Network programming (IT423+IT432)
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Streams

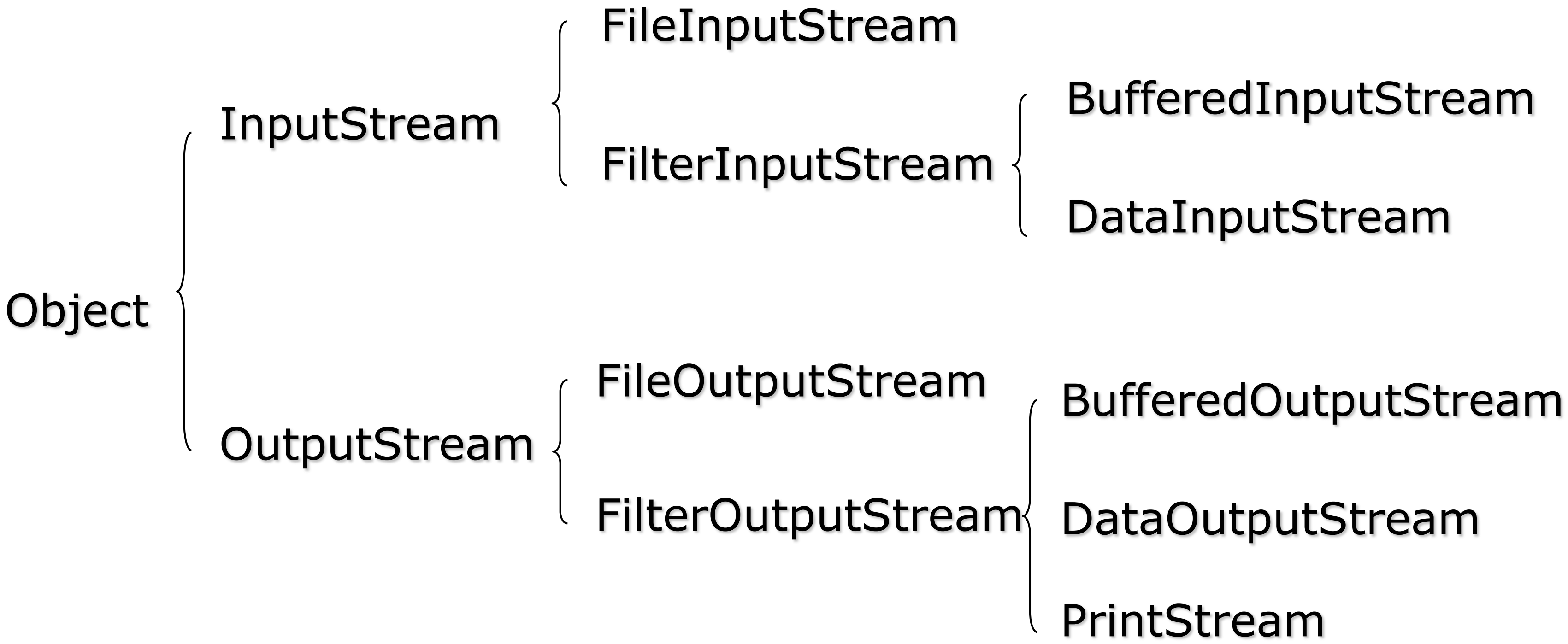
I/O and streams

- Large part of network programming is concerned with data movement from one system to another.
- I/O in Java is built on streams;
  - input streams read data
  - output streams write data.
- Java has different classes to deal with input and output streams.

Java I/O Streams

- I/O Streams
  - Byte stream: Input Stream and Output Stream
    - Filter Stream
    - Buffered Stream
    - Data Stream
    - Print Stream
    - File Stream
  - Character Stream: Reader and Writer
    - Input Stream Reader and Output Stream Writer
    - Buffered Reader/Writer
    - File Reader/Writer

Byte Streams



- Object
  - InputStream
    - FileInputStream
    - FilterInputStream
      - BufferedInputStream
      - DataInputStream
  - OutputStream
    - FileOutputStream
    - FilterOutputStream
      - BufferedOutputStream
      - DataOutputStream
      - PrintStream

InputStream Class

- java.io.InputStream is an abstract class for all input streams.
- It contains methods for reading in raw bytes of data from input stream: key board, files, network client.

