Jumbo ML

Language Support for CS2

Norman Ramsey

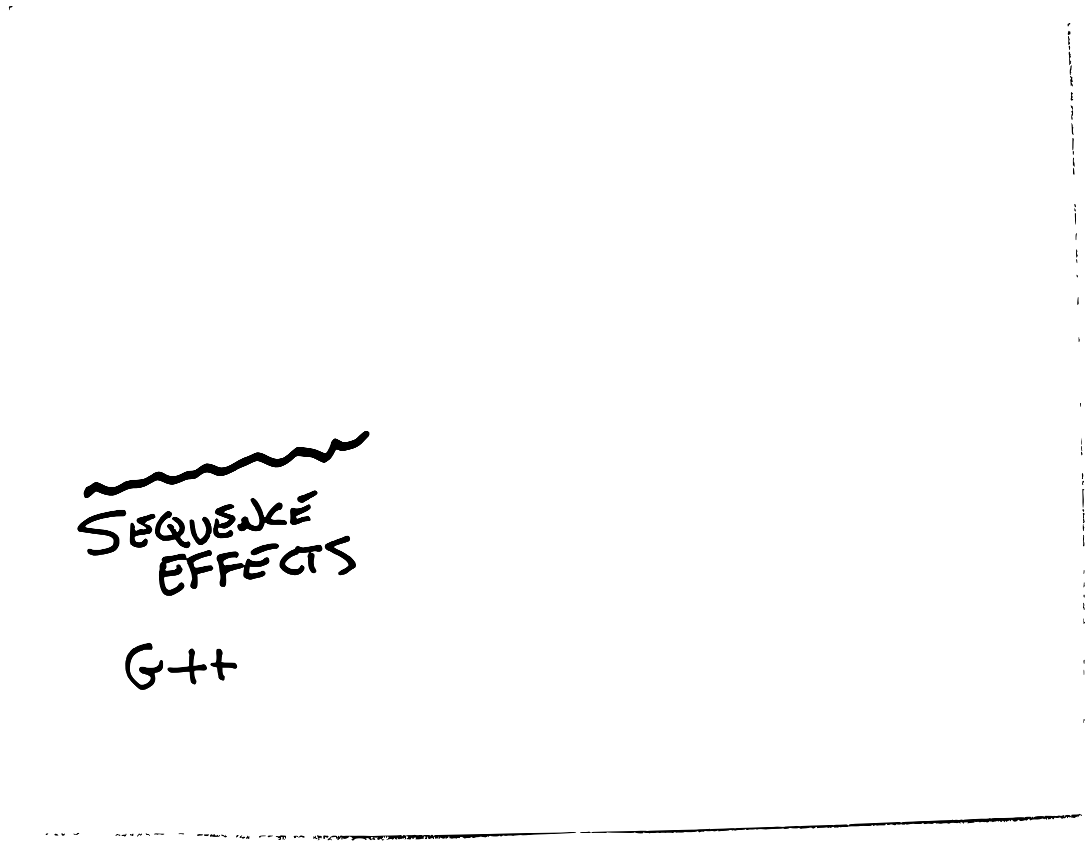
Tufts University

Jumbo ML addresses two problems

Support for curricular revision

Sandbox for beginning research students

Status quo ante contains a cliff



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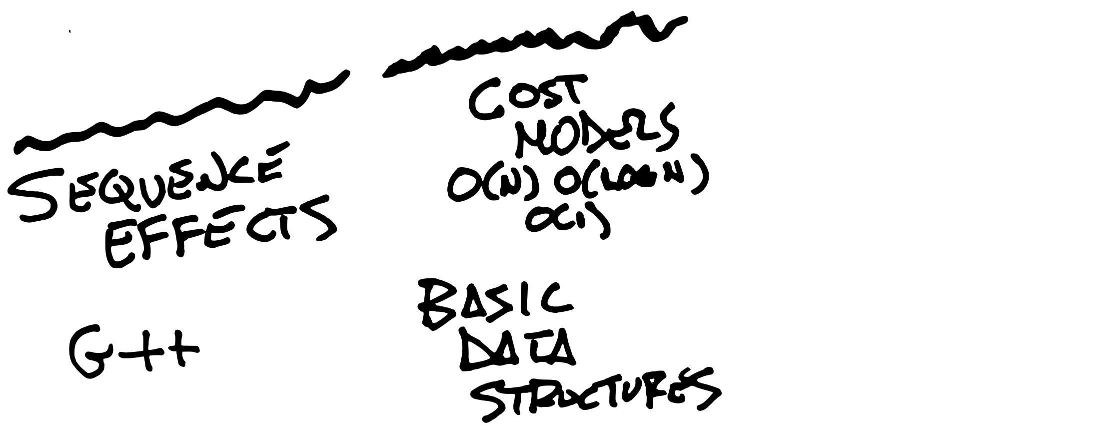

