KATANA

TECHNICAL GUIDE

VERSION 1.6v1

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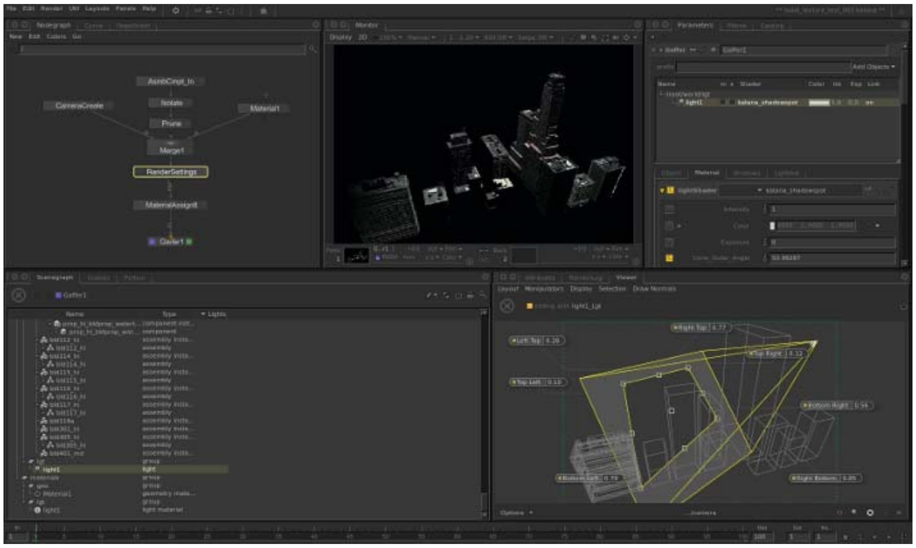
1 Preface

The aim of this guide is to provide an understanding of what Katana is, how it works, and how it can be used to solve real-world production problems. It is aimed at users who are familiar with technical content, such as plug-in writers, R&D TDs, pipeline engineers, and effects uber-artists.



Terminology

To avoid confusion certain terminology conventions are used in this document. These naming conventions are also those used in Katana itself.

- **Nodes**: these are the units used in the Katana interface to build the 'recipe' for a Katana project.
- **Parameters**: these are the values on each node in Katana's node graph. The parameter values on any node can be set interactively in the graphical user interface, or can be set using animation curves or expressions
- **Scene Graph**: this is a hierarchical set of data that can be presented to a renderer or any output process. Examples of data that can be held in the scene graph can include geometry, particle data, lights, instances of shaders and global option settings for renderers.
- **Locations**: the units that make up the scene graph hierarchy. Many other 3D applications refer to these as nodes, but we will refer to them as locations to avoid confusion with the nodes used in the node graph.

2 Katana For The Impatient

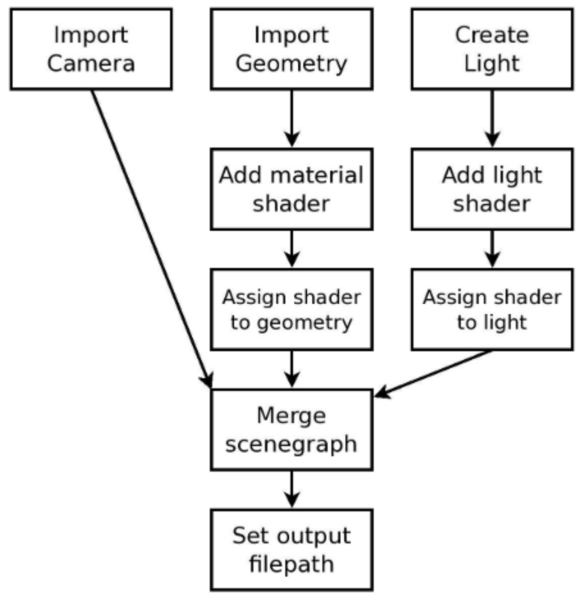
This guide starts at the point Katana is installed, and licensed. For more information on installation and licensing, see the Installation and Licensing chapter in the User Guide.

What Is Katana?

Essentially Katana is a system that allows you to define what to render by using filters that can create and modify 3D scene data. If you're familiar with concepts such as RenderMan's Procedurals and riFilters, think of Katana as being like Procedurals and riFilters on steroids, with a node based interface to define which filters to use, and interactively inspect their results.

Using filters you can arbitrarily create and modifiy scene data. You can, for example:

- Bring 3D scene data in from disk, such as from an Alembic geometry cache or camera animation data.
- Create a new instance of a material, such as a RenderMan or Arnold shader.
- Create cameras and lights.
- Manipulate transforms on cameras, lights and other objects.
- Use rule based expressions to set what materials are assigned to which objects.
- Isolate parts of the scene for different render passes.
- Merge scene components from a number of partial scenes.
- Specify which outputs - such as RenderMan AOVs - you want to use to render multiple- passes in a single renderer.
- Use Python scripting to specify arbitrary manipulation of attributes at any location in the scene hierarchy.



The scene data to be delivered to the renderer is described by a tree of filters, and the filters are evaluated on demand in an iterative manner. Katana is designed to work well with renderers that are capable of deferred recursive procedurals, such as RenderMan and Arnold. Using recursive procedurals, the tree of filters is handed directly to the renderer, with scene data calculated on demand, as the renderer requests it (lazy-evaluation). This is typically done by a procedural inside the renderer that uses Katana libraries, during render, to generate scene data from the filter tree.

Katana can also be used with renders that don't support procedurals or deferred evaluation, by running a process that evaluates the Scene Graph and writes out a scene description file for the renderer. This approach is without the benefits of deferred evaluation at render time, and the scene description file may be very large.

NOTE: Since Katana's filters deliver per-frame scene data in an iterable form, Katana can also be used to provide 3D scene data for processes other than renderers.

At its core, Katana is a system for the arbitrary creation, filtering and processing of 3D scene data, with a user interface primarily designed for the needs of look development and lighting. Katana is also designed for the needs of power users, who want to create custom pipelines and manipulate

3D scene data in advanced ways.

A Short History of Katana

The problems Katana was originally designed to solve were of scalability and flexibility. How to carry out look development and lighting in a way that could deal with potentially unlimited amounts of scene data, and be flexible enough to deal with the requirements of modern CG Feature and VFX production for customized work-flows, and capability to edit or override anything.

Katana's initial focus was on RenderMan, particularly how to harness the power of RenderMan's recursive procedurals. In a RenderMan procedural it is possible to perform arbitrary creation of scene data on demand, but their full capabilities are rarely exploited.

The Katana approach is to have a single procedural powerful enough to handle arbitrary generation and filtering. Essentially a procedural given a custom programe in the form of a tree based description of filters. At render time, Katana's libraries are called from within this procedural to calculate scene data as the renderer demands it.

Scene Graph Iterators

The key to the way Katana executes, filters, and delivers scene data on demand, is that scene data is only ever accessed through iterators. These iterators allow a calling process (such as a renderer) to walk the scene graph and examine any part of the data on request. Since that data can be generated as needed, a large scene graph state doesn't have to be held in memory.

In computer science terms, it is the responsibility of the calling process to maintain its own state. Katana provides a functional representation of how the scene graph should be generated, that can be statelessly lazily-evaluated.
At any location in the scene hierarchy Katana provides an iterator that can be asked:

- What named attributes there are at that location?
- What are the values for any named attribute (values are considered to be vectors of time sampled data)?
- What are the child and sibling locations (if any)?

An understanding of Katana iterators is key to writing new Katana plug-ins to generate and modify scene data. Understanding how scene data is calculated on-demand is important for understanding how to make good, efficient use of Katana. In particular, how input file formats, such as Alembic - which can supply data efficiently, on demand - are potentially much better to use with Katana than formats that have to load all data in one pass.

The Katana User Interface

Katana allows users to create recipes for filters, using a familiar node based user interface (UI). In the UI the user can also interactively examine the scene at any point in the node tree, using the same filters that the renderer runs at render time (but executed in the interface).

When running through the UI, filters are only run on the currently exposed locations in the scene graph hierarchy. This means the user can inspect the results of filters on a controlled subset of the scene.

The way users can view the scene generated at any node is similar to the way users of 2D node-based compositing packages can view composited frames at any node. For users accustomed to conventional 3D packages that have a single 3D scene state it can be a surprise that there is essentially a different 3D scene viewable at each node. Instead of the scene graph being expanded as rays hit bounding boxes it is iterated as the user opens up the scene graph hierarchy in the UI. Complexity is controlled by only executing filters on locations in the scene graph that the user has expanded.

A scene does not need to be entirely loaded in order to be lit. In Katana, you create recipes that allow scene data to be generated, rather than directly authoring the scene data itself. It is only the renderer that needs the ability to see all of the scene data, and then only when it needs it. Katana provides access to any part of the scene data if you need to work on it. You can set an override deep in the hierarchy or, examine what attribute values are set when the filters run, but you can work with just a subset of the whole scene data open at a time. This is key to how Katana deals with scenes of potentially unlimited complexity.

NOTE: As Katana uses procedurally defined iterators, it's possible to define an infinitely sized scene graph, such as a scene graph defining a fractal structure. An infinite scene graph can never be fully expanded, but you can still work with it in Katana, opening it to different depths, and using rule based nodes to set up edits and overrides.

Katana in Look Development and Lighting

Katana's scene generation and filtering are presented as a primary artist facing tool for look development and lighting by having filter functions that allow you to perform all of the classic operations carried out in look development and lighting, such as:

- Creating instances of shaders, or materials, out of networks of components
- Assigning shaders to objects
- Creating lights
- Moving lights
- Changing visibility flags on objects
- Defining different render passes

Katana's node-based interface provides a natural way to create recipes of which filters to use. Higher level operations that may require a number of atomic level filters working together can be wrapped up in a single node so that the final user doesn't have to be concerned with every individual fine-grain operation. Multiple nodes can also be packaged together into single higher level compound nodes (Groups, Macros and Super Tools).

Technical Docs and Examples

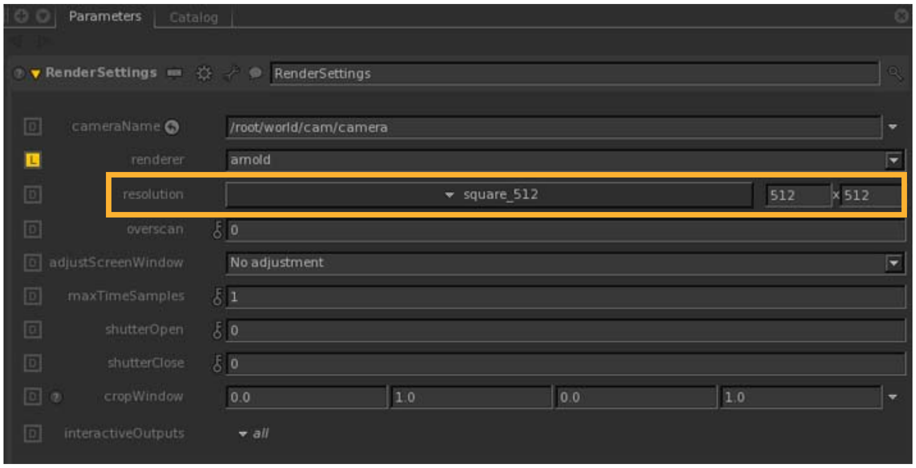
Technical documents and reference examples of specific parts of Katana can be found in the Katana installation in ${KATANA_ROOT}/docs/

3 Custom Render Resolutions

You can define custom render resolutions to supplement or replace Katana's pre-defined resolutions. You can define resolutions in Katana through the UI, using Python, by modifying the Katana resolutions XML file, or by creating your own XML file of resolutions.

Using the UI

You can set the render resolution through any node with a **resolution** field, such as a RenderSettings or ImageColor node. Each node with a **resolution** field has a dropdown menu of pre-defined resolutions, and text entry boxes for manual definition.



Resolutions defined manually are saved —and recalled— with the Katana project, but are not saved for use in other Katana projects. If you select a pre-determined resolution, that selection is saved —and recalled— with the Katana project.

NOTE: The **resolution** field in the **Tab** > **Project Settings** window specifies the resolution for 2D image nodes, not 3D renders.

Modifying the Resolutions XML

The default Katana resolutions are specified in **FoundryResolutions.xml** in ${KATANA_ROOT}/plugins/Resources/Core/Resolutions. You can edit this file directly to add, modify or delete entries. The resolutions are all nested in <formats> elements and take the form:

```
<format width="[int]" height="[int]" pixelAspect="[float]"
name="[string]" groupName="[string]"/>
```

You can edit existing resolutions, or add resolutions within the <format> tags, using the existing form.

Using a Custom Resolutions XML

You can use custom resolutions in an **.xml** file by placing it in a **Resolutions** subdirectory of any location specified in your KATANA_RESOURCES environment variable. This adds the new resolutions specified in your **.xml** file to the resolutions supplied with Katana.

You can also specify a KATANA_RESOLUTIONS environment variable, and point it to the location of a new resolutions **.xml** file. This replaces the resolutions supplied with Katana with the contents of the new **.xml** file.

Using The Python API

To define new resolutions for use in a single Katana project (as with manual definitions specified through the UI), start Katana in UI mode, and in the Python tab enter:

```
from Katana import ResolutionTable;

resolutionTable = ResolutionTable.GetResolutionTable();
r1 = resolutionTable.createResolution(1000, 1000, name="1K",
groupName="Thousands");
r2 = resolutionTable.createResolution(2000, 2000, name="2K",
groupName="Thousands");
r3 = resolutionTable.createResolution(3000, 3000, name="3K",
groupName="Thousands");

resolutionTable.addEntries([r1, r2, r3]);
```

TIP: Using Python to set the render resolution means you can make that resolution conditional on data read from the Node Graph.

The **createResolution()** function takes in two ints, to specify width and height in pixels, and two strings to specify a name, and group name. It creates a new resolution with the given width, height and name, and makes it available in the specified group.

Resolutions entered this way expire with the Katana session. Using the **ResolutionTable** Python API, you can use **createResolutions()** in Python startup scripts, making them persistent across Katana sessions. To do this, add the code above —or your variant of it— to one of Katana's startup scripts. These are files named **init.py**, located in a **Startup** folder, under the path defined in the KATANA_RESOURCES environment variable. Alternatively, you can use a startup script in the form of an **init.py** file placed in the **.katana** folder in your $HOME directory.

4 CUSTOM NODE COLORS

You can set the display color of individual nodes through the UI by selecting a node, then choosing **Colors** > then a color from the presets available in the Node Graph's **Colors** menu.

You can also apply a custom color by selecting a node, then choosing **Colors** > **Set Custom Color**, which brings up a color picker window.

NOTE: To reset a node's color back to the Katana default, select the node, then choose **Colors** > **None**.

You can also define colors for groups of nodes using Python, and apply those changes across your project.

Flavors and Rules

Node colors are defined in **rules**. Rules consist of a rule name, and an RGB color value. Rules are applied to flavors, and a **flavor** is a list of node types.

Rules contain the name of the flavor to apply to in the form of a string, and an RGB value, in the form of three 0 - 1 range floats. To see a list of defined rules, run the following in the Python tab:

```
import Nodes2DAPI.NodeColorDelegate
print( Nodes2DAPI.NodeColorDelegate.rules )
```

You should see something like the following, which is a list of the rules defined with Katana as shipping:

```
[
( 'filter', ( 0.345, 0.300, 0.200 ) ),
( 'keying', ( 0.200, 0.360, 0.100 ) ),
( 'composite', ( 0.450, 0.250, 0.250) ),
( 'transform', ( 0.360, 0.250, 0.380 ) ),
( 'color', ( 0.204, 0.275, 0.408 ) ),
( 'SHOW_MACROS', ( 0.010, 0.010, 0.010 ) ),
( 'SPI_MACROS', ( 0.010, 0.010, 0.010 ) ),
( None, None )
]
```

Each individual rule follows the form:

```
( 'flavorName', ( R value float, G value float, B value float ) )
```

Editing Rules

You can edit rules, and add new ones, by overwriting list entries using **Nodes2DAPI.NodeColorDelegate**. For example, to edit the color associated with the flavour **composite** to pure red, enter the following in the Python tab:

```
Nodes2DAPI.NodeColorDelegate.rules[ 2 ] = ( 'composite', ( 0, 0, 1 ) )
```

Creating New Rules

You can create a new rule using:

```
NodegraphAPI.Flavor.AddNodeFlavor( 'nodeName', 'flavorName')
```

To append a rule to the active rules use:

```
import Nodes2DAPI.NodeColorDelegate
Nodes2DAPI.NodeColorDelegate.rules.append( 'nodeName', 'flavorName' )
```

Editing Flavors

Flavors are collections of node types. You can see a list of all flavours in use in a recipe by entering:

```
print( NodegraphAPI.GetAllFlavors() )
```

You should see something like the following, which is a list of the flavors defined with Katana as shipping:

```
[ '2d', '3d', '_dap', '_hide', '_macro', '_supertool',
'analysis', 'color', 'composite', 'constraint', 'filter',
'i/o', 'input', 'lookfile', 'output', 'procedural',
'resolve', 'source', 'transform' ]
```

You can see a list of all nodes that comprise a particular flavour by entering:

```
NodegraphAPI.GetFlavorNodes( 'flavorName' )
```

For example, to see a list of all nodes in the flavour **color**, enter:

```
print( NodegraphAPI.GetFlavorNodes( 'color' ) )
```

You should see something like the following, which is a list of the members of the flavor **color**, with Katana as shipping:

```
['ImageBrightness', 'ImageBackgroundColor',
'ImageChannels', 'CompressRange', 'ImageContrast',
'ImageExposure', 'ImageFade', 'ImageGain', 'ImageGamma',
'ImageInvert', 'Lab', 'OCIOCDLTransform', 'OCIOColorSpace',
'OCIODisplay', 'OCIOFileTransform', 'OCIOLogConvert',
```

```
'OCIOLookTransform', 'ImageSaturation', 'ImageClamp',
'ImageLevels', 'ImagePixelStats', 'ImageThreshold']
```

NOTE: Flavor assignments are stored on the node itself, and each node can have multiple assignments. If competing rules overlap on the same node type, the first rule applied wins.

Creating New Flavors

To add a new flavor, enter the following in the Python tab:

```
NodegraphAPI.Flavor.AddNodeFlavor( 'nodeName', 'flavorName' )
```

For example, to add the node type Render to a flavor called myRenderFlavor, enter the following:

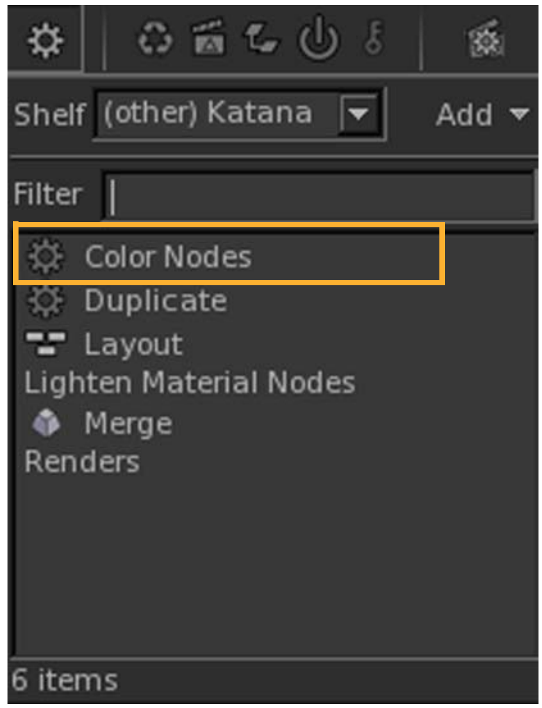
```
NodegraphAPI.Flavor.AddNodeFlavor( 'Render', 'myRenderFlavor' )
```

NOTE: If you want to completely customize node creation, you can also create a class derived from **NodegraphAPI.NodeDelegateManager.SuperDelegate** with a function called processNodeCreate() with one parameter that receives a newly created node:

```
class
MySuperDelegate(NodegraphAPI.NodeDelegateManager.SuperDel
egate):
        def processNodeCreate(self, node):
            print("Processing new node %s..." % node)


NodegraphAPI.NodeDelegateManager.RegisterSuperDelegate(My
SuperDelegate())
```

Updating Node Colors

New rules and flavors created, and applied by entering in the Python tab are not retrospectively applied to existing nodes in the Node Graph. To apply changes to existing nodes, choose the Color Nodes shelf item from the main  menu.



Making Updates Persist

Rules and flavors created or modified this way expire with the Katana session. Using the **Nodegraph** and **Nodes2DAPI.NodeColorDelegate** Python APIs, you can include your rules and flavor changes in Python startup scripts, making them persistent across Katana sessions. To do this, add your code to one of Katana's startup scripts. These are files named **init.py**, located in a **Startup** folder, under the path defined in the KATANA_RESOURCES environment variable. Alternatively, you can use a startup script in the form of an **init.py** file placed in the **.katana** folder in your $HOME directory.

Flavor API

API	Usage
NodegraphAPI.Flavor	
AddNodeFlavor( )	Adds a new flavor Syntax: Takes two strings, the node type, and the flavor name. AddNodeFlavor('nodeType', 'flavorName') Example: NodegraphAPI>Flavor.AddNodeFlavor('Render', 'myNewFlavor') Adds nodes of type **Render** to a new flavor named **myNewFlavor**.
ClearFlavorNodes( )	Clears all entries in a flavor Syntax: Takes a single string, the flavor name. ClearFlavorNodes('flavorName') Example: NodegraphAPI.Flavor.ClearFlavorNodes('myFlavor') Clears all entries in the flavor named **myFlavor**.
GetAllFlavors( )	Gets a list of all flavors. Syntax: Takes no arguments Example: NodegraphAPI.Flavor.GetAllFlavors()
GetFlavorNodes( )	Gets a list of all nodes in a given flavor. Syntax: Takes a single string, the name of the flavor. GetFlavorNodes('flavorName') Example: NodegraphAPI.Flavor.GetFlavorNodes('2d') Gets a list of all nodes in the flavor named **2d**.

API	Usage
NodegraphAPI.Flavor	
GetNodeFlavors( )	Gets a list of the flavors stored on a given node. Syntax: Takes a single string, the name of the node type. GetNodeFlavors('nodeType') Example: NodegraphAPI.Flavor.GetNodeFlavors('Merge') Gets a list of all flavors stored on the node type **Merge**.

API	Usage
NodegraphAPI.Flavor	
NodeMatchesFlavors( )	Checks to see if a specified node is in a specified flavor, and not in any specified ignore flavors. Returns a Boolean. Syntax: Takes three strings, node type, flavor to match, and ignore flavors. The node type must be a single string, while flavor, and ignore flavors can be any sequence of strings. Flavor, and ignore flavors can each also be None. NodeMatchesFlavors('nodeType', 'matchFlavors', 'ignoreFlavors') Examples: To check if a the node type Merge is in the flavor 3d, but not in the flavor 2d: NodegraphAPI.Flavor.NodeMatchesFlavor('Merge', '3d', '2d') Returns **True**. To just check if the node type Merge is the the flavor 3d: NodegraphAPI.Flavor.NodeMatchesFlavor('Merge', '3d', None) Returns **True**. To check if the node type Merge is not in the flavor 2d: NodegraphAPI.Flavor.NodeMatchesFlavors('Merge', None, '2d') Returns **True**.
RemoveNodeFlavor( )	Deletes a flavor. Syntax: Takes a single string, the name of the flavor to remove. RemoveNodeFlavor('flavorName') Example: NodegraphAPI.Flavor.RemoveNodeFlavor('myFlavor') Removes the flavor named **myFlavor**.

5 Message Logging

Error, warning, and informational messages are logged in Katana using the logging module of the Python Standard Library. Messages are logged from contexts including the **Python** tab, shelf scripts and Python startup scripts.

NOTE: More information on logger objects in Python is available in the Python documentation.

You can filter the level of message generated, and the level of message displayed. For more on how to filter the level of message generated see the **Installation and Licensing** > **Configuring Message Level** section in the User Guide. For more on displaying messages, and filtering the level of message displayed, see the **Customizing Your Workspace** > **Message Center** section in the User Guide.

Message Levels

Katana recognises the following standard log message levels from the Python logging module:

- info
- warning
- error
- critical
- debug

Loggers

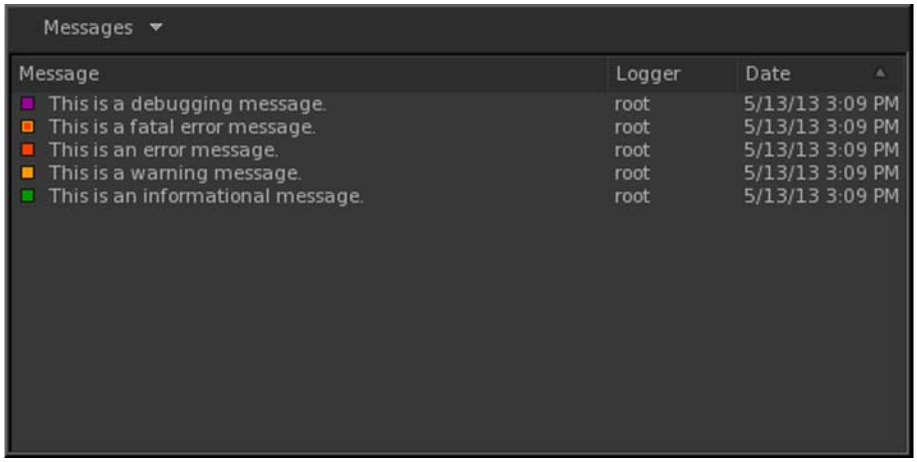
There are two ways of logging messages from a Python context:

- Directly through the Loggers.
- Through a Custom Logger.

Root Logger

The following example logs a message of each supported type, through Python's root logger:

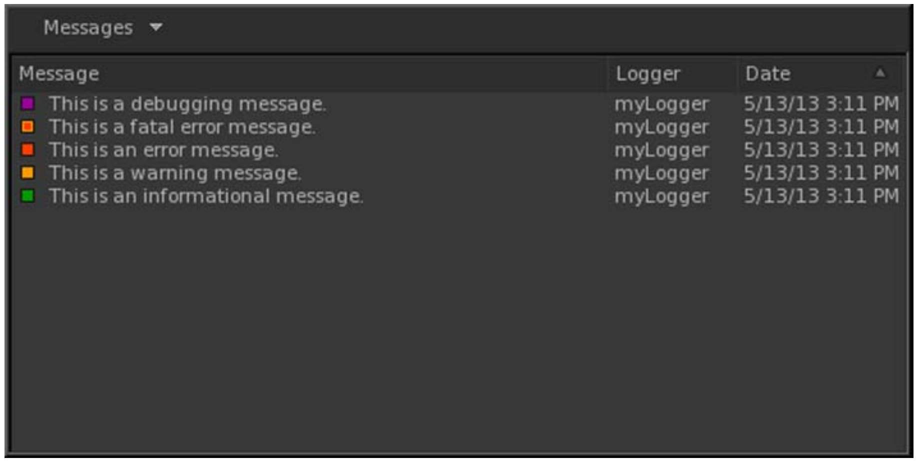
```
import logging

logging.info("This is an informational message.")
logging.warning("This is a warning message.")
logging.error("This is an error message.")
logging.critical("This is a fatal error message.")
logging.debug("This is a debugging message.")
```



Custom Logger

Instead of using the root logger, you can create a custom logger object. The following example creates a custom logger and generates a message of each level using that logger:

```
import logging

log = logging.getLogger("myLogger")
log.info("This is an informational message.")
log.warning("This is a warning message.")
log.error("This is an error message.")
log.critical("This is a fatal error message.")
log.debug("This is a debugging message.")
```



NOTE: The Message level display option in the Messages window is independent of the level of message actually generated. For example, if the Messages window is set to show debug messages, debug messages will only actually be displayed if the level of message generated is also set to include debug.

See **Installation and Licensing** > **Configuring Message Level** in the User Guide for more on how to set the level of message generated..

Logging Exceptions

Exceptions can be logged in a way that automatically includes traceback information in the log message, as in the following example:

```
import logging

try:
    i = 1 / 0
except Exception as exception:
    logging.exception("Error in computation: %s"
                      % str(exception))
```

Run in the **Python** tab, this produces a log message with the following text:

```
Error in computation: float division
Traceback (most recent call last):
    File "<string>", line 4, in <module>
ZeroDivisionError: float division
```

6 KATANA LAUNCH MODES

Launching Katana

You can start Katana in a number of different modes, using command line arguments to start the application:

Interactive	no flags	Runs Katana with the standard GUI.
Batch	--batch	Runs Katana without a GUI to render the output of a specific node in the NodeGraph.
Script	--script	Runs Katana without a GUI, and executes the specified python script.
Shell	--shell	Runs Katana without a GUI, and allows python commands to be run interactively.

Interactive Mode

Interactive mode is the default mode, requiring no additional command line arguments. It also loads additional modules, such as the ScenegraphManager. Interactive is the only mode that launches Katana with the GUI.

To start Katana in Interactive mode:

1. Open a terminal.
2. Navigate to the directory where you installed Katana.
3. Enter:
   ```
   ./katana
   ```
   If a license is present, the interface displays. Otherwise, you need to license Katana. See the Licensing Katana chapter in the User Guide for more on this.

You can also specify a Katana scene to load. To start in Interactive mode, and open a specified Katana scene:

1. Open a terminal.
2. Navigate to the directory where you installed Katana.
3. Enter:
   ```
   ./katana /yourDirectory/yourScene.katana
   ```

You can also specify an asset ID using the --asset flag, to resolve and open a file from your asset management system. The --asset flag takes a single argument, which is the asset ID to resolve. For example:

```
./katana --asset-mock:///show/shot/name/version
```

NOTE: The format of the asset ID iteself is dependent on your assest management system, and the file you attempt to resolve must be a valid Katana scene.

NOTE: The --asset flag also applies to Katana's Batch mode.

For more on Katana's Asset API see the Asset Management System Plug-in API chapter.

Batch Mode

Batch mode is used to start render farm rendering. Batch mode requires the --batch flag, and at least three arguments; --katana-file, --render-node, and -t flags. These arguments give —respectively— the Katana scene to render, the Render node to render from, and the frame range to render.

For example, to start rendering a Katana scene called **yourScene.katana**, at Render node **renderHere**, from frame 1 to frame 1000:

1. Open a terminal.
2. Navigate to the directory where you installed Katana.
3. Enter:

```
./katana --batch --katana-file=/yourDirectory/yourScene.katana --
render-node=renderHere -t 1-1000
```

The following options apply to Batch mode:

Option	Usage
--katana-file	Specifies the Katana recipe to load. Syntax: --katana-file=<filename> Example: ./katana --batch **--katana-file=/tmp/test.katana** --t=1 --render-node=beauty
--asset	Specifies the asset ID to resolve. Syntax: --asset-<asset ID> Example: ./katana --asset-mock:///show/shot/name/version

Option	Usage
-t or --t	Specifies the frame range to render. Syntax: -t <frame range> OR --t=<frame range> Where <frame range> can take the form of a range (such as 1-5) or a comma separated list (such as 1,2,3,4,5). These can be combined, for instance: 1-3,5. The previous example would render frames 1, 2, 3, and 5. Example: ./katana --batch --katana-file=/tmp/test.katana **--t=1-5,8** --render-node=beauty
--threads2d	Specifies the number of additional processors within the application. An additional processor is also used for Katana's main thread. This means that Katana uses 3 processors when --threads2d=2. Syntax: --threads2d=<num threads> Example: ./katana --batch --katana-file=/tmp/test.katana --t=1 **--threads2d=2** --render-node=beauty
--threads3d	Specifies the number of simultaneous threads the renderer uses. Syntax: --threads3d=<num threads> Example: ./katana --batch --katana-file=/tmp/test.katana --t=1 **--threads3d=8** --render-node=beauty
--render-node	Specifies the Render node from which to render the recipe. Syntax: --render-node=<node name> Example: ./katana --batch --katana-file=/tmp/test.katana --t=1 **--render-node=beauty**

Option	Usage
--render-internal-dependencies	Allows any render nodes that don't produce **asset** outputs to be rendered within a single katana --batch process. Asset outputs are determined by asking the current asset plugin if the output location is an assetId, using **isAssetId()**. The default **file** asset plugin that ships with Katana classes everything as an asset. So at present it is not possible to render any dependencies within one katana --batch command without customising the asset plugin.
--render	
--crop-rect	Specifies which part of an image to crop. The same cropping area is used for all renders. Syntax: --crop-rect=<left>,<bottom>,<width>,<height> Example: ./katana --batch --katana-file=/tmp/test.katana --t=1 --render-node=beauty **--crop-rect=0,0,256,256**
--setDisplayWindowToCropRect	Syntax: Example:

Option	Usage

--tile-render	Used to render one tile of an image divided horizontally and vertically into tiles. For instance, using --tile-render=1,1,3,3 splits the image into 9 smaller images (or tiles) in a 3x3 square and then renders the middle tile as the index for tile renders starts at the bottom left corner with 0,0. In the case of 3x3 tiles, the indicies are:
	`0,2    1,2    2,2`
	`0,1    1,1    2,1`
	`0,0    1,0    2,0`
	The results are saved in the same location as specified by the RenderOutputDefine node but with a tile suffix. For instance: tile_1_1.beauty.001.exr
	Syntax:
	--tile-render=<left_tile_index>, <bottom_tile_index>, <total_tiles_width>, <total_tiles_height>
	Example:
	./katana --batch --katana-file=/tmp/test.katana --t=1
	--render-node=beauty **--tile-render=0,0,2,2**
	./katana --batch --katana-file=/tmp/test.katana --t=1
	--render-node=beauty **--tile-render=0,1,2,2**
	./katana --batch --katana-file=/tmp/test.katana --t=1
	--render-node=beauty **--tile-render=1,0,2,2**
	./katana --batch --katana-file=/tmp/test.katana --t=1
	--render-node=beauty **--tile-render=1,1,2,2**

--tile-stitch	Used to assemble tiles rendered with the --tile-render flag into a complete image. When stitching, you must still pass the --tile-render argument, with the number of x and y tiles, so that the stitch knows how many tiles to expect, and their configuration. Syntax: --tile-render=<left_tile_index>, <bottom_tile_index>, <total_tiles_width>, <total_tiles_height> --tile-stitch Example: ./katana --batch --katana-file=/tmp/test.katana --t=1 --render-node=beauty --tile-render=0,0,2,2 **--tile-stitch**

Option	Usage
--tile-cleanup	Used to clean up transient tile images. Can be used in conjunction with --tile-stitch to assemble a complete image, and remove transient tiles in a single operation. When using --tile-cleanup you must still pass the --tile-render argument with the number of x and y tiles, so that cleanup knows how many tiles to remove. Syntax: --tile-render=0,0,<total_tiles_width>,<total_tiles_height> --tile-clean Example: ./katana --batch --katana-file=/tmp/test.katana --t=1 --render-node=beauty --tile-render=0,0,2,2 --tile-stitch --tile-clean
--prerender-publish	Syntax: Example:
--make-lookfilebake-scripts	Used to write out a number of Python files that can be executed in batch mode to write look files. Syntax: --make-lookfilebake-scripts=<script directory> Example: ./katana --batch --katana-file=/tmp/bake.katana --t=1 --make-lookfilebake-scripts=/tmp/bake_scripts ./katana --script /tmp/bake_scripts/preprocess.py ./katana --script /tmp/bake_scripts/lf_bake_default.py ./katana --script /tmp/bake_scripts/postprocess.py
--postrender-publish	Syntax: Example:
--versionup	Used to specify that you want to version up assets when publishing to the asset management system. Syntax: --versionup Example: ./katana --batch --katana-file=/tmp/test.katana --t=1 --render-node=beauty --versionup

NOTE: Setting **threads3d** or **threads2d** through Batch mode launch arguments takes precedence over the **interactiveRenderThreads3D**, and **interactiveRenderThreads2D** settings in Katana's **Edit** > **Preferences** > **application** menu, and your **CUE_THREADS** environment variable.

Script Mode

Script mode allows you to execute Python scripts in Katana's Python environment. Script mode requires the --script flag, followed by a single argument specifying the script you want to run. This launch mode is most usefule for testing. You can import most Katana modules, and perform tasks such as loading Katana scenes, changing some parameters, and rendering.

For example, to start Katana in Script mode using a script named **yourScript.py**:

1. Open a terminal.
2. Navigate to the directory where you installed Katana.
3. Enter:

```
./katana --script /yourDirectory/yourScript.py
```

To open a scene and start rendering from the scene's Render node, open the following Python script in Script mode:

```
import NodegraphAPI
from Katana import KatanaFile
from Katana import RenderManager

def messageHandler( sequenceID, message ):
    print message

yourKatanaScene = "/yourDirectory/yourFile.katana"
KatanaFile.Load( yourKatanaScene ) # Loading scene /yourDirectory/
yourFile.katana
RenderNode = NodegraphAPI.GetNode('Render') # Getting Render node
RenderManager.StartRender(
    node=RenderNode, # Starting render
    hotRender=True,
    frame = 1,
    asynch = False,
    interactive = False,
    asynch_renderMessageCB = messageHandler
)
```

Shell Mode

Shell mode exposes Katana's Python interpreter in the terminal shell. Shell mode requires the --shell flag, and no arguments. All of the modules available in the Python tab in Katana are available in Shell mode.

To start Katana in Shell mode:

1. Open a terminal.
2. Navigate to the directory where you installed Katana.
3. Enter:

```
./katana --shell
```

Querying Launch Mode

To query the current Katana launch mode, call **QtGui.qApp.type()** while in Script or Interactive mode. This returns an int, with value 1 if running in UI mode, and 0 if running in a headless mode.

The following script queries **type()** and prints the current launch mode:

```
from Katana import QtGui

if QtGui.qApp.type() == 1:
    print( "Running in UI mode" )

elif QtGui.qApp.type() == 0:
    print( "Running in headless mode" )

else:
    print( "Error" )
```

While in Batch mode, the KATANA_BATCH environment variable is set. To retreive this from AttributeScripts, use the **getEnv()** syntax.

7 Scene Attributes and Hierachy

A key principle to working with Katana is that it doesn't matter where scene graph data comes from, all that matters is what the attribute values are. For example geometry and transforms can come from external files such as Alembic, but can also be created by internal nodes, or even AttributeScripts that use Python to set attribute values directly.

In principle you could create any scene with just a combination of LocationCreate andAttributeScript nodes, though you'd probably have to be a bit crazy to set your scenes up that way!

The only data handed down the tree from one filter to the next is the scene graph data provided by iterators, such as:

- 3D transforms, such as translate, rotate, scale, or 4x4 homogeneous transformation matrices.
- Camera data, such as projection type, field of view, and screen projection window.
- Geometry data, such as vertex lists.
- Parameter values to be passed to shaders.
- Nodes and connections for a material specified using a network.

As all data is represented by attributes in the Scene Graph, any additional data needed by the renderer, or any data needed by other, downstream, Katana nodes, must also be stored as attributes. Examples include:

- Lists of available lights and cameras.
- Render global settings such as which camera to use, which renderer to use, image resolution, and the shutter open and close times.
- Per object settings such as visibility flags.
- Definitions of what renderer outputs (AOVs) are available.

Common Attributes

Attributes in the hierarchy can make use of inheritance rules. If an attribute isn't set at a location, it can inherit the value for that attribute set at a parent location.

The **/root** location holds settings needed by the renderer, such as flags to be passed to the command that launches the renderer, or global options. Common settings for any renderer include:

- renderSettings.renderer

Which renderer to use.

- renderSettings.resolution
  The image resolution for rendering.
- renderSettings.shutterOpen and renderSettings.shutterClose
  Shutter open and close times for motion blur (in frames relative to the current frame)

Depending which renderer plug-ins you have installed, you will also see renderer specific settings such as:

- prmanGlobalStatements
  For Pixar's RenderMan specific global settings
- arnoldGlobalStatements
  For Arnold specific global statements

Collections defined in the current project are also held as attributes at **/root**, in the **collections** attribute group.

By convention attributes set at **/root** are set to be non-inheriting. In Katana **/root/world** is used as the base location of the object hierarchy, where you can set default values you want inherited by all objects in the scene.

Common attributes at any location in the world hierachy include:

- xform: the transformations (rotation, scale, translate, or homogenous transformation matrices) to be applied at this level in the hierarchy.
- materialAssign: the path to the location of any material to be assigned at this location in the hierarchy.
- Renderer specific, per-object, options such as tessellation settings, and trace visibility flags. These are held in render specific attribute groups such as **prmanStatements** and **arnoldStatements**.

Common attributes at geometry, camera, and light locations include:

- Vertex-lists, UV co-ordinates, and topological data.
  For geometric objects.
- FOV and projection type.
  For cameras and lights.
- geometry.arbitrary is used to hold arbitrary data to be sent to the renderer together with geometry, such as primvars in RenderMan or user data in Arnold.

Common attributes at material nodes include:

- Material.
  For declarations of shaders and their parameters.

