Build-time Optimizations in Frontend Engineering

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Frontend used to have no build steps...

Today

Compilation
Infrastructure

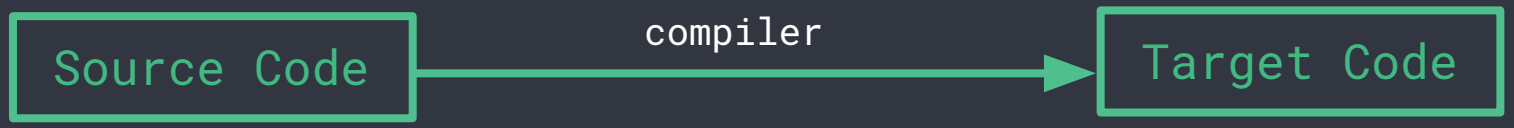
Module
Build Systems

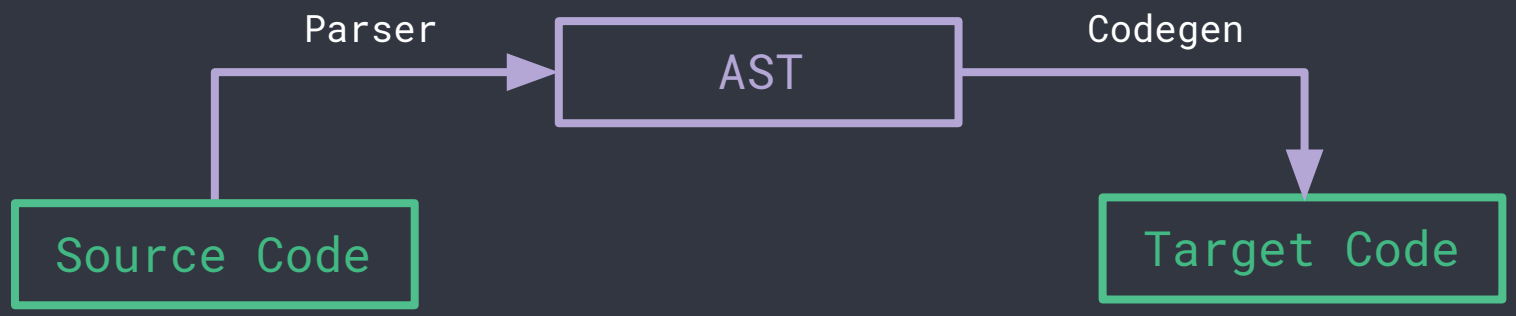
Compile-to-JS
Languages

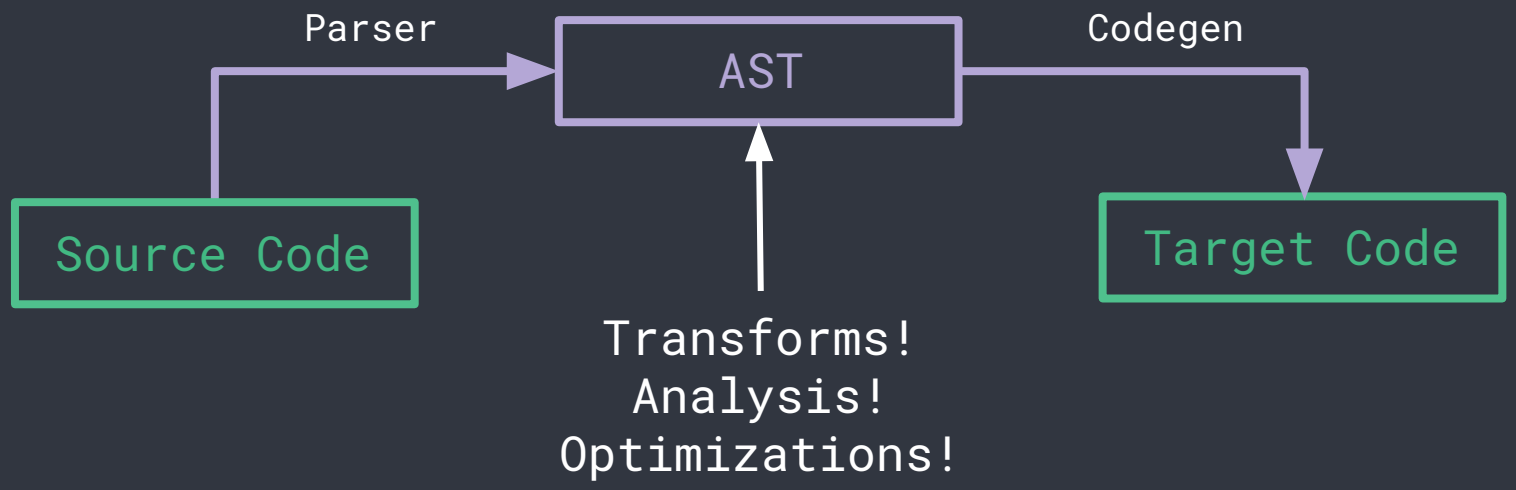
CSS Processors

Make Code Smaller

Minifiers: essentially Compilers


Source Code
compiler
Target Code


Parser
AST
Codegen
Source Code
Target Code


Parser
AST
Codegen
Source Code
Target Code
Transforms!
Analysis!
Optimizations!

Closure Compiler

UglifyJS

Babili

Butternut

Says it's a compiler in its name

Closure Compiler

UglifyJS

Implements its own parser / AST / codegen

Built on top of Babel

Babili

Butternut

Similar architecture to Buble (a lightweight ES2015 compiler)

Early days: concat + minify

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Problem: global scope sucks

Bundlers: let’s use modules

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Problem: modules make things harder to minify

Each module is wrapped inside a separate function scope

```
registerModules([
  function (module, exports) {
    // module 1
  },
  function (module, exports) {
    // module 2
  },
  // ...
])
```

Rollup: use ES modules!

Module Scope Hoisting

main.js

```
import { foo } from './foo.js'
import { bar } from './bar.js'

foo(bar)
```

foo.js

```
export function foo () {
  // ...
}
```

bar.js

```
export const bar = 123
```

Module Scope Hoisting

bundle.js

```
// foo.js
function foo () {
  // ...
}

// bar.js
const bar = 123

// main.js
foo(bar)
```

Treeshaking

bundle.js

```
// foo.js
function foo () {
  // ...
}

// bar.js
