

Colour Management, Freetype 2 and Other Recent Development



Hin-Tak Leung



About Ghostscript

- Ghostscript is a document conversion and rendering engine.
- Essential component of the Linux printing pipeline.
- Dual GPL/Proprietary licensed. Artifex owns the copyright.
- Source and documentation available at www.ghostscript.com



Cross-platform

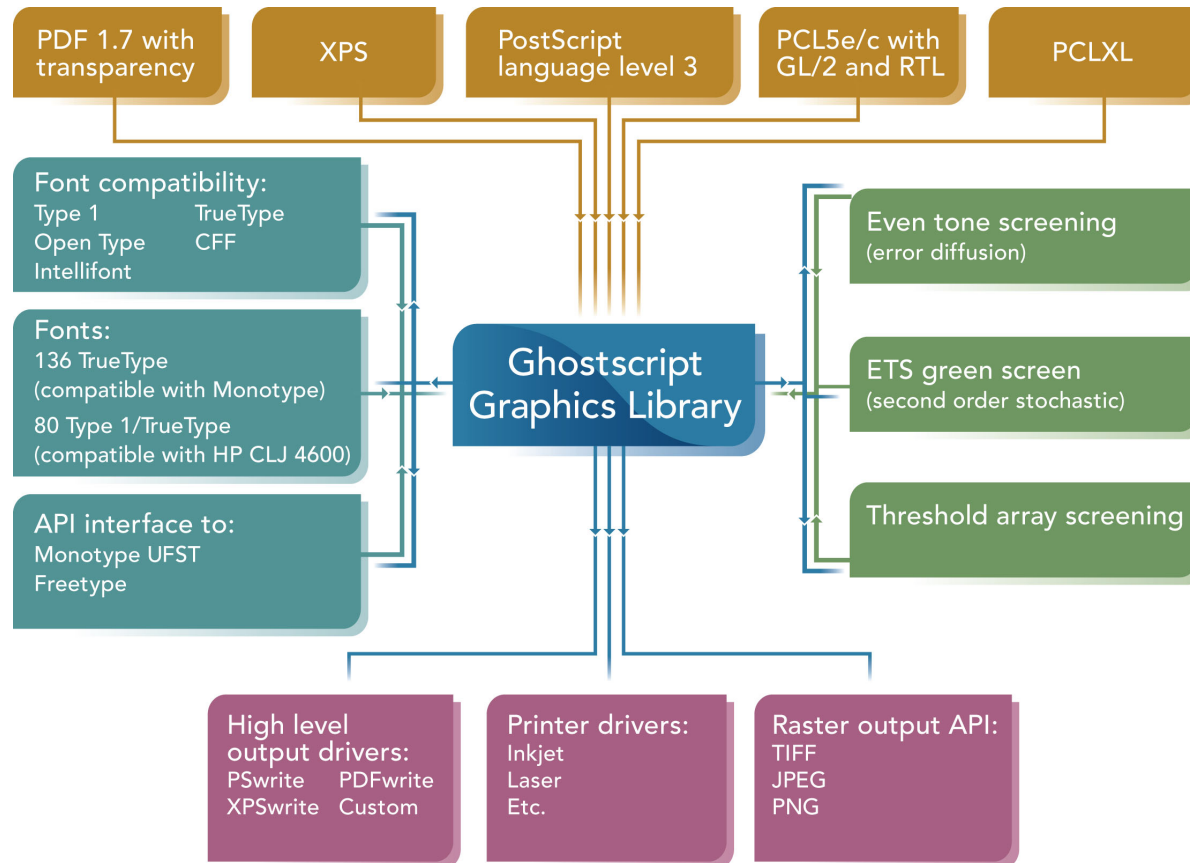
Ghostscript runs on all major operating systems, including:

- MS Windows: 95, 2000, XP, Vista, 7
- Mac OS X
- UNIX
- LINUX
- Embedded environments:
 - VxWorks
 - RTOS
 - ThreadX

Partial Customer List

Ghostscript Overview



PDLs and Color Spaces: Overview

PostScript Level 3 – DeviceGray, DeviceRGB, DeviceCMYK, Device independent color spaces 1, 3, and 4 component (CIE XYZ based), Separation, N-Device, Indexed, and Pattern.

PDF – Essentially same as PSL3, but adds ICCBased as input type and loses some PS CIE based spaces. Adds a LAB type. Only supports 1, 3 or 4 channel ICC profiles.

PCL – RGB based. Color assumed to be sRGB.

XPS, OpenXPS, SVG – All color defined by ICC profiles. XPS allows up to 8 channels.

Ghostscript supports ALL.



