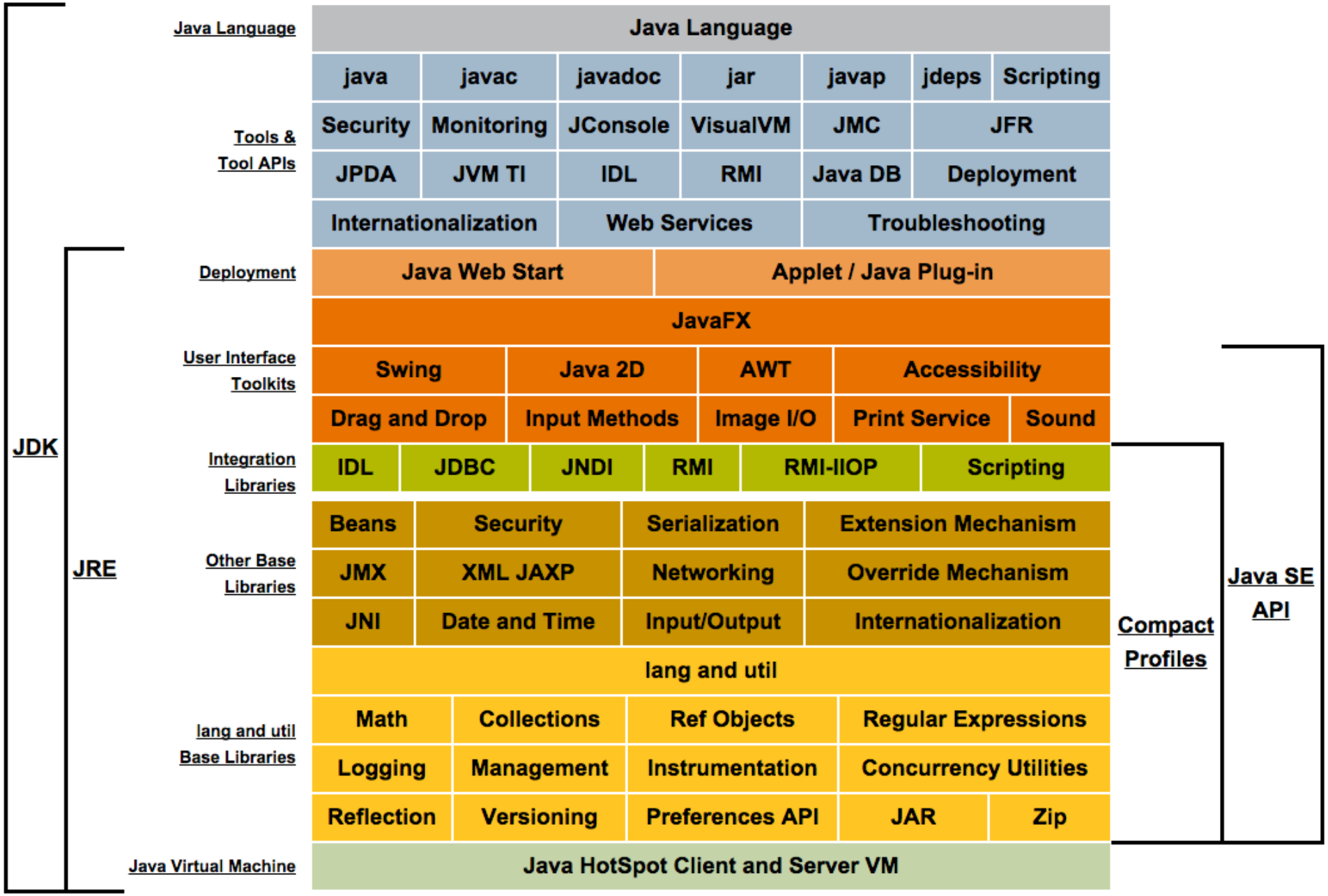
Algorithms

Produced by

Eamonn de Leastar (edeleastar@wit.ie)

