CSE 130 : Fall 2015

Programming Languages

Lecture 1: *Hello, World!*

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A Programming Language

- Two variables
  - `x, y`
- Three operations
  - `x++`
  - `x--`
  - `(x=0)? L1:L2;`

```
L1: x++;
    y--;
    (y=0)?L2:L1
L2: …
```

Fact: This is "equivalent to" to every PL!

Good luck writing quicksort

… or Windows, Google, Spotify!

So why study PL ?

"A different language is a different vision of life"

- Federico Fellini

So why study PL ?

Programming language
shapes
Programming thought

So why study PL ?

Language affects how:

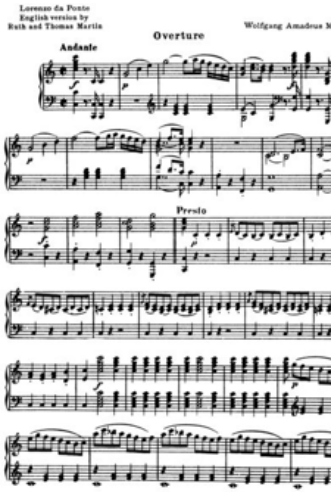
- Ideas are expressed
- Computation is expressed

Course Goals

"Free your mind"

-Morpheus

Learn New Languages/Constructs

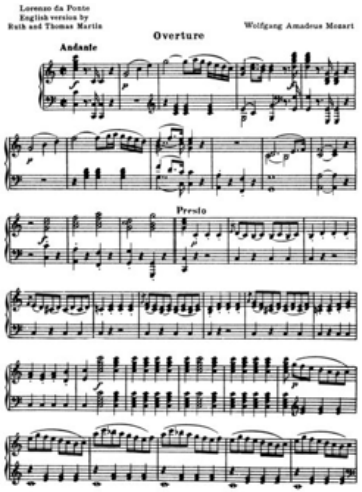


New ways to:

- describe
- organize
- think about

computation

Goal: Enable you to Program



- Readable
- Correct
- Extendable
- Modifiable
- Reusable

Learn How To Learn

Goal: How to learn new PLs

No Java (C#) 15 (10) years ago
AJAX? Python? Ruby? Erlang? F#?...

Learn the anatomy of a PL
- Fundamental building blocks
- Different guises in different PLs

Re-learn the PLs you already know

To Design New Languages

Goal: How to design new PLs

…“who, me ?”

Buried in every extensible system is a PL

- Emacs, Android: Lisp
- Word, Powerpoint: Macros, VBScript
- Unreal: UnrealScript (Game Scripting)
- Facebook: FBML, FBJS
- SQL, Renderman, LaTeX, XML …

Choose Right Language

Enables you to choose right PL

“…but isn’t that decided by

- libraries,
- standards,
- and my boss ?”

Yes.

Speaking of Right and Wrong...

My goal: educate tomorrow’s tech leaders & bosses, so you’ll make informed choices

Imperative Programming

x = x+1

WTF?

x = x+1

Imperative = Mutation

Imperative = Mutation

Bad!

Don’t take my word for it

John Carmack

Creator of FPS: Doom, Quake,...

Don’t take my word for it

Tim Sweeney (Epic, Creator of UNREAL)

“In a concurrent world, imperative is the wrong default”

Functional Programming

Functional Programming ?

No Assignment.

No Mutation.

No Loops.

OMG! Who uses FP?!

So, Who Uses FP ?

Google

MapReduce

So, Who Uses FP ?

Microsoft®

Linq, F#

So, Who Uses FP ?

Erlang

So, Who Uses FP ?

Scala

So, Who Uses FP ?

Wall Street (all of the above)

So, Who Uses FP ?

…CSE 130

Course Mechanics

Mechanics

http://ucsd-progsys.github.io/cse130/

Nothing printed, everything on Webpage!

