Possible Directions for C++0x

Bjarne Stroustrup

AT&T Labs – Research

http://www.research.att.com/~bs

Abstract

The ISO C++ standard comes up for renewal in 2003. By then, we need to have a good idea where the language and standard library is going, and some concrete proposals. So the committee has started a project to create a standard libraries TR (chaired by Matt Austern) and established an "evolution" working group (chaired by me) to chart a course for the standard as a whole and to consider early proposals for new libraries and language features.

This talk presents my views of general directions for C++0x and gives examples of possible new language features and libraries. The brief summary of my position is that we should be reluctant to add language features and add only a few, but ambitious and opportunistic in our pursuit of new standard libraries. I propose two overall goals: Make C++ a better language for systems programming and library building. And, make C++ easier to teach and learn.

60 minutes

Overview

- Problems and general directions
- Minimal core language extensions
- Ambitious standard library extensions
- Religious quagmire: C/C++ compatibility

C++ ISO Standardization

- Membership
  - About 22 nations (8 to 12 represented at each meeting)
    - ANSI hosts the technical meetings
    - Other nations have further technical meetings
  - About 100 active members (50+ at each meeting)
    - About 200 members in all
    - Down ~50% from its height (1996), up again last year
- Process
  - formal, slow, bureaucratic, and democratic
  - “the worst way, except for all the rest”

Standardization – why bother?

- Directly affects millions
  - Huge potential for improvement
    - So much code is appallingly poor
- Defense against vendor lock-in
  - Only a partial defense, of course
- There are still new techniques to get into use
  - Require language or standard library support to affect mainstream use

Why mess with a good thing?

- The ISO Standard is good
  - but not perfect
- ISO rules require review
  - Community demands consideration of new ideas
- We face increasingly difficult tasks
  - We == programmers and system designers
- The world changes
  - and poses new challenges
- We have learned a lot since 1996
  - When the last of the ISO C++ features was proposed
- Stability is good
  - but the computing world craves novelty
  - Without challenges, the best people will depart for greener pastures

Problems

- How to be responsive to real needs
  - Standardization attracts bureaucrats, formalists
- How to gain feedback, experience
  - People are unwilling to try major things unless
    - They can make money selling it,
but then it becomes proprietary and can't become standard
    - It is standard,
but then it's too late to experiment with it
- Compatibility
  - K&R C, C89, C99, ARM C++, C++98
    - "all C++ programmers are also C programmers"
  - Proprietary extensions
    - Often different extensions reflect a common need

Standardization: Why bother?

- Some windmills just have to be fought!
  - It’s simply the right thing to do

Overall goals

- Make C++ a better language for systems programming and library building
  - Rather than providing specialized facilities for a particular sub-community (e.g. numeric computation or Windows application development)
- Make C++ easier to teach and learn
  - Through increased uniformity, stronger guarantees, and facilities supportive of novices (there will always be more novices than experts)

General Directions

- Minimize incompatibilities with C++98
- Many ideas cut across the language/library barrier
  - Look for minimal language support allowing major library improvement
- Prefer library extension to language extension
  - Make rules more general and uniform
  - Support communities
- Language extensions
  - Maintain or increase type safety
  - Zero-overhead principle
  - Increase expressiveness through general mechanisms
- Library extensions
  - Increase facilities of system-independent platform
  - Support distributed systems programming

Language Directions

- Minimize extensions
  - Be careful, deliberate, conservative, skeptic
- Make rules more general and uniform
  - Improve support for generic programming
  - Improve general guarantees (increase uniformity)
- Look to support whole communities, e.g.
  - improve support low-level embedded programming
  - improve binding to “dynamic” systems?
    - Can we support modern GUI/component/system interfaces without major language changes or proprietary extensions?

Core language ideas

- Increase consistency
  - identical lookup for functions and function objects
  - decrease variation between implementations
    - to increase portability
    - Minimize “implementation dependent/undefined/…”
- Improve support for generic programming
  - **typedef template**s
  - maybe **typeof()**
  - maybe better template overload resolution
- Remove embarrassments
  - Frequent questions, frequent novice errors

Example: template typedef

- Typedef templates (mistakenly rejected early on)

```
template<class T1, class T2> class X { /* … */ };
template<class T> typedef X<T,int> Xi;
Xi<double> d;               // equivalent to X<double,int> d;

template<class T, class U>  class X { /* … */ };
typedef<class T> typedef <T,vector<T>> Xv;
Xv<int> v;                  // equivalent to X<int,vector<int>> v;
```