Waterford Institute *of* Technology
INSTITIÚID TEICNEOLAÍOCHTA PHORT LÁIRGE

Streams

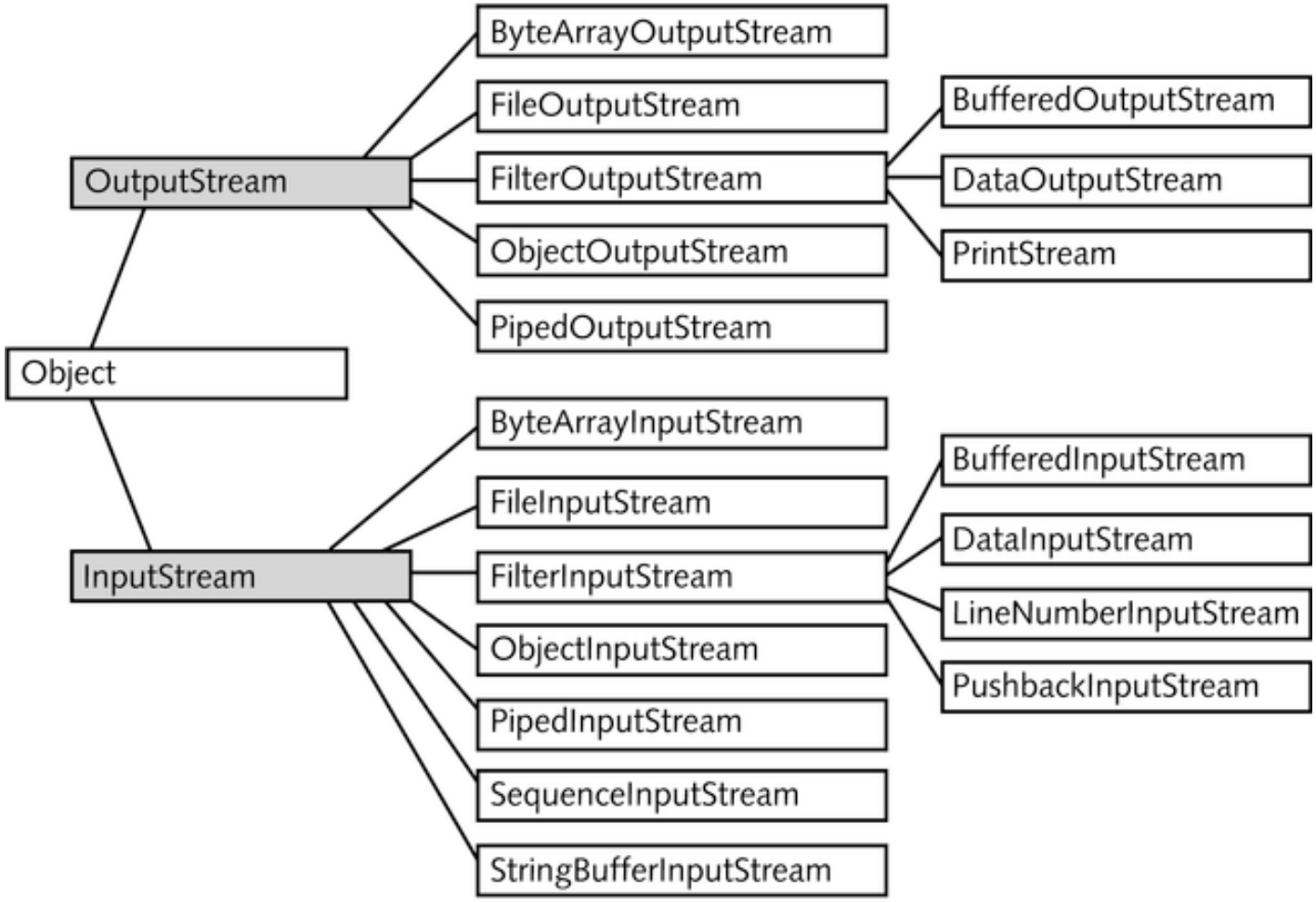


http://www.oracle.com/technetwork/java/javase/tech/index.html

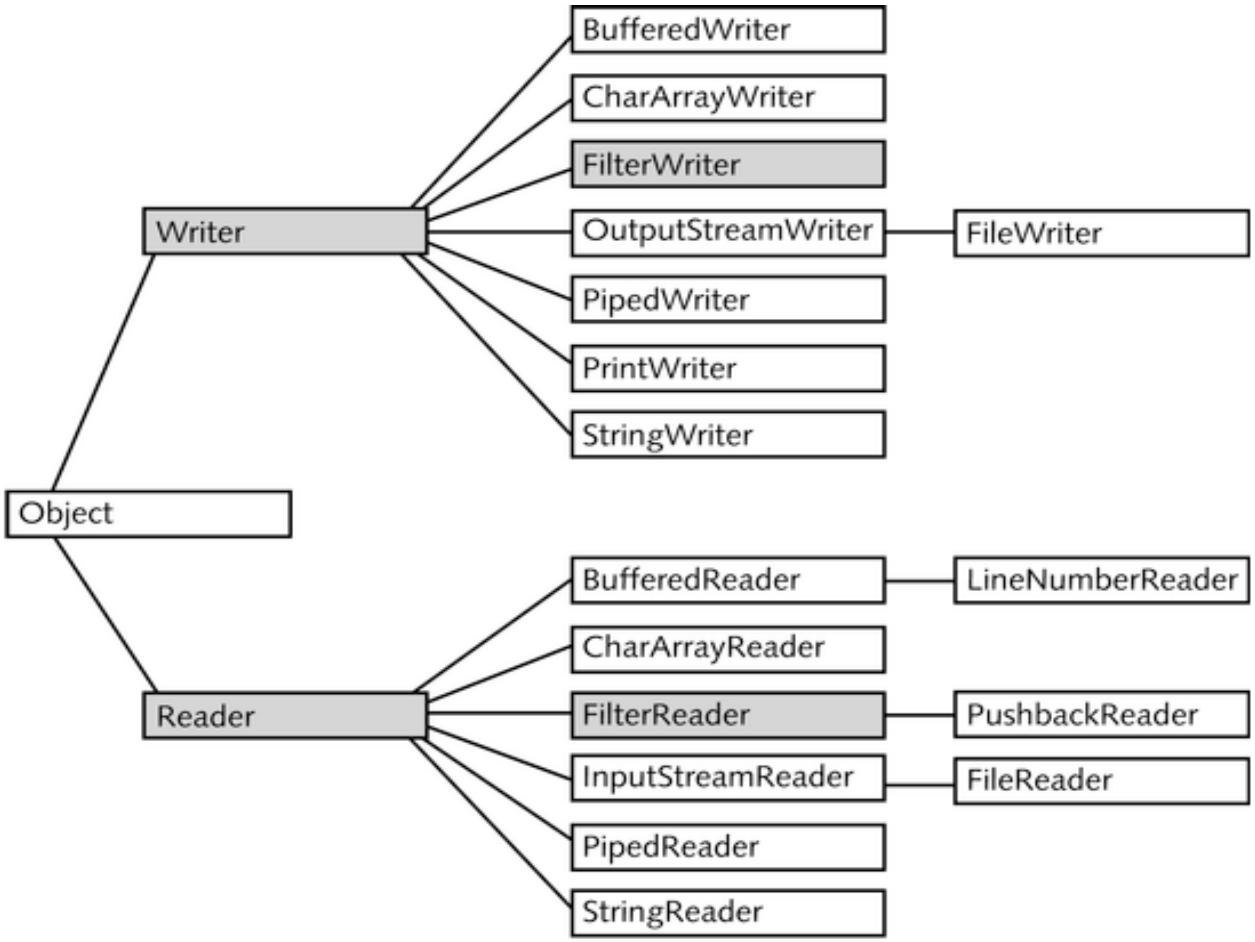
Introduction

- An I/O Stream represents an input source or an output destination.
- A stream can represent
  - disk files
  - devices
  - other programs
- Streams support
  - simple bytes
  - primitive data types
  - localized characters
  - objects.
- Some streams simply pass on data, others manipulate and transform the data in useful ways.

