An Introduction to Fresco

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Xhibition 94

Tutorial Outline

- *Introduction (20%)*
- *Object system (20%)*
- *Resolution-independence (15%)*
- *Graphical embedding (40%)*
- *Interoperability with other toolkits (5%)*
- *Script interpreter (5%)*
- *Conclusions*

Introduction

- *What is Fresco?*
- *What new technology is in Fresco?*
- *What GUI(s) will Fresco provide?*
- *How does Fresco relate to Xlib? Xt? Motif? InterViews? ...?*
- *Will Fresco run on MS-Windows? MacOS?*
- *When will Fresco be publicly available?*

What is Fresco?

- User interface system
- Broad spectrum infrastructure
  - Graphics <–> Widgets <-> Embedded apps
- API covers Xlib, Xt functionality
  - + Structured graphics
  - + Application embedding
- X Consortium standards effort
- Specification, sample implementation

What is the new technology?

- Standard object model
  - Natural C++ usage
- Distributed objects
- MT-aware (supports concurrency)
- Resolution-independence
- Graphical embedding

Standard object model

OMG's CORBA

IDL for defining object interfaces

Choice of implementation languages

Object references instead of pointers

Address space/network transparency

Resolution independence

Floating-point coordinates

Stencil/paint drawing operations

Printing (generation of PostScript)

Device-independent graphics state

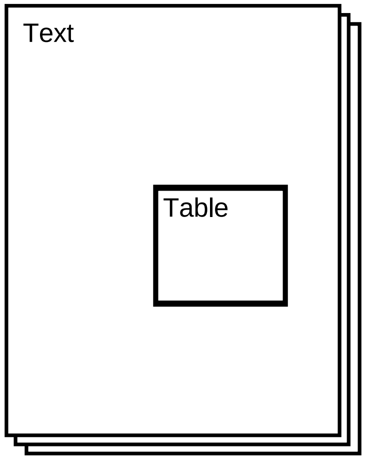
Graphical embedding

Natural blend of structured graphics and application embedding

Embedded objects may be
- Arbitrary shape (with holes)
- Graphically transformed
- Drawn in 3D

Advance over
- ATK, NextStep, OLE 2.0, OpenDoc

Embedding example



Why graphical embedding?

- *Allow natural, 3D appearance*
- *Composition in 2D or 3D scenes:*
  - *Editing rotated text in drawing*
  - *Touching up image in virtual gallery*
  - *Setting 3D clock in virtual room*
  - *City buildings in fly-through browser*
- *Simpler, broader architecture*

How does it work?

- *From structured graphics:*
  - *Damage-based update traversal*
  - *Shared state during traversal*
- *From application embedding:*
  - *Input handling, focus, translations*
  - *Menubar and/or palette sharing*
- *From both:*
  - *Attribute propagation*
  - *Transcription*

Distributed embedding

Fresco viewers can be remote objects
“inside” a window

Applications become objects

User composes objects

Objects may be implemented
in different address spaces or
on different machines

What GUI(s) will Fresco provide?

Architecture can support multiple GUIs

Spec currently does not include a GUI
Might specify Motif and/or Cairo

Sample implementation includes
some Motif-ish widgets

How does Fresco relate to

Xlib

- *Replaces all but low-level functionality*
- *Adds resolution-independence*
- *Sample implementation uses Xlib*

Xt

- *Replaces most if not all functionality*
- *Adds structured graphics, embedding*
- *Provides gateways for interoperability*
  - *Fresco in XtViewer*
  - *XtWidget in Fresco*

How does Fresco relate to

Motif

- *Allows re-implementation of widgets for graphical embedding*
- *Interoperability at Xt level*

InterViews

- *Replaces object model*
- *Evolves glyphs, structured graphics*
- *Adds embedding*

Will Fresco run on

- *Any X platform – Yes*
- *MS-Windows 3.1 – Probably not*
- *MS-Windows Chicago – Maybe*
- *MS-Windows NT – Probably*
- *MacOS – Maybe*
- *DOS - No way*

When will Fresco be available?

- *Fresco 0.7 is in X11R6 core*
  - *General R6 release in late April*
  - *Not adopted as a standard yet*
- *Fresco releases are independent*
  - *Don't have to wait for R7 for update*
- *Fresco 0.8 probably will be available in summer*
- *Fresco 1.0 will be standard*

Status

- *Spec defines about 40 interfaces*
- *Implementation has about 150 classes*
- *Library is about 25,000 lines of C++*
  - *Separate redisplay thread*
- *Applications*
  - *Fdraw – drawing editor demo*
  - *Dish – Fresco scripts in Tcl*
  - *IDL-to-C++ translator (Ix)*

Fresco Summary

- *Advanced technology*
  - *Graphical embedding*
  - *Distributed objects*
- *Open standards effort (honest!)*
- *Spec and implementation on R6*

Object system

Defining object interfaces

Transparent object references

Ix – Interface translator

IDL: Interface Definition Language

Defined by CORBA

More abstract than C++
(no implementation details)

Can be bound to C, C++, ...

