Divorcing Language Dependencies from a Scientific Software Library

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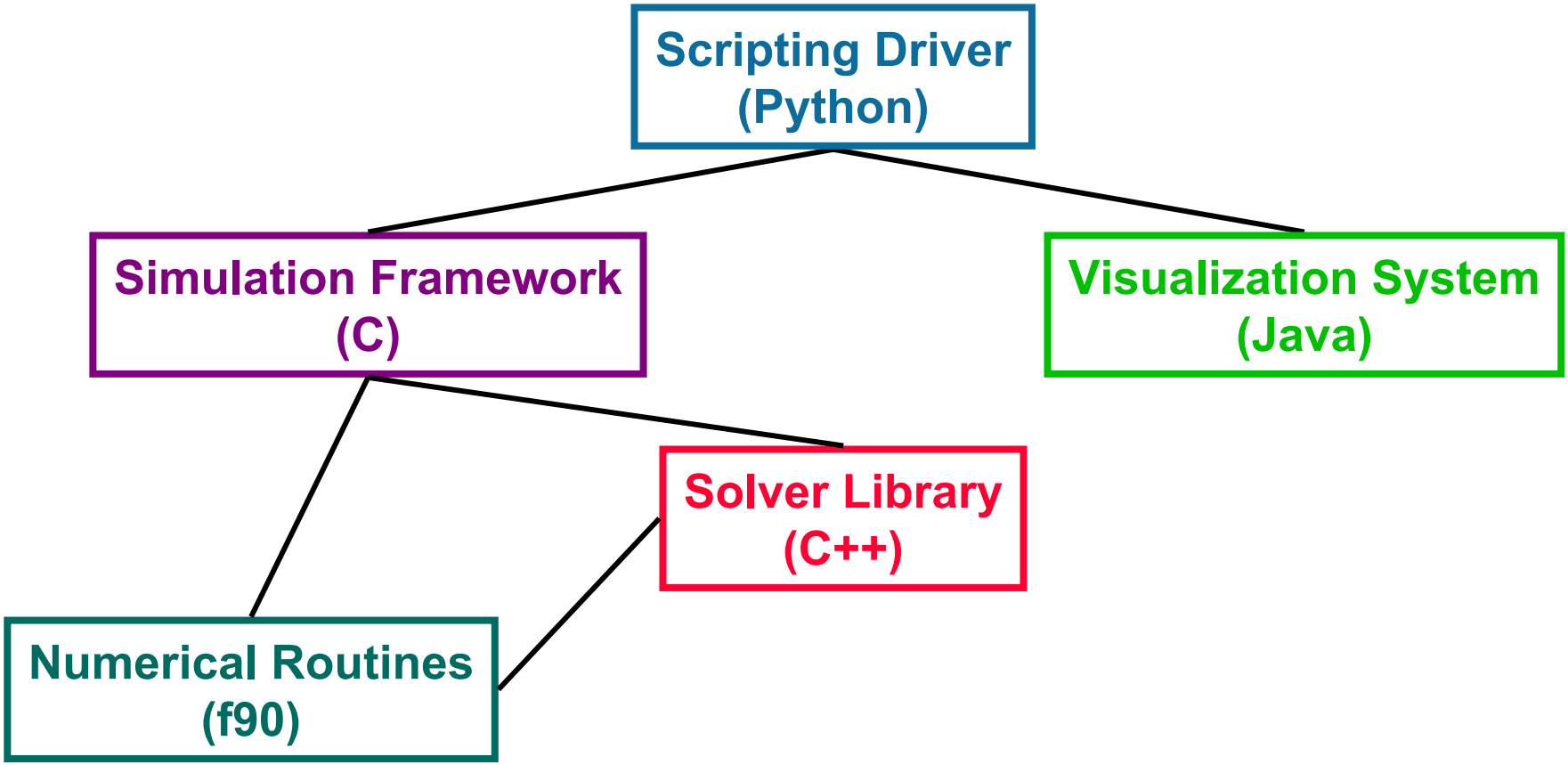
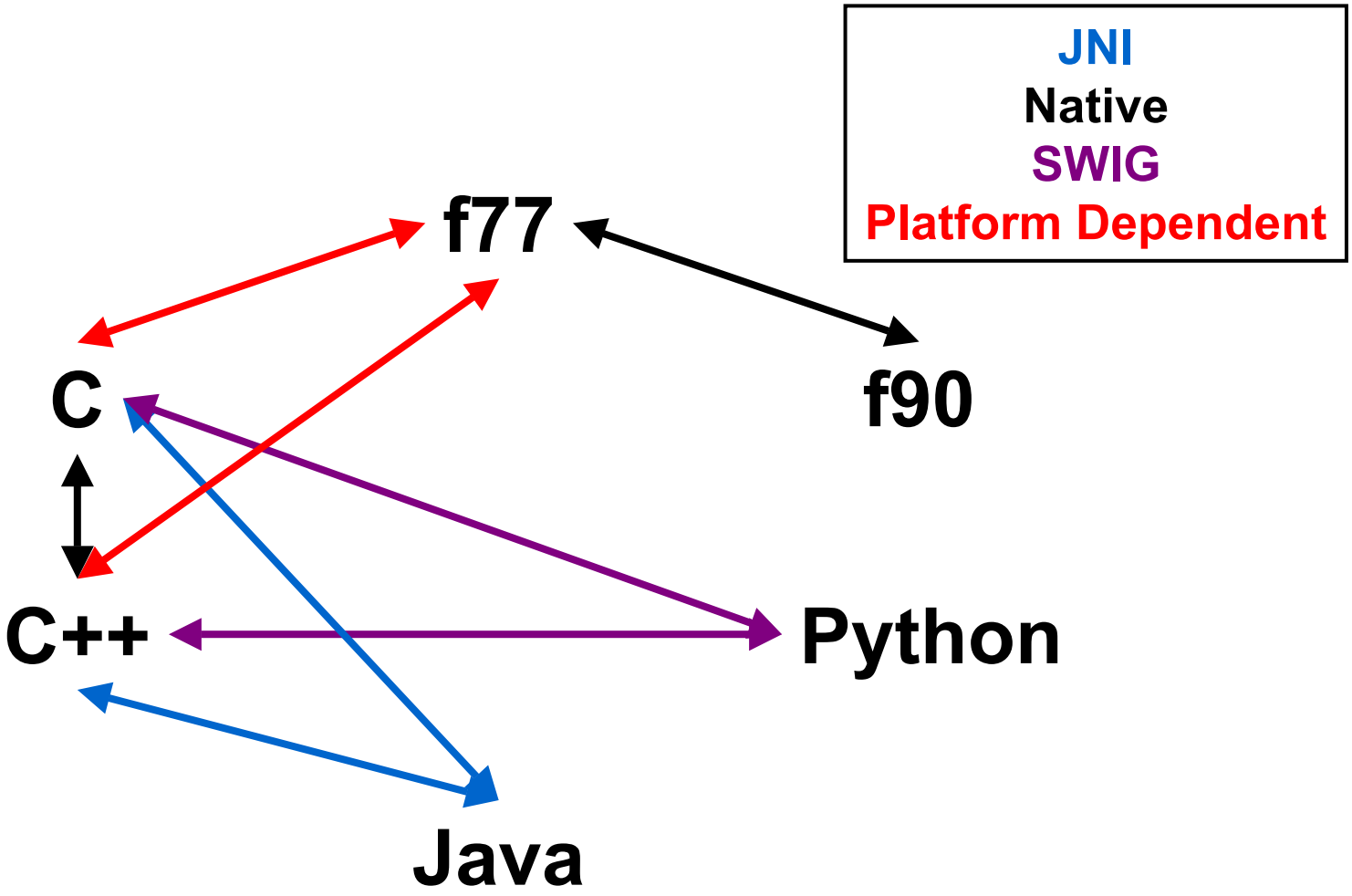
BABEL

