The Ada Standard Generic Library (SGL)

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Computer Science Graduate Seminar
4/24/96

Presentation Overview

- Introduction (S{T|G}L)
- The C++ Standard Template Library (STL)
- Ada 95 Features
- The Ada Standard Generic Library (SGL)
- Conclusion

Standard **Template Library**

- The C++ Standard Template Library (STL) has been adopted by the ANSI/ISO C++ Standards Committtte
- There is nothing standard about SGL !

Standard *Template (Generic)* Library

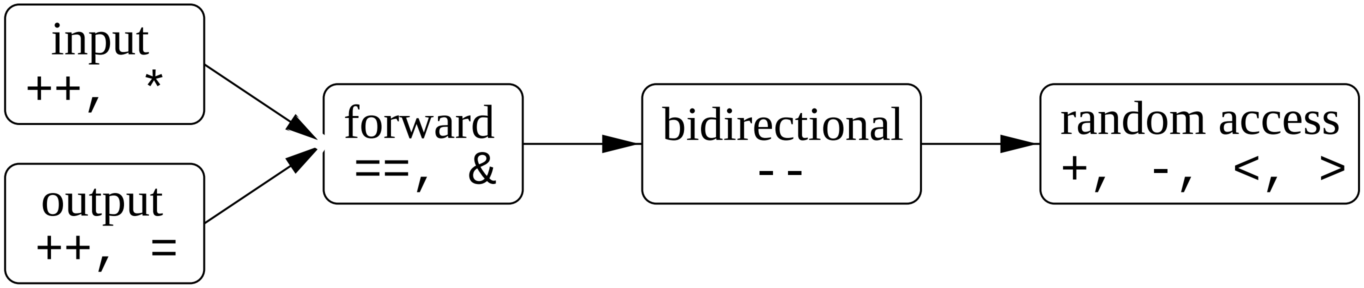
- Generic programming refers to the style of programming in which container classes/packages and algorithms are parameterized by type.
- The two basic approaches used are :
  - dynamic typing and inheritance (Smalltalk)
  - static typing and a facility for arguments of type `T` (C++/Ada)

Stadard Template *Library*

- STL is a general-purpose library of generic algorithms and data structures communicating through iterators
- Contains a lot of different components that can be plugged together and used in an application
- Provides a framework into which different programming problems can be decomposed
- STL pillars : efficiency, orthogonality and a solid theoretical foundation

Overview of STL Components

- **Containers**
  - C++ array, `vector<T>`, `deque<T>`, `list<T>`
  - `set<Key>`, `map<Key, T>`
- **Algorithms**
  - *find*, *count*, *copy*, *remove*, *reverse*, *sort* . . .
- **Iterators**



- **Function Objects**
  - arithmetic, comparison, logical operations
- **Adaptors**
  - Function : binders, negators, adaptors for pointers to functions
  - Container : stack, queue, priority queue
- **Allocators**
  - Enapsulate information about the memory model the program is using (pointers, references, sizes of objects, difference types, allocation/deallocation functions)

Sample STL Program

```
#include <iostream.h>
#include <assert.h>
#include <algo.h>       // include STL algorithms
#include <vector.h>     // include STL vector container

// Function Object
struct least_digit_less : public binary_function<int, int, bool> {
    bool operator()(const int &x, const int &y) {
      return ( (x % 10) < (y % 10) );
    }
};
```

```
int main() {
  vector<int> V;        // implicit instantiation
  ostream_iterator<int> out(cout, " ");

  for (int i=0; i<25; i++) V.push_back(i);

  vector<int>::iterator x = find(V.begin(), V.end(), 10);

  reverse(V.begin(), x);
  copy(V.begin(), V.end(), out); cout << endl;

  sort(V.begin(), V.end(), least_digit_less());
  copy(V.begin(), V.end(), out); cout << endl;
}
```

```
9 8 7 6 5 4 3 2 1 0 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
20 0 10 21 1 11 22 2 12 23 3 13 24 14 4 15 5 16 6 17 7 18 8 19 9
```

Ada

- Named after Countess Augusta Ada Lovelace, who is considered the world's first computer programmer (Charles Babbage's Difference Engine)
- The Ada programming language was designed to :
  - improve correctness, safety, and reliability
  - reduce software development and maintenance costs
  - provide a syntax which is readable and easy to maintain.