Supports distribution
(can’t use inherently local constructs)

IDL example

```
interface Window {
   void map();
   void unmap();
   boolean is_mapped();

   void raise();
   void lower();
};
```


C++ binding

Typedefs, structs, enums, constants

Interfaces –> abstract classes

Operations –> virtual functions

Attributes –> set/get function pairs

Exceptions –> exceptions or extra param

C++ example

```
class Window : public BaseObject {
protected:
   Window();
   virtual ~Window();
public:
   virtual void map();
   virtual void unmap();
   virtual Boolean is_mapped();

   virtual void raise();
   virtual void lower();
};
```


Parameter passing

IDL defines **in***,* **out***,* **inout**

- *in – pass value*
- *out – return value*
- *inout – pass and return value*

For C++

- *in – copy or const ref*
- *out – ref or ref to pointer*
- *inout – ref*
- *return - value or pointer*

Object references

Like pointers, but (potentially)
across address spaces

Interface type is always reference

ORB tracks object location

All operations are virtual function calls
vtbl points to implementation or stubs

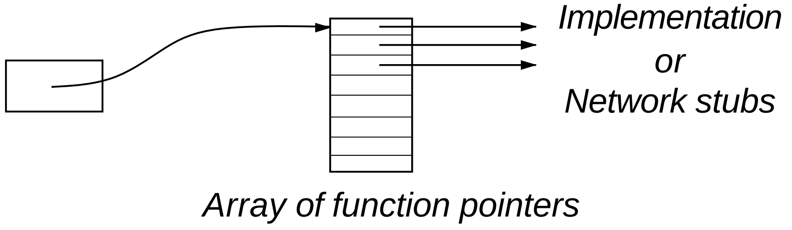
Transparency

Local or remote machine

Direct memory access or
inter-process communication

	Local	Remote
Memory	Function call	Page over network
IPC	Context switch	Network message

Transparent object references



Memory management

“Abstract” reference counting

TRef T::_duplicate(TRef)
returns new or incremented reference

Fresco::ref increments reference

Fresco::unref releases old reference

T_var is “smart” pointer that
automatically releases old reference

Memory management (cont'd)

- *Parameters are normally "shared"*
  - *Callee must duplicate if storing*
- *Results are normally "produced"*
  - *Caller must release if not storing*
- *Probably will vary with operation in future*
  - *Some ops may implicitly "consume" parameters*

Memory management examples

```
// interface T
T_var t = f(); // f returns a TRef
g(t); // implicitly converted to TRef
// t's destructor will release

void g(TRef t) {
  member_ = T::_duplicate(t);
}
```

Ix: Sample interface translator

- *Generates*
  - *C++ or C header declarations*
  - *Client, server stubs*
  - *Dynamic type information*
- *Filters implementations*
- *IDL - (contexts, any)*
- *Usage encapsulated in Imake macros*
  - *MakeHeader, EditImplHeader, EditImpl*

Generating a header file

- *Runs cpp to process #include’s*
- *Use -i option to generate #include’s*
- *Write out file.h, mark read-only*

```
MakeHeaderFlags(display,-i '<Fresco/drawing.h>')
```

Example: Interfaces/screen.idl

```
interface Screen {
  attribute Coord dpi;

  Display screen_display();

  Coord width();
  Coord height();

  PixelCoord to_pixels(in Coord c);
  Coord to_coord(in PixelCoord c);
  Coord to_pixels_coord(in Coord c);

  void move_pointer(in Coord x, in Coord y);
  Window application(in Viewer v);
  Window top_level(in Viewer v, in Window group);
  Window transient(in Viewer v, in Window trans);
  Window popup(in Viewer v);
  Window icon(in Viewer v);
};
```


Generated screen.h

```
/* DO NOT EDIT – Automatically generated ... */

#ifndef Interfaces_screen_h
#define Interfaces_screen_h

#include <X11/Fresco/_enter.h>
#include <X11/Fresco/drawing.h>

class Screen : public FrescoObject {
protected:
  ScreenObj();
  virtual ~ScreenObj();
public:
  virtual void* _this();
  virtual TypeObjId _tid();
```

class Screen (cont’d)

```
static ScreenRef _narrow(BaseObjectRef);
static ScreenRef _duplicate(ScreenRef obj) {
  extern BaseObjectRef _XfScreenStub_create(
    Exchange*
  );
  return (ScreenRef)_BaseObject__duplicate(
    obj, &_XfScreenStub_create
  );
}

virtual void dpi(Coord);
virtual Coord dpi();
virtual Display_return display();
virtual Coord width();
virtual Coord height();
```


class Screen(cont’d)

```
  virtual PixelCoord to_pixels(Coord c);
  virtual Coord to_coord(PixelCoord p);
  virtual Coord to_pixels_coord(Coord c);
  virtual void move_pointer(Coord x, Coord y);
  virtual Window_return application(Viewer_in v);
  virtual Window_return top_level(
    Viewer_in v, Window_in group
  );
  virtual Window_return transient(
    Viewer_in v, Window_in trans
  );
  virtual Window_return popup(Viewer_in v);
  virtual Window_return icon(Viewer_in v);
  virtual TypeObjId _tid();

  static Screen_return _narrow(BaseObject_in);
  static Screen_return _duplicate(Screen_in);
};
```

