Type system in programming languages

An introduction

Definition

- A logical system that consists of set of rules that assigns a **property (type)** to variables, expression or functions.
- Main purpose is to reduce bugs
- Other purposes include abstraction, business rules, compiler optimizations or documentation

Type safety and checking

- The extent a programming language discourages or prevents type errors.
- A type error is undesired program behaviour that might occur due to incompatible data types of variables or functions.
- Verify and enforce contraints of a type either at **compile time** (static) or at **runtime** (dynamic), or a combination of both

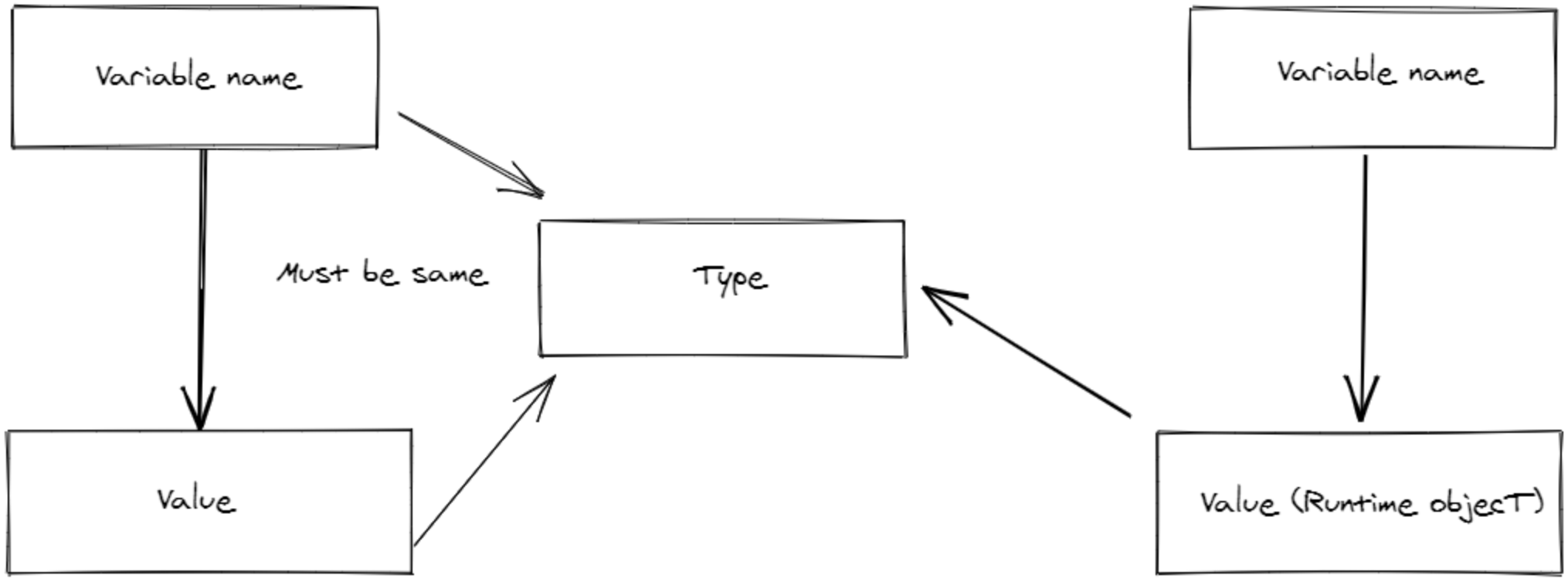
Statically typed languages

- Static type checker
- Analyze source code at compile time
- Type of variable or method is known at compile time
  - Explicitly or by use of type inference (Hindley–Milner)
- A variable declared of a type, cannot be assigned a value of a different type (without casting)
- Some language features cannot be checked statically (i.e downcasting)
- Catch bugs early
- More optimized code, better perf.
- Examples: C, C++, Java, C#, Haskell, F#, Elm, OCaml, Kotlin, Scala, Rust, TypeScript

Dynamically typed languages

- Dynamic type checker (but no static type checker)
- Type check at run time
- Type is associated with run-time objects, the variable has no type
  - Type tag containing type information called, **RTTI**
  - RTTI is alos used for downcasting, reflection and other similar features
- Scripting languages
- No compilation, interpreted languages
- Might result in less optimized code
- Quicker/faster build or debug
- Examples: Python, JavaScript, PHP

Static vs dynamic typing



Static vs dynamic typing

Which ones are valid?

```
//C# - explicit type
int age = 15;
age = "Old";

//C# Type inference
var amount = 500;
amount = "Bouvet";

//Python
salary = 500;
salary = "Bouvet";
```

Strongly typed and weakly typed languages

- How strict the types are enforced
- Rule of thumb: The more *strict* the compiler/interpreter is, the more *strongly typed* a language is
- Strongly typed:
  - No implicit conversion between types
  - Python, C#, F#, Haskell, Java
- Weakly typed:
  - Conversion between types
  - C, C++, PHP, JavaScript

Strongly and weakly typed languages

Which ones are valid?

```
//C#
var age = 26;
var gender = "M";
var result = age + gender;
```

```
//F#
let age = 26
let gender = "M"
let result = age + gender
```

```
#Python
age = 26
gender = "M"
result = age + gender
```

