Disjoint Union Types in P0

Project 9 / Group 8

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Table of Contents

Table of Contents

What are Disjoint Union Types?

What do they look like?

Grammar Changes

- Text visible on slide 1

Grammar Changes

- Text visible on slide 1
- Text visible on slide 2

Grammar Changes

- Text visible on slide 1
- Text visible on slide 2
- Text visible on slide 3

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- Text visible on slide 1
- Text visible on slide 2
- Text visible on slide 3
- Text visible on slide 4

How do we use DUTs?

The anatomy of a case statement.

- cases are the only way to access data inside of DUTs.

```
case <variable> of {
    [nil: <stmtSuite>]
    Kind A: <stmtSuite>
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    ...
    Kind Z: <stmtSuite>
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    ... or ...
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Exhaust your cases!

If you create a non-exhaustive case statement, the compiler will warn you.

`case` WebAssembly Generation

Table of Contents

Example: Maybe

```
type Maybe = Just(value: integer)
           | Nothing

procedure valOr(v: Maybe, n: integer) → (r: integer)
    case v of {
        Just:
            r := v.value
        default:
            r := n
    }

program Main
    var maybe: Maybe

    maybe <- Nothing()
    writeln(valOr(maybe, -1))

    maybe <- Just(1111)
    writeln(valOr(maybe, 0))
```

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Output

```
-1
1111
```

Example: Lists

```
type List = Cons(head: integer, tail: List)
          | Nil

procedure upToList(n: integer) → (l: List)
    if n < 1 then l := Nil() else l := Cons(n, upToList(n−1))

procedure consumeList(l: List)
    case l of {
        Cons: writeln(l.head); consumeList(l.tail)
        default nothing
    }

procedure sumList(l: List) → (n: integer)
    case l of {
        Cons: n := sumList(l.tail) + l.head
        default: n := 0
    }

program Main
    var myList: List
    myList := upToList(5)
    consumeList(myList)
    writeln(sumList(myList))
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program Main
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    myList := upToList(5)
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    writeln(sumList(myList))
```

Output

```
5
4
3
2
1
15
```

Example: Strings

... lists in disguise?

```
type String = SCons(ch: integer, tail: String)
            | SNil

procedure printStr(s: String, ln: boolean)
    case s of {
        SCons: writeChar(s.ch); printStr(s.tail, ln)
        default: if ln then writeNewLine()
    }

// inclusively generating alphabets in a range
procedure genBetwn(start: integer, end: integer) -> (s: String)
    var ch: integer
    ch := end
    s := SNil()

    while start <= end do
        s, start, ch := SCons(ch, s), start + 1, ch - 1

program Main
    // print capital letters
    printStr(genBetwn('A', 'Z'), true)

    // print lowercase letters
    printStr(genBetwn('a', 'z'), true)

    // print numbers 0-9
    printStr(genBetwn('0', '9'), true)

    // print Aramaic letters
    printStr(genBetwn(67648, 67679), true)
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Output

```
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
0123456789
```

Other Examples

% TODO:

Remark

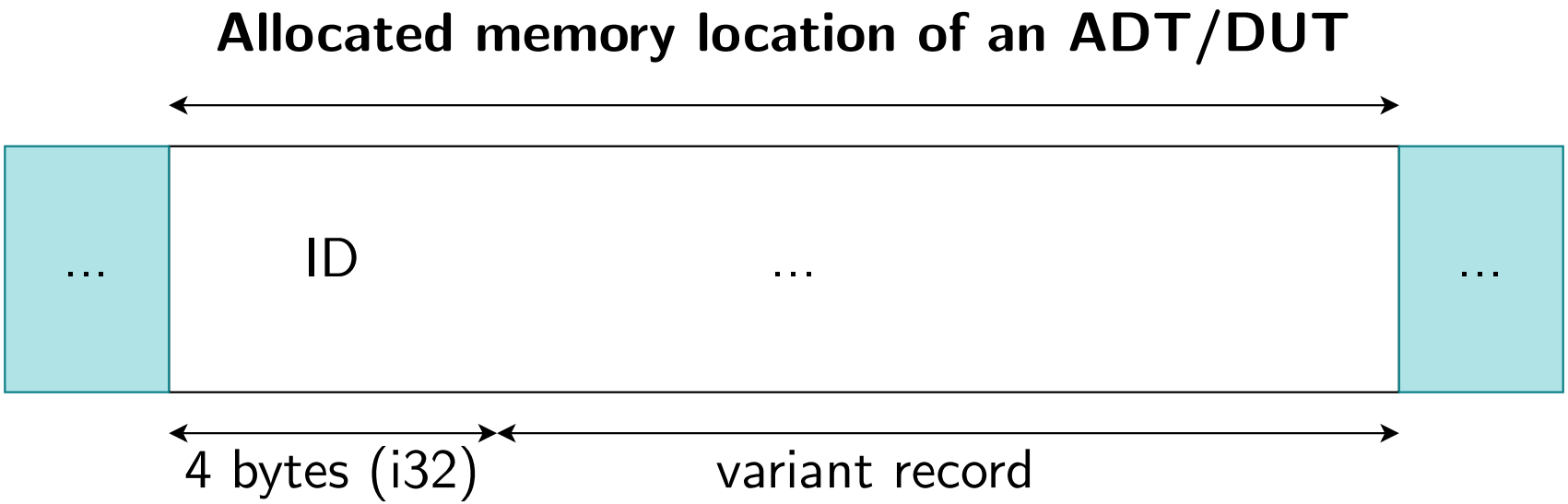
Sample text

Table of Contents

Memory Impact & Management

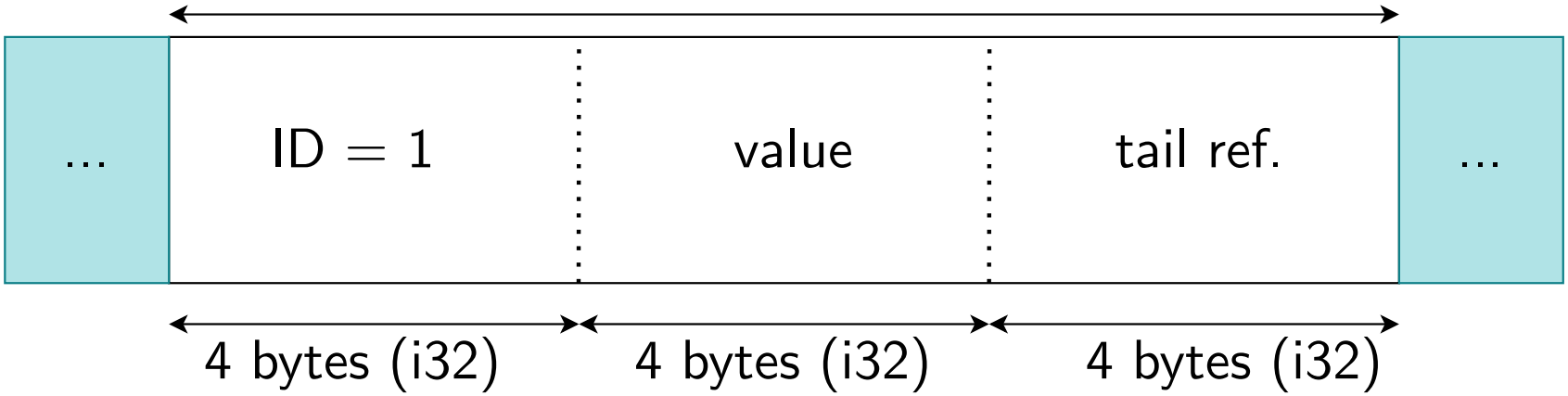
Each instance of a DUT is located on the heap, and instances of local/global DUTs are pointers to the locations of their corresponding DUT on the heap.

- Size of an allocation depends on the size of the variant being instantiated
- Offsets to accessing variables work similar to records, with a 4 byte offset for the variant id.

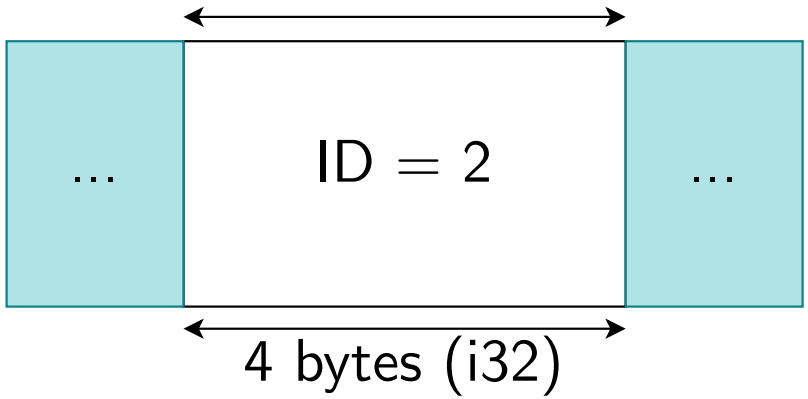


Example: Lists in Memory

Allocated memory location of a ‘Cons‘ (12 bytes)



Allocated memory location of a ‘Nil‘ (4 bytes)



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- This causes issues for **pywasm**
  - Due to being interpreted in Python, a recursive call stack size limitation is imposed onto our programs.
- Thankfully, **wasmer** has no issues!
- In-browser WebAssembly execution also has no issues, but we don't ship a web browser with the compiler.

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  - Strings, Lists, Maps as a basic set of built-in DUTs
  - Stronger syntactic sugar for String generation (e.g., “abcd...” for quickly instantiating large strings)
- Improved Memory Management
  - Memory freeing!
  - Memory reuse!
  - Allocation specialization for built-in DUTs!

References