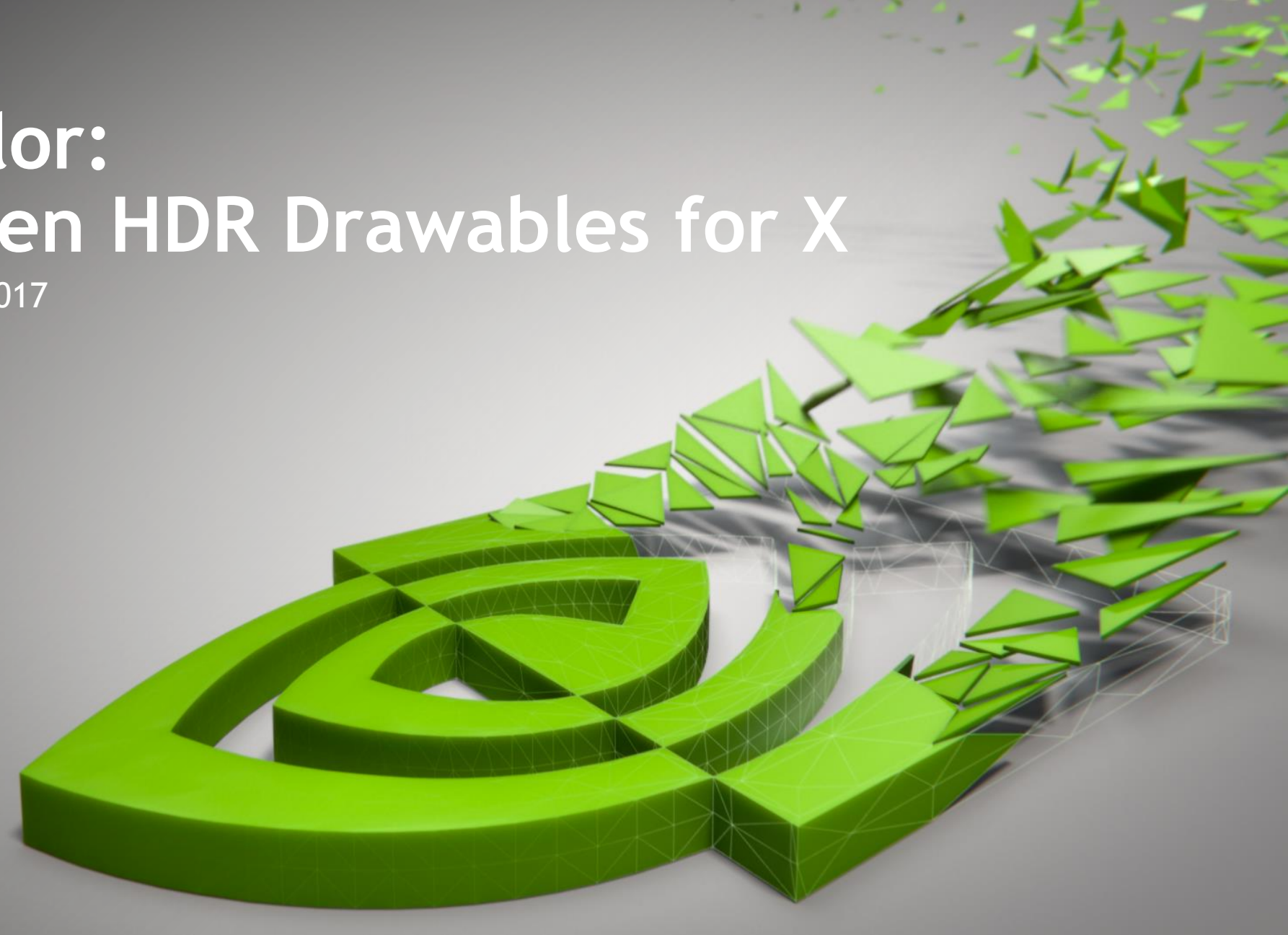
DeepColor: On-Screen HDR Drawables for X

Alex Goins, XDC 2017

NVIDIA



OVERVIEW

Background

Current Status

The Case for a New Visual Class

Extended Visual Info

Window Properties

Control Flow

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Questions

BACKGROUND

HDR *Rendering* As It Stands Today

Many applications already use HDR for rendering

Desire for linearity and preservation of relative brightness

Render into FP16 (aka half-float, 16 bits per component buffer)

