Lecture 5

Casting, Collections, Maps and Threads
Casting Objects

Polygon
------------------------+ numSides:int
------------------------+ display():void

Square
------------------------+ numSides:int
- side:float
------------------------+ Square()
+ Square(side float)
+ display():void

Trapezoid
------------------------+ x1,x2,y:float
------------------------+ Trapezoid(x1:float,x2:float,y:float)
+ display():void
Casting Objects

Square    mySquare = new Square(4.0);
Trapezoid myTrapezoid = new Trapezoid(2.0, 2.0, 3.0);
Polygon   anyPoly;
Square    anotherRef2Trapezoid;

anyPoly = (Polygon)mySquare;
anyPoly.display();                              // what method gets invoked?
System.out.println(anyPoly.numSides);          // which var prints?
System.out.println(mySquare.numSides);         // which var prints?
anyPoly = my Trapezoid;
anyPoly.display();                              // what method gets invoked?
System.out.println(anyPoly.numSides);          // which var prints?
anotherRef2Trapezoid = (Trapezoid) anyPoly;   // is this legal?
anotherRef2Trapezoid.display();                // what method gets invoked?
Casting Objects

- Overridden method in the child will be executed in a reference that is of the parent type. (like C++ virtual). Dynamically determined in runtime.

- Shadowed vars are statically determined at compile time. The one you get is the visibility you have at compile time. Ref of parent type sees parent version of a shadowed var.

- **Shadowed** variables obscure the variables in the parent (not really overiding them)
  - Use `super` in child to get at parent.
  - Use `this` if in a method and arguments are same as class/instance variable;

- If a method is **overloaded** in a child (different parameters, same method name) vs. parent, the parent method may be the one that matches the parameters an it get executed even on a ref of parent type – **bug warning**
Overloading vs. Overriding

• **Overloading** is multiple versions of a method (in a single class) but different parameter signatures. Ex:
  – add(int, int)
  – add(float, float)
  – add(int, int, int)

• **Overriding** is parent method gets replaced by a child with a method def that is same name and parameter signature
  – display()

• **Shadowing** – var has same name is parent and child or as param to method
What are collections?

- a type of class that stores and manipulates groups of objects.
- Java 1.2 introduced the Collections framework (currently Java 1.4)
- maps, dictionaries and associative arrays
- collections are containers of objects a.k.a elements
Collections

- extend the `Collection` interface
- Collections are dynamic in size (unlike arrays).
- List – dups ok
  - `ArrayList` – dynamic length
  - `LinkedList` – order preserved
- Set – no dups
  - `HashSet` - efficient storage of an element
  - `LinkedHashSet` – insertion order is preserved
different types of collections/maps

- **Array** – fixed size stores dups and nulls (not really a collection)
- **List** – variable size, specific insertion order, duplicates allowed (abstract)
- **Set** – variable size, specific insertion order, NO duplicates allowed (abstract)
- **ArrayList** – dynamic length array.
- **LinkedList** – a list with a preserved order. Supports queues and stacks.
- **Vector** – an array that grows and shrinks. Synchronized access.
- **HashSet** – stored via a hashing mechanism. Fast access. Order is not guaranteed over time through iterator. Membership in set is quickly determined.
- **TreeSet** – elements are stored in sorted order using a balance tree algorithm. Order is ascending.
- **HashMap** – (key, object reference) pairs stored. Retrieved by key. Order not preserved. Access to elements optimized by hashing the key and placing elements into buckets
- **LinkedHashSet** – a set that is managed as a hash with a doubly linked list. Order is maintained. Order is determined by insertion.
Collection interface

• Collection
  – List is a Collection
  – Set is a Collection
  – SortedSet is a Collection

• AbstractList implements Collection, List
  – ArrayList is a AbstractList
  – Vector is a AbstractList
methods in the interface

boolean add(Object o) //Ensures that this collection contains the specified element (optional operation).
boolean addAll(Collection c) //Adds all of the elements in the specified collection to this collection (optional).
void clear() //Removes all of the elements (optional)
boolean contains(Object o) //true if this collection contains the specified element.
boolean containsAll(Collection c) //true if this collection contains all of the elements in the specified collection.
boolean equals(Object o) //Compares the specified object with this collection for equality.
int hashCode() //Returns the hash code value for this collection.

