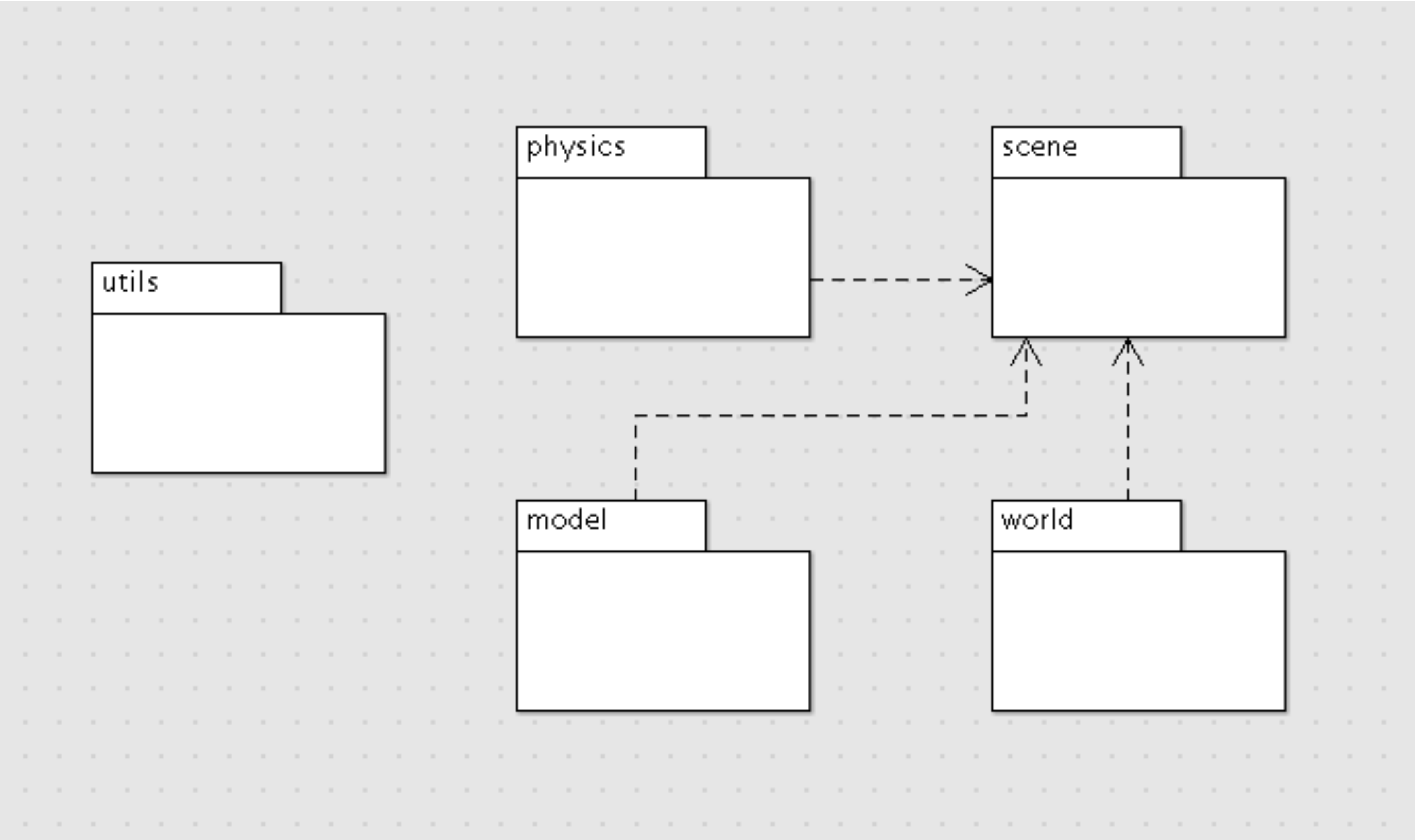
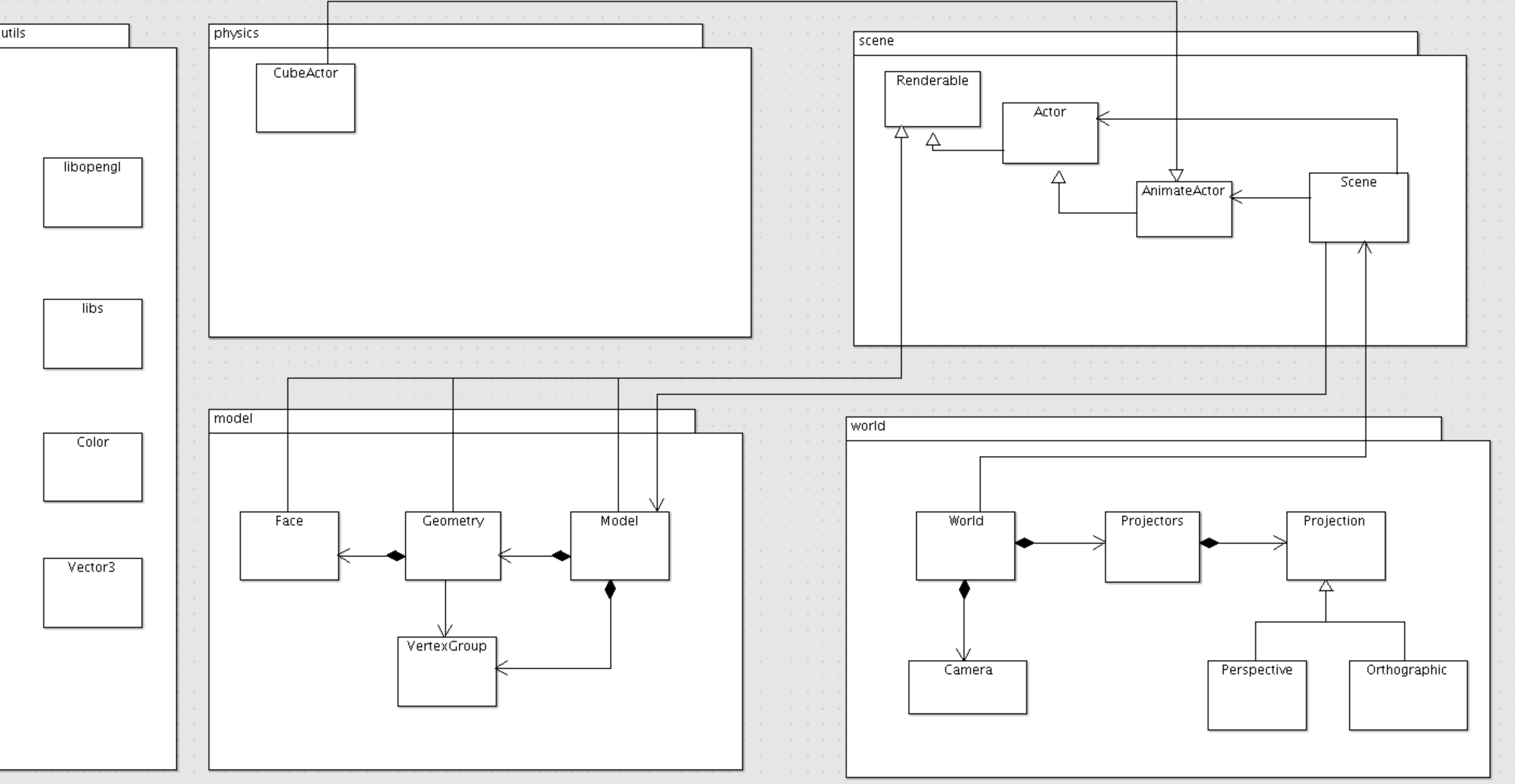
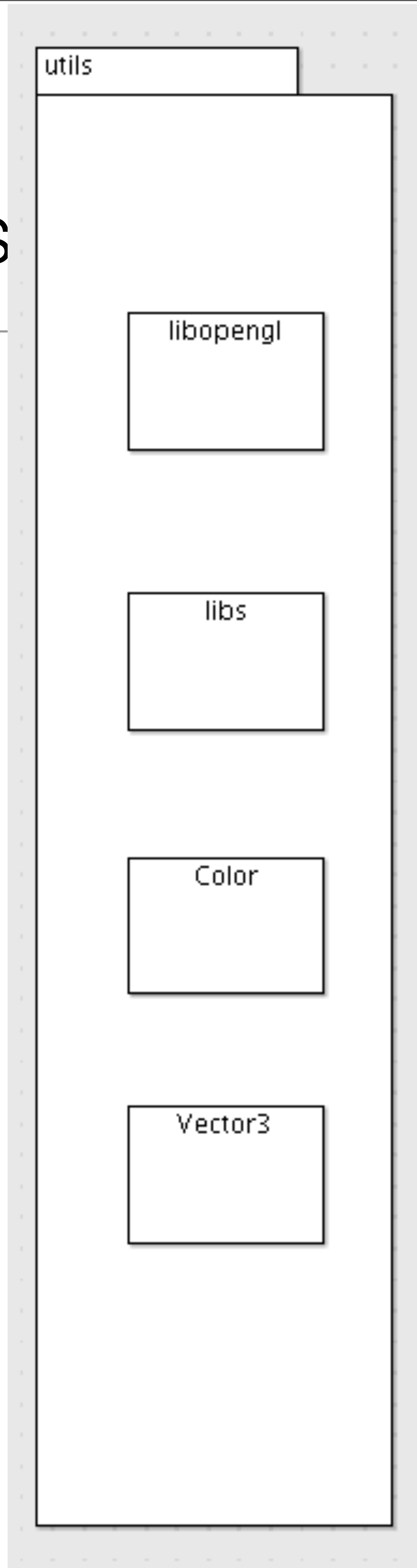
World Model