May 2010: code base and ICC Color Spaces

Today, most print/display color management is handled completely through the use of ICC profiles.

Ghostscript supports all color spaces defined by PSL3 and PDF1.7 with the exception of support of V4 ICC profiles. Ghostscript supports ICC.1:1998-09 (vers 3.4).

The existing architecture is inefficient in its use of ICC profiles due to their late addition into the code. (Last color space added).

This was the status up to **May 24, 2010**.

Primary Color Flows in Ghostscript



A Color Rendering Dictionary (CRD) is PostScript's method for defining a mapping from CIEXYZ to a device color. It can be defined with PS procedures (functions) and/or multi-dimensional look-up-tables.

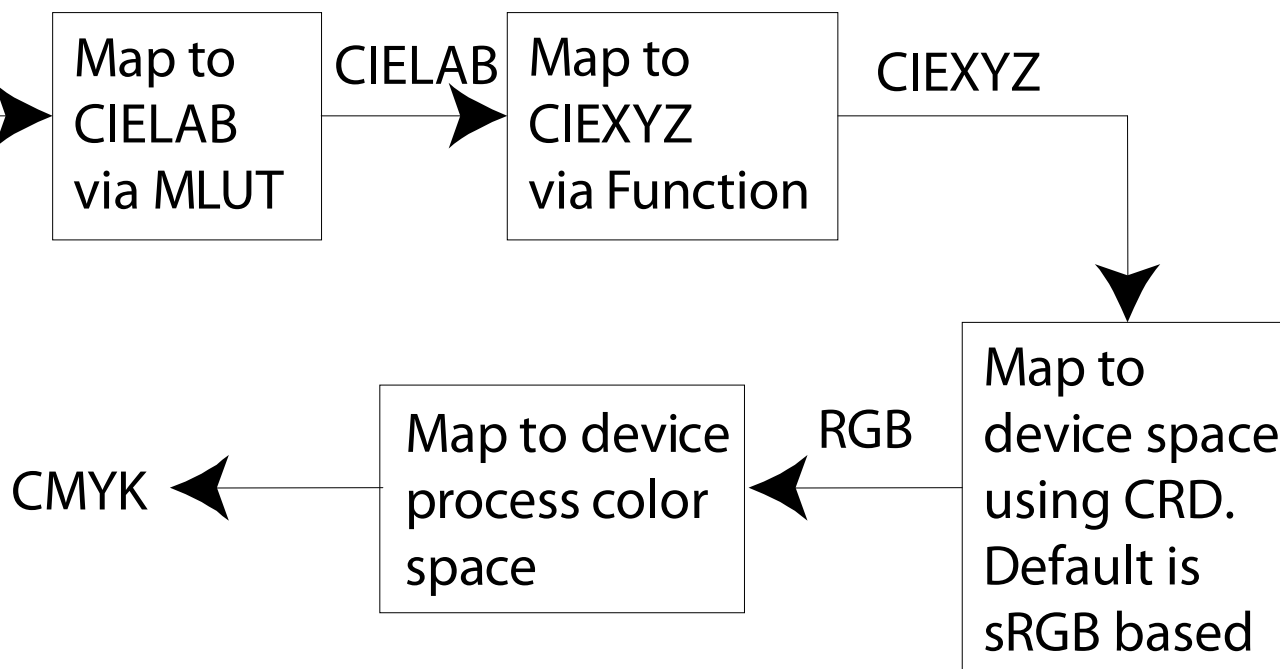
Current ICC Usage in Ghostscript. No Linking!

For each image pixel.....

