CSE 130 : Spring 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:

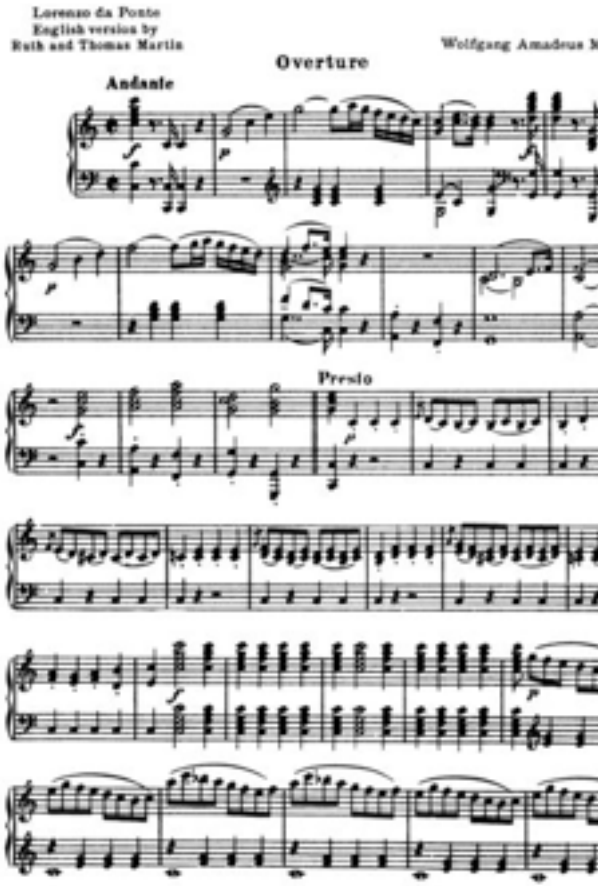
- Ideas are expressed
- Computation is expressed

Course Goals

"Free your mind"

-Morpheus

Learn New Languages/Constructs

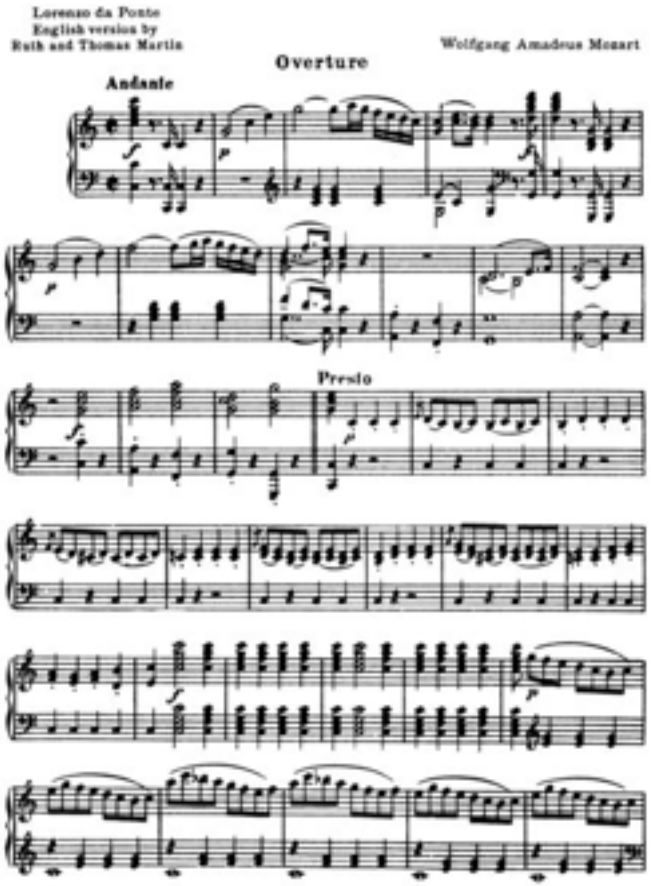


New ways to:

- 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.

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

Speaking of Right and Wrong...

Imperative Programming

$$x = x+1$$

$$x = x+1$$

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

No Assignment.

No Mutation.

No Loops.

OMG! Who uses FP?!

So, Who Uses FP ?

MapReduce

So, Who Uses FP ?

Microsoft®

Linq, F#

So, Who Uses FP ?

Erlang

So, Who Uses FP ?

twitter

Scala

So, Who Uses FP ?

