CCA
Common Component Architecture

Language Interoperable CCA Components via BABEL

CCA Forum Tutorial Working Group
http://www.cca-forum.org/tutorials/
tutorial-wg@cca-forum.org

JPL Lawrence Livermore National Laboratory Los Alamos NASA ornl University of Oregon Sandia National Laboratories

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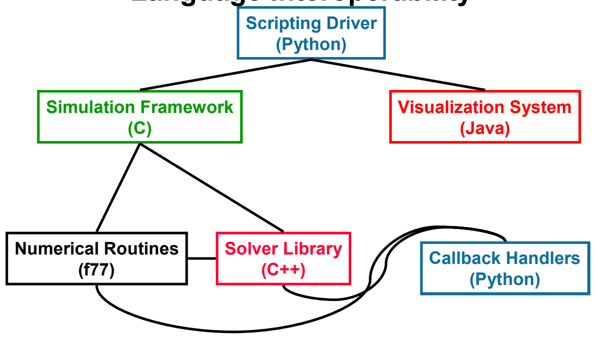
Goal of This Module

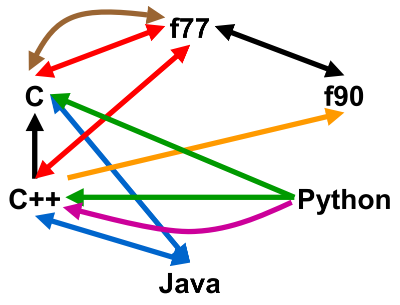
Legacy codes → Babelized CCA Components

- Introduction To:
  - Babel
  - SIDL
- See Babel in use
  - "Hello World" example
  - Legacy Code (Babel-wrapped MPI)
  - CCA Tutorial Example (Numerical Integration)
- Relationship between Babel & CCA

What I mean by "Language Interoperability"


Scripting Driver (Python)
Simulation Framework (C)
Visualization System (Java)
Numerical Routines (f77)
Solver Library (C++)
Callback Handlers (Python)

One reason why mixing languages is hard



Native

cfortran.h

SWIG

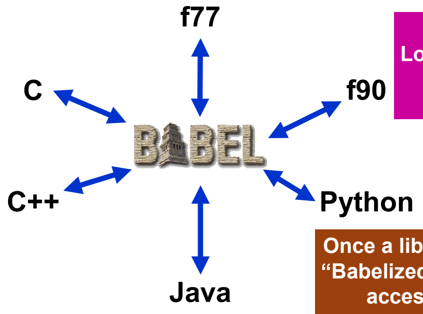
JNI

Siloon

Chasm

Platform Dependent

Babel makes all supported languages peers



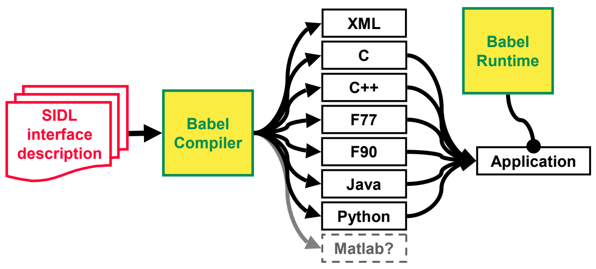
This is not a Lowest Common Denominator Solution!

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

Babel Module’s Outline

- Introduction
- Babel Basics
  - How to use Babel in a “Hello World” Example
  - SIDL Grammar
  - Example: Babel & Legacy Code
- Babel & CCA
  - Relationship between them
  - How to write a Babelized CCA Component

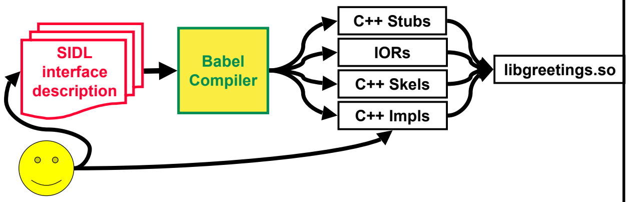
Babel’s Two Parts: Code Generator + Runtime Library



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...



