CS193J: Programming in Java
Winter Quarter 2003

Lecture 11
MVC/JTable, Exceptions and Files

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Handouts

- 3 Handout for today!
  - #24: MVC / Tables
  - #25: Exceptions
  - #26: Files and Streams

Recap

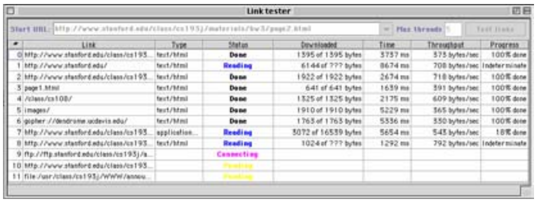
- Last Time
  - Thread Interruption
  - Cooperation
    - Wait/notify
    - Swing/GUI Threading
      - SwingThread Demo
  - Threading conclusions
- Assigned Work Reminder
  - HW 3a: ThreadBank
  - HW 3b: LinkTester
    - Both due before midnight on Wednesday, August 6th, 2003
    - Done with HW3a??

Today

- Today:
  - More HW3b intuition…
  - MVC
    - Model View Controller paradigm
    - JTable
  - Exceptions
  - Files and Streams

Homework #3 Part b intuition

- How many of you have *not* used Napster/Kazaa/Bearshare! ☺
  - The interface HW3 presents for checking links is reminiscent of how P2P filesharing clients download files.

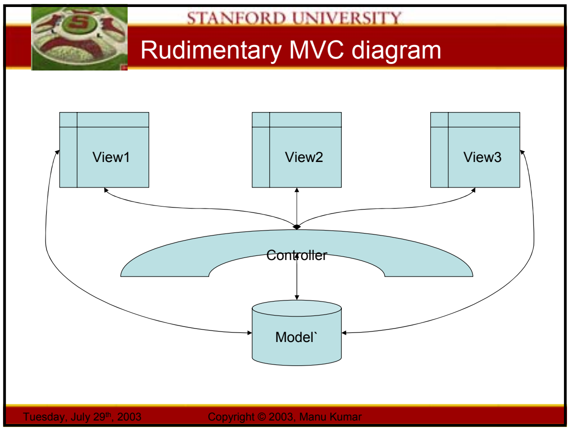


Link tester
Start URL: http://www.stanford.edu/class/cs193j/materials/hw3/page2.html
Max threads 5
Test links

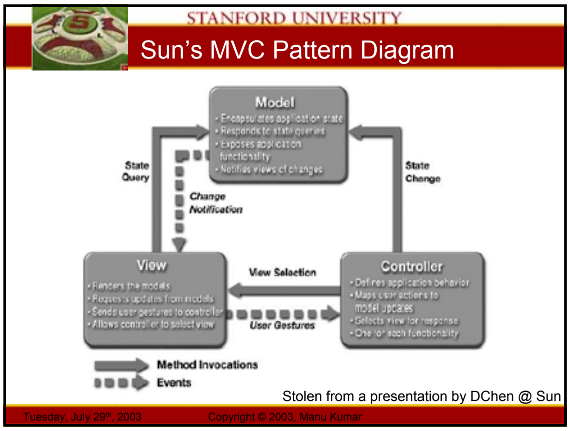
#	Link	Type	Status	Downloaded	Time	Throughput	Progress
0	http://www.stanford.edu/class/cs193...	text/html	Done	1395 of 1395 bytes	3757 ms	373 bytes/sec	100% done
1	http://www.stanford.edu/	text/html	Reading	6144 of ??? bytes	8674 ms	708 bytes/sec	Indeterminate
2	http://www.stanford.edu/class/cs193...	text/html	Done	1922 of 1922 bytes	2674 ms	718 bytes/sec	100% done
3	page1.html	text/html	Done	641 of 641 bytes	1639 ms	391 bytes/sec	100% done
4	/class/cs108/	text/html	Done	1325 of 1325 bytes	2175 ms	609 bytes/sec	100% done
5	images/	text/html	Done	1910 of 1910 bytes	5229 ms	365 bytes/sec	100% done
6	gopher://dendrome.ucdavis.edu/	text/html	Done	1763 of 1763 bytes	5336 ms	330 bytes/sec	100% done
7	http://www.stanford.edu/class/cs193...	application...	Reading	3072 of 16539 bytes	5654 ms	543 bytes/sec	18% done
8	http://www.stanford.edu/class/cs193...	text/html	Reading	1024 of ??? bytes	1292 ms	792 bytes/sec	Indeterminate
9	ftp://ftp.stanford.edu/class/cs193j/a...		Connecting				
10	http://www.stanford.edu/class/cs193...		Pending				
11	file:/usr/class/cs193j/WWW/annou...		Pending				

MVC

- MVC paradigm
  - **M**odel
    - Data storage, no presentation elements
  - **V**iew
    - No data storage, presentation elements
  - **C**ontroller
    - Glue to tie the Model and the view together
- Motivation
  - Provides for a good way to partition work and create a modular design
  - Very flexible paradigm for providing multiple ways to look at the same information



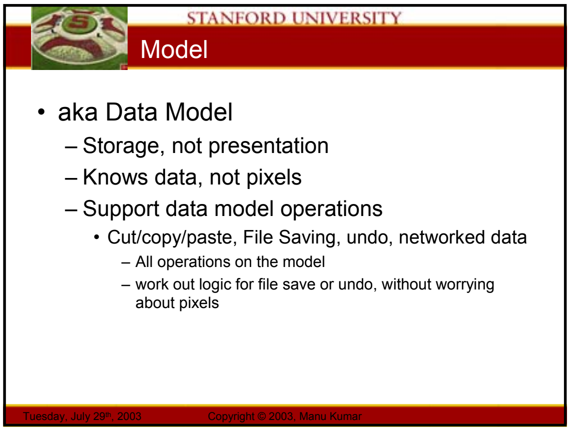
Rudimentary MVC diagram



Sun's MVC Pattern Diagram

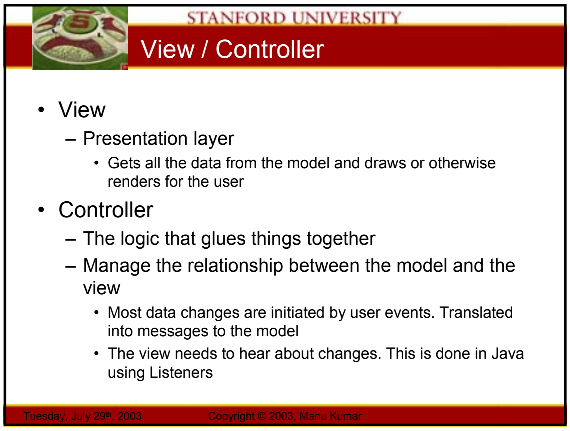
Model
• Encapsulates application state
• Responds to state queries
• Exposes application functionality
• Notifies views of changes
State Query
Change Notification
State Change
View
• Renders the models
• Requests updates from models
• Sends user gestures to controller
• Allows controller to select view
View Selection
User Gestures
Controller
• Defines application behavior
• Maps user actions to model updates
• Selects view for response
• One for each functionality
Method Invocations
Events

