Rendering performance

From the ground up

HolyJS

$ whoami

Head of Engineering @ Archilogic

HolyJS

Всем привет!

Head of Engineering @ Archilogic

@g33konaut

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spaces.archilogic.com

HolyJS

What we will look at

```
<html>
  <body>
    <h1>Hello HolyJS</h1>
    <p>Lorem ipsum...</p>
  </body>
</html>
```

Loading a website

1. HTML is fetched from the network

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3. Tokens are parsed into **objects** (DOM / CSSOM)
4. Objects are laid out on the page
5. Objects are being painted & composited
6. JS or CSS can change the content

(2) & (3): Parsing

Parsing

```
<h1>Hello HolyJS!</h1>
```

- H1 element
- Text node

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<p><img ...></p>
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- H1 element
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- Paragraph element
- Text node
- Paragraph element
- Image element

DOM Tree building

- H1 element
- Text node
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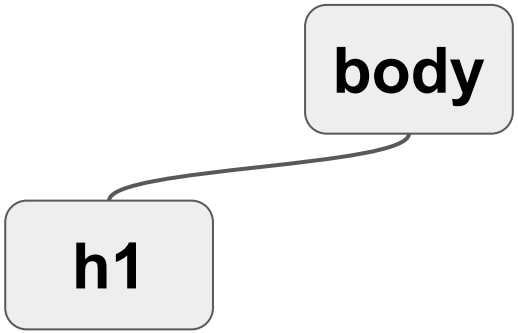
body

DOM Tree building

- **H1 element**
- Text node
- Paragraph element
- Text node
- Paragraph element
- Image element



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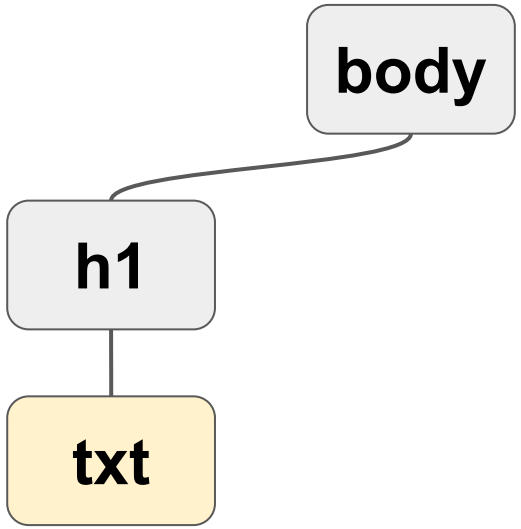

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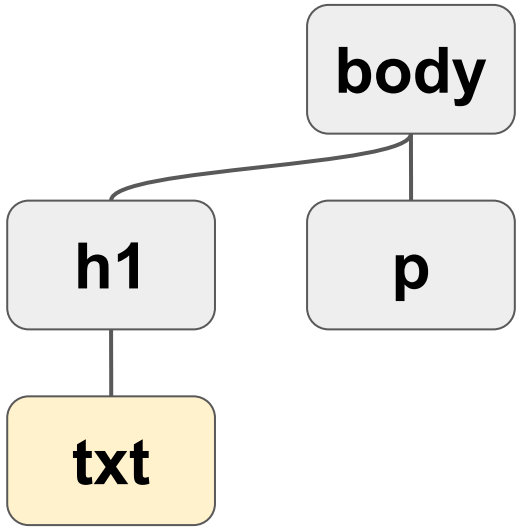

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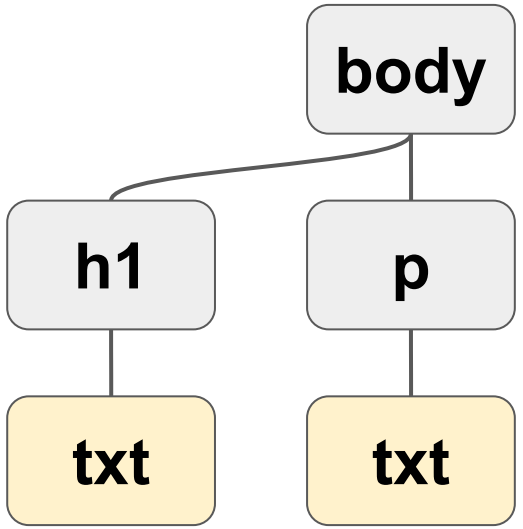

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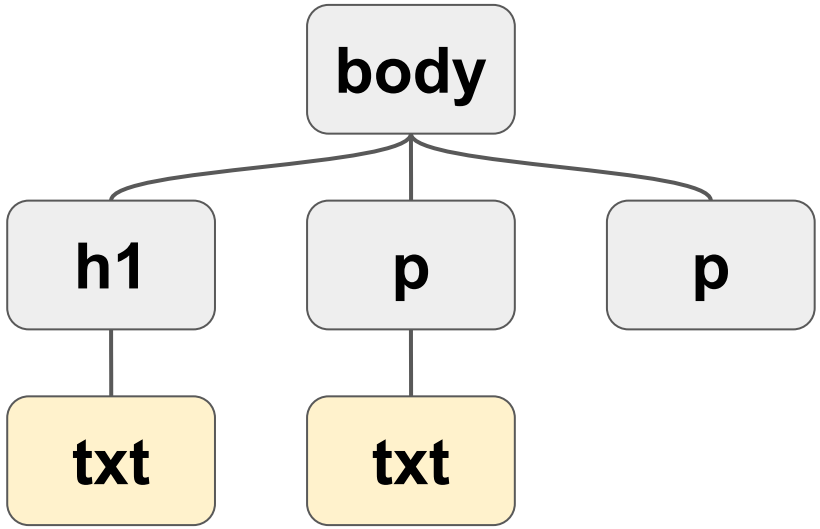