RGB Image

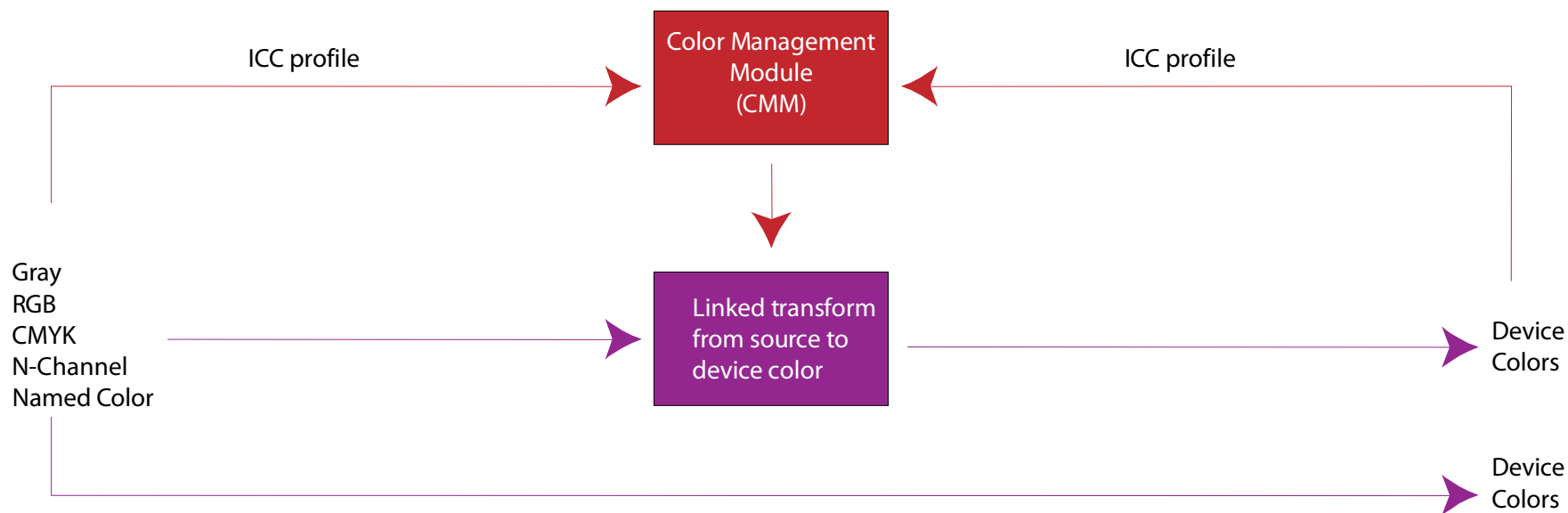


Scanner MLUT
ICC Profile
PCS is CIELAB



Note: If CRD is also an MLUT, we end up going through two MLUTS!

