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1.抽象语法树(Abstract Syntax Tree)

`webpack`和`Lint`等很多的工具和库的核心都是通过`Abstract Syntax Tree`抽象语法树这个概念来实现对代码的检查、分析等操作的

- 通过了解抽象语法树这个概念，你也可以随手编写类似的工具

2.抽象语法树用途

- 代码语法的检查、代码风格的检查、代码的格式化、代码的高亮、代码错误提示、代码自动补全等等
  - 如JSLint、JSHint对代码错误或风格的检查，发现一些潜在的错误
  - IDE的错误提示、格式化、高亮、自动补全等等
- 代码混淆压缩
  - UglifyJS2等
- 优化变更代码，改变代码结构使达到想要的结构
  - 代码打包工具webpack、rollup等等
  - CommonJS、AMD、CMD、UMD等代码规范之间的转化
  - CoffeeScript、TypeScript、JSX等转化为原生Javascript

3.抽象语法树定义

这些工具的原理都是通过`JavaScript Parser`把代码转化为一颗抽象语法树（AST），这颗树定义了代码的结构，通过操纵这颗树，我们可以精准的定位到声明语句、赋值语句、运算语句等等，实现对代码的分析、优化、变更等操作

> 在计算机科学中，抽象语法树（abstract syntax tree或者缩写为AST），或者语法树（syntax tree），是源代码的抽象语法结构的树状表现形式，这里特指编程语言的源代码。

> Javascript的语法是为了给开发者更好的编程而设计的，但是不适合程序的理解。所以需要转化为AST来使之更适合程序分析，浏览器编译器一般会把源码转化为AST来进行进一步的分析等其他操作。

4.JavaScript Parser

- JavaScript Parser，把js源码转化为抽象语法树的解析器。
- 浏览器会把js源码通过解析器转为抽象语法树，再进一步转化为字节码或直接生成机器码。
- 一般来说每个js引擎都会有自己的抽象语法树格式，Chrome的v8引擎，firefox的SpiderMonkey引擎等等，MDN提供了详细SpiderMonkey AST format的详细说明，算是业界的标准。

4.1 常用的JavaScript Parser

- esprima
- traceur
- acorn
- shift

4.2 esprima

- 通过esprima (https://www.npmjs.com/package/esprima) 把源码转化为AST
- 通过estraverse (https://www.npmjs.com/package/estraverse) 遍历并更新AST
- 通过escodegen (https://www.npmjs.com/package/escodegen) 将AST重新生成源码
- astexplorer (https://astexplorer.net/) AST的可视化工具

```
mkdir zhufengast
cd zhufengast

cnpm i esprima estraverse escodegen- S
```

```
let esprima = require('esprima');
var estraverse = require('estraverse');
var escodegen = require("escodegen");
let code = 'function ast(){}';
let ast=esprima.parse(code);
let indent=0;
function pad() {
    return ' '.repeat(indent);
}
estraverse.traverse(ast,{
    enter(node) {
        console.log(pad()+node.type);
        if(node.type == 'FunctionDeclaration'){
            node.id.name = 'ast_rename';
        }
        indent+=2;
     },
    leave(node) {
        indent-=2;
        console.log(pad()+node.type);

     }
 });
let generated = escodegen.generate(ast);
console.log(generated);
```

```
Program
  FunctionDeclaration
    Identifier
    Identifier
    BlockStatement
    BlockStatement
  FunctionDeclaration
Program
```

5.babel插件

- 访问者模式Visitor 对于某个对象或者一组对象，不同的访问者，产生的结果不同，执行操作也不同
- @babel/core (https://www.npmjs.com/package/@babel/core) Babel 的编译器，核心 API 都在这里面，比如常见的 transform、parse
- Babel 的解析器
- babel-types (https://github.com/babel/babel/tree/master/packages/babel-types) 用于 AST 节点的 Lodash 式工具库, 它包含了构造、验证以及变换 AST 节点的方法，对编写处理 AST 逻辑非常有用
- babel-traverse (https://www.npmjs.com/package/babel-traverse)用于对 AST 的遍历，维护了整棵树的状态，并且负责替换、移除和添加节点
- babel-types-api (https://babeljs.io/docs/en/next/babel-types.html)
- Babel 插件手册 (https://github.com/brigand/babel-plugin-handbook/blob/master/translations/zh-Hans/README.md#asts)
- babeljs.io (https://babeljs.io/en/repl.html) babel可视化编译器

5.1 转换箭头函数

- babel-plugin-transform-es2015-arrow-functions (https://www.npmjs.com/package/babel-plugin-transform-es2015-arrow-functions)