  - public abstract int read()
  - public int read (byte[] buf)
  - public int read(byte[] buf, int offset, int length)

InputStream Class

- public long skip(long n)
  . skip n number of bytes
- public int available( )
  . how many bytes can be read before blocking
- pcublic void close( )
- public synchronized void mark (int readlimit)
  . bookmark current position in the stream
- public boolean markSupported( )
- public synchronized void reset( )
  . rewind the stream to the marked position

- All but the last two methods throw an IOException.

The read( ) method

- The basic read() method reads a single unsigned byte of data and returns the integer value of the unsigned byte.
- This is a number between 0 and 255
- Returns a -1 if the end of a stream is encountered.
- The method blocks until input data are available, the end of stream is detected or an exception is thrown.

The read( ) method

```
int[] data = new int[10];
for (int i =0; i <data.length, i++)
      data [i]= System.in.read( );
}
```

BufferedInputStream

- This code reads in 10 bytes from the System.in input stream and stores it in the int array data.
- Notice that although read() reads in a byte, it returns a value of type int. If you want the raw byte, cast the int into a byte.

The read( ) method

- read() has a possibility of throwing an exception.

```
try {
        int data[] = new int[10] ;
        for (int i=0; i<data.length; i++) {
        int datum = System.in.read();
        if (datum == -1) break;
        data[il = datum;
        }//for
}//try
catch (IOException e) {
    System.err.println(e);
}
```

End of stream

The read( ) method

- The value of -1 is returned when the end of stream is reached. This can be used as a check for the stream end.
- Remember that read() blocks. So if there is any other important work to do in your program, try to put your I/O in a separate thread.
- read() is abstract method defined in InputStream. This means you can't instantiate InputStream directly: work with one of it's subclasses instead.

Echo Example(I)

```
import java.io.*,

public class Echo {
    public static void main(String[] args){
    echo(System.in);
    }//main

public static void echo(InputStream is) {
    try {


         for (int j = 0; j < 20; j++) {int i = is.read( );
```

BufferedInputStream

An instance of a subclass
of InputStream
(remember: upcasting)

Echo Example(2)

```
                // -1 returned for end of stream
                if (i == -1)
                    break;
                char c = (char) i ;
                System.out.print(c);
            }//for loop
        }//try
        catch (IOException e){
            System.err.println();
        }//catch
        System.out.println( );
    }//echo method
}//Echo class
```

Reading Multiple Bytes

- Since accessing I/O is slow in comparison to memory access, limiting the number of reads and writes is essential.
- The basic read() method only reads in a byte at a time.
- The following two overloading read() methods read in multiple bytes into an array of bytes.
  - public int read(byte b[])
  - public int read(byte b[], int offset, int length)

Reading Multiple Bytes

- The first method tries to read enough bytes to fill the array b[].

```
try {
    byte[ ] b = new byte[10];
    int j  = System.in.read(b);
    }
catch (IOException e){ }
```

- This method blocks until data are available just like the read() method.

Reading Multiple Bytes

- The second method reads length bytes from the input stream and stores them in the array b[] starting at the location offset.

```
try {//what does this loop do
        byte[] b = new byte[100];
        int offset = 0;
        while (offset < b.length) {
                int bytesRead = System.in.read(b, offset, b.length - offset);
                if (bytesRead == -1) break;
                offset += bytesRead; }//while
catch (IOException e){}
```

Closing Input Streams

- For well behaved programs, all streams should be closed before exiting the program.
- Allows OS to free any resources associated with the stream.
- Use the close() method
  - public void close() throws IOException
- Not all streams have to be closed.
  - System.in does not have to be closed.

