CASC

BABEL

A Language Interoperability Tool for Scientific Computing

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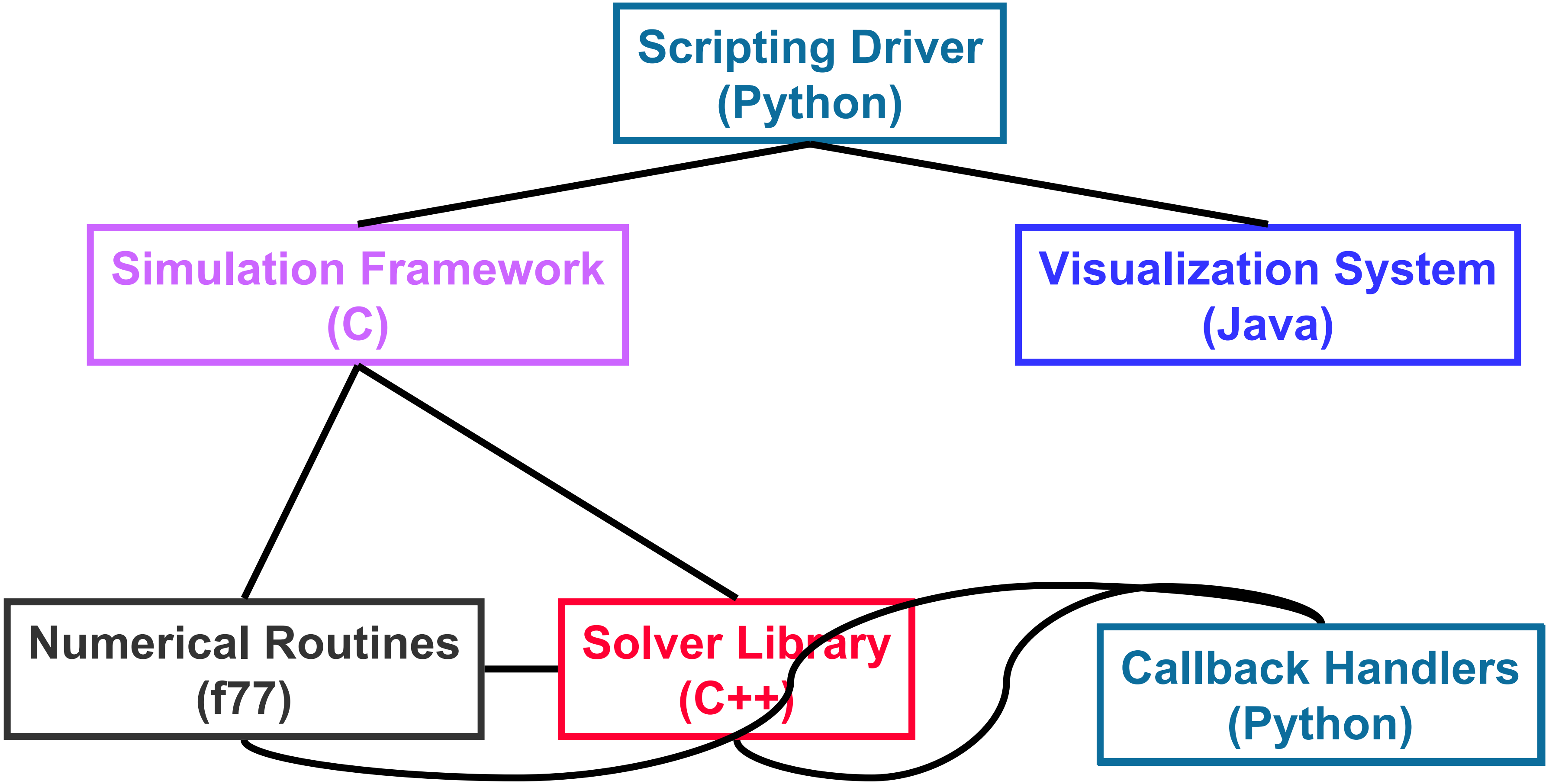
SciDAC
Scientific Discovery through Advanced Computing