Example: typeof/auto

- Problem:
  - Express result of operation dependent on template parameters
- Naïve solution:

```
template<class A, class B>
typeof(a*b) operator*(A a, B b)    // problem: scope of a, b, and *
{
        typeof(a*b) x = a*b;               // problem: expression replicated
        // …
        return x;
}

// problem: typeof(X&) == typeof(X)?
```

Example: typeof/auto

- Solve half the problem
  - (first implemented in 1982!)

```
template<class A, class B> typeof(a*b) operator*(A a, B b)
{
        auto x = a*b;       // avoid replication of expression/type
        // …
        return x;
}
```

- What about non-local uses?:

```
auto glob = x*y;        // would dcl or typeof be a better keyword for this?
```

Example: typeof

- Solutions to scope problem:

```
template<class A, class B>
function operator*(A a, B b) -> typeof(a*b);      // return type last
                    // big change: function keyword
                    // : and return are obvious alternatives for ->

template<class A, class B>
typeof(a*b) operator* (A a, B b) ;        // "lookahead parsing"
                                          // ugly/messy
template<class A, class B>
typeof(A*B) operator*(A a, B b);          // use typenames
                                          // not general
template<class A, class B>
typeof((*(A*)0)*(*(B*)0)) operator*(A a, B b);  // hack
```

Example: Better overloading support?

```
char cvrt(char);            // function

struct Cvrt {
        int v;
        cvrt(int vv) :v(vv)  { }
        int operator()(int vv) { return fct(v,vv); }
};
Cvrt cvrt(10);              // function object

void f(int x, int* b, int* e)
{
    int xx = cvrt(x);       // function object
    char c = cvrt('q');     // function
    foreach(b,e, cvrt);     // function object (but how do we know?)
}
```

Provide trivial solutions to trivial beginners' problems

- Tends to cut across the language/library barrier
  - **string** to **int** and **int** to **string** (without **stringstream**)
  - a **vector** and a **string** that are range checked by default
  - Provide very simple graphics system?
  - Provide very simple GUI functionality?
    - Political quagmire

Remove embarrassments

- Scoped macros:

```
#scope A B C
//…
#endscope C D E
```

- "Natural" end of template testing

```
vector<complex<double>> vcd;    // no space between >s
```

Example: Safelib

```
#include<safelib>
using namespace safelib;

int main()
{
	string s;
	cin >> s;
	int n = extract<int>(s);	// throws if no int to extract
	char p[27];
	cin >> p;		// sorry: safelib::cin doesn't support reading into arrays
	vector<int> v(10);
	int i = v[99];		// oops: throws out_of_range
}
catch (…) {
	cerr << "oops!";
}
```

Explicitly admit GC as a valid implementation technique

- Don’t make the C++ semantics dependent on GC
  - Define destructor semantics
    - GC do not call destructor (“infinite memory model”)
    - Provide “registration” mechanism? (hard: probably not a good idea)
- Encourage GC as an option on every implementation
- Don’t promote GC as a panacea
  - Resource management

Library Directions

- Increase facilities of system-independent platform
  - Opportunistic, ambitious
- Support distributed systems programming
  - Basic concurrency
  - Simple, clean, implementation-independent model
- Support a notion of optional library components
  - Not every system can support every standard library facility
  - “if we support X, it must meet these requirements”

Standard library ideas

- Elements of standard platform
  - set of resource handles supporting “resource acquisition is initialization”
  - directories, TCP/IP, advanced I/O (async, multiplex, memory map), …
- Make the standard library central to bindings to other systems
  - CORBA, SQL, …
- Distributed computing
  - XTI (e**X**tended **T**ype **I**nformation)
  - Threads
  - Remote invocation (incl. Async)
  - Remote instantiation, name server interface
- Add a few “general utility” facilities
  - Hash_map
  - Pattern matching
  - Properties
  - Constraints checking

Example: Constraints checking

```
template<class T> struct Comparable {
    static void constraints(T a, T b) { a<b; a<=b; }  // the constraint check
    Comparable() { void (*p)(T,T) = constraints; }  // trigger the constraint check
};

template<class T> struct Assignable { /* … */ };

template<class T> class Range
    : private Comparable<T>, private Assignable<T> {
    // …
};

Range<int> r1(1,5,10);                       // ok
Range< complex<double> > r2(1,5,10);     // constraint error: no < or <=
```

