6.005 elements of software construction

decoupling & interfaces

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intro

topics for today

last time

- hierarchical naming, scope of vars, importance of minimizing scope
- access modifiers, quoter example (slides you read after class)

role of names in software design

- how does a module name functionality in another module?

locality

- localizing changes within modules
- a form of “separation of concerns"

interfaces in Java

- have seen idea already
- today, see role in design of plugins

locality

software design

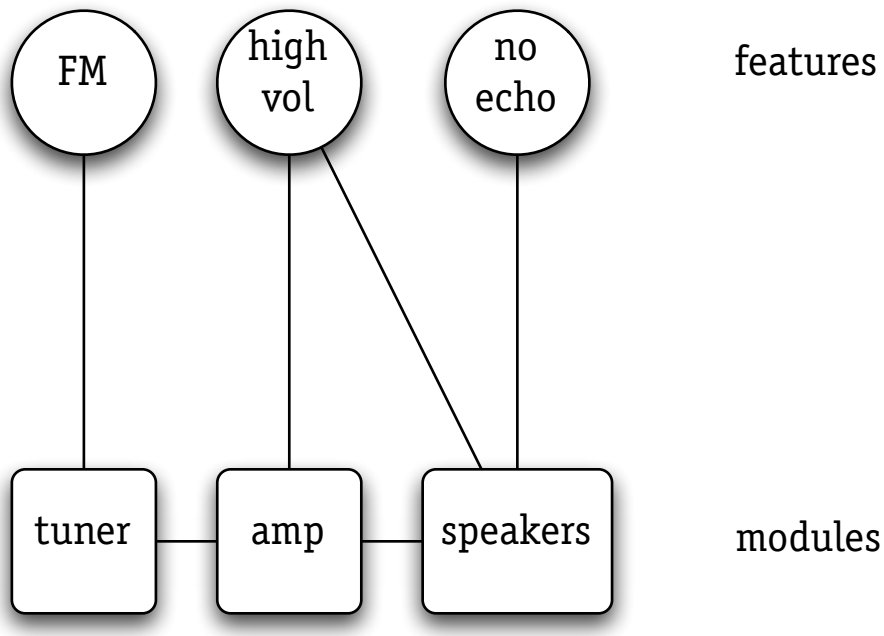
biggest challenge in software design

- locality: understand modules independently
- maintaining locality as software grows

how to design for locality

- assign each specification feature to at most one module
  so change to a feature only affects one module
- avoid dependences (coupling) between modules
  so change doesn't propagate

feature-module assignment



example: change in high-vol feature will impact amp and speakers
note couplings between modules too

see: Nam Suh, Axiomatic Design: Advances and Applications, Oxford University Press, 2001;
David Parnas, On the Criteria to Be Used in Decomposing Systems Into Modules, CACM, 1972.

avoiding coupling

a balancing act

- modules connected by rich channels --> flexible, easy access
- modules connected by thin channels --> changes are contained

solution

- as thin as possible, but no thinner
- module-level software design = design of specs

interfaces in Java

what interfaces give you

what interfaces give you

- anonymous use -- the “better” scenario from above
- implementation determined at runtime, by runtime type of object passed
- so **constructor** call determines choice of implementation

applications

- can design program with “plugins” to parameterize functionality

  class can assume partial properties of objects
  example: java.util.TreeSet takes elements that implement Comparable

marker interfaces

- declare no methods
- used to expose spec properties (eg. java.util.RandomAccess)
- or as hack to add functionality (eg. java.io.Serializable)

declaring an interface

declare List interface

```
package java.util;
public interface List {
    boolean add (Object e);
    void clear ();
    ...
}
```

declare ArrayList class

```
package java.util;
public class ArrayList implements List {
    boolean add (Object e) {...}
    void clear () {...}
    ...
}
```

