Lecture 32:
C++,

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C++ Problems

• Confusing casts and conversions ✓
• Objects allocated on stack
  - what happens w/subtyping? truncation!
• Overloading methods -- see earlier examples!
• Multiple inheritance (later)

Objects on stack

• Doesn't interact well with subtyping.
• Point p; // allocates point on stack
• ColorPoint cp(3,4,BLUE);
• p = cp; // slices and converts to Point
• Call by value has similar problems
• What about reference parameters to methods?

OO Features

• Visibility
  - Public, protected, private
  - Friends ...
• Virtual vs. nonvirtual functions
  - don’t pay the price of dynamic method invocation
• Implemented via vtable
  - no search necessary
  - static typing makes efficient rep possible
    - efficient iff subtype from inheritance!

VTable for Virtual methods

C++ vs Smalltalk implementation

• No search in C++ since offset for given method
  same in base and derived classes
• Smalltalk has no type declaration
  - value not known to be subtype of declared type
  - no idea where method is located
Abstract classes

- Have at least one method undefined
- “Pure” leaves all undefined
- Can’t construct, but can inherit from
- Derived subclasses can be used as subtypes of abstract base class.

Multiple Inheritance

- Appealing: TA derived from Student and Teacher.
- Added to C++ and Smalltalk. In Eiffel from beginning.
- Problems conceptually and with implementation

MI in C++

```cpp
class S {...}
class T {...}
class TA: public S, public T {...}

TA* pta = new TA();
S * ps = pta;
T * pt = pta;
```

Representing MI

Conceptual Problems w/ MI

Diamond Inheritance: Suppose A has virtual f and B and C override it. Which version is inherited in D?

Java Solution

- Most multiple inheritance in C++ involves pure base classes.
- Java: Single inheritance, but can implement multiple interfaces.
- Avoids problems.
- Traits (e.g., in Scala) are modern alternative.
C++ Summary

- One of most complicated languages ever
  - design by accretion
- Meets design goals but very hard to get right
  - C makes it easy to shoot yourself in the foot. In C++ it's harder to shoot yourself in the foot, but when you do, you blow off your whole leg. – Stroustrup
- Memory management is big problem
- Most programmers learn a subset.

Java Design Goals

- Portability across platforms
- Reliability
- Safety (no viruses!)
- Dynamic Linking
- Multithreaded execution
- Simplicity and Familiarity
- Efficiency

Java

- Original implementations slow
  - Compiled to JVML and then interpreted
  - Now JIT
  - Garbage collection
- Safety - 3 levels
  - Strongly typed
  - No pointer arithmetic, unchecked type casts, etc.
  - JVML bytecode also checked before execution
  - Run-time checks for array bounds, etc.
  - Super constructor called at beginning of constructor

C++ Humor

- C++: Hard to learn and built to stay that way.
- Java is, in many ways, C++-
- How C++ is like teenage sex:
  1. It is on everyone's mind all the time.
  2. Everyone talks about it all the time.
  3. Everyone thinks everyone else is doing it.
  4. Almost no one is really doing it.
  5. The few who are doing it are:
     A. Doing it poorly.
     B. Sure it will be better next time.
     C. Not practicing it safely.