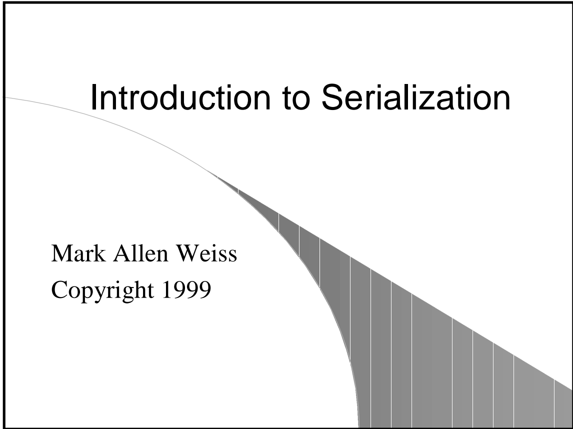
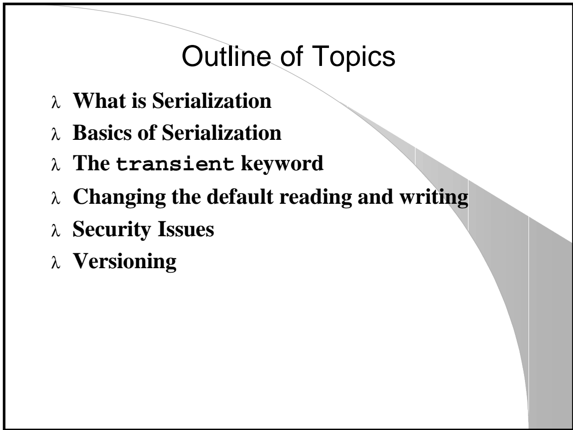
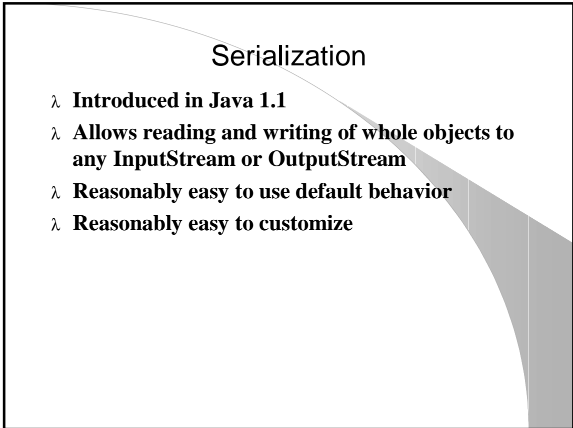

Introduction to Serialization
Mark Allen Weiss
Copyright 1999


Outline of Topics
λ What is Serialization
λ Basics of Serialization
λ The transient keyword
λ Changing the default reading and writing
λ Security Issues
λ Versioning


Serialization
λ Introduced in Java 1.1
λ Allows reading and writing of whole objects to any InputStream or OutputStream
λ Reasonably easy to use default behavior
λ Reasonably easy to customize

Why Serialization?

- Persistence: Storing objects in files and databases (persistence)
- Marshalling: Passing whole objects between VMs over the network

Serializable Interface

- Only objects that implement the `Serializable` interface can be serialized
- This interface is part of Java 1.1
- `String`, `Integer`, `Vector`, `Hashtable` and other typical classes have been retrofitted in Java 1.1 to be `Serializable`
- Easy to implement this interface: it has no methods!

Why Isn't Everything Serializable?

- If it was, there could be information leaks when objects are written.
- We also need to be careful when reading a serialized object (sketch of the details provided later)

Writing an Object

- **Create an `ObjectOutputStream` from any `OutputStream`**
- **Use its `writeObject` method:**

```
void writeObject( Object obj );
```

- **Remember: `obj` must be serializable.**
- **Need to handle `IOException`, `NotSerializableException`, `InvalidClassException`. All are `IOExceptions`.**

Reading an Object

- **Create an `ObjectInputStream` from any `InputStream`**
- **Use its `readObject` method:**

```
Object readObject( );
```

- **Returned type must be downcast to actual type.**
- **Need to handle `IOException`, `ClassNotFoundException`, `OptionalDataException`. All but `ClassNotFoundException` are `IOExceptions`.**

Example of Writing

```
FileOutputStream f;

ObjectOutputStream out = new ObjectOutputStream( f );
Person p = new Person( ... );
...
try {
  out.writeObject( p );
}
catch( NotSerializableException e ) {
  // Oops: Person is not serializable
}
catch( IOException e ) {
  // Oops: Various I/O problems
}
```

Example of Reading

```
FileInputStream f;

ObjectInputStream out = new ObjectInStream( f );
Person p;
...
try {
  p = (Person) in.readObject( );
}
catch( ClassNotFoundException e ) {
  // Oops: Person class not loadable on this VM
}
catch( IOException e ) {
  // Oops: Various I/O problems
}
```

What Gets Written

- **`ObjectStreamClass` object for the object's class**
  - **Includes 64-bit `serialVersionUID` (versioning)**
  - **Names and types of fields**
  - **`ObjectStreamClass` of super class**
- **Non-`transient`, non-`static` fields**
  - **Base class data written first (if base class not serializable, zero-parameter constructor used)**
  - **Fields that are object references are followed; if they can be serialized, they are; otherwise, if `null` ok; otherwise exception is thrown.**

Several References to Same Object

- **When written, each object gets a serial number (hence, serialization)**
- **Each reference is then either null or the appropriate serial number**
- **Long chains of references are followed automatically using a depth-first search; saves you lots of manual labor**
- **When objects are restored, everything looks like it was.**

What Gets Read

- `ObjectStreamClass` object for the object's class
  - Includes 64-bit `serialVersionUID` (versioning)
  - Names and types of fields
  - `ObjectStreamClass` of super class
- Object fields read in next
- If base class is nonserializable, inherited portion is initialized with no-parameter constructor.