Architecture




utils
libopengl
libs
Color
Vector3
physics
CubeActor
scene
Renderable
Actor
AnimateActor
Scene
model
Face
Geometry
Model
VertexGroup
world
World
Projectors
Projection
Camera
Perspective
Orthographic

Utils



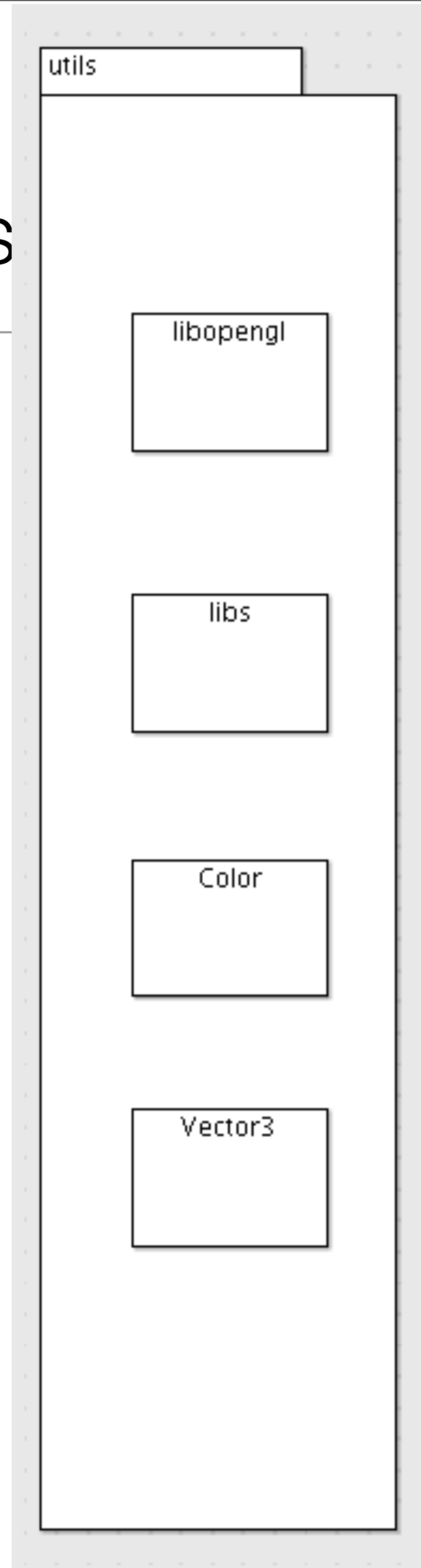
libopengl.h

```
#ifdef WIN32
#include <windows.h>
#include <gl\glu.h>
#include "freeglut.h"
#endif

#ifdef __APPLE__
#include "gl.h"
#include "glu.h"
#include "glut.h"
#endif
```

libs.h

```
#pragma once

#include "libopengl.h"

#include <boost/foreach.hpp>
#define foreach BOOST_FOREACH

#include <iostream>
#include <fstream>
#include <sstream>
#include <string>

#include <vector>
#include <map>

#include <boost/ptr_container/ptr_map.hpp>
```

Utils




```
struct Vector3
{
  float X;
  float Y;
  float Z;

  static Vector3 UnitX;
  static Vector3 UnitY;
  static Vector3 UnitZ;

  Vector3(float x, float y, float z);
  Vector3(float value);
  Vector3();
  Vector3(std::istream& is);

  void translate();
  void rotate (float angle);

  void render();

  static const Vector3 & zero();

  inline Vector3& operator= (const Vector3& rhs)
   ...
  inline Vector3& operator+= (const Vector3& rhs)
   ...
  inline Vector3& operator-= (const Vector3& rhs)
   ...
  inline Vector3& operator*= (float rhs)
   ...
  inline Vector3 operator+ (const Vector3 rhs) const
   ...
  inline Vector3 operator* (float rhs) const
   ...
  friend std::ostream& operator <<(std::ostream& outputStream, const Vector3& v);
};

inline Vector3 operator* (float lhs, const Vector3& rhs)
...
```

