Cairo Graphics Kit (a/k/a CGK)
Getting Modern Graphics with Familiar Tools

Chris Thorgrimsson

STIC 2012 03/19/2012

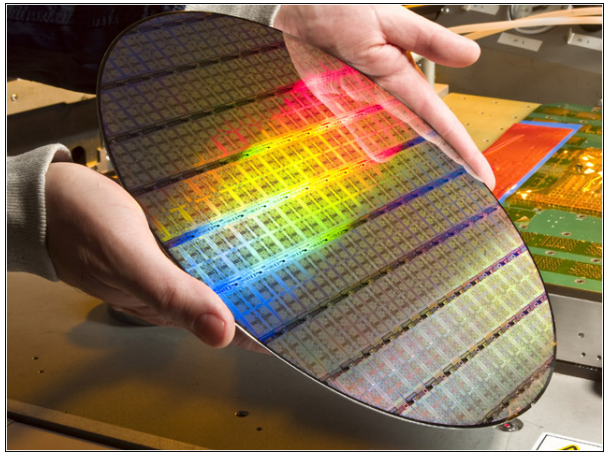
Lam RESEARCH

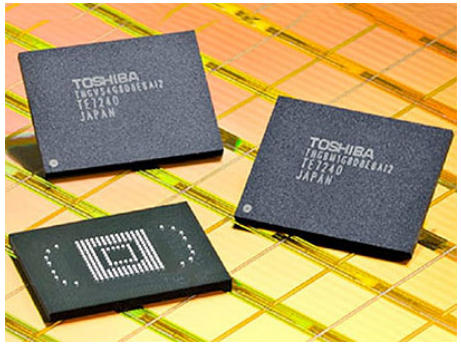
Background

- Who am I ?

Chris Thorgrimsson
Senior Staff Software Engineer
Lam Research Corporation
chris.thorgrimsson@lamrc.com

- What does Lam Research do?
  - Major supplier of wafer fabrication equipment and services to the worldwide semiconductor industry
    - IC components inside cell phones, computers, tablets…etc are manufactured using our equipment
    - VisualWorks Smalltalk is at the heart of our equipment control system
    - ~100 developers , ~20 of them are VW Smalltalk developers (39 tool types)
    - ~2500 employees worldwide



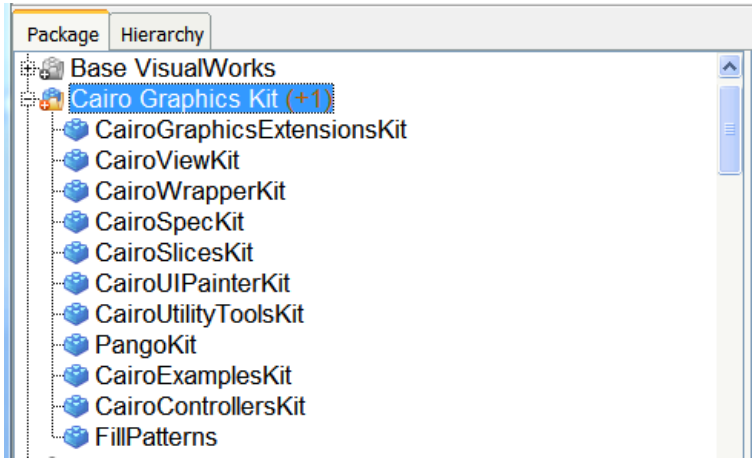


What is cairo?

- cairo is an open source 2D graphics library with support for multiple output targets.
  - Written in C.
  - Usually compiled as an external library. (e.g. DLL)
  - Currently supported output targets include:
    - X Window System (Linux)
    - Quartz (Mac)
    - Win32 (Windows)
    - image buffers (Targets an in-memory image buffer)
    - PostScript (Generates a PostScript file, suitable for high-quality print output)
    - PDF (Generates a vectorized PDF file, suitable for high-quality print output)
    - SVG file output (Generates a “Scalable Vector Graphics file)
- Cincom created a Smalltalk language binding to the cairo C library
  - Utilizes Cincom’s “DLL and C Connect” technology.
  - Published as a package called “CairoGraphics” in the Cincom public STORE .