Closing Input Streams

```
try {
    URL u = new URL(“http://java.sun.com”);
    InputStream in = u.openStream();
    / read from stream ...
    in.close();
}
catch (IOException e){}
```

- Once an input stream has been closed, you can no longer read from it. Doing so will cause an IOException to be thrown.

Reading from File Input Streams

```
import java.io.*;
class FileInputStreamDemo {
    public static void main(String args[]) {
        try {//Create a file input stream
              FileInputStream fis = new FileInputStream(args[0]);
              //read 12 byte from the file
              int i;
              while ((i = fis.read()) != -1)
                   {System.out.println(i);}
              //Close file output stream
              fis.close();
        }catch(Exception e) {System.out.println(“Exception: ” + e);}
}}
```

Reading from Buffered Input Streams

```
import java.io.*;
class FileBufferedStreamDemo {
    public static void main(String args[]) {
        try {//Create a file input stream
            FileInputStream fis = new FileInputStream(args[0]);
            //Create a buffered input stream
            BufferedInputStream bis = new BufferedInputStream(fis);
            //read 12 byte from the file
            int i;
            while ((i = bis.read()) != -1)
                {System.out.println(i);}
            //Close file output stream
            fis.close();
        }catch(Exception e) {System.out.println(“Exception: ” + e);}
}}
```

Reading from Data Input Streams

```
import java.io.*;
class DataInputStreamDemo {
    public static void main(String args[]) {
        try {//Create a file input stream
            FileInputStream fis = new FileInputStream(args[0]);
            //Create a data input stream
            DataInputStream dis = new DataInputStream(fis);
            //read and display data
            System.out.println(dis.readBoolean());
            System.out.println(dis.readByte());
```

Reading from Data Input Streams

```
            System.out.println(dis.readChar());
            System.out.println(dis.readDouble());
            System.out.println(dis.readFloat());
            System.out.println(dis.readInt());
            System.out.println(dis.readLong());
            System.out.println(dis.readShort());
            //Close file input stream
            fis.close();
        }catch(Exception e) {System.out.println(“Exception: ” + e);}
}}
```

Output Streams

- java.io.OutputStream class sends raw bytes of data to a target such as the console, a file, or a network server.
- Methods within this class are:
  - public abstract void write(int b)
  - public void write(byte b[])
  - public void write(byte b[], int offset, int length)
  - public void flush()
  - public void close()
- All methods throw an IOException

Output Streams

- The write() methods sends raw bytes of data to whomever is listening to the stream.
- Sometimes for performance reasons, the operating system buffers output streams.
- When the buffer fills up, the data are all written at once.
- The flush() method will force the data to be written whether the buffer is full or not.

Writing to Output Streams

- The fundamental method in OutputStream is write()
- public abstract void write(byte b)
- This method writes a single unsigned byte of data that should be between 0 and 255.
- Larger numbers are reduced modulo 256 before writing.

Ascii Chart Example

```
import java.io.*;
public class AsciiChart{
   public static void main(String args[]) {
          for (int i=32; i<127; i++)
               System.out.write(i);
               //break line after every 8 characters
          if (i%8 == 7) System.out.write(‘\n’);
          else System.out.write(‘\t’);
          }//for
          System.out.write(‘\n’);
   }//main
}//class
```

Writing Arrays of Bytes

- The two remaining write methods write multiple bytes of data.
  - Public void write(byte b[])
  - Public void write(byte b[], int offset, int length)

- The first writes an entire byte array of data, while the second writes a sub-array of data starting at offset and continuing for length bytes.

- Remember that these methods write bytes, so data must be converted into bytes.

AsciiArray Example

```
import java.io.*;
public class AsciiArray{
    public static void main(String args[]) {
         int index=O;
         byte[] b = new byte[(127-31)*2];
          for (int i=32; i<127; i++) {
              b[index++] = (byte)i;
              //break line after every 8 characters
         if (i%8==7) b[index++] = (byte)‘\n’;
         else b[index++] = (byte) ‘\t’;
```

AsciiArray Example

```
        }//for
        b[index++] = (byte) ‘\n’;
        try {
                System.out.write(b);
        }
        catch(IOException e) {}
    }//main
}//class
```

- The output is the same as AsciiChart.

