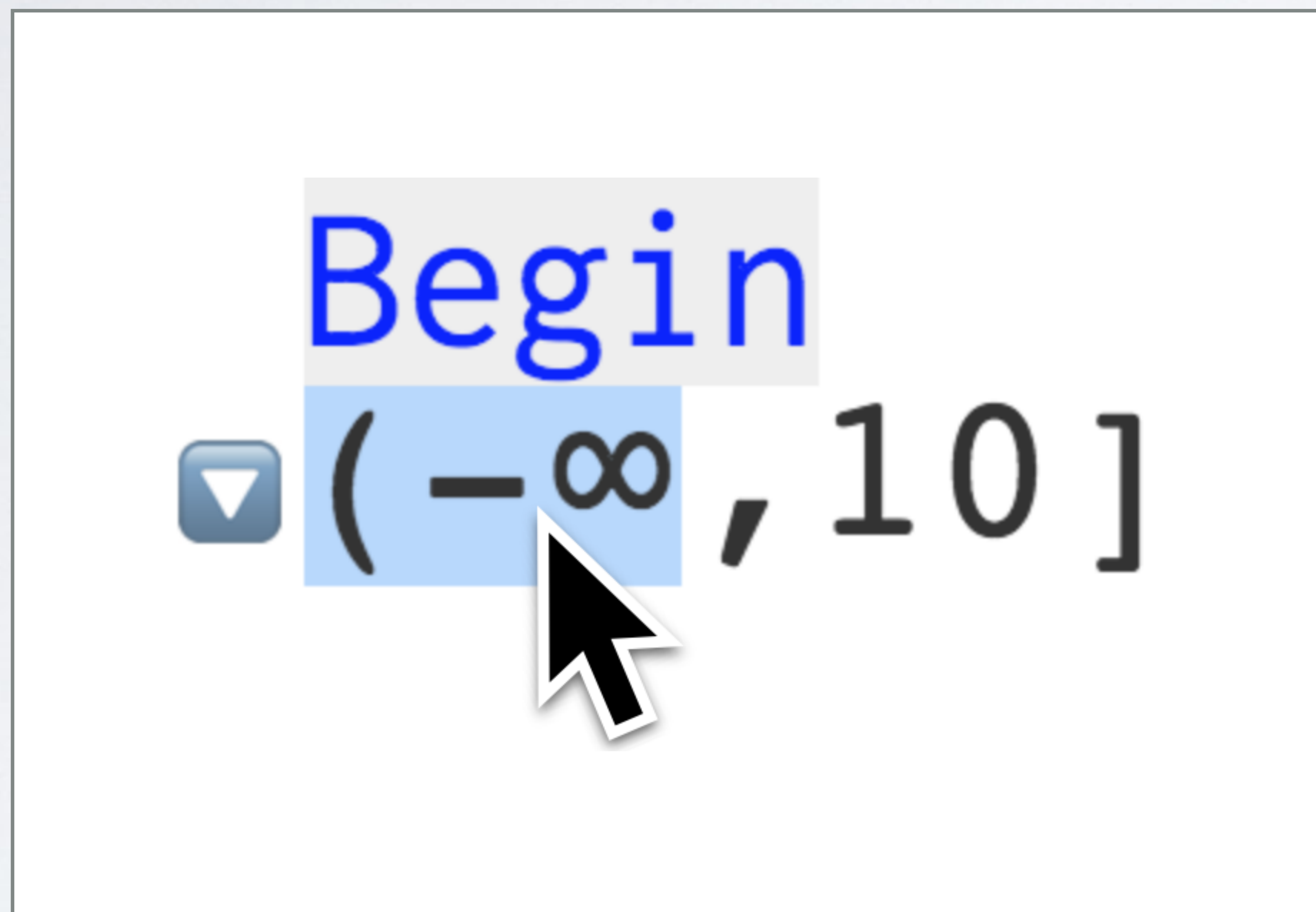
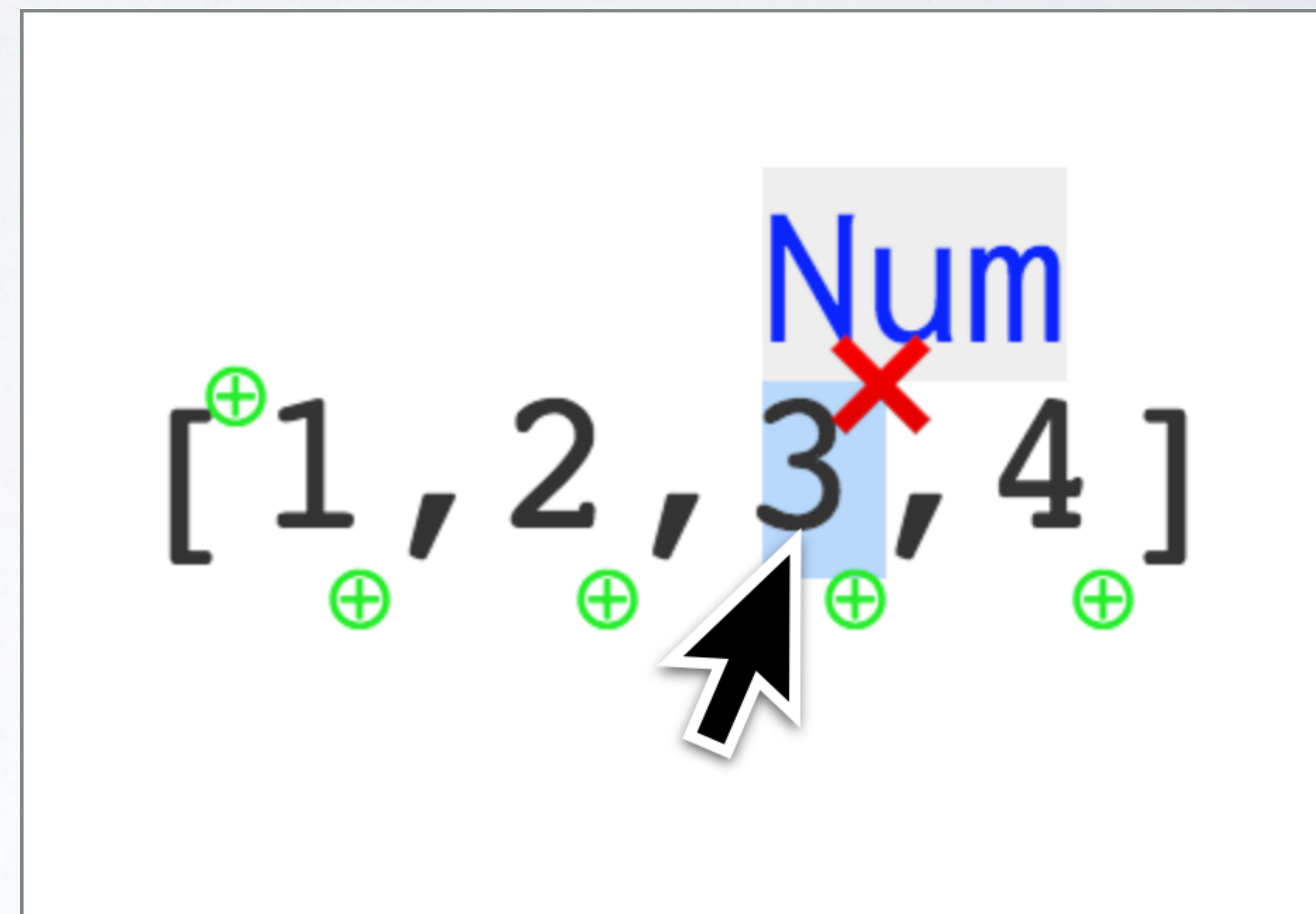
Tiny Structure Editors for Low, Low Prices!