What is the CGK?

- It's a collection of packages that further enhance the *CairoGraphics* and *Pango* packages already provided by Cincom.
- It provides VisualWorks "proper", but cairo based:
  - Views
  - Wrappers
  - Controllers
  - Extensions
  - Utilities
  - Examples



- It's a working example of what you can do with VisualWorks, cairo and Pango.
- It's a free bundle licensed under LGPL for use in VisualWorks 7.7.
  - I also maintain a branch for 7.4.

CGK Origins

- What started it all?
  - A new machine design was in the works.
    - The animation technique used by our older framework couldn't meet the animation requirements of the new design.
    - The new system would require an animation to have three functions that VisualWorks 7.4 couldn't handle very well.
      - I wanted to work with PNG images.
      - I wanted to transform these images in real time.
      - I wanted decent anti-aliasing after the transforms were applied.
    - We were limited to VisualWorks 7.4 .

CGK Origins

- All that CGK work for rotation and PNG images…really?
  - Other developers wanted to use cairo capabilities, but not at the binding level.
  - Developers wanted to maintain a familiar VisualWorks experience.
    - Use tools like UI Builder / Painter
      - WYSIWYG
      - Incorporate familiar functions from vector/pixel based editing programs.
    - MVC
      - MVC reigns supreme in our framework (ControlWORKS).
    - GUIs derived from ApplicationModel (~60 UI Pages)
      - AppModel reigns supreme in our framework (ControlWORKS).
  - It was time to move away from pixel based animation to vector based animation. (this has yet to be realized)

Find out what's already there and build on it!

- We were trying to solve an animation problem, but constrained to make it work within the traditional VisualWorks framework.
- windowSpec = Scene Graph?
  - The VisualWorks GUI framework has so much in common with the notion of a scene graph that we figured it was a perfect fit.
  - The windowSpec could act as a static capture of the intended scene.
  - The Builder could turn it into an active scene.

Find out what's already there and build on it!

- If I use the Wikipedia definition of a scene graph, we need the following components:
  - Tree Structure
    - Group nodes
      - Composites
      - TransformWrapper
      - Tweening Wrapper
    - Leaf Nodes
      - Views
      - Decorator Wrappers
  - Tree Traversal
    - damage repair (up the tree)
    - displayOn: (down the tree)
  - Bounding Volume Hierarchies
    - Each node / leaf in the tree has its own notion of bounds that usually include the bounds of its children.
  - Spatial Partitioning
    - A leaf node's layout wrapper contains the static spatial data.

Staying with what we know…The UI Painter

- It let us break down the process of creating an animation overview into the same process as developing a normal VisualWorks GUI.
  - It provided the WYSIWYG functions we wanted.
- It had “some” of the features found in graphic editing tools I was familiar with so it was the logical place for my own tool creations.
  - New slices were needed to provided support for the various cairo based views.

Staying with what we know…MVC

- The GUI part of our framework still relies heavily on MVC so the CGK components need to follow the same pattern.
- In the beginning of the CGK work, it was more like MV than MVC.
- CairoPNGImageView, PangoMarkupLabelView, and CairoLabeledVisualView don't have a runtime controller.
- CairoActionButtonView and CairoDendrogramView have controllers, but they don't exploit any specific behavior of cairo.
- Most work on controllers has revolved around extending / subclassing existing UIPainter controllers.
  - I also include new trackers as part of the controller work.
  - Trackers play an important role in mimicking the workflow of a package like Illustrator or Photoshop during a UI Painting session.

