CS371m - Mobile Computing

Persistence

Storing Data

- Multiple options for storing data associated with apps
- Shared Preferences
- Internal Storage
  - device memory
- External Storage
- SQLite Database
- Network Connection

Saving State

- We have already seen saving app state into a Bundle on orientation changes or when an app is killed to reclaim resources but may be recreated later

```
@Override
protected void onSaveInstanceState(Bundle outState) {
    super.onSaveInstanceState(outState);

    Log.d(TAG, "in onSaveInstanceState");

    outState.putCharArray("board", mGame.getBoardState());
    outState.putBoolean("mGameOver", mGameOver);
    outState.putCharSequence("info", mInfoTextView.getText());
    outState.putChar("mTurn", mTurn);
    outState.putChar("mGoesFirst", mGoesFirst);
}
```

SHARED PREFERENCES

Shared Preferences

- Private primitive data stored in key-value pairs
- SharedPreferences Class
- Store and retrieve key-value pairs of data
  - keys are Strings
  - values are Strings, Sets of Strings, boolean, float, int, or long
  - So, somewhat limited options
- Not strictly for app *preferences*

SharedPreferences

- Several levels of preferences:
- getPreferences(int mode) for the Activity's Preferences
  - name based on Activity
- getSharedPreferences(String name, int mode) for a an Application's shared preferences
  - multiple activities
- PreferenceManager. getDefaultSharedPreferences() for system wide preferences

Using SharedPreferences

- Obtain a SharedPreferences object for application using these methods:
  - getSharedPreferences(String name, int mode)
  - getPreferences(int mode)

```
// restore the scores and difficulty
SharedPreferences mPrefs = getSharedPreferences("ttt_prefs", MODE_PRIVATE);
mHumanWins = mPrefs.getInt("mHumanWins", 0);
mComputerWins = mPrefs.getInt("mComputerWins", 0);
mTies = mPrefs.getInt("mTies", 0);
mGame.setDifficultyLevel(TicTacToeGame.DifficultyLevel.values()[mPrefs.getI
```

Writing to SharedPreferences

- After obtaining SharedPreferences object:
  - call edit() method on object to get a SharedPreferences.Editor object
  - place data by calling put methods on the SharedPreferences.Editor object
  - also possible to clear all data or remove a particular key

Limited Data Types for SharedPreferences

abstract SharedPreferences.Editor	putBoolean(String key, boolean value) Set a boolean value in the preferences editor, to be wr
abstract SharedPreferences.Editor	putFloat(String key, float value) Set a float value in the preferences editor, to be writte
abstract SharedPreferences.Editor	putInt(String key, int value) Set an int value in the preferences editor, to be written
abstract SharedPreferences.Editor	putLong(String key, long value) Set a long value in the preferences editor, to be writte
abstract SharedPreferences.Editor	putString(String key, String value) Set a String value in the preferences editor, to be writt
abstract SharedPreferences.Editor	putStringSet(String key, Set<String> values) Set a set of String values in the preferences editor, to

Writing to SharedPreferences

- When done writing data via the editor call either apply() or commit()
- apply() is the simpler method
  - used when only one process expected to write to the preferences object
- commit() returns a boolean if write was successful
  - for when multiple process may be writing to preferences
  - blocking operation, so use sparingly or in thread off of the UI thread to avoid ANR

Reading From Shared Preferences

- After obtaining SharedPreferences object use various get methods to retrieve data
- Provide key (string) and default value if key is not present
- get Boolean, Float, Int, Long, String, StringSet
- getAll() returns Map<String, ?> with all of the key/value pairs in the preferences