const bar = 123

// main.js
// foo(bar)
```

Treeshaking

bundle.js

```
// foo.js
function foo () {
  // ...
}

// bar.js
const bar = 123

// main.js
// foo(bar)
```

unused

unused

Treeshaking

bundle.js

```
// nothing left!
```

Treeshaking

Now also in webpack 3.x via
webpack.optimize.ModuleConcatenationPlugin

Conditional Block Trick

source.js

```
if (process.env.NODE_ENV !== 'production') {
  // code to drop in production build
}
```

Conditional Block Trick

Replaced during build

source.js

```
if ('production' !== 'production') {
  // code to drop in production build
}
```

Conditional Block Trick

source.js

```
if (false) {
  // unreachable
}
```

Conditional Block Trick

source.js

```
// nothing left!
```

Make Code Faster

AOT vs. JIT

Do more at build time

Do less at runtime

Angular / Vue / Glimmer

Pre-compile templates to JavaScript
to avoid runtime compilation cost

React

Optimization via Babel plugins

https://github.com/thejameskyle/babel-react-optimize

Hoisting Static Elements

input

```
class MyComponent extends React.Component {
  render() {
    return (
      <div className={this.props.className}>
        <span>Hello World</span>
      </div>
    );
  }
}
```

output

```
var _ref = <span>Hello World</span>;

class MyComponent extends React.Component {
  render() {
    return (
      <div className={this.props.className}>
        {_ref}
      </div>
    );
  }
}
```

Svelte

Compile everything to vanilla JS with no runtime lib

Initial Render

template

```
<h1>Hello {{name}}!</h1>
```

output

```
// only showing initial render code
h1 = createElement( 'h1' );
text = createText(
  text_value = state.msg
);

insertNode( h1, target, anchor );
appendNode( text, h1 );
```