*optional methods not supported must throw the UnsupportedOperationException in their implementation
methods in the interface(2)

boolean isEmpty()            //Returns true if this collection contains no elements.
Iterator iterator()          //Returns an iterator over the elements in this collection.
boolean remove(Object o)     //Removes a single instance of the specified element
                                //from this collection, if it is present (optional)
boolean removeAll(Collection c)  // Removes all this collection's elements that are
                                // also contained in the specified collection (optional)
boolean retainAll(Collection c)  // Retains only the elements in this collection that are
                                // contained in the specified collection (optional)
int size()                    //Returns the number of elements in this collection.
Object[] toArray()            //Returns an array containing all of the elements
Object[] toArray(Object[] a)  //Returns an array containing all of the elements in this
                                //collection; the runtime type of the returned array is
                                //that of the specified array.
                                //AUTOMATICALLY reallocates the array if the supplied
                                //one is too small!
Iterator interface

• Supports getting the objects in a collection
• java.util package

boolean hasNext() //Returns true if the iteration has more elements.
Object next() //Returns the next element in the iteration.
void remove() //Removes from the underlying collection the
//last element returned by the iterator (optional)

throws
UnsupportedOperationException
IllegalStateException
ListIterator interface

- java.util package
- public interface ListIterator
  - extends Iterator

  void add(Object o)     // Inserts the specified element into the
  // list (optional operation).

  boolean hasNext()      // Returns true if this list iterator has
  // more elements when traversing the list
  // in the forward direction.

  boolean hasPrevious()  // Returns true if this list iterator has
  // more elements when traversing the list
  // in the reverse direction.

  Object next()          // Returns the next element in the list.

  int nextIndex()        // Returns the index of the element that
  // would be returned by a subsequent call
  // to next.

  Object previous()      // the previous element in the list.
ListIterator interface(2)

```java
int previousIndex()  //Returns the index of the element that
                     //would be returned by a subsequent call
                     //to previous.

void remove()        //Removes from the list the last element
                     //that was returned by next or previous
                     //(optional)

void set(Object o)   //Replaces the last element returned by
                     //next or previous with the specified
                     //element (optional operation).

throws              
UnsupportedOperationException
IllegalStateException
NoSuchElementException
ClassCastException
IllegalArgumentException
```
CollectionsDemo

- ArrayList myListOfNames;
- HashSet myHashSetOfNames;
- HashMap myHashMapOfStudentInfo;
- Hashtable myHashtableOfStudentInfo;
- TreeSet myTreeSetOfNames;
CollectionsDemo

**************************
ListArray Demo
The iterator.next() returned: Smith
The iterator.next() returned: Chang
The iterator.next() returned: Chen
The iterator.next() returned: Lewin
The iterator.next() returned: Peng
The iterator.next() returned: Chen
====
The iterator.previous() returned: Chen
The iterator.previous() returned: Peng
The iterator.previous() returned: Lewin
The iterator.previous() returned: Chen
The iterator.previous() returned: Chang
The iterator.previous() returned: Smith
CollectionsDemo

*******************************
HashSet Demo
add() failed on Chen
The iterator.next() returned: Peng
The iterator.next() returned: Chen
The iterator.next() returned: Chang
The iterator.next() returned: Lewin
The iterator.next() returned: Smith
====
myHashSetOfNames.size() = 5
The iterator.next() returned: Peng
The iterator.next() returned: Chen
  remove the current element
myHashSetOfNames.size() = 4
The iterator.next() returned: Peng
The iterator.next() returned: Chang
The iterator.next() returned: Lewin
The iterator.next() returned: Smith
CollectionsDemo

