Data Modeling with JML

Curt Clifton
Rose-Hulman Institute of Technology

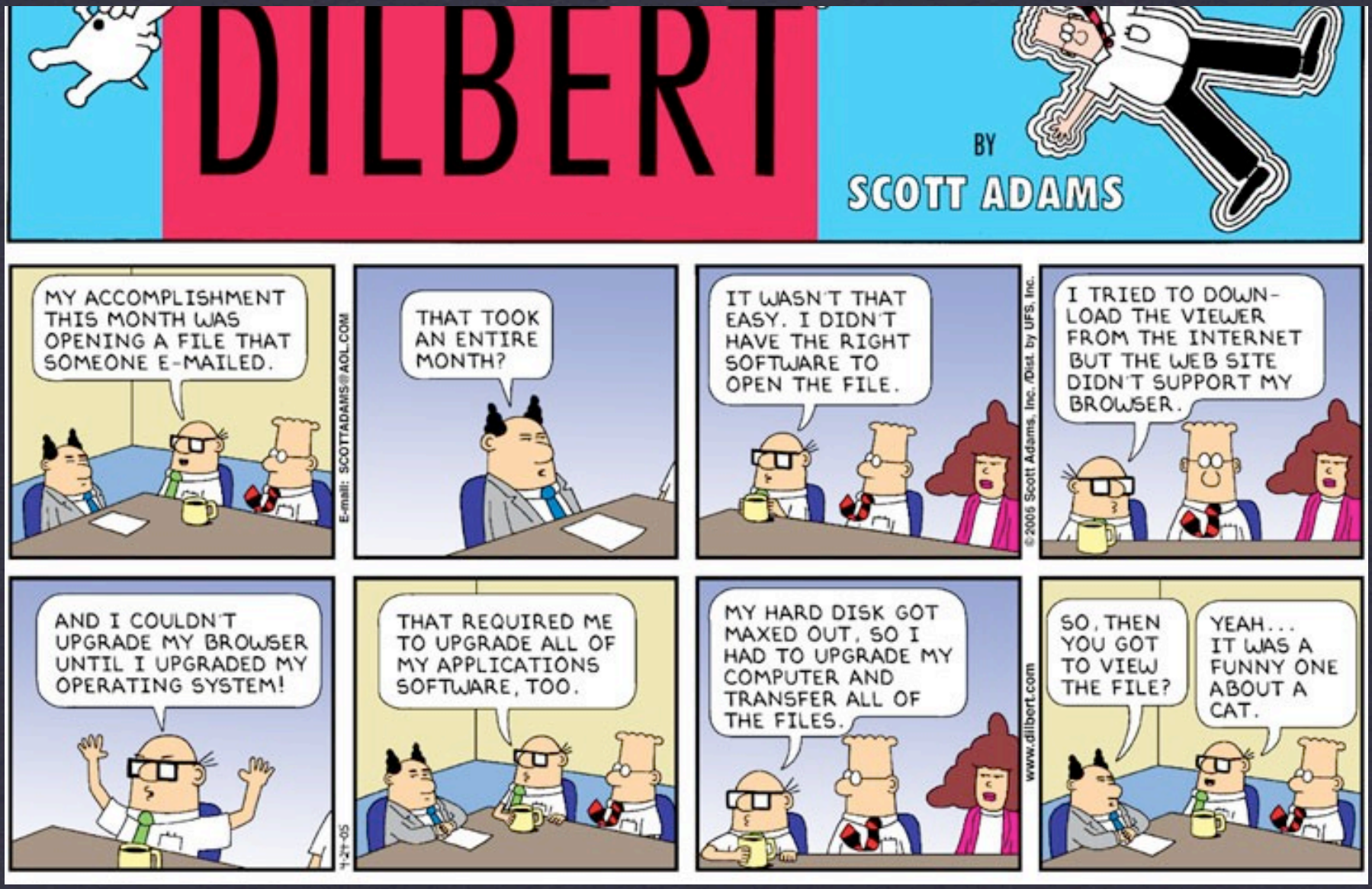
DBC for Methods

- Pre-conditions – **requires**
- Post-conditions – **ensures**
- Frame axioms – **assignable**

DBC for Objects

- Besides specifying what methods do, we also have to constrain what the objects can do
- We use ***class invariants*** for this
- Example: `//@ invariant size <= capacity;`

An Example, but first…



CARTOON OF THE DAY

HOW DID THE MOBIUS INSTALLATION GO?

Example

- BoundedStack
  - A stack with a fixed maximum size
- Live-coding in Mobius PVE…

Starting Projects in Mobius PVE

- Create a new workspace
- Create a new Java project
- Set the project's "nature" to ESC/Java
  - Select project
  - Choose *JML → Setup → Enable ESC/Java nature*

The Outline

```
public class BoundedStack {
    public BoundedStack(int maxSize) {…}
    public void push(Object x) {…}
    public void pop() {…}
    public Object top() {…}
}
```

1. Specify the Data

LETS US TALK ABOUT size IN OUR SPECIFICATION

```
public class BoundedStack {
    private /*@ spec_public @*/ int size;
    private /*@ spec_public @*/
                        Object[] elems;
    ...
```

2. Specify the Invariant

```
public class BoundedStack {
    private /*@ spec_public @*/ int size;
    private /*@ spec_public @*/ Object[] elems;
    //@ public invariant 0 <= size
    //@ public invariant size <= elems.length;
    //@ public invariant elems != null;
    //@ public invariant \typeof(elems) == \type(Object[]);
    /*@ public invariant (\forall int i;
      @                   size <= i && i < elems.length;
      @                   elems[i] == null);
      @*/
    //@ public invariant this.elems.owner == this;
```

TELLS ESC/JAVA2 THAT ELEMS SHOULDN'T BE ALIASED

DISALLOWS JAVA WEIRDNESS LIKE elems = new String[]

3. Specify Public Constructors/Methods

```
/*@ requires n > 0;
  @ assignable elems, size;
  @ ensures elems.length == n && size == 0;
  @*/
public BoundedStack(int n) {
    elems = new Object[n];
    size = 0;
    //@ set this.elems.owner = this;
}
```

TELLS ESC/JAVA2 THAT ELEMS ISN'T ALIASED

Don’t Get Pushy

```
/*@ requires size < elems.length;
  @ assignable elems[size], size;
  @ ensures size == \old(size) + 1;
  @ ensures elems[size-1] == x;
  @*/
public void push(Object x) {
    elems[size] = x;
    size = size + 1;
}
```

All Around the Shoemaker's Bench…

```
/*@ requires size > 0;
  @ assignable size, elems[size-1];
  @ ensures size == \old(size-1);
  @*/
public void pop() {
    size = size - 1;
    elems[size] = null;
}
```

REMEMBER THE INVARIANT INCLUDED:

```
(\forall int i; size <= i && i < elems.length; elems[i] == null)
```

I'm on the Top of the World…

```
/*@ requires size > 0;
  @ assignable \nothing;
  @ ensures \result == elems[size-1];
  @*/
public Object top() {
    return elems[size-1];
}
```

Steps for Specifying a Class

- 1. Specify the data…
  - Using **spec_public** fields for now
  - Later we'll see how to be more abstract
- 2. Specify **invariant**s
- 3. Specify each public method/constructor using:
  - **requires**, **assignable**, and **ensures**