Data Structures Lab 3 - Containers Spring 2019 Burris

Due: Friday March 29th prior to the start of class:

Submission: For all options the results should appear first followed by the complete code!

Most modern programming languages offer a “container” class for the convenience of users. Containers are typically inefficient with respect to CPU time and memory allocation compared to static types. They may however offer great convenience for the developer. Commonly offered container classes include one for constrained objects and a second for unconstrained objects. These classes typically are further refined to incorporate containers termed “sequence” and “associative.” Sequence classes hold sequences of related items. Associative classes associate a key with each element of the class then manipulate elements based on the keys. You may not utilize container classes in any language for any lab during the semester unless the lab specifically states you must use the container class. Ada provides the following container for “defined/constrained” classes:

1. Ada.Containers.Vectors
2. Ada.Containers.Doubly\_lLinked\_Lists
3. Ada.Containers.Hashed\_Maps
4. Ada.Containers.Ordered\_Maps
5. Ada.Containers.Hashed\_Sets
6. Ada.Containers.Ordered\_Sets

A similar group of classes/packages is provided for undefined/unconstrained types using similar names including Ada.Containers.Indefinite\_Vectors with specialized generic procedures such as Ada.Containers.Generic\_Array\_Sort and Ada.Containers.Generic\_Constrained\_Sort. The purpose of this lab is to develop the basic technology to implement (program) these capabilities in languages including Ada, C++, Java, Python and Smalltalk using more basic constructs. Implementation of containers, complex numbers, etcetera using code placed in libraries extends the capabilities of languages. This technique is widely used to extend programming language capabilities and convenience for modern languages.

**“C” Option: Homogeneous (maximum grade is 75):**

**Hint: appendix 1, 2 and 3. For the “C” Option remove the generic in appendix 2, replace “item” with Integer and set max to a specific value like 20. Appendix 3 is closest to the lab. Appendix 6 is helpful if you need to pass functions or operator overloads.**

Implement package/class Integer\_Containers allowing the user to store a list of integers whose meaning is application dependent with respect to the user (a homogeneous list). You must store elements in a doubly linked list (container) with a list head. The following represents a list with 33 inserted first followed by 46 on the right side (front) of the head node. The list head should contain the number of integers currently stored in the list.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 2 |  |  |  | 46 |  |  |  | 33 |  |  |
|  |  | Head |  |  |  |  |  |  |  |  |  |  |

A container (package/class) definition would normally contain procedures and/or functions to insert at the head of the list, insert at the rear of the list, provide the number of items currently in the list, search for an item returning a pointer to it if found (null if not found), print the contents of the item given a pointer to the node containing the item and ask for the next item in the list traversing the list from the front to rear. Finally, you must be able to delete a random item from the doubly linked list given its location (pointer to the item). A partial package/class specification might include the following:

package Integer\_Containers is

type Integer\_Container is private;

type Integer\_Node\_Point is access Integer\_Container;

procedure InsertFront( list: in out Integer\_Container, amt: in Integer, Success: Boolean);

procedure InsertRear( list: in out Integer\_Container, amt: in Integer, success: out Boolean);

function listSize( list: in Integer\_Container) return Integer;

function findItem( list: in Integer\_Container, aValue: Integer) return Integer\_Node\_point);

procedure delete(list: in out: Integer\_Container, Integer\_NodePoint);

-- Additional functions and procedures as needed.

private

type Integer\_Container is record

value: Integer;

next, previous: Integer\_Pointer;

end Integer\_Container;

-- rest of specification.

end Integer\_Containers; -- followed by the body in another file

--Main program

MyList: Integer\_Container; -- create an integer container as a doubly linked list.

**Process all “C” option transactions in the order specified.**

1. Insert 33 in front (right).
2. Insert 57 in front
3. Insert 85 at the rear (left).
4. Insert 62 at the rear.
5. Insert 95 at the front.
6. Print the contents of the list from front to rear.
7. Print the content of the list from rear to front.
8. Find and delete the node containing 57.
9. Find and delete the node containing 33.
10. Find and delete the node containing 33.
11. Find and delete the node containing 62.
12. Insert 22 in front.
13. Delete the node containing 95.
14. Print the contents of the list from front to rear.