Example: XTI/XPR/D++

- Problems to be addressed
  - Programming distributed systems
    - Marshalling/unmarshalling
    - Multitude of IDL “standards”
    - Poor C++ bindings
  - Serialization
  - XML generation
  - Program manipulation
- Possible solutions: my XTI talk

Example: XTI/XPR/D++

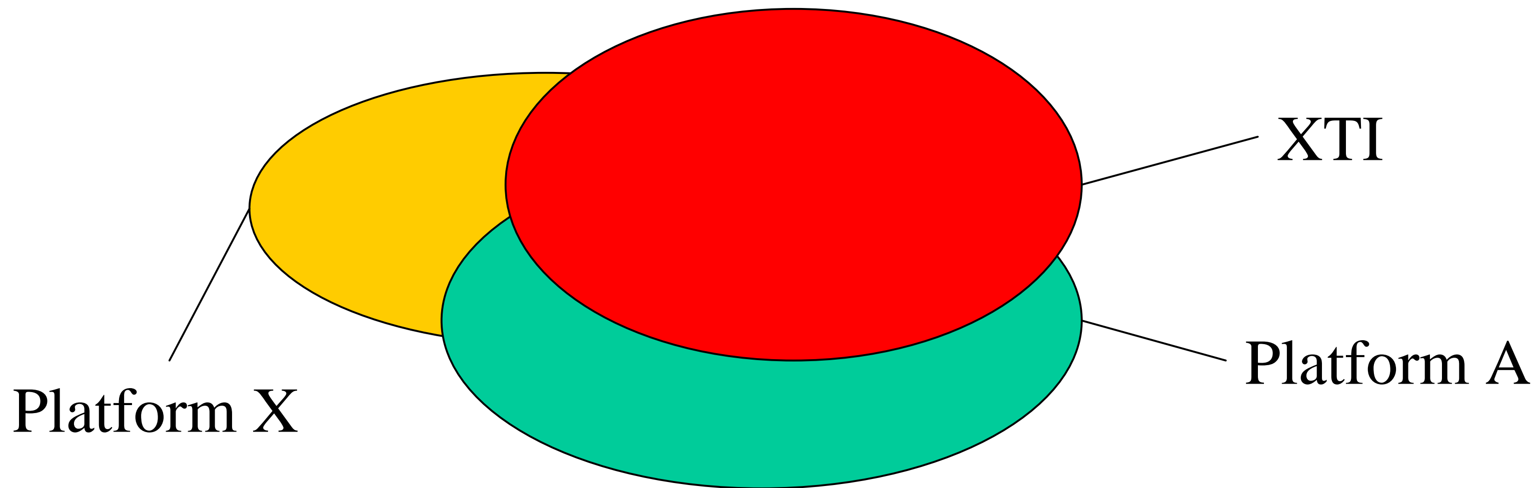
```
// use local object:


X x;
A a;
std::string s("abc");
// …
x.f(a, s);
```

```
// use remote object :
proxy<X> x;
x.connect("my_host");
A a;
std::string s("abc");
// …
x.f(a, s);
```

- “as similar as possible to non-distributed programming, but no more similar”
  - Asynchronous calls, multicasts, etc.

Relationship with platform services



- XTI can
  - be common interface to common services
    - Minimizing a program's platform dependencies
  - extend platform services to cover Standard C++
    - Platforms often support "common language facilities" only
  - support platform-specific facilities through optional extensions to XTI
    - potential for thin layer common interfaces to non-universal services
    - Hard to do

