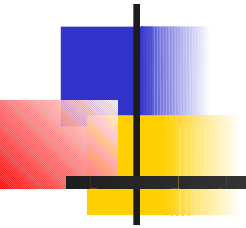

Generics with Discretion

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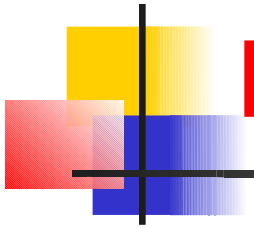
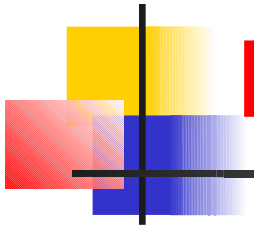


How Generics Work

- The implementation of generics is smoke. The Java compiler (**`javac`**) understands the typing rules which are based on the idea that each instantiation of a generic class (*e.g.*, **`List<Integer>`**, **`List<Number>`**, **`List<Integer>`**) is a disjoint type and enforces the appropriate typing rules based on this conceptual model. But the Java compiler implements generic types by erasing the parametric type information and automatically inserting casts where necessary. In a type-correct program (one that does not violate any typing rule and hence generates no errors or warnings), these casts can never fail.
- Note that subtyping is *not* co-variant: **A <:** (is a subtype of) **B>** ! **`List<A>` <: `List<B>`** . Co-variant subtyping does not hold because object fields can be mutated. If I can change the elements embedded in a composite object consistent with the declared type of the composite object, I cannot soundly treat a **List<Integer>** as a **List<Object>**. These restrictions on generics are determined by the mathematics of type parameterization not the vagaries of Java.

Aside: Accommodating Co-variance

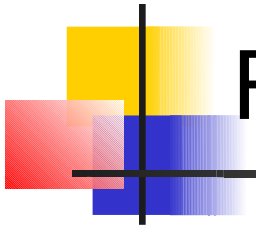
- Co-variant subtyping is mathematically feasible but it requires much more stringent type-checking rules, which make it unacceptable in most situations. Some languages like Scala allow the programmer the option of specifying that a particular generic type is co-variant. Java uses a different approach called wildcards to accommodating occasional co-variance.
- The theory of wildcard types is nearly non-existent. The developers of Java 5.0 decided wildcards were so useful that they should be included in Java despite the fact that the research literature (at the time of Java 5.0's beta release) only included one fragmentary paper (published in a workshop) that discussed wildcard types and a few others that talked about similar but technically different type systems. Unfortunately, the wildcard design in Java 5.0/6.0 is flawed. My recommendation: use only simple forms of wildcards and use them only when there is no other equally good way to produce type-correct code.



Raw Types

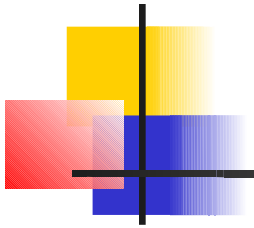
The Java type system refers to the erased form of generic types as *raw* types. Raw types can be used in program text when integrating generic and non-generic code and when working around restrictions in generic type system imposed by erasure, but their usage should be minimized. Most usages of raw types constitute a breach of the Java generic type system. A program that uses raw types is likely to generate type warnings. A raw type `C` is nearly (but not) exactly the same as the wildcard type `C<?>`.

No further discussion of raw types in this course. Raw types should not be necessary in any code written in this course.



Recommendations on Using Generics

- Ideally suited for parameterizing the types of classes that represent program data objects (including closures).
- Do not hesitate to use generics for clarifying the typing of data classes (and hence avoiding explicit casts).
- If a program generates a plethora of warnings, something is wrong. In general warnings should be avoided; they correspond to breaches in the type system and very likely correspond to semantic (run-time) type errors. Every warning message should be justified by a program comment.
- Remember that generics are supposed to serve the programmer, not vice versa



For Next Class

- Homework due on Friday. It consists of doing HW6 in Java given a Scheme solution.
- DrJava bugs. Most anonymous classes defined in the Interactions Pane currently fail. We are working on this problem. As a workaround, define the anonymous inner class in the Definitions Pane.
- Since the JVM does not perform tail optimization and also supports multiple threads (each of which requires a call stack), some viable computations will overflow the stack. You can force the JVM to allocate larger per-thread call stacks by editing DrJava preferences and typing

  `-Xss64M`

  in the dialog box labeled JVM args for Interactions JVM in the Miscellaneous panel of DrJava Preferences.