CCA
Common Component Architecture

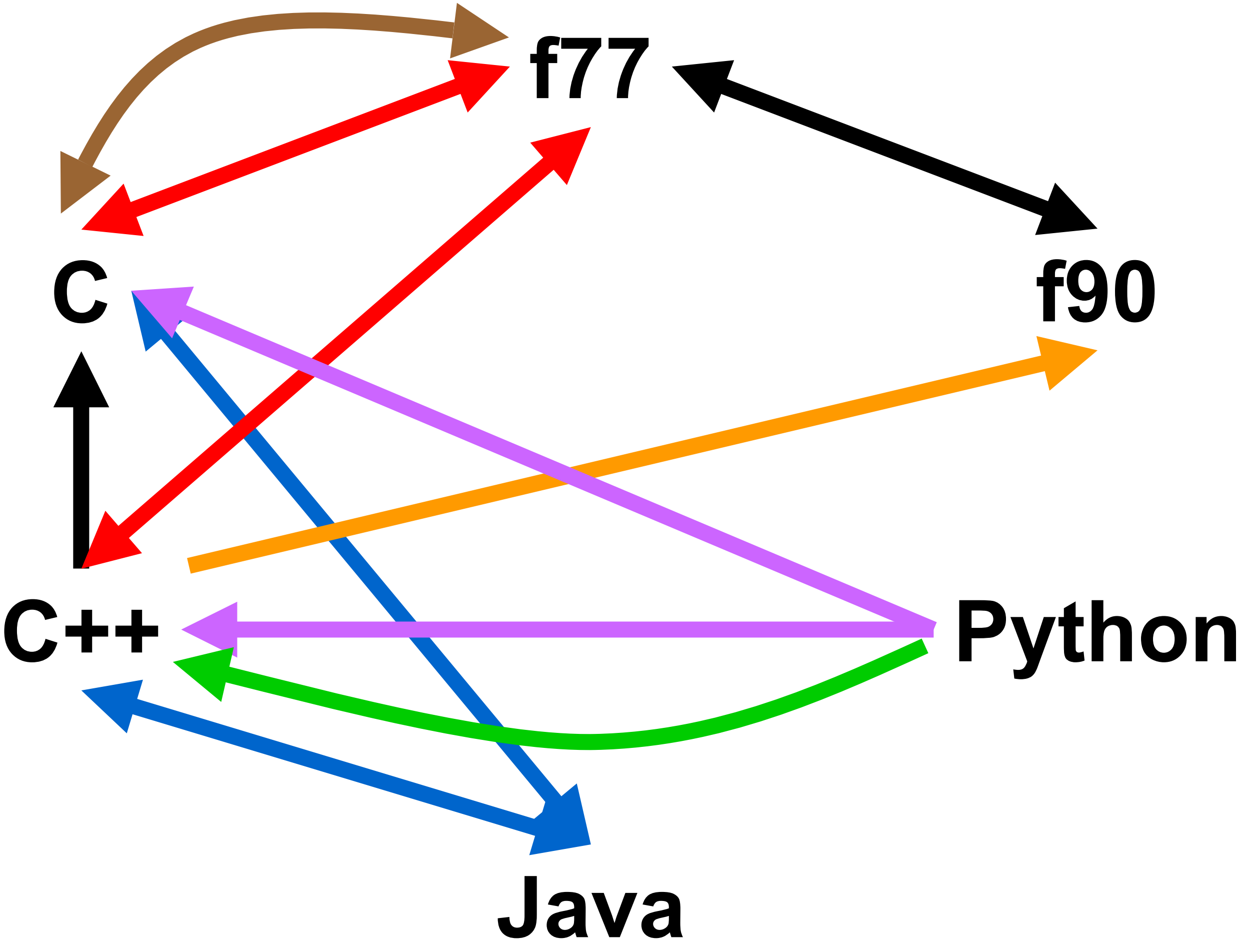
Outline

- Problem: Mixing Languages
- Babel Features
- Babel Performance/Overhead
  - Whole Application
  - Single Method Invocation
- Related Projects
  - IDL-based solutions
  - Source-parsing solutions
- Babel Customers/Collaborators
- Babel on AIX
- Conclusion

What I mean by "Language Interoperability"



