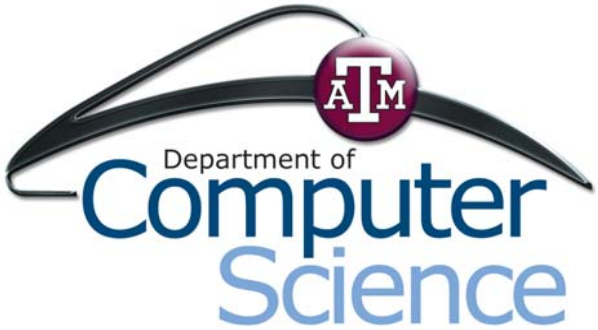

Elegant and efficient code

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Overview

- I'll present our general approach to getting code that is more elegant and more efficient than current code. Our approach have three prongs:
  - Improvements to ISO Standard C++
  - Improvements to library design and implementation techniques
  - A new framework for the analysis and transformation of C++ source code

Traditional hard choices

- Pick any two
  - Quality
  - Speed
  - Features
- In computer science you can base your argument of one of two
  - Elegance
  - Speed
- I hate to choose between elegance and speed
  - Programs should be elegant a**nd** fast
- How do we dodge the horns of this dilemma?

What do we mean?

- Elegance
  - Maintainable
  - Simple to read and write
  - Simple to reason about
  - Simple to analyze
    - Humans and programs
- Performance (efficiency)
  - Equal or better than the current gold standard in any area
    - Fortran for scientific programming
    - C (and sometimes even assembler) for systems programming
- For industrial programs
  - Supported by industry standard tools
    - Tool chains are critical
  - Not just academic exercises

The dilemma is real

- The most elegant languages
  - (e.g. Smalltalk, ML, Haskell, Common Lisp)
  - Are not applicable for many important application areas
  - Are not efficient for many important problems
  - Are apparently not manageable for most programmers
- The most efficient languages
  - (e.g. C, C++, Fortran)
  - Encourage low-level messing/hacking
  - Have problems expressing some important problems elegantly
  - Are hard to “restrain” for reasoning/analysis/transformation
- Many language are neither fish nor fowl
  - (e.g. Java and C#)
  - Neither elegant nor efficient
  - Not applicable for many important application areas

Our approach – three prongs

- Improve ISO Standard C++
  - Performance
  - Ability to express high level concepts
  - Applicable for the widest range of applications
- Add libraries
  - Based on a combination of generic and object-oriented techniques
- Add analysis and transformation support tools
  - Optimization
  - Dialect definition through selective restriction
  - More (we don't yet know how far this may go)

- Why C++?
  - It is closest to our ideals in the largest range of application areas

Consider an example

- World's most powerful marine diesel engine
  - fuel injector and engine control
  - 132,000Hp
  - Service time 20-30 years
  - Delay or injection error is not an option
  - No single point of failure
  - Heat and vibration hardened
  - Hot standby replicated systems (incl. networks)

This we can do today (MAN B&W using modern C++)

how can we make it easier and cheaper to build such systems?

C++

- We support/lead the ISO C++ standards effort
  - Add features for direct expression of guarantees
    - Concepts: a type system for template parameters
      - Separate compilation
      - No hierarchical constraints
      - No performance penalty
    - Notational support for more general expression
      - Generalized constructors
      - Generalized initializers
      - More effective use of type deduction: Decltype/auto
    - Better support for concurrency
      - Memory model
      - Threads
  - Lot's of "usual library stuff"
    - E.g. regular expressions

Dialect support

- Express a domain specific language as a dialect of ISO standard C++
  - Enhanced with (typically high-level) libraries supporting the application domain
    - Note: Libraries usually written in standard C++
    - E.g. STAPL for scientific numeric parallel computation
  - Restricted from (low-level) features that could violate guarantees for the domain
    - Note: the restricted features can be used in the library implementations
    - E.g. arrays, unsafe use of pointers, unsafe use of unions

Advantages of this approach

- The full C++ tool chains are available
  - Compilers, linkers, debuggers, system simulators, libraries, etc.
- The full C++ language is available where needed
- Unless there is a domain specific reason we can link to any C++, C, Fortran, etc. library

- Private, specialized, and unpopular languages die
  - Poor tool chains (e.g. Ada)
  - Excessive education/training costs
  - Too narrow user community
  - …