Wall Street (all of the above)

So, Who Uses FP ?

...CSE 130

Course Mechanics

Mechanics

cseweb.ucsd.edu/classes/sp12/cse130-a/

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 of 3
   - Practice analyzing, talking about tricky notions
   - Reach consensus
   - Have questions, raise your hand!

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

4. Class-wide Discussion:

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

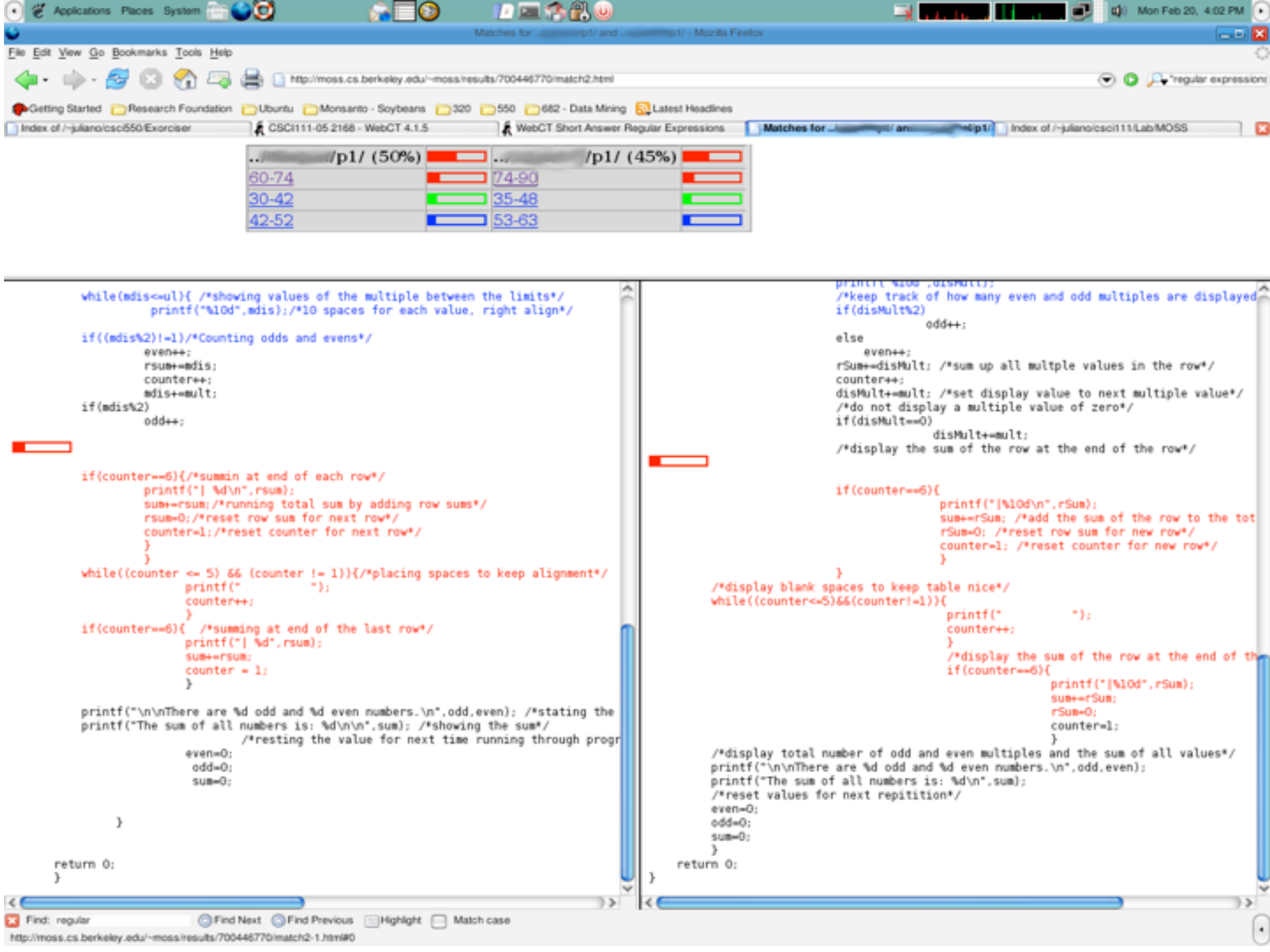
It is not.