Mixing Languages: hard, not portable, and unscalable



f77

C

f90

C++

Python

Java

Native

cfortran.h

SWIG

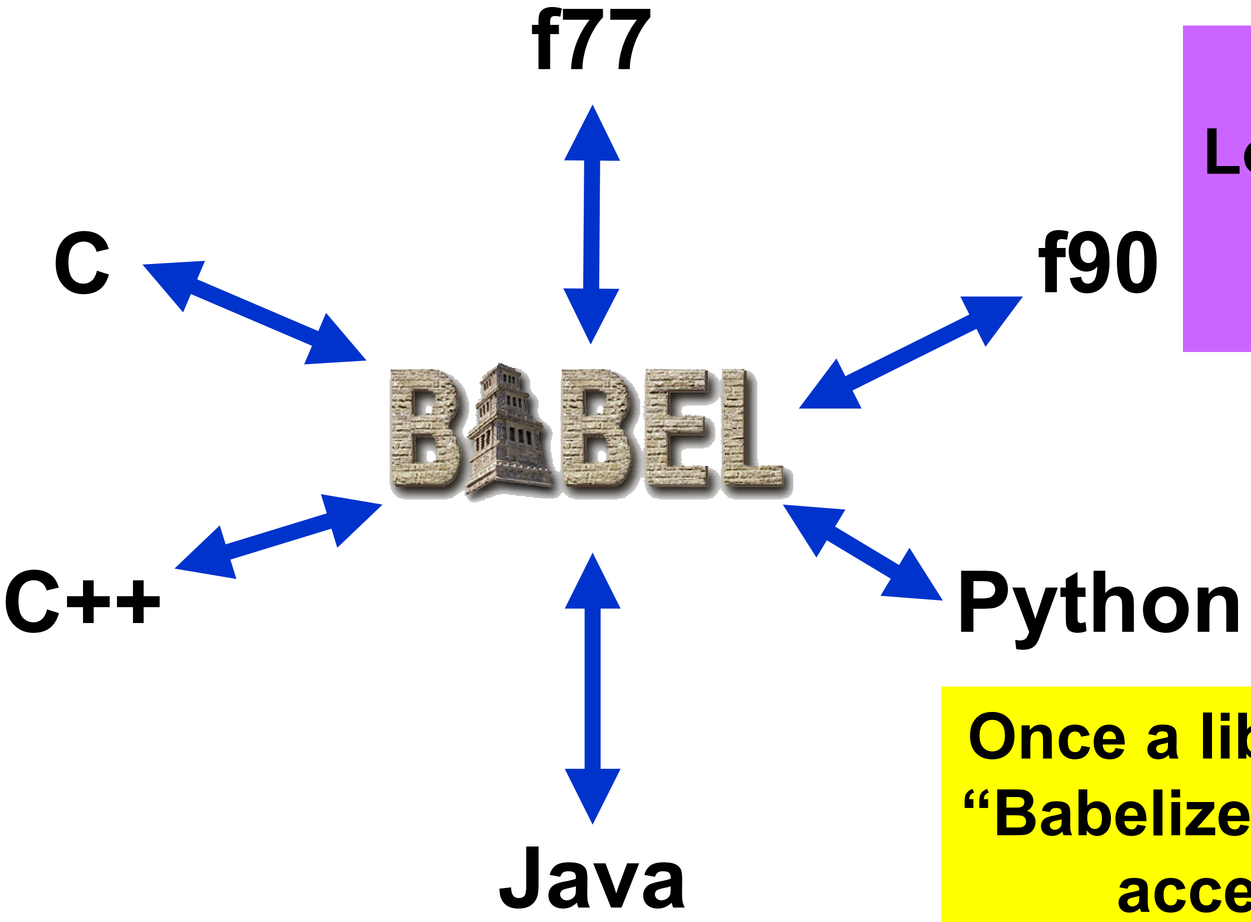
JNI

Siloon

Chasm

Platform Dependent

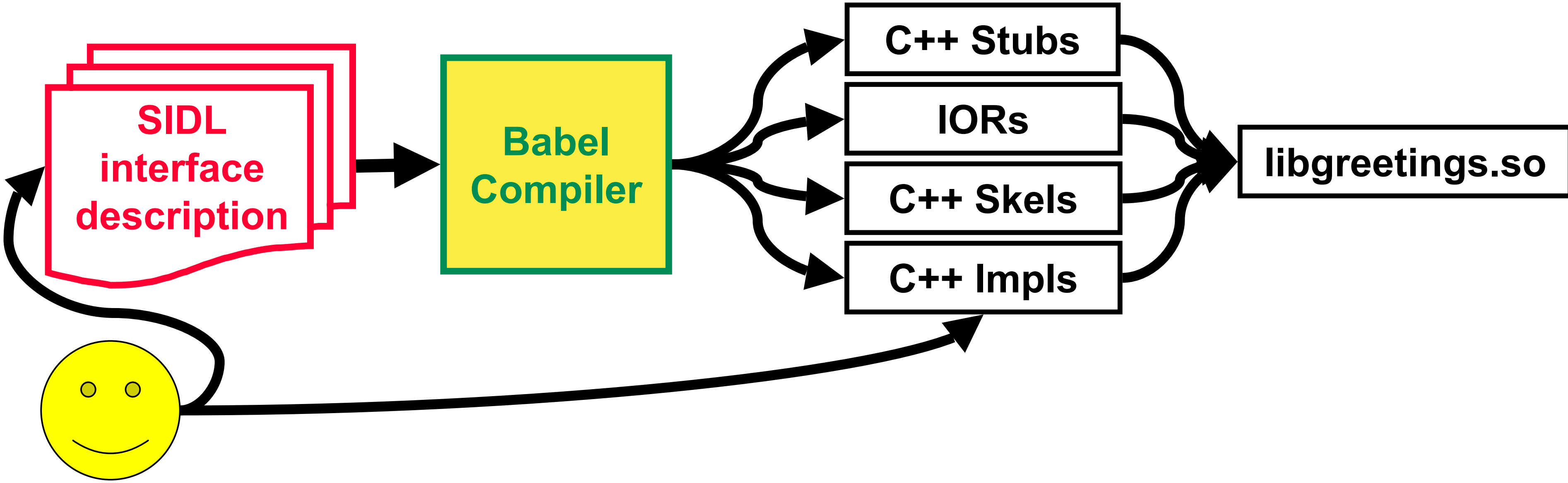
Babel makes all supported languages peers



This is not a Lowest Common Denominator Solution!

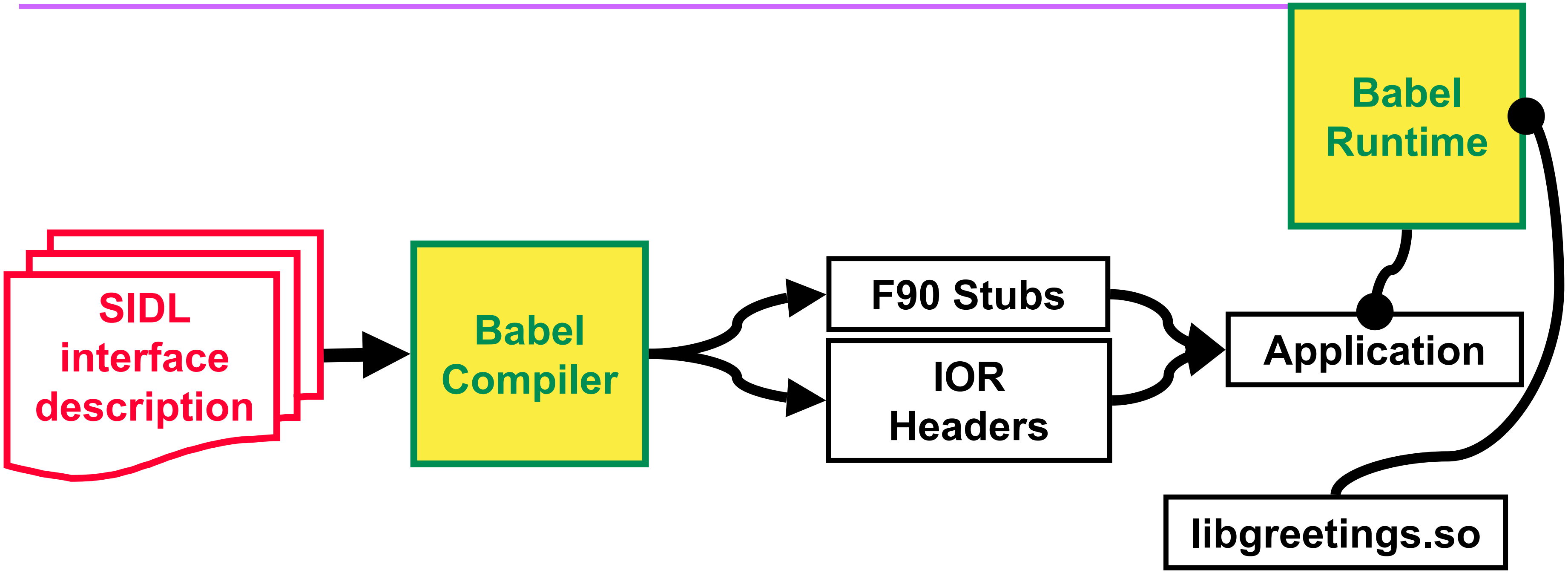
Once a library has been "Babelized" it is equally accessible from all supported languages

Library Developer Does This...