Stolen from a presentation by DChen @ Sun



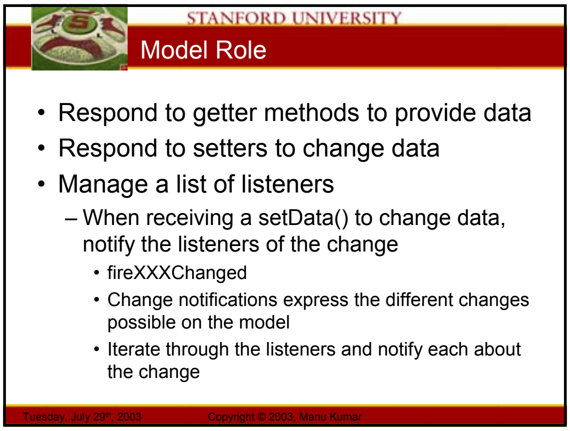
Model

- aka Data Model
  - – Storage, not presentation
  - – Knows data, not pixels
  - – Support data model operations
    - Cut/copy/paste, File Saving, undo, networked data
      - – All operations on the model
      - – work out logic for file save or undo, without worrying about pixels



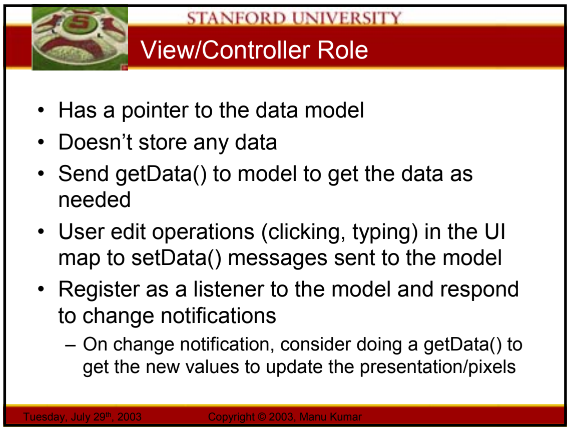
View / Controller

- View
  - – Presentation layer
    - Gets all the data from the model and draws or otherwise renders for the user
- Controller
  - – The logic that glues things together
  - – Manage the relationship between the model and the view
    - Most data changes are initiated by user events. Translated into messages to the model
    - The view needs to hear about changes. This is done in Java using Listeners



Model Role

- Respond to getter methods to provide data
- Respond to setters to change data
- Manage a list of listeners
  - – When receiving a setData() to change data, notify the listeners of the change
    - fireXXXChanged
    - Change notifications express the different changes possible on the model
    - Iterate through the listeners and notify each about the change



View/Controller Role

- Has a pointer to the data model
- Doesn't store any data
- Send getData() to model to get the data as needed
- User edit operations (clicking, typing) in the UI map to setData() messages sent to the model
- Register as a listener to the model and respond to change notifications
  - – On change notification, consider doing a getData() to get the new values to update the presentation/pixels

Tables in Swing

- Tables are one of the more involved UI elements in Swing
  - Basic functionality however it easy
  - Learn by pattern matching!
- Resources:
  - Handout has lots of sample code
    - Source for the code in the handout is available in electronic form on the course website
  - Sun’s Java Tutorial on How to Use Tables
    - http://java.sun.com/docs/books/tutorial/uiswing/components/table.html

Tables in Swing

- Use MVC pattern!
  - Model: TableModel
  - View: JTable
  - Controller: UI elements and listener bindings
- JTable
  - Relies on a TableModel for storage
  - Has lots of features to display tabular data
- TableModel Interface
  - getValueAt(), setValueAt(), getRowCount(), getColumnCount() etc.
- TableModelListener Interface
  - tableChanged(TableModelEvent e)

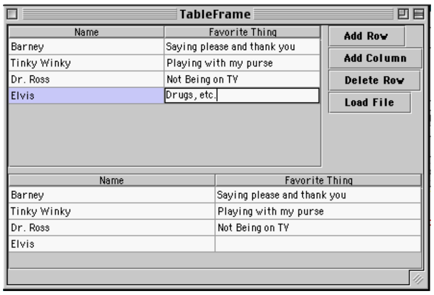
AbstractTableModel

- Implements common functionality for TableModel Interface
  - But it is abstract, so you must extend it
    - getRowCount(), getColumnCount(), getValueAt()
  - Helper methods for things not directly related to storage
    - addTableModelListener(), fire___Changed()
- DefaultTableModel
  - Extends AbstractModel, but uses a Vector implementation

BasicTableModel

- Provided in the course handout
  - Uses ArrayList implementation
  - getValueAt() to access data
  - setValueAt() to change data
    - Notifies of changes by sending fireTable____() methods
  - Handles listeners
- *This is what you should follow!*
  - *Base your code for HW3b on the BasicTableModel code provided in the handout!*

TableFrame Example

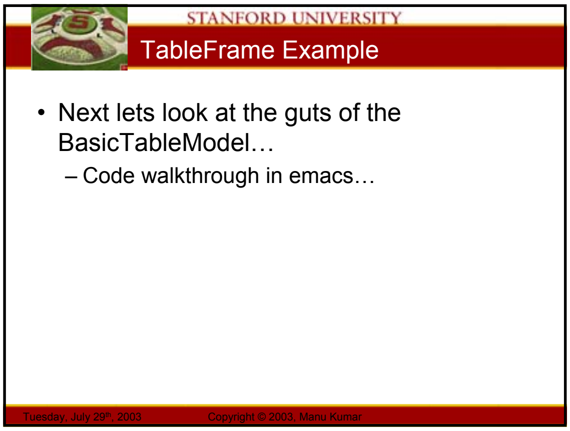


Name	Favorite Thing
Barney	Saying please and thank you
Tinky Winky	Playing with my purse
Dr. Ross	Not Being on TV
Elvis	Drugs, etc.