**“B” Option – Homogeneous (maximum grade is 80):**

**Hint: Appendix 1,2, 3. Appendix 6 is helpful if you need to pass functions or operator overloads.**

You need not do the “C” option. Write a generic/template package/class List\_Package allowing the user the ability to store any programmer defined type in a doubly linked list with the operations defined in the “C” option. Use a list head. You will probably wish to provide an overload for the “=” operator as a generic parameter. Implement the package/class List\_Package allowing for any user defined in a doubly linked list. Each entry in the list other than the head node may be used to store a user defined transaction. Data fields in the head node may be used or ignored by the implementer. The basic package/class definition will contain at least the following methods:

generic

type ItemsType is private;

package List\_Package is

-- Methods for previous grading option

-- See sample specification/code for similar application below inCompStacg.

end List\_Package – followed by the body in another file

-- main program

with List\_Package;

procedure MainLine is

type ItemType is ( Shoes, Kites, Jacks, Food);

currentItem: ItemType;

price: Float;

amt: Integer;

type InventoryItem is record

itemName: ItemType; unitPrice: Float; inStock: Integer;

end InventoryItem;

temp, theItem: InventoryItem;

package InventoryList is new List\_Package (InventoryItem); use InventoryList;

**Process the following transactions in the specified order after creating homogeneous containers for cars and planes (two separate lists).** You may use the code for cars and planes used in the examples below if desired. Place the cars and planes in the correct lists.

1. Insert a Ford with 4 doors at the rear.
2. Insert a Ford with 2 doors at the front.
3. Insert a GMC with 2 doors at the rear.
4. Insert a RAM with 2 doors at the rear.
5. Insert a Chevy with 3 doors at the front.
6. Print the number of items in the list.
7. Print the contents of the list (front to rear).
8. Find and delete the first Ford in the list (search front to rear).
9. Print the number of items in the list.
10. Print the contents of the list (front to rear).
11. Insert a plane with 3 doors and 6 engines by Boeing at the front.
12. Insert a plane with 2 doors and 1 engine by Piper at the front.
13. Insert a plane with 4 doors and 4 engines by Cessna at the front.
14. Print the list.

Hint: You do not need the “abstract stack (inheritance from a common ancestor) to create the car and plane types in appendix 5. You may use my code for cars and planes in your code.

**“A” Option: Heterogeneous Container using Inheritance (maximum grade is 90). Appendix 6 is helpful if you need to pass functions or operator overloads.**

Hint: Appendix 1,4 and 5 for all “A” Options.

You need not do the “C” or “B” options. Rather implement a single package/class using inheritance to allow multiple data types/objects in a heterogeneous list.

**First: Use your package to process all “C” option transactions! You may have to create a new list element to store integers in your “A” option list.**

**Second: Use this package/class to implement a single doubly linked list and process all “B” Option transactions placing the cars and planes in a single list using inheritance.**

A sample list with one plane and one car follows:

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Head |  |  |  |  |  |  |  |  |  |  |
|  |  | 2 |  |  |  | Plane |  |  |  | Car |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

An example of the empty list follows:

Head

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | 0 |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

**“A+” Option: Heterogeneous Container using Inheritance (maximum grade is 95):**

Complete the “A” option. Allow at least one **task** to place items in the list and a second task to remove items from the list.

**“A Super +” Option: Heterogeneous Container using Inheritance (maximum grade is 100):**

**Complete the “A” option. Allow multiple tasks to place items in the list and multiple tasks to remove items from the list preventing RACE conditions!**

**Appendix 1: For all options.**

In most industries employee records (inventory records etcetera) appear 20 or more times in applications. Rather than define them in every application it is convenient do define them once then utilize the same definition for the abstraction in every application. Not only is this convenient but increases sharing, consistency across applications, and ease of update for all applications, The following class illustrates the sharing concept for dates.

-- in file CompStk1.ads

-- Exports IntIO, MonthName, MonthNmaeIO, Date and PrintDate.

with Ada.Text\_IO; use Ada.Text\_IO;

package CompStk1 is

package IntIO is new Ada.Text\_IO.Integer\_IO(Integer);

use IntIO;

type MonthName is (Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep,

Oct, Nov, Dec); -- Enumeration type.

package MonthNameIO is new – Ada generates i/O routines.

Ada.Text\_IO.Enumeration\_IO(MonthName);

use MonthNameIO;

type Date is record

Month: MonthName;

Day: Integer range 1..31; -- Limits range.