**************************************************************************
HashMap Demo
The put(Chang , Chang 212-000-0000 0)
The put(Khan , Khan 212-111-1111 1111)
The put(Donovan , Donovan 212-222-2222 2222)
The put(Patel , Patel 212-333-3333 3333)
The put(Poelman , Poelman 212-444-4444 4444)
The put(Aja , Aja 212-555-5555 5555)
The put(Wu , Wu 212-666-6666 6666)
The put(Josie , Josie 212-777-7777 7777)
The put(Fez , Fez 212-999-9999 9999)
====
Find entries in the map
The myHashOfStudentInfo.get(Chang) = Chang 212-000-0000 0
The myHashOfStudentInfo.get(Khan) = Khan 212-111-1111 1111
The myHashOfStudentInfo.get(Donovan) = Donovan 212-222-2222 2222
The myHashOfStudentInfo.get(Patel) = Patel 212-333-3333 3333
The myHashOfStudentInfo.get(Poelman) = Poelman 212-444-4444 4444
The myHashOfStudentInfo.get(Aja) = Aja 212-555-5555 5555
The myHashOfStudentInfo.get(Wu) = Wu 212-666-6666 6666
The myHashOfStudentInfo.get(Josie) = Josie 212-777-7777 7777
The myHashOfStudentInfo.get(Fez) = Fez 212-999-9999 9999
Search for Chang
key = Chang => Chang 212-000-0000 0
Search for ChangX
no object returned
====

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Hashtable Demo
The put (Chang, Chang 212-000-0000 0)
The put (Khan, Khan 212-111-1111 1111)
The put (Donovan, Donovan 212-222-2222 2222)
The put (Patel, Patel 212-333-3333 3333)
The put (Poelman, Poelman 212-444-4444 4444)
The put (Aja, Aja 212-555-5555 5555)
The put (Wu, Wu 212-666-6666 6666)
The put (Josie, Josie 212-777-7777 7777)
The put (Fez, Fez 212-999-9999 9999)
====
Find entries in the table

The myHashtableOfStudentInfo.get(Chang) = Chang 212-000-0000 0
The myHashtableOfStudentInfo.get(Khan) = Khan 212-111-1111 1111
The myHashtableOfStudentInfo.get(Donovan) = Donovan 212-222-2222 2222
The myHashtableOfStudentInfo.get(Patel) = Patel 212-333-3333 3333
The myHashtableOfStudentInfo.get(Poelman) = Poelman 212-444-4444 4444
The myHashtableOfStudentInfo.get(Aja) = Aja 212-555-5555 5555
The myHashtableOfStudentInfo.get(Wu) = Wu 212-666-6666 6666
The myHashtableOfStudentInfo.get(Josie) = Josie 212-777-7777 7777
The myHashtableOfStudentInfo.get(Fez) = Fez 212-999-9999 9999

Search for Chang
key = Chang => Chang 212-000-0000 0
Search for ChangX
no object returned

====
• Questions
• Comments

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Map Interface

• not a collection

• public class HashMap
  – extends AbstractMap
  – implements Map, Cloneable, Serializable

• key and value pairs stored in the map (dictionary)

• Map implemented in these classes
  – AbstractMap
    • HashMap
    • IdentityHashMap
    • TreeMap
    • WeakHashMap
  – Hashtable a subclass of Dictionary
methods

clear() //Removes all mappings from this map (opt)
boolean containsKey(Object key) //true if this map contains a mapping for 
//the specified key.

boolean containsValue(Object value) //true if this map maps one or more 
//keys to the specified value.
Set entrySet() //a set view of the mappings contained in this map.
boolean equals(Object o) //Compresses the specified object with this 
//map for equality.
Object get(Object key) //Returns the value to which this map maps 
//the specified key.
int hashCode() //Returns the hash code value for this map.
boolean isEmpty() //true if this map contains no key-value 
//mappings.
Set keySet() //Returns a set view of the keys contained 
//in this map.
Object put(Object key, Object value) //Associates the specified value 
//with the specified key in this map (opt) 
//(optional operation).
methods(2)

void putAll(Map t) //Copies all of the mappings from the
               //specified map to this map (opt)

Object remove(Object key) //Removes the mapping for this key from this
                         //map if it is present (opt).

int size() //Returns the number of key-value mappings in
            //this map.

Collection values() //Returns a collection view of the values
                     //contained in this map.
HashMap Class

• Load Factor & Initial Size
  – number of entries in the hashtable exceeds the product of the load factor and the current capacity
  – Will rehash if load factor exceeds specified
  – Takes time
Hashtable Class

• Like a HashMap but older version
• Synchronized
  – Thread safe access
• No nulls
• Load Factor & Initial Size
  – number of entries in the hashtable exceeds the product of the load factor and the current capacity
  – Will rehash if load factor exceeds specified
  – Takes time
Hashtable Class

Hashtable() //Constructs a new, empty hashtable with a default initial capacity (11) and load factor, which is 0.75.