Name	Favorite Thing
Barney	Saying please and thank you
Tinky Winky	Playing with my purse
Dr. Ross	Not Being on TV
Elvis	

TableFrame Example

- First lets look at the Client side
  - i.e. how we *use* the BasicTableModel to implement the TableFrame example
  - Code walk through in emacs…



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TableFrame Example

- Next lets look at the guts of the BasicTableModel…
  - Code walkthrough in emacs…

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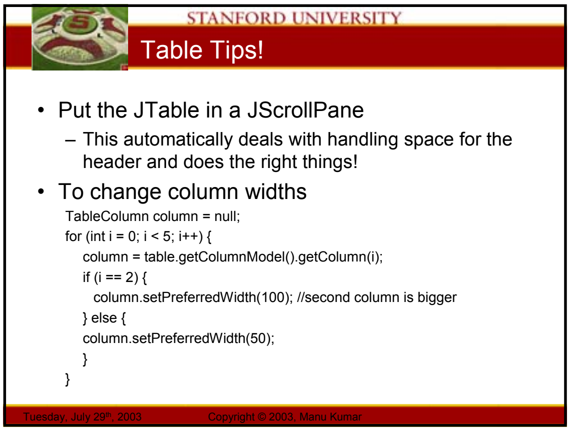

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Table Tips!

- Put the JTable in a JScrollPane
  - This automatically deals with handling space for the header and does the right things!
- To change column widths

```
TableColumn column = null;
for (int i = 0; i < 5; i++) {
    column = table.getColumnModel().getColumn(i);
    if (i == 2) {
      column.setPreferredWidth(100); //second column is bigger
    } else {
    column.setPreferredWidth(50);
    }
}
```

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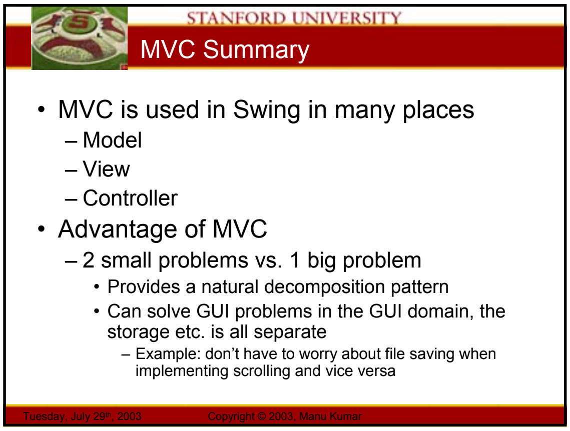

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MVC Summary

- MVC is used in Swing in many places
  - Model
  - View
  - Controller
- Advantage of MVC
  - 2 small problems vs. 1 big problem
    - Provides a natural decomposition pattern
    - Can solve GUI problems in the GUI domain, the storage etc. is all separate
      - Example: don't have to worry about file saving when implementing scrolling and vice versa

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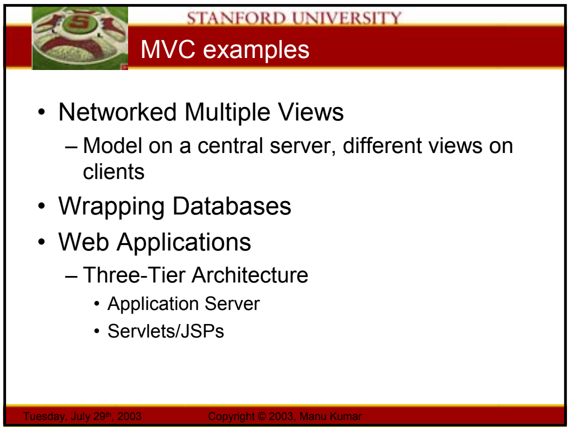

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MVC examples

- Networked Multiple Views
  - Model on a central server, different views on clients
- Wrapping Databases
- Web Applications
  - Three-Tier Architecture
    - Application Server
    - Servlets/JSPs

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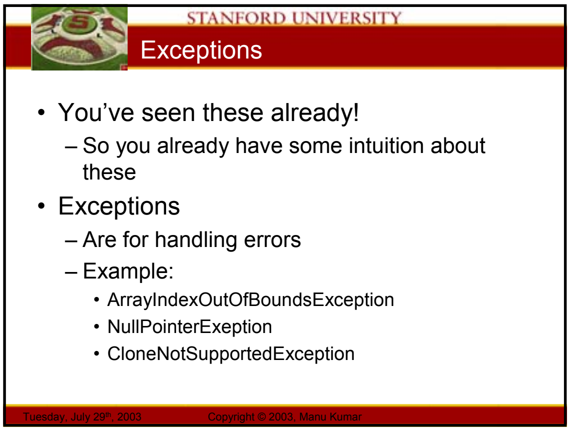

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Exceptions

- You've seen these already!
  - So you already have some intuition about these
- Exceptions
  - Are for handling errors
  - Example:
    - ArrayIndexOutOfBoundsException
    - NullPointerExeption
    - CloneNotSupportedException

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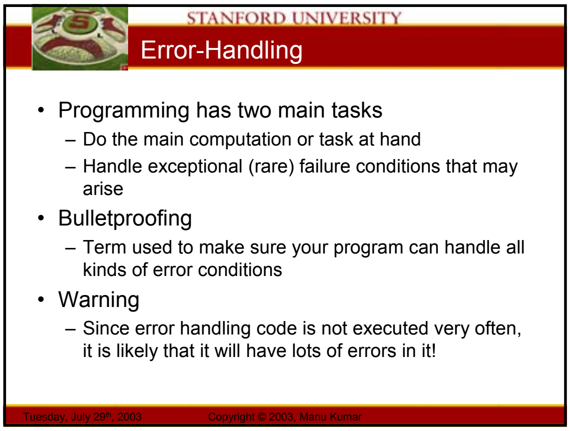

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Error-Handling

- Programming has two main tasks
  - Do the main computation or task at hand
  - Handle exceptional (rare) failure conditions that may arise
- Bulletproofing
  - Term used to make sure your program can handle all kinds of error conditions
- Warning
  - Since error handling code is not executed very often, it is likely that it will have lots of errors in it!