(Generating GUIs from `toString` Functions)





Brian Hempel and Rav

THE UNIVERSITY OF
CHICAGO

```
Interval(NegInf(), Before(10, True()))
```

```
(-∞,10]
```

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Interval(NegInf(), Before(10, True()))

(-∞,10]
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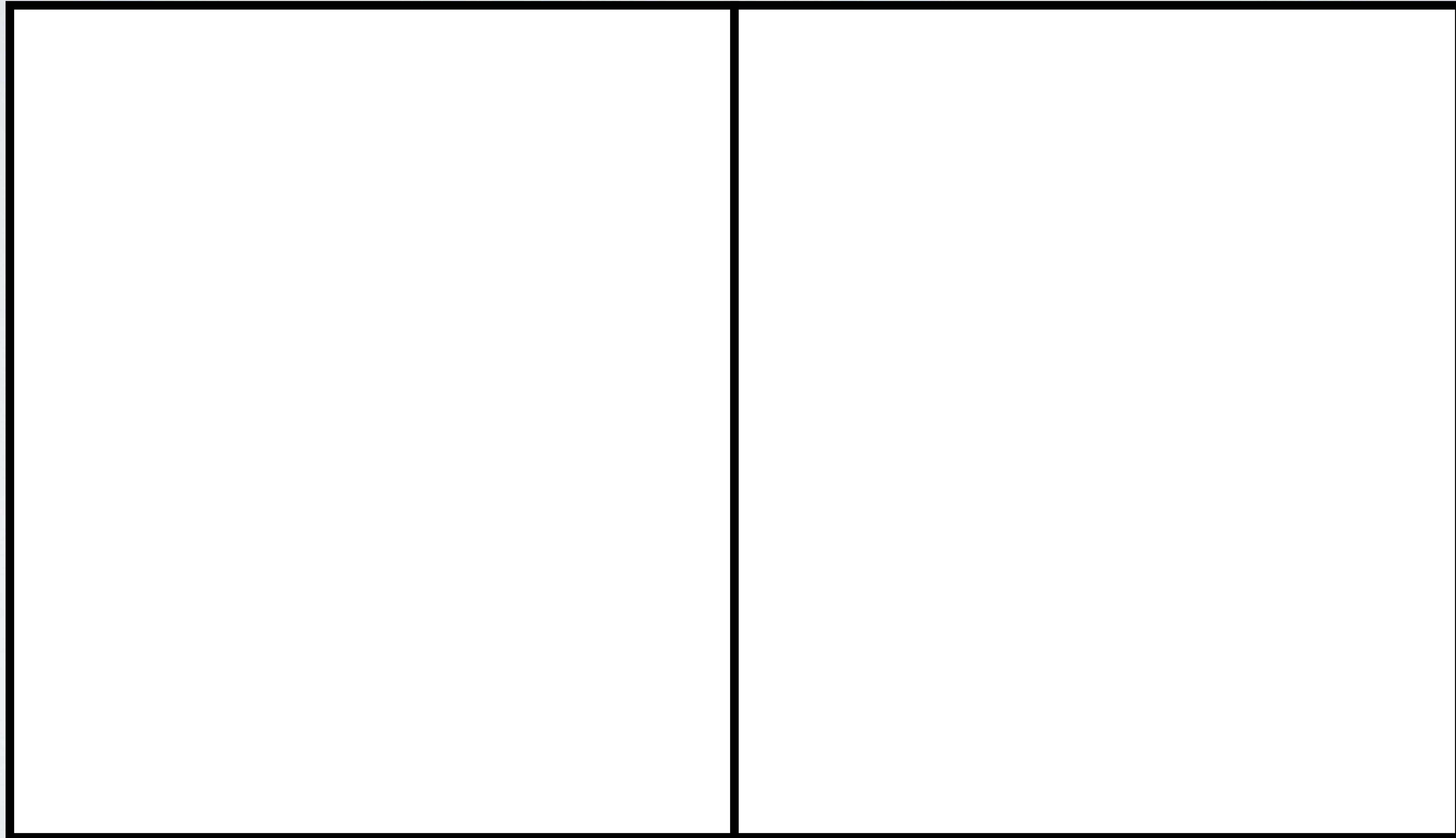
Interval(NegInf(), Before(10, True()))
```

$(-\infty, 10]$

But why?

Long-Term Vision



Long-Term Vision

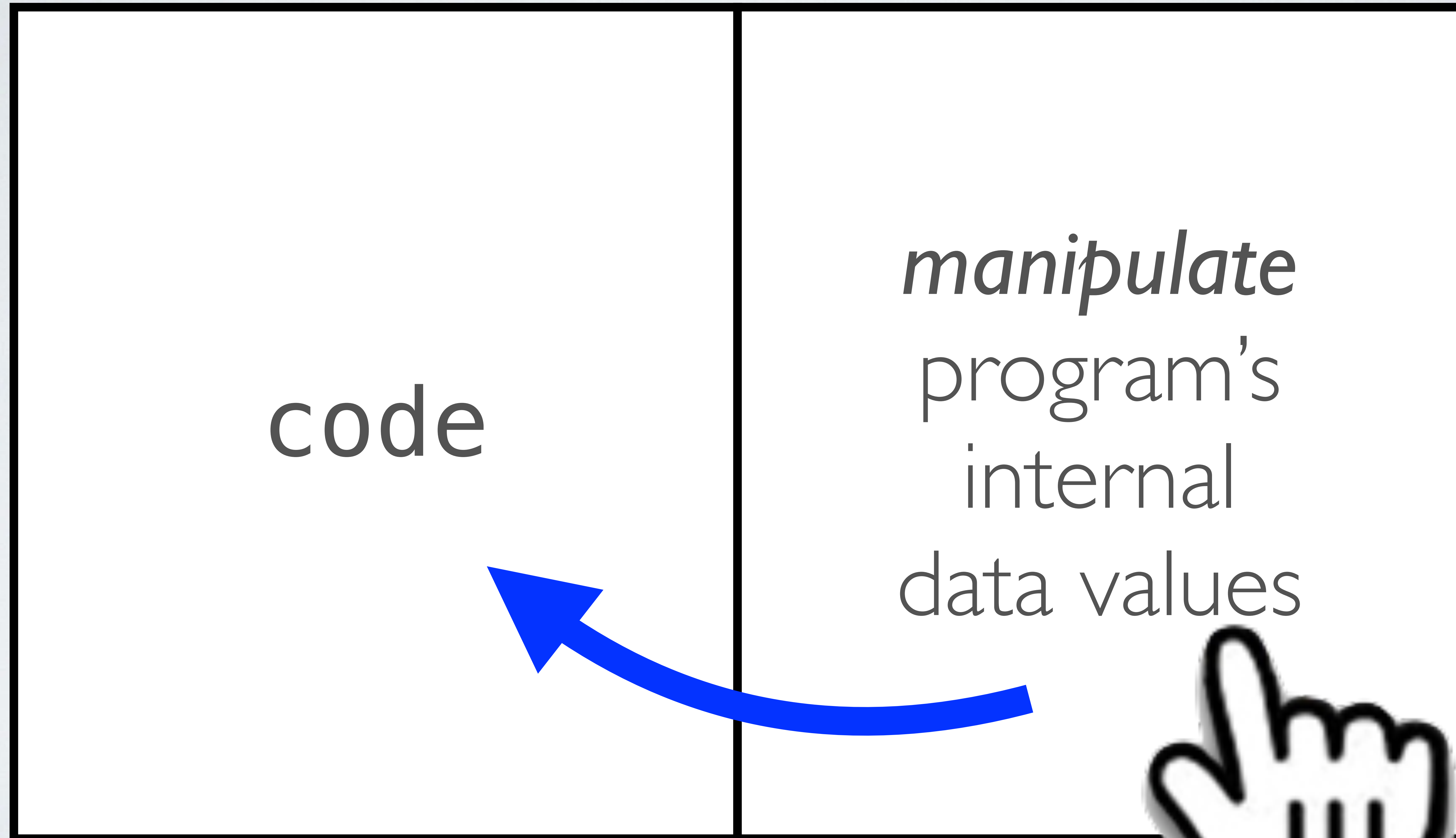
`code`	program's internal data values

Long-Term Vision

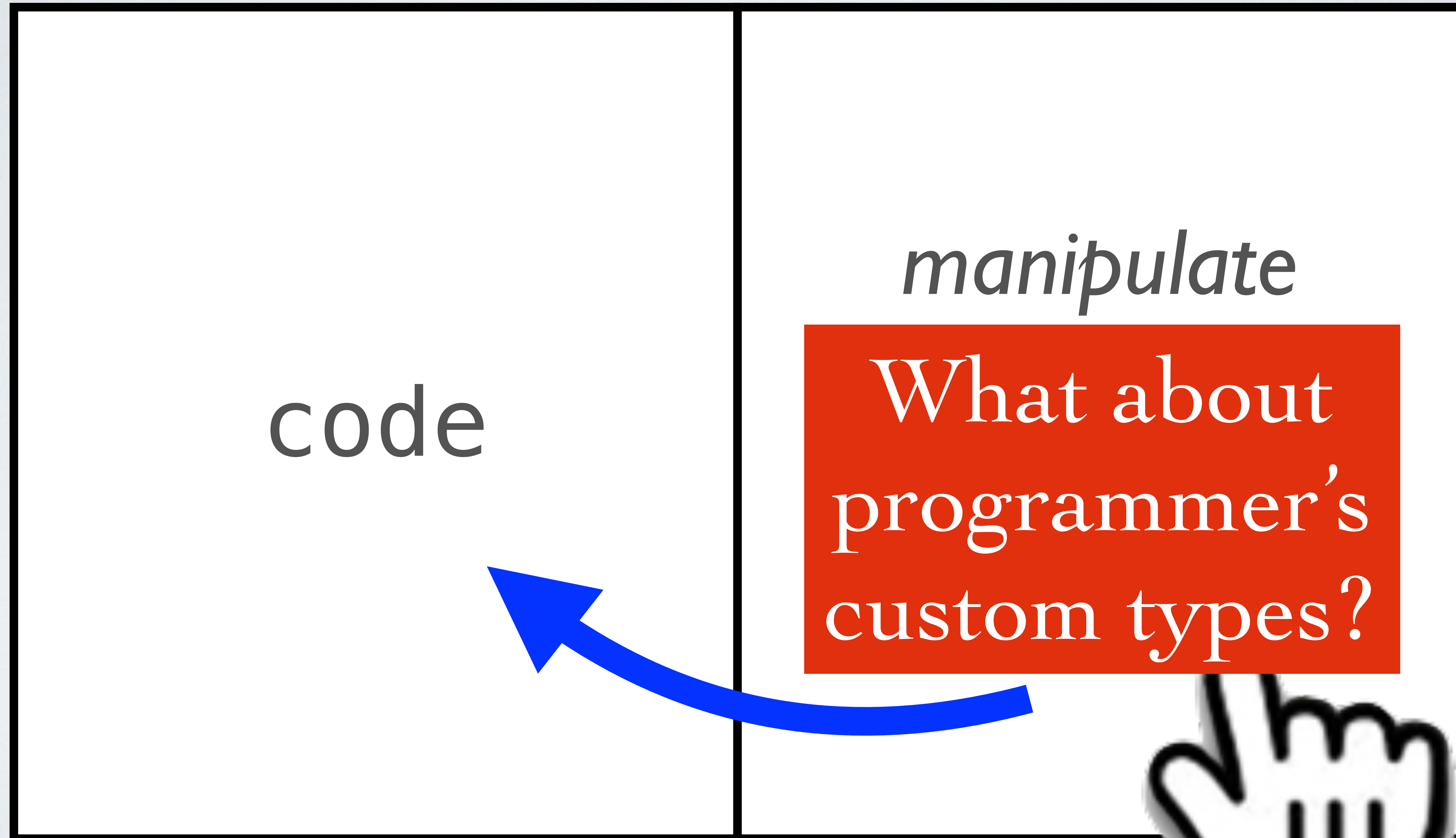
code

manipulate
program's
internal
data values

Long-Term Vision