“Tone-map” from FP16 to lower precision non-linear, e.g. RGBA8 sRGB drawable

TrueColor/DirectColor Visual Classes are adequate for presenting RGBA8 sRGB

BACKGROUND

HDR *Presentation* Is Needed

New displays support 10 or 12 bit HDR input, e.g. HDR10 (10-bit integer BT.2020 PQ)

Linear HDR formats also needed for composition

Future displays may also support FP16 input

Do not “tone-map” to SDR

CURRENT STATUS

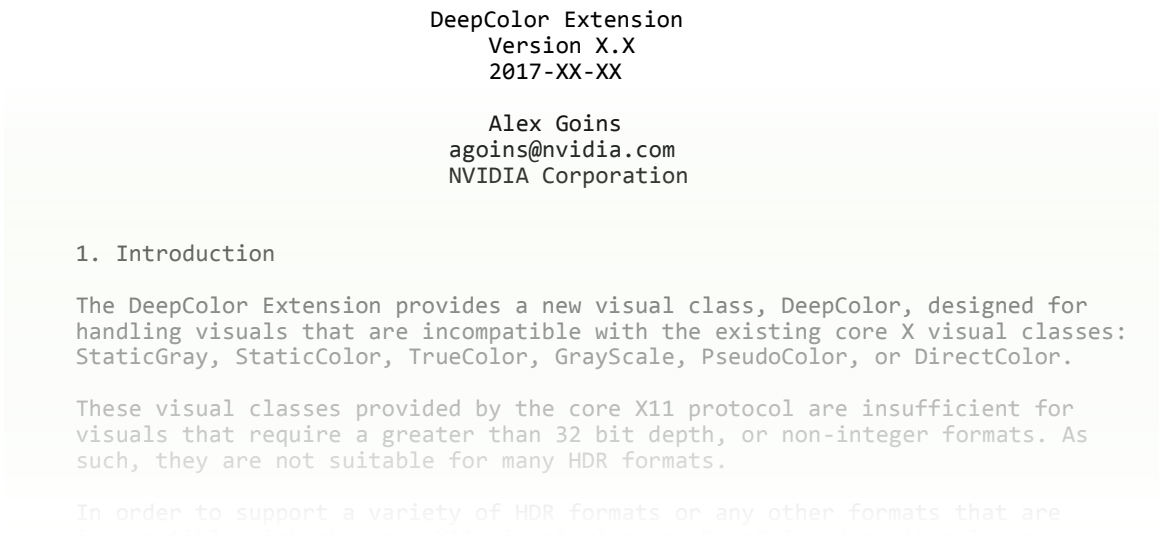
DeepColor X Extension

2nd draft on xorg-devel

Adds new X visual class “DeepColor”

Extra mechanisms for querying new metadata

Protocol perspective, implementation to come



DeepColor Extension
Version X.X
2017-XX-XX

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1. Introduction

The DeepColor Extension provides a new visual class, DeepColor, designed for handling visuals that are incompatible with the existing core X visual classes: StaticGray, StaticColor, TrueColor, GrayScale, PseudoColor, or DirectColor.

These visual classes provided by the core X11 protocol are insufficient for visuals that require a greater than 32 bit depth, or non-integer formats. As such, they are not suitable for many HDR formats.

In order to support a variety of HDR formats or any other formats that are

THE CASE FOR A NEW VISUAL CLASS

THE CASE FOR A NEW VISUAL CLASS

Pixel Formats

```
typedef struct {
        Visual *visual;
        VisualID visualid;
        int screen;
        unsigned int depth;
        int class;
        unsigned long red_mask;
        unsigned long green_mask;
        unsigned long blue_mask;
        int colormap_size;
        int bits_per_rgb;
} XVisualInfo;
```

~~TrueColor~~

~~DirectColor~~

Maximum 32-bit
Only relevant to integers

THE CASE FOR A NEW VISUAL CLASS

Pixel Formats

```
typedef struct {
        Visual *visual;
        VisualID visualid;
        int screen;
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        int class;
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} XVisualInfo;
```