Defining an implementation

Subclass from generated class or from another implementation class

Edit subclass source with ix -filter

EditImplHeader(Xdisplay,$(I)/display.idl)

EditImpl(Xdisplay,$(I)/display.idl $(I)/viewer.idl)

Use annotations to specify filtering

```
//+ Interface::Operation
//+ Interface::Attribute[=?]
//+ Subclass(Interface::Operation)
//+ Subclass(Interface::Attribute[=?])
//+ Interface::%init,type,type+dii,stubs, type-stubs
//+
//+ Interface::%client,server
//+
//+ Subclass : Interface
//+
```

Screen example

```
//+ ScreenImpl : Screen
class ScreenImpl : public Screen {
public:
  ~ScreenImpl();
  TypeObjId _tid();
  static ScreenImpl* _narrow(BaseObjectRef);
//+
  ScreenImpl(Fresco*, DisplayImpl*, long n);

  //+ Screen::*
  /* FrescoObject */
  Long ref__(Long references);
    ...
  /* Screen */
  void dpi(Coord);
  Coord dpi();
  Display_return display();
    ...
  //+
```


ScreenObj example (cont'd)

```
protected:
  SharedFrescoObjectImpl object_;
  Fresco* fresco_;
  DisplayImpl* display_;
  Long number_;
  XWindow root_;
  ScreenVisualList* visuals_;
  ScreenImpl::VisualInfo* default_visual_;
    ...
};
```

Xdisplay.cxx

```
#include <X11/Fresco/display.h>
#include <X11/Fresco/drawing.h>
  ...
//+ ScreenImpl(Screen::dpi=c)
void ScreenImpl::dpi(Coord c) {
  if (!Math::equal(c, float(0), float(1e-4))) {
    pixels_ = 72.0 / c;
    points_ = 1 / pixels_;
}

//+ ScreenImpl(Screen::dpi?)
Coord ScreenImpl::dpi() {
  return 72.0 / pixels_;
}

//+ ScreenImpl(Screen::application)
Window_return ScreenImpl::application(Viewer_in v) {
  return new ApplicationWindow(display_, this, v);
}
```


Stubs

```
//+ Screen::%init,type+dii,client
Screen::Screen() { }
Screen::~Screen() { }
void* Screen::_this() { return this; }

TypeObj_OpData _XfScreen_methods_[] = {
  { “_set_dpi”, &_Xfvoid_type_, 1 },
  { “_get_dpi”, &_XfCoord_type_, 0 },
  ...
};
TypeObj_Descriptor _XfScreen_type_ = {
  /* type */ 0, &_XfScreen_tid_, “Screen”,
  _XfScreen_parents, /* offsets */ nil,
  /* excepts */ nil,
  _XfScreen_methods, _XfScreen_params_,
  &_XfScreen_receive
};
```

Stubs (cont'd)

```
MarshalBuffer::ArgDesc
  _XfScreen_move_pointer_pdesc[4] = {
    3, 4, 49, 49
};
MarshalBuffer::ArgInfo
  _XfScreen_move_pointer_pinfo = {
    &_XfScreen_tid_, 8,
    _XfScreen_move_pointer_pdesc, 0
};

void ScreenObj::move_pointer(Coord x, Coord y) {
  MarshalBuffer _b;
  extern TypeObjId _XfScreen_tid_;
  MarshalBuffer::ArgValue _arg[3];
  _arg[1].u_float = x;
  _arg[2].u_float = y;
  _b.invoke(this, _XfScreen_move_pointer_pinfo, _arg);
}
```


Creating objects

- *Constructors are global functions*
  - *Specify implementation class*
  - *Imply address space*
  - *Inappropriate for interfaces*
- *Can use operation on another object*
- *Kits create certain kinds of objects*
  - *Widgets, figures, layout*
- *Fresco accesses other kits*
- *Global function to access Fresco*

Example: Hello, world

```
#include <X11/Fresco/drawing.h>
#include <X11/Fresco/figures.h>
#include <X11/Fresco/fresco.h>

int main(int argc, char** argv) {
   Fresco* f = Fresco_open("test", argc, argv);
   FigureKit_var figures = f->figure_kit();
   FigureStyle_var fs = figures->default_style();
   f->main(
      nil, _tmp(figures->label(
         fs, Fresco::tmp_string_ref("Hello, world")
      ))
   );
   Fresco::unref(f);
   return 0;
}
```