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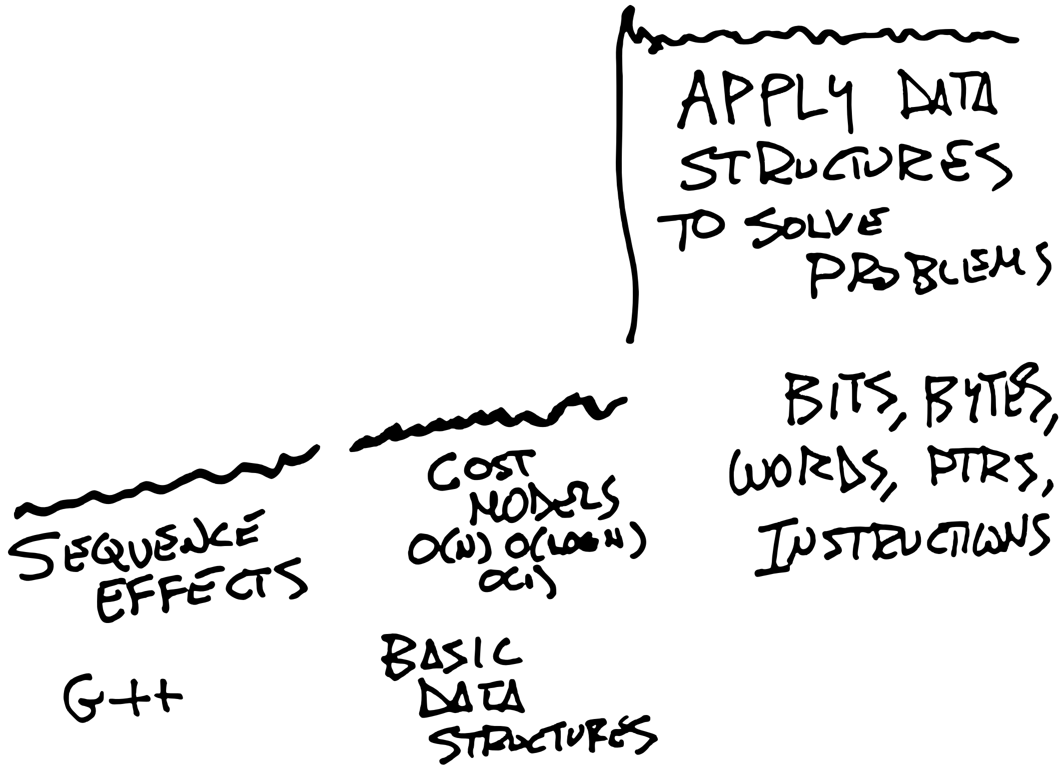

Cliff shows in projects

CS3: Black-edge removal:  => 

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CS3: Black-edge removal:  => 

JPEG compression/decompression

Attack cliff with baby steps

CS2: ***Song Search***

CS3: Black-edge removal:  **=>** 

JPEG compression/decompression

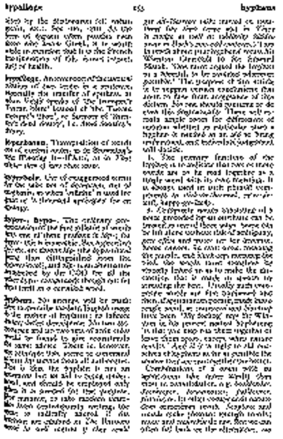
Attack cliff with baby steps

CS1: What language is this web page? (*Trigrams*)

