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Places, People, and Code

Bjarne Stroustrup
Texas A&M University
April 28, 2012

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Places

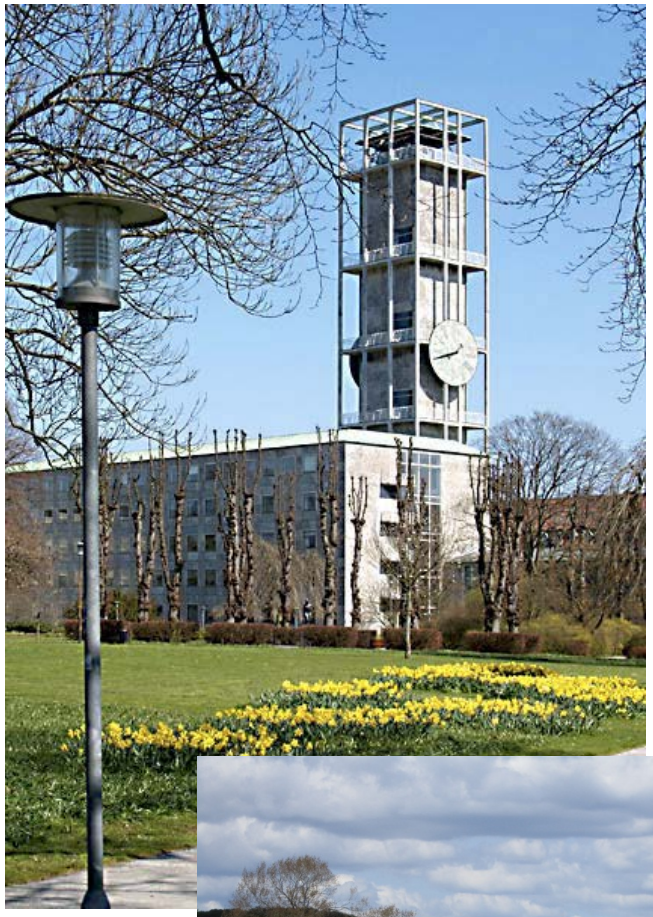
Texas A&M University
College Station

Bell Labs
Murray Hill, NJ

Cambridge

Aarhus

Aarhus

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NORTH SEA
Thisted
Aalborg
Randers
Aarhus Airport (AAR)
Holstebro
Aarhus
Herning
DENMARK
Helsinger
Horsens
Copenhagen
Odense Airport (ODE)
Copenhagen Airport (CPH)
Esbjerg
Odense
Slagelse
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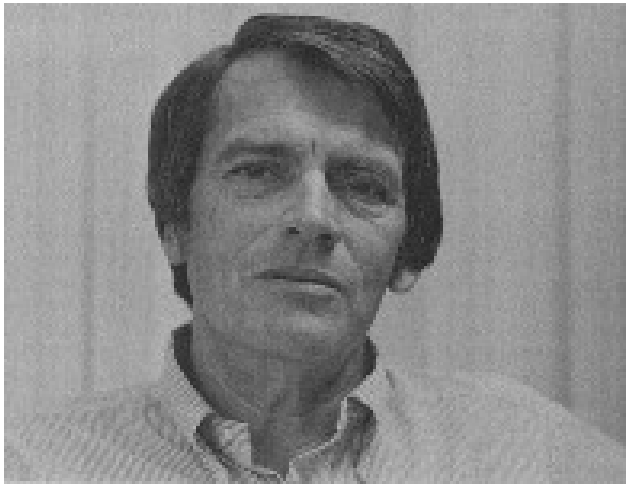
Microprogramming

- Instruction set design
- Machine architecture
- Machine Oriented Languages
- "High-level" instruction sets and interfaces
  - Inspirational talk by Bob Barton
- The OS/hardware interface
- Concurrent execution



Simula

- Object-oriented programming
- Object-oriented design
- Concurrent programming

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Cambridge

Cambridge Computer Lab

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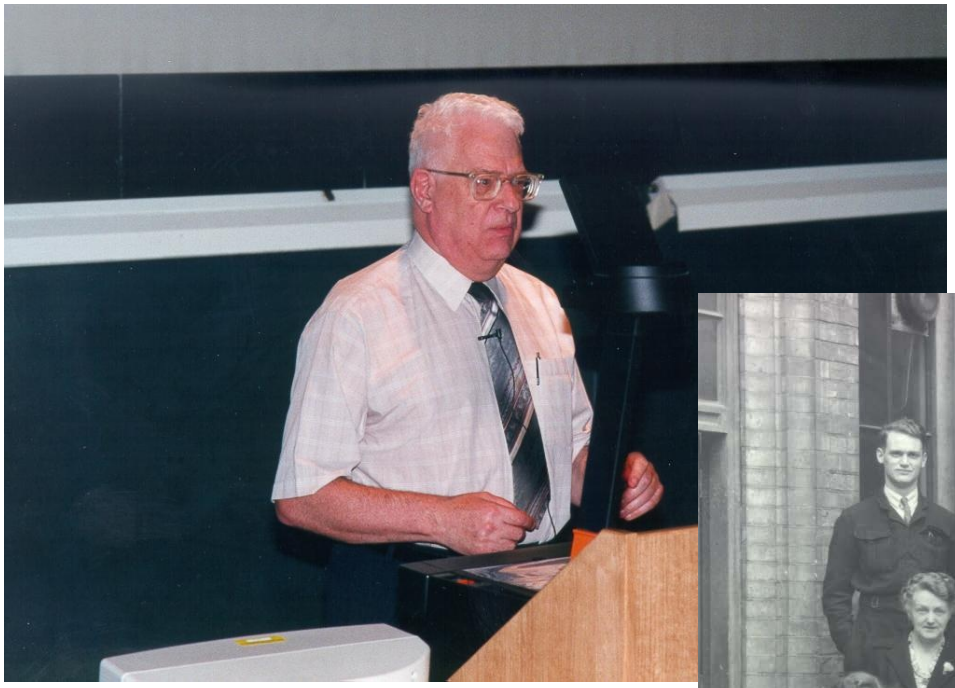

"Keep a high external profile"

1949.
May 6th
Machine in operation for first time. Printed table of squares (0 - 99). time for programme 2 mins. 35 secs. Four tanks of battery 1 in operation.

