Generating language bindings for C/C++ libraries

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What and why ?

SWIG is an interface compiler that connects programs written in C and C++ with scripting languages such as Perl, Python, Ruby, and Tcl.

- Building more powerful C/C++ programs
- Make C libraries 'object oriented'
- Rapid prototyping and debugging
- Systems integration
- Construction of scripting language extension modules

About SWIG

- Homepage: http://www.swig.org
- `# zypper in swig`
- History
  - Initially started in July, 1995 at Los Alamos National Laboratory.
  - First alpha release: February, 1996.
  - Latest release: April 7, 2008. SWIG-1.3.35
- Active development
  - 3-4 releases per year

Supported languages

Allegro Common Lisp

CFFI (Common Lisp)

CLisp

Octave

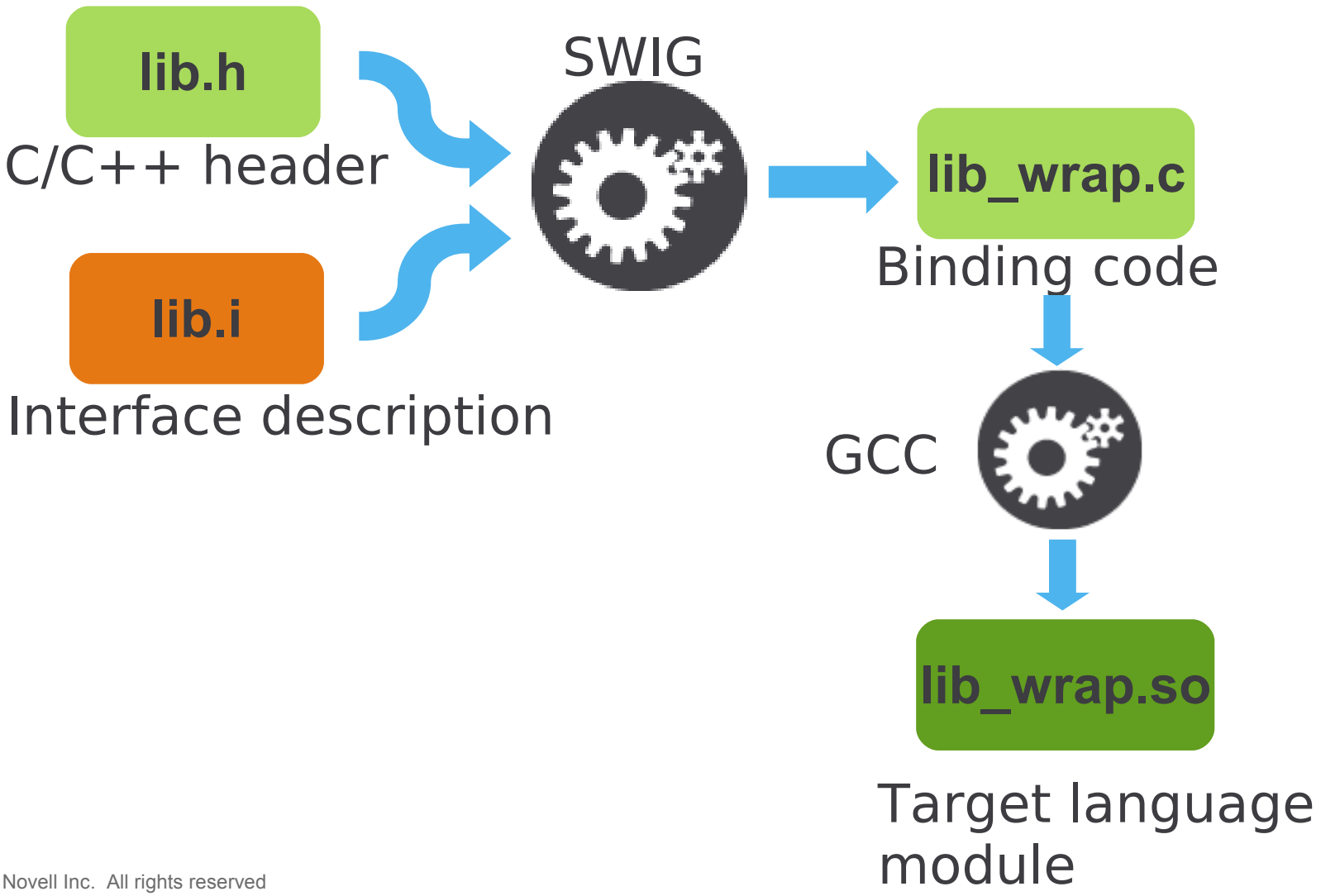
Chicken (Scheme)

