Nick Nisi
THAT Conference 2024

Unleashing TypeScript's Compiler

Adventures in practical code exploration and modification

SPECIAL THANKS TO ALL OUR AWESOME CAMP SPONSORS!

Unspecified

HEARTLAND BUSINESS SYSTEMS

CLOUDFLARE

DATASTAX

Temporal

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PIECES FOR DEVELOPERS

redgate

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AWS Amplify

Who is this talk for?

Software Developers

- TypeScript developers
- Developers interested in Developer Experience (DX)
- Developers facing large refactors
- Anyone who wants to make some **really cool tools!**

typescript.fun/compiler-talk

Talk resources

😠 We’re gonna be using React

But this talk isn’t really about React

- This is a story, and that story uses React
- TypeScript knows all about React/JSX syntax, and that will be a focus of examples
- The core ideas are transferable to any other TypeScript file/app/project

Who am I?

Why am I talking here?

- Software Engineer
- Panelist on JS Party
- Conference Organizer/Emcee
  - NEJS Conf (2015-2019)
  - TypeScript Conf (2018-2022)
- NebraskaJS Organizer
- Avid TypeScript user since 2013

This is a story

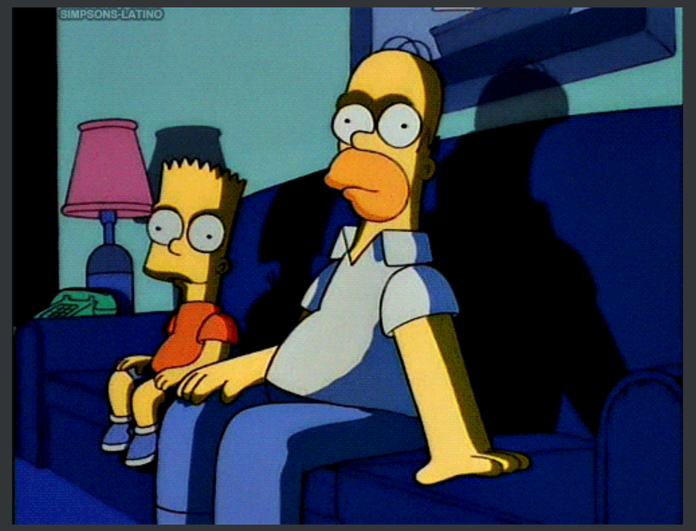
Eternally doomed to strive for laziness

- When I joined my last team, I broke everything on my first PR 
  - Code scanner to find unused i18n keys
    - I didn’t account for statements like `t(keys[name]);` or `t(`core.${name}`);`
- Find untranslated text in an app
- Rewrite tests to use a custom renderer
- Various scripts to analyze and report

Aren’t there better tools?

Maybe.

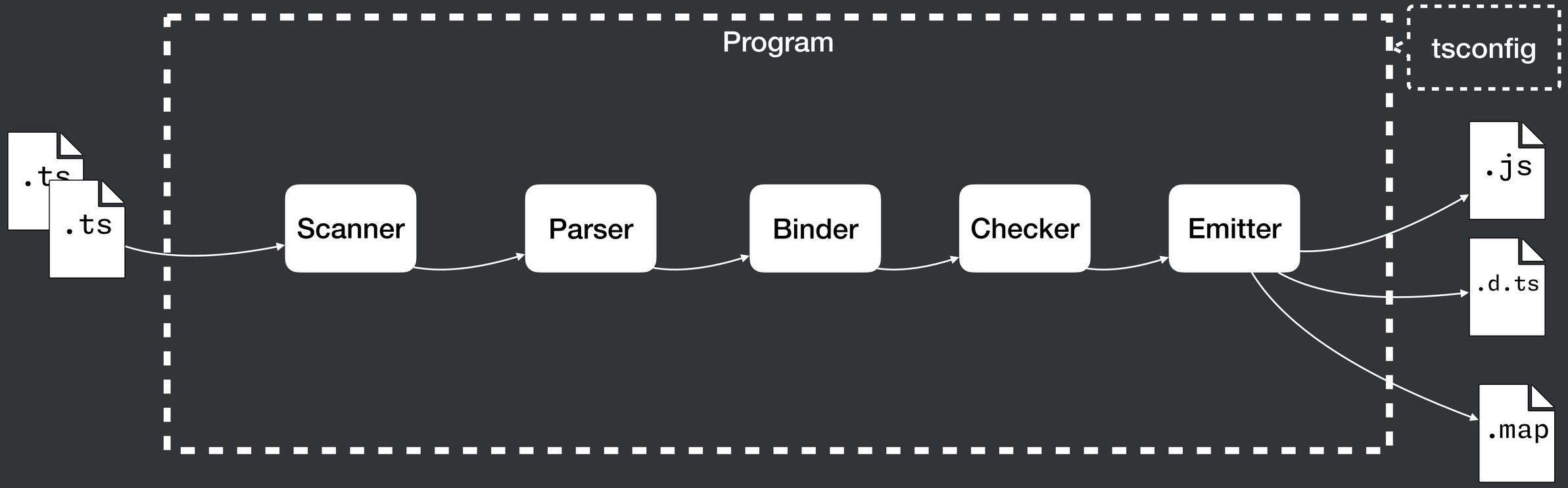
- Used tools like jscodeshift to write codemods. It’s fine.
- Wrote automated upgrader tool for Dojo Toolkit back in the day
- New tools like ast-grep are wonderful for querying and one-offs codemods
- Meanwhile, I wanted to learn more about the **TypeScript compiler**…

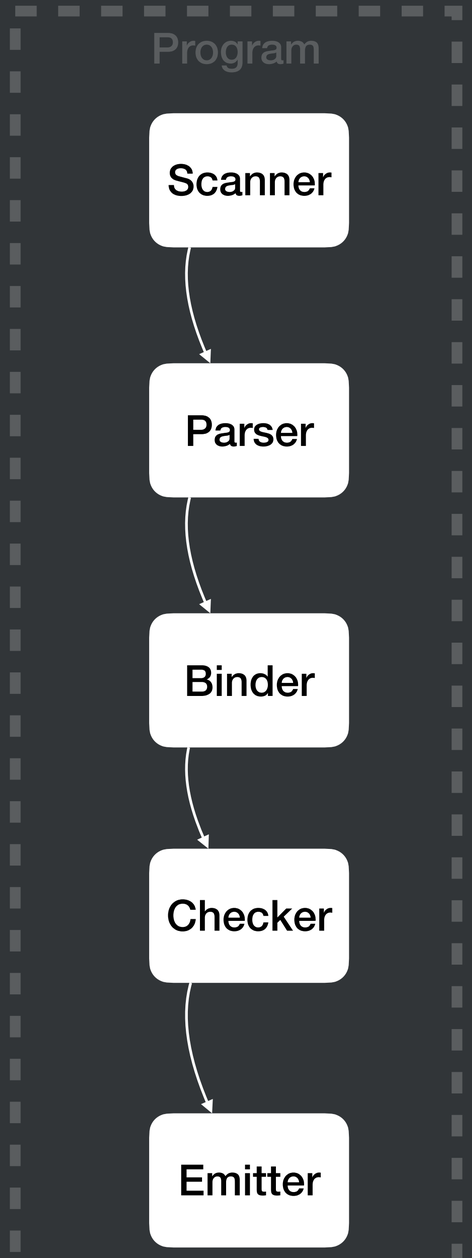


TypeScript Compiler

- **TypeScript** is strongly-typed superset of the JavaScript programing language
  - Adds static types
  - Enhances code quality and developer efficiency by catching errors at compile time and provides for robust developer tooling through a language server
- The **TypeScript Compiler** is a tool that transforms TypeScript into JavaScript code
  - Language Service API
  - Customizing module resolutions