Byte-Oriented Streams

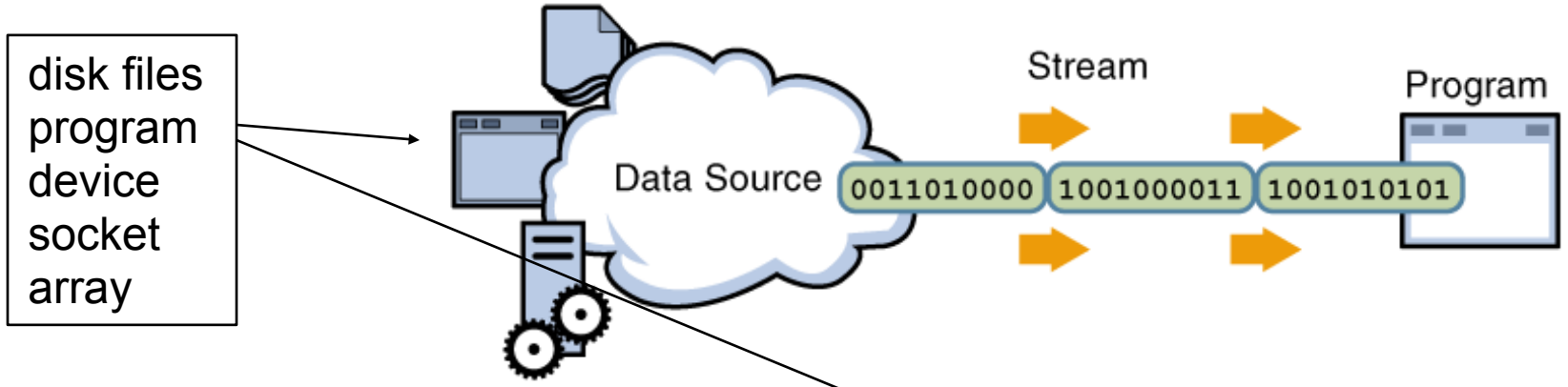


Text Oriented Streams

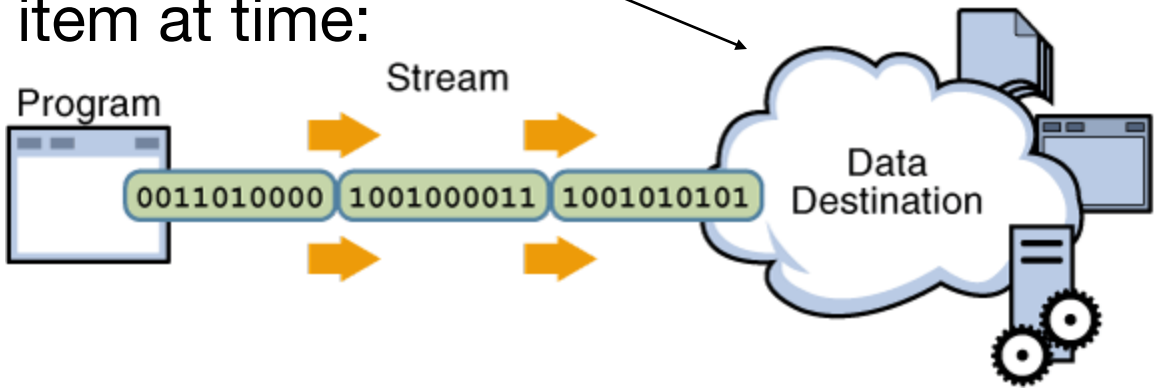


Input/Output Streams

- A stream is a sequence of data.
- A Java program uses an input stream to read data from a source, one item at a time:

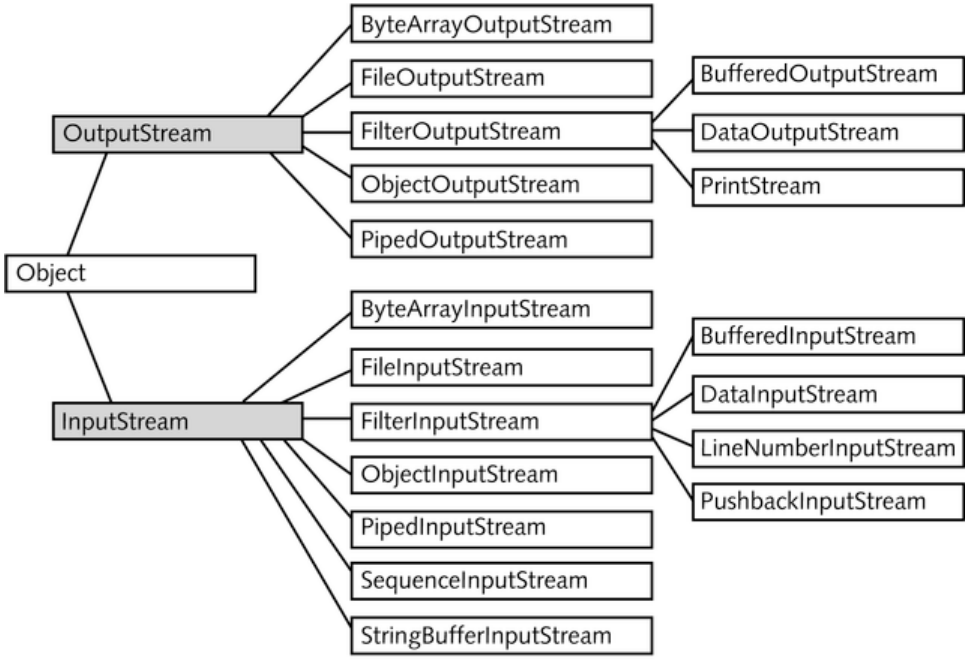


- A Java program uses an output stream to write data to a destination, one item at time:



Byte Streams

- Byte streams perform I/O of 8-bit bytes.
- All byte stream classes are descended from InputStream & OutputStream.
- To read/write from files, use FileInputStream and FileOutputStream.
- Other kinds of byte streams are used much the same way; they differ mainly in the way they are constructed.