Long-Term Vision



Manipulable Visualizations for Custom Types?

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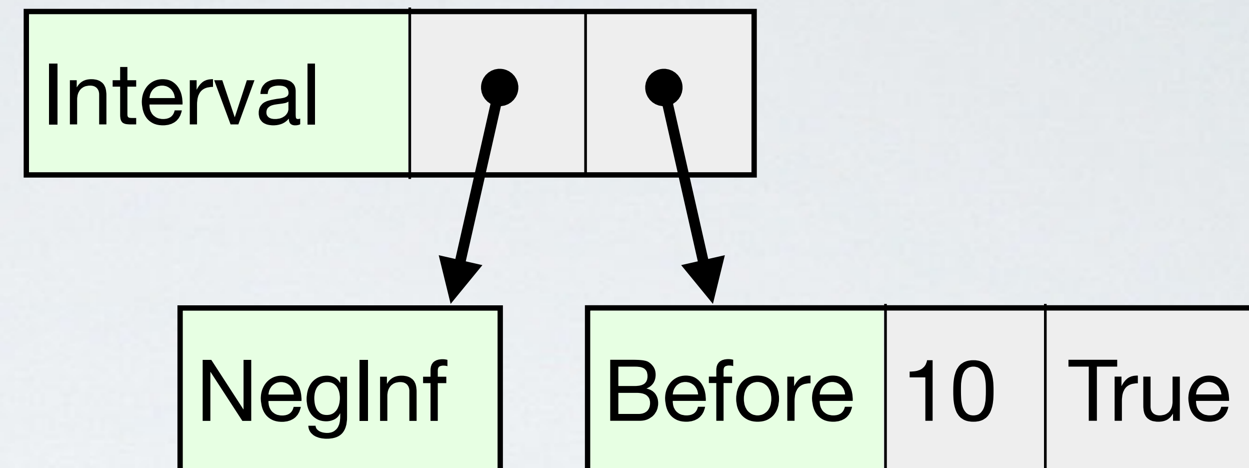
Pointer graph?



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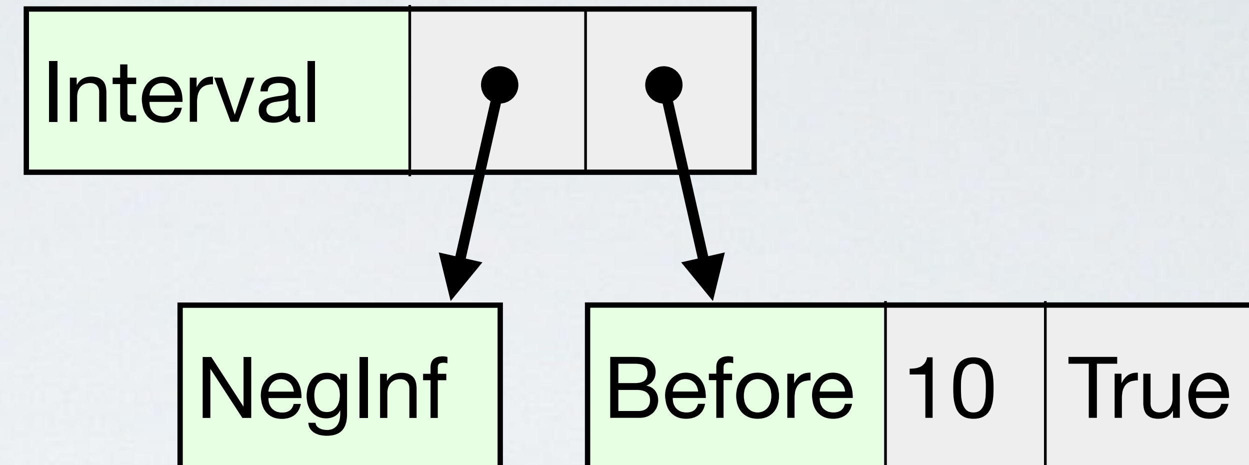

Generic text? `Interval(NegInf(),Before(10,True))`

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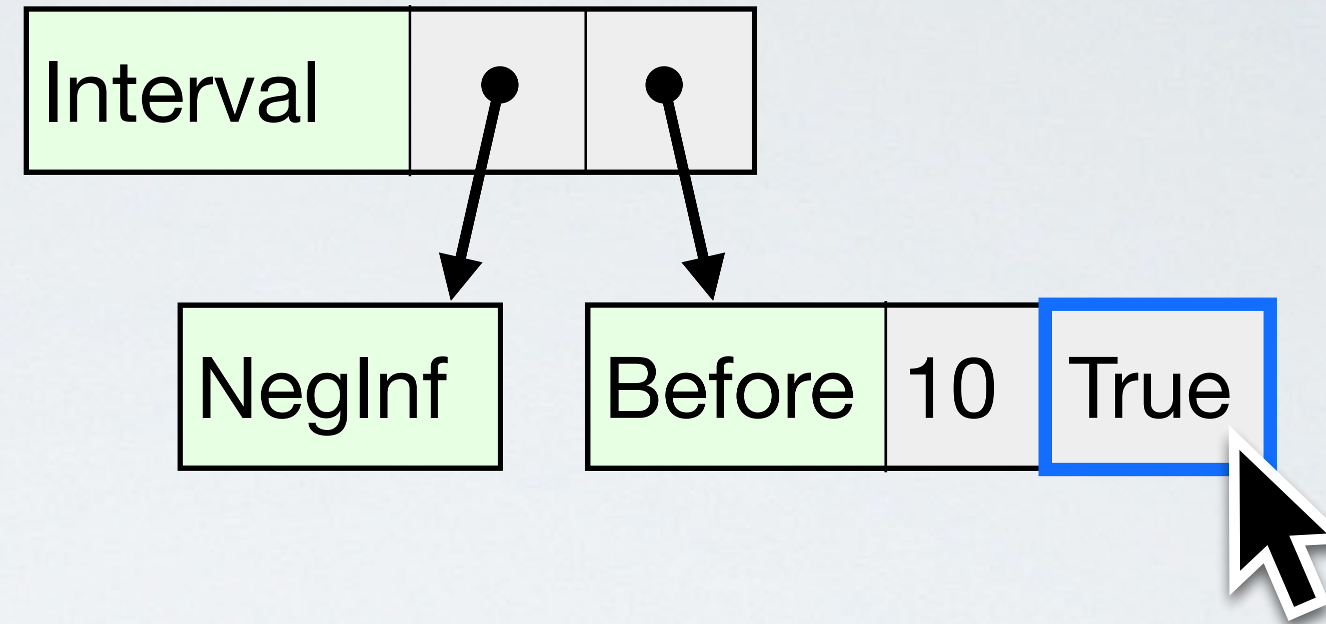

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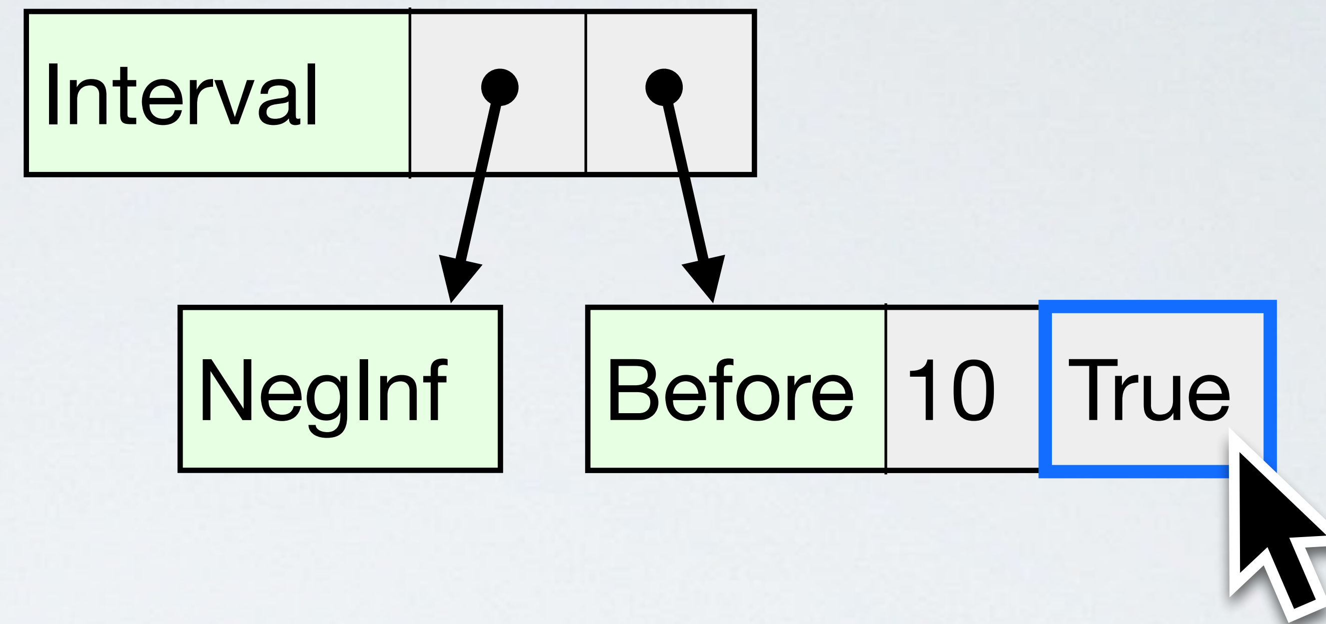

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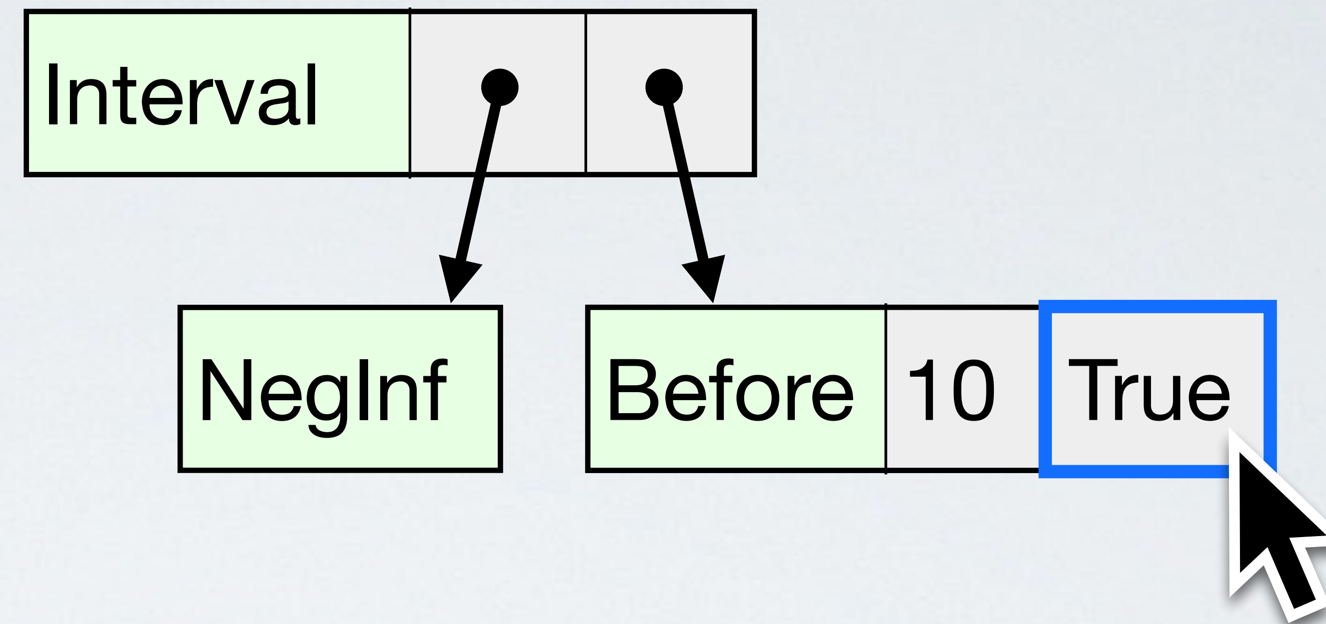

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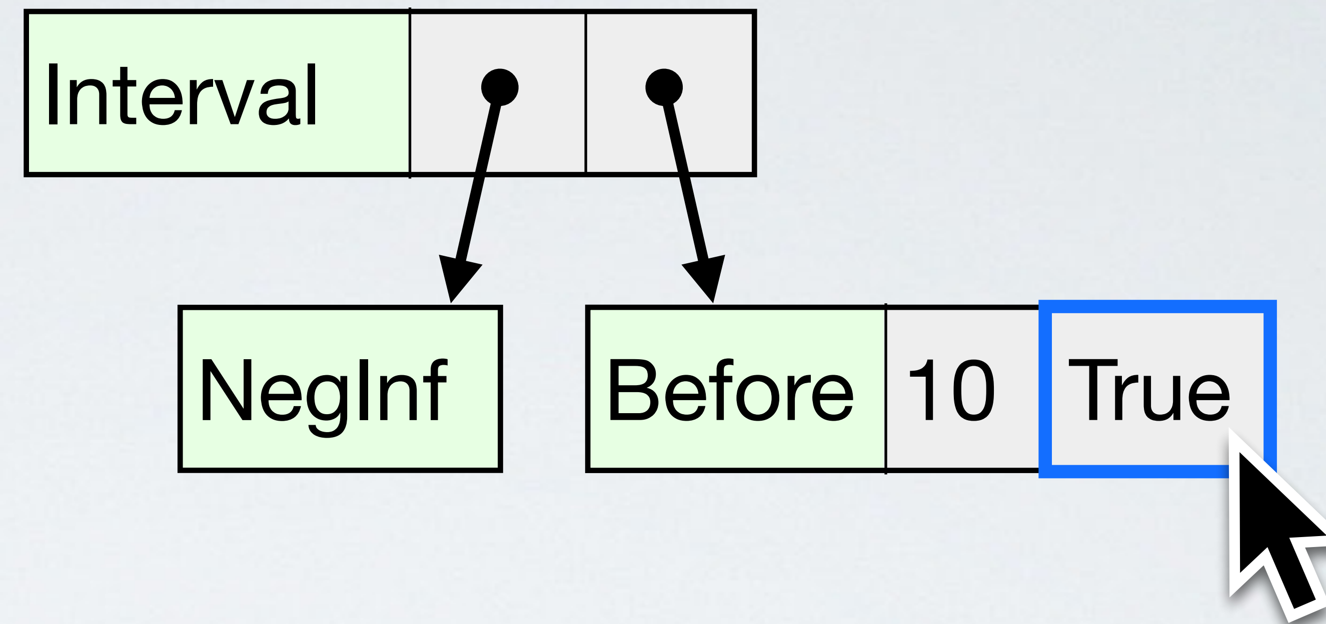