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



Applications Places System Mon Feb 20, 4:02 PM

Matches for .../p1/ and .../p1/ - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://moss.cs.berkeley.edu/~moss/results/700446770/match2.html

Getting Started Research Foundation Ubuntu Monsanto - Soybeans 320 550 682 - Data Mining Latest Headlines

Index of /~juliano/csci550/Exorciser | CSCI111-05 2168 - WebCT 4.1.5 | WebCT Short Answer Regular Expressions | Matches for .../p1/ | Index of /~juliano/csci111/Lab/MOSS

.../p1/ (50%)		.../p1/ (45%)	
60-74		74-90	
30-42		35-48	
42-52		53-63	

```
        while(mdis<=ul){ /*showing values of the multiple between the limits*/
                 printf("%10d",mdis);/*10 spaces for each value, right align*/

        if((mdis%2)!=1)/*Counting odds and evens*/
                even++;
                rsum+=mdis;
                counter++;
                mdis+=mult;
        if(mdis%2)
                odd++;


        if(counter==6){/*summin at end of each row*/
                printf("| %d\n",rsum);
                sum+=rsum;/*running total sum by adding row sums*/
                rsum=0;/*reset row sum for next row*/
                counter=1;/*reset counter for next row*/
                }
                }
        while((counter <= 5) && (counter != 1)){/*placing spaces to keep alignment*/
                        printf("          ");
                        counter++;
                        }
        if(counter==6){  /*summing at end of the last row*/
                        printf("| %d",rsum);
                        sum+=rsum;
                        counter = 1;
                        }

        printf("\n\nThere are %d odd and %d even numbers.\n",odd,even); /*stating the
        printf("The sum of all numbers is: %d\n\n",sum); /*showing the sum*/
                        /*resting the value for next time running through progr
                        even=0;
                         odd=0;
                         sum=0;


             }


    return 0;
    }
```

```
                        /*keep track of how many even and odd multiples are displayed
                        if(disMult%2)
                                odd++;
                        else
                            even++;
                        rSum+=disMult; /*sum up all multple values in the row*/
                        counter++;
                        disMult+=mult; /*set display value to next multiple value*/
                        /*do not display a multiple value of zero*/
                        if(disMult==0)
                                disMult+=mult;
                        /*display the sum of the row at the end of the row*/


                        if(counter==6){
                                printf("|%10d\n",rSum);
                                sum+=rSum; /*add the sum of the row to the tot
                                rSum=0; /*reset row sum for new row*/
                                counter=1; /*reset counter for new row*/
                                }
                        }
                /*display blank spaces to keep table nice*/
                while((counter<=5)&&(counter!=1)){
                                printf("          ");
                                counter++;
                                }
                                /*display the sum of the row at the end of th
                                if(counter==6){
                                        printf("|%10d",rSum);
                                        sum+=rSum;
                                        rSum=0;
                                        counter=1;
                                        }
                /*display total number of odd and even multiples and the sum of all values*/
                printf("\n\nThere are %d odd and %d even numbers.\n",odd,even);
                printf("The sum of all numbers is: %d\n",sum);
                /*reset values for next repitition*/
                even=0;
                odd=0;
                sum=0;
                }
            return 0;
        }
```