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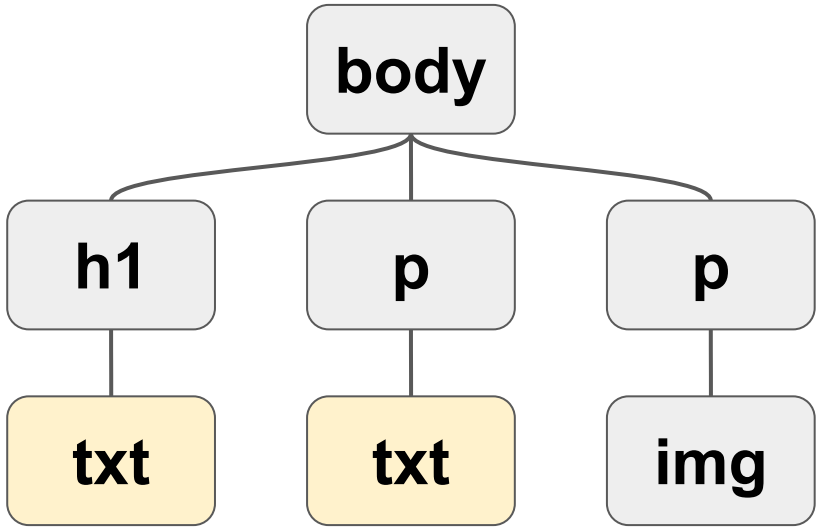

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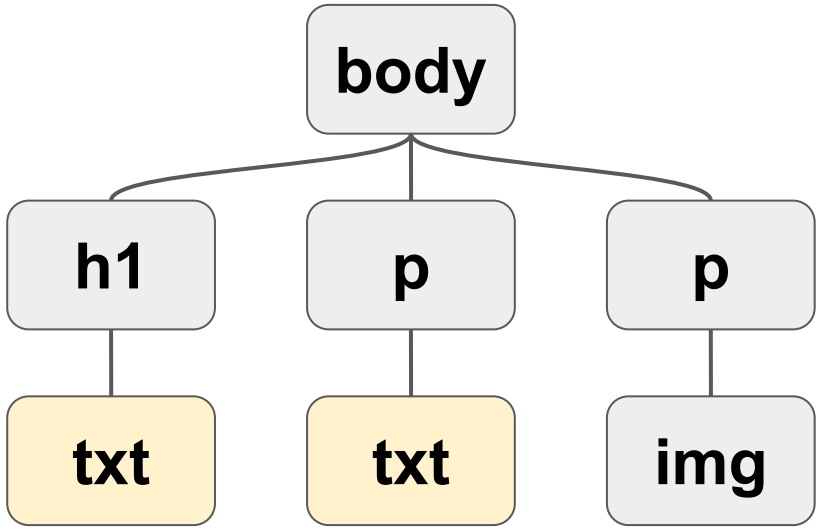

CSSOM building

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<link rel=”stylesheet” href=”style.css”>

<style>

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   h1 { color: blue; }

</style>

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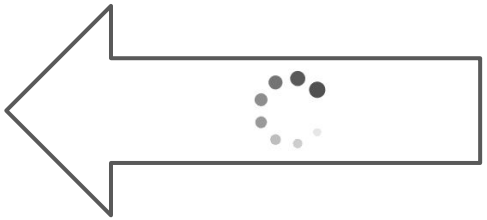

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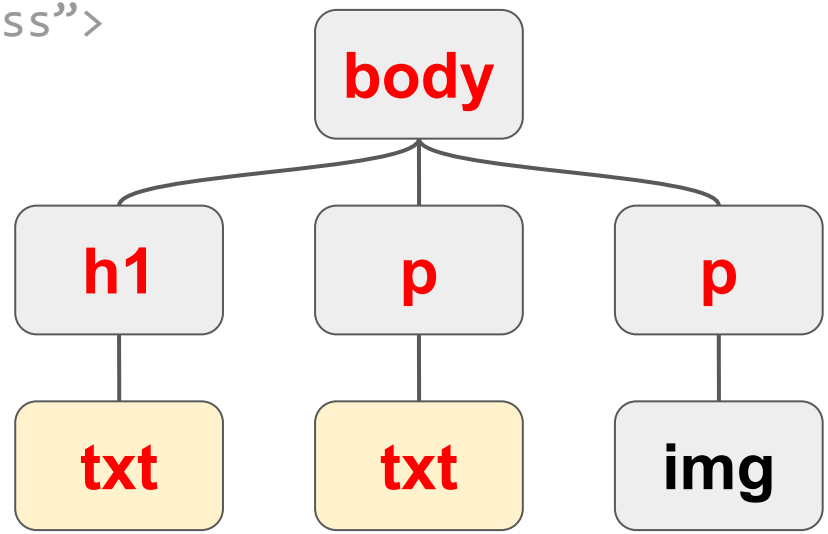

