



AFP Color Management Architecture (ACMA) Overview – XPLOR 2006

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Agenda



□ Overview – Reinhard Hohensee

- What is the AFP Color Consortium (AFPCC) and what are its goals?
- ICC Profiles and Color Management Resources (CMRs)
- CMRs in MO:DCA (AFP) data

□ Color Management Resources (CMRs) – Jean Aschenbrenner

- Color Management Object Content Architecture (CMOCA)
- CMR types and structure
- CMRs in IPDS data

□ AFP Color Management Tools and Utilities – John Meixel

- CMR Installer and the CMR Resource Access Table (RAT)
- CMR Engine (CMRE)
- Data Object Installer and the Data Object RAT
- CMR Usage scenarios

□ Summary

□ Q & A

AFP Color Consortium



- ❑ Formed in October 2004
- ❑ Goal is to develop a comprehensive color management capability within the AFP architecture
 - Customers demand accurate colors regardless of output device
 - Customers demand consistent colors across multi-vendor configurations and workflows
 - To protect significant color investment, products must be based on open standards
 - Many companies provide AFP products, need broad buy-in to have an industry-wide solution
- ❑ First release of architecture was formally approved January 20, 2006 and will now be published
- ❑ For more information, see *afpcolor.org*



Current AFP Color Consortium Membership (27)

■ Document Composition & Resource Creation:

- Cincom
- COPI
- DocuCorp
- Document Sciences
- Elixir Technologies
- Exstream Software
- GMC Software Technology
- Group 1
- Inventive Designers
- Isis-Papyrus
- Metavante
- PrintSoft
- StreamServe

■ Servers & Transforms

- CDP Communications
- Compart Systemhaus
- Crawford Technologies
- Emtex
- MPI
- Solimar Systems
- Xenos Group Inc.

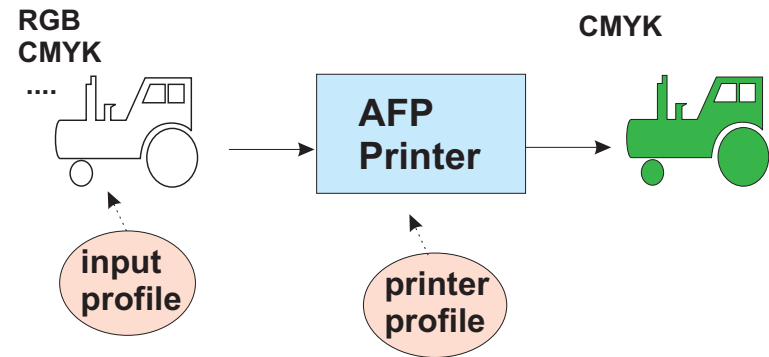
■ Printers & Controllers

- IBM
- Intermate
- Kodak
- Lexmark
- Oce
- Xeikon International
- Xerox

Goals of AFP Color Management (contd)

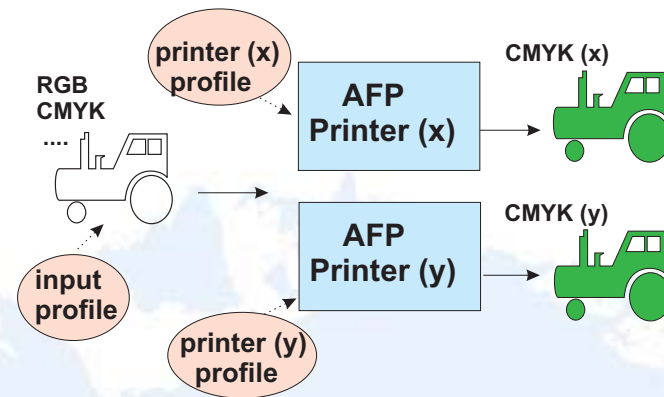


- **Accurate** output color if input color properly defined



- **Standards-based (ICC), open** architecture

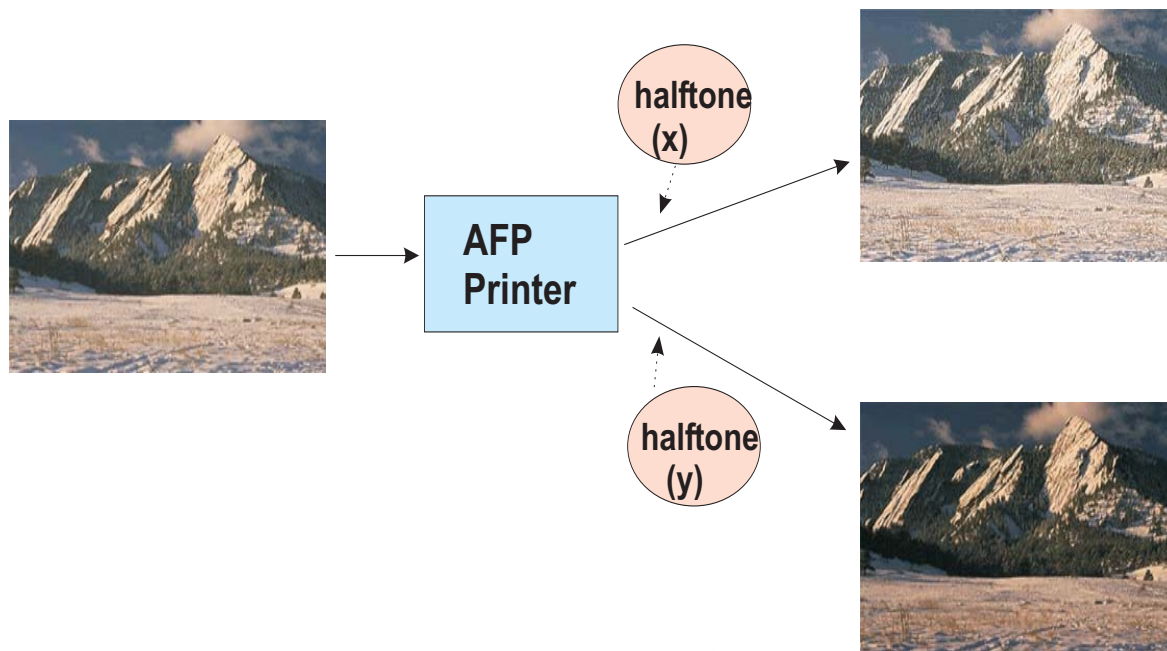
- **Consistent** output color and grayscale simulation on different devices driven by different applications



Goals of AFP Color Management (contd)