Location type, such as camera, light or polygon mesh, is held by an attribute called **type**. Common values for **type** include:

- **group** for general group locations in the hierarchy.
- **camera** for cameras.
- **light** for lights.
- **polymesh** for a polygon mesh.
- **subdmesh** for a sub-division surface.
- **nurbspatch** for a NURBS surface.
- **material** for a location holding a material made of monolythic shaders.
- **shading network material** for a location holding a material defined by network nodes.
- **renderer procedural** for a location to run a renderer specific procedural such as a RenderMan procedural.
- **scenegraph generator** for a location to run a Katana Scenegraph Generator procedural.

NOTE: Attributes are also used to store data about procedural operations that need to be run downsteam, such as AttributeScripts deferred to run later in the node graph, or the set-ups for Scenegraph Generators and Attribute Modifiers. For example, if you create an AttributeScript and ask for it to be run during MaterialResolve, all the necessary data about the script is held in an attribute group called scenegraphLocationModifiers.

Generating Scene Graph Data

The principle end-user interface in Katana is the Node Graph. Here you can create networks of nodes to - among other things - import assets, create materials and cameras, set edits and overrides, and create multiple render outputs in a single project. Node parameters can be animated, set using expressions, and manipulated in the Curve Editor and Dope Sheet. The Node Graph can have multiple outputs, and even separate, disconnected parts, with potentially different parameter settings at any time on the timeline.

When you evaluate scene data, the nodes are used to create a description of all necessary filters. The resulting filter tree has a single root, and represents the recipe of filters needed to create the scene graph data for the current frame, at your chosen output node.

It is this filter tree description that is handed to output processes such as RenderMan or Arnold. This is done by handing a serialized description of the filter tree, as a parameter, to the output process. For example, as a string parameter to a RenderMan or Arnold procedural.

The generation of Scene Graph data uses the serialized description of the filter tree to create Scene Graph iterators. The iterators are used to walk the Scene Graph and access attribute values at any desired Scene Graph locations. This approach - using iterators - is the key to Katana's scalability, and how Scene Graph data can be generated on demand.
Using the filter tree, the first base iterator at **/root** is created. This is interrogated to get:

- A list of the named attributes at that location.
- The value of any particular named attribute or group of attributes. For animated values there may be multiple time samples, with any sample relevant to the shutter interval being returned.
- New iterators for child and sibling locations to walk the hierarchy.

This process is the same as used inside the UI to inspect scene graph data when using the Scene Graph, Attributes and Viewer tabs. In the UI, the same filters and libraries that would be used while rendering are called. So when you select and node, expand the Scene Graph, and inspect the results, you're looking at the Scene Graph data that would be generated at that node, at the current frame. From a TD's perspective the UI is a visual programming IDE for setting up filters, then running those filters to see how they affect the render-time Scene Graph data.

The main API to create and modify elements within the Node Graph is a Python API called NodegraphAPI, and the main ones to create new filters are the C++ APIs Scenegraph Generator API, and Attribute Modifier Plug-in API.

Collections and CEL

Collection Expression Language, or CEL, is used to describe the scene graph locations on which an operation or assignment will act. CEL statements can also be used to define "collections" which may then be referenced in other CEL statements.

There are two different purposes that CEL statements can be used for: matching and collecting

Matching is the most common operation, and is used when scene graph data is being generated. Many nodes in Katana have CEL statements that allow the user to specify which locations the operation defined by this node will act on. For instance, CEL statements are used in the MaterialAssign node to specify which locations in the hierarchy will have a particular material assigned to them. As each scene graph location is generated it is tested against the CEL statement to see if there is a match. If it is a match then the operation is executed at that location. This matching process is generally a very fast one to compute.

Collection is a completely different type of operation: a CEL statement is used to generate the collection of all locations in the scene graph that it matches. Depending on the CEL statement this can potentially be expensive as it may involve having to open up every location in the scene graph to see if there is a match. Collecting is usually done as part of a baking process or to select things in the UI ('Collect and Select'), but also has to be done for light linking if you are using an arbitrary CEL expression to specify the lights.

CEL In the User Interface

In the UI a standard **CEL Widget** interface is provided for CEL expressions. For the convenience of users this allows users to build CEL expressions out of three different types of component (called statements):

- **Paths** – these are explicit lists of scene graph paths.

  If you drag and drop locations from the Scene Graph view onto the 'Add Statements' area of the CEL widget you will be automatically given a CEL expression that based on those paths.
- **Collections** – a pre-defined named collection of scene graph locations.

  Essentially these are arbitrary sets of locations that are handed off for use downstream in the pipeline. Collections can be created in a Katana scene using the 'CollectionsCreate' node, and can also be passed from one Katana project to another using Look Files.
- **Custom** –

  These allow complex rule based expressions, such as using patterns with wildcards in the paths, or 'value expressions' that specify values that attributes must have for matches.

Please see the user guide for a more complete description of how to use the user interface to specify CEL expressions.

Guidlines for Using CEL

Using CEL to specify light lists in the LightLink node

There is only one node that does a collect operation while actually evaluating the Katana recipe: the LightLink node.

LightLink allows you to use a CEL statement to determine which lights to link to, which allows a lot of flexibility in selecting which lights are linked, but involves running a collection operation at runtime. How the CEL statements are used to specify the lights (and where those lights are in the scene graph) should be set up carefully to maximize efficiency and avoid having to evaluate too many scene graph locations. In general it is most efficient to use a list of explicit paths for the light list. If you need to use more general CEL expressions, such as those that use wild cards, it is best to make sure these only need to run to a limited depth in the scene graph. The worst case is an expression with recursion that potentially needs every scene graph location to be tested.

'Collect and Select' isn't a good test of efficiency

It's wrong to run a 'Collect and Select' to test the efficiency of a CEL statement that is only going to be used for matching. For instance, the CEL statement //myGeoShape that only matches with locations called 'myGeoShape' is very fast to run as a match when evaluating any location, but will take a very long time to collect because it will have to expand the whole scene graph looking for locations with that name.

Make CEL statements as specific as possible

The expense is generally in running operations at nodes rather that evaluating if a location matches a CEL expression, so it's good make sure that nodes only run on the locations really necessary.

For instance: if you've got an AttributeScript that should only run on certain types of location it is better to have that test as part of the CEL statement so the script doesn't run at all on locations of the wrong type, instead of having a less specific CEL statement and the test for the correct location type inside the script itself.

Another typical case is using the CEL expression //, which is a very fast expression to match but will usually mean that a node will run at far more locations than it needs to.

Avoid using deep collections

Collections brought in by a Look File are defined at the root location that the Look File is assigned to. If those collections are only used in the hierarchy under the location they are defined at evaluation is efficient. However, if you refer to that collection in other parts of the scene graph then there is a cost as the scene graph has to be evaluated at the location the collection is defined.

A example where this can be a problem is if you've got collections defined at /root that reference a lot of other collections defined deeper in the scene graph. This means that to just evaluate /root you need to examine the scene graph to all those other locations as well.

Avoid complex rules in collections at /root

Collections of other collections are useful and are efficient if all the collections are defined using explicit paths. If these collections are created using more complex rules, in particular recursive rules, you can run into efficiency problems.

Avoid using '*' as the final token in a CEL statement

There are optimizations in CEL to first compare the name of the current location against the last token in the CEL statement. If that doesn't match we can exit very quickly as we definitely haven't got a match. For this reason it's good if you can have a more specific last token in a CEL statement than '*'. For instance, if you've got a rule that is to only run on geometry locations that will all end with the string 'Shape' it's more efficient to have a cell expression such as
`/root/world/geo//*Shape than /root/world/geo//*`

Paths Versus Rules

CEL has a number of optimizations for dealing with explicit lists of paths. This means using paths are the best way of working in many cases, and matching against paths is generally very efficient as long as the list of paths isn't too long.

As a general rule it's more efficient to use explicit lists of paths than active rules for up to around

100 paths. If you have explicit lists with many thousands of paths you can run into efficiency issues where it may be very worthwhile using rules with wild-cards instead.

'Select and Collect' operations are always more efficient with an explicit path list.

Use differences between CEL statements cautiously

Taking the difference between two CEL statements can be expensive. In particular if two CEL statements are made up of paths when you take the difference it's no longer treated as a simple path list so won't use the special optimizations for pure path lists.

Single nodes with complex difference based CEL statements can often be more efficiently replaced by a number of nodes with simpler CEL statements.

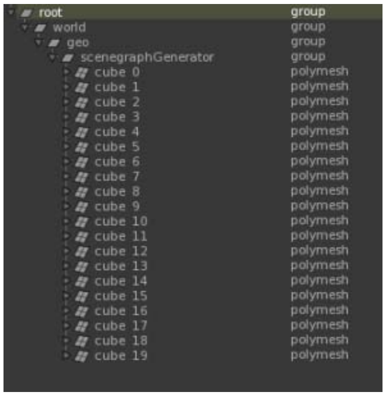
8 Scene Graph Generator Plug-Ins

Katana's operation revolves around two graphs: the Node Graph and the Scene Graph. To reiterate, here are some of Katana's key concepts as described in the User Guide:

Within the Node Graph tab, Katana utilizes a node-based workflow, where you connect a series of nodes to read, process, and manipulate 3D scene or image data. These connections form a non-destructive recipe for processing data. A node's parameters can be viewed and edited in the Parameters tab.

To view the scene generated up to any node within a recipe, you use the Scene Graph tab. The Scene Graph's hierarchical structure is made up of locations that can be referenced by their path, such as **/root**. Each location has a number of attributes which represent the data at that location. You can view, but not edit, the attributes at a location within the Attributes tab.

Katana provides a dedicated C++ API for writing Scene Graph Generator (SGG) plug-ins that can be used to dynamically create entire hierarchies of locations in the scene graph, containing arbitrary attribute data at each location.



It is important to note that a SGG plug-in can only create locations and attributes underneath a single scene graph location, its root location, and that a SGG plug-in does not have access to any other part of the scene graph. The main purpose of a SGG plug-in is to create scene graph locations and attributes from external sources while being controlled by certain parameters.

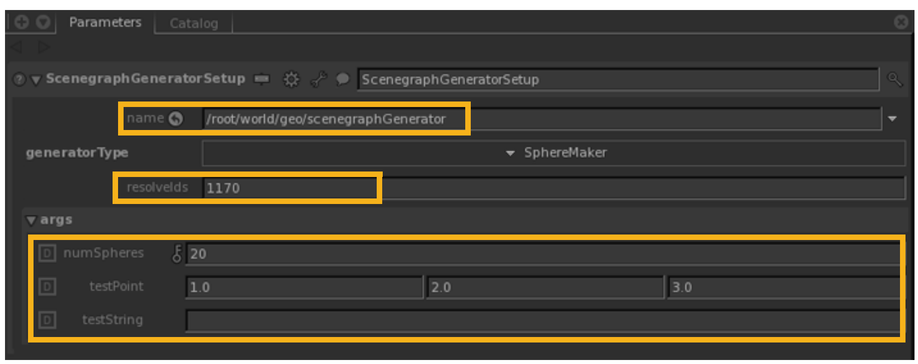
Scene graph generator plug-ins can be regarded as equivalent to procedurals in renderers, and can be used for a variety of purposes, for example to implement an importer for a custom geometry file format or to generate procedural geometry such as debris from particle data.

Running a SGG Plug-in

The creation of scene graph data by SGG plug-ins is executed through the ScenegraphGeneratorResolve node or through an implicit resolver, when triggered by a render, for example. Both operate on locations of type **scenegraphGenerator** that contain attributes that describe SGG plug-ins to run, including arguments that are passed along to the plug-ins as a way to control and customize how they create locations and attributes. The easiest way to create a scenegraphGenerator location with the relevant attributes is by using a ScenegraphGeneratorSetup node.

ScenegraphGeneratorSetup

The ScenegraphGeneratorSetup node is used to create a location of type **scenegraphGenerator**. Each ScenegraphGeneratorSetup node has a field for **name**, a field for the optional **resolveIds**, a dropdown menu showing each available **generatorType**, and fields for the args for the selected generatorType.



NOTE: The args shown in a ScenegraphGeneratorSetup node depend on the args specified in the ScenegraphGenerator itself, and so many vary from those shown above.

Prior to being resolved, the ScenegraphGeneratorSetup node whose parameters are shown above creates the SceneGraph location **/root/world/geo/ScenegraphGenerator** of type **scenegraphGenerator**. This location contains a group of attributes named **scenegraphGenerator** with the name of the selected SGG plug-in and the arguments as they are set up under args. For example, the attribute data for a ScenegraphGenerator location of type **CubeMaker** is structured like this:

```
scenegraphGenerator        group attribute
  generatorType            "CubeMaker"
  args                     group attribute
    system                group attribute (used internally)
      timeSlice            group attribute
        currentTime        1
        ...
    numberOfCubes          23
    rotateCubes            1
    rotateCubes__hints     group attribute (used for UI)
      widget               "checkBox"
    resolveIds             (optional).
```

NOTE: The ScenegraphGeneratorSetup node does not run the plug-in's code itself. Figuratively speaking, it merely loads and aims the cannon, ready for the powder to be lit by a ScenegraphGeneratorResolve node.

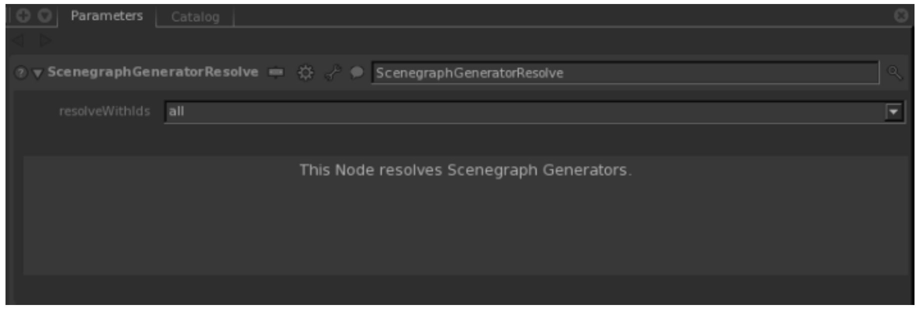
ScenegraphGeneratorSetup nodes can be tagged with a resolveId, or multiple resolveIds in a space, or comma delimited list. As shown above, if a resolveId is entered into a ScenegraphGeneratorSetup node, the resulting, pre-resolve Scene Graph location contains an Attribute named **resolveIds**, holding the specifed resolveId value. This value is used at resolve time to select scenegraphGenerator locations to resolve.

ScenegraphGenerator Resolve

The ScenegraphGeneratorResolve node is used to execute SGG plug-ins in order to create scene graph data. It traverses Katana's Scene Graph, looks for locations of type **scenegraphGenerator** and executes the plug-ins that are described in the attribute data on those locations.

The only parameter to control operation available in a ScenegraphGeneratorResolve node is **resolveWithIds**, which can be set to either **all** or **specified**. If set to **all**, the ScenegraphGeneratorResolve node ignores resolveIds and resolves all locations of type **scenegraphGenerator**. If set to **specified**, the resolve traverses the Scene Graph looking for locations of type **scenegraphGenerator**, with at least one matching **resolveIds**.

It is important to note that a ScenegraphGeneratorResolve node set to ignore resolveIDs operates on all locations of type **scenegraphGenerator** that it finds in the Katana scene, no matter how they were created.



For more on setting, and using resolveIDs in SGG nodes, see the **Generating Scene Graph Data with a Plug-in** section in the User Guide.

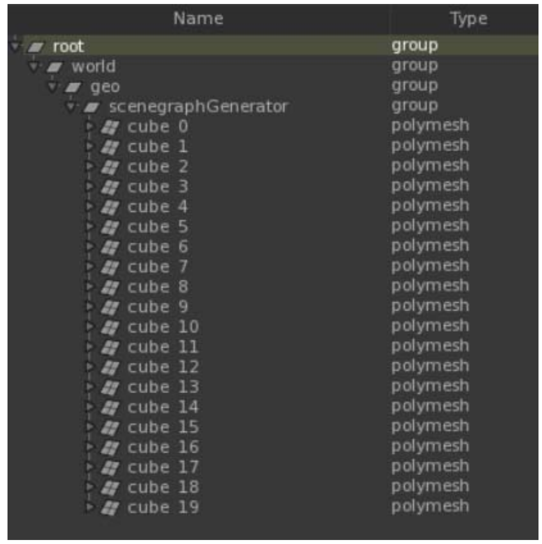
Generated Scene Graph Structure

Internally, Scene Graph Generator plug-ins use contexts to create new locations in the scene graph. A scene graph location may contain child locations, have sibling locations and hold any number of attributes.

The main context created by a SGG plug-in is called the root context. This context represents the first location of the portion of scene graph that is generated by the plug-in. Each context in a SGG plug-in can provide a single first child context (a context one level below the context that created it) and a single next sibling context (a context at the same level as its creating context), both of which are optional.

Katana traverses through the user-defined contexts, starting from the root of the SGG plug-in, which in turn populates the scene graph with the desired locations, their attributes and values. By subsequently providing first child and next sibling contexts from contexts in a SGG plug-in, arbitrarily nested scene graph structures can be created.

The following screenshot shows locations created by a simple CubeMaker SGG example plug-in in the Scene Graph tab. Note how cube_0 is the first child of the scenegraphGenerator location, cube_1 is the second child, and cube_3 is the third. All cube_# locations are of type **polymesh** and contain attributes that define geometry of polygonal cubes.



TIP: A SGG plug-in can be used to create scenegraphGenerator locations when its code is executed, thereby allowing for recursion. This can be used to embed assets in other assets, or to create fractal structures, for example. The ScenegraphXML SGG plug-in supports recursion in this way.

SGG Plug-in API Classes

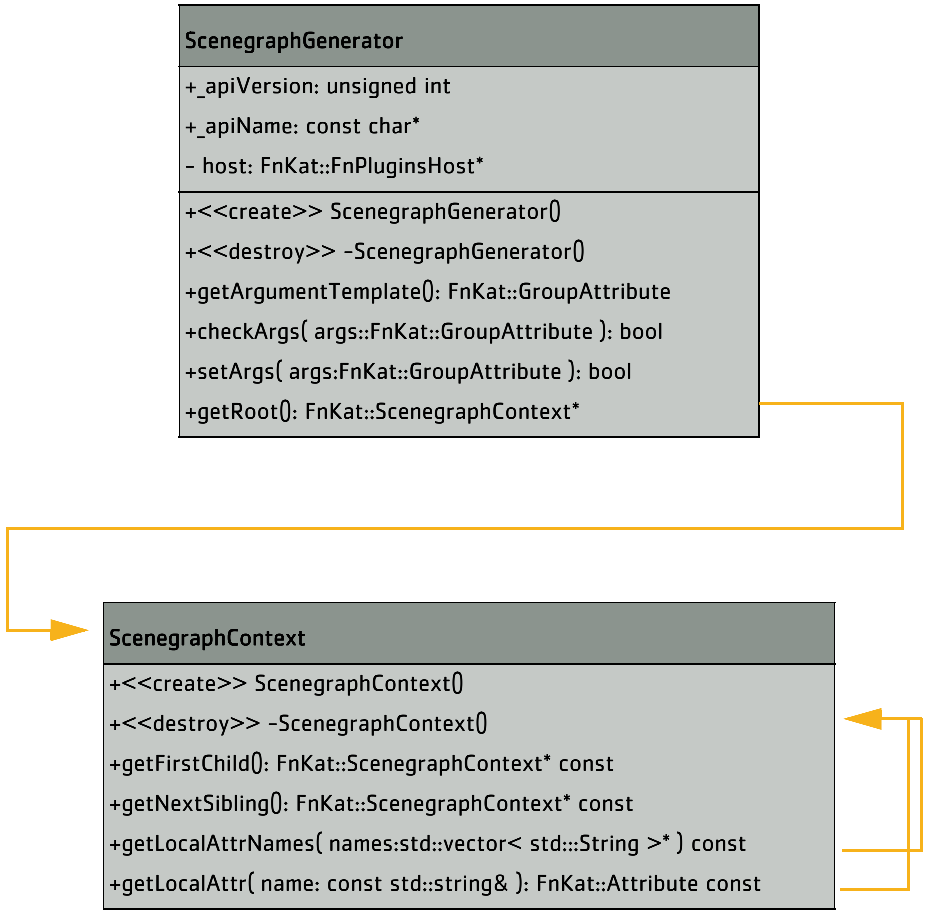
This section details the two classes that are provided in the Scene Graph Generator plug-in API to implement a custom SGG:

- ScenegraphGenerator
- ScenegraphContext

Both of these classes live in the Foundry::Katana namespace, which is usually shortened to FnKat in plug-in source files:

```
namespace FnKat = Foundry::Katana;
```

Class Diagram



ScenegraphGenerator

The ScenegraphGenerator class provides the main entry point for the plug-in. Any new plug-in must extend this interface (once per plug-in). It tells Katana which arguments the plug-in takes and what the ScenegraphContext responsible for generating the root location is. In order to write a custom SGG plug-in both of these classes have to be derived and their abstract functions implemented.

Constructor

The constructor is the place to initialize custom variables for new instances of the class derived from ScenegraphGenerator, like in this example:

```
CubeMaker::CubeMaker() :
    _numberOfCubes(0),
    _rotateCubes(false)
{
```

```
    // empty
}
```

NOTE: The code examples in this document come from a custom SGG plug-in named CubeMaker that creates locations for a number of polygonal cubes in a Katana scene. Its source code can be found in the Katana directory:

`$KATANA_ROOT/plugins/Src/ScenegraphGenerators/GeoMakers/`

Destructor

Usually no special destructor is needed when creating a class derived from ScenegraphGenerator, unless memory or other resources are allocated for the plug-in that should be released again when an instance is destroyed.

Static Methods

The following static methods must be implemented in a a class derived from ScenegraphGenerator of a custom scene graph generator plug-in:

`static FnKat::ScenegraphGenerator* create()`

Returns an instance of the custom scene graph generator's main class, similar to a factory method, as in the following code example:

```
FnKat::ScenegraphGenerator*
    CubeMaker::create()
{
    return new CubeMaker();
}
```

The create() function is not declared in the ScenegraphGenerator class in the API, but is used in the DEFINE_SGG_PLUGIN(class) macro which makes the plug-in known to Katana (cf. Registering a SGG Plug-in).

static FnKat::GroupAttribute getArgumentTemplate()

Returns a group attribute that defines the parameters of the SGG plug-in that appear as part of the ScenegraphGeneratorSetup node's parameter interface, just below the generatorType dropdown parameter.

The group attribute returned may contain other group attributes to provide an arbitrarily nested structure of parameters, including parameter hints, as in the following example:

```
FnKat::GroupAttribute
    CubeMaker::getArgumentTemplate()
{
```

```
    FnKat::GroupBuilder rotateCubesHints;
    rotateCubesHints.set(
        "widget",
        FnKat::StringAttribute("checkBox"));

    FnKat::GroupBuilder gb;
    gb.set("numberOfCubes",
           FnKat::IntAttribute(20));
    gb.set("rotateCubes", FnKat::IntAttribute(0));
    gb.set("rotateCubes__hints",
           rotateCubesHints.build());
    return gb.build();

}
```

NOTE: In order for SGG plug-ins to be found by Katana, their shared object files have to live at a path that is contained in the $KATANA_RESOURCES environment variable.

static void flush()

static void flush() clears allocated memory and reloads data from file (if any). static void flush() is called when flushing Katana's caches, e.g. by clicking the Flush Caches button in the Menu Bar, which works on all nodes in the current Katana scene and forces assets, such as look files, to be dropped from memory and reloaded when needed.

Like the static create() function, the flush() function is not actually declared in the ScenegraphGenerator class in the API, but is used in the REGISTER_PLUGIN() macro when registering the custom plug-in. See Registering a SGG Plug-in for more on this topic.

Instance Methods

The following instance methods are to be implemented in a class derived from the abstract ScenegraphGenerator class:

bool checkArgs(FnKat::GroupAttribute args)

Checks the given argument structure against the expected argument structure regarding types, names, sizes and other attribute properties.

Returns true if the given argument structure is valid as input for the setArgs() function of the SGG plug-in (see below), otherwise false.

The attributes in this case correspond to parameters in the ScenegraphGeneratorSetup node's parameter interface. Any extra arguments in the given argument structure can quietly be ignored.

The default implementation simply returns true. This function does not necessarily need to be implemented, but it is generally seen as good style if it is.

bool setArgs(FnKat::GroupAttribute args)

Applies the parameter values contained in the given argument structure to the scene graph generator plug-in. Returns true if the parameter values were applied successfully, otherwise false.

Katana passes the arguments defined by the static getArgumentTemplate() function with their current parameter values to this function to be used at runtime by the plug-in.

It is common to store values from arguments that are defined for the SGG plug-in in private or protected instance variables of the ScenegraphGenerator-derived class, and to use them in the contexts that create locations and attributes in the scene graph. These variables can be initialized in the constructor of the class and updated in the setArgs() function, as shown in the following example:

```
bool CubeMaker::setArgs(
    FnKat::GroupAttribute args)
{
    if (!checkArgs(args))
        return false;

    // Apply the number of cubes
    FnKat::IntAttribute numberOfCubesAttr = \
        args.getChildByName("numberOfCubes");
    _numberOfCubes = numberOfCubesAttr.getValue();

    // Update the rotation flag
    FnKat::IntAttribute rotateCubesAttr = \
        args.getChildByName("rotateCubes");
    _rotateCubes = \
        bool(rotateCubesAttr.getValue());

    return true;
}
```

FnKat::ScenegraphContext* getRoot()

Returns an instance of a class derived from ScenegraphContext that represents the root location of the tree of scene graph locations that are generated by the SGG plug-in.

This is the first step of traversing the contexts in order to create a scene graph structure where the subsequent steps involve retrieving the child and sibling nodes.

```
FnKat::ScenegraphContext* CubeMaker::getRoot()
{
    return new CubeRootContext(_numberOfCubes,
                               _rotateCubes);
}
```

Registering a SGG Plug-in

In the implementation of a custom ScenegraphGenerator-derived class you also need to add some data structures and functions that make the plug-in known to Katana. These are easy to add using two predefined macros, as shown in the following code example:

```
DEFINE_SGG_PLUGIN(CubeMaker)

void registerPlugins()
{
    REGISTER_PLUGIN(CubeMaker, "CubeMaker", 0, 1);
}
```

DEFINE_SGG_PLUGIN(class)

Declares a data structure of Katana's plug-in system (FnPlugin) that contains information about the scene graph generator plug-in, e.g. its name and API version.

The class to pass to the macro is the class derived from ScenegraphGenerator which must contain the static create() and getArgumentTemplate() functions (cf. Static Methods).

void registerPlugins()

Is called by Katana's plug-in system to identify the plug-ins contained in a shared object file (compiled extension).

Should contain calls of the REGISTER_PLUGIN() macro (see below).

REGISTER_PLUGIN(class, className, majorVersion, minorVersion)

Registers a plug-in with the given class, name, and version information.

The major version and minor version are the version of the SGG plug-in defined in a shared object file.

Fills the plug-in's describing data structure of type FnPlugin with values and calls the internal registerPlugin() function to add the appropriate plug-ins to the global list of plug-ins known to Katana.

ScenegraphContext

The abstract ScenegraphContext class is the base class responsible for providing Katana the information needed to generate a scene graph location along with its attributes. Each custom scene graph context implemented in a SGG plug-in must extend this class.

Typically, at least two types of context are required:

- The first type is used for the root location which replaces the location of type "scenegraph generator" in the scene graph when the SGG plug-in is run. This is also known as the root context.
- The second type of context is used for child and sibling locations that create the desired groups, polygonal geometry, etc. This is sometimes called a leaf context.

Constructor

As in a class derived from ScenegraphGenerator, the constructor in a class derived from ScenegraphContext can be used to initialize instance variables, as shown in the following two examples:

```
CubeRootContext::CubeRootContext(
    int numberOfCubes, bool rotateCubes) :
    _numberOfCubes(numberOfCubes),
    _rotateCubes(rotateCubes)
{
    // empty
}
CubeContext::CubeContext(int numberOfCubes,
                         bool rotateCubes,
                         int index) :
    _numberOfCubes(numberOfCubes),
    _rotateCubes(rotateCubes),
    _index(index)
{
    // empty
```

```
}
```

Destructor

Again similar to the ScenegraphGenerator-derived class, no special destructor is needed in a class derived from ScenegraphContext, unless required for releasing previously allocated resources.

Instance Methods for Locations

The following two instance methods define the structure of the scene graph locations that are created by a custom SGG plug-in:

```
FnKat::ScenegraphContext* getFirstChild()
```

Returns an instance of a class derived from ScenegraphContext that represents the first child location of the location represented by the current context.

Returns 0x0 if the current location should not contain any child locations. Such locations are sometimes called leaf locations and typically provide custom geometry in a scene graph hierarchy.

Consider the following example of a root context for a SGG plug-in that creates a number of locations containing polygonal cube meshes:

```
FnKat::ScenegraphContext*
    CubeRootContext::getFirstChild() const
{
    if (_numberOfCubes > 0)
    {
        return new CubeContext(_numberOfCubes, 0);
    }

    return 0x0;
}
```

The function checks if a number of cubes has been set and if so creates and returns a new instance of the CubeContext class that represents the first child location under the root location.
The implementation of the same function in the corresponding CubeContext class, which represents locations of type polymesh, returns 0x0, as a polymesh location does not contain any child locations:

```
FnKat::ScenegraphContext*
    CubeContext::getFirstChild() const
{
    return 0x0;
}
FnKat::ScenegraphContext* getNextSibling()
```

Returns an instance of a class derived from ScenegraphContext that represents the next location at the same level in the scene graph hierarchy, underneath the same parent as the current location.

Returns 0x0 if the current location does not have any sibling locations. This is typically the case for root locations.

In scenarios with multiple sibling locations, an index number is typically passed on to the next sibling with an incremented value, as in the following example:

```
FnKat::ScenegraphContext*
    CubeContext::getNextSibling() const
{
    if (_index < _numberOfCubes - 1)
    {
        return new CubeContext(_numberOfCubes,
                               _rotateCubes,
                               _index + 1);
    }

    return 0x0;
}
```

Instance Methods for Attributes

The following two instance methods define the names, types and values of attributes that should live on the current custom scene graph location:

`void getLocalAttrNames(std::vector<std::string>* names)`

Fills the given list of names of attributes according to the attributes that should live on the scene graph location represented by the current context.

Each name in the modified list should be the name of either a single attribute, like **type**, or the top-level name of a group of attributes, like **xform**.

The following code snippet shows example implementations from two custom classes derived from ScenegraphContext:

```
void CubeRootContext::getLocalAttrNames(
    std::vector<std::string>* names) const
{
    names->clear();
    names->push_back("type");
    names->push_back("xform");
}
void CubeContext::getLocalAttrNames(
    std::vector<std::string>* names) const
{
    names->clear();
```

```
    names->push_back("name");
    names->push_back("type");
    names->push_back("xform");
    names->push_back("geometry");
}
```

Note that the CubeRootContext::getLocalAttrNames() function does not add the **geometry** attribute to the list of attribute names, as the corresponding scene graph location is of type group which does not hold geometry data, whereas the implementation in the CubeContext class does, as its corresponding location in the scene graph is of type polymesh for which geometry data is provided.

Also note that the getLocalAttrNames() function of the root context does not contain `"name"` in the resulting list of attribute names, as the name of the root location is defined by the location that is set in the ScenegraphGeneratorSetup node's parameters.

The getLocalAttrNames() function is used to tell Katana what attributes are provided in a scene graph context by populating the given list of attribute names. In order to access the actual attribute data, the getLocalAttr() function is called on demand with the name of one of the attributes that are provided.

In certain cases, like when viewing all attributes of a scene graph location in the Attributes tab, Katana iterates over all names provided by the getLocalAttrNames() function and calls getLocalAttr() (see below) with each of them. In other cases, such as during a render and in the viewer, Katana only asks for the attributes it needs at that time.

The getLocalAttrNames() and getLocalAttr() functions can also be used to provide error messages to the user in case the creation of locations and/or attributes fails (cf. Providing Error Feedback).

```
FnKat::Attribute getLocalAttr(const std::string & name)
```

Returns an object of the Attribute class representing the value of the attribute with the given name. All attribute values have to be wrapped in objects of classes derived from the Attribute class, e.g. IntAttribute, DoubleAttribute, StringAttribute etc.

The attribute returned may be a group of attributes, represented by a GroupAttribute object, and therefore contain other attributes or an entire hierarchy of attributes.

An empty attribute can be returned to indicate that no value is available for a given attribute name if the attribute is not supported by a scene graph context, as in the last line in the following function block.

The following code snippet shows an example implementation from the CubeRootContext class:

```
FnKat::Attribute CubeRootContext::getLocalAttr(
    const std::string& name) const
{
    if (name == "type")
    {
        return FnKat::StringAttribute("group");
    }
    else if (name == "xform")
    {
        FnKat::GroupBuilder gb;
        double translate[] = {0.0, 0.0, -10.0};
        gb.set("translate",
               FnKat::DoubleAttribute(translate,
                                      3, 3));
        gb.setGroupInherit(false);
        return gb.build();
    }

    return FnKat::Attribute(0x0);
}
```

Groups of attributes can be built using the GroupBuilder class which provides a function called build() that returns a GroupAttribute instance based on attributes that were added to a group using the set() function.

Attribute data for a "geometry" group attribute may consist of child group attributes like "point", "poly", "vertex" and "arbitrary", which can contain vertex normals and texture coordinates, for example. The actual attributes to include for a "geometry" attribute depend on the type of location (cf. reference documentation for more information).

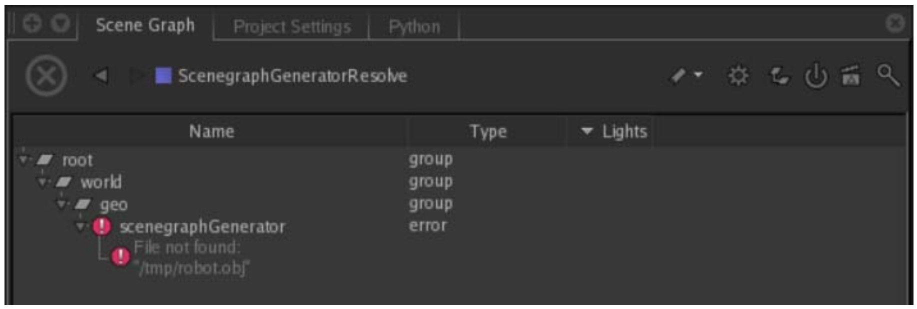
Providing Error Feedback

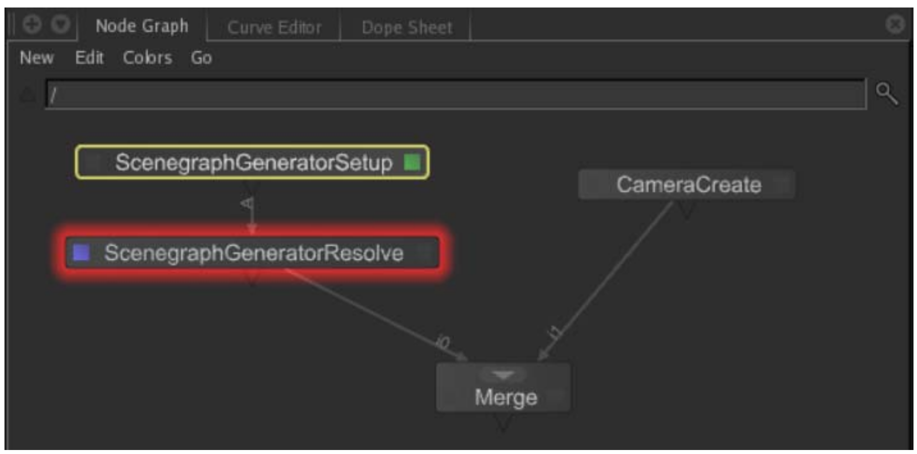
A scene graph generator plug-in can provide error feedback to the user if an error occurs while initializing the plug-in or while generating scene graph locations and/or attributes.

Two scene graph attributes are used for providing error feedback:

- A location's type can be set to **error** to indicate a fatal error. The render output modules abort a render when they encounter a location of type **error** . No further traversal occurs at that point.

• A location can have an errorMessage attribute added to it, which is interpreted as the description of an error that occurred in the location. The given message is displayed underneath the location in the Scene Graph tab, and the ScenegraphGeneratorResolve node that executed the SGG plug-in is displayed with a red halo in the Node Graph tab (see screenshots below).

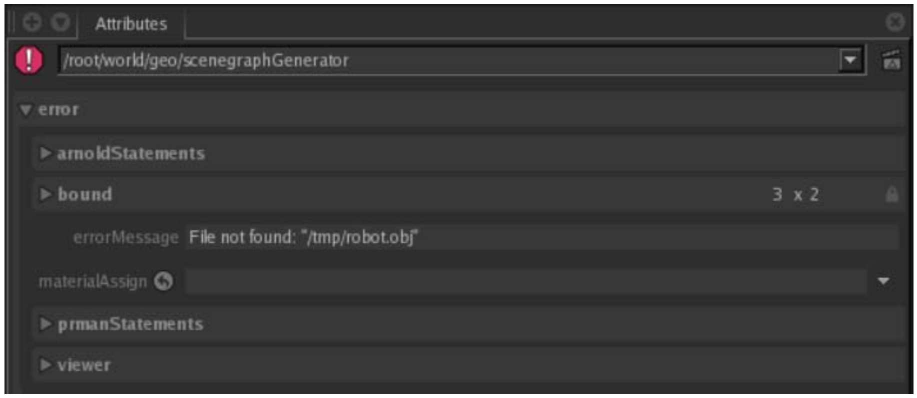




f only an error message is provided without setting the location's type to **error**, the render output modules treat the error as non-fatal and continue with traversing the scene graph for rendering.

To provide an error message the getLocalAttrNames() function can add the **errorMessage** name to the list of attribute names it modifies, and the **getLocalAttr()** function can return a value for the **errorMessage** attribute, wrapped in a StringAttribute as mentioned above.

TIP: The text of an error message can be copied to the clipboard through the context menu of the “errorMessage” attribute in an Attributes tab.



The following code snippet shows examples of how error information can be returned from the getLocalAttrNames() and getLocalAttr() functions. In this example both functions check the value of a boolean instance variable named _errorOccurred which states whether or not an error occurred. The description of the error is stored in an instance variable named _errorMessage of type std::string.

```
void CubeRootContext::getLocalAttrNames(
    std::vector<std::string>* names) const
{
    names->clear();
    names->push_back("type");
    names->push_back("xform");

    if (_errorOccurred && !_errorMessage.empty())
    {
        names.push_back("errorMessage")
    }
}
FnKat::Attribute CubeRootContext::getLocalAttr(
    const std::string& name) const
{
    if (name == "type")
    {
        return FnKat::StringAttribute(
            !_errorOccurred ? "group" : "error");
    }
    else if (name == "xform")
    {
        FnKat::GroupBuilder gb;
        double translate[] = {0.0, 0.0, -10.0};
        gb.set("translate",
               FnKat::DoubleAttribute(translate,
                                      3, 3));
        gb.setGroupInherit(false);
```

```
        return gb.build();
    }
    else if (name == "errorMessage"
             && !_errorMessage.empty())
    {
        return FnKat::StringAttribute(
            _errorMessage);
    }

    return FnKat::Attribute(0x0);
}
```

In order to stop Katana from using a SGG plug-in for creating further scene graph locations if an error in the creation of locations and/or attributes occurs, the plug-in has to explicitly check for errors and the getFirstChild() and getNextSibling() functions of its context classes have to return 0x0, as shown in the following examples:

```
FnKat::ScenegraphContext*
    CubeRootContext::getFirstChild() const
{
    if (!_errorOccurred && _numCubes > 0)
    {
        return new CubeContext(_numCubes, 0);
    }

    return 0x0;
}



FnKat::ScenegraphContext*
    CubeContext::getNextSibling() const
{
    if (!_errorOccurred
        && _index < _numberOfCubes - 1)
    {
        return new CubeContext(_numberOfCubes,
                               _rotateCubes,
                               _index + 1);
    }

    return 0x0;
}
```

The files in $KATANA_ROOT/plugins/Src/ScenegraphGenerators/ offer more complete examples of how scene graph generator plug-ins can be written.

9 Structured Scene Graph Data

While Katana can handle quite arbitrarily structured scene graph data, there are a number of things worth considering, from the point of view of presenting good data to the renderer, as well as enabling users to work with the scene graph data in the user interface.

Bounding Boxes and Good Data

When working with renderers that allow recursive deferred loading the standard way that Katana works is to expand the scene graph until it reaches locations that have bounding boxes defined, then declare a new procedural call-back to be evaluated if the renderer asks for the data inside that box.

To make use of deferred loading these bounding boxes should be declared with assets, and nested bounding boxes should be structured so that only what is needed has to be evaluated. For instance if you have a city scape where only the tops of most of the buildings will be seen by the renderer it is inefficient to have just a single bounding box for the whole of each building as a lot more geometry than is going to be needed will get declared to the renderer whenever the top of a building is seen.