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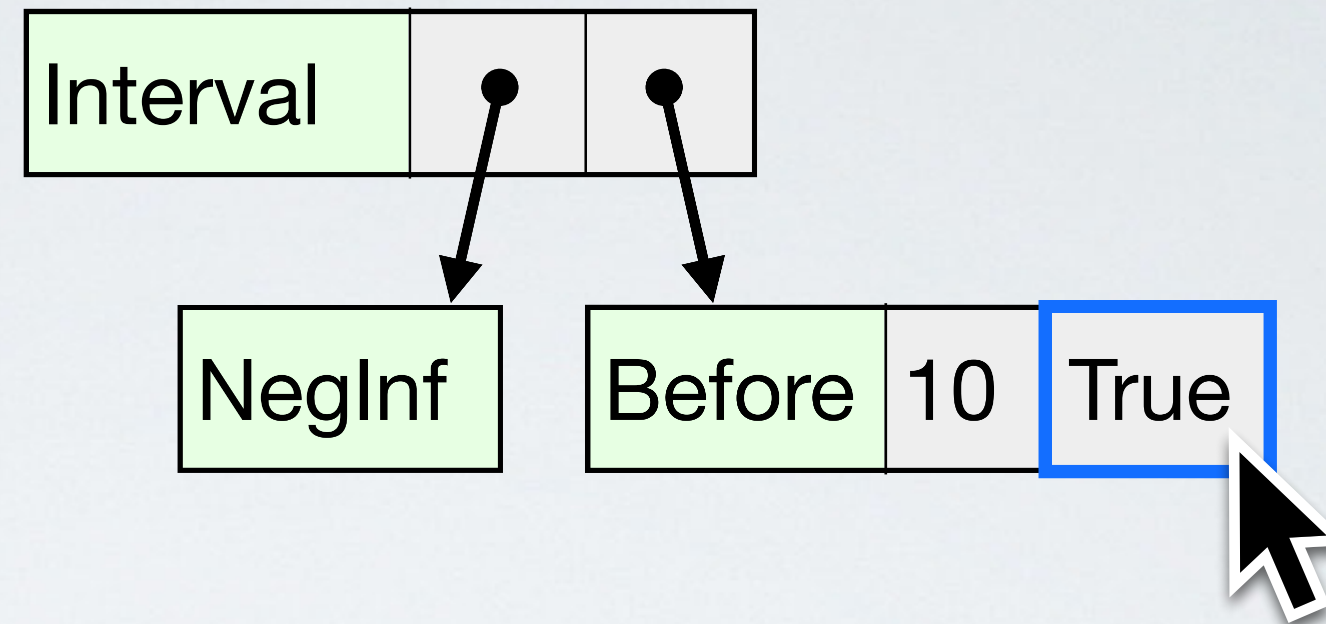

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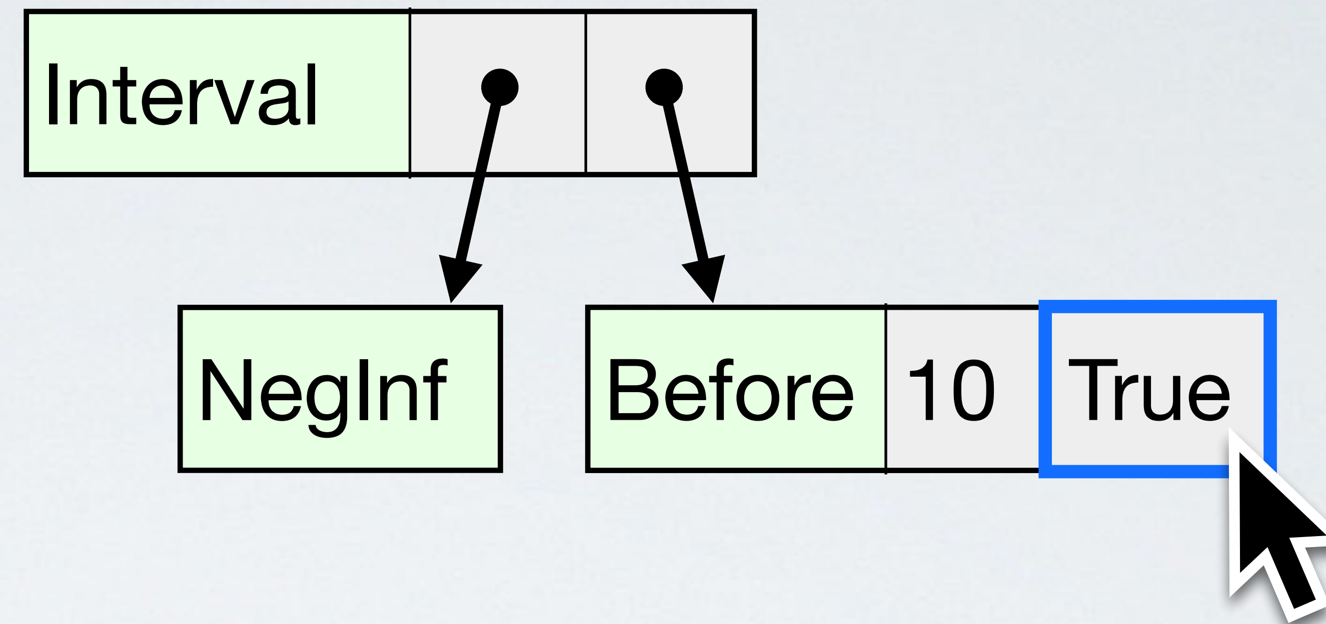

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Related Systems

Track only **strings** to output.

Automating Presentation Changes in Dynamic Web Applications via Collaborative Hybrid Analysis

Xiaoyin Wang[1], Lu Zhang[1]; Tao Xie[2], Yingfei Xiong[1], Hong Mei[1]
[1]Key Laboratory of High Confidence Software Technologies (Peking University), MOE, China
[2]Department of Computer Science, North Carolina State University, USA
{wangxy06,zhanglu,xiongyf04,meih}@sei.pku.edu.cn, xie@csc.ncsu.edu

ABSTRACT

Web applications are becoming increasingly popular nowadays. During the development and evolution of a web application, a typical type of tasks is to change the presentation of the web application, such as correcting display errors, adding user-interface controls, or

1. INTRODUCTION

Recently, web applications are becoming increasingly popular due to easier access to the Internet. Various researchers have developed techniques to facilitate the development and evolution of web applications, such as testing web applications [4, 3, 19], static checking for bugs in web applications [10, 33], and refactoring

Wang et al. (2012)

Source