Ruby

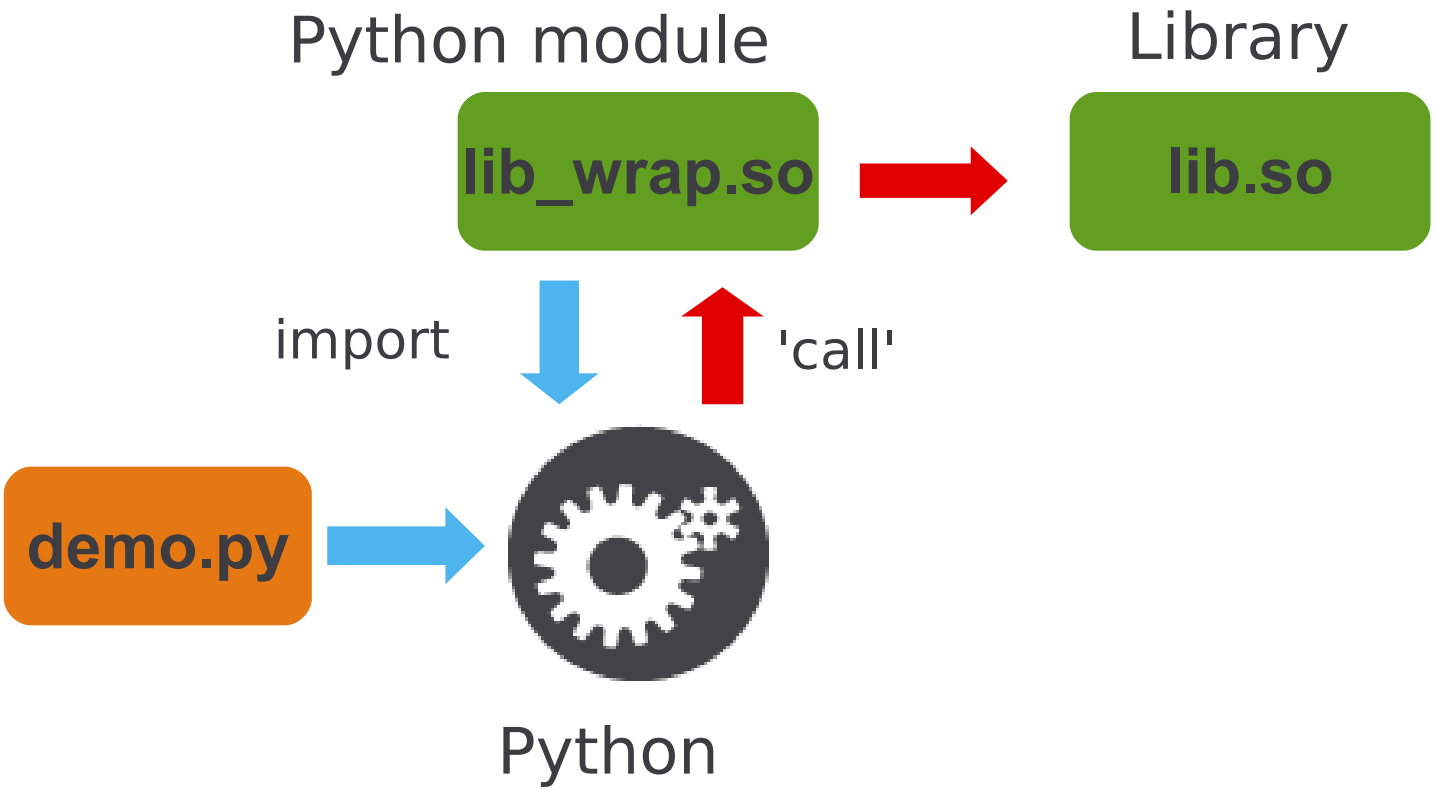
A Programmer's Best Friend

MzScheme

How SWIG works



How SWIG works (cont.)



