TypeScript

TypeScript

TypeScript is JavaScript with syntax for types.

TypeScript is a strongly typed programming language that builds on JavaScript, giving you better tooling at any scale.

Previous Tag-Lines on the project page:

- JavaScript that scales!
- TypeScript is a language for application-scale JavaScript development.

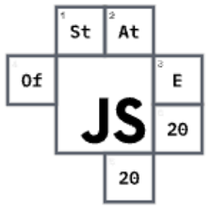
http://www.typescriptlang.org/

TypeScript is very Popular

Loved by Developers

2020 Developer Survey

Voted **2nd most loved programming language** in the Stack Overflow 2020 Developer survey

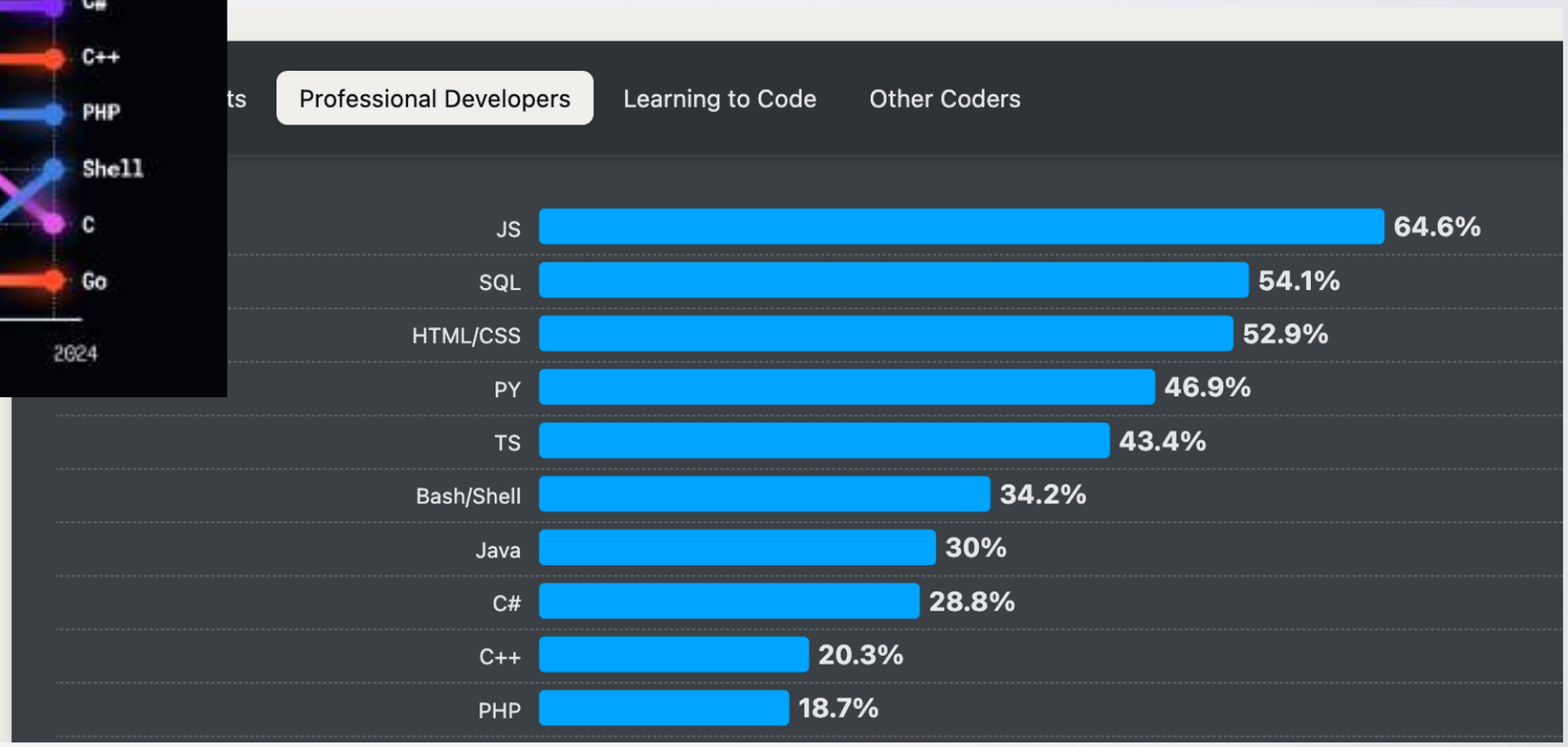


TypeScript was **used by 78%** of the 2020 State of JS respondents, with **93% saying they would use it again**.

TypeScript was given the award for **"Most Adopted Technology"** based on year-on-year growth.

https://survey.stackoverflow.co/2024/technology#most-popular-technologies-language
https://2024.stateofjs.com/en-US/usage/#js_ts_balance
https://innovationgraph.github.com/global-metrics/programming-languages

The Rise of TypeScript



https://github.blog/news-insights/octoverse/octoverse-2024/#the-most-popular-programming-languages
https://survey.stackoverflow.co/2024/technology#most-popular-technologies-language-prof

The History of TypeScript

The Story of TypeScript (6:26)
https://www.youtube.com/watch?v=EUlM3wx546o

TypeScript Origins: The Documentary (1:21:35)
https://www.youtube.com/watch?v=U6s2pdxebSo

TypeScript and the dawn of gradual types:
https://github.com/readme/featured/typescript-gradual-types

There are Alternatives ...

rescript

https://rescript-lang.org/

flow-typed

https://flow.org/

PURESCRIPT

https://www.purescript.org/

HAXE

https://haxe.org/

... but none of them has the momentum of TypeScript.

> Developer platforms get better at a rate proportional to the number of developers using them.
>
> Geoff Schmidt, JavaScript State of the Union 2015
> https://www.youtube.com/watch?v=8G2SMVIUNNk

ECMAScript Versions

- JavaScript: Initial Release in Netscape 2, 1995
- ECMAScript 1: 1997
- ECMAScript 2: 1998
- ECMAScript 3: 1999
- ~~ECMAScript 4~~: abandoned
- ECMAScript 5: 2009
- ECMAScript 2015: 2015
- ECMAScript 2016
- ECMAScript 2017
- …
- ECMAScript 2024
- ECMAScript 2025

2012: TypeScript

https://262.ecma-international.org/

JavaScript was never engineered for large applications. It was intended for 100-1000 lines of codes.