There is an optional attribute called 'forceExpand' that can be placed at any location to force expansion of the hierarchy under that location rather than stopping when a bounding box is reached. This can be useful when you know that the the whole of the contents of a bounding box are going to be needed if any part of it is requested. There are also times when it is more efficient to simply declare the whole scene graph to a renderer than use deferred evaluation, such as if you are calculating a global illumination for a scene that you know can fit into memory. In particular, some renderers can better optimize their spatial acceleration structures if they have all of the geometry data in advance rather than using deferred loading.

Proxies and Good Data

Since users will be working with scene graph data in Katana it's also good to consider things that may help them navigate and make sense of the scene.

The bounding boxes used by the renderer can also help provide a simplified representation in the Viewer of the contents of a branch of the hierarchy when the user opens the scene graph to a given location.

To give an even better visualization you can register proxies at any location which will be displayed in the Viewer but not sent to a renderer. Proxies for the Viewer are simply declared by placing the name of the file to use for the proxy into a string attribute called proxies.viewer at any location.

By default Katana understands proxies created using Alembic, which are simply declared using the path to the relevant .abc file. You can also customize Katana to read proxies from custom data formats by creating a Scenegraph Generator to read the relevant file format and using a plug-in for the Viewer that simply declares which Scenegraph Generator to use for a given file extension.

Proxies can also be animated if required. If the proxy file has animation that will be used by default, but you can also explicitly control what frame from a proxy is read using these additional attributes:
`proxies.currentFrame proxies.firstFrame proxies.lastFrame`

To help users navigate the scene graph, group locations can be indicated as being 'assemblies' or 'components'. The origins of these terms are from Sony Pictures Imageworks where they are used to indicate whether an asset is a building block component or an assembly of other assets, but Katana's user interface they are simply used as indicators for locations that would be good for the user to open the scene graph up to. In the Scene Graph viewer there are options to open to the next Assembly, Component of LOD level, and double clicking on a location automatically opens the scene graph up to the next of these levels.

For the user it's useful if proxies or bounding boxes are at groups indicated as being 'assemblies' or 'components', so the user can open the scene graph to those levels and see a sensible representation of the assets in the Viewer.

To turn a group location into an 'assembly' or 'component' the 'type' attribute at that location simply needs to be set to 'assembly' or 'component'. If you are using ScenegraphXML (see section 5.4) there is support for indicating locations as being 'assemblies' or 'components' within the ScenegraphXML file.

In general it also help users if the hierarchy isn't too 'flat', with groups with very large number of children. Structure can help users navigate the scene graph.

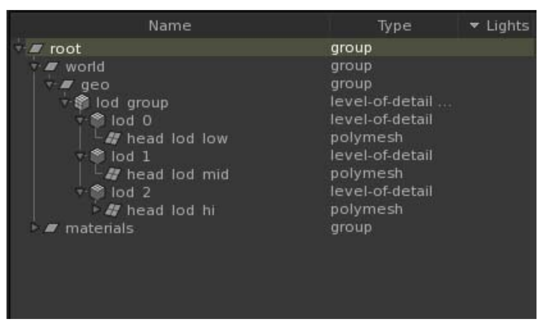
Level of Detail Groups

Levels of Detail (LODs) are used to allow an asset to have multiple representations. Katana can then be used to select which representation is used in a given render output.

Conventionally LODs are used to hold a number of asset versions with different amount of geometric complexity, such as a high level of detail to use if the asset is close to the camera and middle and low levels of detail if the asset is further away. By selecting an appropriate version of each asset to send to the renderer the overall complexity of a shot can be controlled and render times managed.

In Katana LODs can also be used to declare completely different versions of an asset for different target outputs, such as a bounding volume representation for a volumetric renderer in addition to standard geometrical representations such as polygon meshes to be used by conventional scanline renderers or ray-tracers.

Multiple levels of detail for an asset are declared by having a 'Level of Detail Group' location which has a number of 'Level of Detail' child locations. Each of these child locations has meta data to determine when that level of detail is to be used. Under each of these locations you have separate branch of the hierarchy that declares the actual geometry used for that LOD representation of the asset.



The most common meta data used to determine which level of detail to use are tags or weights. Tags allow each level of detail to be given a 'tag' name with a string. Selection of which level of detail to use can be done using this tag name, such as select the level of detail called 'high' or 'boundingVolume'.

Weights allow a floating point value to be assigned to each level of detail. Selection can then be done by choosing the closest level of detail to a given weight value. This allows sparse population of levels of detail, for example not every asset might have a 'medium' level of detail, but if you select them by weight then the most appropriate LOD from whatever representations exist can be selected.

LodSelect can be used to selection of which LOD to use using either tags or weight values. This uses a CEL expression to specify the LOD Groups you want to do the selection on.

Some renderers, such a Pixar's RenderMan, have features to handle multiple LODs themselves. Selection of which LOD to use, and potential blending between the LODs as they transition, is done at render-time. This is specified by having range data associated with each LOD that describes the range of distances from camera to use that LOD for, and the transition range for any blending. LOD range data can be set up using LodGroupCreate or LodValuesAssign nodes.

Alembic and Other Input Data Formats

It is potentially possible to bring in 3D scene data from any source. However, due to the way that filters can get called recursively on-demand it is best to work with formats that can be efficiently accessed in this manner. This is one of the reasons that we recommend Alembic as being ideally suited for delivering assets to Katana.

If you want to write a custom plug-in to read in data from a new source, such as using an in-house geometry caching format, you can write a Scenegraph Generator plug-in. This is a C++ API that allows you to create new locations in the scene graph hierarchy and set attribute value. For more details about the Scenegraph Generator API, and the associated Attribute Modifier API (for C++ plug-ins to modify attributes on existing scene graph locations) please look at sections 12.1 and 12.2.

ScenegraphXML

ScenegraphXML is provided with Katana as a simple reference format that can be using to bring structured hierarchical scene data into Katana using a combination of XML and Alembic files. One example of how it can be used includes using Alembic to declare some base 'building block' components and then use XML files as 'casting sheets' of which assets to bring in.

ScenegraphXML files can also reference other ScenegraphXML files to create higher level structured assets. For instance you could have a multiple level hierarchy where buildings are built out of various standard components, and sets of buildings are assembled together in to city blocks, and city blocks are assembled together into whole cities.

In the hierarchy created by ScenegraphXML locations can be be set to be

'assemblies' or 'components' to help users navigate the scene graph, as described above in section 5.2. By default any reference to another ScenegraphXML creates a location of type 'assembly' and any reference to an Alembic file creates a location of type 'component'. You can also override this behavior by directly stating the type of any location in the ScenegraphXML file.
You can also register proxies at locations, and create Level of Detail groups.

For more details about ScenegraphXML see the ScenegraphXML.pdf file in the technical documents in-

${KATANA_ROOT}/EXTRAS/ScenegraphXML/ScenegraphXML.pdf

10 Look Files

Katana's Look Files are a powerful general purpose tool that can be used in a number of ways. In essence they contain a baked cache of changes that can be applied to a section of scene graph to take it from an initial state to a new one.

Typically there are used to store all the relevant changes that need to be applied to take an asset from its raw state, as delivered from modeling with no materials, to a look developed state ready for rendering. They can also be used for other purposes such as to contain palettes of materials or to hold show standard settings for render outputs such as image resolutions, anti-aliasing settings and what output channels (AOVs) to use.

Different studios define the tasks done by look development and lighting in different ways. In this section we're going to look at what could be considered a typical example of the tasks to give a clear example of possible use, but the actual work done by different departments could bedifferent. Look files should be seen as a useful flexible general tool that can be used to pass baked caches of scene graph modifications from one Katana project to another.

Handing Off Looks

The most standard use of Katana's Look Files is to describe what materials are needed for a given asset, such as a character, car or building, and which material is assigned to each geometry location. The look file can also record any overrides such as modifications to shaders on particular locations, for example if a given object needs the specular intensity on a shader setting to a special value. The Look File can also record the shaders and assignments that are needed for a number of different passes, such as if you are going to do separate renders for the beauty pass, ambient occlusion, volumetric renderer etc...

The traditional workflow is that Look Development will define how each asset should look in all the different render passes required. They then 'bake' out a Look File for each asset, or multiple look files if there are a number of alternative look variants for an asset.

The LookFile records this data in a form that can be re-applied to the 'naked' asset in Lighting. In Lighting the appropriate Look File is assigned to each asset. Downstream in the Katana graph when you want to split into all the different separate passes you do a 'LookFileResolve' which actually does the work of re-applying all the materials and other changes to the asset that are needed for a given pass.

Look File Baking

Look Files are written out by using the LookFileBake node. Using this node you have to set one input to a point in the nodegraph where the scene data is in its original state and another to indicate the point in the nodegraph where the scene data is in its modified state. If you want to

include multiple output passes in the Look File you can add additional inputs to connect to points in the nodegraph where the scene data has been set up for that extra pass.

During LookFileBake every location in the scene graph under the root location is compared with the equivalent scene graph location in the original state. What is written out into the Look File are all the changes, such as changes to attributes (new attributes, modified values of existing attributes, and any attributes that have been deleted).

The details of any new locations that have been added are also written out. This means that new locations that are part of the 'look' can be included, such as face-sets for a polygon mesh that weren't part of the original model, or to add lights such as architectural lights on a building.

One important thing to note here is that while the nodes in the Node Graph represent live recipe, the Look File is a baked cache of the results of those nodes: it's a list of all the changes that the nodes make to the scene graph data rather than the recipe itself.

One of the main reasons for using Look Files rather than keeping everything as live recipe is efficiency. If you have thousands of assets, like you could in a typical shot from a CG Feature or VFX film, it can be inefficient to keep everything as live recipe. The Look Files allow the changes needed to be calculated once and then recorded as a baked list by comparing the state of the scene graph data before and after the filters. If you want to make additional changes in lighting on top of those defined by a Look File you still can do so by using additional overrides.

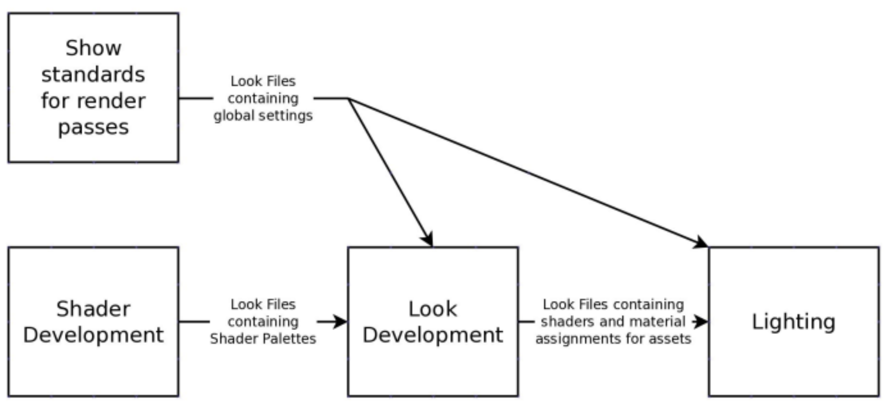
If a new version of the asset if created any associated Look Files will need to be baked out again by re-running the LookFileBake in the appropriate Katana project.

Conversely, if you want to hand off live recipe from one Katana project to another one you should use macros or LiveGroups instead.

Other Uses For Look Files

As mentioned previously, Look Files are actually quite a flexible tool that can be used for a number of different purposes as well as their 'classic' use to hand off looks for Look Dev to Lighting. Some of the other things they can be used for include:

- Defining palettes of standard shaders to use in a show.
- Making additional modifications to assets beyond simple shader assignment, such as:
    - Visibility settings to hide objects if they shouldn't be visible.
    - Adding face-sets to objects for per-face shader assignment.
    - Per-object render settings, such as renderer specific tessellation settings.
    - Defining additional lights that need to be associated with an asset, such as a car that needs head lights or a building that needs architectural lights.
    - Adding additional locations to the asset such as new locations in the asset hierarchy for hair procedurals.
- Specifying global settings for render passes, such as what resolution to render at, defining what outputs (AOVs) are available and anti-aliasing settings.



How Look Files Work

To gain a better understanding of what Look Files are and how they can be used we are going to look in more detail at how they actually work.

The geek-eye view of a Look File is that it's a 'scene graph diff'. In other words it's a list of all the changes that need to be made to a sub-branch of the scene graph hierarchy to take from an initial state (typically a model without any materials assigned) to a new transformed state (typically the model with all its materials assigned to correct pieces of geometry, and any additional overrides such as shader values or to change visibility flags). When you do a LookFileResolve all those changes are re-played back onto the relevant scene graph locations.

To make material assignments work all the materials assigned within the hierarchy are also written out into the Look File. Similarly, any renderer procedurals required are also written out into the LookFile.

For each render pass a separate scene graph diff is supplied. There are two caveats we should mention about Look Files

- The data in Look Files is non-animating, so you can't use them to hand off animating data such as flashing disco lights or lightning strikes. Animating data like this can be handled in a number of ways, including making the animating data part of the 'naked' asset, or by using Katana Macros and Live Groups to hand off actual Katana node that can have animating parameters.
- Currently you can't delete scene graph locations using Look Files, you can only add new locations or modify existing ones. For instance to hide an object you should set its visibility options rather than pruning it from the scene graph.

Setting Material Overrides Using Look Files

Following the core principle in Katana that all scene data should be inspectable and modifiable, mechanisms are needed to allow material settings defined in Look Files to be overridable downstream.

In Katana this is done by bringing the materials into the scene so that the user can use the normal Katana nodes, such as the Material node in 'override' mode, so make changes.

For efficiency, and to avoid lighters scenes becoming littered with every single material that may beused on any asset in the scene, the materials used in by a Look File aren't loaded into scenes by default. If you want to set over-rides on the materials you first need to use a LookFileOverrideEnable node. This brings in the materials from the Look File into the Katana scene and sets them up (by bringing them in a specific locations in the scene graph hierarchy based on the name of the Look File) so that these instances will be used instead of the ones contained in the original Look File.

LookFileOverrideEnable also brings in any renderer procedurals for overriding in a similar manner to materials.

Collections Using Look Files

Look Files can also be used to pass off Collections from one Katana project to another.

When a Look File is baked out for a sub-section of the scene graph hierarchy, for every Collection the baking process notes if any locations inside that sub-section of the hierarchy are in the Collection. If they do the paths for those matching locations are written into the Look File.

When the Look File is brought in and resolved, these baked sub-collections are brought in as Collections that are available at the root location of the asset.

In essence this means that if you're using a Look File to pass off the materials and assignments on an asset from Look Dev to Lighting you can also declare Collections in your Look Dev scene so that they are conveniently available to the lighters.

Look Files for Palettes of Materials

As well as being used to contain the Materials used by a specific asset, Look Files can also be used to contain general collections of shaders. This is particularly useful if you want to have studio or show standard sets of shaders created in 'shader development' which are then made available to other users. Another use of shaders from Look Files is to pre-define standard shader sets for lights (including light shaders made out of network shaders) to be brought in for Lighting.

Materials can be written out into a Look File using the LookFileMaterialsOut node. LookFileBake also has an option to 'alwaysIncludeSelectedMaterialTrees' that allows the user to specify additional locations of materials they want to write out into the Look File whether or not they are assigned to geometry.

To bring the materials from a Look Files into a project you can use the LookFileMaterialsIn node.

Look File Globals

Look Files can also be used to store global settings, so that these values can be brought back in as part of the Look File Resolve. This is usually used to define show standard settings for different passes. It can be used to set things such as:

- What renderer to use for a given pass
- What resolution and anti-aliasing settings to use
- Any additional render output channels (AOVs) you want to define and use.

When using LookFileBake you can specify the option to **includeGlobalAttributes**. Enabling this option means that any values set at /root will be stored in the Look File.

To specify which Look File to use to set global settings use the **LookFileGlobalsAssign** node.

Lights and Contstraints in Look Files

If lights and constraints are declared in a Look File there is some special handling needed when they are brought in because knowledge of lights and constraints is generally needed at the global scene level.

There is a special node called 'LookFileLightsAndConstraintsActivator designed to declare any Look Files that are being used that declare lights and constraints. This handles the work of adding them to the global lists held at /root/world.

The Look File Manager

The LookFileManager is provided to simplify the process of resolving Look Files, applying global settings, and allow the users to specify overrides, such as for materials. This is a Super Tool that makes use of many of the more atomic operation nodes mentioned previously such as LookFileResolve, LookFileOverrideEnable and LookFileGlobalsAssign.

In particular it is designed to help make setting material over-rides that need to be applied to some passes but not all passes a lot easier for the user.

11 USER PARAMETERS AND WIDGET TYPES

Introduction

Nodes usually come with a predefined set of parameters that control their behavior. You can also add custom parameters, called User Parameters in Katana. From a node's **wrench** menu, in the Parameters tab, choose **Edit User Parameters**. This adds a new group parameter to the node, named **user**, to which you can add custom parameters in the **Parameters** tab. You can add User Parameters, edit their names, rearrange them, and set up additional options and hints for each of them.

NOTE: You can add User Parameters, and UI elements to any node, but they are most commonly used in groups and macros.

NOTE: To automatically create a User Parameter that mimics the format of another parameter, select the node you want to add the parameter to, click on the node's **wrench** icon and choose **Edit User Parameters**. Then middle mouse drag the parameter you want to mimic onto the **Add** menu.

Parameter Types

From the **Add** menu in a Group's **Parameters** tab, the available types are:

Parameter Type	Description
Number	A single float.
String	A single string.
Number Array	An array of Katana Number variables.
String Array	An array of Katana String variables.
Float Vector	A text field into which arbitrary text can be entered. The entered text is split at whitespace into text parts, which are then converted to floating point numbers. If the conversion of any part fails, a TypeError exception is raised: `Could not convert string to floatVector`
Color, RGB	A three element array of floats corresponding to the red, green, and blue channel values of an RGB color.
Color, RGBA	A four element array of floats corresponding to the red, green, blue, and alpha channel values of an RGBA color.

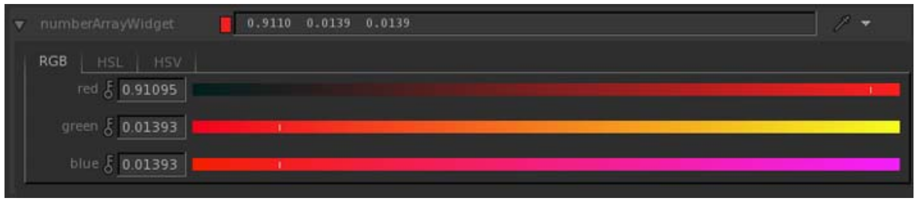
Parameter Type	Description
TeleParameter	A parameter that references another parameter. The UI provides a drop zone, to drag parameters onto. This creates a Python expression referencing the dropped parameter: `getParam( '<name of dropped node>.makeInteractive' ) .param.getFullName( )` In practice this means that a TeleParameter takes on a variable type matching the dropped parameter.
NodeDropProxy	Node drop proxies appear in the title bar of the parameters for any given node, represented by the icon. Their purpose is to allow for node drag and drop operations equivalent to the Node Graph tab but within the Parameter tab. The Node Drop Proxy widget within a group's user parameter editor exists to allow a macro to expose drag-from and drop-to operations onto one of its child nodes. It's conceptually similar to a TeleParameter widget, but for node-level drag and drop. A NodeDropProxy allows you to **Shift** + middle mouse button drag a node, from the Node Graph onto the NodeDropProxy. It creates an expression to the dropped in node, and gives the user a visual shortcut to that node. This visual shortcut can be dragged onto other nodes, or other group or macro widgets, in the same way that nodes can be dragged from the Node Graph into the **Parameters** tab (with the exception that the icon can be **Left** mouse button dragged, rather than **Shift** + middle mouse).

Most of the user parameters you can add are data types, but **Group**, **Button**, and **Toolbar** are interface elements you can add to a node:

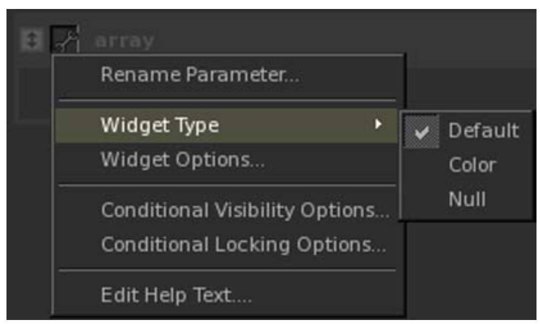
Parameter Type	Description
Group	You can place user adjustable variables, and other interface elements, in a Group inside a Macro's User Interface. You can then apply separate conditional controls to the Group, affecting all elements in it. See Conditional Behavior for more on this.
Button	A UI element that runs a script when selected. A button has two Widget Options: • A string of text to display on the button. • A Python script to run on button press.
Toolbar	A UI element that can contain multiple buttons. Each button has the same display text, and Python script options as a **Button** user parameter. There are also options to add additional buttons, and control spacing.

Widget Types

For each User Parameter, you can set a widget type that controls how the Katana UI presents that parameter. For example, the image below shows a User Parameter of type **Number Array**, with the widget type set to **Color**. Katana displays the array User with the appropriate color component selection widgets.



A number of widget types are available. It's important to note that widget types are closely tied to parameter types: Specific widget types are available for specific parameter types. For example, the Color widget type is only available on parameters of type **Number Array** with three or four entries, for RGB or RGBA components respectively. The widget type of a user parameter can be set in the UI, by choosing an item from the Widget Type menu in a user parameter's wrench menu in the **Parameters** tab.



NOTE: The widget type of a parameter can also be defined by setting a **widget** hint string. See Parameter Hints for more on this.

Katana also has a dynamic array widget type, added to support shaders with dynamic array parameters. The dynamic array widget type is not accessible through the UI. For more on using dynamic arrays in your shaders see your renderers' documentation.

The Widget Types available in the UI are:

Type	Description	Options
Default	The simplest widget type, consisting of a variable type and data entry field (or fields).	Constant (No Animation) • Can be **True** or **False**. If **True**, values entered in the widget are keyable. Display Only • Can be **True** or **False**. If **True**, the widget displays, but without function.
Scenegraph Location	Offers the user a dialog box to browse for a Scene Graph location, and stores the selection. Can be used to pass a selected Scene Graph location to another widget, or to link directly to a node in the group / macro.	Constant (No Animation) • Can be **True** or **False**. If **True**, values entered in the widget are keyable. Display Only • Can be **True** or **False**. If **True**, the widget displays, but without function.
Scenegraph Locations	Offers the user dialog boxes to browse for multiple Scene Graph locations. Can be used to pass the selected Scene Graph locations to another widget, or to link directly to a node - or nodes - in the group / macro.	Constant (No Animation) • Can be **True** or **False**. If **True**, values entered in the widget are keyable. Display Only • Can be **True** or **False**. If **True**, the widget displays, but without function.
CEL Statement	Offers the user a dialog box to add a CEL statement, and stores the statement entered. Can be used to pass the entered CEL statement to another widget, or to link directly to a node in the group / macro.	Constant (No Animation) • Can be **True** or **False**. If **True**, values entered in the widget are keyable. Display Only • Can be **True** or **False**. If **True**, the widget displays, but without function.
Resolution	Offers the user a drop-down menu of the pre-defined render resolutions, and stores the selection. Can be used to pass the selected resolution to another widget, or to link directly to a node in the group / macro.	Constant (No Animation) • Can be **True** or **False**. If **True**, values entered in the widget are keyable. Display Only • Can be **True** or **False**. If **True**, the widget displays, but without function.

<table>
<tr><th>Type</th><th>Description</th><th>Options</th></tr>
<tr><td>Asset</td><td>Offers the user a dialog box to browse for an asset by asset ID, and stores the selection. Can be used to pass the selected asset ID to another widget, or to link directly to a node in the group / macro.</td><td>Sequence Listing
• Can be True or False. If True, the Sequence Listing option in the file browser is checked, displaying sequences of files as a single item.
Constant (No Animation)
• Can be True or False. If True, values entered in the widget are keyable.
Display Only
• Can be True or False. If True, the widget displays, but without function.
Tabs To Show
• A checkbox option, the results of which are dependent on your asset control system.
Asset type tags
• A text entry field to enter lists of tags associated with the volume. For example, geometry|volume.
File Type Filter
• A text entry field to enter lists of file types to filter. For example, exr|pix.
Context
• A text entry field to enter
Image Viewer
• A text entry field to enter the desired image viewer for asset IDs entered into this widget. Defaults to the image viewer specified for the host system, for example, eog.</td></tr>
<tr><td>File Path</td><td>Offers the user a dialog box to browse for an external file, and stores the selection. Can be used to pass the selected file path to another widget, or to link directly to a node in the group / macro.</td><td>Sequence Listing
• Can be True or False. If True, the Sequence Listing option in the file browser is checked, displaying sequences of files as a single item.
Constant (No Animation)
• Can be True or False. If True, values entered in the widget are keyable.
Display Only
• Can be True or False. If True, the widget displays, but without function.</td></tr>
</table>

Type	Description	Options
Boolean	Offers the user a drop-down menu, with Yes and No options, and stores the selection. Can be used to pass the selected Yes or No answer to another widget, or to link directly to a node in the group / macro.	**Constant (No Animation)** • Can be **True** or **False**. If **True**, values entered in the widget are keyable. **Display Only** • Can be **True** or **False**. If **True**, the widget displays, but without function.
Popup Menu	Used to define a drop-down menu of either all strings, or all numbers. Returns the string or number shown in the selected menu entry.	**Constant (No Animation)** • Can be **True** or **False**. If **True**, values entered in the widget are keyable. **Display Only** • Can be **True** or **False**. If **True**, the widget displays, but without function. **Choices** • Used to add or delete entries from the popup menu. Add entries by selecting **Add** > **New Entry**.
Mapping Popup Menu	Used to define a drop-down menu, and return a different value to the one shown in the selected menu entry. For example, to show a Yes / No Boolean menu, but return 0 or 1, map the numbers 0 and 1 to the string menu entries Yes and No.	**Constant (No Animation)** • Can be **True** or **False**. If **True**, values entered in the widget are keyable. **Display Only** • Can be **True** or **False**. If **True**, the widget displays, but without function. **Popup Options** • Used to add or delete entries from the popup menu, and set mapping. Add entries by selecting **Add** > **New Entry**. Each entry has two fields, the field displayed in the popup menu, and the field returned when the menu option is selected. The field displayed in the menu is the leftmost one.
Check Box	Returns a Boolean value, depending on whether the box is checked or not. Used as a value in conditional arguments on other widgets (such as Conditional Visibility, and Conditional Locking).	**Constant (No Animation)** • Can be **True** or **False**. If **True**, values entered in the widget are keyable. **Display Only** • Can be **True** or **False**. If **True**, the widget displays, but without function.

Type	Description	Options
TeleParameter	A parameter that references another parameter. The UI provides a drop zone, to drag parameters onto. This creates a Python expression referencing the dropped parameter. In practice this means that a TeleParameter takes on a variable type matching the dropped parameter.	**Constant (No Animation)** • Can be **True** or **False**. If **True**, values entered in the widget are keyable. **Display Only** • Can be **True** or **False**. If **True**, the widget displays, but without function.
Color	Offers the user a color picker dialog, with tabs for RGBA, HSL, and HSV color schemes.	
Multi	Mimics the structure of a CameraCreate node's screenWindow parameter. Unlike a screenWindow, a Multi is created empty, and you have to add - and name - the individual values manually.	
Null	Hides the parameter from the Parameters tab.	

Widget Availability

Widget type availability is dependent on the User Parameter type. The available widget types for each variable type are:

User Parameter	Available Widget Types
Number	Default, Boolean, Popup Menu, Mapping Popup Menu, Check Box, Null.
String	Default, Scenegraph Location, CEL Statement, Resolution, Asset, File Path, Boolean, Popup Menu, Mapping Popup Menu, Script Button, Check Box, TeleParameter, Null.
Group	Default, Multi, Gradient, Null.
Number Array	Default, Color, Null. **Note:** The **Color** widget type is only available on arrays containing 3 or 4 values (for RGB, and RGBA respectively).
String Array	Default, Scenegraph Locations, Null.

User Parameter	Available Widget Types
Float Vector	Default, Null.
Color RGB	Default, Null.
Color RGBA	Default, Null.
Button	Default, Scenegraph Location, CEL Statement, Resolution, Asset, File Path, Boolean, Popup Menu, Mapping Popup Menu, Script Button, Check Box, TeleParameter, Null.
Toolbar	Default, Scenegraph Location, CEL Statement, Resolution, Asset, File Path, Boolean, Popup Menu, Mapping Popup Menu, Script Button, Check Box, TeleParameter, Null.
TeleParameter	Default, Scenegraph Location, CEL Statement, Resolution, Asset, File Path, Boolean, Popup Menu, Mapping Popup Menu, Script Button, Check Box, TeleParameter, Null.
Node Drop Proxy	Default, Scenegraph Location, CEL Statement, Resolution, Asset, File Path, Boolean, Popup Menu, Mapping Popup Menu, Script Button, Check Box, TeleParameter, Null.

12 Groups, Macros, and Super Tools

Introduction

Groups, Macros and Super Tools are ways of creating higher level compound nodes out of other nodes. Groups and macros are created in the Katana UI, while Super Tools are created using Python.

Groups

Group nodes are nodes that can contain a number of child nodes. They are typically used to simplify the Node Graph by collecting nodes. Group nodes can be duplicated like any other node, creating duplicates of any child nodes. For an introduction to groups, and their uses, see the Groups and Macros > Introduction to Groups chapter in the User Guide.

The simplest way to create a group is by selecting one or more nodes in the Node Graph and pressing **Ctrl** + **G**. A new Group node is created, with the previously selected nodes as it's children. Any connections between selected nodes are preserved. You can also create an empty group by choosing **Group** from the **Tab** hotkey node creation menu.

As well as standard Group nodes - which can have child nodes of any node type - there are two special convenience group nodes to make it easier to collect multiple nodes of the same type: **GroupStack** and **GroupMerge**. GroupStack nodes are for nodes with a single input and output (such as MaterialAssign), and connect all the internal nodes in series. GroupMerge nodes are for nodes with a single output that don't require any input, and connect all the internal nodes in parallel using a Merge node. To create a GroupStack or GroupMerge node of a particular node type simply create a GroupStack or GroupMerge and **Shift** + middle drag a node of the desired type into it, from the **Node Graph** tab.

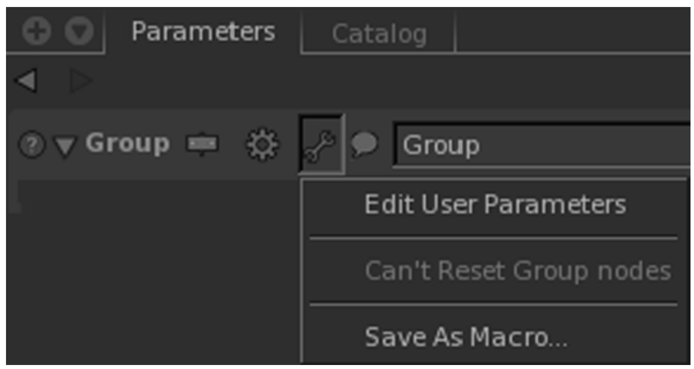
Group nodes - as with any other node - can have user parameters, with which you can add parameters to a node, and interactive connections between parameters. See the Adding User Parameters section for more on adding and using user parameters.

A Group node comprised of nodes with no incoming or outgoing connections outside the group, will itself have no input or output ports. For a group to have input or output ports, its child nodes must have suitable connections outside the group, or they must be explicitly created. For more on Group nodes, and their incoming and outgoing connections, see the Group Nodes section.

Macros

Macros are nodes that wrap any single node, or group of nodes, and publish them so that their state is saved and they can be recalled in other projects. Macros wrap functionality, allowing you to hide logic, or group logic that you can then reuse multiple times. For an introduction to macros, and their uses, see the Groups and Macros > Introduction to Macros chapter in the User Guide.

You can create a macro from any node by using the **wrench** menu at the top of the node's **Parameters** tab, and choosing **Save As Macro...** although Macros are more typically - and more usefully - made from groups. You save a macro from a Group node in the same way you would from any other node (by choosing **Save As Macro...** from the **wrench** menu in a group's **Parameters** tab).



By default - if no other directory options are set - macros are saved into the **Home** directory in **.katana/Macros/_User** and are given the suffix **_User**.

You can also read macros from other directories included in your $KATANA_RESOURCES environment variable. Macros are picked up from subdirectories called **Macros** and take the name of the parent directory as suffix. For example, if you point your $KATANA_RESOURCES to **/production/katana_stuff/_studio** you can put macros in **/production/katana_stuff/studio/Macros** and they will automatically be suffixed with **_studio**.

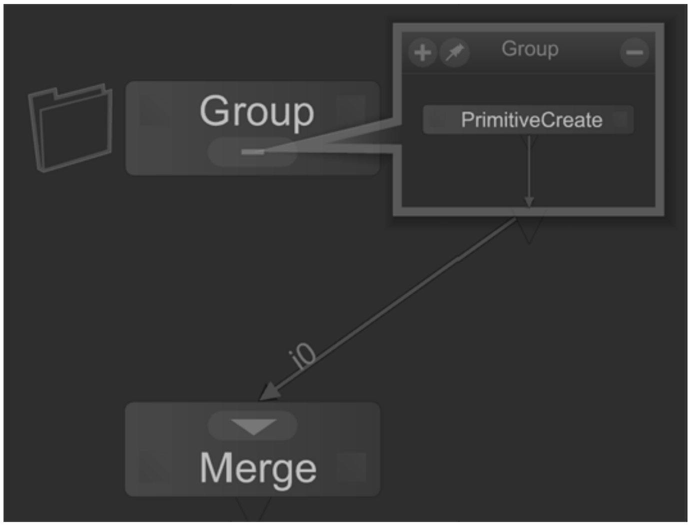
Once exported, you add a macro to a project in the same way you would any other node, such as choosing it from the **Tab** hotkey node creation menu.

Adding User Parameters

You can add user parameters to any node, but they're particularly useful in groups and macros, where user parameters on the parent node can drive parameters on child nodes, or even on nodes in the recipe outside of the group or macro.

The example in the Groups and Macros > Introduction to Groups > User Parameters section of the User Guide links the type of a PrimitiveCreate node inside a group, to the value of a user parameter on the parent. While this works, the user could easily break it by entering an invalid string. It is better to present the user with a series of known, valid choices in the form of a popup menu:

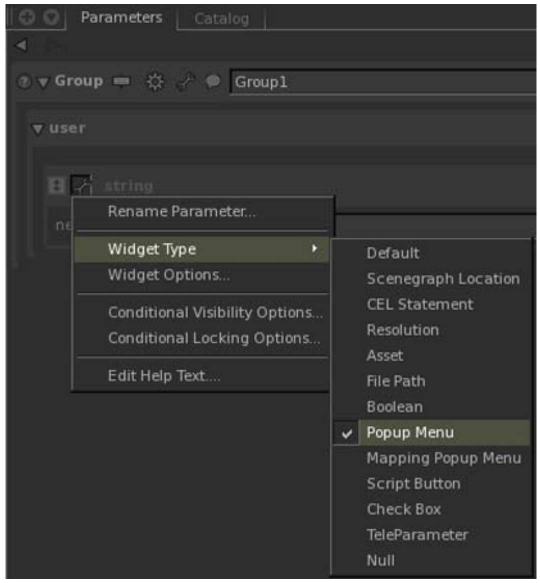
1. Start with a recipe as shown below, consisting of a Group node, with a child PrimitiveCreate node, and a connection out of the group from the PrimitiveCreate to a Merge node.



2. Select the Group node and press **Alt** + **E** to edit it.
3. In the Group node's **Parameters** tab, choose **Edit User Parameters** from the wrench menu.
4. Choose **Add** > **String**.

   A new user parameter of type string is created.
5. Change the widget type of your user parameter to **Popup Menu**.

   In the **wrench** menu of the new parameter, choose **Widget Type** > **Popup Menu**.



This changes the user parameters widget type to popup menu, where each entry in the menu is a string.

For more on the types of user parameters available, see User Parameters and Widget Types.

6. Edit the popup menu to add new entries, each corresponding to a valid PrimitiveCreate node type.

   In the wrench menu of the new parameter, choose **wrench** > **Widget Options...**

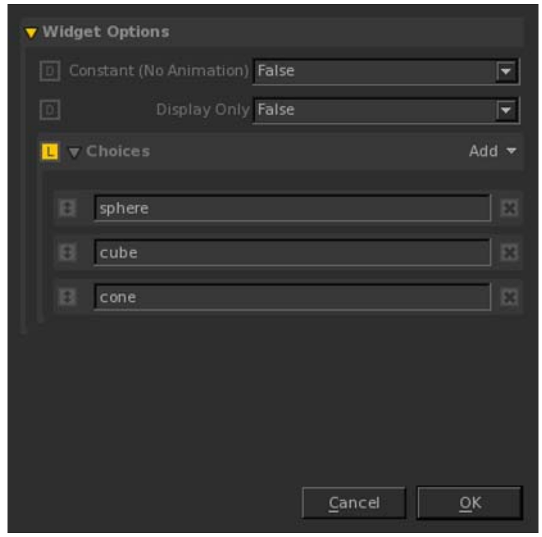
   In the resulting Widget Options Window, choose **Add** > **New Entry**, and add new entries that read **sphere**, **cube**, and **cone**.

7. Link the user parameter popup menu to the **type** parameter of the Primitive Create node.

   Right click on the user parameter popup menu and choose **copy**, then select the PrimitiveCreate node. Right click on its **type** parameter, and select **Paste** > **Paste Expression**. The **type** parameter's background turns blue to let you know it's set by an expression.

8. Finish editing the Group node's user parameters by choosing **Finish Editing User Parameters** from the Group node's **wrench** menu.

9. Select the group, and change the user parameter popup menu between **sphere**, **cube**, and **cone**. The **type** parameter of the PrimitiveCreate node changes to match.



TIP: In the example above, you manually created a popup menu and populated it with suitable entries.

Katana offers a shortcut to automatically create and populate user parameters. Start at step 3) from the example above, then **Shift** + select the PrimitiveCreate node as well as the group. **Shift** + middle drag from the PrimitiveCreate node's **type** parameter onto the Group nodes **Add** menu. A new user parameter of the correct type (in this case a popup menu), populated with the applicable entries is created.

Note that you still need to link the new menu to the PrimitiveCreate node's **type** parameter, as described in step 7) above.

Conditional Behavior

You can make the behavior of user parameters within a Macro, or Group conditional, dependent on any user parameter values. For example, create a group, containing a scene that includes PRMan and Arnold shaders. Select which shader to use from a popup menu, and show and hide shader options using conditional behavior.

Conditional Visibility Example

1. Create a Katana scene with a PrimitiveCreate node, a Material node, a CameraCreate node, and a Merge node. Connect the outputs of the PrimitiveCreate, Material, and CameraCreate nodes to inputs on the Merge node.

2. Create a MaterialAssign node, and place it downstream of the Merge node, then add Gaffer and RenderSettings nodes in series, downstream of that. Finally add a Render node.

> **NOTE:** You can overload Material and Gaffer nodes with more than one shader type. For example, a Material node can hold both Arnold and PRMan shaders.
>
> At render time, only shaders relevant to the selected renderer are considered.

3. In the Material node, add a PRMan surface shader of type **Phong**, and an Arnold surface shader of type **standard**.
4. In the Gaffer node add a PRMan spotlight, and an Arnold spotlight.

   Add two lights, and in their respective Material tabs choose **Add Shader**, then choose either Arnold or PRMan light. From the dropdown menus, choose **spot_light** for the **arnoldLightShader**, and **KatanaSpotlight** for the **prmanLightShader**.

   Position the lights, and remember to set the **decay_type** in the **arnold-LightShader** to **constant**, to match the default decay type of a PRMan spotlight (the Arnold default is **quadratic**).
5. Select all of the nodes, bar the Render node, and enter **Ctrl** + **G** to make a group node containing all of the selected nodes. The result is a Group node, with a single output, connected to a Render node.

To switch between PRMan and Arnold rendering, you can go into the Group node, and change the RenderSettings node **renderer** parameter, but to streamline this operation, you can add a popup menu to the UI of the group node, and link by expression to the renderer parameter on the RenderSettings node.

6. Select the Group, and select the > **Edit User Parameters**.
7. Select **Add** > **String**, and then the new parameter's > **Widget Type** > **Popup Menu**.
8. Select the new parameter's > **Widget Options...**
9. In the widget options window, select **Add** > **New Entry**, so there are two entries in the menu. Edit one entry to read **arnold** and the other to read **prman** then click **OK**.
10. In the group node's **Parameters** tab, right click on the popup menu widget, and select **Copy**.

11. Expand the contents of the group node in the Node Graph, and **Shift** + select the Render Settings node. Right click on the node's **renderer** parameter, and select **Paste Expression**.

    The background of the **renderer** parameter turns blue, to indicate that it's driven by an expression.

The value of the Render Settings node **renderer** parameter is linked by expression to the selected entry in the group node's popup menu. If you select the group's > **Finish Editing User Parameters**, the popup menu displays in the group's **Parameters** tab, and its value selects the renderer.