Updates

template

```
<h1>Hello {{name}}!</h1>
```

output

```
// only showing update code
if (text_value !== (text_value =
state.msg)) {
    text.data = text_value;
}
```

Relay Modern

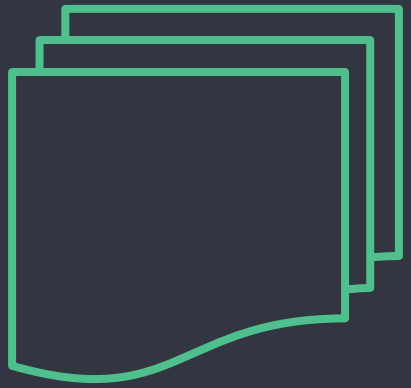
Pre-Compile GraphQL Queries & Schemas

Getting rid of expensive runtime query construction via static build step

GraphQL Query

```
graphql`
  fragment MyComponent on Type {
    field
  }
`
```

Runtime Artifacts & Types



Prepack

Optimize performance via partial evaluation

Partial Evaluation
(moving more computation to build time)

input

```
(function () {
  function fib(x) {
    return x <= 1
      ? x
      : fib(x - 1) + fib(x - 2);
  }
  global.x = fib(23);
})();
```

output

```
(function () {
  x = 28657;
})();
```

Rakt

Application-level optimizations via compilation
(proof of concept)

Compile-time Optimizations in Vue

Hoisting Static Trees

template

```
<div>
  <p class="foo">
    this is static
  </p>
</div>
```

output

```
function render() {
  return this._renderStatic(0)
}
```

Skipping Static Bindings

template

```
<div>
  <p class="foo">
    {{ msg }}
  </p>
</div>
```

output

```
return h("div", [
  h(
    "p",
    { staticClass: "foo" },
    [...]
  )
])
```

Skipping Children Array Normalization

template

```
<ul>
  <li v-for="i in 10">
    {{ i }}
  </li>
</ul>
```

output

```
return h("ul", [
  renderList(10, i => {
    return h("li", i)
  })
], 0) // ← optimization hint
```

SSR: optimizing Virtual DOM
render functions into string concat

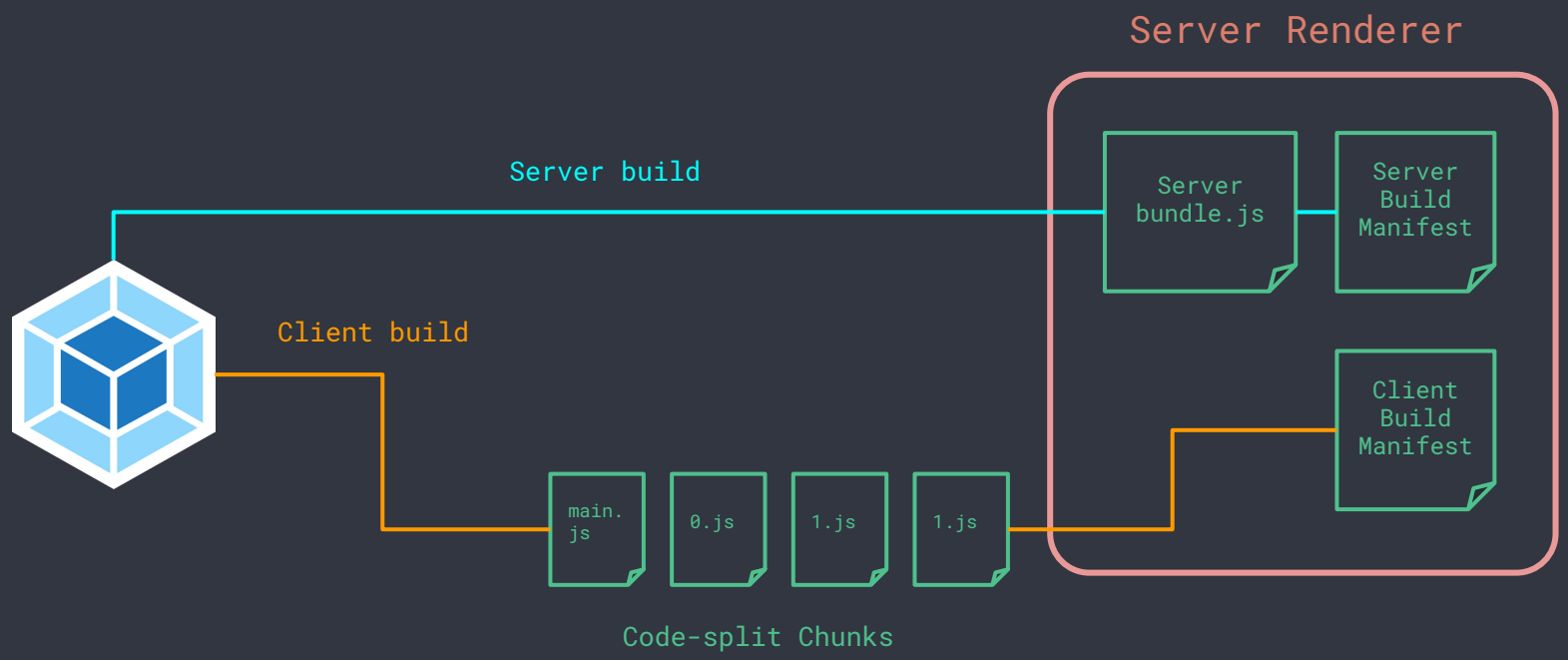
template

```
<div>
  <p class="foo">
    {{ msg }}
  </p>
  <comp></comp>
</div>
```

