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Evolving a widely used language
Why and how?

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Beautiful Bergen

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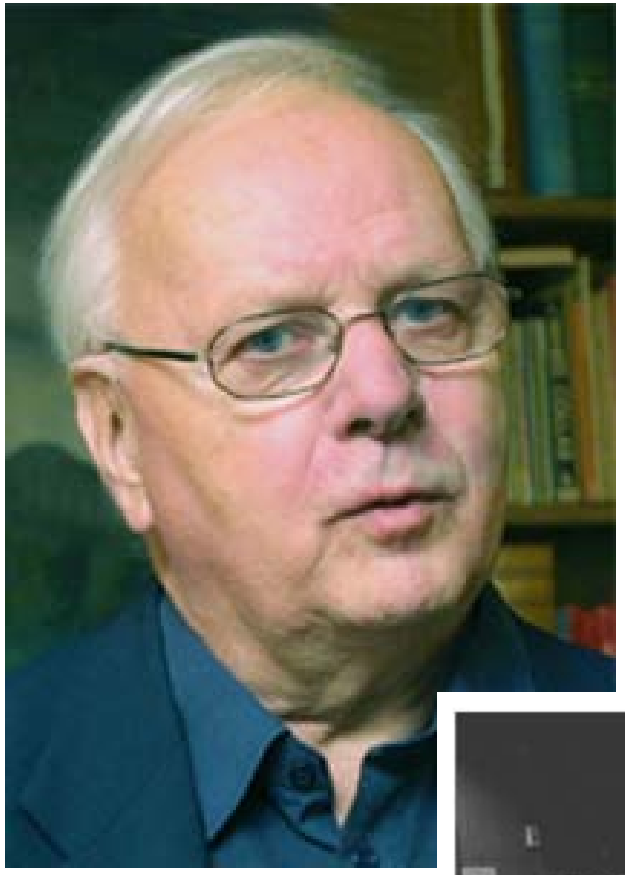
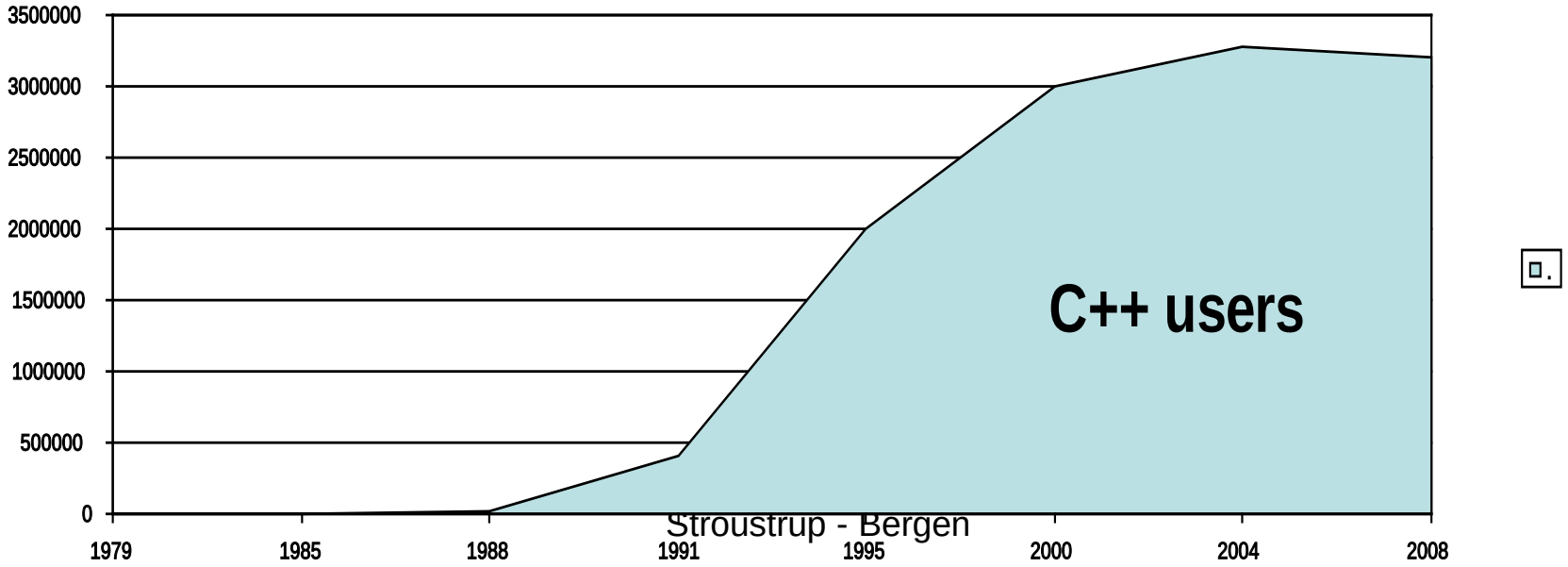