'implements' claim causes compile-time check

- ensures that object of type **ArrayList** has methods of interface **List**

using an interface

now use class only in constructor

- can switch to another class, eg. LinkedList, with edit in just one place

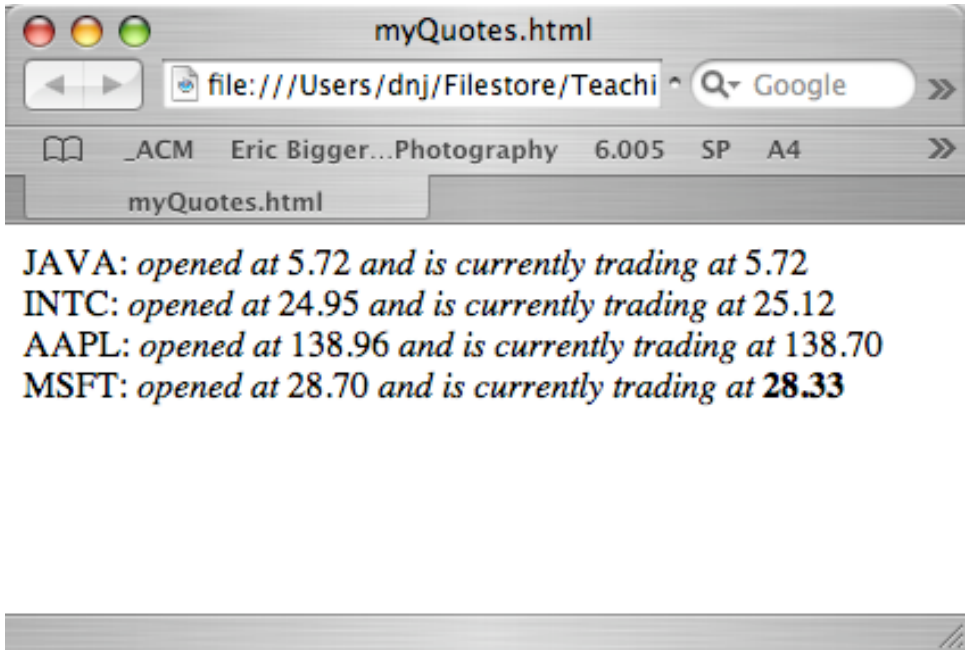
```
package music;
import java.util.List;
import java.util.ArrayList;

public class MusicMachine {
      boolean percussionMode, recordMode;
      List<Character> recording = new ArrayList<Character>();
      ...
      public void noteKeyPressed (char key) {
          Midi.play(key);
          if (recordMode) recording.add (key); }

      public void playKeyPressed () {
          for (char k: recording) Midi.play(k); }

      public void recordKeyPressed () {
          recordMode = !recordMode;
          if (recordMode) recording.clear(); }
}
```

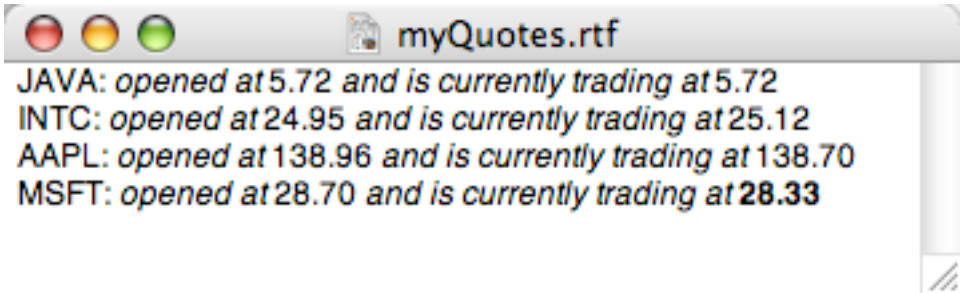
quote generation example

quote generation problem

problem

- want to obtain stock quotes for some ticker symbols
- produce both RTF and HTML output
- put ask price in bold if change since open ≥ ±1%