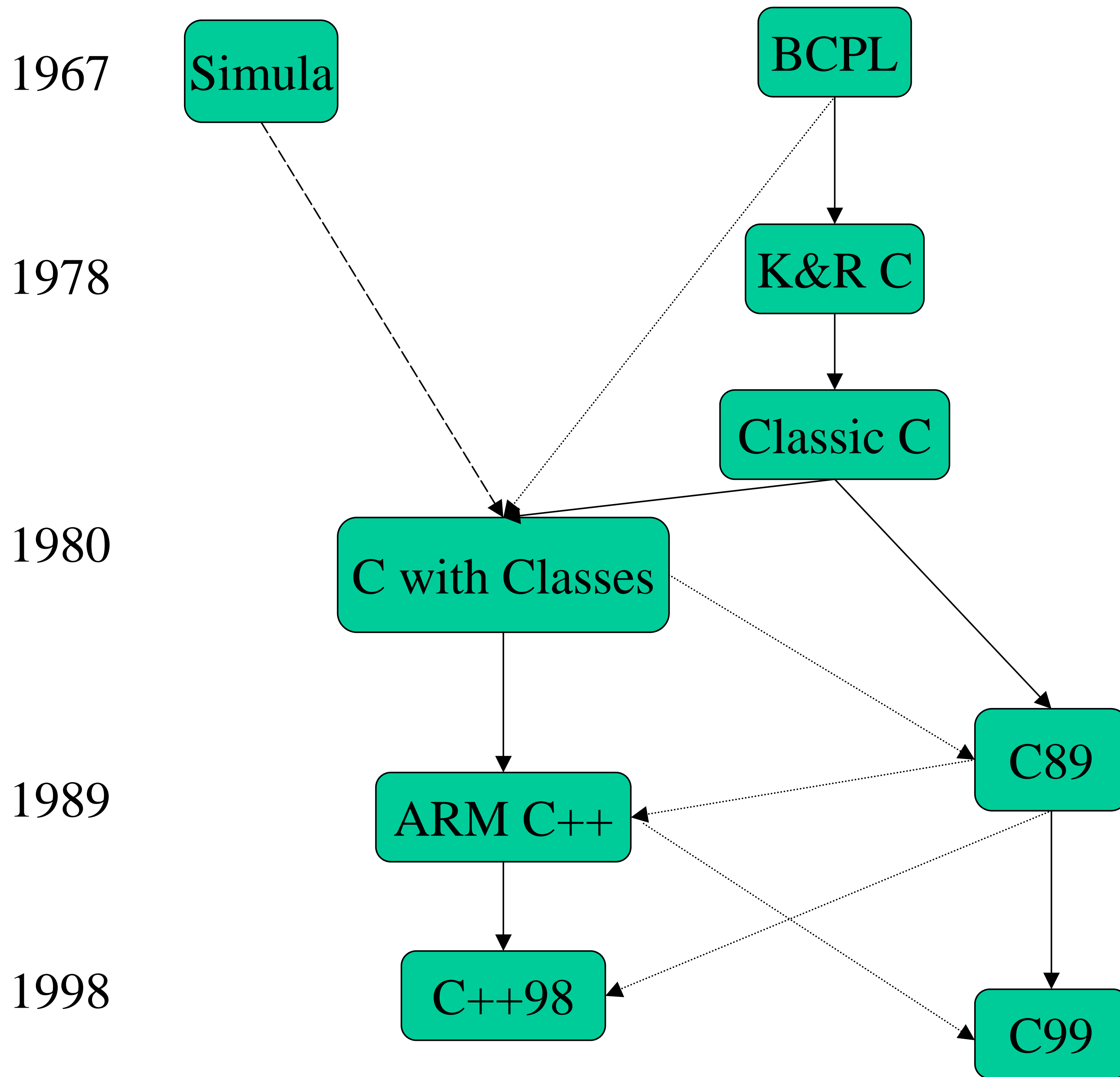
How do we get libraries to include?

- The committee is not a good forum for design
  - Wait and hope?
  - Everybody go off and write their own?
    - Boost.org
  - Look for existing library to co-opt/adopt?
  - Committee requests for proposals?

- Obvious potential problems
  - Lack of experience for new libraries
  - Lack of compatibility for old libraries
  - Proprietary aspects of libraries

C/C++ compatibility

- There is no C/C++ language
  - There is a C/C++ community
- C and C++ are diverging
  - For not very good reasons (IMO)
    - Some consider C/C++ diversion “a good thing”
- “We” should make an effort to minimize incompatibilities
  - Or C++0x and C0x will end up not being able to share
    - data structures, interfaces, and headers
    - Tools, implementations, libraries
  - There will be a holy mess of C/C++ dialects
    - with associated “rwars”


1967
1978
1980
1989
1998
Simula
BCPL
K&R C
Classic C
C with Classes
C89
ARM C++
C++98
C99

Sharing C89/C++ headers

- Relatively easy:
  - Avoid C++ features

```
class X { /* ... */ };                  // not C
```

  - Be slightly careful about C89 features

```
struct S { int class; /* ... */ };      // not C++
```

  - Sometimes simple “mediation code” is needed

```
// C interface:
extern int f(struct X* p, int i);

// C++ implementation of C interface:
extern "C" int f(X* p, int i) { return p->f(i); }
```