- **Tunable** output color



- **High-speed** output color

ICC Profiles

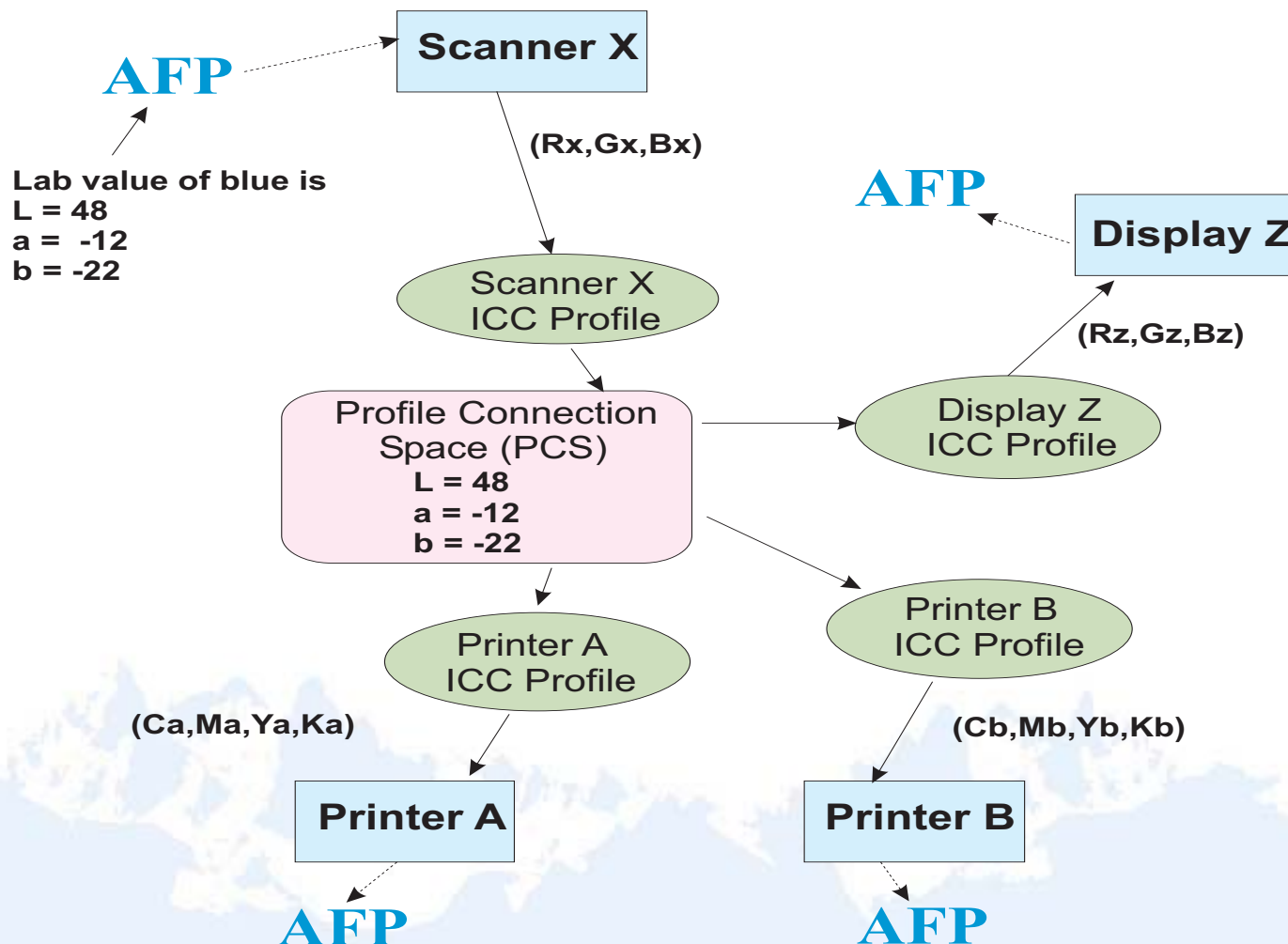


The **International Color Consortium (ICC)** was formed in the early 1990s to address the problem of color management in printers, displays, scanners, operating systems, applications, servers, in an open, industry-standard manner. This work resulted in the ICC Specification, which defines methods for color management that are based on objects called **ICC profiles**.

ICC profiles are created for input and output devices by their manufacturer and are essentially look-up-tables (LUTs) that specify how to convert between the color space of the device, e.g. a specific RGB for a display (input color), or a specific CMYK for a printer (output color), and a standard device-independent color space called the Profile Connection Space (PCS). The color spaces used for the PCS are CIE Lab and CIE XYZ.

This conversion to/from PCS via ICC profiles allows colors to be accurately passed from input devices to output devices.

ICC Profiles – System View



The AFP Color Management Resource (CMR)



- ❑ ICC profiles are the industry-standard for color management and form the basis for color management in AFP; they are integrated into AFP as resources that are called **AFP Color Management Resources (CMRs)**
- AFP CMRs are:
 - Defined in a new formal architecture under the AFP Architecture umbrella – the Color Management Object Content Architecture (CMOCA)
 - Processed as AFP resources – installed, downloaded, activated, captured, re-used
 - Can be associated with a MO:DCA document component:
 - Printfile
 - Document
 - Group of pages/sheets
 - Page or overlay
 - Data object



CMR Types

- ❑ **Color Conversion (CC) CMRs:** Contain ICC profiles (in their ICC-defined syntax) that convert a device-specific color to/from the device-independent ICC Profile Connection Space (PCS)
- ❑ **Tone Transfer Curve (TTC) CMRs:** Transfer curves that are used to modify the values of a particular color component
- ❑ **Halftone (HT) CMRs:** Screens that are applied to multi-bit data
- ❑ **Indexed (IX) CMRs:** Mappings of indexed colors in the data stream to output device colors or colorant combinations
- ❑ **Link Color Conversion (LK) CMRs:** Look-up tables (LUTs) that convert directly from a device-specific input color space in the data to the device-specific output color space of the presentation device

CMR Processing Modes

- ❑ **Audit:** An audit CMR specifies color-management processing that **has been done** on a document component; for example, it may specify a color conversion that has been done on the data
- ❑ **Instruction:** An instruction CMR specifies color-management processing that **is to be done** on a document component; for example, it may specify a halftone that is to be applied to multi-bit data
- ❑ **Link:** A link CMR is used to link an input color space in the presentation data directly to the output color space of the presentation device (without going through the PCS)

The processing mode is not part of the CMR; it is specified in the context in which the CMR is associated with a document component, e.g., on the structured field that references the CMR.