Year: Integer; -- No limit on range.

end record;

procedure PrintDate(aDate: Date);

end CompStk1;

--in file CompStk1.adb

package body CompStk1 is

procedure PrintDate(aDate: Date) is

begin

put("mmm/dd/yyyy is "); put(aDate.Month);put("/");

put(aDate.Day,2); put("/"); put(aDate.Year,4);

end PrintDate;

end CompStk1;

**Appendix 2: For “C” Option**

Sample **homogeneous** stack for intrinsic data types and programmer data type including task types.

**generic -- in file Gstack.ads**

max:integer; -- size of stack

type item is private; -- type to stack

**package gstack is**

**procedure push(x: in item);**

**procedure pop(x: out item);**

Sample run:

enter an integer: 10

enter an integer: 20

enter an integer: 30

enter an integer: 40

result of pop 40

result of pop 30

result of pop 20

result of pop 10

**end gstack;**

%%%%%%%%%%%%%%%%%%%%%%%%%%

**package body gstack is** -- in file Gstack.adb

s:array(1..max) of item; -- allocate in stack.

top: integer range 0..max;

**procedure push(x: in item) is**

begin

top := top + 1; s(top) := x;

**end push;**

**procedure pop(x: out item ) is**

begin

x := s(top); top := top - 1;

**end pop;**

begin

top := 0; --initialize top of stack to empty

**end gstack;**

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

with Ada.Text\_IO; use Ada.Text\_IO; -- in file Gusestac.adb

**with gstack;** -- generic stack defined in gstack10.ads /.adb**procedure genstack is** package IIO is new Ada.Text\_IO.Integer\_IO(integer); use IIO;

**package integer\_stack is new gstack(100,integer); use integer\_stack;** m: integer;begin for i in 1..4 loop put("enter an integer "); get(m); **push(m);** end loop; for i in 1..4 loop put("result of pop "); **pop(m);** put(m); new\_line;

end loop;

**end genstack;**

**-- Consider adding**: **package intStk is new gstack(10,integer); use intStk;-- Now push(m) will result in a compile time error as “Push” cannot be**

**--uniquely determined from the context. Use intStk.push(m) or**

**--integer\_stack.push(m), the full object oriented notation.**

Now consider using the “date” type. A skeleton follows.

with Ada.Text\_IO; use Ada.Text\_IO;

with gstack;;

with CompStkg; use CompStkg;

procedure UCmpStkg is -- in file UCmpStkg

stackSize: integer := 15;

package DateStack is new gstack(stackSize, Date);

use DateStack;

-- rest followed by access, shown 2 ways

push(aDate); --if stack is clearly identifiable (unique0 or to specify using

DateStack.push( aDate ); -- DateStac if there are multiple date stacks.

**Appendix 3: Stack implemented as a linked list.**

The following creates a **homogeneous** stack using a linked list. The “C” option does not require the generic as each stack only stores a specific predefined type. The generic allows for the user to store any intrinsic or user defined type (including tasks, protected types, etc.). Replacing “MyType with “integer,” Float,” Character, Date etcetera creates the desired stack type.

generic -- in file CompStkg.ads

type **MyType** is private;

package CompStkg is

procedure Push(X: MyType);

function Pop return MyType; -- Note parenthesis are not required if there are no parameters.

**private**

type Node; -- Avoid recursive definition.

type NodePtr is access Node; -- Define pointer type to Node.

type Node is record -- Allocated in heap at run time.

MyData: **MyType**;

Next: NodePtr;

end record;

end CompStkg;

with **Ada.Unchecked\_Deallocation**; -- in file CompStkg.adb

package body CompStkg is

-- Provide opportunity for garbage collection and reuse of Nodes.

function free is new Ada.Unchecked\_Deallocation(Node, NodePtr); -- reclaim heap storage.

Head, pt: NodePtr := null; -- Ada actually sets all pointers to null when they are declared.

procedure Push(X: MyType) is

begin -- No check for overflow.

