a Background and introduction

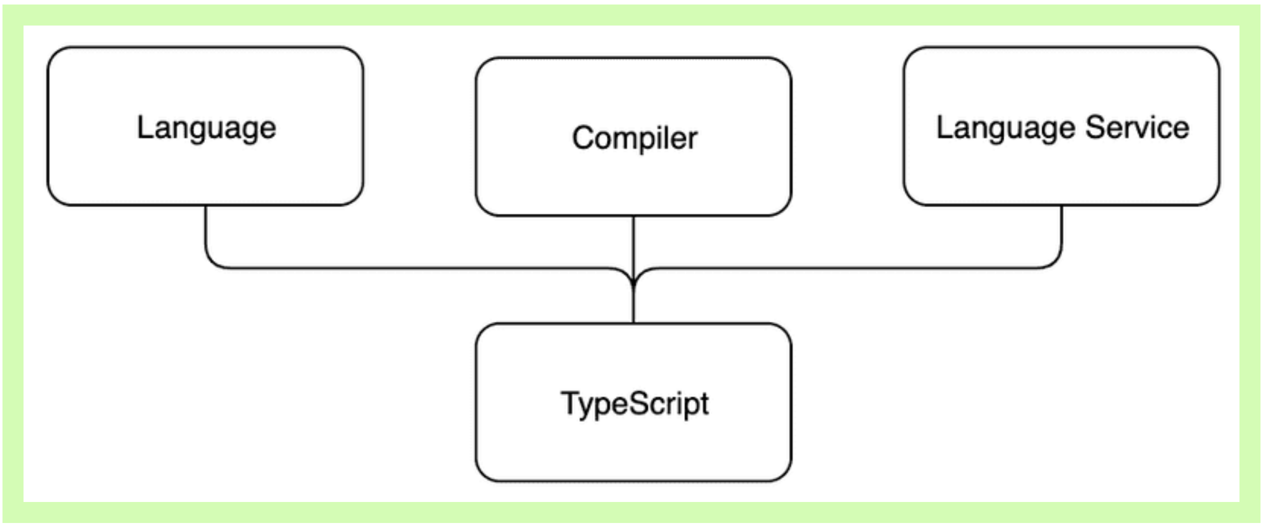
TypeScript is a programming language designed for large-scale JavaScript development created by Microsoft. For example Microsoft's `Azure Management Portal` (1,2 million lines of code) and `Visual Studio Code` (300 000 lines of code) have both been written in TypeScript. To support building large-scale JavaScript applications, TypeScript offers features such as better development-time tooling, static code analysis, compile-time type checking and code level documentation.

Main principle

TypeScript is a typed superset of JavaScript, and eventually it's compiled into plain JavaScript code. The programmer is even able to decide the version of the generated code, as long as it's ECMAScript 3 or newer. TypeScript being a superset of JavaScript means that it includes all the features of JavaScript and its own additional features as well. In fact, all existing JavaScript code is actually valid TypeScript.

TypeScript consists of three separate, but mutually fulfilling parts:

- The language
- The compiler
- The language Service



The language consists of syntax, keywords and type annotations. The syntax is similar to but not the same as JavaScript syntax. From the three parts of TypeScript programmers have the most direct contact with the language.

The compiler is responsible for type information erasure (i.e. removing the typing information) and the code transformations. The code transformations enable TypeScript code to be transpiled into executable JavaScript. Everything related to the types is removed at compile-time, so TypeScript isn't actually genuine statically typed code.

Traditionally, *compiling* means that code is transformed from a human readable format to a machine readable format. In TypeScript human readable source code is transformed into another human readable source code, so the correct term would actually be *transpiling*. However compiling has been the most commonly used term in this context, so we will continue to use it.

The compiler also performs a static code analysis. It can emit warnings or errors if it finds a reason to do so, and it can be set to perform additional tasks such as combining the generated code into a single file.

The language service collects type information from the source code. Development tools can use the type information for providing intellisense, type hints and possible refactoring alternatives.

TypeScript key language features

In this section we will describe some of the key features of the TypeScript language. The intent is to provide you with a basic understanding of TypeScripts' key features to help you understand more of what is to come during this course.

Type annotations

Type annotations in TypeScript are a lightweight way to record the intended *contract* of a function or a variable. In the example below we have defined a function *birthdayGreeter* which accepts two arguments, one of type string and one of type number. The function will return a string.

```
const birthdayGreeter = (name: string, age: number): string => {
  return `Happy birthday ${name}, you are now ${age} years old!`;
};

const birthdayHero = "Jane User";
const age = 22;

console.log(birthdayGreeter(birthdayHero, 22));
```

Structural typing

TypeScript is a structurally typed language. In structural typing, two elements are considered to be compatible with one another if for each feature within the type of the first element a corresponding and identical feature exists within the type of the second element. Two types are considered to be identical if they are compatible with each other.

Type inference

The TypeScript compiler can attempt to infer the type information if no type has been specified. Variable's type can be inferred based on its assigned value and its usage. The type inference take place when initializing variables and members, setting parameter default values, and determining function return types.