Thanks!

Dahl and Nygaard at the time of Simula's development

Programming languages

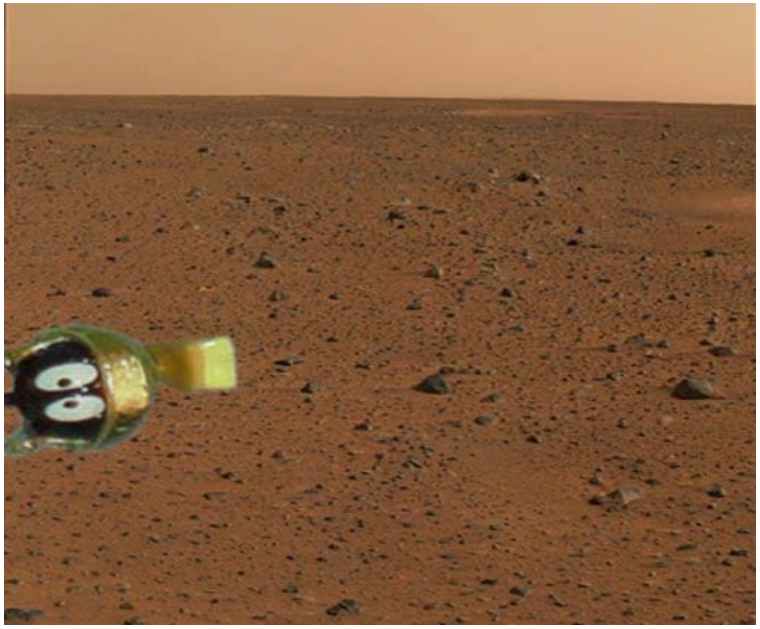
- A programming language exists to help people express ideas
  - To help build useful and/or interesting systems
  - As problems change, a language must evolve (or die)
  - Many more users implies different kinds of users and different problems
  - Language features exist to serve design and programming techniques



C++ applications

www.research.stroustrup/~bs/applications.html

- Telecommunications
- Google
- Microsoft applications and GUIs
- Linux tools and GUIs
- Games
- Financial systems
- PhotoShop
- …



- Mars Rovers
- Marine diesel engines
- Cell phones
- Human genome project
- Micro electronics design and manufacturing
- …

The world of 1975-85

- Much work still done in assembler
  - Essentially all embedded systems programming
  - Most systems programming
  - Quite a lot of applications programming
- OOP – what's that?
  - In both academia and industry
  - The few that have heard of it deem it
    - Just "slow graphics"
    - Unsuitable for ordinary mortals
    - Incapable of interoperate as part of a system

- Academia and industry are quickly drifting apart
  - It was not always so in CS; e.g. Dijkstra, Hoare, Backus, started out in industry

The idea of C++

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- C + Simula
  - Direct map to hardware + abstraction
  - Efficiency + structure
- Known problems
  - Non-uniform handling of built-in and user-defined types in Simula
  - Lack of static type safety in C
  - No parameterized types or procedures in either
- Get something working and then improve on it
  - First non-research user after 6 months
  - C++ compiler in C++
  - Direct support of a variety of colleagues

What's distinctive about C++?