Utils

utils

libopengl

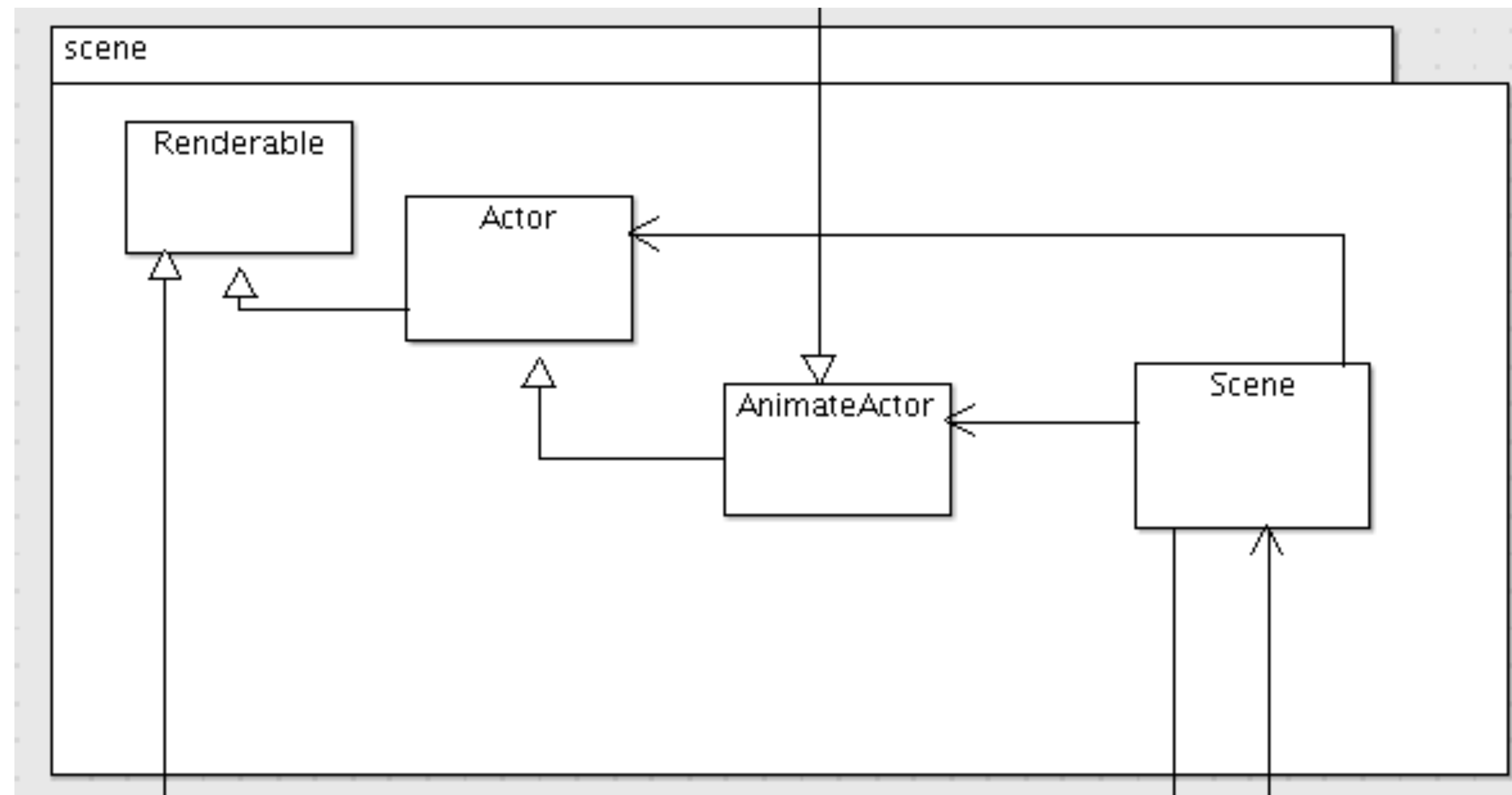
libs

Color

Vector3

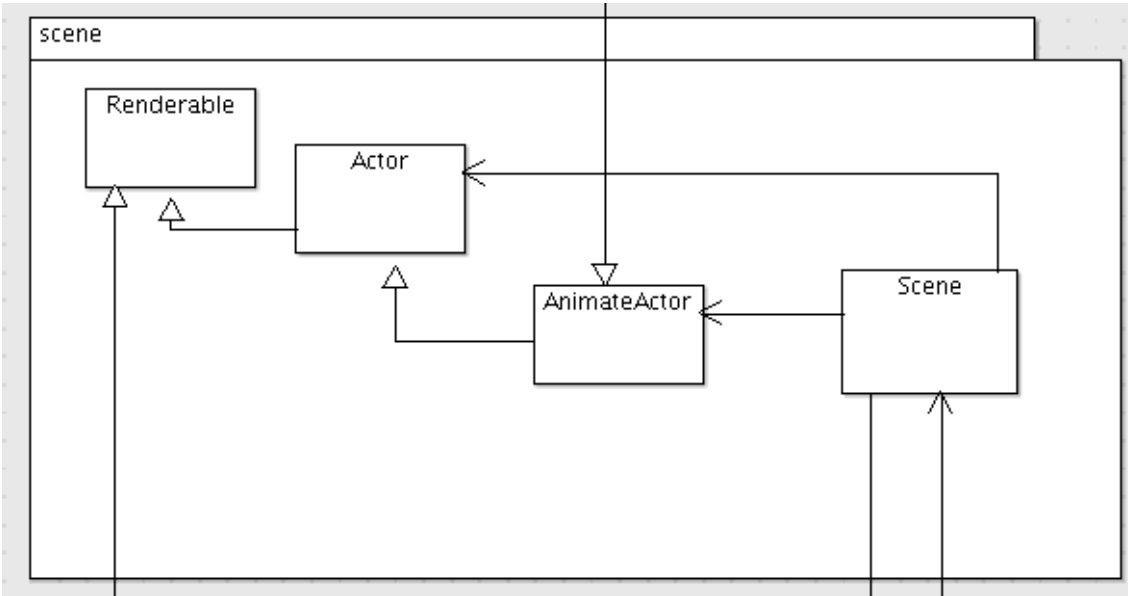
```
struct Color
{
  float R;
  float G;
  float B;
  float A;

  static Color White;
  static Color Yellow;
  static Color Red;
  static Color Magenta;
  static Color Cyan;
  static Color Green;
  static Color Black;
  static Color Blue;


  Color();
  Color(float r, float g, float b, float a=1.0f);
  Color(int r, int g, int b, int a=255);

  void render();
  void renderClear();
};
```

Scene



Actors

```
struct Renderable
{
  virtual void render()=0;
};

typedef boost::ptr_map<std::string, Renderable> RenderableMap;
```

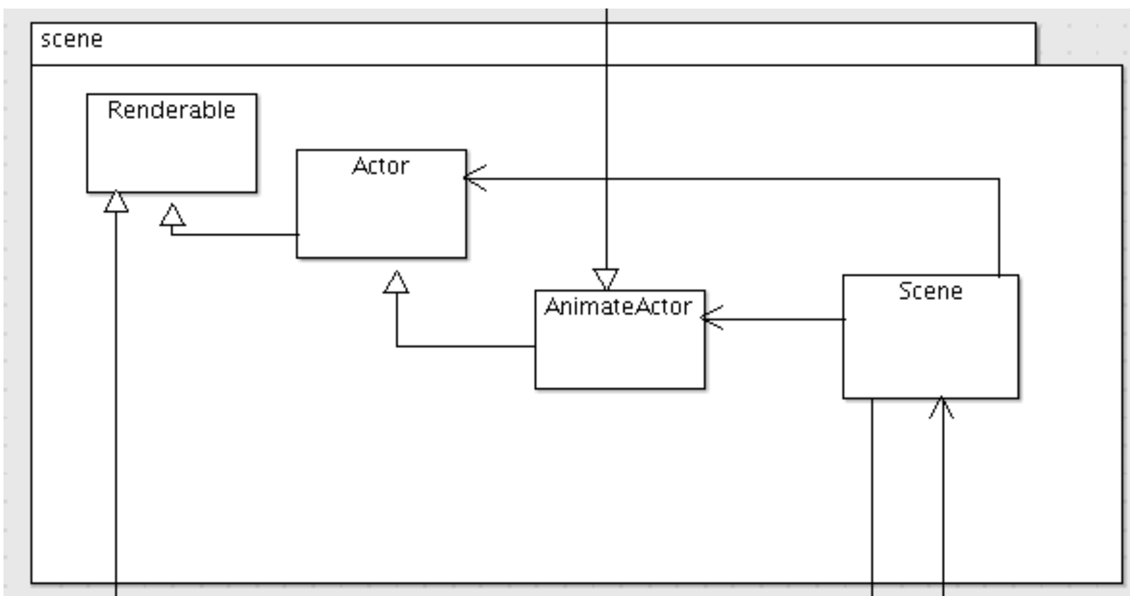



```
struct Actor : public Renderable
{
  Geometry *geometry;

  Actor(Geometry* g) : geometry(g)
  {}

  void render()
  { geometry->render(); }
};

typedef boost::ptr_map<std::string, Actor> ActorMap;
```

```
struct AnimateActor : public Actor
{
  AnimateActor(Geometry* geometry) : Actor (geometry)
  {}

  virtual void integrate(float dt)=0;
};

typedef std::map<std::string, AnimateActor*> AnimateActorMap;
```

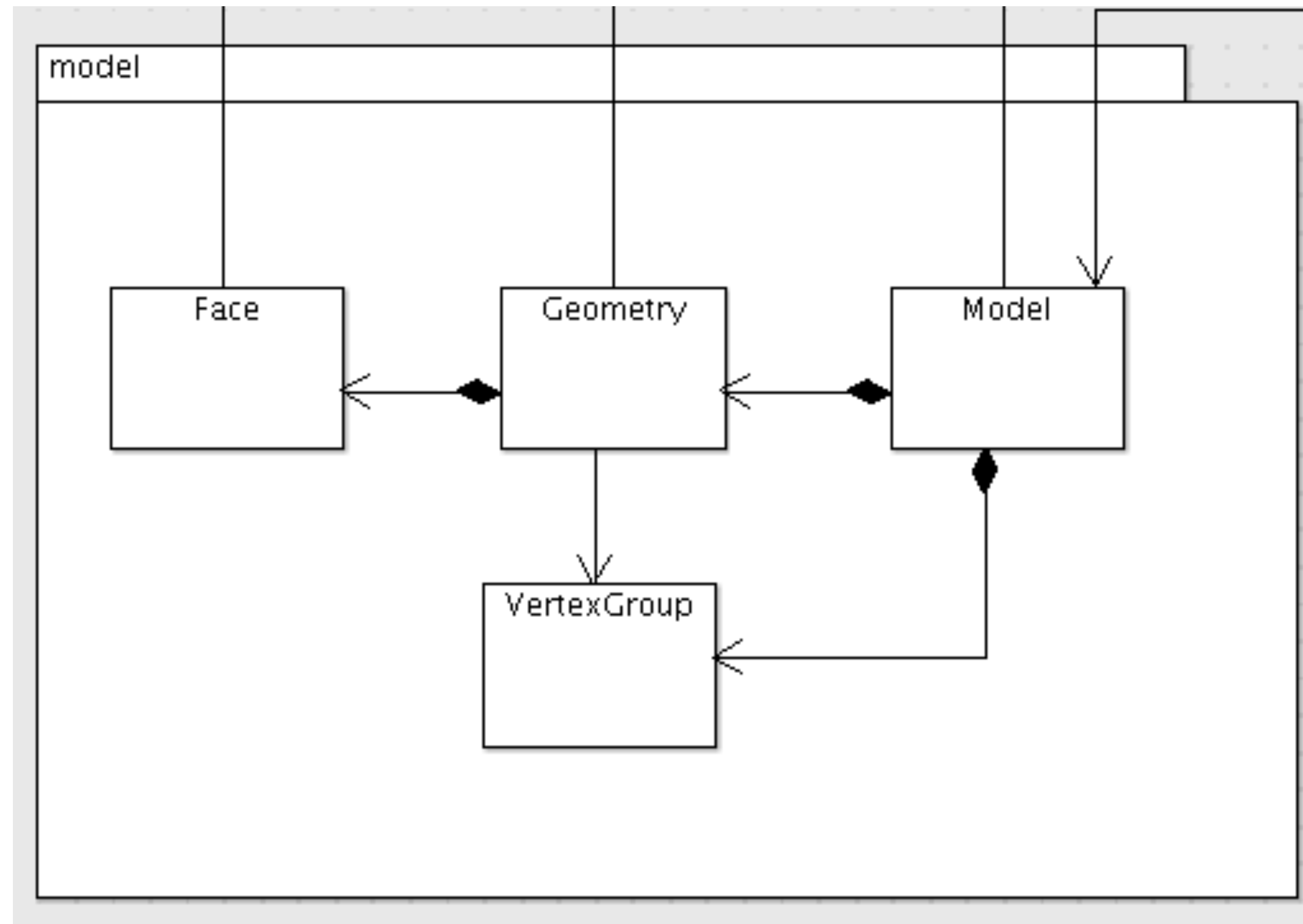
Scene

```
struct Scene
{
  Scene(Model*);

  void render();
  void tick(float secondsDelta);

  ActorMap          actors;
  AnimateActorMap   animateActors;
};
```



