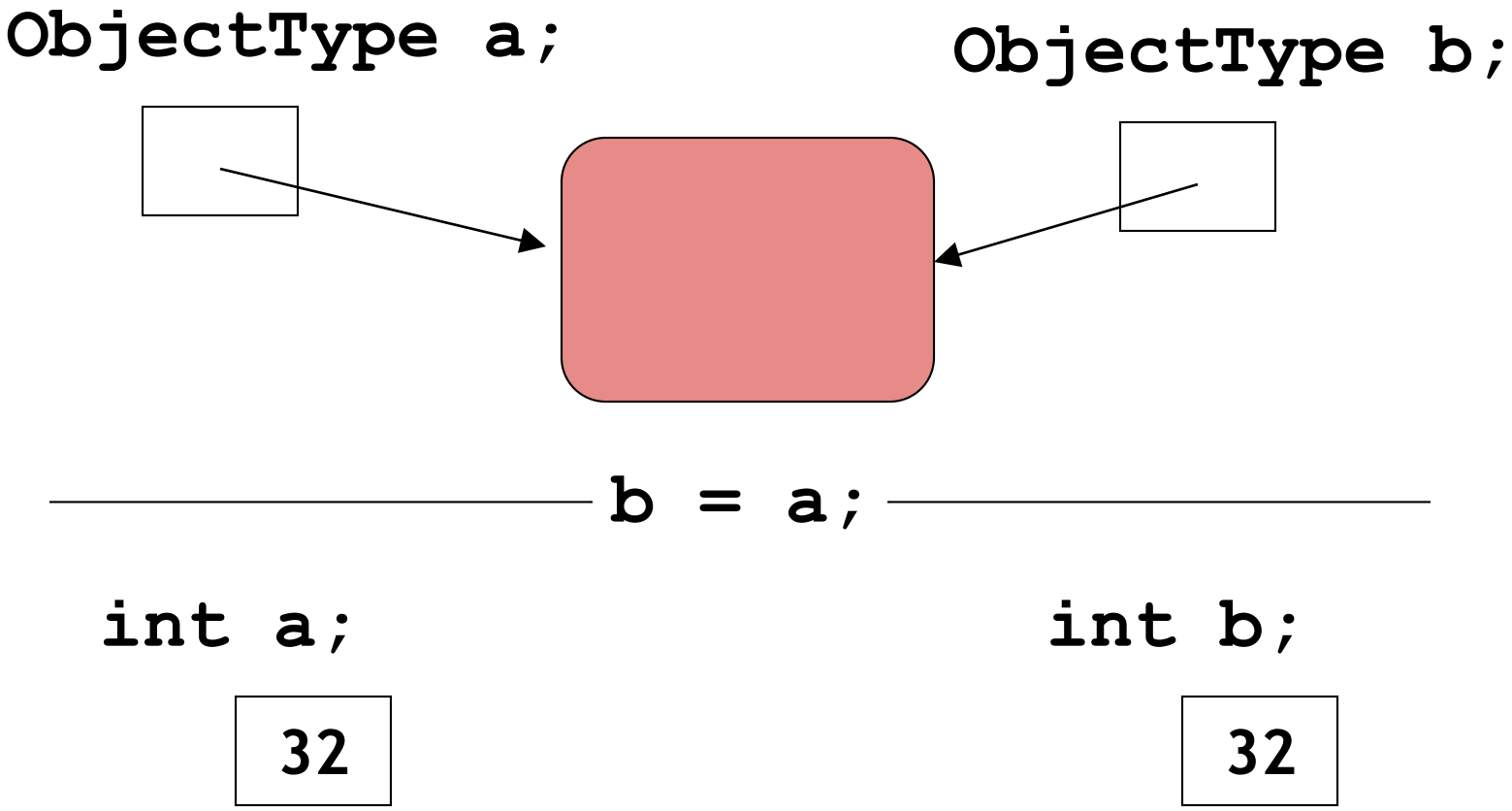
primitive type

Quiz: What is the output?

- ```
  int a;
  int b;
  a = 32;
  b = a;
  a = a + 1;
  System.out.println(b);
  ```

- ```
  Person a;
  Person b;
  a = new Person("Everett");
  b = a;
  a.changeName("Delmar");
  System.out.println(b.getName());
  ```

Primitive types vs. object types



Source code: NumberDisplay

```
public NumberDisplay(int rollOverLimit)
{
    limit = rollOverLimit;
    value = 0;
}

public void increment()
{
    value = (value + 1) % limit;
}
```

The modulo operator

- The 'division' operator (/), when applied to int operands, returns the *result* of an *integer division*.
- The 'modulo' operator (%) returns the *remainder* of an integer division.
- E.g., generally:

  17 / 5 gives result 3, remainder 2
- In Java:

```
17 / 5 == 3
17 % 5 == 2
```

Quiz

- What is the result of the expression

```
8 % 3
```

- For integer `n >= 0`, what are all possible results of:

```
n % 5
```

- Can `n` be negative?