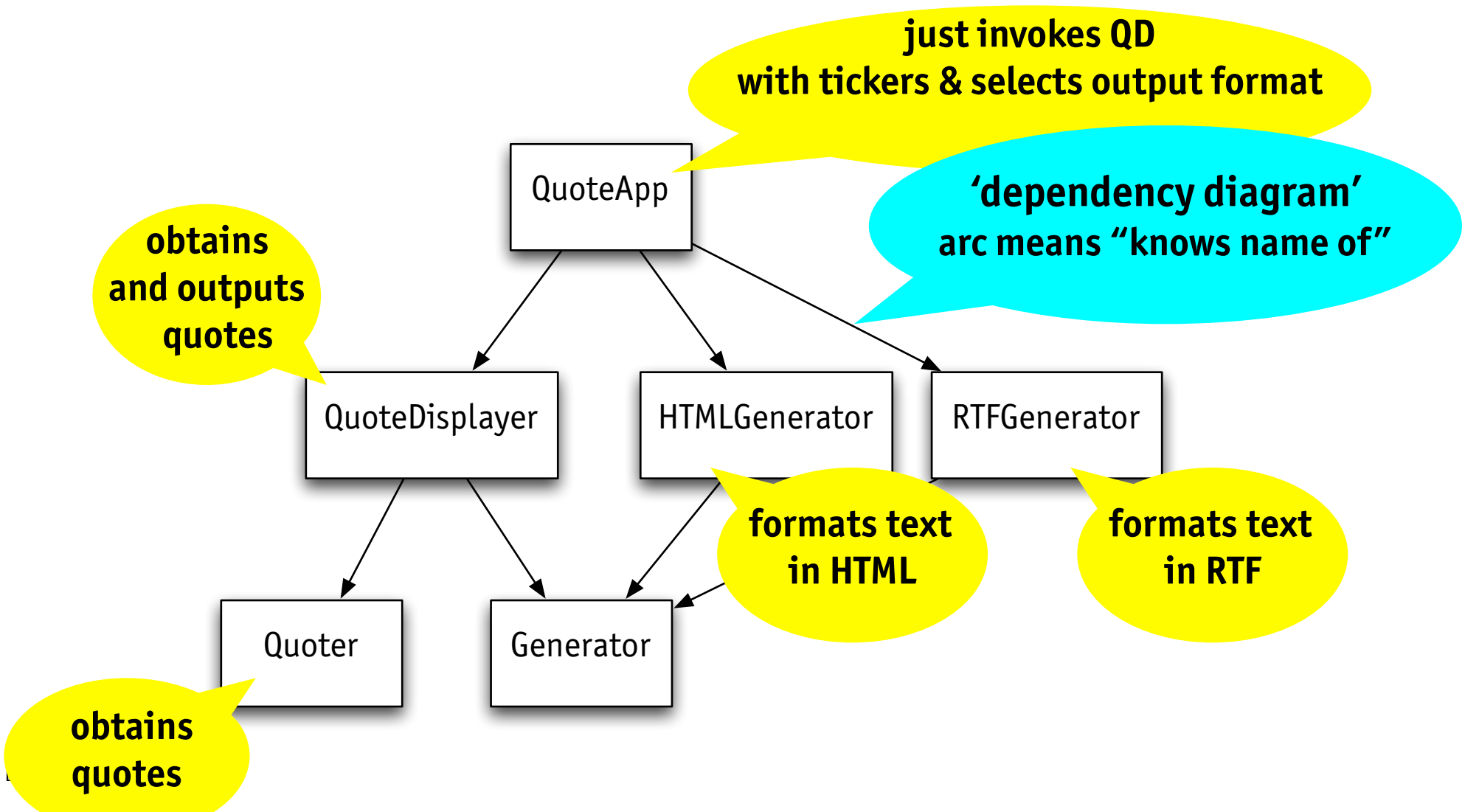




design challenge

separate functionality and minimize coupling

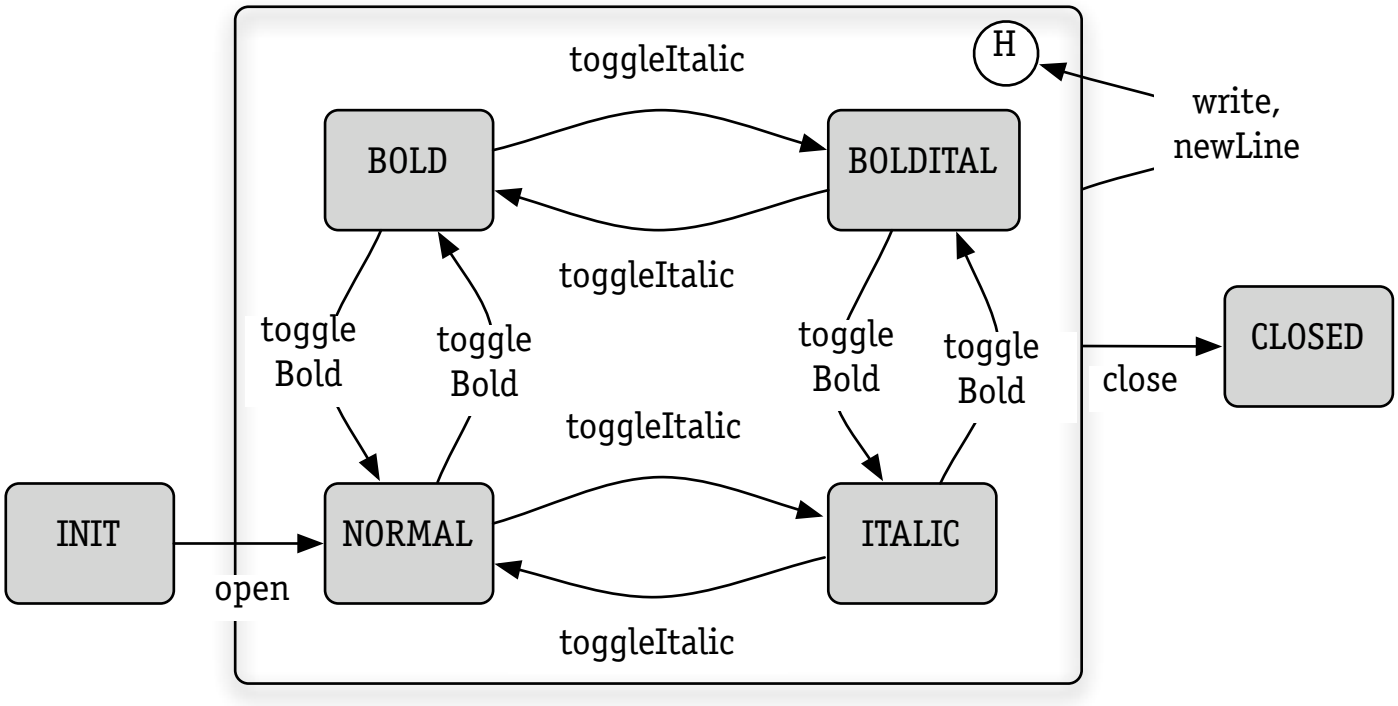
- Quoter doesn't know about generating text
- QuoteDisplayer doesn't know about HTML or RTF



text generator

key design idea

- develop generic interface for text formatting



generator interface, in Java

```
package generator;

public interface Generator {
    public void open () throws Exception;
    public void close ();
    public void newLine ();
    public void toggleBold ();
    public void toggleItalic ();
    public void write (String s);
}
```

sample generator

```
public class RTFGenerator implements Generator {
    boolean italic, bold;
    String filename;
    PrintStream stream;

    public RTFGenerator (String filename) {
        this.filename = filename;}

    public void open() throws FileNotFoundException {
        FileOutputStream fos = new FileOutputStream (filename);
        stream = new PrintStream(fos);
        stream.println ("{\\rtf1\\mac");}

    public void close() {
        stream.println ("}");
        stream.close();}

    public void newLine () {
        stream.println ("\\");}

    public void toggleBold() {
        stream.println (bold ? "\\f\\b0" : "\\f\\b");
        bold = !bold;}
    ...
```