Hashtable(int initialCapacity) //Constructs a new, empty hashtable with the specified initial capacity and default load factor, which is 0.75.

Hashtable(int initialCapacity, float loadFactor) //Constructs a new, empty hashtable with the specified initial capacity and the specified load factor.

Hashtable(Map t) //Constructs a new hashtable with the same mappings as the given Map.
• Questions
• Comments

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Threads

- A unit of execution within a process
- Process may have multiple threads
- Process holds heap, file handles tables etc. Shared across all threads in process.
- Non-atomic operations executed on different threads at the same time can result in unpredictable outcomes
  - Atomic operations happen in a single operation
  - \( x = y; \) //atomic if \( x \& y \) are ints NOT if longs or doubles!
  - Why? Int is 4 bytes long is 8. Most processors work on 4 bytes per instruction cycle NOT 8 or more.
Threads

- Threads have their own:
  - Instruction Counter
  - Stack
  - Local Variables

- Threads share:
  - Process variables
  - Code
  - Heap - Class and Instance Variables
Threads vs. Processes

• Quick communication between threads because they share memory space
• Lighter weight
• Threads share code, objects in memory, processes don’t
Threads in Java

• Platform dependent!
  – some are non-preemptive and some preemptive
• Swing uses a single thread
  – different from the main thread
• Threads share heap objects
  – created via \texttt{new}
• Threads have their own stack
• Threads have private instances of stack variables and local variable in a method
Scheduling

• Preemptive
  – OS switches between threads running based on timeslice and priority
  – Supports concurrent and parallel execution
  – More flexible
  – Easier for developer to implement

• Cooperative
  – threads yield control and application switches to executing a different thread
  – Supports concurrent only – no multiple CPU support
  – Faster
  – Requires coding yield()s into the application code
Relationship between Process and its threads

Process

- Code
- File Table
- Heap
  - Class Vars
  - Instance Vars

- Stack
  - Local Vars
  - IC

- Thread

- Stack
  - Local Vars
  - IC

- Thread

- Stack
  - Local Vars
  - IC

- Thread

- Stack
  - Local Vars
  - IC
Multiple processes share nothing but the JVM and OS
Thread safe

- synchronized
- atomic variables
- immutable objects
- mutexes
thread priority

• higher priority gets more time on the CPU
• Java has 10 levels : 0 - 9
  – Solaris $2^{31}$ & processes have priorities
  – NT 7 levels plus boosting w/no process priorities!
  – Using priority under Java is not reliable across platforms
thread priority (2)

- Thread.MAX_PRIORITY
  - //The maximum priority that a thread can have.
- Thread.MIN_PRIORITY
  - //The minimum priority that a thread can have.
- Thread.NORM_PRIORITY
  - //The default priority that is assigned to a thread.
Using priorities

• Highest for UI
• Medium for calculations
• Low background tasks and clean up
Daemon threads

- Continue to live after the process that created them terminates (unlike regular threads)
- Background tasks and services
- When all processes in the JVM terminate the daemon threads will be stopped by JVM
- use `setDaemon(true)` before you `start()` the thread
join()

• make one thread wait to finish until the other does
• use instead of polling to see if all the threads finished
Creating threads

- FourThreadDemo sample
- Creates four objects and runs them on four separate threads
- Output:

1234123412341234123412341234123412341234123412341234123412341234123412341234123412341234

-------------

Threads should stop now please
-------------
In Debug Mode

Shows the threads we created
FourThreadDemo

• “12341234...” isn’t always the order to expect, especially on a multiprocessor machine

• Sleep time is quite long compared to execution. Shorter sleep will result in less predictable output.