Object system summary

IDL for interfaces

- *No data members, inlines*
- *No overloading, templates, const member functions*

C++ for implementations

- *Parameters are abstract*

Create objects with kits

Cleaner, more extensible design

Allow distibution, multiple languages

Resolution independence

Coordinates and vertices

Regions

Display management

Drawing and printing

Coordinates

```
enum Axis { X_axis, Y_axis, Z_axis };
typedef float Coord;
typedef long PixelCoord;
struct Vertex { Coord x, y, z; };
typedef float Alignment;
```

Transformations

Objects assume real-world units
(inch, mm, pt, ...)

Units may be scaled by parent

Relative coordinates – object-defined

Absolute coordinates – fully-transformed

Regions

Describe an arbitrary shape with origin

May be only bounding box

May be full solid geometry

Region interface

```
interface Region {
  struct BoundingSpan {
    Coord begin, end;
    Coord origin, length;
    Alignment align;
  };

  boolean contains(in Vertex v);
  boolean contains_plane(in Vertex v, in Axis a);
  boolean intersects(in Region r);
  void copy(in Region r);
  void merge_intersect(in Region r);
  void merge_union(in Region r);
  void subtract(in Region r);
  void apply_transform(in Transform t);
  void bounds(out Vertex lower, out Vertex upper);
  void origin(out Vertex v);
  void span(in Axis a, out Region::BoundingSpan s);
};
```


Display management

Display – keyboard/mouse/screens

Screen – output area

Window – opaque portion of screen

Drawing and Printing

Brush – line width and pattern

Color – maps to device RGB

Font – character shapes

Pattern – stippling

Raster – bitmaps and images

Painter – 2d stencil/paint operations

DrawingKit – create paint objects

Drawing Kit interface

```
interface DrawingKit : FrescoObject {
  typedef sequence<octet> Data8;
  typedef sequence<long> Data32;

  Style drawing_style();

  Brush simple_brush(in Coord width);
  Brush dither_brush(in Coord width, in long pattern);
  Brush patterned_brush(
    in Coord width, in DrawingKit::Data pattern
  );

  Pattern solid_pattern();
  Pattern halftone_pattern();
  Pattern stipple(in Data32 d);
  Pattern stipple_4x4(in unsigned long p);
```

Drawing Kit interface (cont'd)

```
Color color_rgb(
  in Color::Intensity r, in Color::Intensity g,
  in Color::Intensity b
);
Color find_color(in CharString name);
Color resolve_color(in Style s, in CharString name);
Color background(in Style s);

Font find_font(in CharString fullname);
Font find_font_match(
  in CharString family, in CharString style,
  in Coord ptsize
);
Font resolve_font(in Style s, in CharString name);
Font default_font(in Style s);
```


DrawingKit interface (cont'd)

```
  Raster bitmap_from_data(
    in Data8 d,
    in Raster::Index rows, in Raster::Index columns,
    in Raster::Index origin_row,
    in Raster::Index origin_column
  );
  Raster bitmap_from_char(in Font f, in CharCode c);
  Raster raster_open(in CharString name);

  Transform identity_matrix();
  Transform transform_matrix(in Transform::Matrix m);

  Painter printer(in CharString output);
};
```

Painter interface

```
interface Painter : FrescoObject {
  Coord to_coord(in PixelCoord p);
  PixelCoord to_pixels(in Coord c);
  Coord to_pixels_coord(in Coord c);

  void begin_path();
  void move_to(in Coord x, in Coord y);
  void line_to(in Coord x, in Coord y);
  void curve_to(
    in Coord x, in Coord y, in Coord x1, in Coord y1,
    in Coord x2, in Coord y2
  );
  void close_path();

  attribute Brush current_brush;
  attribute Color current_color;
  attribute Font current_font;
  attribute Pattern current_pattern;
```


Painter interface (cont'd)

```
  void fill();
  void stroke();
  void clip();

  void line(
    in Coord x0, in Coord y0, in Coord x1, in Coord y1
  );
  void rect(
    in Coord x0, in Coord y0, in Coord x1, in Coord y1
  );
  void fill_rect(
    in Coord x0, in Coord y0, in Coord x1, in Coord y1
  );
  void clip_rect(
    in Coord x0, in Coord y0, in Coord x1, in Coord y1
  );
```

Painter interface (cont'd)

```
  void character(
    in CharCode ch, in Coord width,
    in Coord x, in Coord y
  );
  void image(in Raster r, in Coord x, in Coord y);
  void stencil(in Raster r, in Coord x, in Coord y);

  attribute Transform current_matrix;
  void push_matrix();
  void pop_matrix();
  void premultiply(in Transform t);
  void push_clipping();
  void pop_clipping();
  boolean is_visible(in Region r);
  Region visible();

  void comment(in StringObj s);
  void page_number(in StringObj s);
};
```