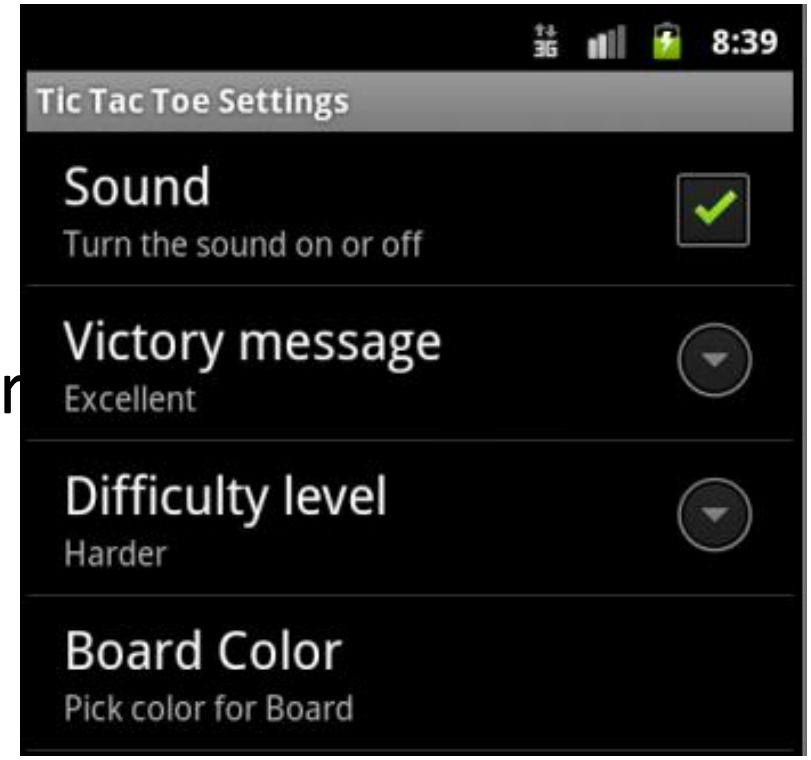
Shared Preferences File

- Stored as XML

```
<?xml version='1.0' encoding='utf-8' standalone='yes' ?>
<map>
<string name="victory_message">Excellent</string>
<int name="board_color" value="-65528" />
<int name="mTies" value="6" />
<string name="difficulty_level">Harder</string>
<int name="mComputerWins" value="1" />
<int name="mDifficulty" value="1" />
<int name="mHumanWins" value="9" />
</map>
```

Preference Activity

- An Activity framework to allow user to select and set preferences for your app
- tutorial 6 has an example
  - difficulty, sound, color, victor message
- Main Activity can start a preference activity to allow user to set preferences
- **Current standard is to use a PreferenceFragment instead**



INTERNAL STORAGE

Internal Storage

- Private data stored on device memory
  - not part of apk
- More like traditional file i/o
  - in fact not that different from Java I/O
- by default files are private to your application
  - other apps cannot access directly
  - recall content providers to share data with other apps
- files removed when app is uninstalled

Internal Storage

- To create and write a private file to the device internal storage:
- call openFileOutput(String name, int mode)
  - method inhertied from Context
  - file created if does not already exist
  - returns FileOutputStream object
    - regular Java class
- Modes include: MODE_APPEND, MODE_PRIVATE
  deprecated: MODE_WORLD_READABLE, MODE_WORLD_WRITEABLE