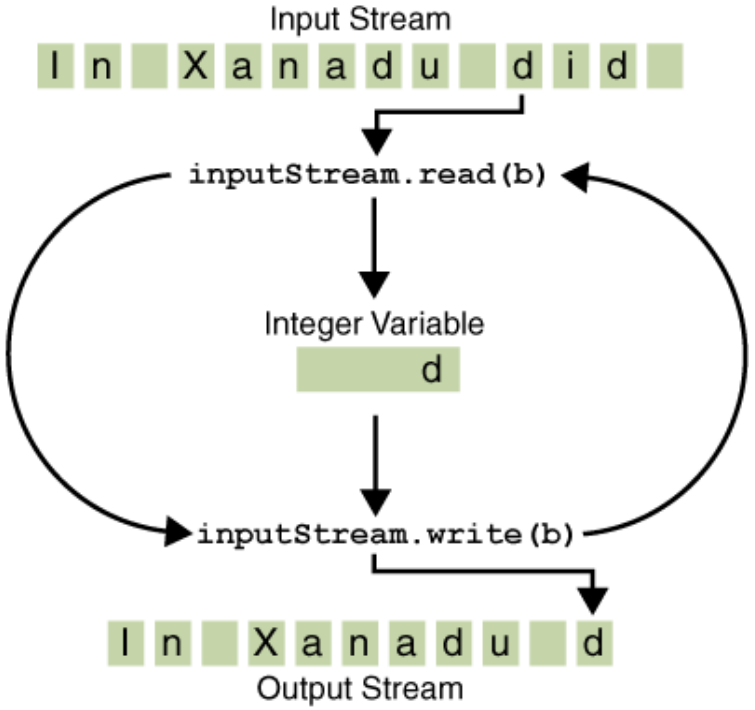


CopyBytes

```
public class CopyBytes
{
  public static void main(String[] args) throws IOException
  {
    FileInputStream in = null;
    FileOutputStream out = null;
    try
    {
      in = new FileInputStream("input.txt");
      out = new FileOutputStream("final.txt");
      int c;
      while ((c = in.read()) != -1)
      {
        out.write(c);
      }
    }
    finally
    {
      if (in != null)
      {
        in.close();
      }
      if (out != null)
      {
        out.close();
      }
    }
  }
}
```

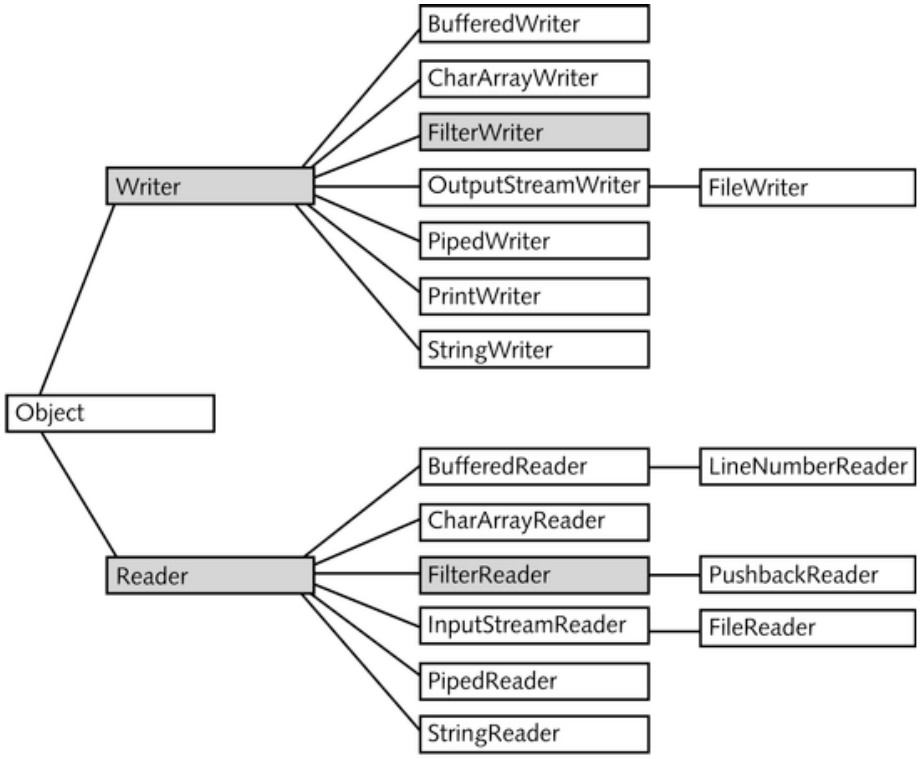
CopyBytes

- An int return type allows read() to use -1 to indicate end of stream.
- CopyBytes uses a finally block to guarantee that both streams will be closed even if an error occurs. this helps avoid resource leaks.
- If CopyBytes was unable to open one or both files the stream variable never changes from its initial null value.
- Byte streams should only be used for the most primitive I/O.
- However, all other stream types are built on byte streams.