Cambridge

- *Systems should be build to do useful things for real people* – Roger Needham
- Martin Richards

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AT&T Bell Labs, Murray Hill, NJ

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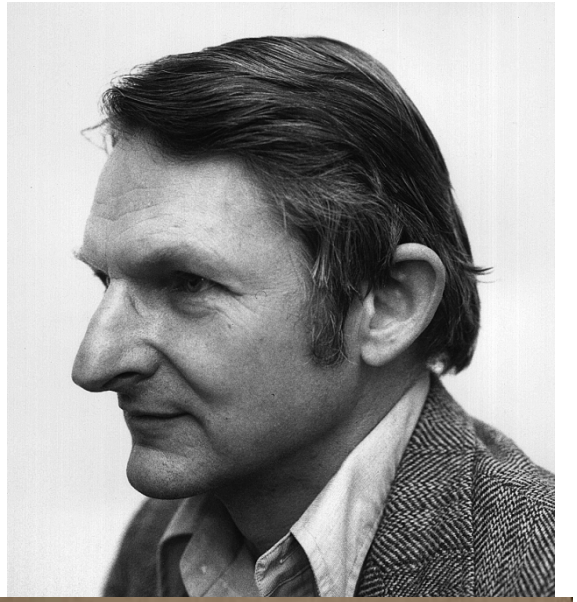
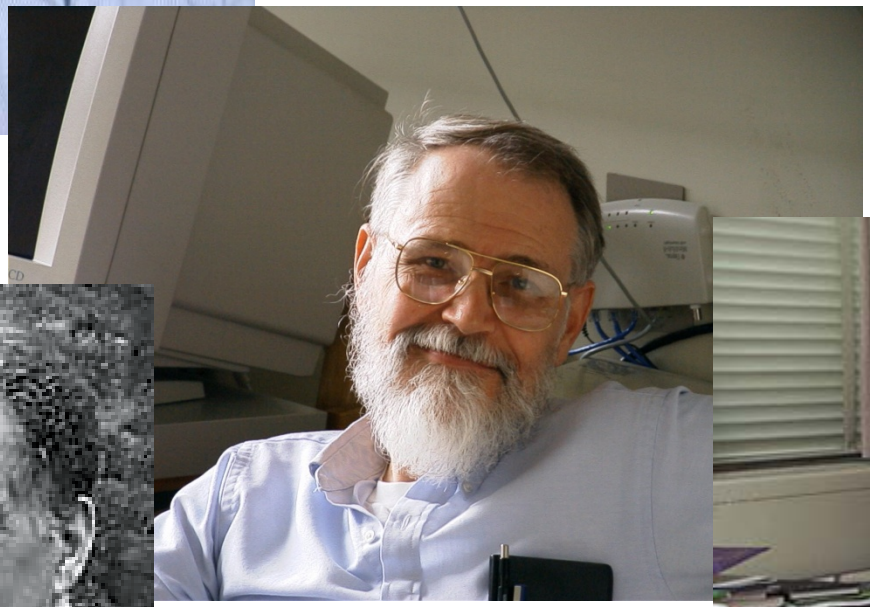
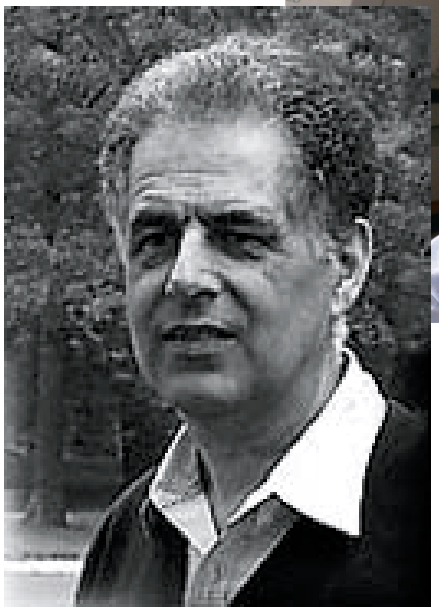
127
aka
CSRC

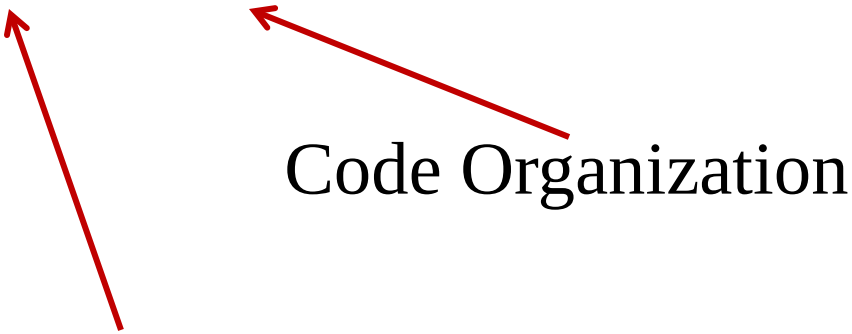






C with Classes

- C + Simula



Systems programming and performance

- A strong and flexible static type system was/is the ideal/aim
- "Elegant ***and*** efficient code"

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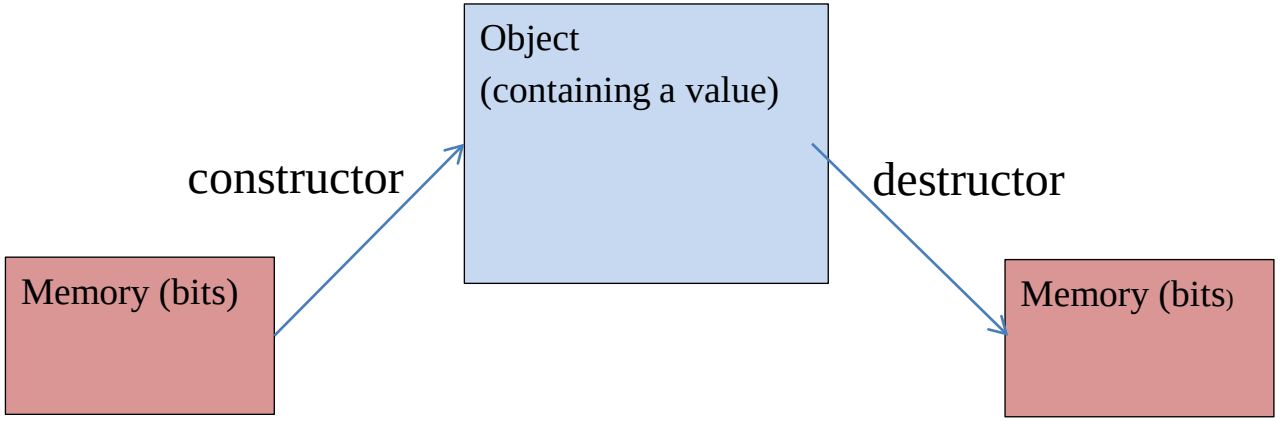
Constructors and destructors

- A constructor established the run-time environment for member functions
  - incl. acquiring needed resources
- The destructor reverses the actions of the constructor
  - incl. releasing owned resources