```
    + "switched to Chinese.";

function keyup(evt) {
  str = evt.target.value;
}

function render() {
  return (<div>
    <input value={str} onkeyup={keyup} />
    <p>
      {str.replace(/keyboard/g,"leopard")}
    </p>
```

Time Control

Version 1

State 1

Output HTML State

Weird, my keyboard jus

Schuster & Flanagan (2016)

Related Systems

Track only **strings** to output.

Wang et al. (2012)

Schuster & Flanagan (2016)

But we want to track **any value of interest** to output.

Two Key Ideas

1. Generic dependency tracing.

Transparent ML (TML) [Acar et al. 2013]

Specifically, the **dependency provenance** scheme.

A Core Calculus for Provenance

Umut A. Acar   Amal Ahmed   James Cheney   Roly Perera

June 4, 2018

299v2 [cs.PL] 3 Jan 2014

Abstract

Provenance is an increasing concern due to the ongoing revolution in sharing and processing scientific data on the Web and in other computer systems. It is proposed that many computer systems will need to become provenance-aware in order to provide satisfactory accountability, reproducibility, and trust for scientific or other high-value data. To date, there is not a consensus concerning appropriate formal models or security properties for provenance. In previous work, we introduced a formal framework for provenance security and proposed formal definitions of properties called disclosure and obfuscation.

In this article, we study refined notions of positive and negative disclosure and obfuscation in a concrete setting, that of a general-purpose programing language. Previous models of provenance have focused on special-purpose languages such as workflows and database queries. We consider a higher-order, functional language with sums, products, and recursive types and functions, and equip it with a tracing semantics in which traces themselves can be replayed as computations. We present an annotation-propagation framework that supports many provenance views over traces, including standard forms of provenance studied previously. We investigate some relationships among provenance views and develop some partial solutions to the disclosure and obfuscation problems, including correct algorithms for disclosure and positive obfuscation based on trace slicing.

1 Introduction

Provenance, or meta-information about the origin, history, or derivation of an object, is now recognized as a central challenge in establishing trust and providing security in computer systems, particularly on the Web. Essentially,

Two Key Ideas

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   ```
   "a" ++ "b" ++ "c" ⇓ "abc"
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Two Key Ideas

1. Generic dependency tracing from TML.

2. To keep track of substrings: defer string concatenation.

~~`“a” ++ “b” ++ “c” ⇓ “abc”`~~

`“a” ++ “b” ++ “c” ⇓ ((“a” ++ “b”) ++ “c”)`

```
Interval(NegInf(), Before(10, True))
```

```
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```

Tag subvalues with identifiers.

$\texttt{Interval(NegInf()}^{\{1.\bullet\}}\texttt{,Before(10}^{\{2.1.\bullet\}}\texttt{,True}^{\{2.2.\bullet\}}\texttt{)}^{\{2.\bullet\}}\texttt{)}^{\{\bullet\}}$

```
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$\texttt{Interval(NegInf()}^{\{1.\bullet\}}\texttt{,Before(10}^{\{2.1.\bullet\}}\texttt{,True}^{\{2.2.\bullet\}}\texttt{)}^{\{2.\bullet\}}\texttt{)}^{\{\bullet\}}$

↓ Call `toString` using TML.