C99 interface features not found in C99 or C89

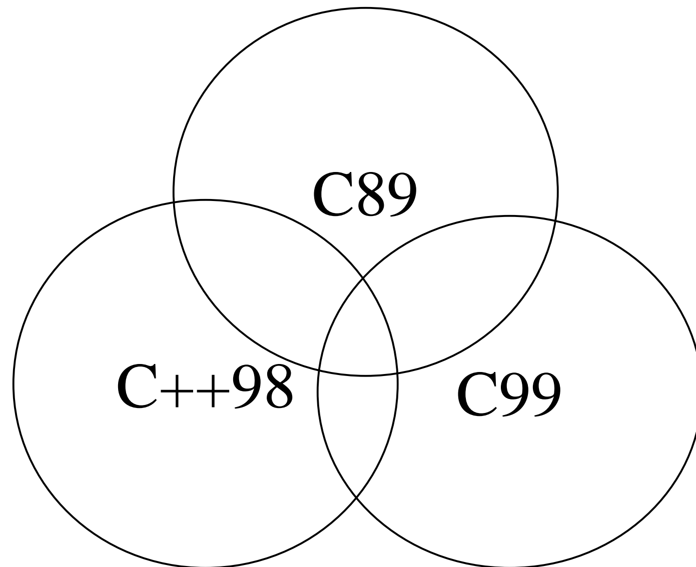
void f1(int[const]); // equivalent to **f(int *const);**
void f2(char p[static 8]); // **p** is supposed to point to at least 8 **char**s
void f3(double *restrict);
void f4(char p[*]); // **p** is a VLA

inline void f5(int i) { /* ... ***/ }** // may or may not be **C++** also

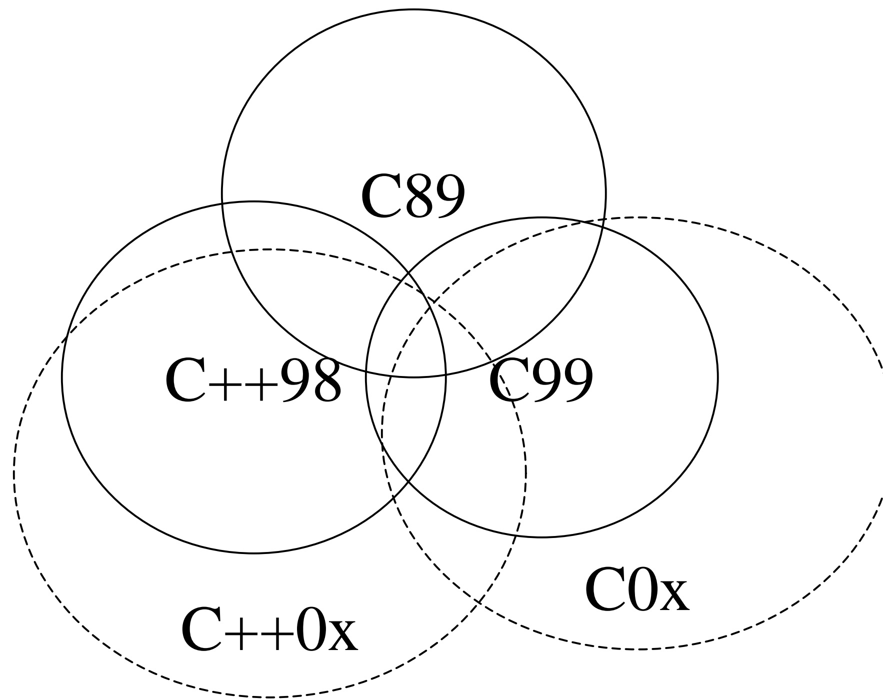
void f6(_Bool);
void f7(_Complex);

#define M(a …) something

C89 only	can call undeclared function
C++ only	templates
C99 only	variable length arrays
C89 and C++	can use restrict as an identifier
C89 and C99	Algol-style definitions
C++ and C99	// comments
C89, C++, and C99	structs



My nightmare



And remember the proprietary dialects

C/C++ compatibility

- My ideal: one language
  - A common language would benefit community
    - C/C++ isn't a language – the notion does harm
    - The is a large C/C++ community
- Politically very difficult
  - Both sides must give up something
  - "Establishments" seem to hate change
- Technically non-trivial
  - Obvious potential problems
    - Type-safety
    - C arrays

Directions

- General
  - Make C++ a better language for systems programming and library building
  - Make C++ easier to teach and learn
  - Minimize incompatibilities with C++98
- Language
  - Minimize extensions
    - Prefer standard library extensions to language extensions
  - Make rules more general and uniform
  - Maintain or increase type safety
  - Zero-overhead principle
- Library
  - Increase facilities of system-independent platform
    - Opportunistic, ambitious
  - Support distributed systems programming
  - Support a notion of "optional library component"