



Serialization

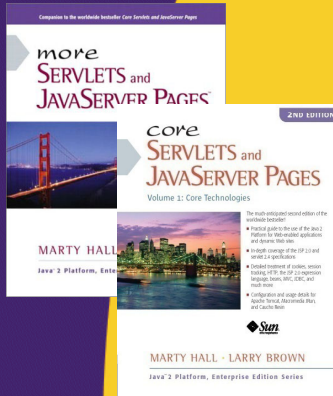
Sending Complex Java Data Structures to Files or Over the Network

Originals of Slides and Source Code for Examples:

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Taught by the author of *Core Servlets and JSP*, *More Servlets and JSP*, and this tutorial. Available at public venues, or customized versions can be held on-site at your organization. Contact hall@coreservlets.com for details.

Agenda

- **Idea**
- **Requirements**
- **Steps for sending data**
- **Steps for receiving data**
- **Example: saving GUI in file**
- **Example: sending GUI across network**

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Idea of Serialization

- **Java lets you send arbitrarily complex data structures with a single command**
 - writeObject from ObjectOutputStream
 - Can write to file, socket, process, servlet, etc.
 - Almost any data type: ArrayList, array, Frame, Panel, custom classes, etc. Arbitrarily nested.
 - Custom classes must implement Serializable
- **Java lets you read data structure in a single command**
 - readObject from ObjectInputStream
 - Can read from file, socket, process, servlet, etc.
 - Must have class files for custom classes
 - Must be on same major version of Java

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Requirements

- **Top-level data structure and all internal components must implement Serializable**
 - Most builtin classes already do
 - ArrayList, HashMap, array, String, Frame/JFrame, Panel/JPanel, Button/JButton, etc.
 - Primitives are OK inside data structures.
 - No need for wrapper classes.
 - Making your own classes serializable is simple
 - Just say “implements Serializable” (no methods!)
 - Have a zero-argument constructor.
- **Both ends must use same major version of Java**
 - I.e., sender cannot use 1.4 and receiver use 1.5 or vice versa
- **Both ends must have same version of class files for custom classes**
 - E.g., if you add a method to your class and recompile, old serialized data is no longer valid

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Sending Data

- **Wrap an ObjectOutputStream around any regular OutputStream**
 - To file

```
FileOutputStream fileOut =
    new FileOutputStream("SomeFile.ser");
ObjectOutputStream out =
    new ObjectOutputStream(fileOut);
```
 - To socket

```
OutputStream socketOut =
    someSocket.getOutputStream();
ObjectOutputStream out =
    new ObjectOutputStream(socketOut);
```
- **Send top-level data structure**

```
out.writeObject(theData);
out.close();
```

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Receiving Data

- **Wrap an ObjectInputStream around any regular InputStream**

- From file

```
FileInputStream fileIn =  
    new FileInputStream(new File("SomeFile.ser"));  
ObjectInputStream in =  
    new ObjectInputStream(fileIn);
```

- From socket

```
InputStream socketIn =  
    someSocket.getInputStream();  
ObjectInputStream in =  
    new ObjectInputStream(socketIn);
```

- **Read top-level data structure**

```
SomeType var = (SomeType)in.readObject();
```

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Example: SaveableFrame

- **Data:**

- Main Frame (Frame already Serializable)
- Frame has internal fields (ints) representing width, height, and location on screen
- Two subpanels (Panel already Serializable)
- Bottom panel has 2 buttons (Button already serializable)
- Top panel has:
 - Custom mouse listener that explicitly implements Serializable
 - BetterCircle objects that are created when user presses mouse. (Extends Component, which already implements Serializable)

- **Sending to/from file**

- Clicking “Save” sends state of Frame to file.
- If file exists when program starts, old state taken from file

- **Sending to/from network**

- Server created that sends state of Frame to any client
- Client created that connects to server and gets copy of Frame

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SaveableFrame (Custom Class)

```
import java.awt.*;
import java.awt.event.*;
import java.io.*;

public class CirclePanel extends Panel {
    private class ClickAdapter extends MouseAdapter
        implements Serializable {
        public void mousePressed(MouseEvent event) {
            BetterCircle circle =
                new BetterCircle(Color.BLACK, 25);
            add(circle);
            circle.setCenter(event.getX(), event.getY());
        }
    }

    public CirclePanel() {
        setLayout(null);
        addMouseListener(new ClickAdapter());
    }
}
```

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SaveableFrame (Base Code to Send Frame)

- SaveableFrame.java

```
public void sendFrame(OutputStream rawOut) {
    try {
        ObjectOutputStream out =
            new ObjectOutputStream(rawOut);
        out.writeObject(this);
        out.close();
    } catch (IOException ioe) {
        System.out.println("Error saving frame: " + ioe);
    }
}
```

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SaveableFrame (Code to Send Frame to File)