Today we build apps with millions of lines of code. Very large JavaScript code bases tend to become “read-only”.

– Anders Hejlsberg, Build 2016

https://channel9.msdn.com/Events/Build/2016/B881

Why TypeScript?

dynamically typed

statically typed

"gradual" typed

(best of both worlds?)

TypeScript and the dawn of gradual types:
https://github.com/readme/featured/typescript-gradual-types

Gradual Typing: https://en.wikipedia.org/wiki/Gradual_typing

ECMAScript Proposal (2022): type annotations
https://github.com/tc39/proposal-type-annotations

David K. 🎹
@DavidKPiano

I love TypeScript. It keeps me from coding too fast.

4:32 PM · Feb 19, 2021 · Twitter Web App

118 Retweets **23** Quote Tweets **1,615** Likes

David K. 🎹 @DavidKPiano · Feb 19
Replying to @DavidKPiano

JavaScript = move fast and break things
TypeScript = move slow and prevent things from breaking

15 33 280

https://twitter.com/DavidKPiano/status/1362787204058263558

Kent C. Dodds

@kentcdodds

"TypeScript isn't making your life worse. It's just showing you how bad your life already is"

— Me, in a workshop right now explaining how annoying form elements are to get actual runtime safety.

TypeScript is "abstract"!

You can't "fix" a bug with TypeScript!

```
interface Person {
  firstName: string;
  movies: string[];
}

async function fetchLuke(): Promise<Person> {
  const lukeResponse = await fetch(`https://swapi.info/api/people/1`);
  const luke = await lukeResponse.json() as Person;
  return luke
}

async function main() {
  console.log("Starting ...");
  const luke = await fetchLuke();
  // 💥 KABOOM! - the following line throws a TypeError at runtime
  console.log(`Luke appears in ${luke.movies.length} movies.`);
}

main();
```

But correctly used TypeScript does prevent bugs ...

west, donavon west
@donavon

If you lie to TypeScript, TypeScript will lie to you.

7:23 PM · Aug 24, 2021 · Twitter Web App

https://twitter.com/donavon/status/1430219301500358658

```
interface Person {
  firstName: string;
  lastName: string;
}
```

using axios with TypeScript

```
const data = await axios.get<Person>(BACKEND_URL);
```

using ky with TypeScript

```
const data = await ky.get(BACKEND_URL).json<Person>();
```

