Lecture 36: OO Languages, Parallel

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Traits in Scala

- Traits can be used like classes
  - But have no constructors
- Can also be used as "mixins"
- Class can extend at most one class or trait
  - but can mixin many traits

Iterator Traits

```
trait AbsIterator[T] {
   def hasNext: boolean
   def next: T
}
```

Can also contain behavior:

```
trait RichIterator[T] extends
                        AbsIterator[T] {
   def foreach(f: T => unit): unit =
      while (hasNext) f(next)
}
```

Trait as Superclass

```
class StringIterator(s: String) extends AbsIterator[char] {
  private var i = 0
  def hasNext = i < s.length
  def next = { val x = s charAt i; i = i + 1; x }
}
```

Traits applied in Order

```
object Test {
  def main(args: Array[String]): unit = {
    class Iter extends StringIterator(args(0))
                with RichIterator[char]
    val iter = new Iter
    iter foreach System.out.println
  }
}
```

- Solves multiple inheritance problems because linearize order
  - last definition wins
  - super refers to previous trait/superclass
  - Can override in body or in any trait

Another Example

```
trait SyncIterator[T] extends AbsIterator[T] {
   abstract override def hasNext: boolean =
                        synchronized(super.hasNext)
   abstract override def next: T =
                        synchronized(super.next)
}
```

abstract because not implemented in AbsIterator

```
StringIterator(someString) with RichIterator[char]
                           with SyncIterator[char]
```

- Order not matter here, but could in other examples
- Super calls go to StringIterator, not AbsIterator

Evaluating OOLs

Evaluation of OOL's

- Pro's (e.g., with Eiffel and Java)
  - Good use of information hiding. Objects can hide their state.
  - Good support for reusability. Supports generics like Ada, run-time creation of objects (unlike Ada)
  - Support for inheritance and subtyping provides for reusability of code.

Evaluation of OOL's

- Con's
  - Loss of locality.
  - Type-checking too rigid, unsafe, or requires link time global analysis. Others require run-time checks.
  - Semantics of inheritance is very complex.
    - Small changes in methods may make major changes in semantics of subclass.
    - Must know definition of methods in superclass in order to predict impact on changes in subclass. Makes provision of libraries more complex.
  - Weak or non-existent support of modules.

Concurrent & Parallel Programming Constructs

What is the difference?

- Parallel programming is about using additional computational resources to produce an answer faster.
- Concurrent programming is about correctly and efficiently controlling access by multiple threads to shared resources.
  - Includes providing reasonable response times.

Definitions by Dan Grossman

Why Important

- Speed-ups limited w/single processors
  - dual/quad/oct processors now standard
- Required for distributed processing
- Concurrency required for event-driven programming

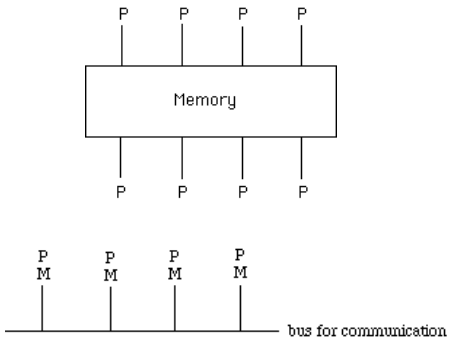
Processes vs Threads

- Processes are independent, process may be composed of multiple threads
- Processes contain separate state info, while threads w/in process share same state/memory
- Context switching between threads much cheaper than between processes.

Flavors of Concurrency

- Multiprogramming -- interleaving on 1 computer
- Multiprocessing -- parallel computation
- Codes:
  - M - Multiple
  - S - Single
  - I - Instruction
  - D - Data
- MIMD most interesting from CS point of view

Shared Memory vs Distributed Models



Problems

- Threads/processes need to
  - Synchronize with other threads
  - Communicate data
- Shared Memory:
  - Synchronization of memory accesses
    - See ATM2 program problem
  - Mutual Exclusion: Reader-Writer problem
- Distributed
  - Asynchronously send and receive messages