- SaveableFrame.java

```
public void actionPerformed(ActionEvent event) {
    if (event.getSource() == clearButton) {
        circlePanel.removeAll();
        circlePanel.repaint();
    } else if (event.getSource() == saveButton) {
        try {
            FileOutputStream fileOut =
                new FileOutputStream("SavedFrame.ser");
            sendFrame(fileOut);
            fileOut.close();
        } catch (IOException ioe) {
            System.out.println("IOException: " + ioe);
        }
    }
}
```

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SaveableFrame (Code to Send Frame to Client on Network)

- FrameServer.java

```
public void listen(int port, SaveableFrame frame) {
    try {
        ServerSocket listener = new ServerSocket(port);
        Socket server;
        while(true) {
            server = listener.accept();
            frame.sendFrame(server.getOutputStream());
        }
    } catch (IOException ioe) {
        System.out.println("IOException: " + ioe);
        ioe.printStackTrace();
    }
}
```

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SaveableFrame (Base Code to Get Frame)

- SaveableFrame.java

```
public static SaveableFrame getFrame(InputStream rawIn) {
    SaveableFrame frame = null;
    try {
        ObjectInputStream in = new ObjectInputStream(rawIn);
        frame = (SaveableFrame)in.readObject();
        frame.setVisible(true);
        return(frame);
    } catch(IOException ioe) {
        System.out.println("Error reading file: " + ioe);
    } catch(ClassNotFoundException cnfe) {
        System.out.println("No such class: " + cnfe);
    }
    return(frame);
}
```

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SaveableFrame (Code to Get Frame from File)

- SaveableFrame.java

```
public static void main(String[] args) {
    SaveableFrame frame;
    File serializeFile = new File(serializeFilename);
    if (serializeFile.exists()) {
        try {
            FileInputStream fileIn =
                new FileInputStream(serializeFile);
            frame = getFrame(fileIn);
        } catch(IOException ioe) {
            System.out.println("IOException: " + ioe);
        }
    } else {
        frame = new SaveableFrame();
    }
}
```

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SaveableFrame (Code to Get Frame from Server on Network)

- **FrameClient.java**

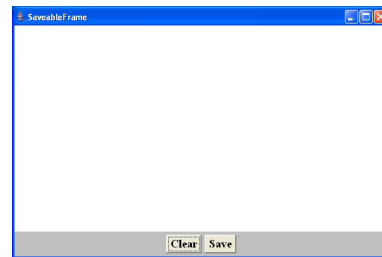
```
public FrameClient(String host, int port) {
    try {
        Socket client = new Socket(host, port);
        SaveableFrame frame =
            SaveableFrame.getFrame(client.getInputStream());
    } catch (UnknownHostException uhe) {
        System.out.println("Unknown host: " + host);
        uhe.printStackTrace();
    } catch (IOException ioe) {
        System.out.println("IOException: " + ioe);
        ioe.printStackTrace();
    }
}
```

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Results: SaveableFrame (Serialization to/from File)

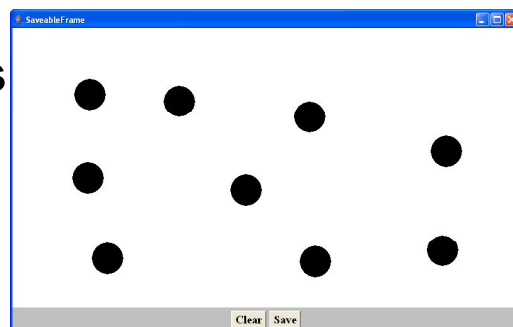
- **Saving to File**

- Open frame (600x400, no circles, top left corner)
- Move window around
- Resize it
- Click to add circles
- Press “Save”



- **Next time program runs**

- Frame pops up at previous location, with previous size, including previous circles



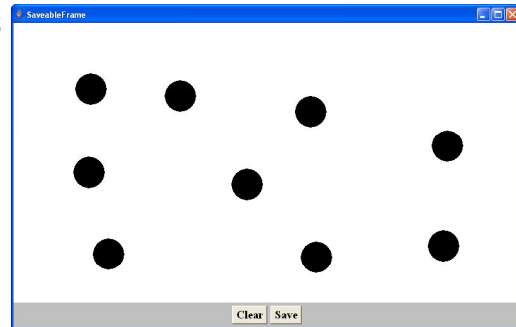
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Results: SaveableFrame (Serialization to/from Network)

- **Machine 1**

```
DOS> java FrameServer 8888
```

- Open frame (600x400, no circles, top left corner)
- Move window around
- Resize it
- Click to add circles



- **Machine 2**

```
DOS> java FrameClient coreservlets.com 8888
```

- Frame pops up with same location, size, and circles as version on the server

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Summary

- **Class format**

- Make sure custom classes implement Serializable and have zero-arg constructors

- **Sending data**

- Wrap an ObjectOutputStream around a raw OutputStream
- Call writeObject(objectYouWantToSend)
- You need to use try/catch blocks

- **Receiving data**

- Wrap an ObjectInputStream around a raw InputStream
- Call readObject
- Cast the result to desired type
- You need to use try/catch blocks

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Questions?

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