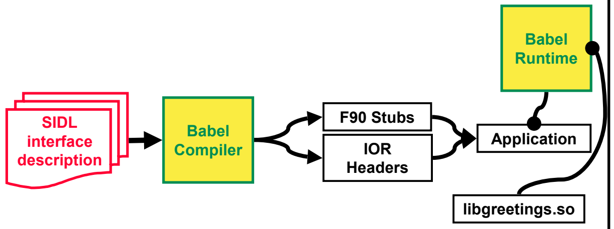
1. `babel --server=C++ greetings.sidl`
2. Add implementation details
3. Compile & Link into Library/DLL

Adding the Implementation

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

```
string
greetings::English_impl::sayIt()
throw ()
{
  // DO-NOT-DELETE splicer.begin(greetings.English.sayIt)
  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`
2. Compile & Link generated Code & Runtime
3. Place DLL in suitable location

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

SIDL Grammar (1/3): Packages and Versions

- Packages can be nested

```
package foo version 0.1 { package bar { ... } }
```

- Versioned Packages
  - defined as packages with explicit version number OR packages enclosed by a versioned package
  - Reentrant by default, but can be declared final
  - May contain interfaces, classes, or enums
- Unversioned Packages
  - Can only enclose more packages, not types
  - Must be re-entrant. Cannot be declared final

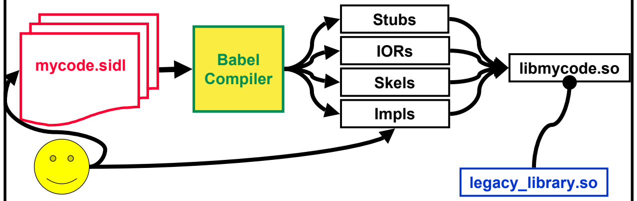
SIDL Grammar (2/3): Classes & Interfaces

- SIDL has 3 user-defined objects
  - Interfaces – APIs only, no implementation
  - Abstract Classes – 1 or more methods unimplemented
  - Concrete Classes – All methods are implemented
- Inheritance (like Java/Objective C)
  - Interfaces may extend Interfaces
  - Classes extend no more than one Class
  - Classes can implement multiple Interfaces
- Only concrete classes can be instantiated

SIDL Grammar (3/3): Methods and Arguments

- Methods are public virtual by default
  - static methods are not associated with an object instance
  - final methods can not be overridden
- Arguments have 3 parts
  - Mode: can be in, out, or inout (like CORBA, but semantically different than F90)
  - Type: one of (bool, char, int, long, float, double, fcomplex, dcomplex, array<*Type*,*Dimension*>, enum, interface, class)
  - Name

Babelizing Legacy Code



1. Write your SIDL interface
2. Generate server side in your native langauge
3. Edit Implementation (Impls) to dispatch to your code (Do NOT modify the legacy library itself!)
4. Compile & Link into Library/DLL

Known Projects Using Babel

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

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.

research.cs.vt.edu/lacsa

Babel & Legacy Code (e.g. MPI)

```
package mpi version 2.0 {
  class Comm {
     int send[Int]( in array<int,1,row-major> data,
                    in int dest, in int tag );
     ...
  }
}
```

mpi.sidl

Babel & Legacy Code (e.g. MPI)

```
struct mpi_Comm__data {
  /* DO-NOT-DELETE splicer.begin(mpi.Comm._data) */
  MPI_Comm com;
  /* DO-NOT-DELETE splicer.end(mpi.Comm._data) */
};
```

mpi_comm_Impl.h