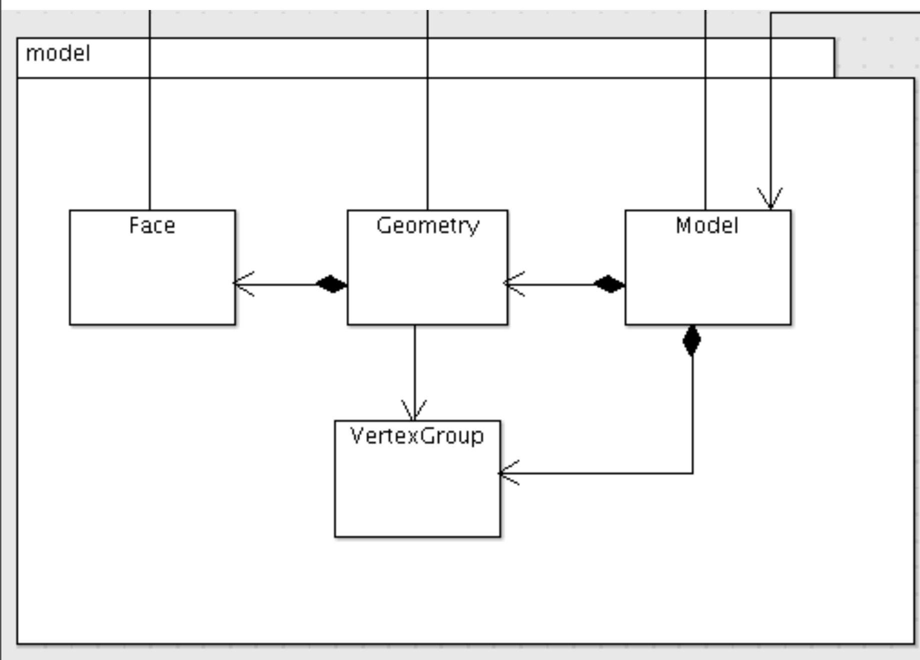

```
Scene:: Scene(Model *model)
{
  foreach (GeometryMap::value_type &value, model->entities)
  {
    string name = value.first;
    Actor *actor;
    if (name == "cube")
    {
      actor = new CubeActor(&value.second);
      animateActors[name] = (AnimateActor*) actor;
    }
    else
    {
      actor = new Actor(&value.second);
    }
    actors.insert(name, actor);
  }
}

void Scene::render()
{
  foreach (ActorMap::value_type value, actors)
  {
    value->second->render();
  }
}

void Scene::tick(float secondsDelta)
{
  foreach (AnimateActorMap::value_type value, animateActors)
  {
    value.second->integrate(secondsDelta);
  }
}
```

Model



Face

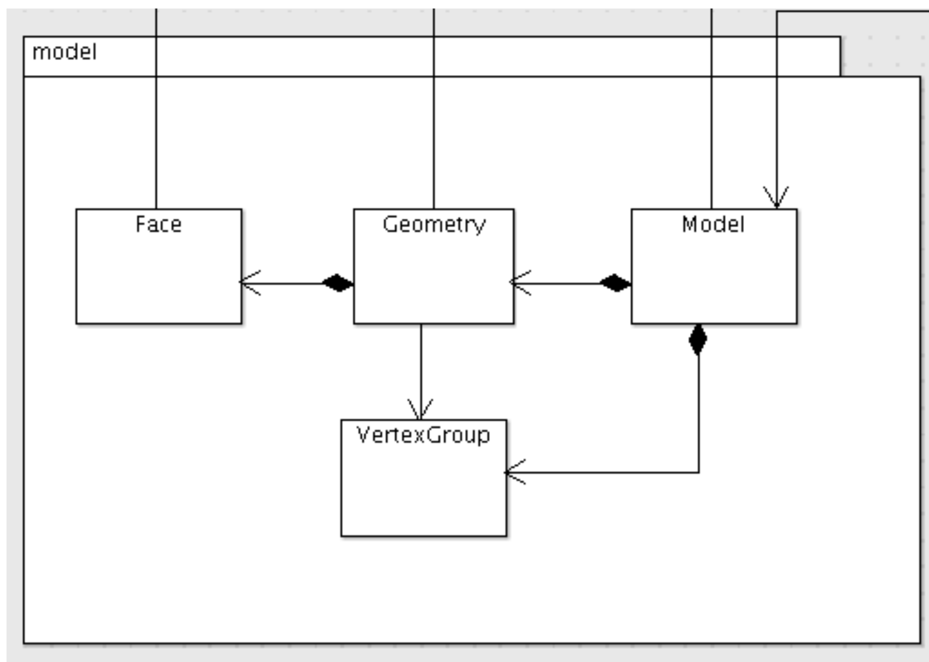
```
struct Face
{
  std::vector<int> vertexIndices;
  std::vector<int> textureIndices;

  Face(std::istream& is);
  void render(std::vector <Vector3>&);
};
```




```
Face::Face(istream& is)
{
  string line;
  getline (is, line);

  stringstream allIndexSets (line);
  string singleIndexSet;

  while( getline(allIndexSets, singleIndexSet, ' ') )
  {
   if (singleIndexSet.size() > 0)
   {
     string vertexIndex = singleIndexSet.substr(0, singleIndexSet.find('/'));
     int index = atoi(vertexIndex.c_str());
     vertexIndices.push_back(index);
   }
  }
}

void Face::render(std::vector <Vector3>&vertexTable)
{
  vertexIndices.size() == 3?
     glBegin(GL_TRIANGLES)
    :glBegin(GL_QUADS);

  foreach (int index, vertexIndices)
  {
    glVertex3f( vertexTable[index-1].X,
                vertexTable[index-1].Y,
                vertexTable[index-1].Z );
  }
  glEnd();
}
```

VertexGroup

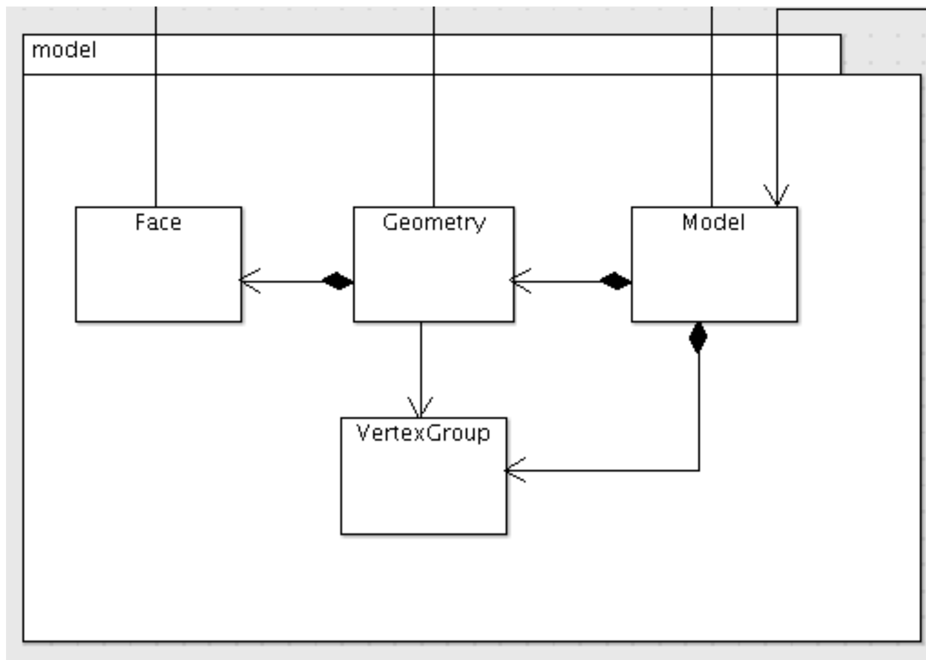
```
struct VertexGroup
{
  std::vector <Vector3> vertices;

  VertexGroup();
  void load(std::istream&);
};
```




```
VertexGroup::VertexGroup()
{}

void VertexGroup::load(istream& is)
{
  string indicator;
  bool stillGroup=true;
  do
  {
    is >> indicator;
    if (indicator == "v")
    {
      vertices.push_back(Vector3(is));
    }
    else if (indicator == "g")
    {
      stillGroup = false;
    }
    else
    {
      string buf;
      getline(is, buf);
    }
  } while (stillGroup && !is.eof());
  is.putback(indicator[0]);
}
```