quoter

```
public class Quoter {
private URL url;
private String open, ask;
private int change;

public Quoter (String symbol) throws MalformedURLException {
    url  = new URL("http://quote.yahoo.com/d/quotes.csv?s="+symbol+"&f=oap2");
}

public String getOpen () {return open;}
public String getAsk () {return ask;}
public int getChange () {return change;}

public void obtainQuote () throws IOException {
    BufferedReader in = new BufferedReader(new InputStreamReader(url.openStream()));
    String csv = in.readLine();
    in.close();
    StringTokenizer tokenizer = new StringTokenizer(csv, ",");
    open = tokenizer.nextToken();
    ask = tokenizer.nextToken();
    change = (int) (100 * (Float.valueOf(ask)-Float.valueOf(open)) / Float.valueOf(open));
}
}
```

quote displayer

```
public class QuoteDisplayer {
    Set<String> symbols = new HashSet<String> ();
    Generator gen;

    public QuoteDisplayer (Generator gen) {this.gen = gen;}
    public void addSymbol (String symbol) {symbols.add (symbol);}

    public void generateOutput () throws Exception {
        gen.open ();
        for (String symbol: symbols) {
            Quoter q = new Quoter (symbol);
            q.obtainQuote();
            gen.write (symbol + ": ");
            gen.toggleItalic (); gen.write ("opened at "); gen.toggleItalic ();
            gen.write (q.getOpen ());
            gen.toggleItalic ();
            gen.write (" and is currently trading at "); gen.toggleItalic ();
            boolean bigChange = Math.abs (q.getChange()) >= 1;
            if (bigChange) gen.toggleBold();
            gen.write (q.getAsk ());
            if (bigChange) gen.toggleBold();
            gen.newLine();
        }
        gen.close();
    }
}
```

no mention of HTMLGenerator or RTFGenerator!

putting everything together

```
public class QuoteApp {

    public static void main(String[] args) throws Exception {

        Generator rtfg = new RTFGenerator ("myQuotes.rtf");
        QuoteDisplayer disp = new QuoteDisplayer (rtfg);
        disp.addSymbol ("AAPL");
        disp.addSymbol ("INTC");
        disp.addSymbol ("JAVA");
        disp.addSymbol ("MSFT");
        disp.generateOutput ();

        Generator htmlg = new HTMLGenerator ("myQuotes.html");
        disp = new QuoteDisplayer (htmlg);
        disp.addSymbol ("AAPL");
        disp.addSymbol ("INTC");
        disp.addSymbol ("JAVA");
        disp.addSymbol ("MSFT");
        disp.generateOutput ();
    }

}
```

plugin is selected here

exercise

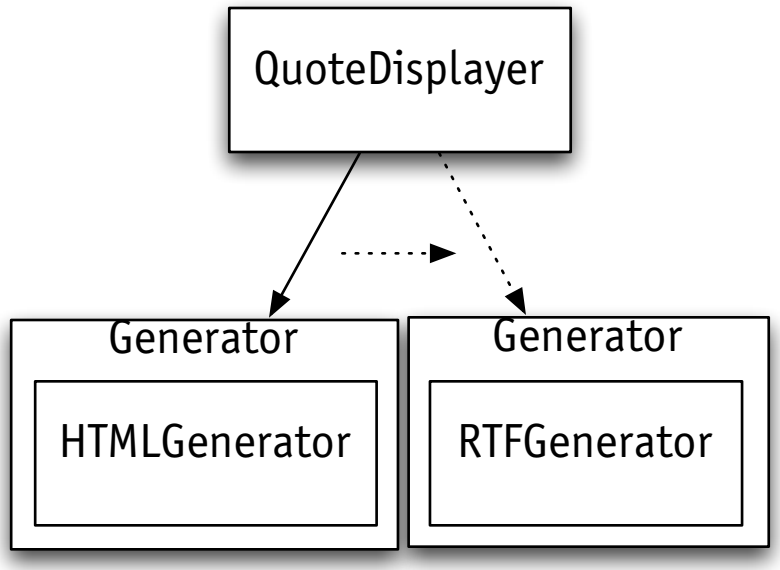
which modules would you need to modify to ...

