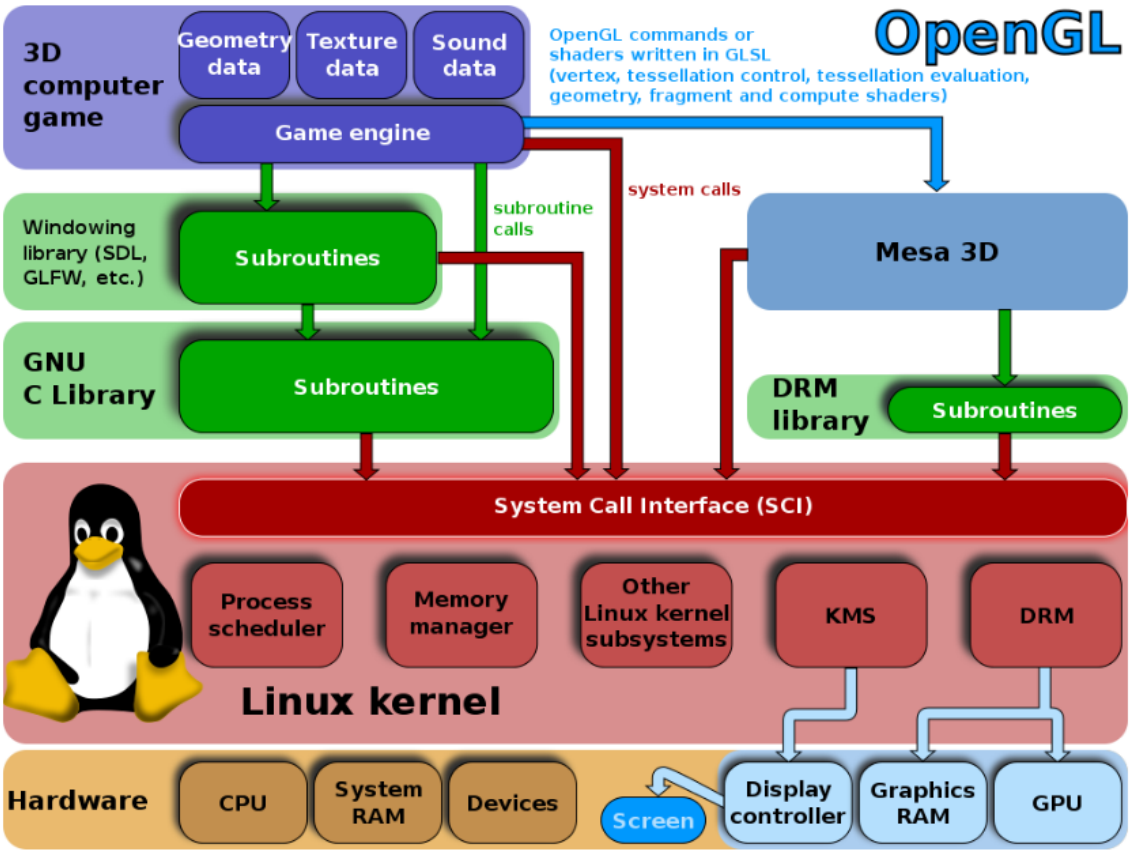
CPU (central processing unit) is a generalized processor that is designed to carry out a wide variety of tasks.

GPU (graphics processing unit) is a specialized processing unit with enhanced mathematical computation capability, ideal for computer graphics and machine-learning tasks.

While GPUs can process data several orders of magnitude faster than a CPU due to massive parallelism, **GPUs are not as versatile as CPUs**. CPUs have large and broad instruction sets, managing every input and output of a computer, which a GPU cannot do.

Device Dependent X: X server will directly communicate to hardware for rendering.

Device Independent X: Indirect rendering.



Processing part: DRM -> Graphics Ram & GPU

Display part: KMS-> Display controller -> screen

Libdrm: provides a user space library for accessing the DRM, direct rendering manager, on operating systems that support the ioctl interface.