Head := new Node'(X, Head); -- Allocated from returned memory, heap is none returned.

end Push; -- Most languages return Head = null if out of storage.

function Pop return MyType is

X: MyType;

begin

X := Head.MyData; -- No check for underflow.

pt := Head;

Head := Head.Next;

**free(pt);** -- Memory hemorraging occurs if forgotten.

return X;

end Pop;

end CompStkg;

-- Example of programming by "Composition" (bottom-up, creating whole from parts)

-- as opposed to programming by "Classification"

-- (top-down) better known as the use of inheritance.

with Ada.Text\_IO; use Ada.Text\_IO;

with CompStk1; use CompStk1;

with CompStkg;

procedure UCmpStkg is -- in file UCmpStkg

package CharStack is new CompStkg(character);

use CharStack;

package DateStack is new CompStkg(CompStk1.Date);

use DateStack;

Char: Character;

ADate: Date;

begin

Push('A'); Push('B'); Push('C');

put(pop); put(Pop); put(Pop); new\_line(2);

Push((Jan, 15, 1992)); Push((Mar, 24, 1994));

Push((Jun, 12, 1999));

ADate := Pop; PrintDate(ADate); new\_line;

Adate := Pop; PrintDate(Adate); new\_line;

Adate := Pop; PrintDate(ADate); new\_line;

end;

**Sample Output:**

CBA

mmm/dd/yyyy is JUN/12/1999

mmm/dd/yyyy is MAR/24/1994

mmm/dd/yyyy is JAN/15/1992

**Appendix 4: “B/A” Option to Implement Containers.**

The preceding examples are limited to stacks containing a single data type, i.e., “**homogeneous**” lists. Industrial grade applications may find it necessary to store more than one type/class item in the container. The assumption is the “**heterogeneous**” items will have similar operations on the data. The software will select the appropriate version of the method for the user selected operation, i.e., polymorphism. Ada is polymorphic by default. We start with an example of homogeneous inheritance (tagged types) then expand the example to allow heterogeneous data types. The secret in most object oriented languages (Java, C++, SamllTalk, Ada, etc.) is for all children to be derived from a common parent type. Similar operations (methods, procedures, functions) on the data type employ polymorphic methods to implement the behavior for each desired type. The container for the parent type implies the ability to include children derived from the parent.

-- Creation of a “cube” type from a “rectangle” type using inheritance.

--in file taged1.adb

with Ada.Integer\_Text\_IO; use Ada.Integer\_Text\_IO;

**procedure taged1 is**

**type Rectangle is tagged -- tagged allows inheritance**

**record**

**length: Integer;**

**width: Integer;**

**end record;**

**function Size(r: in Rectangle) return Integer is -- “intrinsic” method**

begin return r.length \* r.width; **end Size;**

-- create a cube by inheriting from Rectangle.

***type Cube is new Rectangle with – create cube using inheritance***

***record height: Integer; end record;***

-- Cube inherits fields length, width, and function Size.

-- This size may be redefined as:

**function Size(c: Cube) return Integer is -- intrinsic function**

begin

return **Size(** **Rectangle(** C **)** **)** \* C.height; -- cast “Cube” as a rectangle.

**end Size;**

-- Note the type conversion "Rectangle(c)" so that the inherited

-- function Size for Rectangle (overload) can be used.

**rect1: Rectangle := (6,10);**

**cube1: Cube := (length => 6, width => 10, height => 20);**

begin

**put( Size( rect1 ) ); put( Size( cube1 ) );**

**rect1 := Rectangle( cube1 ); cube1 := ( rect1 with 20 );**

end taged1;

-- User-written subprograms are classified as primitive operations

-- if they are declared in the same package specification as the

-- type and have the type as a parameter or result. Derived types

-- inherit all primitive operations that belong to the parent type.

**Appendix 5: “B/A” Heterogenous Abstract Type taking advantage of inheritance. Ada allows definition/implementation of related types/classes in the same file.**

This example uses the object notation for methods as follows to creating intrinsic methods for a package:

“procedures:” <method-name> (<object>, <parameters>)

“functions::” <function-name>( <object>, <parameters>)

return <return-type>

-- Programing by “Classification” (top-down) as opposed to

-- composition by “Composition” (bottom-up).