The problem

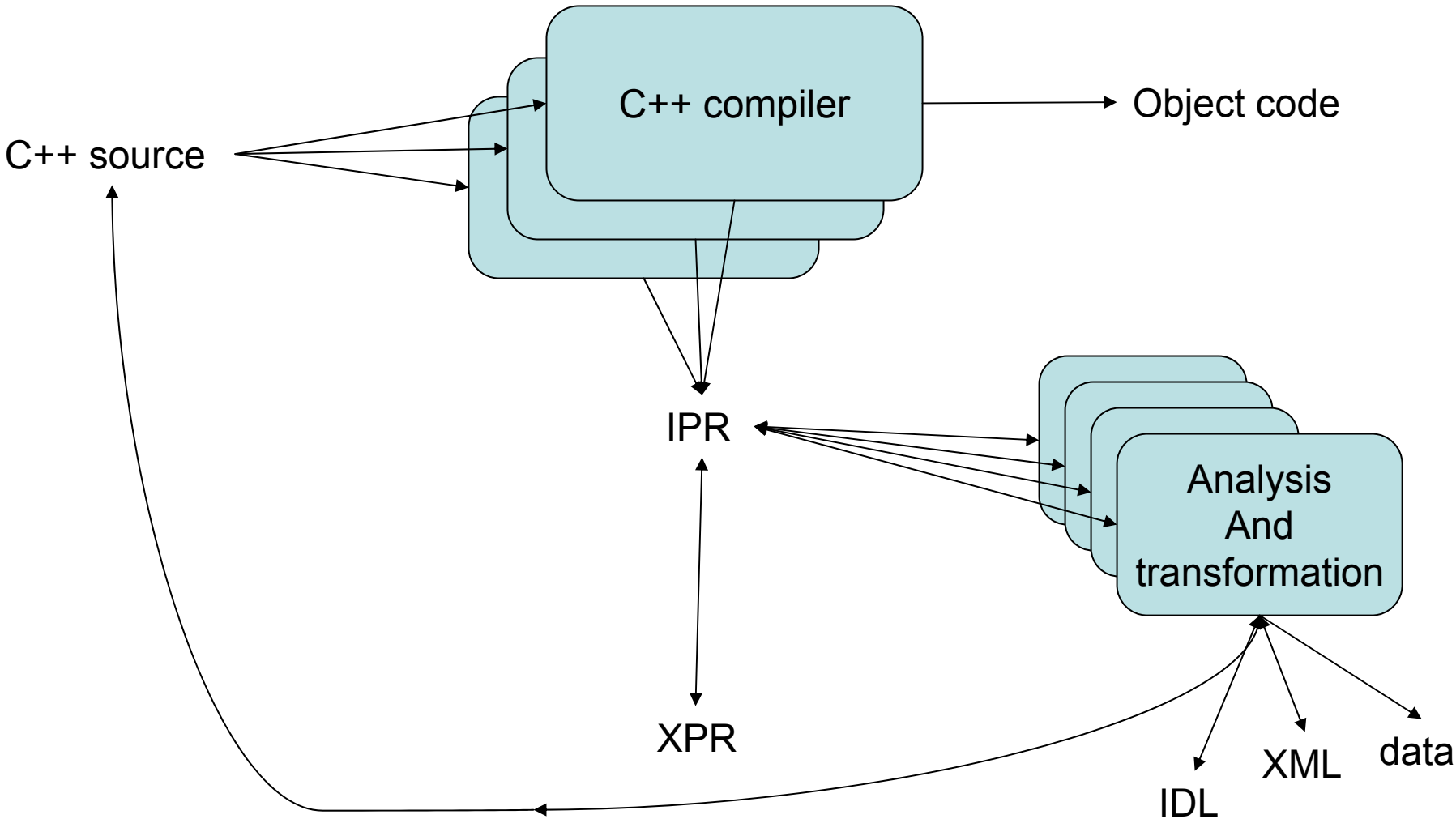
How do we write programs that really understand C++ source code?

- The original problem (inspiration)
  - Poor support for CORBA and for high-level parallel and distributed programming techniques

- There are no widely-available and general static analysis and transformation support for C++
- There are competing many incomplete tools
- The community is fractured
  - Few dare to rely on other groups tools
- None of the existing tools deal with the higher levels of C++ (templates, specialization, concepts)
  - Those are the aspects of C++ that are crucial for advanced optimization, validation of safety, enforcement of dialects, support of advanced libraries

The Pivot

A framework for static analysis and transformation of C++



The Pivot parts

- IPR (Internal Program Representation)
  - And **fully general** typed abstract syntax tree representation of **all of C++** (with the exception of macros)
  - Unified type system
  - Prepared for C++0x facilities; notably concepts
  - Potentially standard
- XPR (eXternal Program Representation)
  - Compact, persistent, user-readable, portable representation of IPR
- Compiler to IPR generators
- IPR ←→ XPR parsers
- Traversal and transformation tools
- Specific tools
  - E.g. IPR ←→ XPR, IPR ←→ IDL, style checker

The Pivot Project

- Phase 1: Infrastructure
  - Build internal representation from compiler info
  - Support persistence of internal representation
- Phase 2: acceptance and low-hanging fruit
  - Present the Pivot to Compiler providers, the C++ standards committee, and static analysis users
    - Build alliances
  - Style checkers
    - E.g. for safety-critical embedded systems work
  - Simple optimizations
  - …
- Phase 3: Research
  - Exception safety validation
  - Support for domain specific libraries
    - Validation and optimization
  - Generate flow-control-oriented representation and tools
  - Tools for integrated symbolic and numeric calculation
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