Find: regular Find Next Find Previous Highlight Match case

http://moss.cs.berkeley.edu/~moss/results/700446770/match2-1.html#0

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

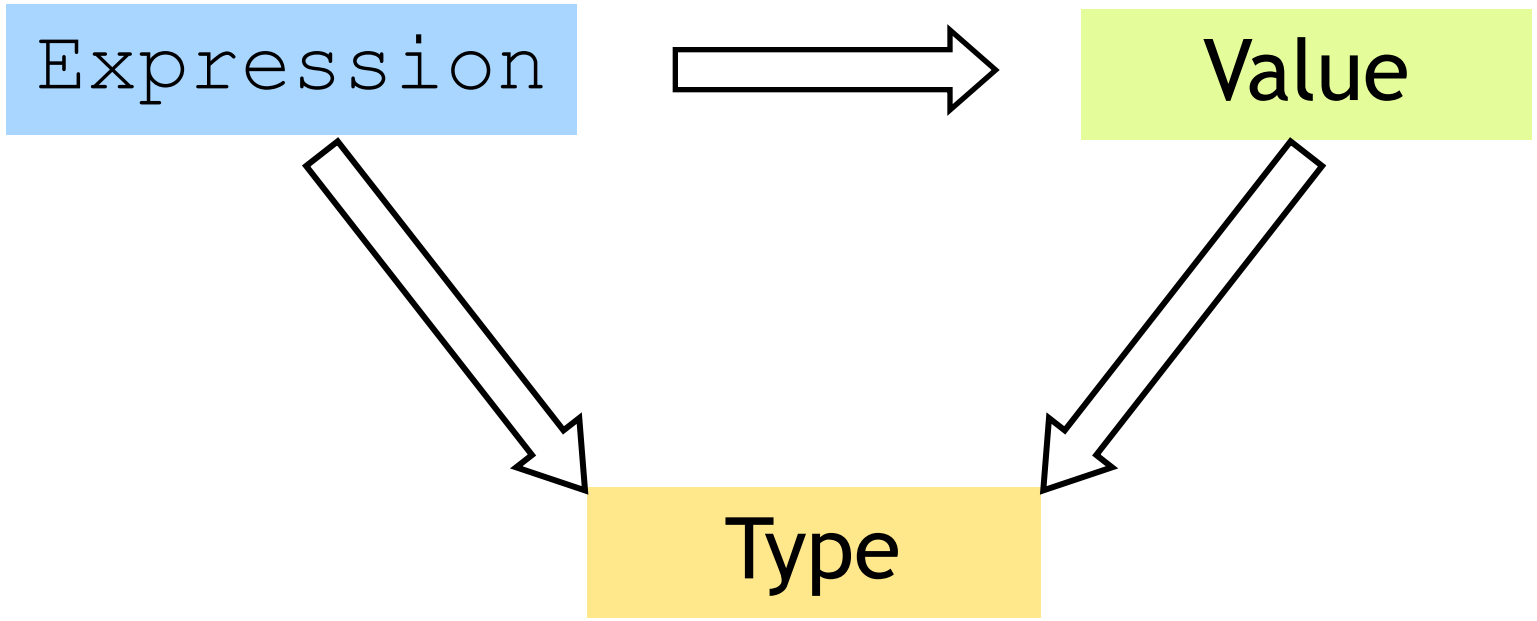
ML: History, Variants

"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

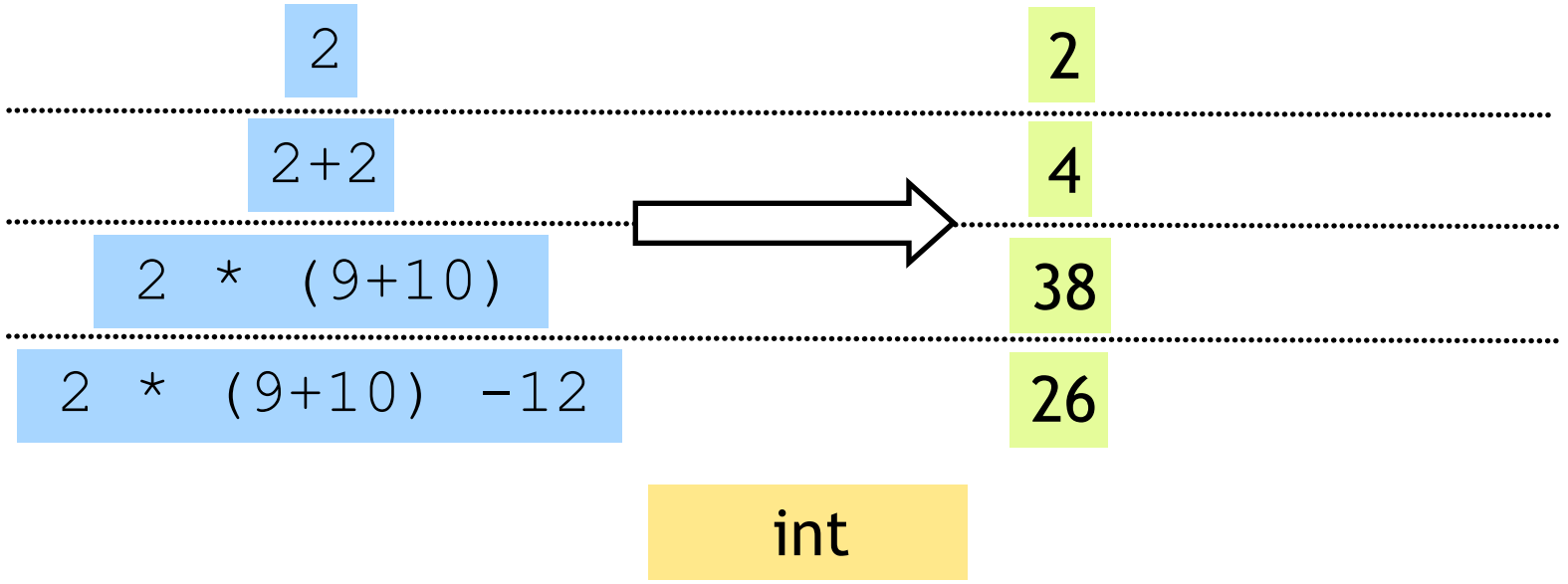
"Read-Eval-Print" Loop

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 ?