The state of the popup menu can also conditionally affect visibility of other user parameters in the group node. Create new user parameters on the group to control the diffuse color values on the PRMan and Arnold shaders contained within it. Add conditional behavior to only show the color controls for shaders relevant to the selected renderer:

1. In the group node's **Parameters** tab, select the > **Edit User Parameters**, then **Add** > **Color, RGB**, twice.
2. Right click on the first **Color, RGB** user parameter, and select **Copy**. Expand the contents of the group in the Node Graph, then **Shift** + select the Material node.
3. Expand the parameters for the **prmanSurfaceShader**, right click on the **kd_color** parameter, and select **Paste Expression**.
4. In the group node's Parameters tab, right click on the second **Color, RGB** user parameter, and select **Copy**. Expand the contents of the group in the Node Graph, then **Shift** + select the Material node.
5. Expand the parameters for the **arnoldSurfaceShader**, right click on the **kd_color** parameter, and select **Paste Expression**.

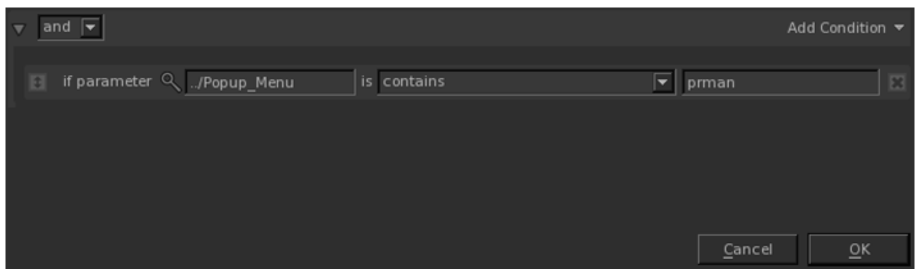
The diffuse color values of the PRMan and Arnold shaders are linked by expression to the color widgets in the groups parameters. If you select the group's **wrench** icon > **Finish Editing User Parameters**, the color widgets display in the group's **Parameters** tab, and their values affect the diffuse colors of the PRMan and Arnold shaders.

Only one shader at a time is considered though, so it would be useful to hide the settings for the shader not applicable to the selected renderer.

1. In the group node's **Parameters** tab, select the  > **Edit User Parameters**, Select the first **Color, RGB** widget's **wrench** menu > **Conditional Visibility Options**.

   The conditional visibility options editor sets and / or conditions for showing the selected widget. Conditions are evaluated against a specified user parameter, in the format **if** <selected parameter> **is** <selected condition> relative to an entered value, then show the widget.

2. In the Conditional Visibility Options window, click on the  icon to choose the user parameter to test against, and select the popup menu from the list.
3. In the Conditional Visibility Options window, choose **Add Condition** > **contains**. In the text entry field, enter **prman**.



   The condition in this case is **if** <the popup menu> **contains** < the string **prman**> then show the target user parameter.

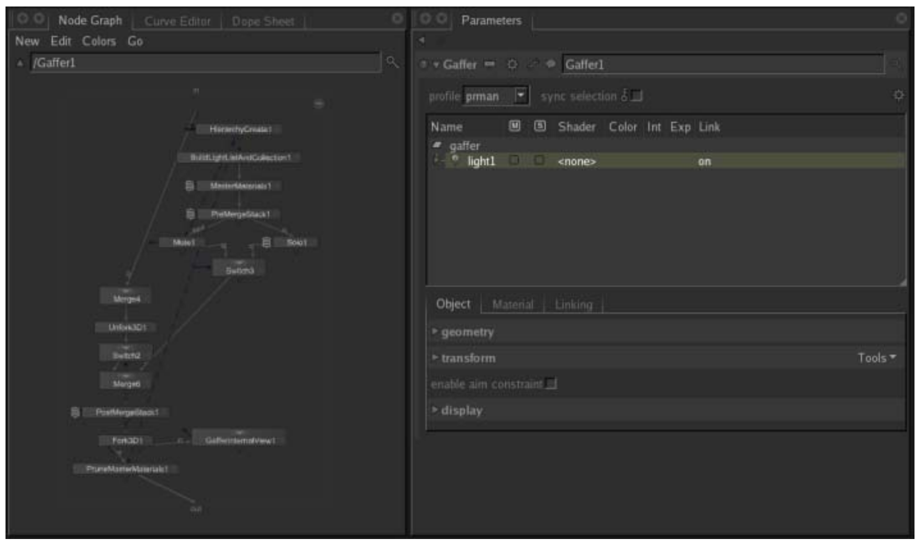
4. Repeat the process above for the second **Color, RGB** widget, and the **Arnold** entry in the popup menu.

If you select the group's  > **Finish Editing User Parameters**, andview the completed Group node's **Parameters** tab, only one color widget at a time displays in the group's **Parameters** tab. Which one that is, is dependent on the value chosen in the popup menu.

Super Tools

Super Tools are compound nodes where the internal structure of nodes is dynamically created using Python scripting. This means that the internal nodes can be created and deleted depending on the user's actions, as well as modifications to the connections between nodes and any input or output ports. The UI that a Super Tool shows in the **Parameters** tab can be completely customized using PyQt, including the use of signals and slots to create callbacks based on user actions. To help with this, we have a special arrangement with Riverbank Computing - the creators of PyQt - allowing us to give user access to the same PyQt that The Foundry uses internally in Katana.

Many of Katana's common user level nodes (such as the Importomatic, Gaffer and LookFileManager) are actually Super Tools created out of more atomic nodes. It can be useful to look inside existing Super Tool nodes and macros to get a better understanding of how they work. If you **Ctrl** + middle click on a suitable node, you open up its internal Node Graph.



In general, Super Tools consist of:

- A Python script written using the Katana NodegraphAPI that declares how the Super Tool creates its internal network.
- A Python script using PyQt that declares how the Super Tool creates its UI in the **Parameters** tab.
- Typically there is a third Python script for common shared utility functions needed by both the nodes and UI scripts.

Super Tools in Katana are written in Python and the suggested convention is that form and function are defined by two separate classes: **<SuperToolName>Node** and **<SuperToolName>Editor**, defined in separate Node and Editor Python modules (where <SuperToolName> is the tool's name, e.g. Gaffer). The Editor class offers a UI to modify the internal network via the API functions, whereas the Node class defines the node itself and the public scripting API.

Following the suggested convention, the internal file structure of a Super Tool could look something like this:

```
HelloSuperTool
 |_ __init__.py
 |_ v1
   |_ __init__.py
   |_ Node.py
   |_ Editor.py
   |_ ScriptActions.py
   |_ Upgrade.py
```

Here a brief description of the files in a Super Tool:

- **Node.py**

  The node itself and the public scripting API (which you can test if you get a reference to the node in the **Python** tab).
- **Editor.py**

  The Qt4 UI (this is only imported in the interactive GUI, not in batch or scripting modes).
- **ScriptActions.py**

  Useful functions that are not part of the node API. Since this module is imported by both Node and Editor modules, it cannot contain any GUI code.
- **Upgrade.py**

  Stub for upgrading the node if we make internal network changes in the future. Allowing compatibility with older versions of the node.

NOTE: The clean separation between the node and the UI is important for being able to script the node in script mode.

TIP: There is no namespacing of nodes inside groups or Super Tools. To reliably get access to nodes with an initial name you should use expressions such as:

```
getNode('Merge').getName()
```

If the node is renamed, Katana will look for all getNode('xxx') calls and rename them appropriately.

Registering and Initialization

The PluginRegistry is used to register new Super Tools. The registration is performed in the **init.py** (at base level) which is also, typically, the place where we check the Katana version to make sure a plug-in is supported. The following example shows the plug-in registration containing separate calls for the node and editor:

```
import Katana
```

```
import logging
log = logging.getLogger('HelloSuperTool')
try:
    import v1 as HelloSuperTool
except Exception as exception:
    log.exception('Error importing Super Tool Python
        package: %s' % str(exception))
else:
    PluginRegistry = [("SuperTool", 2, "HelloSuperTool",
                       (HelloSuperTool.HelloSuperToolNode,
                        HelloSuperTool.GetEditor))]
```

The **init.py** file inside the v1 folder then provides Katana with a function to receive the editor:

```
from Node import HelloSuperToolNode

def GetEditor():
  from Editor import HelloSuperToolEditor
  return HelloSuperToolEditor
```

Node

The Node class declares internal node graph functionality using the NodegraphAPI.
See the following example of a Node.py file:

```
from Katana import NodegraphAPI, Utils, PyXmlIO as XIO,
UniqueName

class HelloSuperToolNode(NodegraphAPI.SuperTool):
  def __init__(self):
    self.hideNodegraphGroupControls()

    self.getParameters().parseXML("""
    <group_parameter>
      <string_parameter name='name' value=''/>
      <number_parameter name='value' value="1"/>
    </group_parameter>""")

    self.addInputPort("mog")
    self.addInputPort("dog")
    self.addOutputPort("out")
    merge = NodegraphAPI.CreateNode('Merge', self)
    self.getSendPort("mog").connect(
                             merge.addInputPort('i0'))
    self.getSendPort("dog").connect(
                             merge.addInputPort('i1'))
    self.getReturnPort("out").connect(
```

```
merge.getOutputPortByIndex(0))
    NodegraphAPI.SetNodePosition(merge, (0,0))

  def upgrade(self, force=False):
    print ("upgrade() has been called.")
```

Editor

The Editor class declares the GUI which listens to change events and syncs itself automatically when the internal network changes. This is particularly important for undo/redo.

See the following example of an Editor.py file:

```
"""
Module containing the C{L{HelloSuperToolEditor}} class.
"""
from Katana import QtCore, QtGui, UI4, QT4FormWidgets,\
    Utils
# Class Definitions --------------------------------------
class HelloSuperToolEditor(QtGui.QWidget):
    """
    Example of a Super Tool editing widget that works on two
    parameters of a given Super Tool node.
    """
    # Initializer ---------------------------------------
    def __init__(self, parent, node):
        """
        Initializes an instance of the class.
        """
        QtGui.QWidget.__init__(self, parent)
        self.__node = node
        # Try to upgrade the given node in...
        # ...an undo stack group
        nodeName = node.getName()
        Utils.UndoStack.\
            OpenGroup('Upgrade "%s"' % nodeName)
        try:
            node.upgrade()
        except Exception as exception:
            log.exception('Error upgrading node "%s": %s'
                          % (nodeName, str(exception)))
        finally:
            Utils.UndoStack.CloseGroup()
            # Get the node's parameters
            nameParameter = \
                self.__node.getParameter('name')
            valueParameter = \
```

```
    self.__node.getParameter('value')
# Create parameter policies...
# ...from the node's parameters
namePolicy = \
    UI4.FormMaster.CreateParameterPolicy\
        (None, nameParameter)
valuePolicy = \
    UI4.FormMaster.CreateParameterPolicy\
        (None, valueParameter)
# Create widgets for editing...
# ...the node's parameters
widgetFactory = \
    UI4.FormMaster.KatanaFactory.\
        ParameterWidgetFactory
nameWidget = \
    widgetFactory.buildWidget(self, namePolicy)
valueWidget = \
    widgetFactory.buildWidget\
        (self, valuePolicy)
# Create a layout and add the...
# ...parameter editing widgets to it
mainLayout = QtGui.QVBoxLayout()
mainLayout.addWidget(widget)
mainLayout.addWidget(widget)
# Apply the layout to the widget
self.setLayout(mainLayout)
```

Examples

The following code examples illustrate various Super Tool concepts and can be used for reference.

NOTE: The Super Tool code examples are shipped with Katana and can be found in the following directory:

`$KATANA_ROOT/plugins/Resources/Examples/SuperTools`

Pony Stack

This Super Tool example manages a network of PonyCreate nodes all wired into a Merge node. You can create and delete ponies, change the parent path of all the ponies, and modify the transform for the currently selected pony.

Interesting things to note are (in no particular order):

- The UI listens to change events and syncs itself automatically when the internal network changes (important for undo/redo).

- There's a hidden node reference parameter on the Super Tool node itself that gives us a reference to the internal Merge node (which tracks node renames).
- The internal PonyCreate nodes are expressioned to the Super Tool **location** parameter to determine where the ponies appear in the scenegraph
- We are using FormWidgets to expose a standard widget for the location parameter, a custom UI for the pony list, and FormItems to expose the transform parameter of the currently selected pony's internal node.

EXPERIMENT: Extend this Super Tool, for example by implementing the ability to rename the pony in the tree widget and having drag/drop reordering of the ponies inside the tree widget.

Shadow Manager

The ShadowManager shows a more complex example of a Super Tool that can be used to manage (PRMan) shadow passes. It takes an input scene and allows a user to define render passes. For each render pass the available lights in the scene can be added to create shadow maps. The user is able to specify settings like resolution and material pruning on a render pass level (in the Shadow Branch) and further adjust resolution, shadow type and output location for each light pass. The user need not set the Shadow_File attribute on the light's material as this is handled internally by the shadowManager. The example code covers:

- Creating a UI using custom buttons, tree widgets and exposing parameters from underlying nodes.
- Adding a custom UI widget to pick a light from a list of lights available at the current node.
- Renaming and reordering items in tree widget lists and applying the necessary changes to the internal node network (rewiring and reordering input and output ports).
- Drag and drop of lights from the Scene Graph into the light list.
- Handling events regarding items in a tree widget such as adding callbacks for key events and creating a right-click menu.
- Creating and managing nodes as well as their input and output ports in order to build a dynamic internal node network. It is also shown how to dynamically re-align nodes and group multiple nodes into one.

EXPERIMENT: Extend this Super Tool with the following:

- It is assumed that all light shaders have the Shadow_File parameter. For use with different shaders or renderers this can be customized.
- There are often shader parameters for dialing the effect of each shadow file which would be visible within the Gaffer. Expose these shader parameters from the Gaffer with the context of the corresponding shadow map directly inside the ShadowManager UI.
- Constraints are often placed on the lights for use as the shadow camera to frame or optimize to specific assets. Per-light controls for managing these constraints could be useful.

13 RESOLVERS

Introduction

Resolvers are filters that need to be run before actual rendering in order to get data into the correct final form. Typically they are used for things like material assignments, executing overrides, and calculating the effects of constraints.

As previously discussed, the only data the can be passed from one filter to the next is the scene graph with its attributes. Resolvers are procedural processes that can be executed purely based on attribute data, which then allows us to separate executing procedural process into two stages:

1. Set up appropriate attributes in the scene graph which define what process to run and any parameters that need to be handed to the procedural.
2. Run a resolver that reads those attributes and executes the procedural process.

This separation into two stages gives us a lot more flexibility than if all procedural processes had to be executed immediately. Because they are only dependent on the correct attributes being set at locations in the scene the configuration to set up the process can be done in variety of different ways.

For instance, material assignment is based on a single string attribute called **materialAssign** which gives the path to the location for the material to be used. This attribute is then used in a resolver called MaterialResolve which takes that material from that path and creates a local copy of the material with all the relevant attributes set to their correct values taking into account things like material overrrides. Because MaterialResolve only looks for an attribute called **materialAssign** we can set up material assignment in a number of different ways:

- Using MaterialAssign nodes, which simply set the **materialAssign** attribute at locations that match the CEL expression on the node.
- Using an AttributeScript to set the value of **materialAssign** using a Python script.
- Using a custom C++ procedural, such as a Scenegraph Generator or Attribute Modifier, that set the values of 'materialAssign' appropriately.

You can also use a LookFile that resolves the correct value for materialAssign onto given objects.

> **NOTE:** Using a LookFile, material assignment is resolved, rather than just setting the materialAssign attribute. The materialAssign attribute does not survive the processing that occurs in a LookFileResolve node.

Resolvers allow us to keep the data high-level and user meaningful as possible since until the resolver runs the user can directly manipulate the attributes that describe how the process should run instead of only being able to manipulate the data that comes out of the process.

For instance, since material assignment is only based on the **materialAssign** attribute we can:

- Change what material an object gets by just changing that one attribute values.
- Change what the material on every object that is assigned a material by changing the attributes of the original material.

In essence they get to manipulate the parameters of the process rather than just the data that comes out of the process, with all the tools that are available in Katana for inspecting, modifying and over-riding attributes.

Examples of Resolvers

As well as MaterialResolve there are a number of other common resolvers:

- ConstraintResolve. This evaluates the effect of a constraint on the transform of a location.
- LookFileResolve. This replays the changes described in a look file back onto an asset. This is probably the resolver that users are most likely to be directly exposed to if they don't use the LookFileManager as they will be directly using LookFileResolve nodes.
- ScenegraphGeneratorResolve. This executes Scenegraph Generators: custom procedural to create new scene graph data. This resolver runs on any location of type scenegraph generator, and looks for an attribute named 'scenegraphGenerator.generatorType' that specifies what .so to use.
- AttributeModifierResolve. This is similar to ScenegraphGeneratorResolve but executes Attribute Modifier plug-ins: custom procedurals that can

modify attribute values. It looks for any location with an attributes called attributeModifiers.xxx.

NOTE: AttributeScripts are actually a type of Attribute Modifier, so AttributeModifierResolve can also be used to execute deferred Attribute Scripts.

Implicit Resolvers

Resolvers can be run by putting nodes explicitly into a project, but there are also a standard set of resolvers that are automatically 'implicitly' run before rendering. In effect these are nodes that are automatically appended to the root of a node graph before rendering so that the users don't have to manually add all the resolvers needed. This allows execution of procedural processes that will always be needed, such as MaterialResolve.
The standard implicit resolvers are:

- AttributeModifierResolve (resolveWithIds=preprocess)
  - This resolves any Attribute Modifier plug-ins (including AttributeScripts) that have their resolveId set to 'preprocess'
- aterialResolve
  - As previously described, this looks for **materialAssign** attributes and creates local copies of materials taking into account any material overrides. It also executes any Attribute Scripts scripts set to execute 'during material resolve', allowing scripts to be be placed on materials that affect their behavior every time they are assigned to a different location.
- RiProceduralResolve
  - This is similar to MaterialResolve but for renderer procedurals, such as RenderMan or Arnold procedurals. It looks for any locations with 'rendererProceduralAssign' attributes.
- ConstraintResolve
  - This looks for any constraints defined at /root/world in 'globals.constraintList' and calculates the effects of any constraint on the transforms of locations.
- AttributeModifierResolve (resolveWithIds=all)
  - This resolves any Attribute Modifier plug-in that hasn't been resolved previously.

Normally when you inspect scene data in Katana's UI you see the results before the implicit resolvers are run. It's only when you render that the implicit resolvers are added. If you want to see the effect of the implicit resolvers on the scene data you can switch them on by clicking on the 'Toggle Scenegraph Implicit Resolvers' clapper-board icon in the menu bar or at top right hand side of the Scene Graph, Attributes or Viewer tabs. It then glows orange and a warning message is displayed to indicate that the implicit resolvers are now active in the UI.

For instance, if you switch the implicit resolvers on and view the attributes at a location that has an assigned material you'll see the following:

- There is now an attribute group called 'material' with a local copy of the assigned material.
- Any material overrides have been applied to the shader parameter values.
- The original **materialAssign** value has been removed.
- Similarly any **materialOverride** attributes have been removed.
- The values of **materialAssign** and **materialOverride** have been copied into **info** so that you can still inspect them for reference, but they are no longer active.

Creating Your Own Resolvers

You can using AttributeScripts or custom Attribute Modifier plug-ins to create your own resolvers, including having them run implicitly .

There are a number of modes available for when AttributeScripts and AttributeModifiers are executed. These are controlled by the 'resolveIds' values in the attributes. For AttributeScripts there are 4 modes available from the UI:

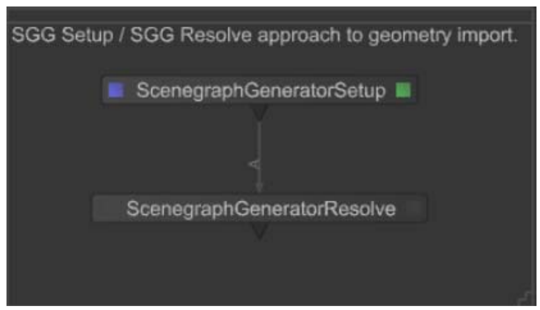
- **immediate**: the script is resolved immediately after being set in the node
- **during attribute modifier resolve**: the script is resolved by the first AttributeModifierResolve node it encounters, either directly in the node graph or by the i AttributeModifierResolve mplicit resolver if the users doesn't put any in.
- **during Katana look file resolve**: the script is resolved during LookFileResolve when the changes from look files are written back on to assets.

NOTE: The LookFileManager includes LookFileResolve nodes.

- **during material resolve**: the script will be executed when local copies of materials are being created on any locations with assigned materials. This mode is designed for placing scripts on Materials which customize how that material behaves when it applied to objects,

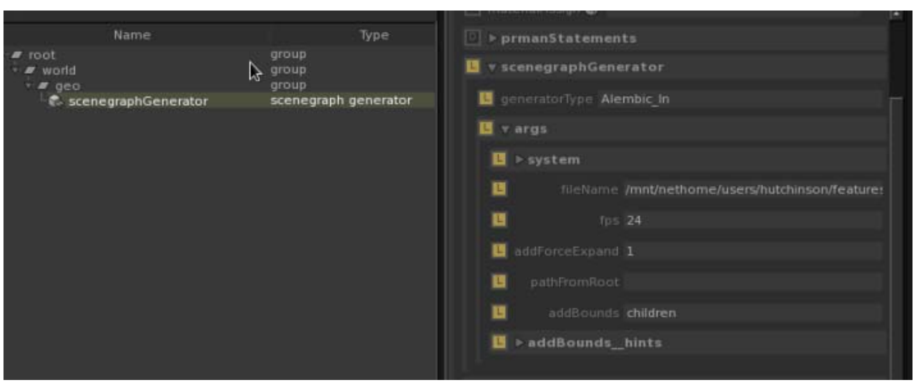
14 Wrapping Scene Graph Generator Plug-Ins In A Custom Node

Scene Graph Generator (SGG) plug-ins allow the arbitrary creation of scene graph locations and attributes. This flexibility means they can be used for a variety of tasks in a Katana scene. One common usage of the SGG is to import proprietary geometry using the familiar node pattern shown below.



This is achieved by creating two nodes within the Node Graph:

1. **ScenegraphGeneratorSetup** – creates a location of type scenegraph generator and a number of attributes at this location which describe the SGG and any configuration options that have been set in the Parameters panel.



2. ScenegraphGeneratorResolve – scans the scene graph for locations of type scenegraph generator and then launches the appropriate SGG passing it the arguments which are stored under scenegraphGenerator.args

This approach is beneficial in a number of situations where the location generated in (1) is to be resolved at some point further downstream.

However, for input nodes: a node with no input ports and one or more output ports, resolution usually occurs immediately following the SGG setup. In such cases it is beneficial to wrap the process within a single node, possibly presenting a simplified UI via the Parameter tab.

This document describes the process by which an SGG plug-in can be wrapped within a custom node, how to expose a UI in the Parameter's tab and pass any arguments from this interface to the SGG plug-in and finally, how to actually resolve the plug-in.

Throughout this document it is assumed that you have already written and successfully complied the SGG plug-in perform your task. For further information on this aspect of plug-in development please refer to **Help** > **Documentation** > **Guides** > **Scene Graph Generator Plug-ins**.

The next section provides an explanation of the python class you must define to create a custom node and how to install this in Katana.

Creating A Custom Node

Before diving into the actual code used to create a Node it is beneficial to first look at the Node in terms of its core elements.

> **NOTE:** The code which accompanies this tutorial is in the archive:
>
> ${KATANA_ROOT}/docs/pdf/GeometryImporterNodeTutorialFiles.tar.gz
>
> One extracted, navigate to //tutorial/Plugins/MyCustomImporter.py
>
> This class provides a custom node which wraps up the Alembic_In SGG and provides a UI to mirror its behaviour. To try out this plug-in simply append the tutorial directory to your $KATANA_RESOURCES environment variable.

What Is A Node?

A typical Node is composed of:

- Zero or more input ports which receive the filter tree from nodes further up the Node Graph.
- Zero or more output ports, responsible for the filter tree onto other nodes
- A User Interface to configure the behaviour of the Node
- Some internal logic that is responsible for creating locations and attributes within the Scene Graph.

In creating a custom Node we are concerned with defining:

1. The user interface through which the Node's behaviour will be configured.
2. The internal logic which will be responsible for launching your SGG plug-in.

In the following sections we will look at each point in turn, but first we need to define the body of the Node to which we will add our custom behaviour.

Defining Your Node Class

The custom nodes you will create in Katana are subclasses of the Node3D class which belongs to the Nodes3DAPI so the first step is to import the required modules to allow us to access this and other required functionality.

Importing Required Modules

```
from Nodes3DAPI import Node3D

from Katana import NodegraphAPI, GeoAPI
from Katana import PyScenegraphAttr, Utils, AssetAPI
ScenegraphAttr = PyScenegraphAttr

from Nodes3DAPI.TimingUtils import GetModifiedFrameTime
from Nodes3DAPI.TimingUtils import GetTimingParameterXML
from Nodes3DAPI.TimingUtils import GetTimingParameterHints
from Nodes3DAPI.ProceduralSetup import
GetProceduralTimeArgs

import logging
```

Declaring the Node Shell

The next step is to declare the class and its constructor, ensuring that we call the base class constructor and add an output port to our node so we can connect it into the Node Graph.

```
class MyCustomImporter(Node3D):
    def __init__(self):
        try:
            Node3D.__init__(self)
            self.getParameters().parseXML(_Parameter_XML)
            self.addOutputPort('out')
        except:
            log.exception("Error initializing %s node: %s"
                          % (self.__class__.__name__,
                             str(exception)))
```

Registering With NodegraphAPI

At this point we need to register our custom node with the Nodegraph API so it can be instantiated through the UI and in the python console. Add the following code to the bottom of your script replacing the node name and node class with your own.

```
NodegraphAPI.RegisterPythonNodeType('MyCustomImporter',
                                     MyCustomImporter)
NodegraphAPI.AddNodeFlavor("MyCustomImporter", "3d")
```

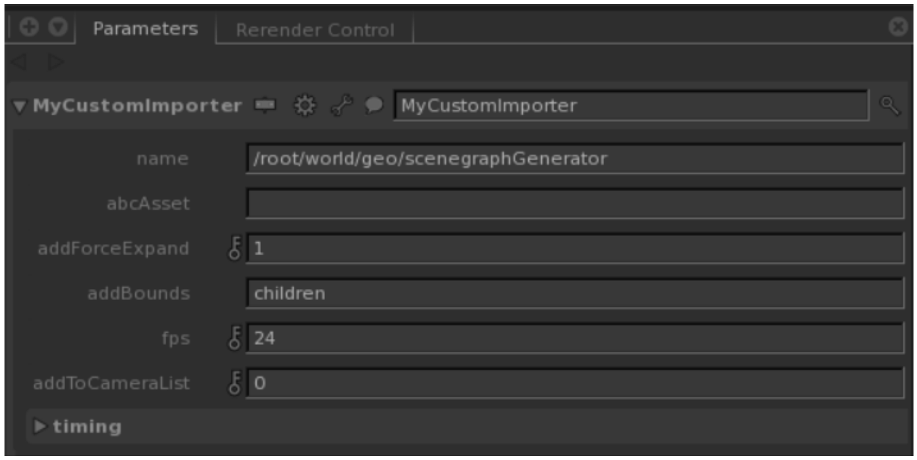
The second line here allows Katana to categorize your custom node within the the right click menu in the Node Graph panel.

Defining the User Interface

With the shell of the Node complete we can now add the first key component, the user interface. The UI that is displayed in the Parameters tab is described using a simple XML structure, an example of which can be found below.

```
_Parameter_XML = """
<group_parameter>
    <string_parameter name='name' value='/root/world/geo/
...'/>
    <string_parameter name='abcAsset' value=''/>
    <number_parameter name='addForceExpand' value='1'/>
    <string_parameter name='addBounds' value='children'/>
    <number_parameter name='fps' value='24'/>
    <number_parameter name='addToCameraList' value='0'/>
  %s
</group_parameter>
""" % (GetTimingParameterXML(),)
```

Which corresponds to the following UI in the Parameters tab.



We parse the XML description during our Node's construction with the following line of code:

```
self.getParameters().parseXML(_Parameter_XML)
```

Specifying UI Hints

In addition to describing the parameters' types, names and default values, we can also describe how they will be displayed in the UI by specifying UI hints. For a complete tutorial on this subject please see Help > Documentation > Args Files.

The approach taken here is to create a dictionary where each key is the name of the parameter, and the value is another dictionary containing the hints for this parameter, See below for a snippet illustrating this.

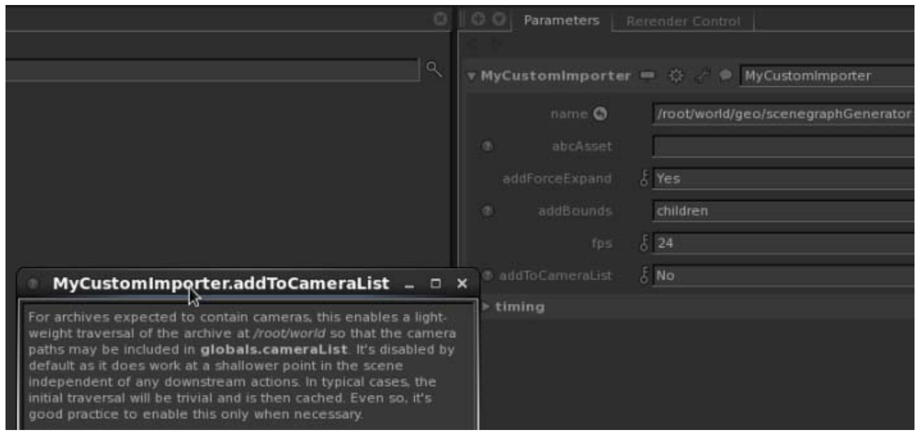
```
_ExtraHints = {
    "MyCustomImporter.name" : {
        "widget" :"newScenegraphLocation",
    },

    'MyCustomImporter.abcAsset':{
        'widget':'assetIdInput',
        'assetTypeTags':'geometry|alembic',
        'fileTypes':'abc',
       'help':"""Specify the ... an Alembic (.abc) file."""
    }
}
```

To pass this dictionary of hints to Katana we add a function to our node class:

```
    def addParameterHints(self, attrName, inputDict):
        inputDict.update(_ExtraHints.get(attrName, {}) )
```

```
inputDict.update(GetTimingParameterHints(attrName))
```

Which is called for each parameter on our node to get the correct hints. At this point the UI for our node will be displaying hints see below for an example of the help hint.



At this point we have a working node displaying an interface to the user. The next step will be to add the logic which will be responsible for calling the SGG plug-in.

Calling the SGG Plug-in

When Katana produces the Scene Graph from a given Node Graph it will traverse the Node Graph calling the _getGeometryProducer() function on each Node.

Our Node's _getGeometryProducer() function will need to perform two tasks:

1. Process the UI's parameters and build the necessary arguments that will be passed to the SGG plug-in
2. Call a helper function in the GeoAPI which will build and resolve the SGG Plug-in.

For a complete description of Scene Graph generation please see **Help > Technical Guide**.

Parsing the UI Parameters

Accessing parameter values is achieved by using the Node's member function getParameter(paramName) and then calling getValue(frameTime) on the returned value, e.g.

```
fps = float(self.getParameter('fps').getValue(frameTime))
```

When all parameters have been parsed they need to be aggregated into a dictionary where the key is the argument name expected by the SGG Plug-in, and the value is an object of type PyScenegraphAttr.Attr.

NOTE: This has been aliased to Attr in the example code:

```
args = { "fileName" : SAttr.Attr("StringAttr", [abcAsset]),
         "addForceExpand" :  SAttr.Attr("IntAttr",...),
         "fps" :  SAttr.Attr("FloatAttr", [fps]),
         "addBounds" : SAttr.Attr("StringAttr", [addBounds]),
}
```

Calling GeoAPI Helper Function

The final stage is to call the helper function within the GeoAPI BuildResolvedScenegraphGenerator() which will call your SGG Plug-in, it takes the following arguments:

Argument	Description
historyName	Pass in self.getName(), this allows attribute changes to be traced under the scene graph.
scenegraphLocationPath	The location in the scene graph the SGG Plug-in should be resolved to.
sggPluginName	The name of the SGG plug-in that will be called.
sggArguments	The arguments that will be passed to the SGG plug-in.
timeArguments	Time dependent arguments also passed to the SGG plug-in.
variableNames	Used internally by Katana, should always pass self.getVariable-Name(port,frameTime).

The arguments are built as follows:

```
BuildResolvedSGG =
GeoAPI.CFilters.BuildResolvedScenegraphGenerator
scenegraphLocationPath =
self.getParameter('name').getValue(frameTime)
sggPluginName = 'Alembic_In'
timeArgs = GetProceduralTimeArgs(modifiedFrameTime)

return BuildResolvedSGG(self.getName(),
                        scenegraphLocationPath,
                        sggPluginName,
                        args,
                        timeArgs,
                      self.getVariableName(port,frameTime))
```

Installing Your Node

Installing your node is easy, simply place the python file under one of your Plug-ins directories pointed to in your $KATANA_RESOURCES path. You will need to restart Katana for it to be picked up by the system, at which point it can be accessed like any other node.

15 Creating New Importomatic Modules

Importomatic Core Files

The Importomatic is a SuperTool which means that it wraps the functionality of multiple nodes into a single node and presents it to the user through a customizable interface. The Node class extends **NodegraphAPI.SuperTool** and sets up the underlying nodegraph such as the group and merge node. The Editor class extends a **QtGui.QWidget** which displays the user interface in the parameter panel.

New modules must register a class that extends **AssetModule** and subsequently override the functions that are needed for a given task. In order to create a hierarchy of elements within the Importomatic list, each level in the hiearchy has to extend from AssetTreeChild which will generate the corresponding element with the corresponding name, type, icon, etc.

Where to Place New Modules

New modules can be placed anywhere, as long as the path where the module lies is included in KATANA_RESOURCES.

Minimum Implementation

Only two files are needed to get a new module going:

1. A main asset file which registers the callbacks and creates the relevant nodes and user interface.
2. An init file which imports the module file and assigns the registration functions to the Importomatic plugin registry.

The following example shows how to implement a camera asset within the Importomatic. Doing so is technically abusing the intended scope of the Importomatic, but is a useful demonstration.

Importomatic Camera Asset Example

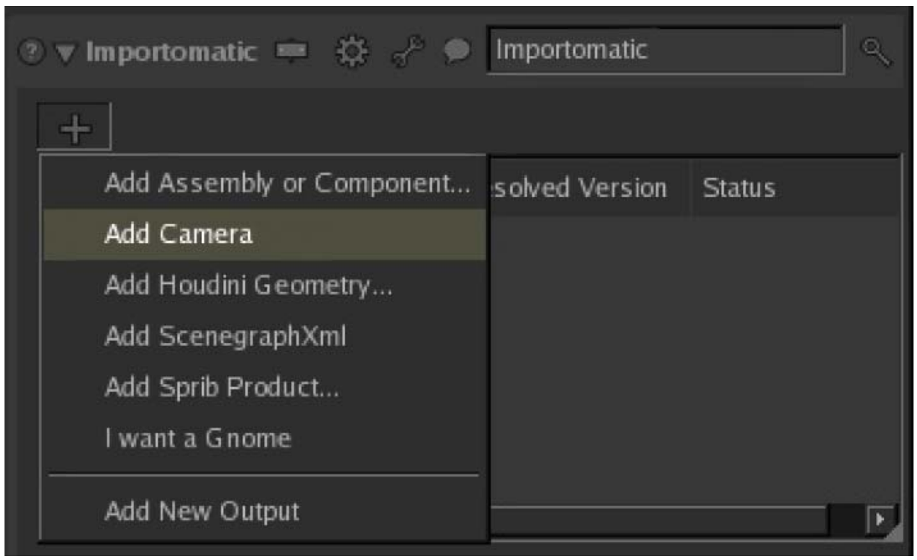
In this example, the main asset file is **CameraAsset.py** into which we need to import the nodegraph API and plugins from Katana. We also include os, solely to acquire the current path when referencing the asset icon.

```
from Katana import NodegraphAPI, Plugins
import os
```

Next, we define the registration function which is called from the init file in order to register the callback and module type for the plugin.

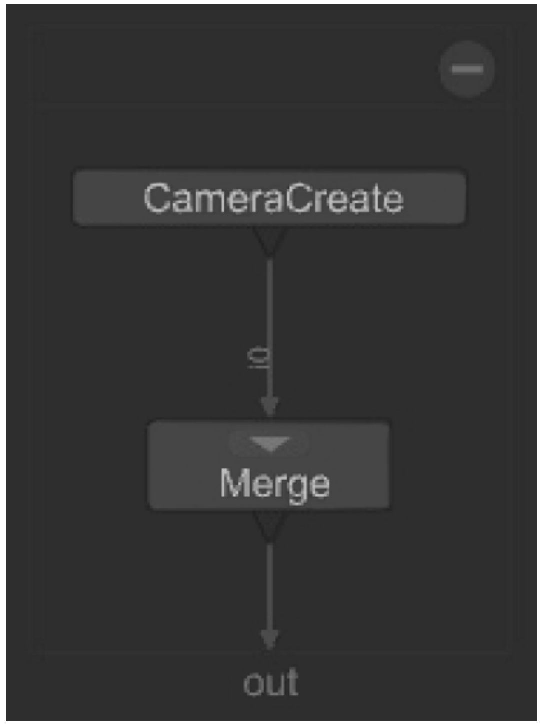
```
def Register( ):
    ImportomaticAPI.AssetModule.RegisterCreateCallback('Add Camera',
AddCamera)
    ImportomaticAPI.AssetModule.RegisterType('CameraCreate' ,
CameraModule( ) )
```

The callback comes into play when the user clicks the plus sign with the intent of instantiating a new module within an Importomatic. The first string specifies the text shown in the menu command



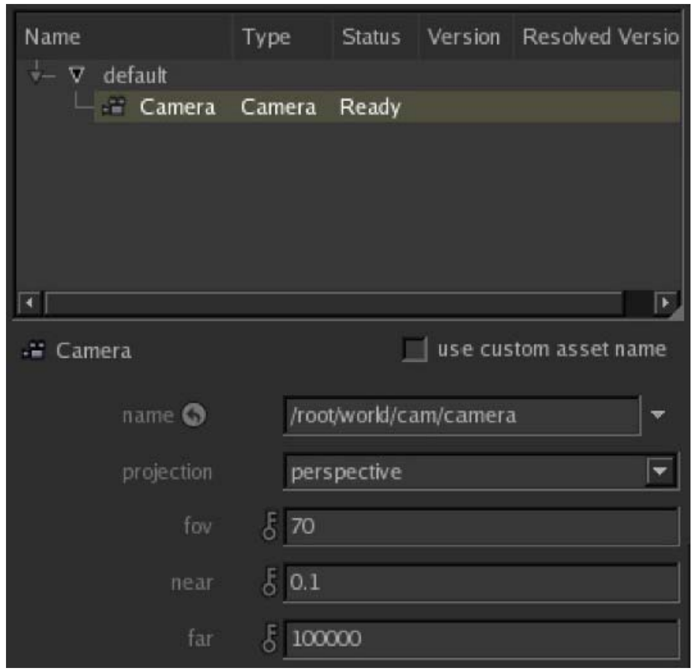
If the Add Camera module is selected from the dropdown list, the AddCamera function is called, which communicates with the nodegraph API and creates a camera node. The output of the camera node is automatically connected to the input of a merge node, within the Importomatic.

```
def AddCamera( importomaticNode ):
    node = NodegraphAPI.CreateNode( 'CameraCreate' )
    node.setName( "CameraCreate" )
    return node
```



The registered type class **CameraModule()** is also instantiated when the user selects the module from the menu. The function setItemState is called —if it exists— which defines the item properties in the Importomatic list.

```
class CameraModule( ImportomaticAPI.AssetModule ):
    def setItemState( self, node, item )
        from Katana import UI4, VpCore
        ScenegraphIconManager = UI4.Util.ScenegraphIconManager
        IconManager = UI4.Util.IconManager
        iconPath = os.path.dirname(__file__) + '/camera16. png'
        item.setText( ImportomaticAPI.NAME_COLUMN, 'Camera' )
        item.setText( ImportomaticAPI.TYPE_COLUMN, 'Camera' )
        item.setIcon( ImportomaticAPI.NAME_COLUMN, IconManager.GetIcon(
iconPath) )
            item.setText( ImportomaticAPI.STATUS_COLUMN, 'Ready' )
```



The parameter editor is resolved automatically in cases where the user is allowed to change properties. The UI4 and VpCore packages are imported within this scope, because this function is only called in interactive mode (these packages are not allowed in batch mode).

