



High-level real-time 3D graphics development with Coin3D

Karin Kosina (vka kyrah)

Introduction



- * Karin Kosina (vka kyrah)
- * Computer graphics programmer and lecturer
- * Maintainer of Coin3D Mac OS X port
- * Feel free to get in touch with me at:
kyrah@coin3d.org

PGP fingerprint:

10EA 9B79 1DDB 7535 1AAB
4E8D C2B8 C0AC BE32 63FE



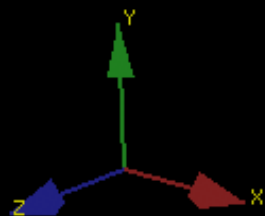
Introduction (your turn)

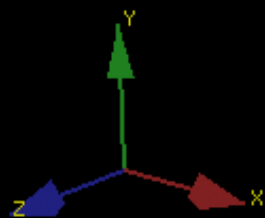
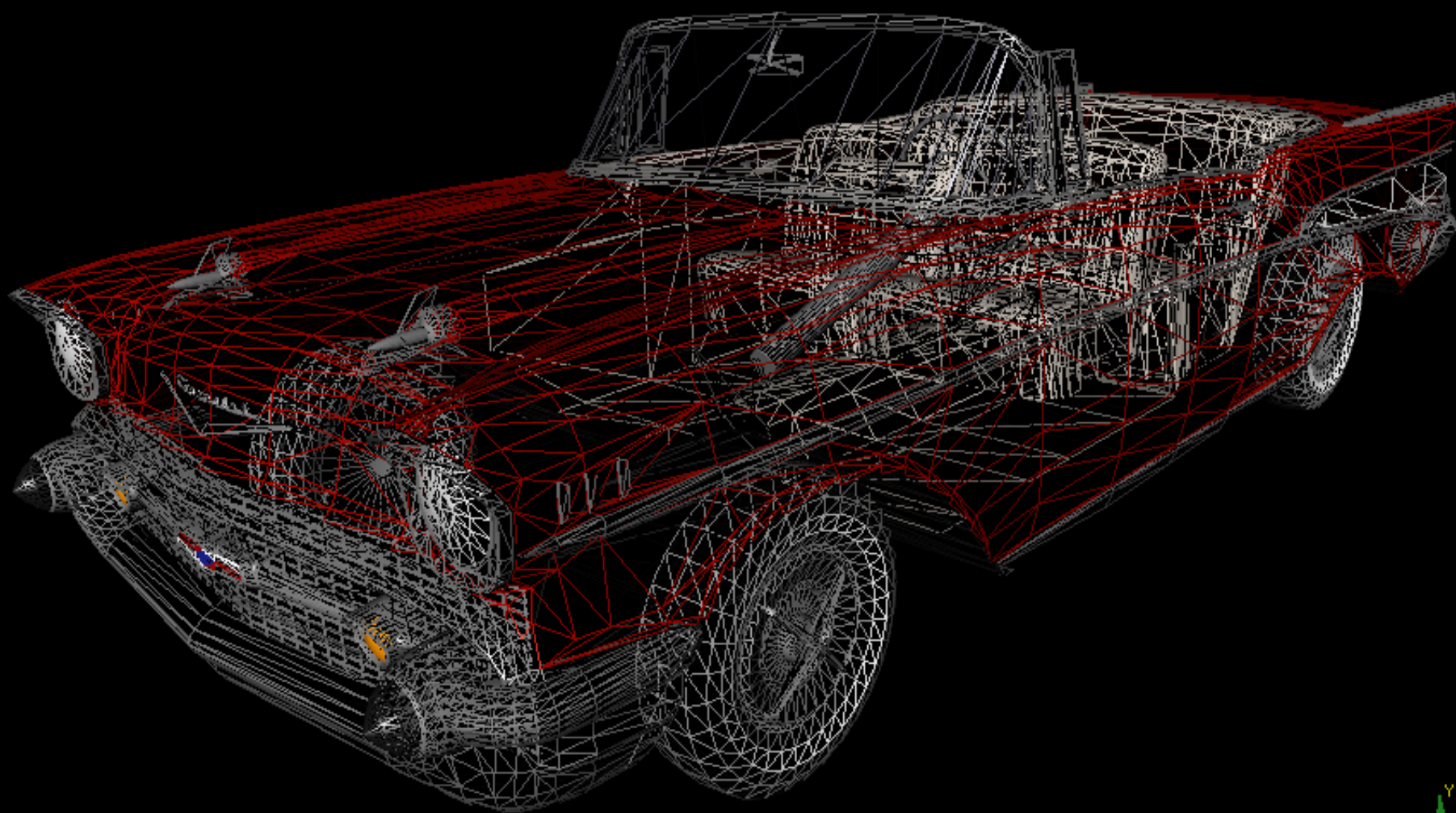
- * Programmers?
 - * C++?
 - * Python?
- * Computer graphics?
 - * OpenGL?
 - * High-level toolkits?
 - * Coin3D/Open Inventor?



What is 3D Graphics?

- * Relatively new scientific field (first papers from the 1960s)
- * We want to display a virtual (3D) scene on a (2D) screen
 - * Concept: taking a picture with a virtual camera
 - * This process is often called *rendering*.
- * 3D model (mathematical description of an object)
 - * e.g. a sphere: defined by its radius
- * Relationship between the objects in the scene
 - * position of the objects in "world space"
- * Attributes
 - * colour, lighting,...







So how does this work?

- * Most widely used library for 3D graphics is OpenGL.
- * Cross-platform standard, very flexible, very fast.
- * Direct3D
 - * Microsoft Windows' proprietary 3D library.



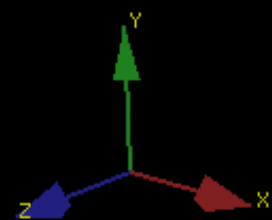
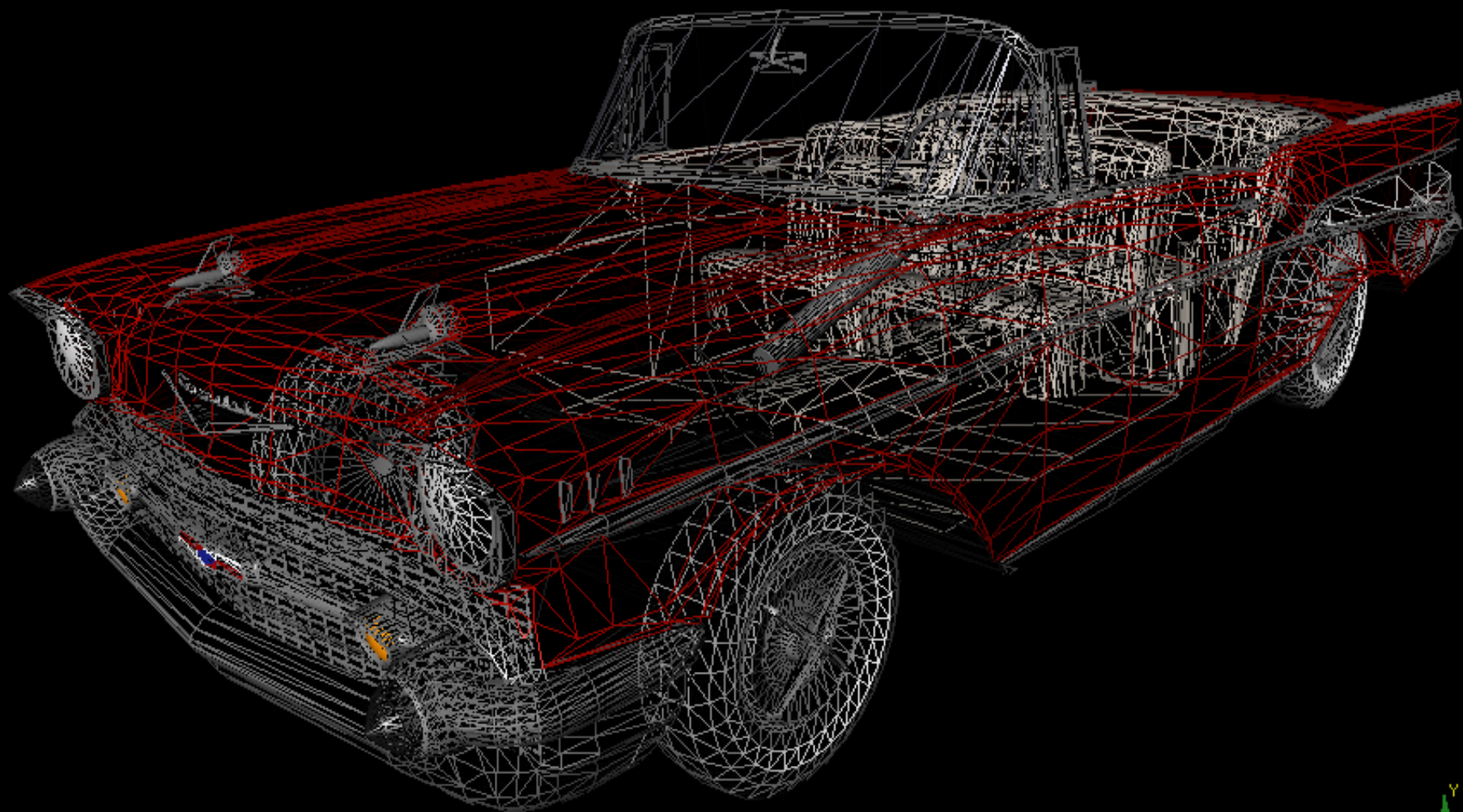
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So how does this work?