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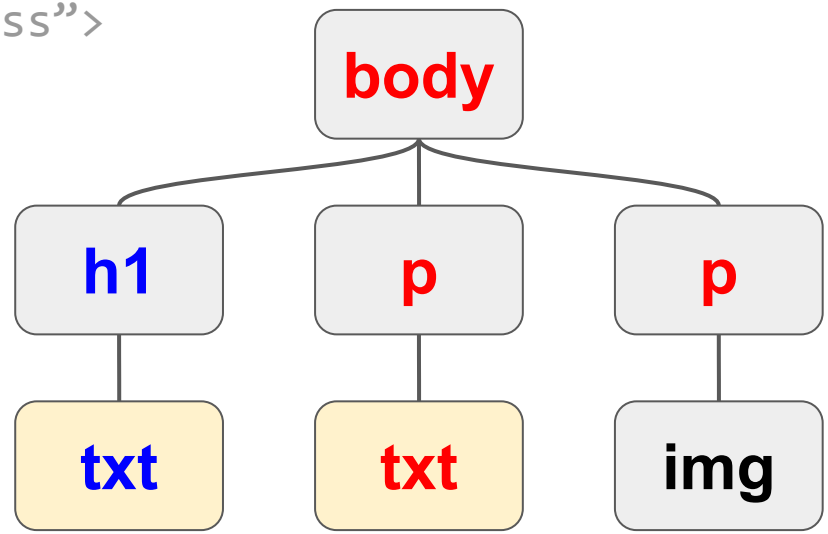

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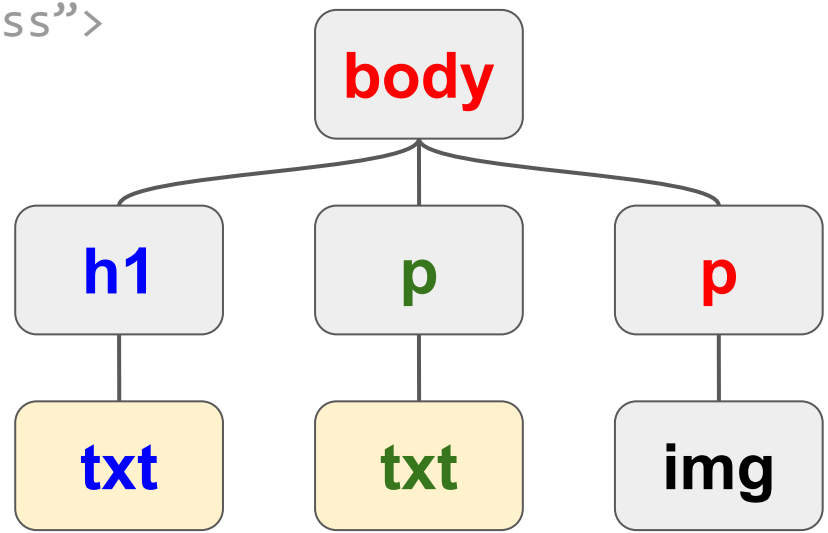
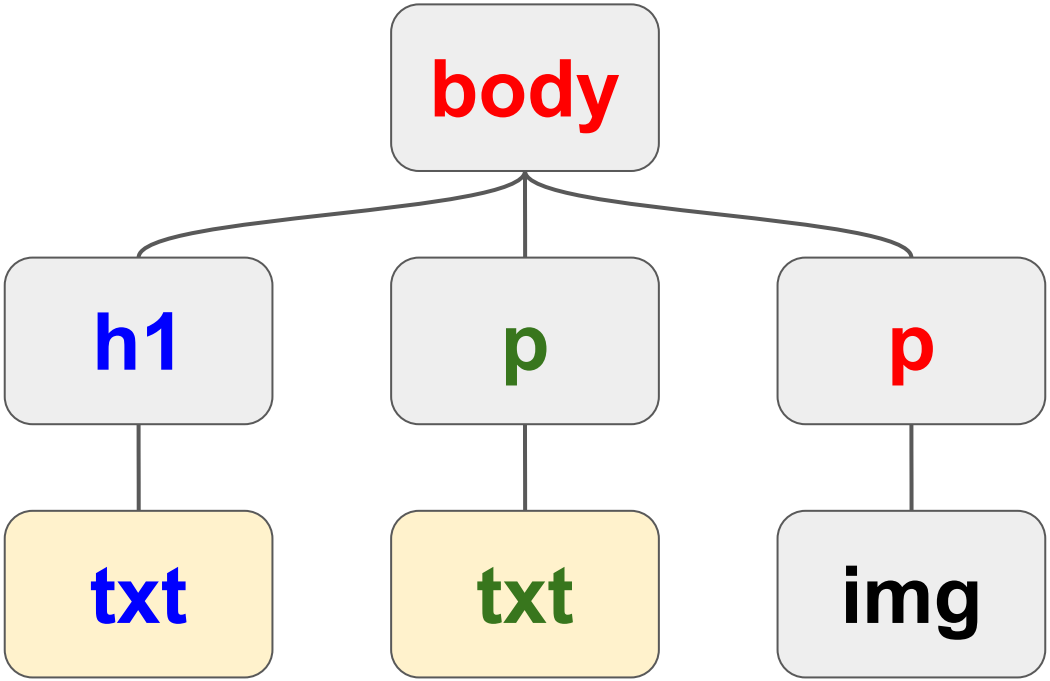


CSSOM + DOM



Lessons to learn

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- Inline *critical* CSS
- HTML source order matters during parsing
- Minimise forcing repeated tree building
- Static HTML for initial render 