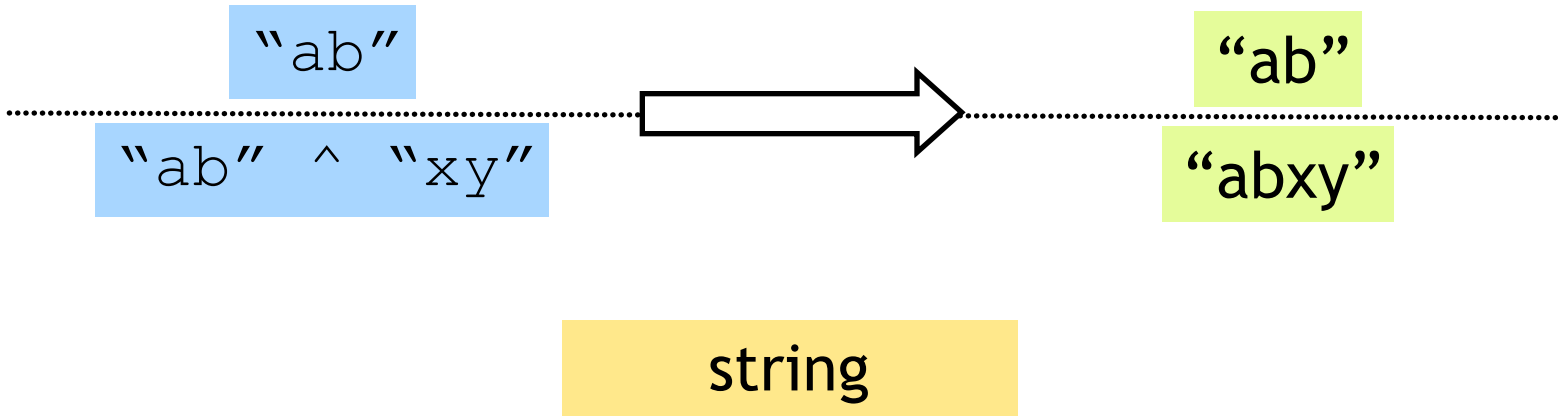
Base type: Integers



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

- +, -, *
- div, mod

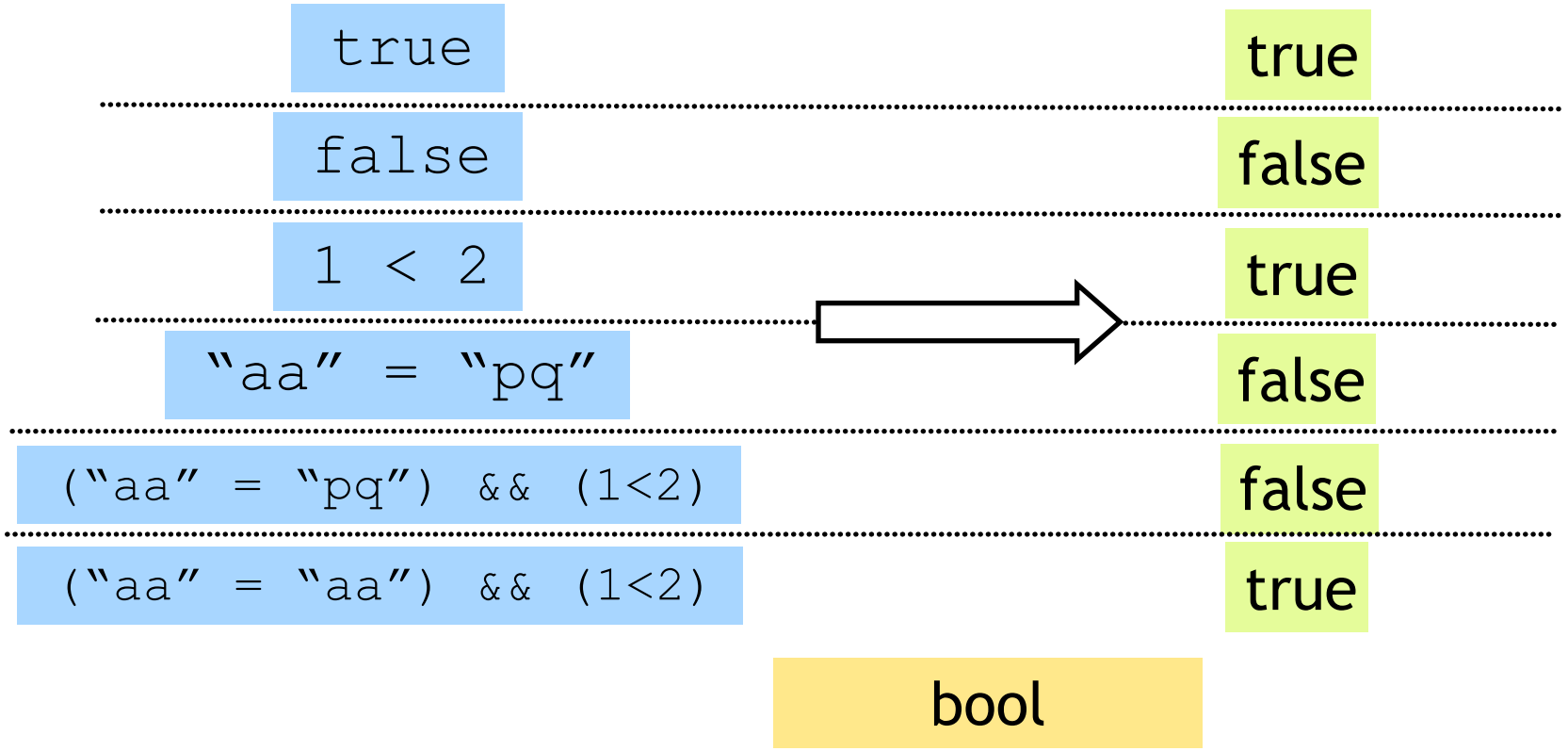
Base type: Strings



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
```

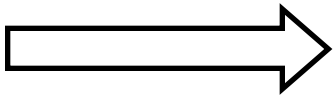
```
(2 + "a")
```