CS2: *Song Search*

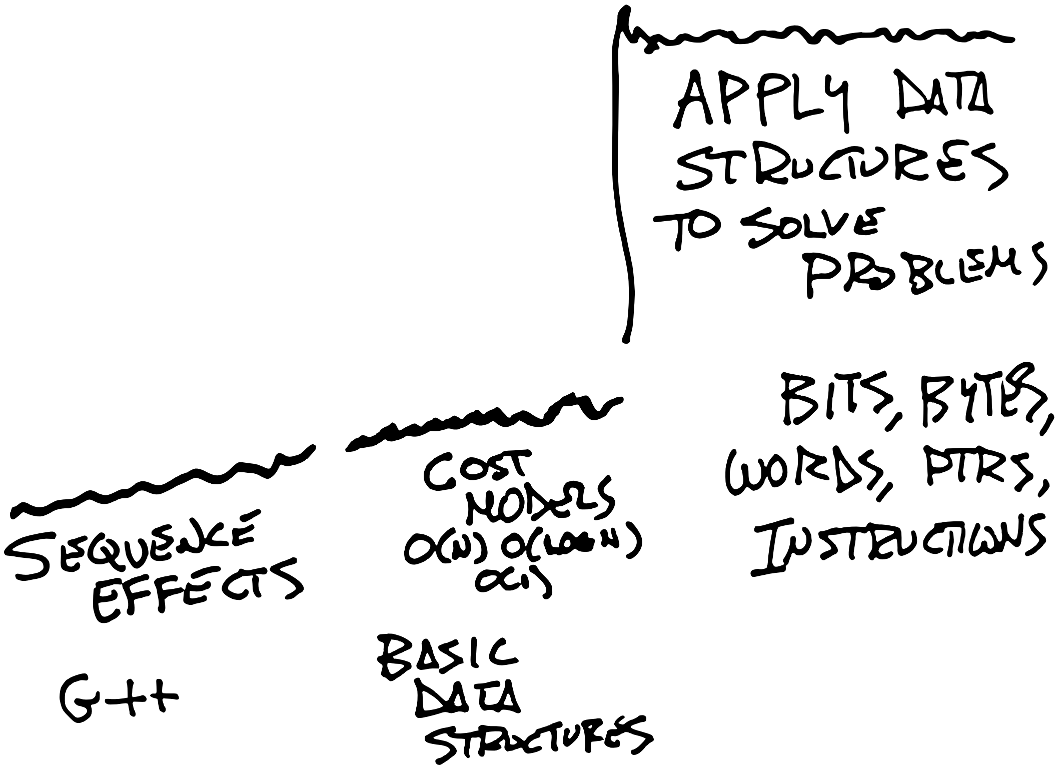
CS3: Black-edge removal:

=>

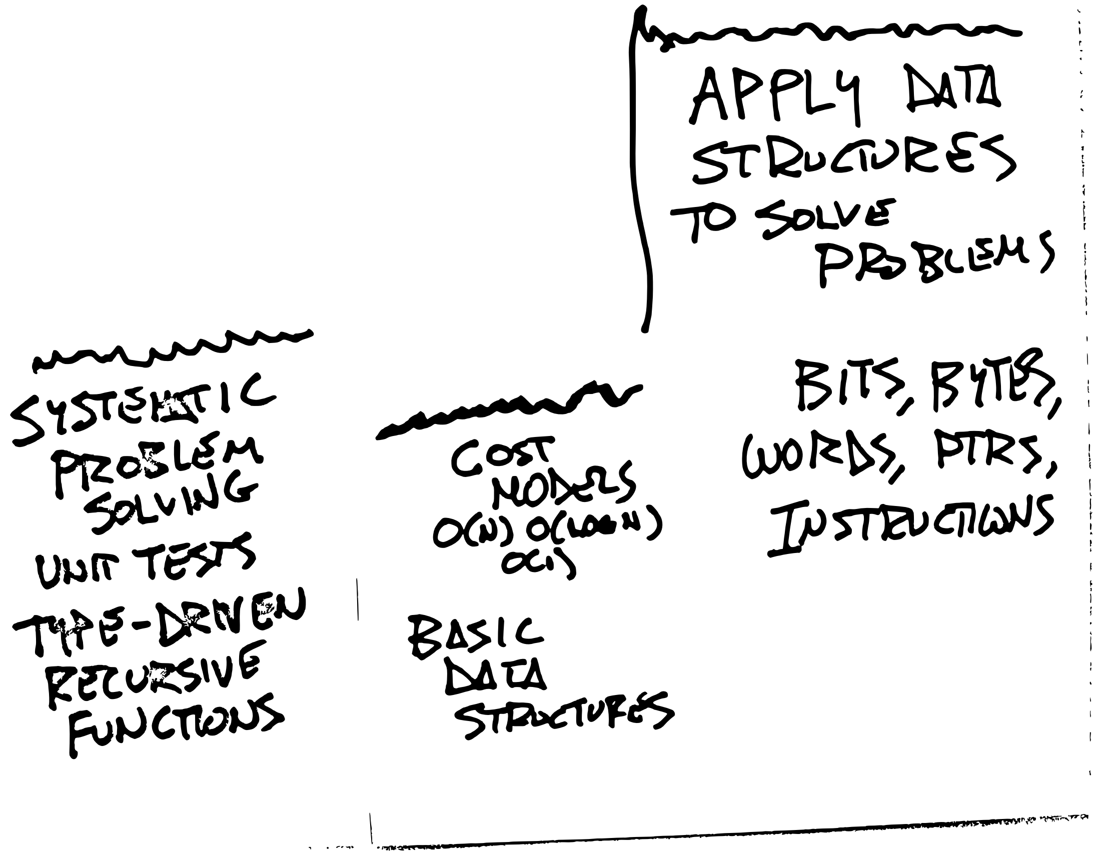


JPEG compression/decompression

The cliff is still there



To reduce cliff, shift learning goals



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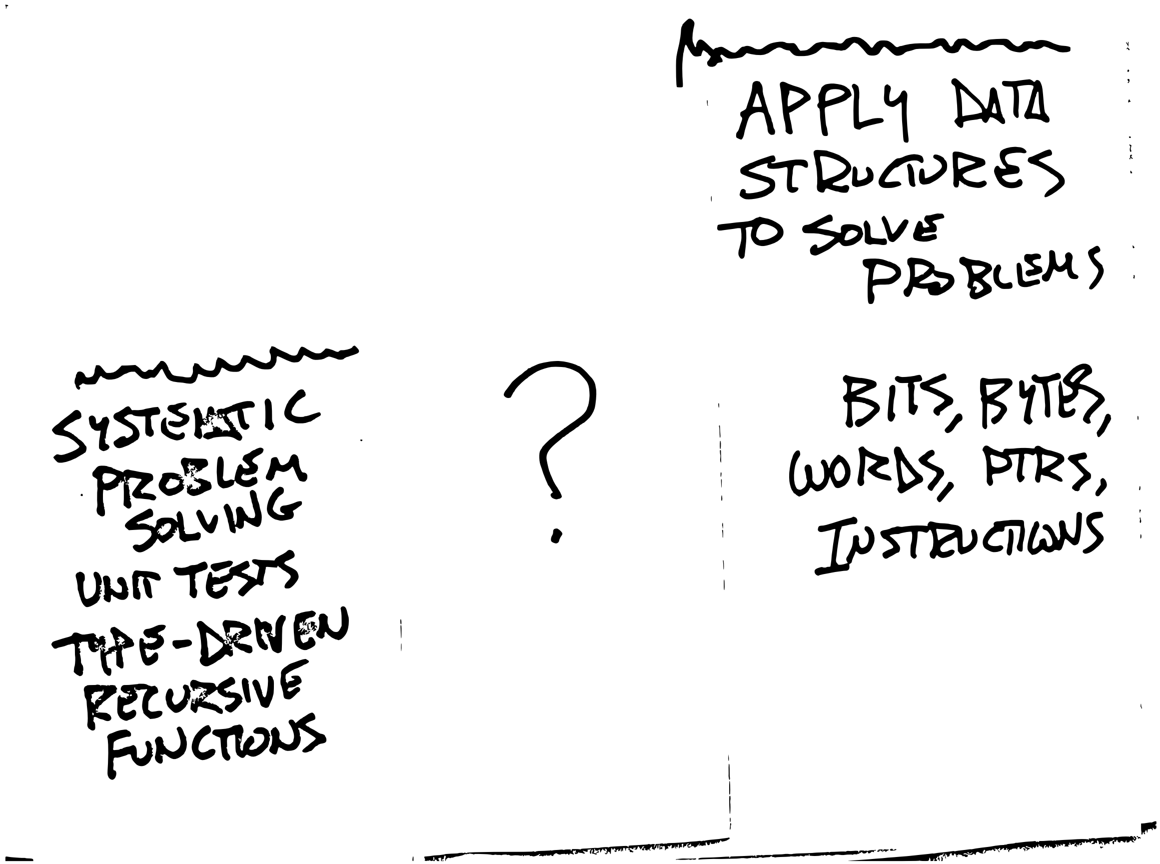