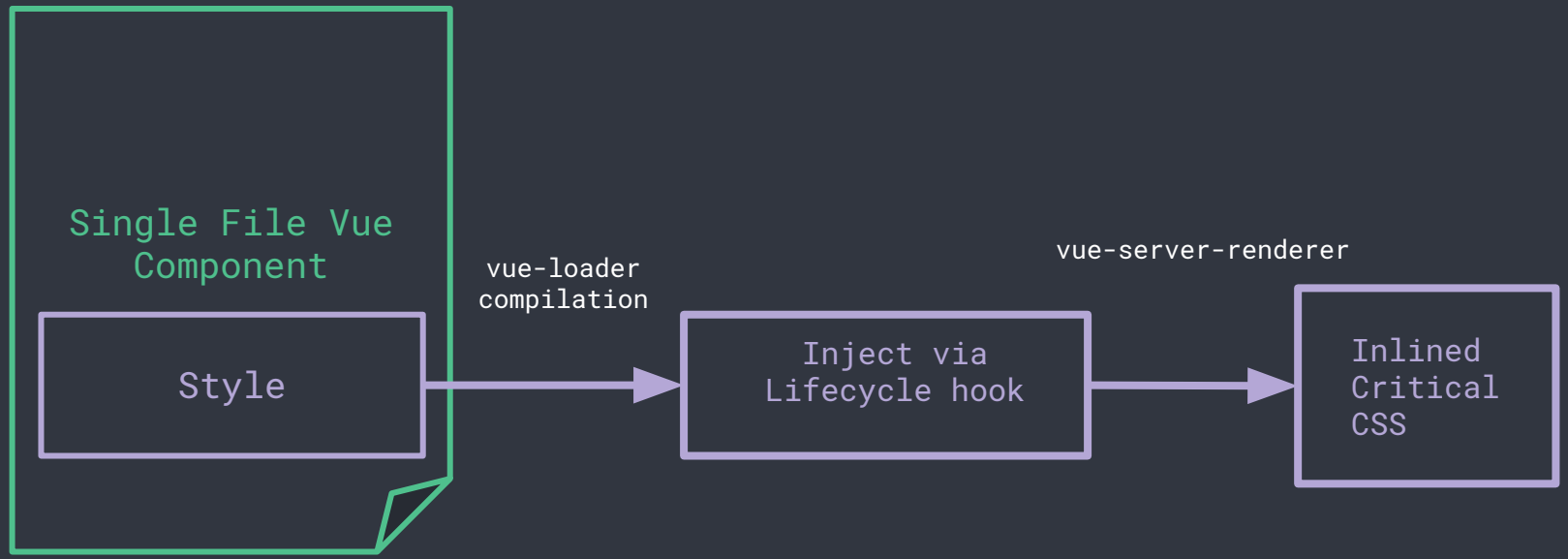
output

```
function render() {
  return h("div", [
    this._ssrString(
      "<p class=\"foo\">" +
      this.msg +
      "</p>"
    ),
    h("comp") // mix w/ vdom
  ])
}
```