Writing to File Output Streams

```
import java.io.*;
class FileOutputStreamDemo {
    public static void main(String args[]) {
        try {//Create a file output stream
            FileOutputStream fos = new FileOutputStream(args[0]);
            //Write 12 byte to the file
            for (int i = 0; i < 12; i++) {
                fos.write(i);}
            //Close file output stream
            fos.close();
        }catch(Exception e) {System.out.println(“Exception: ” + e);}
}}
```

Flushing and Closing Output Streams

- As mentioned, many operating systems buffer output data to improve performance.
- Rather than sending a bytes at a time, bytes are accumulated until the buffer is full, and one write occurs.
- The flush() method forces the data to be written even if the buffer is not full.
  - public void flush( ) throws IOException
- Like input streams, output streams should be closed. For output streams, closing them will also flush the contents of the buffer.

Filter Streams

- java. io.FilterInputStream and java. io.FilterOutputStream are subclasses of InputStream and OutputStream, respectively.
- These classes are rarely used, but their subclasses are extremely important.

Filter Streams Classes

- Buffered Streams
  - These classes will buffer reads and writes by first reading the data into a buffer (array of bytes)
- Data Streams
  - These classes read and write primitive data types and Strings.
- Print Stream
  - referenced by System.out and System.err.
  - It uses the platforms default character encoding to convert characters into bytes.

Buffered Streams

- Buffered input stream read more data than initially needed and store them in a buffer.
- So when the buffered stream's read() method is called, the data is removed from the buffer rather than from the underlying system.
- When the buffer is empty, the buffered stream refills the buffer.
- Buffered output stream store data in an internal byte array until the buffer is full or the stream is flushed. The data is then written out once.

Buffered Streams

- Constructors
  - BufferedInputStream(InputStream in)
  - BufferedInputStream(Inputftream in, int size)
  - BufferedOutputStream(OutputStream out)
  - BufferedOutputStream(OutputStream out, int size)
- The size argument is the size of the buffer.
- If not specified, a default of 512 bytes is used.

Buffered Streams

- Example:

  ```
  URL u=new URL(“httP://java.sun.Com”);
  BufferedInputStream bis;
  bis= new BufferedlnputStream(u.openStream( ), 256)
  ```

- BufferedInputStream and BufferedOutputStream do not declare any new methods but rather override methods from Inputstream and outputstream, respectively.

Writing to Buffered Output Streams

```
import java.io.*;
class BufferedOutputStreamDemo {
    public static void main(String args[]) {
        try {//Create a file output stream
            FileOutputStream fos = new FileOutputStream(args[0]);
            //Create a buffered output stream
            BufferedOutputStream bos = new BufferedOutputStream(fos);
            //Write 12 byte to the file
            for (int i = 0; i < 12; i++) {
                bos.write(i);}
            //Close file output stream
            bos.close(); fos.close();
        }catch(Exception e) {System.out.println("Exception: " + e);}
}}
```

Data Streams

- java.io.DataInputStream and java.io.DataOutputStream read and write primitive data types and strings using the java.io.DataInput and java.io.DataOutput interfaces, respectively.

Data Streams

- Generally you use DataInputStream to read data written by DataOutputStream
- public DataInputStrem(InputStream in)
- public DataOutputStream(OutputStream out)
- The usual methods associated with input and output streams are present in data stream as well.
- However, data streams have other methods that allow them to read and write primitive type.