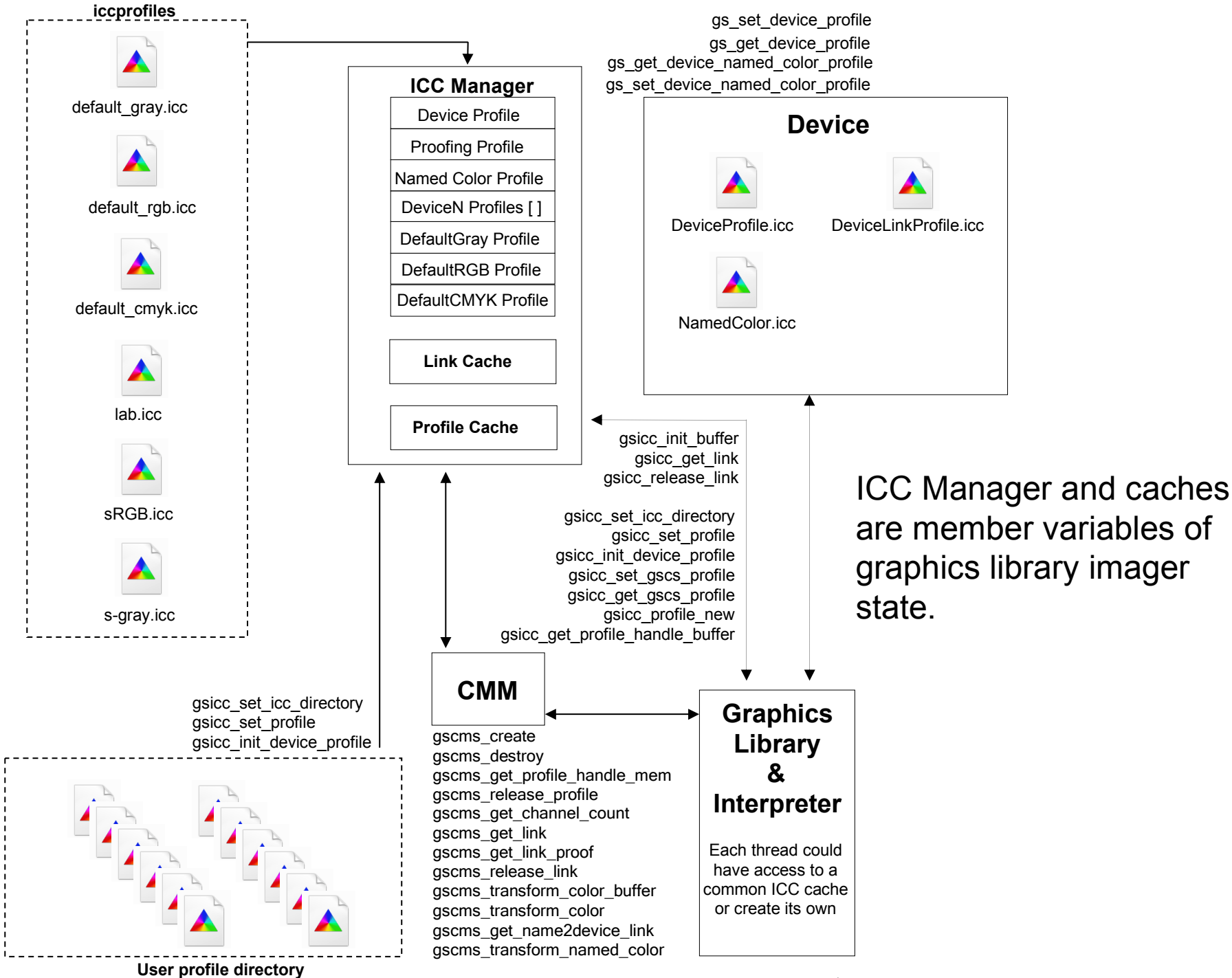
Desired Color Flows



Even if it is ICC centric, Ghostscript will continue to support the non-ICC color spaces of PDF and PostScript.

Goals of New Ghostscript Color Architecture

- Easy to interface different CMM with Ghostscript.
- Define ALL color spaces in terms of ICC profiles.
- Cache linked transformations and internally generated profiles.
- Easily accessed manager for ICC profiles.
- Devices communicate their ICC profiles and have their ICC profile set.
- Include object type (e.g. image, graphic, text) and rendering intent into the computation of the linked transform.
- Operate efficiently in a multithreaded environment.
- Handle named colors with ICC named color profile or proprietary format.
- Color management of Device-N colors.
- Flexibility for proofing, profile override, default settings and device link profiles.



Typical Graphics Library Usage

- Graphics library will request link from link cache.
- Once link obtained, graphics library will apply link to buffers. Typical buffer may be a single scan line.
- When done, graphics library will notify cache.
- Ideal buffer transform case occurs in transparency code when transforming from blending color space during transparency group pop.

Command Line Interface

Source Default Profiles

-sDefaultGrayProfile = my_gray_profile.icc
-sDefaultRGBProfile = my_rgb_profile.icc
-sDefaultCMYKProfile = my_cmyk_profile.icc
-sDeviceNProfile = my_device_n.icc

Device Profile

-sOutputICCPProfile = my_device_profile.icc

ICC Search Directory

-sICCPProfilesDir = c:/my_iccprofiles/

Other Settings

-sProofProfile = my_proof_profile.icc
-sNamedProfile = my_namedcolor_profile.icc
-sDeviceLinkProfile = my_link_profile.icc

ICC and PDF Rendering Intents

Relative Colorimetric – White point of the **medium** is mapped to the white point of the reference illuminant.

Absolute Colorimetric – No media white point mapping. Generally no alteration of data other than gamut clipping.

Perceptual – Implementation specific. Gamut compressed or expanded, intended to give visually pleasing result for images.

Saturation – Implementation specific. Preserve saturation at expense of hue and lightness. Intended for graphics.

Abuse of Rendering Intent: an example



Correct

Wrong (→PCL XL→)

What's wrong with that PDF file?

```
<< /Intent /RelativeColorimetric  
/ColorSpace 149 0 R >>  
149 0 obj  
[ /Lab <</WhitePoint [ 0.9642 1 0.82491 ]>>]  
endobj
```

The image has a non-white “white point” (tinted) with Intent to correct.