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);
```

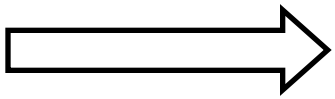


(4,false)

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 …

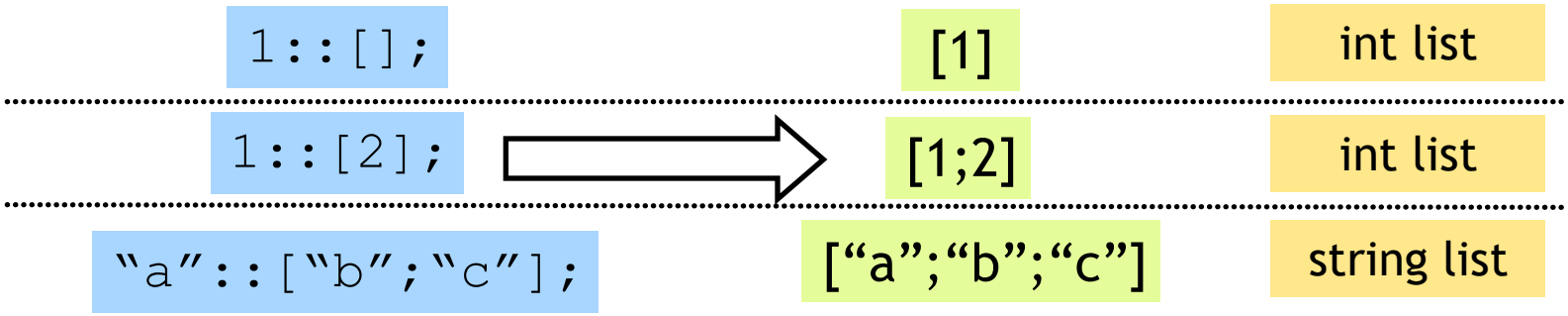
Complex types: Lists

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

All elements must have same type

Complex types: Lists

List operator “Cons” ::