• Separate objects on separate threads will only have synchronization issues on the class variables and methods!
**FourThreadDemo_SameObject**

- Single object executing on four threads concurrently
- Shows thread shared and private variables
- *thread “label” [counter] thread name*
- Each thread increments the same counter variable

1[0] - Limberger
1[1] - Gruyere
1[2] - Gorgonzola
1[3] - Fontina
1[4] - Limberger
1[5] - Gruyere
1[6] - Gorgonzola
1[7] - Fontina
1[8] - Limberger
1[9] - Gruyere
FourThreadDemo_SameObject

- If you set the sleep time to 5 milliseconds instead of 500 things are different!
- Remember incrementing a long isn’t an atomic operation
Execution of threads

- 1 CPU – interleaved (timesliced)
- \( n \) CPUs – in parallel (depends on the JVM)
- Threads can be executed in any sequence – not just sequentially (round robin)
- One thread can change part of an object while a different part is being changed by a different thread unless synchronized
- Bugs can be hard to reproduce and fix
ThreadContentionDemo

- Output:

  No thread contention

  -----------
  Pass 0: Time lost (non vs. sync-ed): 30 ms. 175% increase
  Pass 1: Time lost (non vs. sync-ed): 1 ms. 101.43% increase
  Pass 2: Time lost (non vs. sync-ed): 40 ms. 233.33% increase
  Pass 3: Time lost (non vs. sync-ed): 0 ms. 100% increase
  Pass 4: Time lost (non vs. sync-ed): 40 ms. 233.33% increase
  Pass 5: Time lost (non vs. sync-ed): 0 ms. 100% increase
  Pass 6: Time lost (non vs. sync-ed): 41 ms. 236.67% increase

  With thread contention

  -----------
  Pass 7: Time lost (non vs. sync-ed): 711 ms. 1,522% increase
  Pass 8: Time lost (non vs. sync-ed): 791 ms. 2,736.67% increase
HotSpot Compiler

• http://java.sun.com/products/hotspot/Q+A.html
• Questions
• Comments

• 8.5
Ways to use threads

- Extend the `Thread` class
- Implement the `Runnable` interface
Thread class

• public class Thread
  – extends Object
  – implements Runnable

• Thread()
  – Allocates a new Thread object.

• Thread(Runnable target)
  – Allocates a new Thread object.

• Thread(Runnable target, String name)
  – Allocates a new Thread object.

• Thread(String name)
  – Allocates a new Thread object. Give a name to the thread.
Thread class (2)

- static int activeCount() //number of active threads
- static Thread currentThread()
- void destroy() //Destroys this thread, without any cleanup.
- String getName()
- int getPriority()
- ThreadGroup getThreadGroup() //thread group to which this thread belongs.
- boolean isAlive() //Tests if this thread is alive.
- boolean isDaemon()
- void join() //Waits for this thread to die.
- void run() //If this thread was constructed using a separate Runnable run object, then that Runnable object's run method // is called; otherwise, this method does nothing and returns.
- void setDaemon(boolean on)
- void setName(String name)
- void setPriority(int newPriority)
Thread class (3)

- static void sleep(long millis)
- void start() //Causes this thread to begin execution; the Java //Virtual Machine calls the run method of this thread.
- void stop() //Deprecated. This method is inherently unsafe.
- void suspend() //Deprecated. This method has been deprecated, //as it is inherently deadlock-prone.
- static void yield() //Causes the currently executing thread //object to temporarily pause and allow other threads to //execute.

- Rarely do you extend Thread
- So how do you stop a thread?
Thread class methods

- `currentThread();`
- `yield();` //need this for some platforms (Solaris)
- `sleep();` //number of milliseconds and implicitly yields
- or blocking IO calls
Implementing the **Runnable** interface

class MyNewClass implements Runnable
{
    void run()
    {
    } 
}
public static void main(String[] args)
{
    MyNewClass instanceOfMyNewClass = new MyNewClass();
    Thread newThread = new Thread(instanceOfMyNewClass);
    newThread.start();
}

Swing

- uses a single thread \texttt{AWT-EventQueue-0}
- automatically creates that thread
- \textbf{all} parts of your swing GUI run on that thread
- Swing is not synchronized
Hang demo

• Sleep button blocks the swing thread for 5 seconds, queuing up button presses.

• Output:
  Hello world
  Hello world
  Hello world
ThreadDemo2

```
Thread name = AWT-EventQueue-0
priority   = 6
group      = java.lang.ThreadGroup[name=main,maxpri=10]
activeCount = 7
toString()  = Thread[AWT-EventQueue-0,6,main]
```

```
Thread name = AWT-EventQueue-0
priority   = 6
group      = java.lang.ThreadGroup[name=main,maxpri=10]
activeCount = 6
toString()  = Thread[AWT-EventQueue-0,6,main]
```

```
Thread name = AWT-EventQueue-0
priority   = 6
group      = java.lang.ThreadGroup[name=main,maxpri=10]
activeCount = 8
toString()  = Thread[AWT-EventQueue-0,6,main]
```
ThreadDemo2

- Shows shared variables
- Main thread updates the counter field once per second
- The AutoIncrementer object will update it. Shows single Swing thread and spawning separate AutoIncrementer object and thread. It increments and updates the counter every 1/10 second.
- AutoIncrementer is related to different JFrames
- Even when you create a new thread with a dialog it will be on the same single swing thread.
Why use threads at all?

