COMP130: Game Architecture

4: Game engine architecture

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The main loop

Basic game architecture

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  - E.g. PyGame isn't a game engine, so you have to implement your own main loop

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It does these **once per frame** (typically 30 or 60 times per second)

The basic main loop

```
bool running = true;

while (running)
{
    update();
    render();
}
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Rendering

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- Also draw any **heads-up display (HUD)** elements, e.g. score, lives, mini-map, etc.
- Most modern game engines **clear the screen and redraw everything** on every frame

Screen refresh rate

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- Other monitor technologies work differently, but still refresh the screen at regular intervals

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- If the main loop runs too quickly, we waste resources on drawing things faster than the display can show them

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  - High-end gaming monitors: 120Hz or higher

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  - The game could appear to run in slow or fast motion, completely changing the gameplay
- This was the situation on older consoles: American/Japanese versions of games actually ran a little faster than European versions, due to the NTSC TV standard having a higher refresh rate than PAL!

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- do this:

```
player.positionX += player.velocityX * deltaTime;
```

Variable time step

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float lastFrameTime = getCurrentTime();

while (running)
{
  float currentFrameTime = getCurrentTime();
  float deltaTime = currentFrameTime - lastFrameTime;

  update(deltaTime);
  render();
  waitForVerticalRefresh();

  lastFrameTime = currentFrameTime;
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- If refresh rate $>$ 50Hz, update once every few frames

Fixed time step

```
bool running = true;
float lastUpdateTime = getCurrentTime();
float timePerUpdate = 1.0f / 50.0f;

while (running)
{
  float currentFrameTime = getCurrentTime();

  while (currentFrameTime - lastUpdateTime >=
      timePerUpdate)
  {
    update();
    lastUpdateTime += timePerUpdate;
  }