转换前

```
const sum = (a,b)=>a+b
```

转换后

```
var sum = function sum(a, b) {
  return a + b;
};
```

```
npm i @babel/core babel-types -D
```

实现

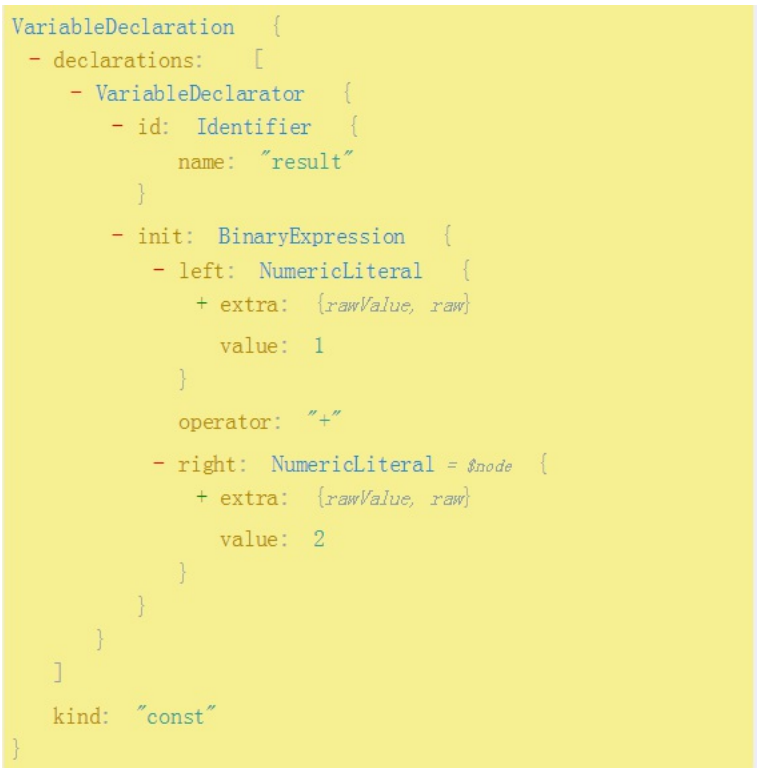
```
let babel = require('@babel/core');
let t = require('babel-types');
const code = `const sum = (a,b)=>a+b`;
let transformArrowFunctions = {
    visitor: {
        ArrowFunctionExpression: (path) => {
            let node = path.node;
            let id = path.parent.id;
            let params = node.params;
            let body=t.blockStatement([
                t.returnStatement(node.body)
            ]);
            let functionExpression = t.functionExpression(id,params,body,false,false);
            path.replaceWith(functionExpression);
        }
    }
}
const result = babel.transform(code, {
    plugins: [transformArrowFunctions]
});
console.log(result.code);
```

5.2. 预计算babel插件

- path.parentPath 父路径

转换前

```
const result = 1 + 2;
```



```
VariableDeclaration  {
  - declarations:  [
      - VariableDeclarator  {
          - id:  Identifier  {
                name:  "result"
            }
          - init:  BinaryExpression  {
              - left:  NumericLiteral  {
                  + extra:  {rawValue, raw}
                    value:  1
                }
                operator:  "+"
              - right:  NumericLiteral = $node  {
                  + extra:  {rawValue, raw}
                    value:  2
                }
            }
        }
    ]
    kind:  "const"
}
```

转换后

```
const result = 3;
```

```
let babel = require('@babel/core');
let t=require('babel-types');
let preCalculator={
    visitor: {
        BinaryExpression(path) {
            let node=path.node;
            let left=node.left;
            let operator=node.operator;
            let right=node.right;
            if (!isNaN(left.value) && !isNaN(right.value)) {
                let result=eval(left.value+operator+right.value);
                path.replaceWith(t.numericLiteral(result));
                if (path.parent&& path.parent.type == 'BinaryExpression') {
                    preCalculator.visitor.BinaryExpression.call(null,path.parentPath);
                }
            }
        }
    }
}

const result = babel.transform('const sum = 1+2+3',{
    plugins:[
        preCalculator
    ]
});
console.log(result.code);
```

5.3. 把类编译为Function

- babel-plugin-transform-es2015-classes (https://www.npmjs.com/package/babel-plugin-transform-es2015-classes)

es6

```
    class Person {
        constructor(name) {
            this.name=name;
        }
        getName() {
            return this.name;
        }
    }
```

es5

```
function Person(name) {
    this.name=name;
}
Person.prototype.getName=function () {
    return this.name;
}
```