- Language Interoperability Tool
  - You specify “interfaces” in our language
  - We generate glue code between application and library
- Part of a Component Framework
  - Enables OOP in non-OOP languages
  - Enables safe Dynamic Casting and QueryInterface capabilities

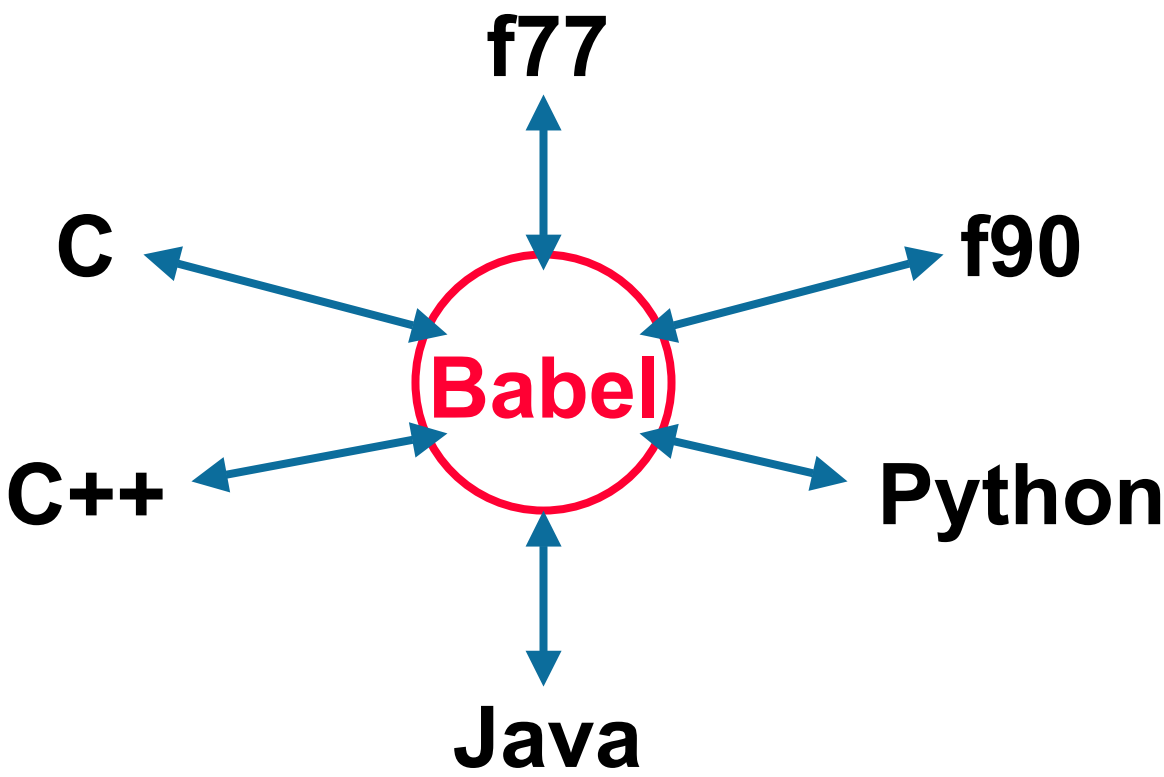
What I mean by "Language Interoperability"