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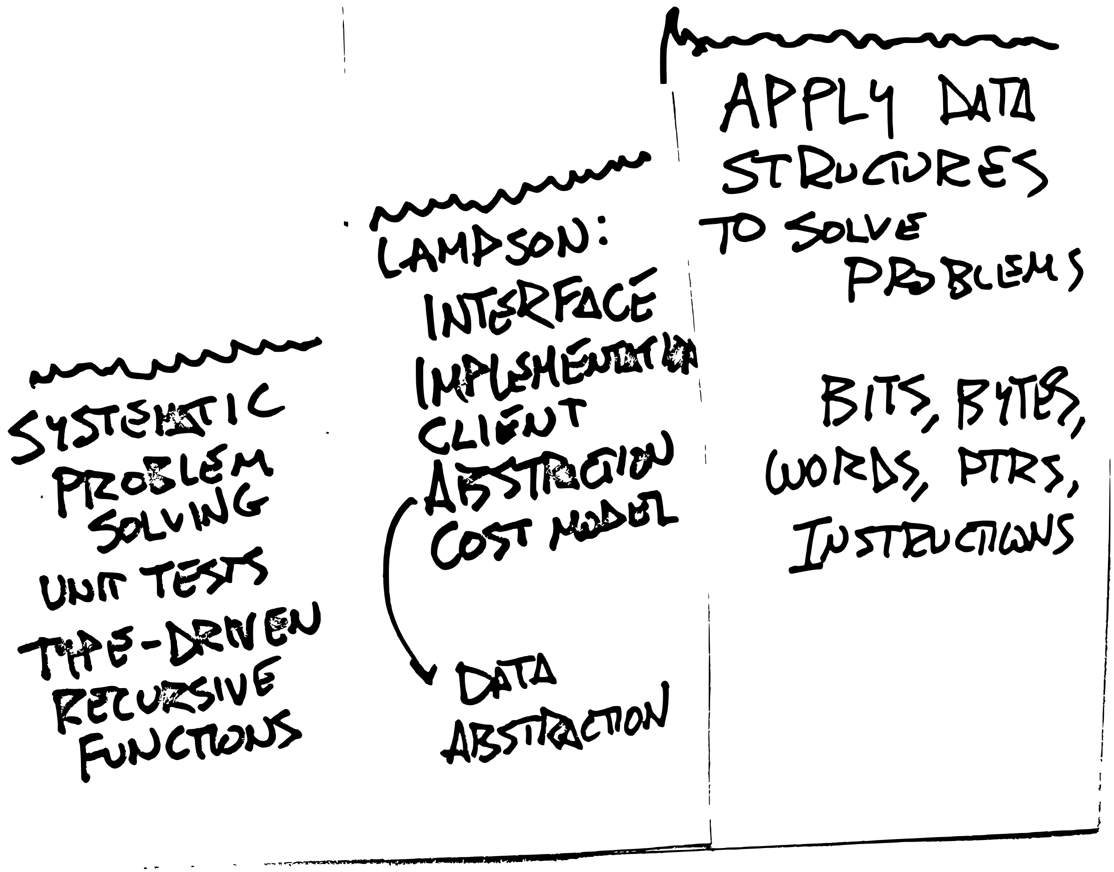

Top learning goals for CS2

Dip toes into Butler Lampson’s pool

A design is a collection of interfaces

Data structures not on stone tablets

Abstraction + cost model = data structure

Supported by what language?