In the init file **_init_.py** we import the camera asset, append it to the plugin registry as an importomatic module, and pass in the registration function. Alternatively, pass an additional GUI registration function —if needed— in the form of a tuple.

```
PluginRegistry=[ ]
import CameraAsset
PluginRegistry.append(
    ( "ImportomaticModule", "0.0.1", "CameraAsset", CameraAsset.Register),
)
```

Custom hierarchy structures and extensions

Enhancing the functionality of a module requires following a specific design pattern, where the core ideas are:

- No global variables are allowed. Instead any persistent data must be written as parameters on the primary node. This parameter meta-data is used to generate the underlying nodegraph, and corresponding hierarchy structure in the Importomatic interface.

- The module class returns an object of type AssetTreeChild which corresponds to the root item of the tree.
- The remaining nodes in the tree are implemented using a class which extends a base handler where each derived class either inherits or overrides the functions that interact with the UI.
- A separate GUI registration is defined in the init file, to avoid errors while running Katana in batch mode.
- The main node, and any other nodes used to implement the custom Importomatic module are placed in a Group node. This ensures a clean and clutter-free internal structure of the Importomatic node, with each module encapsulated using a single node, all of which connect to the merge node. It is not possible to create nodes between the merge node and the group's out port (a module should not affect the outcome of other modules anyway) because disconnecting the out port has implications that hinder any further processing.

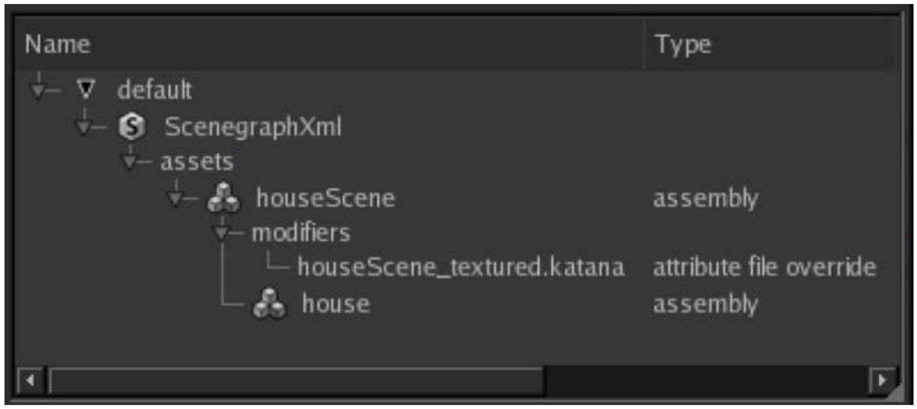
Creating a tree structure

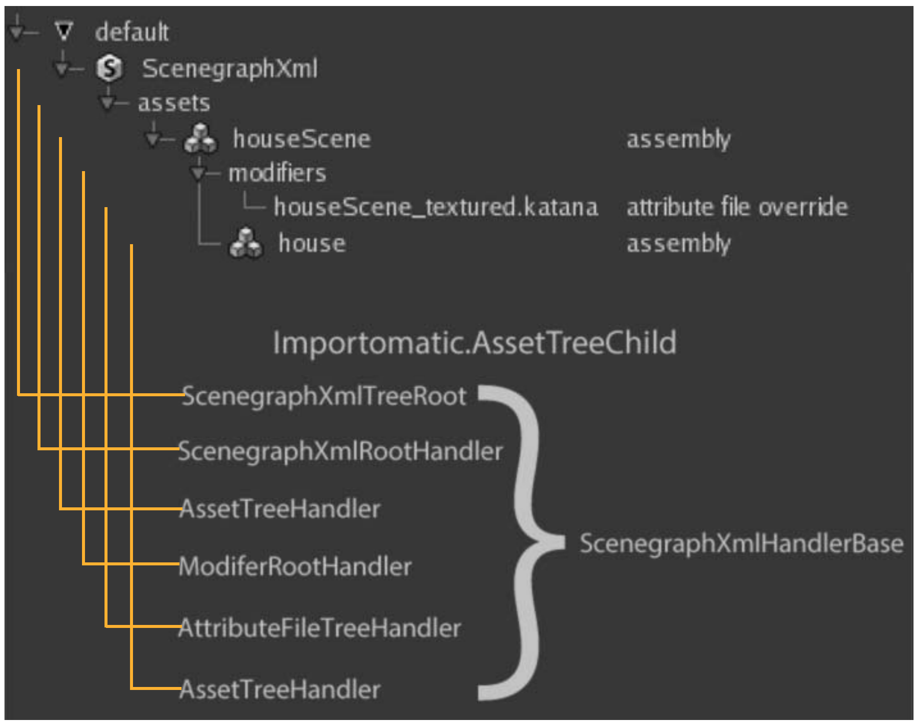
Here we look at the concepts discussed in Custom hierarchy structures and extensions in more detail, using the ScenegraphXML module as a reference. ScenegraphXML loads a scenegraph from an XML file using the ScenegraphXml_In node, then applies modifiers and look files, which can either be read from the XML file, or through manual interaction in the Importomatic. If applied through manual interaction, modifiers and look files are called overrides.

The first step involves parsing the XML file to extract the geometric data in terms of assemblies, as well as any assigned modifiers / look files. This information is written as parameters on the group node which encapsulates the module. This automatically creates the top node ScenegraphXml of type ScenegraphXmlTreeRoot. See Custom hierarchy structures and extensions for more information.

The second step uses these node parameters to generate the nodegraph and hierarchy within the Importomatic. The ScenegraphXmlTreeRoot is instantiated and the traversing process begins where its method getChildren is called, which instantiates the ScenegraphXmlRootHandler.

The root handler contains every other handler by going through the group-node's meta-data, instantiating an AssetTreeHandler for every asset, which subsequently calls the getChildren function that goes on to instantiate any sub-asset / modifier / look-file etc. recursively. The image below shows an example generated hierarchy.





Each class has to implement the setItemState function which specifies the item name and type. If the item relates to a particular node in the nodegraph the node interface can be exposed to the user within the Importomatic, using the function getEditor.

Updating The Nodegraph

Similar to the CameraAsset example in Importomatic Camera Asset Example, the scenegraph module registers a call which adds the geometry, which in this case is the group node, which encapsulates every node for this module and the ScenegraphXml_In node.

A function which recursively reads the meta-data parameters from the group node and builds the remaining nodes representing the modifiers / look-file is called at the end of the registered function. and in functions that will have an effect on the nodegraph.

Additional Context Menu Actions

Delete item

Declare in the class if the item can be deleted. For instance:

```
def isDeletable( self ):
    return True
```

If this function returns True, a delete menu option is added to the context menu when the item is right clicked. The method **delete(self)** implements what will happen when the delete option is selected.

Ignore item

Similar to Delete item the function **isIgnorable(self)** defines if the item can be ignored and will add the appropriate context menu option if this method returns true.

The functions **isIgnored(self)** and **setIgnored(self)** are used to determine and set the ignore state. **isIgnored(self)** returns True or False depending on the defined ignore state.

Custom actions

You can add custom actions to the context menu using the addToContextMenu function (only allowed in GUI mode). A new action is added using **menu.addAction([QtGui.QAction])**. The class extending the QAction has to be within a GUI scope, which is registered seperately in the init file. See Registering the GUI for more information.

The custom action instantiates a QAction with the context menu description, and connects a listener to the signal which is triggered when the menu option is selected.

Registering the GUI

When GUI commands are needed, they are registered in a seperate definition which contains a scoped import of the QtGui and QtCore. This avoids illegal calls to these packages when running Katana in batch mode.

This done using a tuple in the init file when registering the plugin. The GUI registration class is the second item as shown here using the scenegraph XML module as a reference:

```
PluginRegistry=[ ]
import ScenegraphXmlAsset
PluginRegistry.append(
    ( "ImportomaticModule" , "0.0.1" , "ScenegraphXmlAsset" ,
    ( ScenegraphXmlAsset.Register, ScenegraphXmlAsset.RegisterGUI) ),
)
```

Adding Importomatic Items Using a Script

Using the Alembic module as a reference, adding a new Alembic item in the Importomatic is achieved by registering the callback:

```
ImportomaticAPI.AssetModule.RegisterCreateCallback( 'Add Alembic',
AddAlembicGeometry)
```

Where the menu option 'Add Alembic' is added which calls AddAlembicGeometry when selected.

The function AddAlembicGeometry can be called from a script in order to automate the population of Alembic files but the node it returns has to be inserted into the output merge of the Importomatic (which is something the caller does for you in the callback case above).
This is achieved using the **insertNodeIntoOutputMerge** function:

```
importomaticNode.insertNodeIntoOutputMerge( returnedNode, 'default' )
```

Where the node will be connected to the default port.

16 HANDLING TEXTURES

Because textures are handled in a number of different ways by shader libraries and studio pipelines, Katana doesn't enforce rigid standards for how textures are declared but acts as a flexible framework with some common conventions.

In particular there is a convention to use string attributes with the naming convention **textures.xxx** where xxx is the name of the file path for a texture. For example **textures.ColMap** specifies the filepath for a texture called ColMap.

> **TIP:** The following demo scenes shows different ways of handling textures:
>
> $KATANA_ROOT/demos/katana_files/texture_resolving_prman.katana
>
> $KATANA_ROOT/demos/katana_files/texture_resolving_arnold.katana

Different Approaches to Determine Texture

Materials With Explicit Textures

The simplest way of assigning individual pieces of geometry their own texture map, is to create a separate material for each piece of geometry, and assign separate texture maps in each material's parameters.

Though this is simple it lacks flexibility. In particular it doesn't allow the use of the same material on multiple objects where each object picks up its own textures.

Using Material Overrides to Specify Textures

If you have exposed parameters on a material that define the textures to use, you can use material overrides to create new object specific versions of materials that substitute the relevant textures. Depending on your renderer, you can assign the base material to a location high up the Scene

Graph hierachy and use inheritance, or assign the base material to every geometry location.

Use a MaterialOverride set on the individual object locations to override the shader parameters that specify the textures, with new object specific values. This can be done using MaterialAssign nodes, but since all MaterialAssign nodes do is create attributes in an group called **materialOverride** we can perform material overrides by setting the necessary attributes directly, such as by using AttributeScripts.

For instance, the fragment of AttributeScript below reads the attribute value contained in **textures.SpecMap** and uses it to override an Arnold shader parameter called **SpecMapTexture**:

```
SpecMapPath = GetAttr( 'textures.SpecMap' )\
    SetAttr( 'materialOverride.arnoldSurfaceParams.\
        SpecMapTexture', SpecMapPath )
```

The result is a new copy of the material created for each object the Attribute Script runs on, with the shader's **SpecMapTexture** parameter changed to the value stored in **textures.SpecMap**.

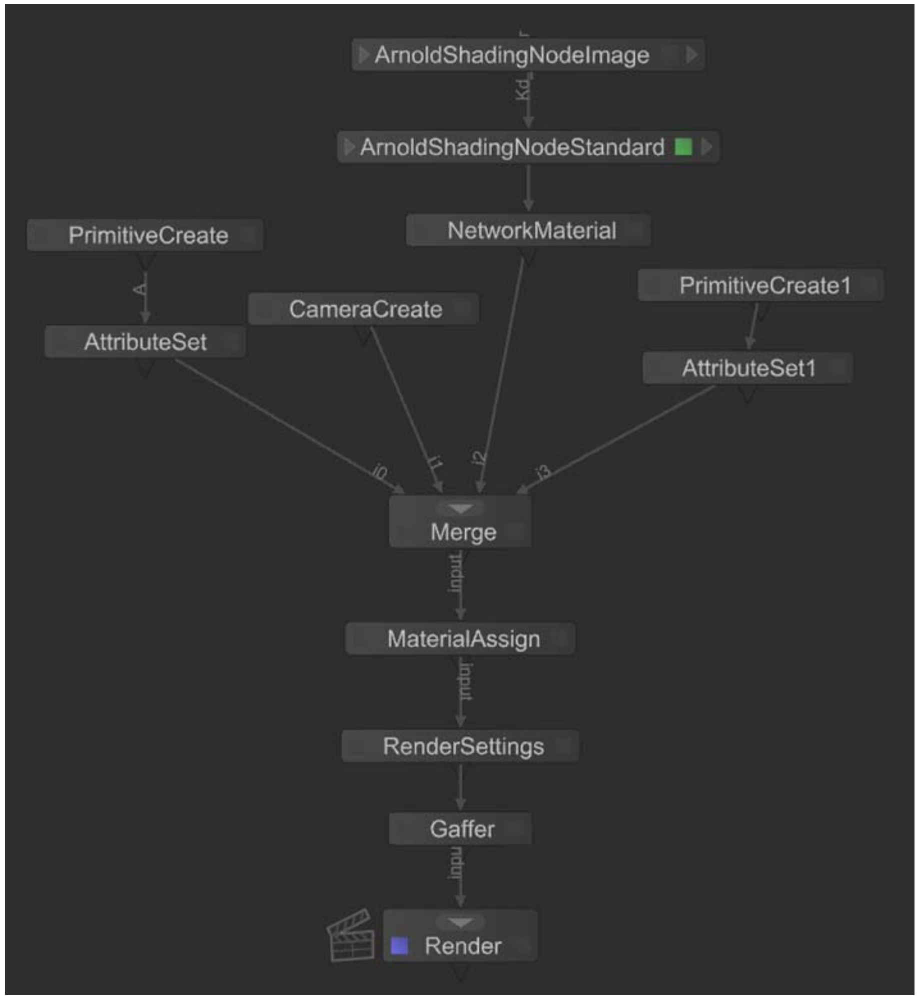
NOTE: Material overrides actually take place as part of MaterialResolve, one of Katana's implicit resolvers. During MaterialResolve Katana looks for attributes in the **materialOverride** group, and creates a new copy of the material at that location with the relevant changes to shader parameters.

Using The {atttr:xxx} Syntax For Shader Parameters

You can declare string shader parameters to use the value of another attribute. If you define any string parameter on a shader to be **{attr:xxx}** then during MaterialResolve it looks for an attribute called **xxx** at the location the material is being assigned to, and uses that as the shader value.

For example, if you have an Arnold image reader shader with a parameter called **filename** and you set **filename** to **{attr:textures.SpecMap}**, **filename** is set to the value of the attribute **textures.SpecMap** on any location the material is assigned to. This means you can set up the original shader to automatically pick up relevant texture name attributes for every object it is applied to. For example, create an Arnold Network Material with an image read node, and have the filename parameter of the image read node linked to a **textures.ColMap** attribute on geometry locations:

1. In an empty Katana scene create two ArnoldShadingNodes, set one to type **image**, and one to type **standard**. Link the output of the **image** node, to the **Kd_Color** parameter of the **standard** node.
2. In the **filename** field in the image node's parameters enter:
   `{attr:textures.ColMap}`
3. Add a NetworkMaterial node, with an Arnold standard terminal. Connect the output of the ArnoldShadingNode of type **standard** to the input of the NetworkMaterial node.
4. Add two PrimitiveCreate nodes, and two AttributeSet nodes. With the AttributeSet nodes set a string attribute with the attributeName textures.ColMap on each primitive location. Set the stringValue for each to the path to a texture (for example /tmp/yourTexture.tx and /tmp/yourOtherTexture.tx).
5. Add a CameraCreate node.
6. Connect the outputs of PrimitiveCreate nodes, the CameraCreate, and the NetworkShading node to inputs on a Merge node. Add a MaterialAssign node below the Merge node. Assign the NetworkShading material to each applicable Scene Graph location. For example, use the CEL statement:
   `/root/world/geo//*`
   Assignments created using **{attr:yourParameter}** are evaluated during material resolve. Therefore any material using those parameters must be explicitely assigned to any relevant Scene Graph locations, rather than relying on inheritance.
7. Add a RenderSettings node below the MaterialAssign node, and set the renderer to **arnold**.
8. Add a Gaffer below the RenderSettings node, set it to the **arnold-c** profile, and add a spot light.
9. Add a Render node below the Gaffer node.
10. Position the spotlight, and the camera.
11. Right click on the Render node and select Preview Render.
    At material resolve time Katana picks up the **texture.ColMap** parameter on each of the geometry locations, and creates an instance of the assigned material for each, with the material's filename parameter set to the value of **textures.ColMap**.



NOTE: Because **{attr:xxx}** is evaluated during MaterialResolve you must apply the base material directly to every object that needs it, rather than using material inheritance in the hierarchy.

Using primvars In Renderman

RenderMan has a feature called primvars that allow you to directly override the value of any shader parameter. This means that you can have a single instance of a shader used by multiple pieces of geometry (for example by being placed high up in the hierarchy and inherited) with string parameters for textures, but each piece of geometry can use its own specific textures by creating a primvar with the same name as the shader parameter.

In Katana any string attribute called **textures.xxx** is automatically written out to RenderMan as a primvar called **xxx**. For instance if your shader has a string parameter called **BumpMap**, setting an attribute called **textures.BumpMap** on a piece of geometry means a primvar called **BumpMap** is created on the geometry, with the value of the **textures.BumpMap** attribute.

This means that with suitably named shader parameters you can create attributes in Katana called **textures.xxx** on geometry locations, allowing each piece of geometry to pick up its individual textures.

You can also do per-face assignment of textures using primvars. If **textures.xxx** is set to an array of string values, with the number of elements matching the number of faces, that array is written out as a varying primvar instead of a constant, so each face picks up its own value.

Using Custom User Data

Some renderers don't support RenderMan style primvars, but allow some form of custom user data that can be looked up by shaders. With a little more work and suitable shaders these can be used to give similar results.

For instance, in Arnold if you have shaders designed to look for user data that contain strings declaring the paths to textures (instead of the paths to the textures being direct parameters on the shaders) you can use user data to have a shared material on multiple objects and each object picks up its own individual textures.

Any string attribute called **textures.xxx** is automatically written out to Arnold as a piece of string user data called **xxx**, which is looked up inside applicable shaders.

You can also do per-face assignment of textures using user data. If **textures.xxx** is set to an array of string values, with the number of elements matching the number of faces, that array will be written out as a per-face array of user data so each face can pick up its own value.

Using Pipeline Data to Set Textures

Different pipelines often use different methods to specify which textures should be used on a particular asset.
As discussed above, the normal convention in Katana is to use attributes called **textures.xxx** on geometry to hold the individual texture paths needed for that piece of geometry. That data can be set in a number of different ways.

Metadata on Imported Geometry

Arbitrary metadata can be read in with geometry on import, such as string data containing the texture paths written out into an Alembic and read in as arbitrary geometry data. This means that assets can be created with additional metadata, such as by adding string attributes to shape nodes in Maya before writing the data to Alembic.

In Katana the convention is for arbitrary geometry data to be read in as attributes called **geometry.arbitrary.xxx**, which are then - by default - also written out as user or primvar data to renderers.

Meta Data From Another Source

If texture assignment is specified by other sources in the pipeline, such as by having separate XML files associated with assets that give the texture paths to be used on any named piece of geometry, that metadata can be added to objects using AttributeModifiers.

Katana comes with an example Attribute Modifier called AttributeFile that reads data from a simple XML format to create new attributes at locations in the Scene Graph. One of the demo scenes - houseScene_textured.katana - makes use of AttributeFile, together with an AttributeScript to read in attribute values then do some additional processing to turn those attributes into final texture file paths.

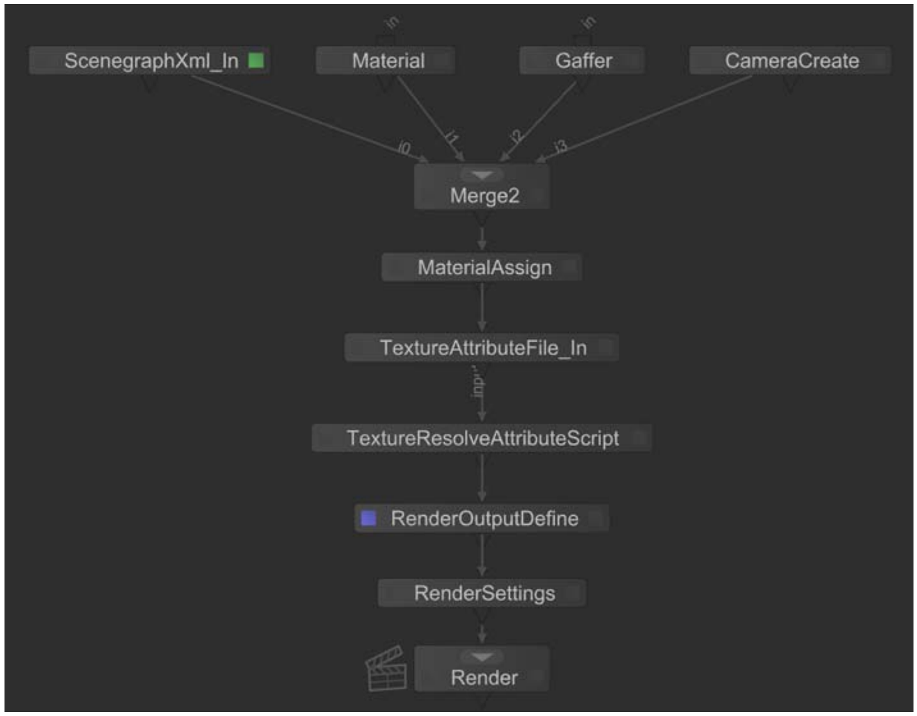
In the houseScene_textured example, an AttributeFile_In node brings in an external XML file - houseScene_textures.xml - which provides two string attributes for each geometry location, **channel**, and **path**. For example, the following exceprt from houseScene_textures.xml specifies that the **channel** attribute on the Scene Graph location **doorShape** is **ColorMap**, and the **path** attribute is **door.tx**:

```
<attributeList location="doorShape">
    <attribute name="channel" type="string" value="ColorMap"/>
    <attribute name="path" type="string" value="door.tx"/>
</attributeList>
```

The attributes read in through the AttributeFile_In node appear under **attributeFile.xxx**. Translating these to a **textures.ColMap** attribute is performed by an AttributeScript, which reads the value of **attributeFile.path** at each target location, and if it is not **None**, appends that value to the texture path, and writes the attribute **textures.ColMap** with the result:

```
txDir = user.tx_directory
ColMap = GetAttr('attributeFile.path')
if ColMap is not None:
    ColMapPath = [txDir[0] + "/" + ColMap[0]]
```

```
SetAttr('textures.ColMap', ColMapPath)
```



Procedurally Resolving Textures

You could also use a resolver to procedurally set **textures.xxx** to appropriate file paths, including allowing the actual creation of these file paths as one of the last automatic processes in the pipeline.

The robot_textured.katana example demo project illustrates how meta data that comes in with a ScenegraphXML asset can be further processed by an AttributeScript to turn it into the final texture paths. By setting these in attributes called **textures.ColMap**, **textures.SpecMap** and **textures.BumpMap** these are exported to RenderMan as primvars named ColMap, SpecMap and BumpMap.

17 Typed Connection Checking

The constituent nodes of a Network Material can specify which connections are valid, based on simple string tags. Shaders can declare a set of named tags that indicate what they provide as outputs, and input connections. Shaders can specify what what tags they require for that connection to be valid.

Shader Outputs

Any shader can declare a set of tags to represent what outputs the shader provides. Tags are all simple string values and are declared in **.args** files using the following syntax:

```
<args format="1.0">
    <output name="out">
        <tags>
            <tag value="color"/>
            <tag value="color4"/>
            <tag value="diffuse"/>
        </tags>
    </output>
</args>
```

The following is the equivalent hint dictionary syntax:

```
{"PrmanShadingNode.parameters": {
    "containerHints":{
        "": {"outputs":{"out":{"tags":["color","color4","diffuse"]}}},
        "open": "True"},
}
```

For PRMan coshaders, tag values are typically the names of methods the coshader provides, that can be interrogated by another shader. For example, if a shader provides a method called **outColor**, this can be advertised by declaring an output tag called **outColor**. The ability to declare multiple tags allows coshaders to advertise any number of different methods they provide.

For renderers - such as Arnold - where shader components provide strongly typed data, these tags can simply be the names of the data types they provide, such as **float**, **vector** or **color**.

Tag values can also be used for higher level constructs, such as declaring that a shader provides all the outputs necessary for a **layerShader**.

Shader Inputs

Each connectable input parameter for a shader can declare what tag values it requires for a connection to be valid. The user interface makes use of these declarations to only allow the user to make valid connections.

Tag values for an input input parameter are declared in **.args** files with the following syntax:

```
<args format="1.0">
    <param name="diffStr" >
        <tags>
           <tag value="(color and diffuse and color4) or test"/>
        </tags>
    </param>
</args>
```

The following is the equivalent hint dictionary syntax:

```
{"PrmanShadingNode.parameters.diffStr": {
       "widget": "null",
       "name": "diffStr",
       "transientHints": {"helpCaption": true},
       "tags": ["color and diffuse"],
       "helpCaption": "shader: MyShaderName  -  diffStr",
       "coshaderPort": "True"
    }
}
```

Logical Inputs

Boolean logic is available to make more advanced rules specifying which connections are valid for any input parameter. The available operators are **and**, **or**, **not**, **(', ')**

AND

```
<param name="diffStr" >
    <tags>
        <tag value="color and color4 and diffuse"/>
    </tags>
</param>
```

This tag states that the output of the shader connected to this parameter needs to provide all of the tags **color**, **color4** and **diffuse**. If any tag is omitted, then the connection is not allowed.

OR

```
<param name="diffStr" >
    <tags>
        <tag value="color or color4 or diffuse"/>
    </tags>
</param>
```

This tag states that the output of the shader connected to this parameter needs to provide at least one of the tags **color**, **color4** or **diffuse**. If none of the tags are provided, then it will not allow you to make the connection.

NOT

```
<param name="diffStr" >
    <tags>
        <tag value="not float"/>
    </tags>
</param>
```

The not operator allows you to specify exception rules. So the above tag allows the incoming shader parameter to have any tag value except **float**.

PARENTHESIS (', ')

```
<param name="diffStr" >
    <tags>
        <tag value="diffuse and (color or color4)"/>
    </tags>
</param>
```

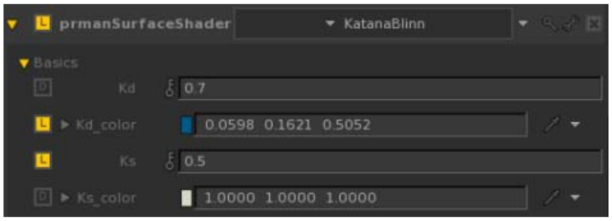
Tag rules can also contain parenthesis to allow you to group logic together, for either readability or for pure logic purposes. The above rule allows any connection that provides **diffuse** as well as at least one of **color** or **color4**.

18 Universal Attributes

One of the key strengths of Katana is its ability to deal efficiently with scenes of potentially unlimited complexity. Consider for example a complex surface shader with thousands of configurable parameters. Katana will not only allow efficient configuration of the shader within Katana, but also handle communication of these parameters to renders in an efficient manner.

One way it achieves this by only sending to the renderer, parameters which have actually been modified. As the renderer has knowledge of the remaining, default values, Katana does not need to duplicate them. For example, see the extract below which is a portion of a RIB file produced by Katana for a simple material assignment operation and the settings as they appear in the Parameters tab (the extract has been truncated for clarity).

```
Attribute "iden..." "uniform ... name" ["/root/.../
primitive"]
                                    ...
                                    Surface "Blinn" "Kd_color"
[0.059 ...] "Ks" [0.5]
AttributeEnd
```



However, this poses the question, how does Katana know what values to display in the user interface of say, the Material Node for parameters that are not set in Katana if it only passes the values which are set by Katana to the renderer?

This document will explain a number of important concepts in Katana, namely:

- Universal Attributes – these allow Nodes to access incoming Scene Graph attributes which may not have been set within the Katana project.
- Default Attribute Producers (DAPs) – Closely related to universal attributes, DAPs are the mechanism by which universal attributes are populated with default values.

- Dynamic Parameters – These are parameters of a node which depend on Scene Graph attributes. An example of this is the RenderSettings node which depends on the attributes under renderSettings, at location /root and is used for the configuration of render settings such as output resolution. Another node where dynamic parameters are used heavily is the Material node. When used in edit mode it can manipulate the values of incoming scene graph attributes at a particular material location.

NOTE: Example scripts and scenes referenced in this document are found under the tutorials directory which accompanies this document.

The scripts contained in this document are designed to be run in Katana's script mode which is invoked from the command line as follows:

```
katana -script <script name>
```

Default Attributes

As discussed earlier, Katana only communicates values that have been set explicitly in a Katana project. As there are a number of ways in which a particular parameter or Scene Graph attribute can obtain its value, a number of colour codes are used to denote how the value you see has been derived (for a full list see **Help** > **User Guide** > **Editing a Node's Parameters**). For example, load MaterialScene.katana from the scenes directory, here you can see that under the Material node, parameters Kd_color and Ks have been set and this is indicated by the state badge next to the parameter name.

To see what is actually communicated to the renderer right click a Gaffer node and select **Debugging** > **Open .rib output in** <your selected viewer> or **Debugging** > **Open .ass output in** <your selected viewer>

Reading Parameters

Reading the parameters that have been set on a particular node, like in the above example, can be achieved by running the following example script:

```
katana -scripts ViewParams.py
```

Which simply obtains a reference to the Material node and outputs the value of the Ks parameter to the console.

Now, suppose our script wanted to read both the Ks parameter (set on the Node) and Kd parameter (taking its default) and make some decision based on their values. Intuitively, you would expect the following code fragment would achieve this:

```
# Access the Ks and Kd parameter on the material node
specularParam =
m.getParameter('shaders.prmanSurfaceParams.Ks.value')
diffuseParam =
m.getParameter('shaders.prmanSurfaceParams.Kd.value')

# Make decision to do something
if specularParam.getValue(1) > 0.1:
    if diffuseParam.getValue(1) > 0.5:
        print 'diffuse > 0.5'
    else:
        print 'diffuse < 0.5'
```

This code can be found in ViewSetAndDefaultParamsError.py and run using:

```
katana –scripts ViewSetAndDefaultParamsError.py
```

However, you will find that this script does not work, complaining that diffuseParam is of NoneType. This would suggest that our call to getParameter failed to return a Parameter object.

Why is this the case when we can clearly see the values present in the Parameters tab, or, when inspecting the generated location in the Attributes panel? The reason for this lies in the node's dynamic parameters, how they are updated using universal attributes, and how universal attributes are populated using DAPs. In the following section you will learn how to read dynamic parameters and gain an understanding of the process used to generate them.

Reading Default Parameters

For values that have not been set locally, there exists a mechanism through which Katana is able to learn about these values so they can be displayed in the UI and via its APIs. There are three concepts related to this which are encapsulated within a single function call you will need to use.

Universal Attributes and DAPs

Universal attributes are the complete set of scene graph attributes for a particular scene graph location, including default values (where they have not been specified) and UI hints allowing them to be displayed correctly. Values are provided in a waterfall fashion, such that if a local value has not been set it will fall back on inherited scene graph attributes, Args files and the DAP mechanism.

Universal attributes are generated automatically in UI mode each time you open the Parameter interface, or inspect the values generated at a location in the Scene Graph tab. Katana will request the universal attributes for a particular location then use the returned object to display the required values.

As mentioned earlier, within Katana there is group of systems known as Default Attribute Producers that are responsible for providing default values to universal attributes where no value has been specified. To force the production of the universal attributes for a given Node you can call getUniversalAttr() on it, which will return a PyScenegraphAttr object which you can view by running the script, GetUniversalAttrs.py.

With this object, Katana can then update the appropriate portions of the UI by simply iterating over this object to obtain the required values.

Dynamic Parameters

Closely related to the universal attributes are Node parameters which are dependent on attributes in the incoming Scene Graph.

Taking the Material node in MaterialScene.katana as an example, if we want to edit our existing material using another Material node downstream in edit mode, we need to be able to display the existing material's values in the downstream Node's parameters. We do this by using the universal attributes as these provide us with all the data we need to be able to fully display them in the Katana UI.

This means the parameters on our downstream node will dynamically update based on our upstream Node, this creates the concept of dynamic parameters: parameters dependent on incoming scene graph attributes.

When creating Nodes in script mode, Katana will not by default create the dynamic parameters on the node, only those set locally. Therefore, to ensure you can access these scene graph dependent parameter values, you must call the function checkDynamicParameters() on the Node.

When you call checkDynamicParameters(), the universal attributes will be generated for you so there is no need to call it explicitly, after doing so you will be able to access them as normal. Run ViewSetAndDefaultParams.py to see an example of this.

You must remember to call checkDynamicParameters() on your node *before* attempting to read them. or you will experience the issues highlighted in ViewSetAndDefaultParamsError.py.

NOTE: You may find that in UI mode you sometimes do not experience this error because user interactions such as inspecting the parameters will automatically call the checkDynamicParameters() function for you.

Summary

Universal attributes are used by the Katana to allow it to display parameter values and attributes in the UI, and through the NodegraphAPI. The universal attribute object provides a complete description of scene graph attribute values and UI hints that should be applied to them, this includes default values not set explicitly in Katana. These default values are provided by Default Attribute Producers.

Dynamic Parameters are parameters dependent on scene graph attributes. Dynamic Parameters will be generated automatically by the Katana UI as you reveal dependent parameter values, it does this by calling checkDynamicParameters(). However, when you are using the NodegraphAPI in script mode you will have to manually call checkDynamicParameters() to ensure you can access these values.

19 ARGS FILES IN SHADERS

Args files provide hints about how parameters are presented in the user interface. One of their main uses is describing how shader parameters are presented. Various aspects such as options for a shader parameter's widget, conditional options, and help text can be modified interactively inside Katana's UI. Further details, such as grouping parameters into pages, are defined in **.args** files.

When loading a shader, Katana looks in the following directories for the associated **.args** file:

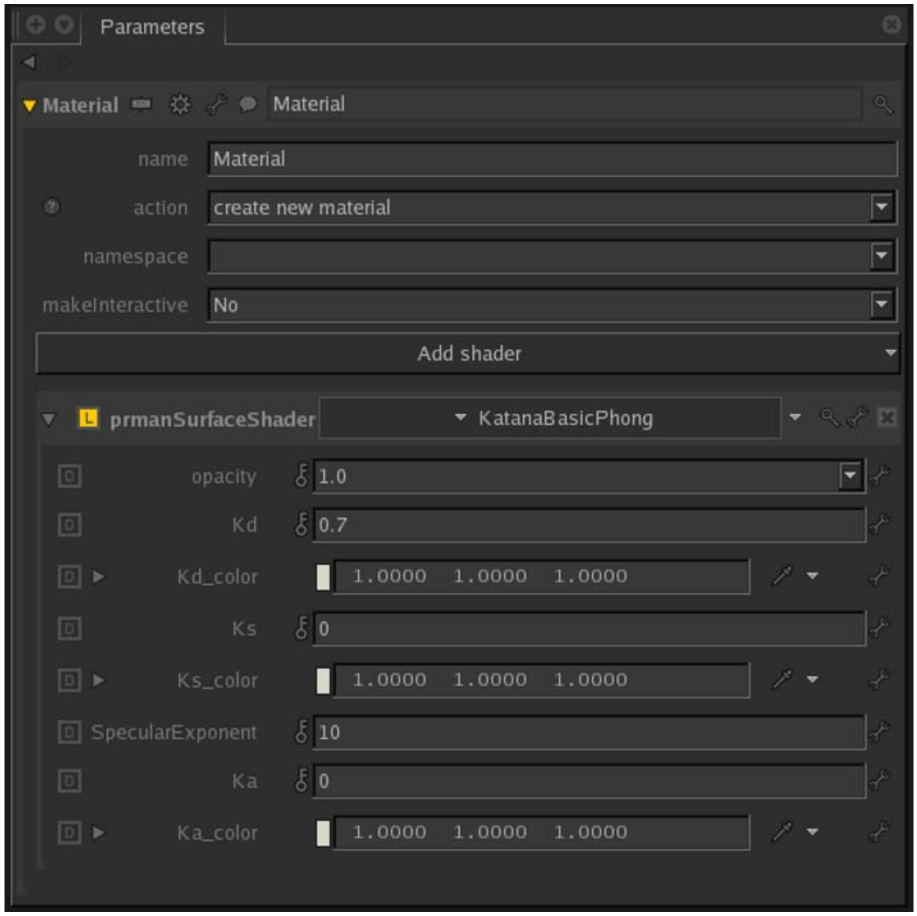
- An **Args** subdirectory of the shader directory
- A **../Args** directory relative to the shader directory
- A **../doc** directory relative to the shader directory
  For backwards compatibility.
- Any **Args** subdirectories of $KATANA_RESOURCES

NOTE: Args files must be named to match the name of the shader they correspond to, rather than the filename of the library that produced the shader.

The **.args** file for **KatanaBasicPhong** reads as follows:

```
<args format="1.0">
 <param name="opacity"/>
 <param name="Kd"/>
 <param name="Kd_color" widget="color"/>
 <param name="Ks"/>
 <param name="Ks_color" widget="color"/>
 <param name="SpecularExponent"/>
 <param name="Ka"/>
 <param name="Ka_color" widget="color"/>
</args>
```

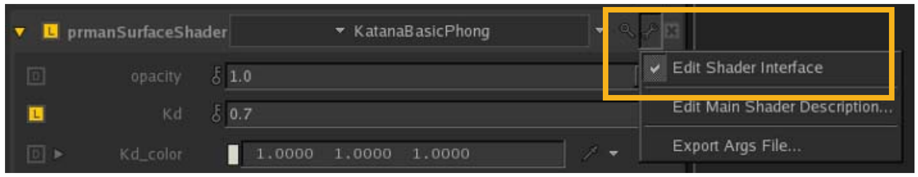
The **.args** file shown above controls how the parameters of the **KatanaBasicPhong** shader appear in **Parameters** tabs, as shown below:



Edit Shader Interface interactively in the UI

Enabling Editing the User Interface

To allow for editing of the shader interface, turn on **Edit Shader Interface** in the **wrench** menu that opens when clicking the **wrench** icon to the right-hand side of a shader in a Parameters tab of a Material node. When turned on, a **wrench** button appears to the right of every parameter, allowing the configuration of the parameter's widget and help text.



Edit Main Shader Description

By choosing **Edit Main Shader Description...** from the wrench menu, you can add context help for the selected shader. This can include HTML, and is shown when clicking the  icon next to the shader name.

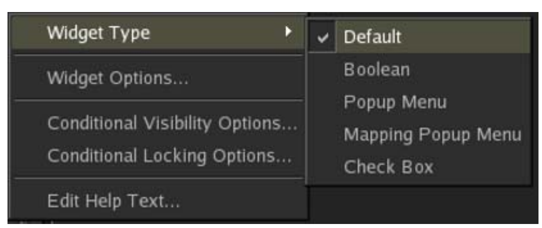
Export Args File

The shader interface can be exported using the **Export Args File...** command in the wrench menu.

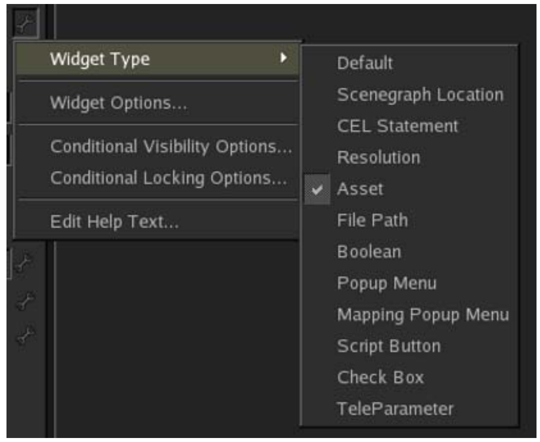
NOTE: By default the shader interface is saved to the /tmp directory, but alternate directories can be specified.

Widget Types

Depending on the widget defined in a shader's Args File, different Widget Types are available to choose from. The main types are string, number and color. The Widget Types available for a number shader parameter are shown below.



The Widget Types for a string shader parameter are shown below.



The primary widget types and widget hint values for user parameters of type **string** and **number** are shown in the table below:

Widget Type	Widget Hint Values	Description and Example
String and Number		
Mapping Popup Menu	mapper	Similar to Popup Menu, but with the option to map values. See Widget Options for more information. <param name="opacity" widget="mapper"> <hintdict name="options"> <float value="0.0" name="A"/> <float value="0.5" name="B"/> <float value="1.0" name="C"/> </hintdict> </param>
Check Box	checkBox	Similar to Boolean, but displayed as a check box. <param name="RepeatS" widget="checkBox"/>
Scenegraph Location	scenegraphLocation	Widget for specifying locations in the Scene Graph, e.g. /root/world/geo/pony1 <param name="loc" widget="scenegraphLocation"/>
Resolution	resolution	A resultion, e.g.: 1024x768. <param name="loc" widget="resolution"/>
File Path	fileInput	String parameter representing a file on disk. Uses the standard Katana file browser for selection. <param name="texname" widget="fileInput"/>

Widget Type	Widget Hint Values	Description and Example
Asset	assetIdInput	Widget to represent an asset. The fields that are displayed in the UI and the browser that is used for selection can be customized using the Asset Management System API. <param name="EnvMap" widget="assetIdInput"/>

Script Button	scriptButton	A button executing a Python script when clicked.
		<param scriptText="print 'Hello'"
		    name="btn"
		    buttonText="Run Script"
		    widget="scriptButton"/>

Dynamic Array	dynamicArray	A number or string array of dynamic size. Not available through the UI **wrench** menu.
		<numberarray_parameter
		hints="{'widget':'
		    dynamicArray'}"
		name="testNumArray" size="3"
		    tupleSize="1">
		 <number_parameter name="i0"
		     value="0"/>
		 <number_parameter name="i1"
		     value="0"/>
		 <number_parameter name="i2"
		     value="0"/>
		</numberarray_parameter>

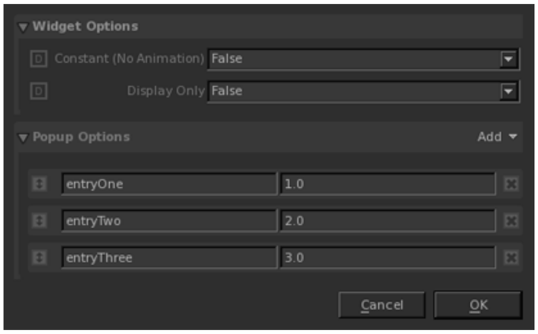
String Only		
CEL Statement	cel	Specify a CEL Statement. For more information on CEL Statements, consult the Katana User Guide. <param name="loc" widget="cel"/>

NOTE: See Parameter Hints for more on setting hint strings on User Parameters.