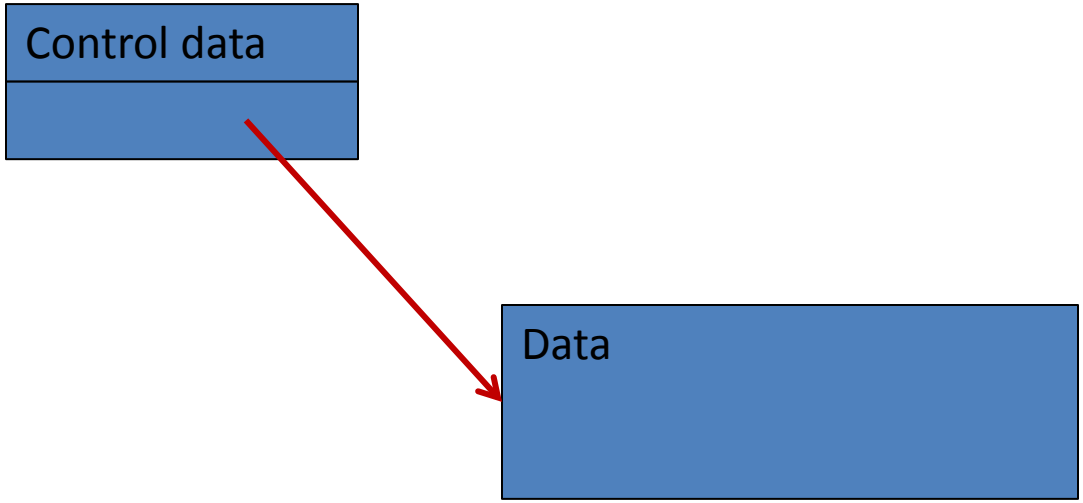
"The idea was to allow the programmer to establish guarantees, sometimes called ''invariants,'' that other member function could rely on."

Constructors and destructors



- Constructor: make an object from memory
  - An object holds a value
  - Has a type
  - Has an interface
  - Has meaning
- Destructor: make an object (back) into memory
  - Memory is just interpreted bits

A resource handle



- Examples
  - Containers
    - vector, list, map, …
  - Smart pointers
    - unique_ptr, shared_ptr, delayed_value, remote_object, …
  - Locks, thread handles, sockets, iostreams, file handles
  - …

Vector: the archetypical resource handle

- Slight simplification of **std::vector**

```
template<typename T>                    // T is the element type
class Vector {
public:
    Vector();                           // default constructor: make empty vector
    Vector(int  n);                     // constructor: initialize to n elements
    Vector(initializer_list<T>) ;       // constructor: initialize with element list
    ~Vector();                          // destructor: deallocate elements
    int size() ;                        // number of elements
    T& operator[](int i);               // access the ith element
    void push_back(const T& x);         // add x as a new element at the end
    T* begin();                         // fist element
    T* end();                           // one-beyond-last element
private:
    int sz;                             // number of elements
    T* elem;                            // pointer to sz elements of type T
};
```

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Some liked C++, some didn't

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Bell Labs – many years later

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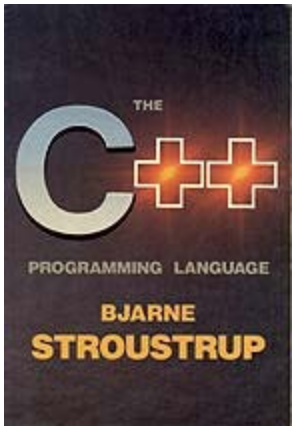
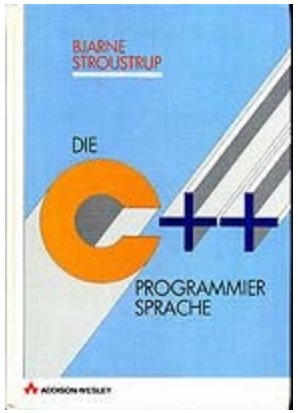
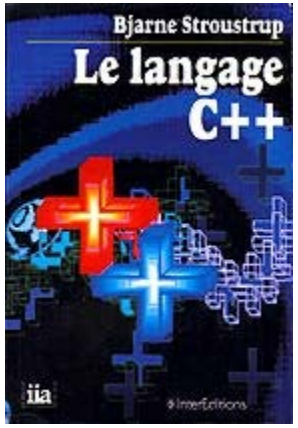
TC++PL







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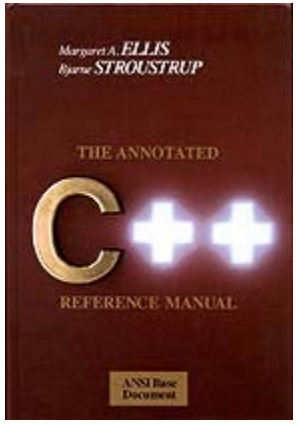
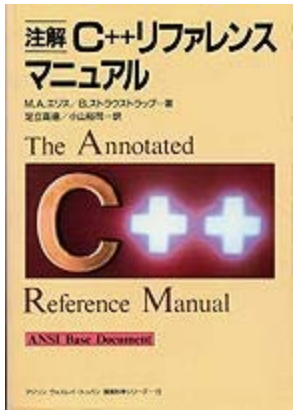
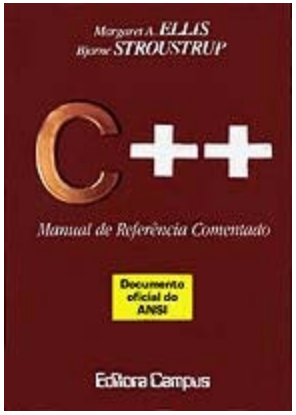
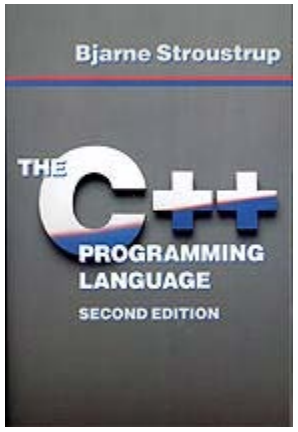
The ARM







TC++PL2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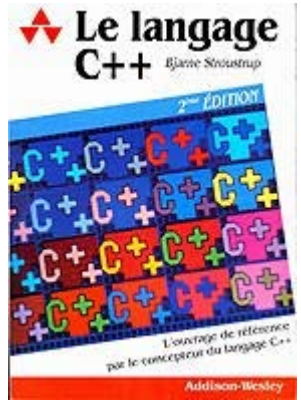
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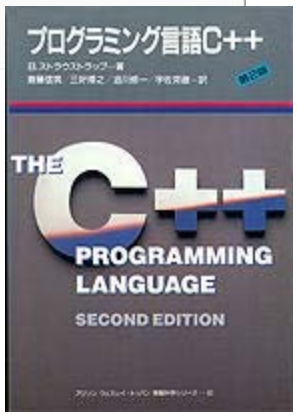
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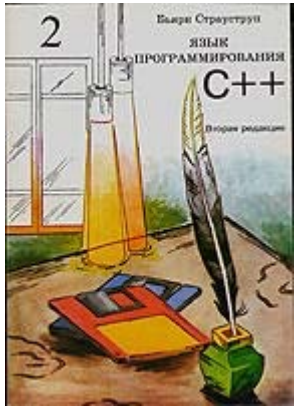
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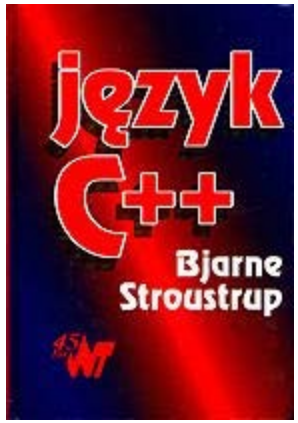
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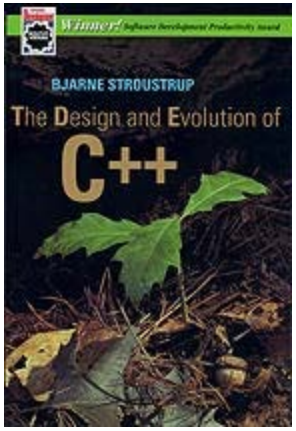