- * Most widely used library for 3D graphics is OpenGL.
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- * OpenGL works great, but it is very low-level.
- * You have to think in triangles, not in objects.





So how does this work?

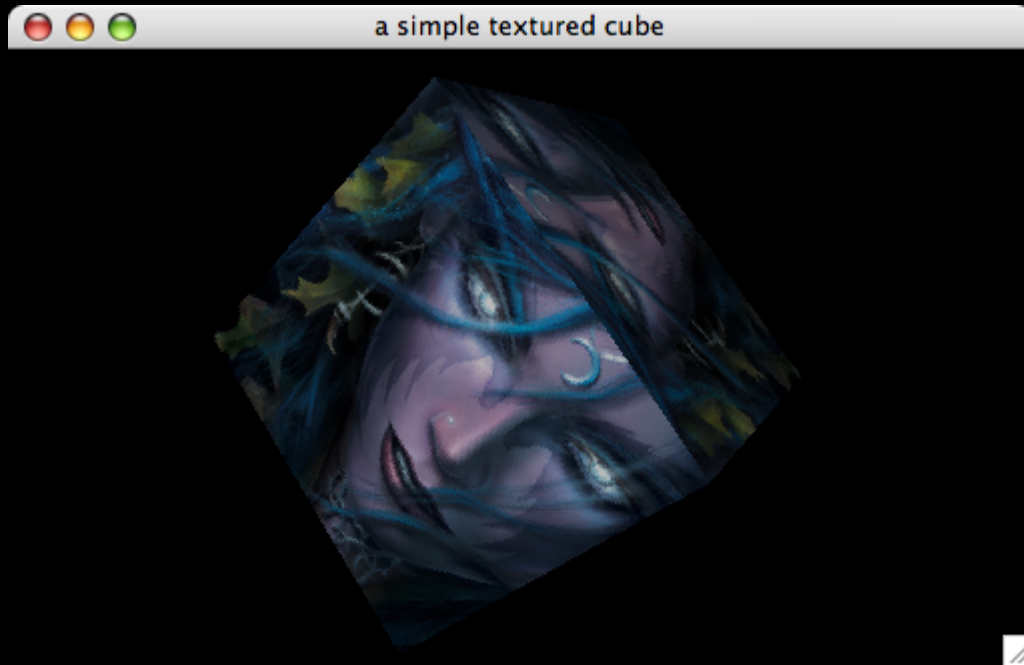
- * Most widely used library for 3D graphics is OpenGL.
- * Cross-platform standard, very flexible, very fast.
- * OpenGL works great, but it is very low-level.
- * You have to think in triangles, not in objects.
- * You have to organise the scene yourself.
- * You have to optimise for different graphics cards.
- * **Alternative: High-level 3D graphics**
 - * Scene arranged in hierarchical structure
 - * Higher abstraction level
 - * Ease of use, programmer convenience



Let me show you what I mean...



A simple textured cube:



- * OpenGL: 560 loc
- * Coin: 37 loc



High-Level 3D Graphics APIs

- * All 3D graphics projects end up using *some* kind of scene abstraction...
- * Option #1: Re-invent the wheel and write your own...
 - * especially popular in games
- * Option #2: Use an existing SDK
 - * Open Inventor/Coin3D
 - * Performer, OpenSG, Java3D,...



Coin3D Overview

- * C++ object oriented high-level 3D graphics API
- * Available as Free Software under the GNU GPL
- * Portable across a wide range of platforms
 - * GNU/Linux, Mac OS X, Windows, SGI Irix,...
- * Uses OpenGL for accelerated rendering
- * Native file format: Inventor files (.iv)
- * GUI bindings available for various toolkits
 - * SoQt for cross-platform applications using Qt
 - * Others (SoXt, SoWin, Sc21)
- * C++ SDK
 - * Bindings to other languages available, e.g. *Pivy* for Python



Hello World



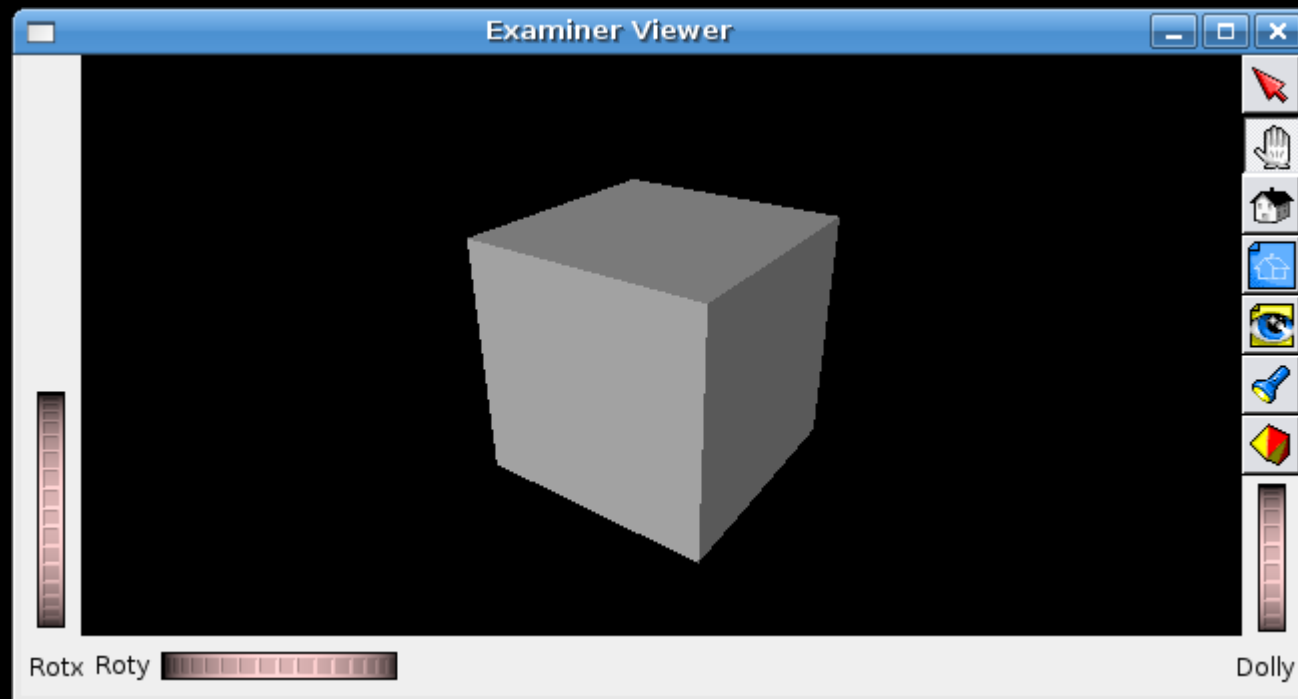
```
#include <Inventor/Qt/SoQt.h>
#include <Inventor/Qt/viewers/SoQtExaminerViewer.h>
#include <Inventor/nodes/SoSeparator.h>
#include <Inventor/nodes/SoCube.h>

int main(int argc, char ** argv)
{
    QWidget * mainwin = SoQt::init(argc, argv, argv[0]);

    SoSeparator * root = new SoSeparator;
    root->ref();
    SoCube * cube = new SoCube;
    root->addChild(cube);

    SoQtExaminerViewer * eviewer = new
SoQtExaminerViewer(mainwin);
    eviewer->setSceneGraph(root);
    eviewer->show();
    SoQt::show(mainwin);
    SoQt::mainLoop();

    root->unref();
    delete eviewer;
    return 0;
}
```