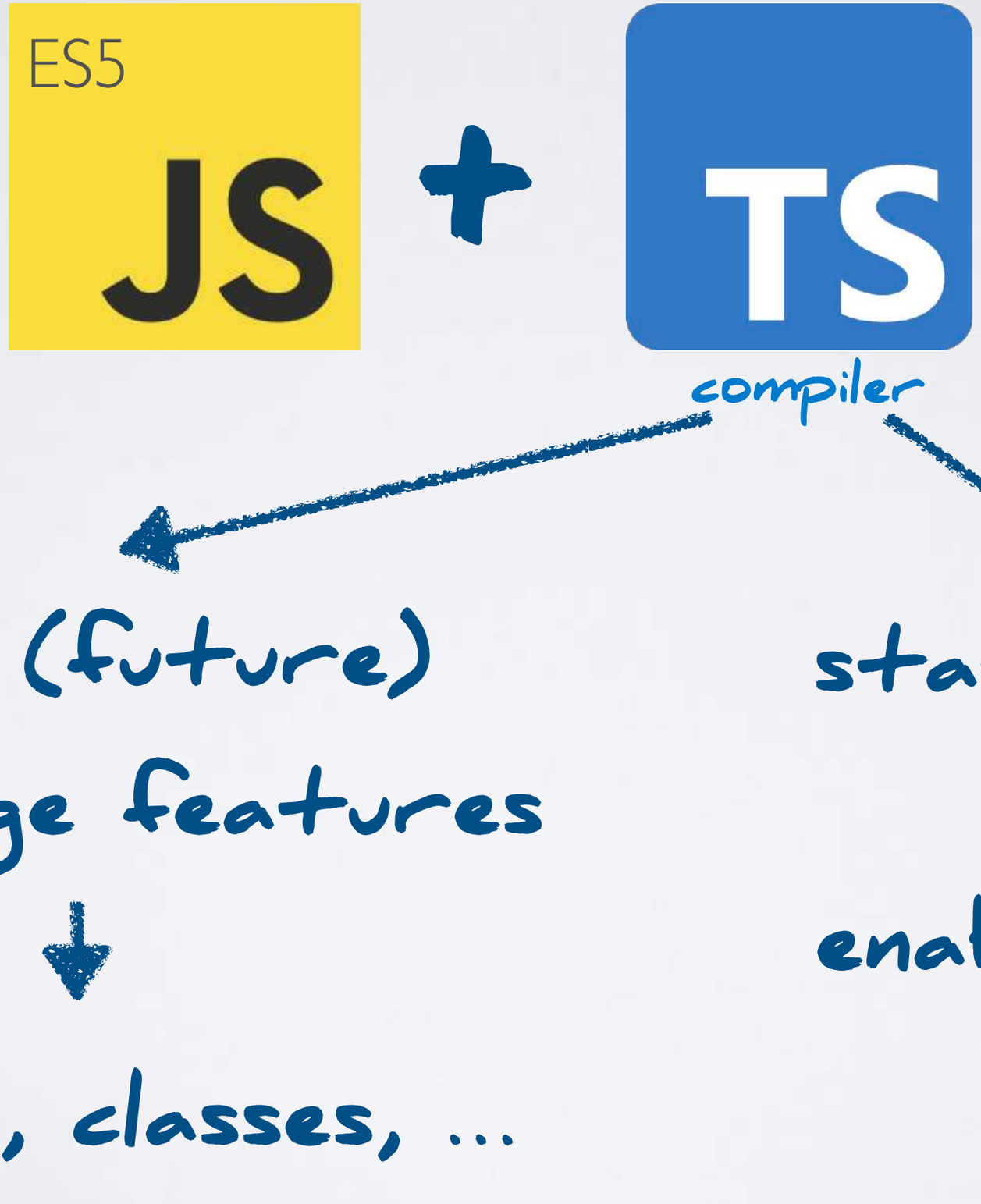
using Angular HttpClient

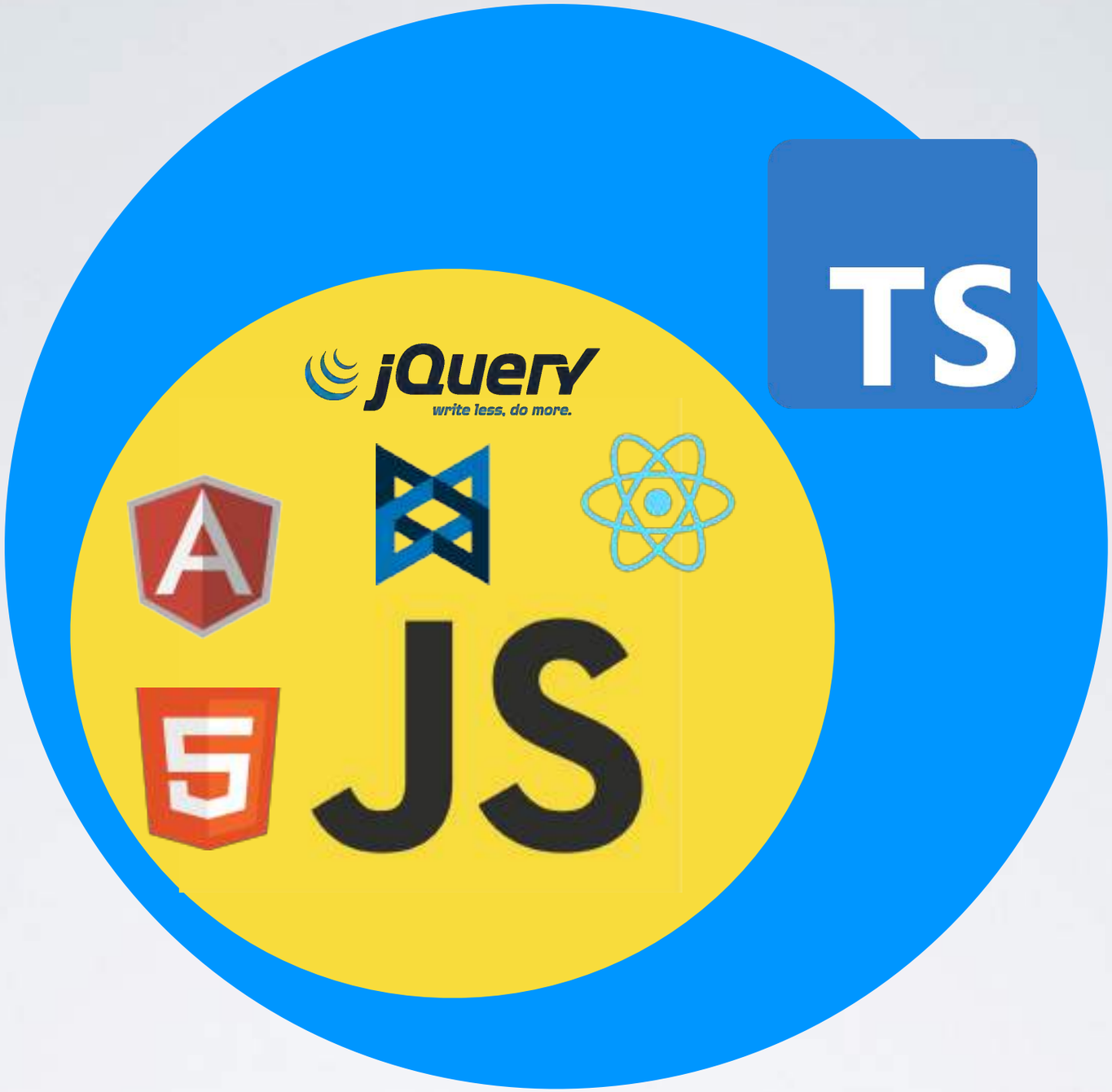
```
fetchData(): Observable<Person> {
  return this.http.get<Person>(BACKEND_URL);
}
```

The type information is only for the TypeScript compiler at build time. At runtime there is no guarantee or check that the network call really returns objects of the specified type.

You should only use **`interface`** or **`type`** as *type arguments* for backend access (not **`class`**).

The Goal of TypeScript in 2012





"TypeScript is a superset of JavaScript."

Any valid JavaScript (theoretically) is valid TypeScript. But TypeScript adds syntax for types, which is not valid JavaScript.

"TypeScript is a subset of JavaScript."

TypeScript throws buid-time errors for valid JavaScript, constraining the "flexibility" of JavaScript.

This is a differentiating factor compared other languages that compile to JavaScript: https://github.com/jashkenas/coffeescript/wiki/List-of-languages-that-compile-to-JS

TS is a superset of JS. Start with your existing JS and "enhance" it ...

It starts with JavaScript.

It ends with JavaScript.

After transpilation it's pure JS again. At runtime there is nothing left of TS!

TypeScript "Compilation"

At runtime TypeScript is just JavaScript.
Type information is stripped before runtime, typically at build-time.

TypeScript becomes JavaScript via the delete key.

```ts
type Result = "pass" | "fail"

function verify(result: Result) {
  if (result === "pass") {
    console.log("Passed")
  } else {
    console.log("Failed")
  }
}
```

TypeScript file.

```ts
type Result = "pass" | "fail"

function verify(result: Result) {
  if (result === "pass") {
    console.log("Passed")
  } else {
    console.log("Failed")
  }
}
```

Types are removed.

```ts
function verify(result) {
  if (result === "pass") {
    console.log("Passed")
  } else {
    console.log("Failed")
  }
}
```

JavaScript file.

