Computer Language Interoperability Using Chasm

(or why can't I program in the language I want to?)

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Slashdot Question

"I'm beginning to wonder if I should invest the time in learning FORTRAN. Although it is arcane, it seems to be the best tool when it comes to demanding optimization tasks and heavy computations. C/C++ does not cut it for me - it is simply too easy to make mistakes and I find myself using half of my time hunting bugs unrelated to the problem at hand. Additionally, although tools like Matlab exist they don't provide the power that justify the huge price tag they carry. I find any script based language (Matlab, Numeric Python, Scilab) to be inadequate as soon as it is necessary to use loops to describe a problem and using such tools for recursive systems can be a real pain. As another data-point, the Netlib repository seems to be very FORTRAN oriented, and it is a true gold mine when it comes to free routines for solving almost any computing task. What bothers me though is that FORTRAN code is really ugly and the language lacks almost any modern day language feature (I know about Fortran 90 but it is not much nicer than F77, and no one seems to use it). Can it really be true that the best tool we have for heavy duty computing is a 25 year old language, or have you found anything better - free or non-free?"

Overview

- Motivation
- Language interoperability architecture
  - interface definition languages
  - bridging code (stubs and skeletons)
  - function argument marshalling
- Chasm example
- XML transformations (XSLT)

Why Not Only FORTRAN?

- Physicists were raised on Fortran
- So why is interoperability important
  - Because there are both computer scientists and physicists
- Computer scientists prefer C++ (or Java, or Scheme, or …)
- Students increasingly learning C++
- So why not only C++?
- "C++ is for professionals" *[Stroustrup]*

Anecdotal Evidence

- Two scientific codes that have both Fortran and C++ versions.
- ACTS workshop, mostly Fortran with a few C++ users
- CCA Forum meeting (component middle-ware developers)
  - 1/2 person interested in Fortran
  - But Fortran required by many users of CCA
- DOE
  - Fortran, C++, and Python (Fred Johnson)
- NASA
  - Earth System Modeling Framework requires all interfaces to be in both Fortran and C++

Fortran 95 Interoperability

- NOT!
- Fortran 95 was not designed with interoperability in mind
- We all know the problems of symbol names
  - whether to _ or not to _
  - module, symbol name example, function.in.module
- But the real problem is with arrays
  - F95 passes arrays by descriptor
  - F95 descriptors depend on compiler vendor implementation
- No way to pass multidimensional array to from C++ to F95