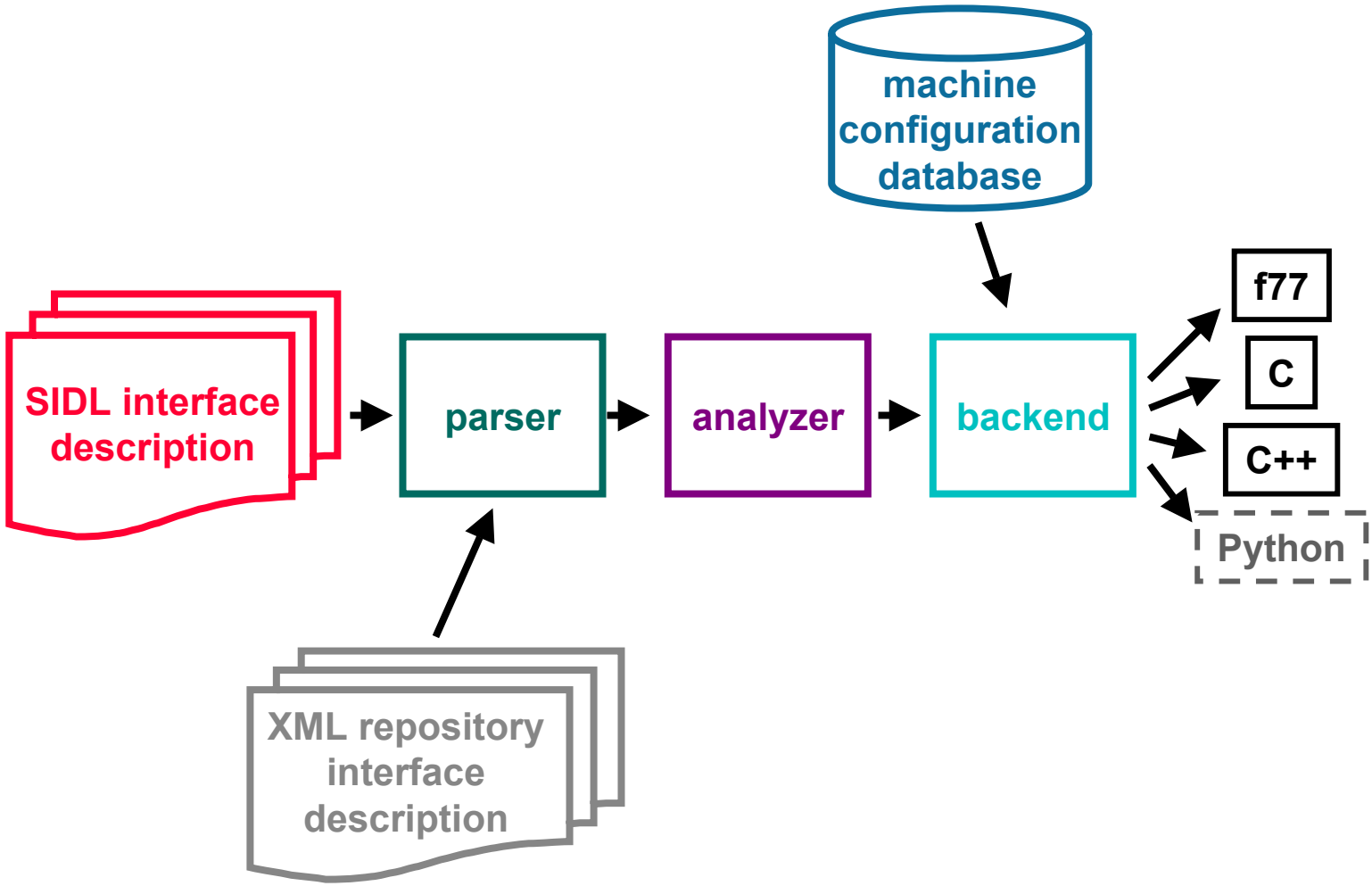
Hand Coded Solutions



Objects, Virtual Functions, RMI & Reference Counting: all from Babel



Babel generates glue code



Scientific Interface Definition Language (SIDL)

```
version Hypre 0.5;
version ESI 1.0;

import ESI;

package Hypre {
   interface Vector extends ESI.Vector {
      double dot(in Vector y);
      void axpy(in double a, in Vector y);
   };
   interface Matrix {
      void apply(out Vector Ax, in Vector x);
   };
   class SparseMatrix implements Matrix, RowAddressable {
      void apply(out Vector Ax, in Vector x);
   };
};
```