Geometry

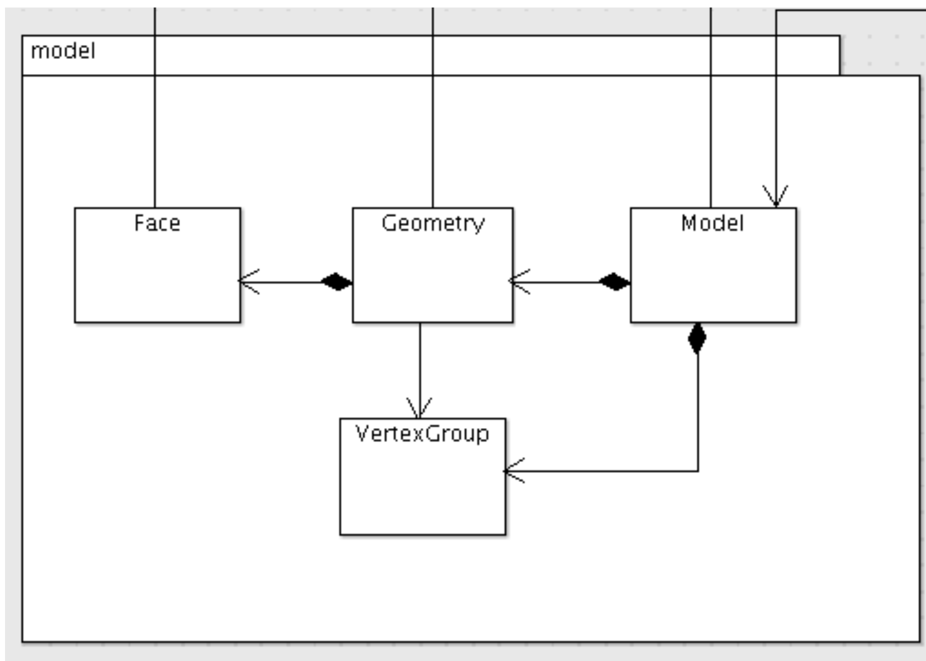
```
struct Geometry : public Renderable
{
  std::string name;
  std::vector<Face> faces;
  VertexGroup *vertexGroup;

  Geometry();
  Geometry(std::string name, std::istream&, VertexGroup*);
  void render();
};

typedef std::map <std::string, Geometry>  GeometryMap;
```




```
Geometry::Geometry()
{}

Geometry::Geometry(string groupName, istream& is,
VertexGroup*group)
: name(groupName), vertexGroup(group)
{
  string indicator;
  bool stillGroup=true;
  do
  {
    is >> indicator;
    if (indicator == "f")
    {
      faces.push_back(Face(is));
    }
    else if (indicator == "g")
    {
      stillGroup = false;
    }
    else
    {
      string buf;
      getline(is, buf);
    }
  } while (stillGroup && !is.eof());
  is.putback(indicator[0]);
}

void Geometry::render()
{
  foreach (Face &face, faces)
  {
    face.render(vertexGroup->vertices);
  }
}
```

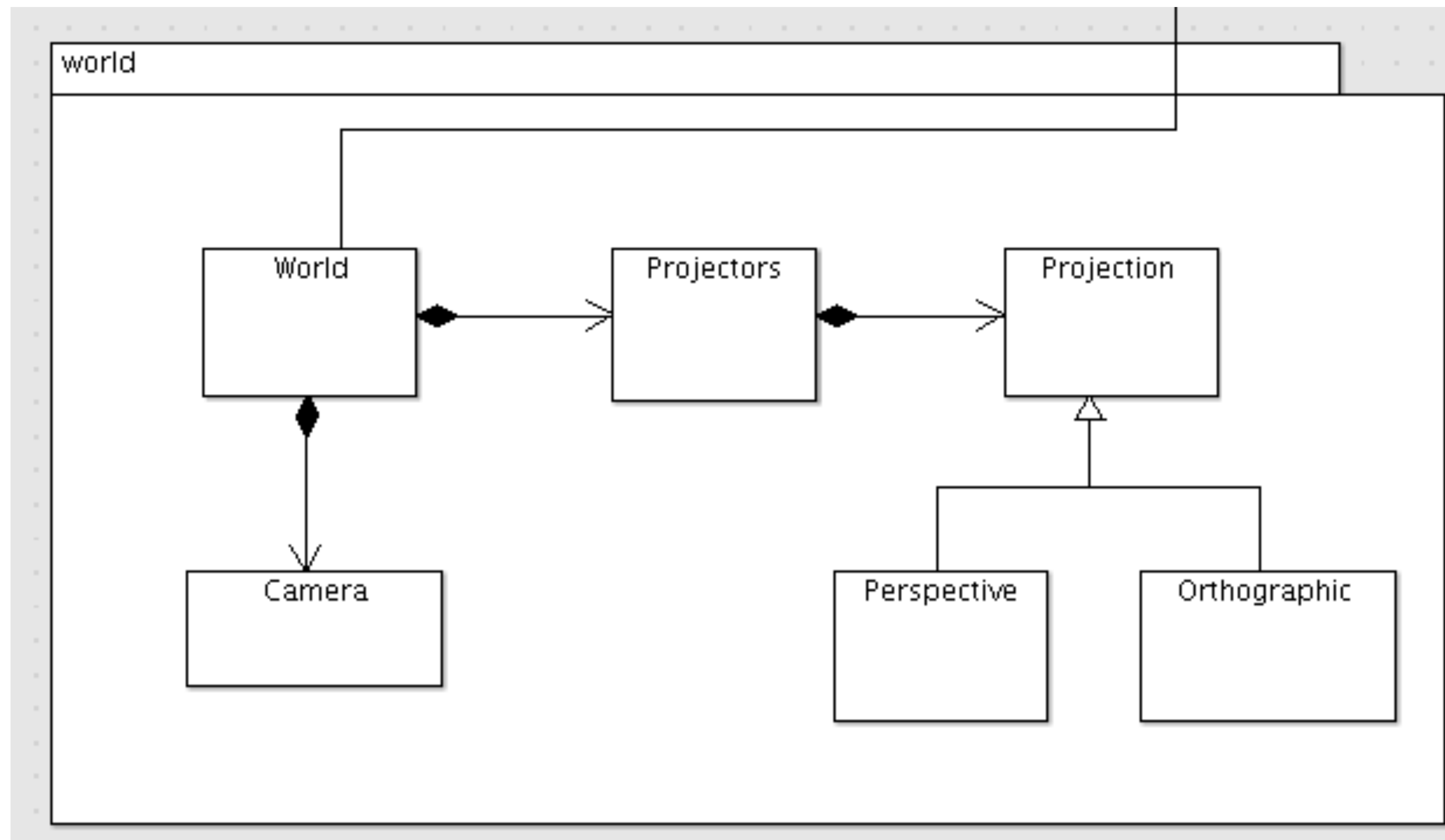
Model

```
struct Model : public Renderable
{
  GeometryMap entities;
  VertexGroup defaultGroup;

  Model();
  bool load(std::istream &is);
  void render();
};
```

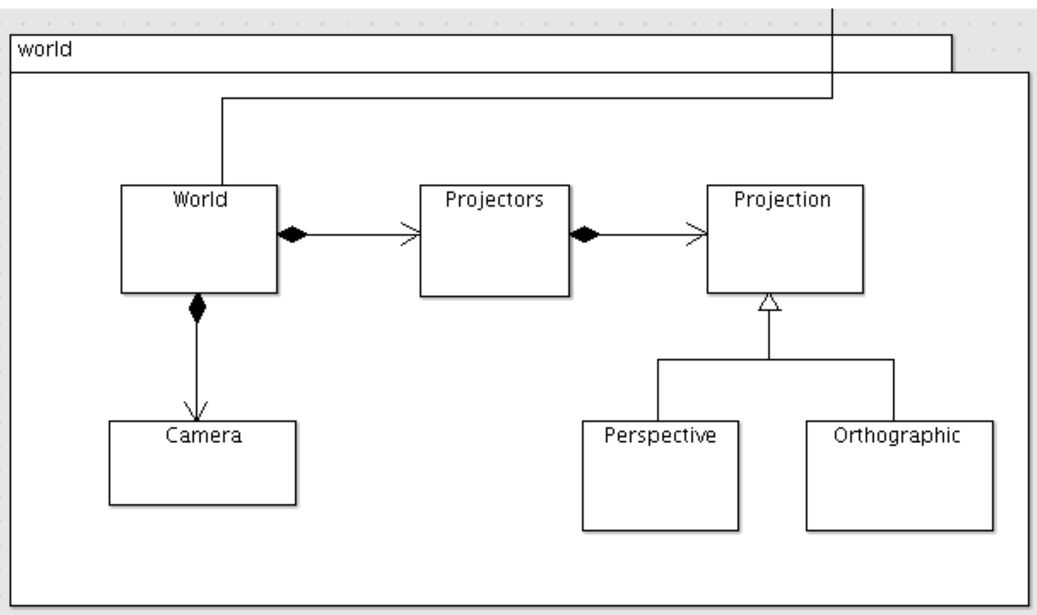



```
Model::Model()
{
}

bool Model::load(istream& is)
{
  string indicator;
  is >> indicator;
  while (!is.eof())
  {
    if (indicator == "#")
    {
      string buf;
      getline(is, buf);
    }
    else if (indicator == "g")
    {
      string name;
      is >> name;
      if (name == "default")
      {
        defaultGroup.load(is);
      }
      else
      {
        Geometry a(name, is, &defaultGroup);
        if (entities.find(a.name) == entities.end())
        {
          entities[a.name] = a;
        }
      }
    }
    is >> indicator;
  }
  return true;
}

void Model::render()
{
  foreach (GeometryMap::value_type &value, entities)
  {
    value.second.render();
  }
}
```