Interoperability Architecture

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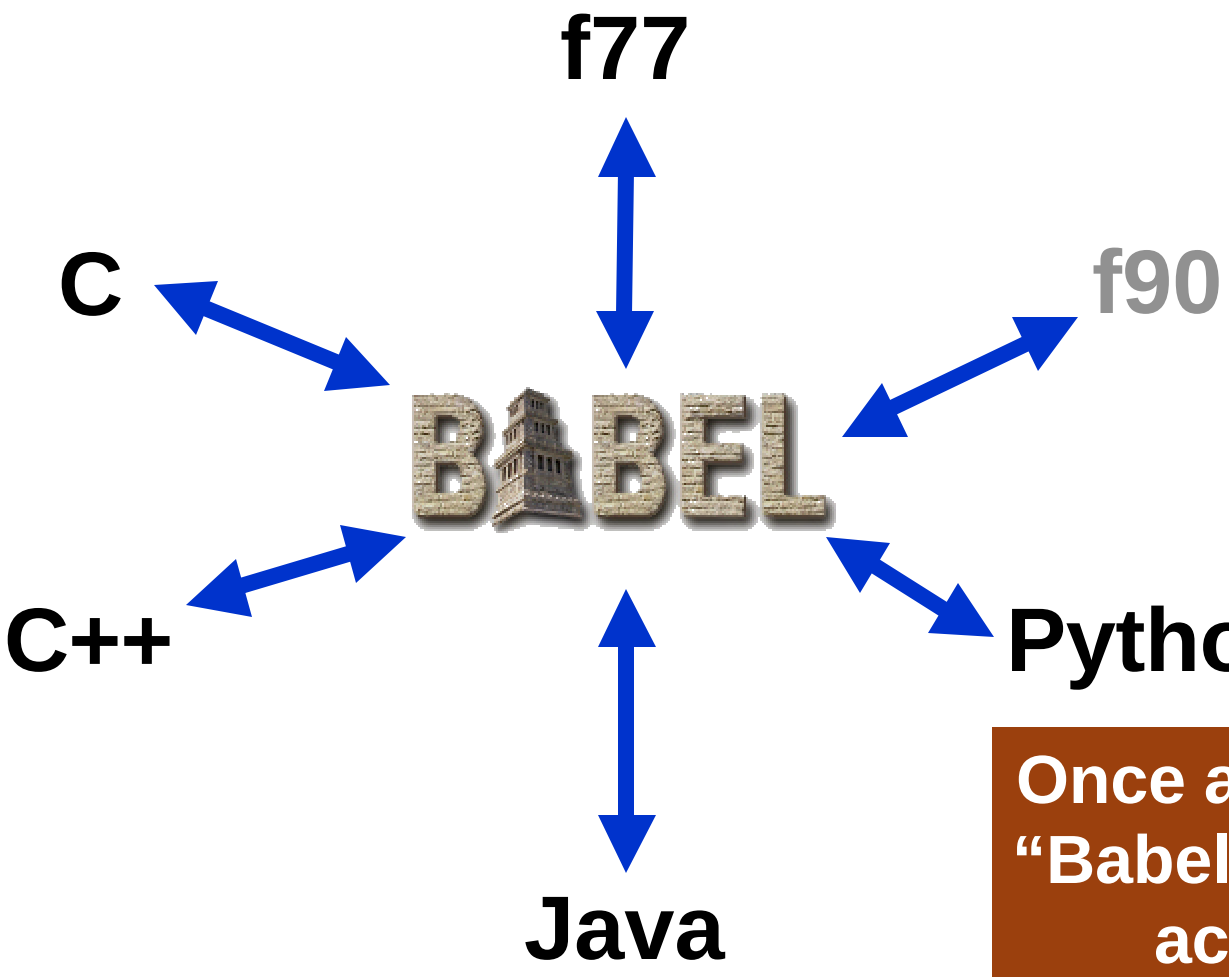
Interface Definition Languages (IDL)

- A way to specify function interfaces in a language independent manner
- Corba uses an IDL
- Babel uses Scientific IDL (SIDL)
- SIDL, Function-component example:

```
version tutorial 1.0;

package tutorial {
    interface Function extends cca.Port {
        double evaluate( in double x );
    }
}
```

Babel Make All Languages Peers



This is not an LCD Solution!

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

Chasm Interfaces

- Chasm specifies interfaces in a language dependent manner
  - in XML, automatically generated from user source files
- Why XML?
  - It's a standard, lots of existing tools
- Why language dependence?
  - use existing source files
  - potentially export more of the server language to client language
  - performance
- Example

```
<library lang="Fortran" name="LinearFunction.f90">
  <scope name="LinearFunction">
    <method name="LF_evaluate">
      <arg name="x" kind="ffloat" fkind="dbl">
      <return kind="ffloat" fkind="dbl">
```

