The Design of the WxOCaml library

An experiment with binding C++ libraries

Fabrice Le Fessant (INRIA/OCamlPro)

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A new GUI Toolkit

- How to write GUIs in OCaml ?
  - LablTK ?
    - Pros: included in the distrib
    - Cons: bad look and feel, few widgets
  - LablGTK ?
    - Pros: well tested, interface builder
    - Cons: no win64, not native on Win & MacOS
  - HTML5 ?
    - Pros: js_of_ocaml good, lots of JS libraries
    - Cons: webapp + http server, debug hard
  - No Interface ? Curses ? Other ones ?

Idea: binding for WxWidgets

- Good multi-platform support:
  - GTK under Linux, native on Windows and Mac OS
  - But the dev has been very slow in the last years :-(
- With bindings for MANY languages...
  - Very famous Python bindings
  - Also wxHaskell, wxEiffel, etc.
  - Except OCaml...
    - Not completely true : wxCaml, not finished

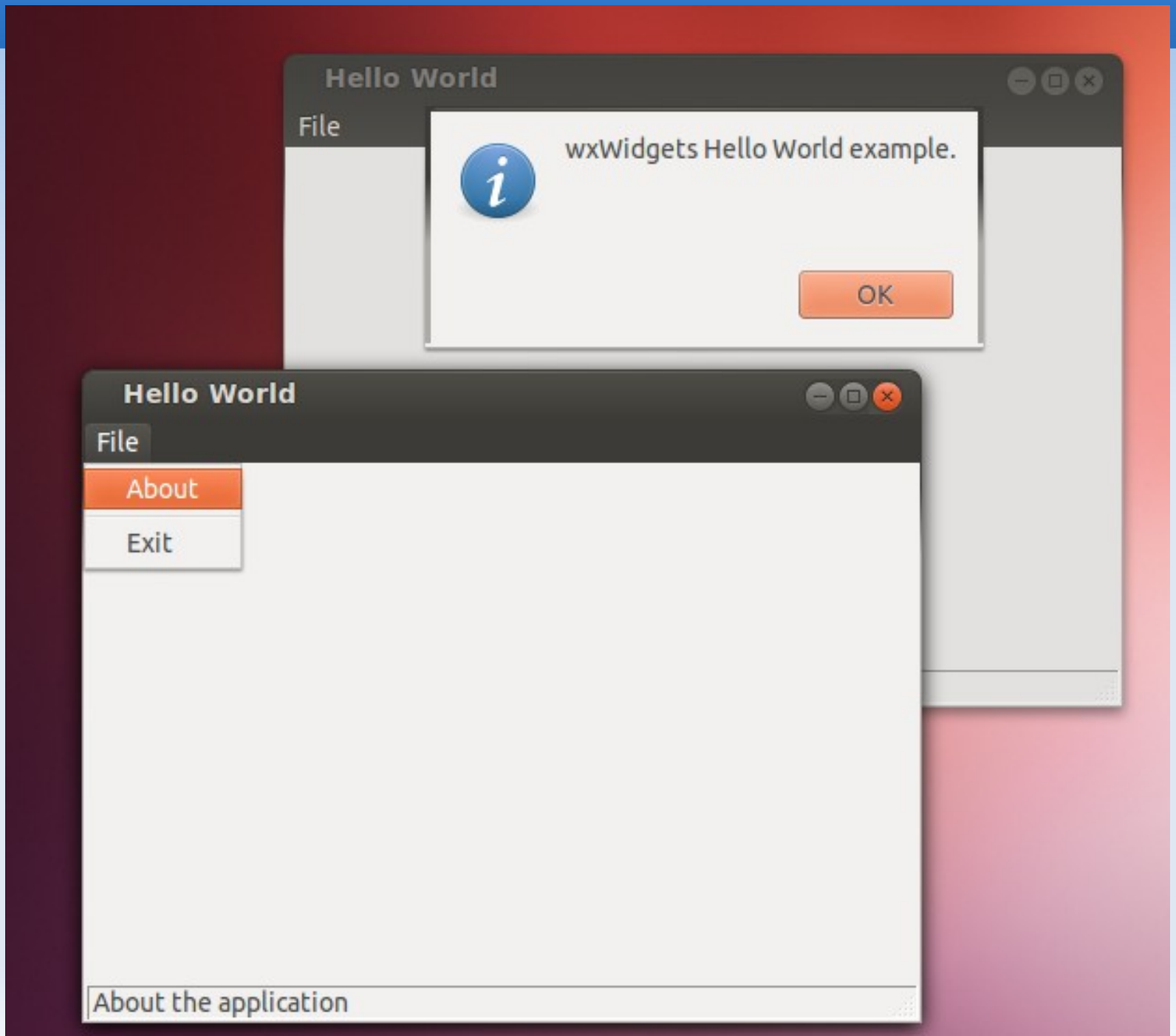
1st try: finishing WxCaml

- Going from OCaml to C++:
  - Use camlidl to generate stubs between C and OCaml from a ”wxc.idl” file
  - C++ ↔ C stubs manually written (”elj” library)
- Problems:
  - Mostly untyped:
    - C stub arguments are not correctly typed
    - All widget types are equivalent !
  - WxCaml forked ”wxc.idl” and ”elj” to solve these problems, but they come from wxHaskell... that forked them from wxEiffel... unmaintainable !

2nd try: Goals

- Easy to maintain/extend:
  - No dependency towards wxHaskell or wxEiffel
- Easily accessible by beginners:
  - No fancy types: no Classes/Objects, no Polymorphic Variants, no GADT, no labels/optional arguments (for now...)
  - Should be usable from the first OCaml lesson !
  - Error messages for those are too complex to read
  - OO makes code unreadable with meth overloading
- Build a more abstract layer afterwards !
  - But write a few applications first...

Hello World


Hello World
File
wxWidgets Hello World example.
OK
Hello World
File
About
Exit
About the application

Hello World

```
open WxClasses
open WxWidgets
open WxDefs
let _ =
  let onInit (app : wxApp) =
    let frame = WxFrame.createAll None wxID_ANY
        "Hello World"  (50, 50)  (450, 350) wxDEFAULT_FRAME_STYLE in
    WxFrame.setIcon frame (WxIcon.createFromXPM Sample_xpm.sample_xpm);

    let about_id = wxID() in
    MENU_BAR.(wxFrame frame [
        "&File", [
          Append(about_id, "&About");
          AppendSeparator();