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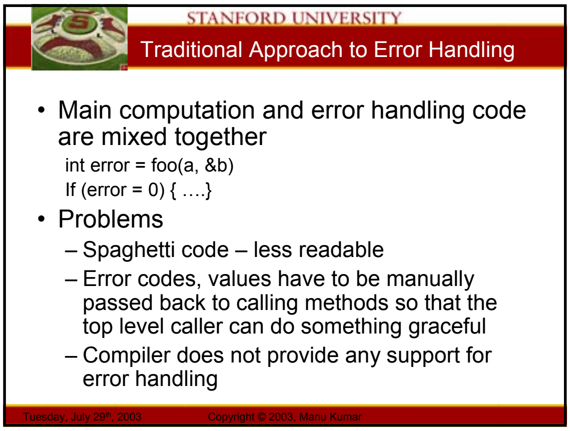

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Traditional Approach to Error Handling

- Main computation and error handling code are mixed together

```
int error = foo(a, &b)
If (error = 0) { ….}
```

- Problems
  - Spaghetti code – less readable
  - Error codes, values have to be manually passed back to calling methods so that the top level caller can do something graceful
  - Compiler does not provide any support for error handling

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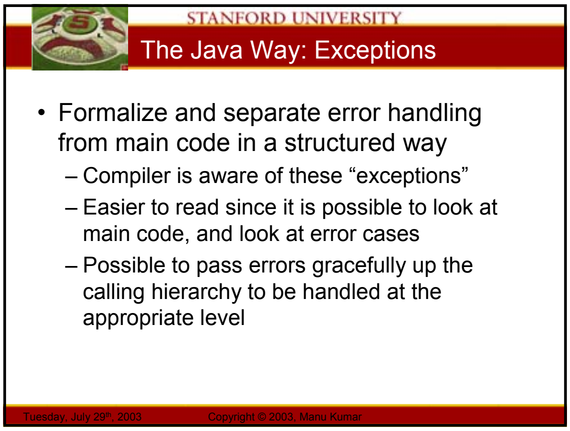

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The Java Way: Exceptions

- Formalize and separate error handling from main code in a structured way
  - Compiler is aware of these “exceptions”
  - Easier to read since it is possible to look at main code, and look at error cases
  - Possible to pass errors gracefully up the calling hierarchy to be handled at the appropriate level

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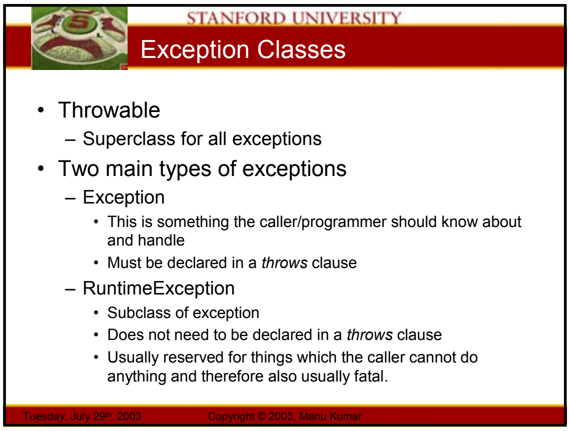

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Exception Classes

- Throwable
  - Superclass for all exceptions
- Two main types of exceptions
  - Exception
    - This is something the caller/programmer should know about and handle
    - Must be declared in a *throws* clause
  - RuntimeException
    - Subclass of exception
    - Does not need to be declared in a *throws* clause
    - Usually reserved for things which the caller cannot do anything and therefore also usually fatal.

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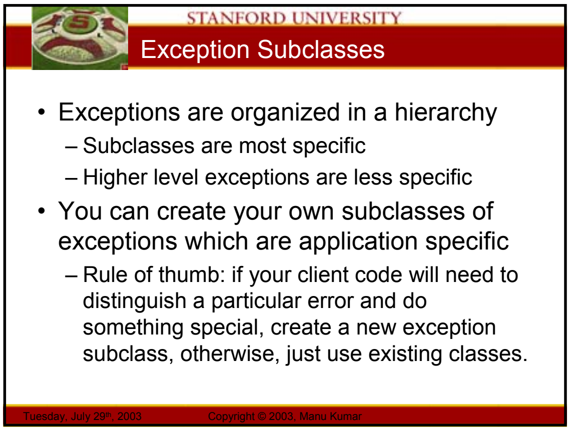

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Exception Subclasses

- Exceptions are organized in a hierarchy
  - Subclasses are most specific
  - Higher level exceptions are less specific
- You can create your own subclasses of exceptions which are application specific
  - Rule of thumb: if your client code will need to distinguish a particular error and do something special, create a new exception subclass, otherwise, just use existing classes.

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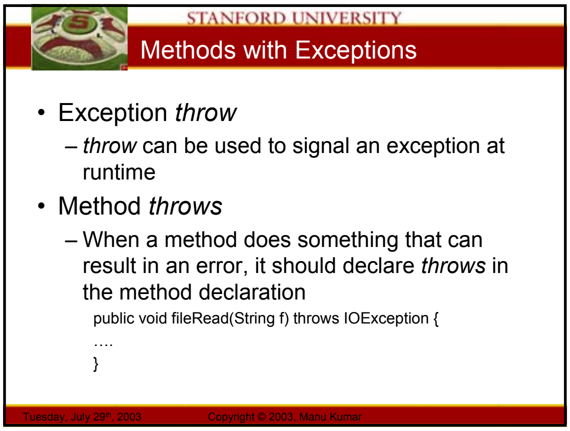

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Methods with Exceptions

- Exception *throw*
  - *throw* can be used to signal an exception at runtime
- Method *throws*
  - When a method does something that can result in an error, it should declare *throws* in the method declaration

```
public void fileRead(String f) throws IOException {
….
}
```