DRM: The Direct Rendering Manager is a subsystem of the Linux kernel responsible for interfacing with GPUs and Graphics RAM/Card.

KMS: Kernel Mode Setting (KMS) is **a method for setting display resolution and depth in the kernel space rather than user space.**

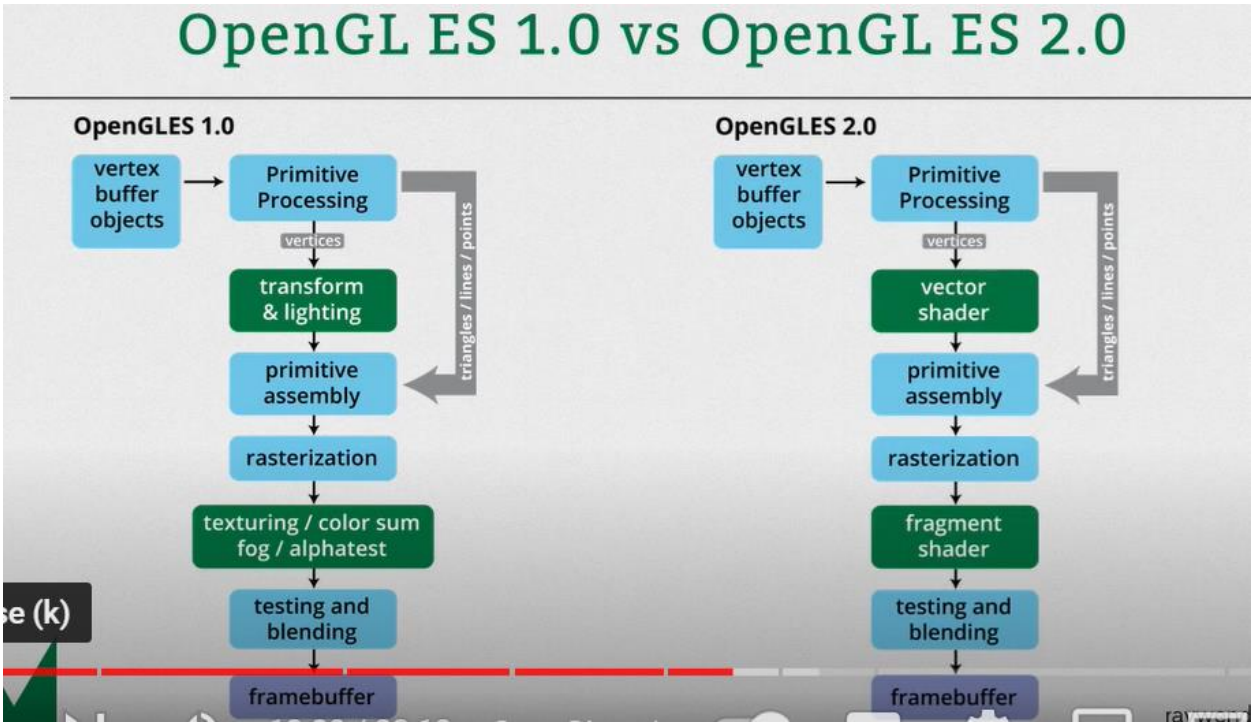
Mesa: is **an open-source implementation of OpenGL, Vulkan, and other graphics API specifications**.

OpenGL: Opengl provides sets of APIS for rendering 2D and 3D vector graphics.

We can use OpenGL or DirectX but opengl is platform independent.

Shaders: Shaders produce lit and shadowed image.

For example we have six numbers as input and o/p will be image->



Primitive processing:

Primitive assembly: Identify the required triangles\lines\quad.

Fragment Shader: is the Shader stage that will **process a Fragment generated by the Rasterization into a set of colors and a single depth value**

Rasterization: is the act of converting an image described in a vector format(shapes) into a raster image (pixels or dots) to display on a video device, print it or to save it in a bitmap file format.

Vertex Shaders: transform shape positions into 3D drawing coordinates.

Vertex shaders describe the attributes (position, texture coordinates, colors, etc.) of a vertex, while pixel shaders describe the traits (color, z-depth and alpha value) of a pixel.