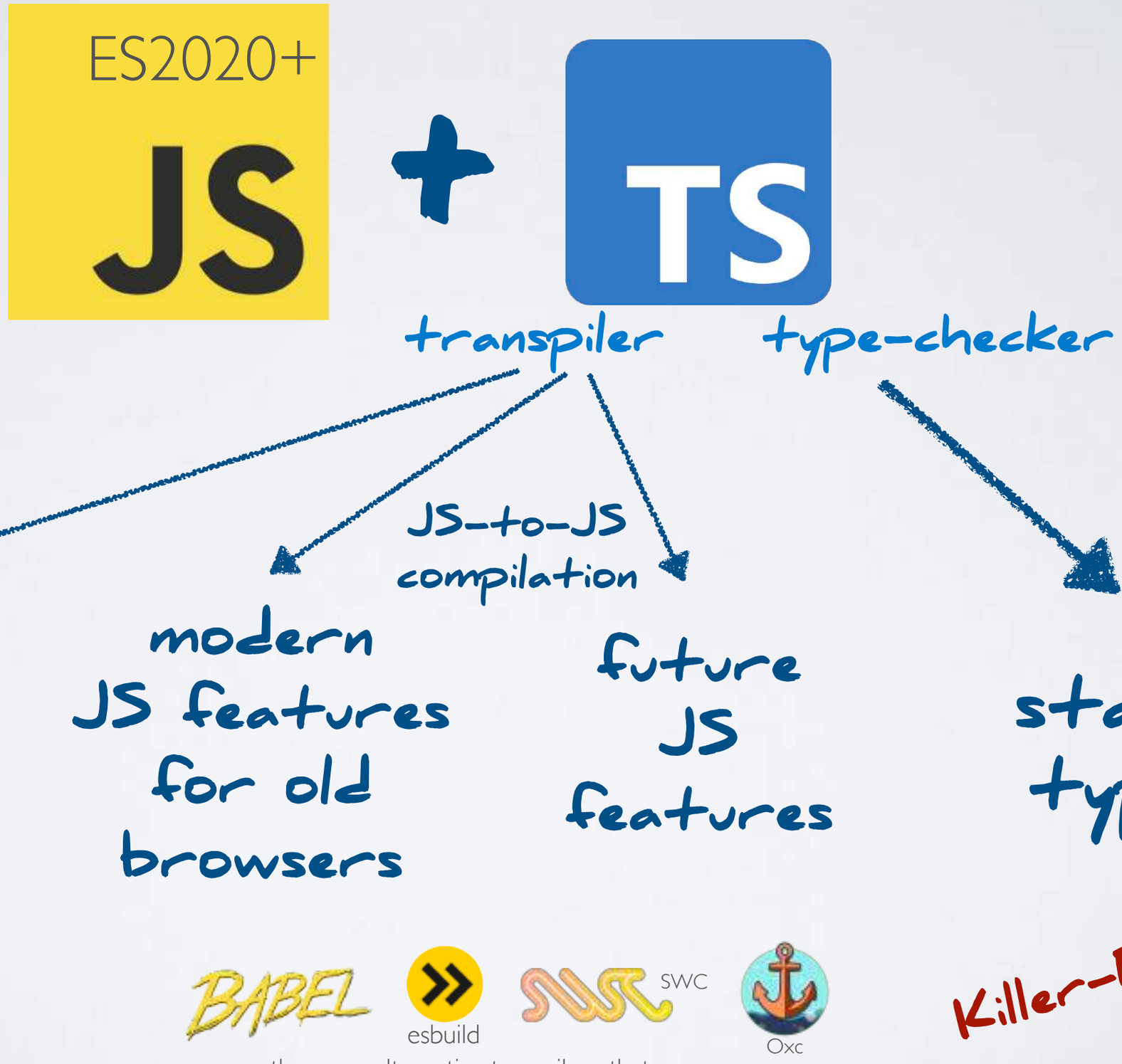
https://www.typescriptlang.org/

TypeScript Today

- … is a compiler that provides modern (ES2015+) language features for older Browsers
- … is a compiler that provides some future ESnext language features (i.e. decorators, `using` declarations …)
- … is a compiler that adds an optional static type system on top of JavaScript.
- … is also compiler that provides a few constructs that are not available in JavaScript (enums, namespaces) - however today it is "good practice" not to use these.
  Since TypesScript 5.8 this can be switched of with `erasableSyntaxOnly: true`

How does the TypeScript team try to avoid negative effects on the JS ecosystem? - https://www.youtube.com/watch?v=8qm49TyMUPI

TypeScript Today



see: `erasableSyntaxOnly`

there are alternative transpilers, that are
used in many "state-of-the-art" toolchains

TypeScript is currently rewritten in Go

(announced March 2025)

https://devblogs.microsoft.com/typescript/typescript-native-port/

Expectations:

- The TypeScript compilation step in the build pipeline becomes 10x faster
- The "IDE experience" will become 10x faster
- You code does not have to change

Try it: https://github.com/microsoft/typescript-go

TypeScript Design Goals

https://github.com/Microsoft/TypeScript/wiki/TypeScript-Design-Goals

Impose no runtime overhead on emitted programs.

Align with current and future ECMAScript proposals.

Preserve runtime behavior of all JavaScript code.

Avoid adding expression-level syntax.

Use a consistent, fully erasable, structural type system.

Consequences:

- integrating existing JavaScript is easy.
- migrating from JavaScript is easy.
- *You can't be proficient in TypeScript without (deep) knowlege of JavaScript!*

Myth:
There can be only one ...

Movie reference: "Highlander"

JavaScript VS TypeScript: Which is better? (2020 Updated)

Infinijith Apps & Technologies Mar 10, 2020 · 6 min read

https://shrtm.nu/RmGK

Is JavaScript Becoming TypeScript?

What might the future hold in store?

Mahdhi Rezvi Follow
Feb 4 · 9 min read

https://shrtm.nu/Q0Cx

A Post-Mortem in 5 Acts, of How Microsoft Privatized Open Source, killing JavaScript in the Process

After Microsoft's blitzkrieg take-over, the Open Source JavaScript community, as we know it, is coming to an end.

Alex Kleydints Feb 6 · 9 min read ★

https://shrtm.nu/KWLb

It is TypeScript *with* JavaScript ...

... not TypeScript *versus* JavaScript!

... but TypeScript *on top* of JavaScript

A bet on TypeScript is a bet on JavaScript!

TypeScript and JavaScript are allies in trying to make cool things in JavaScript.

The TypeScript team doesn't want to be in-front of JavaScript development but to let JS lead and TS follow.

- Orta Therox from the TypeScript team
https://www.youtube.com/watch?v=8qm49TyMUPI

We don't see it as our job to add new features in the core languguage. We closely track ECMA Script. We innovate in the type system, which is a "development-time-only-thing".