Learning goals drive language needs

Separately compiled interfaces (w/static types)

Code against interfaces that aren't yet implemented

Data abstraction

Perspicuous cost model

Bridge teaching languages $\longrightarrow$ industrial languages

Standard ML isn’t simple enough

Problems already encountered in our teaching:

- **Core language lacks type signatures**
- **Concrete syntax has traps and pitfalls**
- **Allocation costs aren’t so obvious**
- **In polymorphic types, `forall` is implicit**
- **Value restriction baffles students**
- **Fibration (`where type t = t`) *really* baffles ’em**

Simplicity looks like *SL

Beginning Student Language:

- **Type is *atomic data*, *sum*, or *named product***
- **Syntax is**

$$
\begin{aligned}
\textit{exp} \Rightarrow\ & x \\
\mid\ & v \\
\mid\ & (x\ \textit{exp}_1 \ldots \textit{exp}_n) \\
\mid\ & (\texttt{cond}\ \{(\textit{exp}\ \textit{exp})\}\ [(\texttt{else}\ \textit{exp})]) \\
\mid\ & (\texttt{and}\ \textit{exp}\ \textit{exp}) \mid (\texttt{or}\ \textit{exp}\ \textit{exp}) \\
\textit{def} \Rightarrow\ & (\texttt{define}\ (x\ x_1 \ldots x_n)\ \textit{exp}) \\
\mid\ & (\texttt{define}\ x\ \textit{exp}) \\
\mid\ & (\texttt{define-struct}\ x\ (x_1 \ldots x_n)) \\
\mid\ & \textit{unit-test}
\end{aligned}
$$

Simplicity looks like *SL

Intermediate Student Language (with lambda) adds

- **First-class functions**
- **Let-bindings**

Add *arrow types*

Add these terms:

$$\begin{array}{rcl} \textit{exp} & \Rightarrow & \texttt{(}\textit{exp}\ \textit{exp}_1 \ldots \textit{exp}_n\texttt{)} \\ & | & \texttt{(lambda (}x_1 \ldots x_n\texttt{)}\ \textit{exp}\texttt{)} \\ & | & \texttt{(local (}\{\textit{def}\}\texttt{)}\ \textit{exp}\texttt{)} \end{array}$$

“Systems thinking” needs more complexity

Consensus irreducible complexity:

terms	types
definitions	declarations
modules	module types

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Hidden irreducible complexity?

Compilation unit?

Component?

Program?

Let’s talk

Facing many decisions:

- **Definitions: letrec, let-star, or “mostly letrec”?**
- **What should sum types look like?**
  What about pattern matching?
- **Include exceptions? What kind?**
- **How to reflect purity in types?**
- **Components: modules, mixins, units?**

Sequencing definitions matters

Let-star (ML), letrec (Haskell), “mostly letrec” (Scheme):

	ML	Haskell	Scheme
Teach def before use	✓	☹	✓
Easy type inference	✓	✓	?
Easy core type signatures	☹	✓	?
Easy mutual recursion	☹	✓	✓
Simple theory	✓	✓	☹

This week: understand Scheme model better

Pattern matching should be restricted

Decided:

- **No anonymous tuples or flex records (want constructor function for allocation)**
- **Pattern matching only in `case`**
- **No pattern matching on products?**

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- Pattern matching only in `case`
- No pattern matching on products?

Known problems with algebraic data types:

- Pattern matching militates against abstraction
- Bundle sum tagging with recursion, generativity

Wanted: simpler sums

Goals, ideas:

- “Mostly letrec:” all types (mutually) recursive
- Unbundled generativity (Modula-3 `BRANDED`)
- Keep checks for exhaustive, redundant patterns?

What should sum elimination look like?

- ML-like with a binding construct?
- CLU-like with selector functions?

Exceptions come in many flavors

From least flexible to most flexible:

- Checked run-time error (C `abort`)
- Checked RTE with recovery (Erlang)
- Alternate return for abstract data type (CLU)
- “Oh dear, I can’t go on” (Haskell)
- Control operator, reflected in type (Java)
- Control operator, anything goes (ML)

CLU has a teaching story. Do others?

Effects should be controlled

Purity claimed as major benefit of Haskell (PJ'03)

BSL, ISL are pure

Purity can eliminate the value restriction

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Jumbo ML needs I/O, mutable data

How? Basic Jumbo ML won't have type classes

- Should it have an IO monad? With `do` notation?
- Would a type-and-effect system be better?

Modules/Components: Too many choices

ML functors: The devil I know

Typed units (Owens and Flatt 2006): Attractive, complex

Backpack (Kilpatrick *et al* 2014): Simpler, less expressive

Many module calculi (Dreyer 2003–2014): Core calculi

This week: get advice, hear war stories

I’m eager to talk

Much more at

`http://www.cs.tufts.edu/~nr/pubs/jml-aug14.pdf`