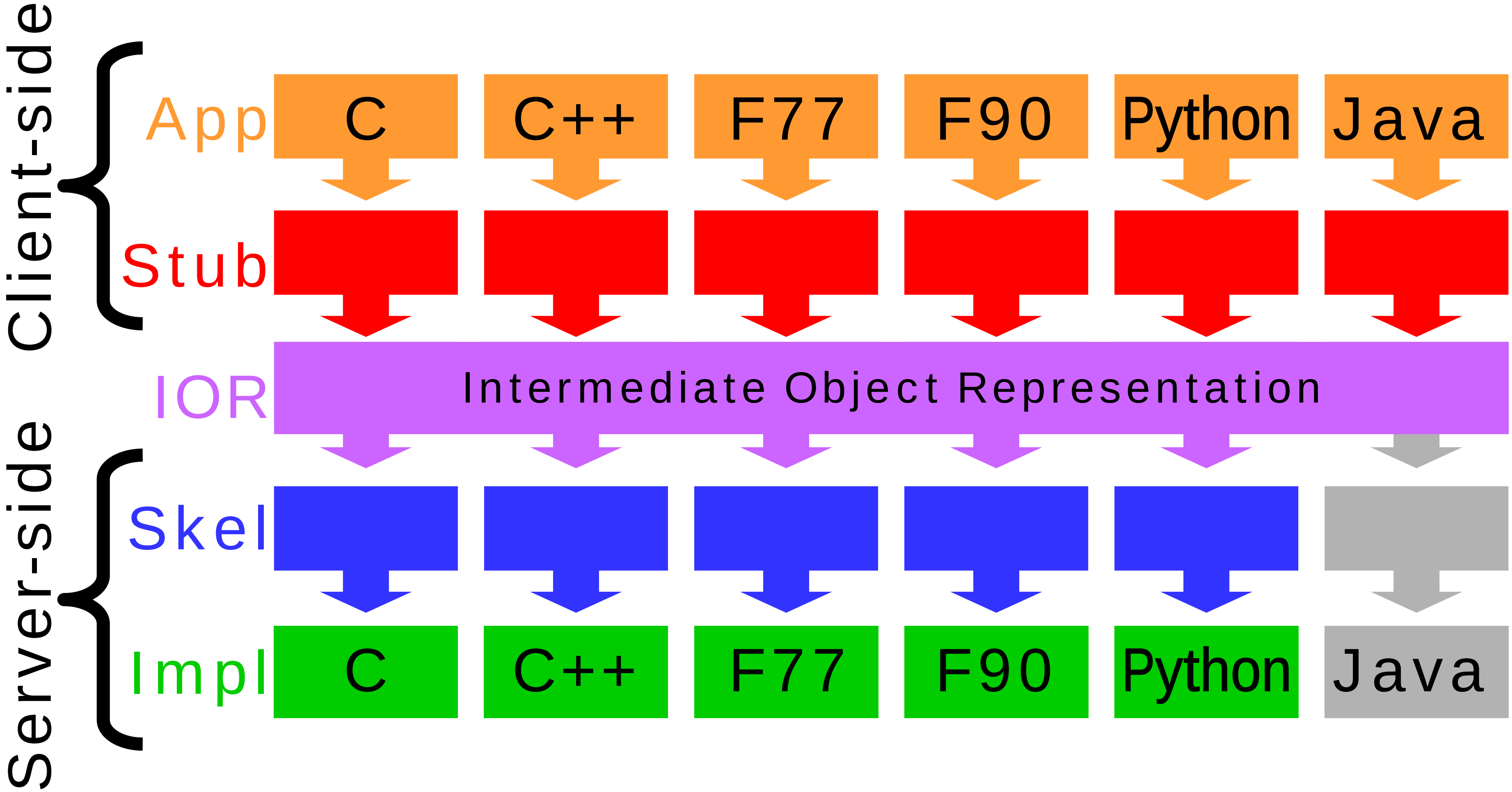
1. Write SIDL File
2. `babel --server=C++ greetings.sidl`
3. Add implementation details
4. Compile & Link into Library/DLL

Library User Does This...



1. `babel --client=F90 greetings.sidl`
2. Compile & Link generated Code & Runtime
3. Place DLL in suitable location

Babel Architecture



Client-side

App: C, C++, F77, F90, Python, Java

Stub

IOR: Intermediate Object Representation

Server-side

Skel

Impl: C, C++, F77, F90, Python, Java

Features Tested Nightly

- **Basic Types**
  - bool
  - char
  - int
  - long
  - float
  - double
  - fcomplex
  - dcomplex
  - string
  - opaque

- **Extended Types**
  - Objects
  - enumerations
  - arrays of any the above
    - multidimensional
    - strided
    - dynamically allocated
    - no arrays of arrays

- **Modes**
  - in
  - out
  - inout
  - return value

Features Tested Nightly

- Basic Types
  - dcomplex
  - string
  - opaque

- Extended Types
  - any the
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  - ally
    allocated
    - no arrays of arrays

- Modes
  - in
  - inout
  - return value

- **OO Method Dispatch**
  - **regular**
  - **final**
  - **static**
  - **interfaces**
  - **classes**

