CS 3110

Lecture 1: Course Overview

Prof. Clarkson

Fall 2014

Today's music: Prelude from *Final Fantasy VII*
by Nobuo Uematsu (remastered by Sean Schafianski)

Welcome!

We have 15 weeks to finish your university education as a programmer

- Programming isn't hard
- Programming well is very hard
  - High variance among professionals' productivity: 10x or more
  - With hard work, patience, and an open mind, this course makes you a better programmer

Evolution

- CS 1110: Write code for your professor
- CS 2110: Write code for yourself
- **CS 3110:** Write code for others
  - Emphasis on design, performance, correctness
  - Also, with others: techniques and tools for collaboration
  - MAIN GOALS for this course:
    write code for and with others

How we'll approach goals

1. Functional programming (OCaml)
   - Challenge you to think outside the Python/Java *imperative* family of languages
   - Realize that programming transcends programming in a language
     - Language features: syntax, semantics, idioms, tools

How we'll approach goals

2. Data structures and modern programming paradigms
   - Challenge you to think about *abstraction*
   - Rigorously analyze performance and correctness
   - Learn to write *concurrent* programs
   - Learn to write *scalable* programs

How we'll approach goals

3. Software engineering
   - Experience with modular design, specification, integrated testing, source control, code reviews
   - Expose you to tools used in the real world (git, Linux)

Challenges in our way

You might think programming = Java

- For the next five weeks, please let go of Java
- Learn OCaml as a totally new way of programming
- Thinking "Oh, that's like this thing in Java" will confuse you, slow you down, make you learn less

Challenges in our way

You might think programming = hack until it works

- As you begin this semester, please develop the mindset of a professional: disciplined work habits
- Common challenge: type first, think later
  - *"A year in the lab saves an hour at the library"*
  - **Fact:** there is an infinite number of incorrect programs
  - **Corollary:** tweaking your code is unlikely to help
  - …we hope you'll think first and type less

Keep the end in sight

We want to help you learn to write code that is

- Reliable
- Efficient
- Readable
- Testable
- Provable
- Maintainable
- BEAUTIFUL

OCaml

A pretty good language for writing beautiful programs

O = Objective, Caml=not important
ML is a family of languages; originally the “meta-language” for a tool

OCaml is awesome because of...

- Immutable programming
  - Variable's values cannot destructively be changed; makes reasoning about program easier!
- Algebraic datatypes and pattern matching
  - Makes definition and manipulation of complex data structures easy to express
- First-class functions
  - Functions can be passed around like ordinary values
- Static type-checking
  - Reduce number of run-time errors
- Automatic type inference
  - No burden to write down types of every single variable
- Parametric polymorphism
  - Enables construction of abstractions that work across many data types
- Garbage collection
  - Automated memory management eliminates many run-time errors

Why immutability?

Imperative (mutable) programming:

- *commands* specify how to compute by destructively changing *state*
  - `x = x+1;`
  - `a[i] = 42;`
  - `p.next = p.next.next;`

- and functions/methods have *side effects*
  - ```
    int wheels(Vehicle v) {
      v.size++; return v.numWheels;
    }
    ```
    ```

Why immutability?

The fantasy of mutability:

- There is a single state
- The computer does one thing at a time

The reality of mutability:

- There is no single state
  - Programs have many threads, spread across many cores, spread across many processors, spread across many computers… each with its own view of memory
- There is no single program
  - Most applications do many things at one time

…mutable programming is not well-suited to modern computing!

Why immutability?

Functional (immutable) programming:

expressions specify what to compute

- Variables never change value
- Functions never have side effects

The reality of immutability:

- No need to think about state
- Powerful ways to build concurrent programs

Functional vs. imperative

Functional languages:

- Higher level of abstraction
- Easier to develop robust software

Imperative languages:

- Lower level of abstraction
- Harder to develop robust software

You don't have to believe me now.
You will by the end of the course. ☺

Functional languages predict the future

Dismissed as "beautiful, worthless, slow things professors make you learn in school":

- Garbage collection
  Java [1995], LISP [1958]
- Generics
  Java 5 [2004], ML [1990]
- Higher-order functions
  C#3.0 [2007], Java 8 [2014], LISP [1958]
- Type inference
  C++11 [2011], Java 7 [2011] and 8, ML

Functional languages matter in the real world

- F#, C# 3.0, LINQ (Microsoft)
- Scala (Twitter, LinkedIn, FourSquare)
- Java 8
- Haskell (dozens of small companies/teams)
- Erlang (distributed systems, Facebook chat)
- OCaml (Jane Street)

A GLIMPSE OF OCAML...

Example 1: Sum Squares

