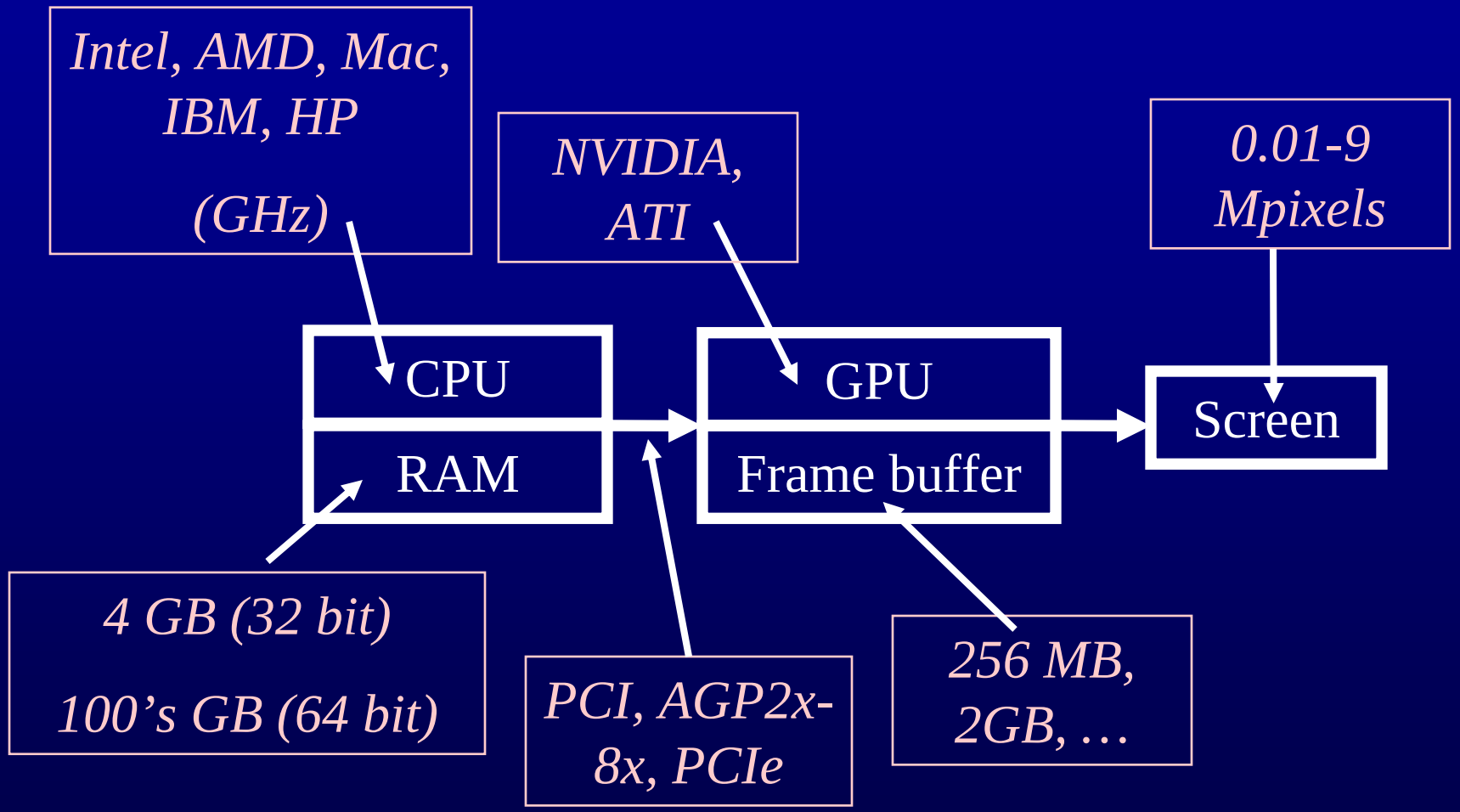
Hardware rendering

Graphics hardware



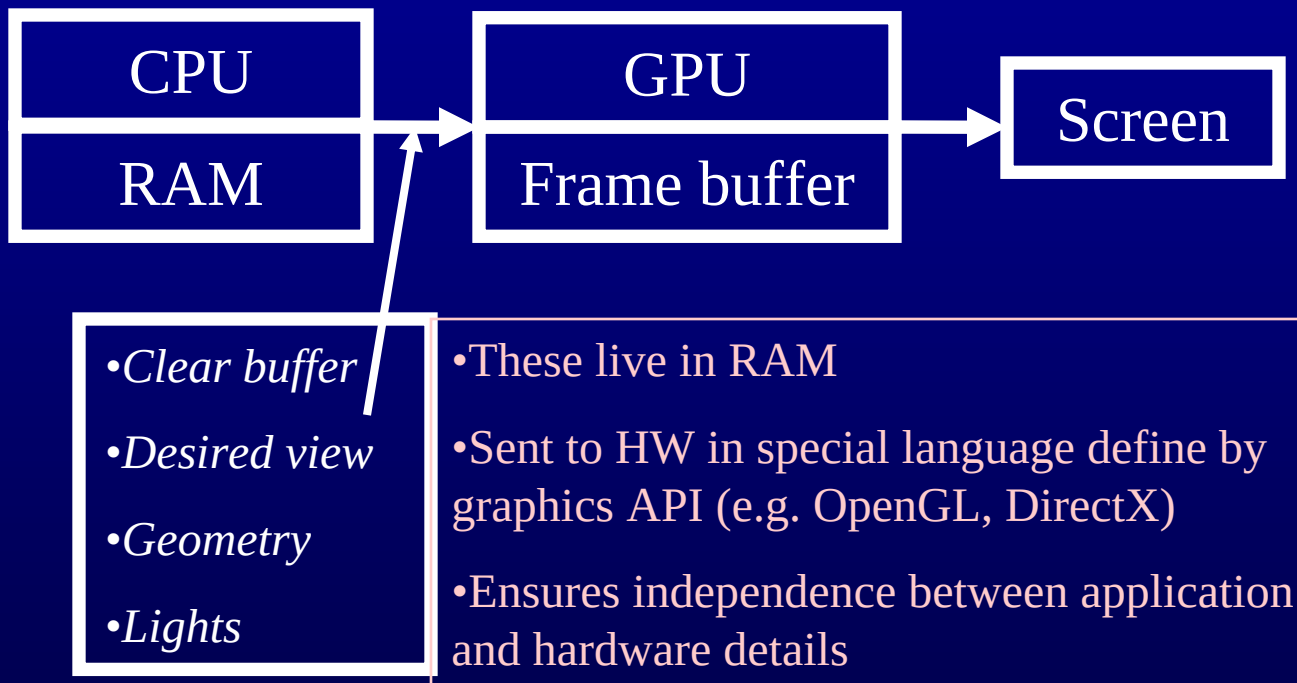
Fixed pipeline hardware support

- What hardware does
  - Transformation
  - Projection
  - Clipping
  - Lighting (ambient, diffuse, specular)
  - Shading (Gouraud, Phong)
  - Texture, environment, reflection, perspective, and shadow mapping
  - Antialiasing
  - Some image processing
- and does not do
  - Model the scene geometry for you
  - Light the scene for you
  - Find nice paths in the model
  - Animate the model for you
  - Implement the laws of physics
  - Create and manage windows
  - Decide which parts of the model to process for each frame

Programmable pipeline

- Vertex programs
  - Define your own transformation
  - Define your own lighting
  - Compute per vertex values needed at pixel level
- Pixel programs
  - aka pixel shaders
  - aka fragment programs
  - Define your own shader (way to compute color from vertex data)
- Geometry programs
  - Programmability at primitive level
  - Define your own primitive

Input to graphics hardware



- These live in RAM
- Sent to HW in special language define by graphics API (e.g. OpenGL, DirectX)
- Ensures independence between application and hardware details
- The HW driver takes API calls and converts them to low level HW specific calls