- **Exception Handling**

Features Tested Nightly

- Basic Types

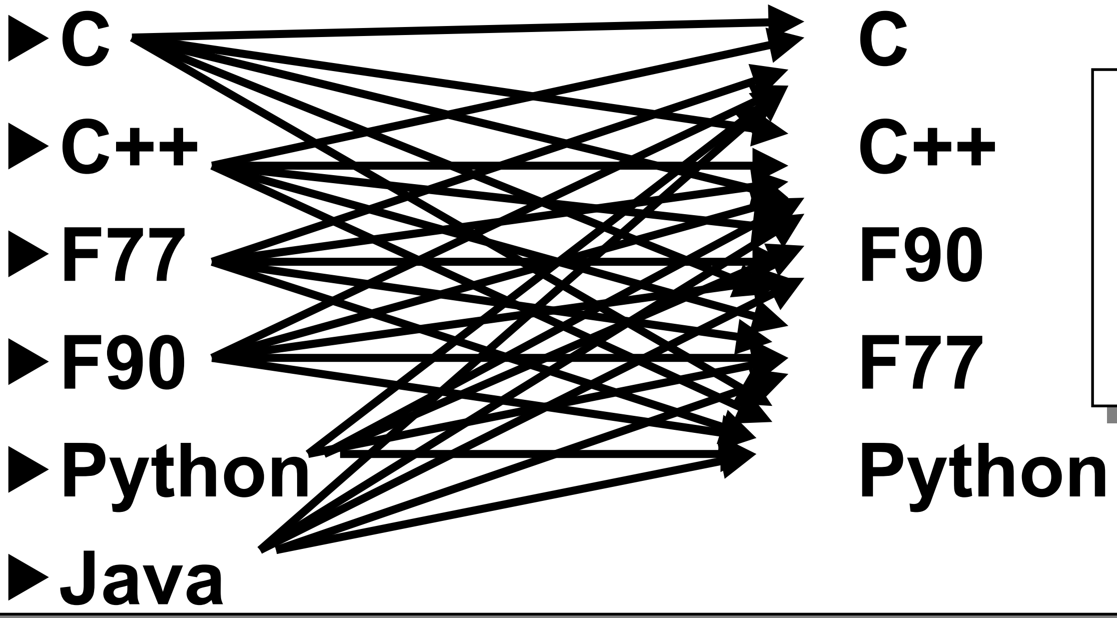
- Extended Types

- Modes
  - in

- OO Method Dispatch
  - regular

- Exception Handling

- For All Combinations of Languages



- C
- C++
- F77
- F90
- Python
- Java

C

C++

F90

F77

Python

- Linkage
  - Static
  - Run Time

Features Tested Nightly

- Basic Types

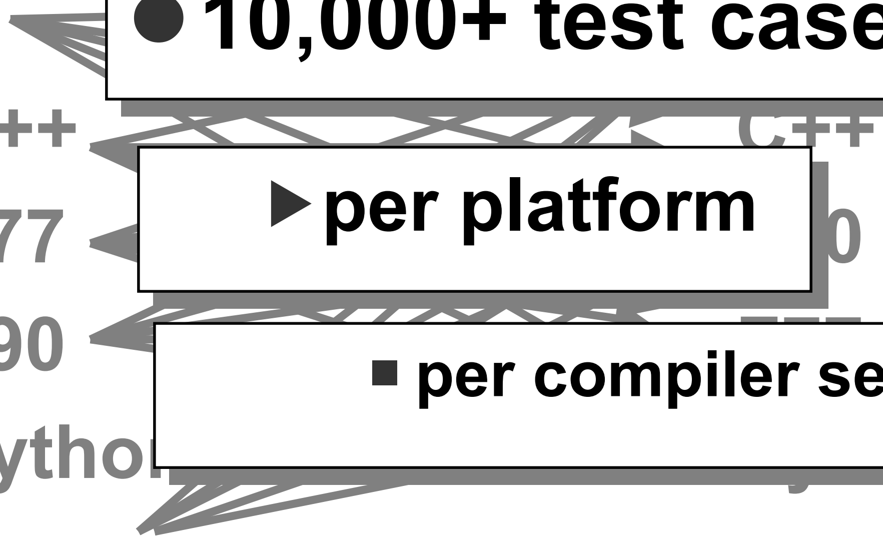
- Extended Types

- Modes
  - in

- OO Method Dispatch
  - regular

- Exception Handling

- For All Combinations of Languages
  - C
  - C++
  - F77
  - F90
  - Pytho
  - Java



- Linkage
  - Static
  - Run Time

- **10,000+ test cases**
  - **per platform**
    - **per compiler set**

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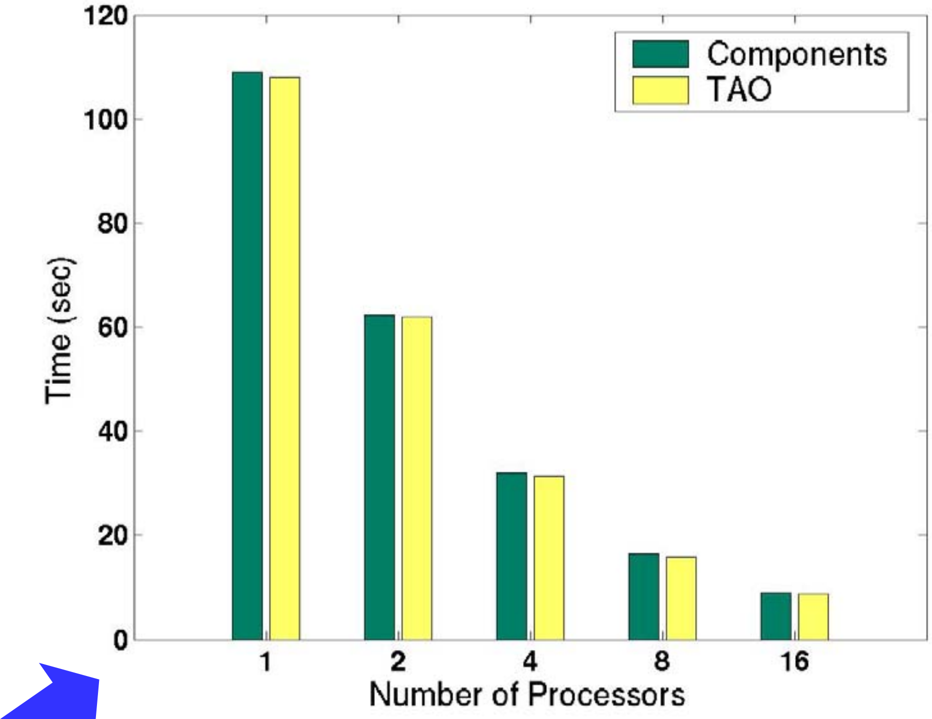
Performance Impact on Whole Apps: Negligible

- **hypre:**
  “Lost in the noise”
  - **Kohn et. al. *Divorcing Language Dependencies from a Scientific Software Library*. SIAM PP01. Portsmouth, VA, March 12-14, 2001**
- **TAO/PETSc: “overhead of using components is negligible and it does not affect the scalability of the algorithm”**