- Anders Hejlsberg 2018
https://www.youtube.com/watch?v=ET4kT88JRXs

Myth:
TypeScript makes my program typesafe like C++, C# or Java.

TypeScript is purely a build-time construct.
The TypeScript compiler ensures type safety for all the code it "sees" at compile time.

If your program interacts with code the TypeScript compiler can't see, like

- network
- local storage
- 3rd party libraries

... then you have the untyped behavior of JavaScript.

The type system of TypeScript is optional. Programmers can always "opt out" and work with untyped JavaScript.

Myth : Angular is the best choice if I want to use TypeScript.

TypeScript sees itself as the Switzerland for JavaScript Frameworks

- Anders Hejlsberg, TypeScript: Static types for JavaScript
https://www.youtube.com/watch?v=ET4kT88JRXs

Angular is written in TypeScript and the whole Angular ecosystem and its community has fully embraced TypeScript.

But Angular versions have a tighter coupling to TypeScript versions than other frameworks:
https://angular.dev/reference/versions#actively-supported-versions

TypeScript support is especially strong for React, since React does not have it's own templating "language". JSX is directly supported by TypeScript in a typesafe way.

Vue 3 was a full rewrite in TypeScript
One of the goals was to provide better support for TypeScript projects.

Myth:
TypeScript is easy

The Challenge of TypeScript

The start is easy:

```ts
export type Todo = {
  id: number;
  title: string;
  completed: boolean;
}

const todoItem: Todo = {
  id: 1234, title: 'Buy milk', completed: false
}

const todoItem2 = {
  id: 5, title: 'Go to gym', completed: false
}

const todos: Todo[] = [todoItem, todoItem2];
```

… but it can become quite complex:

```ts
export type OmitK<T, K> = Pick<T, Exclude<keyof T, K>>;

export interface BiBaseEvent {
  msgId: string;
  src: number;
  hosting: string;
}

export type BiBaseParams<T extends BiBaseEvent> = Omit<T, 'src' | 'hosting'> & { viewMode: string };

export interface BaseComponentProps {
  id: string;
  disabled: boolean;
  className?: string;
  onClick?: (id: string, event: React.MouseEvent<HTMLButtonElement>) => void;
}
```

https://medium.com/swlh/understanding-the-weird-parts-of-typescript-20c0fe26d314

```ts
@Component({
  moduleId: module.id,
  selector: 'signup',
  templateUrl: 'signup.component.html',
  directives: [REACTIVE_FORM_DIRECTIVES],
  providers: [AuthenticationService]
})
export class SignupComponent implements

  signupForm: FormGroup;
  submitted = false;
  errorMessage: string;
  accountTypes: SelectItem[];
  selectedType: any;

  constructor(public router:Router, pelv
    this.accountTypes = [];
    this.accountTypes.push({label: 'Ind1
    this.accountTypes.push({label: 'Orga

    this.signupForm = this.fb.group({
      'email' : ['', Validators.compose([Validators.required, ValidationService.emailValidator])],
      'username' : ['', Validators.compose([Validators.required, Validators.minLength(6)])],
```

```
[ts]
Argument of type '(((control: AbstractControl) => { [key: string]: boolean; }) | ((control:
AbstractControl) => { [...' is not assignable to parameter of type 'ValidatorFn[]'.
  Type '((control: AbstractControl) => { [key: string]: boolean; }) | ((control: AbstractControl) => {
[k...' is not assignable to type 'ValidatorFn'.
    Type '(control: AbstractControl) => { [key: string]: boolean; }' is not assignable to type
'ValidatorFn'.
      Types of parameters 'control' and 'c' are incompatible.
        Type 'AbstractControl' is not assignable to type 'AbstractControl'.
          Types of property 'validator' are incompatible.
            Type 'ValidatorFn' is not assignable to type 'ValidatorFn'.
              Types of parameters 'c' and 'c' are incompatible.
                Type 'AbstractControl' is not assignable to type 'AbstractControl'.
                  Types of property 'validator' are incompatible.
                    Type 'ValidatorFn' is not assignable to type 'ValidatorFn'.
                      Types of parameters 'c' and 'c' are incompatible.
                        Type 'AbstractControl' is not assignable to type 'AbstractControl'.
(method) ValidationService.emailValidator(control: AbstractControl): {
    [key: string]: boolean;
}
```

https://stackoverflow.com/questions/38954021/angular-2-error-type-abstractcontrol-is-not-assignable-to-type-abstractcont

```
[ts]
Argument of type '{ declarations: (typeof ConversationPage)[];
 imports: (ModuleWithProviders | typeof moment)[]; en...' is no
t assignable to parameter of type 'NgModule'.
  Types of property 'imports' are incompatible.
    Type '(ModuleWithProviders | typeof moment)[]' is not assig
nable to type '(any[] | Type<any> | ModuleWithProviders)[]'.
      Type 'ModuleWithProviders | typeof moment' is not assigna
ble to type 'any[] | Type<any> | ModuleWithProviders'.
        Type 'typeof moment' is not assignable to type 'any[] |
 Type<any> | ModuleWithProviders'.
          Type 'typeof moment' is not assignable to type 'Modul
eWithProviders'.
```

https://stackoverflow.com/questions/51081676/not-able-to-use-moment-mini-ts-lib

Adam Rackis
@AdamRackis

* wife flies to DC for the week *

Expectation: "Tons of free time. Gonna catch up on some reading. Gonna catch up on some TV 🚀"

Reality:

```ts
type TuplesOverlapPerfectly<T, U> = T extends []
  ? true
  : U extends []
  ? true
  : T extends [infer THead, ...infer TRest]
  ? U extends [infer UHead, ...infer URest]
    ? UHead extends THead
      ? THead extends UHead
        ? TuplesOverlapPerfectly<TRest, URest>
        : false
      : false
    : false
  : false;

type TupleOneIsLongerOrEqual<T, U> = U extends []
  ? true
  : T extends []
  ? false
  : T extends [infer _, ...infer TRest]
  ? U extends [infer _, ...infer URest]
    ? TupleOneIsLongerOrEqual<TRest, URest>
    : never
  : never;

type GetBroaderTuple<T, U> = TuplesOverlapPerfectly<T, U> extends true
  ? TupleOneIsLongerOrEqual<T, U> extends true
    ? T
    : U
  : never;
```

6:31 AM · May 8, 2024 · **1M** Views

DHH @dhh · May 9

Never seen a better ad for ditching TypeScript. You don't have to live like this!!

https://twitter.com/i/bookmarks?post_id=1788597500192133257

TypeScript

Project Setup

Global installation:

~~`npm install -g typescript`~~ avoid!