- Stability
  - Essential for real-world software
  - 1985-2008
  - 1978-2008 (C and C with Classes)
- Non-proprietary
  - Yet almost universally supported
  - ISO standard from 1998
- Direct interface to other languages
  - Notably C, assembler, Fortran
- Abstraction + machine model
  - Zero overhead principle
    - For basic operations (e.g. memory access) and abstraction mechanisms
  - User-defined types receive the same support as built-in types
  - Standard library written in the language itself
    - And most non-standard libraries

Aims for C++

- Support real-world software developers
  - "better software now"
  - by "better" I mean correct, maintainable, efficient, portable, …
- Change the way people think about software
  - Object-oriented programming
  - Generic programming
  - Resource management
  - Error handling
- Functional, not academic, beauty
  - "even I could have designed a much prettier language" – B.S. 1984 or so

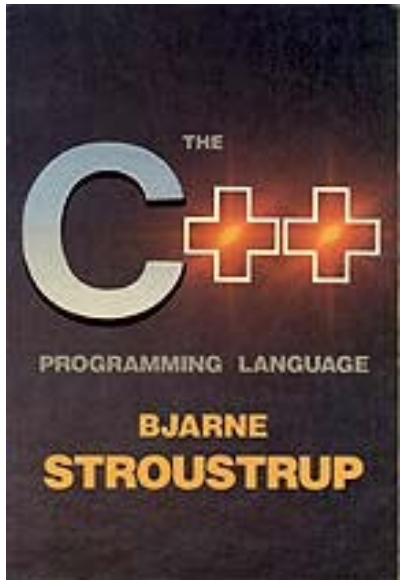
Language features – 1979-1990

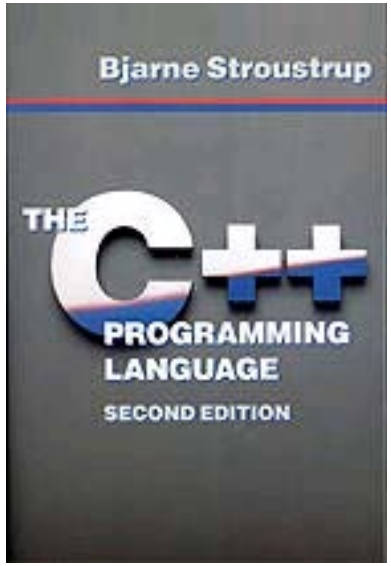
- C with Classes (1979-84)
  - Function argument declarations and checking
  - **const** (also in constant expressions)
  - Classes
  - Derived classes
  - Constructors, destructors
  - **new** and **delete**
  - Inline functions
- C++ (in 1983-86)
  - Overloading (incl. =, [], and ())
  - **virtual** functions
  - Type-safe linkage
- C++ (1988-90)
  - Templates
  - Exceptions

Not in C until much later

Huge impact

Rather late





C++ ISO Standardization – Membership

- About 22 nations
  (8 to 12 at a meeting)
  - ANSI (US national committee) hosts the technical meetings
  - Other nations have further technical meetings
- Membership have varied
  - 100 to 200+
    - 200+ members currently
  - 40 to 100 at a meeting
    - ~60 currently
- Most members work in industry
- Most are volunteers
  - Even many of the company representatives
- Most major platform, compiler, and library vendors are represented
  - E.g., IBM, Intel, Microsoft, Sun
- End users are underrepresented

C++ ISO Standardization – Process

Formal, slow, bureaucratic, and democratic

- "the worst way, except for all the rest" (apologies to W. Churchill)

Most technical work happens

- in "working groups"
- electronically between meetings

C++ ISO Standardization – Organization

- (ad hoc) Working groups
  - Core
  - Library
  - Evolution
    - Concurrency
- "mailings"
  - "papers" presenting issues and proposals
    - Hundreds each year; see WG21
- "reflectors"
  - Achieved mailing lists
- Many (even) more "ad hoc" activities
  - E.g. implementers presenting progress

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C++ standardization – why bother?

