JAVA

Persisting Objects with Serialization

Date: 12-December-2019
Course: Programming Languages

Overview

- Purpose and capabilities of serialization
- Making a type serializable
- Serializing/deserializing an object
- Creating class version compatibility
- Custom serialization
- Transient fields

Persisting Java Objects

Java has built-in ability to persist objects

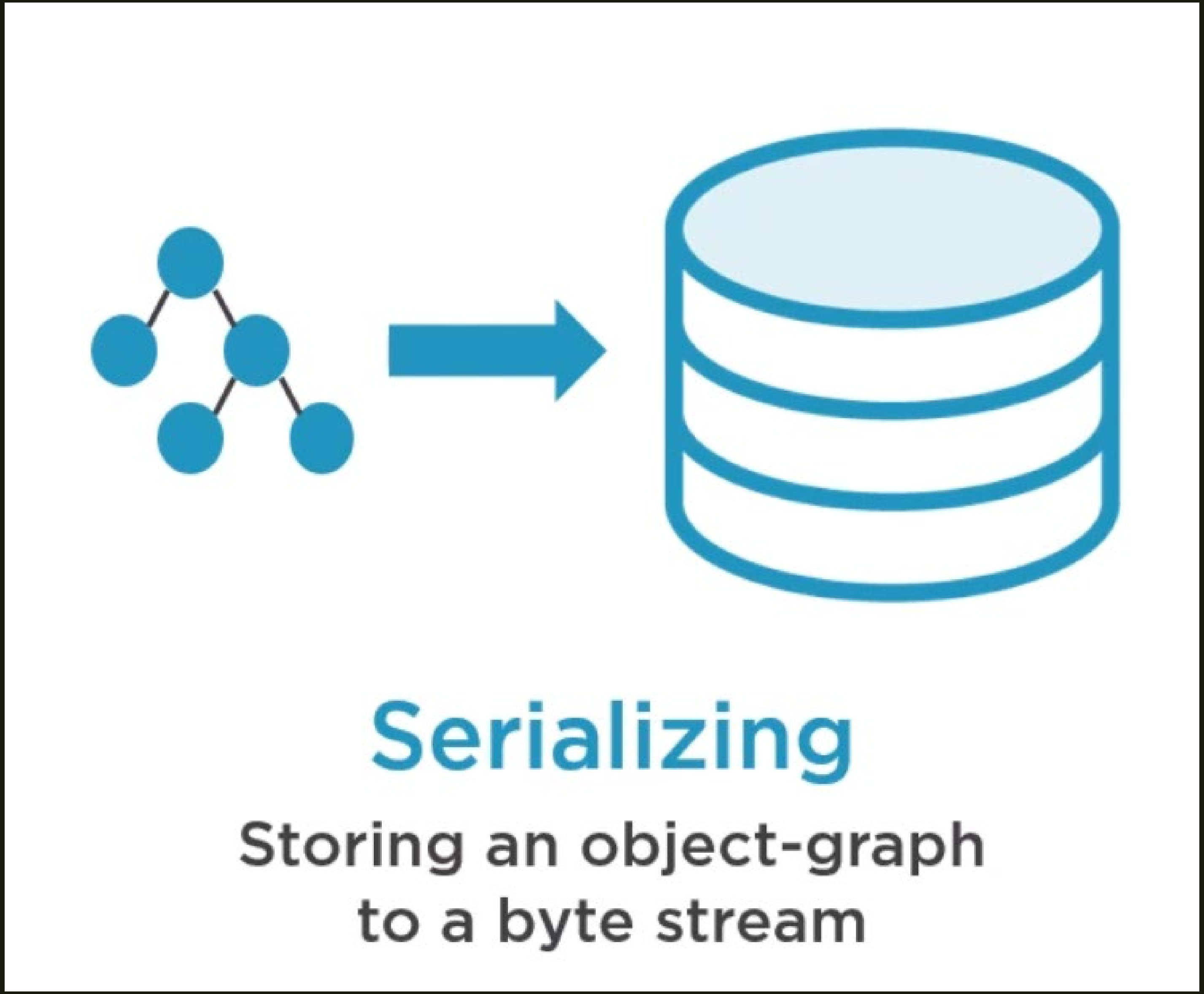
- Store from runtime into a byte stream
- Restore from byte stream into runtime

Most classes require very little programming

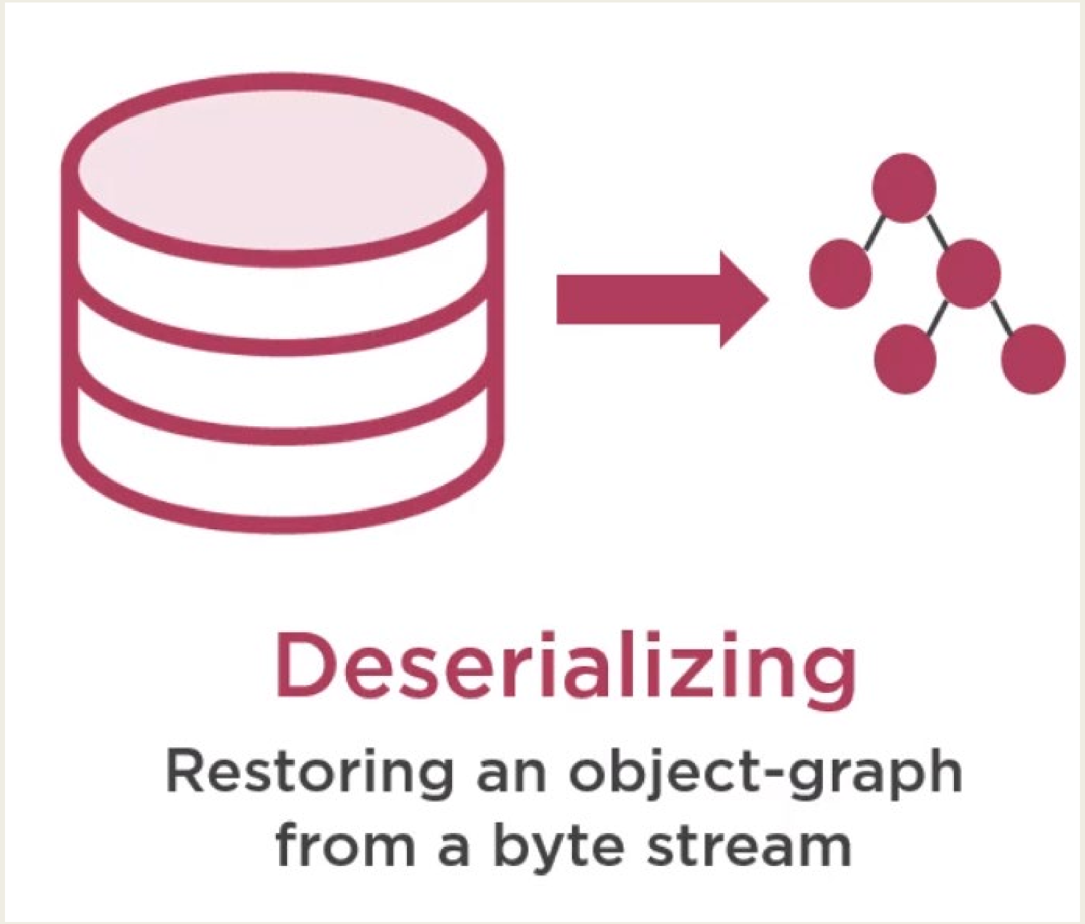
- Leverages reflection
- Operates only on instance members

Persisting Java Objects

- Opens up many possibilities
  - *Save to file stream*
  - *Save in a database*
  - *Pass across memory address boundaries*
  - *Pass over network*



SERIALIZATION



DESEARILIZING

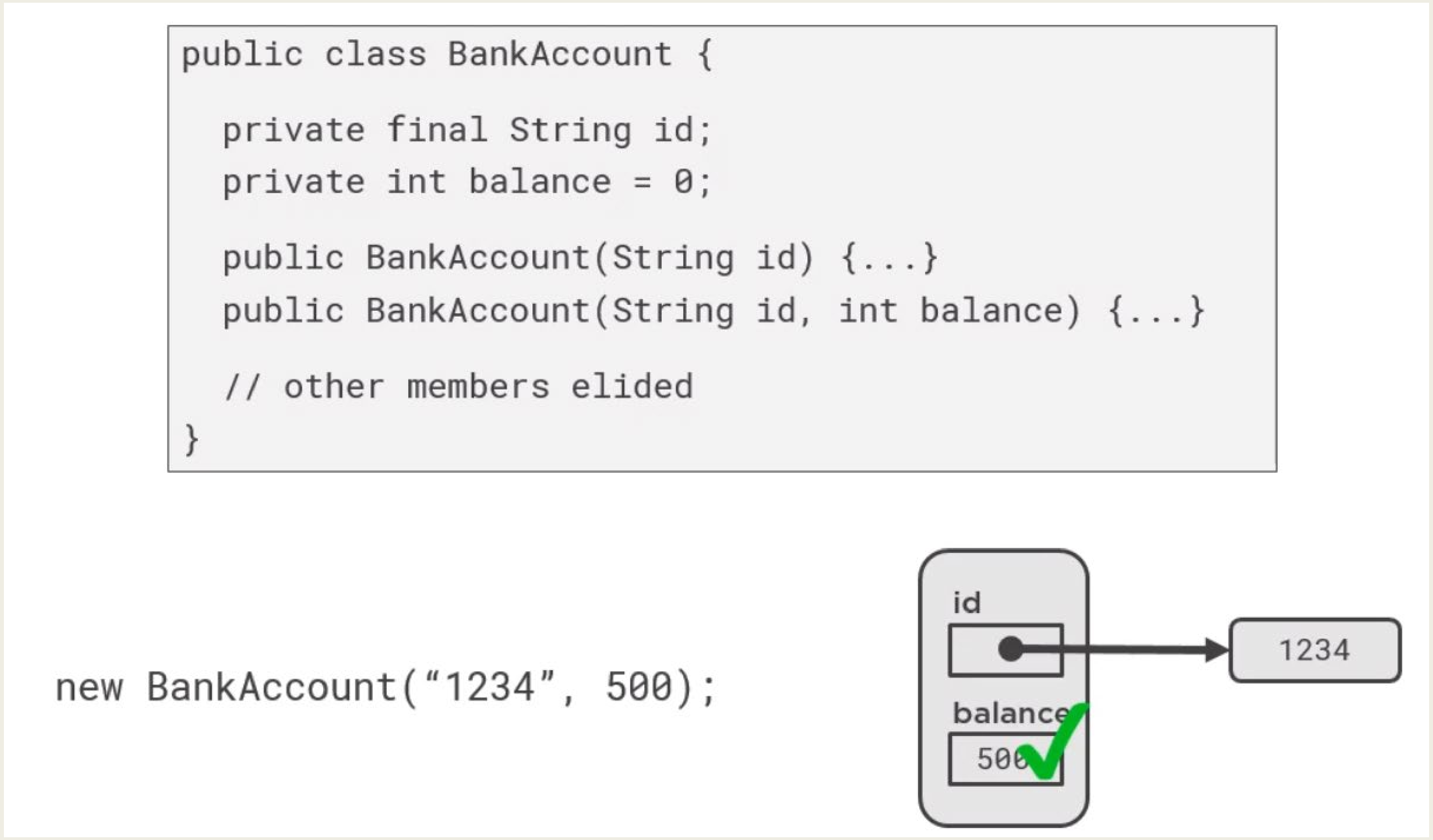
Serialization Types

Serializable	• *Implemented by serializable types* • *Indicates that type supports serialization* • *Has no methods*
ObjectOutputStream	• *Serializes object-graph to stream*
ObjectInputStream	• *Deserializes stream to object-graph*