Writing to Data Output Streams

```
import java.io.*;
class DataOutputStreamDemo {
    public static void main(String args[]) {
        try {//Create a file output stream
            FileOutputStream fos = new FileOutputStream(args[0]);
            //Create a data output straem
            DataOutputStream dos = new DataOutputStream(fos);
            //Write various types of data to the file
            dos.writeBoolean(false);
            dos.writeByte(Byte.MAX_VALUE);
```

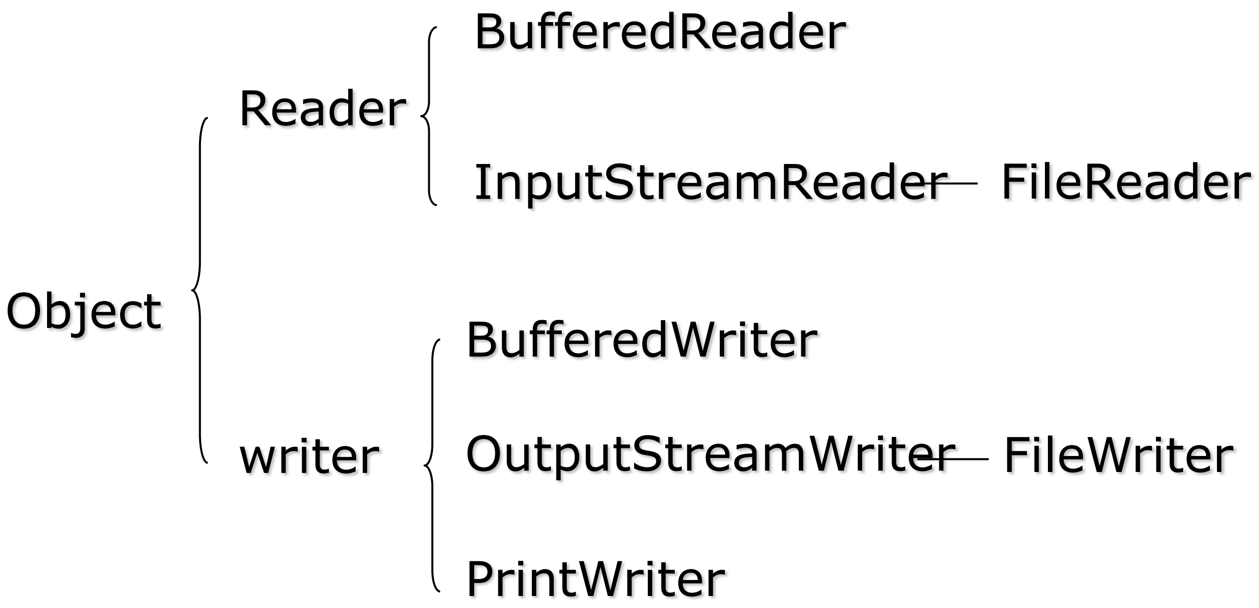
Writing to Data Output Streams

```
            dos.writeChar(‘A’);
            dos.writeDouble(Double.MAX_VALUE);
            dos.writeFloat(Float. MAX_VALUE);
            dos.writeInt(int. MAX_VALUE);
            dos.writeLong(Long. MAX_VALUE);
            dos.writeShort(Short. MAX_VALUE);
            //Close file output stream
            fos.close();
        }catch(Exception e) {System.out.println(“Exception: ” + e);}
}}
```

Print Streams

- Allows very simple printing of both primitive values, objects, string literals.
- There are many overloaded print( ) and println( ) methods.
- This method is deprecated in Java 1.1.
- The biggest problem with this class is that it does not properly handle international character sets.
- Use the PrintWriter class instead.

Character Streams



Object

Reader

BufferedReader

InputStreamReader — FileReader

writer

BufferedWriter

OutputStreamWriter — FileWriter

PrintWriter

Readers and Writers

- Classes that read and write character based data.
- These characters can have varying widths depending on the character set being used.
- Readers and writers know how to handle many different character sets.

Reader Class

- java.io.Reader

- This class is deliberately similar to the java.io.InputStream class.

- Methods in the Reader class are similar to the InputStream class except that the methods work on characters not bytes.

Writer Class

- Java.io.Writer
- This class is similar to the java.io.OutputStream class.
- Methods in the Writer class now work on characters and not bytes.

InputStreamReader

- java. io.InputStreamReader acts as a translater between byte streams and character streams.

- It reads bytes from the input stream and translates them into characters according to a specified character encoding.

