

# Programming Paradigms

## Type Systems (Part 4)

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# Overview

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- Introduction
- Types in Programming Languages
- Polymorphism
- Type Equivalence ←
- Type Compatibility
- Formally Defined Type Systems

# Type Equivalence

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**Prerequisite for type checking:**

**Clarify **whether two types are equivalent****

**Two approaches**

- **Structural equivalence**
  - Same structure means same type
- **Name equivalence**
  - Same type name means same type

# Structural Equivalence

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- Given two types, **compare** their **structure recursively**
- **Example: Any class with**
  - an int field called “age”,
  - a boolean field called “isRegistered”, and
  - a method called “printRecord”

# Variation Across Languages

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- **Do names matter?**

- Same memory representation, but differently named
- E.g., different field names in a record

- **Does order matter?**

- Different memory representation, but lossless reordering possible
- E.g., same fields but in different order

Examples

(Pascal-like syntax)

T1 = record a: integer, b: real end;

T2 = record c: integer, d: real end;

T3 = record b: real, a: integer end;

T = record info: integer, next: ^T end;

U = record info: integer, next: ^V end;

V = record info: integer, next: ^U end;

# Limitation of Structural Equivalence

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- Cannot distinguish **different concepts** that happen to be **represented the same way**
- **Example:**

```
type student = record
  name, address : string;
  age: integer
end;
```

vs.

```
type school = record
  name, address : string;
  age: integer
end;
```

# Limitation of Structural Equivalence

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- Cannot distinguish **different concepts** that happen to be **represented the same way**
- **Example:**

```
type student = record
  name, address : string;
  age: integer
end;
```

VS.

```
type school = record
  name, address : string;
  age: integer
end;
```

```
{ This is allowed: }
x : student; y : school;
x := y;
```

# Name Equivalence

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- Types with **different names** are **different**
- Assumption: Programmer wants it that way
- Used in many modern languages, e.g., Java

# Limitations of Name Equivalence

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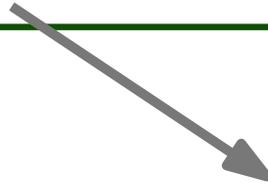
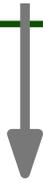
- **Alias types** cause difficulties
- **Example:**

```
{ Here, we want both types to be the same }  
type stack_element = integer;
```

```
{Here, we want distinct types,  
  to prevent mixed computations}  
type celsius = real;  
type fahrenheit = real;
```

# Strict vs. Loose Name Equivalence

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- Aliases are **distinct types**
- `type A = B;` is a **definition**

- Aliases are **equivalent types**
- `type A = B;` is a **declaration**

# Type Conversion

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- **Explicit conversion (cast) of a value form one type to another**
- **Three cases**
  - Types are **structurally equivalent**: Conversion is only conceptual, no code generated
  - Types have **different sets of values**, but are **represented in the same way** in memory: May need check that value is in target type
  - **Different low-level representations**: Need special instructions for conversion

## Examples (Ada)

n:	integer	
r:	long-float	
t:	test_score	-- integer range 0...100
c:	celsius_temp	-- type alias for integer
t :=	test_score(n)	-- runtime, semantic check needed
n :=	integer(t)	-- no check needed
r :=	long-float(n)	-- runtime conversion
n :=	integer(r)	-- runtime conversion & check
n :=	integer(c)	-- purely conceptual
c :=	celsius_temp(n)	-- purely conceptual

# Quiz: Types

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**Which of the following statements is true?**

- Types are compatible if and only if they are equal
- Coercions mean that a programmer casts a value from one type to another type
- Type conversions are guaranteed to preserve the meaning of a value
- PLs with type inference may provide static type guarantees

*Please vote in Ilias.*

# Quiz: Types

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- ~~Types are compatible if and only if they are equal~~
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