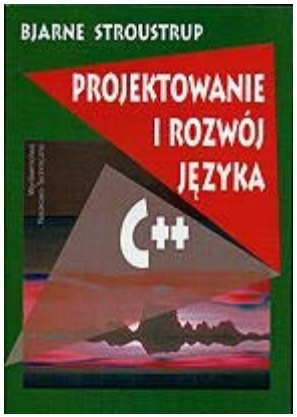

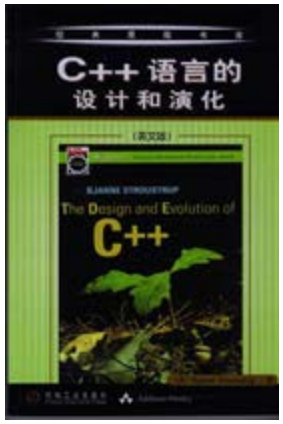

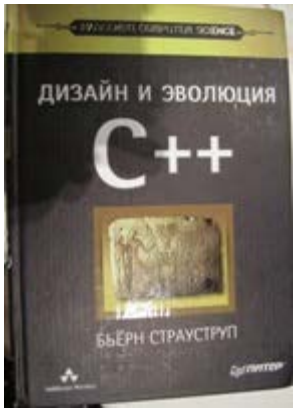


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C++ Standardization

J16/WG21 Meetings 1979-2012-…

- Austin
- Batavia
- Bellevue
- Berlin
- Bloomington
- Boston
- Curacao
- Copenhagen
- Dublin
- Frankfurt
- Kona
- Lillehammer
- London
- Lund
- Madrid
- Morristown
- Monterey
- Mt. Tremblant
- Nashua
- Oxford
- Portland
- Pittsburg
- Portland
- Rapperswil
- Redmond
- Santa Cruz
- San Diego
- San Francisco
- Sidney
- Seattle
- Somerset
- Sophia Antipolis
- Stockholm
- Summit
- Tokyo
- Toronto
- Valley Forge
- Washington, D.C.

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C++ standardization – why bother?

- The ISO standards process is central
  - C++ has no rich owner
    - who can dictate changes, pay for design, implementation, marketing, etc.
  - The C++ standards committee is the central forum of the C++ community
    - Endless discussions among people who would never meet otherwise
  - The committee receives massive feedback from a broad section of the community
    - Much of it industrial
  - The committee is somewhat proactive
    - Adds features not previously available in the C++ world
  - Standard support needed for mainstream use
    - Huge potential for improvement of application code
    - For (far too) many “if it isn’t in the standard it doesn’t exist”
  - Significant defense against vendor lock-in

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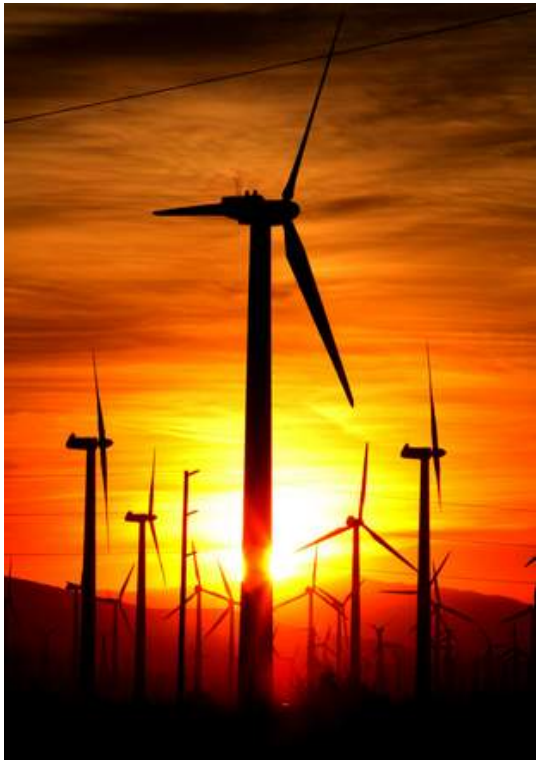
Interlocking themes

- Stability and Compatibility
  - "make the language much better but don't break my code"
- Scale
  - Million-line projects became common
  - Specification – precise and complete
  - Portability
- Resource management
  - Invariants
- Type safety
  - Containers
- Performance
  - Compactness
- Equal support for user-defined and built-in types
  - Value types, scoped objects
- User skills required



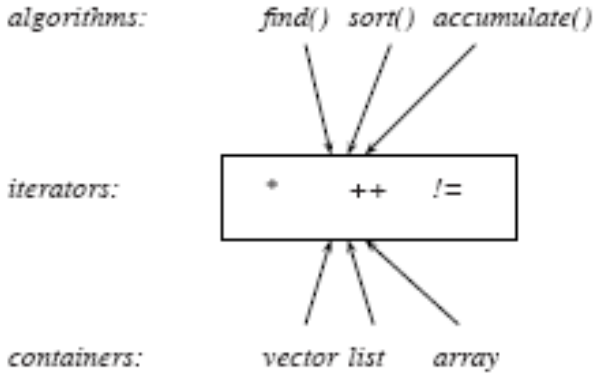
C++98 example: Resource management

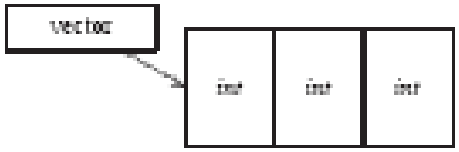
- Standard library containers
  - with exception-safety guarantees (e.g., **vector**)
  - the techniques can be used by every user (e.g., **File_handle**)
- No resources are leaked
  - Based on a simple and systematic view of resource management
    - Exception safety guarantees
    - RAII
  - Destructors do cleanup
    - guaranteed, implicitly

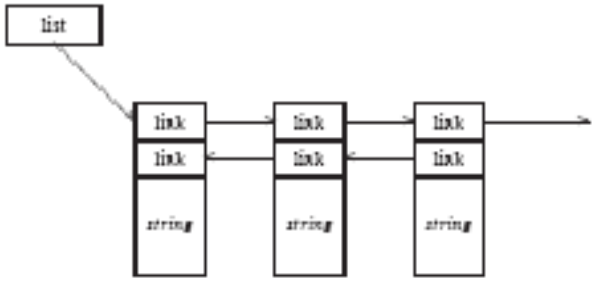
```
void f(string s)
{
    vector<int> v;
    File_handle h(s,"r"");
    // …
    int x;
    while (cin>>x) {
      if (x<=0) throw Bad_value(x);
      v.push(x);
    }
    // …
}
```