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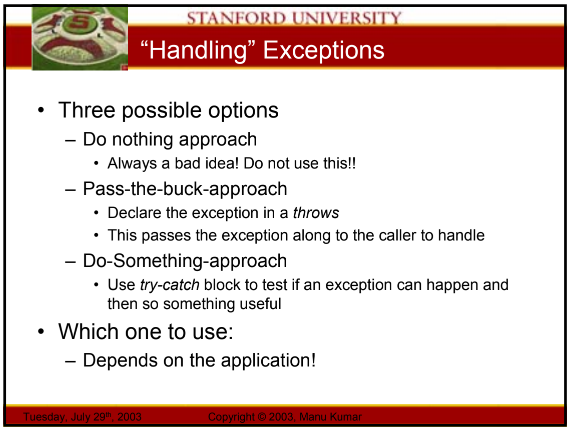

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“Handling” Exceptions

- Three possible options
  - Do nothing approach
    - Always a bad idea! Do not use this!!
  - Pass-the-buck-approach
    - Declare the exception in a *throws*
    - This passes the exception along to the caller to handle
  - Do-Something-approach
    - Use *try-catch* block to test if an exception can happen and then so something useful
- Which one to use:
  - Depends on the application!

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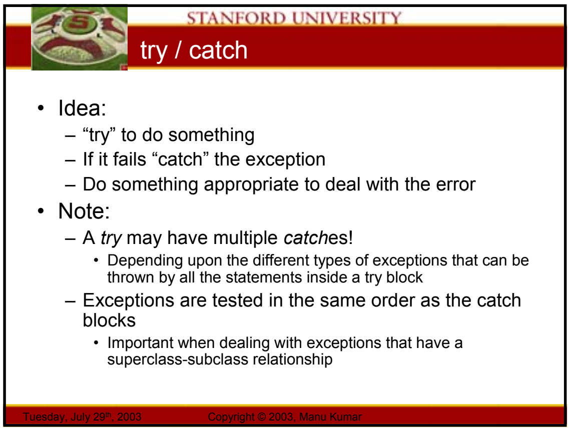
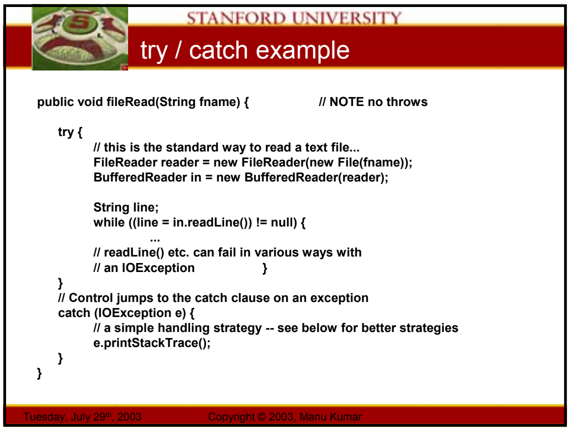


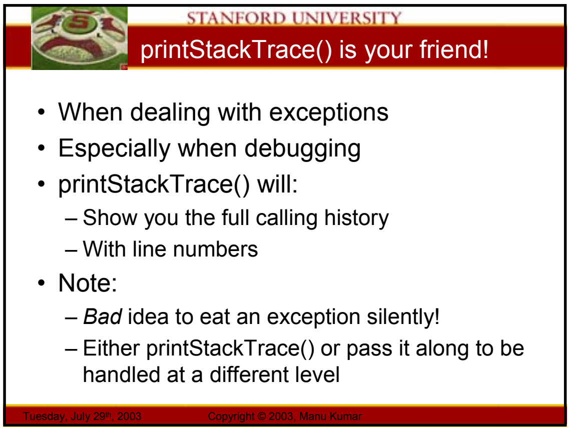
try / catch

- Idea:
  - “try” to do something
  - If it fails “catch” the exception
  - Do something appropriate to deal with the error
- Note:
  - A *try* may have multiple *catch*es!
    - Depending upon the different types of exceptions that can be thrown by all the statements inside a try block
  - Exceptions are tested in the same order as the catch blocks
    - Important when dealing with exceptions that have a superclass-subclass relationship



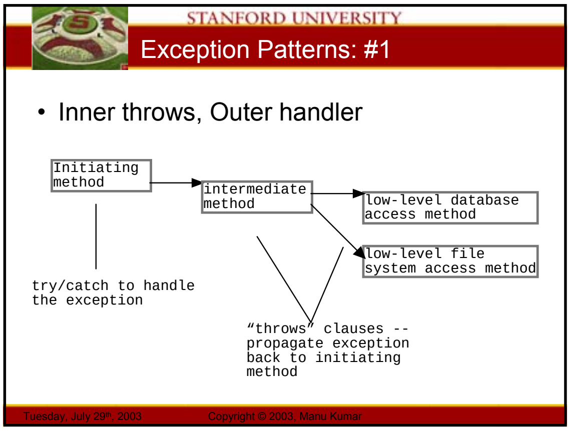
try / catch example

```
public void fileRead(String fname) {          // NOTE no throws

    try {
        // this is the standard way to read a text file...
        FileReader reader = new FileReader(new File(fname));
        BufferedReader in = new BufferedReader(reader);

        String line;
        while ((line = in.readLine()) != null) {
            ...
        // readLine() etc. can fail in various ways with
        // an IOException          }
    }
    // Control jumps to the catch clause on an exception
    catch (IOException e) {
        // a simple handling strategy -- see below for better strategies
        e.printStackTrace();
    }
}
```



printStackTrace() is your friend!

