Aufgabe 2 - ADT: Multiset

**Lösungsidee:**Standardfunktionen eines BST einbauen für strings und helper Funktionen/Prozeduren verwenden, um so viel code Duplikation wie möglich zu vermeiden.

**Zeitaufwand: ~**1h 30min

**Code:**

unit Multiset;

interface

type

  PstrNode = ^StrNode;

  StrNode = record

    value: string;

    count: integer;

    left: PstrNode;

    right: PstrNode;

  end;

  StrMSet = record

    root: PstrNode;

  end;

procedure InitStrMSet(var ms: StrMSet);

procedure DisposeStrMSet(var ms: StrMSet);

procedure Insert(var ms: StrMSet; value: STRING);

procedure Remove(var ms: StrMSet; value: STRING);

function IsEmpty(ms: StrMSet): BOOLEAN;

function Contains(ms: StrMSet; value: STRING): BOOLEAN;

function Count(ms: StrMSet; value: STRING): INTEGER;

function Cardinality(ms: StrMSet): INTEGER;

function CountUnique(ms: StrMSet): INTEGER;

// helper procedure for easier debugging

procedure PrintTree(ms: StrMSet);

implementation

// helper functions

function NewStrNode(value: string): PstrNode;

var

  node: PstrNode;

begin

  New(node);

  node^.value := value;

  node^.count := 1;

  node^.left := nil;

  node^.right := nil;

  NewStrNode := node;

end;

function InsertStrNode(var node: PstrNode; value: string): PstrNode;

begin

  if node = nil then

  begin

    InsertStrNode := NewStrNode(value);

    Exit;

  end;

  if value < node^.value then

    node^.left := InsertStrNode(node^.left, value)

  else if value > node^.value then

    node^.right := InsertStrNode(node^.right, value)

  else

    Inc(node^.count);

  InsertStrNode := node;

end;

function RemoveStrNode(var node: PstrNode; value: string): PstrNode;

var

  successor: PstrNode;

begin

  if node = nil then

  begin

    RemoveStrNode := nil;

    Exit;

  end;

  if value < node^.value then

    node^.left := RemoveStrNode(node^.left, value)

  else if value > node^.value then

    node^.right := RemoveStrNode(node^.right, value)

  else if node^.count > 1 then

    Dec(node^.count)

  else if node^.left = nil then

  begin

    RemoveStrNode := node^.right;

    Dispose(node);

    Exit;

  end else if node^.right = nil then

  begin

    RemoveStrNode := node^.left;

    Dispose(node);

    Exit;

  end else begin

    successor := node^.right;

    while successor^.left <> nil do

      successor := successor^.left;

    node^.value := successor^.value;

    node^.count := successor^.count;

    node^.right := RemoveStrNode(node^.right, successor^.value);

  end;

  RemoveStrNode := node;

end;

function FindStrNode(node: PStrNode; value: STRING): PStrNode;

begin

  if node = nil then

    FindStrNode := nil

  else if value < node^.value then

    FindStrNode := FindStrNode(node^.left, value)

  else if value > node^.value then

    FindStrNode := FindStrNode(node^.right, value)

  else

    FindStrNode := node;

end;

function CountNodeValues(node: PstrNode; uniqueOnly: Boolean): Integer;

begin

  if node = nil then

    CountNodeValues := 0

  else if uniqueOnly then

    CountNodeValues := 1 + CountNodeValues(node^.left, uniqueOnly) + CountNodeValues(node^.right, uniqueOnly)

  else

    CountNodeValues := node^.count + CountNodeValues(node^.left, uniqueOnly) + CountNodeValues(node^.right, uniqueOnly);

end;

procedure DisposeStrNode(node: PStrNode);

begin

  if node <> nil then

  begin

    DisposeStrNode(node^.left);

    DisposeStrNode(node^.right);

    Dispose(node);

  end;

end;

procedure PrintTreeNodes(root: PstrNode; level: integer);

var

  i: integer;

begin

  if root = nil then

    exit;

  PrintTreeNodes(root^.right, level + 1);

  for i := 1 to level do

    write('  ');

  writeln(root^.value, ':', root^.count);