Example: Bevelled rectangle

```
void Beveler::fill_path(
  Painter_in p, Vertex* v, long n
) {
  p->begin_path();
  p->move_to(v[0].x, v[0].y);
  for (long i = 1; i < n; i++) {
    p->line_to(v[i].x, v[i].y);
  }
  p->close_path();
  p->fill();
}
```

Example (cont'd)

```
// Bevelled rectangle
Coord left_inside = left + thickness;
Vertex v[10];
/* left edge */
set_color(p, light);
v[0].x = left; v[0].y = bottom;
v[1].x = left; v[1].y = top;
v[2].x = left_inside; v[2].y = top;
v[3].x = left_inside; v[3].y = bottom;
fill_path(p, v, 4);
```


Summary

Coordinate units

Regions, vertices

Display, Screen, Window

Drawing and printing

Brush	*Pattern*
Color	*Raster*
Cursor	*Region*
Display	*Screen*
DrawingKit	*Transform*
Font	*Window*
Painter	

Graphical embedding

- Natural blend of
  - structured graphics and
  - application embedding
- Embed a UI application object in
  - a graphical scene
- Scene may involve
  - Arbitrary shapes (including holes)
  - Graphical rotatation or zooming
  - 3D

Structured graphics

- Graphical objects
  - Shapes, properties, transforms
  - Overlays, transparency
  - Double-buffering
  - Sharing instances
- Draw, pick, bounding box
- Grouping into composites
- Attribute propagation
- Transcription – save to file

Application Embedding

- *Graphical output*
- *Geometry management*
- *Input handling*
- *Attribute propagation*
- *Focus management*
- *Menubar, palette sharing*
- *Transcription – save to a file*

Common framework

- **Viewer** – *user interface to data*
  - *Subtype of structured graphics object*
  - *Input handling, focus management*
  - *Menubar, palette sharing*
- **Glyph** – *graphical output*
  - *Geometry management*
  - *Screen update with instancing*
- **Style** – *attribute propagation*

Advantages of common framework

Simplicity – fewer overall concepts

Scalability – span range of granularity

Interoperability – mix and match

Flexibility – 3d friendly

Power – editing rotated text in drawing

Viewers - UI to data

Present and possibly edit

Like ATK views, OLE edit-in-place,
Xt widgets (with extensions)

Wide range of sizes and functionality
Button, Hypertext link, Field editor
Movie order form, Table editor
Image viewer, Drawing editor, Builder
Word processor
Interactive encyclopedia

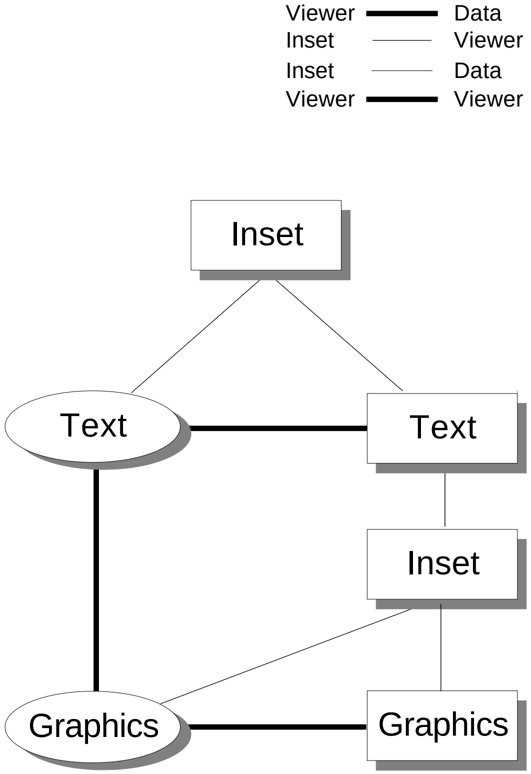
Viewer hierarchy

Viewer children correspond to embedded data

Embedded “inset” contains data and default viewer information

“Main” viewer at root implements focus, sharing menubars, palettes

Inset example



Viewer interface

```
interface Viewer : Glyph {
  Viewer parent_viewer();
  Viewer next_viewer();
  Viewer prev_viewer();
  Viewer first_viewer();
  Viewer last_viewer();

  void append_viewer(in Viewer v);
  void prepend_viewer(in Viewer v);
  void insert_viewer(in Viewer v);
  void replace_viewer(in Viewer v);
  void remove_viewer();
  void set_viewer_links(
    in Viewer parent, in Viewer prev, in Viewer next
  );
  void set_first_viewer(in Viewer v);
  void set_last_viewer(in Viewer v);
```