Using SWIG

Example interface description

```
# Trivial example
%module example
%{
#include "satsolver/solver.h"
%}

%include satsolver/solver.h
```

Running SWIG

- Generating

```
swig -ruby -I/usr/include example.i
```

- Compiling

```
gcc -fPIC -I /usr/lib64/ruby/1.8/x86_64-linux -c example_wrap.c
```

- Linking

```
gcc -shared  example_wrap.o -lsatsolver -o example.so
```

- Running

```
irb
irb(main):001:0> require "example"
=> true
irb(main):002:0> s = Example::Solver.new
=> #<Example::Solver:0x7ffd300d4de8>
```

Structure of interface descriptions

```
# Trivial example                          Comment
%module example                            Namespace
%{
#include "satsolver/solver.h"              C/C++ code
%}
%include satsolver/solver.h                Declarations
```

- C syntax, no C compiler
- Only minimal syntax checking

What does SWIG do for you ?

- Namespace
- Constants
- Type conversion
  - For simple types (int, float, char *, enum)
- Wraps complex types
  - Pointers to structs and classes
- Exposes functions
- Memory management
  - Constructors, destructors

Example (Python)
(taken from libyui-bindings)

YaST2/yui/YUI.h

```
class YUI
{
...
    static YWidgetFactory *
 widgetFactory();
...
}
```

demo.py

```
import yui
factory = yui.YUI.widgetFactory()
dialog = factory.createPopupDialog()
vbox = factory.createVBox( dialog )
factory.createLabel( vbox, "Hello,
 World!" )
```

yui.i

```
%module yui
%{
#include "YaST2/yui/YUI.h"
%}
%include YUI.h
```

Now how does it look like in ...

Ruby

```
require 'yui'
factory = Yui::YUI::widget_factory
dialog = factory.create_popup_dialog
vbox = factory.create_vbox dialog
factory.create_label vbox, "Hello, World!"
```

Perl

```
use yui;
my $factory = yui::YUI::widgetFactory;
my $dialog = $factory->createPopupDialog;
my $vbox = $factory->createVBox( $dialog );
$factory->createLabel( $vbox, "Hello, World!" );
```

Things to watch out for

- Function names (target language conventions)

```
factory.create_popup_dialog
```

```
$factory->createPopupDialog;
```

- Comparing objects

  SWIG *wraps* pointers to structs/classes, resulting in target languages objects (Python: `PyObject*`, Ruby: `VALUE`)

  'a == b' compares PyObject* (resp. VALUE), not the wrapped C++ object pointer

- Object ownership

  No explicit 'free' in e.g. Ruby and Python

Controlling the bindings

Exposure

- Swig recognizes C/C++ declarations
  - 'struct' or 'class'
  - functions
- Hiding elements

```
%ignore solver::noupdate;
%include “satsolver/solver.h”
```

- Hiding everything

```
typedef struct solver {} Solver;
%extend Solver {
  ...
```

Memory management

- Complex types (struct/class) as pointers
- SWIG runs constructor ('malloc (sizeof struct)')
- Might not be useful

```
%nodefault solver;
```

- Explicit constructor/destructor

```
%extend Solver {
  Solver( Pool *pool, Repo *installed = NULL )
  { return solver_create( pool, installed ); }
  ~Solver()
  { solver_free( $self ); }
```

Making C object-oriented

- Swig maps function calls 1:1, Ok for C++, bad for C

```
void solver_solve(Solver *solv, Queue *job);
```

(Ruby)

```
solver = Solver.new
solver_solve solver, job   # Bad
solver.solve job           # Good
```

- The power of %extend

```
%extend Solver {
  int solve( Queue *job )
  {
    solver_solve( $self, job);
    return $self->problems.count == 0;
  }
```

Multiple target languages

- .i files are generic
- The target language is a SWIG runtime parameter

```
swig -ruby bindings.i
```