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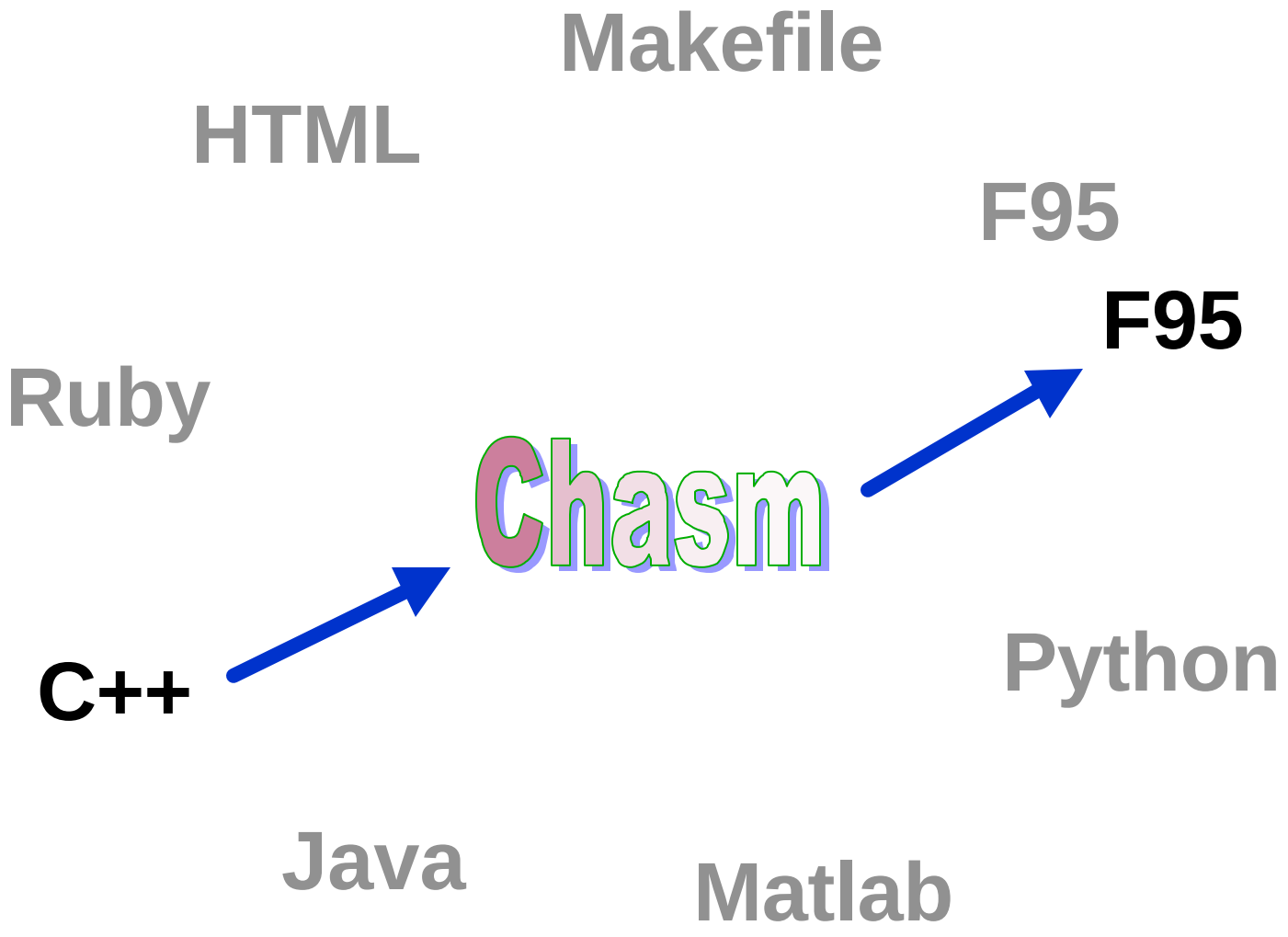