The TypeScript Compiler





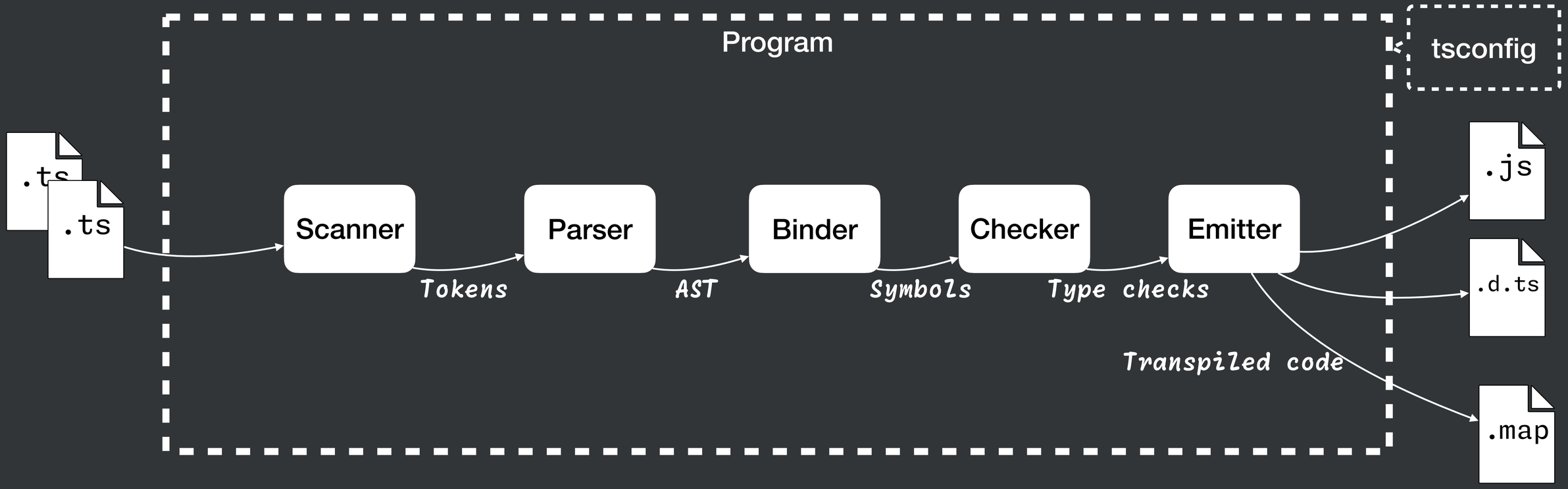
Converts source code into a stream of syntax tokens for the parser

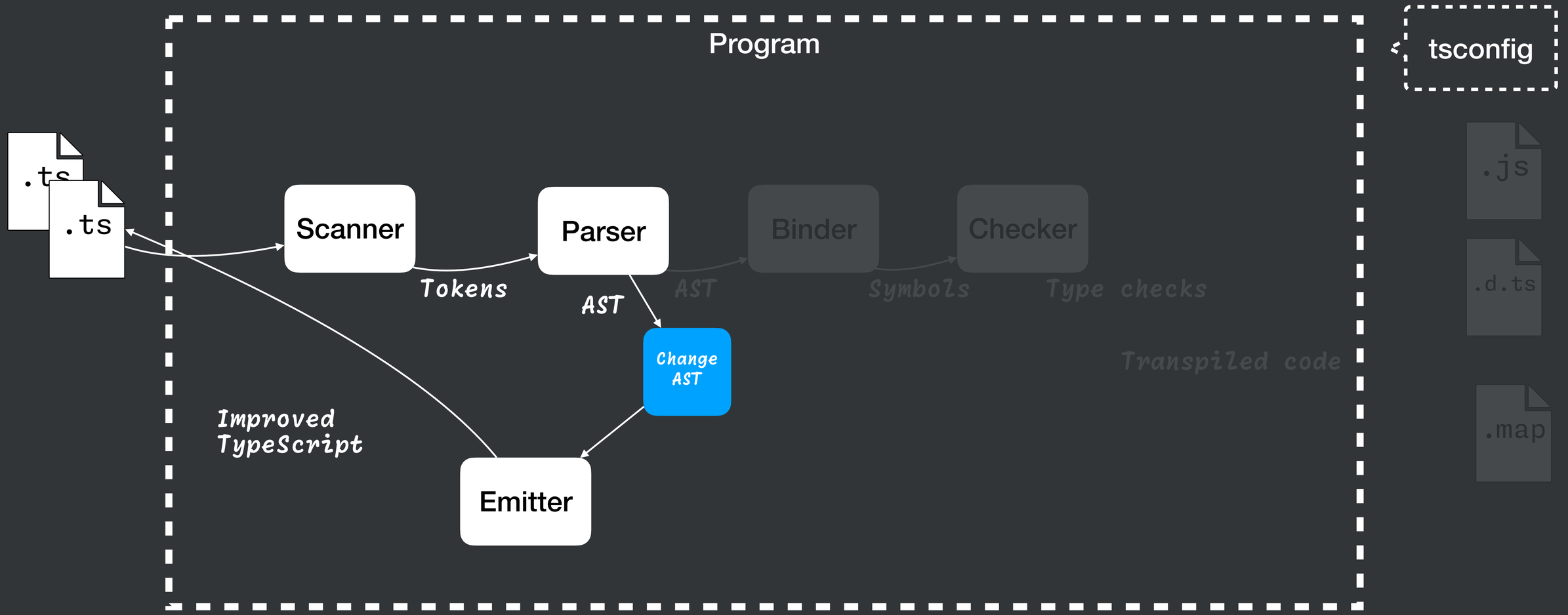
Converts the output of the scanner into an Abstract Syntax Tree (AST)

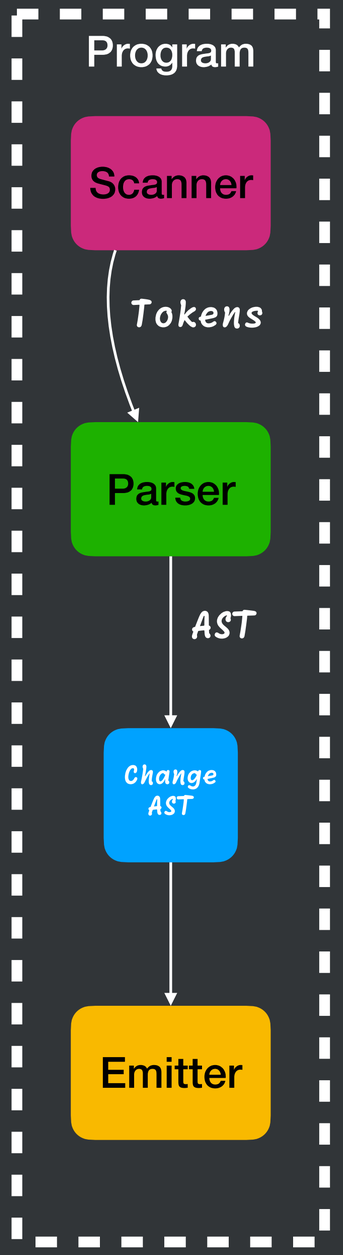
Traverses the AST to enable type checking and control flow