Being Serializable

- Requirements to be serializable
  - *Implements Serializable*
  - *Members are serializable*
    - Primitive types are serializable
    - Others must implement Serializable

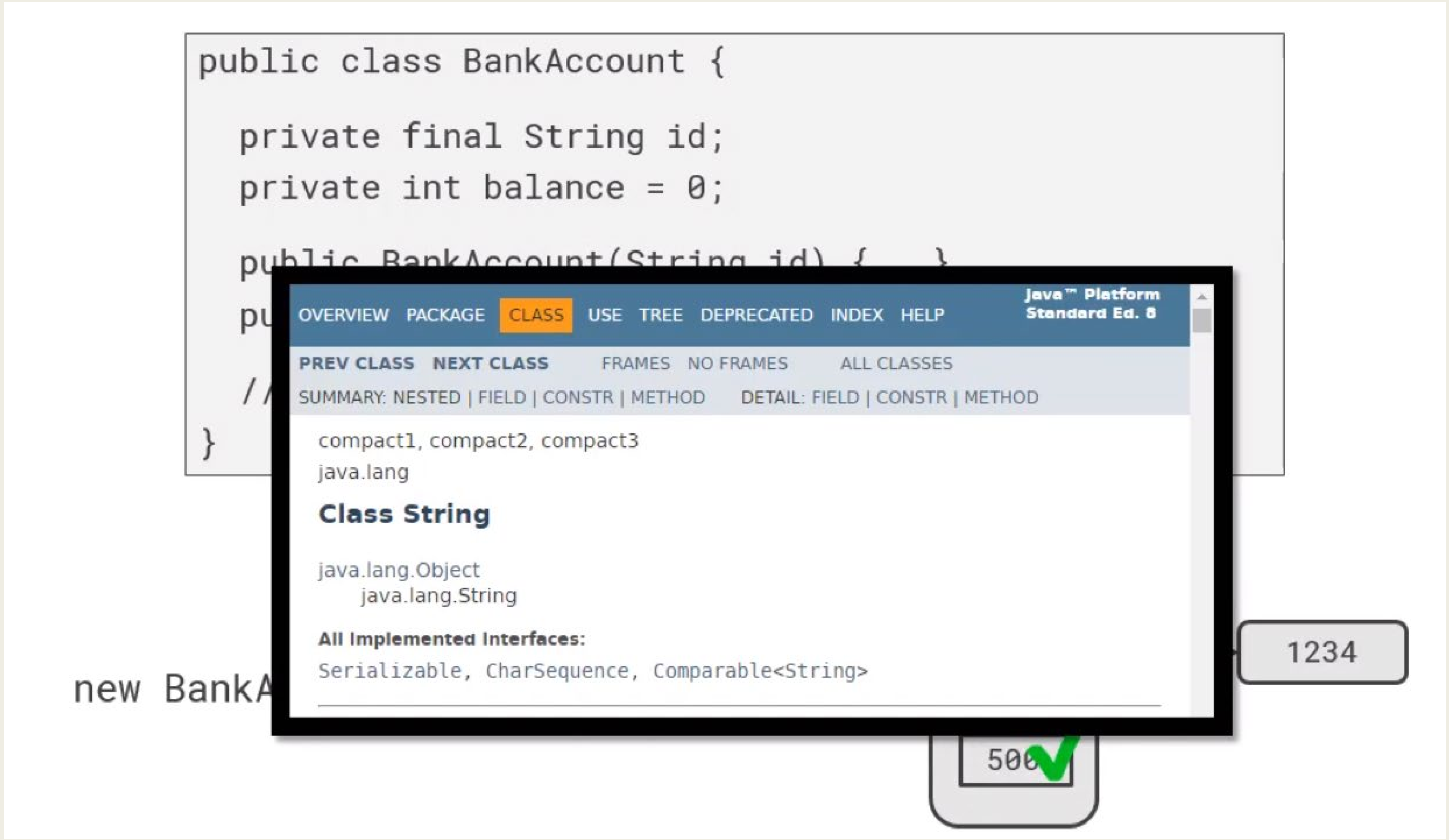
Being Serializable



```
public class BankAccount {

  private final String id;
  private int balance = 0;

  public BankAccount(String id) {...}
  public BankAccount(String id, int balance) {...}

  // other members elided
}
```

```
new BankAccount(“1234”, 500);
```

Being Serializable



```
public class BankAccount {

  private final String id;
  private int balance = 0;

  public BankAccount(String id) { … }
  pu

  //
}
```

new BankA

1234

500

OVERVIEW PACKAGE CLASS USE TREE DEPRECATED INDEX HELP

Java™ Platform Standard Ed. 8

PREV CLASS NEXT CLASS FRAMES NO FRAMES ALL CLASSES

SUMMARY: NESTED | FIELD | CONSTR | METHOD DETAIL: FIELD | CONSTR | METHOD

compact1, compact2, compact3

java.lang

Class String

java.lang.Object
    java.lang.String

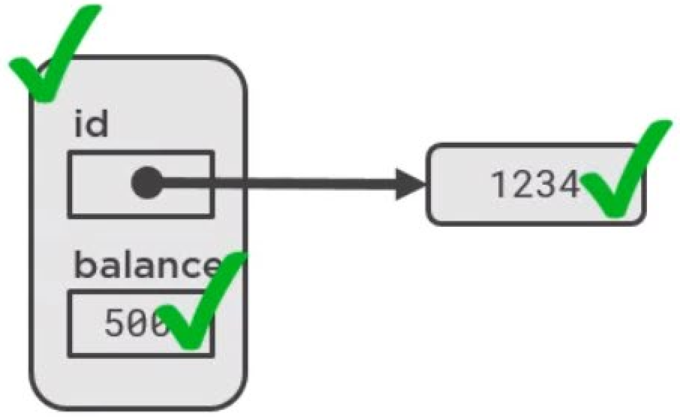
All Implemented Interfaces:

Serializable, CharSequence, Comparable<String>

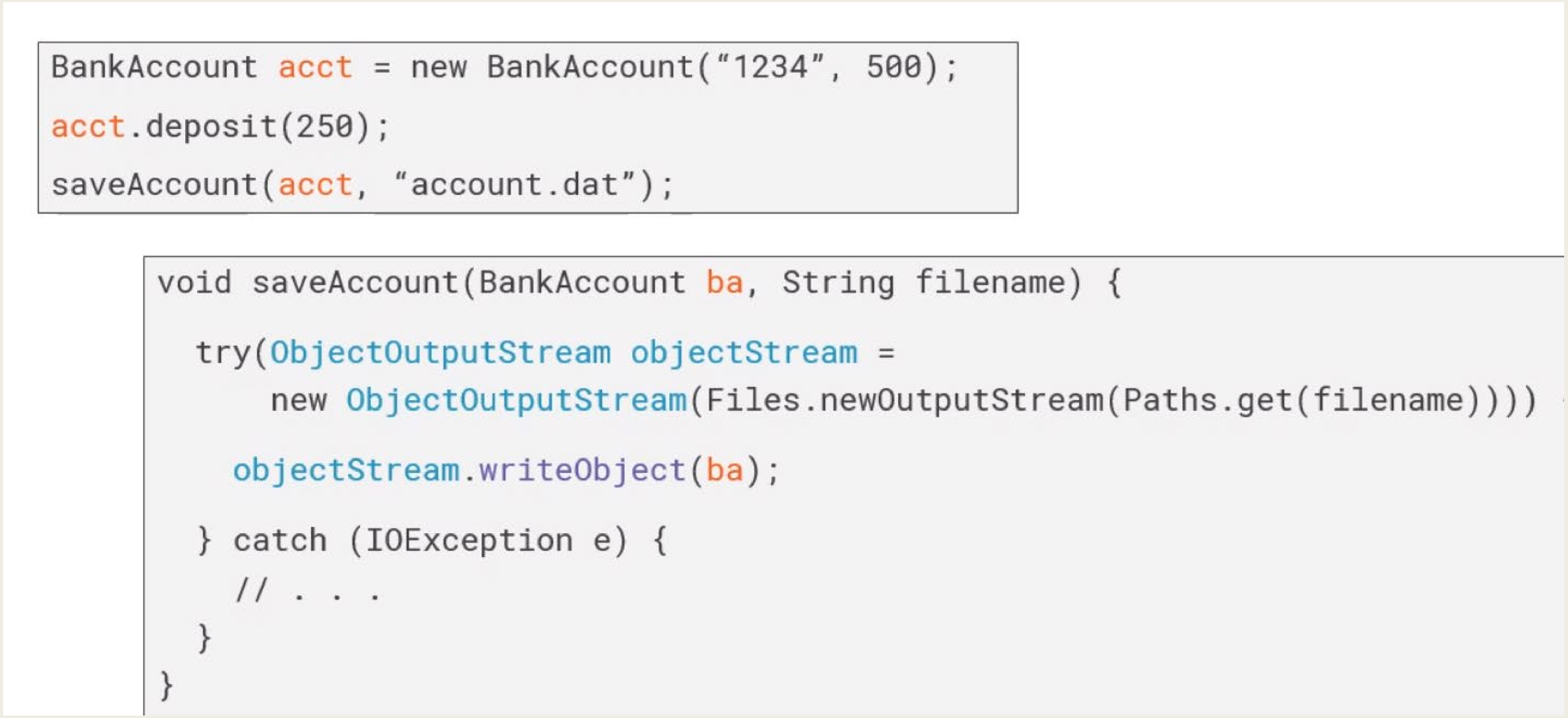
Being Serializable

```
public class BankAccount implements Serializable {

  private final String id;
  private int balance = 0;

  public BankAccount(String id) {...}
  public BankAccount(String id, int balance) {...}

  // other members elided
}
```

```
new BankAccount("1234", 500);
```