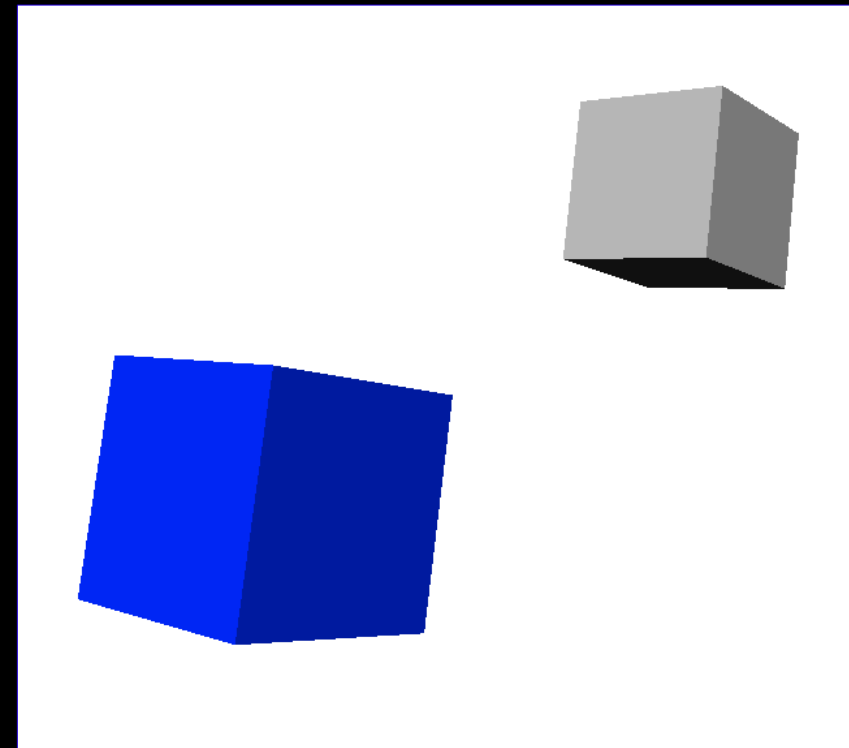
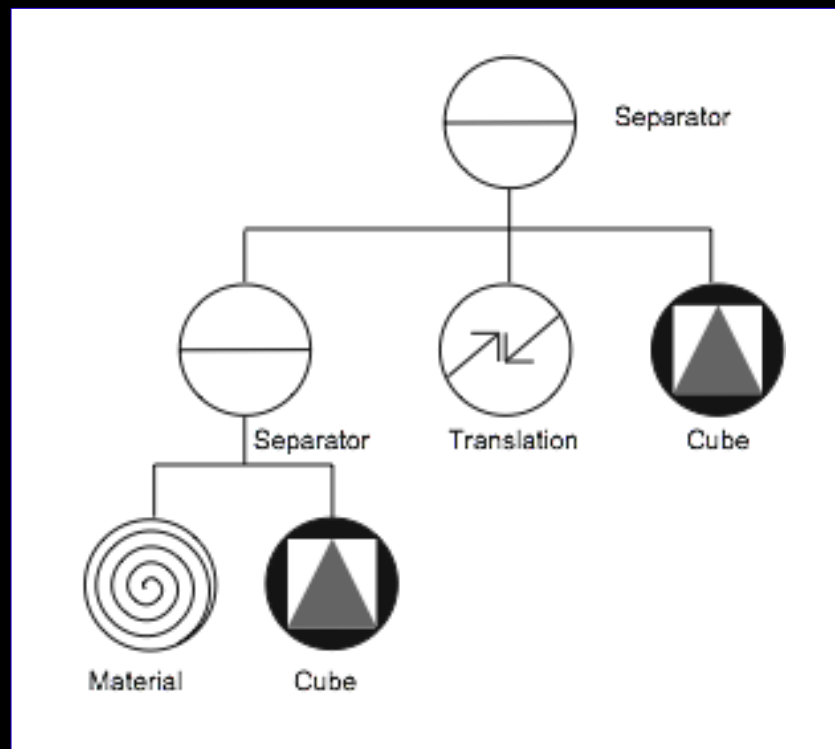




The Scenegraph

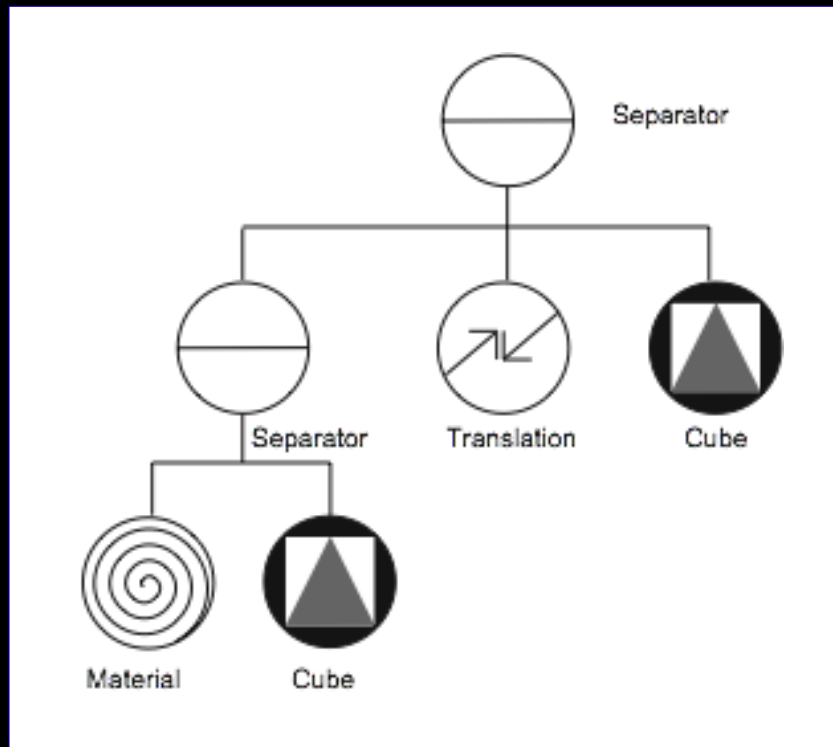


A very simple scene





A very simple scene



```
Separator {  
  Group {  
    Material {  
      diffuseColor 0 0 1  
    }  
    Cube {  
    }  
  }  
  Translation {  
    translation 3 2 0  
  }  
  Cube {  
  }  
}
```



Inventor files vs. C++ code

```
Separator {  
  Group {  
    Material {  
      diffuseColor 0 0 1  
    }  
    Cube {  
    }  
  }  
  Translation {  
    translation 3 2 0  
  }  
  Cube {  
  }  
}
```

```
SoSeparator *root = new SoSeparator;  
root->ref();
```

```
SoGroup *group = new SoGroup;  
root->addChild(group);  
SoMaterial *mat = new SoMaterial;  
mat->diffuseColor.setValue(0,0,1);  
SoCube *cube = new SoCube;  
group->addChild(mat);  
group->addChild(cube);
```