```
("(-∞" ++ ("," ++ ("10" ++ "]")))
```

```
Interval(NegInf(), Before(10, True))
```

Tag subvalues with identifiers.

`Interval(NegInf()`$^{\{1.\bullet\}}$`,Before(10`$^{\{2.1.\bullet\}}$`,True`$^{\{2.2.\bullet\}}$`)`$^{\{2.\bullet\}}$`)`$^{\{\bullet\}}$

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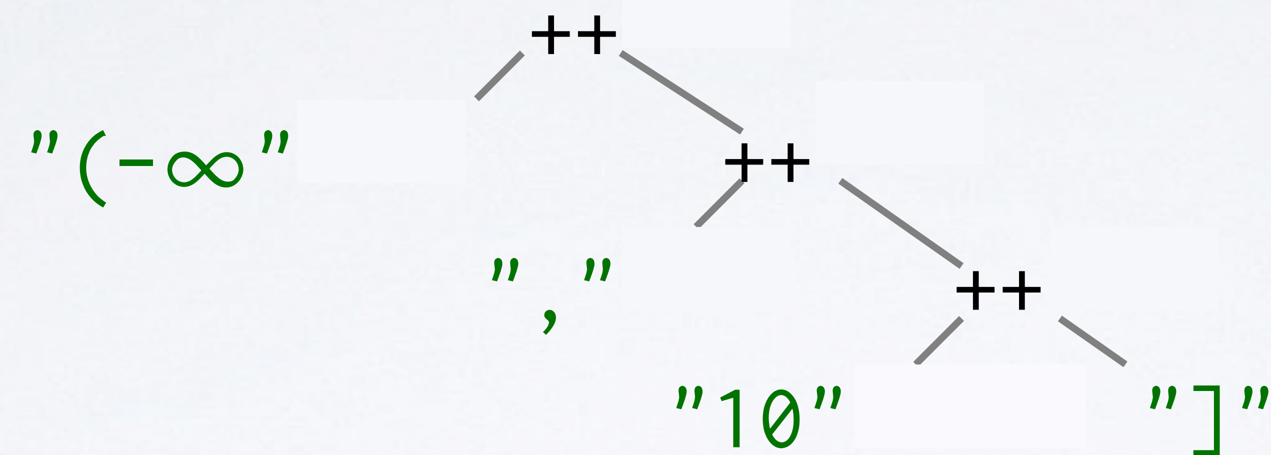

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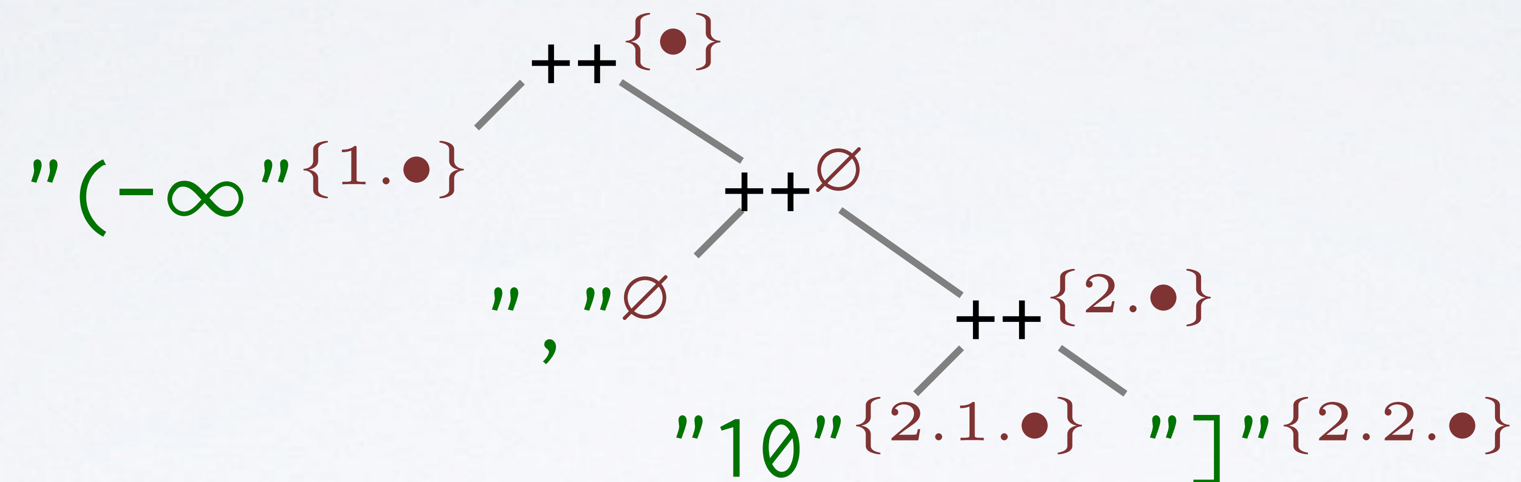

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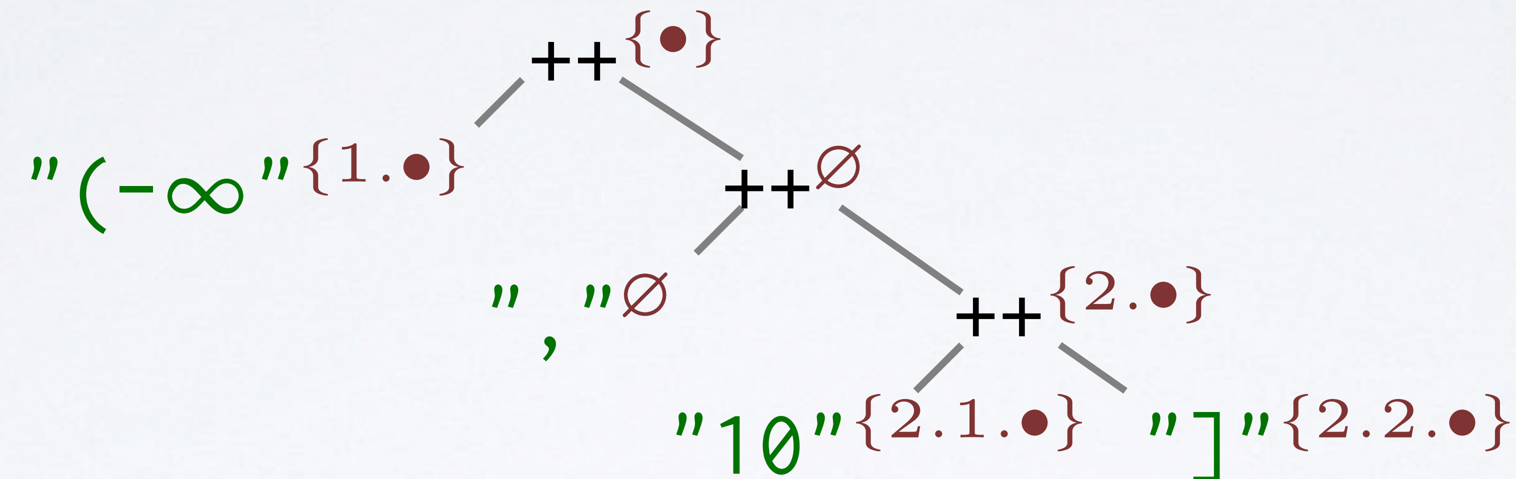
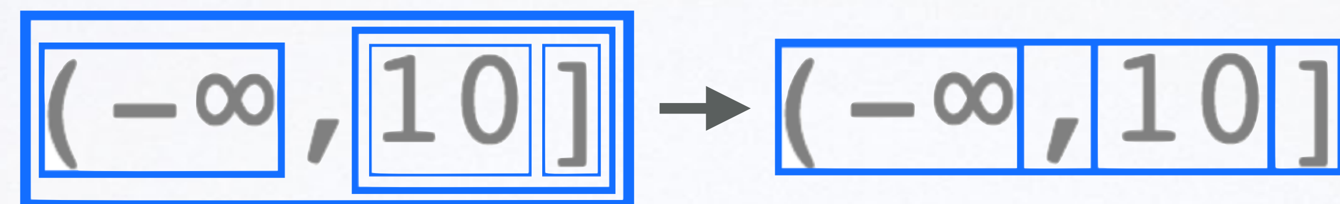


Assign **spacial regions**.



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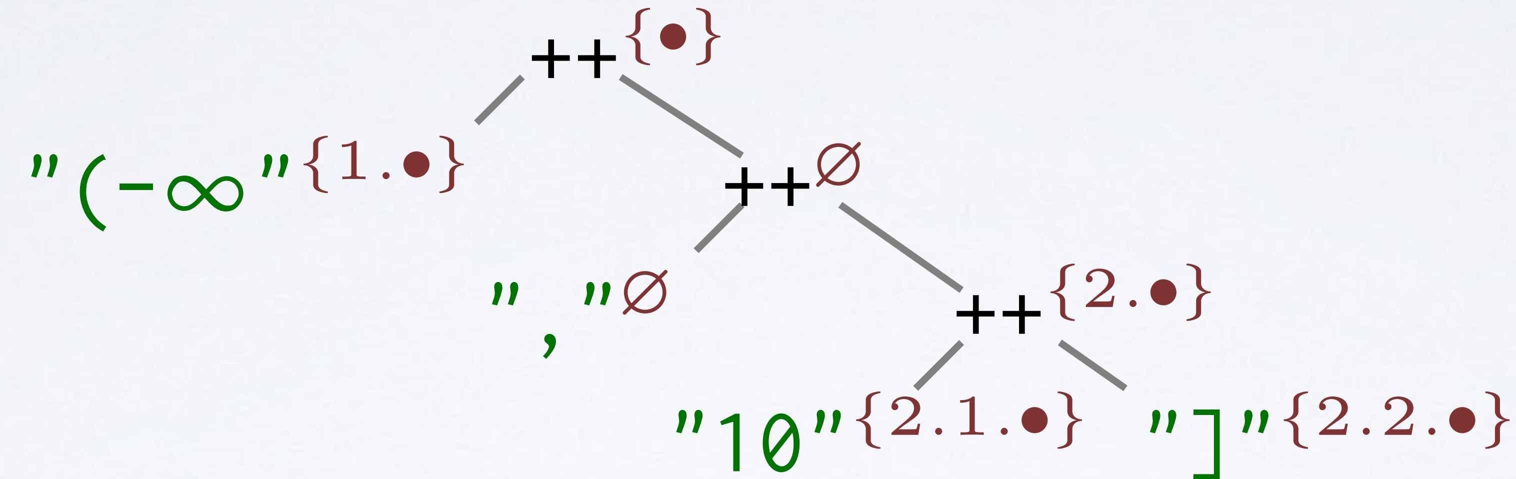
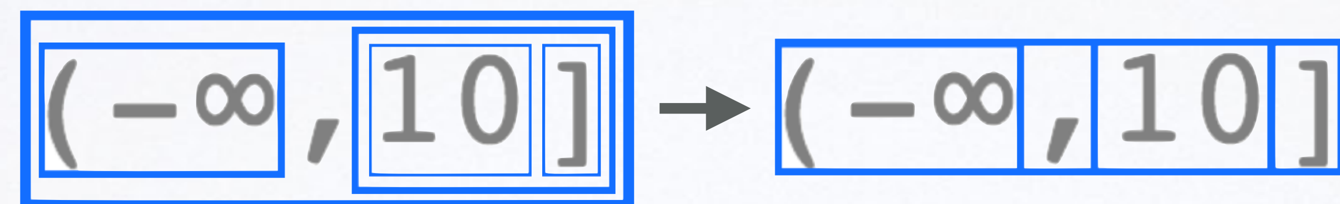
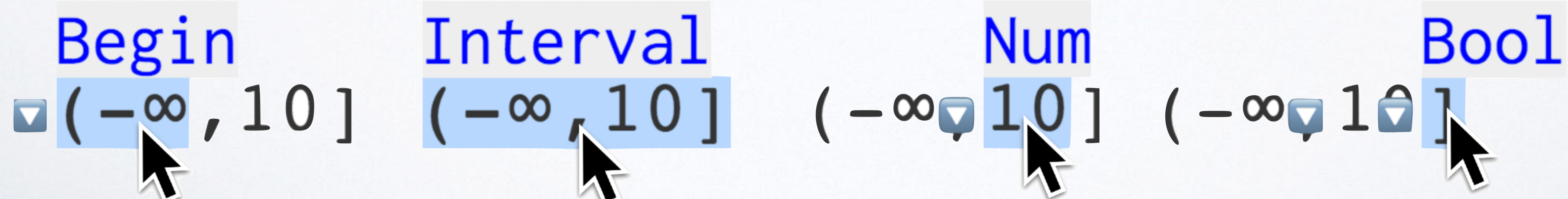


↓ Assign **spacial regions**.



↓ Assign **action buttons** (▼ swaps variants).