CMR Creation and Installation: CMR Installer and CMRE



- ❑ CMRs are **installed** as resources in an AFP resource library with a workstation-based **CMR Installer** that is part of a new **Resource Installer**. The CMR Installer:
 - uploads the CMR into the resource library of a print server
 - builds the CMR Resource Access Table (RAT) entry that maps the CMR name to a file name, to an object-OID, and optionally to other CMRs
- ❑ CMRs are **created** by the **CMR Engine (CMRE)**, which runs in conjunction with the Resource Installer to:
 - Generate Color Conversion (CC) CMRs from ICC profiles, including profiles that were copied/extracted from data objects
 - Generate Halftone (HT), Tone Transfer Curve (TTC), and Indexed (IX) CMRs from input data
 - Generate Link Color Conversion (LK) CMRs that convert the input color space defined in an audit CC CMR to the output color space of configured presentation devices

Inline CMRs

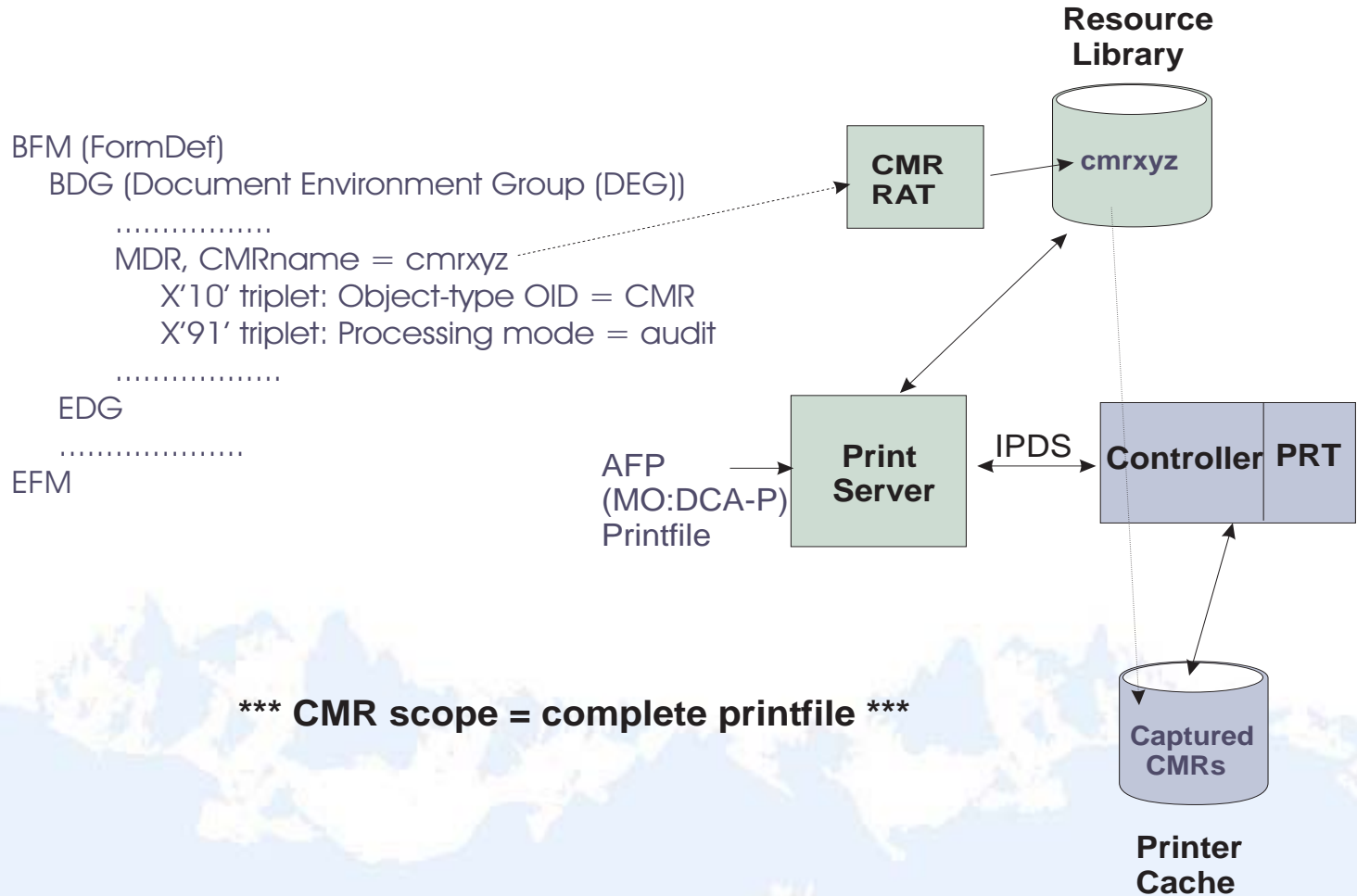
- CMRs may also be carried in a printfile-level resource group in a BRS - BOC/EOC – ERS container, and are then called **inline** CMRs
 - BRS specifies CMR name
 - For inline Color Conversion CMRs, BRS may specify Link Color Conversion CMRs that convert directly to output color spaces of different target devices
 - For inline generic Halftone or Tone Transfer Curve CMRs, BRS may specify device-specific HT or TTC CMRs; such CMRs are used in place of the inline generic CMR if the device type and model match the target device

Associating CMRs with a MO:DCA document component



- ❑ CMRs can be associated with document components at all levels of the MO:DCA document hierarchy:
 - Printfile (highest)
 - Document
 - Group of pages/sheets
 - Page/overlay
 - Data object (lowest)
- ❑ A CMR at a lower level always overrides – for that document component only – a conflicting CMR at a higher level
 - Example: CC CMR at printfile level defines RGB = scanner (y) RGB, CC CMR at page (n) level defines RGB = scanner (x) RGB. According to rule, since CC CMRs conflict, all RGB for page (n) is interpreted as scanner (x) RGB

Example: Associating CMRs with a Document Component: Printfile



Associating CMRs with a MO:DCA document component (Cont'd)



- ❑ A similar method can be used to associate CMRs with a single document in the printfile by specifying the offset to the document in the printfile
- ❑ CMRs can be associated with a group of pages/sheets by referencing the CMRs in a Medium Map; the scope of the CMRs is then the group of pages/sheets that follow
- ❑ CMRs can be associated with a page or overlay by referencing the CMRs in the Active Environment Group (AEG) if the page/overlay
- ❑ CMRs can be associated with a data object, such as an IOCA FS45 color image, in a number of ways:
 - By referencing the CMRs in the Object Environment Group (OEG) of the data object

Associating CMRs with a MO:DCA document component (Cont'd)



- By referencing the CMRs on the Include Object (IOB) structured field that places the data object on the page/overlay
- Data objects may be installed by a component of the **Resource Installer** called the **Data Object Installer**. This installer builds a Data Object Resource Access Table (RAT) that maps the object name to a file name, to an object OID, and optionally to one or more CMRs. ***This provides a method for associating CMRs with a data object that does not require any changes to the object or the data stream that references the object.***