Class Versioning

- 64 bit `serialVersionUID` is stored; it is based on the class members
- If the class changes in any significant way, the `serialVersionUID` changes too
- When object is read from an object stream, system ensures that version UIDs of `ObjectStreamClass` and local class are the same
- If not, exception is thrown

Version UIDs

- Computed using SHA (only 64 of the 160 bits are retained); can obtain it by running `serialvar`, which is part of the JDK.
- Will change if you add or delete members or change signatures (even from public to private)
- You can declare your opinion that a class is compatible by adding a `private static final long` member named `serialVersionUID`.

Version UIDs (continued)

- **If UIDs match, attempt to load class will continue**
- **During the read, new fields (those not written by the write) will get default values (null for references, etc.)**
- **Removed fields will be ignored**
- **If VM isn't happy, an exception is thrown. May happen if field type has changed**

Security Problems

- **The constructor for the `Serializable` object is NOT called.**
  - Some fields may be `null`, which might not be what was expected based on constructors
- **Serializable object is read in without checks. Consider a serializable `Date` class.**
  - Can write the `Date` out to a file
  - Can edit the file, and generate an illegal date
  - When it is read in, fields are copied, blindly
  - There's no check, and `Date` is now inconsistent
  - Don't even need files: can use ByteStreams.

Customizing `readObject`

- **Can have `readObject` do extra work by implementing (in the serialized object's class)**

```
private void readObject( ObjectInputStream in )
  throws IOException, ClassNotFoundException;
```

- **`readObject` (and only `readObject`) can call an `ObjectInputStream` method to do the normal default read, and can then add code to do error checks or other additional work. The method call would be**
- `in.defaultReadObject( );`
- **Note: `readObject` must be private**

Example: Making `Date` Safer

```
public class Date implements Serializable
{
    ...
  private boolean isValid( )
    { /* implementation omitted */ }

  private void readObject( ObjectInputStream in )
      throws IOException, ClassNotFoundException
  {
    in.defaultReadObject( );
    if( !isValid( ) ) throw new IOException( );
  }
}
```

Customizing `writeObject`

- **Not surprisingly, can do similar things with `writeObject`**
  - **Can have private `writeObject` method (throws `IOException` only)**
  - **Private `writeObject` method can call `out.defaultWriteObject( )`**
- **This is useful for writing output in a special way. For instance, can write a transient field in an encrypted format. Of course, need to implement `readObject` to match.**

`readObject` and `writeObject`

```
public class Secure implements Serializable {
  transient private String password;
            private String name;

  private void writeObject( ObjectOutputStream out )
                           throws IOException {
    out.defaultWriteObject( );
    out.writeUTF( NSA.encrypt( password ) );
  }

  private void readObject( ObjectInputStream is )
        throws IOException, ClassNotFoundException {
    in.defaultReadObject( );
    password = NSA.decrypt( in.readUTF( ) );
  }
}
```

Dealing With Changing Fields

- Uses nested class `ObjectInputStream.GetField`
- Call `ObjectInputStream.readFields` to get a collection of name/value pairs
  - unfortunately, cannot enumerate over collection
  - must know exact field name in stream format
- Various `get` methods extract objects
  - Two parameters: name of field, and value to return if field is not in the stream (but is in current class)
  - if field not in the stream AND field is not in the current class, you get an exception
  - Must explicitly assign values to all class fields, or they will get zero for primitives, null for references

Using ObjectInputStream.GetField

```
class Person {
  static final long serialVersionUID = ...;
    ...
  private void readObject( ObjectInputStream in )
            throws IOException, ClassNotFoundException {
    ObjectInputStream.GetField gf = in.readFields( );

    fullName = (String) gf.get( "fullName", null );
    if( fullName == null )
      fullName = gf.get( "lastName", null )
                + ", " + gf.get( "firstName", null );
    age = gf.get( "age", 0 );
  }

  private String fullName;       // the new version
  // private String lastName;    // the old version
  // private String firstName;   // the old version
}
```

Externalization

- Serializable is nice, but has some overhead. May not be appropriate in all instances.
- The `Externalizable` interface extends `Serializable`. Must implement

```
public void writeExternal( ObjectOutput out )
  throws IOException;
public void readExternal( ObjectInput in )
  throws IOException, ClassNotFoundException;
```

- Your object has complete control over how it is written but you deal with base classes, and serializing object references.
- Object and all super classes must have 0-param constructor

`Externalizable` Date Class

```
class Date implements Externalizable
{
  public Date( )
    { this( 1, 1, 2000 ); }

  public Date( int m, int d, int y )
    { month = m; date = d; year = y; }

  public void writeExternal( ObjectOutput out ) throws IOException
    { out.writeInt( month ); out.writeInt( date ); out.writeInt( year ); }

  public void readExternal( ObjectInput  in )
           throws IOException, ClassNotFoundException
    { month = in.readInt( ); date = in.readInt( ); year = in.readInt( ); }

  private int month;
  private int date;
  private int year;
}
```

Summary

- **Serialization is easy to use; it tracks down and serializes all objects reachable from the basic object being serialized**
- **Usually have to implement private `readObject` to do security check**
- **May need to watch out for class version changes and set the `serialVersionUID`**
- **Externalization is hard to use unless class is trivial, but can be faster and more compact**