Traverses the AST to perform type checking and ensure code correctness

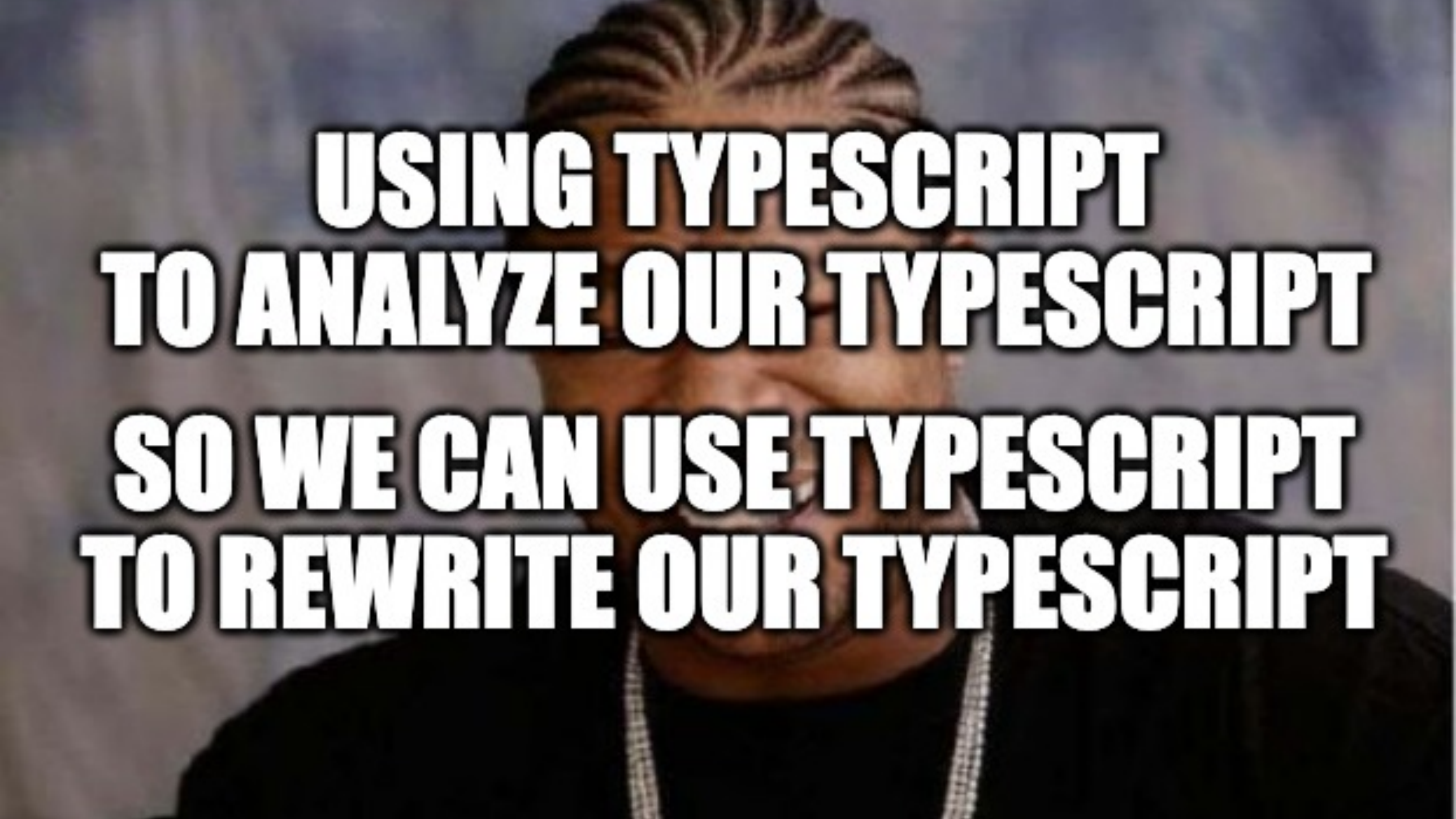
Goes through the AST and emits source code


Program
tsconfig
.ts
.ts
Scanner
Parser
Binder
Checker
Emitter
.js
.d.ts
.map
Tokens
AST
Symbols
Type checks
Transpiled code


Program
tsconfig
.ts
.ts
Scanner
Parser
Binder
Checker
Tokens
AST
AST
Symbols
Type checks
Change AST
Transpiled code
.js
.d.ts
.map
Improved TypeScript
Emitter



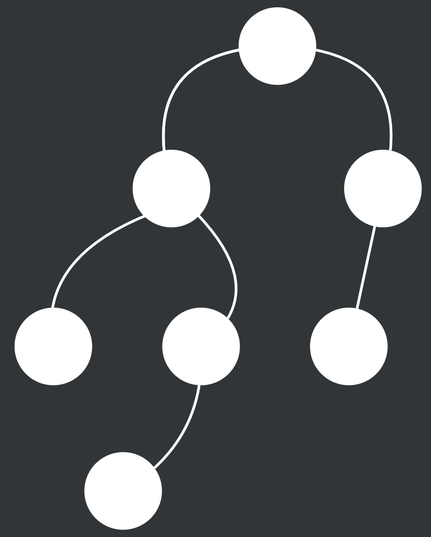

```ts
import { writeFileSync } from "fs";
import ts from "typescript";

const program = ts.createProgram(["main.ts"], {
  module: ts.ModuleKind.ESNext,
  noImplicitAny: true,
});

const rootFileNames = program.getRootFileNames();

for (const rootFileName of rootFileNames) {
  // get the AST
  const ast = program.getSourceFile(rootFileName);

  // … Perform transformations on the AST

  // write out the results
  const printer = ts.createPrinter({ newLine: ts.NewLineKind.LineFeed });
  writeFileSync(rootFileName, printer.printFile(ast));
}
```