User Input: Rendering Intent



- The ICC defines four rendering intents to specify how out-of-gamut colors should be mapped to in-gamut colors; each may produce a different output appearance:
 - **Perceptual**: Tries to preserve appearance by maintaining color relationships; typically used to render continuous-tone images
 - **Saturation**: Tries to generate vivid, saturated colors, even at the expense of color accuracy; typically used for business graphics
 - **Media-relative colorimetric**: Maps white point of source color to white point of output media; colors ‘look right’ but may not be accurate colorimetrically. Typically used for vector graphics or images.
 - **ICC-absolute colorimetric**: Does not map white point of source color to white point of output media. If source white is bluish and media white is yellowish, system adds cyan to simulate blue on output medium. Colors are accurate colorimetrically but may not ‘look right’. Typically used for logos or proofing.
- To properly process Color Conversion CMRs and Link Color Conversion CMRs, the system needs to know the end user’s rendering intent

Rendering Intent (Cont'd)



- End users can associate rendering intent with MO:DCA document components at the same levels of the document hierarchy as CMRs
 - Specified with a Rendering Intent (RI) triplet:
 - In the DEG of the FormDef to specify RI for the printfile or for a specific document in the printfile
 - In the AEG of a page or overlay to specify RI for that page/overlay
 - In the OEG of a data object to specify RI for the data object
 - On an IOB to specify RI for the included object
 - On a PPO to specify RI for an object to be preprocessed
 - Can also be associated with a data object in the Data Object RAT
 - Specified independently for each major AFP object-type category
 - IOCA
 - Object containers (EPS/PDF/TIFF/JFIF/GIF)
 - PTOCA
 - GOCA

CMR Architecture



□ **ACMA** → AFP Color Management Architecture

- Developed by AFP Color Consortium w/ IBM's leadership
- Additions to MO:DCA, IPDS, IOCA ...
- CMOCA: new tower in AFP
- White Paper: draft is available at www.afpcolor.org

□ **CMOCA** → Color Management Object Content Architecture

- Defines CMRs - Color Management Resources
- Documents how CMRs are used
- CMR is an AFP resource; carried in an Object Container
- Specification coming soon to www.afpcolor.org

CMR Structure



Length (bytes)	Name	Description
164	<i>CMRHeader</i>	header
N	<i>CMRData</i>	CMR data (tag format)

CMR Structure - CMR Header



Length (bytes)	Name	Description
4	<i>Length</i>	CMR length
4	<i>CMRSig</i>	Signature for CMR type Eye-catcher string X'434D5239' → CMR9
2	<i>Reserved</i>	Set to zero
146	<i>CMRName</i>	Used to reference the CMR in data stream (UTF-16BE format)
8	<i>Reserved</i>	Set to zero
N	<i>CMRData</i>	

CMR Structure - CMR Name

Length (bytes)	Name	Description
4	<i>Length</i>	
4	<i>CMRSig</i>	
2	<i>Reserved</i>	
16	CMR Alias	Human-readable name
4	CMR Type	CMR Type: HT, TTC, CC, LK, IX
14	CMR Version Or 'generic'	Version of this CMR
28	Device-specific fields	
22	Media-specific fields	
46	CMR-type-specific fields	
16	Reserved	Set to "@...@"
8	<i>Reserved</i>	
N	<i>CMRData</i>	

CMR Structure : CMRData



- All CMR data is carried in CMR tags
 - Each type of CMR tag has an ID
 - CMR tags are specified in ascending order of ID
 - Tag has header and data
 - All **tags** (headers) occur first in the CMR data field
 - Tag **data** follows

- Tags used depend on the CMR type:
 - Halftone
 - Calibration Curve
 - Color Conversion
 - Indexed
 - Link Color Conversion

CMR Structure – Tag Syntax



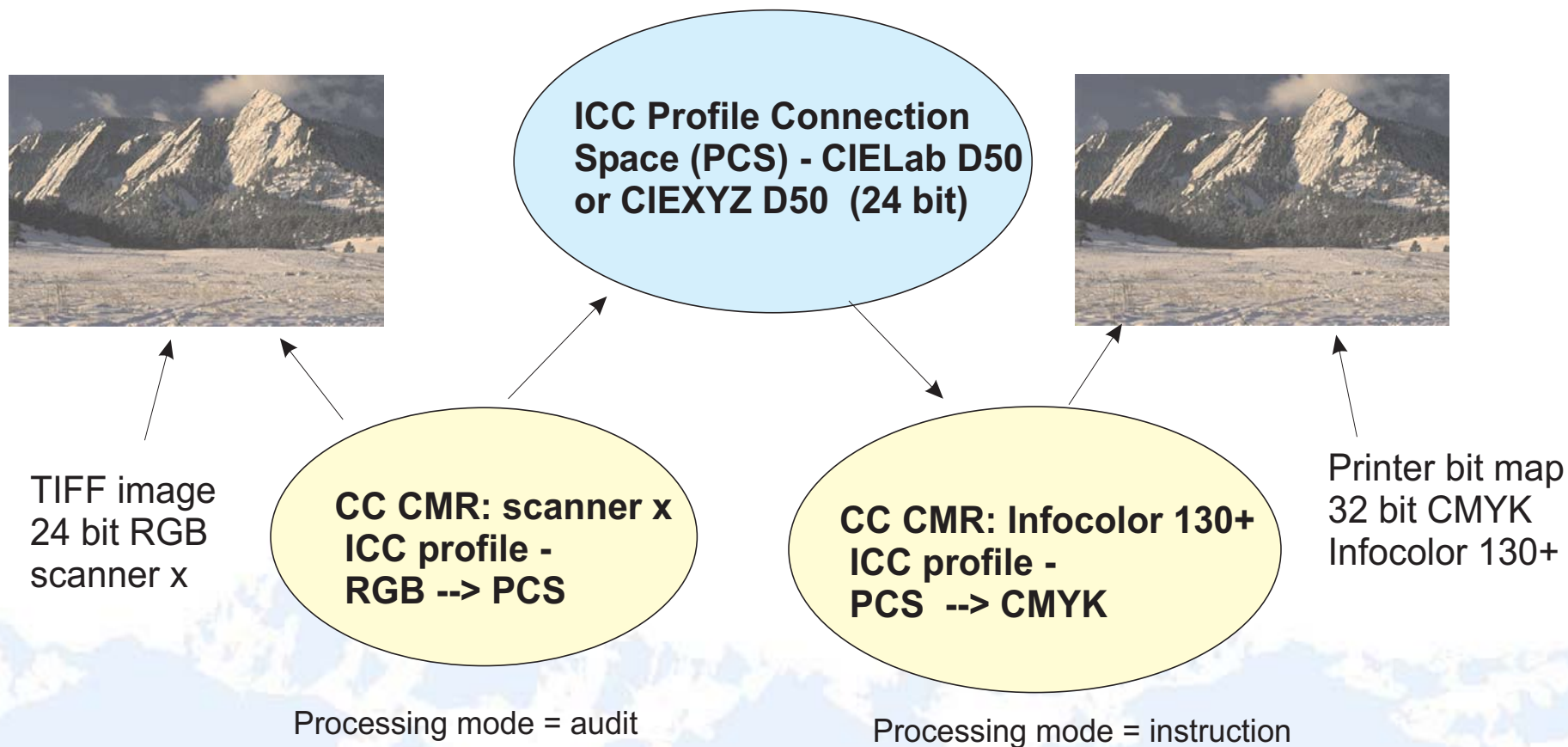
Length (bytes)	Name	Description
2	<i>TagID</i>	Unique identifier for tag
1	<i>Reserved</i>	Set to zero
1	<i>FieldType</i>	Data format of field
4	<i>Count</i>	Number of values of indicated field type
4	<i>Value/Offset</i>	if <4 bytes: Data , left aligned else: offset to data from byte 164