Serializing an Object



```
BankAccount acct = new BankAccount(“1234”, 500);

acct.deposit(250);

saveAccount(acct, “account.dat”);
```

```
void saveAccount(BankAccount ba, String filename) {

  try(ObjectOutputStream objectStream =
      new ObjectOutputStream(Files.newOutputStream(Paths.get(filename)))

    objectStream.writeObject(ba);

  } catch (IOException e) {
    // . . .
  }
}
```

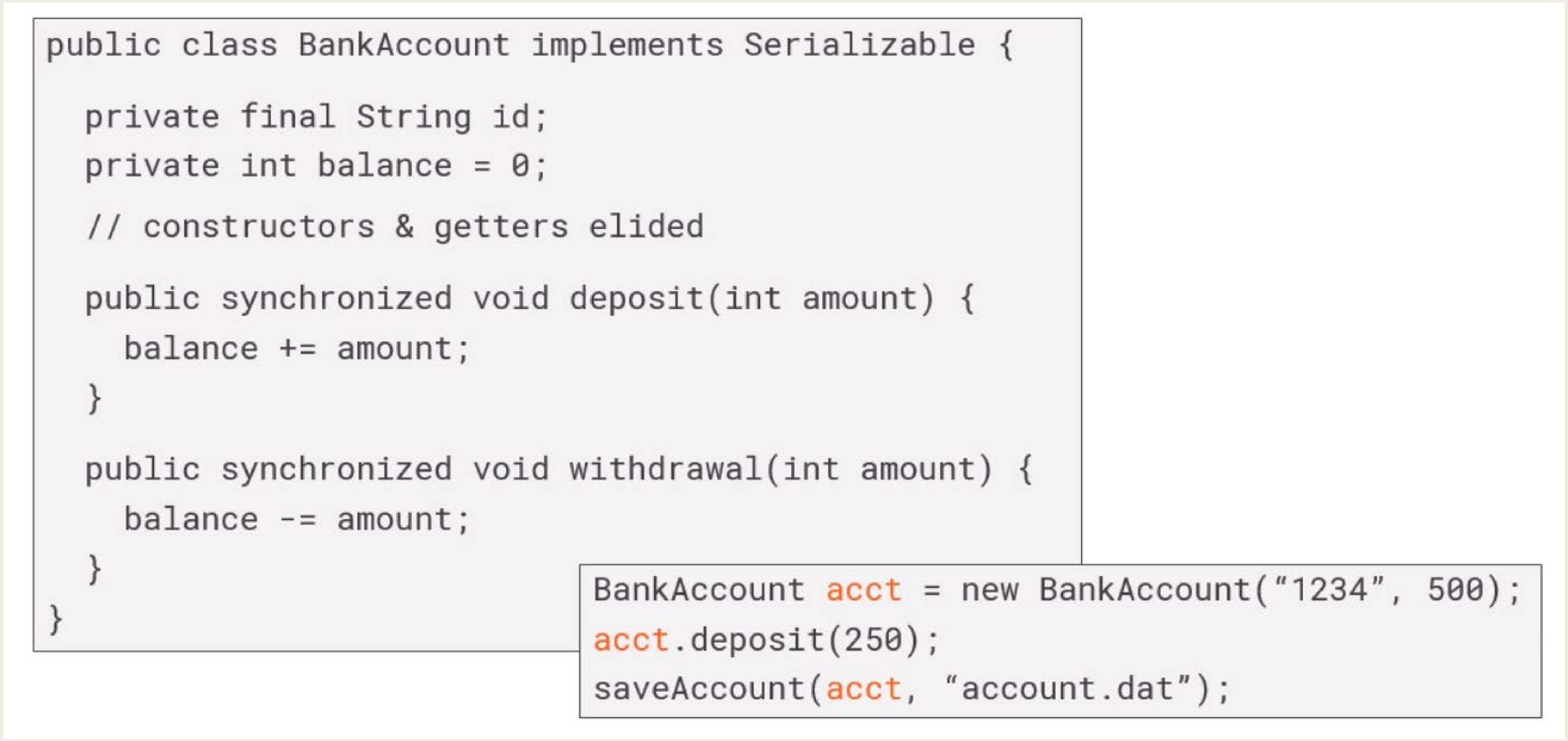
Deserializing an Object

```
BankAccount loadAccount(String filename) {

  BankAccount ba = null;

  try(ObjectInputStream objectStream =
      new ObjectInputStream(Files.newInputStream(Paths.get(filename)))) {

    ba = (BankAccount) objectStream.readObject();

  } catch (IOException e) {
    // . . .
  } catch (ClassNotFoundException e) {
    // . . .
  }
  return ba;
}
```

```
1234 : 750
```

```
BankAccount acct = loadAccount(“account.dat”);

System.out.println(acct.getId() + “ : ” + acct.getBalance());
```

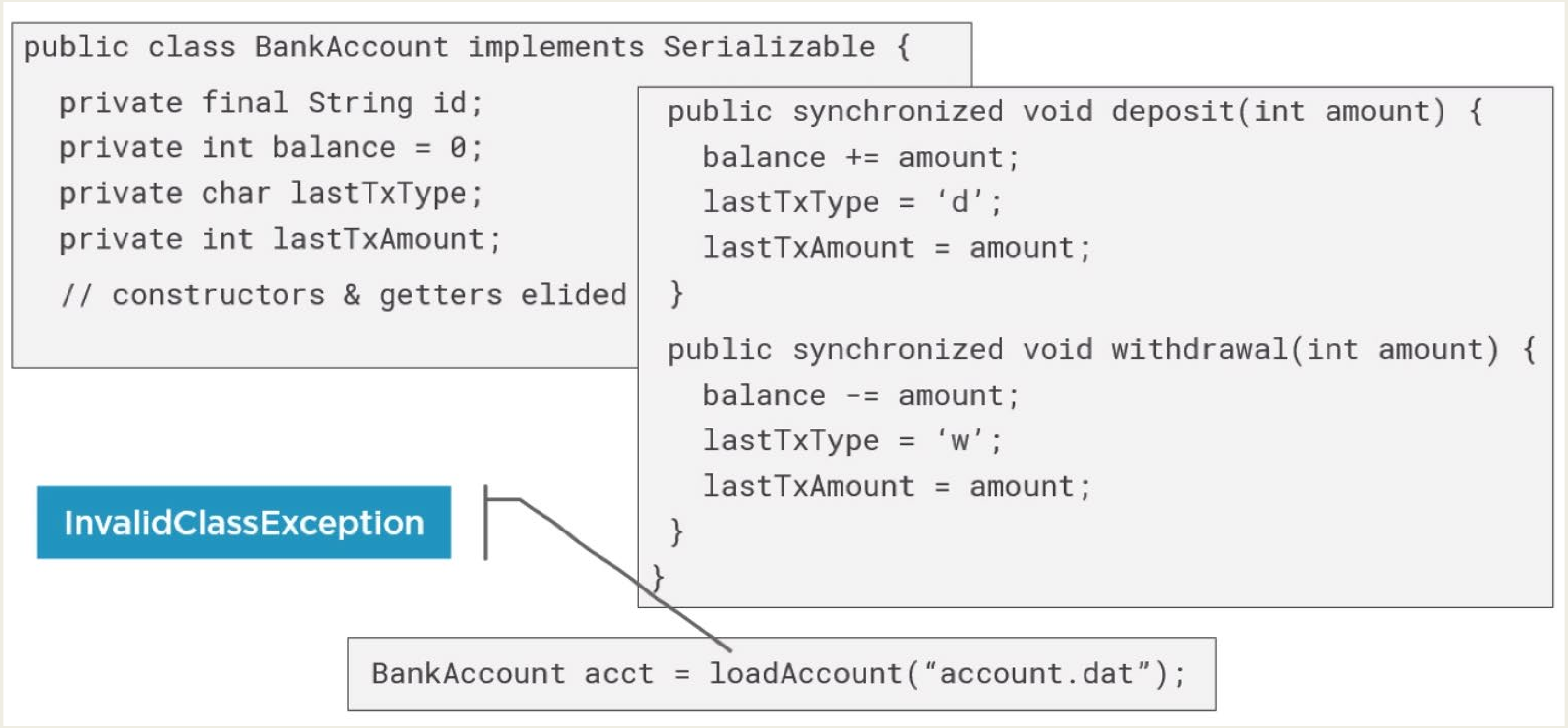
Class Version Incompatibility



```java
public class BankAccount implements Serializable {

  private final String id;
  private int balance = 0;

  // constructors & getters elided

  public synchronized void deposit(int amount) {
    balance += amount;
  }

  public synchronized void withdrawal(int amount) {
    balance -= amount;
  }
}
```

```java
BankAccount acct = new BankAccount(“1234”, 500);
acct.deposit(250);
saveAccount(acct, “account.dat”);
```