```
int32_t
impl_mpi_Comm_sendInt( mpi_Comm self, SIDL_int__array data,
                       int32_t dest, int32_t tag ) {
  /* DO-NOT-DELETE splicer.begin(mpi.Comm.sendInt) */
  struct mpi_Comm__data *dptr = mpi_Comm__get_data( self );
  void * buff = (void*) SIDL_int__array_first(data);
  int count = length(data);
  return mpi_send( buff, count, MPI_INT, dest, tag, dptr->comm);
  /* DO-NOT-DELETE splicer.end(mpi.Comm.sendInt) */
}
```

mpi_comm_Impl.c

Investing in Babelization can improve the interface to the code.

"When Babelizing LEOS [an equation of state library at LLNL], I completely ignored the legacy interface and wrote the SIDL the way I thought the interface should be. After running Babel to generate the code, I found all the hooks I needed to connect LEOS without changing any of it. Now I've got a clean, new, object-oriented python interface to legacy code. Babel is doing much more than just wrapping here."

-- Charlie Crabb, LLNL (conversation)

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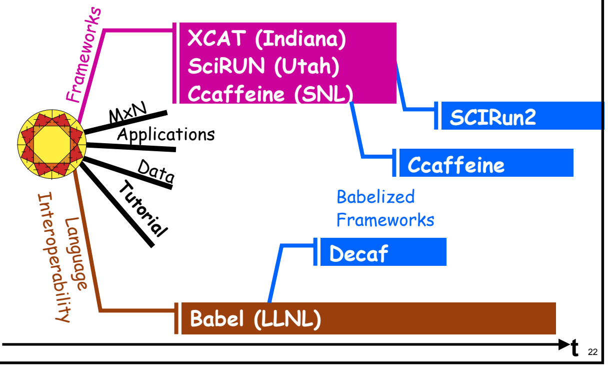
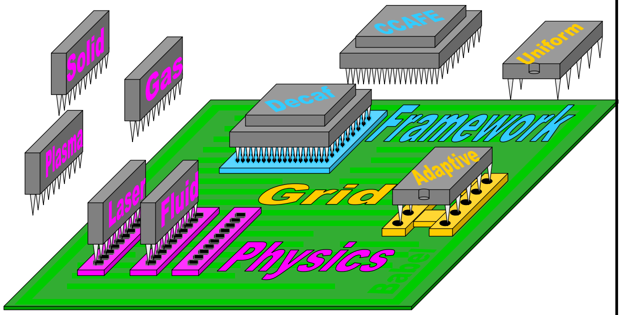
History of Babel & CCA



The CCA Spec is a SIDL File

```
package gov {
package cca version 0.6.1 {
    interface Port { }
    interface Component {
        void setServices( in Services svcs );
    }
    interface Services {
        Port getPort( in string portName );
        registerUsesPort( /*etc*/ );
        addProvidesPort( /*etc*/ );
    /*etc*/
```

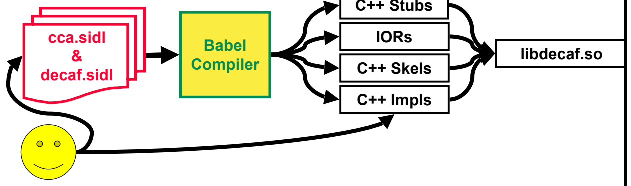
The CCA from Babel's POV



Decaf: Details & Disclaimers

- Babel is a hardened tool
- Decaf is an example, not a product
  - Distributed in "examples" subdirectory of Babel
  - Decaf has no GUI
- Decaf is CCA compliant
  - Babelized CCA Components can be loaded into Decaf, CCAFFEINE, and SCIRun2
- **"Understanding the CCA Specification Using Decaf"** **http://www.llnl.gov/CASC/components/docs/decaf.pdf**

How I Implemented Decaf



1. wrote decaf.sidl file
2. `babel --server=C++ cca.sidl decaf.sidl`
3. Add implementation details
4. Compile & Link into Library/DLL

How to Write and Use Babelized CCA Components

1. Define "Ports" in SIDL
2. Define "Components" that implement those Ports, again in SIDL
3. Use Babel to generate the glue-code
4. Write the guts of your component(s)

How to Write A Babelized CCA Component (1/3)

1. Define "Ports" in SIDL
   - CCA Port =
     - a SIDL Interface
     - extends gov.cca.Port

```
package functions version 1.0 {
    interface Function extends gov.cca.Port {
        double evaluate( in double x );
    }
}
```

How to Write A Babelized CCA Component (2/3)

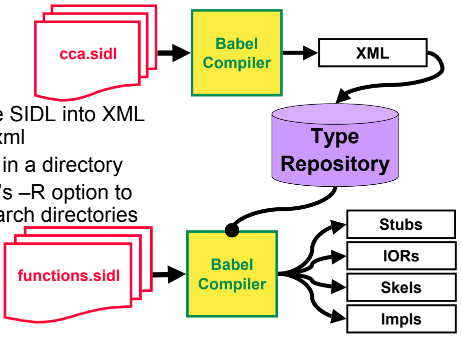
2. Define “Components” that implement those Ports
   - CCA Component =
     - SIDL Class
     - implements gov.cca.Component (& any provided ports)