World



Projection

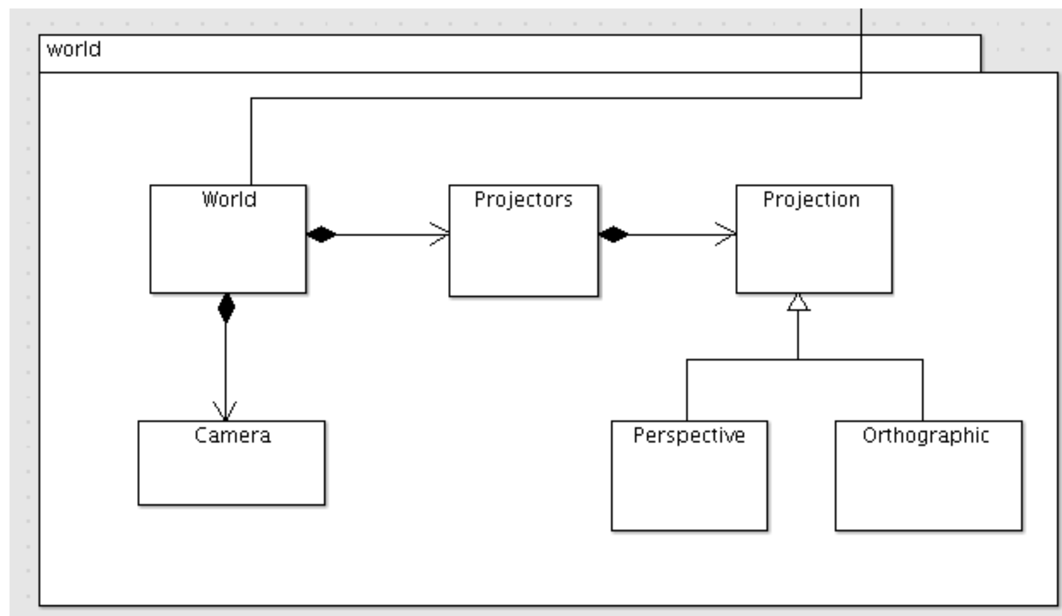



```
typedef std::pair<float, float> Range;

struct Projection
{
  Range windowSize;

  void resize(Range size);
  virtual void render()=0;
};

struct Orthographic: public Projection
{
  Range xRange;
  Range yRange;
  Range zRange;
  Vector3 axis;
  int angle;

  Orthographic(Range x, Range y, Range z, int angle, Vector3 axis);
  void render();
};

struct Perspective : public Projection
{
  float fovy;
  Range zRange;
  float zDistance;

  Perspective (float fovy, Range zRange, float zDistance);
  void render();
};

typedef boost::ptr_map <std::string, Projection>  ProjectionMap;
```

Projection Implementation

```
void Projection::resize(Range size)
{
  windowSize = size;
}

Orthographic::Orthographic(Range x, Range y, Range z, int theAngle, Vector3 theAxis)
: xRange(x), yRange(y), zRange(z), angle(theAngle), axis(theAxis)
{
}

void Orthographic::render()
{
  glLoadIdentity();
  glViewport(0, 0, windowSize.first, windowSize.second);
  glMatrixMode ( GL_PROJECTION);
  glLoadIdentity();
  glOrtho(xRange.first, xRange.second, yRange.first, yRange.second, zRange.first,
zRange.second);
  glMatrixMode ( GL_MODELVIEW);

  axis.rotate(angle);
}

Perspective::Perspective (float fovy, Range zRange, float zDistance)
: fovy(fovy), zRange(zRange), zDistance(zDistance)
{
}

void Perspective::render()
{
  glLoadIdentity();
  glViewport(0, 0, windowSize.first, windowSize.second);
  glMatrixMode (GL_PROJECTION);
  glLoadIdentity();
  gluPerspective(fovy, windowSize.first/windowSize.second, zRange.first, zRange.second);
  glMatrixMode (GL_MODELVIEW);
  Vector3(0,0,zDistance).translate();
}
```

Projectors

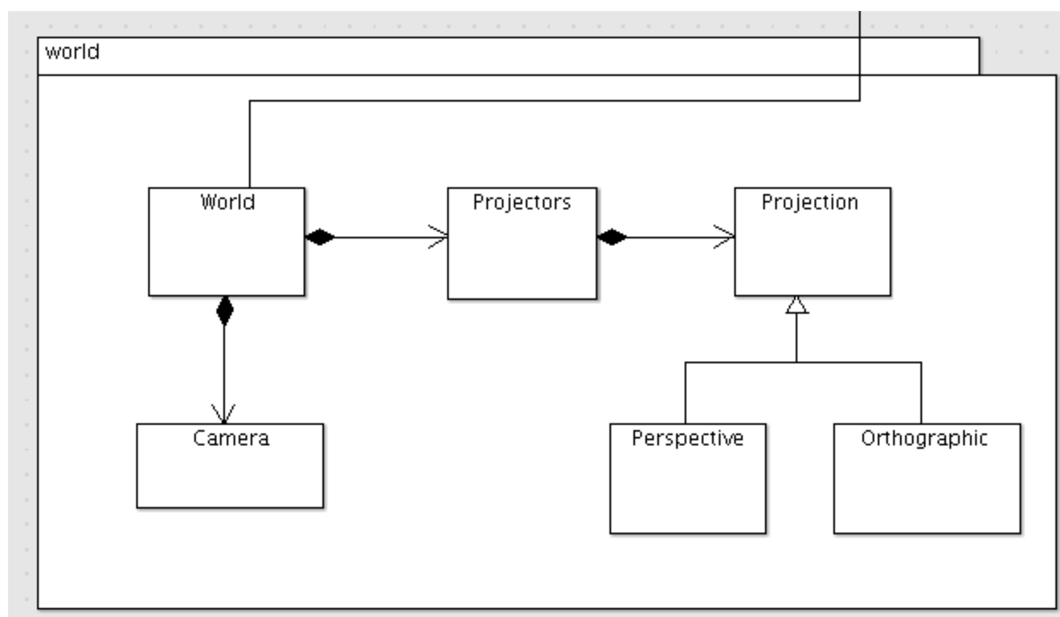



```
struct Projectors
{
  Projectors();

  bool isPerspective();
  void keyPress(unsigned char key);
  void windowReshape(int w, int h);

  void addProjection(std::string, Projection *projection);

  ProjectionMap projections;
  Projection   *currentProjection;
};
```

Projectors

```
Projectors::Projectors()
{
  currentProjection = new Perspective(60, Range(1,1000), -5);

  addProjection("1", currentProjection);
  addProjection("2", new Orthographic (Range(-10,10), Range(-10,10), Range(-10,10), 90, Vector3::UnitX));
  addProjection("3", new Orthographic (Range(-10,10), Range(-10,10), Range(-10,10), 90, Vector3::UnitY));
  addProjection("4", new Orthographic (Range(-10,10), Range(-10,10), Range(-10,10), 90, Vector3::UnitZ));
}

bool Projectors::isPerspective()
{
  Perspective *p = dynamic_cast<Perspective*> (currentProjection);
  if (p)
  {
    return true;
  }
  else
  {
    return false;
  }
}

void Projectors::keyPress(unsigned char ch)
{
  Range windowSize = currentProjection->windowSize;
  string projection;
  projection+=ch;
  ProjectionMap::iterator iter = projections.find(projection);
  if (iter != projections.end())
  {
    currentProjection = iter->second;
    currentProjection->resize(windowSize);
    currentProjection->render();
  }
}

void Projectors::addProjection(std::string str, Projection *projection)
{
  projections.insert(str, projection);
}

void Projectors::windowReshape(int w, int h)
{
  currentProjection->resize(Range(w,h));
  currentProjection->render();
}
```