- The ISO standards process is central
  - 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
  - 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

C++ ISO Standardization – Results

1998 ISO standard
- 22-0 vote

2003 Technical Corrigenda
- "bug fix release"; no new features

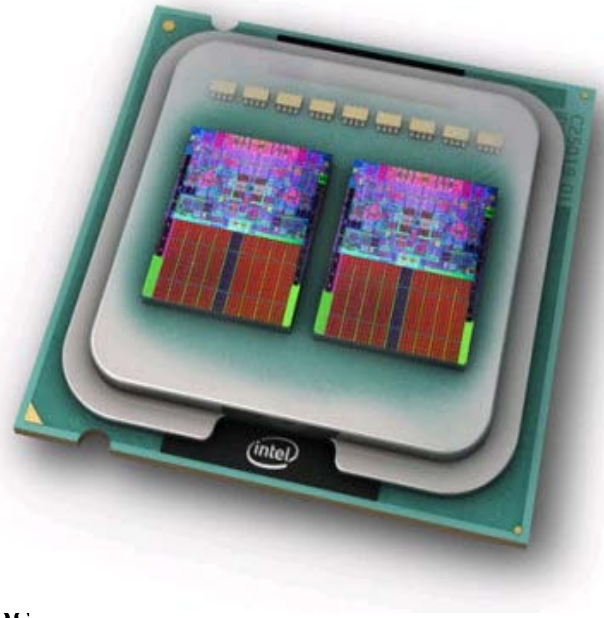
2008 Registration draft for C++0x
- We hoped for C++09

2010 CD expected
- Should lead to C++0B

- Technical reports
  - Library (2004)
  - Performance (2004)
  - Decimal floating point (2008)
  - Library2
  - Modularity

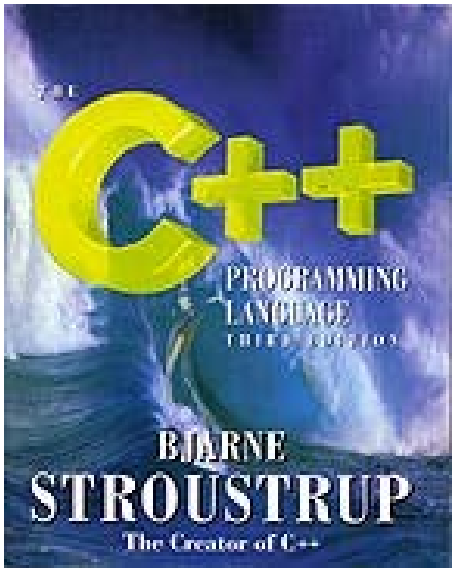
Interlocking themes

- 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, RAII
- Type safety
  - Containers
- Performance
  - Compactness
- Equal support for user-defined and built-in types
  - Value types, scoped objects
- User skills required
  - C++ should not be just expert friendly