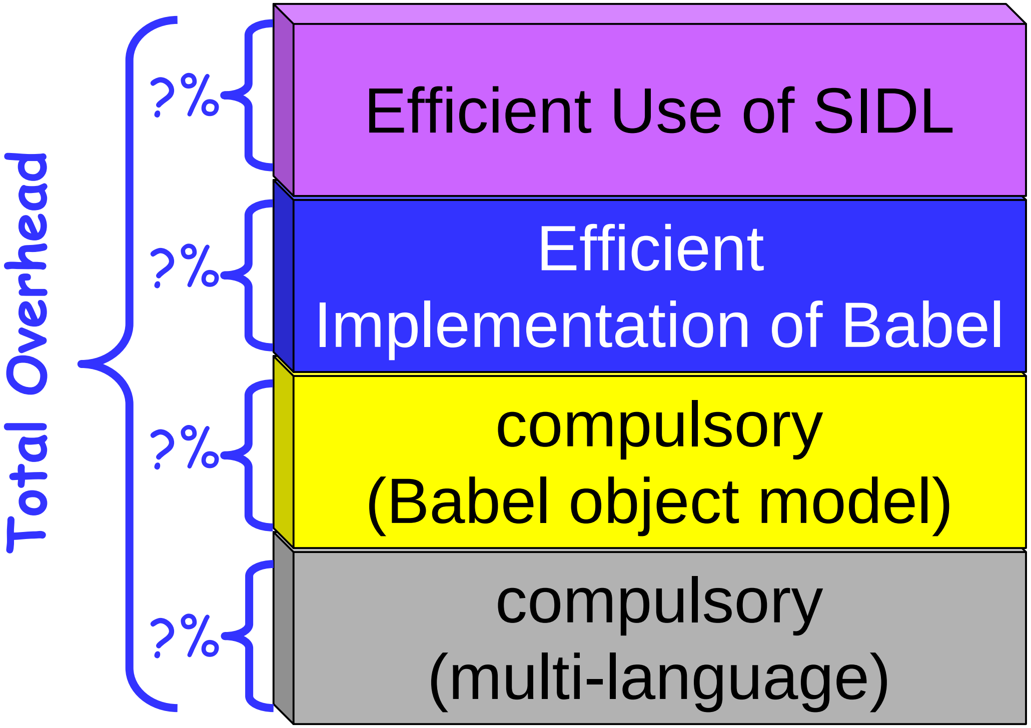


Total execution time for a surface minimization problem using a fixed-sized 250x250 mesh. Dual 550 MHz Pentium III nodes with 1-Gb of RAM each, connected with Myrinet

Overhead on Single Function Call: Small & Variable

- Bernholdt, et. al. *A Component Architecture for High-Performance Computing*, POHLL-02 New York, NY. 22 June 2002
  - "avg" Babel overhead ≈ 3.8 * F77
    - Depends on argument modes, argument types and languages involved
    - All Babel calls are virtual (C++ virtual ≈ 2.2 *F77)
  - CORBA ≈ 25 * Babel

Babel Performance Models: Joint work /w PERC & TSTT


Total Overhead
?%
Efficient Use of SIDL
?%
Efficient Implementation of Babel
?%
compulsory (Babel object model)
?%
compulsory (multi-language)

also, how hard for customer to use SIDL efficiently?

not performance tuned yet

e.g. no IOR shortcut if caller & callee in same language

e.g. No C++-style inline

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Other IDL Projects In Scientific Computing

- ASE: Argonne SIDL Environment
  - http://www.mcs.anl.gov/ase
  - Knepley and Smith @Argonne
  - Based on Babel-0.6 (Dec'01)
  - Foundation for PETSc 3.0
- PIDL: Parallel Interface Definition Language
  - http://www.cs.utah.edu/~damevski/thesis.pdf
  - Damevski & Parker @SCI Institute, Utah
  - C++ only
  - Parallel RMI

SWIG v. Babel

(David Beazley @ U Chicago)

- Call from Tcl, Perl, Python, Java, Ruby, mzscheme, or Guile
- Implement in C, C++
- Reads existing code
  - Library User can do independently
  - C++ "type system"
  - Auxiliary .i files fill in details
- Better suited for fast prototyping

- Call from C, C++, F77, F90, Python, and Java
- Implement in C, C++, F77, F90, and Python
- Hand-written SIDL
  - Library Developer task (or "motivated" user?)
  - SIDL "object model"
  - SIDL is self contained, no extra hints needed
- Better suited for production use

Projects Citing Babel In Their Pubs

(see www.llnl.gov/CASC/components/gallery.html for more)

CCA
Common Component Architecture

hypre
high performance preconditioners

NWChem
High Performance Computational Chemistry Software

> I implemented a Babel-based interface for the hypre library of linear equation solvers. The Babel interface was straightforward to write and gave us interfaces to several languages for less effort than it would take to interface to a single language.
>
> --Jeff Painter, LLNL.

TSTT

τ
Tuning and Analysis Utilities

SAMRAI
Structured Adaptive Mesh Refinement Application Infrastructure

ALPS

TOPS

research.cs.vt.edu/lacsa

Babel 0.8.6 supports IBM compilers on AIX

- "support" =
  gtar; ./configure; make check
- Major barrier was the build, not code
  - use autoconf, automake, libtool, & distutils
- Run-time linking (aka dlopen()) on AIX remains a challenge
  - needed for server-side Java and Python
  - still having trouble building libpython.so on AIX

Critical Resources for AIX Port

- **Cobb, Hook, Strauss, Ambati, Govindjee, Huang & Kumar.** ***AIX Linking and Loading Mechansims*** **http://www-1.ibm.com/servers/esdd/pdfs/aix_ll.pdf**

- **GNU libtool 1.5 (or better)**

Conclusion: Babel makes software easier to use

- “Babelizing” a library is generally ____ than hand crafting wrappers
  - more scalable
  - easier / more sustainable
  - less error-prone
  - more portable
- Our customers also like
  - having polymorphism in non-OO languages
  - stronger encapsulation than even C++
  - producing new interfaces without modifying legacy code
  - SIDL for specifying API standards
  - Easier incremental evolution via looser coupling

