CSCE 314
Programming Languages
Haskell: The Module System

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Modules

- A Haskell program consists of a collection of modules. The purposes of using a module are:
  1. To control namespaces.
  2. To create abstract data types.

- A module contains various declarations: First, import declarations, and then, data and type declarations, class and instance declarations, type signatures, function definitions, and so on (in any order)

- Module names must begin with an uppercase letter

- One module per file
Example of a Module

module Tree ( Tree(Leaf/Branch), fringe ) where

data Tree a = Leaf a | Branch (Tree a) (Tree a)

fringe :: Tree a -> [a]
fringe (Leaf x) = [x]
fringe (Branch left right) = fringe left ++ fringe right

- A module declaration begins with the keyword `module`.
- The module name may be the same as that of the type.
- Same indentation rules as with other declarations apply.
- The type name and its constructors need be grouped together, as in `Tree(Leaf/Branch); short-hand possible, Tree(...)`.
- Now, the `Tree` module may be imported:

```haskell
module Main (main) where
import Tree ( Tree(Leaf/Branch), fringe )
main = print (fringe (Branch (Leaf 1) (Leaf 2)))
```

- import list: omitting it will cause all entities exported from `Tree` to be imported.
Qualified Names

module Fringe(fringe) where
import Tree(Tree(..))

fringe :: Tree a -> [a] -- A different definition of fringe
fringe (Leaf x) = [x]
fringe (Branch x y) = fringe x

module Main (main) where
import Tree ( Tree(Leaf,Branch), fringe )
import qualified Fringe ( fringe )

main = do print (fringe (Branch (Leaf 1) (Leaf 2)))
         print (Fringe.fringe (Branch (Leaf 1) (Leaf 2)))

- Qualifiers are used to resolve conflicts between different entities with the same name

- imported names are prefixed by the name of the module imported
More Features

• Entities can be hidden in the import declaration. For example, the following explicit import of the Prelude:

  import Prelude hiding (length, sum)

will not import length and sum from the Standard Prelude.

• Entities can be renamed with as. Used to shorten long names:

  import AnExtremelyLongModuleName as A
  myFun n = A.foo n

• or to easily adapt to a change in module name without changing all qualifiers (the following is possible if there are no name conflicts):

  import Module1 as M
  import Module2 as M
Abstract Data Types – Tree (1)

Modules are Haskell’s mechanism to build abstract data types (ADTs). For example, an ADT for the Tree type might include the following operations:

```haskell
data Tree a  -- just the type name
leaf       :: a -> Tree a  -- construct a leaf
branch     :: a -> Tree a -> Tree a -> Tree a  -- construct a branch
cell       :: Tree a -> a  -- return a value of the tree
left, right :: Tree a -> Tree a  -- return left or right subtree
isLeaf     :: Tree a -> Bool  -- check is a leaf
```

A module supporting this is:

```haskell
module TreeADT (Tree, leaf, branch, cell, left, right, isLeaf) where
data Tree a  = Leaf a | Branch (Tree a) (Tree a)
leaf        = Leaf
branch      = Branch
cell (Leaf a) = a
left (Branch l _) = l
right (Branch _ r) = r
isLeaf (Leaf _)  = True
isLeaf _        = False
```

Leaf and Branch are not exported – information hiding (at a later time the representation type could be changed without affecting users of the type)
Abstract Data Types – Tree (2)

An ADT for the Tree type:

```haskell
data Tree a = Tnil | Node a (Tree a) (Tree a)
leaf :: a -> Tree a
branch :: a -> Tree a -> Tree a -> Tree a
cell :: Tree a -> a
left, right :: Tree a -> Tree a
isLeaf :: Tree a -> Bool
```

Another module supporting this is:

```haskell
module TreeADT (Tree, leaf, branch, cell, left, right, isLeaf) where
data Tree a = Tnil | Node a (Tree a) (Tree a)
leaf = \x -> (Node x Tnil Tnil)
branch = Node
cell (Node a Tnil Tnil) = a
cell (Node _ l Tnil) = cell l
cell (Node _ Tnil r) = cell r
left (Node _ l _) = l
right (Node _ _ r) = r
isLeaf (Node _ Tnil Tnil) = True
isLeaf _ = False
```
Another Example ADT - Stack

module Stack ( StkType, push, pop, top, empty ) where

data StkType a = EmptyStk | Stk a (StkType a)
push x s = Stk x s
pop (Stk _ s) = s
top (Stk x _) = x
empty = EmptyStk

module Stack ( StkType, push, pop, top, empty ) where

newtype StkType a = Stk [a]
push x (Stk xs) = Stk (x:xs)
pop (Stk (_,xs)) = Stk xs
top (Stk (x:_)) = x
empty = Stk []

module Main where
import Stack
myStk = push 3 . push 4 . push 2 $ empty