Source code: NumberDisplay

```
public String getDisplayValue()
{
    if(value < 10) {
        return "0" + value;
    }
    else {
        return "" + value;
    }
}
```

Concepts

- abstraction
- modularization
- classes define types
- class diagram

- object diagram
- object references
- object types
- primitive types

Objects creating objects

```
public class ClockDisplay
{
    private NumberDisplay hours;
    private NumberDisplay minutes;
    private String displayString;

    public ClockDisplay()
    {
        hours = new NumberDisplay(24);
        minutes = new NumberDisplay(60);
        …
    }
}
```

Objects creating objects

in class ClockDisplay:

```
hours = new NumberDisplay(24);
```

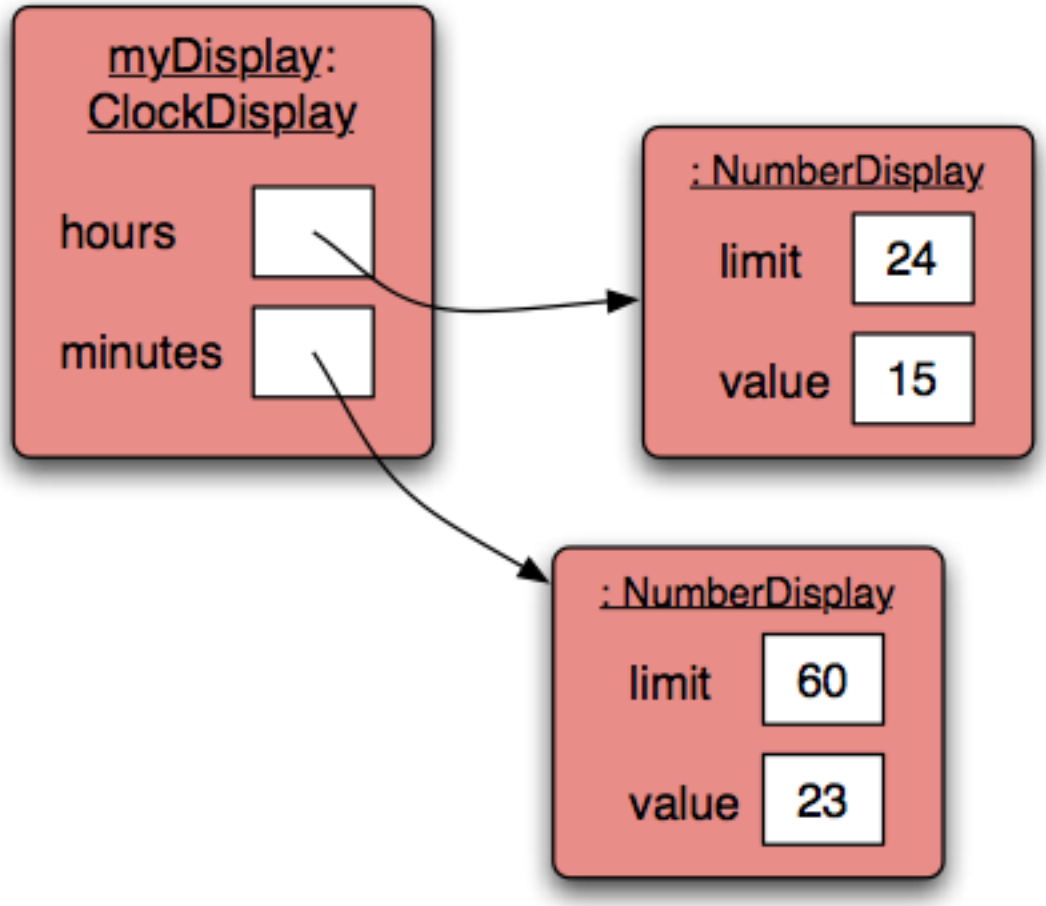
actual parameter

in class NumberDisplay:

```
public NumberDisplay(int rollOverLimit);
```

formal parameter

ClockDisplay object diagram



Method calling

```
public void timeTick()
{
    minutes.increment();
    if(minutes.getValue() == 0) {
        // it just rolled over!
        hours.increment();
    }
    updateDisplay();
}
```

External method call

- external method calls

```
minutes.increment();
```

object . *methodName* (*parameter-list*)

Internal method call

- internal method calls

```
updateDisplay();
```

- No variable name is required.
- **`this`**
  - could be used as a reference to the invoking object, but not used for method calls.