Image with ICC source profile RGB MLUT



Renders twice as fast with new architecture

CIELAB Image

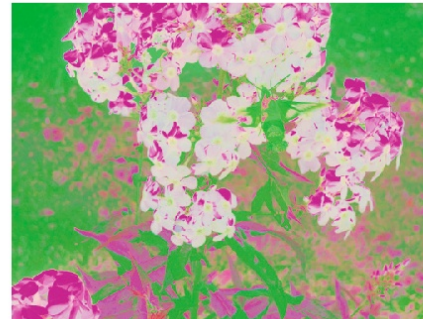


Renders three times as fast with new architecture

Rendering intent test with trunk



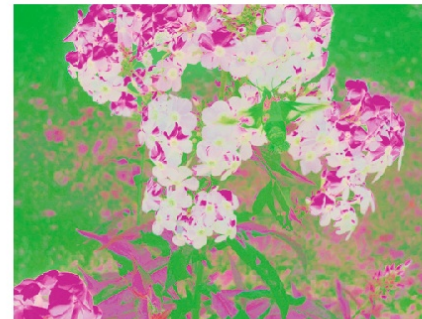
Perceptual Rendering Intent



Saturation Rendering Intent

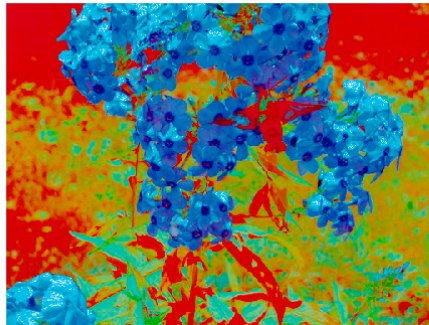


Relative Colorimetric Rendering Intent



Absolute Colorimetric Rendering Intent

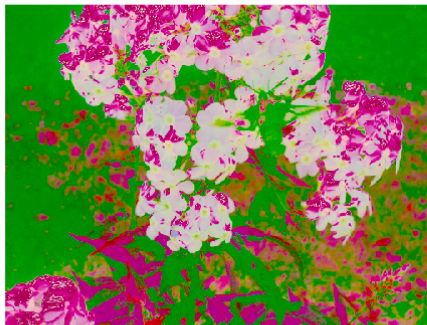
Rendering intent test with new architecture



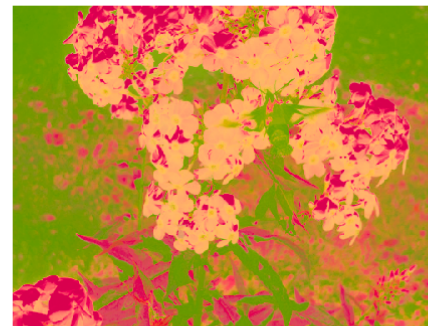
Perceptual Rendering Intent



Saturation Rendering Intent

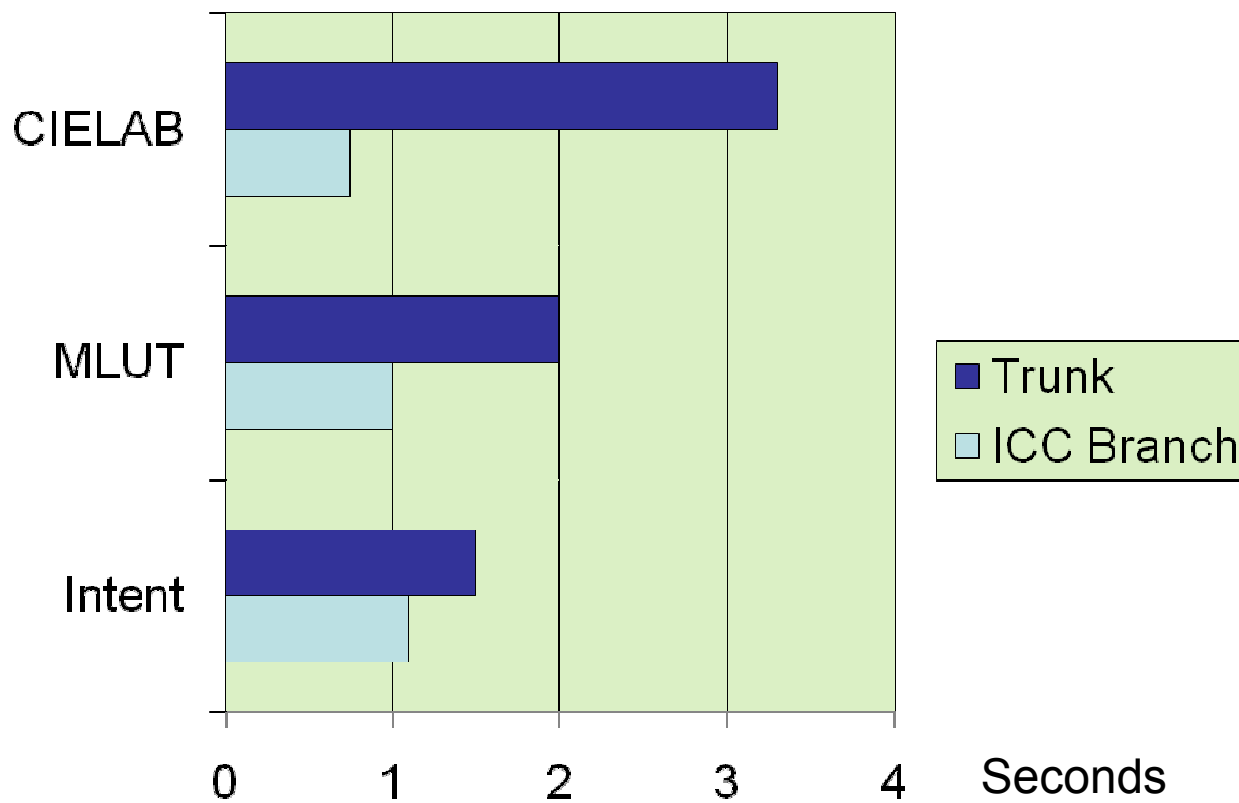


Relative Colorimetric Rendering Intent



Absolute Colorimetric Rendering Intent

Performance





ICC Branch Attained

- Speed/Performance: +30% to x3
- Support for v4 ICC profiles
- Support for rendering intent per graphic object