  render();
  waitForVerticalRefresh();
}
```

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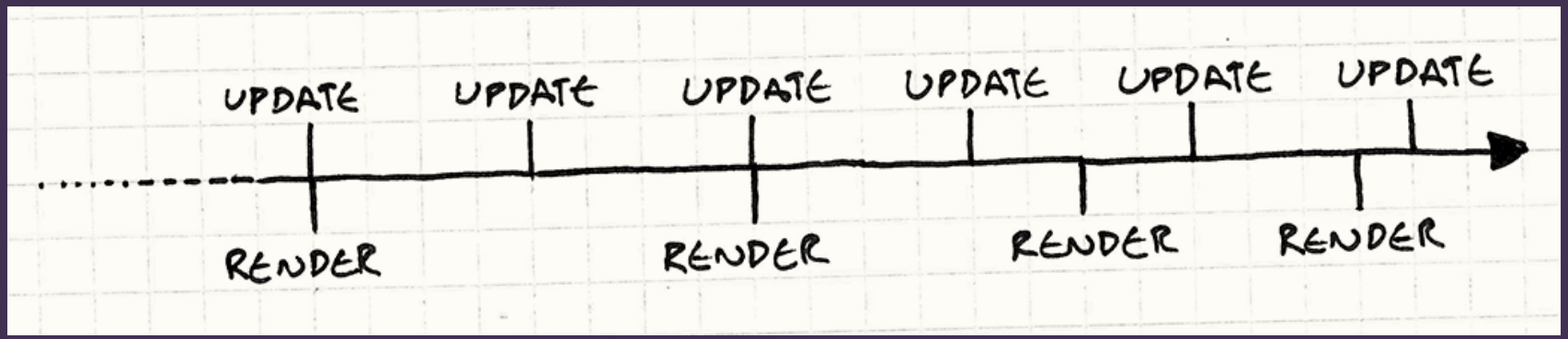
- The `while` loop will perform more and more iterations in an effort to catch up, eventually grinding the game to a halt
- **Solution:** `break` out of the loop after a maximum number of iterations (e.g. 10)

Interpolation



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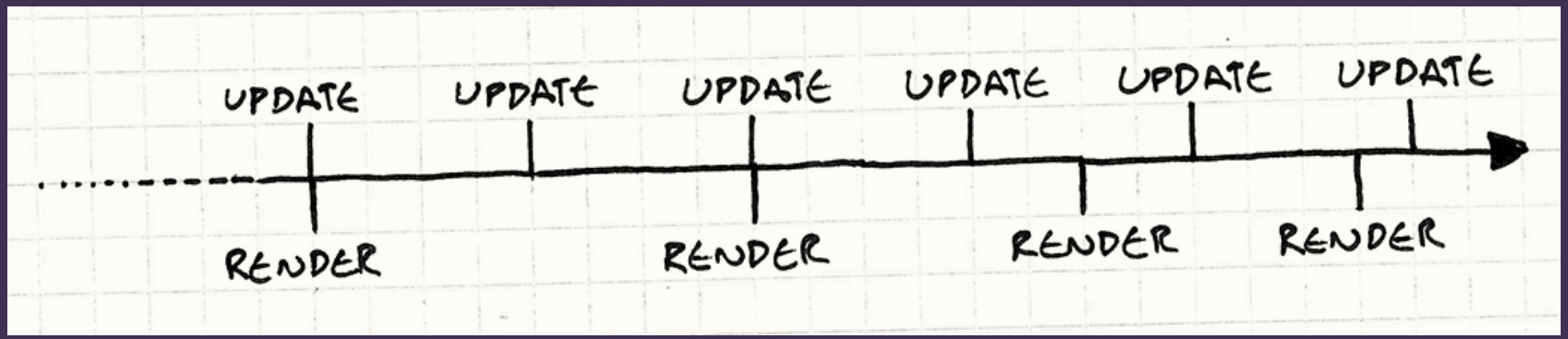

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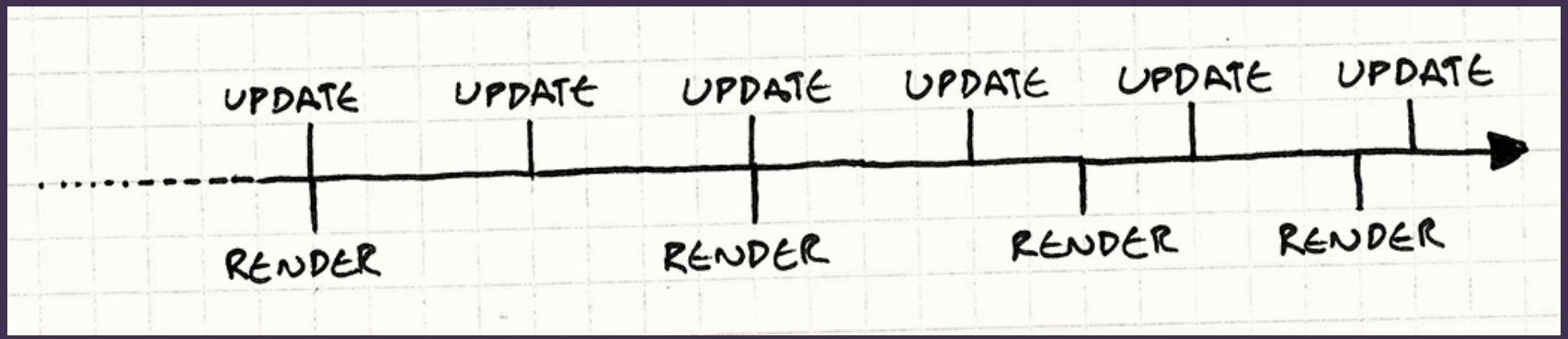

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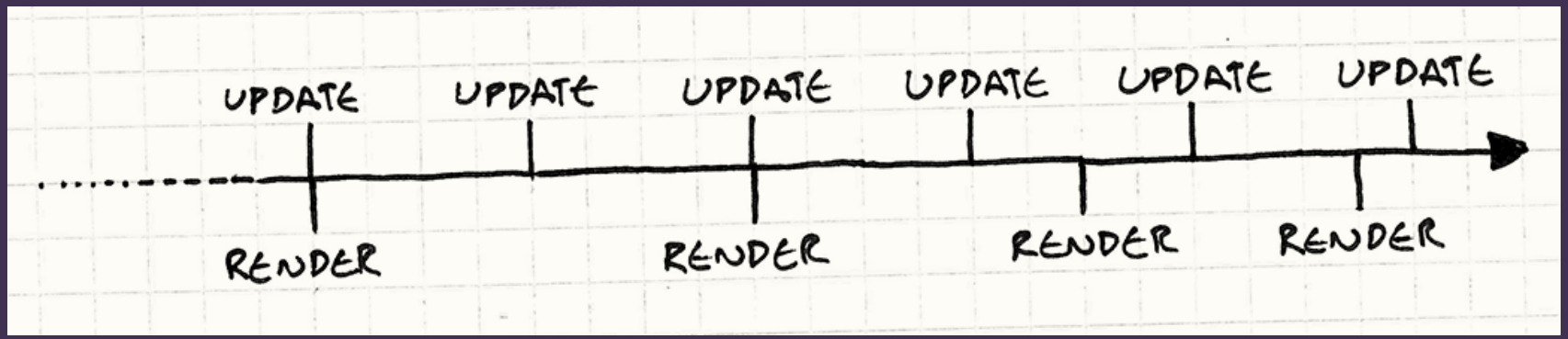

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- Solution: **interpolate** between the two previous updates
  - E.g. if the render falls exactly halfway between two updates, render each object exactly halfway between its positions **before** and **after** the most recent update

Further information on fixed time steps

- http://gafferongames.com/game-physics/fix-your-timestep/
- http://gameprogrammingpatterns.com/game-loop.html

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- E.g. again with a target update rate of 50Hz
- If refresh rate $<$ 50Hz, update several times per frame, with a `deltaTime` of $\frac{1}{50}$
- If refresh rate $>$ 50Hz, update once every frame, with `deltaTime` measured as for variable time step

Substepping

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bool running = true;
float lastFrameTime = getCurrentTime();
float timePerUpdate = 1.0f / 50.0f;

while (running)
{
  float currentFrameTime = getCurrentTime();
  float deltaTime = currentFrameTime - lastFrameTime;

  if (deltaTime <= timePerUpdate)
  { // Variable time step
    update(deltaTime);
  }
  else
  { // Fixed time step
    while (deltaTime > 0)
    {
      update(timePerUpdate);
      deltaTime -= timePerUpdate;
    }
  }

  render();
  waitForVerticalRefresh();
  lastFrameTime = currentFrameTime;
}
```