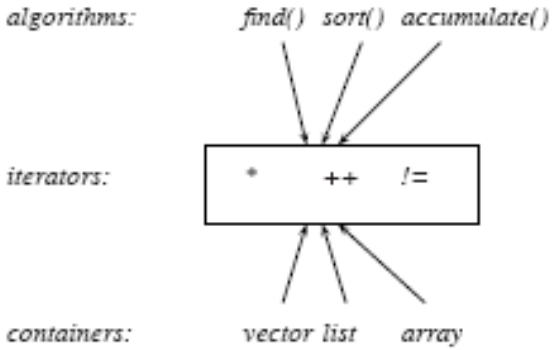
Alternatives to ISO Standardization

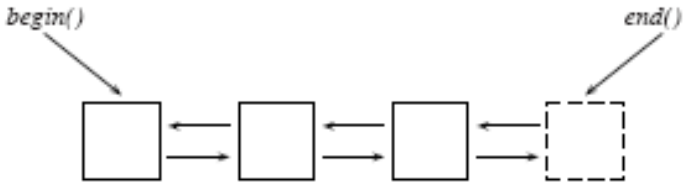
- Corporate ownership
  - Maybe “softened” by customer involvement
- Tame standards bodies
- “Benign dictator for life”
  - “Benign”
- No change
  - Just get it right at first and don’t change
- Chaos
  - Dialects

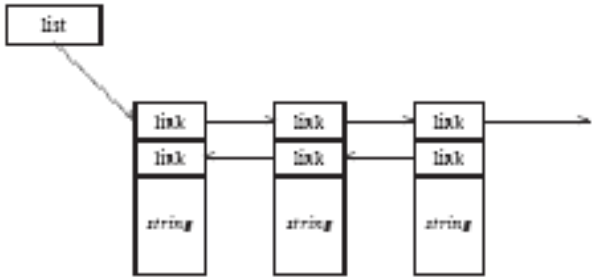


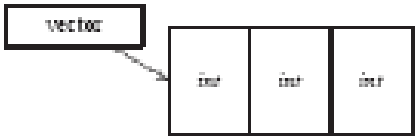
What could be done: The STL

- Ideal: The most general and most efficient expression of an algorithm
  - Focus on algorithms
  - Separate algorithms from data
    - Using iterators
  - 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









C++0x: 2002-2008

- Overall goals
  - Make C++ a better language
    - for systems programming
    - for library building
  - Make C++ easier to teach and learn
    - generalization
    - better libraries
- Massive pressure for
  - More language features
  - Stability / compatibility
    - Incl. C compatibility
- Insufficient pressure for
  - More standard libraries
    - The committee doesn't have the resources required for massive library development

C++0x: Areas of change

- Machine model and concurrency
  - Memory model
  - Threads library, asynchronous return
  - Atomic API
  - Thread-local storage
- Support for generic programming
  - **auto**, **decltype**, template aliases, Rvalue references, …
  - General and uniform initialization
  - Lambdas
- Etc.
  - improved **enum**s
  - **long long**, C99 character types, etc.
  - …
- Libraries
  - Regular expressions
  - Hashed containers
  - …

A feature too far

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- Concepts
- High-level concurrency features
- Garbage collection
- Modules

- How much can be done to a widely used language?
  - We have pushed the envelope
  - Maybe that can't continue?
    - If so, more for person issues than for technical issues
    - And the technical issues mostly relates to complexity from "feature interactions"

What kind of people participates?

- Idealists
  - To change the language and the world
  - Often busy at other things (essential), sometimes single issue (very bad), sometimes undisciplined (bad), often lasts just a couple of years (just enough to do something, good or bad)
- Damage controllers
  - To protect the language from the idealists
- Corporate representatives
  - To guard their corporation's interests
  - Big companies differ from small companies
- Bureaucrats
  - People who like to go to meetings
  - Can be on time and keep long lists (essential skills)

What kinds of people participates?

- Lots of implementers
  - Compilers
  - Libraries
  - tools
- Few users (far too few)
  - Application builders
  - Educators
  - Researchers

More information

- My HOPL-II and HOPL-III papers
- The Design and Evolution of C++ (Addison Wesley 1994)
- My home pages
  - Papers, FAQs, libraries, applications, compilers, …
    - Search for "Bjarne" or "Stroustrup"
- The ISO C++ standard committee's site:
  - All documents from 1994 onwards
    - Search for "WG21"
- The Computer History Museum
  - Software preservation project's C++ pages
    - Early compilers and documentation, etc.
      - http://www.softwarepreservation.org/projects/c_plus_plus/
      - Search for "C++ Historical Sources Archive"