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Them Threads, Them Threads, Them Useless Threads

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Aims and Objectives of the Session

- Raise awareness that threads are the problem as much as the solution.
- Show that threads are a low-level language implementation tool not an application programming tool.
- Show that higher-level abstractions are needed to manage parallelism in the brave, new, multicore world.

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Structure of the Session

- Look at the threads support in Java, C++, and C.
- Look at some of the most obvious problems.
- Look at how Erlang and Occam deal with this.
- Tentatively, propose a new next layer model for Java, C++, and C.

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On Expertise In Programming

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Aims and Objectives

- To convince people that learning and using multiple programming paradigms is the road to improved competence.

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On Expertise

- Expertise is *not* the number of years of experience in a given language – though that is a factor.
- Expertise is strongly related to the number of different types of language a person is fluent in.

Learning and being able to use C, C++, Java, Python, Ruby, Groovy, Fortran, Haskell, Erlang, etc. ***properly*** *makes you a better programmer.*

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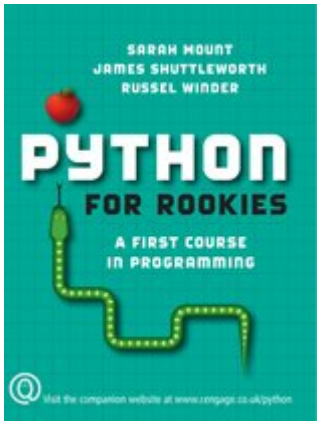

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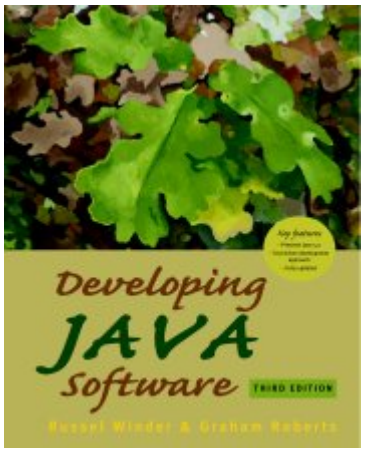

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My Camera and Me

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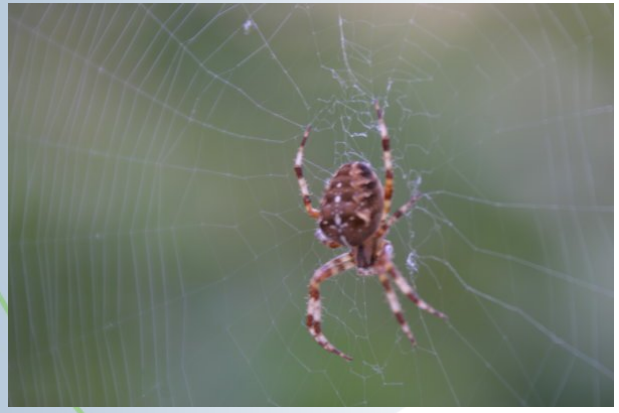
Some Photos I Have Taken



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The Keywords

- Multiprogramming
- Multitasking
- Multithreading
- Concurrency
- Multiprocessing
- Parallelism

- SISD
- SIMD
- MISD
- MIMD

- Tightly coupled
- Loosely coupled

- Data parallel

- Multicore
- Cluster

- Livelock
- Deadlock

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A Bit of History
In the Beginning

- Computer hardware was expensive and hard to find; maximizing utilization was critical.
- Multitasking (multiple concurrent processes) was crucial for maximizing availability and utilization.
- Virtualization was flirted with, but it did not become mainstream – though recently it has become de rigeuer.

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A Bit of History
The Early Middle Period

- Tasks/processes seen as too heavyweight.
- Lightweight processes, aka threads, introduced.
- Issues:
  - Tasks/processes had hardware and operating system support, threads did not.
  - Tasks/processes have separate memory; threads are a shared memory approach.

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A Bit of History
The Late Middle Period

- Sun LWP
- PThreads
- ???