The STL

- Ideal: The most general and most efficient expression of an algorithm
  - Focus on algorithms
  - Separate algorithms from data
  - Go from the concrete to the abstract
    - Not the other way
  - Use compile-time resolution to eliminate overheads
    - Inlining and overloading
  - Where needed, parameterize with policies
    - E.g. sorting criteria



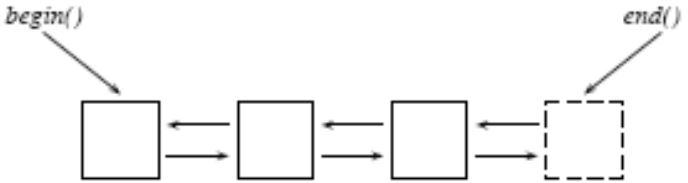




STL example: find_if()

- Definition

```
template<class Iter, class Pred>
Iter find_if(Iter first, Iter last, Pred p)
{
    while (first!=last && !p(*first)) // while not at end and predicate not met
      ++first;                        // advance to next element
    return first;  // return the element reached
}
```

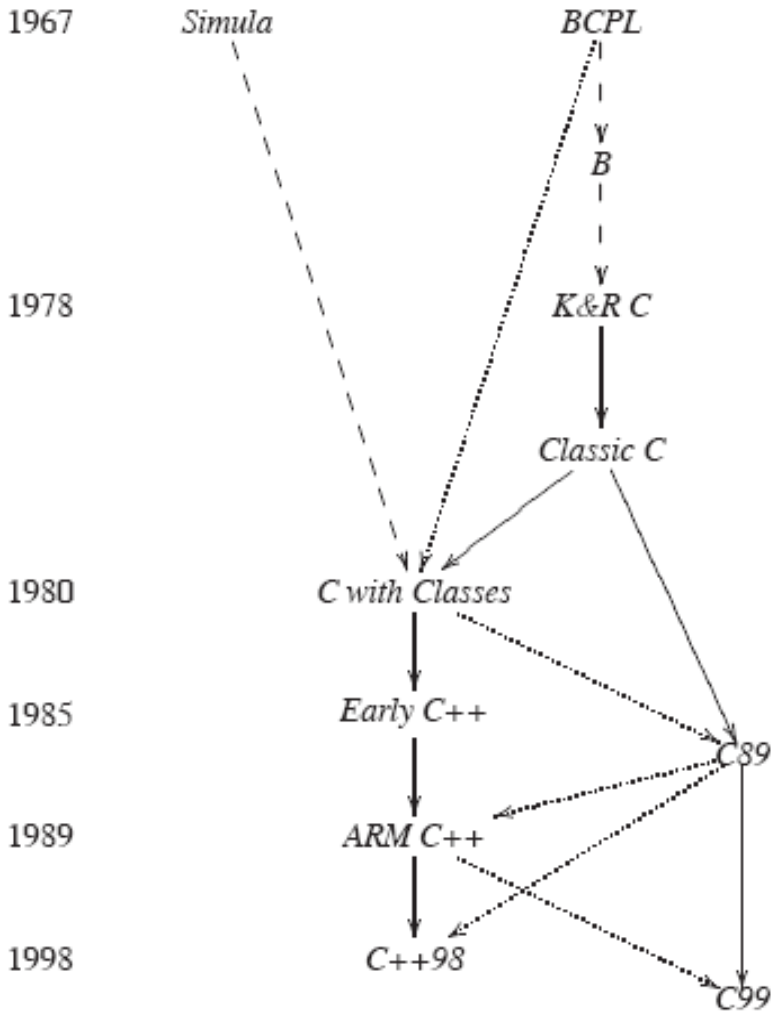


Design

- By committee?

C/C++ compatibility

- A constant sore point
  - Separate standards committees
    - A tragedy
  - Constant borrowing
    - Both ways
    - Often incompatibly
  - Widely demanded by users
    - Rightfully so
  - Widely despised by users
    - “Against OO”
    - “Against the spirit of C”



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C++11

- And now – just a year later – large parts of C++ is shipping!
  - GCC4.7
  - Microsoft 11 beta
  - …
  - "Everybody" ships the libraries

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- John Lakos: Bloomberg
- Stepanus Du Toit: Intel, Canada
- Loic Joly: INRIA, France

- Herb Sutter: Microsoft
- Steve Clamage: Oracle (Sun)
- Bill Plauger: Dinkumware
- Howard Hinnant: Apple

- Howard Hinnant: Apple
- Richard Corden : Programming Research
- Clark Nelson: Intel

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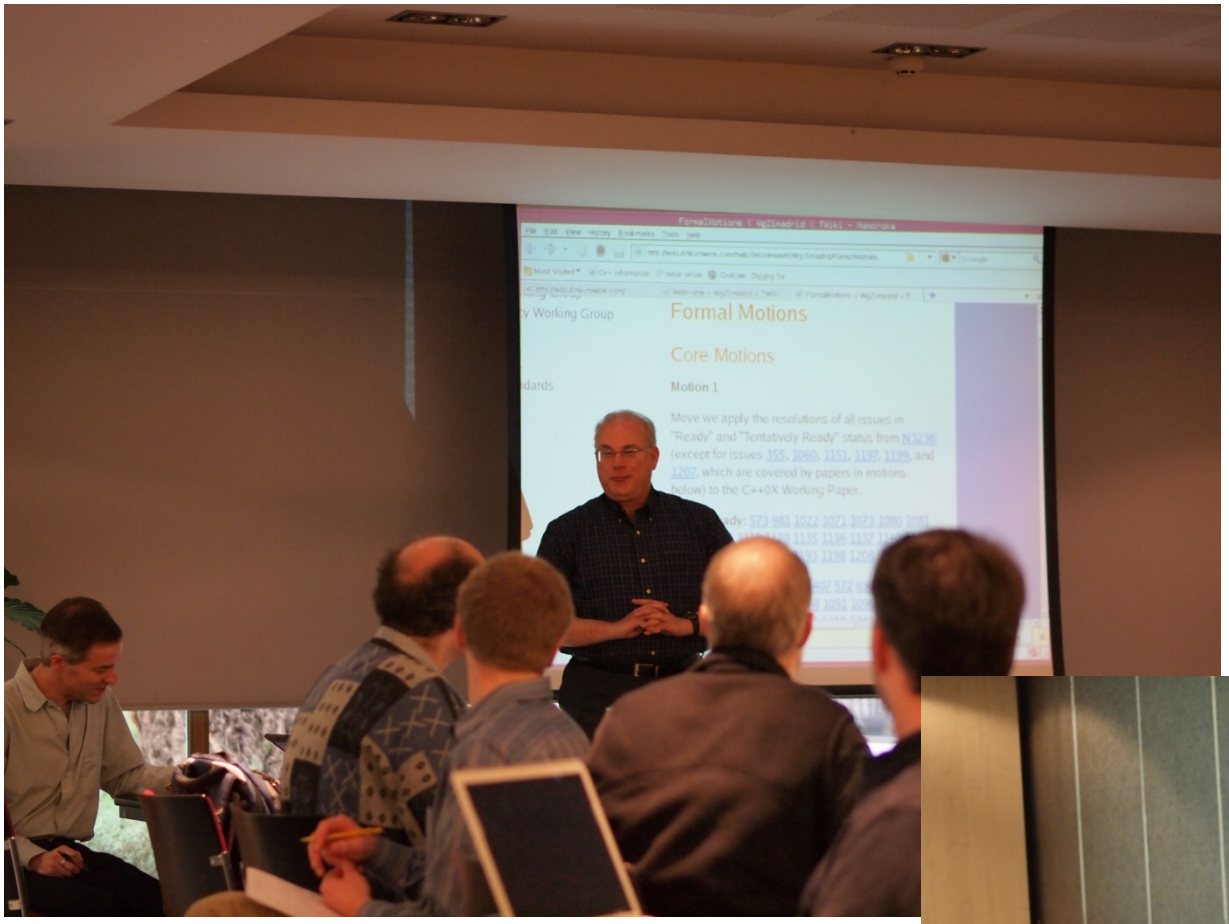