Local installation:

```
npm init -y
npm install -D typescript
```

Configuration:

`npx tsc --init`

edit `tsconfig.json`

Usage:

run via: `npx tsc`

or via npm script: `tsc`

(modern frontend templates are setting up TypeScript, so typically you don't have to do this manually today)

tsconfig setup

The TypeScript compiler is configured in `tsconfig.json`

```
{
  "compilerOptions": {
   "strict": true,
    "noImplicitOverride": true,
    "noPropertyAccessFromIndexSignature": true,
    "noImplicitReturns": true,
    "noFallthroughCasesInSwitch": true,
    "skipLibCheck": true,
    "isolatedModules": true,
    "experimentalDecorators": true,
    "importHelpers": true,
    "target": "ES2022",
    "module": "preserve"
}
```

(example generated by Angular CLI v20)

Special mention: `erasableSyntaxOnly`

https://www.typescriptlang.org/docs/handbook/release-notes/typescript-5-8.html#the---erasablesyntaxonly-option

https://www.typescriptlang.org/tsconfig
https://www.typescriptlang.org/docs/handbook/tsconfig-json.html

Type System Features

- Zero Cost: Static types only during development time, *no effect at runtime*
- Type inference
- Gradual typing
- Configurable type checking

Using Basic Types

Types are an optional, opt-in feature in TypeScript.

Basic Types:

```
let b:boolean = true;
let n:number = 42;
let s:string = 'Hello!';
let a1: number[] = [1,2,3];
let a2:Array<string> = ['Hello','World', '!'];
enum ArrowDirection { Up, Down, Left, Right}
let e: ArrowDirection = ArrowDirection.Up;
```

Basic type checking:

```
let x:string = 'Hello World';
x = 42; // => compiler error
```

Type inference:

```
let x = 'Hello World'; // the type of x is 'string'
x = 42; // => compiler error
```

The compiler will infer types if possible. It's considered a 'good style' to omit type annotations if they can be derived.

Built-In Types

TypeScript has built-in support for JavaScript types:

```
[1,2,3,4].reduce(
    (acc : {sum: number} , e : number ) => {
        return {sum: acc.sum + e}
    }, {sum: 0});
```

TypeScript has built-in support for browser APIs:

```
document.addEventListener( type: 'keydown',  listener: function(event : KeyboardEvent ) {
  console.log(event.clientX, event.clientY);
});
```

```
document.querySelector<HTMLDivElement>('#app')!.innerHtml = '';
```

TS2551: Property 'innerHtml' does not exist on type 'HTMLDivElement'. Did you mean 'innerHTML'?

lib.dom.d.ts(9130, 5): 'innerHTML' is declared here.

Rename reference ⌥⇧⏎ More actions... ⌥⏎

Installing 3rd-Party Type Definitions

Some libraries are not written in TypeScript.
Their type definitions can still be available via npm:

```
npm install @types/jquery
```

(`@types` is called a "scope" in npm)

The type definitions are maintained in the Definitely Typed repository:

- https://github.com/DefinitelyTyped/DefinitelyTyped/tree/master/types
- https://definitelytyped.org/

Advanced Types

Union Types:

```
let pet: IBird | IFish = {fly(){}, layEggs(){}};
pet = new Fish();
```

Intersection Types:

```
let flyingFish: IFish & IBird = {swim(){}, fly(){}, layEggs(){}};
flyingFish.swim();
```

Type Guards:

```
(pet as IFish).swim();
(<IFish>pet).swim();

if (pet instanceof Fish){
    pet.swim();
}
```

User defined type-guards:

```
function isFish(pet: Fish | Bird): pet is Fish {
    return (pet as any).swim !== undefined;
}
```

```
if (isFish(pet)) {
    pet.swim();
} else {
    pet.fly();
}
```

any Type

Types are optional. TypeScript allows you to to gradually opt-in and opt-out of type-checking during compilation.

```
let v: any = 42;
v = 'Hello!'; // anything can be assigned to v

let n:number = 43;
n = v; // v can be assigned to anything!!!
```

Variables have the implicit type **`any`** if TypeScript does not know it's type.

Typing can be enforced by setting **`noImplicitAny: true`** in **`tsconfig.json`**

https://www.typescriptlang.org/docs/handbook/2/everyday-types.html#any
https://www.typescriptlang.org/tsconfig#noImplicitAny

`never` & `unknown` Types

Some functions *never* return a value:

```
function fail(msg: string): never {
  throw new Error(msg);
}
```

The *unknown* type represents any value. But it is not legal to do anything with an *unknown* value:

```
function f1(a: any) {
  a.b(); // OK
}
function f2(a: unknown) {
  a.b(); //ERROR: Object is of type 'unknown'.
}
```

https://www.typescriptlang.org/docs/handbook/2/functions.html#never
https://www.typescriptlang.org/docs/handbook/2/functions.html#unknown

Type Narrowing

```
function padLeft(padding: number | string, input: string): string {
  if (typeof padding === "number") {
    return " ".repeat(padding) + input; // -> padding is of type "number"
  }
  return padding + input; // -> padding is of type "string"
}
```

There are many mechanisms how TypeScript performs type narrowing:

https://www.typescriptlang.org/docs/handbook/2/narrowing.html

```
function isFish(pet: Fish | Bird): pet is Fish {
  return (pet as Fish).swim !== undefined;
}
```

https://www.typescriptlang.org/docs/handbook/2/narrowing.html#using-type-predicates

Function Types

A function has a type defined by its signature

```
let operation: string = 'add';

let mathFunc: (x: number, y:number) => number;

function add(x: number, y:number) : number {
  return x + y;
}

const subtract = (x: number, y:number):number => x - y;

if (operation === 'add')
  mathFunc = add;
else
  mathFunc = subtract;

console.log(mathFunc(4,2))
```

See also: https://kentcdodds.com/blog/typescript-function-syntaxes

Note: functions with fewer parameters are assignable to functions that take more parameters.

https://github.com/Microsoft/TypeScript/wiki/FAQ#why-are-functions-with-fewer-parameters-assignable-to-functions-that-take-more-parameters

Function Overloads

In my experiance a feature that is rarely used / useful.

overload signatures

```
// declaration
function doIt(): number;
function doIt(arg1: number): number;
function doIt(arg1: number, arg2: string): number;
function doIt(arg1?: number, arg2?: string): number {
    return 42;
}

// usage options
doIt();
doIt(44);
doIt(44, 'test');
```

implementation signature

The implemantation signature must be compatible to all overlaod signatures.