- When dealing with exceptions
- Especially when debugging
- printStackTrace() will:
  - Show you the full calling history
  - With line numbers
- Note:
  - *Bad* idea to eat an exception silently!
  - Either printStackTrace() or pass it along to be handled at a different level



Exception Patterns: #1

- Inner throws, Outer handler

Initiating method

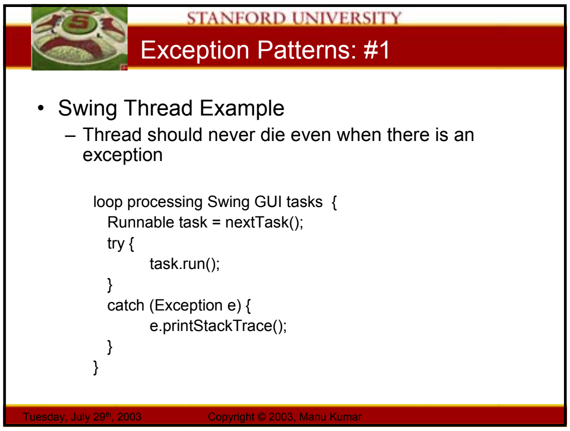
intermediate method

low-level database access method

low-level file system access method

try/catch to handle the exception

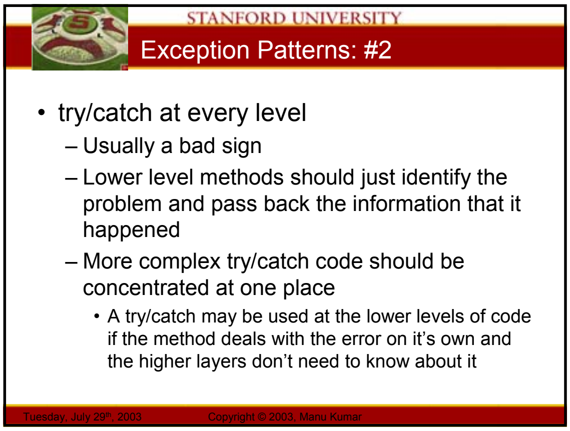
“throws” clauses -- propagate exception back to initiating method



Exception Patterns: #1

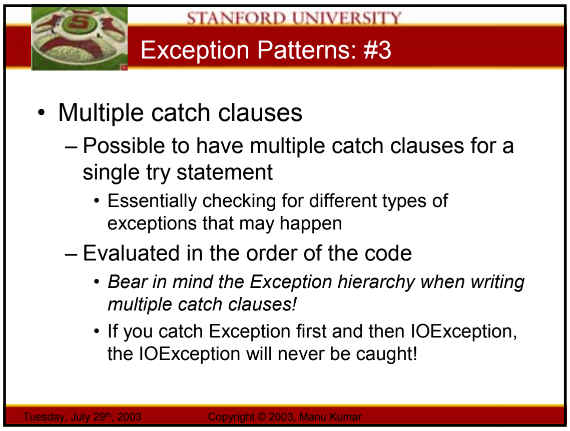
- Swing Thread Example
  - Thread should never die even when there is an exception

```
loop processing Swing GUI tasks {
    Runnable task = nextTask();
    try {
            task.run();
    }
    catch (Exception e) {
            e.printStackTrace();
    }
}
```



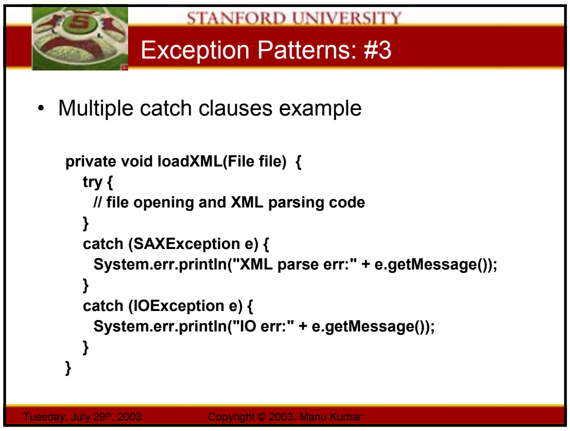
Exception Patterns: #2

- try/catch at every level
  - Usually a bad sign
  - Lower level methods should just identify the problem and pass back the information that it happened
  - More complex try/catch code should be concentrated at one place
    - A try/catch may be used at the lower levels of code if the method deals with the error on it’s own and the higher layers don’t need to know about it



Exception Patterns: #3

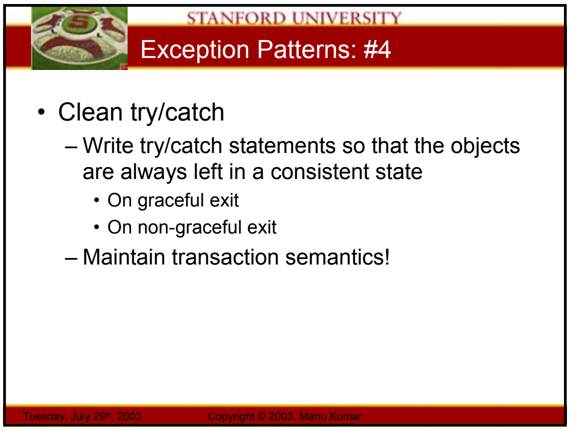
- Multiple catch clauses
  - Possible to have multiple catch clauses for a single try statement
    - Essentially checking for different types of exceptions that may happen
  - Evaluated in the order of the code
    - *Bear in mind the Exception hierarchy when writing multiple catch clauses!*
    - If you catch Exception first and then IOException, the IOException will never be caught!



Exception Patterns: #3

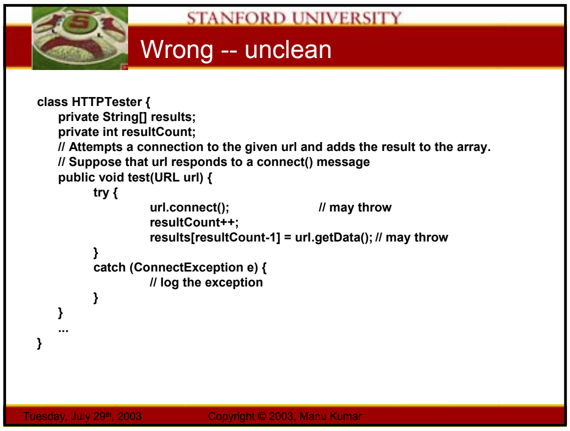
- Multiple catch clauses example

```
private void loadXML(File file)  {
   try {
     // file opening and XML parsing code
   }
   catch (SAXException e) {
     System.err.println("XML parse err:" + e.getMessage());
   }
   catch (IOException e) {
     System.err.println("IO err:" + e.getMessage());
   }
}
```



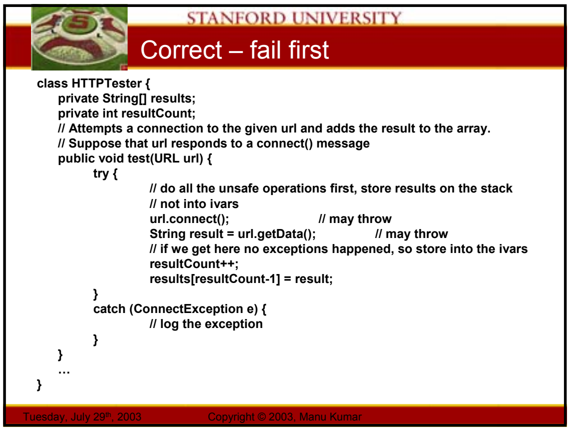
Exception Patterns: #4

- Clean try/catch
  - Write try/catch statements so that the objects are always left in a consistent state
    - On graceful exit
    - On non-graceful exit
  - Maintain transaction semantics!