THE CASE FOR A NEW VISUAL CLASS

Color Spaces and Encodings

SDR

sRGB

HDR

BT.2020 PQ BT.2020 HLG

BT.2020 Linear

DCI-P3 Linear DCI-P3 Gamma

ACES AP0 ACES AP1

scRGB Linear

THE CASE FOR A NEW VISUAL CLASS

Design Goals

Support high precision integer and half-float formats

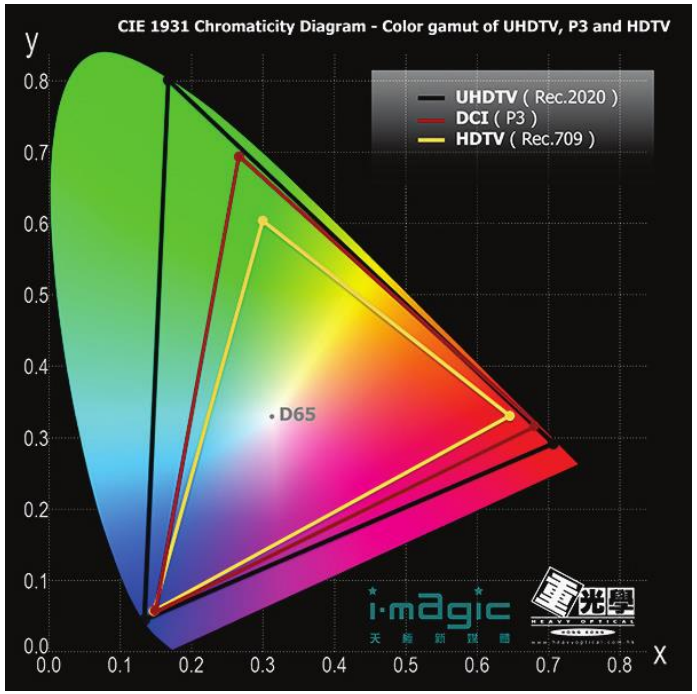
Enumerate set of color spaces and encodings

Flexible selection

Support composite managers (“external compositors”)

Support in-server compositing (“internal compositors”)

Avoid breaking existing applications



EXTENDED VISUAL INFO

EXTENDED VISUAL INFO

DPCGetVisualInfo

struct XVisualInfo is not adequate for describing many HDR pixel formats

Adding additional fields to struct XVisualInfo could complicate compatibility

Follow formula of e.g. EVI and DBE X extensions

Pixel format exposed through extended visual info requested by Visual ID

Changing pixel format requires destroying and recreating drawable with new visual

EXTENDED VISUAL INFO

Pixel Formats

Half-Float

FP_R16G16B16A16

Integer

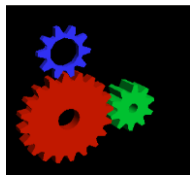
UINT_R16G16B16A16

UINT_A2R10B10G10
UINT_A2B10G10R10

WINDOW PROPERTIES

WINDOW PROPERTIES

Exposing Color Space and Encoding



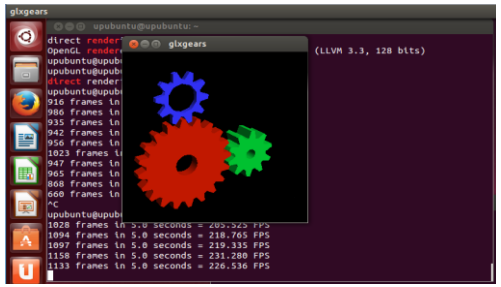
Expose color space and encoding being rendered by application