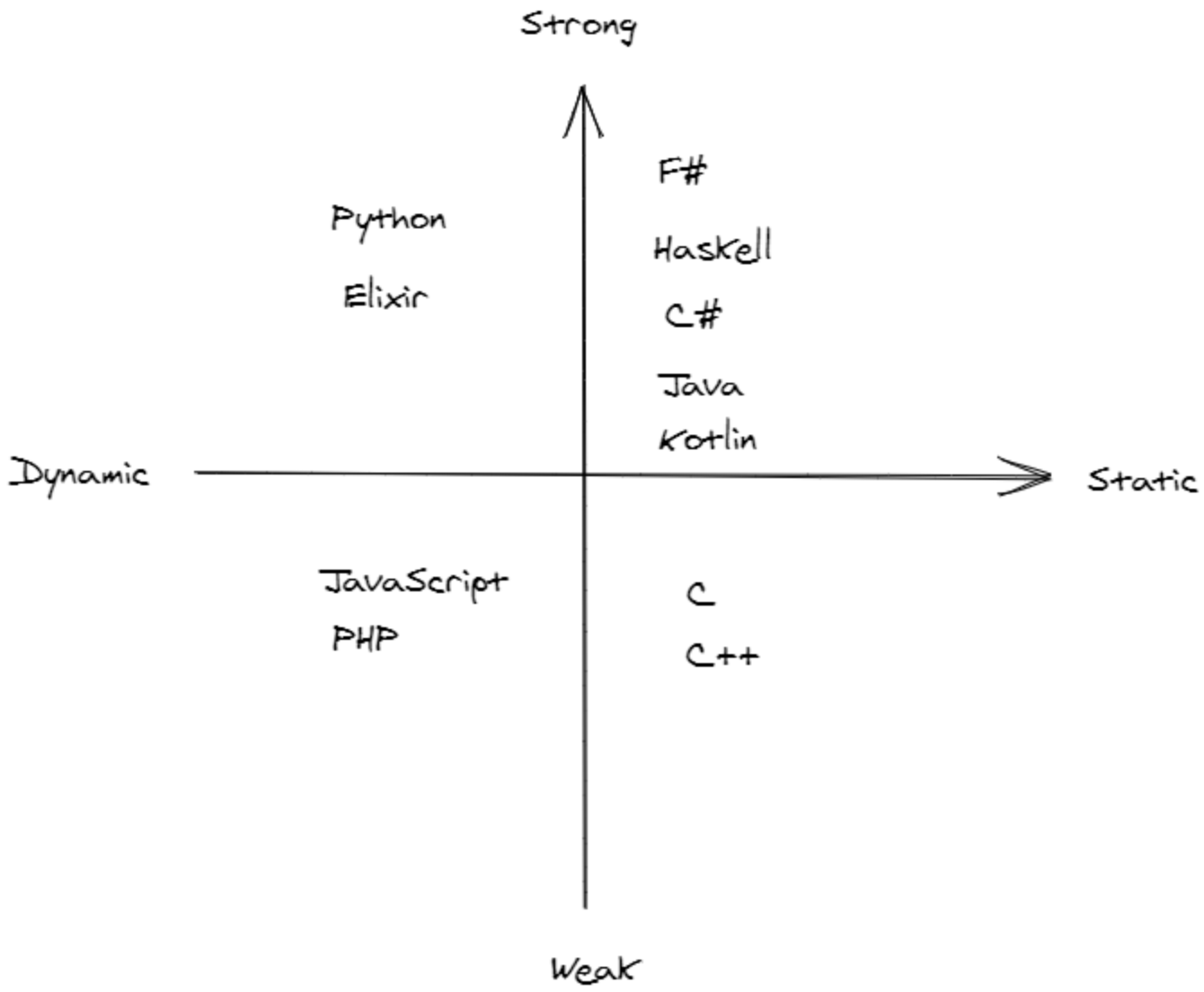
Strongly and weakly typed languages

Which ones are valid?

```
//JS;
const age = 26;
const gender = "M";
const result = age + gender;

//JS;
const age = 26;
const genders = ["M","F","Other"];
const result = age + genders;
```

Overview


Strong
F#
Python
Haskell
Elixir
C#
Java
Kotlin
Dynamic
Static
JavaScript
C
PHP
C++
Weak

Nominal and structural type system

- Nominal:
  - Uses the name to determine equality and subtypes
  - Java, F#, Rust, C#
- Structural
  - Uses the structure to determine equality
  - OCaml, TypeScript, Haskell

```
//F# Nominal
type Employee = {
    Name: string
}

type Manager ={
    Name: string;
}

let manager: Manager = {Name= "Ivar"}
let employee: Employee = {Name= "Terje"}

let names (employee:Employee) (manager:Employee) =
    employee.Name + manager.Name

names employee manager |> ignore //Problem
```

Nominal and structural type systems

```
//TypeScript structural

type Employee = {
    name: string
}

type Manager ={
    name: string;
}

const names = (employee: Employee, manager: Employee) => {
    return employee.name + manager.name
}

let manager: Manager = { name: "Ivar" };
let employee: Employee = { name: "Terje" };
names(employee, manager) // OK
```

That`s it

https://github.com/terjebra/typesystem