- handle new RTF syntax for italics?
- put ask price in bold if down since open?
- use google finance instead of yahoo?
- add year-to-date change to report?

recap of examle

what's happening

- QuoteDisplayer uses plugin to generate formatted text
- ignorant of whether it's using HTML or RTF generator
- refers to generator only by interface name Generator

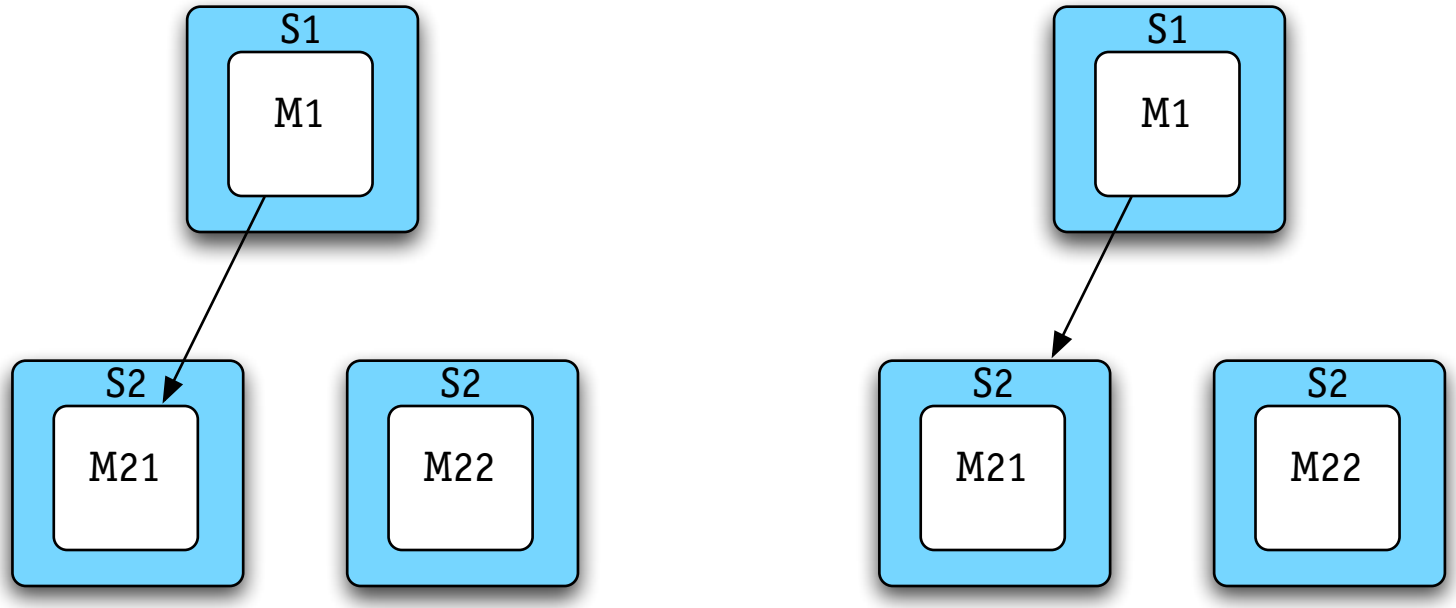


costs of knowledge

illustrates general principle

- suppose module M1 used module M2
- if M1 knows M2's internals, then M2 is not a **replaceable component**
- if M1 knows M2's name, then two versions of M2 **cannot coexist**

the joy of ignorance



good (left)

- M1 depends only on service S2 provided by M21
- can switch to M22 by modifying refs in M1, or renaming M22 to M21

better (right)

- M1 depends only on S2, and doesn't even name M21
- M21 and M22 can coexist; different approaches for configuring

review

summary

locality

- achieved by containing functions within modules
- and by limiting coupling between modules

interfaces

- key mechanism for achieving decoupling
- class depends only on spec of another class

dependency diagram

- show code modules as boxes
- arc from A to B when A uses a name declared in B, or the name B itself