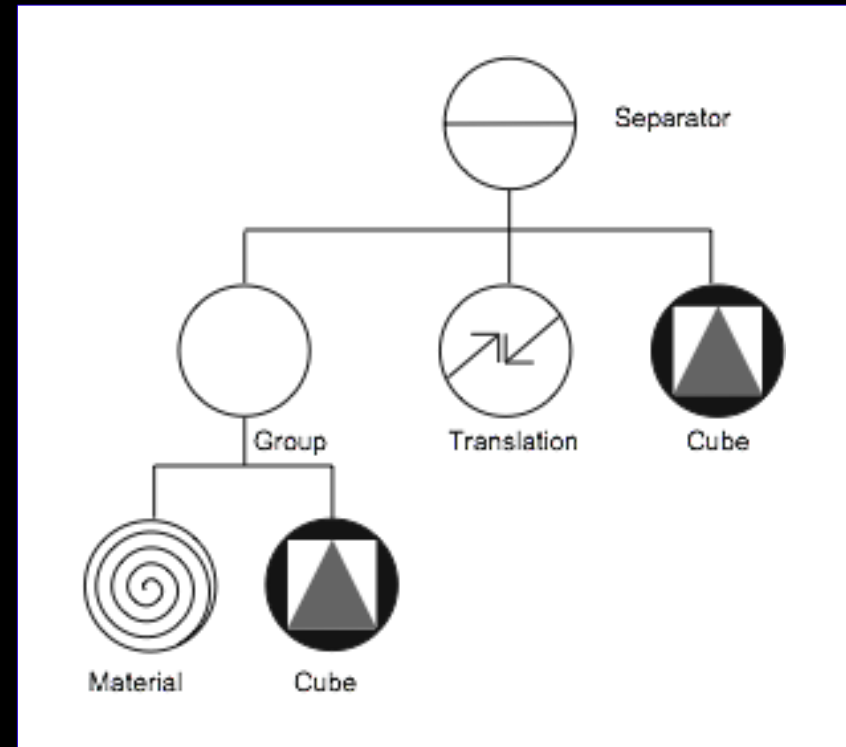
```
SoTransform *trans = new SoTransform;  
trans->translation.setValue(3,2,0);  
root->addChild(trans);
```

```
SoCube *cube2 = new SoCube;  
root->addChild(cube2);
```

Scenegraph components



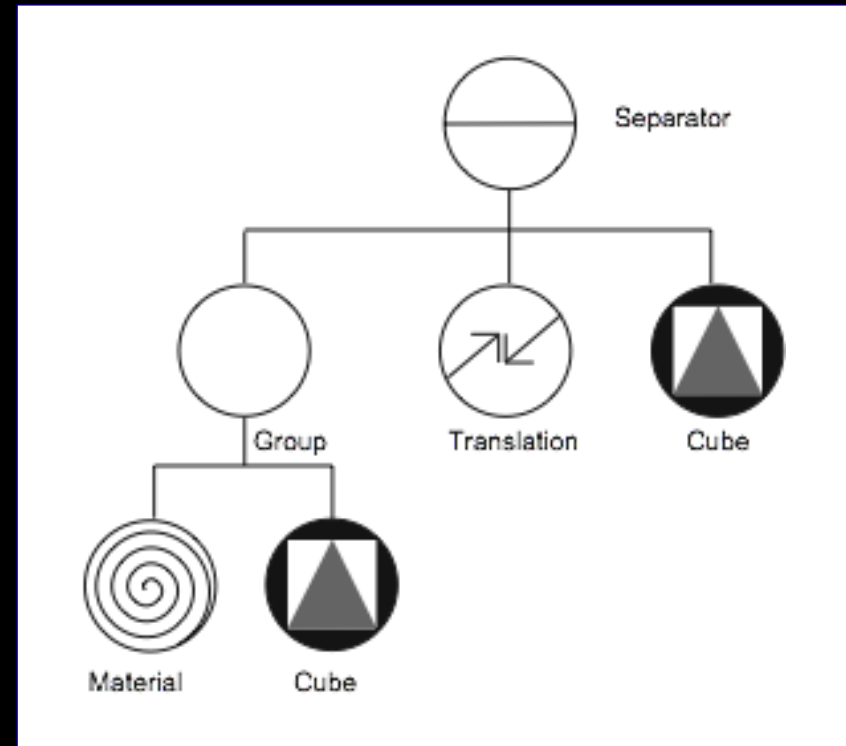
```
Separator {  
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    Material {  
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    }  
    Cube {  
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    translation 3 2 0  
  }  
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}
```



Scenegraph components



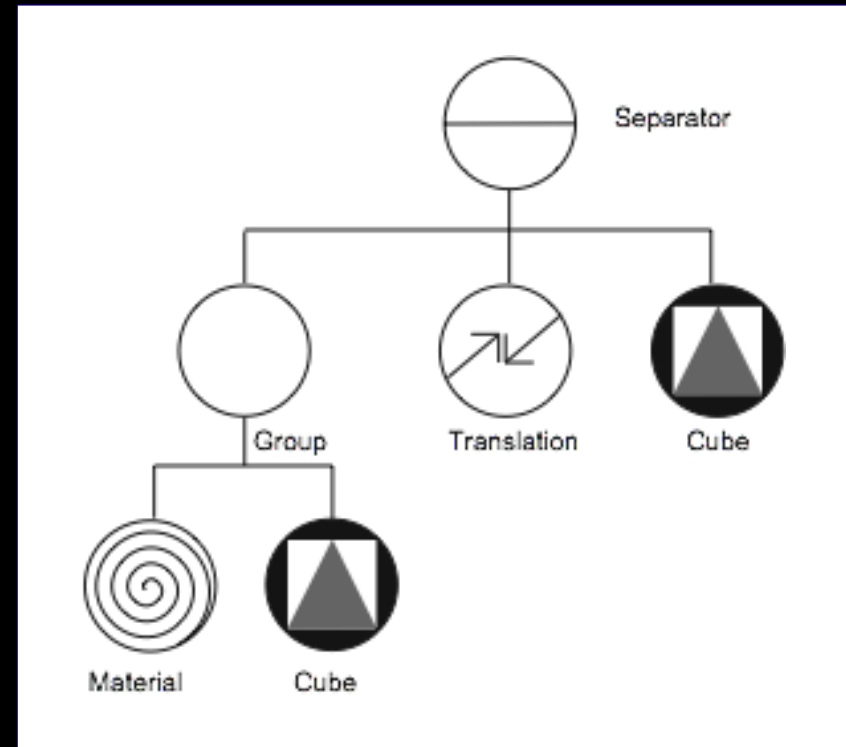
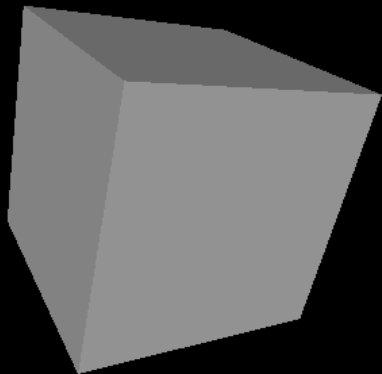
- * Shape nodes
- * Geometry in the scene





Scenegraph components

- * Shape nodes
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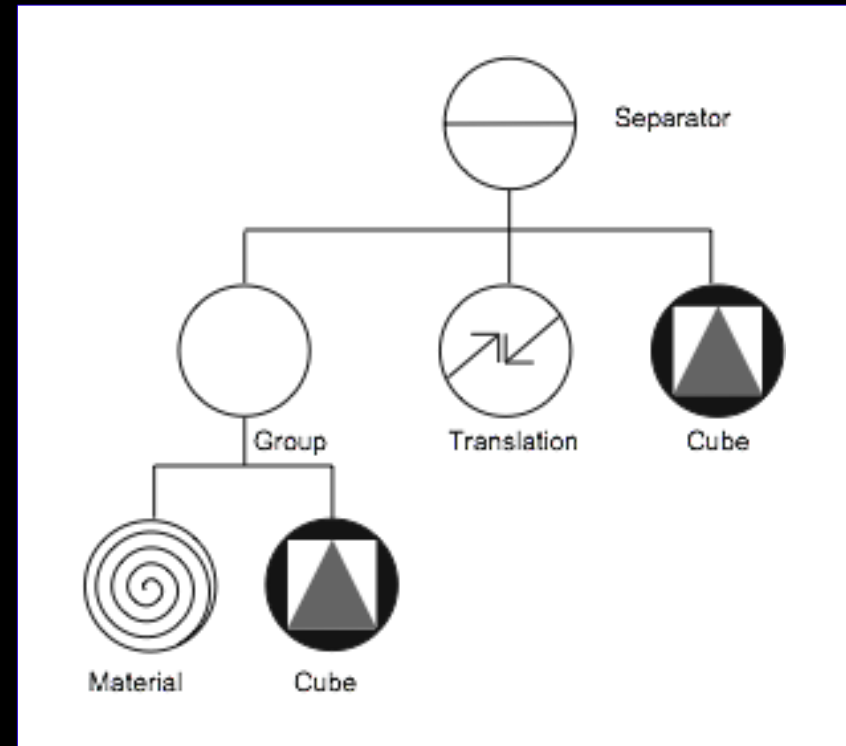