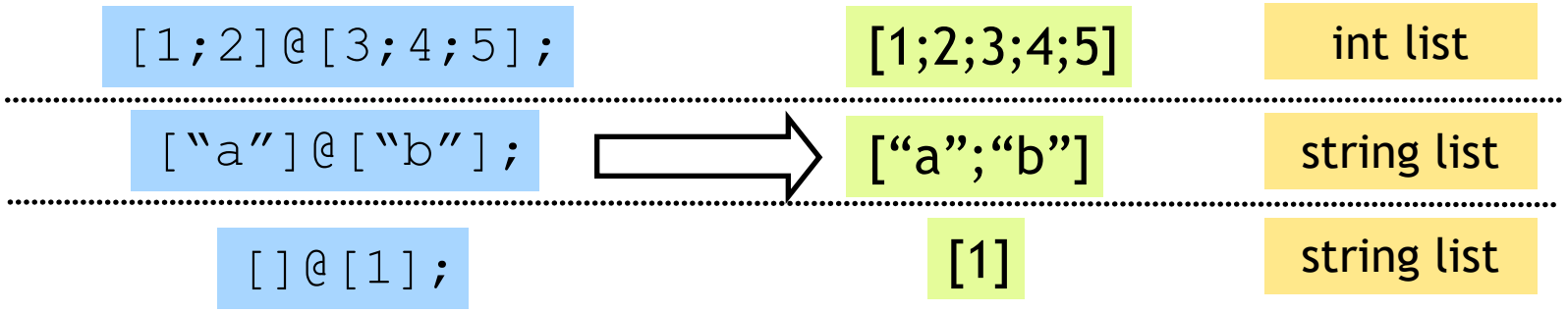


Can only “cons” element to a list of same type

```
1::[“b”; “cd”];
```

Complex types: Lists

List operator “Append” `@`



Can only append two lists

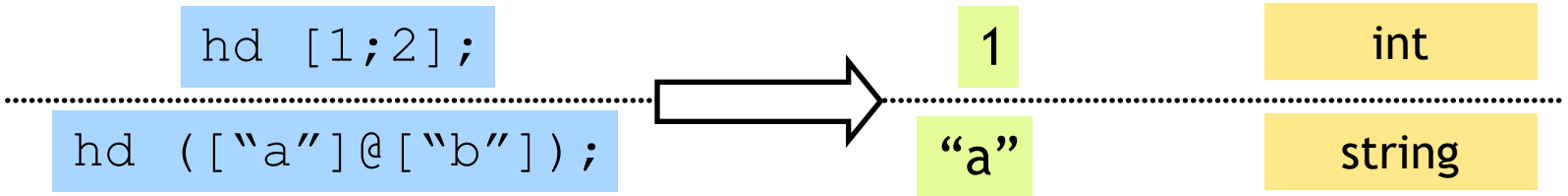
```
1 @ [2;3];
```

… of the same type

```
[1] @ [“a”;“b”];
```

Complex types: Lists

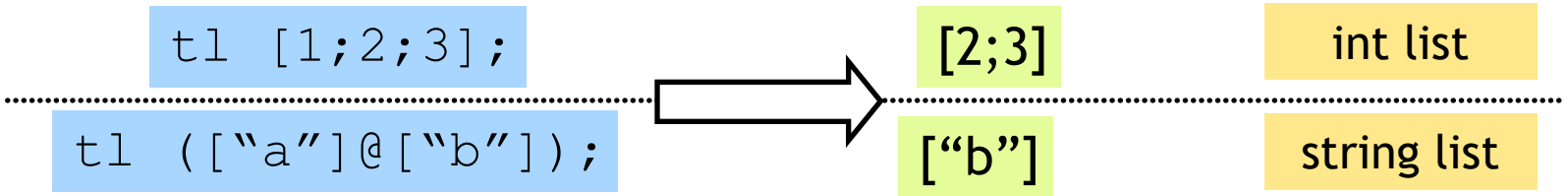
List operator “head” `hd`



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 ?