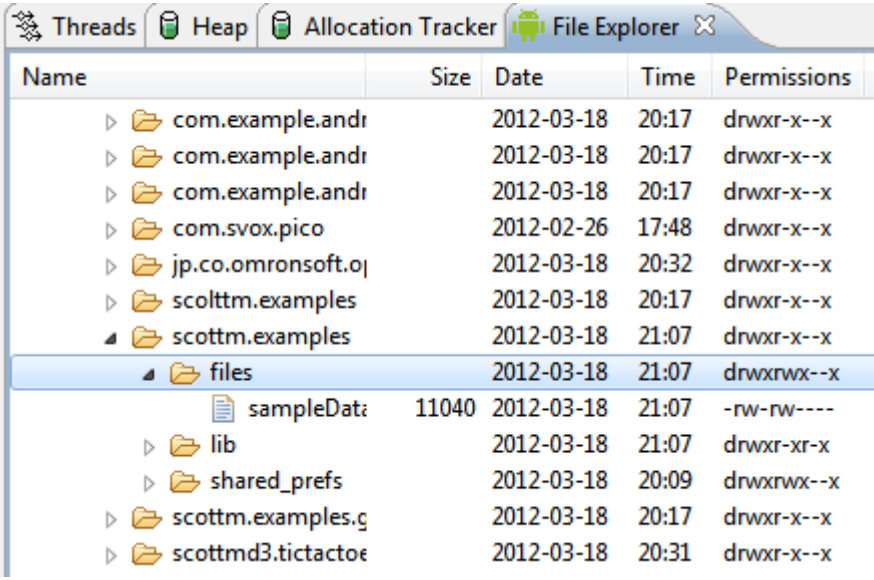
Writing to Files

- FileOutputStream writes raw bytes
  - arrays of bytes or single bytes
- Much easier to wrap the FileOutputStream in PrintStream object

```
public void writeFile(View v) {
    try {
        FileOutputStream fos
            = openFileOutput("sampleData", MODE_PRIVATE);
        PrintStream writer = new PrintStream(fos);
        Random r = new Random();
        for(int i = 0; i < 1000; i++) {
            writer.println(r.nextInt());
        }
        writer.close();
    }
    catch(FileNotFoundException e) {
        Log.d(TAG, "Exception trying to open file: " + e);
    }
}
```

Reading from Files

- files saved to device
  - data directory for app
- call openFileInput(String name) method to obtain a FileInputStream
- FileInputStream reads bytes
  - for convenience may connect to Scanner object or wrap in a DataInputStream object



Static Files

- If you need or have a file with a lot of data at compile time:
  - create and save file in project res/raw/ directory
  - open file using the openRawResource(int id) method and pass the R.raw.*id* of file
  - returns an InputStream to read from file
  - cannot write to the file, part of the apk

Cache Files

- If need to cache data for application instead of storing persistently:
  - call getCacheDir() method to obtain a File object that is a directory where you can create and save temporary cache files
  - files may be deleted by Android later if space needed but you should clean them up on your own
  - recommended to keep under 1 MB

Internal Files - Other Useful Methods

- All of these are inherited from Context
- File getFileDir()
  - get absolute path to filesystem directory where app files are saved
- File getDir(String name, int mode)
  - get and create if necessary a directory for files
- boolean deteleFile(String name)
  - get rid of files, especially cache files
- String[] fileList()
  - get an array of Strings with files associated with Context (application)

EXTERNAL FILES

External Storage

- Public data stored on shared external storage
- may be removable SD (Secure Digital) card or internal, non-removable storage
- files saved to external storage are **world-readable**
- files may be unavailable when device mounts external storage to another system
- files may be modified by user when they enable USB mass storage for device
- request WRITE_EXTERNAL_STORAGE permission in manifest

Checking Media Availability

- Call Environment.getExternalStorageState() method to determine if media available
  - may be mounted to computer, missing, read-only or in some other state that prevents accessing

Checking Media State

```
boolean mExternalStorageAvailable = false;
boolean mExternalStorageWriteable = false;
String state = Environment.getExternalStorageState();

if (Environment.MEDIA_MOUNTED.equals(state)) {
    // We can read and write the media
    mExternalStorageAvailable = mExternalStorageWriteable = true;
} else if (Environment.MEDIA_MOUNTED_READ_ONLY.equals(state)) {
    // We can only read the media
    mExternalStorageAvailable = true;
    mExternalStorageWriteable = false;
} else {
    // Something else is wrong. It may be one of many other states,
    //  to know is we can neither read nor write
    mExternalStorageAvailable = mExternalStorageWriteable = false;
}
```

- other states such as media being shared, missing, and others

Accessing Files on External Storage

- call getExternalFilesDir(String type) to obtain a directory (File object) to get directory to save files
- type is String constant from Environment class
  - DIRECTORY_ALARMS, **DIRECTORY_DCIM** (Digital Camera IMages), DIRECTORY_DOWNLOADS, DIRECTORY_MOVIES, **DIRECTORY_MUSIC**, DIRECTORY_NOTIFICATIONS, **DIRECTORY_PICTURES**, DIRECTORY_PODCASTS, DIRECTORY_RINGTONES