(4) Layout process

Layouting

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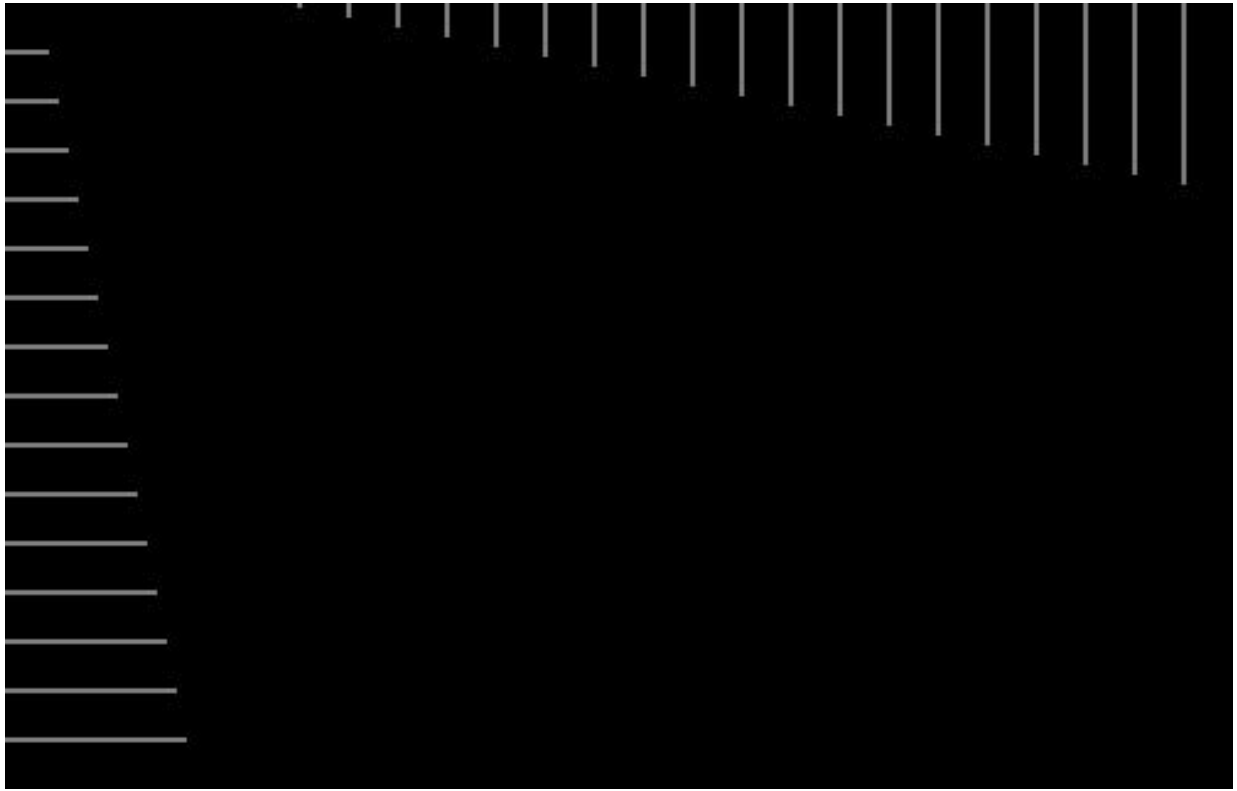
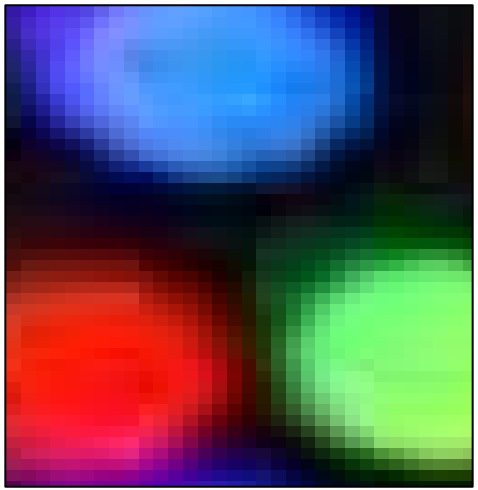
- Based on CSSOM + DOM
- Determines the actual size of each element
- Expensive algorithm
- Change may require repaint
- Animations may cause relayout

5. Painting pixels



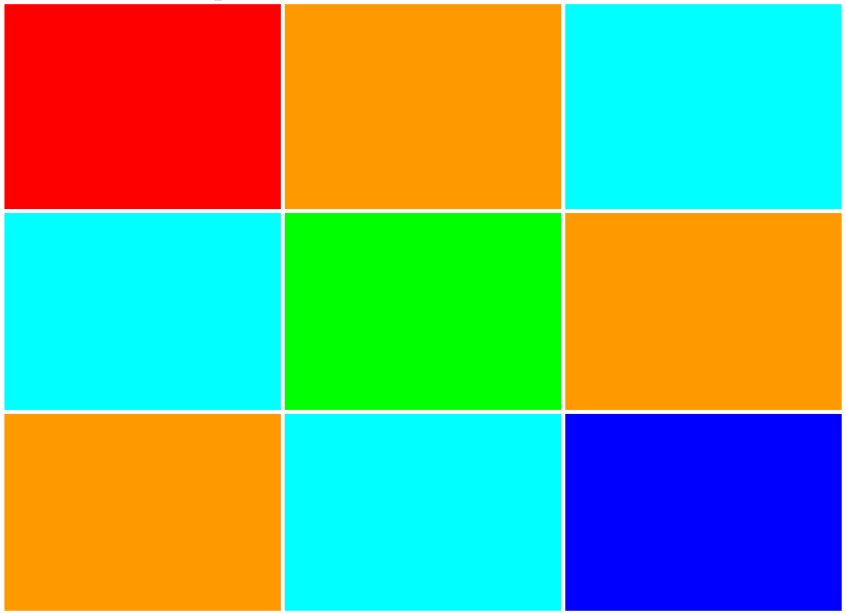
Let's paint



1 pixel = (red, green, blue)