Going from Input to Output with CMRs

- Color Conversion
 - Input (e.g. RGB) → PCS → Output (e.g. CMYK)
- Tone Transfer Curve : calibration
 - 1-D for each color plane
- Halftone (each color plane)

- Indexed CMRs : maps index to color components
 - Will be discussed later

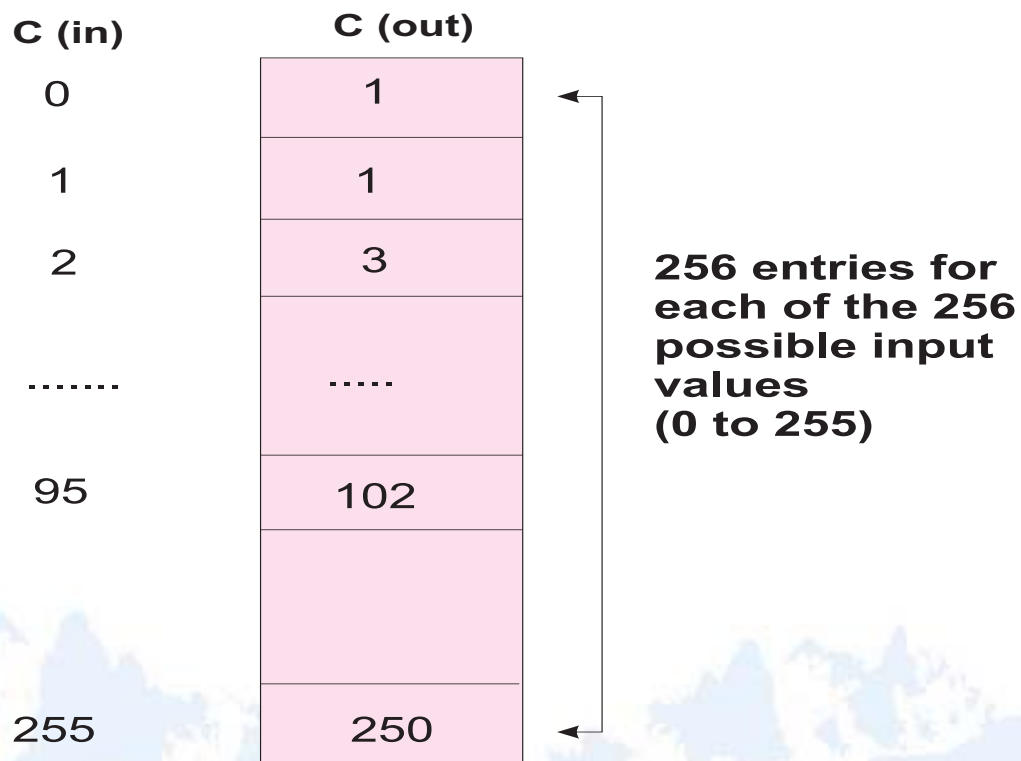
CMR Type: Color Conversion (CC) CMR



CMR Type: Tone Transfer Curve (TTC) CMR



Tone Transfer Curve Data Tag - Cyan Component



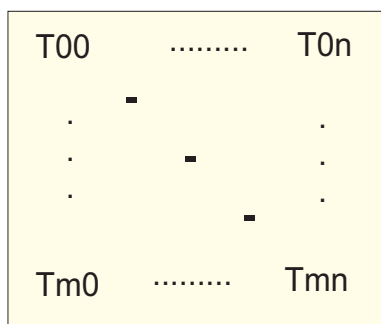
4 tables total if output color space is CMYK

CMR Type: Halftone (HT) CMR



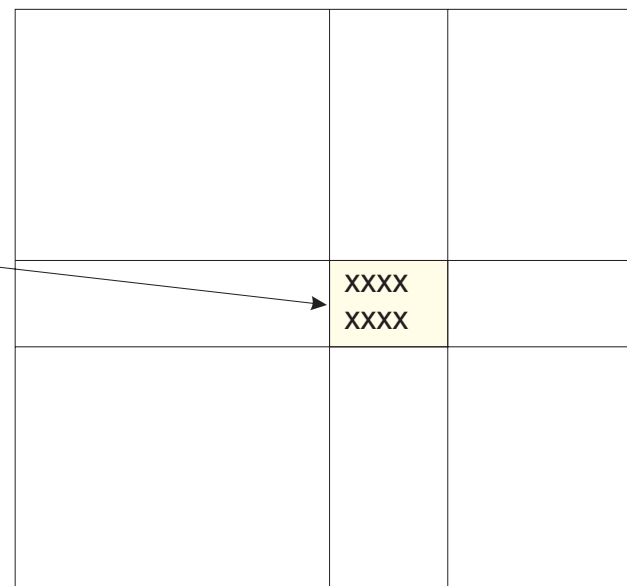
**Bilevel Point-Operation
Screen Data Tag -
Cyan component**

Cell
height (m)



Cell width (n)

**Threshold array for
n x m halftone cell**



Page pixel grid

Halftone cells are superimposed on pixel grid;
if pixel value corresponding to T_{ij} is less than T_{ij} ,
output pixel = B'0', otherwise it is B'1'

CMR Type: Link Color Conversion (LK) CMR



- ❑ Look-up tables (LUTs) that convert **directly**
 - from the input color space of the data
 - to the output color space of the presentation device
- ❑ Improves performance since Links avoid conversion to/from PCS
- ❑ Formally associates an audit Color Conversion CMR with an instruction Color Conversion CMR by specifying the object OIDs for each CMR
- ❑ Each Link CMR actually contains 4 LUTs
 - one for each rendering intent
- ❑ Transparent to end-user; not referenced in data stream

