Types: Concluding remarks

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Overall theme of the class

• Study programming languages at three levels
  – Basic concepts
  – How concepts are incorporated into languages
  – Implications of language decisions
• First part of the course looked at types at each of the three levels
Types: Important concepts

- Static or dynamic typing
- Strong or weak typing
- When types are equal
- What assignments are legal (subtyping issues)
- Polymorphism
- Type inference

How types are incorporated into languages

- Smalltalk: dynamically typed; single inheritance; inheritance for reuse.
- Java: statically and strongly typed; single inheritance of classes; multiple inheritance of interfaces; inheritance for reuse and subtyping; inclusion polymorphism; designed to be clean; assignability based on subtyping rules (narrowing and widening); explicit method for info hiding; name equality.
How types are incorporated into languages (II)

• Modula-3: statically and strongly typed; single inheritance; inclusion polymorphism; designed for efficiency; assignability based on subtyping rules; subclassing for reuse, subtyping, and info hiding; structural equality

• C++: weakly typed; multiple inheritance; inheritance for subtyping and code reuse; inclusion polymorphism; assignability based on subtyping rules; explicit method for info hiding; name equality.

How types are incorporated into languages (III)

• SML: statically and strongly typed; type inference; parametric polymorphism; mostly functional.
Implications of concepts in languages

• Strong typing has a cost: may require run-time checking
• Polymorphism may be costly (Smalltalk), inexpensive (Modula-3, SML), or so-so (Java, C++).
• Inheritance may interact with encapsulation (situation particularly bad with C++ multiple inheritance)
• Types can be used to speed up programs. Type safety doesn't imply slow

Next area of study

• Control structures
  – We won't bother with the mundane ones (conditionals, loops, etc.) but the exciting ones
  – Closures
  – Exceptions
  – Continuations