          Append2(wxID_EXIT, "E&xit", "Exit from the application");
        ]]);
    ignore_wxStatusBar (WxFrame.createStatusBar frame);
    WxFrame.setStatusText frame  "Welcome to wxWidgets!" 0;

    WxEVENT_TABLE.(wxFrame frame frame [
        EVT_MENU(wxID_EXIT, (fun _ _ -> exit 0));
        EVT_MENU(about_id, (fun _ _ ->
            ignore_int (
              WxMisc.wxMessageBoxAll
                "wxWidgets Hello World example."
                "About Hello World"
                (wxOK lor wxICON_INFORMATION)
                (Some (WxFrame.wxWindow frame))
                wxDefaultCoord wxDefaultCoord
            ))));

    ignore_bool ( WxFrame.show frame );
    WxApp.setTopWindow (WxFrame.wxWindow frame)
  in
  wxMain onInit
```

A DSL to generate stubs

- Describes the C++ hierarchy of classes and their methods

```
class wxTimer inherit wxEvtHandler begin
    new Create (wxEvtHandler *owner, int id =-1 )
    wxEvtHandler *GetOwner () const
    void SetOwner (wxEvtHandler *owner, int id=-1)
    bool Start (int milliseconds=-1, bool oneShot=false)
    version 2.9 begin
       bool IsOneShot () const
       void Notify ()
    end
end
```

For Each C++ class

- Two OCaml types:
  - type wxTimer_class : the C++ object
  - type wxTimer = wxTimer_class wx : OCaml value
- A module ”WxTimer” with:
  - ALL its methods (including ancestors methods !)
    - ”o->meth(x,y,z)” becomes

      ”WxTimer.meth o x y z”
  - Safe coercions (identity) to all ancestors
  - An ”Unsafe” sub-module, with coercions to all descendants (with runtime test)

Generated OCaml Code

- For module WxTimer:

```
external create : wxEvtHandler -> int -> wxTimer =
                                                "wxTimer_Create_c"
[…]                                        (* methods of this class *)
external getOwner : wxTimer -> wxEvtHandler =
                                              "wxTimer_GetOwner_c"
external setOwner : wxTimer -> wxEvtHandler -> int -> unit =
                                              "wxTimer_SetOwner_c"
[…]                          (* Methods inherited from parents, if any *)
external processEvent : wxTimer -> wxEvent -> bool  =
                                     "wxEvtHandler_ProcessEvent_c"
[…]                                        (* Cast functions to parents *)
external wxEvtHandler : wxTimer -> wxEvtHandler =
                                                    "%identity"
external wxObject : wxTimer -> wxObject = "%identity"
```