NOTE: See Parameter Types for a full list of the User Parameter types accessible through the UI.

Widget Options

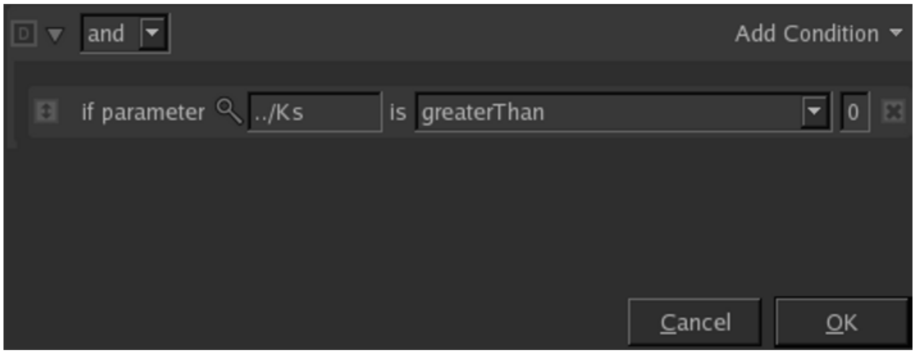
Based on the specified widget type, there are a number of options available. In case of a color parameters for example, these options allow settings like the restriction of the components (RGBA) to a range between 0 and 1. For numeric parameters, the display format and slider options, such as range and sensitivity can be specified.



For example, in the widget options of a Mapping Popup Menu, if you specify a list of numbers and their labels, they are displayed as a drop-down list.

Conditional Visibility Options

Some shader parameters are not applicable or do not make sense under certain conditions. To hide these parameters from the UI, select **Conditional Visibility Options...** from the **wrench** menu. Multiple conditions are matched and combined using AND OR keywords.



This looks as follows In an .args file:

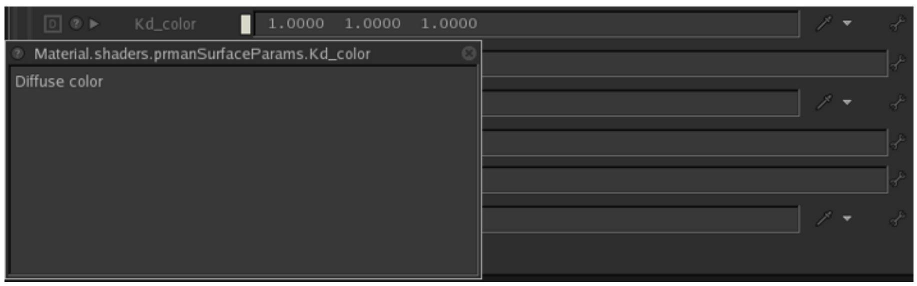
```
<param name="SpecularExponent">
 <hintdict name="conditionalVisOps">
  <string value="greaterThan" name="conditionalVisOp"/>
  <string value="../Ks" name="conditionalVisPath"/>
  <string value="0" name="conditionalVisValue"/>
 </hintdict>
</param>
```

Conditional Locking Options

Conditional Locking works exactly like the Conditional Visibility Options, except that parameters are locked under the specified conditions rather than hidden.

Editing Help Text

Similar to the Main Shader Description, you can specify an HTML help text for every parameter. The text is specified using the **Edit Help Text...** command from the **wrench** menu.

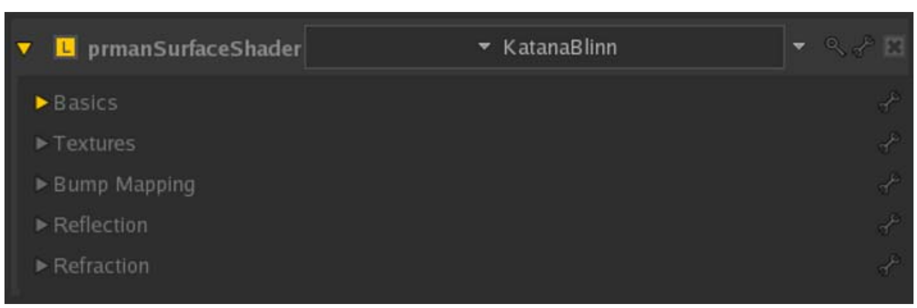


In the **.args** file, the tooltip shown above is stored as follows:

```
<args format="1.0">
 <param name="Kd_color" widget="color">
  <help>
   Diffuse color
  </help>
 </param>
</args>
```

Grouping Parameters into Pages

Pages allow parameters to be grouped and displayed in a more organized way.



This is achieved in one of two ways when editing **.args** files:

1. Adding a page attribute with the name of the page to each parameter:

```
<param name="Kd" page="myPage"/>
```

2. Grouping parameters using a page tag:

```
<page name="myPage">
   .
   .
</page>
```

TIP: The attribute open can be set to **True** to expand a group by default. The open hint also works for group parameters and attributes, which are closed by default. For example:

```
<page name="Basics" open="True">
```

NOTE: Currently, when using pages, only attributes listed in a page are visible! Any parameter not specifically assigned to a page is hidden.

Co-Shaders

It is a RenderMan convention to specify co-shaders used in a shader interface using parameters of type **string** or **shader**. If specified using type **shader**, Katana detects that this is a co-shader port automatically. If specified using type string, you must provide a hint in the **.args** file.

```
<param name="Kd_color_mycoshader" coshaderPort="True" />
```

Co-Shader Pairing

Katana allows co-shaders to be represented as network materials. For user convenience, there is a convention that allows pairs of parameters, representing a value and a port for a co-shader, to be presented to the user to look like a single connectable value in the UI.

RenderMan co-shader pairing is used by adding a co-shader port and specifying the co-shader's name in the coshaderPair attribute of the parameter. In the args file, this is achieved as follows:

```
<args format="1.0">
 <param name="Kd_color_mycoshader" coshaderPort="True" />
 <param name="Kd_color"
   coshaderPair="Kd_color_mycoshader" widget="color"/>
</args>
```

Example Args File

An example of an **.args** file using pages and different types of widgets is KatanaBlinn.args, saved in ${KATANA_ROOT}/plugins/Resources/PRMan17/Shaders/Args:

```
<args format="1.0">
    <page name="Basics" open="True">
        <param name="Kd"/>
        <param name="Kd_color" widget="color"/>
        <param name="Ks"/>
        <param name="Ks_color" widget="color"/>
        <param name="Roughness"/>
        <param name="Ka"/>
        <param name="Ka_color" widget="color"/>
        <param name="opacity"/>
    </page>
    <page name="Textures">
        <param name="ColMap" widget="filename"/>
        <param name="SpecMap" widget="filename"/>
        <param name="RepeatS" widget="boolean"/>
        <param name="RepeatT" widget="boolean"/>
    </page>
    <page name="Bump Mapping">
        <param name="BumpMap" widget="filename"/>
        <param name="BumpVal"/>
    </page>
    <page name="Reflection">
        <param name="EnvMap" widget="filename"/>
        <param name="EnvVal"/>
        <param name="UseFresnel" widget="boolean"/>
    </page>
    <page name="Refraction">
        <param name="RefractMap" widget="filename"/>
        <param name="RefractVal"/>
        <param name="RefractEta"/>
    </page>
</args>
```

Args Files for Render Procedurals

Similar to their use in shader interfaces, UI hints can be defined for PRMan and Arnold procedurals. The RendererProceduralArgs node looks for an **.args** file called <proceduralName>.so.args in the same directory as the .so file for the procedural.

In contrast to their use with Shaders, Args files for a procedural must specify a default value for each parameter, as shown in the **procedural.so.args** file below:

```
<args format="1.0" outputStyle="typedArguments">
 <int name='count' default='100'/>
 <int name='segments' default='3'/>
 <float name='rootWidth' default='0.04'/>
 <float name='tipWidth' default='0.00'/>
```

```
 <float name='lengthMin' default='0.4'/>
 <float name='lengthMax' default='1.3'/>
 <float name='turnsMin' default='0.5'/>
 <float name='turnsMax' default='2.0'/>
 <float name='radiusMin' default='0.06'/>
 <float name='radiusMax' default='0.09'/>
 <float name='min_pixel_width' default='1.0'/>
</args>
```

Parameters are parsed from Args file to procedural as either serialized key-value pairs, or typed arguments. If the Args file does not specify an output style, it defaults to serialized key-value pairs.

Examples

Serialized Key-Value Pairs

If an Args files does not specify an output style, parameters are output to the procedural as serialized key-value pairs. In which case, all parameters are read into a string variable, which must be tokenized to extract individual parameters. In the case of the PRMan procedural extract shown below, the expected parameters are an array of RtColor, and a float.

```
struct MyParams
{
    RtColor csValues[4];
    float radius;

    MyParams(RtString paramstr)
    : radius(1.0f)
    {
        printf("paramstr: %s\n", paramstr);
        //initialize defaults
        for (int i = 0; i < 4; ++i)
        {
            csValues[i][0] = 1.0f;
            csValues[i][1] = 0.0f;
            csValues[i][2] = 0.0f;
        }

        //tokenize input string
        std::vector<char *> tokens;

        //copy the paramstr because strtok wants to mark it up
        char * inputParamStr = strdup(paramstr);
        char * separator = const_cast<char *>(" ");
```

```
    char * inputSource = inputParamStr, * cursor;
    while ((cursor = strtok(inputSource, separator)))
    {
        inputSource = NULL;
        tokens.push_back(cursor);
    }

    for (unsigned int i = 0; i < tokens.size(); ++i)
    {
        if (!strcmp(tokens[i], "-color"))
        {
            ++i;
            if (i+2 < tokens.size())
            {
                for (unsigned int j = 0; j < 3; ++j, ++i)
                {
                    float value = atof(tokens[i]);

                    for (int k = 0; k < 4; ++k)
                    {
                       csValues[k][j] = value;
                    }
                }

                --i;
            }
        }
        else if (!strcmp(tokens[i], "-radius"))
        {
            ++i;
            if (i < tokens.size())
            {
                radius = atof(tokens[i]);
            }
        }
    }

    //free the copied parameter string
    free(inputParamStr);
}
```

```
};
```

NOTE: Parameters are passed from **.args** file to procedural as either serialized key-value pairs, or typed arguments. If the Args file does not specify an output style, it defaults to serialized key-value pairs. The example shown in Example Args File uses typed arguments.

For procedurals, the type and default value of a parameter have to be declared. This is in contrast to the use of .args files in shaders, where the type can be interrogated directly from the shader.

UI hints for Plug-ins using Argument Templates

Instead of using .args files, Scene Graph Generators (SGG) and Attribute Modifier Plug-ins (AMP) must declare UI hints directly in their source code as part of the Argument Template. The Argument Template is used to declare what arguments need to be passed to the plug-in.

The syntax used for these is the same as you would use in an .args file, just that you're handing the values as attributes instead of declaring them inside an XML file.

Usage in Python Nodes

In Python, additional UI hints such as widget or help text are specified by defining them in a dictionary. The dictionary is passed to Katana in the NodegraphAPI **addParameterHints()** function.

For example, set extra hints on an Alembic_In node:

```
_ExtraHints = {
    "Alembic_In.name" : {
        "widget" :"newScenegraphLocation",
    },
    'Alembic_In.abcAsset':{
        'widget':'assetIdInput',
        'assetTypeTags':'geometry|alembic',
        'fileTypes':'abc',
        'help':"""Specify the asset input for an Alembic
                                (.abc) file."""
    },
}
```

Usage in C++ Nodes

In C++ nodes, the Argument Template consists of - nested - groups containing the UI hints. Each UI element has its group of hints which then is added to a top-level group. The resulting hierarchy for a simple example using a checkbox, file chooser and drop-down looks as follows:

```
+ top-level group
| + checkBoxArg (float)
| + checkBoxArg__hints (group)
| | + widget (string)
| | + help (string)
| | + page (string)
| + fileArg (string)
| + fileArg__hints (group)
| | + widget (string)
| | + help (string)
| | + page (string)
| + dropBoxArg (string)
| + dropBoxArg__hints (group)
| | + widget (string)
| | + options (string)
| | + help (string)
| | + page (string)
```

The following example code shows the implementation of the hierarchy shown above and how the top-level group is built and returned in **getArgumentTemplate( )**:

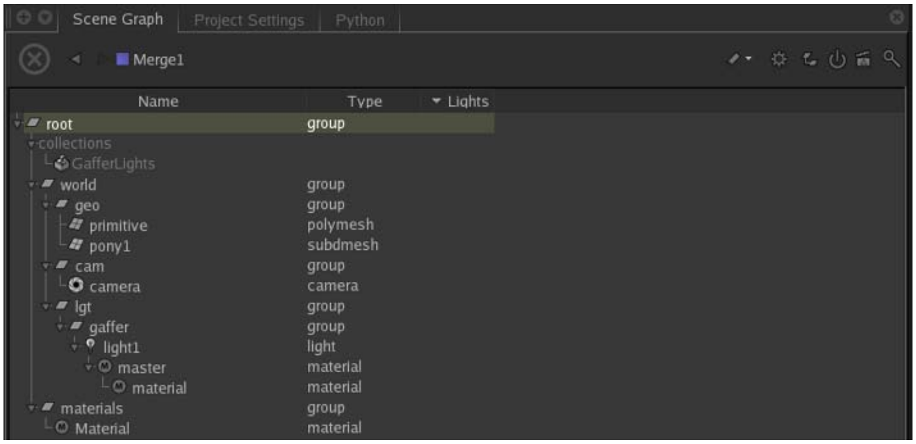
```
static FnKat::GroupAttribute getArgumentTemplate()
{
    FnKat::GroupBuilder gb_checkBoxArg_hints;
    gb_checkBoxArg_hints.set("widget",
        FnKat::StringAttribute( "checkBox" ) );
    gb_checkBoxArg_hints.set("help",
        FnKat::StringAttribute( "the mode value" ) );
    gb_checkBoxArg_hints.set("page",
        FnKat::StringAttribute( "pageA" ) );
    FnKat::GroupBuilder gb_fileArg_hints;
    gb_fileArg_hints.set("widget", FnKat::StringAttribute(
        "assetIdInput" ) );
    gb_fileArg_hints.set("help", FnKat::StringAttribute(
        "the file to load" ) );
    gb_fileArg_hints.set("page", FnKat::StringAttribute(
        "pageA" ) );
    FnKat::GroupBuilder gb_dropBoxArg_hints;
    gb_dropBoxArg_hints.set("widget",
        FnKat::StringAttribute( "mapper" ) );
    gb_dropBoxArg_hints.set("options",
        FnKat::StringAttribute( "No:1|SmoothStep:2|
            InverseSquare:3" ) );
    gb_dropBoxArg_hints.set("help", FnKat::StringAttribute(
        "a dropbox argument" ) );
    gb_dropBoxArg_hints.set("page", FnKat::StringAttribute(
```

```
        "pageA" ) );
    FnKat::GroupBuilder gb;
    gb.set("checkBoxArg", FnKat::FloatAttribute(
        DEFAULT_SCALE ) );
    gb.set("checkBoxArg__hints",
        gb_checkBoxArg_hints.build() );
    gb.set("fileArg", FnKat::StringAttribute( "/tmp/
        myFile.xml" ) );
    gb.set("fileArg__hints", gb_fileArg_hints.build() );
    gb.set("dropBoxArg", FnKat::StringAttribute( "No" ) );
    gb.set("dropBoxArg__hints",
        gb_dropBoxArg_hints.build() );
    return gb.build();
}
```

20 LOCATIONS AND ATTRIBUTES

The Scene Graph in Katana consists of a hierarchy of Scene Graph Locations. Each location is of a specific **type** depending on the data it represents. Renderer plug-ins have special behaviors when these types are encountered during Scene Graph traversal. Furthermore, the Viewer uses this information to determine how to display cameras, lights, or geometry, for example, as a polygonal mesh or point cloud.

Scene Graph Locations have additional attributes attached to them. These attributes are organised in a hierarchy of groups and store the information in various data structures. A location of type polymesh, for example, follows certain attribute conventions to form such a mesh (how vertices, faces, and normals are defined).



Useful facts about behavior in Katana:

- When the renderer traverses the Scene Graph, all locations that have an unknown type are treated as a **group**.
- Scene Graph locations in Katana are **duck typed**. "If it looks like a polymesh, and acts like a polymesh, it's a polymesh".

The chapter Appendix D: Standard Attributes on page 208 provides a list of Standard Location Types and Key Locations used in Katana. Location Types in Bold are recognized by the Viewer tab.

Inheritance Rules for Attributes

By default, attributes are inherited from parent locations. However, attributes can be overwritten at specified locations where the values differ from ones defined higher up in the hierarchy, as used for Light Linking.

Some attributes are not inherited, for instance the globalStatements of a renderer defined at **/root** or the globals defined at **/root/world**. Another example is the xform attribute, where it would not make sense to inherit a transform defined for a group to all its children and thus perform the operation multiple times.

Setting Group Inheritance using the API

To prevent an attribute from being inherited, use the API function **setGroupInherit()** to disable group inheritance. For example:

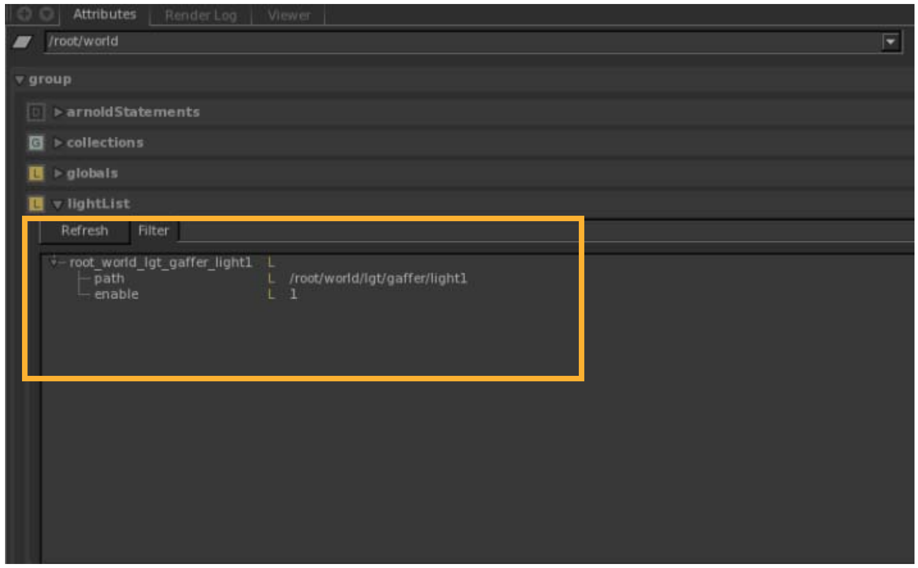
```
FnKat::GroupBuilder gb;
gb.setGroupInherit(false);
gb.build();
```

Light Linking

Light linking is a typical example of how a standard setting is defined high up in the hierarchy and then overridden at a specified Scene Graph location where a different setting is needed. Shadow Linking works in the exact same way.

1. In an empty scene, create a sphere using a PrimitiveCreate Node.
   Set the name to **/root/world/geo/sphere**.
2. Add a plane with a PrimitiveCreate node.
   Set the name to **/root/world/geo/plane**.
3. Add a Merge node and connect both PrimitiveCreate nodes as inputs.
4. Add a light with a Gaffer node.
5. Connect the output of the Merge node to the input of the Gaffer node.
6. Add a LightLink node.
7. Connect the output of the Gaffer node to the input of the LightLink node.
8. Select the LightLink node and press **Alt+E** to edit it.
9. Set the effect field to illumination, and the action field to off.
10. Add the primitive sphere to the objects field.
11. Add the light to the lights field.

Creating the light adds a **lightList** attribute group under **/root/world** with the **enable** attribute set to 1.



NOTE: With the default behavior of the light set to off - by changing the **defaultLink** dropdown to **off** - the enable attribute is set to 0.

The primitive sphere's **lightList** enable attribute is set to 0, as it is overridden locally by the LightLink node. Attributes are inherited from parent scene graph locations. If needed, they can be locally overridden as shown above where a specific light (/root/world/lgt/gaffer/light1) is disabled for a certain node (/root/world/geo/sphere).

NOTE: A **G** label next to an attribute signifies that its value has been inherited from a parent Scene Graph Location, whereas the label **L** means the attribute is stored locally at the selected location.

21 PRMan Technical Notes

Use of the "id" identifier attribute

The id pass that Katana uses in the Monitor for picking objects makes use of an identifier attribute called "id". This makes use of a special feature in PRMan where if an identifier attribute is called "id", it is automatically available as an AOV without the need for any explicit code in shaders to write the value into an AOV.

This can cause potential issues if you want to make use of the "id" identifier attribute for other custom purposes, such as to write out your own id pass during renders. The "id" attribute is only used by Katana in **Preview Render** mode so the "id" identifier attribute can be safely set for **Disk Renders**. To avoid conflict with Katana's internal use of the "id" attribute, an Interaractive Render Filter can be used to remove the "id" attribute in **Preview Render** mode.

Custom id passes can also be created with other names by means of explicit writeraov calls added to shader's code. The following code snippets show two versions of a very simple surface shader that use the writeaov function to tag objects with a "material_id" identifier. materialId_v1 relies on a shader parameter to assign an id to a location, while materialId_v2 uses the attribute function to read a user:myId attribute (the user attribute can be assigned to a location using an AttributeSet node or an AttributeScript node).

```
surface materialId_v1(uniform float _id = 0;)
{
    writeaov("material_id", _id);

    Ci = Os * Cs * normalize(N).-normalize(I);
    Oi = Os;
}

surface materialId_v2()
{
    uniform float myId = 1;
    attribute("user:myId", myId);

    writeaov("material_id", myId);

    Ci = Os * Cs * normalize(N).-normalize(I);
    Oi = Os;
}
```

22 NODEGRAPH API

The Nodegraph API is a Python interface for creating Katana recipes by adding and connecting nodes, and setting Parameters. The Nodegraph API cannot access the Scene Graph. In order to understand the limitations of the Node Graph it's important to have a clear understanding of the difference between the Node Graph and the Scene Graph. See Katana For The Impatient for more on this.

The Node Graph API can be accessed by Python scripts in the **Python** tab, Super Tools, plug-ins, shelves and other custom UI. It is available to scripts used running in **script** and **shell** modes, but is hidden from, and so should not be used by Attribute Scripts or Parameter expressions. Attempting to access the Node Graph API from Attribute Scripts or Parameter expressions could result in topological changes to the Node Graph whilst it is being evaluated. The Node Graph API can only be used inside a running Katana session, it is not a standalone Python module.

Nodegraph API Basics

When Katana iterates over the Scene Graph it performs what is effectively a depth-first graph search. Starting at a single top level node, it asks for any nodes adjacent to that location, then interrogates each of those nodes on their adjacent nodes, and so on. For this reason, a Katana Scene Graph is always nested under a single root location.

Creating a New Node

Nodes must be created under the root node, or under a node that accepts child nodes (such as a Group node, or SuperTool), nested under the root node. To create nodes directly under the root node, you must pass the Node Graph root location as an argument. To create nodes under a Group node, enter the group location as an argument. For example, to add a Primitive Create node under the root node enter the following in the Python Tab:

```
# Get the root node
root = NodegraphAPI.GetRootNode()
# Create a new node under the root node
node = NodegraphAPI.CreateNode( 'PrimitiveCreate', root )
```

This creates a new PrimitiveCreate node which - in turn - generates a Scene Graph location containing a single primitive. By default the PrimitiveCreate node is set to type **sphere**.

The new node is an instance of a Python class that represents that node type, and may contain additional methods specifically for working with that type. For example, a Gaffer node has **addLight()** and **getLightPaths()** methods that do not exist for other node types.

NOTE: You can use the Python **help** function to get information about a particular function call. For example:

```
help( NodegraphAPI.CreateNode )
```

Referencing a Node

You can reference a node using the function **GetNode()**. For example, to reference a node called **PrimitiveCreate** to the name **node** use:

```
node = NodegraphAPI.GetNode( 'PrimitiveCreate' )
```

Referencing a Parameter

Parameters are referenced in a similar way to nodes, using the function **getParameter()**. For example, to reference the **type** parameter of a node called PrimitiveCreate, to the name **nodeType** use:

```
nodeType = NodegraphAPI.GetNode('PrimitiveCreate').getParameter( 'type' )
```

NOTE: **Shift** + middle drag to the **Python** tab from a node in the **Node Graph** tab, or a parameter in the **Parameters** tab to automatically create the path to that node or parameter. For example, dragging from a node **PrimitiveCreate** in the Node Graph produces:

```
NodegraphAPI.GetNode( 'PrimitiveCreate' )
```

Node Position

The function **SetNodePosition()** sets the position of a node in the Node Graph UI. For example, to create then position a PrimitiveCreate node:

```
# Get the root node
root = NodegraphAPI.GetRootNode()
# Create a new node at root level
node = NodegraphAPI.CreateNode( 'PrimitiveCreate', root )
# Define X & Y values
x = 0
y = 100
position = ( x, y )
# Set node position
NodegraphAPI.SetNodePosition( node, position )
```

Node Naming

Each node has a name, which is unique within the bounds of a Katana recipe. Name-spacing does not exist for node names, which means that a call to:

```
node = NodegraphAPI.GetNode( 'PrimitiveCreate' )
node.setName( name="Teapot" )
print ( node.getName() )
```

may not behave as expected if the chosen name is already in use by another node in the scene. In that case **setName()** finds a similar - but unique - name, uses that, and returns the new unique node name.

It's possible to store a string **user attribute** on a node that utilities can search for in order to reference a node in a smaller context. This is a simple pattern that can provide a more localized pseudo node name. See User Parameters for more on adding User Parameters.

Getting the Parameters of a Node

The parameters of a node are organized in a tree inside the node. The tree allows better organization of nodes with many parameters, avoids parameter name collisions, and makes it simple to construct more complex re-usable parameter definitions.

The function **getParameters()** returns the root parameter of a node. The children of that root parameter are the top level entries you see in the **Parameters** Tab. For example, to get the children of the root parameter on a node enter:

```
for p in node.getParameters().getChildren():
print( p )
```

Which - assuming **node** is a reference to a PrimitiveCreate node - prints the following:

```
<Parameter 'name'>
<Parameter 'type'>
<Parameter 'fileName'>
<Parameter 'previewTexture'>
<Parameter 'previewAlpha'>
<Parameter 'enableClippingPlane'>
<Parameter 'reverseClippingDirection'>
<Parameter 'transform'>
<Parameter 'makeInteractive'>
<Parameter 'includeBounds'>
<Parameter 'viewerPickable'>
```

You can get a complete text dump of all parameters on a node using **getXML()**. For example, to see the XML structure of all the parameters on a node referenced by **node** enter the following:

```
print ( node.getParameters().getXML() )
```

Which displays the XML of the selected node:

```
<group_parameter name="PrimitiveCreate">
<string_parameter name="name" value="/root/world/geo/
primitive"/>
<string_parameter name="type" value="sphere"/>
...
</group_parameter name>
```

Getting Parameter Values

To return the value of a parameter, use **getParameter().getValue()**. For example, to return the value of the name parameter at time 0, enter the following:

```
node.getParameter( 'name' ).getValue( 0 )
```

Setting the Parameters of a Node

Values on a node are set using **getParameter().setValue()**. As node behavior is set by parameters who's values can change over time, you must specify a value and a time, when setting a parameter.

For example, to change the type Parameter of a PrimitiveCreate node to teapot, when time is 10, enter the following:

```
# Get the root node
root = NodegraphAPI.GetRootNode()
# Create a new node at root level
node = NodegraphAPI.CreateNode('PrimitiveCreate', root)
# Set the type parameter at time 10
node.getParameter('type').setValue( "teapot", 10 )
```

Input and Output Ports

Creating Ports

Katana recipes are created by adding and connecting nodes in the Node Graph. Nodes are connected through their input and output ports. Some node types have a fixed number of ports, while others allow for an arbitrary number. The Merge node, for example, takes any number of inputs and combines them into a single output. To create a Merge node referenced as **merge** at root level, and add two input ports enter the following:

```
merge = NodegraphAPI.CreateNode( 'Merge', root )
firstPort = merge.addInputPort( "First" )
secondPort = merge.addInputPort( "Second" )
```

Ports can be added by index as well as by name which allows direct control of their ordering. For example, to add an input port to the merge node created above, add the following:

```
betweenFirstAndSecondPort =\
    merge.addInputPortAtIndex( "BetweenFirstAndSecond", 1 )
```

Connecting Ports

The **connect()** method links ports. For example, to take an output port on a PrimitiveCreate node - referenced as **node** - and connect it to an input port on a Merge node - referenced as **merge** - enter the following:

```
primitiveOut = node.getOutputPort( "out" )
mergeInput = merge.getInputPort( "i0" )
primitiveOut.connect( mergeInput )
```

Connecting ports works in either direction:

```
mergeInput.connect( primitiveOut )
```

Disconnecting Ports

The **disconnect()** method unlinks two ports. For example, to unlink the two ports connected in Connecting Ports enter the following:

```
mergeInput.disconnect( primitiveOut )
```

or

```
primitiveOut.disconnect( mergeInput )
```

Renaming Ports

The **renameInputPort()** and **renameOutputPort()** methods rename ports. For example, to rename the input port at index position 0 on the node referenced by **merge**, enter the following:

```
merge.renameInputPort( "i0", "input" )
```

To rename the output port on the same node, enter:

```
merge.renameOutputPort( "out", "output" )
```

Duplicating Nodes

Serialize to XML

Katana uses a copy and paste pattern to duplicate nodegraph nodes, which means that to copy a node you must serialize it to XML using **BuildNodesXmlIO()**, then deserialize. For example, to create then serialize a

PrimitiveCreate node referenced by **node** enter the following:

```
# Get the root node
root = NodegraphAPI.GetRootNode()
# Create a new node at root level
node = NodegraphAPI.CreateNode('PrimitiveCreate', root)
nodesToSerialize = [ node ]
xmlTree = NodegraphAPI.BuildNodesXmlIO( nodesToSerialize )
```

NOTE: BuildNodesXmlIO() accepts a sequence of nodes, so a network of nodes can be serialized in a single operation.

Deserialize

Use **Paste()** in the **KatanaFile** module to deserialize an xmlTree. The xmlTree can contain an arbitrary number of nodes, and the contents are pasted under a given location (which can be either **/root** or a Group node).

For example, to paste the XML created in Serialize to XML under **/root** enter the following:

```
root = NodegraphAPI.GetRootNode()
KatanaFile.Paste( xmlTree, root )
```

Printing An XML Tree

It can be useful to print the serialized XML tree of a node to see what it contains. For example, to view the XML of the merge in the example above node enter the following:

```
print( xmlTree.writeString() )
```

Which - depending on your Katana version - prints:

```
<katana release="1.5" version="1.5.1.000001">
 <node name="__SAVE_exportedNodes" type="Group">
  <node baseType="Merge" name="Merge" type="Merge"
      x="228.000000" y="-311.000000">
   <port name="input" type="in"/>
   <port name="Second" type="in"/>
   <port name="output" type="out"/>
   <group_parameter name="Merge">
    <string_parameter name="showAdvancedOptions"
        value="No"/>
     <group_parameter name="advanced">
      <string_parameter name="sumBounds" value="No"/>
      <string_parameter name="preserveWorldSpaceXform"
          value="No"/>
      <stringarray_parameter
          name="preserveInheritedAttributes"
              size="0" tupleSize="1"/>
```

```
      <group_parameter name="preferredInputAttributes">
       <stringarray_parameter name="name" size="0"
           tupleSize="1"/>
       <numberarray_parameter name="index" size="0"
           tupleSize="1"/>
      </group_parameter>
     </group_parameter>
    </group_parameter>
   </node>
  </node>
</katana>
```

Group Nodes

A Group node acts as a container for a sub-network of nodes. To add a Group node to a recipe under the root location, then create a PrimitiveCreate node inside that group enter the following:

```
# Create a Group node at root, referenced as group
group = NodegraphAPI.CreateNode( 'Group', root )
```

Then, create a PrimitiveCreate, as in Creating a New Node but give the Group node as the level to create at, rather than root as in the previous example:

```
groupChildNode = NodegraphAPI.CreateNode\
    ( 'PrimitiveCreate', group )
```

Alternatively, create a Group node and a PrimitiveCreate node at the root level, then parent the PrimitiveCreate node under the Group node:

```
# Get the root node
root = NodegraphAPI.GetRootNode()
# Create the Group node at root level
group = NodegraphAPI.CreateNode( 'Group', root )
# Create the PrimitiveCreate node at root level
node = NodegraphAPI.CreateNode('PrimitiveCreate', root)
# Set the Group node as parent of the PrimitiveCreate node
node.setParent( group )
```

NOTE: Groups can be nested arbitrarily to form a Node Graph tree.

A Group Node Example

The following stand alone example produces a group node containing a network that produces a Scene Graph with sphere and cube locations. It uses only Nodegraph API calls covered by this chapter. There is no access to the generated Scene Graph from outside of the group node.

```
# Constants
TIME = 0
HALF_DISTANCE_APART = 1.0
# Create the group at root level
root = NodegraphAPI.GetRootNode()
group = NodegraphAPI.CreateNode('Group', root)
# Create the sphere at group level
sphere = NodegraphAPI.CreateNode('PrimitiveCreate', group)
sphere.setName( 'Sphere' )
sphere.getParameter( 'name' )\
    .setValue( "/root/world/geo/sphere", TIME )
# Set the type to sphere
sphere.getParameter( 'type' ).setValue( 'sphere', TIME )
sphere.getParameter( 'transform.translate.x' ).\
    setValue( HALF_DISTANCE_APART, TIME )
NodegraphAPI.SetNodePosition(sphere, ( -100, 100 ) )
# Create the cube
cube = NodegraphAPI.CreateNode( 'PrimitiveCreate', group )
cube.setName( 'Cube' )
cube.getParameter( 'name' ).\
    setValue( "/root/world/geo/cube", TIME )
# Set the type to cube
cube.getParameter( 'type' ).setValue( 'cube', TIME )
cube.getParameter( 'transform.translate.x' ).\
    setValue( - HALF_DISTANCE_APART, TIME )
NodegraphAPI.SetNodePosition( cube, ( 100, 100 ) )
# Create a Merge node at group level
merge = NodegraphAPI.CreateNode( 'Merge', group )
# Connect the two PrimitiveCreate nodes to a Merge node
mergeSphere = merge.addInputPort( 'sphere' )
mergecube = merge.addInputPort( 'cube' )
mergeSphere.connect( sphere.getOutputPort( 'out' ) )
mergecube.connect(cube.getOutputPort( 'out' ) )
# Rename our merge node to 'Result' to make it clear that
# this is the final result.
merge.setName( 'Result' )
```

NOTE: **Ctrl** + middle click on the Group node to see its contents, and observe the PrimitiveCreate nodes named **Sphere** and **Cube**, with their outputs connected to the input of a Merge node.

View the Merge node, and expand the Scene Graph to see the two Scene Graph locations created by the two Primitive Create nodes.

Send and Return Ports

The example created in A Group Node Example has no connections to or from the Group node. For Group nodes to be of any significant use, you need to be able to connect their internal structure to the ports of external nodes. The quickest - in the short term - way of doing this is to directly connect a port on a node inside the group to a port on a node outside the group. To do this however, you need to know the internal structure of the Group node and be aware of the maintenance burden on the Python code that does the connecting. Any change to the internal structure of the group can mean the port connecting code needs updating.

A more encapsulated approach is to connect the internal ports to corresponding **Send** or **Return** ports on the Group node. If a Group node were a function in Python, the Send ports would be the arguments and the Return ports would the return values.

NOTE: The **Send** and **Return** ports on a Group node only exist if the group has inputs and outputs created. Creating an input or output port on a group automatically creates a **Send** or **Return** port with the same name.

See Input and Output Ports for more on creating, and connecting inputs and outputs.

Return Port Example

The advantage of **Send** and **Return** ports is that you can connect to them without any knowledge of the group's internal structure. For example, create a Group containing a PrimitiveCreate node and a Merge node. Connect the output of the PrimitiveCreate node to the input of the Merge node, and connect the output of the Merge node to the **Return** port of the Group node:

```
# Create the group at root level
root = NodegraphAPI.GetRootNode()
group = NodegraphAPI.CreateNode( 'Group', root )
group.addOutputPort( "out" )
# Create the PrimitiveCreate node at group level
primitive = NodegraphAPI.CreateNode( 'PrimitiveCreate',\
    group)
# Create a Merge nodes at group level
mergeOne = NodegraphAPI.CreateNode( 'Merge', group )
# Connect PrimitiveCreate output to Merge input
# Get the out port of the PrimitiveCreate node
primitiveOut = primitive.getOutputPort( "out" )
mergeSphereIn = mergeOne.addInputPort( 'sphere' )
primitiveOut.connect( mergeSphereIn )
# Get the groups Return port
# First create an output port on the group
groupOut = group.addOutputPort( "goingOut" )
groupReturn = group.getReturnPort( "goingOut" )
```

```
# Get the output port on the Merge node
mergeOut = mergeOne.getOutputPort( "out" )
# Connect the Merge node's out to the Group node's Return
mergeOut.connect( groupReturn )
```

Now you can connect the output of the Group node to external nodes without accessing its internal structure. For example, take the example above, and connect the output of the Group node to a new Merge node:

```
# Create a Merge node at root level
mergeTwo = NodegraphAPI.CreateNode( 'Merge', root )
# Get the input port of the Merge node
mergeTwoInput = mergeTwo.getInputPort( 'input' )
# Connect the Group's output to the Merge node's input
mergeTwoInput.connect( groupReturn )
```

Send Port Example

The Group node created in Return Port Example does not take any inputs. For a group to accept inputs, it must have an input port linked to its **Send** port. For example, create a group that merges geometry from a PrimitiveCreate node inside the group, with geometry from a PrimitiveCreate node outside the group:

```
# Create the group at root level
root = NodegraphAPI.GetRootNode()
group = NodegraphAPI.CreateNode( 'Group', root )
# Create input and output on the group
group.addInputPort( "in" )
group.addOutputPort( "out" )
# Get the corresponding Send and Return ports
groupOut = group.getReturnPort( "out" )
groupIn = group.getSendPort( "in" )

# Create a PrimitiveCreate node at group level
primitiveGroup = NodegraphAPI.\
    CreateNode('PrimitiveCreate', group)
primitivePosition = ( 0, 100 )
NodegraphAPI.SetNodePosition( primitiveGroup,\
    primitivePosition )
# Get the output port on the PrimitiveCreate
primitiveGroupOut = primitiveGroup.getOutputPort( "out" )

# Create a merge node at group level
mergeOne = NodegraphAPI.CreateNode( 'Merge', group )
# Add two inputs and get the output ports
mergeOneIn0 = mergeOne.addInputPort( "in0" )
mergeOneIn1 = mergeOne.addInputPort( "in1" )
mergeOneOut = mergeOne.getOutputPort( "out" )
```

```
# Connect the PrimitiveCreate out to Merge in0
mergeOneIn0.connect( primitiveGroupOut )
# Connect the Merge node to the Group inputs and outputs
mergeOneIn1.connect( groupIn )
mergeOneOut.connect( groupOut )
```

Anything connected to the input of the Group node is now merged with the output of the PrimitiveCreate node contained in the group.

EXPERIMENT: Try creating another PrimitiveCreate node, of a different primitive type, outside the Group. Connect the output of the new node to the input of the group. View the result to see the outputs of both PrimitiveCreate nodes together.

Logical and Physical Connections

Conceptually, a port has two forms of connection, **Physical** and **Logical**.