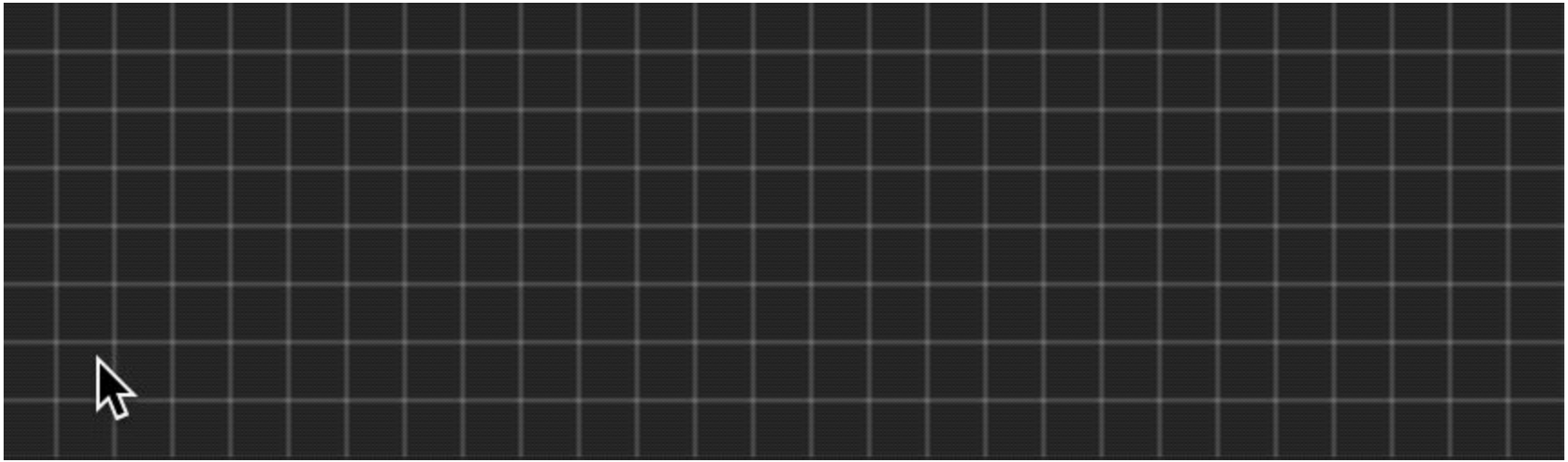
Let's paint

3x3 pixels screen = 3*3*3 values



255 0 0	255 255 0	0 255 255
0 255 255	0 255 0	255 255 0
255 255 0	0 255 255	0 0 255

Painting is...



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- Basically writing into memory
- e.g. 500x500 pixel * 3 bytes = 750 kb to write

Compositing

+

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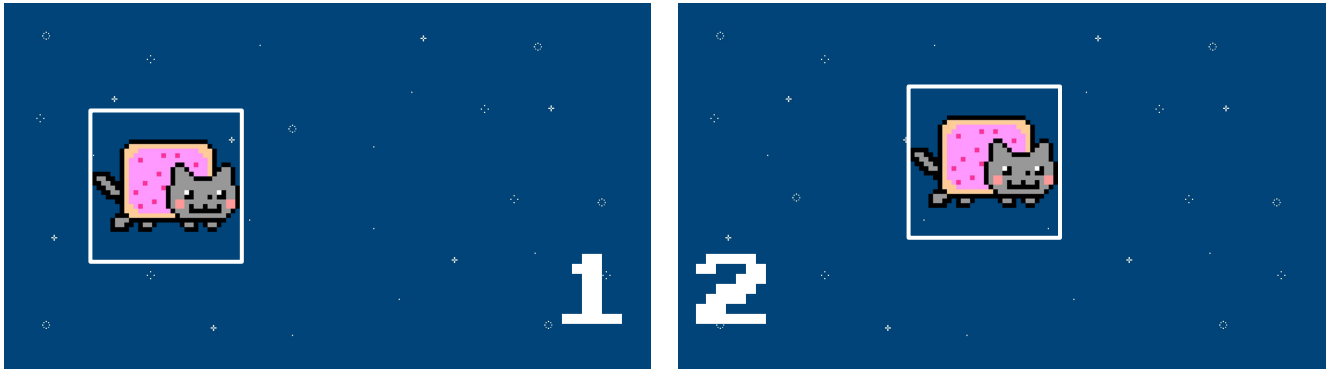