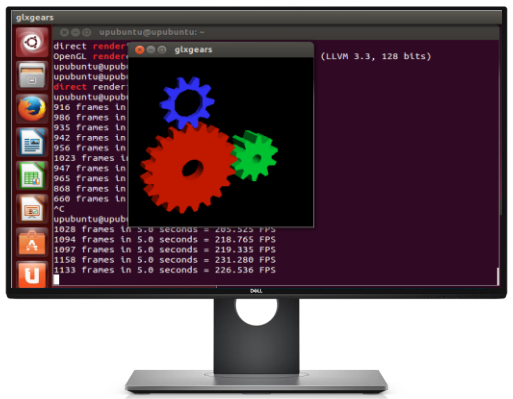
Expose capabilities of compositor

Expose capabilities of display

Support both external and internal compositors

PropertyNotify feedback





WINDOW PROPERTIES

Enumerated color spaces and encodings

Constant definitions describing set of possible color spaces / encoding pairs

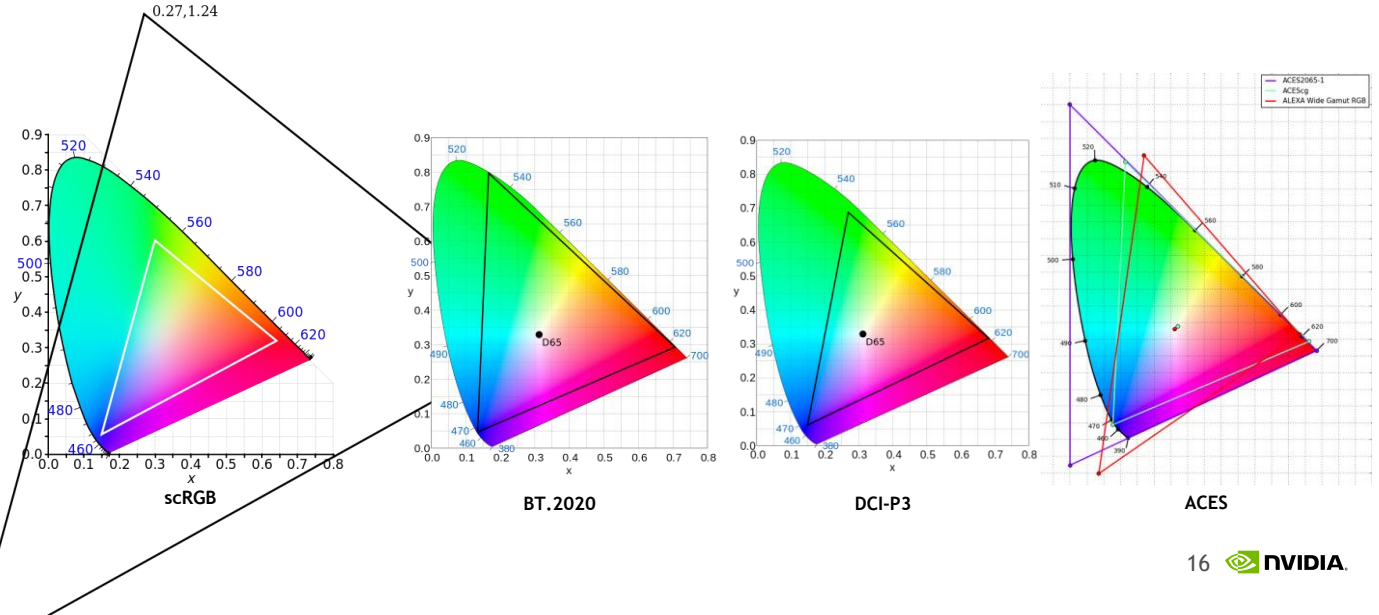
Additional color spaces / encodings require revision of spec

scRGB Linear

BT.2020 Linear, PQ, HLG

DCI-P3 Linear, Gamma

ACES AP0 (Linear), AP1 (Linear)



WINDOW PROPERTIES

Property of Root Window

_DEEPCOLOR_PROPERTIES, WINDOW/32

Global window properties must be associated with root window

Problem: Listening to PropertyNotify events on root window results in spam

Create child of root window named “DEEPCOLOR_PROPERTIES”

Find child via root window property _DEEPCOLOR_PROPERTIES

WINDOW PROPERTIES

Property of “DEEPCOLOR_PROPERTIES”

_DEEPCOLOR_COMPOSITOR_COLORSPACES, colorspace, score, CARDINAL[][2]/32

Set of color spaces and encodings supported by compositor

Initialized by internal compositor, overridden by external compositor

Selection prioritized by score

Target surface should correspond to highest score to minimize conversion overhead

WINDOW PROPERTIES

Property of “DEEPCOLOR_PROPERTIES”

_DEEPCOLOR_DISPLAY_COLORSPACES, colorspace, score, CARDINAL[][2]/32

Set of color spaces and encodings supported by server for display

Initialized by server (X driver)