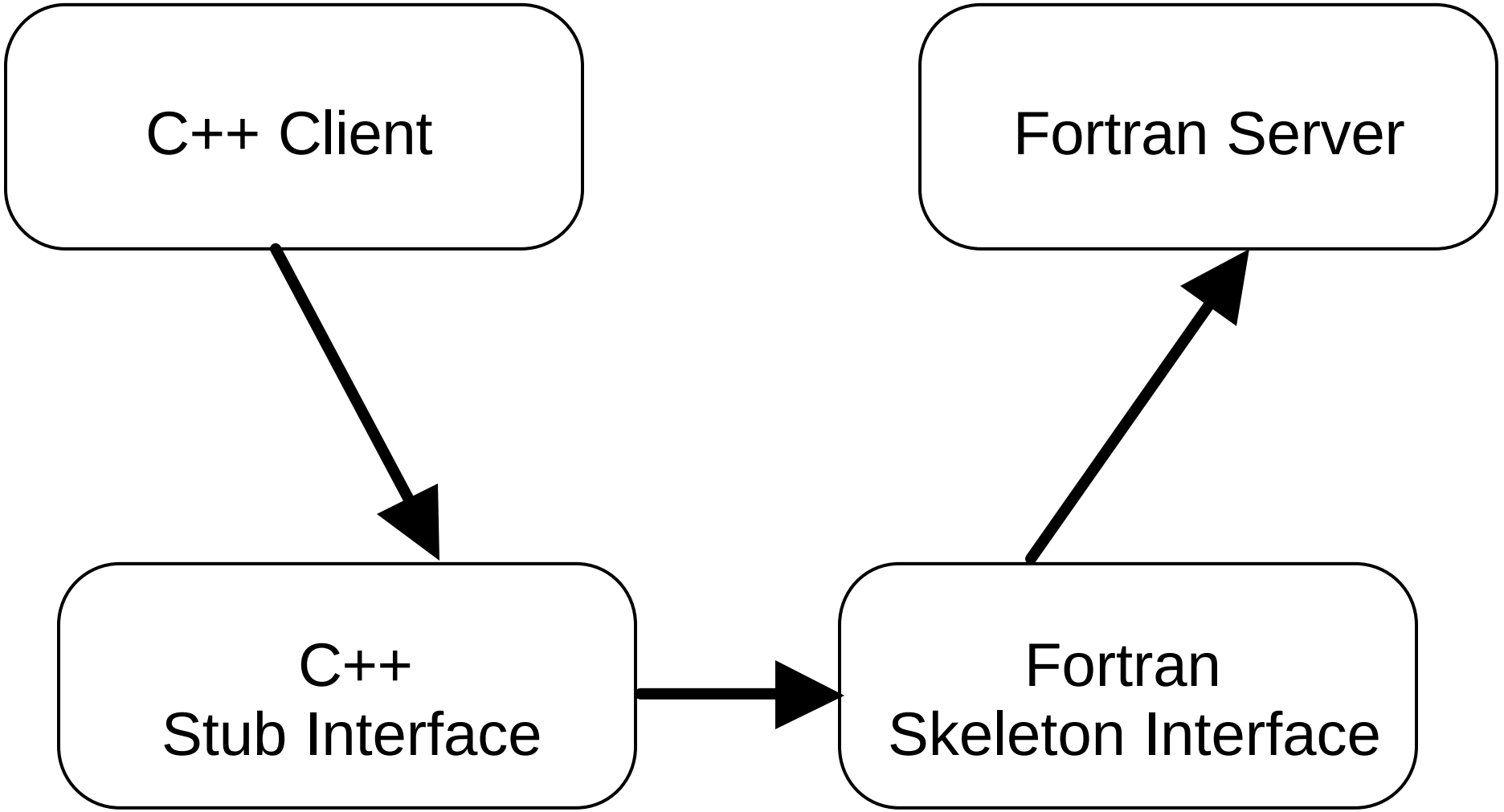
Language Pairs