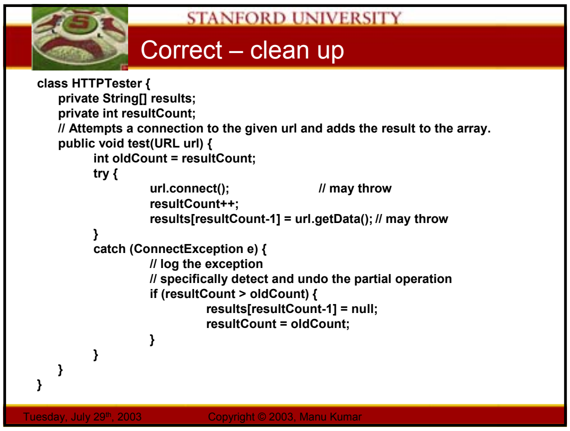
Wrong -- unclean

```
class HTTPTester {
    private String[] results;
    private int resultCount;
    // Attempts a connection to the given url and adds the result to the array.
    // Suppose that url responds to a connect() message
    public void test(URL url) {
        try {
                url.connect();                    // may throw
                resultCount++;
                results[resultCount-1] = url.getData(); // may throw
        }
        catch (ConnectException e) {
                // log the exception
        }
    }
    ...
}
```



Correct – fail first

```
class HTTPTester {
    private String[] results;
    private int resultCount;
    // Attempts a connection to the given url and adds the result to the array.
    // Suppose that url responds to a connect() message
    public void test(URL url) {
        try {
                // do all the unsafe operations first, store results on the stack
                // not into ivars
                url.connect();                // may throw
                String result = url.getData();          // may throw
                // if we get here no exceptions happened, so store into the ivars
                resultCount++;
                results[resultCount-1] = result;
        }
        catch (ConnectException e) {
                // log the exception
        }
    }
    ...
}
```



Correct – clean up

```
class HTTPTester {
    private String[] results;
    private int resultCount;
    // Attempts a connection to the given url and adds the result to the array.
    public void test(URL url) {
        int oldCount = resultCount;
        try {
                url.connect();                    // may throw
                resultCount++;
                results[resultCount-1] = url.getData(); // may throw
        }
        catch (ConnectException e) {
                // log the exception
                // specifically detect and undo the partial operation
                if (resultCount > oldCount) {
                        results[resultCount-1] = null;
                        resultCount = oldCount;
                }
        }
    }
}
```

finally clause

- Try-catch-finally
  - Finally section includes code that is always executed before the block exits
    - Executes in both graceful and ungraceful cases
  - Usually used for
    - Doing cleanup
      - Closing streams and handles
  - A return statement in the try clause will execute the finally clause before returning
    - This is stylistically not good since it is confusing to the reader

Finally example

```
public void processFile() {
  processing = true;
  try {
        …
  }
  catch (IOException e) {
        e.printStackTrace();
  }
  finally {
        processing = false;
  }
}
```

Files and Streams

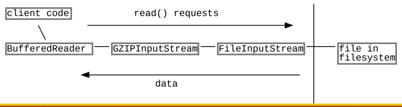
- File
  - Represents a file or directory
  - Java abstracts away the ugliness of dealing with files quite nicely
- Streams
  - Way to deal with input and output
  - A useful abstraction…

Streams!??

- Water analogy
  - Think of streams as pipes for water
  - Do you know whether the water that comes out of your tap is coming from a) the ocean b) some river c) a water tank d) a water buffalo?
- Idea:
  - You abstract away what the stream is connected to and perform all your I/O operations on the stream
  - The stream may be connected to a file on a floppy, a file on a hard disk, a network connection or may even just be in memory!

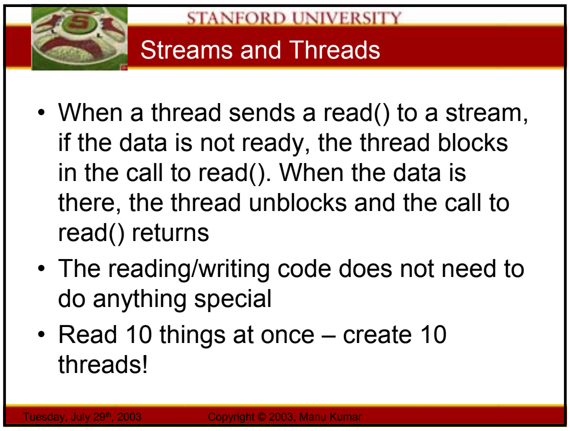
Hierarchy of Streams

- Java provides a hierarchy of streams
  - Think of this as different "filters" you can add on to your water pipe
    - Some may compress/decompress data
    - Some may provide buffers
- Common Use Scenario
  - Streams are used by layering them together to form the type of "pipe" we eventually want



Types of Streams

- InputStream / OutputStream
  - Base class streams with few features
  - read() and write()
- FileInputStream / FileOutputStream
  - Specifically for connecting to files
- ByteArrayInputStream / ByteArrayOutputStream
  - Use an in-memory array of bytes for storage!
- BufferedInputStream / BufferedOutputStream
  - Improve performance by adding buffers
  - Should almost always use buffers
- BufferedReader / BufferedWriter
  - Convert bytes to unicode Char and String data
  - Probably most useful for what we need



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Streams and Threads

- When a thread sends a read() to a stream, if the data is not ready, the thread blocks in the call to read(). When the data is there, the thread unblocks and the call to read() returns
- The reading/writing code does not need to do anything special
- Read 10 things at once – create 10 threads!