Scenegraph components

- * Shape nodes
- * Geometry in the scene

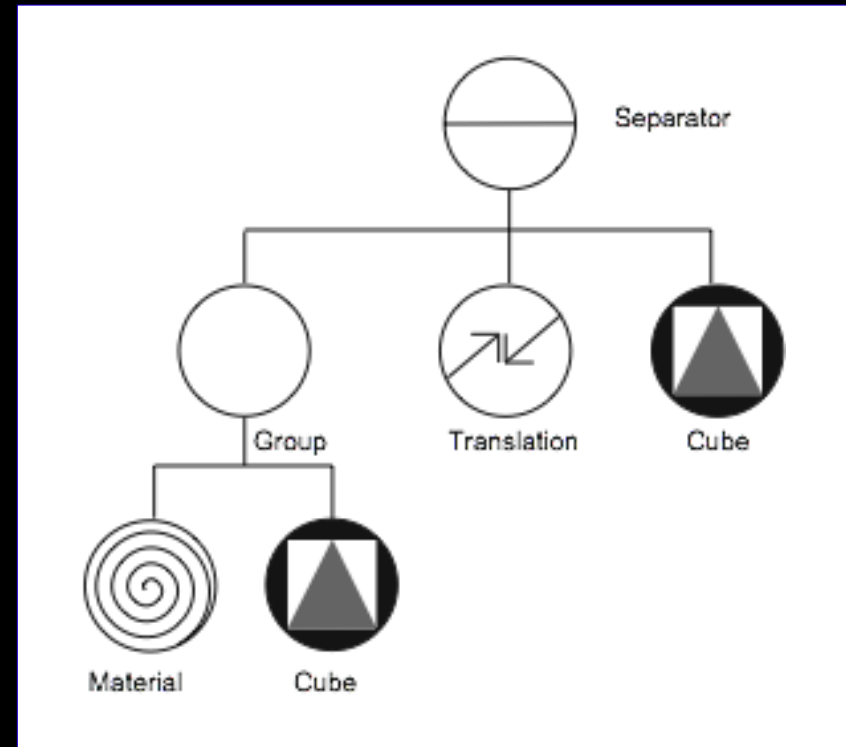
Hello World!





Scenegraph components

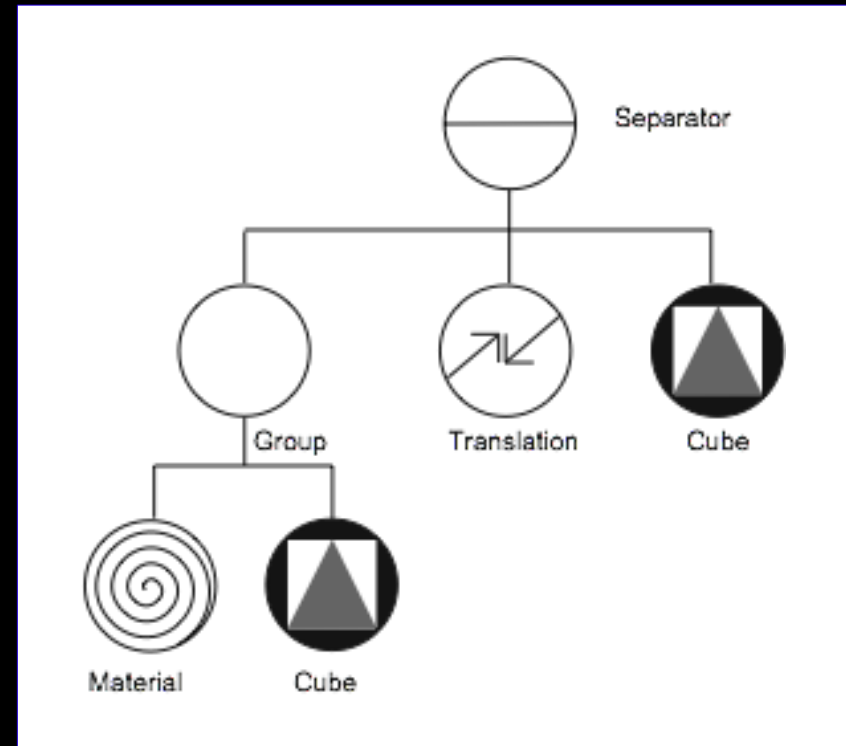
- * Shape nodes
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Scenegraph components

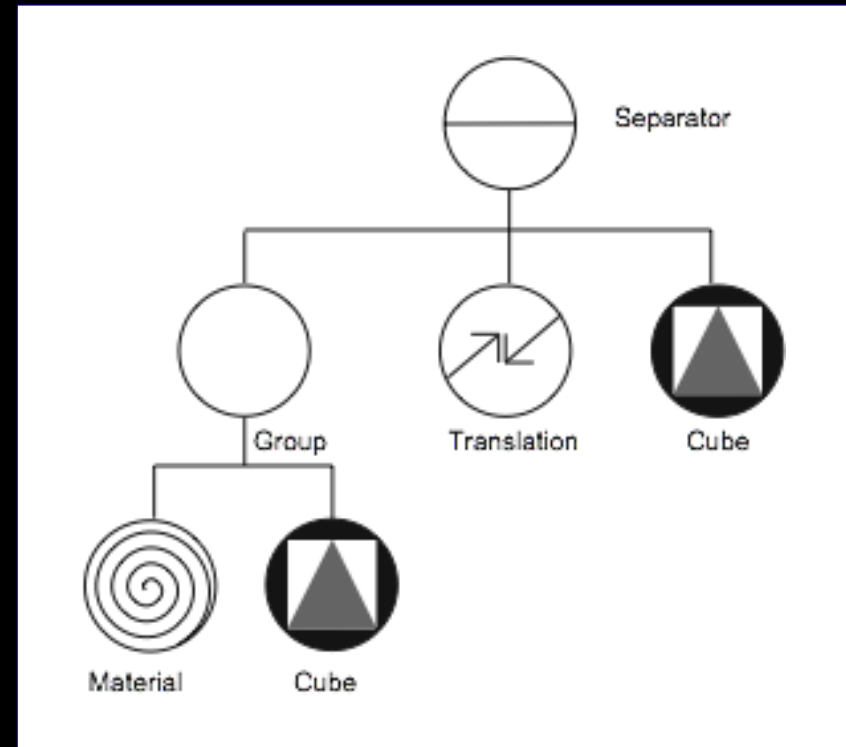
- * Shape nodes
- * Geometry in the scene
- * Property nodes
- * OpenGL state
- * Inventor state





Scenegraph components

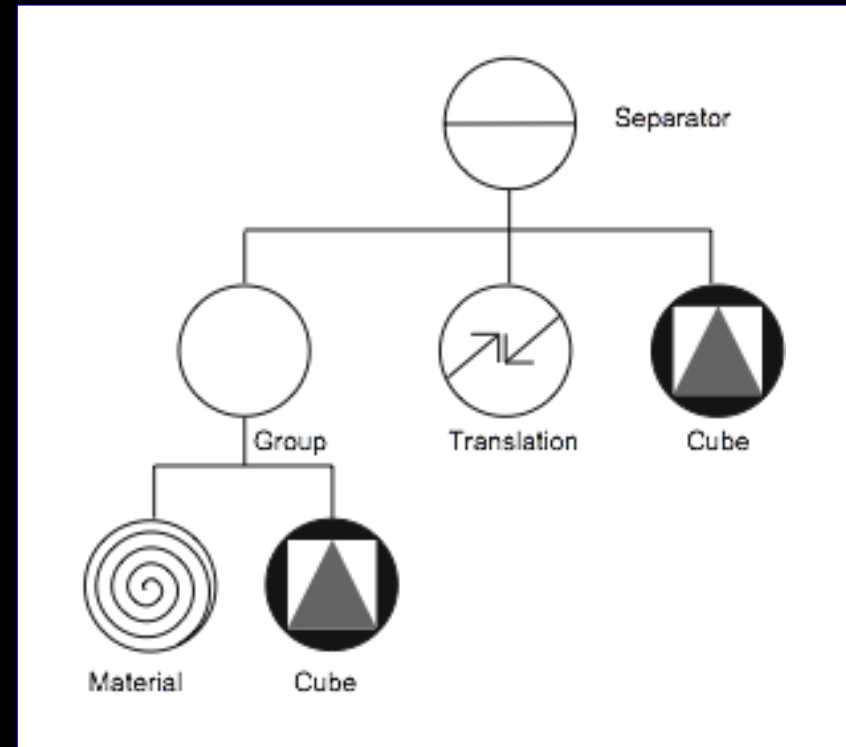
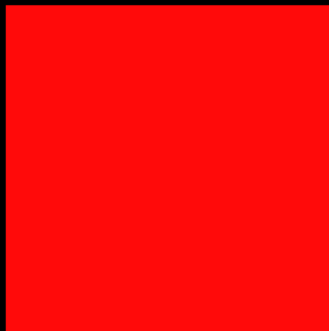
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Scenegraph components