- Steve Clamage: Oracle (Sun)
- Jean-Paul Rigoux: U. de Provence, France
- J.C. Van Vinkel: Netherlands and Google
- Beeman Dawes: Boost
- Detleff Vollman: Switzerland

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- Loic Joly: INRIA, France
- Mike Miller: EDG
- Doug Gregor: Apple
- Roger Orr: UK
- Alisdair Meredith: Bloomberg

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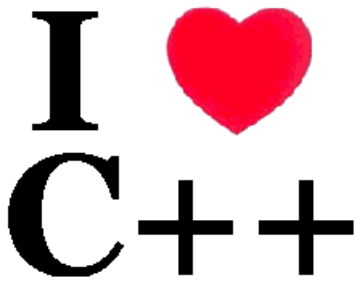
- Martin Sebor: Rogue Wave
- Pete Becker: Roundhouse Consulting
- Jaakko Jarvi: TAMU
- Daniel Garcia: U. Charlos III

- Hans Boehm: HP
- Beeman Dawes: Boost
- Mike Wong: IBM
- Lawrence Crowl: Google

- Herb Sutter: Microsoft
- Daniel Krugler: ???
- John Lakos: Bloomberg

Copy and move

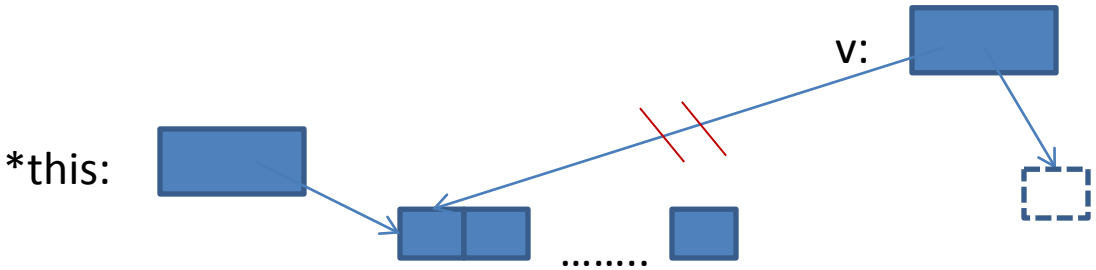
```
Vector<int*> find_all(Vector<int>& v, int val)      // find all occurrences of val in v
{
    Vector<int*> res;
    for (int& x : v)
        if (x==val)
            res.push_back(&x);          // add the address of the element to res
     return res;
}

void  test()
{
    Vector<int> lst {1,2,3,1,2,3,4,1,2,3,4,5};
    for (int* p :  find_all(lst,3))
        cout << "address: " << p << ", value: " << *p << "\
    // …
}
```



Copy and move

- Move constructor

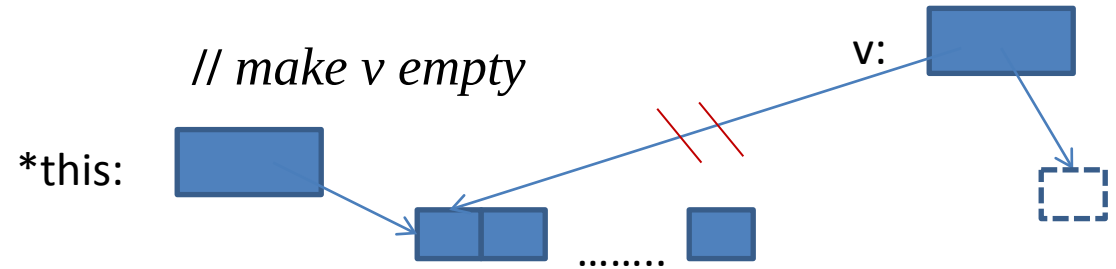
```
template<typename T>
Vector<T>::Vector(const Vector&& v)                    // move constructor
    : sz{v.sz}, elem{v.elem}      // grab v's elements
{
    v.elem = nullptr;             // make v empty
    v.sz = 0;
}
```



Copy and move

- Move assignment

```
template<typename T>
Vector<T>& Vector<T>::operator=(Vector<T>&& v)    // move assignment
{
    destroy<T>(elem,sz);        // delete old elements
    elem = v.elem;              // grab v's elements
    sz = v.sz;
    v.elem = nullptr;           // make v empty
    v.sz = 0;
    return *this;
}
```