Classes & Interfaces

With classes & interfaces we can create custom types in TypeScript

```
interface IPerson {
    name: string,
}

class Person implements IPerson {
    name: string = 'Tyler';
    private age: number = 42;

    getInfo() {
        console.log(this.name); // inspect `this`
        return this.name + this.age;
    }
}

const p1: IPerson = new Person();
const p2: Person = new Person();
```

Interfaces are a pure build-time construct. They are not present at runtime!

TypeScript Classes

Differences to JavaScript classes:

parameter property
(properties declared in constructor signature
Note: not supportet with `erasableSyntaxOnly`)

```
class Car {
  private distanceDriven: number = 0;

  constructor(private engine: Engine){}

  drive(): number {
    this.engine.start();
    this.increaseDistance(1);
    return this.distance;
  }

  private increaseDistance(amount: number): void {
    this.distanceDriven + amount;
  }
}
```

access modifiers
(private, public, protected)
(optional, default is public)

type anotations
(optional)

The Structural Type System

The structure of an objects defines the compatiblity with a type, the object does not have to be explicitly declaread as a type (aka. "Duck Typing")

```
interface IPerson {
    name: string,
    age: number
}

const p3: IPerson = {
    name: 'Tyler',
    age: 42
};
```

Type Aliases

https://www.typescriptlang.org/docs/handbook/advanced-types.html#type-aliases

Type Aliases give a name to a type.

Describe the shape of an object:

```
type Person = {
 firstName: string;
  lastName: string;
  greet: (message: string) => string
}
```

Name a union type:

```
type ID = number | string;
```

Enums in TypeScript

In many cases Enums are not recommended!
Use union types instead!

```
enum Status {
  Admin,
  User,
  Moderator,
}
```

```
type Status = "Admin" | "User" | "Moderator";
```

prefer!

```
enum Status {
  Admin = "Admin",
  User = "User",
  Moderator = "Moderator",
}
```

avoid!

emitted JavaScript

```
var Status;
(function (Status) {
    Status["Admin"] = "Admin";
    Status["User"] = "User";
    Status["Moderator"] = "Moderator";
})(Status || (Status = {}));
```

Note:
`enums` can't be used native Node / Bun / Deno and with `erasableSyntaxOnly: true`

Reason: https://fettblog.eu/tidy-typescript-avoid-enums/
More Info: https://stackoverflow.com/a/60041791/32749

In modern TypeScript, you may not need an enum when an object with `as const` could suffice:

https://www.typescriptlang.org/docs/handbook/enums.html#objects-vs-enums

```
const ODirection = {
  Up: 0,
  Down: 1,
  Left: 2,
  Right: 3,
} as const;
type Direction = typeof ODirection[keyof typeof ODirection];
```

```
function run(dir: Direction) {}

run(ODirection.Right);
```

Types Aliases vs. Interfaces

In most cases type alias is interchangeable with an interface.

equivalent

```ts
type Person = {
  firstName: string;
  lastName: string;
  greet: (message: string) => string
}
```

```ts
interface Person {
  firstName: string;
  lastName: string;
  greet: (message: string) => string
}
```

Special cases, not possible with interfaces:

```ts
type Second = number;
```

alias for primitive type

```ts
type Status = "Admin" | "User" | "Moderator";
```

union types

A simple strategy to decide what to use:
use interfaces to describe objects, use types for everything else.

Main difference: Interfaces can be defined/extended in multiple files. Types can't.
Differences: https://www.typescriptlang.org/docs/handbook/2/everyday-types.html#differences-between-type-aliases-and-interfaces

TypeScript recommends to use interfaces over type aliases:
Better error messages: https://www.typescriptlang.org/play?q=378#example/types-vs-interfaces
Performance: https://www.typescriptlang.org/play?q=378#example/types-vs-interfaces

Marking values as readonly with `as const`

```ts
const obj = {
  direction: "up" as const,
  foo: {
    bar: 42,
  },
} as const;

obj.foo.bar = 43;
console.log(obj.direction);
```

compile error

type is "up"
not string!

```ts
const arr = [ 42, "test" ] as const;
arr.push(43);

function fn(num: number){
    console.log(num);
}

fn(arr[0]);
fn(arr[1]);
```

compile error

ok, because type is number

compile error because type is "test"/string

https://www.totaltypescript.com/concepts/as-const
https://www.typescriptlang.org/docs/handbook/typescript-in-5-minutes-func.html#readonly-and-const

Creating Types from Types

"Metaprogramming with Types"

https://www.typescriptlang.org/docs/handbook/2/types-from-types.html

Example:

```
const person = {
    firstName: 'Jonas',
    age:42,
    address: {street: 42}
};

type T1 = typeof person;
type T2 = keyof typeof person;
type T4 = T1['address']['street'];

function getVal(){
    return new Promise<T1>(resolve => {
        resolve(person)
    });
}

type T3 = keyof Awaited<ReturnType<typeof getVal>>;
```

https://www.zhenghao.io/posts/type-programming
https://medium.com/@imkelen009/advanced-usage-of-typescript-%E4%B8%80-5b102a459b8d
https://obaranovskyi.medium.com/10-typescript-features-you-might-not-be-using-yet-or-didnt-understand-d1f28888ea45

Crazy: TypeScript Types can run DOOM!

(game from 1993)

https://www.youtube.com/watch?v=0mCsluv5FXA

To prove that TypeScript Types are Turing Complete, someone implemented a TypeScript program that is running DOOM:

calling `tsc` returns a TypeScript object that
represents the ASCII-Art of a Frame of DOOM.