For example consider the function *add*

```
const add = (a: number, b: number) => {
  /* The return value is used to determine
     the return type of the function */
  return a + b;
}
```

The function's return value is inferred by retracing the code back to the return expression. The return expression performs an addition of the parameters a and b. We can see that a and b are numbers based on their types. Thus, we can infer the return value to be of type *number*.

As a more complex example let's consider the code below. If you have not used TypeScript before, this example might be a bit complex. But do not worry, you can safely skip it for now.

```
type CallsFunction = (callback: (result: string) => any) => void;

const func: CallsFunction = (cb) => {
  cb('done');
  cb(1);
}

func((result) => {
  return result;
});
```

First we have a declaration of a type alias called *CallsFunction*. CallsFunction is a function type with one parameter *callback*. The parameter *callback* is of type function which takes a string parameter and returns any value. As we will learn later in this part *any* is a kind of "wildcard" type that can represent any type.

Next we define the function *func* of type *CallsFunction*. From the function's type we can infer that its parameter function cb will only accept a string argument. To demonstrate this, there is also an example where the parameter function is called with a numeric value, which will cause an error in TypeScript.

Lastly we call *func* giving it the following function as a parameter

```
(result) => {
  return result;
}
```

Despite the types of the parameter function not being defined, we can infer from the calling context that the argument *result* is of the type string.

Type erasure

TypeScript removes all type system constructs during compilation.

Input:

```
let x: SomeType;
```

Output:

```
let x;
```

This means that no type information remains at runtime - nothing says that some variable x was declared as being of type *SomeType*.

The lack of runtime type information can be surprising for programmers who are used to extensively using reflection or other metadata systems.

Why should one use TypeScript?

On different forums you may stumble upon a lot of different arguments either for or against TypeScript. The truth is probably as vague as: it depends on your needs and use of the functions that TypeScript offers. Anyway, here are some of our reasons behind why we think that the use of

TypeScript may have some advantages.

First of all, TypeScript offers *type checking and static code analysis*. We can require values to be of a certain type, and have the compiler warn about using them wrong. This can reduce runtime errors and you might even be able to reduce the amount of required unit tests in a project, at least concerning pure type tests. The static code analysis doesn't only warn about wrongful type usage, but also other mistakes such as misspelling a variable or function name or trying to use a variable beyond its scope.

The second advantage of TypeScript is that the type annotations in the code can function as a type of *code level documentation*. It's easy to check from a function signature what kind of arguments the function can consume and what type of data it will return. This form of type annotation bound documentation will always be up to date and it makes it easier for new programmers to start working on an existing project. It is also helpful when returning to an old project.

Types can be reused all around the code base, and a change to a type definition will automatically reflect everywhere the type is used. One might argue that you can achieve similar code level documentation with e.g. JSDoc, but it is not connected to the code as tightly as TypeScript's types, and may thus get out of sync more easily and is also more verbose.

The third advantage of TypeScript is, that IDEs can provide more *specific and smarter intellisense* when they know exactly what types of data you are processing.

All of these features are extremely helpful when you need to refactor your code. The static code analysis warns you about any errors in your code, and the intellisense can give you hints about available properties and even possible refactoring options. The code level documentation helps you understand the existing code. With the help of TypeScript it is also very easy to start using the newest JavaScript language features at an early stage just by altering its configuration.

What does TypeScript not fix?

As mentioned above, TypeScript type annotations and type checking exist only at compile time and no longer at runtime. Even if the compiler does not throw any errors, runtime errors are still possible. These runtime errors are especially common when handling external input, such as data received from a network request.

Lastly, below we list some issues many have with TypeScript, which might be good to be aware of:

Incomplete, invalid or missing types in external libraries

When using external libraries you may find that some libraries have either missing or in some way invalid type declarations. Most often this is due to the library not being written in TypeScript, and the person adding the type declarations manually not doing such a good job with it. In these cases you might need to define the type declarations yourself. However, there is a good chance someone has already added typings for the package you are using. Always check DefinitelyTyped or their GitHub pages first. They are probably the most popular sources for type declaration files. Otherwise you might want to start off by getting acquainted with TypeScript's own documentation regarding type declarations.

Sometimes type inference needs assistance

The type inference in TypeScript is pretty good but not quite perfect. Sometimes you may feel like you have declared your types perfectly, but the compiler still tells you that the property does not exist or that this kind of usage is not allowed. In these cases you might need to help the compiler out by doing something like an "extra" type check, but be careful with type casting and type guards. Using type casting or type guards you are basically giving your word to the compiler that the value really is of the type that you declare. You might want to check out TypeScript's documentation regarding Type Assertions and Type Guards.

Mysterious type errors

The errors given by the type system may sometimes be quite hard to understand, especially if you use complex types. As a rule of thumb, the TypeScript error messages have the most useful information at the end of the message. When running into long confusing messages, start reading them from the end.

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