Current Status

- In trunk (merged from icc_work branch on May 24, 2010) – no going back!
<http://svn.ghostscript.com/ghostscript/trunk/gs>
- Currently interfacing to littleCMS <http://www.littlecms.com/> Marti Maria.
- Reviewing regression differences.
- Some source snapshots (gs-*.tar.gz) and also windows binary installers (GS872W32-*.exe) on
<http://www.ghostscript.com/~hintak/>
for LGM

Usage of ICC Profiles in CUPS

- Integration needed for network spooler (CUPS)
 - CUPS supports per-queue server-resident ICC profiles
 - Print jobs can embed per-job profiles
 - What about per-user profiles?
- Per-user profile use-cases:
 - Tuned to the user's monitor/previewer/proof-printer?
 - Custom expensive or rarely used media? Cloth fabric?
 - Caching/Uploading user profile for server-side recall?
- User-interface (GUI/CLI) Design?

Font renderers for all major font formats

- TrueType
- Type 1
- Type 42
- CID
- CFF
- Double-byte
- OpenType
- Intellifont

Font packages:

- Type 1: 35 PS or 80 PS fonts
- TrueType: 80 PCL/PS or 136 PCL/PS
- Compatible with Monotype UFST and Bitstream



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Software Inc.

Tricky fonts — MingLiU and KaiU

Original PDF (Distiller 7, viewed in AR 9)

source.pdf - Adobe Reader

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20	Banner 尺寸: 3X8 尺 材質: 燈布 解像度: 720dpi 加工: 包邊不見白打孔 設計費: \$250.00	\$ 84.00	\$1,680.00
			\$250.00



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Tricky fonts — MingLiU and KaiU

Re-Distilled in GS 8.63, viewed in xpdf 3.x

Xpdf: result-863.pdf

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Page 1 of 1 fit width ? Quit



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Tricky fonts — MingLiU and KaiU

Re-Distilled in GS 8.63, viewed in AR 9

result-863.pdf - Adobe Reader

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			\$250.00

Font Rendering in Ghostscript up to 8.71

- Type 1/CFF/Type 3 developed in-house
- TrueType/Type 42 interpreter code from Freetype 1
- pdfwrite = read+write fonts
- In 8.63, we saw problems with:
 - stroke width
 - outline as clip-path/mask
 - patented TrueType bytecode instructions
- xpdf (viewer) problematic with pdfwrite output



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Tricky fonts — MingLiU and KaiU

Re-Distilled in GS 8.71, viewed in AR 9

result-871.pdf - Adobe Reader

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Tricky fonts — MingLiU and KaiU