Staying with what we know…Wrappers

- If the widgets were going to be VisualWorks “proper”, then they would need to work with most of the usual VisualWorks wrappers .
  - Some were extended and some were are a subclass.
- The wrapping process works in the same way as a VisualWorks visual component.
  - It’s part of the component spec and is done during UI building.
- Cairo based components interact with their wrappers more than their VisualWorks counterparts.
  - SpecWraper
  - TransformWrapper
  - LayoutWrapper

Cairo Based View (CairoSimpleView)

- Any cairo based view can always get to its spec wrapper.
  - The spec holds the visual component DNA and in the CGK, I modify the DNA a lot.
- Any cairo based view can always get to its transform wrapper.
  - The transform wrapper is an integral part of the CGK and gives most Views their ability to scale, rotate, translate etc…
- Any cairo based view or subclass of VisualPart implements a “double dispatch” approach to the *displayOn:* method.
  - Cairo based components may be handed an instance of ScreenGraphicsContext or CiaroContext and therefore, need to know how to render themselves on either context.
  - Using the visual hierarchy browser is an example of when a component may get either type of context object .

Finally, The Affine Transform and its role in the CGK

- Its so important, it got its own wrapper.
- The transform wrapper is at the heart of the CGK.
- It provides a CGK View with a full range of transformation capabilities.
  - A view can be rotated, scaled or translated either during runtime or during canvas editing.
- Transform wrappers also act as a composite container, allowing it to apply a single transform to multiple components.
  - Transform wrappers can also be nested within each other.
- Transform wrappers also understand how to translate Point objects in or out of their coordinate space no matter how deeply nested.
  - globalToLocal:
  - localToGlobal:
- Controllers that interact with transform wrappers don't need to worry about mouse point translation, the wrapper will take care of this form them.
- The transform wrapper maintains its own damage repair policy.

Conclusion

The Good and the Bad about cairo and the CGK

- The Good
  - We've been able the achieve our goal of integrating more advanced graphics capabilities into our software while staying with VisualWorks.
  - We can continue to use GUI development tools and methodologies we're familiar with.
  - Cairo has a fantastic community behind it. It is constantly evolving and continues to offer cutting edge features.
- The Bad
  - It's a binding to the outside world. External DLL bindings make our developers nervous.
    - Stay within the VM is usually our motto.
    - The first sign of trouble with the VM usually involves me defending cairo.
  - Most Smalltalk developers aren't graphics guys. Looking pretty usually isn't a high priority in Smalltalk.
    - I respectfully disagree!
  - Using pre-built cairo binaries can be tricky.
    - I ended up building my own for Win32.

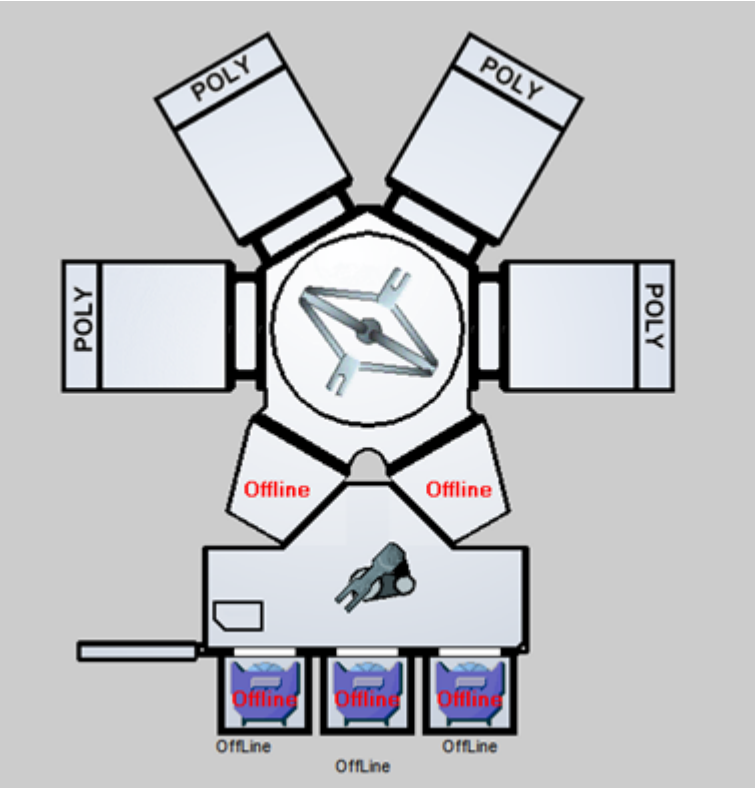
What's next for the CGK?