- Multiple CPUs can do work in parallel
- Improve responsiveness of an application
- Efficiently utilize CPU with tasks that block for periods of time (waiting for a key press, for example).
- Better design
- Support multiple users more easily
Why use threads at all?(2)

- Garbage collection
- Background processes – rebalancing a tree, rehashing a HashMap
- Support polling with stopping your whole program
- Animations
- Simulations
synchronized key word

- methods
- code blocks
- objects
- a mutex is required to gain access to the code block. Only one thread can hold the mutex at a time. (Mutually Exclusive object)
- synchronization can be 150 times slower than non-synchronized access!
- make sync blocks as small as possible
synchronized keyword (2)

- not part of a method signature and thus is NOT inherited!
- Mutex is released on a return, break or exception
- You need do nothing but the synchronized
- Less flexible but easier to use
- Locks the object instance NOT the code! – different instance with a synchronized method will execute in parallel with no blocking from the synchronized.
synchronized keyword (3)

• All the synchronized instance methods and instance variables on an object share a single mutex

• All the synchronized class methods and class variables on an class share a single mutex (a different one from each object).

• So, when a thread acquires that mutex, all other threads are blocked from executing and accessing the other methods and variables!
Volatile keyword

- tells java not to optimize this chunk of code
- Even though access to a variable is atomic optimizations might break your program logic.
- `boolean myBoolean; //could get loaded in a register`. Registers aren’t shared across threads. Could lead to bugs. Especially in a multiple CPU environment (actually volatile doesn’t quite work right for multiple CPUs).
- `volatile boolean myBoolean;`
ThreadContentionDemo

• Shows the cost of threads competing for a mutex on execution time of non-synchronized vs. synchronized methods

• Output:

  No thread contention

  ________

  Pass 0: Time lost (non vs. sync-ed): 30 ms. 175% increase
  Pass 1: Time lost (non vs. sync-ed): 30 ms. 175% increase
  Pass 2: Time lost (non vs. sync-ed): 20 ms. 150% increase
  Pass 3: Time lost (non vs. sync-ed): 40 ms. 233.33% increase
  Pass 4: Time lost (non vs. sync-ed): 30 ms. 175% increase
  Pass 5: Time lost (non vs. sync-ed): 51 ms. 227.5% increase
  Pass 6: Time lost (non vs. sync-ed): 20 ms. 150% increase
  With thread contention

  ________

  Pass 7: Time lost (non vs. sync-ed): 1,072 ms. 1,074.55% increase
  Pass 8: Time lost (non vs. sync-ed): 1,152 ms. 1,745.71% increase
is the following class thread safe?

class X
{
    public static int Age;
    public synchronized int incrementAge()
    {
        age++;
        return age;
    }
}

Deadlocks

synchronized public methodA()
{
    methodB();
}

synchronized public methodB()
{
    methodA();
}

threadA.methodA();                threadB.methodB();
When can I ignore thread issues?

- single threaded applications
- reads of immutable objects – ex: Strings
- constructors (as long as they don’t touch class variables)
- Objects only used by a single thread
- create immutable objects – all fields `final`
- use a synchronization wrapper when needed
  - see the collection classes
  - the decorator pattern from GOF
two phase locking

- if locking multiple objects first acquire ALL the locks
- then do your operations on the objects
- then release the locks in the opposite order of acquiring them
- Always acquire them in the same order through out your program
- Never release some locks and acquire new ones, if you can avoid it.
UsingTheThreadClassDemo

• Shows the Thread class
• Shows signaling a thread by `interrupt()` and checking a boolean variable in the `catch()` to see if the thread should terminate
in the `main()`

myUsingTheThreadClassDemo.keepRunning=false;
myUsingTheThreadClassDemo.interrupt();