Camera



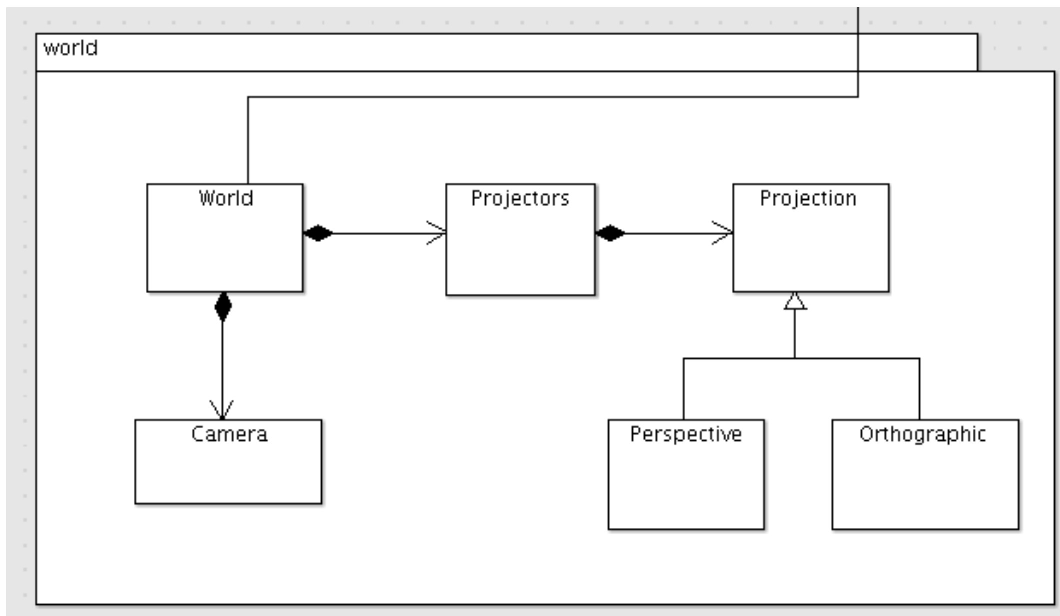

```
struct Camera
{
  Camera();
  void keyStroke (unsigned char key);
  void render();

  float xrot;
  float yrot;
  Vector3 position;
  float controlPrecision;
  float zoomPrecision;
};
```

Camera

```
Camera::Camera()
: position (0,0,-10)
{
  controlPrecision = 0.5;
  zoomPrecision = 0.1;
}

void Camera::render()
{
  Vector3::UnitX.rotate(xrot);
  Vector3::UnitY.rotate(yrot);
  position.translate();
}
```

```
void Camera::keyStroke (unsigned char key)
{
  if (key == 'q')
  {
    xrot += controlPrecision;
    if (xrot > 360)
      xrot -= 360;
  }
  else if (key == 'z')
  {
    xrot -= controlPrecision;
    if (xrot < -360)
      xrot += 360;
  }
  else if (key == 'd')
  {
    yrot += controlPrecision;
    if (yrot > 360)
      yrot -= 360;
  }
  else if (key == 'a')
  {
    yrot -= controlPrecision;
    if (yrot < -360)
      yrot += 360;
  }
  else if (key == 'w' || key == 's')
  {
    float xrotrad, yrotrad;
    yrotrad = (yrot / 180 * GL_PI);
    xrotrad = (xrot / 180 * GL_PI);
    if (key == 'w')
    {
      position.X += float(sin(yrotrad));
      position.Y -= float(sin(xrotrad));
      position.Z -= float(cos(yrotrad))  * zoomPrecision;
      //position.Z -= controlPrecision;
      cout << position.Z << endl;
    }
    else if (key == 's')
    {
      position.X -= float(sin(yrotrad));
      position.Y += float(sin(xrotrad));
      position.Z += float(cos(yrotrad)) * zoomPrecision;
      //position.Z += controlPrecision;
      cout << position.Z << endl;
    }
  }
```

World




```
#define theWorld World::GetInstance()

struct World
{
  void initialize(std::string name, int width, int height);
  void keyPress(unsigned char ch);
  void start();
  void render();
  void tickAndRender();

  static World& GetInstance();
  static World  *s_World;

  Scene         *scene;
  Projectors     projectors;
  Camera         camera;
};
```

World (1)

```
World& World::GetInstance()
{
  if (s_World == NULL)
  {
    s_World = new World();
  }
  return *s_World;
}

void World::initialize(string name, int width, int height)
{
  int argc=0;
  char** argv;
  glutInit(&argc, argv);

  glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB | GLUT_DEPTH);
  glutInitWindowSize(width, height);
  glutCreateWindow(name.c_str());

  Color::Black.renderClear();
  glEnable(GL_DEPTH_TEST);
  glFrontFace(GL_CCW);
  glPolygonMode(GL_FRONT,GL_LINE);
  glPolygonMode(GL_BACK,GL_LINE);

  glMatrixMode(GL_PROJECTION);
  glLoadIdentity();
  gluPerspective(60.0f, 1, 1.0, 1000.0);

  glMatrixMode(GL_MODELVIEW);
  glLoadIdentity();

  glutKeyboardFunc(keyboard);
  glutReshapeFunc(reshape);
  glutDisplayFunc(renderScene);
}

void World::start()
{
  timerFunc(0);
  glutMainLoop();
}
```

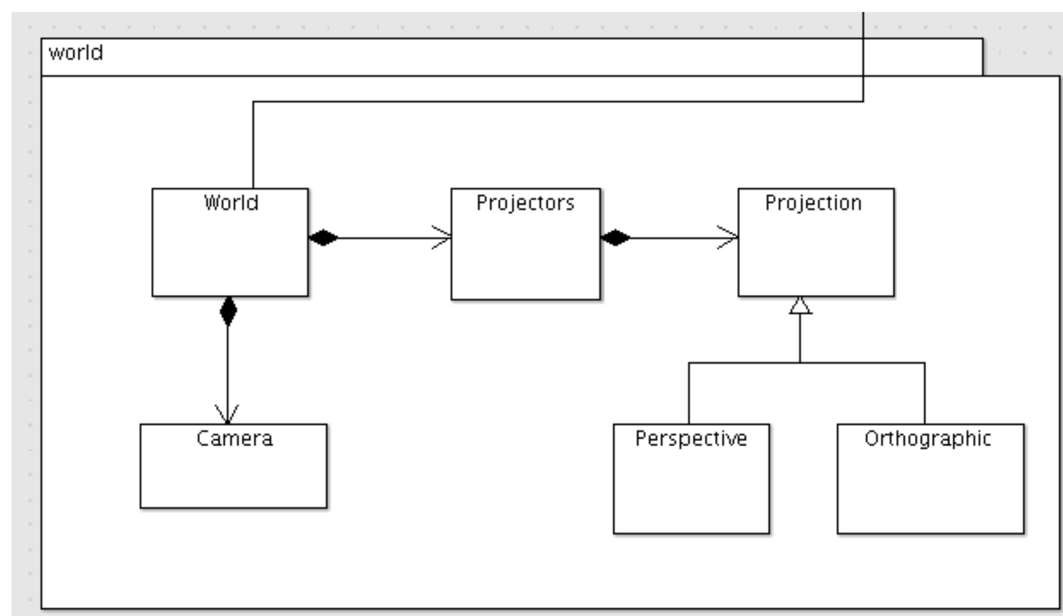
Glutadapter

```
void reshape(int w, int h);
void renderScene(void);
void keyboard(unsigned char key, int x, int y);
void timerFunc(int value);
```

```
void reshape(int w, int h)
{
  theWorld.projectors.windowReshape(w,h);
}

void renderScene(void)
{
  theWorld.render();
}

void keyboard(unsigned char key, int x, int y)
{
  theWorld.keyPress(key);
}

void timerFunc(int value)
{
  theWorld.tickAndRender();
  glutTimerFunc(50, timerFunc, 1);
}
```

