CS 3110

Modular Programming

Nate Foster
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Today's music: "Giorgio By Moroder" by Daft Punk

Moog modular synthesizer

Based in Trumansburg, NY, 1953-1971
Game changing! picked up by the Beatles, the Rolling Stones…

Review

Previously in 3110:

- how to build *small* programs

Today:

- language features for building *large* programs: structures, signatures, modules

Scale

Staff solution to A1:	100 LoC
OCaml:	200,000 LoC
Unreal engine 3:	2,000,000 LoC
Windows Vista:	50,000,000 LoC

http://www.informationisbeautiful.net/visualizations/million-lines-of-code/

...can’t be done by one person

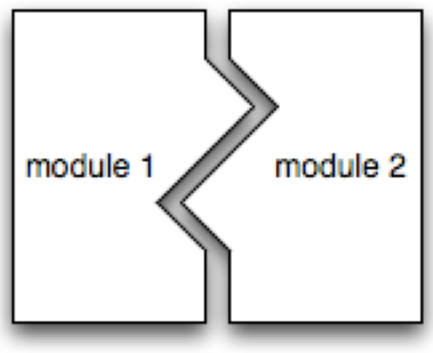
...no individual programmer can understand all the details

...too complex to build with OCaml we’ve seen so far

Modularity

Modular programming: code comprises independent *modules*

- developed separately
- understand behavior of module in isolation
- reason locally, not globally



Java features for modularity

- **classes, packages:** organize identifiers (classes, methods, fields, etc.) into namespaces
- **interfaces:** describe related classes
- **public, protected, private:** control what is visible outside a namespace
- **subtyping, inheritance:** enables code reuse

OCaml features for modularity

- **structures:** organize identifiers (functions, values, etc.) into namespaces
- **signatures:** describe related modules
- **abstract types:** control what is visible outside a namespace
- **functors, includes:** enable code reuse

...the OCaml *module system*

STRUCTURES

Demo

Structures

- Collections of definitions
- Evaluated in order
- Structure value can be bound to module name
- Structure values are second class

SIGNATURES

Demo

Signatures

- Collections of declarations (and some definitions)
- Not evaluated; just type checked
- Signature type can be bound to module type name

Type checking

If you give a module a type...

```
module Mod : Sig = struct ... end
```

Then type checker ensures...

1. **Signature matching:** everything declared in `Sig` must be defined in `Mod`
   (OK to add new definitions to `Mod` that aren't declared in `Sig`)
2. **Encapsulation:** nothing other than what's declared in `Sig` can be accessed from outside `Mod`

Demo

ABSTRACT TYPES

Demo

Exposure is bad

- Client code shouldn't **need to know** what the representation type is
- Rule of thumb: clients will exploit knowledge of representation if you let them
- Client code shouldn't **get to know** what the representation type is

COMPILATION UNITS

Demo

OCaml features for modularity

- **structures:** organize identifiers (functions, values, etc.) into namespaces
- **signatures:** describe related modules
- **abstract types:** control what is visible outside a namespace
- **functors, includes:** enable code reuse

Upcoming events

- [Now] Team #1 boot-up!
  - Complete survey announced on Discourse
  - Short written assignment due Sunday
- [Wed] A1 due
- [Wed] A2 out

This is game changing.

THIS IS 3110