-- In file AbstStck.ads, Creation of abstract stack.

package AbstStck is

type AbstractStack is limited private;

type AbstractStackElement is tagged private;

type AbstractStackElementPtr is

access all AbstractStackElement'Class;

--Allows access to AbstractStackElement and any class inheriting

--(created from using inheritance) from AbstractStackElement.

procedure Push(Stack: access AbstractStack; Y: in AbstractStackElementPtr);

function Pop(Stack: access AbstractStack) return AbstractStackElementPtr;

function StackSize(Stack: AbstractStack) return integer;

-- function “=” (aNode: AbstractStackElementPtr,

valueToCompare: genreric-parameter-for-comparison) return Bollean;

private

type AbstractStackElement is tagged – Allow for heterogeneous

record -- stacks via inheritance.

Next: AbstractStackElementPtr;

end record;

type AbstractStack is limited

record

Count: integer := 0; -- used to track the number of items in stack.

Top: AbstractStackElementPtr := null;

end record;

end AbstStck;

-- In file AbstStck.adb

package body AbstStck is

procedure Push(Stack: access AbstractStack; Y: in AbstractStackElementPtr) is

Pt: AbstractStackElementPtr;

begin

Y.Next := Stack.Top; Stack.Top := Y; Stack.Count := Stack.Count + 1;

end Push;

function Pop(Stack: access AbstractStack) return AbstractStackElementPtr is

Pt: AbstractStackElementPtr;

begin

if Stack.Top = null then -- Check for underflow.

return null;

end if;

Stack.Count := Stack.Count - 1;

Pt := Stack.Top; Stack.Top := Stack.Top.Next; -- Pop stack, note hemmoraging.

return Pt; -- Storage should be returned to an available storage list for applications

end Pop; -- with high activity or executing for extended periods of time.

function StackSize(Stack: AbstractStack) return integer is

begin return Stack.Count; end StackSize;

end AbstStck;

**Creation/use of a Car type used with a stack.**

-- in file MakeCar.ads

with AbstStck;

package MakeCar is

type String4 is new String(1..4);

type Car is new AbstStck.AbstractStackElement with record

NumDoors: integer;

Manufacturer: String4 := "GMC "; -- Sample default value.

end record;

procedure AssignNumDoors(aCar: in out Car; N: in integer);

procedure AssignManufacturer(aCar: in out Car; Manu: in String4);

procedure PrintNumDoors(aCar: in Car);

procedure PrintManufacturer(aCar: in Car);

procedure IdentifyVehicle(aCar: in Car);

end MakeCar;

-- in file MakeCar.adb

with Ada.Text\_IO; use Ada.Text\_io;

with AbstStck;

package body MakeCar is

package IntIO is new Ada.Text\_IO.Integer\_IO(Integer); use IntIO;

procedure AssignNumDoors(aCar: in out Car; N: in integer) is

begin aCar.NumDoors := N; end AssignNumDoors;

procedure AssignManufacturer(aCar: in out Car; Manu: in String4) is

begin aCar.Manufacturer := Manu; end AssignManufacturer;

procedure PrintNumDoors(aCar: in Car) is

begin put("Num doors = "); put(aCar.NumDoors); new\_line; end PrintNumDoors;

procedure PrintString4(PrtStr: String4) is

begin for I in 1.. 4 loop

put(PrtStr(I));

end loop; end PrintString4;

procedure PrintManufacturer(aCar: in Car) is

begin put("Manufacturer is "); PrintString4(aCar.Manufacturer); new\_line; end;

procedure IdentifyVehicle(aCar: in Car) is

begin

put("Car with "); put(aCar.NumDoors, 4); put(" doors");

put(" made by "); PrintString4(aCar.Manufacturer); new\_line;

end IdentifyVehicle;

end MakeCar;

--in file UAbstStc.adb: place cars in the stack.

with Ada.Text\_IO; use Ada.Text\_io;

with AbstStck; use AbstStck;

with MakeCar; use MakeCar;

procedure UAbstStc is

type Stack\_Ptr is access AbstractStack;

CarStack: Stack\_Ptr := new AbstractStack;

StackPoint: Stack\_Ptr;

NewCar, CarPt: AbstractStackElementPtr;

begin --Create 1st car.

NewCar := new Car'(AbstractStackElement with 4, "Ford"); --Heap allocation

push(CarStack, NewCar);

NewCar := new Car; -- Create 2nd car.

AssignNumDoors(Car'Class(NewCar.All), 2);

AssignManufacturer(Car'Class(NewCar.all), "Chev");

push(CarStack, NewCar);

NewCar := new Car; -- Create 3rd car.