Dealing with C++ Objects

- C++ Objects are embedded in OCaml values as pairs (Class_ID, pointer)

```
value wxTimer_GetOwner_c(value self_v)
{
  CAMLparam0();
  CAMLlocal1(ret_v);
  wxTimer* self_c = (wxTimer*)Abstract_val(WXCLASS_wxTimer,  self_v);
  wxEvtHandler * ret_c = self_c->GetOwner();
  ret_v = Val_abstract(WXCLASS_wxEvtHandler, (wxEvtHandler*)  ret_c );
  CAMLreturn(ret_v);
}
```

Dealing with C++ Objects

- C++ Objects are embedded in OCaml values as pairs (Class_ID, pointer)
- For every method, only the ancestor stub is generated, with a generic cast

```
value wxEvtHandler_ProcessEvent_c(value self_v, value event_v)
{
  CAMLparam0();
  CAMLlocal1(ret_v);
  wxEvtHandler* self_c =
          (wxEvtHandler*)Abstract_val(WXCLASS_wxEvtHandler,  self_v);
  wxEvent* event_c =
          (wxEvent*)Abstract_val(WXCLASS_wxEvent,  event_v);
  bool ret_c = self_c->ProcessEvent(*event_c);
  ret_v = Val_bool( ret_c);
  CAMLreturn(ret_v);
}
```

Dealing with C++ Objects

- A generic cast function is generated to perform C++ cast:

```
extern "C" {
void* wxOCaml_cast(int dest_id, int src_id, void* ptr)
{
  if( dest_id == src_id) return ptr;
  if( ptr == NULL) return ptr;
  switch(dest_id * 167 + src_id){
  case 16375 : return (wxObject*)(wxAcceleratorTable*)ptr;
  case 8569 : return (wxEvent*)(wxActivateEvent*)ptr;
  case 16311 : return (wxEvtHandler*)(wxTimer*)ptr;
  case 16418 : return (wxObject*)(wxActivateEvent*)ptr;
  […]
}
}
```

Dealing with Virtual Methods

- C++ classes can need method overriding:

```
class wxWizardPage inherit wxPanel begin
    wxBitmap GetBitmap() const
    wxWizardPage? GetPrev() const
    wxWizardPage? GetNext() const

    new Create (wxWizard? parent, const wxBitmap& bitmap)

    virtuals [
      (* These ones MUST be instantiated ! *)
            GetPrev, GetNext,
      (* These ones CAN be instantiated *)
             GetBitmap?,
             Validate? (* from wxWindow *)
          ]
end
```