```
type Begin    = NegInf()               | After(Num, Bool)
type End      = Before(Num, Bool) | Inf()
type Interval = Interval(Begin, End)
```

```
Interval(NegInf(), Before(10, True()))

(-∞,10]
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```
Interval(NegInf(), Before(10, True()))
```

(−∞,10]

```
type List<a> = Nil() | Cons(a, List<a>)
```

```
Cons(1, Cons(2, Cons(3, Nil())))

[1,2,3]
```

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Case Studies

Data Structure	%Selectable Subvalues	Items

Case Studies

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	Subvalues	Items
Interval		
Date		
JSON (multiline)		
List		
List ("]" in base case)		
List (via `join`)		
List (via different `join`)		
Tree (S-exp)		
Tree (indented hierarchy)		

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Pair [22]		
List [22]		
ADT (recursive) [22]		
Record [22]		
Set [13]		

Case Studies

Data Structure	%Selectable Subvalues	Items
Interval	80% (4/5)	
Date	100% (4/4)	
JSON (multiline)	33% (14/43)	
List	86% (6/7)	
List (`"]"` in base case)	100% (7/7)	
List (via `join`)	71% (5/7)	
List (via different `join`)	86% (6/7)	
Tree (S-exp)	53% (10/19)	
Tree (indented hierarchy)	21% (4/19)	
Pair [22]	100% (3/3)	
List [22]	100% (7/7)	
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Record [22]	100% (9/9)	
Set [13]		

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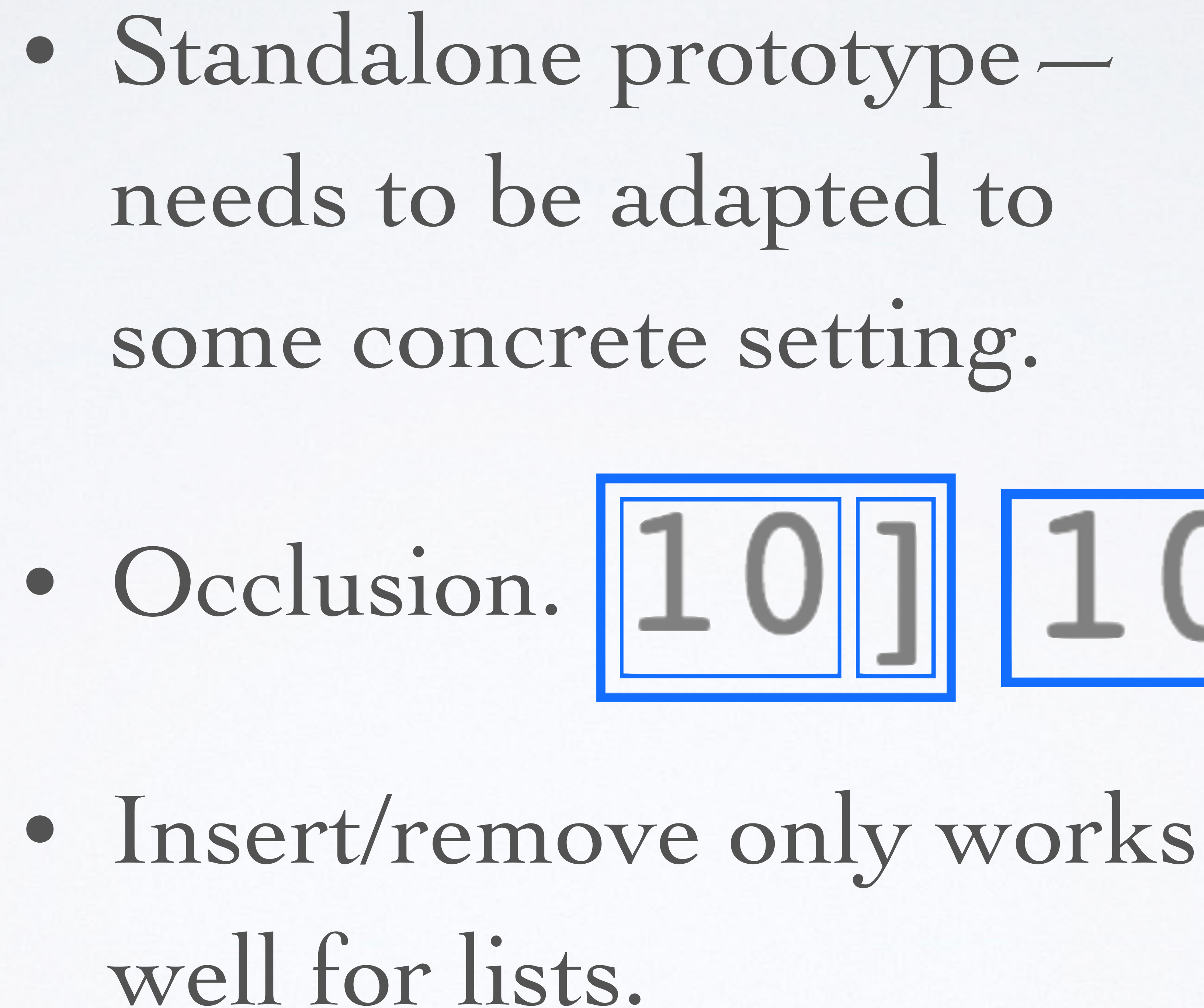
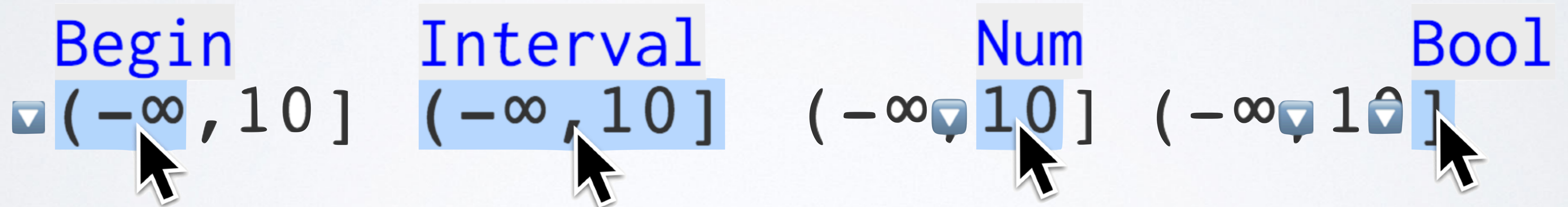


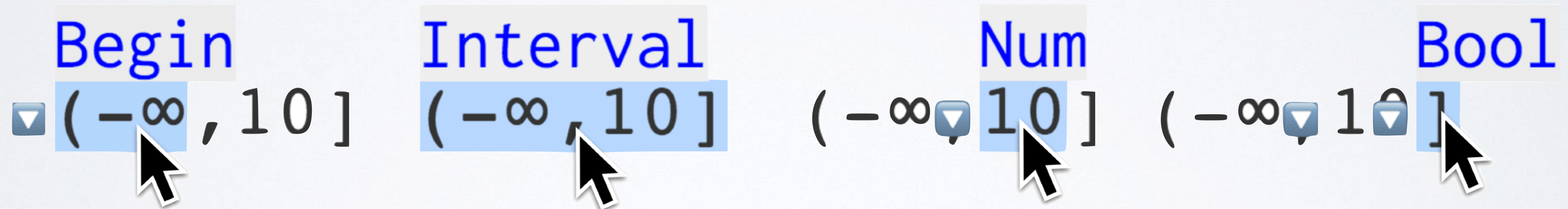
- Insert/remove only works well for lists.

Tiny Structure Editors for Low, Low Prices!



Tiny Structure Editors for Low, Low Prices!

Use **generic dependency tracing** + **deferred concatenation** to generate tiny structure editors from `toString` functions.



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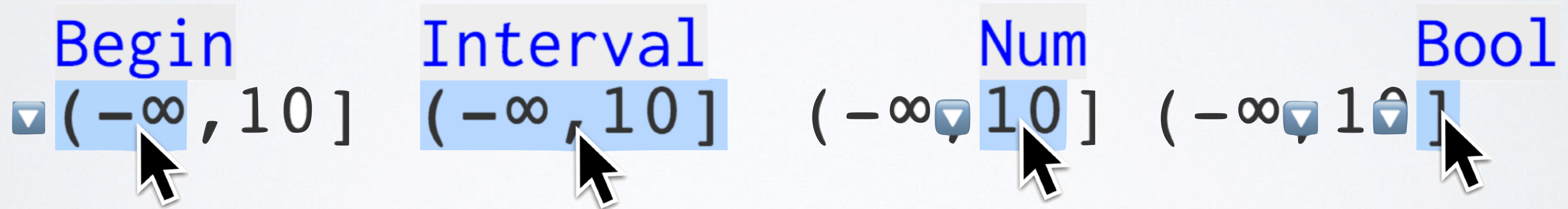

⇒ Custom, manipulable visualizations for user-defined types.

Tiny Structure Editors for Low, Low

Thank You!

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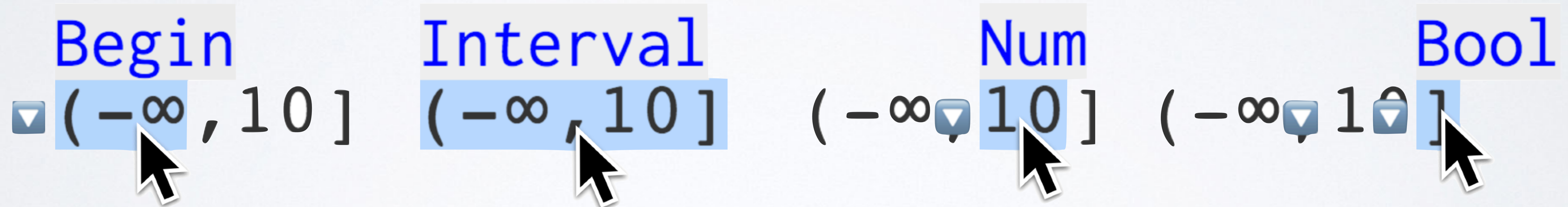

⇒ Custom, manipulable visualizations for user-defined types.

TML in TSE

$$
\begin{array}{rcl}
\textbf{Expressions } e & ::= & x \mid f(x).e \mid e_1(e_2) \\
& \mid & C(e_1, \ldots, e_n) \\
& \mid & \texttt{case } e \texttt{ of } \overline{C_i(x_1, \ldots, x_n) \to e_i} \\
& \mid & s \mid e_1 +\!\!+ e_2 \mid \texttt{strLen}(e) \\
& \mid & n \mid e_1 \oplus e_2 \mid \texttt{numToStr}(e) \\
& \mid & \texttt{basedOn}(e_d, e) \\
\textbf{Projection Paths } \pi & ::= & \bullet \mid i.\pi \\
\textbf{(Tagged) Values } w & ::= & v^{\{\pi_1, \ldots, \pi_n\}} \\
\textbf{(Untagged) Pre-Values } v & ::= & [E]\, f(x).e \mid C(w_1, \ldots, w_n) \\
& \mid & s \mid w_1 +\!\!+ w_2 \mid n \\
& \mid & \texttt{dyncall}(f) \\
\textbf{Tagged Environments } E & ::= & - \mid E, x \mapsto w
\end{array}
$$

Evaluation with Dependency Provenance $\boxed{E \vdash e \Downarrow w}$

[EvalCase]

$$
\frac{E \vdash e \Downarrow C_j(w_1, \ldots, w_n)^p \qquad E, x_1 \mapsto w_1, \ldots, x_n \mapsto w_n \vdash e_j \Downarrow {v_j}^{p_j}}{E \vdash \texttt{case } e \texttt{ of } \overline{C_i(x_1, \ldots, x_n) \to e_i} \Downarrow {v_j}^{p \cup p_j}}
$$

```
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type End      = Before(Num, Bool) | Inf()
type Interval = Interval(Begin, End)

toString : Begin -> String
toString(begin) = case begin of
  NegInf()                  -> "(-∞"
  After(num, isClosed) ->
    (if isClosed then "[" else "(") ++ toString(num)

toString : End -> String
toString(end) = case end of
  Inf()                      -> "∞)"
  Before(num, isClosed) ->
    toString(num) ++ (if isClosed then "]" else ")")

toString : Interval -> String
toString(interval) = case interval of
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    toString(begin) ++ "," ++ toString(end)

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Algebraic data types (ADTs)

express **variants** a.k.a. **constructors**

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  Inf()                 -> "∞)"
  Before(num, isClosed) ->
    toString(num) ++ (if isClosed then "]" else ")")

toString : Interval -> String
toString(interval) = case interval of
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valueOfInterest : Interval
valueOfInterest =
  Interval(NegInf(), Before(10, True))
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(−∞,10]

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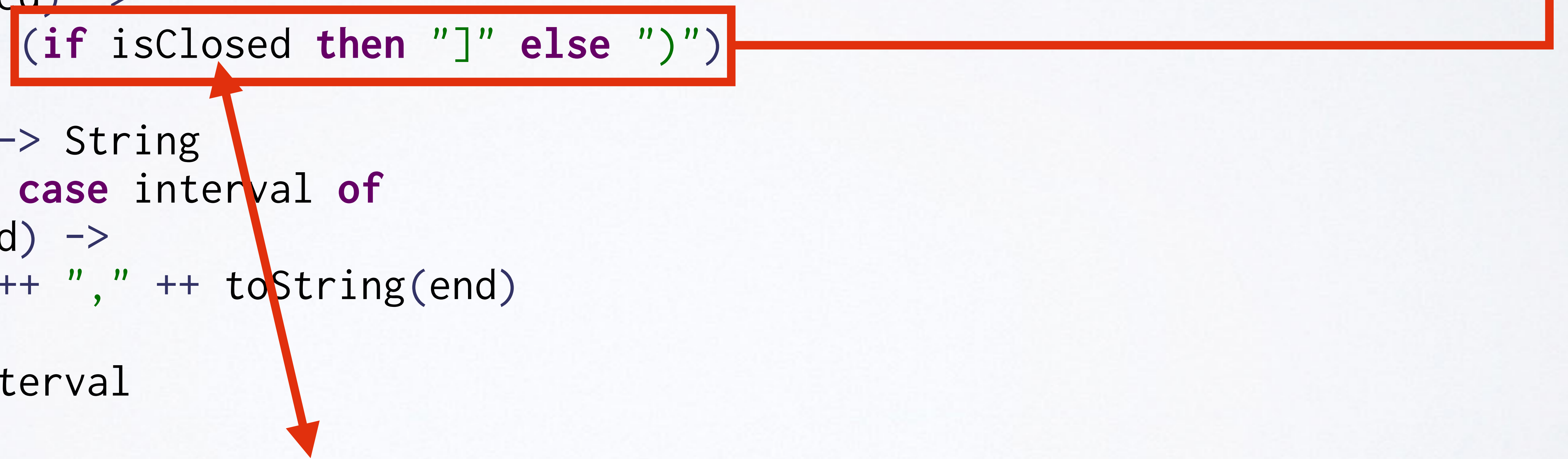

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