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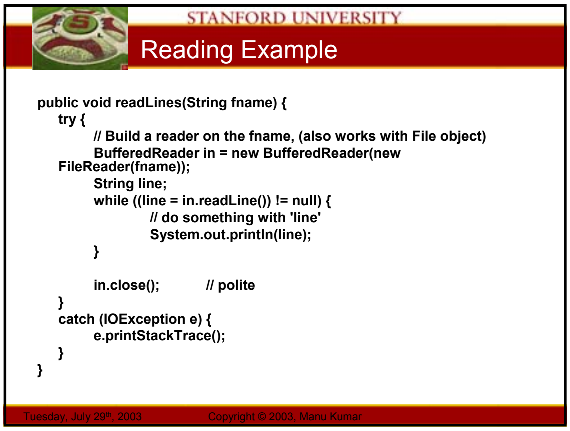

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Reading Example

```
public void readLines(String fname) {
    try {
        // Build a reader on the fname, (also works with File object)
        BufferedReader in = new BufferedReader(new
    FileReader(fname));
        String line;
        while ((line = in.readLine()) != null) {
                // do something with 'line'
                System.out.println(line);
        }

        in.close();        // polite
    }
    catch (IOException e) {
        e.printStackTrace();
    }
}
```

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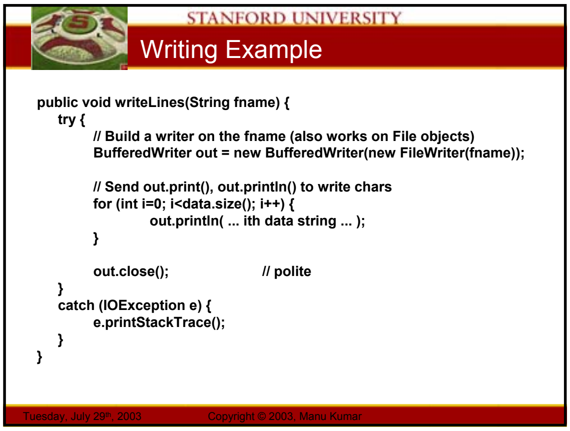

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Writing Example

```
public void writeLines(String fname) {
    try {
        // Build a writer on the fname (also works on File objects)
        BufferedWriter out = new BufferedWriter(new FileWriter(fname));

        // Send out.print(), out.println() to write chars
        for (int i=0; i<data.size(); i++) {
                out.println( ... ith data string ... );
        }

        out.close();                // polite
    }
    catch (IOException e) {
        e.printStackTrace();
    }
}
```

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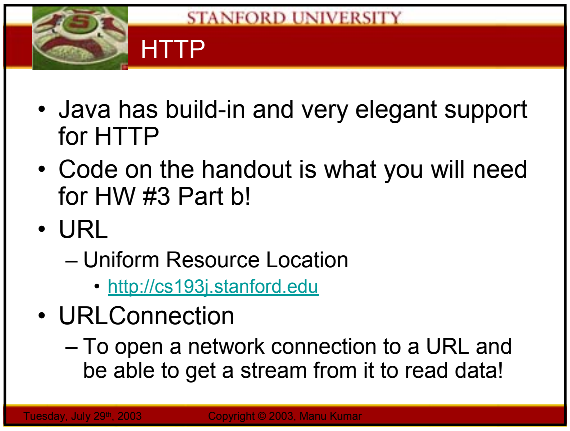

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HTTP

- Java has build-in and very elegant support for HTTP
- Code on the handout is what you will need for HW #3 Part b!
- URL
  - Uniform Resource Location
    - http://cs193j.stanford.edu
- URLConnection
  - To open a network connection to a URL and be able to get a stream from it to read data!

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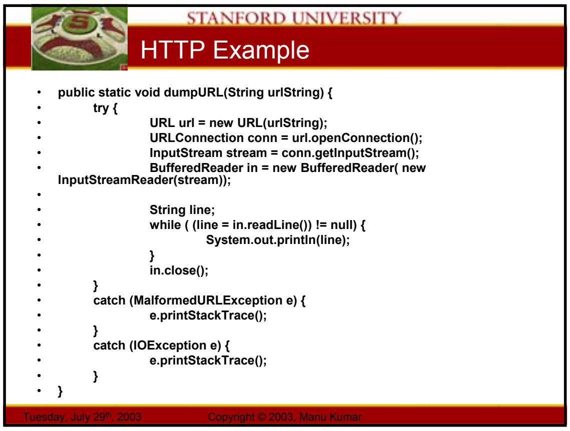

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HTTP Example

```
•   public static void dumpURL(String urlString) {
•           try {
•                   URL url = new URL(urlString);
•                   URLConnection conn = url.openConnection();
•                   InputStream stream = conn.getInputStream();
•                   BufferedReader in = new BufferedReader( new
    InputStreamReader(stream));
•
•                   String line;
•                   while ( (line = in.readLine()) != null) {
•                           System.out.println(line);
•                   }
•                   in.close();
•           }
•           catch (MalformedURLException e) {
•                   e.printStackTrace();
•           }
•           catch (IOException e) {
•                   e.printStackTrace();
•           }
•   }
```

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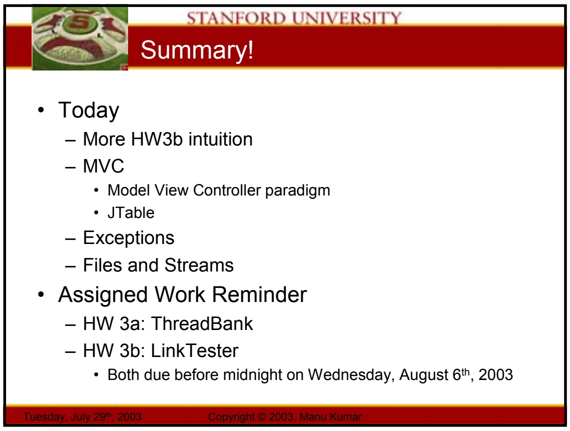

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Summary!

- Today
  - More HW3b intuition
  - MVC
    - Model View Controller paradigm
    - JTable
  - Exceptions
  - Files and Streams
- Assigned Work Reminder
  - HW 3a: ThreadBank
  - HW 3b: LinkTester
    - Both due before midnight on Wednesday, August 6th, 2003

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