A Brief Look at C++

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ABSTRACT

This note describes some key aspects of what C++ is and of how C++ has developed over the years. The perspective is that of an experienced C++ user looking at C++ as a practical tool. No attempts are made to compare C++ to other languages, though I have tried to answer some questions that I have often heard asked by Lisp programmers.

1 Introduction

Like all living languages, C++ has grown and changed over the years. For me, the improvements to C++ have seemed almost glacially slow and inevitable; they are natural developments of C++'s own internal logic and deliberate responses to the experiences of hundreds of thousands of users. To many who wanted to use C++ aggressively, this growth has been frustratingly slow and timid. To some who considered C++ only infrequently, the developments have seem like unpredictable lurches into the unknown. To others, C++ has simply been something peripheral about which little concrete was known, but about which a multitude of strange rumors persisted.

However you look at it, C++ has developed significantly since its first appearance. As an example, consider a simple function that sorts a container and then counts the number of entries between Dahl and Nygaard:

```cpp
template<class C> int cnt(C& v)
{
    sort(c.begin(), v.end());
    C::iterator d = find(v.begin(), v.end(), "Dahl");
    return count(d, find(d, v.end(), "Nygaard"));
}
```

A container is seen as a sequence of elements from `begin()` to `end()`. An iterator identifies an element in a container.

This template function will work as described for any container that conforms to the conventions of the C++ standard library with elements that can be compared to string literals. For example:

```cpp
vector<char*> v; // vector of C-style strings
list<string> lst; // list of C++ strings
// ...
int i1 = cnt(v);
int i2 = cnt(lst);
```

The types `vector`, `list`, and `string` are parts of the standard C++ library.

Naturally, we need not build the string values Dahl and Nygaard into our little function. In fact, it is easy to generalize the function to do perform an arbitrary action on a range of values of arbitrary types in a container of arbitrary type.

Clearly, this style of programming is far from traditional C programming. However, C++ has not lost touch with C's primary virtues: flexibility and efficiency. For example, the C++ standard library algorithm `sort()` used here is for many simple and realistic examples several times faster than the C standard library `qsort()` function.
2 The C++ Standard

C++ is a statically-typed general-purpose language relying on classes and virtual functions to support object-oriented programming, templates to support generic programming, and providing low-level facilities to support detailed systems programming. That fundamental concept is sound. I don’t think this can be proven in any strict sense, but I have seen enough great C++ code and enough successful large-scale projects using C++ for it to satisfy me of its validity.

By 1989, the number of C++ users and the number of independent C++ implementors and tools providers made standardization inevitable. The alternative was to allow C++ to fracture into dialects. In 1995, the ANSI and ISO C++ standards committees reached a level of stability of the language and standard library features and a degree of precision of the description that allowed a draft standard to be issued [Koenig,1995]. A formal standard is likely in late 1996 or early 1997.

During standardization, significant features and libraries were added to C++. In general, the standards process confirmed and strengthened the fundamental nature of C++ and made it more coherent. A description of the new features and some of the reasoning that led to their adoption can be found in [Stroustrup,1994]. So can discussions of older features and of features that were considered but didn’t make it into C++.

2.1 Language Features

Basically Standard C++ is the language described in “The C++ Programming Language (2nd edition)” [Stroustrup,1991] with namespaces, run-time type information, plus a few minor features added. Among the many minor improvements, the refinements to the template mechanisms are the most significant.

Here is one of the classical examples of object-oriented programming in C++:

```cpp
class Shape {
  virtual void draw() = 0;
  virtual void rotate(int) = 0;
  // ...
};
```

Class Shape is an abstract class; that is, a type that specifies an interface, but no implementation. Specific types that conforms to that interface can be defined. For example, this defines Circle to be a kind of Shape:

```cpp
class Circle : public Shape {
  Point center;
  int radius;
public:
  Circle(Point, int); // constructor
  void draw();
  void rotate(int) { }
  // ...
};
```

We can now manipulate all kinds of shapes through their common interface. For example, this function rotates a vector of arbitrary Shapes r degrees:

```cpp
void rotate_all(vector<Shape*>& v, int r)
{
  for (int i = 0; i<v.size(); i++) v[i]->rotate(r);
}
```

For each Shape, the appropriate rotate() is called. In particular, if the Shape rotated is a Circle, Circle::rotate() is called.

Consider reading Shapes from a stream:
Here, the `dynamic_cast` operator is used to check that the objects really are `Shape`es. Any kind of `Shape`, for example a `Circle`, is acceptable. We throw an exception if an object that is not a `Shape` is encountered.

This example is rather trivial. However, the techniques presented and the language features supporting them have been used in the construction of some of the largest and most demanding applications ever built.
typed language with the benefits of a sophisticated environment like the ones usually associated with dynamically-typed languages.

One of the benefits of a large user community is the availability of libraries. By now, there is a bewildering variety of C++ libraries, but the development of libraries have been hampered by both the differences between compilers and by the lack of a standard library. The former problem has led to unnecessary segmentation of the community, and to the emergence of libraries especially designed to allow crossplatform development. The latter problem forced library developers to re-invent basic concepts, such as string and list, over and over again. Though it will takes years to work these problems out of the system, we now have an alternative and can get on with more important and interesting tasks.

Automatic garbage collection is possibly the issue over which the C and Lisp communities has traditionally been most at odds. The Lisp community was certain that memory management was far too important to leave to users, and the C community was sure that memory management was far too important to leave to the system. C++ takes an intermediate approach. Automatic garbage collection is possible, but not compulsory in C++. Traditionally, this simply meant that C++ programs didn’t use automatic garbage collection, but now both commercial and free garbage collectors for C++ has found their way into non-experimental use. The performance of these collectors is respectable, and in particular, far better than the pessimistic predictions that I have repeatedly heard over the years. Even where a garbage collector isn’t used, well-designed C++ programs suffer far less from memory management problems than traditional C programs. Memory management is often encapsulated in user defined types so that users don’t have to allocate and deallocate memory directly. In particular, standard containers such as `string`, `vector`, and `list` do their own memory management and provide variable-sized data structures.

4 Programming Styles

C++ is a multi-paradigm language. In other words, C++ was designed to support a range of styles. No single language can support every style. However, a variety of styles that can be supported within the framework of a single language. Where this can be done, significant benefits arise from sharing a common type system, a common toolset, etc. These technical advantages translates into important practical benefits such as enabling groups with moderately differing needs to share a language rather than having to apply a number of specialized languages.

For starters, C++ supports traditional C-style. Other styles emphasize the use of classes, abstract classes, class hierarchies, and templates to express concepts and relationships between concepts directly, cleanly, and affordably. For example, §1 used generic programming and §2.1 demonstrated abstract classes and class hierarchies.

Much of the work on styles (for example [Kornig,1995b]) and patterns (for example, [Gamma,1994]) in the C++ community has focussed on finding ways to express ideas from a variety of languages and systems in a way that can be effectively and efficiently be utilized by C++ programmers writing larger production systems. The emphasis is on effective use of C++’s flexible and extensible static type system.

5 Acknowledgements

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6 References