- Use `#if defined(SWIG<lang>)`

```
#if defined (SWIGRUBY)
...
#endif
```

Useful commands

- Renaming

```
%rename("to_s") asString();
%rename( "name=" ) set_name( const char *name );
%rename("empty?") empty();
```

- Aliasing

```
%alias get "[]";
```

- Constants

```
%constant int Script = C_CONSTANT;
```

- Defines

```
%define YUILogComponent "bindings"
%enddef
%define %macro(PARAMETER)
...
```

Type conversions

- SWIG has default conversions for most types
- Look at the SWIG 'library'

  /usr/share/swig/<*version*>

  %include “carray.i”
- Typemaps

```
#if defined(SWIGRUBY)
  %typemap(in) (int bflag) {
    $1 = RTEST( $input );
  }
  %typemap(out) int problems_found
    "$result = ($1 != 0) ? Qtrue : Qfalse;";
  %rename("problems?") problems_found();
#endif
```

Target specifics

- Bypassing SWIG type conversion
- Use target-specific types

  Ruby: `VALUE`

  Python: `PyObject *`
- Example

```
%rename( "attr?" ) attr_exists( VALUE attrname );
VALUE attr_exists( VALUE attrname )
{
...
```

Generating Documentation

- SWIG can generate target-specific documentation
  e.g. rdoc for Ruby, pydoc for Python
- Enable with `%feature("autodoc","1");`
- Converts C-style comments in .i files
- Needs fixing ...