InputStreamReader Class

- You can set the encoding scheme or you can use the platforms default setting.

- public InputstreamReader(Inputstream in)

- public InputStreamReader(InputStream in, String enc)
        throws UnsupportedEncoding Exception

OutputStreamWriter

- java. io.OutputStreamWriter will write bytes of data to the output stream after translating the characters according to the specified encoding.
- public OutputStreamWriter(OutputStream out)
- public OutputStreamWriter(OutputStream out, String enc)
  throws UnsupportedEncodingException

Buffered Reads/Writes

- There are classes that allow for a more efficient reading and writing of characters by buffering.
- java.io.BufferedReader
- java.io.BufferedWriter
- These classes are similar to the Buffered Stream classes.
- Most notable for the readLine() Method. This allows data to be read a line at a time.
- public String readLine() throws IOException

Buffered Reads/Writes

```
import java.io.*;

public class StringInputFile {
    public static void main(String[] arg) throws Exception {
        PrintStream backup;
        FileOutputStream backupFileStream;
        File  backupFile;
        backupFile = new File(“backup”);
        backupFileStream = new FileOutputStream(backupFile);
        backup = new PrintStream(backupFileStream);
```

Buffered Reads/Writes

```
System.out.println(“This is my first data file”);
          backup.println(“This is my first data file”);
          System.out.println(“... but it won't be my last”);
          backup.println(“... but it won’t be my last”);
          }
}
```

Buffered Reads/Writes

Writing output to a file involves three steps as follows:

- Create a File object
- Create a FileOutputStream object
- Create a PrintStream object

Buffered Reads/Writes

```
import java.io.*;

public class StringInputFile {
      public static void main(String[] arg) throws Exception {
           InputStreamReader backup;
           BufferedReader br;
           FileInputStream backupFileStream;
           File  backupFile;

           String inputline;
```

Buffered Reads/Writes

```
        backupFile = new File(“backup”);
        backupFileStream = new FileInputStream(backupFile);
        backup = new InputStreamReader(backupFileStream);
        br = new BufferedReader(backup);
        inputline = br.readLine();
        System.out.println(inputline);
        inputline = br.readLine();
        System.out.println(inputline);
        }
}
```

Buffered Reads/Writes

Reading data from a file involves three steps as follows:

- Create a FileInputStream or BufferedInputStream object
- Create a InputStreamReader object which we use to
- Create a BufferedReader object

Example: Send Data(I)

```
import java.net.*; import java.io.*;

public class SendData extends Thread  {
        Socket sock;

        public SendData (Socket sock) {

        this.sock = sock;
    }//SendData constructor

public void run() {
    string line;
```

Example: Send Data(2)

```
try {
    OutputStreamWriter outw=new
    outputstreamwriter(sock.getOutputStream());
    BufferedWriter sockout=new
    BufferedWriter(outw);
    InputStreamReader inr = new InputStreamReader(System.in);
    BufferedReader in = new BufferedReader(inr);

    while ((line = in.readLine()) != null) {

        sockout.write(line+ “\n”);
```

Example: Send Data(3)

```
                sockout.flush(); yield( );
            }//while
        } //try
        catch (java.io.IoException e) {
            System.out.println(e);
            System.exit(0);
        }//catch
    } //run
}//SendData
```

Example: Receive Data(I)

```
import java.net.*;
import java.io.*;

public class RcveData extends Thread  {
    Socket sock;

    public RcveData(Socket sock) {
         this.sock = sock;
    }

public void run() {

    String line;
```

Example: Receive Data(2)

```
try {
    InputStreamReader inr = new
    InputStreamReader(sock.getlnputStream());

    BufferedReader in = new BufferedReader(inr);

    while ((line = in.readLine()) != null) {

         System.out.print(mReceiving:
         System.out.println(line);
         yield();
    }//while
)//try
```

Example: Receive Data(3)

```
          catch (java.io.IOException e) {

             System.out.println(e);

             System.out.println(0);

I         }//catch
       }//run

    }//RCVeData
```