```
// yields Σ1<=i<=n i²
int sum_squares(int n) {
   sum=0;
   for (int x = 1; x <= n; x++) {
      sum = sum + x*x
   }
   return sum;
}
```

How can you do that without mutability?

Example 1: Sum Squares

```
// yields Σ_{1<=i<=n} i^2
int sum_squares(int n) {
  if (n==0) {
    return 0;
  } else {
    return n*n + sum_squares(n-1);
  }
}
```

Example 1: Sum Squares

```
(* yields Σ1<=i<=n i² *)
let rec sum_squares (n:int) : int =
   if n=0 then 0
   else n*n + sum_squares (n-1)
```

Better yet…

```
(* yields Σ1<=i<=n i² *)
let rec sum_squares n =
   if n=0 then 0
   else n*n + sum_squares (n-1)
```

Example 2: Reverse List

```
// return a copy of x,
// with the order of its elements reversed
List reverse(List x) {
   List y = null;
   while (x != null) {
      List t = x.next;
      x.next = y;
      y = x;
      x = t;
   }
   return y;
}
```

Example 2: Reverse List

```
(* return the reverse of lst *)
let rec reverse lst =
  match lst with
   | [] -> []
   | h::t -> (reverse t) @ [h]
```

Example 3: Quicksort

- Describe quicksort in English.
- Describe quicksort in Java. (No.)
- Describe quicksort in OCaml:

```
(* returns lst sorted according to < *)
let rec qsort lst =
    match lst with
    | [] -> []
    | pivot::rest -> (* poor choice of pivot *)
       let (left,right) = partition ((<) pivot) rest
       in (qsort left) @ [pivot] @ (qsort right)
```

THE SYLLABUS

Course staff

Instructor: Michael Clarkson

- PhD 2010 Cornell University
- Research area: security and programming languages
- I go by "Prof. Clarkson" in this course

TAs and consultants: 35 at last count

– Course administrator ("head TA"): Remy Jette (rcj57)

Course meetings

- **Lectures:** TR 10:10-11:00 am
  - Attendance is expected and will be checked
  - If you miss, get notes from another student

- **Recitations:** mostly MW
  - Attendance is expected
  - Cover new material, not just rehash of lecture
  - TR sections are effectively MW delayed one day
  - You may attend any, regardless of registration, subject to room capacity; best to stick to one

- **Consulting:** coverage Sunday-Thursday

Course website

http://www.cs.cornell.edu/Courses/cs3110/2014fa/

- Full syllabus (required reading)
- Lecture and recitation notes
  - Typically go live the night of lecture
  - Supplement, do not replace, attendance

Piazza

- Online discussion forum
- Primary vehicle for announcements
  - Set up email notifications now
- Monitored almost continuously by staff
- Ask for help, don't post solutions
- Post **anonymously** (to classmates)
- Post **privately** (only seen by staff)

Email

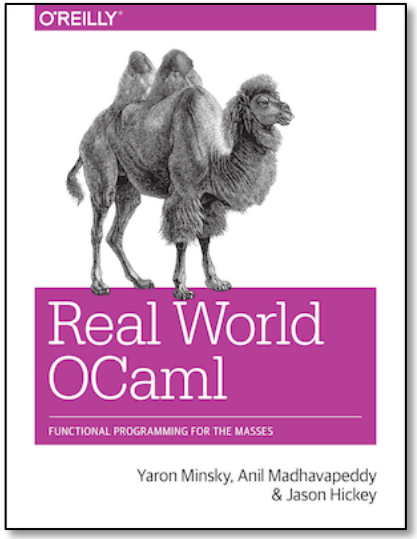
- Don't. 300 >> 1. ☹
- Post a private message on Piazza instead.
- Exception: sometimes email to Course Administrator is okay

CMS

- Course Management System
- Grades, regrades, materials we don't want to post publicly
- Make sure you have access to CS 3110 now
  - If not, notify Course Administrator and provide your full name and NetID
- Gets overloaded at due time; submit early

Course materials

- No textbook
  - Online course notes
  - If you want a book, *Real World OCaml* is good and written 2/3 by Cornellians
  - Other free resources linked on website



- i>clickers
  - Required; will be used to take attendance
  - Buy one at Cornell Store or download i>clicker GO app
  - We start using them on Thursday in lecture

Problem Sets

- Six problem sets (PS's)
  - Plus an ungraded, uncollected PS0
  - Due Thursdays at 11:59 pm
  - Electronic submission by CMS, never by email
  - Length of time ranges from 1 week (PS1) to 3+ weeks (PS5 and 6)
  - Mostly done in pairs

Exams

- Two prelims
  - Prelim 1: 10/09/14, 7:30 pm
  - Prelim 2: 11/20/14, 7:30 pm
  - Put them on your calendar now
  - Makeups offered same night only, 5:15-7:15 pm
    - Notify Course Administrator by Sept. 9 if you need to take one of these makeups, so that we have big enough rooms
    - **No other makeups will be offered**
    - If you miss without advance permission, you get a zero
    - If you miss with Instructor's permission, you most likely get an average of your other exam scores
- Final
  - University will announce date and time later

Grading

- Problem sets: 40%
- Prelims: 15% each
- Final: 25%
- Participation: 3%*
- Meet your professor: 1%
- Course evaluation: 1%

Historical median grade: B/B+ range

* For full credit, ≥75% of i>clicker questions answered in class

Problem set grading

- **Automated grading** for correctness
  - Critical for you to program to the specification we give you
  - No-compile grace period: we notify you Thursday night, you get till Saturday 11:59 pm to fix it
  - If you submit a small patch (2-3 lines) that gets code to compile, just a minor penalty
  - If your code still can't be compiled, you get a zero
- You get two *late passes*
  - Automatic 48-hour extension: assignment becomes due Saturday at 11:59 pm
  - No-compile grace period does not apply
- In case of true emergency (medical, family) contact Instructor ASAP

Academic integrity

- You are bound by the Cornell Code of Academic Integrity and the CS Department Code of Academic Integrity
  - Both linked from course website
  - You are responsible for understanding them
- If you have a question about what is or is not allowed, please ask
- The course staff uses automated software to detect cheating. It works.

Registration

- The course is full. Yay!
- **I can't add anybody yet**. Boo.
- If you (still) want in, just keep attending for now
  - Talking to me after class won't help
  - Coming to my office hours won't help
- We will talk more about this later…

Upcoming events

- No recitations today, start tomorrow
  - Double check the room; university changed some today
- **PS 0 is out now**
- **OCaml tutorial** this week only**:**
  - TWR 7:30-9:30 pm, rooms posted on website
  - Led by expert TA Arjun Biddanda
- **Clarkson office hours** this week only:
  - TWR 1:30-3:00 pm, 461 Gates
  - If you need me to sign something (*other than registration forms*), come to office hours
- Real office hours and consulting start next week
- i>clickers start on Thursday (in two days)

…why are you still here? Get to work! ☺

THIS IS 3110