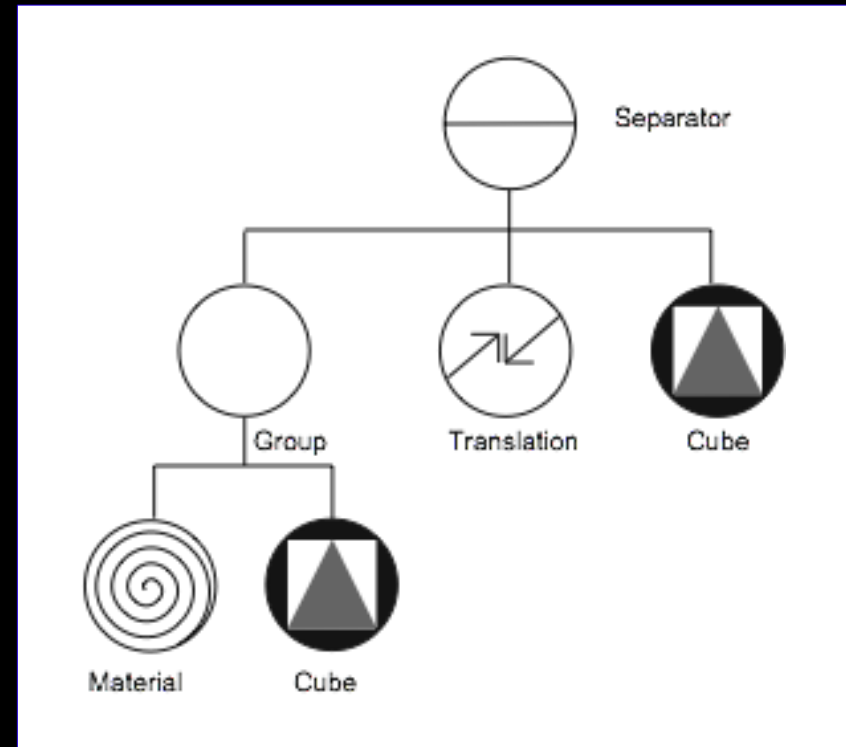
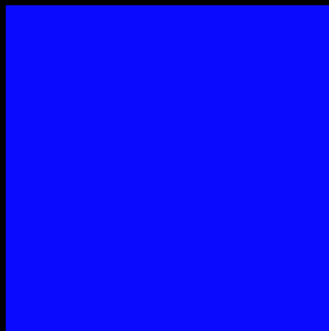
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Scenegraph components

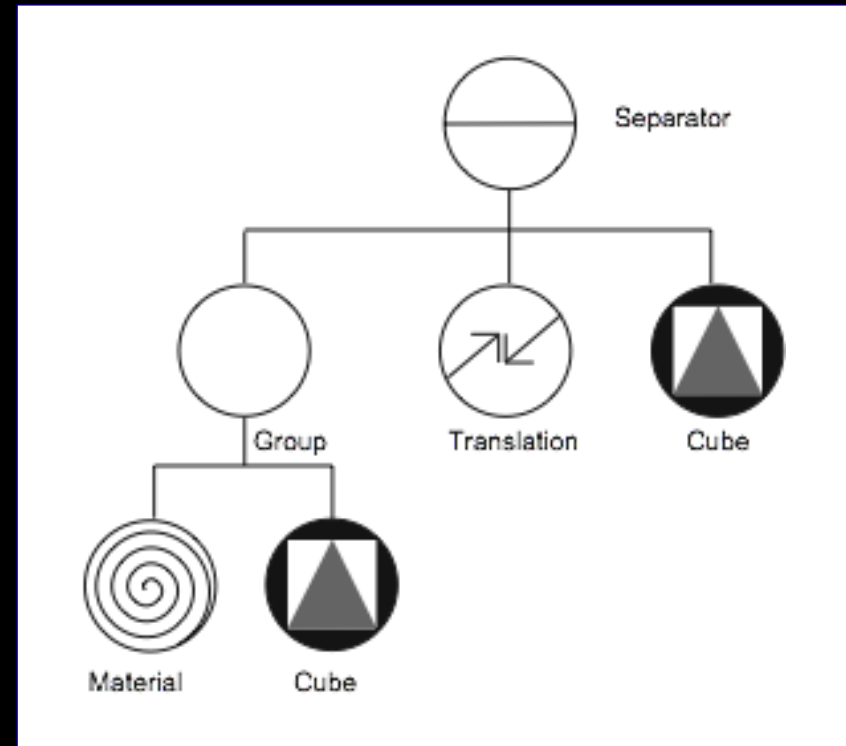
- * Shape nodes
- * Geometry in the scene
- * Property nodes
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- * Inventor state





Scenegraph components

- * Shape nodes
 - * Geometry in the scene
- * Property nodes
 - * OpenGL state
 - * Inventor state
- * Group nodes
 - * Collect groups of nodes into a subtree to build a hierarchy