External File Directory

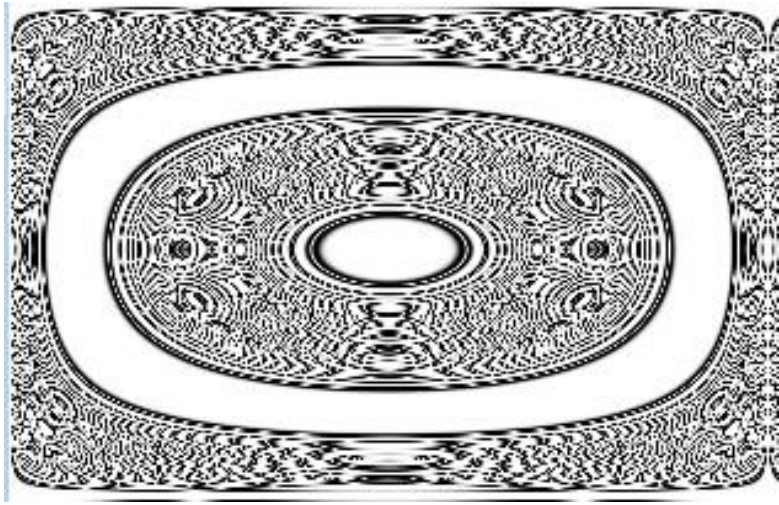
- If not a media file then send **null** as parameter to getExternalFilesDir() method
- The DIRECTORY_<TYPE> constants allow Android's Media Scanner to categorize files in the system
- External files associated with application are deleted when application uninstalled

External Data Shared Files

- If you want to save files to be shared with other apps:
- save the files (audio, images, video, etc.) to one of the public directories on the external storage device
- Environment.getExternalStoragePublicDirectory(String type) method returns a File object which is a directory
- same types as getExternalFilesDir method

Sharing Data

- Example:
  - In the random art app
  - add a button to save images



  - if we want images to show up with other "images" save to the DIRECTORY_PICTURES directory
  - now, other apps can view / use these images via the media scanner
  - NOT deleted when app deleted

Examining Shared Directories

```
private void showDirs() {
    for(String type : types) {
        File dir = Environment
                .getExternalStoragePublicDirectory(type);
        Log.d(TAG, "type: " + type + ", dir: " + dir);
        File[] files = dir.listFiles();
        if(files != null)
            for(File f : dir.listFiles())
                Log.d(TAG, f + "");
    }
}
```

Result

```
PTest    type: Alarms, dir: /mnt/sdcard/Alarms
PTest    type: DCIM, dir: /mnt/sdcard/DCIM
PTest    /mnt/sdcard/DCIM/.thumbnails
PTest    /mnt/sdcard/DCIM/100ANDRO
PTest    type: Download, dir: /mnt/sdcard/Download
PTest    type: Movies, dir: /mnt/sdcard/Movies
PTest    type: Music, dir: /mnt/sdcard/Music
PTest    /mnt/sdcard/Music/Susan Boyle - Amazing grace.mp3
PTest    /mnt/sdcard/Music/Rem - Losing My Religion.mp3
PTest    type: Notifications, dir: /mnt/sdcard/Notifications
PTest    type: Pictures, dir: /mnt/sdcard/Pictures
PTest    type: Podcasts, dir: /mnt/sdcard/Podcasts
PTest    type: Ringtones, dir: /mnt/sdcard/Ringtones
```