Viewer interface (cont'd)

```
  Focus request_focus(
    in Viewer v, in boolean temporary
  );
  boolean receive_focus(
    in Focus f, in boolean primary
  );
  void lose_focus(in boolean temporary);
  boolean first_focus();
  boolean last_focus();
  boolean next_focus();
  boolean prev_focus();

  boolean handle(in GlyphTraversal t, in Event e);
  void close();
};
```

Focus interface

```
interface Focus : FrescoObject {
  void add_focus_interest(in Viewer v);
  void receive_focus_below(
    in Viewer v, in boolean temporary
  );
  void lose_focus_below(
    in Viewer v, in boolean temporary
  );
  void map_keystroke(
    in Event::KeySym k, in Action a
  );
  void map_keychord(
    in Event::KeyChord k, in Action a
  );
};
```


Implementation classes

#include <Fresco/Impls/viewers.h>

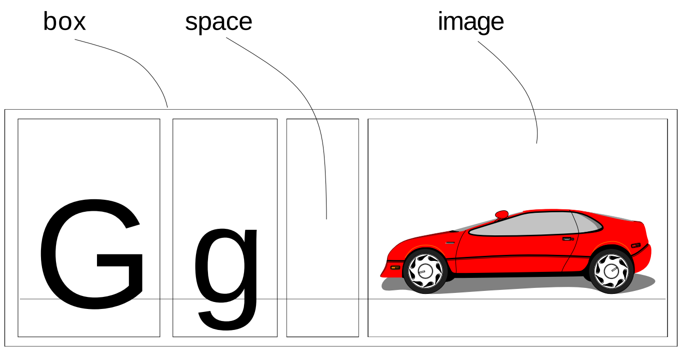
ViewerImpl
- *implements hierarchy, input operations*
  - *move, press, drag, release,*
  - *double_click, other*

ActiveViewer
- *enter, leave*

MainViewer
- *implements focus, damage*

Glyphs - objects that draw

Think of a glyph as a character



Glyph composition

Directed acyclic graph (dag)

Glyphs are nodes

GlyphOffsets are edges

Offset implementations knows about parent implementation

GlyphTraversal

- *Shared state during a traversal*
- *Path (“trail”) from root to current node*

Glyph interface

```
interface Glyph : FrescoObject {
    struct Requirement {
        boolean defined;
        Coord natural, maximum, minimum;
        Alignment align;
    };
    struct Requisition {
        Requirement x, y, z;
        boolean preserve_aspect;
    };
    struct AllocationInfo {
        Region allocation;
        Transform transformation;
        Damage damaged;
    };
    typedef sequence<AllocationInfo> AllocationInfoSeq;
    typedef sequence<GlyphOffset> OffsetSeq;
```


Glyph interface (cont'd)

```
Glyph clone_glyph();
attribute Style glyph_style;
Transform transformation();

void request(out Glyph::Requisition r);
void extension(
    in Glyph::AllocationInfo a, in Region r
);
void shape(in Region r);

void traverse(in GlyphTraversal t);
void draw(in GlyphTraversal t);
void pick(in GlyphTraversal t);

attribute Glyph body;
```

Glyph interface (cont'd.)

```
    void append(in Glyph g);
    void prepend(in Glyph g);

    Tag add_parent(in GlyphOffset parent_offset);
    void remove_parent(in Tag add_tag);
    GlyphOffset first_child_offset();
    GlyphOffset last_child_offset();
    void parent_offsets(inout OffsetSeq parents);

    // screen update
    void allocations(out Glyph::AllocationInfoList a);
    void need_redraw();
    void need_redraw_region(in Region r);
    void need_resize();
};
```


Geometry management

Requisition - what a glyph wants
- *Requirement per axis*
- *Returned by Glyph::request*

Allocation - region a glyph gets
- *BoundingSpan per axis*
- *Passed as part of GlyphTraversal*

Extension - bounds of glyph output
- *Computed by Glyph::extension*
- *Useful for update, culling*

Offsets

```
interface GlyphOffset : FrescoObject {
  Glyph parent();
  Glyph child();
  GlyphOffset next_child();
  GlyphOffset prev_child();
  void allocations(out Glyph::AllocationInfoSeq a);
  void insert(in Glyph g);
  void replace(in Glyph g);
  void remove();
  void notify();
  void visit_trail(in GlyphTraversal t);
};
```


Traversals

```
enum Operation {
  draw, pick_top, pick_any, pick_all, other
};

Operation op();
Operation swap_op(in Operation op);

void begin_viewer(in Viewer v);
void end_viewer();

void traverse_child(
  in GlyphOffset o, in Region allocation
);
void visit();

GlyphTraversal trail();
Viewer current_viewer();
Glyph current_glyph();
GlyphOffset current_offset();
boolean forward();
boolean backward();
```