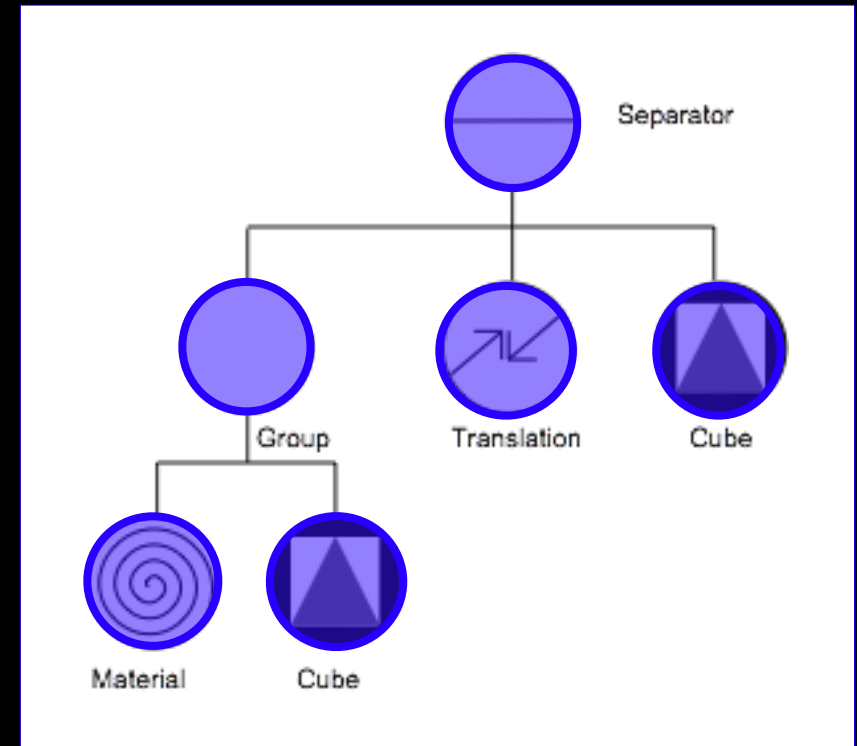


Scenegraph rendering



Actions

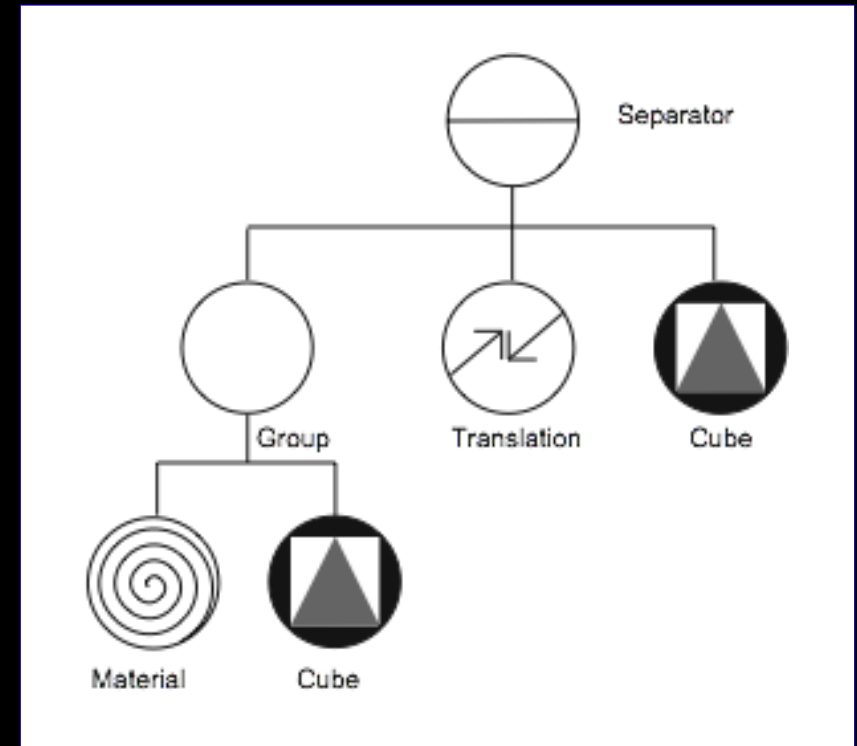
- * Scenegraph is traversed from top to bottom and from left to right
- * Each node can react to the action (behaviour depending on node type)
- * Nodes inherit state from nodes visited earlier
- * Rendering the scene is an action





The SoGLRenderAction - behaviours

- * Group nodes traverse their children
- * Shape nodes draw their geometry
- * Property nodes set the OpenGL state
 - * usually replacing the previous state
 - * except transformation (concatenated) and light sources (added)



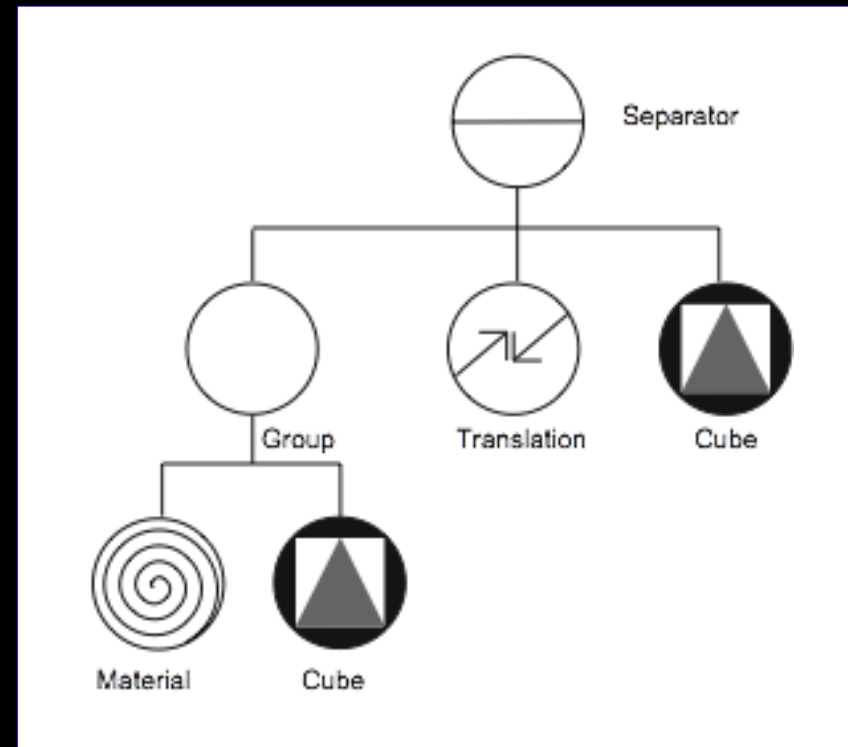


SoGroup vs. SoSeparator



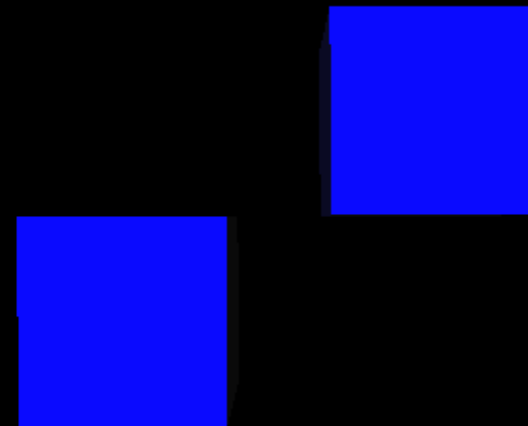
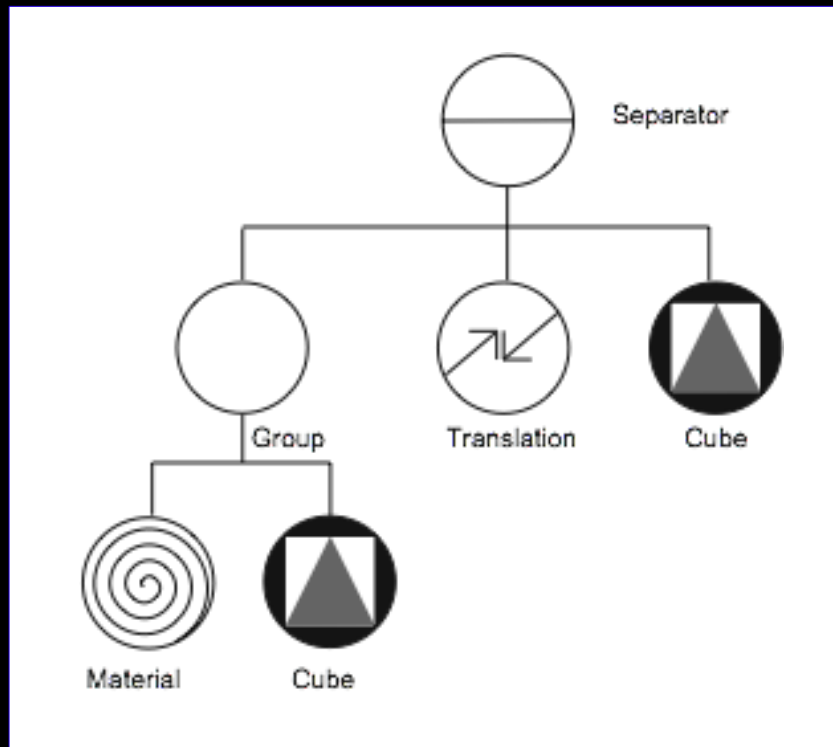
Group Nodes Revisited

- * **SoGroup**: Nodes inherit state from to the left and above
- * **SoSeparator** saves the state before traversing its children, and restores it when done.
- * cf. OpenGL push and pop



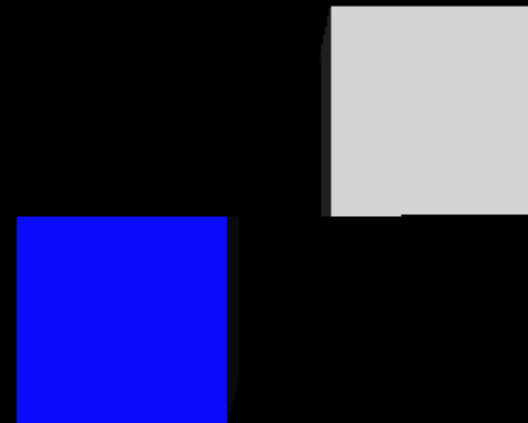
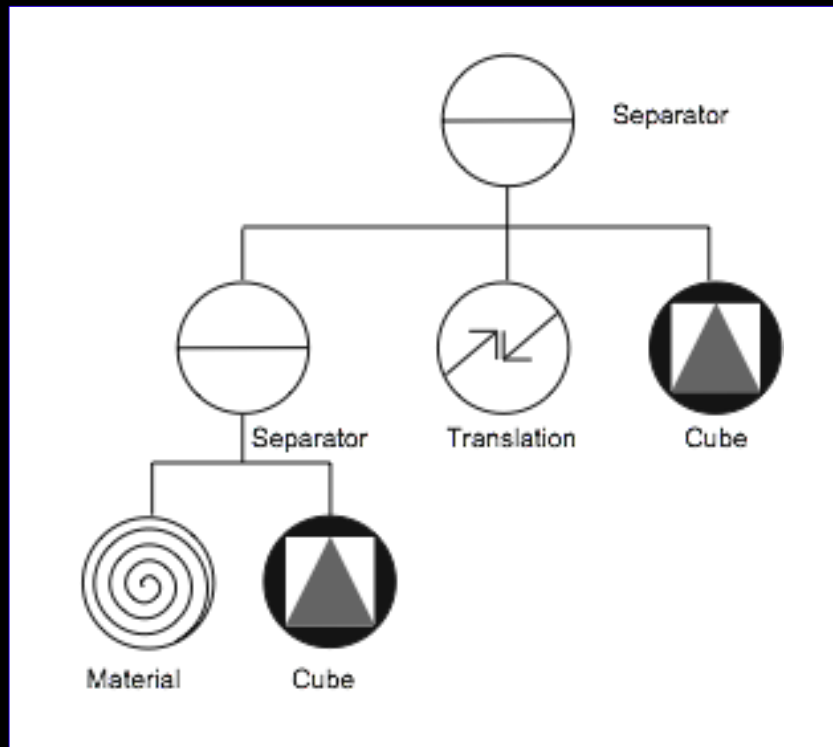