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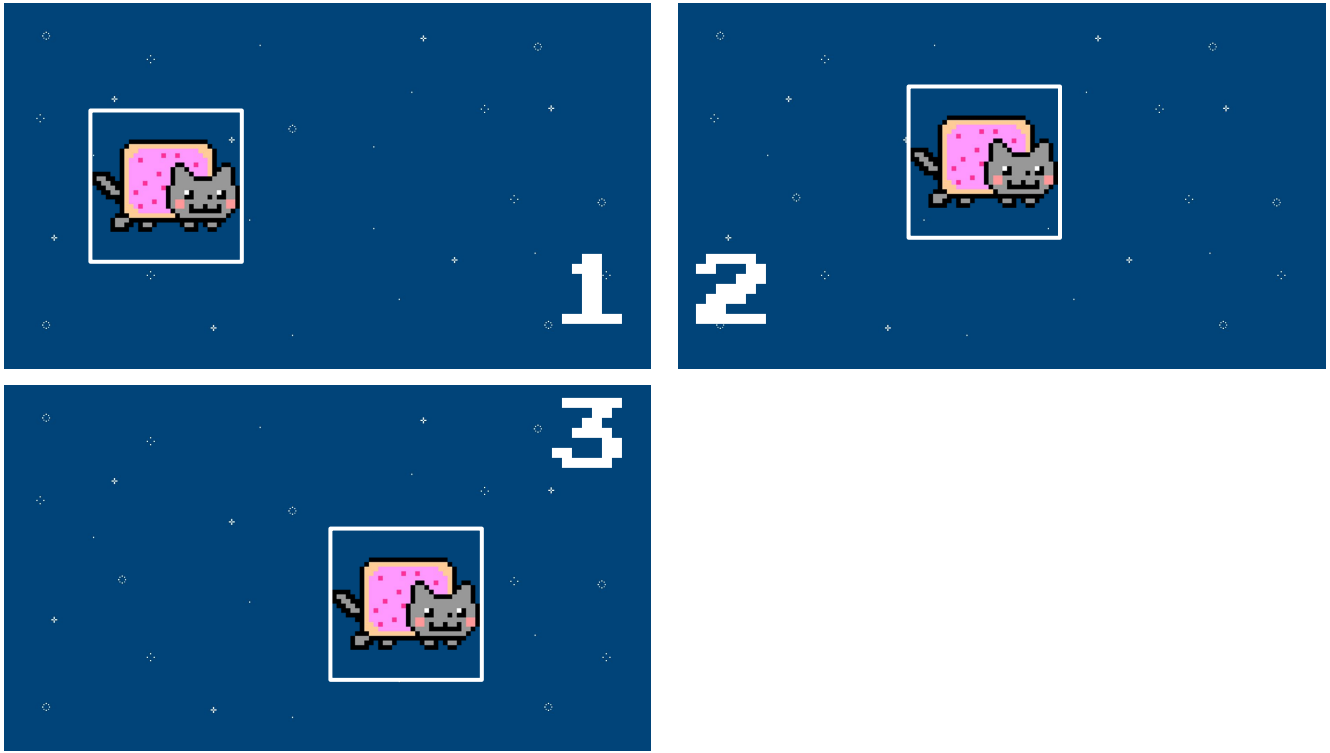

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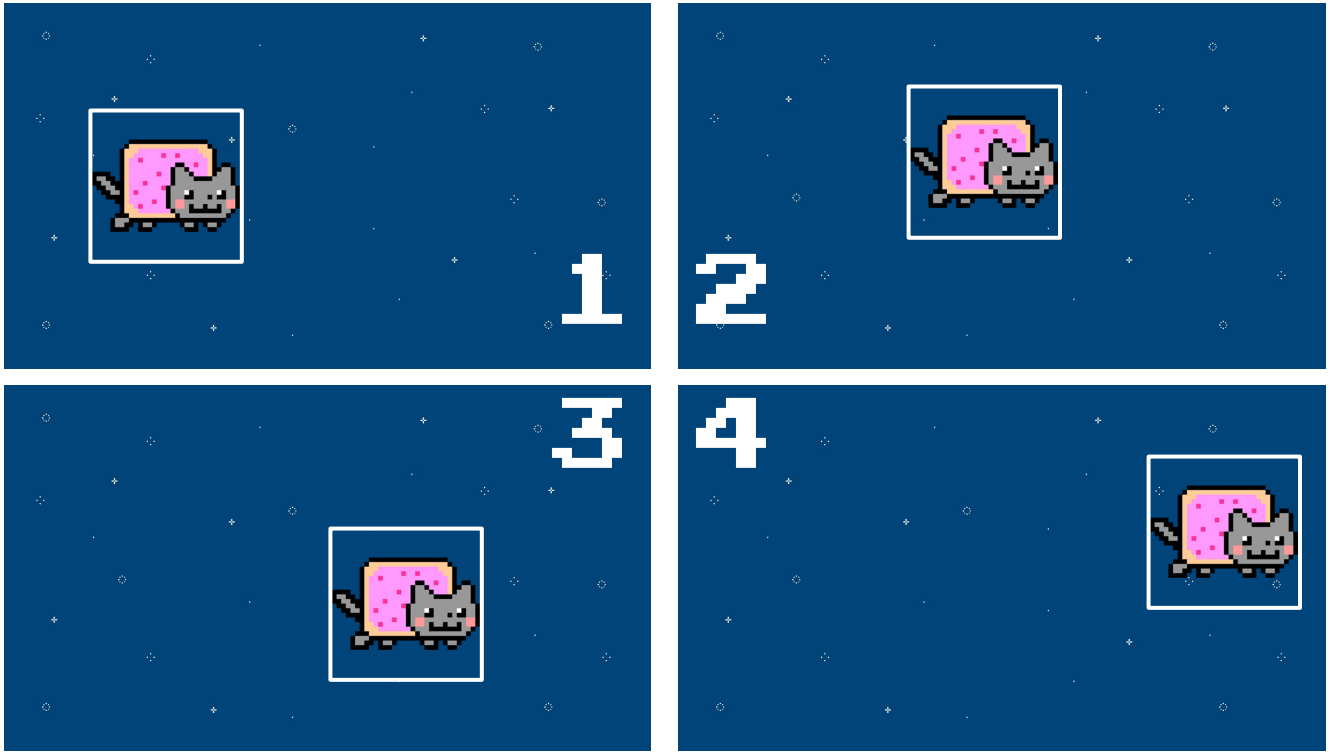