Peer Instruction (ish)

Peer Instruction/Clickers

- Make class interactive
  - Help YOU and ME understand whats tricky
- **Clickers Not Optional**
  - Cheap ones are fine
  - 5% of your grade
  - Respond to 75% questions
- **Seating in groups** (links on Piazza)
- Bring laptop if you have one

In Class Exercises

1. **Solo Vote**: Think for yourself, select answer

2. **Discuss**: Analyze Problem in Groups
   + Reach consensus
   + Have questions, raise your hand!

3. **Group Vote**: Everyone in group votes
   + Must have same vote to get points

3. **Class Discuss**: Everyone in group votes
   - What was easy/hard?

Requirements and Grading

- The good news: No Homework

- In-Class Exercises: 5%
- Midterm: 30%
- Programming Assignments (7-8): 30%
- Final: 35%

Grading on a curve. Two hints/rumors:

1. Lot of work
2. Don't worry (too much) about grade

No Recommended Text

- Online lecture notes
- Resources posted on webpage
- Pay attention to lecture and section!
- Do assignments yourself!

Suggested Homeworks

- On webpage after Thursday lecture
- Based on lectures, section of previous Tue, Thu
- Recommended, ungraded, HW problems are sample exam questions
- Webpage has first samples already

Weekly Programming Assignments

Schedule up on webpage

Due on Friday 5 PM

Deadline Extension:

- Four "late days", used as "whole unit"
- 5 mins late = 1 late day
- Plan ahead, **no other extensions**

Plan

1. FP, Ocaml, 4 weeks
2. OO, Scala, 4 weeks
3. Logic, Prolog, 1 week

Weekly Programming Assignments

Unfamiliar languages
+ Unfamiliar environments

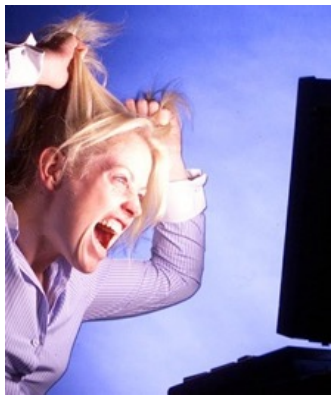
Start Early!

Weekly Programming Assignments

Scoring = Style + Test suite

No Compile, No Score

Weekly Programming Assignments



Forget Java, C, C++ …

… other 20th century PLs

Don't complain

… that Ocaml is hard

… that Ocaml is @!%@#

Immerse yourself in new language

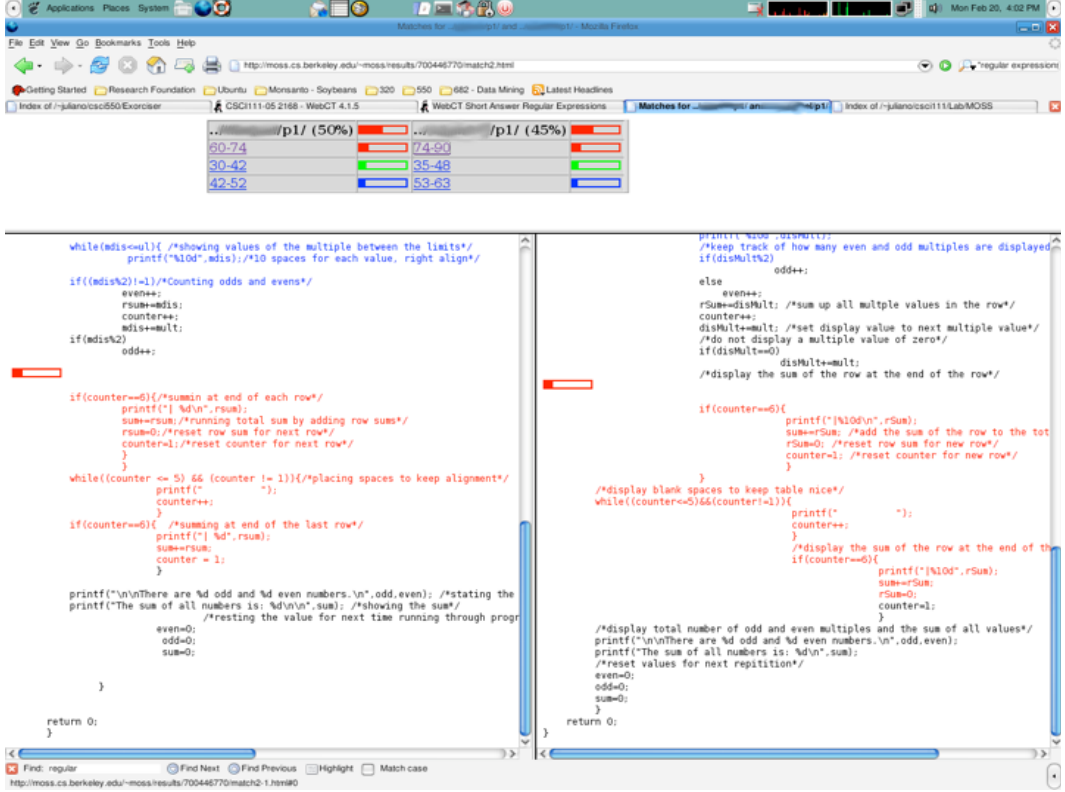
It is not.