USING TYPESCRIPT
TO ANALYZE OUR TYPESCRIPT
SO WE CAN USE TYPESCRIPT
TO REWRITE OUR TYPESCRIPT

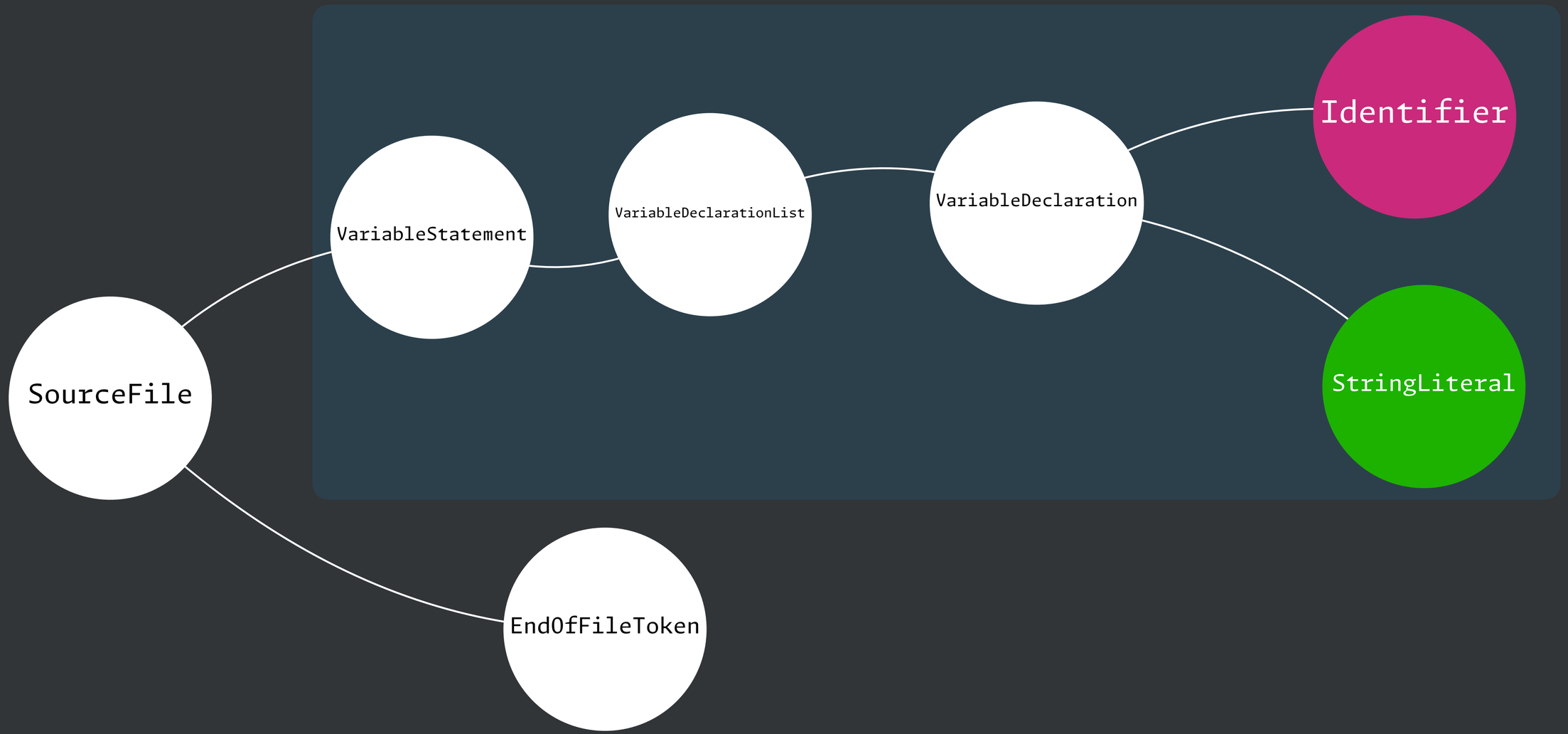
Abstract Syntax Trees

ASTs

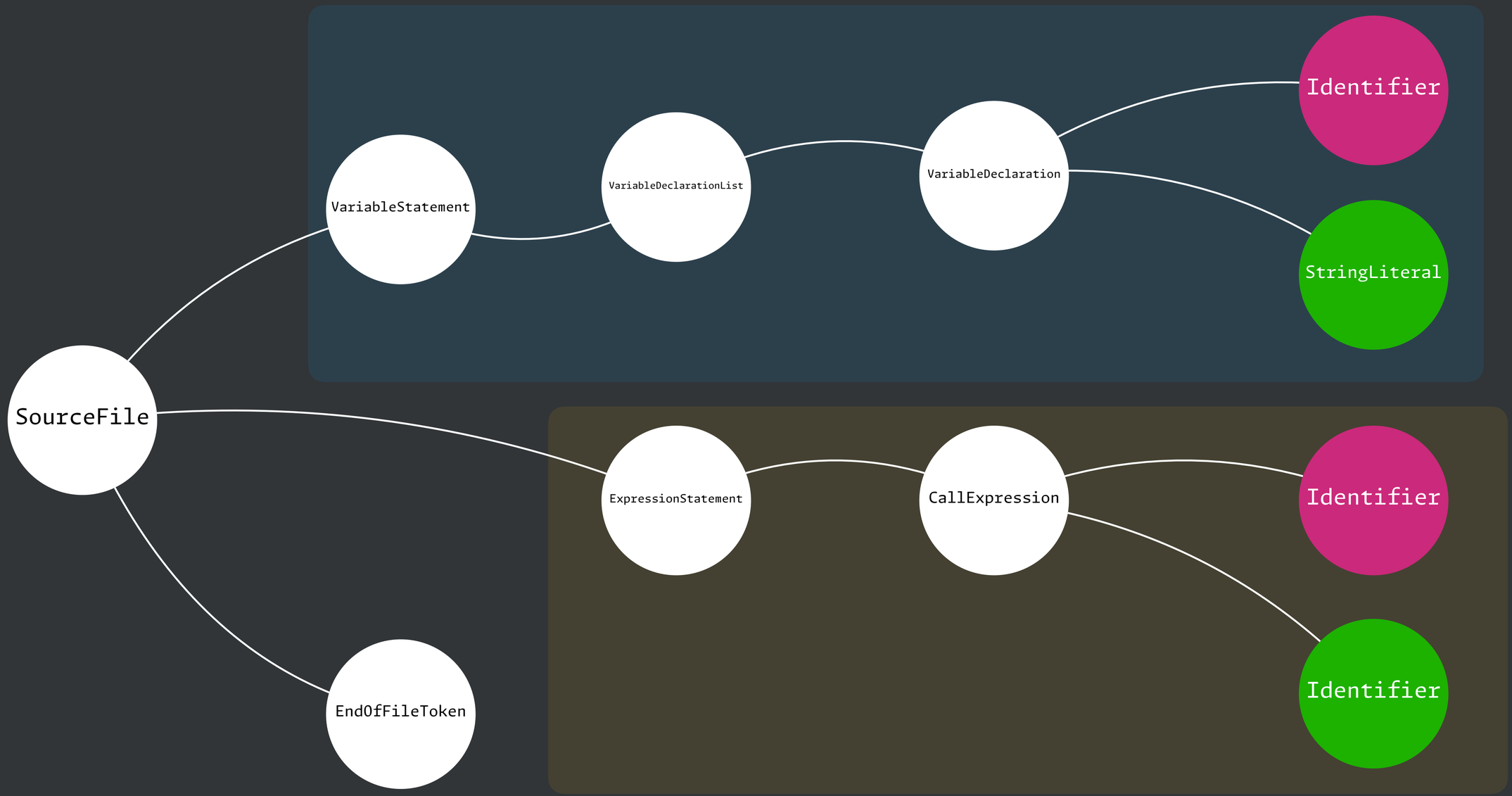
- An intermediate representation of source code as a tree structure
- Starts with a root node that points to other nodes, which point to others…
- Nodes represent constructs occurring in the source code
  - Literals, operators, identifiers
- Edges represent relationships between nodes