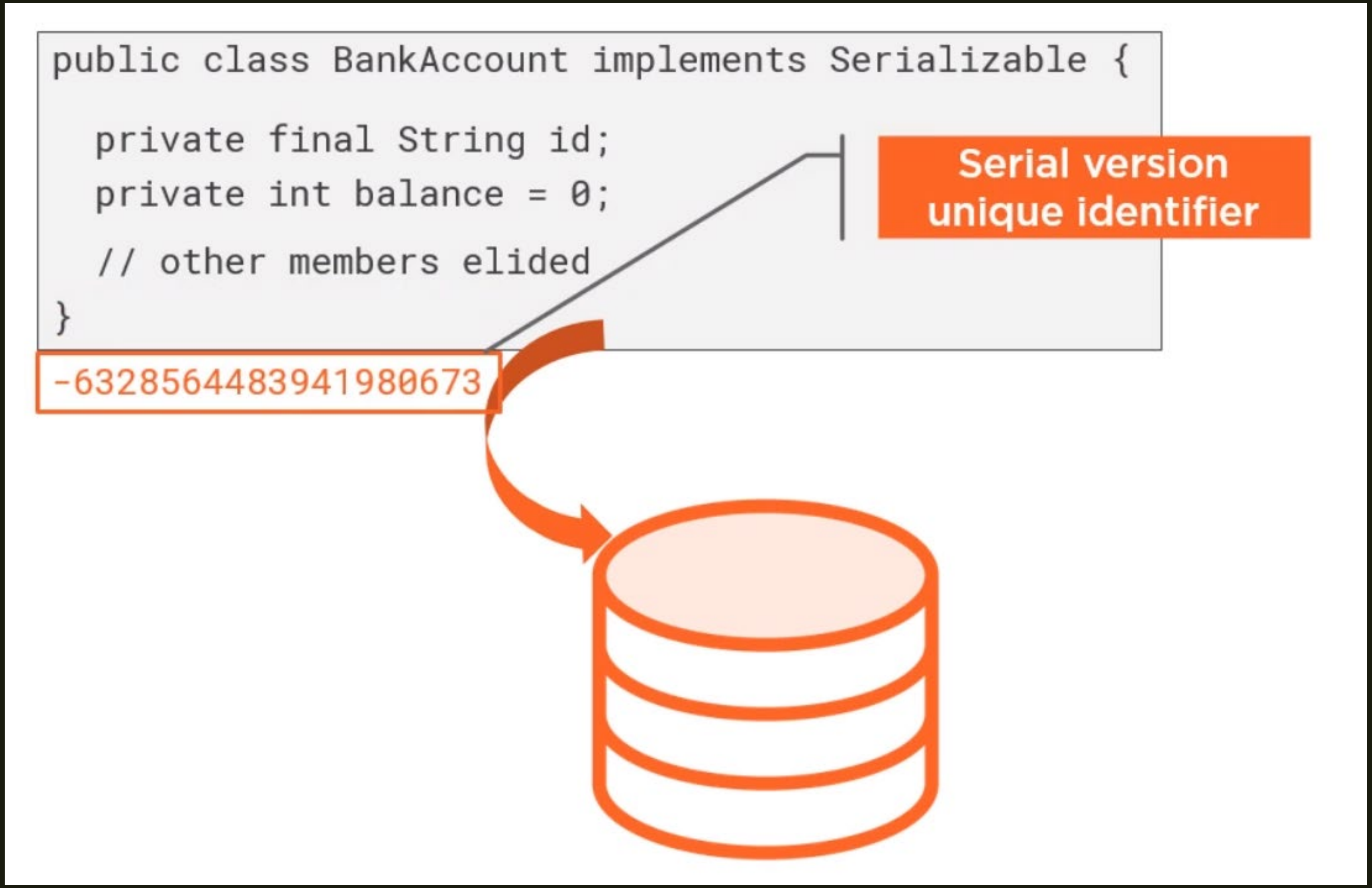
Class Version Incompatibility



```
public class BankAccount implements Serializable {
  private final String id;
  private int balance = 0;
  private char lastTxType;
  private int lastTxAmount;
  // constructors & getters elided
```

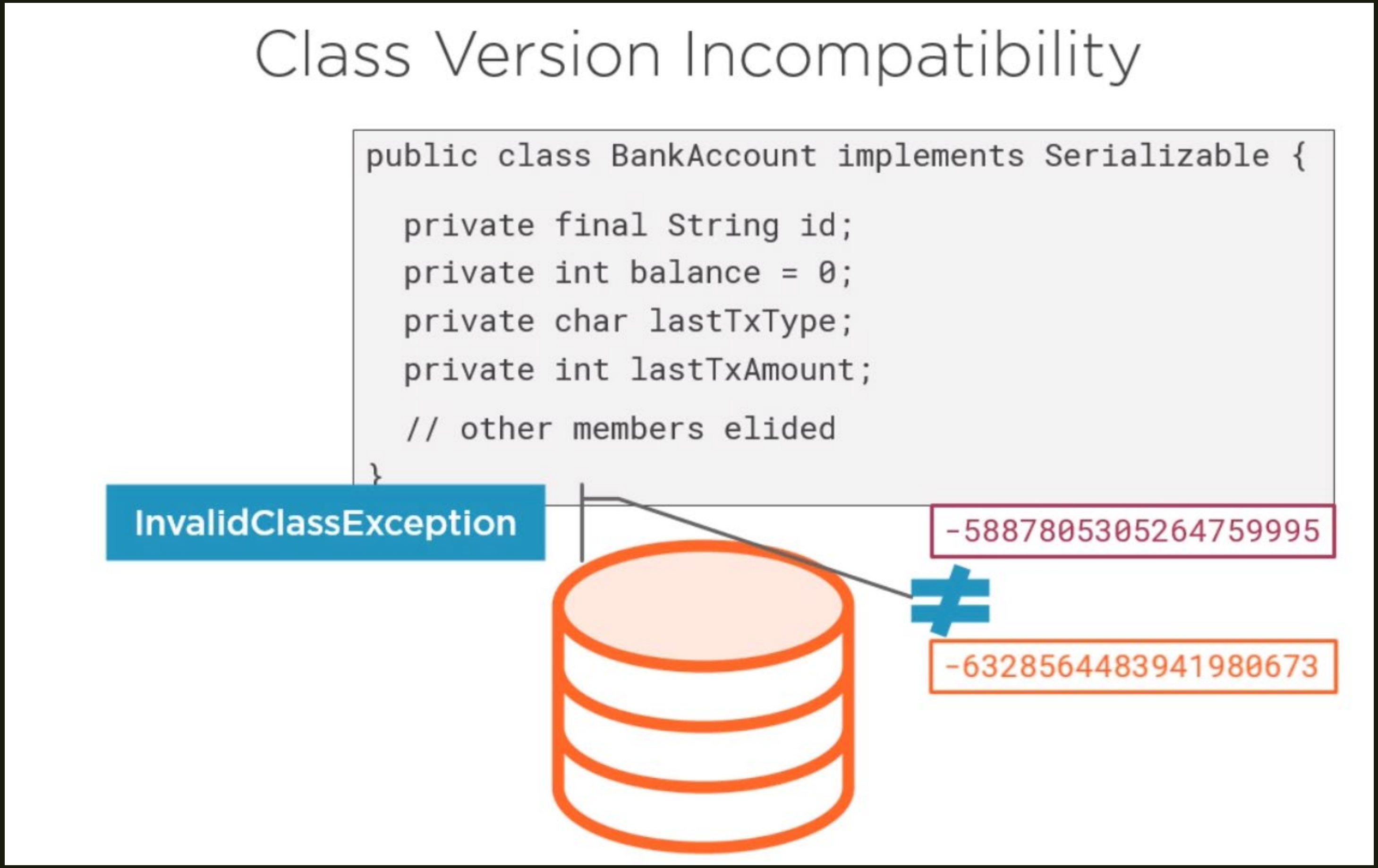
```
public synchronized void deposit(int amount) {
  balance += amount;
  lastTxType = 'd';
  lastTxAmount = amount;
}
public synchronized void withdrawal(int amount) {
  balance -= amount;
  lastTxType = 'w';
  lastTxAmount = amount;
}
}
```

```
BankAccount acct = loadAccount("account.dat");
```



```
public class BankAccount implements Serializable {

  private final String id;
  private int balance = 0;

  // other members elided
}
```

CLASS VERSION INCOMPATIBILITY



Class Version Incompatibility

```
public class BankAccount implements Serializable {

  private final String id;
  private int balance = 0;
  private char lastTxType;
  private int lastTxAmount;

  // other members elided
}
```

CLASS VERSION INCOMPATIBILITY

Creating Class Version Compatibility

Serial version unique identifier

- *Indicates version compatibility*
  - Compatible versions have same value

Java can calculate at runtime

- *Value affected by a number of factors*
  - Full type name
  - Implemented interfaces
  - Members
- *Type content determines compatibility*

Can specify as part of type definition

- *Developer determines compatibility*

Creating Class Version Compatibility

Specifying serial version unique identifier

- *Add serialVersionUID field*
  - Must be long
  - Must be static final
  - Should be private

Calculate for initial version of type

- *Use serialver utility*

Use same value for future versions

Creating Class Version Compatibility

The serialver utility

Performs same calculation as Java runtime

Found in JDK bin folder

- IDEs often provide a plug-in

Using serialver utility

Uses class' class file

- Will search in local folder
- Can specify –classpath

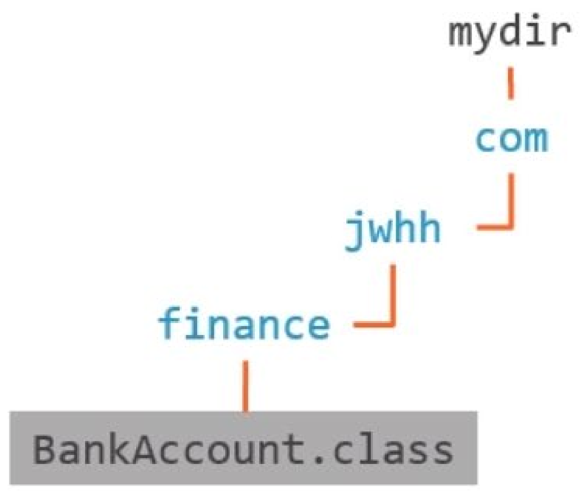
Can pass class name on command line

- Displays value to console

Creating Class Version Compatibility

```
package com.jwhh.finance;

public class BankAccount implements Serializable {

  private final String id;
  private int balance = 0;

  // other members elided
}
```

```
C:\mydir> serialver
```