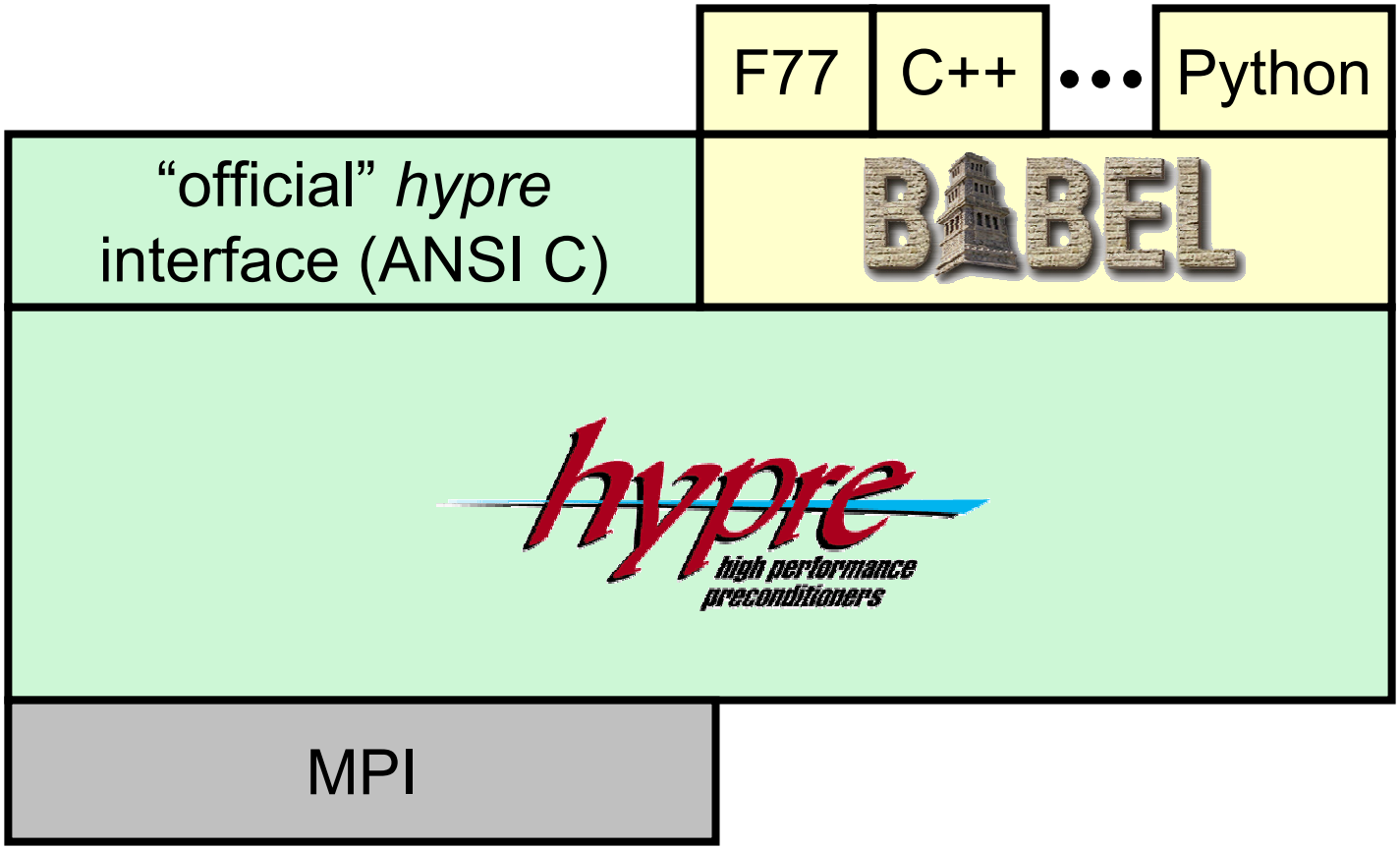
class
exception
interface
package

- Software to be “divorced” from its language dependence
- Scalable parallel linear solvers and preconditioners (LLNL)
- Implemented in ANSI C using MPI
- “Object Based”

Collaboration Objectives

- Babel side:
  - demonstrate Babel technology
  - feedback from library developers
- Hypre side:
  - Automatically create Fortran bindings
  - Explore new designs
    - Object-Oriented
    - Component-Based
  - Integrate other software
    - C++ or F77

Envisioned Architecture



Approach

- Identify minimal working subset of *hypre*
  - Structured Solvers
- Create SIDL description
- Add base classes to create heirarchy
- Tie generated code to existing *hypre* library
- Iterate

Problem: Creating wrong types

- SIDL has 3 types of objects
  - interfaces - no implementations (pure abstract)
  - abstract classes - partial implementations
  - concrete classes - full implementations

```
interface Foo {
   int doThis( in int i );
   int doThat( in int i );
}

class Bar implements Foo {
   int doThis( in int i );
};

class Grille implements Foo {
   int doThis( in int i );
   int doThat( in int i );
};
```

- Users were creating abstract classes when they meant to create concrete classes