Physical Connection

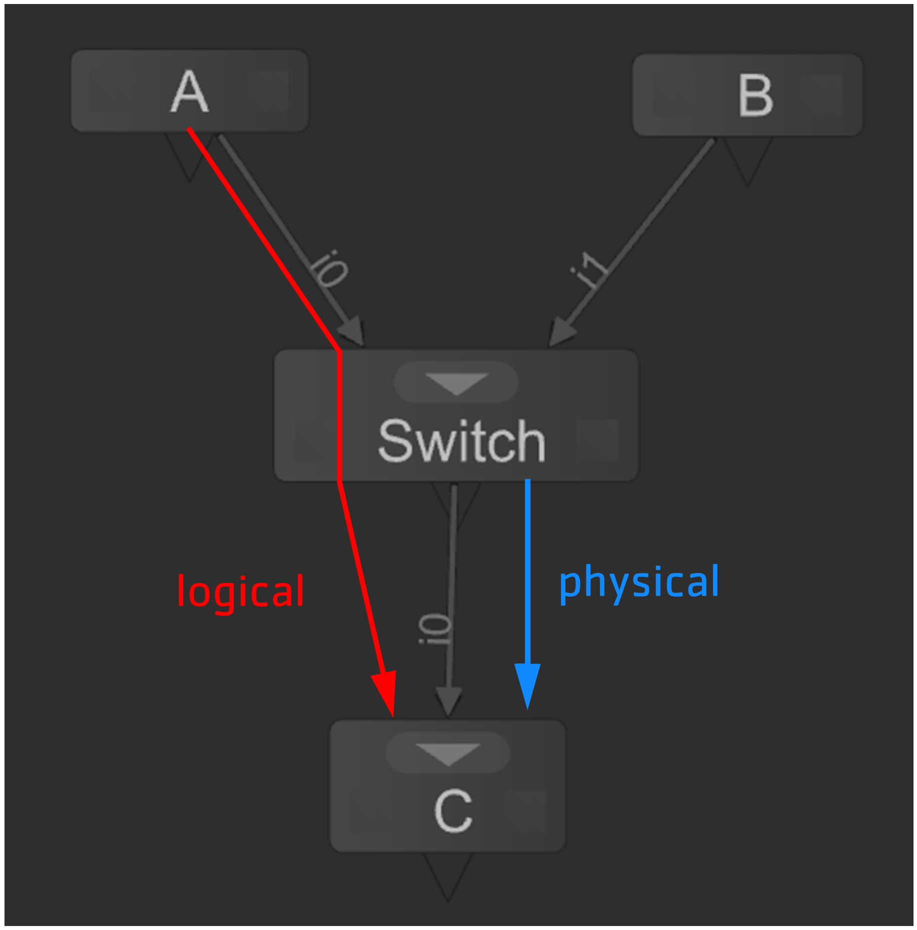
A physical connection is determined directly by what output ports any given input port is connected to in the user interface. The physical connections are those you see represented by connection arrows in the Node Graph.

Logical Connection

Logical connections are those used to traverse up the Node Graph at render time. Conditional logic, parameter values and time are used to determine the next relevant source of data, and this is represented by a logical connection between the current node and the next.

The diagram below shows an example of physical and logical connections in the Node Graph. Nodes A and B have physical connections to inputs on the Switch node, and node C has a physical connection to the output of the Switch node.

The logical connection from node A or B to node C, depends on the setting of the switch. When the Switch node's **in** parameter is set to 0, there is a logical connection from node A, to node C, passing through the Switch node. When the Switch node's **in** parameter is set to 1, there is a logical connection from node B to node C, passing through the Switch node.



Physical and Logical Source

Physical Source

To find the physical source from a given port, use **<yourPortName>.GetConnectedPorts()**. For example, create a PrimitiveCreate node and a Merge node, connect the output of the PrimitiveCreate node to an input on the Merge node, then get the source of the connection into the Merge node:

```
# Get the root node
root = NodegraphAPI.GetRootNode()
# Create a PrimitiveCreate node at root level
primitive = NodegraphAPI.CreateNode\
    ( 'PrimitiveCreate', root)
# Create a Merge node at root level
mergeOne = NodegraphAPI.CreateNode( 'Merge', root )
# Add an output port to the PrimitiveCreate node
```

```
primOut = primitive.addOutputPort( "newOutputPort" )
# Add an input to the Merge node
mergeIn = mergeOne.addInputPort( "fromPrim" )
# Connect PrimitiveCreate to Merge
primOut.connect( mergeIn )
# Use getConnectedPorts to find connections on mergeIn
mergeInConnected = mergeIn.getConnectedPorts()
# Print the connected port
print( mergeInConnected )
```

This returns:

```
[ < Port Producer 'yourPortName' > ]
```

Logical Source

To find the logical source of an input node use **<yourNodeName>.getInputSource()**, which takes the name of the port and a time as arguments, and returns a tuple containing the source port and the time. If no port is found, it returns **None**.

For example, recreate the scene shown in Logical and Physical Connections with two nodes connected to the inputs of a switch node, and one node connected to the output, then find the input source at the output:

```
root = NodegraphAPI.GetRootNode()
# Create TheInputSourceNode at root level
primitive1 = NodegraphAPI.CreateNode( 'PrimitiveCreate',\
    root )
primitive2 = NodegraphAPI.CreateNode( 'PrimitiveCreate',\
    root )
primitive1.setName( "A" )
primitive2.setName( "B" )
primitive1Out = primitive1.getOutputPort( "out" )
primitive2Out = primitive2.getOutputPort( "out" )

# Create the Switch node at root level
switch = NodegraphAPI.CreateNode( 'Switch', root )
switchInput1 = switch.addInputPort( "input1" )
switchInput2 = switch.addInputPort( "input2" )
switchOutput = switch.getOutputPort( "output" )

# Create a Render node at root level
render = NodegraphAPI.CreateNode( 'Render', root )
renderInput = render.getInputPort( "input" )

# Connect the primitie to the switch, and switch to render
primitive1Out.connect( switchInput1 )
primitive2Out.connect( switchInput2 )
switchOutput.connect( renderInput )
```

```
# Get the logical input of the render.input port
TIME = 0.0
inputSource = render.getInputSource( "input", TIME )
PORT_INDEX = 0
inputPort = inputSource[ PORT_INDEX ]

# Get hold of the source node so that we can print its name.
inputNode = inputPort.getNode()
inputNodeName = inputNode.getName()

# Print the name of the source node
print( inputNodeName )
```

User Parameters

You can add custom User Parameters to a node, allowing nodes to be tagged with additional information. This ability to add User Parameters is particularly useful when creating Macros and Super Tools with a custom UI. For more information on Macros and Super Tools, and uses for User Variables, please see Groups, Macros, and Super Tools, and for a list of all available User Parameter types and widgets please see User Parameters and Widget Types.

User Parameters are defined from the following basic types, and their behavior is dictated by their assigned widget:

- **Group**
  Containers for one or more ohter User Parameters, including other groups. Requires a name argument.
- **Number**
  A single float. Requires a default value argument.
- **Number Array**
  An array of floats. Requries name and size arguments.
- **String**
  A single string object. Requires a default value argument.
- **String Array**
  An array of string objects. Requires name and size arguments.

Top Level User Parameters

As covered in Getting the Parameters of a Node the node parameters that you see at the top level in a node's **Parameters** tab are all children of the node's root parameter. User Parameters on a node are also added as children of the root parameter. For example, to create a new PrimitiveCreate node, and add a User Parameter of type **number**, enter the following:

```
# Get the root node
root = NodegraphAPI.GetRootNode()
# Add a PrimitiveCreate node at root level
node = NodegraphAPI.CreateNode( 'PrimitiveCreate', root )
# Get the PrimitiveCreate node's root parameter
rootParam = node.getParameters()
# Add a User Parameter of type number
numberParam = rootParam.createChildNumber( "Foo", 123.0 )
```

Nested User Parameters

Complex hierachies of User Parameters are possible, by nesting User Parameters under **Group** User Parameters. For example, create a new PrimitiveCreate node, and add a User Parameter of type **number**, nested under a User Parameter of type **Group**:

```
# Get the root node
root = NodegraphAPI.GetRootNode()
# Add a PrimitiveCreate node at root level
node = NodegraphAPI.CreateNode( 'PrimitiveCreate', root )
# Get the PrimitiveCreate node's root parameter
rootParam = node.getParameters()
# Add a User Parameter of type Group under the root
parameter
groupParam = rootParam.createChildGroup( "yourGroup" )
# Add a User Parameter of type Number under the group
numberParam = groupParam.createChildNumber( "yourNumber",\
    123.00 )
```

Parameter Hints

Parameter hints are arbitrary meta data, most commonly used to tell the user interface what a User Parameter contains. For example, add a User Parameter of type string to represent a file path to an asset, and use a hint to tell Katana to use the asset browser widget for that User Parameter:

```
# Get root level
root = NodegraphAP.GetRootNode()
# Create a PrimitiveCreate node at root level
prim = NodegraphAPI.CreateNode( 'PrimitiveCreate', root )
# Get the root parameter of the PrimitiveCreate node
rootParam = prim.getParameters()
# Add a new User Parameter of type string
stringParam = rootParam.createChildString( "yourFilePath",
"yourFile.txt" )
# Tell Katana to use the assetIdInput widget to represent
this parameter
stringParam.setHintString( "{'widget': 'assetIdInput'}" )
```

Or, to add a User Parameter of type string, as a dropdown menu:

```
# Get root level
root = NodegraphAP.GetRootNode()
# Create a PrimitiveCreate node at root level
prim = NodegraphAPI.CreateNode( 'PrimitiveCreate', root )
# Get the root parameter of the PrimitiveCreate node
rootParam = prim.getParameters()
# Add a new User Parameter of type string
stringParam = rootParam.createChildString( "yourDropdown",
"yourDefaultValue" )
# Tell Katana to use the popup widget
# and fill out the menu values
stringParam.setHintString( "{'widget':'popup',\
    'options':[ 'a', 'b', 'c' ]}" )
```

See Widget Types for a table of the widget types seen in the UI.

Parameter Expressions

Python

A parameter can have its value computed dynamically using a Python expression. Expressions are set using **Parameter.setExpression()**, which takes a Python string representing the expression as its first argument and an optional enable parameter to specify whether to implicitly enable the expression.

A parameter expression must evaluate in the same way that a Python **eval** expression would (as a condition list). The global and local scopes of a parameter expression are sandboxed so that it is not possible to make topological changes to the Node Graph whilst it it being resolved.

It is possible to write an expression that will reference a node by name and not break when the node name changes, see APPENDIX B: EXPRESSIONS In the User Guide for more information and a list of what functions are available to an expression.

NOTE: you should avoid using the nodeName variable for parameter expressions that specify Scene Graph locations, and must take care when using them anywhere that a scenegraph attribute is set. Node names are not namespaced and can therefore change unpredictably.

The following example script sets the expression on a parameter:

```
# Add a PrimitiveCreate node
root = NodegraphAPI.GetRootNode()
primitive = NodegraphAPI.CreateNode( 'PrimitiveCreate', root )
# Add a User Parameter of type Number, called myNumber
rootParam = primitive.getParameters()
rootParam.createChildNumber( "myNumber", 7.0 )
# Link myNumber to the node's scale x parameter by expression
scaleX = NodegraphAPI.GetNode( 'PrimitiveCreate' )\
    .getParameter( 'transform.scale.x' )
scaleX.setExpression( "getParam( 'PrimitiveCreate.myNumber' )" )
```

You can disable an expression with the **setExpressionFlag()** method.

```
yourExpression.setExpressionFlag( False ) # Disable
yourExpression.setExpressionFlag( True ) # Enable
```

CEL

Parameters that contain CEL expressions are set like any other string parameter only the value of the parameter is evaluated to a CEL expression. For example create a CEL expression on a CollectionCreate node that sets to the **/root/geo** location:

```
TIME = 0
root = NodegraphAPI.GetRootNode()
collection = NodegraphAPI.CreateNode( 'CollectionCreate',\
    root)
c = collection.getParameter( 'CEL' )
c.setValue( "( (/root/geo) )", TIME )
```

For more on CEL, and collections using CEL, see the Collections & CEL chapter in the User Guide.

Enableable Parameter Groups

An Enableable Parameter Group is a parameter that has a default value, but can also take on a locally set value. The local value is used when the Enableable Parameter Group is enabled.

In order to manipulate this type of parameter through a script it's important to understand that the Enableable Parameter Group is a group parameter with four children:

Name	Value Type	Description
_hints	String	Metadata telling the UI how to display this parameter group.
enable	Number	Defines whether the paramater is enabled or not. When enabled, the parameter takes on **value**, and when disabled in takes on **default**.
value	String / StringArray / Number / Number-Array	The value to be assigned to the corresponding attribute when the parameter group is enabled. Updated with value entered through the UI.
default	String / StringArray / Number / Number-Array	The default parameter value.

To modify an Enableable Parameter Group, access the individual child parameters. For example, create a RenderSettings node, then edit the Enable Parameter Groups for camera name to set a local value, and enable it:

```
# Get the root node
root = NodegraphAPI.GetRootNode()
# Create a RenderSettings node
renderSettings = NodegraphAPI.\
    CreateNode( 'RenderSettings', root)
# Get the value and enable parameters from the cameraName
group parameter
cameraNameValue = renderSettings.\
    getParameter( 'args.renderSettings.cameraName.value' )
cameraNameEnable = renderSettings.\
    getParameter( 'args.renderSettings.cameraName.enable' )
# Change the name
cameraNameValue.\
    setValue("/root/world/cam/myCamera", time = 0 )
# Enable the parameter
cameraNameEnable.setValue(float(True), time = 0 )
```

Dynamic Arrays for PRMan Shader Parameters

Katana has a widget type dynamicArray, which was added to support PRMan shaders with dynamic array parameters. Unlike the other array types listed in Widget Types, dynamicArrays cannot be created as User Parameters on nodes through the UI wrench menu.

NOTE: The Arnold plug-in for Katana currently only supports array parameters of type AI_TYPE_POINTER (arbitrary pointer). Support for specific types of array parameter values will be added in a future release.

The following Nodegraph API functions apply to dynamic arrays, as well as groups:

reorderChild( )

Moves an array child parameter. Takes two arguments, the child parameter to move, and the index position to move to. For example:

```
arrayParameter.reorderChild(
    arrayParameter.getChildByIndex( 1 ), 0 )
```

reorderChildren( )

Moves a given number of child elements in an array, starting at a specified index, moving to a specified index. Takes three arguments - all ints - giving the index to start at, the index to move to, and the number of elements to move.

removeArrayElement( )

Removes a single element from an array. Takes a single argument - an int - giving the index position in the array to remove.

removeArrayElements( )

Removes a given number of elements from an array, starting at a given index. Takes two arguments - both ints - giving the index to start at and the number of elements to remove.

23 Asset Management System Plug-in API

The Katana Asset plug-in API is a Python and C++ interface for integrating Katana with asset management systems. It permits retrieval and publishing of assets within Katana. The asset management plug-in API provides four core mechanisms which are described in the Asset API chapter of the User Guide.

The Asset plug-in API does not provide any functions for traversing over a Katana Scene Graph or for editing nodes, and it is not a replacement asset management system. It is referenced when resolving a recipe and should therefore not traverse the Node Graph directly, or instantiate a geometry producer. An Asset plug-in is invoked during interactive Katana sessions and also during rendering.

Katana ships with an example Asset plug-in, called PyMockAsset. The source file **MockAsset.py** for the example plug-in is located in:
`${KATANA_ROOT}/plugins/Src/Resources/Examples/AssetPlugins/`

As well as source file **PyMockAssetWidgetDelegate.py** for the corresponding UI widget used with PyMockAsset, which is found in:
`${KATANA_ROOT}/plugins/Src/Resources/Examples/UIPlugins/`

Concepts

Asset ID

An Asset ID is a serialization of an asset's fields. In a simple case, using the default **File** Asset plug-in, the Asset ID is the file path, but in more complex systems it could be an SQL query, a URL, a GUID or a direct string representation of the asset's fields, such as the PyMockAsset Asset ID shown below.
`mock:///show/shot/name/version`

As it's a single string, an Asset ID can be passed as part of an argument string to a subprocess, such as a shell command or a procedural. It is important therefore that the format of an Asset ID is such that it can be easily found in a larger string and parsed.

Asset Fields

The fields of an asset are the key components needed to retrieve an asset from an asset management system. Katana assumes that an asset has a **name** field and - if provided - also uses a **version** field.

Asset Attributes

An asset can optionally have attributes where additional metadata is stored, such as comments, or information about the type of asset.

Katana does not rely on particular attributes to exist, but it presumes that there is a mechanism in place for this additional data to be read from and written to.

NOTE: It is fine to leave these methods unimplemented if your asset management system has no use for them.

Asset Publishing

Assets are published by users. When an asset is published it is in a finalized state, accessible to other users. Publishing can involve incrementing the asset version.

Transactions

A Transaction is a container for submitting multiple publish operations at once. Rather than submit one publish operation per asset, operations can be grouped. This means that if an error occurs whilst publishing many assets, the whole operation may be aborted.

```
beginTransaction (createTransaction)
publish asset A
publish asset B
publish asset C
endTransaction (commit)
```

The transaction is final only after the **endTransaction(commit)** operation.

A transaction must have a **commit** method and a **cancel** method. The **cancel** method can be used to rollback.

NOTE: Implementing plug-in support for Transactions is optional.

Creating an Asset Plug-in

A Python Asset plug-in is created by making a new Python file in an **AssetPlugins** sub-directory of a folder in a KATANA_RESOURCES directory.

NOTE: Asset management plug-ins can also be written in C++. See The C++ API for more on this.

Core Methods

The core methods for an Asset plug-in are:

Handling Asset IDs

- **buildAssetId()**
  Serialize asset fields into an Asset ID.
- **getAssetFields()**
  Deserialize an Asset ID into asset fields.
- **isAssetId()**
  Check if a string is an Asset ID.

Publishing an Asset

- **createAssetAndPath()**
  Create an entry for a new asset and optionally pre-publish it. This could have very little in it if your asset management system does most of its work post creation in postCreateAsset.
- **postCreateAsset()**
  Publish the new asset. This could have very little in it if your asset management system does most of its work immediately when the resource is allocated in createAssetAndPath.

Retrieving an asset

- **resolveAsset()**
  Convert an Asset ID to a file path.
- **resolvePath()**
  Convert an Asset ID and a frame number to a file path.

Publishing an Asset

The methods for publishing an Asset in a custom Asset Management System are **createAssetAndPath()** and **postCreateAsset()**.

createAssetAndPath() creates or updates an asset entry, given a collection of fields and an asset type. It returns the ID of the asset which resolves to a valid file path. It is invoked prior to writing an asset. The fields passed to **createAssetAndPath()** may be the result of a decomposed Asset ID stored as a parameter on a node.

Both **createAssetAndPath()** and **postCreateAsset()** are used by Katana mechanisms that write assets. The Asset ID returned from **createAssetAndPath()** is used to create the fields passed to **postCreateAsset()**. The result from **postCreateAsset()** is used from that point onward (such as in the **File** > **Open Recent** menu or in any references to that asset ID in the current scene):

```
assetFields1 = assetPlugin.getAssetFields(assetId, True)
id1 = assetPlugin.createAssetAndPath(..., assetFields1, ...)
[Write Katana scene file, etc.]
assetFields2 = assetPlugin.getAssetFields(id1, True)
id2 = assetPlugin.postCreateAsset(..., assetFields2, ...)
```

This is done to allow a temporary file path to be used for the write operation. The LookFileBake node and the Render node use these methods.

createAssetAndPath()

The arguments for **createAssetAndPath()** are:

- **txn**

  The Asset Transaction (implementation optional). Can be used to group create/publish operations together into one cancelable operation. This transaction is created via the createTransaction method.

- **assetType**

  A string representing which of the supported asset types is published. See Asset Types & Contexts for a list of the asset types, and contexts.

- **fields**

  A dictionary of strings containing the asset fields that represent the location of the asset. These are typically produced by de-serializing an Asset ID stored as a parameter on a node (such as a LookFileBake node). These fields are based on the Asset ID returned by **createAssetAnd-Path()**.

- **args**

  A dictionary containing additional information about what asset type to create. For example, should we increment the asset version? Is it an image, is it a Katana file? This is populated directly by the caller of **cre-ateAssetAndPath()** and varies with the asset type.

- **createDirectory**

  A Boolean indicating that a new directory for the asset needs to be cre-ated.

createAssetAndPath() should return the Asset ID of the newly created asset. This may be different to the serialized Asset ID representation of the fields passed in. For example, if **createAssetAndPath()** were to **versionUp** the asset the returned Asset ID would likely be different to the serialized fields passed in. The returned Asset ID can be stored as a parameter on the node using this plug-in (if it is being used by a node).

The important arguments are **assetType**, **fields** and **args**. There are no rules for how the args dictionary is populated. It depends on the calling context and the Asset Type that **createAssetAndPath()** was invoked for.

postCreateAsset()

postCreateAsset() is invoked after Katana has finished writing to an asset file and is used to finalize the publication of the asset.
The args dictionary for this type contains:

- **txn**
  The Asset Transaction.
- **assetType**
  A string representing which of the supported asset types is published. See Asset Types & Contexts for a list of the asset types, and contexts.
- **fields**
  The fields that represent the location of the asset. These fields are the identical to those given to **createAssetAndPath()**.
- **args**
  A dictionary of strings containing additional information about what asset type to create. For example, should we increment the asset version? If it is an image, what resolution should it be?

Examples

Selecting **File** > **Version Up and Save** triggers **createAssetAndPath()** to be invoked with an **args** dictionary, in which the **versionUp** and **publish** keys are set to 'True'. This results in a different Asset ID to that of the serialized fields passed in. **versionUp** indicates that a new version of the asset should be published.

Selecting **File** > **Save** triggers **createAssetAndPath()**, invoked with **versionUp** and **publish** set to **False**, unless a custom asset browser has been written. In that case, **versionUp** and **publish** are based on the values returned from the **getExtraOptions()** method of a custom browser class. See Configuring the Asset Browser for more on this.

Asset Types & Contexts

The following asset types are available to the **AssetAPI** module:

- **Katana project**
  kAssetTypeKatanaScene
- **Macro**
  kAssetTypeMacro
- **Live Group**
  kAssetTypeLiveGroup
- **Image**
  kAssetTypeImage
- **Look File**
  kAssetTypeLookFile
- **Look File Manager Settings**
  kAssetTypeLookFileMgrSettings
- **Alembic Files**
  kAssetTypeAlembic
- **ScenegraphXML Files**
  kAssetTypeScenegraphXml
- **Casting Sheets**
  kAssetTypeCastingSheet
- **Attribute Files**
  kAssetTypeAttributeFile
- **F Curves**
  kAssetTypeFCurveFile
- **Gaffer Light Rig**
  kAssetTypeGafferRig
- **Scene Graph Bookmarks**
  kAssetTypeScenegraphBookmarks
- **Shaders**
  kAssetTypeShader

In addition, the following list of contexts is available inside the **AssetAPI** module, and passed as hints to the asset browser whenever it is invoked:

- kAssetContextKatanaScene.
- kAssetContextMacro.
- kAssetContextLiveGroup.
- kAssetContextImage.
- kAssetContextLookFile.
- kAssetContextLookFileMgrSettings.
- kAssetContextAlembic.

- kAssetContextScenegraphXml.
- kAssetContextCastingSheet.
- kAssetContextAttributeFile.
- kAssetContextFCurveFile.
- kAssetContextGafferRig.
- kAssetContextScenegraphBookmarks.
- kAssetContextShader.
- kAssetContextCatalog.
- kAssetContextFarm.

A constant to hold the relationship between assets has been added. This constant is used when the **getRelatedAssetId()** function is called:

- kAssetRelationArgsFile.

Accessing an Asset

The **resolveAsset()** method must be implemented in order for Katana to gain access to the asset itself.

It takes an Asset ID as its first argument and returns a string containing a file path to the asset. This handle is a path to a file which can be read from and written to..

NOTE: An Asset plug-in must not attempt to use any NodegraphAPI, user interface, or callback modules when resolving an Asset ID. This is because Asset ID resolution occurs at render time, when these modules are not available. Reading from the Scene Graph while writing to it will result in undefined behaviour

Additional Methods

In addition to the core methods that need to be implemented by an Asset plug-in there are additional methods, many of which are variants.

reset()

Triggered when the user requests that Katana flush its caches. This is used to clear local Asset ID caches to allow retrieval of the latest version of an asset.

resolveAllAssets()

Used for expanding Asset IDs in a string containing a mix of Asset IDs and arbitrary tokens, such as a command. It takes a single string parameter which may contain one or more Asset IDs and replaces them with resolved file paths. **resolveAllAssets()** is used by:

- Python expressions, which have access to a function called **assetResolve()** which resolves a string of Asset IDs split by white space.
- String parameters, which has a method called **getFileSequenceValue()** that returns the value of the string with automatic expansion of Asset IDs into file paths.
- ImageWrite node postScripts. An ImageWrite node can execute post scripts commands. The Asset IDs in these commands are automatically expanded.

resolvePath()

This resolves an Asset ID and frame number pair, where time is a factor in determining the asset resolution (such as a sequence of images). **resolvePath()** is called in place of **resolveAsset()** whenever time is a significant factor in asset resolution.

resolvePath() is used extensively for resolving procedural arguments in render plug-ins. It is used by the Material and RiProcedural resolvers, and the Look File Manager. It can be accessed in Attribute Scripts via the **AssetResolve()** function in an Attribute Script Util module.

resolveAssetVersion()

This accepts an Asset ID that references a tag or meta version such as **latest** or **lighting** and returns the version number that it corresponds to. It also accepts an Asset ID that contains no version information and an optional **versionTag** parameter, and produces the version number that corresponds to the **versionTag** argument.

This is used by the LookFile resolver, Katana in batch mode, the Casting Sheet plug-in, and the Importomatic user interface.

createTransaction()

It allows Katana to create assets in bulk. If createTransaction is implemented to return a custom transaction object, then the object must have **commit** and **cancel** methods that take no arguments. The **commit** method should submit the operations accumulated in the transaction to the Asset Repository. The **cancel** method should rollback the publish operations accumulated in the transaction.

The transaction is passed by Katana to **createAssetAndPath()** and to **postCreateAsset()**. An example of this is in the Render node.

> **NOTE:** This method must be implemented but it can return **None**.

containsAssetId()

Reports if a string contains an Asset ID.

The string parameter uses this method prior to expanding the Asset IDs it may contain, when **getFileSequenceValue()** is called.

getAssetDisplayName()

Is used to produce a short name for an asset. For example, a name that can be used in the UI.

This is used by the Alembic Importomatic plug-in and the LookFileManager.

getAssetVersions()

Lists the versions that are available for an asset as a sequence of strings.

This is used by the Importomatic, to allow users to choose an asset version in the Importomatic versions column and by the CastingSheet plug-in.

getUniqueScenegraphLocationFromAssetId()

Provides a Scene Graph path for an asset, as a string, so that it can be placed easily in the Scene Graph, and is currently used by the LookFileManager.

getRelatedAssetId()

Given an Asset ID and a string representing a relationship or connection, returns another Asset ID. For example, with a shader file that has an Args file **getRelatedAssetId()** can be used to get the Asset ID of the Args file from the Asset ID of the shader. The contexts listed in Asset Types & Contexts are passed to **getRelatedAssetId()**.

> **NOTE:** If **getRelatedAssetId()** returns either **None**, or an empty string, Katana looks up the Args file in the default fashion, relative to the **.so** file location.

NOTE: If **getRelatedAssetId()** returns anything other than **None** or an empty string, Katana attempts to load the returned Asset ID. If for any reason that Asset ID is not valid, Katana will not fall back to the default behavior, but will give a load error.

getAssetIdForScope()

This truncates an Asset ID to the given scope, where the scope is an asset field.

For example:

```
getAssetIdForScope( "mock://myShow/myShot/myName/myVersion", "shot" )
```

Produces:

```
mock://myShow/myShot
```

The returned Asset ID no longer contains the **name** and **version** components.

This is used by the **assetAttr()** built-in function that Python expressions have access to, and by Katana internally.

setAssetAttributes()

Allows users to set additional metadata on an asset.

This is not used by anything in the Katana codebase. It is entirely up to the users to make use of this function.

getAssetAttributes()

Allows users to store additional metadata on an asset.

The casting sheet example plug-in uses this method and Python expressions have access to an assetAttr built-in method that retrieves asset attribute information.

Top Level Asset API Functions

The top level Asset API functions can be found by opening a **Python** tab and typing:

```
help( AssetAPI )
```

The most useful are:

- **SetDefaultAssetPluginName()**
  Sets the default asset plug-in to use in the user interface for this Katana project.
- **GetDefaultAssetPlugin()**
  Retrieves an asset plug-in by name.
- **GetAssetPluginNames()**
  Lists the names of all the currently registered asset plug-ins.

LiveGroup Asset Functions

Permissions may be set to username, workstation name, or certain environment variables for a project, such as show, shot, or sequence. When a function to check permissions in a specific context is called, the asset API plug-in queries the Asset Management System (AMS) to check general permissions or permissions for working with the asset with the given ID in the given context. Checking permissions for a given ID can be used to check whether the current user has sufficient permissions to edit the asset or whether the asset has already been checked out for editing.

The function signature for checking permissions is:
`checkPermissions(assetID: string, context: map of string to string): bool`

The context dictionary contains information about the context from which to check permissions, with names of information fields as keys and values of information fields as values. For example, the following might be produced:

- `action = edit`
- `shot = ts520`
- `show = srow`
- `username = name`
- `workstation = seat`

When the function to run a custom asset plug-in command is called the asset API plug-in uses the AMS to check if the command succeeds or fails. The function signature to run the plug-in command is:
`runAssetPluginCommand(assetID: string, command: string, commandArgs: map of string): bool`

The command parameter receives the command to execute, for example:

- `acquireLock`
- `releaseLock`

  The `commandArgs` dictionary contains information about the arguments with which to customize the execution of the given command, with names of command arguments as keys and values of command arguments as values. The `commandArgs` dictionary may be empty.

Extending the User Interface with Asset Widget Delegate

Katana provides a mechanism for configuring the asset related parts of its user interface. This is achieved by implementing and registering an AssetWidgetDelegate.

The PyMockAssetWidgetDelegate.py provides a good reference. This file is shipped with Katana in:
`${KATANA_ROOT}/plugins/Src/Resources/Examples/UIPlugins/`

This allows users to:
- Configure the asset / file browser. Typically this is done by extending with a custom asset browser tab.
- Implement a custom Python QT widget for displaying and editing Asset IDs in the **Parameters** tab.
- Implement a custom Python QT widget for displaying and editing render output locations in the **Parameters** Tab.
- Customize the QuickLink paths used by the file browser.

To create an AssetWidgetDelegate plug-in, create a new Python file and place it in a directory called **UIPlugins** in a folder in your KATANA_RESOURCES.

NOTE: The UI4 module is the main Python module for working with the Katana user interface.

Configuring the Asset Browser

The entry point for extending the Katana asset browser is the method **configureAssetBrowser()**, which must be implemented in your AssetWidgetDelegate plug-in. **configureAssetBrowser()** takes a single browser argument, which is the Katana Asset Browser to configure. At its core the Asset Browser is a QT dialog window (QDialog) with additional utility methods. The most useful of these are:
- **addBrowserTab()**
  Add a new tab to the Asset Browser.
- **addFileBrowserTab()**
  Add a standard file browser tab to the Asset Browser.
- **getCurrentIndex()**
  Return the index of the currently open tab.

- **setCurrentIndex()**
  Set the currently open tab.

The base implementation of **configureAssetBrowser()** sets the window title from the given hints and creates a file browser tab. If you want to avoid creating a file browser tab, implement a **shouldAddFileTabToAssetBrowser()** method with a return value of False.

The following methods exist but need minimal implementation:

- **setSaveMode()**
  Tells us whether the browser is invoked for opening a file or for saving one. If the saveMode is True, then the browser has been opened for saving a file.
- **selectionValid()**
  Checks whether the current asset path refers to a valid asset. For a file browser dialog window this returns false if a chosen path does not exist.
- **setLocation()**
  Sets the default location with which to open the browser.
- **getExtraOptions()**
  This is used to support a **versionUp** and a **publish** option for LookFileBake and create a new Katana file. If those options are displayed in the custom user interface Katana will retrieve them using this method:

```
{"versionup" : False/True, 'publish' : False/True }
```

> **NOTE:** The function **getExtraOptions()** should return a dict.

The Asset Control Widget

The AssetWidgetDelegate plug-in API makes it possible to replace the default string widget that allows users to view and edit an Asset ID in the node parameters tab.

Typically you edit the fields of an asset through a UI. Internally those fields are serialized into a single string as an Asset ID, and stored as a parameter on a node.

Using a custom Asset Control Widget you can replace the widget displaying the fields. Katana knows to use the custom widget through the **assetIdInput hint**, which is associated with all string parameters that represent an Asset ID.

Implementing A Custom Asset Control Widget

The entry point that Katana needs, in order to create a custom asset control widget is the **createAssetControlWidget()** method of our custom AssetWidgetDelegate class.

The **createAssetControlWidget()** method instantiates the SimpleMockAssetControlWidget, which must inherit from BaseAssetControlWidget. BaseAssetControlWidget is a QT QWidget with an HBoxLayout. **createAssetControlWidget()** then adds the control widget to the parent layout. The parent is a QWidget and part of the Parameter tab.

The following methods must be implemented by an asset control widget:

- **buildWidgets()**
  This is invoked by the BaseAssetControlWidget constructor to build the child widgets. This is where most of the work happens.
- **setValue()**
  Updates this widget with the given Asset ID.
- **getValue()**
  Return the Asset ID from this widget.
- **setReadOnly()**
  Enable/Disable editing of this widget.

The BaseAssetControlWidget supplies an **emitValueChanged()** method for notifying Katana that the user has changed the Asset ID in the widget. This must be called when the value in the UI has changed.

The Asset Render Widget

The Asset Widget Delegate allows customization of the display of the render output location shown in a Render node's **Parameters** tab. This is useful for when rendering to a location in a custom asset management system.

This output location could be an automatically generated temporary path or one set explicitly using a Render Output Define node. It is set on a Render Node and therefore the Asset Render Widget is read-only.

Implementing an Asset Render Widget

Implementing an Asset Render Widget is optional. The Asset Management user interface does not require this. The entry point for a custom widget delegate is similar to that of the Asset Control Widget.

The Asset Widget Delegate must implement **createAssetRenderWidget()** which in turn must return a class that inherits from **baseAssetWidgetDelegate()** and implements two methods, **buildWidgets()** and **updateWidgets()**.

createAssetRenderWidget() has an additional **outputInfo** argument which is a dictionary of output information and must be passed to the **BaseAssetRenderWidget** constructor. The outputInfo dictionary contains the output location's Asset ID along with additional information (such as the image file type and resolution). **BaseAssetRenderWidget** provides a utility method, **getOutputInfo()** for accessing this dictionary.

The key for the Asset ID of the output location is **outputLocation**.

Additional Asset Widget Delegate Methods

There are several methods used to make small customizations to the Asset Management UI. These are implemented as overridable methods on the Asset Widget Delegate.

addAssetFromWidgetMenuItems()

Allows you to extend the menu item to the right of an Asset ID in the **Parameters** tab with additional items.

```
def addAssetFormWidgetMenuItems(self, menu):
       menu.addAction("Custom Action",
                      self.__customCallback)

def __customCallback(self, *args):
       print args
```

shouldAddStandardMenuItem()

When **False** is returned from this method, the menu item to the right of an Asset ID in the Parameters tab is not displayed when clicked on.

shouldAddFileTabToAssetBrowser()

The File Tab is not displayed in the Asset Browser when this is set to return **False**.

getQuickLinkPathsForContext()

For customization of the quicklink paths displayed at the bottom of the File tab. Must return a sequence of file paths.

Locking Asset Versions Prior to Rendering

In many pipelines it is considered desirable to lock all the assets used in a shot to specific versions prior to rendering. When an asset is locked, meta versions (or tags) are resolved to a fixed static version, represented by a number. This ensures that the same asset version is used for rendering all frames. Conventional ways of doing this include creating a look-up table to specify which explicit version of an asset to use for all asset references, or by supplying an additional date-stamp to use when resolving assets.

The FarmAPI is a mechanism that allows users to take charge of the submission of jobs to a render farm and the construction of a look up table might be implemented within this API. See the Farm API docs for how to write a Farm API plug-in.

Setting the Default Asset Management Plug-in

The default Asset plug-in and file sequence is defined with two environment variables. If you want to set your own plug-in and sequence as default, make sure the following are set on your system:

```
KATANA_DEFAULT_ASSET_PLUGIN = yourAssetPlug-in
KATANA_DEFAULT_FILE_SEQUENCE_PLUGIN = yourFileSequence
```

The C++ API

You can implement an Asset plug-in in C++ as well as in Python. This is done by inheriting from the FnAsset class in the C++ plug-in SDK. Almost exactly the same methods must be implemented in C++ as in Python.

It is not possible to implement a custom Asset Browser, Asset Control Widget or Asset Render Widget via the C++ plug-in SDK. However, these user interfaces can still be implemented in Python and will work alongside a C++ Asset Management Plug-in.

Asset management plug-ins implemented in C++ and Python are accessed via the same Python interface inside of Katana and similarly, C++ plug-ins that make use of an asset management plug-in have access to those implemented in Python and in C++.

In order for Katana to load a custom asset management plug-in, it must be compiled as a shared object and placed in a directory called **Libs** inside your

KATANA_RESOURCES directory.

24 Render Farm API

The Render Farm Python API is an interface with hooks and utility functions for customizing the way jobs are submitted to a render farm from Katana. It provides functions for adding options to the **Render Farm** menu, for creating custom farm parameters, and for retrieving render node dependencies and render pass information.

The Render Farm API cannot export Scene Graphs or Katana recipes, and cannot be used for writing complex user interfaces or for modifying the Node Graph. Katana provides other modules for accomplishing these tasks.

The Farm API works exclusively with the Render, RenderScript and ImageWrite nodes, which are typically the final nodes in a recipe.

What scripts work with the Farm API?

To use the Farm API you must create a plug-in that is instantiated at the start of each Katana session. Python plug-ins are modules which must be placed in a **Plugins** subdirectory of a location in your KATANA_RESOURCES.

For example, make a directory called **MyResources**, with a subdirectory called **Plugins** and append the path to **MyResources** to your KATANA_RESOURCES environment variable. Plug-ins located in the **Plugins** directory are instantiated at the start of each Katana session.

> **NOTE:** The way plug-ins are picked up is similar to the way that Macros are located. See the Macros chapter for more on this.

Farm XML Example

Katana ships with an example Farm API plug-in called Farm XML. When invoked, this plug-in produces an example configuration script for submission to a Render Farm.

The Python source for this example is provided in:
`${KATANA_ROOT}/plugins/Src/Resources/Examples/Plugins/FarmXML.py`

The onStartup Callback

Plug-ins are initialized during the Katana startup sequence. Once initialized, a plug-in can register new node types or callback handlers. For example, a Render Farm plug-in must register an **onStartup** handler to be invoked once initialization is complete:

```
from Katana import Callbacks
def onStartup(**kwargs):
    pass
Callbacks.addCallback(Callbacks.Type.onStartup, onStartup)
```

The onStartup callback handler is used to add Farm menu options to the UI and register Farm specific node parameters.

Farm Menu Options

A Render Farm menu option is a UI hook for triggering a custom Render Farm Submission tool, which in turn could launch a File Browser or a custom dialog.

Two UI menus can be extended by the Farm API. The Util menu in the top menu bar and the Render Farm menu, which appears in a popup when you right click on a node in the Node Graph

The Util Menu

The function **AddFarmMenuOption()** adds a new menu item to the **Util** menu. It's arguments are a menu item title and a callback function to invoke when the menu item is chosen. For example:

```
from Katana import FarmAPI, Callbacks

def runMyOption(**kwargs):
    print("My Render Farm Util Menu Option has been clicked")
def onStartup(**kwargs):
    FarmAPI.AddFarmMenuOption("My Render Farm Util Menu
                              Option", runMyOption)
Callbacks.addCallback(Callbacks.Type.onStartup, onStartup)
```

Render Farm Popup Menu Option

The function **AddFarmPopupMenuOption()** adds a new item to the Render Farm section of a supported node's right-click menu. Like the Util menu, its arguments are an item title and a callback function to invoke when the item is chosen. For example:

```
from Katana import FarmAPI, Callbacks

def runMyOption(**kwargs):
    print(“My Render Farm Menu Option has been clicked”)
def onStartup(**kwargs):
    FarmAPI.AddFarmPopupMenuOption("My Render Farm Menu
                                   Option", runMyOption)
Callbacks.addCallback(Callbacks.Type.onStartup, onStartup)
```

Farm Node Parameters

The Farm API provides a mechanism for storing persistent settings in a Katana recipe. These settings appear as parameters under a **farmSettings** parameter on nodes of type Render, ImageWrite or RenderScript. You can add parameters of the following types:

- String
- StringArray
- Number
- NumberArray

As with menu items, these settings must be registered when the **onStartup()** handler in invoked. For example:

```
from Katana import FarmAPI, Callbacks

def onStartup(**kwargs):
    FarmAPI.AddFarmSettingString("My_Custom_Farm_Parameter")
Callbacks.addCallback(Callbacks.Type.onStartup, onStartup)
```

All settings can have UI hints. Array settings can be constructed with an initial size, and single value settings can be constructed with a default value.