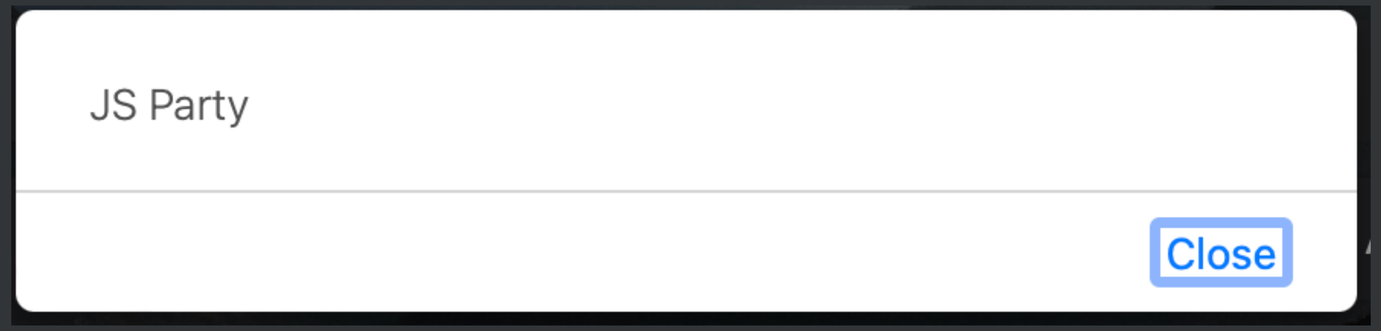


```
const bestPodcast = "JS Party";
```



```
const bestPodcast = "JS Party";
alert(bestPodcast);
```





jsparty.fm

@nicknisi.com

Using ASTs

Why are we looking at ASTs?

Because parsing gets to the root of the code! 🌳

- ASTs let us **find** with precision
  - Find exactly where a function is called
  - Ignore commented-out code
  - Determine what a variable is named and then follow its usage throughout a file
  - Count exactly how many times a function is called in a codebase
- ASTs let us **replace** with precision
  - Change variable names
  - Replace deprecated API calls

We can completely rewrite the code!

Another experiment at work

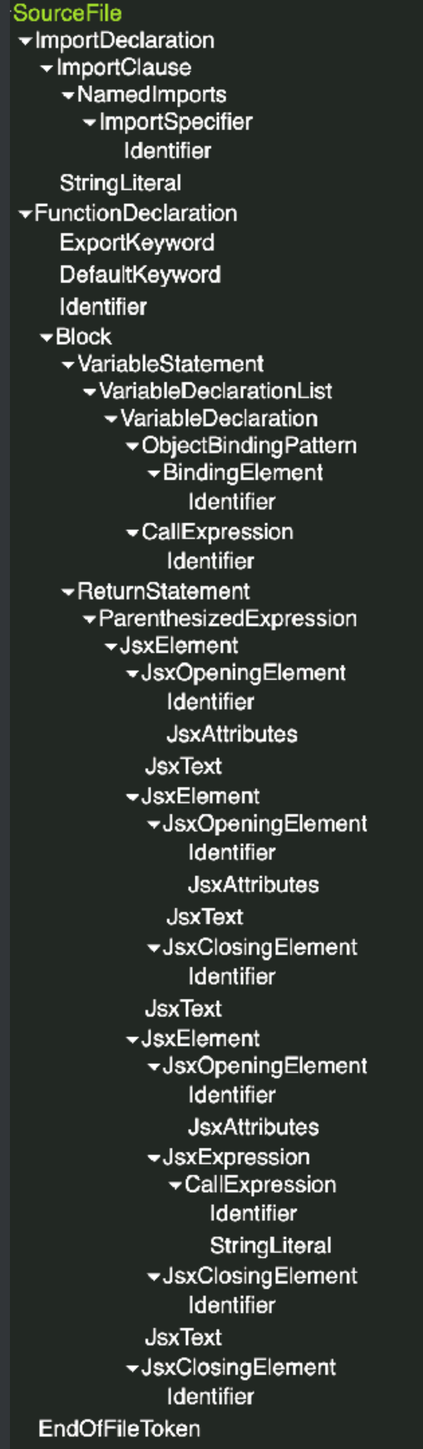
Another attempt at i18n mods

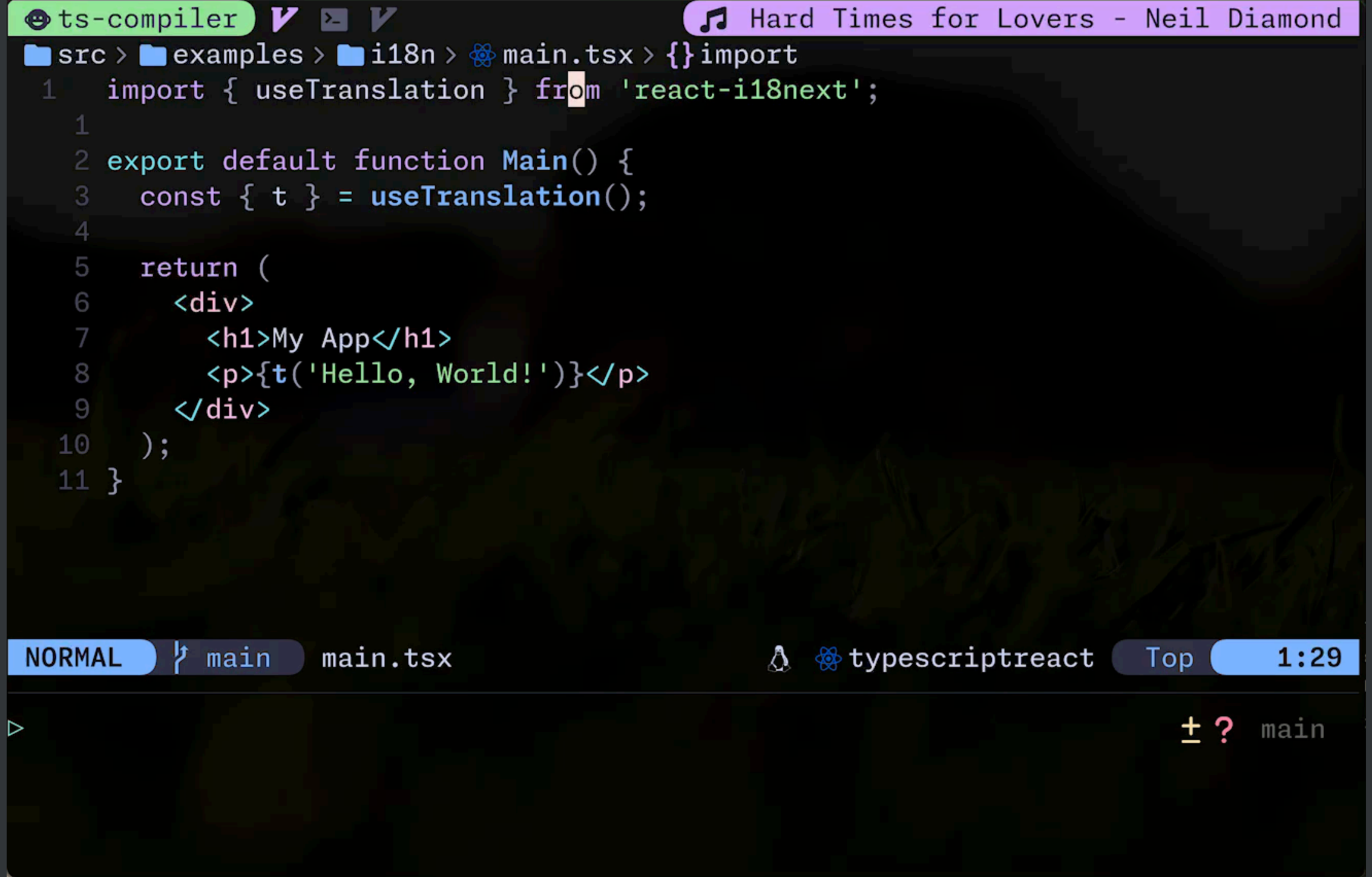
- Find all `JsxText` nodes that aren’t whitespace
- Count them to get an idea of how much of an app isn’t translated
  - Assume that the existence of this text indicates non-translated text
  - Might be an approximation, but the script can be refined and re-run