Dealing with Virtual Methods

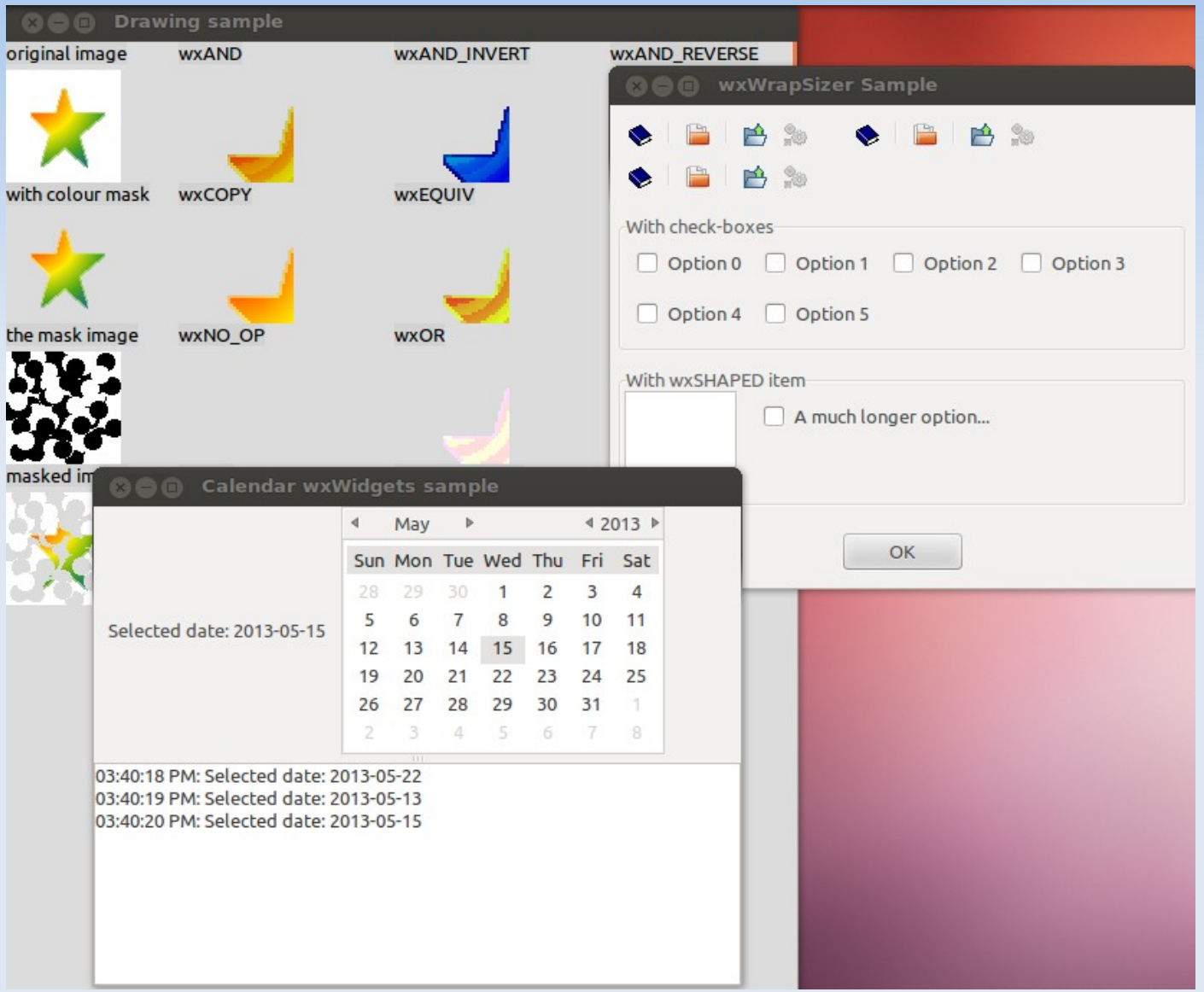
- OCaml constructors takes 2 extra arg:
  a record of methods and an initial state
- Virtual methods take the state and this

```
[...]
let methods = WxVirtuals.WxOCamlWizardPage.({
        getPrev = (fun state this ->
          Some (WxOCamlWizardPage.wxWizardPage this));
        getNext = (fun state this ->  None);
        getBitmap = Some (fun state this ->  wxNullBitmap);
        validate = None;
      }) in
    let m_page1 = WxOCamlWizardPage.create methods
          initial_state (Some wizard) wxNullBitmap in
[…]
```

Conclusion

- The ”DSL + stub generator” approach works well for C++ libraries
- QT better than WxWidgets ?
  - The same approach would probably work !
- Easy to extend WxOCaml:
  - Currently, 90+ classes, 1600 C++ methods
  - Write your WxOCaml application, and
  - Add the classes/methods you need in the DSL
- Web Site with GitHub link for sources: http://www.typerex.org/ocplib-wxOCaml/

Questions ?


Drawing sample
original image
wxAND
wxAND_INVERT
wxAND_REVERSE
with colour mask
wxCOPY
wxEQUIV
the mask image
wxNO_OP
wxOR
masked im
wxWrapSizer Sample
With check-boxes
Option 0
Option 1
Option 2
Option 3
Option 4
Option 5
With wxSHAPED item
A much longer option...
OK
Calendar wxWidgets sample
Selected date: 2013-05-15
May
2013
Sun Mon Tue Wed Thu Fri Sat
28 29 30 1 2 3 4
5 6 7 8 9 10 11
12 13 14 15 16 17 18
19 20 21 22 23 24 25
26 27 28 29 30 31 1
2 3 4 5 6 7 8
03:40:18 PM: Selected date: 2013-05-22
03:40:19 PM: Selected date: 2013-05-13
03:40:20 PM: Selected date: 2013-05-15