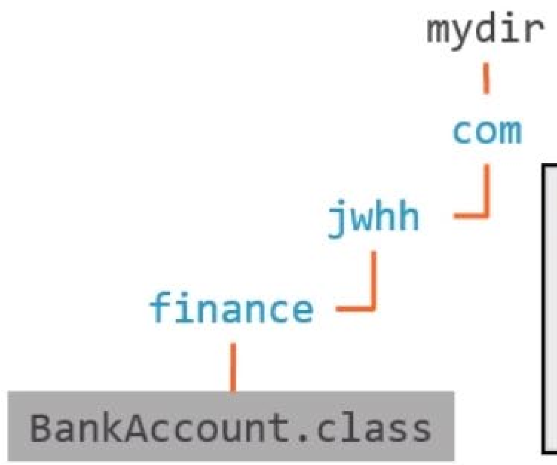


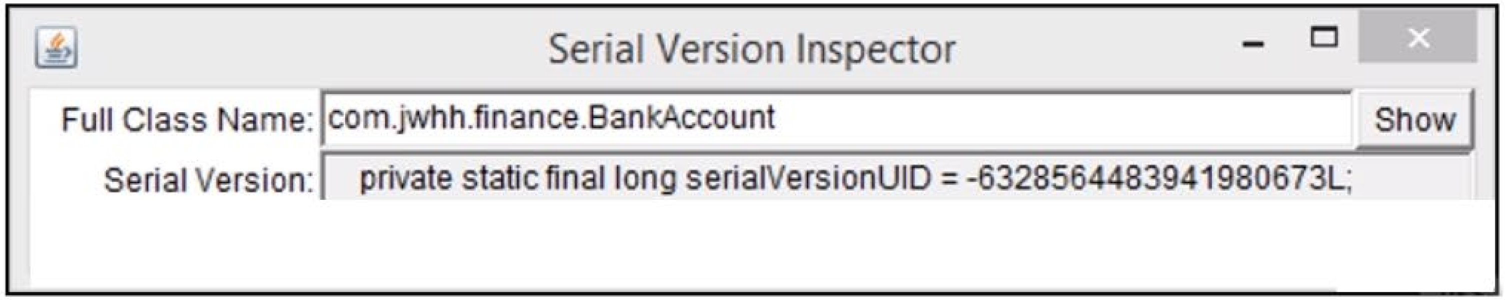
Creating Class Version Compatibility

```
package com.jwhh.finance;

public class BankAccount implements Serializable {

  private final String id;
  private int balance = 0;

  // other members elided
}
```

```
C:\mydir> serialver com.jwhh.finance.BankAccount
```

```
C:\mydir> serialver -show
```

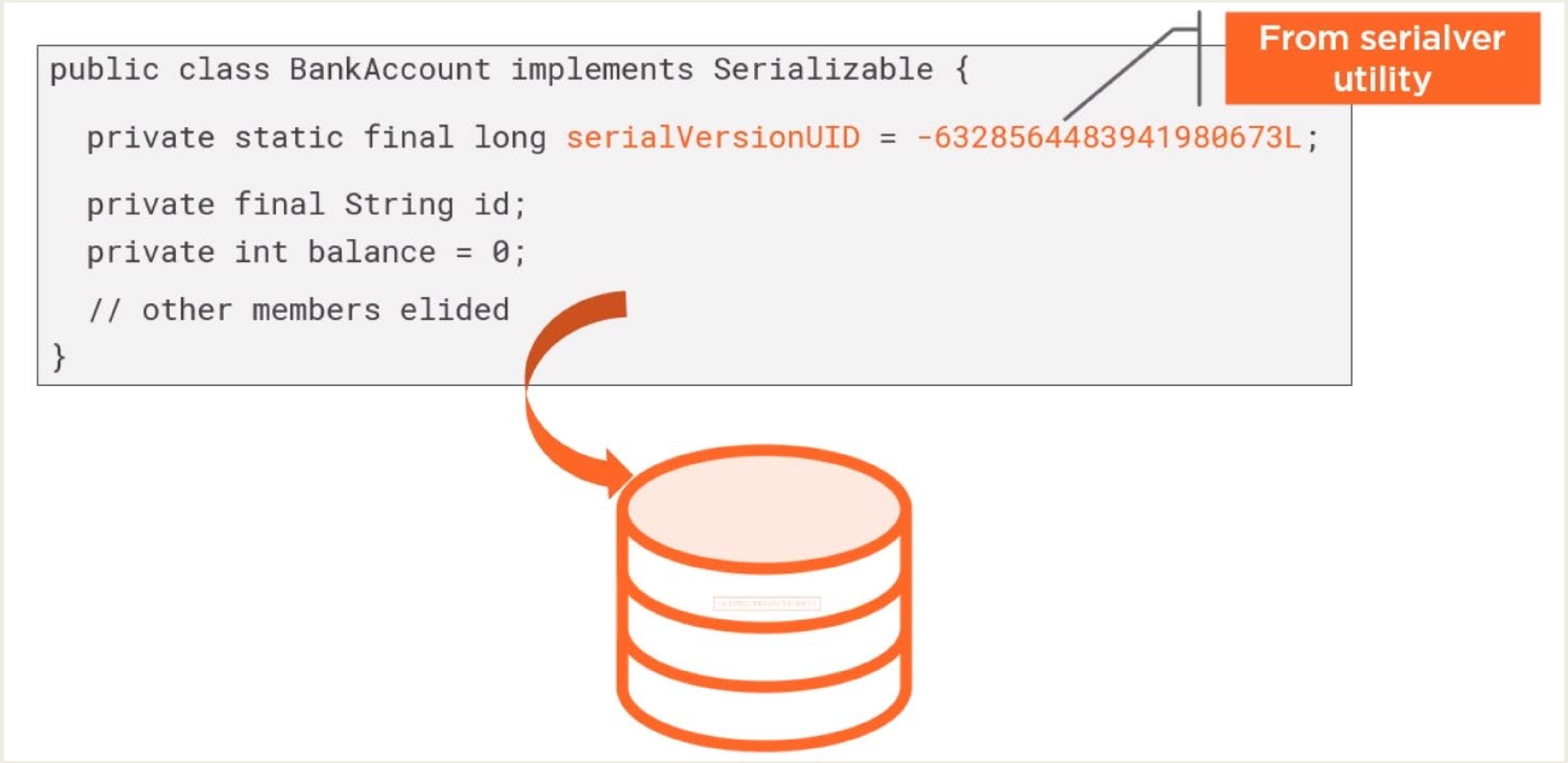




Full Class Name: com.jwhh.finance.BankAccount

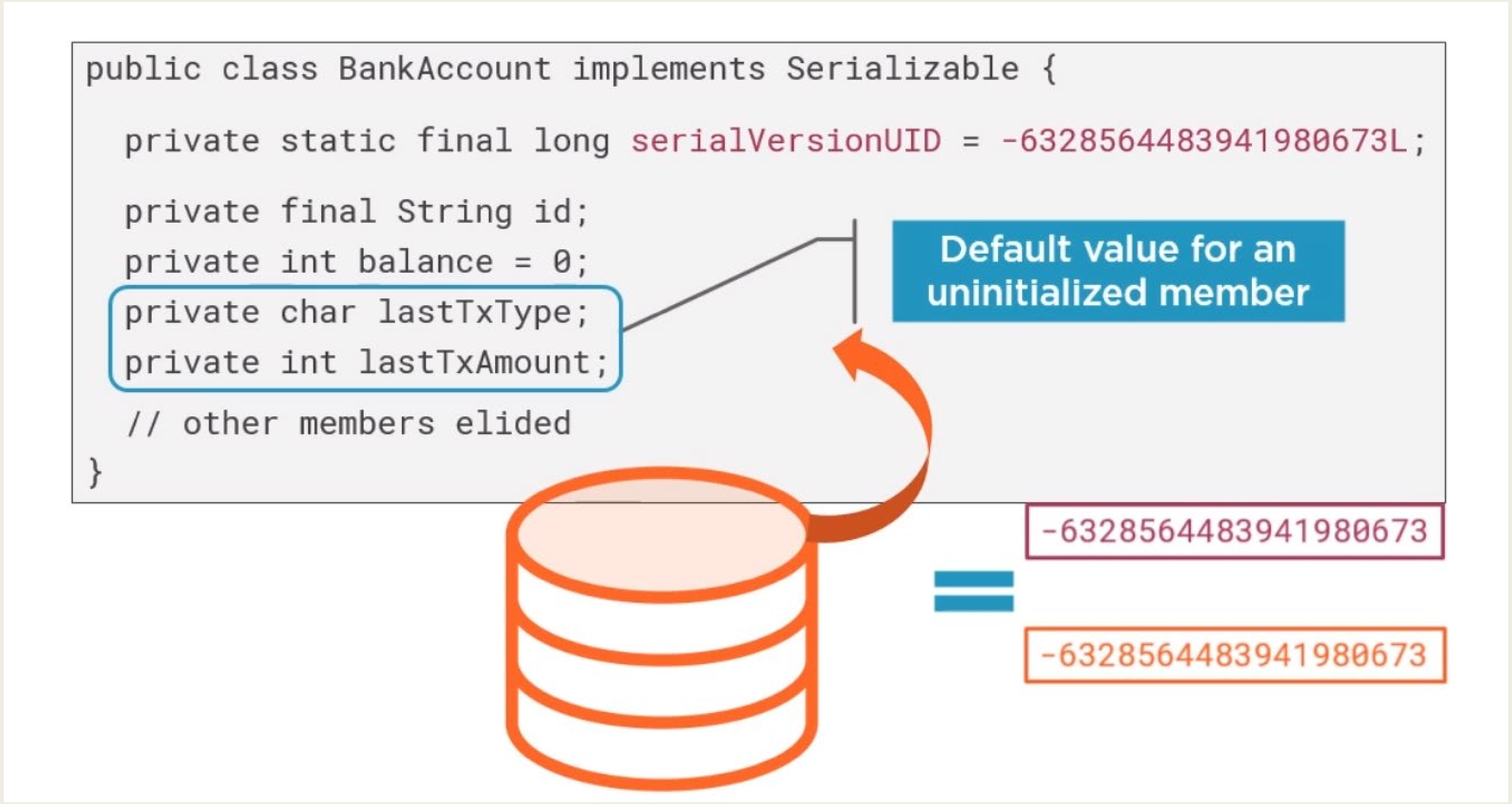
Serial Version: private static final long serialVersionUID = -6328564483941980673L;