Used to bootstrap external compositors

Primary mode should correspond to highest score to minimize conversion overhead

Set of color spaces and encodings cannot change, but score can change

WINDOW PROPERTIES

Property of HDR Window

_DEEPCOLOR_COLORSPACE, CARDINAL/32

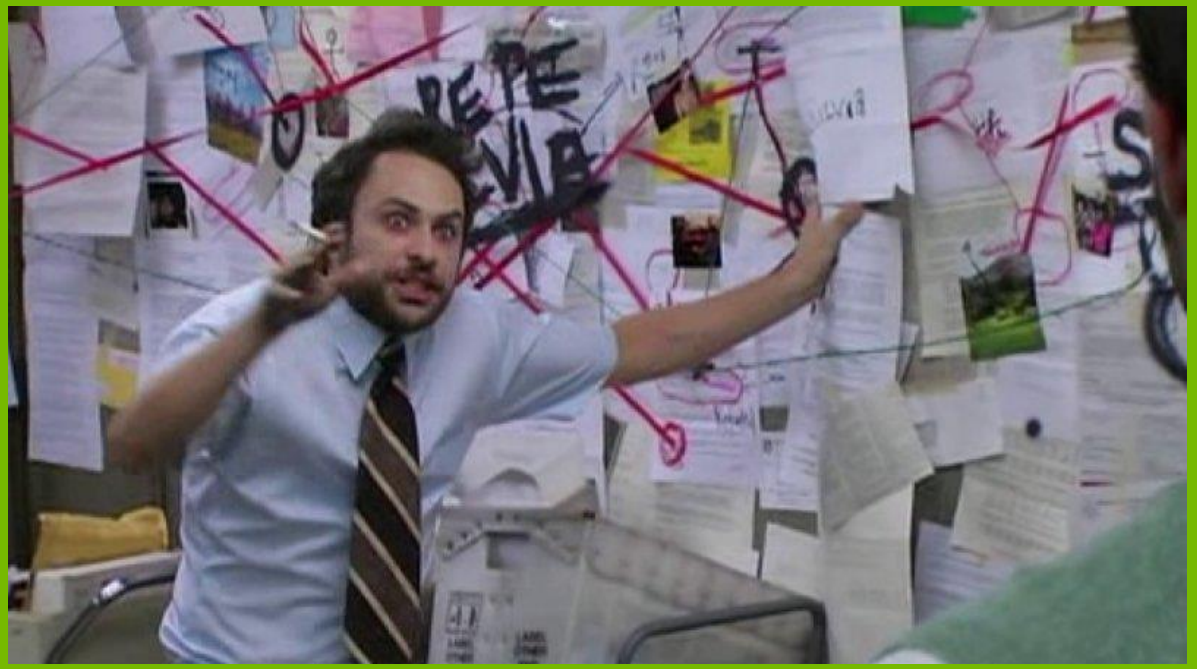
Color space and encoding being used for rendering into window

Selected based on scoring of compositor color spaces

Application must listen for PropertyNotify events to determine if capabilities change

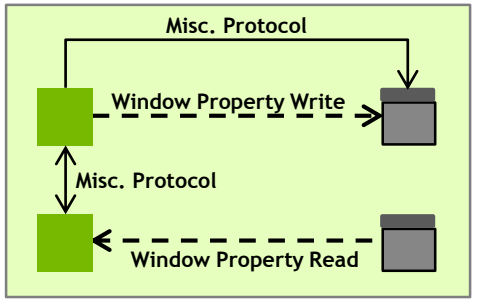
Application may change to any supported option at any time