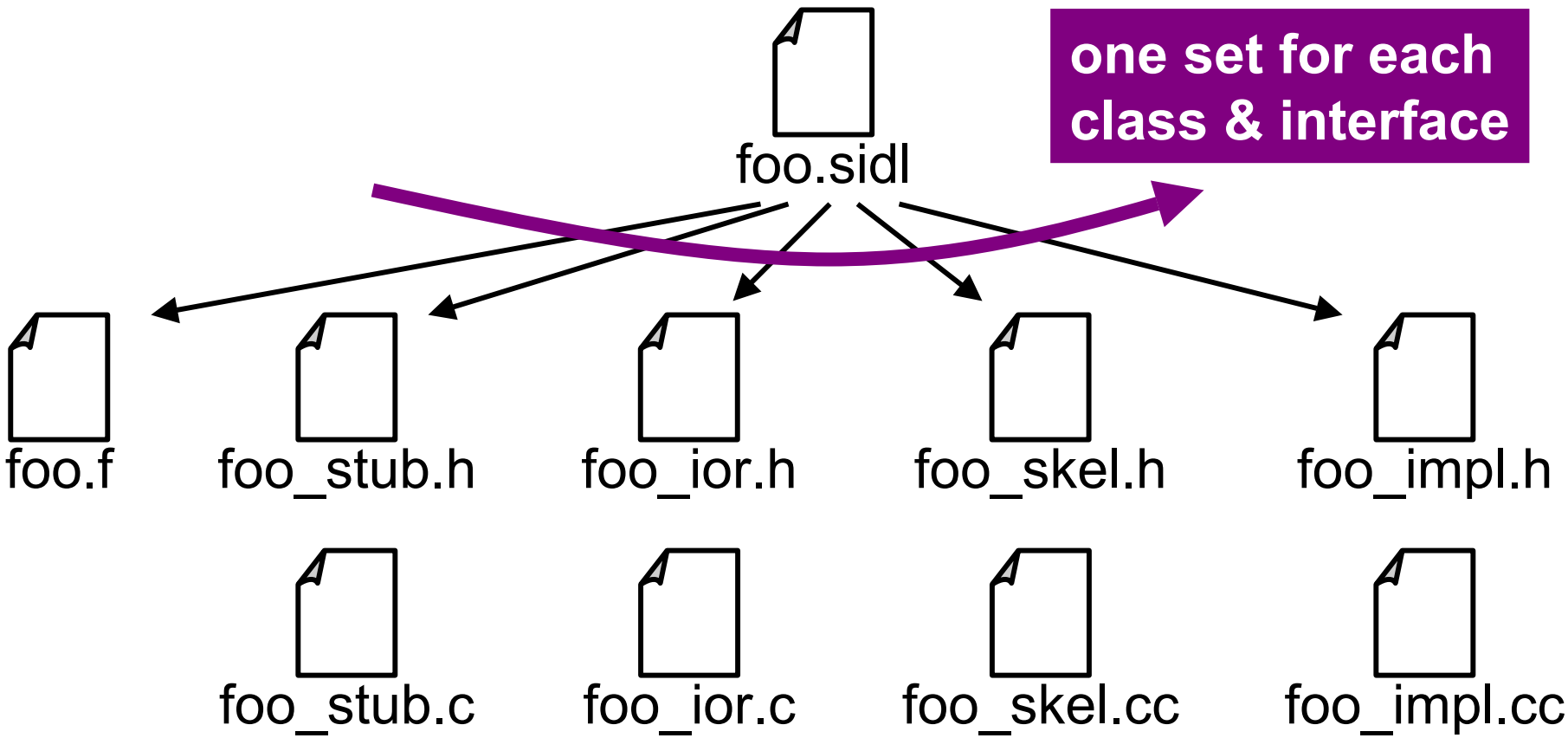
Solution: Fix The Grammar

- Added the "abstract" keyword
  - Compiler issues error if a method is undefined and class is not declared abstract
- Added the "implements-all" keyword
  - declares all methods as overridden
  - saves user typing

```
interface Foo {
   int doThis( in int i );
   int doThat( in int i );
}

abstract class Bar implements Foo {
   int doThis( in int i );
};

                                    {

};
```

Problem: Managing all the Files

- **Babel creates many source files**



Solution: Babel Generates Makefile Macros

- A “babel.make” file is generated

```
IORSRCS = foo_ior.c \
          bar_ior.c \
          grille_ior.c

IORHDRS = foo_ior.h \
          bar_ior.h \
          grille_ior.h
```

- Users include it into their own makefiles
  - They control the build rules
  - We provide the file names

Problem: Incremental Development

- Library Developer would do the following:
  - write SIDL file
  - run Babel to generate bindings
  - hand edit “Impl” files to call their library code

```
#include “mylib.h”

int impl_Foo_doThis( Foo * self, const int i ) {

  return  mylib_Foo_doThis(
                          (mylib_Foo*) self->userdata,
                          i
                          );

}
```

Problem: Incremental Development (2)

- Now assume this was done for 20 classes, each with 20 methods.
- Now assume a class needed a 21st method
- Babel would regenerate all files and wipe out Developer's edits

```
#include "mylib.h"

int impl_Foo_doThis( Foo * self, const int i ) {

  return mylib_Foo_doThis(
                          (mylib_Foo*) self->userdata,
                          i
                          );

}
```