- This code throws an exception via the `interrupt()` that gets `catch()`-ed by the thread object.
infinite loop in the thread object

```java
while(true)
{
    try {
        System.out.println("THREAD - doing something and about to sleep");
        Thread.currentThread().sleep(5000); // every 5 second wake up
        System.out.println("THREAD - done sleep() ing");
    } catch (InterruptedException e) {
        System.out.println("THREAD - INTERRUPTED : "+e);
        System.out.println("THREAD - threadName = "+
                          Thread.currentThread().getName());
        if (!keepRunning)
        {
            System.out.println("THREAD - terminating the thread");
            break; // jumps out of the while loop and we gracefully end
        }
    }
}
```
communicating with a thread

- wait();
- notify(), notifyAll();
Summary

• Different types of collections are available through the JDK
  – Arrays, Lists, Sets and Maps
  – ArrayList, LinkedList, Vector, HashSet, TreeSet, HashMap, LinkedHashSet, Hashtable
Summary

• Threads
  – Not standard on the platforms
  – concurrency and parallelism

• Scheduling
  – Preemptive vs. Cooperative

• Swing runs on a single and different thread

• synchronized & mutexs
  – Class has a shared mutex
  – Each object instance has a different mutex

• Deadlocks still possible

• Two phase locking
• Questions
• Comments

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Resources

• Design patterns
  – GOF http://hillside.net/patterns/DPBook/DPBook.html
1.3 additions to Collections

- This page summarizes the differences between the 1.2 and 1.3 releases of the Collections Framework, along with a brief rationale for each change. **Convenience Implementations**
- **Added** `singletonList` and `singletonMap`. Previously, there was a convenience implementation for singleton Set, but no corresponding implementation for List and Map.
- **Added** `EMPTY_MAP`. Previously, there were constants for the empty Set and List, but no corresponding constant for Map.
- **Special-purpose Implementation**
- **Added** `Map constructor` for `WeakHashMap`. The `Map` interface dictates that most Map implementations should have a "copy constructor" that takes a Map argument. `WeakHashMap` lacked such a constructor in the 1.2 release.
Since 1.4

- This page summarizes the enhancements made to the collections framework in version 1.4 of the JavaTM 2 SDK.
- The Collections utility class has several new methods:
  - `rotate(List list, int distance)` - Rotates all of the elements in the list by the specified distance. This operation is common in GUI computations: moving one or more columns in a table can be accomplished efficiently by applying this operation to a sublist. This operation is also common in mathematical and scientific calculations.
  - `replaceAll(List list, Object oldVal, Object newVal)` - Replaces all occurrences of one specified value with another. This is essentially a convenience method. Though not difficult to program, it's very commonly needed.
  - `indexOfSubList(List source, List target)` - Returns the index of the first sublist of source that is equal to target. Commonly used in many domains including text processing.
  - `lastIndexOfSubList(List source, List target)` - Returns the index of the last sublist of source that is equal to target. Commonly used in many domains including text processing.
  - `swap(List list, int i, int j)` - Swaps the elements at the specified positions in the specified list. Essentially a convenience method, though this implementation is faster than the naive implementation.
  - `list(Enumeration e)` - Returns an ArrayList containing the elements returned by the specified enumeration. This convenience method provides interoperability between legacy APIs that return enumerations and new APIs that require collections.
- New interface RandomAccess is a marker interface that allows List implementations to indicate that they support fast (generally constant time) random access. This allows generic algorithms to alter their behavior to provide good performance when applied to either random or sequential access lists.
- New class LinkedHashMap provides an insertion-ordered Map implementation that runs nearly as fast as HashMap. Internally, it uses a hash table with a doubly linked list running through it in insertion order. Also available is a corresponding Set implementation, called LinkedHashSet.
- New class IdentityHashMap is an identity-based Map implementation based on a hash table. This class is useful for topology-preserving object graph transformations (such as serialization or deep-copying). To perform such transformations, you need to maintain an identity-based “node table” that keeps track of which objects have already been seen. Identity-based maps are also used to maintain object-to-meta-information mappings in dynamic debuggers and similar systems. Finally, identity-based maps are useful in thwarting “spoof attacks” resulting from intentionally perverse equals methods. (IdentityHashMap never invokes the equals method on its keys.) An added benefit of this implementation is that it is fast.