Character Streams

- Java stores character values using Unicode
- Character stream I/O automatically translates this to and from the local character set.
- In Western locales, the local character set is usually an 8-bit superset of ASCII.
- I/O with character stream classes automatically translates to/from the local character set.



CopyCharacters

```
public class CopyCharacters
{
  public static void main(String[] args) throws IOException
  {
    FileReader inputStream = null;
    FileWriter outputStream = null;
    try
    {
      inputStream = new FileReader("input.txt");
      outputStream = new FileWriter("final.txt");
      int c;
      while ((c = inputStream.read()) != -1)
      {
        outputStream.write(c);
      }
    }
    finally
    {
      if (inputStream != null)
      {
        inputStream.close();
      }
      if (outputStream != null)
      {
        outputStream.close();
      }
    }
  }
}
```

CopyCharacters vs CopyBytes

- CopyCharacters is very similar to CopyBytes.
  - CopyCharacters uses FileReader and FileWriter
  - CopyBytes uses FileInputStream and FileOutputStream.
- Both use an int variable to read to and write from.
  - CopyCharacters int variable holds a character value in its last 16 bits
  - CopyBytes int variable holds a byte value in its last 8 bits
- Character streams are often "wrappers" for byte streams.
  - A byte stream to perform the physical I/O
  - The character stream handles translation between characters and bytes.
- E.g. FileReader uses FileInputStream, while FileWriter uses FileOutputStream.

Buffered IO

- So far we have used unbuffered I/O:
  - Each read or write request is handled directly by the underlying OS.
  - Can be less efficient, since each such request often triggers disk or network access.
- To reduce this kind of overhead use buffered I/O streams.
  - Read data from a memory area known as a buffer
  - Native input API is called only when the buffer is empty.
  - Buffered output streams write data to a buffer
  - Native output API is called only when the buffer is full.

Line-Oriented IO

- Character I/O usually occurs in bigger units than single characters.
- One common unit is the line:
  - a string of characters with a line terminator at the end.
- A line terminator can be
  - a carriage-return/line-feed sequence ("\r\n")
  - a single carriage-return ("\r"), or a single line-feed ("\n").
- Supporting all possible line terminators allows programs to read text files created on any of the widely used operating systems.

CopyLines

```
public class CopyLines
{
  public static void main(String[] args) throws IOException
  {
    BufferedReader inputStream = null;
    PrintWriter outputStream = null;
    try
    {
      inputStream = new BufferedReader(new FileReader("xanadu.txt"));
      outputStream = new PrintWriter(new FileWriter("characteroutput.txt"));
      String l;
      while ((l = inputStream.readLine()) != null)
      {
        outputStream.println(l);
      }
    }
    finally
    {
      if (inputStream != null)
      {
        inputStream.close();
      }

      if (outputStream != null)
      {
        outputStream.close();
      }
    }
  }
}
```

BufferedReader

- An unbuffered stream can be converted into a buffered stream using the wrapper idiom:
- The unbuffered stream object is passed to the constructor for a buffered stream class.

```
try
 {
   inputStream = new BufferedReader(new FileReader("input.txt"));
   outputStream = new PrintWriter(
                        new BufferedWriter(
                          new FileWriter("characteroutput.txt")));

   String l;

   while ((l = inputStream.readLine()) != null)
   {
     outputStream.println(l);
   }
 }
```

Flushing Buffers

- There are four buffered stream classes used to wrap unbuffered streams:
  - BufferedInputStream and BufferedOutputStream for byte streams,
  - BufferedReader and BufferedWriter for character streams.
- It often makes sense to write out a buffer at critical points, without waiting for it to fill.
  - This is known as flushing the buffer.
- Some buffered output classes support autoflush, specified by an optional constructor argument.
- When autoflush is enabled, certain key events cause the buffer to be flushed. For example, an autoflush PrintWriter object flushes the buffer on every invocation of println or format.
- To flush a stream manually, invoke its flush method.

Scanning

- Objects of type Scanner break input into tokens and translate individual tokens according to their data type.
- By default, a scanner uses white space to separate tokens.
- To use a different token separator, invoke useDelimiter(), specifying a regular expression.
- Even though a scanner is not a stream, you need to close it to indicate that you're done with its underlying stream.

ScanFile

```
public class ScanFile
{
  public static void main(String[] args) throws IOException
  {
    Scanner s = null;
    try
    {
      s = new Scanner(new BufferedReader(
                                    new FileReader("input.txt")));
      while (s.hasNext())
      {
        System.out.println(s.next());
      }
    }
    finally
    {
      if (s != null)
      {
        s.close();
      }
    }
  }
}
```

Translating Individual Tokens

```
public class ScanSum
{
  public static void main(String[] args) throws IOException
  {
    Scanner s = null;
    double sum = 0;

    try
    {
      s = new Scanner(new BufferedReader(new FileReader("usnumbers.txt")));
      while (s.hasNext())
      {
        if (s.hasNextDouble())
        {
          sum += s.nextDouble();
        }
        else
        {
          s.next();
        }
      }
    }
    finally
    {
      s.close();
    }
    System.out.println(sum);
  }
}
```

Translating Individual Tokens

- ScanSum reads a list of double values and adds them up
- The ScanFile example treats all input tokens as simple String values.
- Scanner also supports tokens for all of the Java language's primitive types as well as BigInteger and BigDecimal.

Command Line I/O

- A program is often run from the command line, and interacts with the user in the command line environment.
- The Java platform supports this kind of interaction in two ways:
  - Standard Streams
  - Console.

Standard Streams

- A feature of many operating systems, they read input from the keyboard and write output to the display.
- They also support I/O on files and between programs (controlled by the shell).
- The Java platform supports three Standard Streams:
  - Standard Input, accessed through System.in;
  - Standard Output, accessed through System.out;
  - Standard Error, accessed through System.err.
- These objects are defined automatically (do not need to be opened)
- Standard Output and Standard Error are both for output
- Having error output separately allows the user to divert regular output to a file and still be able to read error messages.