Contact Info

- **Project:** http://www.llnl.gov/CASC/components
- **Project Team Email:** components@llnl.gov
- **Mailing Lists:** majordomo@lists.llnl.gov

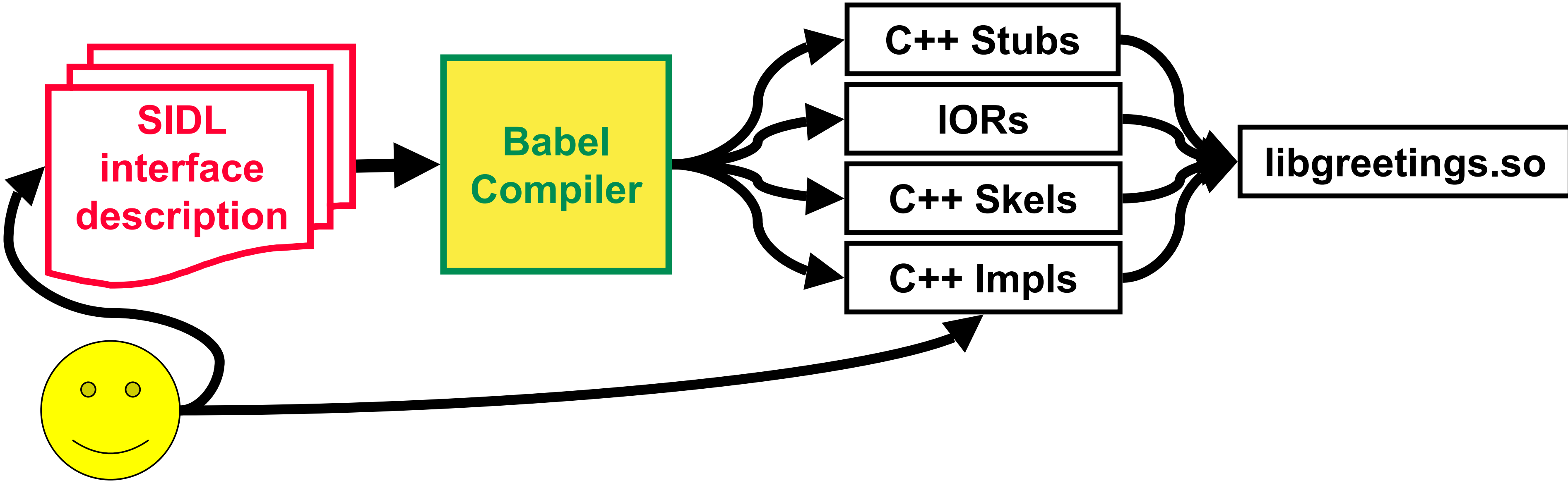
  subscribe babel-users *[email address]*

  subscribe babel-announce *[email address]*

greetings.sidl: A Sample SIDL File

```
package greetings version 1.0 {
    interface Hello {
        void setName( in string name );
        string sayIt ( );
    }
    class English implements-all Hello {  }
}
```

Library Developer Does This...



1. Write SIDL File
2. `babel --server=C++ greetings.sidl`
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Adding the Implementation

```
namespace greetings {
class English_impl {
  private:
    // DO-NOT-DELETE splicer.begin(greetings.English._impl)
    ::std::string d_name;
    // DO-NOT-DELETE splicer.end(greetings.English._impl)
```

```
::std::string
greetings::English_impl::sayIt()
throw ()
{
  // DO-NOT-DELETE splicer.begin(greetings.English.sayIt)
  ::std::string msg(”Hello ”);
  return msg + d_name + ”!”;
  // DO-NOT-DELETE splicer.end(greetings.English.sayIt)
}
```

Adding th

```
package greetings version 1.0 {
    interface Hello {
        void setName( in string name );
        string sayIt ( );
    }
    class English implements-all Hello {  }
}
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::std::string
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throw ()
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  ::std::string msg(”Hello ”);
  return msg + d_name + ”!”;
  // DO-NOT-DELETE splicer.end(greetings.English.sayIt)
}
```
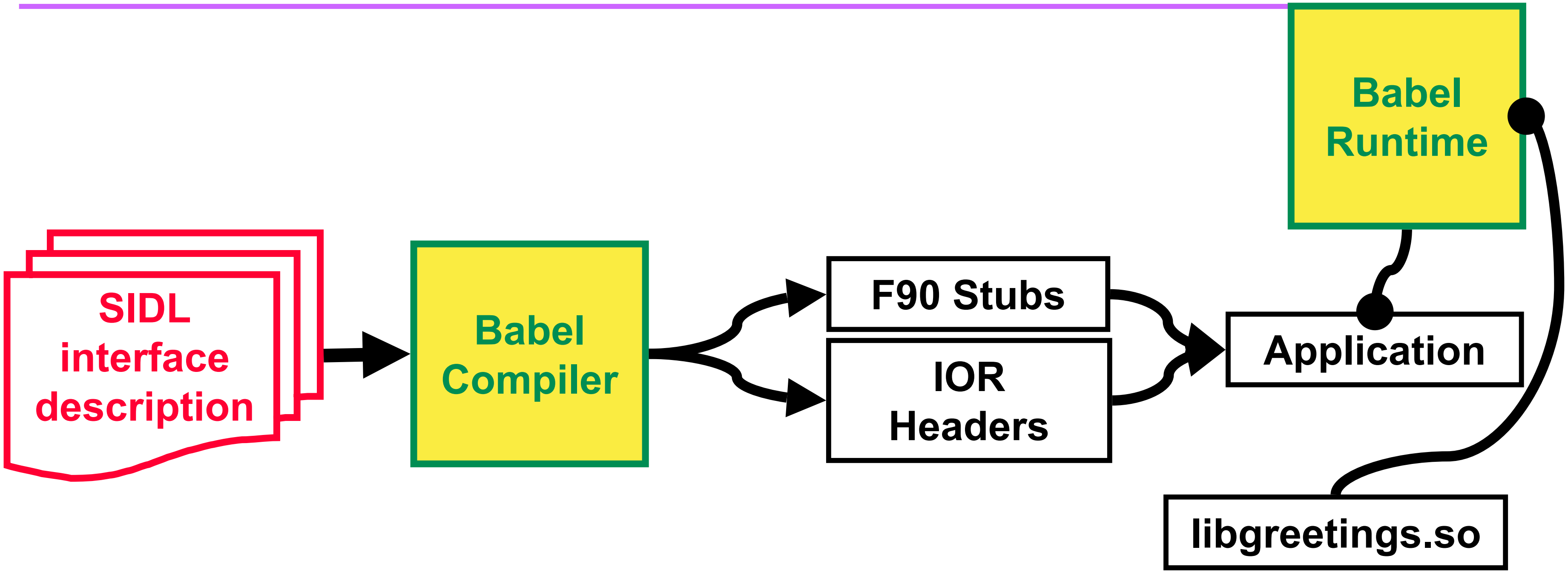