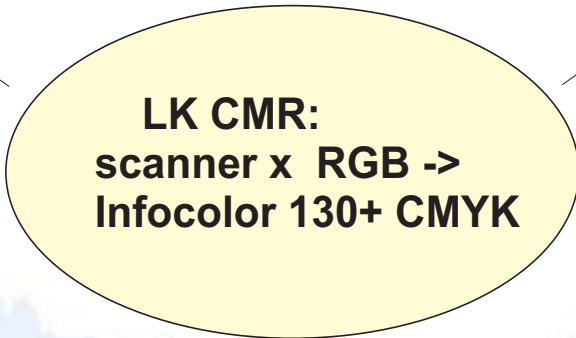
Link Color Conversions (contd)



TIFF image
24 bit RGB
scanner x



Printer bit map
32 bit CMYK
Infocolor 130+



Processing mode = link

CMR Type: Indexed (IX) CMR

- ❑ Color Specified = Highlight Color Space (X'4E' triplet format)
 - X'0000' – X'00FF' → spot color
 - X'0100' – X'FFFF' → resolve with Indexed CMR
- ❑ Indexed CMR tells how to create output given the index
- ❑ Different types of tags:
 - CMYK Tag: Index values → CMYK values
 - Gray Tag: Index values → grayscale values
 - Named Colorant Tag: Index values → combinations of named colorants
 - **All** tags: Index values → CIELAB values
 - Used if device does not support the selected color space

Indexed CMR: Named Colorant Tag



.....
ID = X'xxxx'	CIELAB value	Intensity of 1st colorant
		Intensity of 2nd colorant
	
		Intensity of nth colorant
.....

Indexed CMR: Colorant Identification Tag



Length	Colorant 1 Name
Length	Colorant 2 Name
.....
Length	Colorant n Name

Generic CMRs



- ❑ **Instruction** CMRs provide a mechanism whereby the output can be **tuned** to a specific output device.

- ❑ **Generic** (instruction) CMRs provide a mechanism whereby the output can be **tuned consistently** across different devices.
 - Use **generic** CMRs to request an intended output appearance.

Generic CMRs (contd)

- Generic Halftone CMR examples:
 - 71 lpi (clustered dot)
 - 85 lpi (clustered dot)
 - 106 lpi (clustered dot)
 - Stochastic
 - Error diffusion

- Generic Tone Transfer Curve examples:
 - Dark
 - Accutone
 - Highlight Midtone
 - Standard



Generic CMRs (contd)

- ❑ Only Halftone and Tone Transfer Curve CMRs can be specified as **generic** CMRs.

- ❑ Generic CMRs are identified with the fixed character pattern “generic” in the version field of the CMR name

- ❑ All generic CMRs are **registered** in the CMR Architecture Spec.

- ❑ Generic CMRs are never used directly by an output device
- ❑ They are always replaced by device-specific CMRs
 - Done by the print server based on a device-specific CMR mapping in the CMR RAT **or**
 - Done by the output device



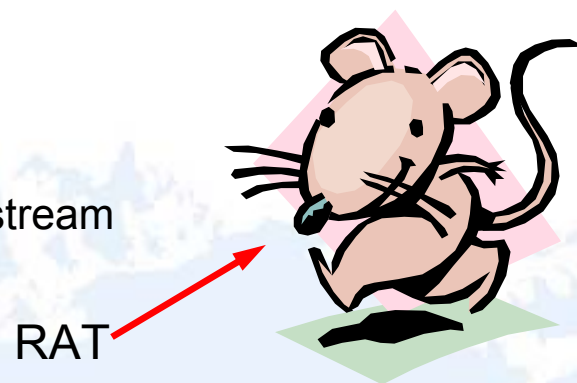
IPDS Considerations

- ❑ CMRs are **activated/deactivated** like all other resources
- ❑ Printer selects CMRs using the following hierarchy:
 - Data-object level
 - Page overlay level
 - Page level
 - Homestate level (printfile, document-level, and page/sheet group level CMRs)
 - Default level
- ❑ **Invoking CMRs**
 - Audit and instruction CMRs must be explicitly invoked
 - New Invoke CMR command for homestate-level invocation
 - New Invoke CMR triplet for object-level invocation
 - Link CMRS need not be invoked

CMR Resource Access Table (RAT)



- ❑ When CMRs are installed in resource libraries, they are processed using a CMR Resource Access Table (RAT)
 - RAT concept first introduced in AFP with TrueType/OpenType fonts
 - Architected structure defined in the MO:DCA reference (SC31-6802)
- ❑ Allows CMRs to be referenced in data stream by their inherent, native name, not by a platform-specific file name
 - Data stream is platform-independent
 - Mapping to platform-specific file name, to object-OID, and to other processing information accomplished via RAT
- ❑ CMR RAT is located in same library as CMRs
- ❑ RAT consists of repeating groups (RGs)
 - One repeating group for each CMR in library
 - Repeating group is indexed with CMR name from data stream

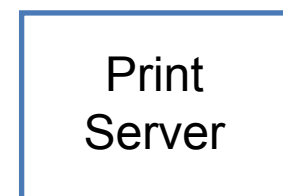


RAT Processing to Find TrueType Font

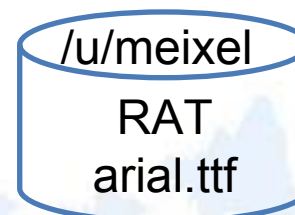
1. Job specifies “Arial” font
2. Print Server looks in RAT contained in path /u/meixel specified by:
 1. Job FONTPATH parameter
 2. Print Server FONTPATH parameter
 RAT has reserved name of:
 IBM_DataObjectFont.rat
3. Print Server finds RAT entry for font name “Arial”
4. Arial RAT entry point to TrueType file name of “arial.ttf”
5. Print Server downloads “arial.ttf” to printer



MDR = Arial
 FONTPATH = '/u/meixel'



FONTPATH = '/u/meixel'



TrueType Font Specified in Application File



Map Data Resource, MDR

Data-Object Font Descriptor

```
otf.afp
00C0: 00 08 D3 A8 C9 00 00 04 5A 00 5B D3 AB C3 00 00 .....Z.[.....
00D0: 05 00 53 18 10 00 41 00 00 A8 00 06 07 2B 12 00 ..S...A.....+..
00E0: 04 01 01 33 00 00 00 00 00 00 00 04 50 41 00 0C ...3.....Pa..
00F0: 02 85 00 A3 F1 A5 F1 F0 F5 F0 F0 10 8B 00 20 01 .....
0100: 90 00 00 00 00 00 03 00 01 00 00 06 01 00 00 04 .....
0110: B0 0E 02 DE 00 00 41 00 72 00 69 00 61 00 6C 05 .....A.r.i.a.l.
```

Fully Qualified Name "Arial"