System.in, System.out, System.err

- For historical reasons, the standard streams are byte streams (more logically character streams).
- System.out and System.err are defined as PrintStream objects.
- Although it is technically a byte stream, PrintStream utilizes an internal character stream object to emulate many of the features of character streams.
- By contrast, System.in is a byte stream with no character stream features.
- To utilize Standard Input as a character stream, wrap System.in in InputStreamReader.

```
InputStreamReader cin = new InputStreamReader(System.in);
```

Console

- New for Java 6 - a more advanced alternative to the Standard Streams
- This is a single pre-defined object of type Console that has most of the features provided by the Standard Streams.
- The Console object also provides input and output streams that are true character streams, through its reader and writer methods.
- Before a program can use the Console, it must attempt to retrieve the Console object by invoking System.console().
  - If the Console object is available, this method returns it.
  - If it returns NULL, then Console operations are not permitted, either because the OS doesn't support them, or because the program was launched in a non-interactive environment.

Password Entry

- The Console object supports secure password entry through its readPassword method.
  - This method helps secure password entry in two ways. it suppresses echoing, so the password is not visible on the users screen.
  - readPassword returns a character array, not a String, so that the password can be overwritten, removing it from memory as soon as it is no longer needed.

Password (1)

```
public class Password
{
  public static void main(String[] args) throws IOException
  {
    Console c = System.console();

    if (c == null)
    {
      System.err.println("No console.");
      System.exit(1);
    }

    String login = c.readLine("Enter your login: ");
    char[] oldPassword = c.readPassword("Enter your old password: ");
    //..

  }
}
```

Password (2)

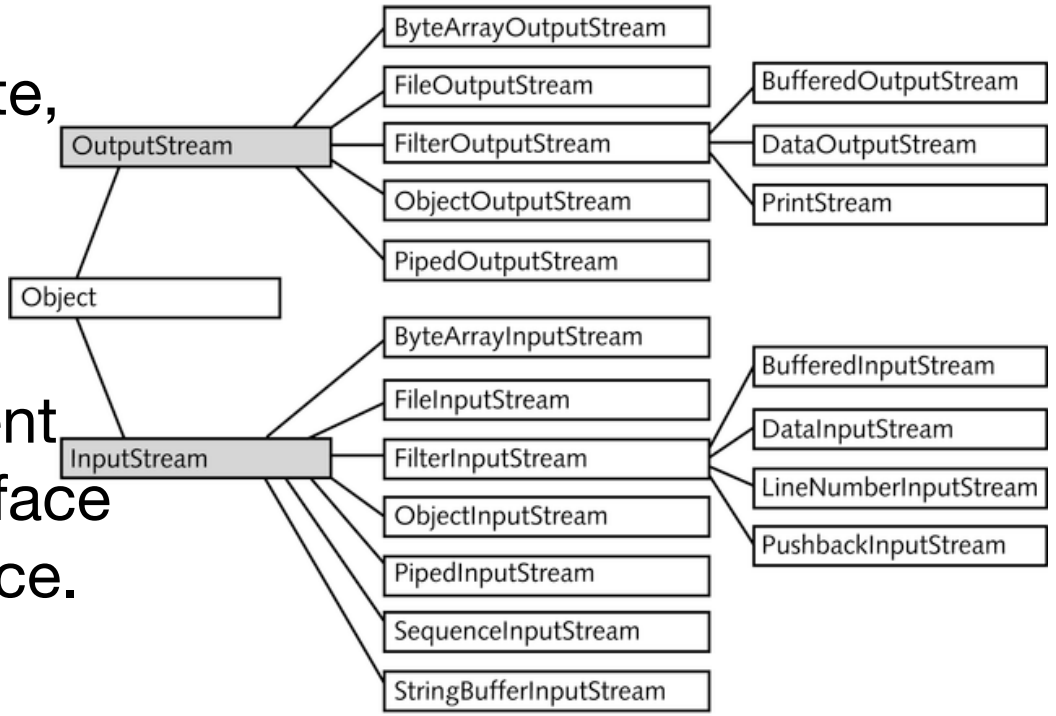
```
//..
if (verify(login, oldPassword))
  {
    boolean noMatch;
    do
    {
      char[] newPassword1 = c.readPassword("Enter your new password: ");
      char[] newPassword2 = c.readPassword("Enter new password again: ");
      noMatch = !Arrays.equals(newPassword1, newPassword2);
      if (noMatch)
      {
        c.format("Passwords don't match. Try again.%n");
      }
      else
      {
        change(login, newPassword1);
        c.format("Password for %s changed.%n", login);
      }

      Arrays.fill(newPassword1, ' ');
      Arrays.fill(newPassword2, ' ');
    }
    while (noMatch);
  }
  Arrays.fill(oldPassword, ' ');
}
```

Method Summary

void	**flush**() Flushes the console and forces any buffered output to be written immediately .
Console	**format**(String fmt, Object... args) Writes a formatted string to this console's output stream using the specified format string and arguments.
Console	**printf**(String format, Object... args) A convenience method to write a formatted string to this console's output stream using the specified format string and arguments.
Reader	**reader**() Retrieves the unique Reader object associated with this console.
String	**readLine**() Reads a single line of text from the console.
String	**readLine**(String fmt, Object... args) Provides a formatted prompt, then reads a single line of text from the console.
char[]	**readPassword**() Reads a password or passphrase from the console with echoing disabled
char[]	**readPassword**(String fmt, Object... args) Provides a formatted prompt, then reads a password or passphrase from the console with echoing disabled.
PrintWriter	**writer**() Retrieves the unique PrintWriter object associated with this console.