Compositing in detail

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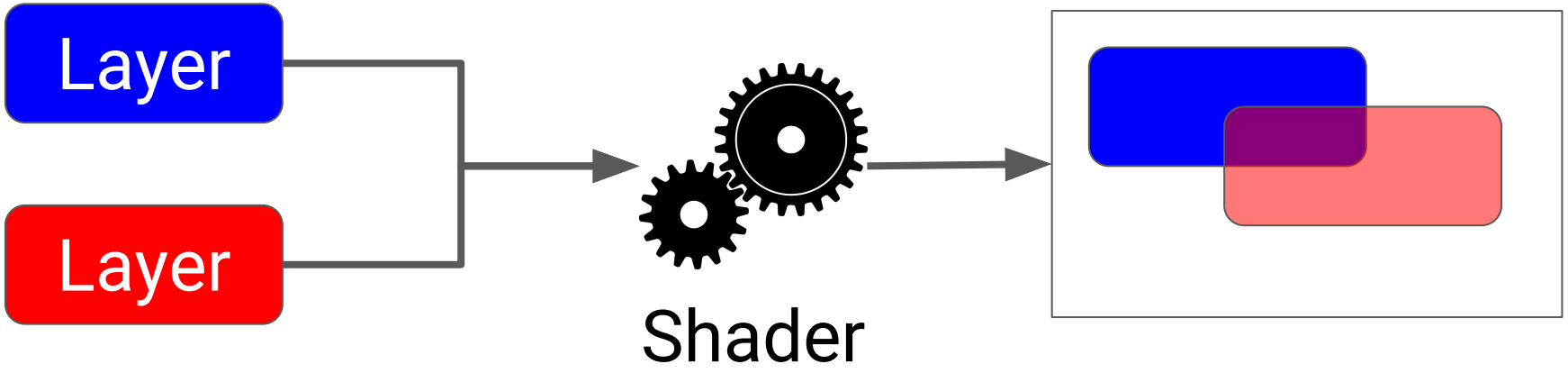

Shader?

```
let shader = (x, y, layers, blend, filter) => {
  return filter(
    blend(x, y, layers) // returns colour
  ) // returns final colour
}
```

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- Takes a pixel of all layers and combines them

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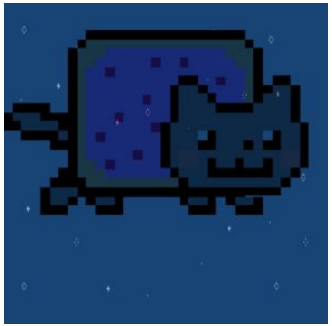
- Different functions available
- Example: “**screen**” blending:

```
color(x,y) = 1 - (1 - cat(x,y)) * (1 - sky(x,y))
```

Blending?

- Takes a pixel of all layers and combines them
- Different functions available
- Example: “**multiply**” blending:

```
color(x,y) = cat(x,y) * sky(x,y)
```



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  - grayscale
  - blur
  - contrast
  - hue-rotate
  - invert
  - opacity
  - saturate
  - sepia
  - drop-shadow

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  - grayscale
  - blur
  - contrast
  - hue-rotate
  - invert
  - opacity
  - saturate
  - sepia
  - drop-shadow
- grayscale: `(r, g, b) => (r + g + b) / 3`

A real shader

```
varying highp vec2 coord;
uniform sampler2D layer;

void main(void) {
  vec4 color = texture2D(layer, vec2(coord.s, coord.t));
  float grayScale = (color.r + color.g + color.b) / 3.0;
  gl_FragColor = vec4(grayScale, grayScale, grayScale, 1.0);
}
```

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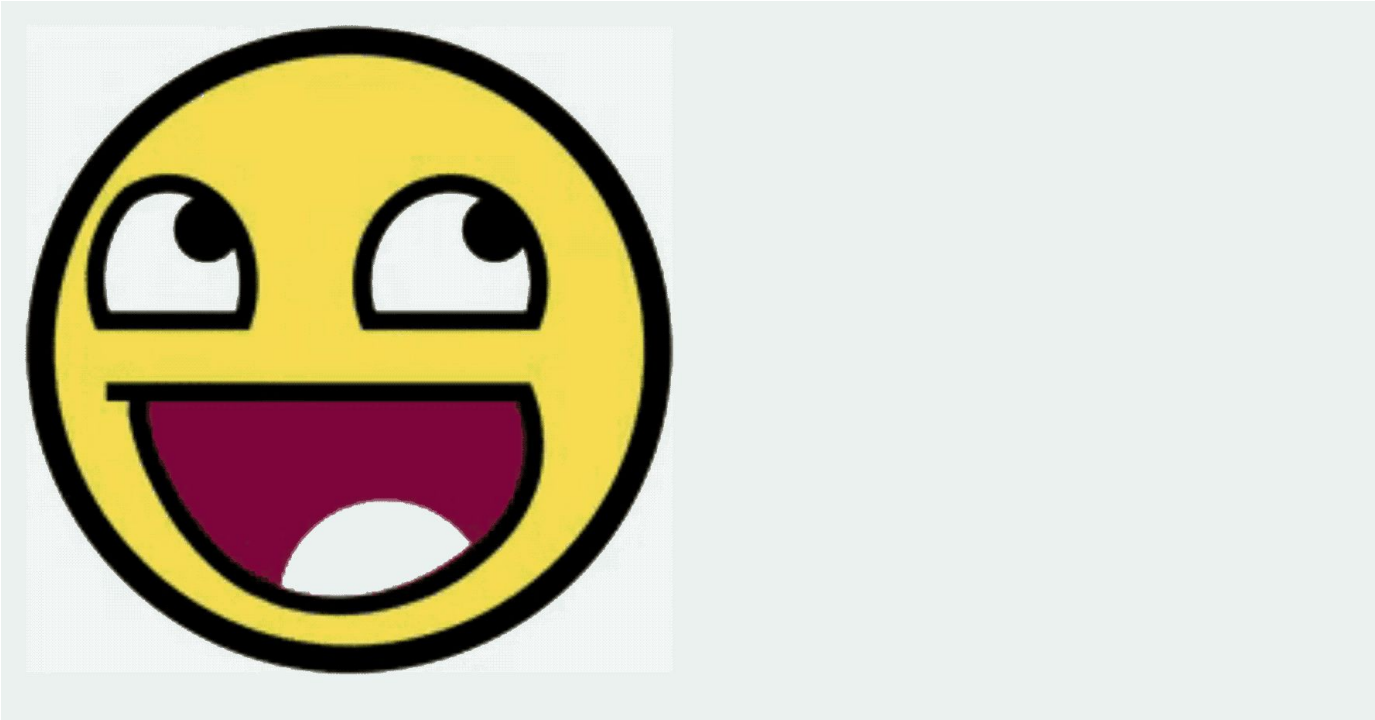
  - `<video>`, `<canvas>`
  - **3D** transforms (*“translateZ hack”*)
  - **composite-only** animations
  - `will-change`