Library User Does This...



1. `babel --client=F90 greetings.sidl`
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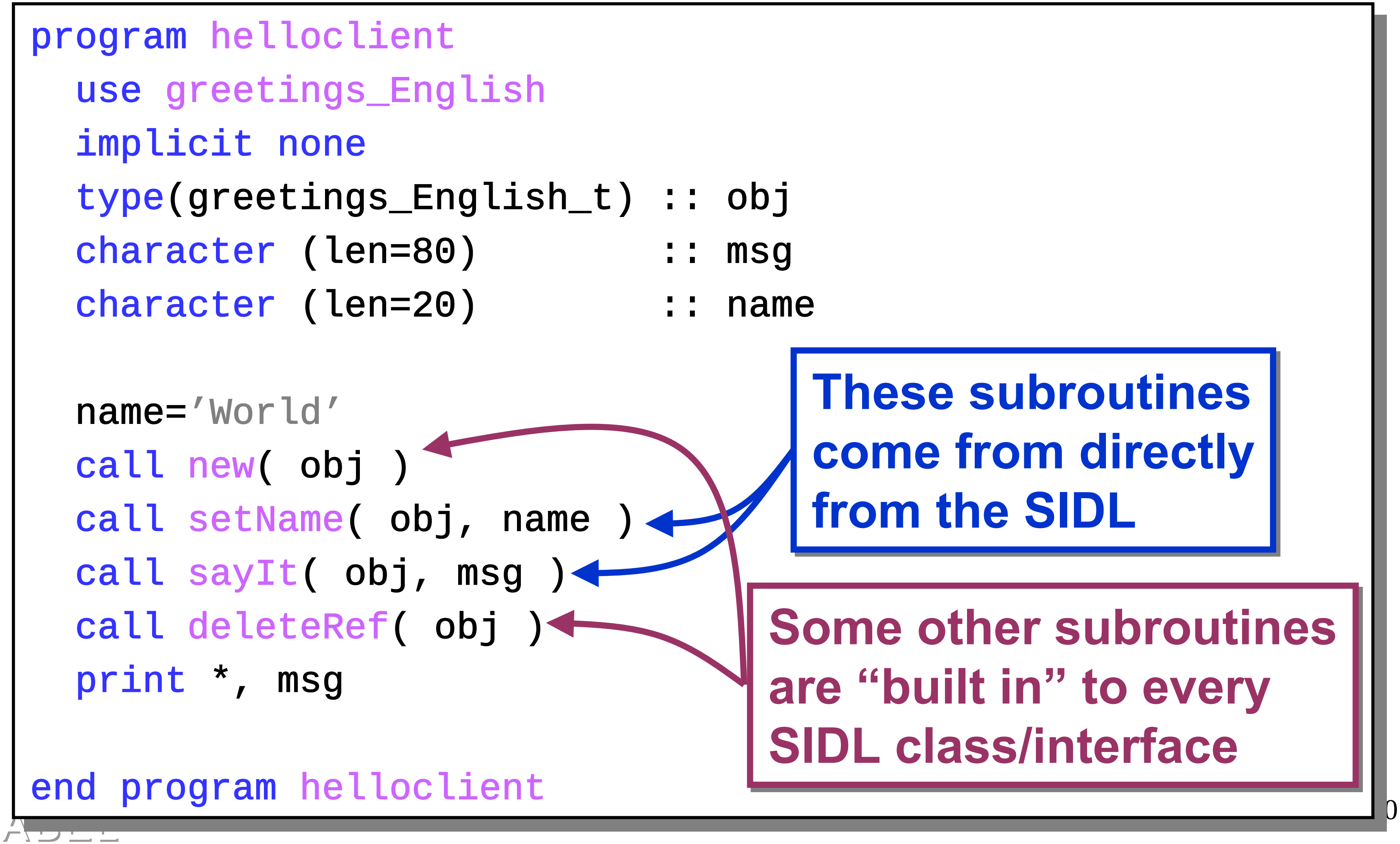
F90/Babel "Hello World" Application



```
program helloclient
  use greetings_English
  implicit none
  type(greetings_English_t) :: obj
  character (len=80)        :: msg
  character (len=20)        :: name

  name='World'
  call new( obj )
  call setName( obj, name )
  call sayIt( obj, msg )
  call deleteRef( obj )
  print *, msg

end program helloclient
```

These subroutines come from directly from the SIDL

Some other subroutines are "built in" to every SIDL class/interface

F90/Babe
A

```
package greetings version 1.0 {
    interface Hello {
        void setName( in string name );
        string sayIt ( );
    }
    class English implements-all Hello {  }
}
```

```
program helloclient
  use greetings_English
  implicit none
  type(greetings_English_t) :: obj
  character (len=80)        :: msg
  character (len=20)        :: name

  name='World'
  call new( obj )
  call setName( obj, name )
  call sayIt( obj, msg )
  call deleteRef( obj )
  print *, msg

end program helloclient
```

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