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- More info: `http://www.aclockworkberry.com/unreal-engine-substepping/`

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- `FixedUpdate` function is tied to fixed physics updates

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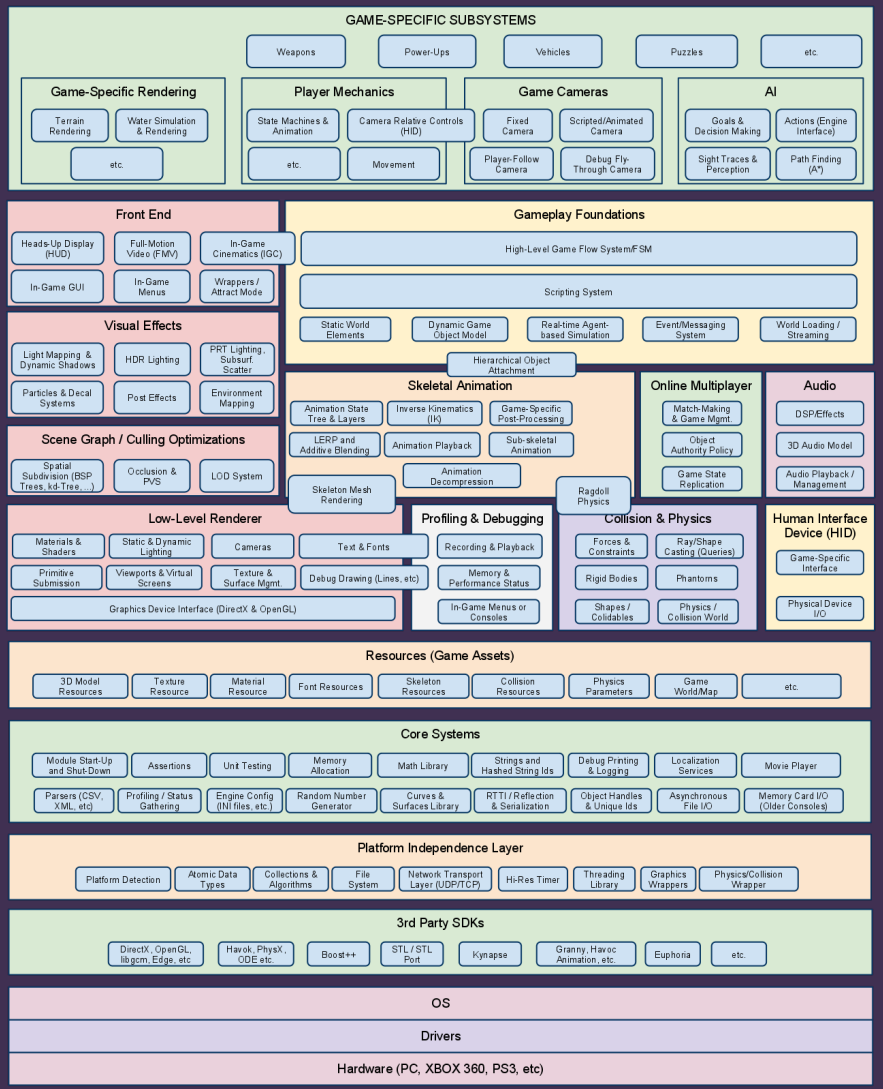
Game engine components

Common engine components



Jason Gregory, Game Engine Architecture. CRC Press, 2009.