NOTE: The Farm API function **GetAddedFarmSettings()** returns a dictionary of any added settings.

NOTE: The function **ExtractFarmSettingsFromNode()** returns a dictionary of the values of any addedl settings on a given node.

The Farm API automatically registers default settings. The documentation for these settings can be found in the Parameters Tab by clicking on the help icon to the left of a parameter's name.

- **setActiveFrameRange**
  The frame range to process on the farm.
- **dependAll**
  Render nodes that depend on this render node require all of its outputs to complete before the next process is launched.
- **forceFarmOutputGeneration**
  Force this node to appear in the farm file submitted to the render farm regardless of whether it has any outputs.
- **ExcludeFromFarmOutputGeneration**
  Do not include this node in the render farm file.

Although the parameters listed above exist for each renderable node, it is the responsibility of the writer of a Farm Plug-in to chose whether and how to implement them.

Get Sorted Dependency List

The Farm API provides a function for obtaining rendering dependencies and minimal render pass and output file information. This is all obtained via the **GetSortedDependencyList()** function, which returna a list of dictionaries, with one dictionary per rendering node. Dictionaries are ordered so that each entry appears after its dependencies. For example:

```
from Katana import FarmAPI, Callbacks

def displayOutputs(**kwargs):
    renderNodeInfo = FarmAPI.GetSortedDependencyList()
    print(renderNodeInfo)
def onStartup(**kwargs):
    # For the Util menu
    FarmAPI.AddFarmMenuOption("Display Outputs", displayOutputs)
    # For the popup
    FarmAPI.AddFarmPopupMenuOption("Display Outputs", displayOutputs)
Callbacks.addCallback(Callbacks.Type.onStartup, onStartup)
```

In a new Katana session, make a CameraCreate node and connect it to a Render node. When invoked, **displayOutputs()** produces console text similar to the following:

```
[{'name': 'Render', 'service': 'prman', 'views': '', 'outputs':
[{'outputLocation':
'/tmp/katana_tmpdir_9514/Render_rgba_square_512_lnf.#.exr',
'enabled': True, 'name': 'primary',
'tempRenderLocation': ''}], '2Dor3D': '3D', 'dependAll': 'No',
'range': None, 'deps': [], 'memory': '',
'output': True, 'renderInternalDependencies': 'No',
'farmFileName' : '' }]
```

Get Sorted Dependency List Keys

Many of the keys produced by **GetSortedDependencyList()** mirror a FarmSetting parameter value:

Key	Type	Description
2Dor3D	String	Describes whether the node works with 2D or 3D data. An ImageWrite node is 2D, while a Render node is 3D.
dependAll	String	Describes whether dependencies must wait until all outputs are complete.
deps	String[ ]	The names of the RenderNodes that this render node depends on.
name	String	The name of the render node that this dictionary represents.
outputs	Dictionary[ ]	A list of dictionaries. The render passes the current node outputs. Each dictionary contains a render pass name, a temp location and a proper location as an asset id.
range	Float[ ]	A tuple of floats giving the range to render, as set by the Farm settings parameters.
service	String	The renderer used. Could be **prman**, **arnold** or another renderer.

Render Dependencies

The function **GetSortedDependencyList()** provides the information needed to obtain the names of any other nodes a Render node depends on. For example, the following script returns the names of a Render node's dependencies, as a sequence:

```
def dependencyList(nodeName):
"""
Use GetSortedDependencyList to retrieve the entire
dependency tree for a render node.
Each entry is ordered so that render nodes are sorted by
number of dependencies, in descending order.
"""
# Get hold of the node and all of its dependencies as a
sequence of dictionaries
node = NodegraphAPI.GetNode(nodeName)
info = FarmAPI.GetSortedDependencyList( [ node ] )
# Extract the 'deps' for each entry in the sequence
# to produce a flat list.
allDeps = [ dep for i in info for dep in i["deps"] ]
return allDeps
```

Render Passes & Outputs

As with Render Dependencies, the sequence of dictionaries returned by **GetSortedDependcyList()** contains the names, paths, and temporary paths of the outputs a Render node produces.

Render Output Names

The following example script defines a function that returns a sequence comprised of the names of the output passes produced by a render node:

```
def outputNames(nodeName):
    """
    Get the render outputs of a render node
    """
    # Get hold of the node and all of its dependencies as a
    # dictionary
    node = NodegraphAPI.GetNode(nodeName)
    info = FarmAPI.GetSortedDependencyList( [ node ] )
    # Extract the names of the outputs
    # of a render node
    allDeps = [
              # The output name
              output["name"]
              # Each info entry
              for i in info
                # We only want the info for our particular node
                if i["name"] == nodeName
                    # We only want output info
                    for output in i["outputs"]
]

return allDeps
```

Render Output File Paths

Each image file rendered is written to a temporary location before being copied to the chosen final location. It therefore has two locations, the temporary (which is always a local file path) and the final (which can be an Asset ID). The default temporary path contains the Proccess ID of the current Katana session (not the one running on the farm). This path can be changed through the UI or the Nodegraph API, so knowledge of is useful.

The following example script defines a function that produces a sequence with each entry containing the name of an output, the path for the image files it produces, and the temporary file location:

```
def outputNames(nodeName):
"""
Get the render outputs of a render node
"""
# Get hold of the node and all of its dependencies as a dictionary
node = NodegraphAPI.GetNode(nodeName)
info = FarmAPI.GetSortedDependencyList( [ node ] )
# Extract the names of the outputs
# of a render node
allDeps = [
           # The output information
           (
           # Name
           output["name"],
           # Location
           output["outputLocation"],
           # Temp location
           output["tempRenderLocation"]
           )

           # Each info entry
           for i in info
               # We only want the info for our particular node
               if i["name"] == nodeName
               # We only want output info
                   for output in i["outputs"]
           ]

return allDeps
```

A File Browser Example

The following example plug-in retrieves rendering information and dumps it to a JSON file. The UI4 module is used to display a File Browser dialogue window:

```
from Katana import FarmAPI, Callbacks
import json
def writeRenderInfo(**kwargs):
    from Katana import UI4
    renderNodeInfo = FarmAPI.GetSortedDependencyList()
    farmFilePath = UI4.Util.AssetId.BrowseForAsset
    (
     '', 'Specify a filename', \
        True,{'fileTypes':'json','acceptDir': False}
    )
    with open(farmFilePath, "w") as farmFile:
        farmFile.write(
            json.dumps(
```

```
                renderNodeInfo
                )
            )
    def onStartup(**kwargs):
        FarmAPI.AddFarmMenuOption("Display Out", \
            writeRenderInfo)
Callbacks.addCallback(Callbacks.Type.onStartup, onStartup)
```

A Custom Dialogue

The default dialogue is a starting point for a farm plug-in dialogue window, but for a custom plug-in, it may be necessary to create a custom dialog window. In this case PyQT and the UI4 module should be used.

Errors, Warnings and Scene Validation

It is useful to check particular conditions of a recipe's state before submitting it to a render-farm. For example, the recipe should have no unsaved changes, so that what is rendered is consistent with what is displayed in Katana.

The utility **IsSceneValid()** checks for unsaved changes, and returns a boolean with a value of **True** if the recipe is eligible for submission. For example:

```
eligibleForSubmission = FarmAPI.IsSceneValid(
    nodeScope = FarmAPI.NODES_ALL,
    allowUnsavedChanges=False,
    allowCapitalLetters=False,
    allowDigits=False,
    unwantedSymbols=["_"]
)
```

The **nodeScope** argument specifies which nodes are submitted. The argument value is stored in the internal state of the Farm API and can be retrieved with **GetNodeProcessType()**, which returns one of the following:

- NODES_SINGLE
- NODES_SELECTED
- NODES_ALL

The function **GetNodeList()** retrieves the nodes specified by the **nodeScope**, if **IsSceneValid()** was successful. For example:

```
eligibleForSubmission = FarmAPI.IsSceneValid(
    nodeScope = FarmAPI.NODES_ALL,
    allowUnsavedChanges=False,
    allowCapitalLetters=False,
    allowDigits=False,
    unwantedSymbols=["_"]
```

```
)
if eligibleForSubmission:
    nodesForFarm = FarmAPI.GetNodeList()
```

If a scene fails the **IsSceneValid()** check, any errors and warnings are retrieved using **GetErrorMessages()** and **GetWarningMessages()**. The following example displays any errors in a message box:

```
errorText = FarmAPI.GetErrorMessages()
if len(errorText) > 0:
    UI4.Widgets.MessageBox.Warning('Error', \
        ' '.join(errorText))
return
```

The functions **AddErrorMessage()** and **AddWarningMessage()** are used to issue additional error messages. These are only used when writing a custom dialogue.

Additional Utils

The following table details the utility functions that the Farm API provides. Refer to the Python help function for more information on these functions:

Name	Type	Description
GetKatanaFile-Name()	String	Returns the Asset ID of the currently open Katana recipe.
GetSelectedNodes()	Node[ ]	Returns a list of the currently selected nodes.
GetCurrentNode()	Node	Returns the node currently under the mouse, if the mouse has been clicked. If there is no qualifying node, returns the first element in the list of selected nodes.
GetClickedNode()	Node	Returns the node currently under the mouse, if the mouse has been clicked.
GetSceneFrameR-ange()	Dictionary of floats with string keys	Returns the **In Time** and **Out Time** of the currently open Katana recipe.
GetCurrentNode-FrameRange()	Dictionary of floats with string keys	Returns the FarmSettings frame range of the cur-rent node.

APPENDIX A: CUSTOM KATANA FILTERS

There are two C++ APIs for writing new scene graph filters: the Scenegraph Generator API and Attribute Modifier API. Scenegraph Generators allow you to create new scene graph locations, and Attribute Modifiers allow you to modify attributes at existing location. These are are often used together.

Scenegraph Generators

Scenegraph Generators are custom filters that allow new hierarchy to be created, and attributes values to be set on any locations in the newly created locations.

Typical uses for Scenegraph Generators include reading in geometry from custom data formats (for example, Alembic_In is written as a Scenegraph Generator), or to procedurally create data such as geometry at render-time (such as the for render-time created debris or plants).

From a RenderMan perspective, Scenegraph Generators can be seen as Katana's equivalent ofRenderMan procedurals. The main advantages of using Scenegraph Generators are:

The data can be used in different target renderers.

Render-time procedurals are usually black-boxes that are difficult for users to control. Data produced by a Scenegraph Generator can be inspected, edited and over-riden directly in Katana.

Since Katana filters are be run on demand as the scene graph it iterated, Scenegraph Generators have to be written to deliver data on demand as well. The API reflects this: for every location you create you provide methods to respond to requests for:

- What are the names of attribute groups at this location.
- For any named attribute group, what are its values for the current time range.
- What are iterators for the first child and next sibling of this location, to enable walking the scene graph.

Example code for a number of different Scenegraph Generators are supplied in the Katana installation:

- ${KATANA_ROOT}/plugins/Src/ScenegraphGenerators/GeoMakers
- ${KATANA_ROOT}/plugins/Src/ScenegraphGenerators/SphereMakerMaker
- ${KATANA_ROOT}/plugins/Src/ScenegraphGenerators/ScenegraphXml
- ${KATANA_ROOT}/plugins/Src/ScenegraphGenerators/Alembic_In

Documentation of the API classes is provided in:

- ${KATANA_ROOT}/docs/plugin_apis/html/group__SG.html

Attribute Modifiers

Attribute Modifier plug-ins (AMPs) are filters that can change attributes but can't change the scene graph topology. Incoming scene graph data can be inspected through scene graph iterators, and attributes can be created, deleted and modified at the current location being evaluated. New locations can't be created or old ones deleted.

In essence this is the C++ plug-in equivalent of the Python 'AttributeScripts'. It is common to prototype modifying attributes using Python in AttributeScript nodes and then converting those to C++ Attribute Modifiers if efficiency is an issue such as for more complex processes that are going to be run in many shots.

Using the Attribute Modifier API:

- An input is provided by a scene graph iterator. This can be interrogated to find the existing attribute values at the current location being evaluated, as well as inspect attribute values at any other location (e.g. /root) if required.
- You provide methods to respond to any requests for attribute names of values of attributes at the current location. Using this you can pass existing data through, create new attributes, delete attributes, or modify the values of attribute.

From a RenderMan perspective, AttributeModifiers can be largely seen as the equivalent of riFilters.

Example code

- PLUGINS/Src/AttributeModifiers/GeoScaler
- PLUGINS/Src/AttributeModifiers/Messer
- PLUGINS/Src/AttributeModifiers/AttributeFile
- Documentation of the API classes is provided in:
- ${KATANA_ROOT}/docs/plugin_apis/html/group__AMP.html

Appendix B: Other APIs

File Sequence Plug-in API

API that tells how a file sequence should be described as a string, and how to resolve that string into a real file path when given a frame number.
File Sequence plug-ins can be implemented in either Python or C++.

Attributes API

C++ API to allow manipulation of Katana attributes in C++ plug-ins.

Render Farm API

Python API to allow implementation of connection of Katana with custom render farm management and submission systems.

Importomatic API

Python API to allow creation of custom new asset types to use in the Importomatic node.

Gaffer Profiles API

Python API to allow custom profiles when using specified renderers in the Gaffer node.

Viewer Manipulator API

Python API to allow rules to be set up to connect OpenGL manipulators in the viewer to custom shaders, and to create new custom manipulators.

Viewer Modifier API

C++ API to allow customization of how the Viewer displays new custom location types in the scene graph.

Viewer Proxy Loader API

Python API to specify custom Scenegraph Generators to use in the Viewer to display new proxy file types.

Renderer API

Python and C++ API to integrate new renders with Katana.

Appendix C: Glossary

Glossary

Node

A reusable user interface component for processing a KATANA scene graph in a deferred manner. A Node contains parameters.

Asset Fields

A dictionary containing the minimum components needed to retrieve an Asset from an Asset Management System. The fields may contain a name, version, the name of a parent directory or anything else needed to locate the asset.

Asset ID

A single string representing the serialization of an Asset's Fields.
Asset Widget Delegate

A Python class that implements methods for customizing the Asset Management System user interface inside of Katana.

Widget

A user interface component that implements a mechanism for displaying and editing data. All Katana widgets inherit from QT Qwidget.

Hint

Meta data that contains information about how a piece of Katana data will be presented in the user interface.

Katana Scene Graph

A data tree containing all the information needed to render a scene.

Katana Node Graph

A network of nodes for processing a scene graph in a deferred manner.

Look File

A collection of changes to apply to a Scene Graph. A look file is static data stored on disk.
Node Parameter

String and Number data used to calibrate how a node processes a Scene Graph. A node will contain parameters.

Scene Graph Attribute

The leaf elements of a Scene Graph. Attributes contain the actual data in a Scene Graph.

Scene Graph Location

A branch in a Scene Graph. A Scene Graph Location will contain one or more Scene Graph Attributes and will contain an arbitrary number of Scene Graph Locations.

Appendix D: Standard Attributes

Key Locations

The following table gives an overview of the standard attributes conventions at various important Scene Graph Locations. Attribute data types use the notation <type>[<tuple size>].

Attribute and Location	Type	Description
/root		This group is located at the top of the hierarchy and contains collections, output settings, and global render settings. Most of these attributes are not inherited.
rendererGlobalStatements (not inherited)		This defines global renderer-specific settings and has a different name, depending on which renderer is used, for instance prmanGlobalStatements, arnoldGlobal-Statements, and similar.
collections		Containing definitions of collections that are globally available, for example GafferLights.
collections.GafferLights.baked	string[ ]	A list of scene graph locations for all lights created through a gaffer.
lookfile.asset (not inherited)	string	The file path to the look file.
renderSettings.cameraName (not inherited)	string	The scene graph location of the camera, for example, /root/world/cam/camera.
renderSettings.renderer (not inherited)	string	The renderer; for example, PRMan.
renderSettings.resolution (not inherited)	string	The render resolution preset; for example, 512sq.
renderSettings.overscan (not inherited)	float	Overscan value in pixels.
renderSettings.adjustScreenWindow (not inherited)	string	The method for auto-adjusting the pixel ratio.
renderSettings.maxTimeSamples (not inherited)	integer	Defines how many times a point is sampled when the shutter is open.
renderSettings.shutterOpen (not inherited)	float	The timing of the opening of the camera shutter (0, where 0 represents the current frame.)
renderSettings.shutterClose (not inherited)	float	The timing of the closing of the camera shutter.

Attribute and Location	Type	Description
renderSettings.cropWindow (not inherited)	float4	The render crop window in normalized co-ordinates.
renderSettings.interactiveOutputs (not inherited)	string	Indicates which outputs (defined under renderSettings.outputs) to use for interactive renders.
renderSettings.producerCaching.limitProducerCaching (not inherited)	integer	Controls how the Katana procedural caches potentially terminal scenegraph locations.
renderSettings.outputs.<passname>		Contains a sub group for every render pass. The default pass is named primary. The rendererSettings/locationSettings are configurable per output. Output types are customizable by plug-ins. For instance, a color output has different rendererSettings than a shadow output.
renderSettings.outputs.<passname>.type (not inherited)	string	The type of output.
renderSettings.outputs.<passname>.includedByDefault (not inherited)	string	When enabled, this Render Definition is sent to the Render node.
renderSettings.outputs.<passname>.rendererSettings.colorspace (not inherited)	string	The color space.
renderSettings.outputs.<passname>.rendererSetting.fileExtension (not inherited)	string	The file extension of the output file.
renderSettings.outputs.<passname>.rendererSettings.channel (not inherited)	string	The channel of the output file.
renderSettings.outputs.<passname>.rendererSettings.convertSettings (not inherited)		Attribute group with file format-dependent conversion settings.
renderSettings.outputs.<passname>.rendererSettings.clampOutput (not inherited)	integer	Post-render, clamps negative RGB values to 0 and alpha values to 0-1.
renderSettings.outputs.<passname>.rendererSettings.colorConvert (not inherited)	integer	Post-render, converts rendered image data from linear to output colorspace specified in the filename.
renderSettings.outputs.<passname>.rendererSettings.cameraName (not inherited)	string	Scene graph location of camera to render from.

Attribute and Location	Type	Description
renderSettings.outputs.<pass-name>.rendererSettings.locationType (not inherited)	string	The type of location.
renderSettings.outputs.<pass-name>.locationSettings.renderLocation (not inherited)	string	The file path and name of the output.
/root/world		This group defines attributes that are inherited by the whole world, for instance, geometry, cameras, or lights. Some attributes like the lightList are inherited further down the hierarchy; others like globals, however, define universal settings and are not inherited.
globals.cameraList (not inherited)	string[ ]	The list of scene graph locations of cameras; for example, **/root/world/cam/camera** and **/root/world/cam/camera2**.
lightList.<light>		A sub group for every light; for example, **/root/world/lgt/gaffer/light1**.
lightList.<light>.path	string	Scene graph location of the light, for example, **/root/world/lgt/gaffer/light1**.
lightList.<path>.enable	integer	Defines whether the light is enabled.
viewer.default.pickable	integer	Defines whether the object can be selected in the Viewer.
viewer.default.drawOptions.hide	integer	Defines whether the object/group is visible in the Viewer.
viewer.default.drawOptions.fill	string	The fill setting used in the Viewer.
viewer.default.drawOptions.light	string	The lighting setting used in the Viewer.
viewer.default.drawOptions.smoothing	string	The smoothing setting used in the Viewer.
viewer.default.drawOptions.pointSize	float	The point size used for drawing.
viewer.default.annotation.text	string	The text of the annotation.
viewer.default.annotation.color	float3	The color of the annotation text.

Attribute and Location	Type	Description
xform.<group>		The xform attribute contains a sub group for every transform in the order these transforms are applied. A sub group with the name interactive contains the transform used for manipulation in the Viewer. An object can have only one interactive group. If another transform is added (using a Transform3D node for example), the previous interactive group automatically gets renamed. The group can be any arbitrary name, but uses the conventions: occurrence of 'interactive' to receive transformations for the Viewer, 'constraintN' for any number of constraints, or 'groupN' for the default group of regular transforms created by transform3D nodes. This supports an arbitrary list of transform commands, similar to RScale and Rtranslate in PRMan. The name prefix (translate, rotate, scale, matrix, origin) is how Katana determines how to use each xform child attribute it finds.
xform.<group>.translate (not inherited)	double3	Translation on the xyz axes.
xform.<group>.rotateX (not inherited)	double4	The first number indicates the angle of rotation. The remaining three define the axis of rotation (1.0/0.0/0.0 for X axis).
xform.<group>.rotateY (not inherited)	double4	The first number indicates the angle of rotation. The remaining three define the axis of rotation (0.0/1.0/0.0 for Y axis).
xform.<group>.rotateZ (not inherited)	double4	The first number indicates the angle of rotation. The remaining three define the axis of rotation (0.0/0.0/1.0 for Z axis).
xform.<group>.scale (not inherited)	double3	Scale on the xyz axes.

Location Type Conventions

Location types follow specific conventions and contain a certain attribute structure. The following table documents these attributes for the most common Location types.

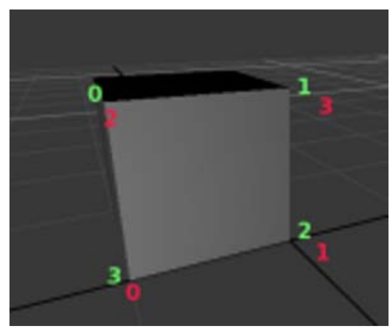
Location Type or Attribute	Type	Description
Groups		

Assembly		A regular group location as far as any renderers are concerned, but can be used as indicators that there are sensible depths for users to open the scene graph to.
		As a convention for complex hierarchies, assemblies should be for nesting groups while a component is usually the group right above the actual mesh or geometry data.
		`/ root`
		`+ world`
		`  + assembly`
		`  - assembly`
		`    - assembly`
		`      - component`
		`        - polymesh`
		`  + assembly`
		`  + assembly`

Group Attributes		The following attributes are commonly found on groups but can be found at any location type. For materialAssign may be assigned directly at a polymesh location.
component		See Assembly
group		Base location type to create Scene Graph hierarchy. Groups inherit their attributes from /root/world. The types assembly and component contain the same attributes as group.
rendererStatements		This defines local renderer-specific settings and has a different name, depending on which renderer is used (for example, prmanStatements and arnoldStatements).
attributeEditor.exclusiveTo	string	The scene graph location of the node that is manipulated when using the interactive manipulators.
bound		List of six doubles defining two points that define a bounding box. The order of the values is xmin, xmax, ymin, ymax, zmin, and zmax. Bounds are in local (object) space, not world space.
attributeModifiers.<modifierName>		Subgroups are created for deferred evaluation/loading of Attribute Modifier Plug-ins or Attribute Scripts. The scenegraphLocationModifiers attribute is a legacy version of attributeModifiers and is deprecated.

Location Type or Attribute	Type	Description
attributeModifiers.<modifier-Name>.type	string	The type of attribute modifier, for example, OP_Python.
attributeModifiers.<modifier-Name>.recursiveEnable	integer	Indicates if recursion is enabled.
attributeModifiers.<modifier-Name>.resolvedIds	string	The resolve Ids. Individual resolvers can be instructed to pay attention to only modifiers containing an expected resolveId Value.
attributeModifiers.<modifier-Name>.args	group	This attribute group contains the arguments defined in the Attribute Modifier Plug-in or Attribute Script.
lookfile		See /root.
materialAssign	string	The scene graph location of the assigned material, for example /root/materials/material1.
viewer		See /root/world.
xform		See /root/world.
Geometry		
Polymesh		Polygonal mesh geometry. A polygonal mesh is formed of points, a vertex list (defining vertices) and start index list (defining faces). Additional information, such as normals and arbitrary data, can also be defined.
geometry.point.N	float3[ ]	List of point normals.
geometry.point.P	float3[ ]	List of points. The geometry points are unique floating point positions in world space coordinates (x, y, z). Each point is only stored once but it may be indexed many times by a particular vertex.

Location Type or Attribute	Type	Description

geometry.poly.startIndex	integer[ ]	Is a list of indices defining the faces of a mesh. For example, consider a cube. A cube has a startIndex list size equal to the number of faces in the mesh plus one. This is because we must store the index of the first point on the first face as well as the end point of all the faces (including the first). So, for example, the beginning of a cube's startIndex list may look like:
		`0 - 0`
		`1 - 4`
		`2 - 8`
		`......`
		The indices for each polyon N are from startIndex(N) to startIndex(N+1)-1. The value at index 0 of the list tells us the first face should start at index 0 in the vertexList, the second value in the list tells us the first face ends at index 3 (n-1).
		This indicates the first face is a quadrilateral polygon. The image below shows the startIndex values of the first face in green. The red text shows the indexed values of the vertexList.
		

geometry.poly.vertexList	integer[ ]	The vertexList describes the vertex data of a mesh. There is a vertex at each edge intersection. The value of the vertexList is used as an index into the geometry.point.P list which stores the actual world coordinates of each unique point. Many indices in a vertexList can index the same point in the geometry.point.P list. This saves space as a vertex is described as a simple integer rather then the three floating point values required to describe a 3D geometry point (x, y, z).
geometry.vertex.N	float3[ ]	List of vertex normals.
geometry.vertex.UV	float2[ ]	List of texture coordinates (per vertex, non face-varying).

Location Type or Attribute	Type	Description
geometry.arbitrary.<group>		This group contains any sort of user data, such as custom attributes, defined in other applications. Texture coordinates, for example, are defined using a group called st.
geometry.arbitrary.<group>.scope	group	The scope of the attribute. Valid values are: primitive (equivalent to "constant" in PRMan), face (equivalent to "uniform" in PRMan), point (equivalent to "varying" in PRMan), vertex (equivalent to "facevarying" in PRMan). Support for the different scope types depends on the renderer's capabilities. Therefore, not all of these are supported in every renderer. Katana currently supports the following types: float, double, integer, string, color3, color4, normal2, normal3, vector2, vector3, vector4, point2, point3, point4, matrix9, and matrix16. Depending on the renderer's capabilities, all these nodes might not be supported.
geometry.arbitrary.<group>.inputType	string	Type under 'value' or 'indexedValue'. It's important to note that the specified 'inputType' must match the footprint of the data as described.
geometry.arbitrary.<group>.outputType	string	Output type for the arbitrary attribute can be specified, if the intended output type (and footprint) differs from the input type but can be reasonably converted. Examples of reasonable conversions include: float -> color3 , color3 -> color4.
geometry.arbitrary.<group>.value	integer, float, double, or string	The value is specified by either a 'value' attribute or an indexed list using the 'index' and 'indexedValue' attributes. Attribute containing the value. The type is dependent on the type specified. The base type can be integer, float, double, or string.
geometry.arbitrary.<group>.index	integer[ ]	List of indexes (if no index is present, the index is implicitly defined by the scope).
geometry.arbitrary.<group>.indexedValue	integer, float, double, or string	List of values. The base type can be integer, float, double, or string.
geometry.arbitrary.<group>.elementSize	integer	This optional attribute determines the array length of each scoped element. This is used by some renderers, for example, PRMan maps this to the "[n]" portion of a rendermant type declaration: "uniform color[2]"
pointcloud		Point cloud geometry. A point cloud is the simplest form of geometry and only requires point data to be specified.
geometry.point		See polymesh.

Location Type or Attribute	Type	Description
geometry.arbitrary.<group>		See polymesh.
subdmesh		Subdivision surfaces geometry. Subdivision surfaces (Subds) are similarly structured to polygonal meshes.
geometry.facevaryinginterpolate-boundary		A single integer flag, used by PRMan in the RiHierarachicalSubdivisionMeshV call by renderer output. Ignored in other renderers. See the Renderman documentation for more information.
geometry.facevaryingpropagate-corners		A single integer flag, used by PRMan in the RiHierarachicalSubdivisionMeshV call by renderer output. Ignored in other renderers. See the Renderman documentation for more information.
geometry.interpolateboundary		A single integer flag, used by PRMan in the RiHierarachicalSubdivisionMeshV call by renderer output. Ignored in other renderers. See the Renderman documentation for more information.
geometry.point geometry.poly geometry.vertex geometry.arbitrary.<group>		See polymesh.
Locator		Used only in the Viewer; ignored by the renderers.
geometry.point geometry.poly geometry.arbitrary.<group>		See polymesh.
spheres		A more efficient way of creating a group of spheres in PRMan at once. This is ignored by other plug-ins.
geometry.point.P	float3	List of points that represent the sphere centers.
geometry.point.radius	float[ ]	The spheres radii.
geometry.constantRadius	float	Can be used instead of geometry.point.radius to specify a single radius for all spheres.
curves		For creating groups of curves parented to the same transform. Curves cannot be created by the UI but can be created through the Python API.
geometry.degree	integer	Specifics whether curve(s) are linear or cubic, linear = 1, cubic = 3.

Location Type or Attribute	Type	Description
geometry.knots	float[ ]	Knot vector, a sequence of parameter values, which defines the index positions of the points in **geometry.point.P**. For example, a curve with 6 points in geometry.point.P, with knots [0 1 2 0 1 2] creates 2 curves. Curves must have at least one float value in the tuple **knots**, although knots are ignored for all curve types aside from trimmed curves. Note: When splitting **geometry.point.P** into multiple curves using knots, the values in **numVertices** must correspond. For example, given 6 control points in **geometry.point.P** and knots [0 1 2 0 1 2] **numVertices** must read [3 3].

geometry.numVertices	float[ ]	The number of vertices in each curve.
		The following XML is from a Scene Graph that creates 3 linear curves with 3 segments:
		`<attr type="GroupAttr"`
		`inheritChildren="false">`
		`<attr type="IntAttr" name="degree"`
		`tupleSize="1">`
		`<sample value="1 " size="1" time="0"/>`
		`</attr>`
		`<attr type="FloatAttr" name="knots"`
		`tupleSize="1">`
		`<sample value="0.0 " size="1" time="0"/>`
		`</attr>`
		`<attr type="IntAttr" name="numVertices"`
		`tupleSize="1">`
		`<sample value="4 4 4 " size="3" time="0"/>`
		`</attr>`
		`<attr type="GroupAttr" name="point"`
		`inheritChildren="false">`
		`<attr type="FloatAttr" name="P"`
		`tupleSize="3">`
		`<sample value=" 0.2  0  5 -2.8  0  2.0  0.5`
		`0  1.0 -0.3 0`
		`-1.5 1.8 0 4.9 -0.4  0  2.2  2.5  0  1.0`
		`1.6  0 -1.4  3.8 0  4.9 1.6 0 2.2 4.5 0 1.0`
		`3.6  0 -1.4 " size="36" time="0"/>`
		`</attr>`
		`</attr>`
		`</attr>`
		The numVertices list defines the index ranges of the knots used by each curve.

geometry.point.P	float3	List of points. The geometry points are unique floating point positions in world space coordinates (x, y, z). Each point is only stored once but it may be indexed many times by the same knot.

Location Type or Attribute	Type	Description
geometry.point.orientation	float3	For Arnold-oriented curves. An *n*X3 tuple of floats, where *n* is the number of control points in the curve. Specifies the orientation, relative to camera, of each point in the curve.
geometry.point.constantWidth	float[ ]	A float which defines the width of a curve, which is applied uniformly to each control point.
geometry.point.point.width	float[ ]	An *n*X1 tuple of floats, where *n* is the number of control points in the curve. Defines the width of the curve at each control point. Note: If both **geometry.constantWidth** and **geometry.point.width** are set, the values in **geometry.point.width** are used.
nurbspatch		NURBS patch geometry. NURBS patches are a special type of geometry, quite different from conventional mesh types. A NURBS curve is defined by its order, a set of weighted control points and a knot vector.
geometry.uSize geometry.vSize	integer	The size.
geometry.point.Pw	float4[ ]	List of control points and their weights.
geometry.u.order geometry.v.order	integer	The order.
geometry.u.min geometry.u.max	float	Parameters defining the NURBS patch.
geometry.u.knots geometry.v.knots	float[ ]	Knot vector, a sequence of parameter values.
geometry.trimcurves		Parameters defining the NURBS patch.
geometry.arbitrary.<group>		See polymesh.
sphere		Built-in primitive type for a sphere, supported by some renderers.
geometry.radius	double	The radius of the sphere.
geometry.id	integer	Object ID. This is not used for output, originally it was added as an example for SGG plug-in.
camera		Location type to declare a camera.
geometry.projection	string	The light projection mode (perspective or orthographic).
geometry.fov	double	The field of view angle in degrees
geometry.near	double	Distance of the near clipping plane
geometry.far	double	Distance of the far clipping plane

Location Type or Attribute	Type	Description
geometry.left geometry.right geometry.bottom geometry.top	double	The screen window placement on the imaging plane. The bound of the screen window.
geometry.centerOfInterest	double	This is used for tumbling in the viewer it has no affect on the camera matrix.
geometry.orthographicWidth	double	The orthographic projection width.
light		Location type to declare a light.
geometry		Shares the same attributes as camera.
geometry.radius	float	The radius of the light.
geometry.previewColor	float3	The color of the light in the Viewer.
Instancing		
Arnold		
instance source		
instance.type	string	Sets the instance type. Optional. If not set, it defaults to **object**.
		Note: Instancing in Arnold works by either specifying an instance source location for each instance, or by specifying an instance ID, in which case the first location encountered with a given ID becomes the instance source for all subsequent locations with the same ID. If specifying an instance source, the attributes under **Instancing** > **Arnold** > **instance** apply. If specifying an instance ID, the attributes under **Instancing** > **Arnold** > **geometry** apply.
instance		
geometry.instanceSource	string	Specifies the Scene Graph location of the instance source.
instance.arbitrary	group	Follows the same conventions as geometry.arbitrary for specifying per-instance user data overrides.
geometry		
instance.ID	string	A string attribute **instance.ID**. Locations sharing the same value for instance.ID become instances of the first location with that ID encountered.
PRMan		
instance source		

Location Type or Attribute	Type	Description
instance.type	string	Optional. If not set, it defaults to object. Available options are: • object • katana • inline.archive **NOTE:** Defining an object as instance source captures the state of the RIB file at that object block, including shaders and other attributes, whether set in the object block, or inherited from higher in the stack. This generally overrides the state at the point of instantiation at **instance** locations. Because of this, care should be taken when using PRMan instancing. For more information, see the PRMan documentation, and the *Instancing* chapter in the User Guide.
forceExpand	integer	An integer that, when set to 1, ensures the instance source location is forced to expand before any of the instances.
instance		
geometry.instanceSource	string	Specifies the Scene Graph location of the instance source.
instance.arbitrary	group	Follows the same conventions as **geometry.arbitrary** for specifying per-instance primvar overrides.
bound	double6	List of six doubles defining two points that define a bounding box. The order of the values is xmin, xmax, ymin, ymax, zmin, and zmax.
Materials		
material		Location type for a shader definition.
material.viewerShaderSource	string	Source of the Viewer shader.
material.<renderer><ShaderCategory>Shader	group	This group has different names depending on the renderer and shader used, for example, prmanLightShader or arnoldSurfaceShader. The group contains all the shader attributes used by a particular shader type for a specific renderer.
Other		
brickmap		PRMan only - a brickmap is a file used by Renderman to store 3D information.
geometry	string	Filename: Katana passes this value to PRMan as: RiGeometry("brickman," "filename", <geometry.filename>, RI_NULL)

Location Type or Attribute	Type	Description
volume		**PRMan only**
geometry.type	string	This attribute controls how the volume location is interpreted. Different render plug-ins support specific attribute conventions based on this attribute. As of the PRMan 17 plug-in, the following volume types are supported: • riblobby • riblobbydso • rivolume • rivolumedso The corresponding attribute conventions for each are described in the rest of this section. Primvars are supported through the canonical **geometry.arbitrary** attribute convention.
riblobby		The **riblobby** type is mapped to a prman RiBlobbyV call. The required attributes for this type reflect the parameter of the RiBlobbyV function. See PRMan documentation for more details.
geometry.type	string	type == riblobby
geometry.nleaf	integer	Number of primitive blobs
geometry.code	integer[ ]	Sequence of op-codes describing the object's primitive blob fields.
geometry.floats	float[ ]	Float parameters of the primitive fields (optional)
geometry.strings	string[ ]	String parameters of the primitive fields (optional)
riblobbydso		The **riblobbydso** is a convenience type that is mapped to a single 1004-opcode RiBlobbyV call. The dso filename provided through the **dso** attribute is prepended to the **stringargs** attribute values and then passed as **strings** parameter. A typical Blobby call for a **riblobbydso** type looks as follows: Blobby 1 [1004 0 *size*(<*floatargs*>) 0 *size*(<*stringargs*>) 1] [<*floatargs*>] [<*dso*> <*stringargs*>] See the PRMan documentation for more details.
geometry.type	string	type == riblobbydso
geometry.dso	string	Specifies the path to the plug-in to be used to evaluate the volume region.

Location Type or Attribute	Type	Description
geometry.volumetric	integer	Defines if the primitive field is rendered as an iso-surface (0) or as a volumetric region (1). If the 'volumetric' attribute is set and its value is 1, an opcode 8 is prepended to the opcodes array.
geometry.floatargs	float[ ]	Float parameters of the primitive fields (optional).
geometry.stringargs	string[ ]	String parameters of the primitive fields (optional).
rivolume		The **rivolume** type is mapped to a PRMan RiVolumeV call. The **shape** attribute value must be set to one of the PRMan supported shapes, such as **box**, **ellipsoid**, or **cone**. The RiVolume bounds parameter is set using the value of the **bound** attribute defined on the current location, this parameter must be set. The RiVolume **nvertices** parameter is set using the value of the **voxelResolution** attribute. See the PRMan documentation for more details.
geometry.type	string	type == rivolume
geometry.shape	string	Defines the shape of the volume region.
geometry.voxelResolution	integer3	Specifies the number of vertex and varying storage class primitive variables (if omitted defaults to [0, 0, 0])
bounds	double6	See **Location Type Conventions** > **Group Attributes** > **bound** for more details.
rivolumedso		The **rivolumedso** type is mapped to a PRMan RiVolumeV call using the **blobbydso:** prefix for the RiVolumeV type parameter. The RiVolume bounds parameter is set using the value of the **bound** attribute defined on the current location. The RiVolume **nvertices** parameter is set using the value of the **voxelResolution** attribute. **floatargs** and **stringargs** are mapped to primitive variables **blobbydso:floatargs** and **blobbydso:stringargs**. A typical RiVolume call for a **rivolumedso** type looks as follows: Volume “blobbydso:<dso>” <*bound*> <*voxelResolution*> "constant string[n] blobbydso:<*stringargs*>" "constant float[*m*] blobbydso:<*floatargs*>" See the PRMan documentation for more details.
geometry.type	string	type == rivolumedso
geometry.dso	string	Specifies the path to the plug-in to be used to evaluate the volume region.

Location Type or Attribute	Type	Description
geometry.voxelResolution	integer3	Specifies the number of vertex and varying storage class primitive variables (if omitted defaults to [0, 0, 0]).
geometry.floatargs	float[ ]	Float parameters of the primitive fields (optional).
geometry.stringargs	string[ ]	String parameters of the primitive fields (optional).
bounds	double6	See **Location Type Conventions** > **Group Attributes** > **bound** for more details.
collection		This is not a real location type. Katana displays collections that appear in the **collections** attribute on any location as a fake hierarchy location in the Scene Graph. The location is shown with gray text to indicate that it's not a real location.
error		Renders halt if this type is encountered (fatal error). An error message is written to the Render Log and displayed in the console.
Scene Graph.		The string Attribute errorMessage can be set at any location to display a non-fatal error message.
faceset		Describe a set of faces of a parent geometry. (Only valid as an immediate child of polymesh or submesh)
info		This location can be used to embed user-readable info in a klf or assembly. It's ignored in rendering. Its **text** attribute is displayed as HTML in the **Attribute** tab.
info.text	string	Info text to display in the **Attributes** tab.
level-of-detail group		Geometry with a specific level of detail. These are children of a single level-of-detail group.
lodRanges	float	MinVisible
	float	maxVisible
	float	lowerTransition
	float	upperTransition
		These values can be set by lodValuesAssign.
light material		A material to be assigned to a light.
procedural		A legacy attribute for older plug-ins, all new plug-ins should be scenegraph generators.
renderer procedural		Location containing attributes that define a renderer-specific procedural.
renderer procedural arguments		Definition of a renderer procedural arguments that can be assigned to a renderer procedural.

Location Type or Attribute	Type	Description
ribarchive		RenderMan-specific rib files can be loaded and passed to the renderer. Such a file can be seen as a black box, for instance, the Scene Graph only contains the file name to the rib file and has no insight to the data containing within.
geometry	string	filename: The path and file name of the .rib file, for example, /tmp/archive.rib.
scenegraph generator		Contains attributes that define a Scene Graph Generator for deferred evaluation.
generatorType	string	String indicating the generator type.
args	group	Arguments defined by the Scene Graph Generator.