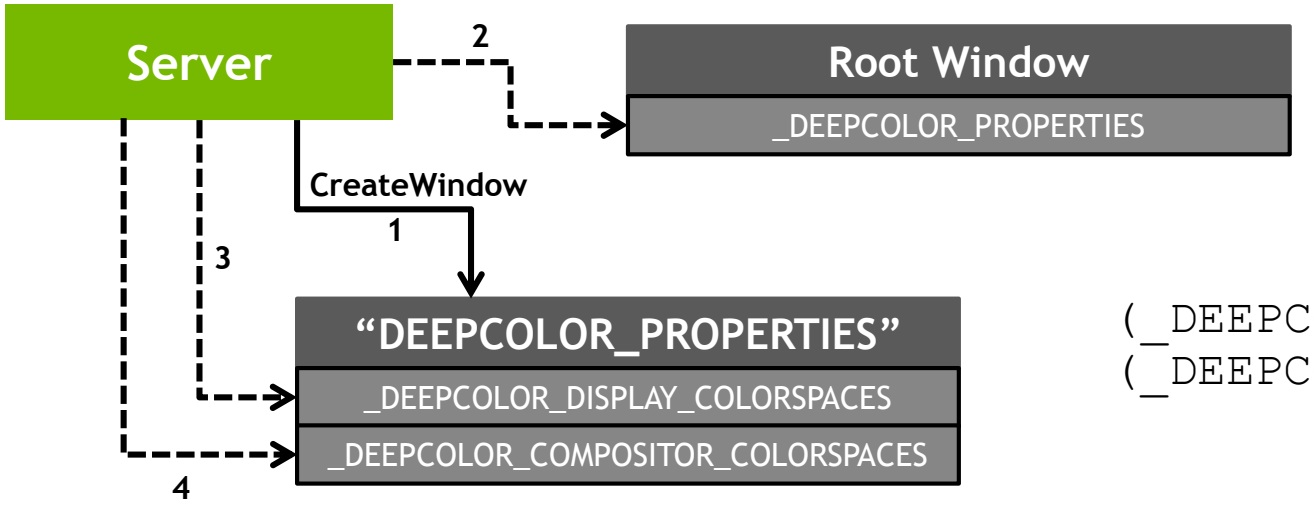
CONTROL FLOW



CONTROL FLOW

Server Initialization



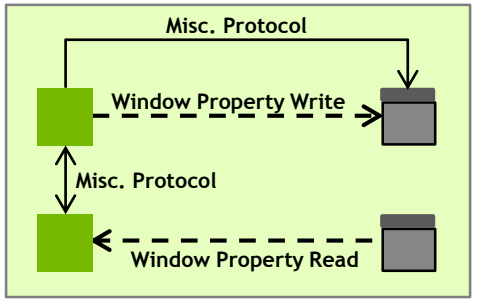



```
(_DEEPCOLOR_BT2020_PQ,          100),
(_DEEPCOLOR_BT2020_LINEAR,       85)
```

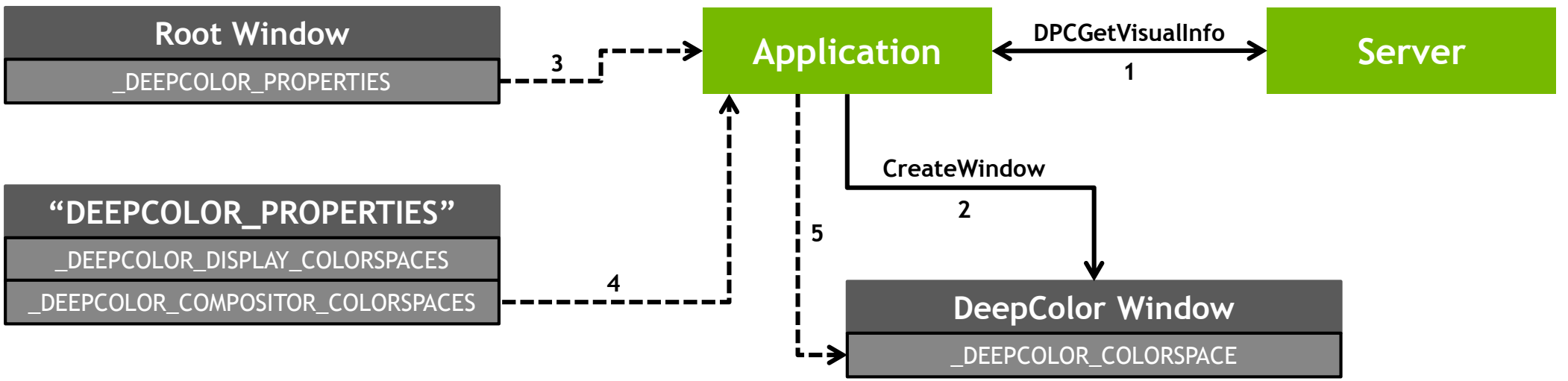
```
(_DEEPCOLOR_BT2020_LINEAR,      100),
(_DEEPCOLOR_BT2020_PQ,           85),
(_DEEPCOLOR_SCRGB_LINEAR,        75)
```