OBJECT SERIALIZATION

Clicker

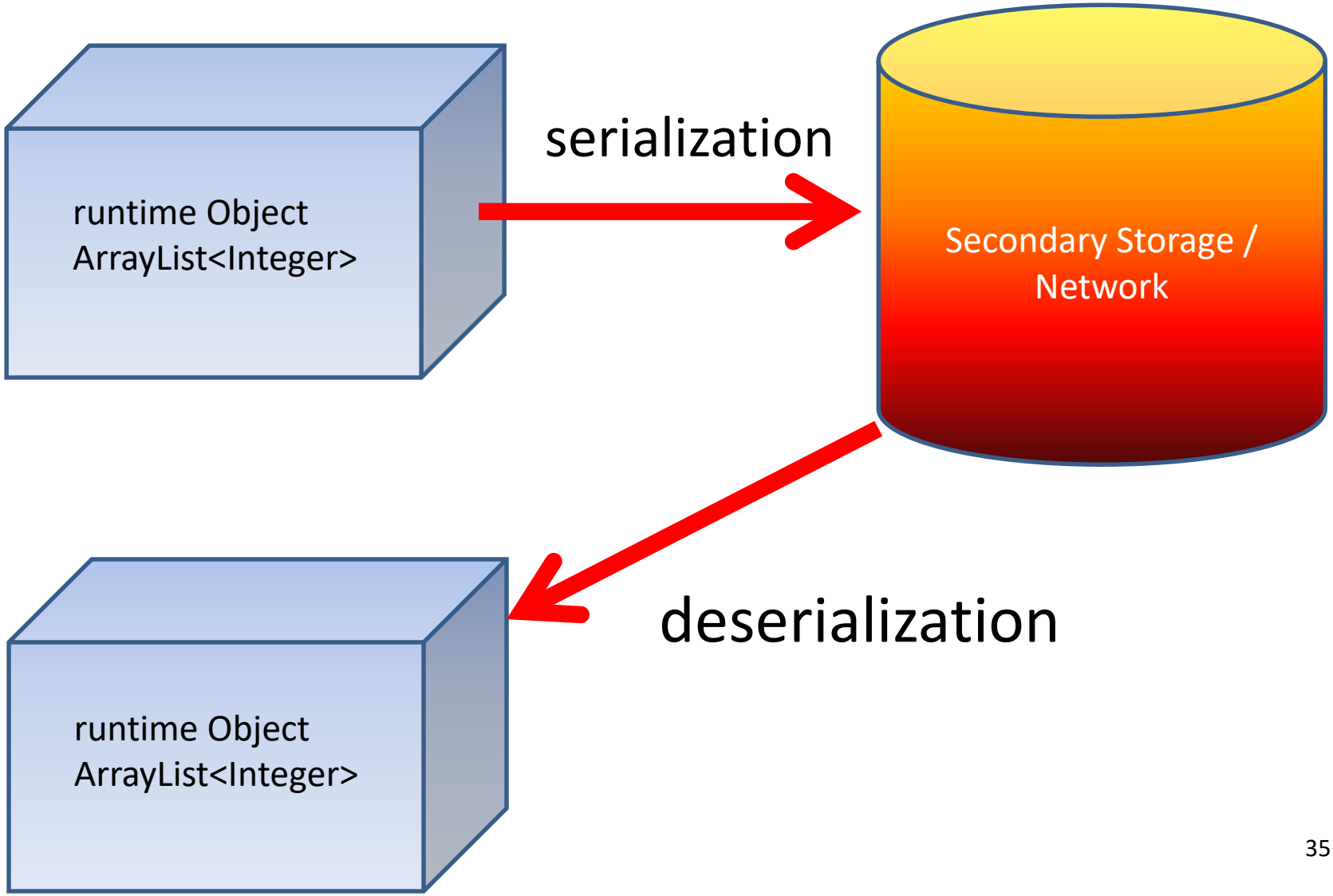
- What is Object Serialization?

A. Giving a number to object for sorting
B. Converting object to a byte stream
C. Searching for objects
D. Converting Object to a file
E. Reading Objects from files

Object Serialization

- Taking a runtime data structure or object and converting it to a form that can be stored and / or transmitted
  - converted to a byte stream
- store the object in between program runs
- transmit the object over a network
- store the data, **not the methods / ops**
  - **not the class definition**

Object Serialization



Serialization - Why?

- Could just do it by hand
  - write out fields and structure to file
  - read it back in
- Serialization provides an abstraction in place of the "by hand" approach
- Much less code to write
- Example, Java has a specification for serializing objects
  - little effort on your part

Serialization in Java

- java.io.Serializable interface
- Here are the methods in the Serializable interface:

- Really, that's it
- A *TAG* interface
- A way for a class to mark that is Serializable

Serialization in Java

java.util

Class ArrayList<E>

java.lang.Object
    java.util.AbstractCollection<E>
        java.util.AbstractList<E>
            java.util.ArrayList<E>

All Implemented Interfaces:

Serializable, Cloneable, Iterable<E>, Collection<E>, List<E>, RandomAccess

Direct Known Subclasses:

AttributeList, RoleList, RoleUnresolvedList

Serialization in Java

- Data is serialized, not the class definition
- Program that deserializes must have the class definition
- Use an ObjectOutputStream object to write out Serializable objects
  - serialize, deflate, flatten, dehydrate, marshal
- Later, use an ObjectInputStream to read in Serializable objects
  - deserialize, inflate, unflatten, hydrate, unmarshal

ObjectOutputStream Example

- from CS307 / CS314
- Evil Hangman test cases
- play the game and test student results
- for each guess we want the patterns and the number of words in each pattern
  - Map<String, Integer>

ObjectOutputStream Example
Create tests

```
private static final String DICTIONARY_FILE = "dictionary.txt";
private static final int NUM_TESTS = 13;
private static final String OUTPUT_FILE = "evilGraderTests.eht";

public static void main(String[] args) {
    try {
        ObjectOutputStream os
            = new ObjectOutputStream(new FileOutputStream(new File(OUTPUT_FILE)));
```