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A Bit of History
Modern Times

- Java integrates threads in the core model.
  - One model makes programming more consistent.
  - Monitors as well as locks are an integral part of the language.
- C++ has no standard so the plethora remains.
  - C++0x shows that the C++ committee consider threads need standardizing.
  - Basically PThreads.
  - What happened to Boost.Thread?
  - No integration of higher-level mechanisms.

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Quick Quiz

- Who said:

  "Multithreaded programming is fraught with many challenges, and can rightly be considered something that the majority of programmers should steer clear of."

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Consequences

- All computers are parallel processors.
- Multicore processors and multiprocessor systems offer threads as the mechanism of control.

- The majority of programmers should steer clear of computers.

- Only write single-threaded programs.

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Thread Safety

- Java really brought thread-based programming to the masses.
- C and C++ had threads but they were an add on.
- Java brought "thread safety" front and centre:
  - Library classes made thread safe.
  - Programmers taught to think about concurrency and thread safety.
  - Thread safety kills performance of single-threaded applications.

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The StringBuffer Problem

- StringBuffer is a thread-safe class (well as much as possible).
- It is heavyweight and slow.
- String manipulation is at the core of everything.
- StringBuilder is a necessity.

Is there "too much thread safety"?

No just inappropriate thread safety.

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Collections as an Example

- The basic data structures are not thread safe, they are as fast as possible in a single-threaded context.
- Thread safety is achieved through added adapters.

Collection.synchronizedSet

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Collections as Anti-Pattern?

public static <T> Set<T> synchronizedSet(Set<T> s)
Returns a synchronized (thread-safe) set backed by the specified set. In order to guarantee serial access, it is critical that all access to the backing set is accomplished through the returned set.
It is imperative that the user manually synchronize on the returned set when iterating over it:

```
 Set s = Collections.synchronizedSet(new HashSet());
     ...
 synchronized(s) {
     Iterator i = s.iterator(); // Must be in the synchronized block
     while (i.hasNext())
         foo(i.next());
 }
```

Failure to follow this advice may result in non-deterministic behavior.
The returned set will be serializable if the specified set is serializable.
Parameters:
s - the set to be "wrapped" in a synchronized set.
Returns:
a synchronized view of the specified set.

From Sun's API manual

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Java Util Concurrent

- Does ConcurrentSkipListSet solve the problem?

Possibly, but probably not.

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Dissention

- Concurrency in Java is hard:
  - Threads is the biggest problem in all Java training.
  - java.util.concurrency still doesn't make it easy enough.
- Occam and Erlang never bought into the threads model for programming:
  - Message passing is the only model.
  - No synchronization because there is no shared memory.

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The Problems of Threads

- Shared memory.
- Flow control.
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Event-driven Programming

- Event loop
- Callbacks/even handlers to deal with things.
- Standard architecture for GUI and networking.
  - Swing/AWT
  - Gnome
  - Twisted Internet

Does this solve the problem – no.

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Taxonomy Of Parallelism

- Shared memory.
- Distributed Memory:
  - Slow communications:
    - errors likely.
  - Fast communications:
    - errors unlikely.

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Cluster Parallelism

- Processes on separate computers.
- Communication by message passing.

- PVM
- MPI
- Erlang

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Multiprocessor Parallelism

- Single system.
  - Shared memory.
  - Bus-based message passing.
- Processes/IPC
- Threads
- Message passing:
  - Occam
  - Erlang

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What To Do

- Refuse to use multiple threads.
- Never use shared mutable state.
- Always use message passing.

Put a layer on Java for doing message passing.

Something pairing with java.util.concurrent.

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What have the HPC People Done?

- OpenMP
  - Data parallelism.
  - Fine-grain parallelism.
  - Thread implemented.
- MPI:
  - Message passing.
  - Cluster-level parallelism.
  - Process implemented.

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Summary

- Threads are needed but they are not a programmer tool.
- Why bother with an explicit threads API when OpenMP is available?
- Why not use a language that supports parallelism directly:
  - Erlang
  - Haskell
  - Occam

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