Immerse yourself in new language

Free your mind.

Word from our sponsor …

- Programming Assignments done **ALONE**
- We use plagiarism detection software
  - I am an expert
  - Have code from **all previous classes**
  - MOSS is fantastic, plagiarize at your own risk
- **Zero Tolerance**
  - offenders punished ruthlessly
- Please see academic integrity statement



To Ask Me Questions?

Say hello to OCaml

```
void sort(int arr[], int beg, int end){
  if (end > beg + 1){
    int piv = arr[beg];
    int l = beg + 1;
    int r = end;
    while (l != r-1){
       if(arr[l] <= piv)
          l++;
       else
          swap(&arr[l], &arr[r--]);
    }
    if(arr[l]<=piv && arr[r]<=piv)
       l=r+1;
    else if(arr[l]<=piv && arr[r]>piv)
       {l++; r--;}
    else if (arr[l]>piv && arr[r]<=piv)
       swap(&arr[l++], &arr[r--]);
    else
       r=l-1;
    swap(&arr[r--], &arr[beg]);
    sort(arr, beg, r);
    sort(arr, l, end);
  }
}
```

Quicksort in C

```
let rec sort xs =
  match xs with [] -> []
  |(h::t) ->
     let(l,r)= List.partition ((<=) h) t in
     (sort l)@h::(sort r)
```

Quicksort in Ocaml

Why readability matters...

```
sort=:((($:@(<#[),(=#[),$:@(>#[))({~ ?@#))^:  (1:<#)
```

Quicksort in J

Say hello to OCaml

```
let rec sort xs =
  match xs with
  | [] -> []
  | h::t ->
     let (l,r)= List.partition ((<=) h) t in
     (sort l)@h::(sort r)
```

Quicksort in OCaml

Plan (next 4 weeks)

1. Fast forward
   - Rapid introduction to whats in ML
2. Rewind
3. Slow motion
   - Go over the pieces individually

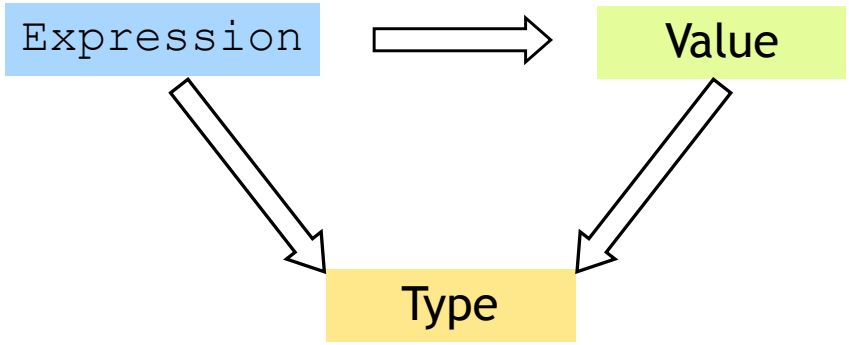
ML: History, Variants

"Meta Language"
Designed by Robin Milner
To manipulate theorems & proofs

Several dialects:

- Standard ML (SML)
  - Original syntax
- Objective Caml: (Ocaml)
  - "The PL for the discerning hacker"
  - State-of-the-art, extensive library, tool, user support
- F# (Ocaml+.NET) released in Visual Studio

ML's holy trinity



- Everything is an expression
- Everything has a value
- Everything has a type

Interacting with ML

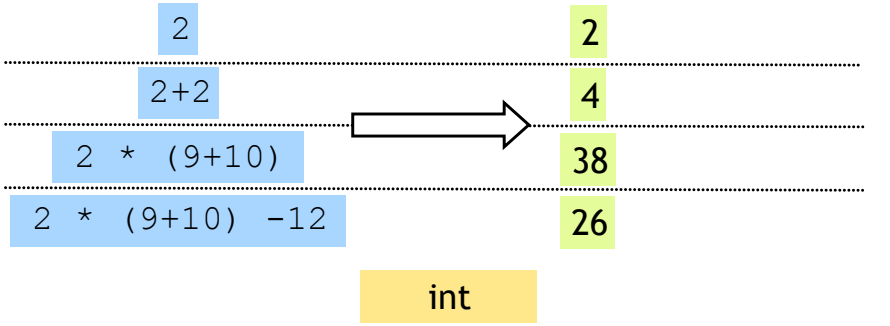
"Read-Eval-Print" Loop

Repeat:

1. System reads expression **e**
2. System evaluates **e** to get value **v**
3. System prints value **v** and type **t**

What are these expressions, values and types ?

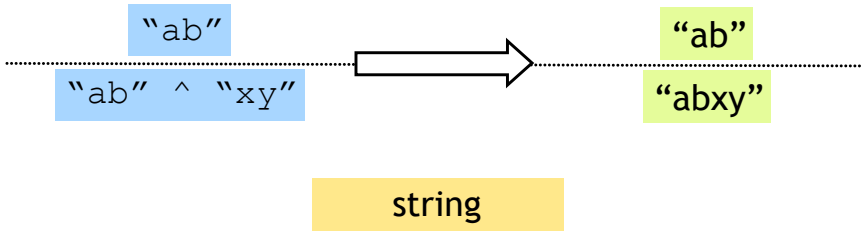
Base type: Integers



Complex expressions using "operators": *(why the quotes ?)*

- +, -, *
- div, mod

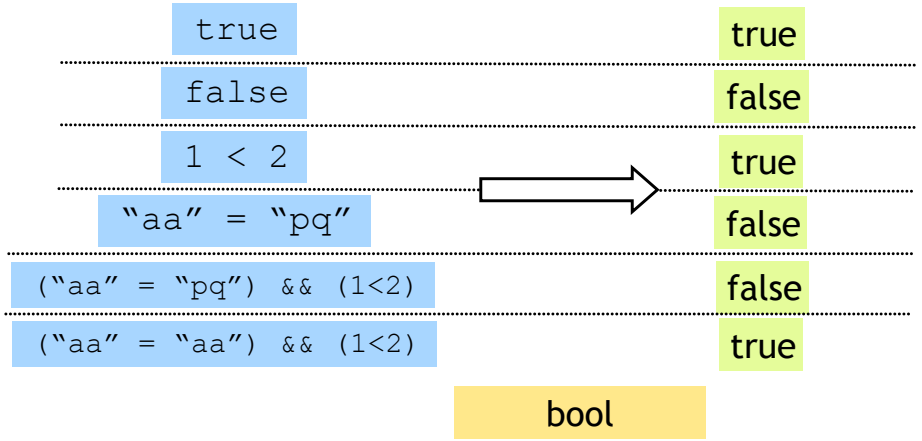
Base type: Strings



Complex expressions using "operators": *(why the quotes ?)*

- Concatenation ^

Base type: Booleans



Complex expressions using "operators":

- "Relations": = , <, <=, >=
- &&, ||, not

Type Errors

```
(2+3) || ("a" = "b")
```

```
"pq" ^ 9
```

```
(2 + "a")
```

Untypable expression is rejected

- No casting, No coercing
- Fancy algorithm to catch errors
- ML's single most powerful feature *(why ?)*