Traversals (cont'd)

```
  attribute Painter current_painter;
  Display current_display();
  Screen current_screen();
  Transform current_transform();

  Region allocation();
  boolean bounds(
    out Vertex lower, out Vertex upper, out Vertex origin
  );
  boolean allocation_is_visible();

  Damage damaged();

  void hit();
  attribute long hit_info;
  GlyphTraversal picked();
  void clear();
};
```


Glyphs are lightweight

Simple set of operations

No required base class storage

Pass context during traversal

Can be shared
- *Of course, they may be heavyweight*

Screen update

need_redraw

Damage all allocations for glyph

need_resize

Damage old/new allocations for glyph

Root object is drawn to repair damage

Output is clipped to damage

Objects may check if they are visible

If not then avoid drawing children

Advantages

Objects can share area

e.g., a label on top of an image

Output may be double-buffered

Supports smooth interaction, animation

Sample implementation uses pixmaps

Objects control granularity of update

Cheap objects just draw

Attribute management

Separate for independent use

Loosely-coupled to structured graphics

Tightly-coupled to embedding

FrescoObject – observability, notification

Action – callbacks

StyleObj – inherited name-value pairs

StyleValue – associated value

Style interface

```
interface Style : FrescoObject {
    attribute CharString name;
    void alias(in CharString s);

    Style new_style();
    Style parent_style();
    void link_parent(in Style parent);
    void unlink_parent();
    Tag link_child(in StyleObj child);
    void unlink_child(in Tag link_tag);
    void merge(in Style s);
```

StyleObj interface (cont'd)

```
    boolean is_on(in CharString name);
    StyleValue bind(in CharString name);
    StyleValue resolve(in CharString name);
    void unbind(in CharString name);

    void visit_aliases(in StyleVisitor v);
    void visit_attributes(in StyleVisitor v);
    void visit_children(in StyleVisitor v);

    void lock();
    void unlock();
};
```


StyleValue interface

```
interface StyleValue : FrescoObject {
    CharString name();
    boolean uninitialized();
    attribute long priority;

    boolean is_on();
    boolean read_boolean(out boolean b);
    void write_boolean(in boolean b);

    boolean read_string(out CharString s);
    void write_string(in CharString s);

    boolean read_coord(out Coord c);
    void write_coord(in Coord c);

    boolean read_value(out FrescoObject v);
    void write_value(in FrescoObject v);

    void lock();
    void unlock();
};
```

FrescoObject

```
// reference counting

// observability
Tag attach(in FrescoObject observer);
void detach(in Tag attach_tag);
void disconnect();

// notication
void notify_observers();
void update();
```


Callbacks

```
interface Action {
   void execute();
   boolean reversible();
   void unexecute();
};
```

Example

```
#include <X11/Fresco/figures.h>
#include <X11/Fresco/fresco.h>
#include <X11/Fresco/layouts.h>
#include <X11/Fresco/widgets.h>
#include <X11/Fresco/Impls/action.h>
#include <stdio.h>

class App {
public:
  App() { }
  ~App() { }

  int main(int argc, char** argv);
private:
  void push_me();
};

declareActionCallback(App)
implementActionCallback(App)

void App::push_me() { printf(“pushed\n”); }
```


Example (cont’d)

```
int main(int argc, char** argv) {
  App a;
  return a.main(argc, argv);
}

int App::main(int argc, char** argv) {
  Fresco* f = Fresco_open(“Test”, argc, argv);
  FigureKit_var figures = f->figure_kit();
  WidgetKit _varwidgets = f->widget_kit();
  LayoutKit_var layouts = f->layout_kit();
  Button_var b = widgets->push_button(
    _tmp(figures->label(
      _tmp(figures->default_style()),
      Fresco::string_ref(“Push me”)
    )),
    new ActionCallback(App)(this, &App::push_me)
  );
  f->main(b, _tmp(layouts->margin(b, 10.0)));
  return 0;
}
```

Graphical embedding summary

Unify structured graphics and embedding

Glyphs

- Graphics, layout, lightweight,
- Shared, damage-based update

Viewers

- User interface to data
- Input handling and focus management
- Menubar, palette sharing

Distributed embedding “for free”

Interfaces

- Action
- Adjustment
- Damage
- Event
- Focus
- Glyph
- GlyphOffset
- GlyphTraversal
- Style
- StyleValue
- StyleVisitor
- Viewer

Interoperability with other toolkits

- *Structured graphics may be used inside another toolkit*
- *Viewers may be implemented with X subwindows, use Xlib drawing*
- *Partial functionality – embedding without full graphics support*
- *Gateway objects to/from Xt*