- LATER FOR EACH GUESS

```
// make guesses and write results
for(int i = 0; i < guesses.length(); i++) {
    char guess = guesses.charAt(i);
    Map<String, Integer> result = hm.makeGuess(guess);

    os.writeObject(result);
    os.writeInt(hm.numWordsCurrent());
    os.writeObject(hm.getPattern());
```

- data methods (writeInt, …) for primitives

ObjectOutputStream writeObject

writeObject

```
public final void writeObject(Object obj)
                        throws IOException
```

Parameters:

`obj` - the object to be written

Throws:

`InvalidClassException` - Something is wrong with a class used by serialization.

`NotSerializableException` - Some object to be serialized does not implement the java.io.Serializable interface.

`IOException` - Any exception thrown by the underlying OutputStream.

ObjectOutputStream Data Methods

void	**writeDouble**(double val) Writes a 64 bit double.
void	**writeFields**() Write the buffered fields to the stream.
void	**writeFloat**(float val) Writes a 32 bit float.
void	**writeInt**(int val) Writes a 32 bit int.
void	**writeLong**(long val) Writes a 64 bit long.

- … and others

Output File - not human readable

```
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```

ObjectInputStream

- When ready to run tests

```
ObjectInputStream reader
        = new ObjectInputStream(new FileInputStream(new File(TEST_FILE_NAME)));
```

- Make the guesses

```
for(int i = 0; i < actualGuesses.length(); i++) {
    char ch = actualGuesses.charAt(i);
    System.out.println("\nRound Number: " + roundNumber

    // read in expected reuslts
    Map<String, Integer> expectedMap
        = (Map<String, Integer>) reader.readObject();
```

Externalizable

- A sub-interface of Serializable
- Gives more control over the format of the serialization to the class itself
- Two methods:

Methods

Modifier and Type	Method and Description
`void`	**`readExternal`**`(`**`ObjectInput`**` in)` The object implements the readExternal method to restore its contents by calling the methods of DataInput for primitive types and readObject for objects, strings and arrays.
`void`	**`writeExternal`**`(`**`ObjectOutput`**` out)` The object implements the writeExternal method to save its contents by calling the methods of DataOutput for its primitive values or calling the writeObject method of ObjectOutput for objects, strings, and arrays.

Externalizable

- ObjectOutputStream will test if object is Serializable
  - if not, throws an exception
- Then tests if Externalizable
  - if so calls the writeExtenal method on the object
  - if not, uses default specification for serialization

PARCEL AND PARCELABLE

Bundles Again

- What can you add to Bundles?
- Recall Bundles sent to onCreate when restoring an Activity
- Bundles attached to Intents
- put
  - Bundle, byte, char, CharSequence (includes String), float, Parcelable, Serializable, short, Size (width and height)
  - arrays and ArrayLists of some of those types

Parcelable?

- Parcel:
- Android class for sending data via IPC
- Inter Process Communication
- Send an object (data) from one process to another
- Generally faster (at run time) than Serializable
  - long term storage vs. short term storage

Parcelable

- interface
- have class implement interface
- implement writeToParcel method
  - not just a Tag interface
  - writes current state of object to Parcel
  - void writeToParcel (Parcel dest, int flags)
  - add a static field named CREATOR to class
    - object that implements Parcelable.Creator interface

Typical Implementation

```
public class MyParcelable implements Parcelable {
    private int mData;

    public int describeContents() {
        return 0;
    }

    public void writeToParcel(Parcel out, int flags) {
        out.writeInt(mData);
    }

    public static final Parcelable.Creator<MyParcelable> CREATOR
            = new Parcelable.Creator<MyParcelable>() {
        public MyParcelable createFromParcel(Parcel in) {
            return new MyParcelable(in);
        }

        public MyParcelable[] newArray(int size) {
            return new MyParcelable[size];
        }
    };

    private MyParcelable(Parcel in) {
        mData = in.readInt();
    }
}
```

OTHER STORAGE OPTIONS

SQLite Database

- Structured data stored in a private database
- More on this next lecture

Network Connection

- Store data on web with your own network server
- Use wireless or carrier network to store and retrieve data on web based server
- classes from java.net and android.net