A simple example: English strings

```tsx
import { useTranslation } from 'react-i18next';

export default function Main() {
  const { t } = useTranslation();

  return (
    <div>
      <h1>My App</h1>
      <p>{t('Hello, World!')}</p>
    </div>
  );
}
```

- Generates 639 lines of AST JSON
- We're specifically interested in `JsxText`, or the "plain English" in the file.
- Not interested in "plain English" passed to the `t` function, for example.




ts-compiler
Hard Times for Lovers - Neil Diamond
src > examples > i18n > main.tsx > {}import
import { useTranslation } from 'react-i18next';
export default function Main() {
const { t } = useTranslation();
return (

<h1>My App</h1>
{t('Hello, World!')}

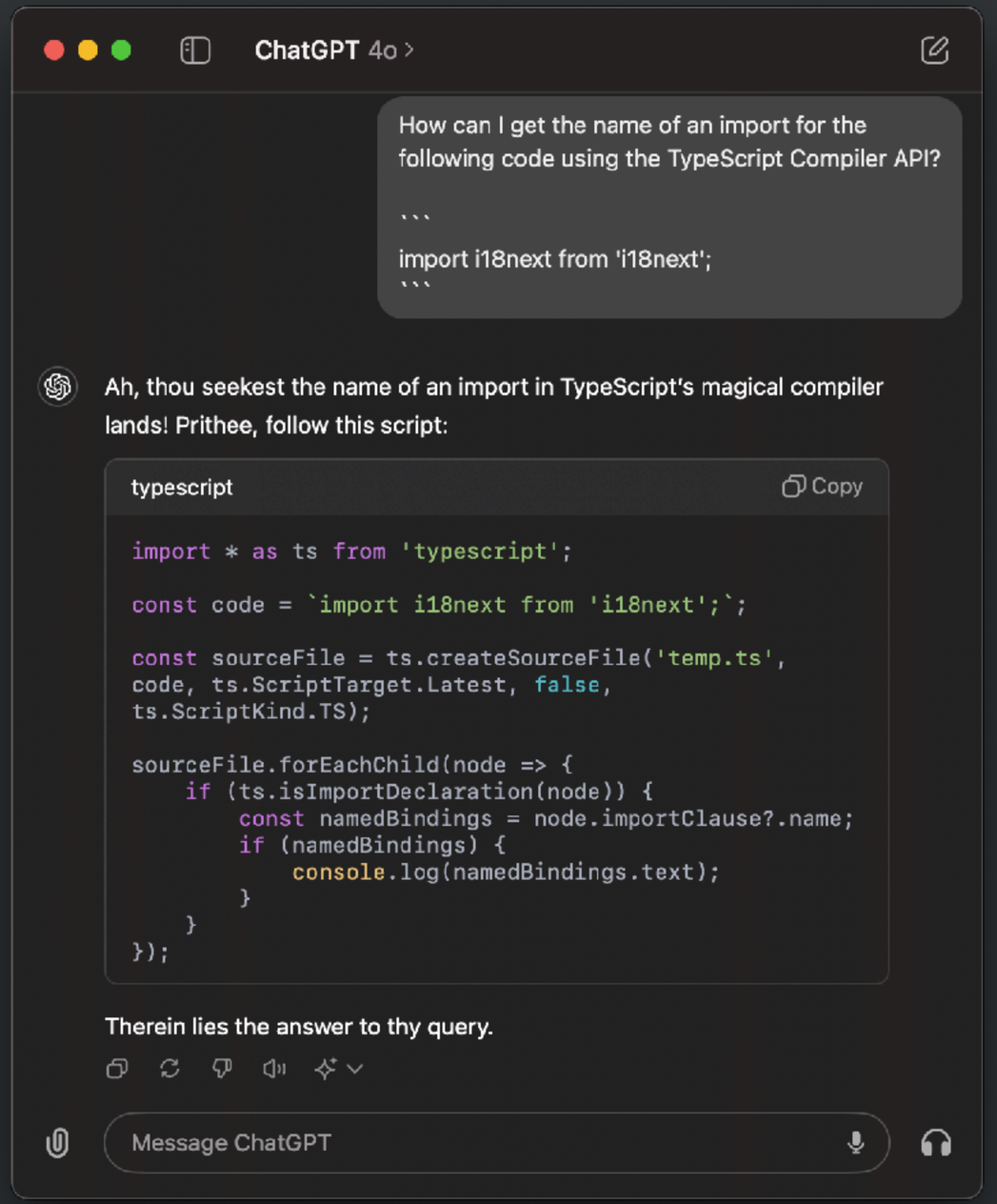
);
}
NORMAL
main
main.tsx
typescriptreact
Top
1:29
main

```ts
import ts from 'typescript';

function getDescendantsOfKind<T extends ts.Node>(node: ts.Node, kind: ts.SyntaxKind): T[] {
  const descendants: T[] = [];

  function visit(node: ts.Node) {
    if (node.kind === kind) {
      descendants.push(node as T);
    }
    ts.forEachChild(node, visit);
  }

  visit(node);
  return descendants;
}

const clean = (text: string) => text.replace(/[.,\/#!$%\^&\*;:{}=\-_~()]/g, '').trim();

const program = ts.createProgram(['src/examples/i18n/main.tsx'], {
  module: ts.ModuleKind.ESNext,
  jsx: ts.JsxEmit.React,
  target: ts.ScriptTarget.ESNext,
});

const filename = program.getRootFileNames()[0]!;
const ast = program.getSourceFile(filename)!;
const texts = getDescendantsOfKind<ts.JsxText>(ast, ts.SyntaxKind.JsxText).filter({text} => clean(text));
texts.forEach(text => console.log(`JSX Text: ${text.text}`));
```