Creating Class Version Compatibility



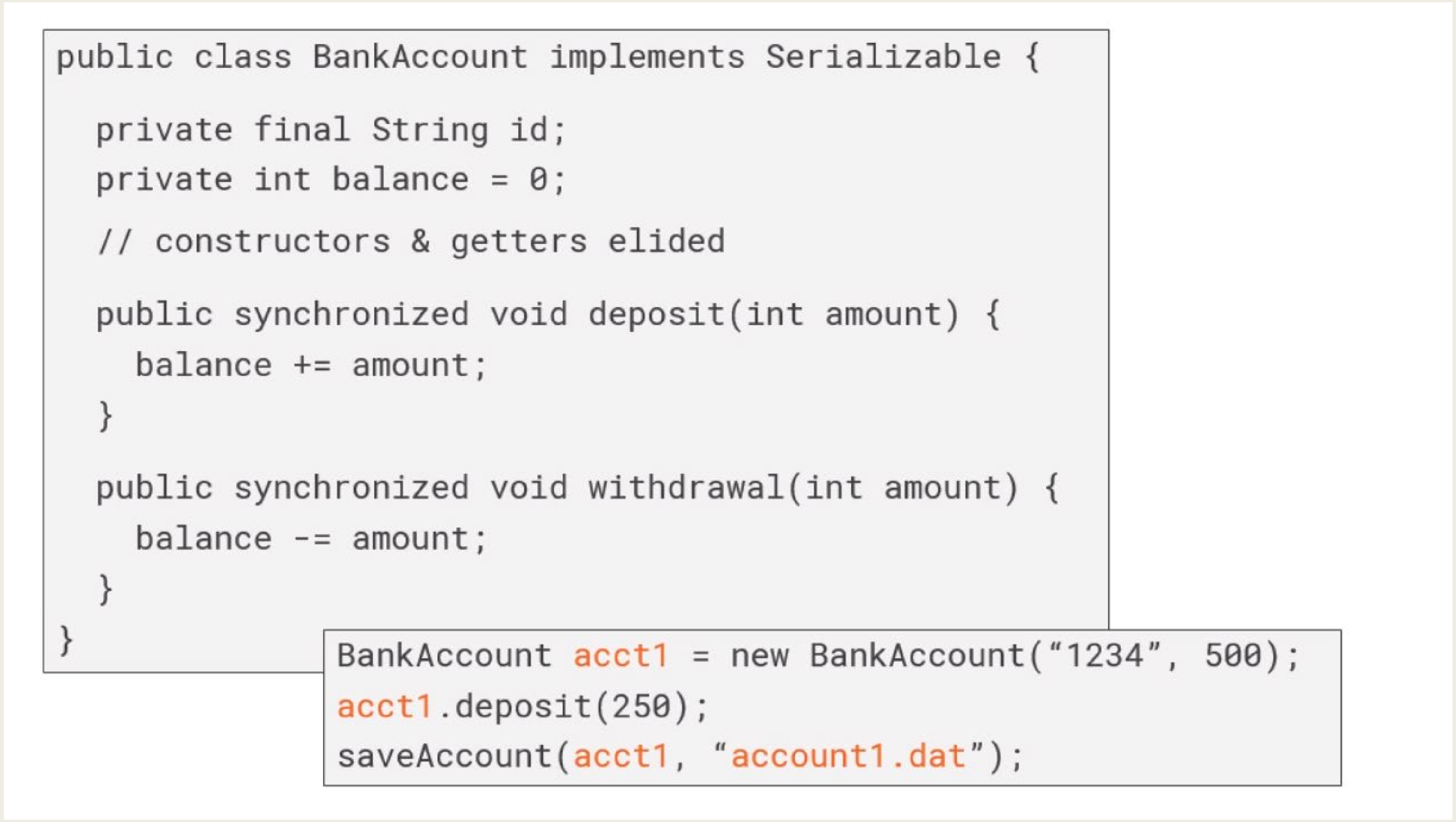
```java
public class BankAccount implements Serializable {

  private static final long serialVersionUID = -6328564483941980673L;

  private final String id;
  private int balance = 0;

  // other members elided
}
```

Creating Class Version Compatibility



```
public class BankAccount implements Serializable {

  private static final long serialVersionUID = -6328564483941980673L;

  private final String id;
  private int balance = 0;
  private char lastTxType;
  private int lastTxAmount;

  // other members elided
}
```

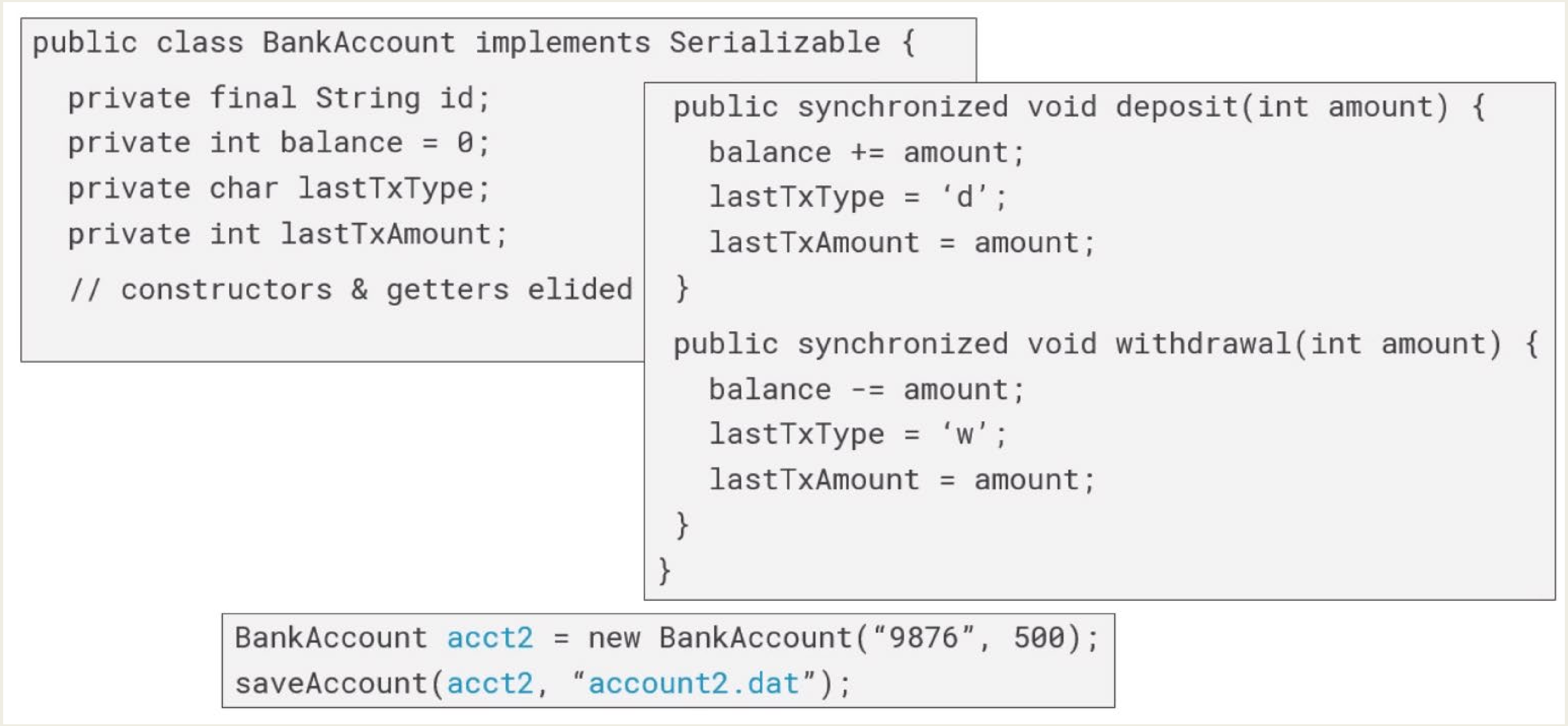
Custom serialization



```java
public class BankAccount implements Serializable {

  private final String id;
  private int balance = 0;
  // constructors & getters elided

  public synchronized void deposit(int amount) {
    balance += amount;
  }

  public synchronized void withdrawal(int amount) {
    balance -= amount;
  }
}
```

```java
BankAccount acct1 = new BankAccount(“1234”, 500);
acct1.deposit(250);
saveAccount(acct1, “account1.dat”);
```

Custom serialization

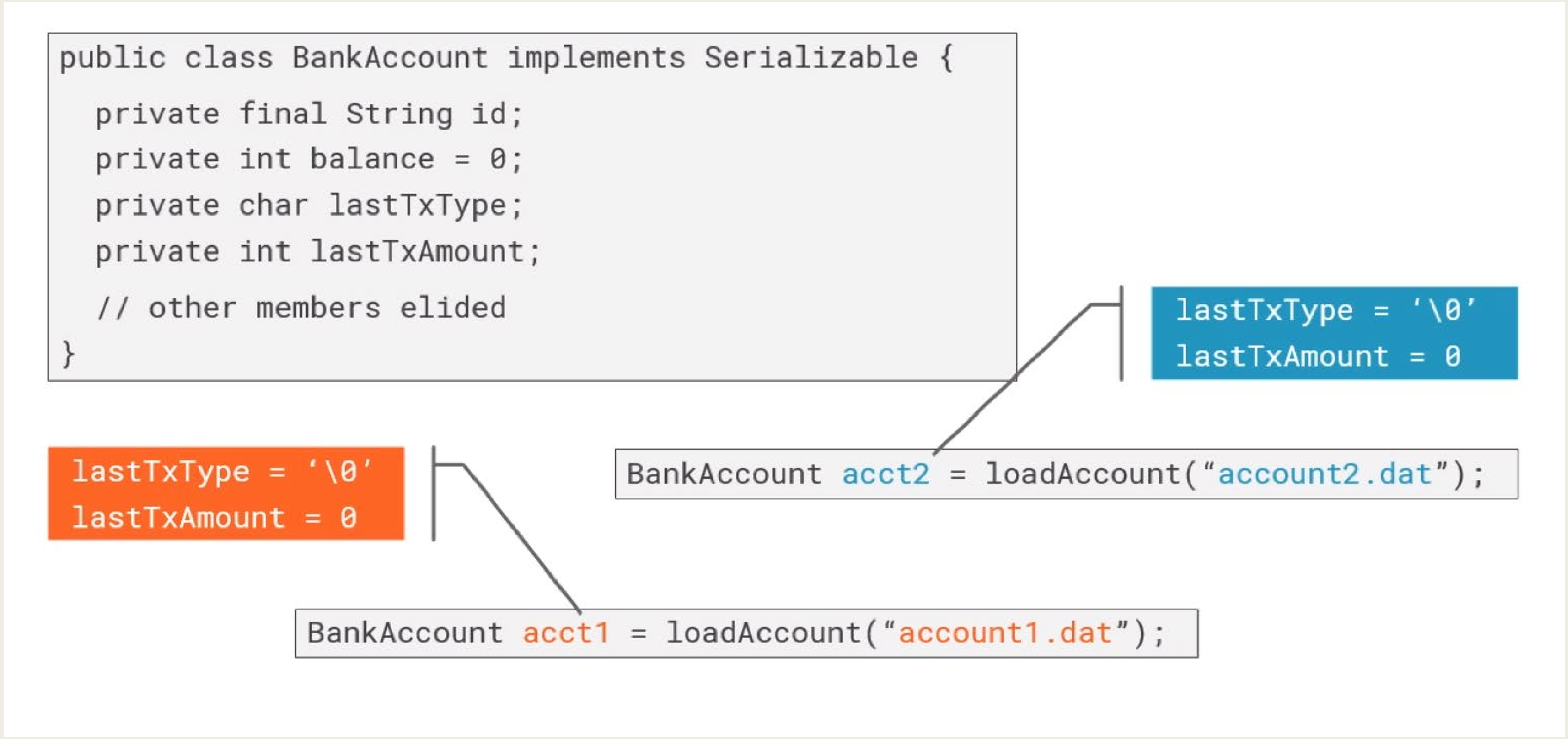


```java
public class BankAccount implements Serializable {

  private final String id;
  private int balance = 0;
  private char lastTxType;
  private int lastTxAmount;

  // constructors & getters elided
```

```java
 public synchronized void deposit(int amount) {
   balance += amount;
   lastTxType = ‘d’;
   lastTxAmount = amount;
 }

 public synchronized void withdrawal(int amount) {
   balance -= amount;
   lastTxType = ‘w’;
   lastTxAmount = amount;
 }
}
```

```java
BankAccount acct2 = new BankAccount(“9876”, 500);
saveAccount(acct2, “account2.dat”);
```