Data Streams

- Data streams support binary I/O of primitive data type values (boolean, char, byte, short, int, long, float, and double) as well as String values.
- All data streams implement either the DataInput interface or the DataOutput interface.
- The most widely-used implementations of these interfaces are DataInputStream and DataOutputStream.



DataStream (1)

```
public class DataStream
{
  static final String dataFile = "invoicedata";
  static final double[] prices = { 19.99, 9.99, 15.99, 3.99, 4.99 };
  static final int[] units     = { 12, 8, 13, 29, 50 };
  static final String[] descs = { "Java T-shirt", "Java Mug",
                                  "Duke Juggling Dolls",
                                  "Java Pin", "Java Key Chain"};

  public static void main(String[] args) throws IOException
  {
    DataOutputStream out = new DataOutputStream(
              new BufferedOutputStream(new FileOutputStream(dataFile)));

    for (int i = 0; i < prices.length; i++)
    {
      out.writeDouble(prices[i]);
      out.writeInt(units[i]);
      out.writeUTF(descs[i]);
    }
    out.close();

    //…continued
```

DataStream (2)

```
    DataInputStream in = new DataInputStream(
                             new BufferedInputStream(
                               new FileInputStream(dataFile)));
    double price;
    int unit;
    String desc;
    double total = 0.0;
    try
    {
      while (true)
      {
        price = in.readDouble();
        unit = in.readInt();
        desc = in.readUTF();
        System.out.format("You ordered %d units of %s at $%.2f%n",
                                                          unit, desc, price);
        total += unit * price;
      }
    }
    catch (EOFException e)
    {
      System.out.println("End of file");
    }
  }
}
```

Data Streams Observations

- The writeUTF method writes out String values in a modified form of UTF-8.
  - A variable-width character encoding that only needs a single byte for common Western characters.
- Generally, we detects an end-of-file condition by catching EOFException, instead of testing for an invalid return value.
- Each specialized write in DataStreams is exactly matched by the corresponding specialized read.
- Floating point numbers not recommended for monetary values
  - In general, floating point is bad for precise values.
  - The correct type to use for currency values is java.math.BigDecimal.
- Unfortunately, BigDecimal is an object type, so it won't work with data streams – need Object Streams.

Object Streams

- Data streams support I/O of primitive data types, object streams support I/O of objects.
  - A class that can be serialized implements the marker interface Serializable.
- The object stream classes are ObjectInputStream and ObjectOutputStream.
  - They implement ObjectInput and ObjectOutput, which are subtypes of DataInput and DataOutput.
  - Thus all the primitive data I/O methods covered in Data Streams are also implemented in object streams.
  - An object stream can contain a mixture of primitive and object values
- If readObject() doesn't return the object type expected, attempting to cast it to the correct type may throw a ClassNotFoundException.

ObjectSteams

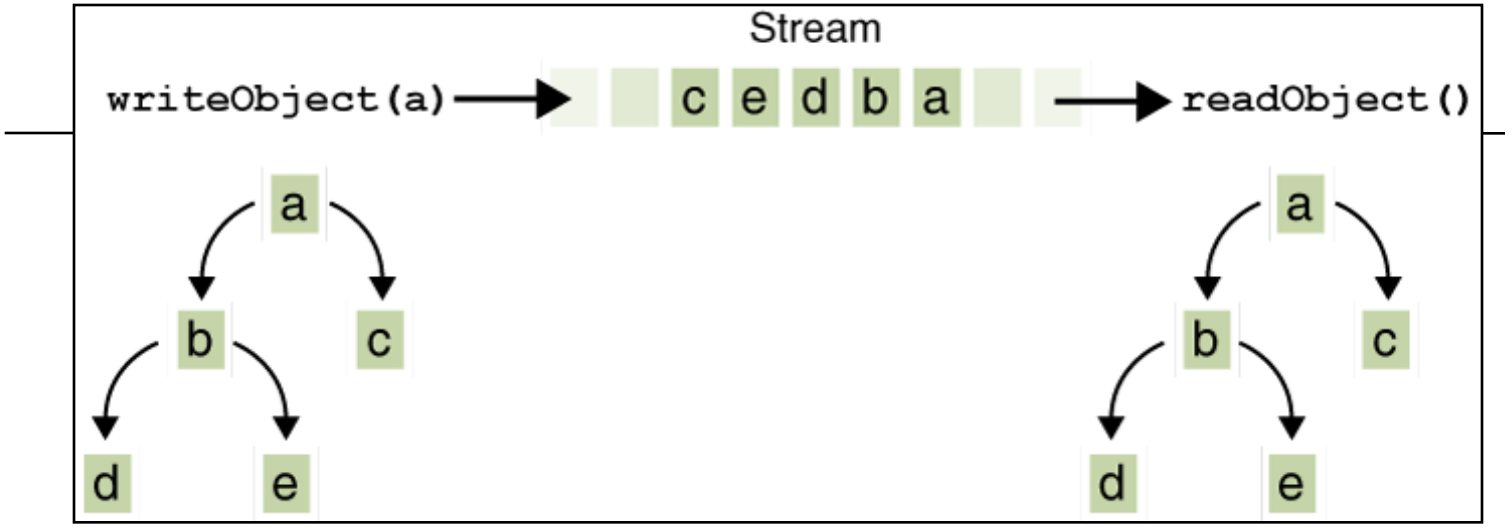
```
public class ObjectStreams
{
  static final String dataFile = "invoicedata";
  static final BigDecimal[] prices = {new BigDecimal("19.99"),
                                      new BigDecimal("9.99"),
                                      new BigDecimal("15.99"),
                                      new BigDecimal("3.99"),
                                      new BigDecimal("4.99") };
  static final int[] units = { 12, 8, 13, 29, 50 };
  static final String[] descs = { "Java T-shirt", "Java Mug",
                                  "Duke Juggling Dolls",
                                  "Java Pin", "Java Key Chain" };
  public static void main(String[] args)
                        throws IOException, ClassNotFoundException
  {
    ObjectOutputStream out = null;
    try
    {
      out = new ObjectOutputStream(
              new BufferedOutputStream(new FileOutputStream(dataFile)));
      out.writeObject(Calendar.getInstance());
      for (int i = 0; i < prices.length; i++)
      {
        out.writeObject(prices[i]);
        out.writeInt(units[i]);
        out.writeUTF(descs[i]);
      }
    }
    finally
    {
      out.close();
    }
  //…
  }
```