Inversion of control

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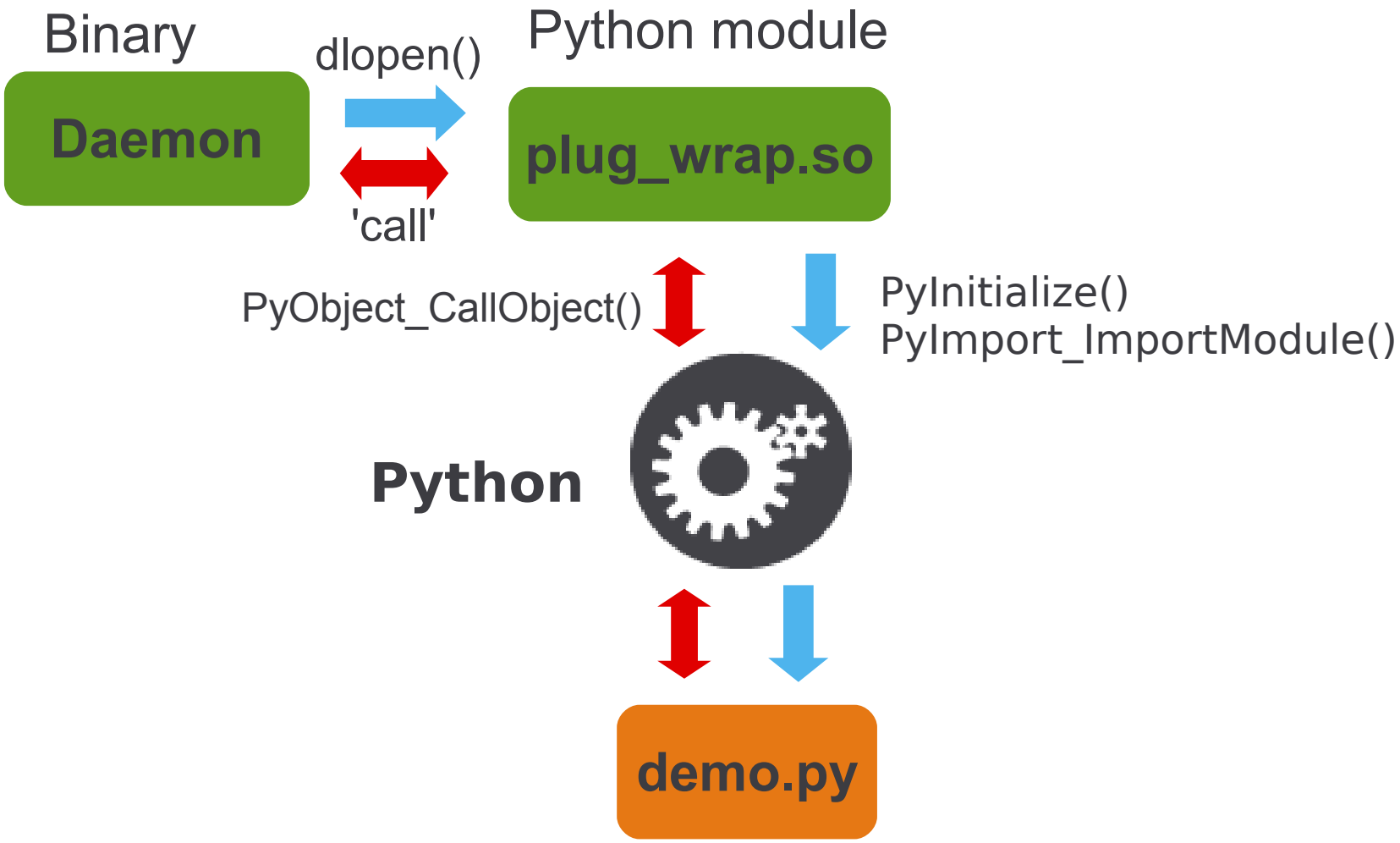
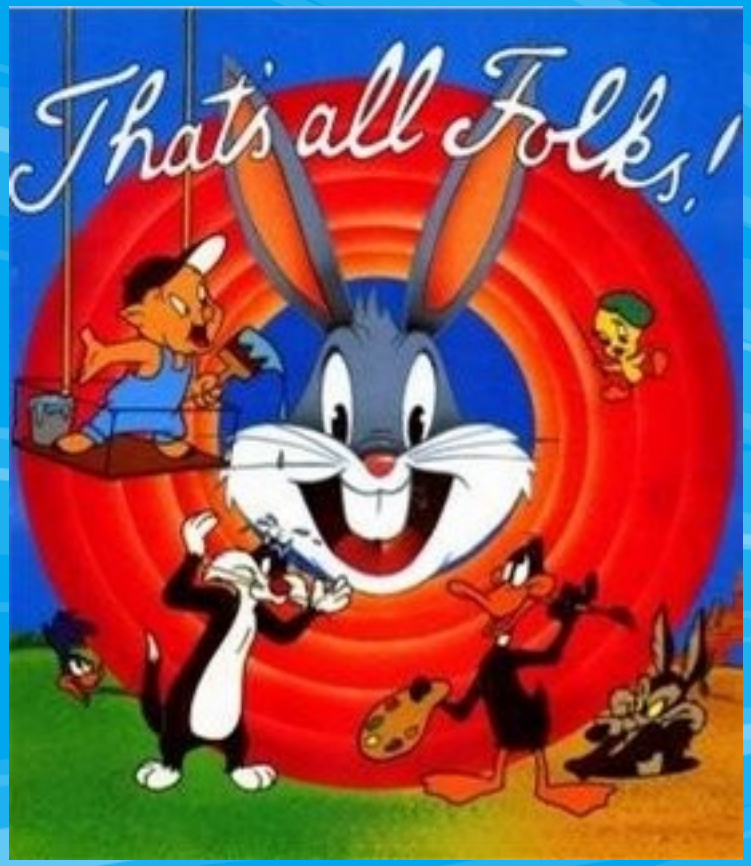


Wrap up / Lessons learned

- SWIG is a tool, use it wisely
- Take the (script language) programmers view
  - How should it look in Python/Ruby/Perl/... ?
- Tweak the bindings, not the target language
- Look at other SWIG code
- SWIG is very well documented
  - But not without bugs ...
- Memory ownership is tricky

Links for inspiration

- C++ Library
  - libyui-bindings (YaST user interface)
    - http://svn.opensuse.org/svn/yast/trunk/libyui-bindings
- C Library
  - Sat-solver (package dependency resolver)
    - http://svn.opensuse.org/svn/zypp/trunk/sat-solver/bindings
  - openwsman (Web Services for Management protocol)
    - http://www.openwsman.org/trac/browser/openwsman/trunk/bindings
- Inversion of control
  - cmpi-bindings (CIM Provider interface)
    - http://omc.svn.sourceforge.net/viewvc/omc/cmpi-bindings


That's all Folks!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