Custom serialization



```
public class BankAccount implements Serializable {
  private final String id;
  private int balance = 0;
  private char lastTxType;
  private int lastTxAmount;
  // other members elided
}
```

```
lastTxType = '\0'
lastTxAmount = 0
```

```
BankAccount acct2 = loadAccount("account2.dat");
```

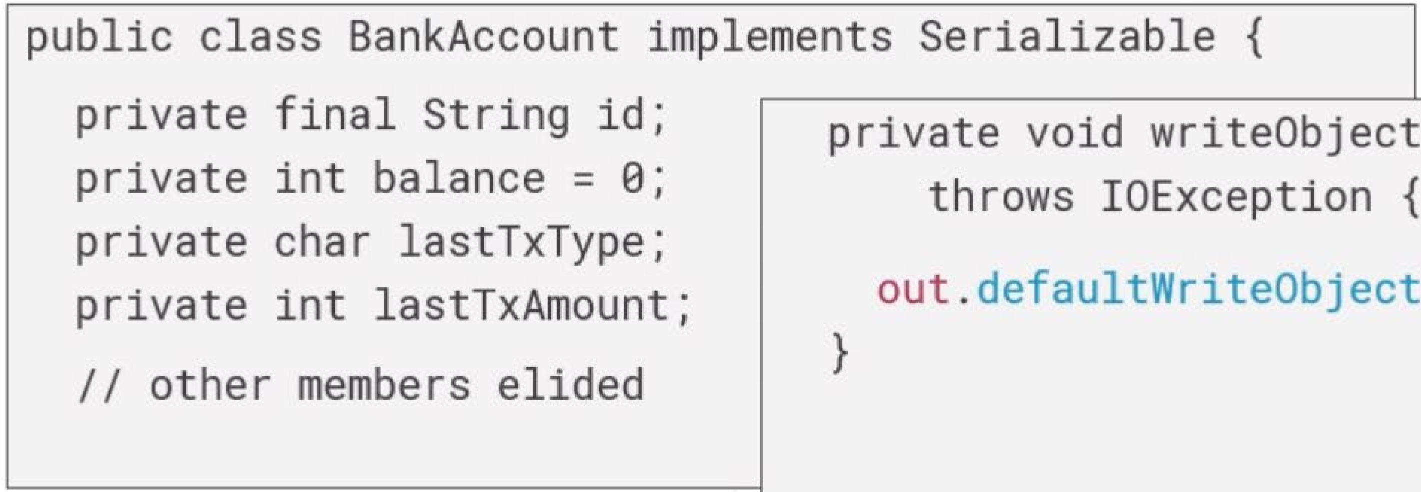
```
lastTxType = '\0'
lastTxAmount = 0
```

```
BankAccount acct1 = loadAccount("account1.dat");
```

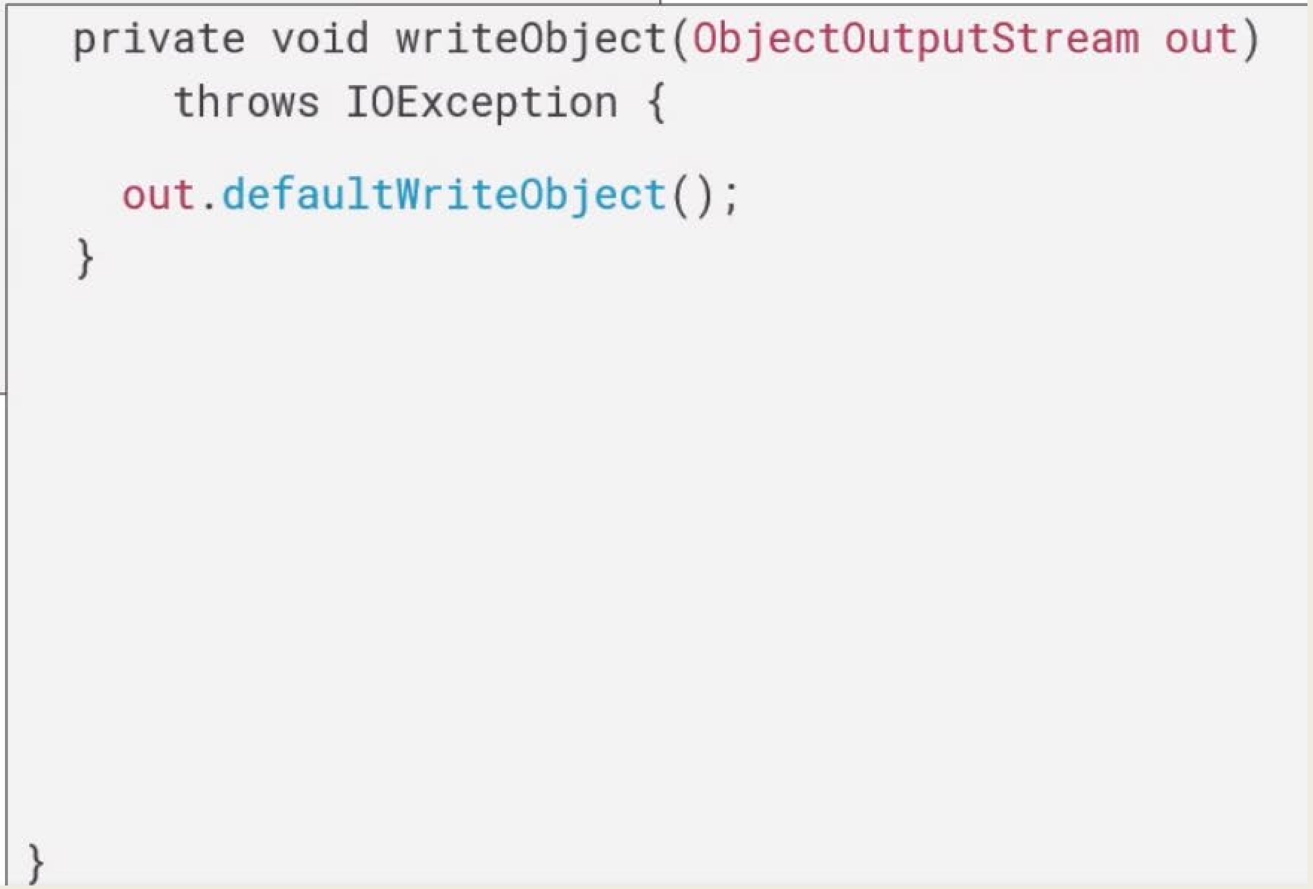
Custom serialization

- Implementing writeObject method
  - *Return type of void*
  - *Include throws clause*
    - IOException
  - *Accepts ObjectOutputStream*
    - Use to write values
    - defaultWriteObject for default behavior

Custom serialization



```
public class BankAccount implements Serializable {

  private final String id;
  private int balance = 0;
  private char lastTxType;
  private int lastTxAmount;

  // other members elided
```