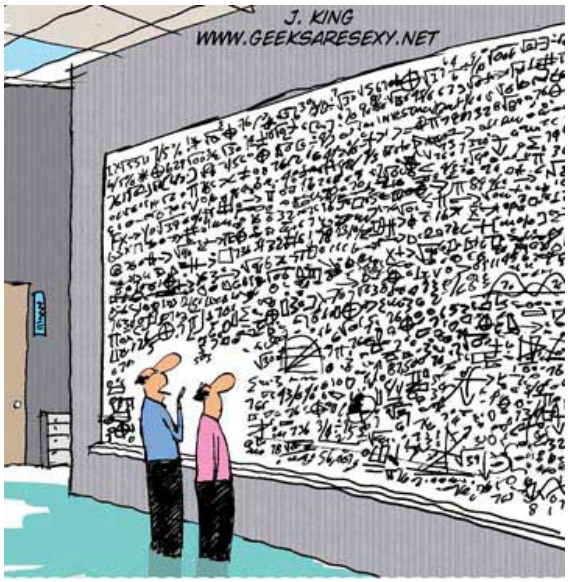
Vector

- Copy and move declarations added to Vector

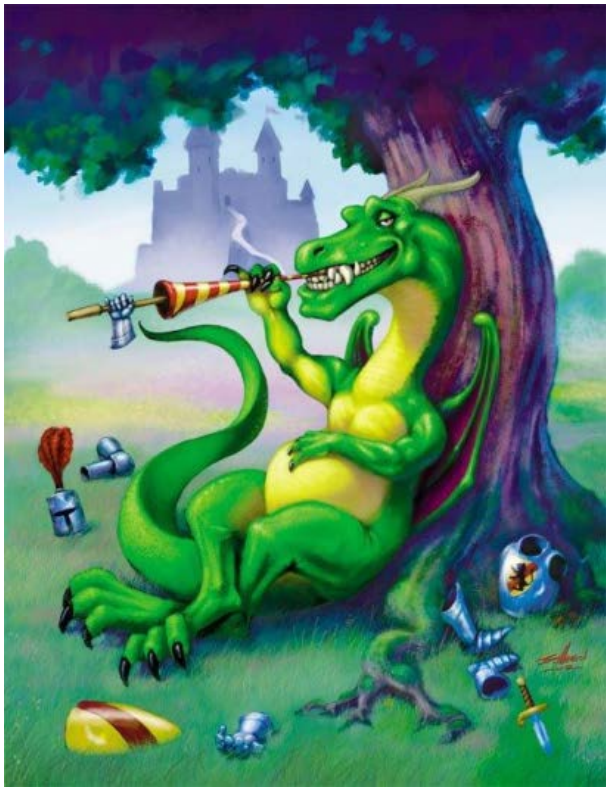
```
template<typename T>          // T is the element type
class Vector {
public:
    // …
    Vector(const Vector&);                  // copy constructor
    Vector(Vector&&);                       // move constructor
    Vector& operator=(const Vector&);       // copy assignment
    Vector& operator=(Vector&&);            // move assignment
    // …
};
```

The real problems

- Help people to write better programs
  - Easier to write
  - Easier to maintain
  - Easier to achieve acceptable resource usage



"...And that, in simple terms, is what's wrong with your software design."



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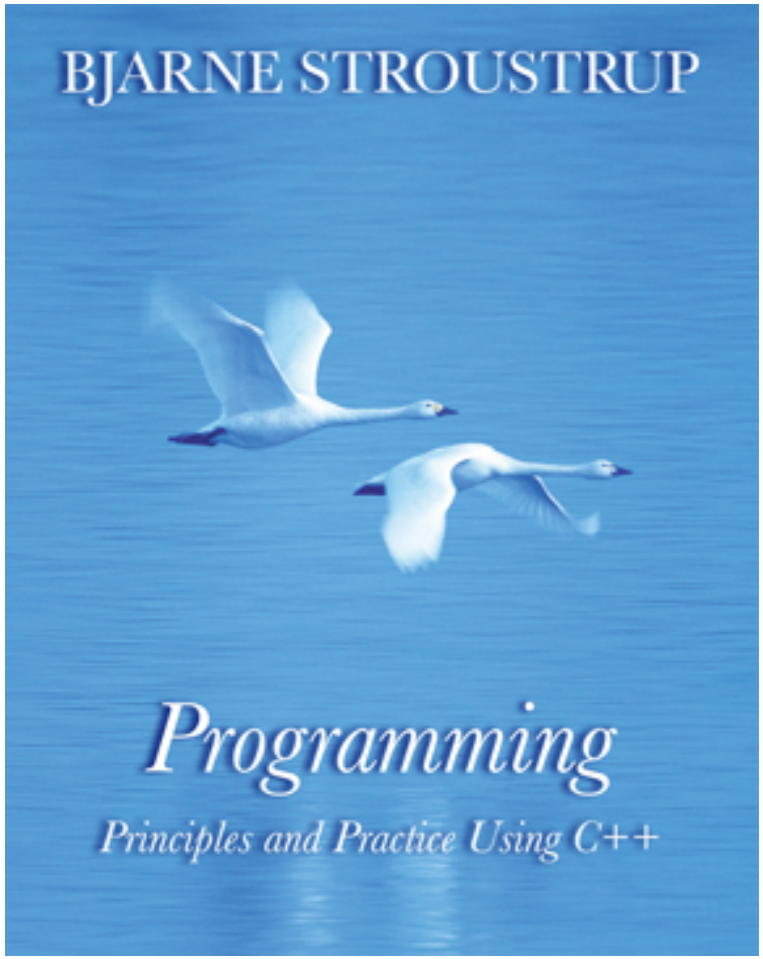
C++ is shockingly misused

- "If that's C++, then I don't like it either!"
  - Bjarne Stroustrup, 2004
    - (after surveying a couple of dozen C++ textbooks)



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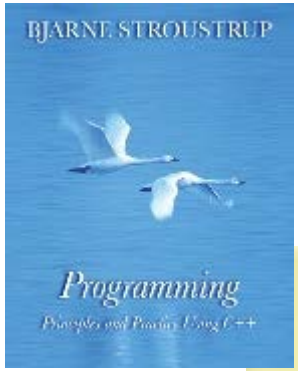
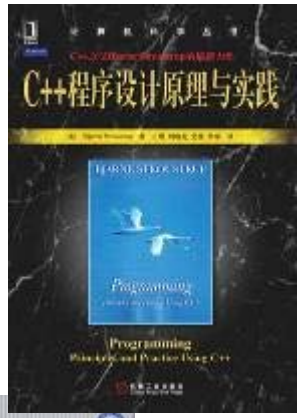
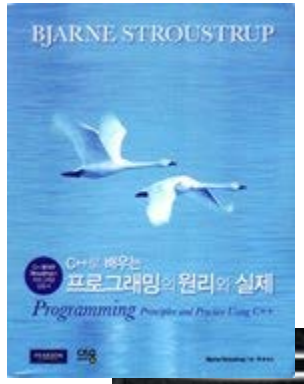
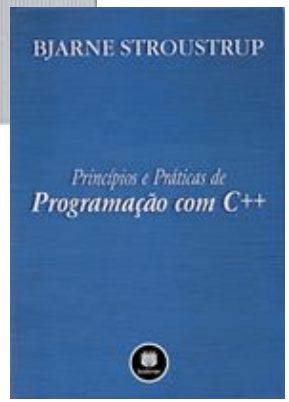
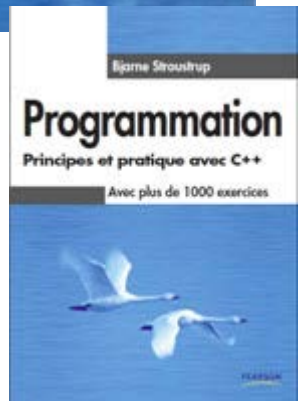
PPP