Group nodes revisited





Group nodes revisited





Transformations revisited

- * Transformations are property nodes in the scenegraph
- * Convenience nodes for basic transformations:
 - * SoRotation
 - * SoTranslation
 - * SoScale
- * It is also possible to specify the transformation matrix directly
 - * SoMatrixTransform

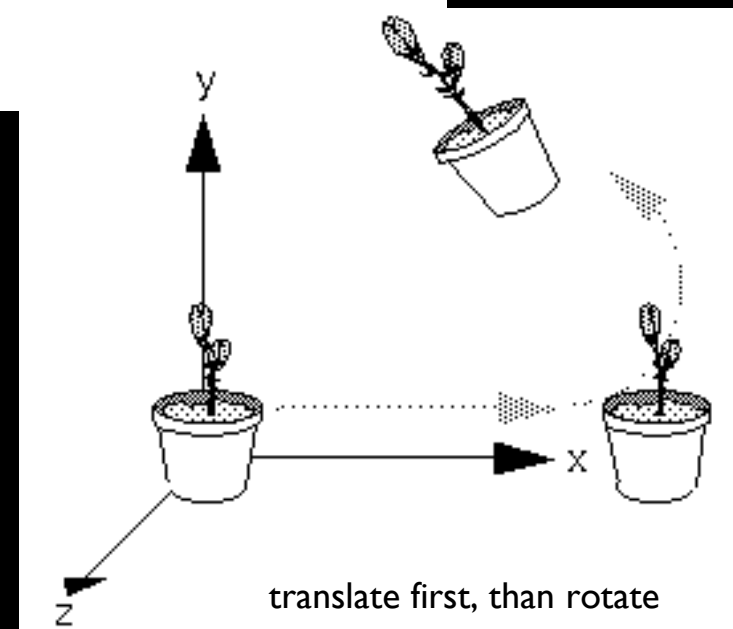
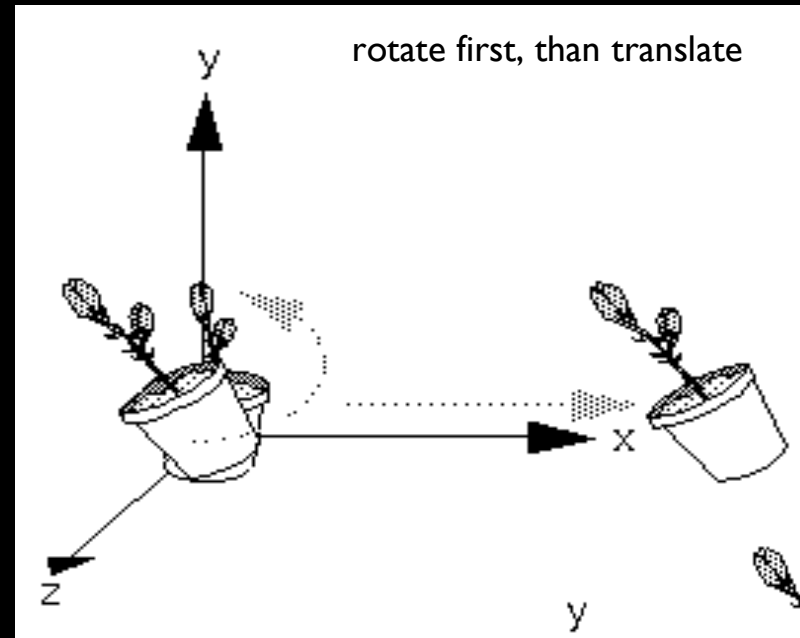


Achtung! Here lies dragons...



Transformations revisited

- * Matrix multiplication is not commutative
- * The order of operations is important
- * Example: combined rotation and translation

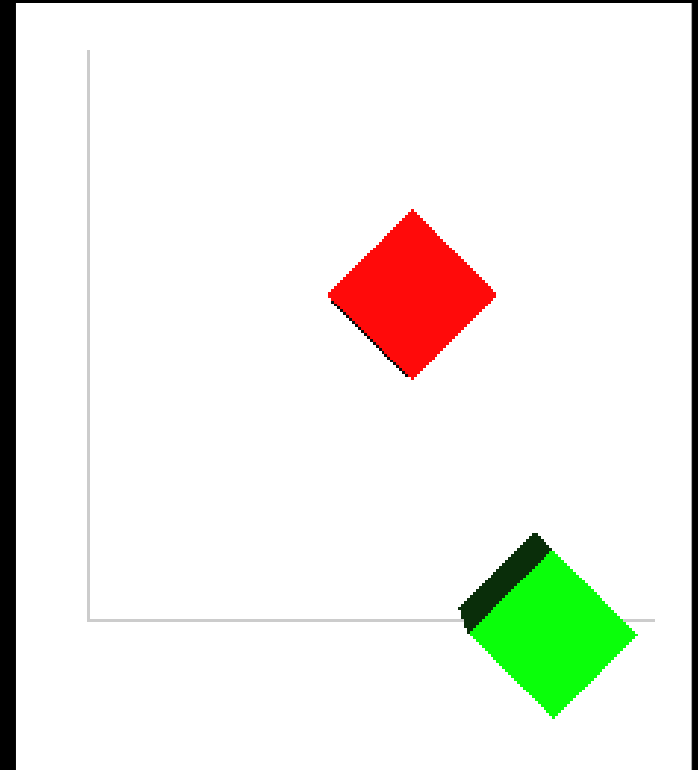




Transformations revisited

```
#Inventor V2.1 ascii
```

```
Separator {  
  Separator {  
    Rotation { rotation 0 0 1 0.785 }  
    Translation { translation 8 0 0 }  
    Material { diffuseColor 1 0 0 }  
    Cube { }  
  }  
  Separator {  
    Translation { translation 8 0 0 }  
    Rotation { rotation 0 0 1 0.785 }  
    Material { diffuseColor 0 1 0 }  
    Cube { }  
  }  
}
```





Summary:

- * Hierarchical scene description in a *scenegraph*.
- * Group nodes, shape nodes, property nodes.
- * Created programmatically or via Inventor files.
- * To render the scene, the scenegraph is traversed top-down and left-right by the *render action*.
- * State is inherited from nodes visited earlier.
- * The order of operations is important.



Qt integration

- * Qt is a cross-platform GUI toolkit developed by Trolltech
 - * Free Software edition available under the GPL
 - * excellent solution for cross-platform development
- * The SoQt library provides integration with the Qt toolkit
 - * OpenGL setup
 - * Event translation
- * SoQt also provides a set of convenient viewer components
 - * e.g. the SoQtExaminerViewer



Getting started



First steps

- * Download Coin3D from <http://www.coin3d.org>.
- * Build and install the Coin, SoQt, and simage libraries.
- * Play around with the sample code.
- * Documentation:
 - * API documentation: <http://doc.coin3d.org>
 - * The "Inventor Mentor" and "Inventor Toolmaker" books
 - * coin-discuss open mailing list hosted by SIM
<https://www.coin3d.org/mailman/listinfo/coin-discuss/>



Other Coin3D features...

- * Easy way to read and write files
- * Including animations
- * Field connections, notification mechanism
 - * Automatic update based on scenegraph changes
- * Interactive components
 - * Draggers and manipulators
- * Picking
 - * Select and identify objects in the scene
- * Event handling
- * Sensors

io/readfile.cpp
io/writefile.cpp

drama/dragger.cpp



Questions?

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