In digital images, each pixel contains color information (such as values describing intensity of red, green, and blue) and also contains a value for its opacity known as its 'alpha' value. **An alpha value of 1 means totally opaque, and an alpha value of 0 means totally transparent**.

Culling: the act or process of selecting and removing desirable or undesirable individuals from a group.

In OpenGL, an object is made up of geometric primitives such as triangle, quad, line segment and point. A primitive is **made up of one or more vertices**. OpenGL supports the following primitives: A geometric primitive is defined by specifying its vertices via glVertex function, enclosed within a pair glBegin and glEnd .

OpenGL's native language is C, so a C++ program can make direct OpenGL function calls. There are 3 variants (opengl, opengles, webgl).

OpenGL doesn't draw to a computer screen. Rather, it renders to a *frame buffer*, and it is the job of the individual machine to then draw the contents of the frame buffer onto a window on the screen.

GLSL is an example of a *shader language*. Shader languages are intended to run on a GPU, in the context of a graphics pipeline.

glClearColor() command specifies the color value to be applied when clearing the background—in this case (1,0,0,1), corresponding to the RGB values of the color red (plus a "1" for the opacity component). We then use the OpenGL call glClear(GL_COLOR_BUFFER_BIT) to actually fill the color buffer with that color. Opacity is transparency.

- **In the constructor, we call QGLWidget::setFormat() to specify the OpenGL display context, and we initialize the class's private variables.**

```
Ex: Tetrahedron::Tetrahedron(QWidget *parent)
: QGLWidget(parent)
{
setFormat(QGLFormat(QGL::DoubleBuffer | QGL::DepthBuffer));
rotationX = -21.0;
rotationY = -57.0;
rotationZ = 0.0;
faceColors[0] = Qt::red;
faceColors[1] = Qt::green;
faceColors[2] = Qt::blue;
faceColors[3] = Qt::yellow;
}
```

- **The initializeGL() function is called just once, before paintGL() is called. This is the place where we can set up the OpenGL rendering context, define display lists, and perform other initializations.**

Ex: void Tetrahedron::initializeGL()
{
200 *8. 2D and 3D Graphics*
qglClearColor(Qt::black);
glShadeModel(GL_FLAT);
glEnable(GL_DEPTH_TEST);
glEnable(GL_CULL_FACE);
}

glShadeModel — select flat or smooth shading:

`void` **`glShadeModel`**`(`GLenum *mode*`);`

Accepted values for GLenum *mode* are `GL_FLAT` and `GL_SMOOTH`. The initial value is `GL_SMOOTH`.

glEnable — enable or disable server-side GL capabilities:

`void` **`glEnable`**`(`GLenum *cap*`);`

`void` **`glDisable`**`(`GLenum *cap*`);`

- **The resizeGL() function is called before paintGL() is called the first time, but after initializeGL() is called. It is also called whenever the widget is resized. This is the place where we can set up the OpenGL viewport, projection, and any other settings that depend on the widget's size.**

Ex: void Tetrahedron::resizeGL(int width, int height)
{
glViewport(0, 0, width, height);
glMatrixMode(GL_PROJECTION);
glLoadIdentity();
GLfloat x = GLfloat(width) / height;
glFrustum(-x, x, -1.0, 1.0, 4.0, 15.0);
glMatrixMode(GL_MODELVIEW);
}

glViewport — set the viewport:

`void` **`glViewport`**`(` GLint *x*,
GLint *y*,
GLsizei *width*,
GLsizei *height*`);`

Description

`glMatrixMode` sets the current matrix mode. *`mode`* can assume one of these values:

`GL_MODELVIEW`

Applies subsequent matrix operations to the modelview matrix stack.

`GL_PROJECTION`

Applies subsequent matrix operations to the projection matrix stack.

`GL_TEXTURE`

Applies subsequent matrix operations to the texture matrix stack.

glLoadIdentity — replace the current matrix with the identity matrix(An identity matrix is a **square** matrix having 1s on the main diagonal, and 0s everywhere else)