OpenGL: clear buffers

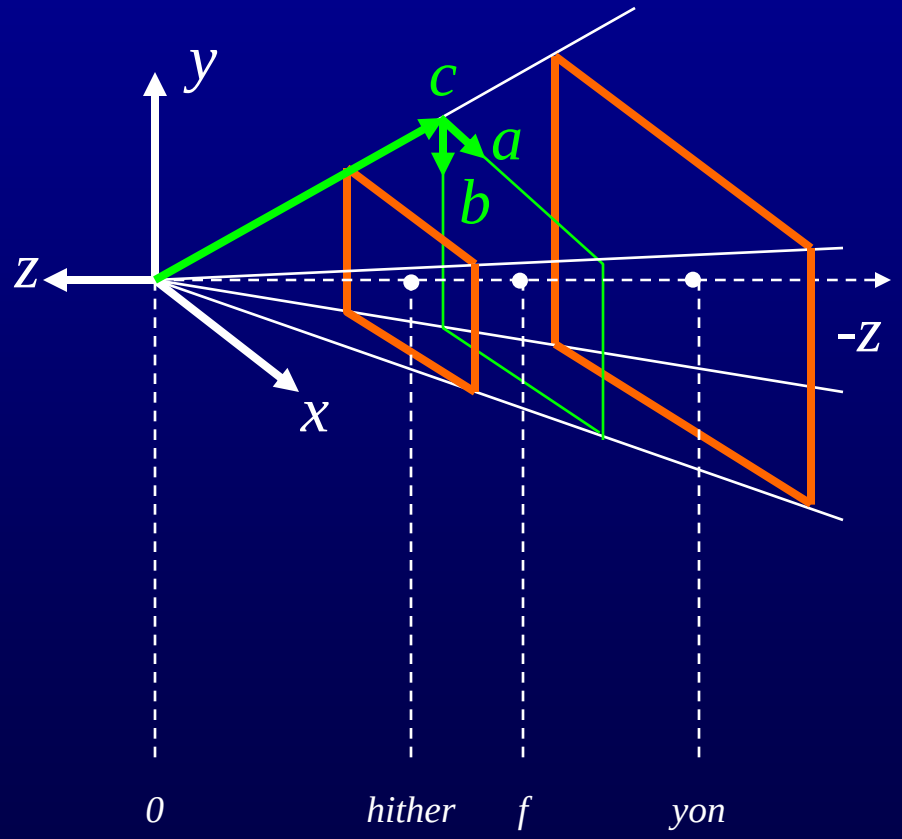
- void TiffView::GLFrameSetup() {
-
-
- glClearColor(0.0f, 0.0f, 0.5f, 1.0f);
- glClearStencil(0);

- glClear(GL_COLOR_BUFFER_BIT |
  GL_DEPTH_BUFFER_BIT |
  GL_STENCIL_BUFFER_BIT);
-
- }

Specify desired view

- Convert “software” planar pinhole camera (PHC) model to hardware view
  - Step 1: specify intrinsics
    - Analogous to PHC constructor
    - At the beginning of session & when intrinsics change (e.g. after change of FOV, and of resolution operations)
    - Many ways of doing it
  - Step 2: specify extrinsics (camera location and orientation)
    - Every time the view changes (for every frame)
    - Many ways of doing it

PHC to OpenGL: intrinsics



PHC to OpenGL: intrinsics

```
void TiffView::InitializeGL(PHCamera *phc, float hither, float yon) {
  int dvW = phc->w, dvH = phc->h;
  glViewport(0, 0, dvW, dvH);
  glMatrixMode (GL_PROJECTION);
  glLoadIdentity ();
  float f = phc->Getf();
  float scalef = hither / f;
  float wf = phc->a.Length() * dvW;
  float hf = phc->b.Length() * dvH;
 // specify rectangle on hither plane and distances to hither and yon planes
glFrustum (-wf/2.0f*scalef, wf/2.0f*scalef, -hf/2.0f*scalef, hf/2.0f*scalef,
hither, yon);
  glMatrixMode (GL_MODELVIEW);  // default matrix mode
}
```

PHC to OpenGL: extrinsics

- void TiffView::SetGLView(PHCamera *phc) {
- Vex3 eye, look, down;
- eye = phc->GetC();
- look = phc->GetLookAtPoint();
- down = (phc->Getb()).UnitVector();
- int dvW = phc->w, dvH = phc->h;
- glLoadIdentity();
- // COP, point to look at (C + axb), up vector
- gluLookAt(eye[0], eye[1], eye[2], look[0], look[1], look[2], -down[0], -down[1], -down[2]);
- }

Specify geometry

```
void TriangleMesh::RenderSharedVertexHW(int renderMode) {
if (renderMode & TRIANGLE_RENDERMODE_WF) {
    glPolygonMode(GL_FRONT_AND_BACK, GL_LINE);
    if (glColor[0] != -1.0f)
      glColor4fv(glColor);
  }
  else
    glPolygonMode(GL_FRONT_AND_BACK, GL_FILL);
  glEnableClientState(GL_VERTEX_ARRAY);
// similar for array of colors and array of texture coordinates
  if (glNormals)
    glEnableClientState(GL_NORMAL_ARRAY);
  glVertexPointer(3, GL_FLOAT, 0, glVertices);
  if (glNormals)
    glNormalPointer(GL_FLOAT, 0, glNormals);
glDrawElements(GL_TRIANGLES, 3*trianglesN, GL_UNSIGNED_INT,
connectivity);
glDisableClientState(GL_NORMAL_ARRAY);
glDisableClientState(GL_VERTEX_ARRAY);
}
```