SSR: inferring async chunks

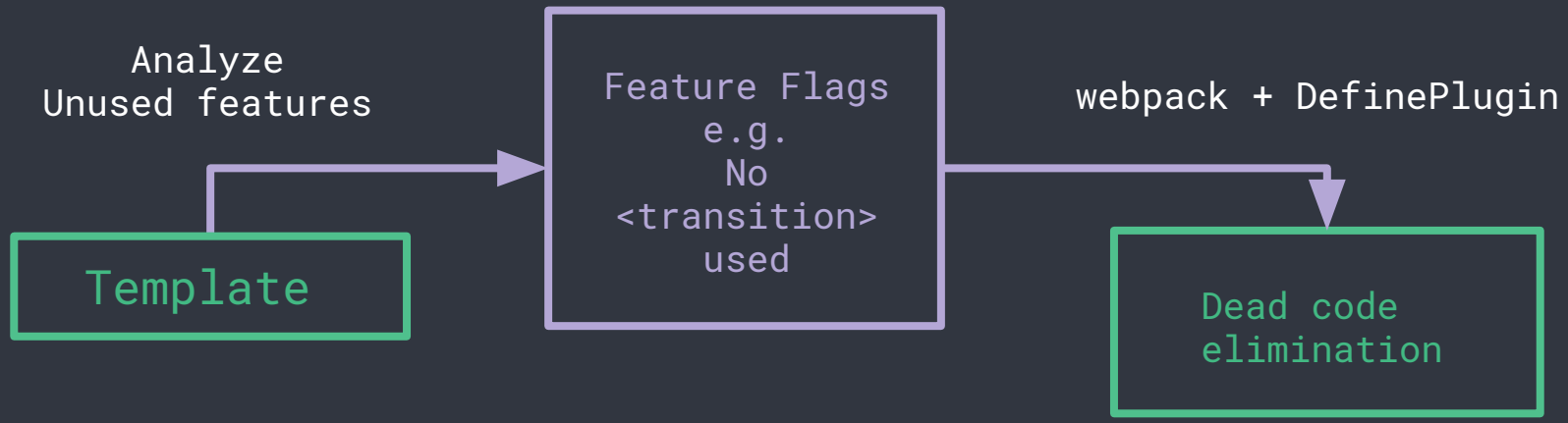


SSR: inlining Critical CSS

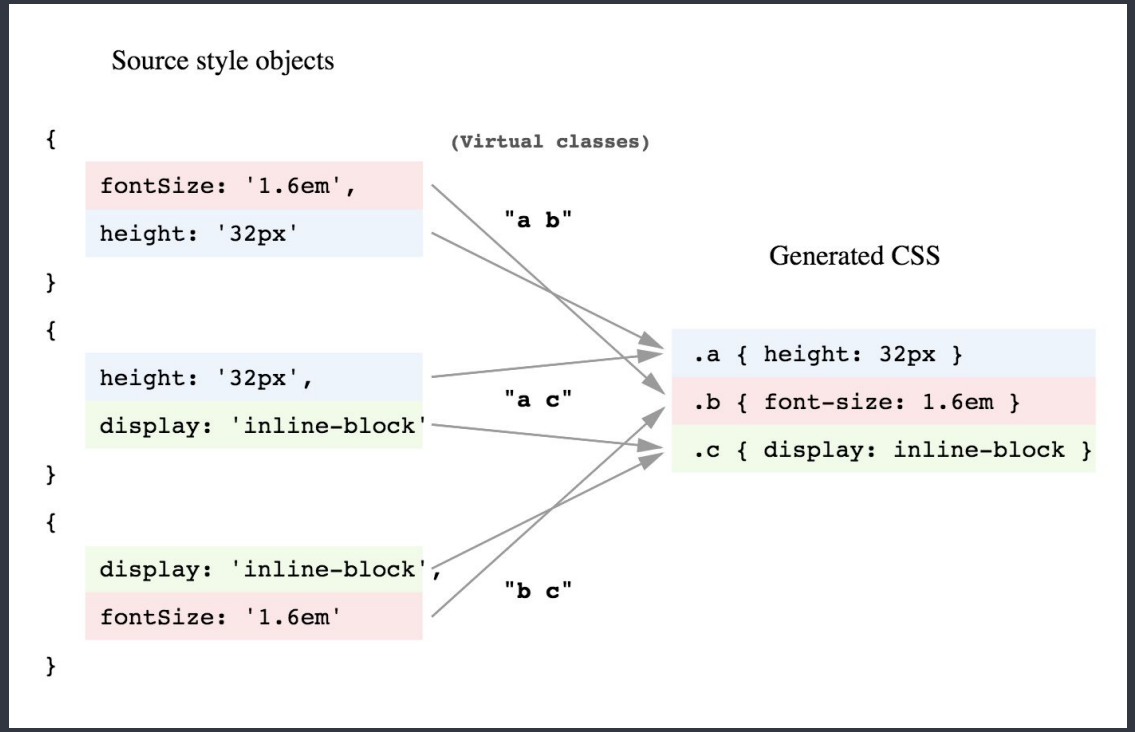


```
<!DOCTYPE html>
<html lang="en">
▼<head>
    <title>Vue HN 2.0 | Top</title>
    <meta charset="utf-8">
    <meta name="mobile-web-app-capable" content="yes">
    <meta name="viewport" content="width=device-width, initial-scale=1, maximum-scale=1, user-
    scalable=no, minimal-ui">
    <link rel="shortcut icon" sizes="48x48" href="/public/logo-48.png">
    <meta name="theme-color" content="#f60">
    <link rel="manifest" href="/manifest.json">
    <link rel="preload" href="/dist/manifest.1e547b25b2af27b910d8.js" as="script">
    <link rel="preload" href="/dist/vendor.e4d69e40768f3a87479f.js" as="script">
    <link rel="preload" href="/dist/app.dd8b3eb63d43f4647423.js" as="script">
    <link rel="preload" href="/dist/common.dd8b3eb63d43f4647423.css" as="style">
    <link rel="preload" href="/dist/1.482045dce837afbcc821.js" as="script">      Async chunks used in SSR