Internal method

```
/**
 * Update the internal string that
 * represents the display.
 */
private void updateDisplay()
{
    displayString =
        hours.getDisplayValue() + ":" +
        minutes.getDisplayValue();
}
```

Method calls

- NB: A method call on another object of the same type would be an external call.
- ‘Internal’ means ‘this object’.
- ‘External’ means ‘any other object’, regardless of its type.

null

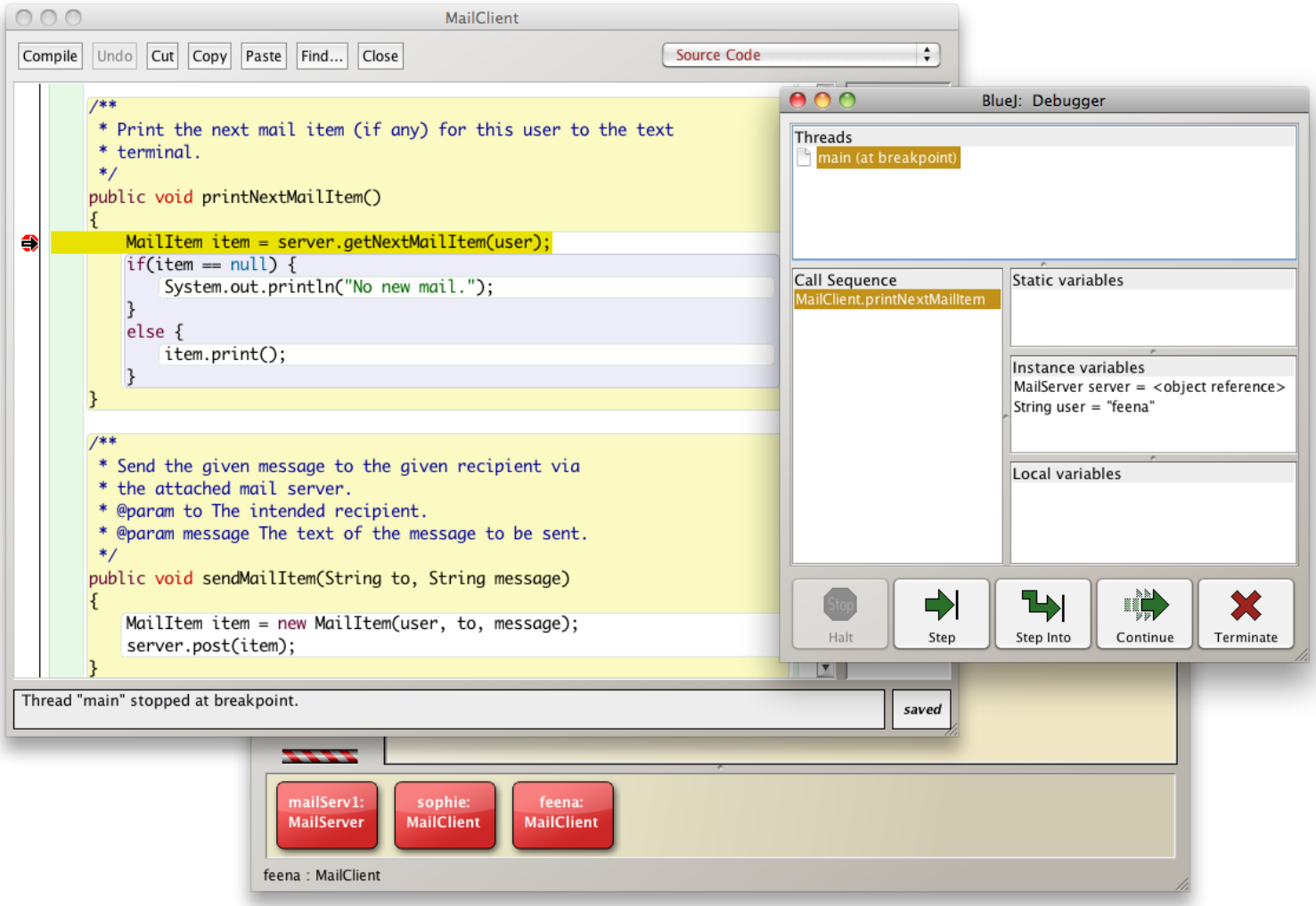
- **`null`** is a special value in Java
- Object fields are initialized to **`null`** by default.
- You can test for and assign **`null`**:

```
private NumberDisplay hours;

if(hours != null) { ... }

hours = null;
```

The debugger

- Useful for gaining insights into program behavior …
- … whether or not there is a program error.
- Set breakpoints.
- Examine variables.
- Step through code.

The debugger



Concept summary

- object creation
- overloading
- internal/external method calls
- debugger