CONTROL FLOW

HDR Window Creation



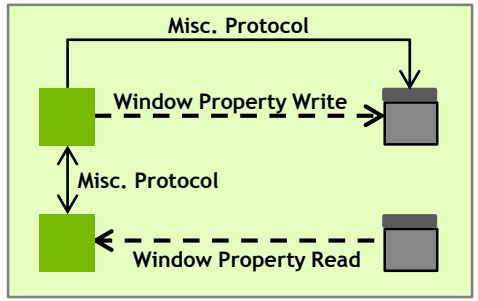
FP_R16G16B16A16



_DEEPCOLOR_BT2020_LINEAR

CONTROL FLOW

HDR-Aware External Compositor Override



RedirectSubwindows

4

Compositor

PropertyNotify

8

1

Root Window

_DEEPCOLOR_PROPERTIES

2

3

"DEEPCOLOR_PROPERTIES"

_DEEPCOLOR_DISPLAY_COLORSPACES

_DEEPCOLOR_COMPOSITOR_COLORSPACES

Server

6

DeepColor Window

_DEEPCOLOR_COLORSPACE

7

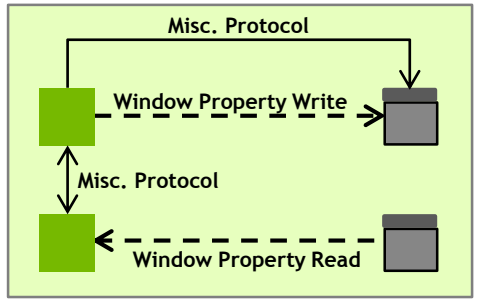
Application

PropertyNotify

5

CONTROL FLOW

HDR-Unaware External Compositor Override



RedirectSubwindows

1

Compositor

Root Window

_DEEPCOLOR_PROPERTIES

"DEEPCOLOR_PROPERTIES"

_DEEPCOLOR_DISPLAY_COLORSPACES

_DEEPCOLOR_COMPOSITOR_COLORSPACES

2

Server

4

DeepColor Window

_DEEPCOLOR_COLORSPACE

5

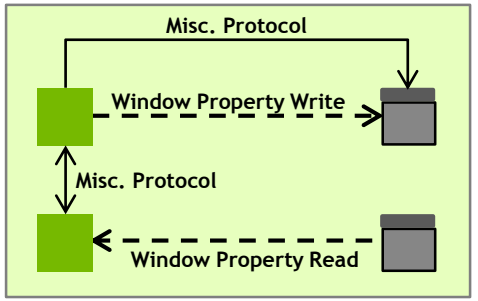
Application

PropertyNotify

3

CONTROL FLOW

Transition Back to Internal Compositor



UnredirectSubwindows
1 (or connection dies)

Compositor

Root Window
_DEEPCOLOR_PROPERTIES

"DEEPCOLOR_PROPERTIES"
_DEEPCOLOR_DISPLAY_COLORSPACES
_DEEPCOLOR_COMPOSITOR_COLORSPACES

2

Server

4

DeepColor Window
_DEEPCOLOR_COLORSPACE

5

Application

PropertyNotify
3

ISSUES

ISSUES

HDR Unaware Clients

DeepColor visuals could cause naïve clients to crash

Suggestion for TrueColor-masquerading DeepColor visuals

Downsample automatic redirection, XGetImage(), core X11 / RENDER rendering

Problem: Duplicate TrueColor visuals could cause unnecessary conversions

Opt-in mechanism via core protocol minor version bump?

ISSUES

DCI-P3 White Point and Gamma

DCI-P3 doesn’t have a defined white point or gamma

Relatively small set of possible white points could be enumerated

Gamma could be anything, varies by display

Additional gamma field in window property tuples?

White point and gamma need to be more clearly documented for other options

ISSUES

Frame-based Color Space Transitions

Applications can change _DEEPCOLOR_COLORSPACE at any time

When does this correspond to a change in rendering?

“Frames” are poorly defined in X without the Present extension

Hand off atomic updating of _DEEPCOLOR_COLORSPACE to Present extension?

