# CSE 341: Programming Languages

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Lecture 3— Lack of Mutation, let bindings, options

# List Review

- Build lists: `[]`, `::`, and shorthand `[e1,e2,...,en]`
- Use lists: `null`, `hd`, `tl`
- Types: Each list has elements of the same type. Examples:

```
int list
(int*int) list
((int*int) list) list
```

- So what are the typing rules for `[]`, `::`, `null`, `hd`, and `tl`?
- Functions that build or use lists are usually recursive
  - And/or use other recursive functions
  - Elegant algorithms by “thinking high-level” (e.g., append)

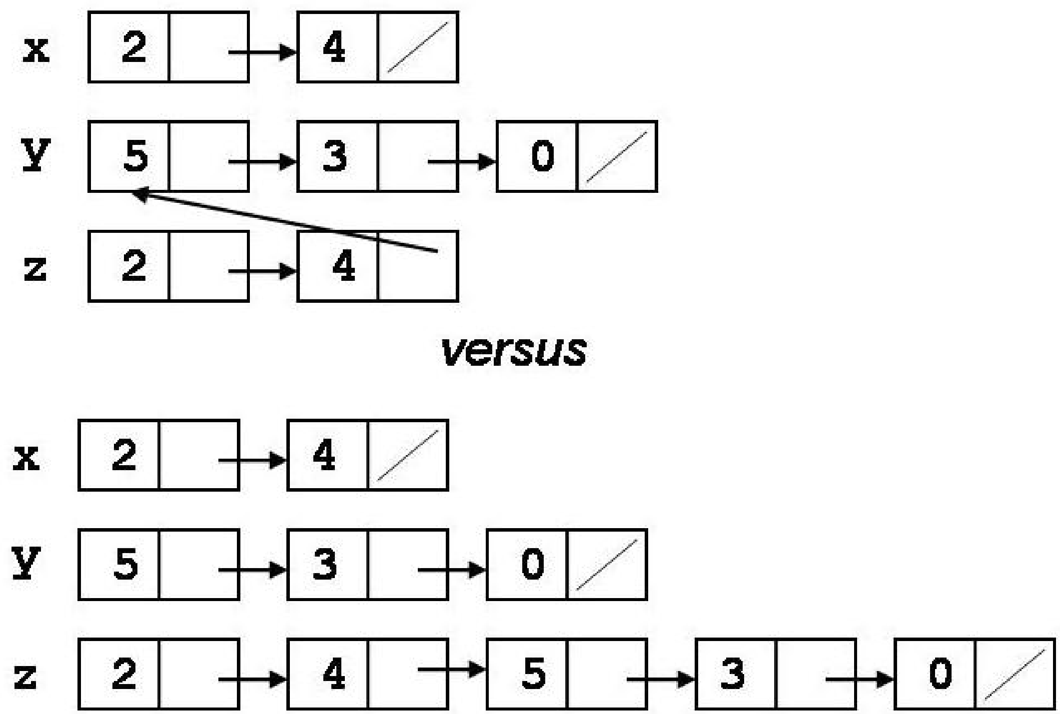
# Sharing

Recall `append([2,4],[5,3,0])` evaluates to `[2,4,5,3,0]`.

Similarly, `tl [9,7,4,2]` evaluates to `[7,4,2]`.

Do the results *share*, i.e., *alias* the arguments?

Example: `val x=[2,4]; val y=[5,3,0]; val z=append(x,y)`



# Sharing, good or bad?

Java programmer's view:

- A never-ending *obsession* with what is shared. This obsession is *necessary* because everything is mutable.
- Sharing is wrong if you don't want a mutation of "one list" to "affect the other" and right if you do.
- So sometimes make copies just to avoid sharing in case some other code might do a mutation.

# Sharing, good or bad?

ML programmer's view:

- It is actually *impossible* to tell if there is sharing or not!
- So stop worrying and just write append; all lists `[2,4,5,3,0]` behave the same no matter what they do or do not share with.
- Amount of sharing is just a "space optimization"
  - Usually good to share.
  - `tl` shares, which makes it very fast ($\boldsymbol{O(1)}$).

# Let bindings

Motivation: Functions without local variables can be poor style and/or really inefficient.

Syntax: `let b1 b2 ... bn in e end` where each `bi` is a *binding*.

Typing rules: Type-check each `bi` and `e` in context including previous bindings. Type of whole expression is type of `e`.

Evaluation rules: Evaluate each `bi` and `e` in environment including previous bindings. Value of whole expression is result of evaluating `e`.

Elegant design worth repeating:

- Let-expressions can appear anywhere an expression can.
- Let-expressions can have any kind of binding.
  - Local functions can refer to any bindings *in scope*.
  - Better style than passing around unchanging arguments.

# More than style

Exercise: hand-evaluate `bad_max` and `good_max` for lists, `[3,2,1]`, `[1,2]`, and `[1,2,3]`.

Moral: Repeating expensive (recursive) computations is not just bad style; it is the wrong algorithm performance-wise.

# Options

"Options are like lists that can have at most one element."

- Create a `t option` with `NONE` or `SOME e` where `e` has type `t`.
- Use a `t option` with `isSome` and `valOf`

Why not just use lists? An interesting style trade-off:

- Options better express purpose, enforce invariants on callers, maybe faster.
- But cannot use functions for lists already written.

# Summary and general pattern

Major progress: recursive functions, pairs, lists, let-expressions, options

Each has a syntax, typing rules, evaluation rules.

Functions, pairs, lists, and options are very different, but we can describe them in the same way:

- How do you create values?
  - function definition; pair expressions; `[]` and `::`; `NONE` and `SOME`
- How do you use values?
  - function application; `#1` and `#2`; `null`, `hd`, and `tl`; `isSome` and `valOf`

Soon: much better ways to use pairs and lists (pattern-matching)