exporting Ada software to Python and Julia

applying GPRbuild to make shared object files

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make Ada software available to Python and Julia

Two goals when exporting Ada software:
1. Make the build process as simple as possible.
2. Give control to as many functionality as possible.

Jupyter = Julia, Python, R, and many others . . .
- The Jupyter notebook is popular for interactive computing.
- Used in SageMath, an open source mathematical software.
- Not tied to any particular programming language.

GPRbuild is the project manager of the gnu-ada compiler GNAT.

GPRbuild enables mixed-language development, combining Ada, C, and C++ software.

The interfacing in this talk is mainly intended for programmers.
Julia, Python, R, and many others

The Jupyter notebook comes with many kernels.
  - Python is a widely used scripting language.
  - Julia is a new programming for scientific computing.

Both Python and Julia interface well with C code.

The main point is to automate the build process with GPRbuild.
mixed language development with GPRbuild

GPRbuild recognizes Ada, C, and C++ as languages.

C is a some kind of least common multiple:
- widely available on almost all computers,
- most languages interface to C.

Therefore, if your software can be used by a C programmer, then applications in other languages are also likely to benefit.

Library projects build shared object files, files with the extension `.so (Linux), .dll (Windows), .dylib (Mac OS X).`
developing an interface

Two types of interfaces:
1. The Ada program `main` remains in control.
2. The interface package gives control to a C program.

Example: program that swaps the characters in a string.

```
"hello" → swap → "olleh"
```

Two types of interfaces:
1. The Ada `main` reads the string, swaps, and writes.
2. The C program has control:
   - passes data to some Ada package
   - calls a procedure exported by the Ada package to swap
   - extracts the data from the Ada package

A string in this context is an array of ASCII codes (32-bit integers).
a demonstration package, and its C interface

**Ada package:** swap

- Initialize(s)
- DoIt
- s := Retrieve

```ada
with C_Integer_Arrays; use C_Integer_Arrays;

function call_swap ( jobnbr : integer; sizedata : integer; swapdata : C_intarrs.Pointer; verbose : integer ) return integer;

where C_Integer_Arrays defines C_Integer_Array as an array of Interfaces.C.int, and it contains

package C_intarrs is
  new Interfaces.C.Pointers(Interfaces.C.size_T, Interfaces.C.int, C_Integer_Array, 0);
```

Jan Verschelde (UIC) exporting Ada software
testing the C interface

sizeword = strlen(word);

for(int idx = 0; idx < sizeword; idx++)
    dataword[idx] = (int) word[idx];

adainit();
fail = _ada_call_swap(0,sizeword,dataword,1);
fail = _ada_call_swap(1,sizeword,dataword,1);
fail = _ada_call_swap(2,sizeword,dataword,1);
adafinal();

for(int idx = 0; idx < sizeword; idx++)
    word[idx] = (char) dataword[idx];
applying GPRbuild — the file demo.gpr

project Demo is

   for Languages use ("Ada", "C");

   for Source_Dirs use ("src");

   for Main use
      (  
         "hello_world.adb",
         "main.adb",
         "test_call_swap.c"
      );

   for Object_Dir use "obj";

   for Exec_Dir use "bin";

end Demo;
for Library_Dir use "lib";
for Library_Name use "demo";
for Library_Kind use "dynamic";
for Library_Auto_Init use "true";
for Library_Interface use
  (  
    "hello_world", "main", "swap", "call_swap", "c_integer_arrays"
  );
for Library_Standalone use "encapsulated";

package Compiler is

    for Switches ("call_swap.adb") use ("-c");

end Compiler;

package Binder is

    -- the "-Lada" is needed for the adainit and adafinal functions
    for Default_Switches ("Ada") use ("-n", "-Lada");

end Binder;
the Julia `ccall()` function

The Julia code below calls the `call_swap` procedure.

```julia
LIBRARY = "../Ada/lib/libdemo"

word = [Cint('h'), Cint('e'), Cint('l'), Cint('l'), Cint('o')]
println(word)
ptr2word = pointer(word, 1)
p = ccall((:_ada_call_swap, LIBRARY), Cint,
        (Cint, Cint, Ref{Cint}, Cint), 0, 5, ptr2word, 1)
p = ccall((:_ada_call_swap, LIBRARY), Cint,
        (Cint, Cint, Ref{Cint}, Cint), 1, 5, ptr2word, 1)
p = ccall((:_ada_call_swap, LIBRARY), Cint,
        (Cint, Cint, Ref{Cint}, Cint), 2, 5, ptr2word, 1)
println(word)
```

To make code available to Python:

1. Define an extension module in C or C++.
2. Define `setup.py`, adding
   
   ```
   extra_objects=['../Ada/lib/libdemo.a', 
               ADALIB + 'libgnat_pic.a', 
               ADALIB + 'libgnarl_pic.a']
   ```

   where `ADALIB` is the location of the Ada libraries.
3. Run `python setup.py build_ext`, which compiles the extension module and makes the shared object.

The shared object can be imported in a Python session.
an application: PHCpack

PHCpack is software for Polynomial Homotopy Continuation, to solve systems of polynomial equations.

- Mostly written in Ada, developed over almost 30 years.
- Contains DEMiCs, written in C++ by Mizutani and Takeda.
- phcpy is an interface to Python, for Linux and Mac OS X.
- phcpy is motivated by the open source software SageMath.
- A Julia interface is under development.

From the Julia folder of the PHCpack source distribution:

```
$ julia version.jl
-> in use_c2phc4c.Handle_Jobs ...
PHCv2.4.85 released 2021-06-30
$
```

ccall() uses the libPHCpack shared object, made with GPRbuild.
free and open source software

Pointers to github repositories (GPL-3.0 License):

- github.com/janverschelde/PHCpack
- github.com/janverschelde/ExportAdaGPRbuild

The ExportAdaGPRbuild contains the demo code for this talk.

*Thanks for your interest in this work.*