AssignNumDoors(Car'Class(NewCar.All), 2);

-- Default manufacturer to "GMC ".

push(CarStack, NewCar);

for I in 1..StackSize(CarStack.all) loop

CarPt := pop(CarStack);

PrintManufacturer(Car'Class(CarPt.All));

PrintNumDoors(Car'Class(CarPt.All));

new\_line;

**Sample Output:**

Manufacturer is GMC

Num doors = 2

Manufacturer is Chev

Num doors = 2

Manufacturer is Ford

Num doors = 4

end loop;

end UAbstStc;

-- file MakePlane.ads: Create planes for use with heterogeneous container.

with AbstStck;

package MakePlane is

type String8 is new String(1..8);

type Plane is new AbstStck.AbstractStackElement with record

NumDoors: integer;

NumEngines: integer;

Manufacturer: String8 := "Boeing ";

end record;

procedure AssignNumDoors(aPlane: in out Plane; N: in integer);

procedure AssignManufacturer(aPlane: in out Plane; Manu: in String8);

procedure AssignNumEngines(aPlane: in out Plane; NE: in integer);

procedure PrintPlane(aPlane: in Plane);

procedure IdentifyVehicle(aPlane: in Plane);

end MakePlane;

-- In file MakePlane.adb

with Ada.Text\_IO; use Ada.Text\_io; with AbstStck;

package body MakePlane is

package IntIO is new Ada.Text\_IO.Integer\_IO(Integer); use IntIO;

procedure AssignNumDoors(aPlane: in out Plane; N: in integer) is

begin aPlane.NumDoors := N; end AssignNumDoors;

procedure AssignManufacturer(aPlane: in out Plane; Manu: in String8) is

begin aPlane.Manufacturer := Manu; end AssignManufacturer;

procedure AssignNumEngines(aPlane: in out Plane; NE: in integer) is

begin aPlane.NumEngines := NE; end AssignNumEngines;

procedure PrintString8(PrtStr: String8) is

begin for I in 1..8 loop put(PrtStr(I)); end loop; end PrintString8;

procedure PrintPlane(aPlane: in Plane) is

begin

put("Num doors for plane = "); put(aPlane.NumDoors, 4); new\_line;

put("Number engines = "); put(aPlane.NumEngines); new\_line;

put("Manufacturer = "); PrintString8(aPlane.Manufacturer); new\_line;

end PrintPlane;

procedure IdentifyVehicle(aPlane: in Plane) is

begin

put("Plane with "); put(aPlane.NumDoors, 4); put(" doors, ");

put(aPlane.NumEngines, 4); put(" engines, made by ");

PrintString8(aPlane.Manufacturer); new\_line;

end IdentifyVehicle;

end MakePlane;

**Using heterogeneous stack with cars and planes in same stack.**

with Ada.Text\_IO; use Ada.Text\_io;

with AbstStck; use AbstStck;

with MakeCar, MakePlane; use MakeCar, MakePlane;

procedure UAbstSt2 is

type Stack\_Ptr is access AbstractStack;

VehicleStack: Stack\_Ptr := new AbstractStack;

StackPoint: Stack\_Ptr;

NewCar, CarPt, NewPlane, PlanePt, VehiclePt:

AbstractStackElementPtr;

begin

NewCar := new Car'(AbstractStackElement with 4, "Ford"); -- Heap allocation!

push(VehicleStack, NewCar); -- 1st car.

NewPlane := new Plane'(AbstractStackElement with 2, 2, "Northrup"); -- in heap!

push(VehicleStack, NewPlane); --1st plane.

for I in 1..StackSize(VehicleStack.all) loop

VehiclePt := pop(VehicleStack);

if VehiclePt.all in Car then *-- \*\* Identify class of object at run time.*

IdentifyVehicle(Car'Class(VehiclePt.all));

elsif VehiclePt.all in Plane then

IdentifyVehicle(Plane'Class(VehiclePt.all));

end if;

new\_line;

end loop;

end UAbstSt2;

**Sample Output:**

Plane with 2 doors, 2 engines, made by Northrup

Car with 4 doors made by Ford

**\*\*\*\* Heterogeneous versus Homogeneous!**

**Appendix 6: Passing Functions and Operator Overloads**

-- In file GIOEX.ads**. Creates a rectangle with user defined data type for length and**

**-- width.**  **Note that it is frequently desirable to pass methods including I/O routines**

**-- for programmer defined data types.**

-- The following demonstrates how to pass I/O procedures to a generic package.