Re-Distilled with GS HEAD + bytecode interpreter

result-r11228+tt.pdf - Adobe Reader

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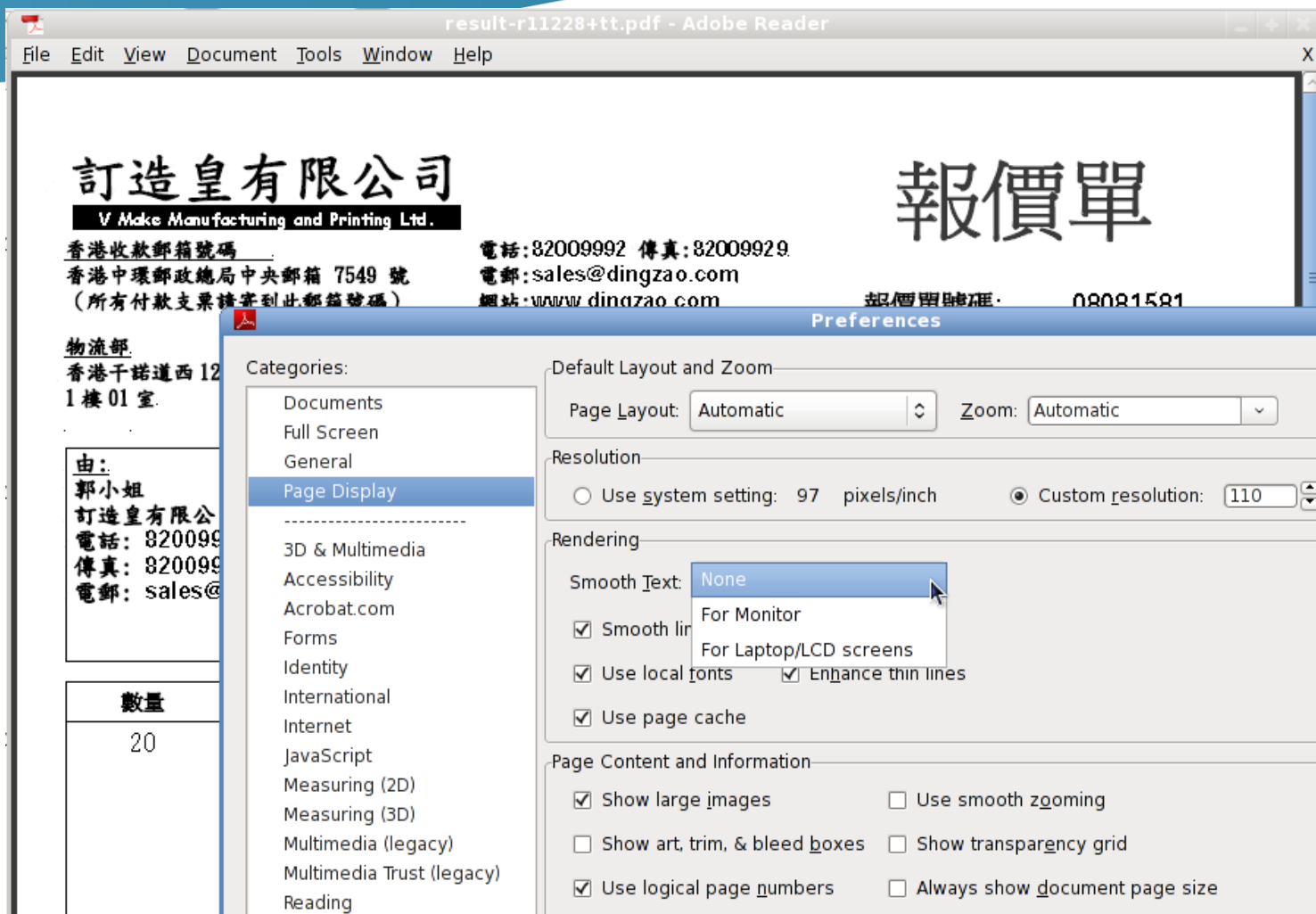
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Tricky fonts — MingLiU and KaiU

Switching off Text Smoothing (AR 9)



The screenshot shows the Adobe Reader interface with a PDF document titled "result-r11228+tt.pdf". The document content includes the company name "訂造皇有限公司" (Dingzao Huang Co., Ltd.), contact information, and a "報價單" (Quotation) form. The "Preferences" dialog box is open, showing the "Page Display" category selected. The "Smooth Text" dropdown menu is open, showing options: "None", "For Monitor", and "For Laptop/LCD screens". The "None" option is currently selected.

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數量
20

Categories:
Documents
Full Screen
General
Page Display
3D & Multimedia
Accessibility
Acrobat.com
Forms
Identity
International
Internet
JavaScript
Measuring (2D)
Measuring (3D)
Multimedia (legacy)
Multimedia Trust (legacy)
Reading

Default Layout and Zoom
Page Layout: Automatic
Zoom: Automatic

Resolution
 Use system setting: 97 pixels/inch
 Custom resolution: 110

Rendering
Smooth Text: None
 Smooth lines
 Use local fonts
 Enhance thin lines
 Use page cache

Page Content and Information
 Show large images
 Use smooth zooming
 Show art, trim, & bleed boxes
 Show transparency grid
 Use logical page numbers
 Always show document page size