ISSUES

EGL and Vulkan Extensions

EGL_EXT_gl_colorspace_*

VK_EXT_swapchain_colorspace

GLX

Definitions of color spaces and encodings need to align

ACKNOWLEDGEMENTS

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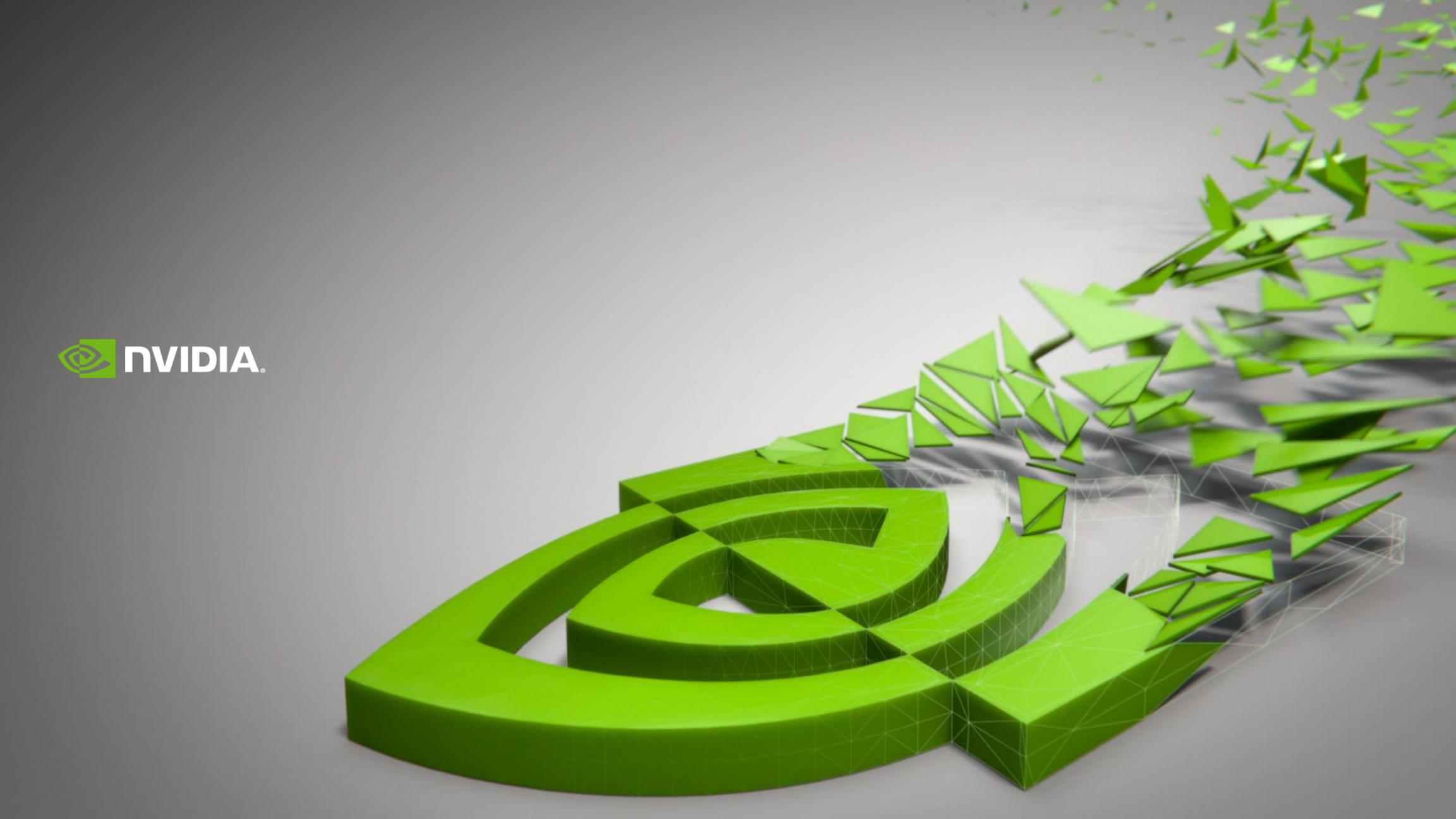
QUESTIONS?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