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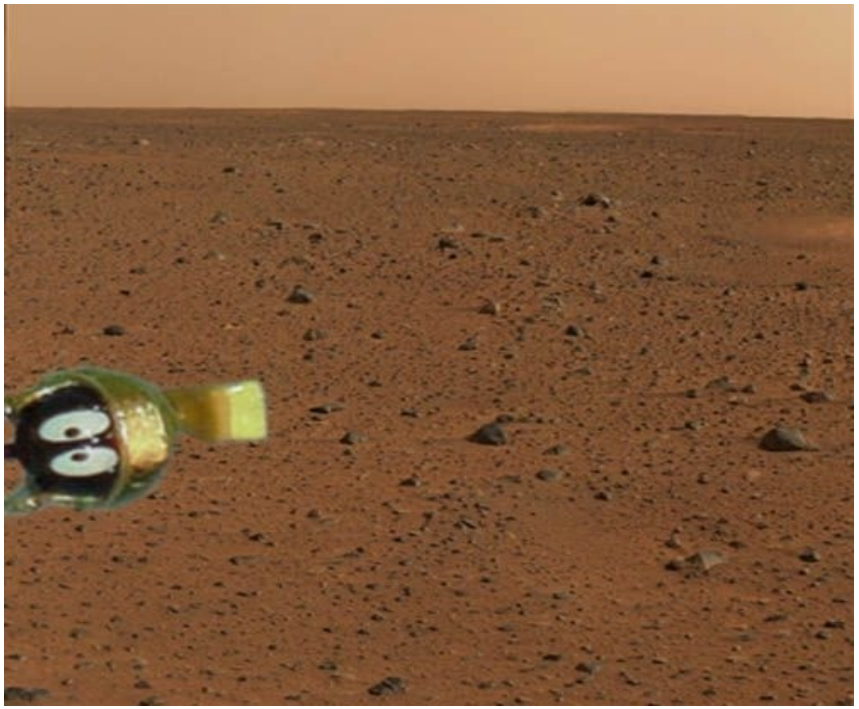
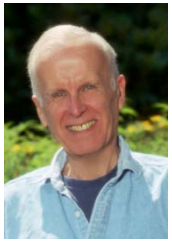
Programming languages

- A programming language exists to help people express ideas
- Programming language features exist to serve design and programming techniques
- The primary value of a programming language is in the applications written in it



The quest for better languages has been long and must continue

Programming Languages



Domain-specific abstraction

Fortran

Cobol

General-purpose abstraction

Simula

Java

C++

C++11

C#

Direct mapping to hardware

Assembler

BCPL

C

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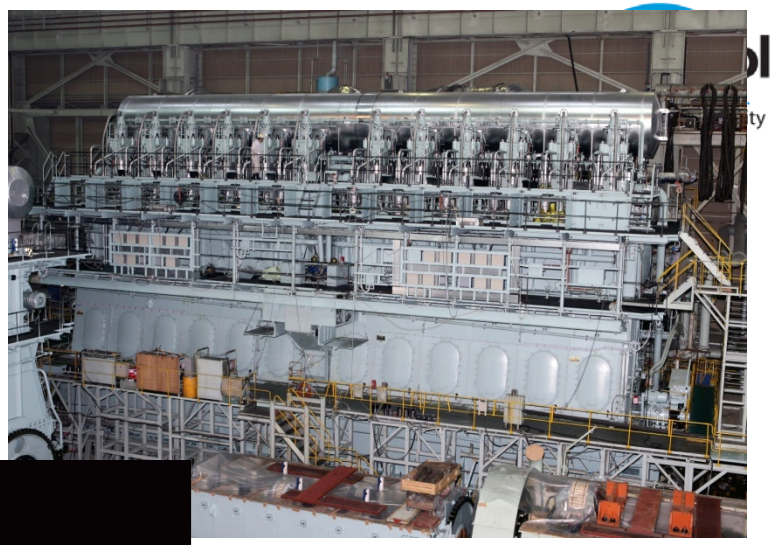
C++

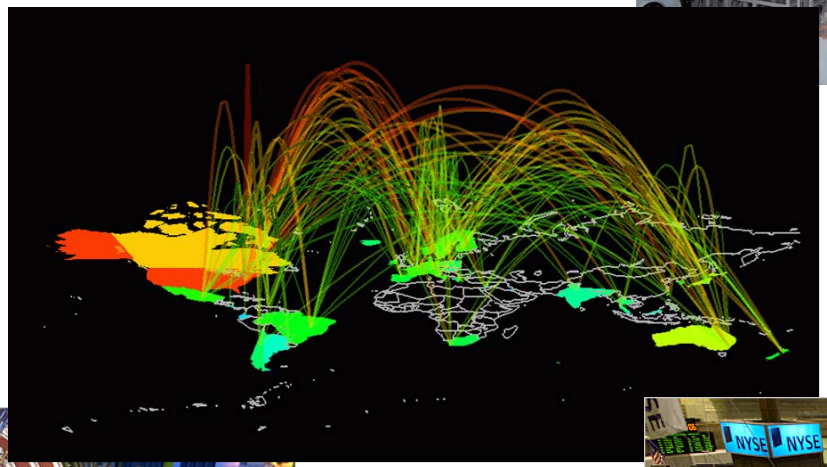
Key areas of strength:

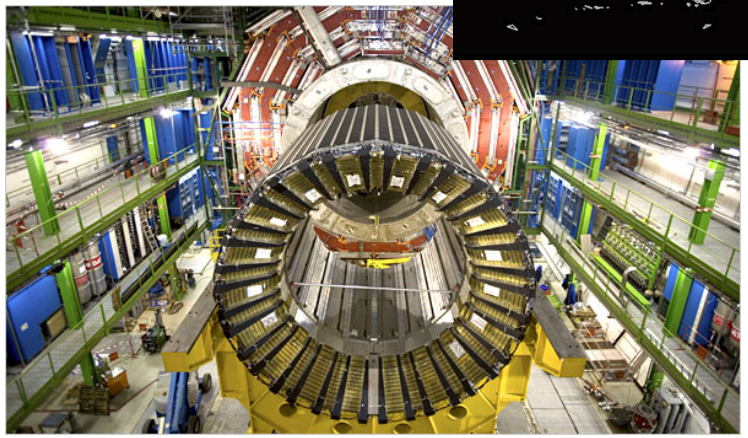
- Software infrastructure
- Resource-constrained applications

A light-weight abstraction programming language

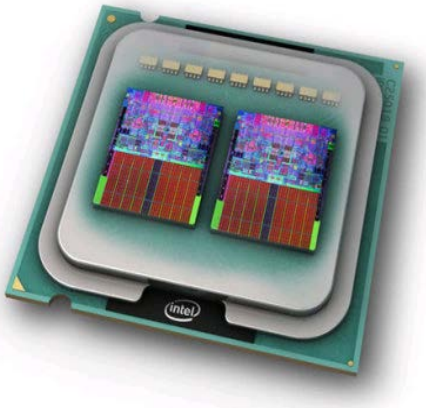
C++ applications







C++ Applications



- www.research.att.com/~bs/applications.html

C++ Applications

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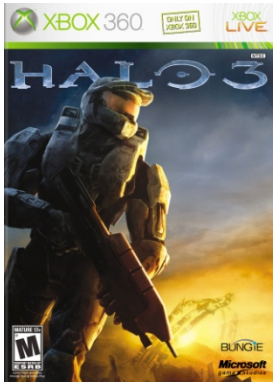
TOMTOM

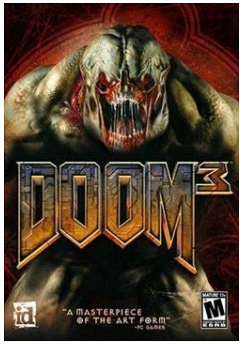
GARMIN

MySQL

PayPal

amazon





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Thanks!