    <link rel="prefetch" href="/dist/0.f1fe6a270f9d53dc7cb2.js" as="script">     Unused async chunks
    <link rel="prefetch" href="/dist/2.560d8fe30d673faffdaa.js" as="script">
    <link rel="stylesheet" href="/dist/common.dd8b3eb63d43f4647423.css">         Extracted common CSS
  ▶<style data-vue-ssr-id="2cf0ef4f:0 2f664187:0">…</style>                      Critical SSR CSS (inlined)
  </head>
▼<body>
  ▶<div id="app">…</div>
  ▶<script>…</script>
    <script src="/dist/manifest.1e547b25b2af27b910d8.js"></script>
…   <script src="/dist/1.482045dce837afbcc821.js"></script> == $0   Async chunks used in SSR
    <script src="/dist/vendor.e4d69e40768f3a87479f.js"></script>
    <script src="/dist/app.dd8b3eb63d43f4647423.js"></script>
    <div data-v-b9f0df9e class="progress" style="width: 0%; height: 2px; background-color: rgb(255,
    202, 43); opacity: 0;"></div>
  </body>
</html>
```

IDEA: compile away parts of Vue that’s not used in your app



IDEA: Styletron-style Atomic CSS generation at build time



The build step affords many more possibilities!

We’ve only scratched the surface