Rendering the first frame of DOOM took running the program
for 12 days with 20 million type instatiations per second ...

https://github.com/MichiganTypeScript/typescript-types-only-wasm-runtime

TypeScript Decorators

Decorators are an upcoming ECMAScript feature that allow us to customize classes and their members in a reusable way.

Decorators are heavily used in Angular.

```
function loggedMethod(originalMethod: any,
                      context: ClassMethodDecoratorContext) {
    const methodName = String(context.name);

    function replacementMethod(this: any, ...args: any[]) {
        console.log(`LOG: Entering method '${methodName}'.`)
        const result = originalMethod.call(this, ...args);
        console.log(`LOG: Exiting method '${methodName}'.`)
        return result;
    }

    return replacementMethod;
}
```

```
class Person {
    name: string;
    constructor(name: string) {
        this.name = name;
    }

    @loggedMethod
    greet() {
        console.log(`Hello, my name is ${this.name}.`);
    }
}

const p = new Person("Ron");
p.greet();
```

```
// Output:
//
//   LOG: Entering method.
//   Hello, my name is Ron.
//   LOG: Exiting method.
```

https://devblogs.microsoft.com/typescript/announcing-typescript-5-0/#decorators

Runtime Type-Safety

(typesafe backend access and input validation)

west, donavon west
@donavon

If you lie to TypeScript, TypeScript will lie to you.

7:23 PM · Aug 24, 2021 · Twitter Web App

https://twitter.com/donavon/status/1430219301500358658

```
interface Person {
  firstName: string;
  lastName: string;
}
```

using axios with TypeScript

```
const data = await axios.get<Person>(BACKEND_URL);
```

using ky with TypeScript

```
const data = await ky.get(BACKEND_URL).json<Person>();
```

using Angular HttpClient

```
fetchData(): Observable<Person> {
  return this.http.get<Person>(BACKEND_URL);
}
```

The type information is only for the TypeScript compiler at build time. At runtime there is no guarantee or check that the network call really returns objects of the specified type.

You should only use **`interface`** or **`type`** as *type arguments* for backend access (not **`class`**).

TypeScript Generators

Open API Generator: https://openapi-generator.tech/

https://github.com/OpenAPITools/openapi-generator

```
npx @openapitools/openapi-generator-cli \
    generate -i https://petstore.swagger.io/v2/swagger.json -g typescript-angular -o .
```

Generated code is very different for: `typescript-angular`, `typescript-fetch`, `typescript-axios` ...

Alternative: https://swagger.io/tools/swagger-codegen/ resp. https://github.com/swagger-api/swagger-codegen

Nx Plugin for Open API Generator: https://github.com/trumbitta/nx-trumbitta/tree/main/packages/nx-plugin-openapi

Orval - Restful Client Generator https://orval.dev/overview

Alternative simple generator for Java: https://github.com/vojtechhabarta/typescript-generator

not maintained?

```
public class Person {
    public String name;
    public int age;
    public boolean hasChildren;
    public List<String> tags;
    public Map<String, String> emails;
}
```

```
interface Person {
    name: string;
    age: number;
    hasChildren: boolean;
    tags: string[];
    emails: { [index: string]: string };
}
```

Very easy to configure in a Maven or Gradle build.
Can detect DTOs automatically for JAX-RS or DTOs can be specified via pattern.
Somehow configurable (mapping, naming ...)
Limitation: One single generated file / module containing all the types.

Graphql:
- https://graphql-code-generator.com/

.NET:
- NSwag: https://github.com/RicoSuter/NSwag, Swashbuckle: https://github.com/domaindrivendev/Swashbuckle.AspNetCore
- TypeWriter Visual Studio Extension: https://github.com/AdaskoTheBeAsT/Typewriter/
- "Handmade": https://github.com/lmcarreiro/cs2ts-example

Runtime Type-Checking

Runtime type-checks can only happen via JavaScript.

Modern validation libraries let you describe types/schemas for runtime checking in a way that lets TypeScript derive types at build time.

Zod: describe types (schemas) in TS code: https://zod.dev/
→ infer TS types from schemas

ArkType: describe types (schemas) in TS code: https://arktype.io/
→ better runtime performance and better and more concise and readable syntax than Zod

Valibot: describe types (schemas) in TS code: https://github.com/fabian-hiller/valibot
→ infer TS types from schemas / a smaller and modular alternative to Zod

Alternatives: io-ts, typia, joi, ajv, yup ...

The traditional Problem with Runtime Type-Checking

Using a user defined type guard with a type predicate:

https://www.typescriptlang.org/docs/handbook/2/narrowing.html#using-type-predicates

```
interface Person {
  name: string;
  films: string[];
}

function checkPersonSchema(obj: any): obj is Person {
  return !(obj.name === undefined || typeof obj.name !== 'string'
    || obj.films === undefined
    || typeof obj.films !== 'object' || !(obj.films instanceof Array)
    || obj.films.forEach((film: any) => typeof film !== 'string'));
}

async function fetchLuke() {
  const lukeResponse = await fetch(`https://swapi.info/api/people/1`);
  const luke = await lukeResponse.json();
  if(checkPersonSchema(luke)){
    return luke;
  }
  throw new Error('Invalid Person Object!');
}
function printMessage(person: Person) {
  console.log(`Luke appears in ${person.films.length} movies.` );
}

export async function main() {
  const luke = await fetchLuke();
  printMessage(luke);
}
```

compile time type definition → duplicated definition!

runtime type check

runtine check

compile time check

Zod Demo

"runtime type-checking"

```
import z from 'zod';

const personSchema = z.object({
  name: z.string(),
  films: z.array(z.string())
})
type Person = z.infer<typeof personSchema>;

async function fetchLuke() {
  const lukeResponse = await fetch(`https://swapi.info/api/people/1`);
  const luke = await lukeResponse.json();
  return personSchema.parse(luke);
}

function printMessage(person: Person) {
  console.log(`Luke appears in ${person.films.length} movies.` );
}

async function main() {
  const luke = await fetchLuke();
  printMessage(luke)
}
```

central definition!

runtine check

compile time check

Runtime Type-Checking

Usage Scenarios

Client:

- data fetching from an API
- validating user-inputs
  - form data
  - url query parameters
- data from web storage or indexedDB

Server:

- validating client data in an API call
- validating env parameters or json config