实现

```
let babel = require('@babel/core');
let t=require('babel-types');
let source=`
    class Person {
        constructor(name) {
            this.name=name;
        }
        getName() {
            return this.name;
        }
    }
`;
let ClassPlugin={
    visitor: {
        ClassDeclaration(path) {
            let node=path.node;
            let id=node.id;
            let constructorFunction = t.functionDeclaration(id,[],t.blockStatement([]),false,false);
            let methods=node.body.body;
            let functions = [];
            methods.forEach(method => {
                if (method.kind == 'constructor') {
                    constructorFunction = t.functionDeclaration(id,method.params,method.body,false,false);
                    functions.push(constructorFunction);
                } else {
                    let memberObj=t.memberExpression(t.memberExpression(id,t.identifier('prototype')),method.key);
                    let memberFunction = t.functionExpression(id,method.params,method.body,false,false);
                    let assignment = t.assignmentExpression('=',memberObj,memberFunction);
                    functions.push(assignment);
                }
            });
            if (functions.length ==0) {
                path.replaceWith(constructorFunction);
            }else if (functions.length ==1) {
                path.replaceWith(functions[0]);
            } else {
                path.replaceWithMultiple(functions);
            }
        }
    }
}

const result = babel.transform(source,{
    plugins:[
        ClassPlugin
    ]
});
console.log(result.code);
```

6. webpack babel插件

```
var babel = require("@babel/core");
let { transform } = require("@babel/core");
```

6.1 实现按需加载

- lodashjs (https://www.lodashjs.com/docs/4.17.5.html#concat)
- babel-core (https://babeljs.io/docs/en/babel-core)
- babel-plugin-import (https://www.npmjs.com/package/babel-plugin-import)

```
import { flatten,concat } from "lodash"
```

转换为

```
import flatten from "lodash/flatten";
import concat from "lodash/flatten";
```

6.2 webpack配置

```
cnpm i webpack webpack-cli -D
```

```
const path=require('path');
module.exports={
    mode:'development',
    entry: './src/index.js',
    output: {
        path: path.resolve('dist'),
        filename:'bundle.js'
    },
    module: {
        rules: [
            {
                test: /\.js$/,
                use: {
                    loader: 'babel-loader',
                    options: {
                        plugins:[['import',{library:'lodash'}]]
                    }
                }
            }
        ]
    }
}
```

> 编译顺序为首先 plugins从左往右,然后 presets从右往左

6.3 babel插件

- babel-plugin-import.js放置在node_modules目录下

```
let babel = require('@babel/core');
let types = require('babel-types');
const visitor = {
    ImportDeclaration:{
        enter(path,state={opts}){
            const specifiers = path.node.specifiers;
            const source = path.node.source;
            if(state.opts.library == source.value && !types.isImportDefaultSpecifier(specifiers[0])){
                const declarations = specifiers.map((specifier,index)=>{
                    return types.ImportDeclaration(
                        [types.importDefaultSpecifier(specifier.local)],
                        types.stringLiteral(`${source.value}/${specifier.local.name}`)
                    )
                });
                path.replaceWithMultiple(declarations);
            }
        }
    }
}
module.exports = function(babel){
    return {
        visitor
    }
}
```

9. AST

9.1 解析过程

AST整个解析过程分为两个步骤

- 分词：将整个代码字符串分割成语法单元数组
- 语法分析：建立分析语法单元之间的关系

9.2 语法单元

Javascript 代码中的语法单元主要包括以下这么几种

- 关键字：`const`、`let`、`var`等
- 标识符：可能是一个变量，也可能是 if、else 这些关键字，又或者是 true、false 这些常量
- 运算符
- 数字
- 空格
- 注释

9.3 词法分析

```
let jsx = `let element=hello`;

function lexical(code) {
    const tokens=[];
    for (let i=0;ilet char=code.charAt(i);
        if (char == '=') {
            tokens.push({
                type: 'operator',
                value:char
            });
        }
        if (char==') {
            const token={
                type: 'JSXElement',
                value:char
            }
            tokens.push(token);
            let isClose = false;
            for (i++;iif (char=='>') {
                    if (isClose) {
                        break;
                    } else {
                        isClose=true;
                    }
                }
            }
            continue;
        }
        if (/[a-zA-Z\$\_]/.test(char)) {
            const token={
                type: 'Identifier',
                value:char
            }
            tokens.push(token);
            for (i++;iif (/[a-zA-Z\$\_]/.test(char)) {
                    token.value+=char;
                } else {
                    i--;
                    break;
                }
            }
            continue;
        }

        if (/\s/.test(char)) {
            const token={
                type: 'whitespace',
                value:char
            }
            tokens.push(token);
            for (i++;iif (/\s/.test(char)) {
                    token.value+=char;
                } else {
                    i--;
                    break;
                }
            }
            continue;
        }
    }
    return  tokens;
}
let result=lexical(jsx);
console.log(result);
```

```
[
  { type: 'Identifier', value: 'let' },
  { type: 'whitespace', value: ' ' },
  { type: 'Identifier', value: 'element' },
  { type: 'operator', value: '=' },
  { type: 'JSXElement', value: 'hello' }
]
```