RAT Processing to Find TrueType Font

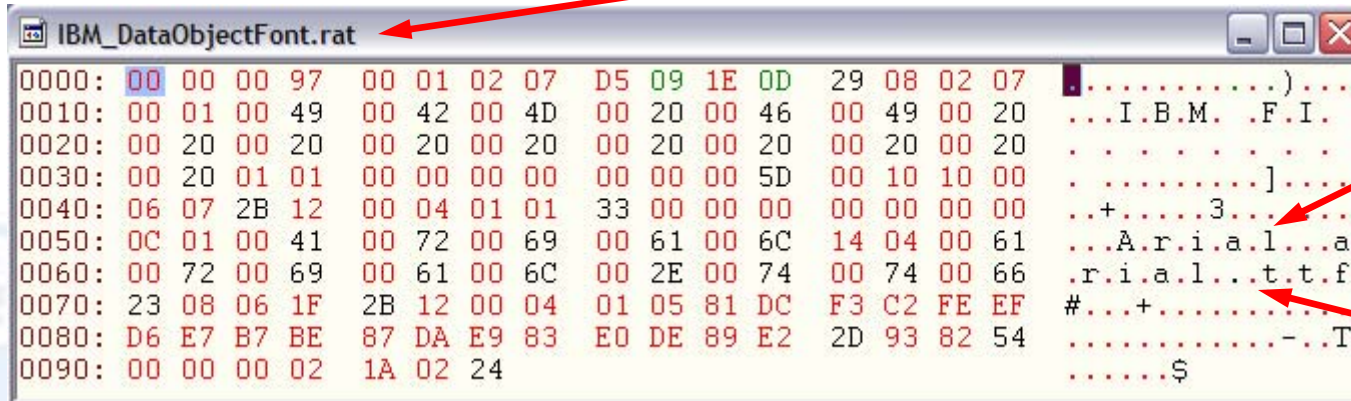
Application or Print Server Fontpath Parameter

FONTPATH = '/u/meixel' →

Font Resource Directory “/u/meixel”

```
EUID=888613003 /u/meixel/
Type Filename
_ Dir .
_ Dir ..
_ File arial.ttf
_ File IBM_DataObjectFont.rat
```

RAT



```
IBM_DataObjectFont.rat
0000: 00 00 00 97 00 01 02 07 D5 09 1E 0D 29 08 02 07 .....
0010: 00 01 00 49 00 42 00 4D 00 20 00 46 00 49 00 20 ...I.B.M. .F.I.
0020: 00 20 00 20 00 20 00 20 00 20 00 20 00 20 00 20 .....
0030: 00 20 01 01 00 00 00 00 00 00 00 5D 00 10 10 00 .....]
0040: 06 07 2B 12 00 04 01 01 33 00 00 00 00 00 00 00 ...+.3
0050: 0C 01 00 41 00 72 00 69 00 61 00 6C 14 04 00 61 ...A.r.i.a.l...a
0060: 00 72 00 69 00 61 00 6C 00 2E 00 74 00 74 00 66 ...r.i.a.l...t.t.f
0070: 23 08 06 1F 2B 12 00 04 01 05 81 DC F3 C2 FE EF #...+
0080: D6 E7 B7 BE 87 DA E9 83 E0 DE 89 E2 2D 93 82 54 .....-T
0090: 00 00 00 02 1A 02 24 .....$
```

Full Font Name
(internal application
name): “Arial”

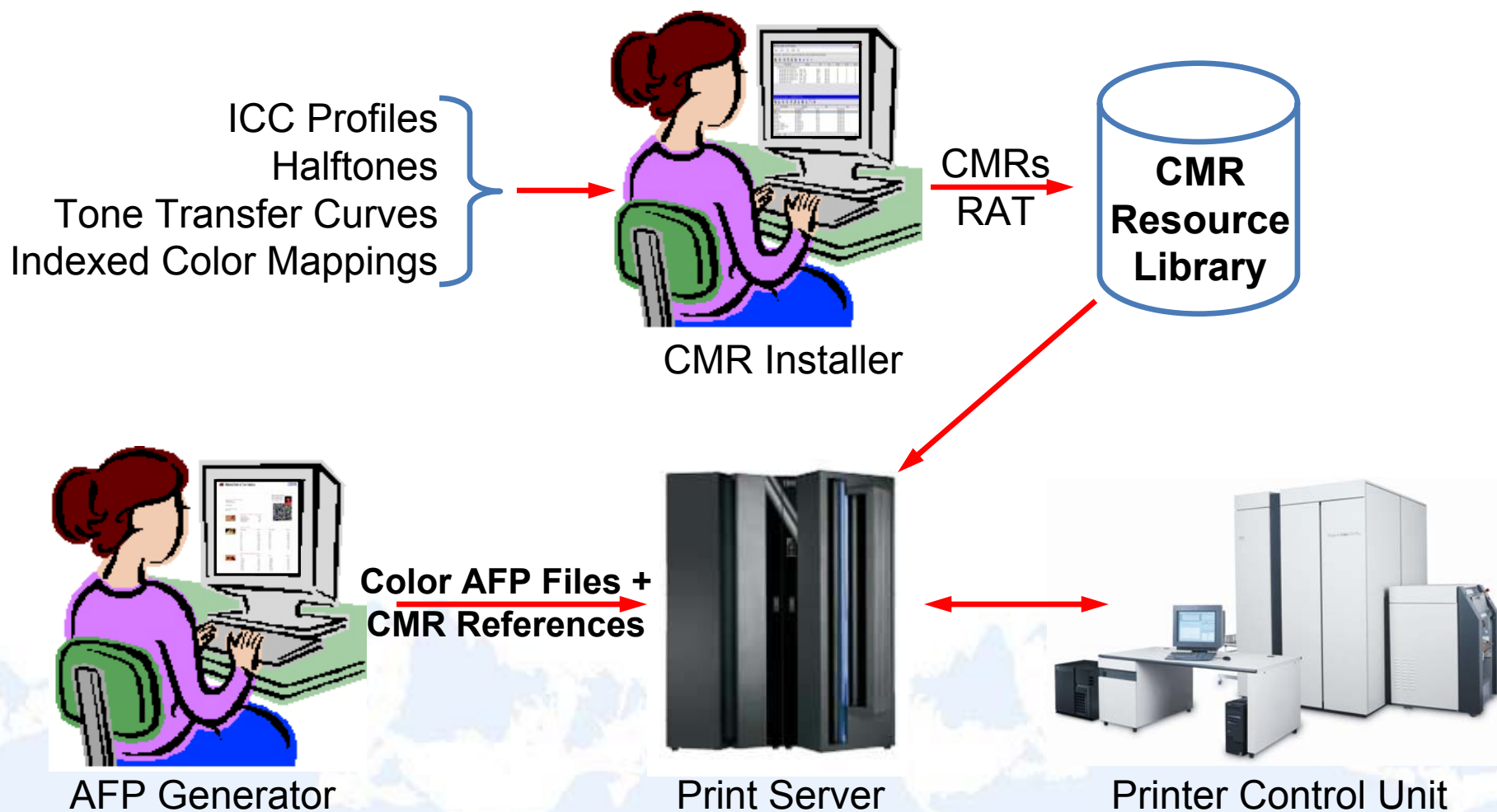
Font File Name
(external): “arial.ttf”