ObjectStreams(2)

```
ObjectInputStream in = null;
try
{
  in = new ObjectInputStream(
         new BufferedInputStream(new FileInputStream(dataFile)));
  Calendar date = null;
  BigDecimal price;
  int unit;
  String desc;
  BigDecimal total = new BigDecimal(0);

  date = (Calendar) in.readObject();

  System.out.format("On %tA, %<tB %<te, %<tY:%n", date);
  try
  {
    while (true)
    {
      price = (BigDecimal) in.readObject();
      unit = in.readInt();
      desc = in.readUTF();
      System.out.format("You ordered %d units of %s at $%.2f%n",unit, desc, price);
      total = total.add(price.multiply(new BigDecimal(unit)));
    }
  }
  catch (EOFException e)
  {
  }
  System.out.format("For a TOTAL of: $%.2f%n", total);
}
finally
{
  in.close();
}
```

readObject() and writeObject()

- The writeObject and readObject methods contain some sophisticated object management logic.
- This particularly important for objects that contain references to other objects.
- If readObject is to reconstitute an object from a stream, it has to be able to reconstitute all the objects the original object referred to.
  - These additional objects might have their own references, and so on.
- In this situation, writeObject traverses the entire web of object references and writes all objects in that web onto the stream. Thus a single invocation of writeObject can cause a large number of objects to be written to the stream.



- Suppose:
  - If writeObject is invoked to write a single object named a.
  - This object contains references to objects b and c,
  - while b contains references to d and e.
- Invoking writeobject(a) writes a and all the objects necessary to reconstitute a
- When a is read by readObject, the other four objects are read back as well, and all the original object references are preserved.

Streams in TDD-04 Lab

```
public interface Serializer
{
  void push(Object o);
  Object pop();
  void write() throws Exception;
  void read() throws Exception;
}
```

- A Specification for a general purpose serialisation mechanism
- We can devise various implementations of this interface to use specific serialisation strategies.

XMLSerializer -

```
public class XMLSerializer implements Serializer
{
  private Stack stack = new Stack();
  private File file;

  public XMLSerializer(File file)
  {
    this.file = file;
  }

  public void push(Object o)
  {
    stack.push(o);
  }

  public Object pop()
  {
    return stack.pop();
  }

  public void read() throws Exception
  { ... }

  public void write() throws Exception
  { ... }
}
```

- Enable an application to ‘push’ various objects onto a stack
- At some suitable time, write this entire stack to a file
- Subsequently, this entire stack can be read back and recovered (popped) by the application.

XMLSerializer - write()

```
public class XMLSerializer implements Serializer
{
  ...

  public void write() throws Exception
  {
    ObjectOutputStream os = null;

    try
    {
      XStream xstream = new XStream(new DomDriver());
      os = xstream.createObjectOutputStream(new FileWriter(file));
      os.writeObject(stack);
    }
    finally
    {
      if (os != null)
      {
        os.close();
      }
    }
  }

  ...
}
```

XMLSerializer - read()

```
public class XMLSerializer implements Serializer
{
  ...

  public void read() throws Exception
  {
    ObjectInputStream is = null;

    try
    {
      XStream xstream = new XStream(new DomDriver());
      is = xstream.createObjectInputStream(new FileReader(file));
      stack = (Stack) is.readObject();
    }
    finally
    {
      if (is != null)
      {
        is.close();
      }
    }
  }
  ...
}
```

```
public class PacemakerAPI
{
  private Serializer serializer;

  private Map<Long,   User>   userIndex       = new HashMap<>();
  private Map<String, User>   emailIndex      = new HashMap<>();
  private Map<Long, Activity> activitiesIndex = new HashMap<>();

  public PacemakerAPI()
  {}

  public PacemakerAPI(Serializer serializer)
  {
    this.serializer = serializer;
  }

  @SuppressWarnings("unchecked")
  public void load() throws Exception
  {
    serializer.read();
    activitiesIndex = (Map<Long, Activity>) serializer.pop();
    emailIndex      = (Map<String, User>)   serializer.pop();
    userIndex       = (Map<Long, User>)     serializer.pop();
  }

  void store() throws Exception
  {
    serializer.push(userIndex);
    serializer.push(emailIndex);
    serializer.push(activitiesIndex);
    serializer.write();
  }
```

- Using the Serializer from the PacemakerAPI

```
<object-stream>
  <java.util.Stack serialization="custom">
    <unserializable-parents/>
    <vector>
      <default>
        <capacityIncrement>0</capacityIncrement>
        <elementCount>3</elementCount>
        <elementData>
          <map>
            <entry>
              <long>0</long>
              <models.User>
                <id>0</id>
                <firstName>Bart</firstName>
                <lastName>Simpson</lastName>
                <email>bart@simpson.com</email>
                <password>secret</password>
                <activities/>
              </models.User>
            </entry>
            <entry>
              <long>1</long>
              <models.User>
                <id>1</id>
                <firstName>Homer</firstName>
                <lastName>Simpson</lastName>
                <email>homer@simpson.com</email>
                <password>secret</password>
                <activities>
                  <entry>
                    <long>0</long>
                    <models.Activity>
                      <id>0</id>
                      <type>walk</type>
                      <location>tramore</location>
```