Solution: Code Splicing

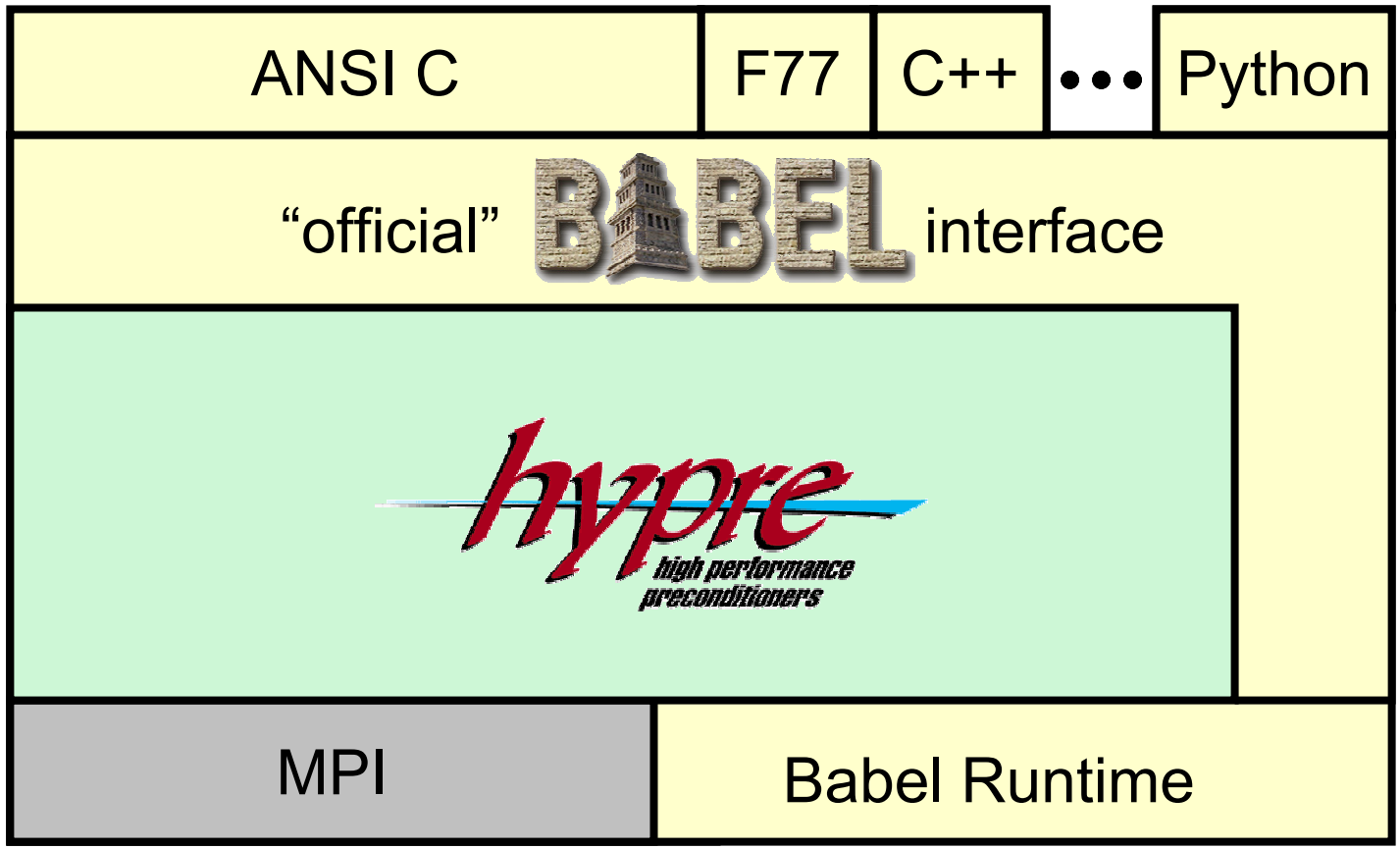
- Added preservation of developer's edits
- Code Splicer works line-by-line
  - interleaves old code into new code
  - looks for begin-end pairs embedded in comments

```
/* DO NOT DELETE splicer.begin( user-includes ) */
#include "mylib.h"
/* DO NOT DELETE splicer.end( user-includes ) */

int impl_Foo_doThis( Foo * self, const int i ) {
  /* DO NOT DELETE splicer.begin( Foo_doThis ) */
  return mylib_Foo_doThis(
                    (mylib_Foo*) self->userdata,
                    i
                    );
  /* DO NOT DELETE splicer.end( Foo_doThis ) */
}
```

Results

- Call *hypre*
  - from C, F77, or C++
  - on SPARC Solaris or DEC/OSF
  - (more languages & platforms coming)
- No interference with MPI
- Babel overhead within runtime noise

Best Result: Change of Architecture



Reasons for Change

- Liked using the tool
- No Hand F77 bindings
  - incompatible
  - outdated
- Preferred discussing designs in SIDL
  - easy for email
  - impossible to mix implementation & interface
- Convinced of Babel's longevity
- Babel enforces regularity in code
- Liked automatic reference counting
- Excellent compromise between:
  - Wanting polymorphism and OO techniques
  - Wanting all ANSI C for maximum portability

Current & Future Work

- Language Support
  - Current: C, C++, F77, Python (Client)
  - Coming: Python(Server), Java, F90, Matlab
- Platform Independence
  - Implies RMI / Distributed Computing
  - SOAP
- Parallel Data Redistribution
- Babelization efforts in LLNL
  - *hypre*
  - SAMRAI
  - ALPS

Public Beta Release

Late Summer

Components @llnl.gov

- **Our Website**

  http://www.llnl.gov/CASC/components

  - **Alexandria (Component Repository)**
  - **Quorum (Online Voting)**
  - **Generic Parallel Redistribution**