- Views
  - Vector Shape
- P&ID Toolkit
- UI Painter Slices
  - Replacing the Color and Pattern Slice with a new Fill/Stroke slice.
    - Color, Pattern, or Gradient selection in one unified slice.
- AppModelView
  - Our answer to the difficulties of creating a VisualWorks "proper" widget.

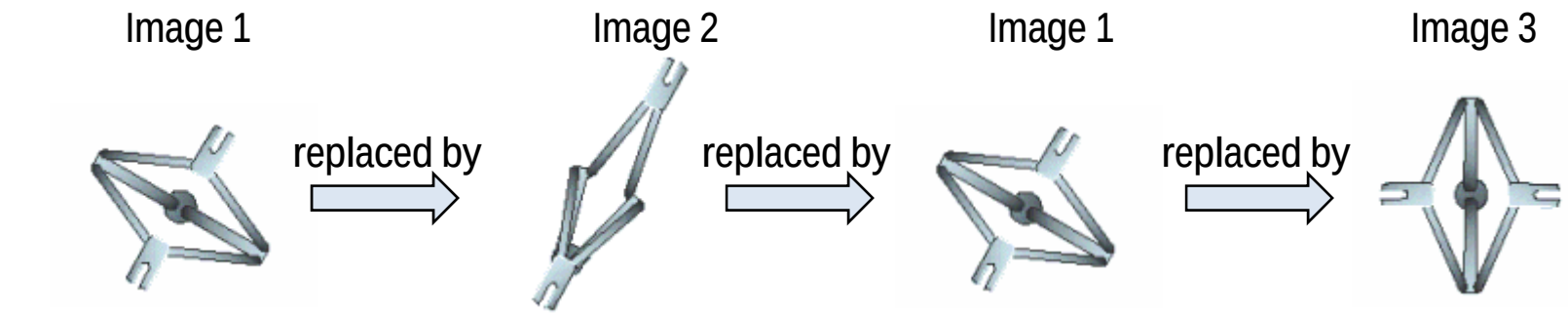

FAST to Customer Solutions™
Lam RESEARCH

Supplemental Slides

Animation The Old Way

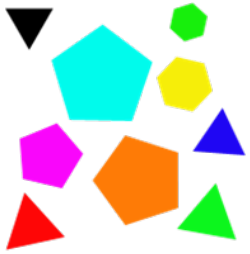


- Images are added or removed from a CompositePart at runtime
  - All possible images reside in a Dictionary that's maintained by the application model
  - Events drive the animation
  - The sequence below would animate an arm extension, retraction and rotation event sequence



Dealing with PNG Files…VisualWorks versus cairo

Test PNG Image

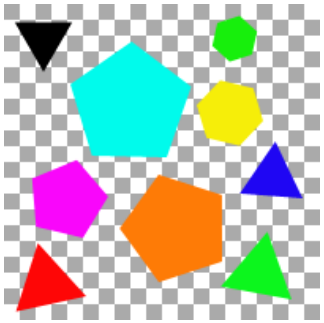


VisualWorks (7.4)

The result after the PNGImageReader reads the file.

The result after a 15 degree rotation.

cairo



The result after using cairo to render the image

Using a cairo affine transform to rotate the image