```
class LinearFunction implements functions.Function,
                                gov.cca.Component {
      double evaluate( in double x );
      void setServices( in cca.Services svcs );
}
```

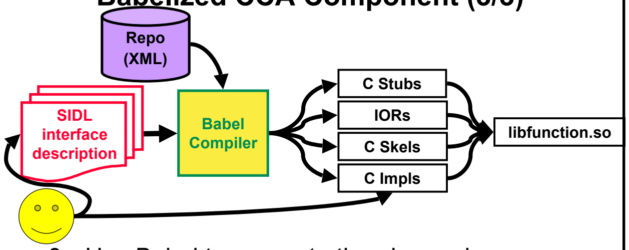
```
class LinearFunction implements-all
       functions.Function, gov.cca.Component { }
```

Tip: Use Babel’s XML output like precompiled headers in C++

1. precompile SIDL into XML
   --text=xml
2. store XML in a directory
3. Use Babel’s –R option to specify search directories

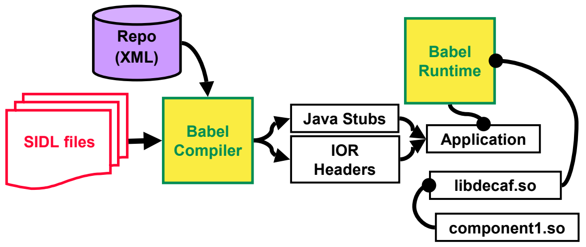


How to Write A Babelized CCA Component (3/3)



3. Use Babel to generate the glue code
   - `babel --server=C –Rrepo function.sidl`
4. Add implementation details

To Use the Decaf Framework

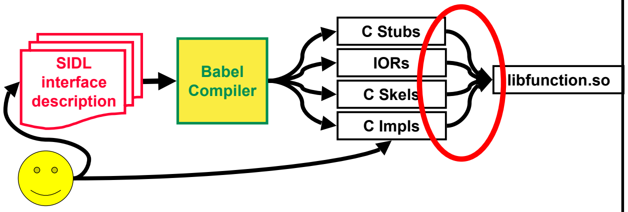


1. `babel --client=Java –Rrepo function.sidl`
2. Compile & Link generated Code & Runtime
3. Place DLLs in suitable location

Limitations of Babel's Approach to Language Interoperabilty

- Babel is a code generator
  - Do obscure tricks no one would do by hand
  - Don't go beyond published language standards
- Customized compilers / linkers / loaders beyond our scope
  - E.g. icc and gcc currently don't mix on Linux
  - E.g. No C++-style templates in SIDL. (Would require special linkers/loaders to generate code for template instantiation, like C++ does.)
- Babel makes language interoperability feasible, but not trivial
  - Build tools severely underpowered for portable multi-language codes

What's the Hardest Part of this Process?



- Properly building libraries for multi-language use
- Dynamically loadable .so files are especially error prone
  - Not a lot of understanding or expertise in community
  - Causality chain between improperly constructed DLLs and observed bugs is often inscrutable and misleading

Summary

Legacy codes → Babelized CCA Components

- Reclassify your objects in your legacy code
  - Things customers create → CCA components
  - Logical groups of a component's functionality → CCA Port
  - Low level objects in your implementation → not exposed
- Generate SIDL File
  - CCA port → Babel Interface that extends the Babel interface called "gov.cca.Port"
  - CCA component → Babel Class that implements the Babel interface called "gov.cca.Component" (and possibly its "provides ports")
- Run Babel (choose server-language for your code)
- Articulate Impl files to dispatch to legacy code

Contact Info

- Project: http://www.llnl.gov/CASC/components
  - Babel: language interoperability tool
  - Alexandria: component repository
  - Quorum: web-based parliamentary system
  - Gauntlet (coming soon): testing framework
- Bug Tracking: http://www-casc.llnl.gov/bugs
- Project Team Email: components@llnl.gov
- Mailing Lists: majordomo@lists.llnl.gov

  subscribe babel-users *[email address]*

  subscribe babel-announce *[email address]*