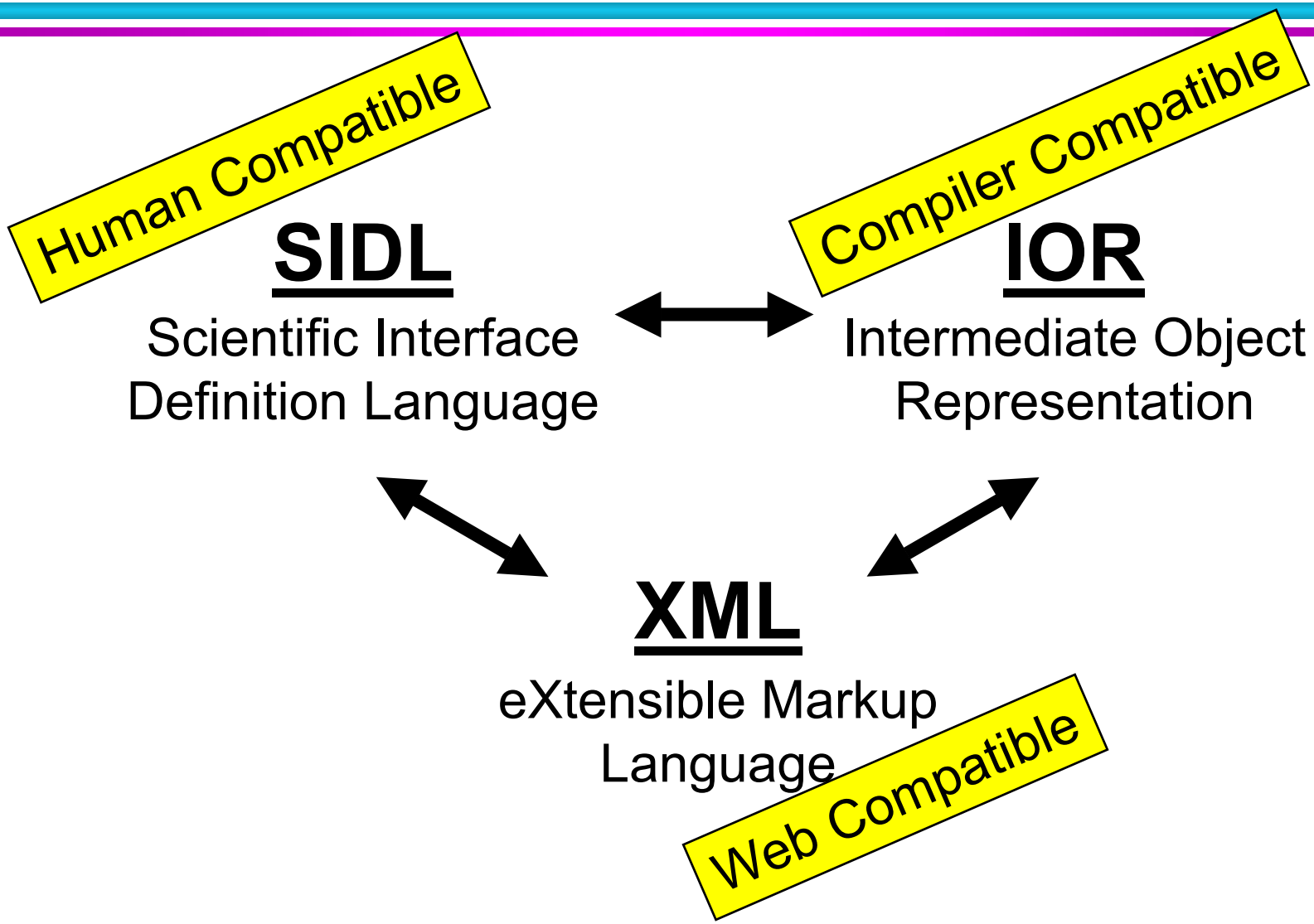
- **hypre**

  http://www.llnl.gov/CASC/hypre

UCRL-VG-140349 Rev 1

Work performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48

Key to Babel's Interoperability...



Business Component Frameworks

- CORBA
  - Language Independent
  - Wide Industry Acceptance
  - Primarily Remoting Architecture
- COM
  - Language Independent
  - Most Established
  - In Process Optimization
  - Network Transparent
- Enterprise Java Beans (EJB)
  - Platform Independent
  - Runs wherever Java does

~~Business~~ Science Component Frameworks

- CORBA
  - Language Independent
  - Wide Industry Acceptance
  - Primarily Remoting Architecture
  - Huge Standard
  - No In-Process Optimization
- COM
  - Language Independent
  - Most Established
  - In Process Optimization
  - Network Transparent
  - not Microsoft Transparent
  - Relies on sophisticated development tools
- Enterprise Java Beans (EJB)
  - Platform Independent
  - Runs wherever Java does
  - Language Specific
  - Potentially highest overhead
- All The Above
  - No Complex Intrinsic Datatype
  - No Dynamic Multidimensional Arrays
  - No Fortran77/90/95 bindings
  - No Parallel Components
  - No Concept of SPMD Programming