Stub and Skeleton Code



Stub and Skeleton Code

- Has major advantages
- Stubs
  - natural C++ interface
  - e.g., Function::evaluate(C++ parameters…)
  - no “_” routines or strange macros
- Skeletons
  - marshal parameters
  - e.g., converts C++ array class to fully typed F95 array
- Chasm normally combines the two
  - reduces overhead

Marshalling of Arguments

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Type Conversion

integer	int &
real	float &
type(user_type)	struct
character(len=)	string &
real, dimension(:,:)	F95Array<float>

Fortran Derived Types

- Fortran derived type is essentially just a C struct
- Chasm creates a shadow struct in C++

```
type particle
  real :: position(3)
  real :: velocity(3)
  real :: mass
end type
```

```
typedef Particle_ {
  float position[3]
  float velocity[3]
  float mass
} Particle;
```

Marshalling Fortran Arrays

- Fortran arrays passed by descriptor
  - contains array meta data
    - rank (# of dimensions)
    - extent (# of elements in each dimension)
- Compiler specific representation (yuk)
- F95Array< T > class supplied
  - can supply your own
  - chasm is extensible (yea)
- C descriptor library
  - long getArrayRank(void* desc);

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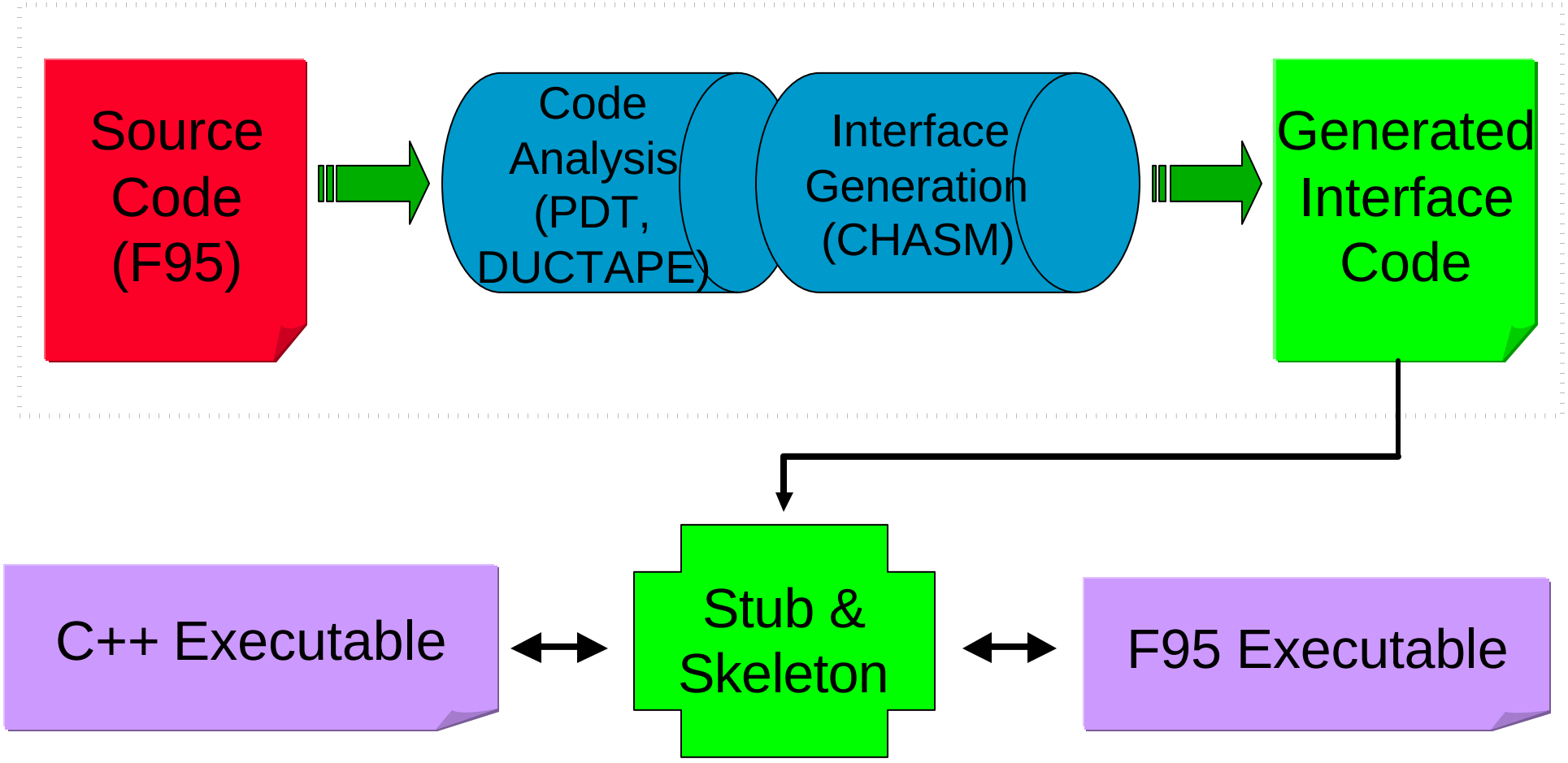
Using Chasm


Source Code (F95)
Code Analysis (PDT, DUCTAPE)
Interface Generation (CHASM)
Generated Interface Code
C++ Executable
Stub & Skeleton
F95 Executable

XML Transformations

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Stylesheet Example

- Code segment to print the names of procedures in a module

```
<library name="LinearFunction.f90” lang=“f90”>
  <scope name="LINEARFUNCTION">
    <method name="EVALUATE_LINEAR" kind="static”>
      <arg name="X" kind="ffloat" fkind="dbl”/>
      <return kind="ffloat" fkind="dbl”/>
```

```
<xsl:template match=“/”>
  <xsl:apply-templates select=“library/scope/method”/>
</xsl:template>

<xsl:template match=“library/scope/method”>
  <xsl:text>  Found procedure: </xsl:text>
  <xsl:value-of select=“@name”/>
  <xsl:value-of select=“$newline”/>
</xsl:template>
```

Chasm Status

- Received funding in July
- C++ calling Fortran mostly completed
- C array-descriptor library completed for 3 compilers (MIPSpro, Compaq, Absoft)
- Demonstration stylesheet transformations for
  - Fortran CCA Components
  - Ruby
- Would like to talk to people interested in
  - Matlab
  - Python
  - ?

Conclusions

- Chasm transforms code
- Why use Chasm
  - shear drudgery of hand coding
  - bridging code doesn't get out of sync
  - impose project-wide language transformation standards
- Chasm is extensible
  - modify code generation to fit the needs of your project
- No long-term "dependency" on Chasm project
  - except for array-descriptor library?
- Your project "owns" the generated code

Links

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

Chasm - http://sourceforge.net/projects/chasm-interop/