-- The rectangle may also be used for **inheritance** if desired.

**generic**

**type MyType is private;**

**with function "\*"(X,Y: MyType) return MyType;**

**with procedure Put(X: MyType);**

**package GIOEX is**

type Rectangle is **tagged**

record

Length: MyType;

Width: MyType;

end record;

function Size(r: in Rectangle) return MyType; -- intrinsic functions

function RectLength(r: in Rectangle) return MyType;

**end GIOEX;**

--in file GIOEX.adb

with Ada.Text\_IO; use Ada.Text\_IO; -- Access restricted to body.

**package body GIOEX is**

**function Size(r: in Rectangle) return MyType is**

begin

put("The Size of the Rectangle with length "); **put(r.Length);**

put(" and width "); **put(r.Width);** put(" is ");

**put( r.Length \* r.Width);** put("!"); new\_line(2);

return **r.Length \* r.Width**;

**end Size;**

**function RectLength(r: in Rectangle) return MyType is**

begin

put("The length is "); **put(r.Length);**

new\_line;

return r.Length;

end;

**end GIOEX;**

-- Sample program to show how to pass a programmer defined data type

-- and I/O methods to a generic.

-- in file UGIOEX.adb

**with GIOEX;**

with Ada.Text\_IO; -- Use Ada.Text\_IO;

**procedure UGIOEX is**

package MyFloatIO is new Ada.Text\_IO.Float\_IO(Float);

use MyFloatIO;

--The generic put statement format in Ada.Text\_IO.Float\_IO.

-- procedure Put( item: float;

-- fore: Ada.Text\_IO.field := 0; -- “0” means use minimum space.

-- aft: Ada.Text\_IO.Field := 0;

-- exp: Ada.Text\_IO.Field := 0

-- );

-- Supply an overload for the generic written by the compiler in MyFloat\_IO.

**procedure MyPut(X: Float) is**

**begin MyFloatIO.Put(X, 0, 0, 0); end;**

-- Note that “\*” is defined for the intrinsic type Float.

**package MyGIOEX is new GIOEX( Float, MyPut, "\*");**

**use MyGIOEX;**

Rect1: Rectangle := (5.0, 6.0); //Create class object using constructor!

Len: Float;

begin

Len := Size(Rect1); Len := RectLength(Rect1);

end UGIOEX;

c:\>UGIOEX

The Size of the Rectangle with length 5.0 and width 6.0 is

30.0! -- 3.00000E+01

The length is 5.0 -- 5.00000E+00

-- in file usegioex2.adb. Use of Venus units for measurement.

-- These operations are required for our human mission to Venus.

**Sample overloading the “\*” Operator**

with Ada.Text\_IO; use Ada.Text\_io;

**with GIOEX;**

procedure UseGioex2 is

package MyIntIO is new Ada.Text\_IO.Integer\_IO(Integer);

package MyFloatIO is new Ada.Text\_IO.Float\_IO(Float);

**type VenusMeasure is record**

**F1: Integer;**

**F2: Float;**

**end record;**

-- Define I/O for VenusMeasurement.

**procedure Put(v: VenusMeasure) is**

**begin**

**MyIntIO.put(v.F1);**

**put(" ");**

**MyFloatIO.put(v.F2);**

**new\_line;**

**end;**

-- Define mutliplication for VenusMeasurement.

**function "\*"(p1: VenusMeasure; p2: VenusMeasure)**

**return VenusMeasure is**

**temp: VenusMeasure;**

**begin**

**temp.F1 := p1.F1 \* p2.F1;**

**temp.F2 := p1.F2 \* p2.F2;**

**return temp;**

**end;**

**package MyVenusRectangle**

**is new GIOEX(VenusMeasure, Put, "\*");**

**use MyVenusRectangle;**

width: VenusMeasure := ( 5, 5.5);

height: VenusMeasure := (3, 2.4);

Rect1: Rectangle := (width, height); -- Creates a rectangle using

-- Venus measurements.

Ans: VenusMeasure;

begin

Ans := Size( Rect1 );

end UseGIOEx2;