  PrintTreeNodes(root^.left, level + 1);

end;

// helper functions end

procedure InitStrMSet(var ms: StrMSet);

begin

  ms.root := nil;

end;

procedure DisposeStrMSet(var ms: StrMSet);

begin

  if ms.root <> nil then

    DisposeStrNode(ms.root);

  ms.root := nil;

end;

procedure Insert(var ms: StrMSet; value: string);

begin

  ms.root := InsertStrNode(ms.root, value);

end;

procedure Remove(var ms: StrMSet; value: string);

begin

  ms.root := RemoveStrNode(ms.root, value);

end;

function IsEmpty(ms: StrMSet): Boolean;

begin

  IsEmpty := ms.root = nil;

end;

function Contains(ms: StrMSet; value: STRING): BOOLEAN;

begin

  Contains := FindStrNode(ms.root, value) <> nil;

end;

function Count(ms: StrMSet; value: STRING): INTEGER;

var

  node: PStrNode;

begin

  node := FindStrNode(ms.root, value);

  if node <> nil then

    Count := node^.count

  else

    Count := 0;

end;

function Cardinality(ms: StrMSet): Integer;

begin

  Cardinality := CountNodeValues(ms.root, False);

end;

function CountUnique(ms: StrMSet): Integer;

begin

  CountUnique := CountNodeValues(ms.root, True);

end;

procedure PrintTree(ms: StrMSet);

begin

  PrintTreeNodes(ms.root, 0);

end;

end.

**Test Code:**

program StrMSetTests;

uses Multiset;

var

  ms: StrMSet;

begin

  // Initialize an empty multiset

  InitStrMSet(ms);

  // Test inserting elements

  Insert(ms, 'apple');

  Insert(ms, 'banana');

  Insert(ms, 'apple');

  Insert(ms, 'cherry');

  Insert(ms, 'banana');

  Insert(ms, 'cherry');

  // Test counting elements

  WriteLn('Test counting elements:');

  WriteLn('Count of ''apple'': ', Count(ms, 'apple')); // should print 2

  WriteLn('Count of ''banana'': ', Count(ms, 'banana')); // should print 2

  WriteLn('Count of ''cherry'': ', Count(ms, 'cherry')); // should print 2

  WriteLn('Count of ''grape'': ', Count(ms, 'grape')); // should print 0

  WriteLn;

  WriteLn;

  // Test count unique and cardinality

  WriteLn('Test count unique and cardinality:');

  WriteLn('Number of unique elements: ', CountUnique(ms)); // should print 3

  WriteLn('Cardinalitys: ', Cardinality(ms)); // should print 6

  WriteLn;

  WriteLn;

  // Test checking if elements are present

  WriteLn('Test checking if elements are present');

  WriteLn('Contains ''apple'': ', Contains(ms, 'apple')); // should print True

  WriteLn('Contains ''banana'': ', Contains(ms, 'banana')); // should print True

  WriteLn('Contains ''cherry'': ', Contains(ms, 'cherry')); // should print True

  WriteLn('Contains ''grape'': ', Contains(ms, 'grape')); // should print False

  WriteLn;

  WriteLn;

  // Test removing elements

  WriteLn('Test removing elements');

  Remove(ms, 'apple');

  WriteLn('Count of ''apple'': ', Count(ms, 'apple')); // should print 1

  Remove(ms, 'banana');

  WriteLn('Count of ''banana'': ', Count(ms, 'banana')); // should print 1

  Remove(ms, 'cherry');

  WriteLn('Count of ''cherry'': ', Count(ms, 'cherry')); // should print 1

  Remove(ms, 'cherry');

  WriteLn('Count of ''cherry'': ', Count(ms, 'cherry')); // should print 0

  WriteLn;

  WriteLn;

  // Test checking if multiset is empty

  WriteLn('Is empty: ', IsEmpty(ms)); // should print False

  // Test disposing of multiset

  DisposeStrMSet(ms);

  WriteLn('Is empty: ', IsEmpty(ms)); // should print True

end.

**Test Ausgabe:**

Ein Bild, das Text enthält.

Automatisch generierte Beschreibung