Complex types: Product (tuples)

```
(2+2 , 7>8);
```

⟹ (4,false)

int * bool

Complex types: Product (tuples)

```
(9-3,"ab"^"cd",(2+2 ,7>8))
```

⟹ (6, "abcd",(4,false))

(int * string * (int * bool))

- Triples,…
- Nesting:
  - Everything is an expression
  - Nest tuples in tuples

Complex types: Lists

`[];`	[]	'a list
`[1;2;3];`	[1;2;3]	int list
`[1+1;2+2;3+3;4+4];`	[2;4;6;8]	int list
`["a";"b"; "c"^"d"];`	["a";"b"; "cd"]	string list
`[(1,"a"^"b");(3+4,"c")];`	[(1,"ab");(7,"c")]	(int*string) list
`[[1];[2;3];[4;5;6]];`	[[1];[2;3];[4;5;6]];	(int list) list

- Unbounded size
- Can have lists of anything (e.g. lists of lists)
- but …

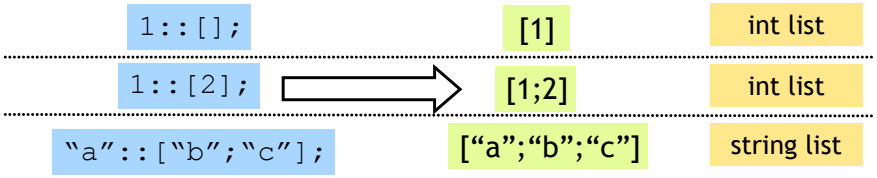
Complex types: Lists

```
[1; "pq"];
```

All elements must have same type

Complex types: Lists

List operator "Cons" ::

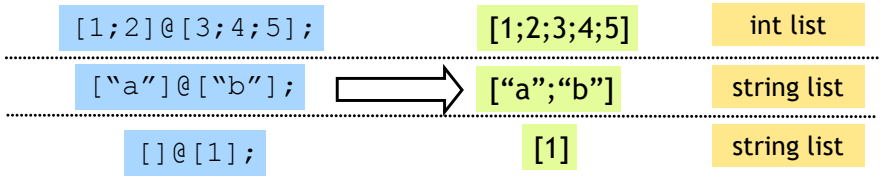


Can only "cons" element to a list of same type

```
1::["b"; "cd"];
```

Complex types: Lists

List operator "Append" @

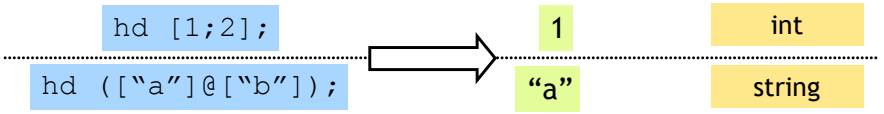


Can only append two lists `1 @ [2;3];`

… of the same type `[1] @ ["a";"b"];`

Complex types: Lists

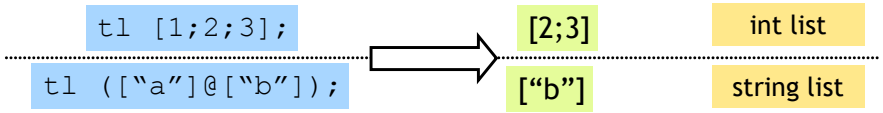
List operator "head" hd



Only take the head a nonempty list `hd [];`

Complex types: Lists

List operator “tail” tl



Only take the tail of nonempty list `tl [];`

Recap: Tuples vs. Lists ?

What’s the difference ?

- Tuples:
  - Different types, but fixed number:
    (3, “abcd”) (int * string)
    - pair = 2 elts

    (3, “abcd”,(3.5,4.2)) (int * string * (float* float))
    - triple = 3 elts
- Lists:
  - Same type, unbounded number:
    [3;4;5;6;7] int list

So far, a fancy calculator…

… what do we need next ?