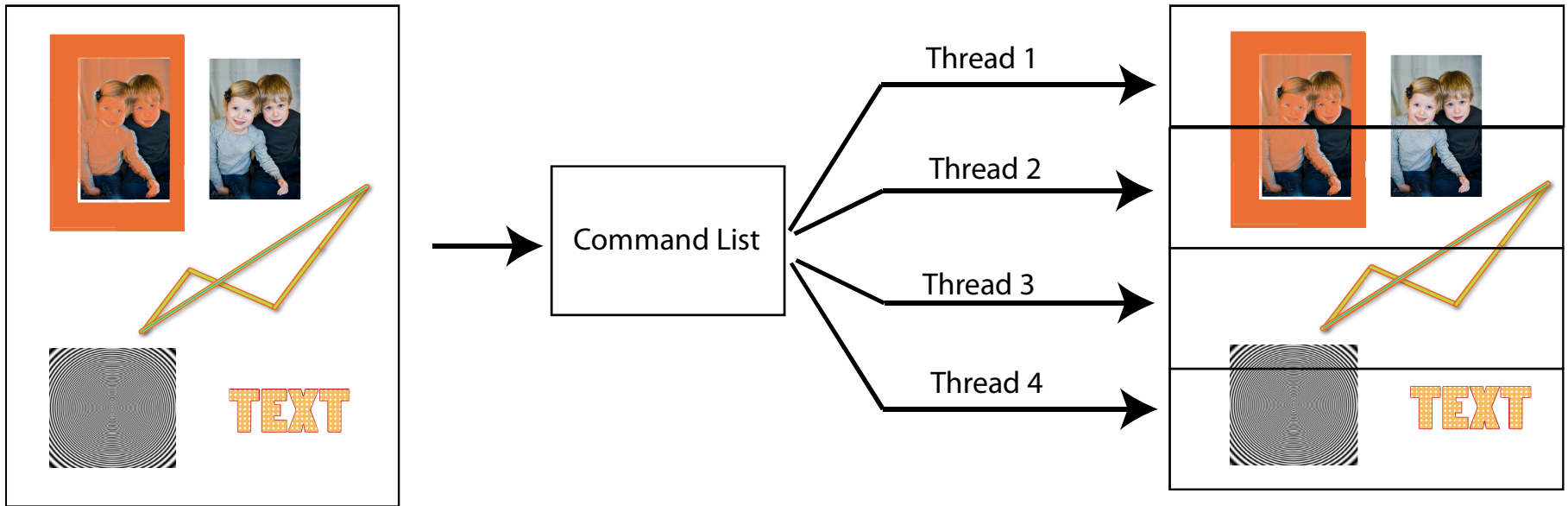
Freetype 2 Integration

- Default font renderer as of April 2010
 - Can be disabled with `-dDisableFAPI=true`
- Built-in font-scaler (fallback) continues to improve
- Apple patents on TrueType bytecode expire soon
- Some “issues” are due to viewer (Acrobat Reader)
Text Smoothing settings

Ghostscript's Command List

- Ghostscript normally renders in immediate mode.
- Can also generate a command list for asynchronous processing.
- Subdividing a job into bands reduces peak memory usage.
- Threads can process bands simultaneously.

Ghostscript Multithreaded



Command List and ICC Profiles

- Due to table look-ups and interpolations color conversion is expensive.
- Would like to distribute the load in threaded rendering.
- ICC profiles are embedded in the command list.

Multi-Threaded Environment

- During command list read phase, each thread obtains the same initial imaging state that includes a pointer to the primary link cache.
- In a single page, it is very likely that similar links will be needed.
- This suggests sharing a common cache amongst the threads.
- Links are reference counted to ensure only unreferenced ones are removed.
- Necessary to have a lock and release feature on the cache.

Clist (banding)

- Switches on automatically at high resolution
 - Can be switched off with `-dMaxBitmap=0`
 - Available since 8.5x
 - Lower memory usage, no parallel rendering (yet)
 - Mult-threading rendering can be enabled by
option `-dNumRenderingThreads=n` (default 0)
- Removal of globals to prepare for multi-threading

Raster Formats

- TIFF separation: libtiff (Nov 2009, 8.71 onwards)
- JBIG2: improved decoding
- JPEG 2000: openjpeg as alternative to JasPer
- JPEG XR – Windows Media Photo/HD Photo:
 - possible future support

Introducing GhostLite



GhostLite has been specifically designed as a viewer for implementation into ebooks, browsers and PDA's. GhostLite is built on Artifex's MuPDF renderer. MuPDF is a lightweight PDF viewer and toolkit written in portable C.

- Tailored for high quality anti-aliased graphics
- Renders text with metrics and spacing accurate to within fractions of a pixel for the highest fidelity in reproducing the look of a printed page on screen
- Small footprint. A binary that includes the standard Roman fonts is only one megabyte. A build with full CJK support (including an Asian font) is approximately five megabytes.

- Targeting the embedded small device market
 - Speed
 - Memory footprint
 - Rendering optimized for anti-aliased low-res fidelity
- Concentrates on Windows/ARM development
 - 3rd Party windows GUI: sumatrapdf
(<http://code.google.com/p/sumatrapdf/>)
 - Some PDA vendor ships it...
- Can benefit from better (Gtk/QT?) GUI
- In discussion with Debian for shipment
- Commercial licensing: <http://www.artifex.com/>