Let's play a game...

```
#transform {
  transform: translateX(150px);
}
setTimeout(() => {
  el.style.transform = 'translateX(0)'
}, 2000)
```

Will it paint?

Yes.



Round 2:

```
#transform { transform: translate3d(150px, 0,0); }


setTimeout(() => {
  el.style.transform = 'translate3d(0, 0, 0)'
}, 2000)
```

Will it paint?

3D transform = layer!

Round 3:

```
@keyframes move {
  0% { left: 0; }
  100% { left: 200px; } }

#transform {
  will-change: left;
  animation: move 2s infinite; }
```

Will it paint?

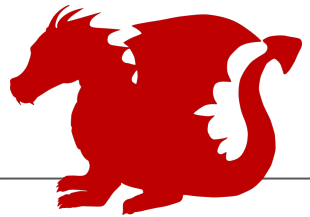
will-change = layer

Elements Cons

will-change.html ×

```
12
13    @keyframes slide {
14      0% {
15        left: 0px;
16      }
17      50% {
18        left: 300px;
19      }
20      100% {
21        left: 0px;
22      }
23    }
24  </style>
25  <img src="cool-yay.jp
26  <script>
27  </script>
28  </body>
29  </html>
```

Will-change & layout



This **only** works if the element isn't in the layout flow

(e.g. `position: absolute`)

Lessons learned

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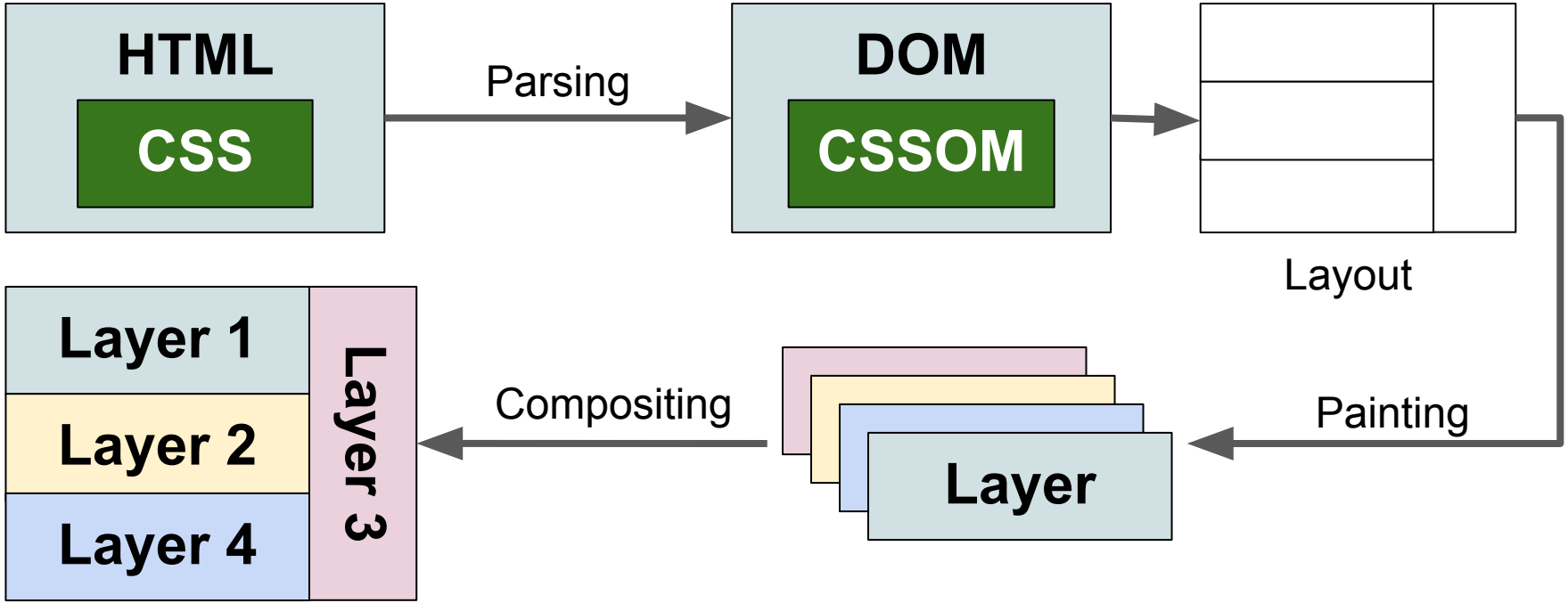
- Layers can help, but be careful
- 3D transforms are composite-only

Putting it together



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- Make critical content **static & inline**
- Minimise **relayout** & **repaint**
- Use **layers** reasonably
- **Measure first**, then optimise

“Performance is the *art of avoiding work*”

- Paul Lewis

спасибо

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HolyJS