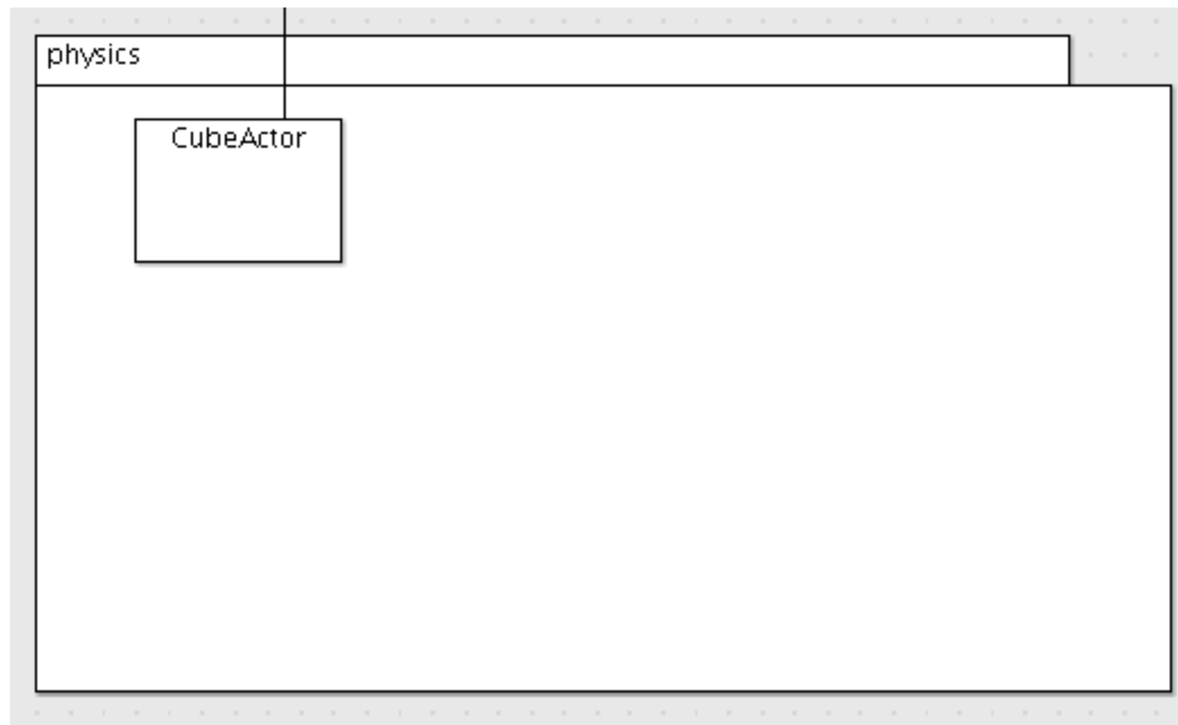
World (2)

```
void World::keyPress(unsigned char ch)
{
  if (ch >= '1' && ch <= '4')
  {
    projectors.keyPress(ch);
  }
  else
  {
    if (projectors.isPerspective())
    {
      camera.keyStroke(ch);
    }
  }
  glutPostRedisplay();
}
```




```
void World::render()
{
  glClearColor(0.0, 0.0, 0.0, 1.0);
  glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);

  if (projectors.isPerspective())
  {
    glLoadIdentity();
    camera.render();
  }

  scene->render();

  glutSwapBuffers();
}

void World::tickAndRender()
{
  static clock_t lastTime = 0;

  if (lastTime == 0)
    lastTime = clock();

  clock_t currTime = clock();
  clock_t deltaTime = currTime - lastTime;
  float secondsDelta = (float)deltaTime/CLOCKS_PER_SEC;

  scene->tick(secondsDelta);

  glutPostRedisplay();
}
```

Physics

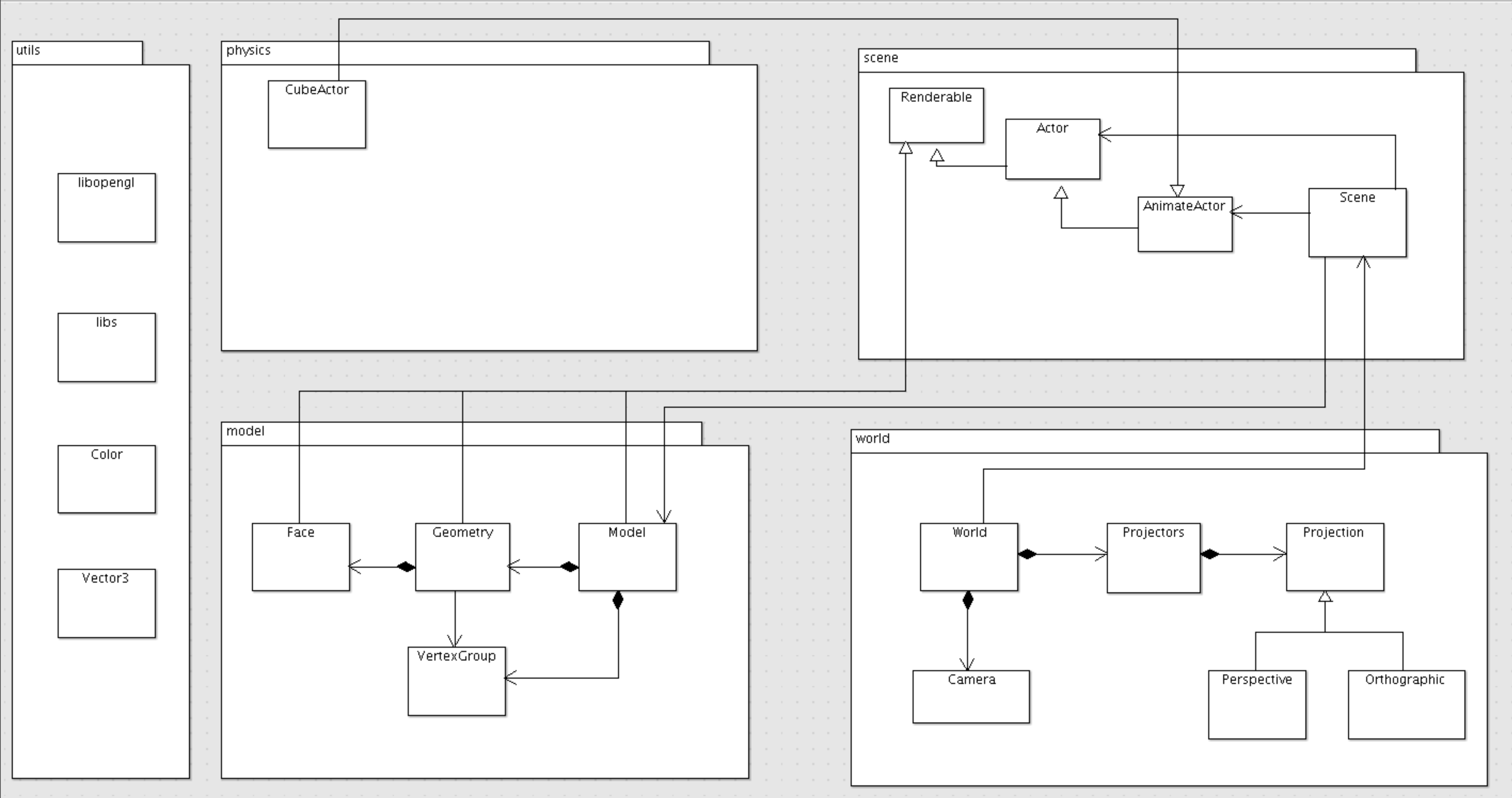



```
struct CubeActor : public AnimateActor
{
  Vector3 position;
  Vector3 velocity;
  Vector3 acceleration;

  Vector3 force;

  float inverseMass;
  float damping;

  CubeActor(Geometry *);

  void integrate(float dt);
  void render();
};
```

Physics

```
CubeActor::CubeActor(Geometry *geometry)
: AnimateActor(geometry)
{
  position = Vector3::zero();
  foreach (Face &face, geometry->faces)
  {
    foreach (int index, face.vertexIndices)
    {
      Vector3 vector = geometry->vertexGroup->vertices[index-1];
      position += vector;
    }
  }
  position *= 1.0f/8.0f;
  velocity = Vector3(0,1,0);
  acceleration = Vector3(0,-.1,0);
  inverseMass = 1.0f;
  damping = 1.0f;

  foreach (Face &face, geometry->faces)
  {
    foreach (int index, face.vertexIndices)
    {
      geometry->vertexGroup->vertices[index-1] -= position;
    }
  }
}
```

```
void CubeActor::integrate(float dt)
{
  // An unmovable particle has zero inverseMass.
  if (inverseMass <= 0.0f) return;

  // Work out the acceleration from the force.
  Vector3 resultingAcceleration(acceleration +
force*inverseMass);

  // Update linear velocity from the acceleration.
  velocity +=  dt*resultingAcceleration;

  // Impose artificial drag.
  velocity *= pow(damping, dt);

  // Update linear position.
  position += dt*velocity;

  // Clear the forces.
  force = Vector3::zero();

  return;
};

void CubeActor::render()
{
  glPushMatrix();
    glTranslatef(position.X, position.Y, position.Z);
    Actor::render();
  glPopMatrix();
}
```


utils
libopengl
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Color
Vector3
physics
CubeActor
scene
Renderable
Actor
AnimateActor
Scene
model
Face
Geometry
Model
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Camera
Perspective
Orthographic

Grading Spectrum (Indicative only, to be updated...)

Range	*UML Model: 10%*	*Model: 30%*	*Rendering 30%*	*Physics: 30%*
Baseline	Simple class diagrams	Multiple Entities	Perspective + Multiple Orthographic Views	Determine Properties of some Physical Objects (Cube, sphere, position, orientation)
Good	+Packages	Textures & Materials	Windowed Display (shows Perspective + 3 Orthographic like Maya)	Simulations involving forces (gravity, spring)
Excellent	+Sequence	Lighting	Navigable Camera	Simulations involving forces with constrains (e.g. Newtons cradle)
Outstanding	+Activity diagrams	Aggregate Multiple Model Files	Scriptable Camera (proceed on some trajectory)	Collisions