9.4 语法分析

- 语义分析则是将得到的词汇进行一个立体的组合，确定词语之间的关系
- 简单来说语法分析是对语句和表达式识别，这是个递归过程

```
function parse(tokens) {
    const ast={
        type: 'Program',
        body: [],
        sourceType:'script'
    }
    let i=0;
    let currentToken;
    while ((currentToken = tokens[i])) {
        if (currentToken.type == 'Identifier' && (currentToken.value == 'let'||currentToken.value == 'var')) {
            const VariableDeclaration={
                type: 'VariableDeclaration',
                declarations:[]
            }
            i+=2;
            currentToken=tokens[i];
            let VariableDeclarator = {
                type: 'VariableDeclarator',
                id: {
                    type: 'Identifier',
                    name:currentToken.value
                }
            };
            VariableDeclaration.declarations.push(VariableDeclarator);
            i+=2;
            currentToken=tokens[i];
            if (currentToken.type=='JSXElement') {
                let value=currentToken.value;
                let [,type,children]=value.match(/([^([^/);
                VariableDeclarator.init={
                    type: 'JSXElement',
                    openingElement:{
                       type:'JSXOpeningElement',
                       name:{
                           type:'JSXIdentifier',
                           name:'h1'
                       }
                    },
                    closingElement:{
                       type:'JSXClosingElement',
                       name:{
                           type:'JSXIdentifier',
                           name:'h1'
                       }
                    },
                    name: type,
                    children:[
                        {
                            type:'JSXText',
                            value:'hello'
                        }
                    ]
                }
            } else {
                VariableDeclarator.init={
                    type: 'Literal',
                    value:currentToken.value
                }
            }
            ast.body.push(VariableDeclaration);
        }
        i++;
    }
    return ast;
}

let tokens=[
    {type: 'Identifier',value: 'let'},
    {type: 'whitespace',value: ' '},
    {type: 'Identifier',value: 'element'},
    {type: 'operator',value: '='},
    {type: 'JSXElement',value: 'hello'}
];
let result = parse(tokens);
console.log(result);
console.log(JSON.stringify(result));
```

```
{
    "type": "Program",
    "body": [{
        "type": "VariableDeclaration",
        "declarations": [{
            "type": "VariableDeclarator",
            "id": {
                "type": "Identifier",
                "name": "element"
            },
            "init": {
                "type": "JSXElement",
                "openingElement": {
                    "type": "JSXOpeningElement",
                    "name": {
                        "type": "JSXIdentifier",
                        "name": "h1"
                    }
                },
                "closingElement": {
                    "type": "JSXClosingElement",
                    "name": {
                        "type": "JSXIdentifier",
                        "name": "h1"
                    }
                },
                "name": "h1",
                "children": [{
                    "type": "JSXText",
                    "value": "hello"
                }]
            }
        }]
    }],
    "sourceType": "script"
}
```

9. 参考

- Babel 插件手册 (https://github.com/brigand/babel-plugin-handbook/blob/master/translations/zh-Hans/README.md#asts)
- babel-types (https://github.com/babel/babel/tree/master/packages/babel-types)
- 不同的parser解析js代码后得到的AST (https://astexplorer.net/)
- 在线可视化的看到AST (http://resources.jointjs.com/demos/javascript-ast)
- babel从入门到入门的知识归纳 (https://zhuanlan.zhihu.com/p/28143410)
- Babel 内部原理分析 (https://octman.com/blog/2016-08-27-babel-notes/)
- babel-plugin-react-scope-binding (https://github.com/chikara-chan/babel-plugin-react-scope-binding)
- transform-runtime (https://www.npmjs.com/package/babel-plugin-transform-runtime) Babel 默认只转换新的 JavaScript 语法，而不转换新的 API。例如，Iterator、Generator、Set、Maps、Proxy、Reflect、Symbol、Promise 等全局对象，以及一些定义在全局对象上的方法（比如 Object.assign）都不会转译,启用插件 `babel-plugin-transform-runtime` 后，Babel 就会使用 babel-runtime 下的工具函数
- ast-spec (https://github.com/babel/babylon/blob/master/ast/spec.md)
- babel-handbook (https://github.com/jamiebuilds/babel-handbook/blob/master/translations/zh-Hans/README.md)