(We'll talk about simplifying this with ts-morph later)

Getting help with ASTs

- ASTExplorer
- TS AST Viewer
- ChatGPT is actually pretty good at it




AST Explorer
Snippet
JavaScript
typescript
Transform
default
Parser: typescript-5.0.4
1 const bestPodcast = "JS Party";
2 alert(bestPodcast);
Tree
JSON
1ms
{
"pos": 0,
"end": 51,
"flags": 0,
"modifierFlagsCache": 0,
"transformFlags": 4457472,
"kind": 308,
"statements": [
{
"pos": 0,
"end": 31,
"flags": 0,
"modifierFlagsCache": 0,
"transformFlags": 4457472,
"parent": "[Circular ~]",
"kind": 240,
"declarationList": {
"pos": 0,
"end": 30,
"flags": 2,
"modifierFlagsCache": 0,
"transformFlags": 4457472,
"parent": "[Circular ~.statements.0]",
"kind": 258,
"declarations": [
{
"pos": 5,
"end": 30,
Built with React, Babel, Font Awesome, CodeMirror, Express, and webpack | GitHub | Build: 8888701

What other tools use ASTs?

- Language Servers
  - typescript-language-server
- Editors for syntax
  - treesitter
- Formatters
  - Prettier
  - Biome
- Linters
  - ESLint

Understanding ASTs is crucial to enable powerful code analysis and transformations that enhance our everyday development tools.



Biome


Mo’ MUI Mo’ Problems

Muy MUI Problems - let’s get back to the story

- 🙈 Our main app is written in TS and React, using Material-UI v4.x
- 👴 MUI 4 is using old versions of everything (TypeScript 3 😱, React 16 😱)
- 💄 MUI 4 uses JSS, MUI 5 is emotion
- 🌝 We were sowing wild oats, experimenting with things like RSC and Next.js
- 🍹 We have also tasted the Tailwind Kool-Aid 😋

How do we justify the work?


Tailwind
is great
CHANGE MY MIND
imgflip.com

Analyze first

We need to know what we’re getting into

Analyzing a codebase

- Create a list of all files that are using MUI components
- Get a list of MUI components used in those files, sorted by most used
- Make a reporting tool to provide data about the number of component changes that can be automated away
  - Help determine that `<Grid />` and `<Box />` usage is high in all components

```ts
let used = 0;
files.forEach(file => {
  const source = readFile(join(MAIN_PATH, file), 'utf8');
  const ast = ts.createSourceFile(file, source, ts.ScriptTarget.Latest, true);
  ts.forEachChild(ast, node => {
    if (node.kind === ts.SyntaxKind.ImportDeclaration) {
      const importDeclaration = node as ts.ImportDeclaration;
      const importPath = importDeclaration.moduleSpecifier.getText();
      if (importPath === "'@material-ui/core'") {
        ++used;
      }
    }
  });
});
```

```
▷ pnpm analyze                                                    main *

> ts-compiler-api-talk@1.0.0 analyze /Users/nicknisi/Developer/ts-compiler-api-talk
> node --import=tsimp/import scripts/bin/analyze.ts

Here's the total usage I found, per component exported by '@material-ui/core':

Total usage per component:


Component     | Count
------------- | -----
Box           | 3
Grid          | 2
ThemeProvider | 1
SvgIcon       | 1


Overall, there are 7 components imported from "@material-ui/core" across the app.

Per-component breakdown:


File                         | Count
---------------------------- | -----
src/components/ProTip.tsx    | 3
src/components/Copyright.tsx | 2
src/main.tsx                 | 1
src/App.tsx                  | 1



Material UI components are used in 80% (4 of 5) of the components in the app.

~/Developer/ts-compiler-api-talk  v20.10.0
▷                                                                 main *
```

Reality check

What was the run like in the real repo?

- `<Box />` imported in 273 of 654 files and used 670 times
- `<Grid />` imported in 114 of 654 files and used 430 times

😱 **A single developer writing a single script to focus on just these two components to start can do 39% of the conversion by themselves.**

Making modifications

Say hello to my little friend

- Use the TS Compiler API to rewrite our own TS, back to the files
- Formatting can be lost, but easy to pair with a Prettier run to fix
- Search for `<Grid />` and `<Box />` components and replace them with Tailwind divs

ts-morph

Wrap the TS Compiler API to simplify working with it

- Wrapper around TS Compiler API to simplify working with it
- One downside of transforming with the TS Compiler API:
  - Generating new nodes to replace existing ones can be tedious
- ts-morph simplifies project setup
- Helpers for finding nodes
- Traversal control (up, down, skip)
- Element wrapper provides a `replaceWithText` to simplify new node generation

Let’s create a reusable converter

- Convert layout components to divs with Tailwind classes
- Properly handle dynamic expressions
- Clean up unused imports

```
▷ npx convert -o                                          main
projectRoot: /Users/nicknisi/Developer/ts-compiler-api-talk
/
glob: /Users/nicknisi/Developer/ts-compiler-api-talk/src/**
/*.tsx

Converting <Box/> components...

Converting <Grid/> components...

Organizing imports...


🚀 Converted 13 elements across 5 files

~/Developer/ts-compiler-api-talk  v20.10.0
▷                                                         ± main
```

1467 elements across 654 files (in a real project)

src/components/ProTip.tsx

```
1:
```

```
1  import { Box, Grid, SvgIcon, type SvgIconProps } from '@material-ui/core';
   1  import { SvgIcon, type SvgIconProps } from '@material-ui/core';
2  2  import { useTranslation } from 'react-i18next';
3  3
4  4  function LightBulbIcon(props: SvgIconProps) {
```

```
12: function LightBulbIcon(props: SvgIconProps) {
```

```
12 12 export default function ProTip() {
13 13         const { t } = useTranslation();
14 14         return (
15            <Box mt={6} mb={3} color="secondary">
16              <Grid container direction="column" alignItems="center" justifyContent="center">
17                <Grid item>
   15           <div className="text-secondary mb-3 mt-6">
   16             <div className="items-center flex flex-wrap flex-col justify-center">
   17               <div className="flex-auto box-border">
18 18                <LightBulbIcon />
19               </Grid>
20               <Grid item container direction="row" spacing={2} alignItems="center">
21                 <Grid item>
22                   <Box color="secondary">
   19             </div>
:
```

```ts
export abstract class Converter {
  /**
   * Create a Converter class with a given prop lookup
   */
  static createConverter({ baseClasses = [], lookup }: CreateConverterOptions) {}
  /**
   * The base attributes that can be found on components and should be copied over, verbatim to the new component.
   */
  static readonly baseAttributes = [] as const;

  constructor(element: JsxElement | JsxSelfClosingElement): Converter;

  /**
   * The base classes that should be added to every component that is converted
   */
  abstract lookup: PropLookup;
  /**
   * A list of base classes that should be added to every component that is converted
   */
  protected readonly baseClasses: string[] = [];
  /**
   * Convert the element into a new element string with the appropriate classes and props
   * @returns The new element string
   */
  convert(): string {}
}
```