CMR Installer



- ❑ CMRs are installed as resources in an AFP resource library
- ❑ The CMR Installer is part of a new workstation Resource Installer
- ❑ The CMR Installer:
 - uploads the CMR into the resource library of a print server
 - builds the CMR Resource Access Table (RAT) entry that maps the CMR name to a file name, to an object-OID, and possibly to one or more device-specific CMRs

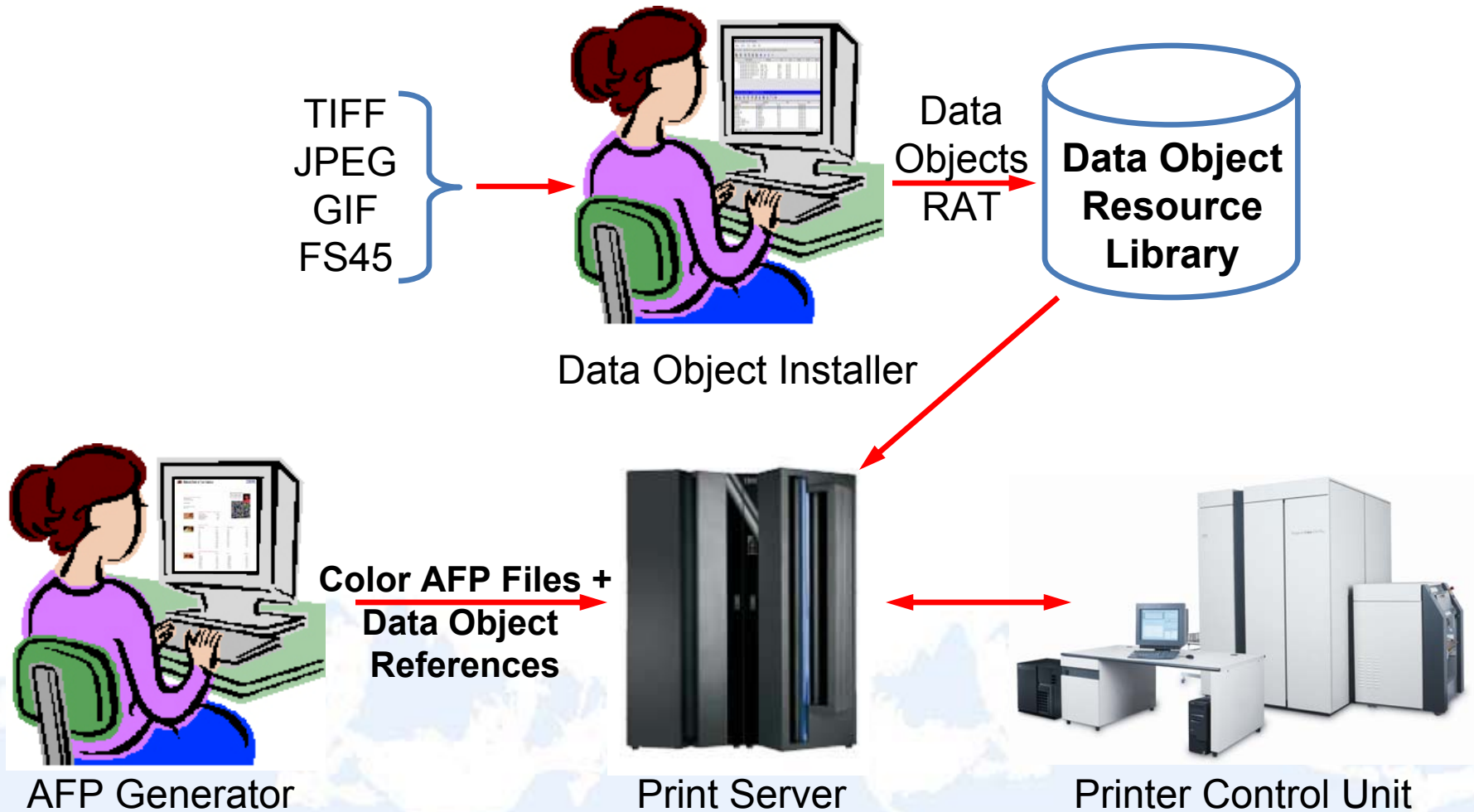
CMRs – System View



Data Object Installer

- ❑ Copies TIFF, JPEG, GIF, FS45, and other color object files, to the Data Object resource library without modification
- ❑ Adds entry to Data Object RAT to associate internal application object name, (object-OID), with the object's external file name
- ❑ Builds Color Conversion CMRs for Data Objects that contain embedded ICC profiles
- ❑ Optionally builds a Compacted Data Object, by removing the embedded ICC profile, to improve object download performance

Data Objects – System View



CMR Usage Scenarios



- “What’s the least amount of work I need to do to get accurate and consistent colors?”
- “I like my output with saturated colors; can I tune the data stream to achieve this regardless of where I print?”
- “I’m very picky and am not afraid of AFP structured fields - can I control the whole process?”

Usage scenario: least amount of work

- ❑ Ensure that every device-dependent color in the printfile is properly defined using audit CC CMRs
 - If all colors created by same device, e.g. same scanner or same digital camera, need only associate the CC CMR for that device at the printfile-level in the FormDef (as an audit CMR)
 - If differently-sourced colors at different levels of the hierarchy, need to associate appropriate CC CMRs as audit CMRs with those document components
- ❑ Don't specify instruction CMRs – let the output device select the appropriate defaults

Usage scenario – tuned, consistent output



- Reference generic instruction TTC/HT CMRs in data stream; output devices will make reasonably consistent adjustment to the output.

Example: Specify following generic CMRs as instruction CMRs for printfile in FormDef:

Generic HT CMR = 106 lpi

Generic TTC CMR = Highlight Midtone

Each output device will apply device-specific CMRs that simulate the requested output appearance

Usage scenario – control it all

- ❑ Ensure that every device-dependent color in the printfile is properly defined using audit CC CMRs
 - If all colors created by same device, e.g. same scanner or same digital camera, need only associate the CC CMR for that device at the printfile-level in the FormDef (as an audit CMR)
 - If differently-sourced colors at different levels of the hierarchy, need to associate appropriate CC CMRs as audit CMRs with those document components
- ❑ Specify instruction CC, HT, and TTC CMRs for the printfile
 - Use device-specific HT and TTC CMRs tuned for the output device
 - Tune CC, HT, and TTC CMRs for the specific output media

Summary: AFP Color Management System