Ada Features

- Fully specified and standardized (ANSI/ISO)
  - Compilers validated by U.S. Gov. & other agencies
- Supports modern Software Engineering methods :
  - Abstact Data Types (Modular programming)
  - Object-Oriented Programming (classes, inheritance, polymorphism, late binding)
  - Built-in tasking constructs/exceptions
  - Generic Programming
- Strongly typed (contractual model)

Evolution of Ada 95

- Revision initiated in January 1988 (Ada 9X)
- Requirements document broken into two groups :
  - Internationalization, Programming Paradigms (OO), Real-Time Requirements, Systems Programming, and General Requirements
  - Parallel/Distributed Processing, Safety-Critical Applications, Information Systems, and Scientific/Mathematical Applications
- Revised international standard (ISO/IEC 8652:1995)

SGL Relevant Ada (83 & 95) Features

- Generic Programming Support
  - Generic packages and subprograms (83)
  - Generic package parameters (95)
- Object Oriented Programming Support
  - Controlled types (95)
- Systems Programming Support
  - Storage Pool Management (95)

Some Ada Syntax

Generic Function Specification & Body

```
-- basic_algorithms.ads
generic
   type T is private;
procedure Swap(A, B: in out T);
pragma Inline(Swap);

-- basic_algorithms.adb
procedure Swap(A, B: in out T) is
   Tmp: T := A;
begin
   A := B;
   B := Tmp;
end Swap;
```

Generic Package Specification

```
generic
   type T1 is private;
   type T2 is private;
   with function "="(A, B: T1) return Boolean is <>;
   with function "="(A, B: T2) return Boolean is <>;
package Pairs is
   subtype Value_Type1 is T1;
   subtype Value_Type2 is T2;

   type Pair is record
         First  : Value_Type1;
         Second : Value_Type2;
   end record;

   function "="(A, B: Pair) return Boolean;
   pragma Inline ("=");
end Pairs;
```

Designing the Ada Standard Generic Library

- **Containers**
  - Similar interface to STL; export iterators
- **Iterators Signatures**
  - Provide the iterator interface specification
- **Algorithms**
  - Parameterized by iterator signatures :

```
generic
   with package Iterators is new Forward_Iterators(<>);
procedure Forward_Distance(First, Last: Iterators.Iterator;
                           N: in out Iterators.Distance_Type);
```

- **Function Objects**
  - Become simple functions in SGL
- **Adaptors**
  - *Should* be similar (unimplemented)
- **Allocators**
  - Are modeled almost directly from STL !

```
-- Bidirectional iterators signature package
generic
   type Value_Type is private;
   type Iterator is private;
   type Pointer is private;
   type Distance_Type is (<>);

   with procedure Inc( I: in out Iterator );
   with procedure Dec( I: in out Iterator );

   with function "="( i: Iterator; j: Iterator ) return Boolean;

   with function Val( I: in Iterator ) return Value_Type ;
   with procedure Assign( I: in Iterator; V: Value_Type );
   with function Ref( I: in Iterator ) return Pointer;

package Bidirectional_Iterators is end;
```

Sample STL Program Revisited

```
with Gnat.IO;
with Basic_Algorithms;
with Algorithms;
with Vectors;
with Put_Iterators;

package Integer_Vectors is new Vectors(Integer);

procedure Example is
   use Gnat.IO;
   use Integer_Vectors;

   -- Local Functions
   procedure Put_Space(I : in Integer) is
   begin
      Put(V);
      Put(" ");
   end Put_Space;
```

```
function Least_Digit_Less(A, B: in Integer) return boolean is
begin
   return (A mod 10) < (B mod 10);
end Least_Digit_Less;

-- Instantiate Packages
package Put_Space_Iterators is new Put_Iterators(Integer, Put_Space);
use Put_Space_Iterators;

-- Instantiate algorithms
function Find is new Algorithms.Find
  (Integer_Vectors.Input_Iterator, "=");

procedure Sort_LD is new Algorithms.Sort
  (Integer_Vectors.Random_Access_Iterator, Least_Digit_Less);

procedure Copy is new Basic_Algorithms.Copy
  (Integer_Vectors.Input_Iterator,
   Put_Space_Iterators.Output_Iterator);
   V : Integer_Vectors.Vector;
   X : Integer_Vectors.Iterators.Iterator;
   OS : Put_Space_Iterators.Iterator;
begin
   for I in 0..24 loop
      Push_Back(V, I);
   end loop;

   X := Find(Start(V), Finish(V), 10);

   reverse(Start(V), X);
   OS := Copy(Start(V), Finish(V), OS);

   Sort_LD(Start(V), Finish(V));
   OS := Copy(Start(V), Finish(V), OS);
end Example;
```

Wish List

- Language features :
  - C++ friend construct
  - Overloading of generic functions
  - Some mechanism for delaying type checking until instantiation time (i.e. IterSwap)
- Compiler features (GNAT) :
  - Better error reporting in generic package/subprogram instantiation errors

Summary (C++ vs. Ada)

- The Ada syntax for parameter passing and function adaptors is simpler and more intuitive
- Iterator signatures provide a cleaner interface
- Explicit instantiation has certain advantages, provided the library design helps out
- The strong typing split personality syndrome :
  - Strong typing is good !
  - Strong typing is bad !
- SGL cannot quite achieve the same orthogonality as STL

- The Ada syntactic separation of functions and procedures presents problems and results in a cluttering of the interface
- `gnat` is a more stable compiler than `g++`