The `Grid` component

Flexbox grid component in Material-UI

```
<Grid container spacing={1}>
  <Grid item>
    <a href="https://nicknisi.com">{t('core.copyright')}</a>
  </Grid>
  <Grid item>{year}</Grid>
</Grid>
```

```
<div className="flex flex-wrap gap-1">
  <div className="flex-auto box-border">
    <a href="https://nicknisi.com">{t('core.copyright')}</a>
  </div>
  <div className="flex-auto box-border">{year}</div>
</div>
```

Conversion Steps

- Convert the element into a list of props
- Convert each prop into a class string or a complex class expression
- Get a list of additional props
- Construct a new `<div>`
  - Add the new `className`
  - Add remaining props back (`data-test-id` or `key`, for example)

```ts
export default Converter.createConverter({
  baseClasses: [],
  lookup: {
    alignContent: "content",
    alignItems: "items",
    container: () => "flex flex-wrap",
    direction: (_name, value) =>
      value ? `flex-${value.replace(/column/, "col")}` : "",
    item: "flex-auto box-border",
    justify: "justify",
    justifyContent: "justify",
    lg: calculateWidth,
    md: calculateWidth,
    sm: calculateWidth,
    xl: calculateWidth,
    xs: calculateWidth,
    spacing: "gap",
    wrap: "flex-wrap",
    zeroMinWidth: (_name, value) => (value === "true" ? "min-w-0" : ""),
    color: "text",
  },
});
```

Note: this is not an exhaustive list of all `<Grid>` props, only what's used in the project. I checked 😉

```ts
convert(){
  const { attribute } = this;
  let twClass: string = "";
  const initializer = attribute.getInitializer();

  if (!initializer) {
    // this is a boolean prop
    twClass = this.runTransform(undefined);
  } else if (initializer?.isKind(SyntaxKind.StringLiteral)) {
    twClass = this.runTransform(initializer.getLiteralValue());
  } else if (initializer?.isKind(SyntaxKind.JsxExpression)) {
    const expression = initializer.getExpression();

    if (expression?.isKind(SyntaxKind.ObjectLiteralExpression)) {
      twClass = Object.entries(getProperties(expression))
        .map(([key, value]) => `${key}:${this.runTransform(value)}`)
        .join(" ");
    } else if (expression?.isKind(SyntaxKind.ConditionalExpression)) {
      this.isComplexClass = true;
      twClass = this.transformConditionalExpression(expression);
    } else {
      twClass = this.runTransform(expression?.getText());
    }
  }

  return twClass;
}
```

```
convert(){
  const { attribute } = this;
  let twClass: string = "";
  const initializer = attribute.getInitializer();

  if (!initializer) {
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      this.isComplexClass = true;
      twClass = this.transformConditionalExpression(expression);
    } else {
      twClass = this.runTransform(expression?.getText());
    }
  }

  return twClass;
}
```

```
<Grid container />
```

```
convert(){
  const { attribute } = this;
  let twClass: string = "";
  const initializer = attribute.getInitializer();

  if (!initializer) {
    // this is a boolean prop
    twClass = this.runTransform(undefined);
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        .join(" ");
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      this.isComplexClass = true;
      twClass = this.transformConditionalExpression(expression);
    } else {
      twClass = this.runTransform(expression?.getText());
    }
  }

  return twClass;
}
```

```
<Grid direction="row" />

-> this.runTransform("row");
```

```ts
convert(){
  const { attribute } = this;
  let twClass: string = "";
  const initializer = attribute.getInitializer();

  if (!initializer) {
    // this is a boolean prop
    twClass = this.runTransform(undefined);
  } else if (initializer?.isKind(SyntaxKind.StringLiteral)) {
    twClass = this.runTransform(initializer.getLiteralValue());
  } else if (initializer?.isKind(SyntaxKind.JsxExpression)) {
    const expression = initializer.getExpression();

    if (expression?.isKind(SyntaxKind.ObjectLiteralExpression)) {
      twClass = Object.entries(getProperties(expression))
        .map(([key, value]) => `${key}:${this.runTransform(value)}`)
        .join(" ");
    } else if (expression?.isKind(SyntaxKind.ConditionalExpression)) {
      this.isComplexClass = true;
      twClass = this.transformConditionalExpression(expression);
    } else {
      twClass = this.runTransform(expression?.getText());
    }
  }

  return twClass;
}
```

```tsx
<Box p={{
  sm: 2,
  md: 4
}} />
```

```
convert(){
  const { attribute } = this;
  let twClass: string = "";
  const initializer = attribute.getInitializer();

  if (!initializer) {
    // this is a boolean prop
    twClass = this.runTransform(undefined);
  } else if (initializer?.isKind(SyntaxKind.StringLiteral)) {
    twClass = this.runTransform(initializer.getLiteralValue());
  } else if (initializer?.isKind(SyntaxKind.JsxExpression)) {
    const expression = initializer.getExpression();

    if (expression?.isKind(SyntaxKind.ObjectLiteralExpression)) {
      twClass = Object.entries(getProperties(expression))
        .map(([key, value]) => `${key}:${this.runTransform(value)}`)
        .join(" ");
    } else if (expression?.isKind(SyntaxKind.ConditionalExpression)) {
      this.isComplexClass = true;
      twClass = this.transformConditionalExpression(expression);
    } else {
      twClass = this.runTransform(expression?.getText());
    }
  }

  return twClass;
}
```

```
<Grid direction={
  isMobile ?
  ? 'row'
  : 'column' }
/>
```

```ts
convert(){
  const { attribute } = this;
  let twClass: string = "";
  const initializer = attribute.getInitializer();

  if (!initializer) {
    // this is a boolean prop
    twClass = this.runTransform(undefined);
  } else if (initializer?.isKind(SyntaxKind.StringLiteral)) {
    twClass = this.runTransform(initializer.getLiteralValue());
  } else if (initializer?.isKind(SyntaxKind.JsxExpression)) {
    const expression = initializer.getExpression();

    if (expression?.isKind(SyntaxKind.ObjectLiteralExpression)) {
      twClass = Object.entries(getProperties(expression))
        .map(([key, value]) => `${key}:${this.runTransform(value)}`)
        .join(" ");
    } else if (expression?.isKind(SyntaxKind.ConditionalExpression)) {
      this.isComplexClass = true;
      twClass = this.transformConditionalExpression(expression);
    } else {
      twClass = this.runTransform(expression?.getText());
    }
  }

  return twClass;
}
```

```tsx
<Box p={2} />
```

Tips and Takeaways

- The code can be a little dense. ChatGPT is actually pretty good at finding nodes
- You only have to handle the cases in your code base. `analyze` to find those
- Encourage your team to run them as they are making other changes
  - Breaks up conversions into much smaller diffs
  - More likely to actually get reviewed 😉
  - Write tests for your codemods
    - Iteration becomes much faster
- For one-off queries/mods, check out ast-grep

Experiment and iterate

Thanks!

typescript.fun/compiler-talk

- Freelance TypeScript Enthusiast at dilemmas.dev
- Check out JS Party
- @nicknisi on everything social

Talk resources

Questions?