XtfviewerWidgetClass example

```
#include <X11/Fresco/Impls/XtIntrinsic.h>
#include <X11/Fresco/Impls/Xdefs.h>
#include <X11/StringDefs.h>
  ...
#include <X11/Fresco/Impls/Xundefs.h>
#include <X11/Fresco/figures.h>
#include <X11/Fresco/layouts.h>
#include <X11/Fresco/Impls/XtfFresco.h>
#include <X11/Fresco/Impls/XtfViewer.h>

static void exit_callback(Widget, XtPointer, XtPointer) {
  exit(0);
}

int main(int argc, char** argv) {
  XtToolkitInitialize();
  XtAppContext app = XtCreateApplicationContext();
  XDisplay* xdisplay = XtOpenDisplay(
    app, NULL, "xtcircle", "XtCircle", NULL, 0,
    &argc, argv
  );
```

Xtf example (cont'd)

```
Arg arglist[2];
XtSetArg(arglist[0], XtNallowShellResize, FALSE);
Widget toplevel = XtAppCreateShell(
  "XtTest", NULL, applicationShellWidgetClass,
  xdisplay, arglist, 1
);

Widget paned = XtCreateManagedWidget(
  "paned", panedWidgetClass, toplevel, NULL, 0
);
Widget buttons = XtCreateManagedWidget(
  "buttons", panedWidgetClass, paned, NULL, 0
);
Widget quit_button = XtCreateManagedWidget(
  "quit", commandWidgetClass, buttons, NULL, 0
);

XtfFresco* f = XtfFresco_init(
  app, xdisplay, "XtTest", argc, argv
);
```


Xtf example (cont'd)

```
  FigureKit_var figures = f->figure_kit();
  Glyph_var g = figures->figure_root(
    figures->circle(
      FigureKit::fill, figures->default_style(),
      0.0, 0.0, 100.0
    )
  );

  Widget fw = XtCreateManagedWidget(
    "circle", XtfviewerWidgetClass, paned, nil, 0
  );
  f->init_widget_glyph(fw, g);

  XtRealizeWidget(toplevel);
  XtMapWidget(fw);
  XtAppMainLoop(app);
  Fresco::unref(f);
  return 0;
}
```

Script interpretation

- *CORBA Dynamic invocation*
- *Tcl scripting language*
- *Dish interpreter*

CORBA Dynamic invocation

- *Create request object*
- *Fill in operation name (as a string)*
- *Fill in parameters*
- *Call invoke on request*
- *Examine result*

Tcl scripting language

Shell-like: cmd args ...

Everything is a string

Variables (set, $var)

Procedures, if, for, while

Nested function calls

Commands may be compiled functions

Dish: Dynamic invocation shell

Standard Tcl interpreter

Interactive or batch script

Fresco class operations builtin

Unknown cmd uses dynamic invocation to convert parameters, invoke method, and convert back results (including out parameters)

Tcl command registry is automatic

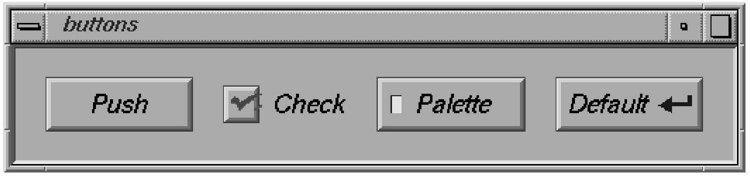
Example: Hello, world

```
main 0 [
  figure_kit label [figure_kit default_style] “Hello, world”
]
```


Another example: circle

```
set style [figure_kit default_style]
main 0 [
  figure_kit figure_root [
    figure_kit circle 0 style 0 0 100
  ]
]
```

Button example




```
proc print {message} {
  puts $message
  flush stdout
}
proc label {s} {
  global figure_kit
  figure_kit label [figure_kit default_style] s
}
```

Button example (cont’d)

```
set buttons [widget_kit viewer_group [layout_kit hbox]]

proc add_button {b} {
  global buttons
  global layout_kit
  buttons append_viewer $b
  buttons append [layout_kit vcenter $b]
}

proc add_sep {} {
  global buttons
  global layout_kit
  buttons append [layout_kit hglue_fil 15]
}
```


Buttons example (cont’d)

```
add_button [
  widget_kit push_button [label “Push”] [
    action print “pushed”
  ]
]
add_sep
add_button [
  widget_kit check_box [label “Check”] [
    action print “toggled”
  ]
]
add_sep
add_button [
  widget_kit default_button [label “Default”] [
    action print “toggled”
  ]
]
main buttons [
  widget_kit inset_frame [layout_kit margin buttons 15]
]
```

Conclusions

- Fresco is a new user interface system
- Broad spectrum of functionality
- Technology advances:
  - Graphical embedding
  - CORBA-based
  - Scripting access is automatic
  - Multithreading
- Working toward X Consortium standard
  - Sample implementation on R6

What to do now?

- Get R6
- Join X Consortium

Future work

- *Finish up structured graphics (patterns)*
- *Input focus, embedding*
- *Text*
- *NT port*
- *Distributed embedding demo*
- *Time elasticity (Pacers)*
  - *...*