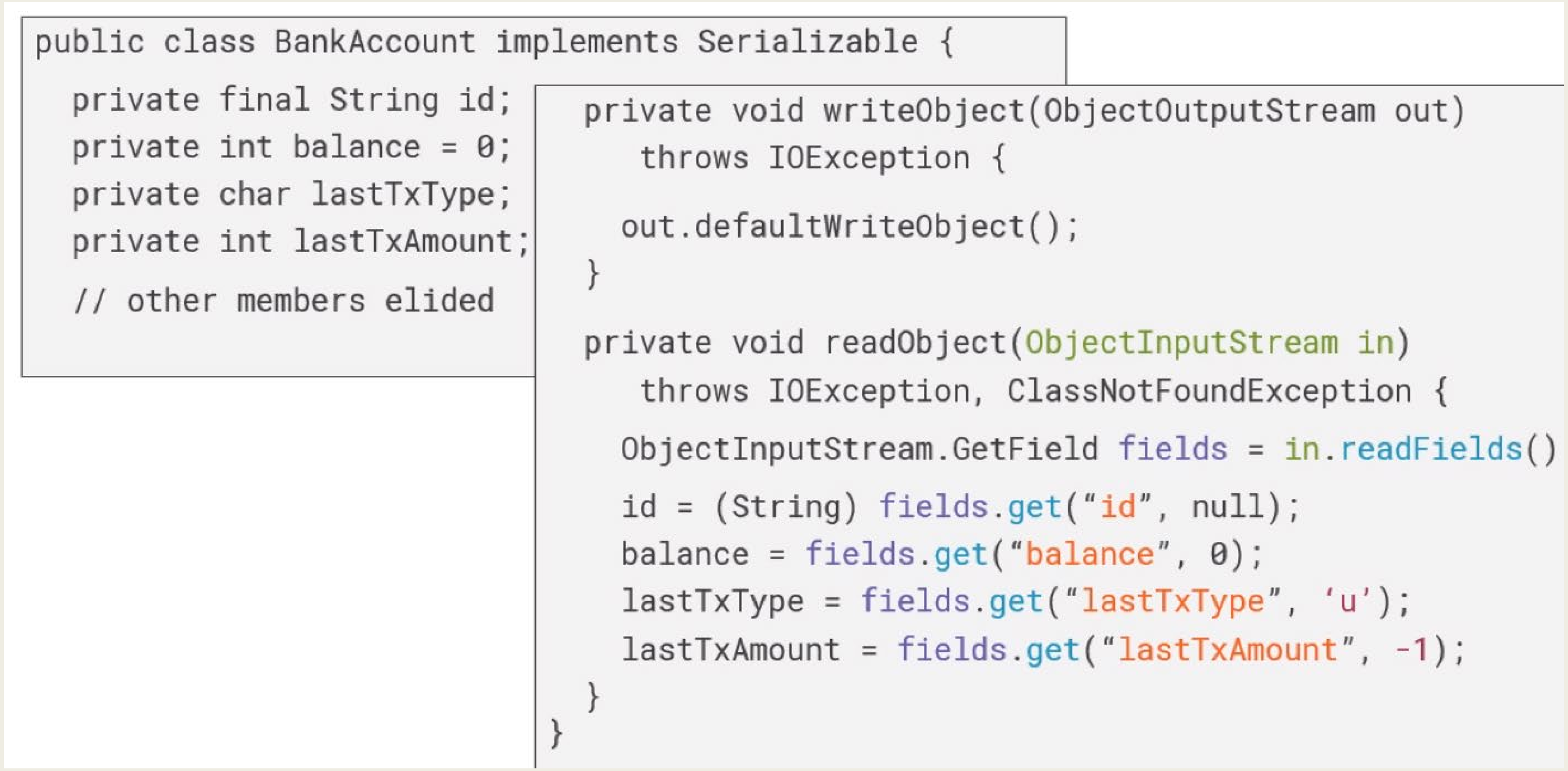


```
  private void writeObject(ObjectOutputStream out)
      throws IOException {

    out.defaultWriteObject();
  }




}
```

Custom serialization

- Implementing readObject method
  - *Return type of void*
  - *Include throws clause*
    - IOException
    - ClassNotFoundException
  - *Accepts ObjectFoundException*
    - Use to read values
    - Use readFields to get field name info
      - *Can access values by name*
    - defaultReadObject for default behavior

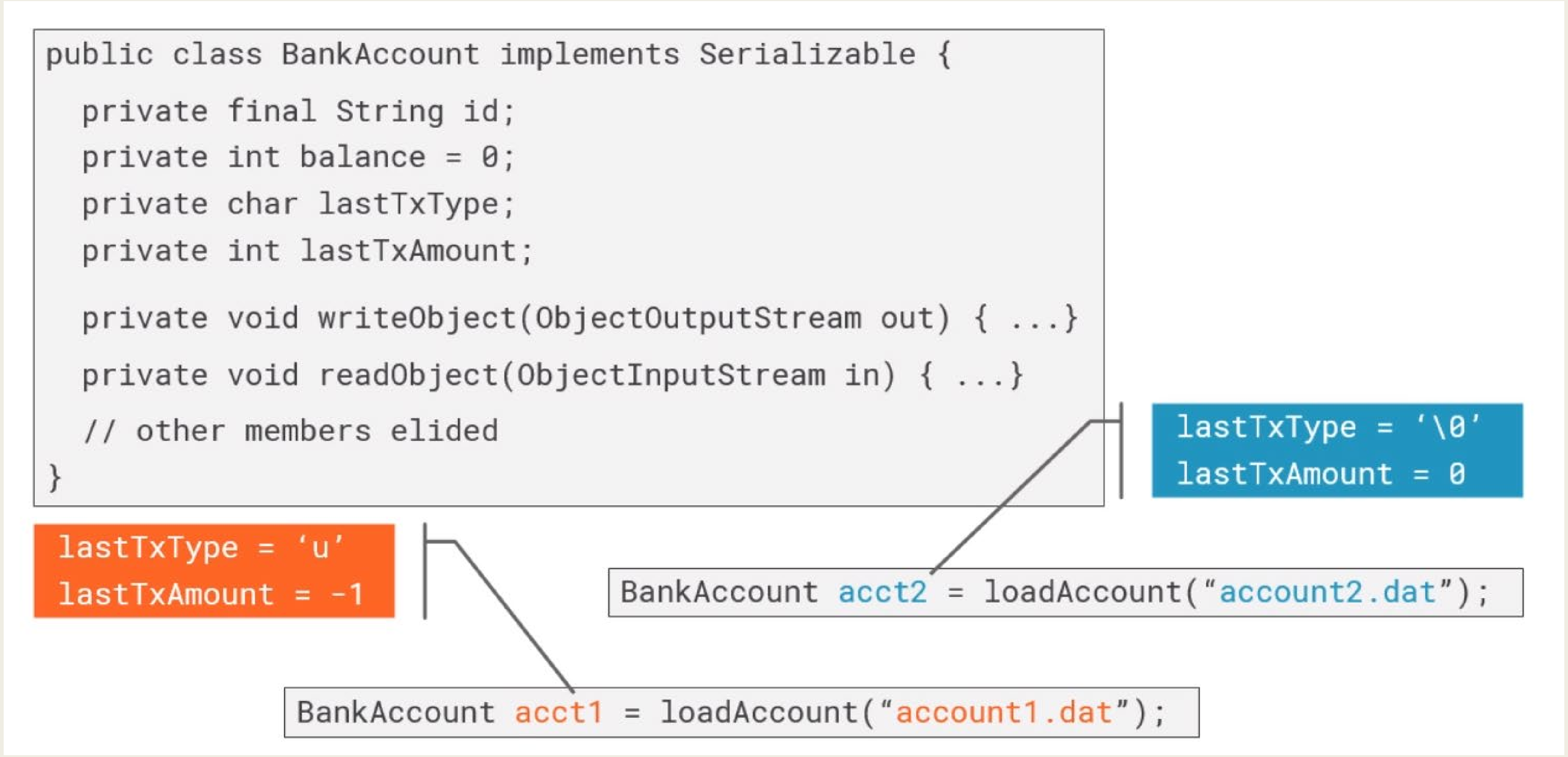
Custom serialization



```
public class BankAccount implements Serializable {

  private final String id;
  private int balance = 0;
  private char lastTxType;
  private int lastTxAmount;

  // other members elided
```

```
  private void writeObject(ObjectOutputStream out)
      throws IOException {

    out.defaultWriteObject();
  }

  private void readObject(ObjectInputStream in)
      throws IOException, ClassNotFoundException {

    ObjectInputStream.GetField fields = in.readFields()

    id = (String) fields.get(“id”, null);
    balance = fields.get(“balance”, 0);
    lastTxType = fields.get(“lastTxType”, ‘u’);
    lastTxAmount = fields.get(“lastTxAmount”, -1);
  }
}
```

Custom serialization



```
public class BankAccount implements Serializable {
  private final String id;
  private int balance = 0;
  private char lastTxType;
  private int lastTxAmount;

  private void writeObject(ObjectOutputStream out) { ...}

  private void readObject(ObjectInputStream in) { ...}

  // other members elided
}
```

```
lastTxType = ‘\0’
lastTxAmount = 0
```

```
lastTxType = ‘u’
lastTxAmount = -1
```

```
BankAccount acct2 = loadAccount(“account2.dat”);
```

```
BankAccount acct1 = loadAccount(“account1.dat”);
```

Transient Fields

In some cases don’t want all fields serialized

Useful for fields derived from another

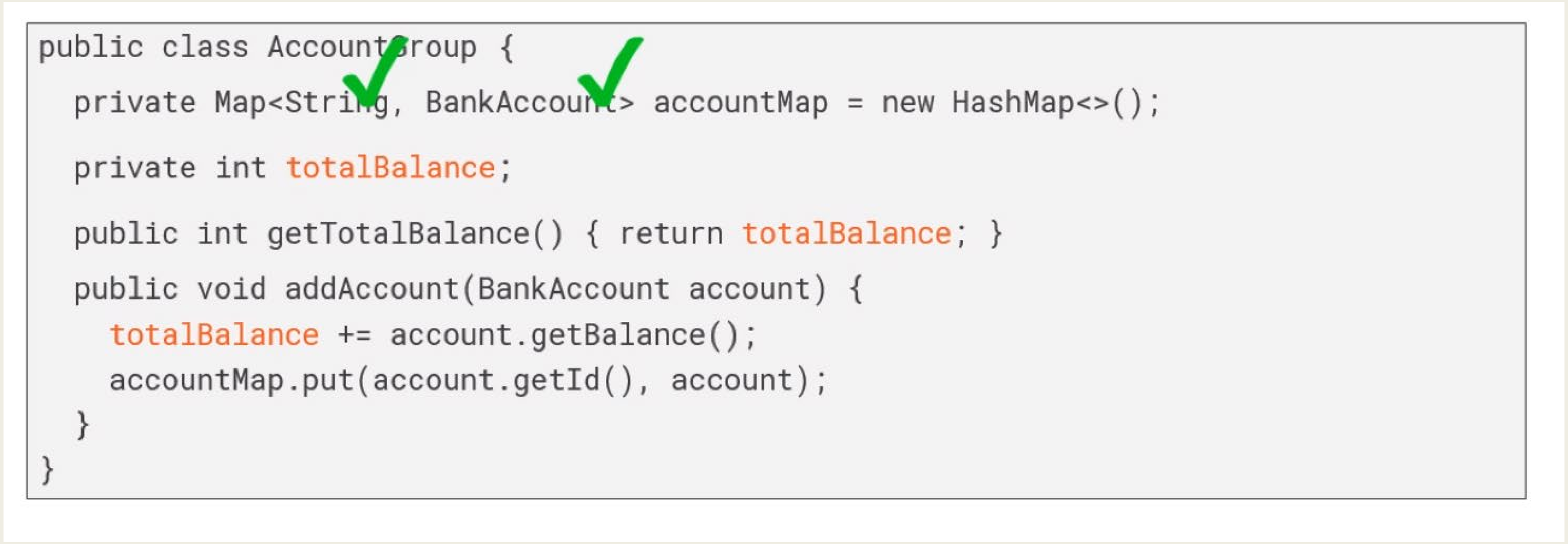
Avoids unnecessary use of storage

Use transient keyword

Exclude fields from serialization

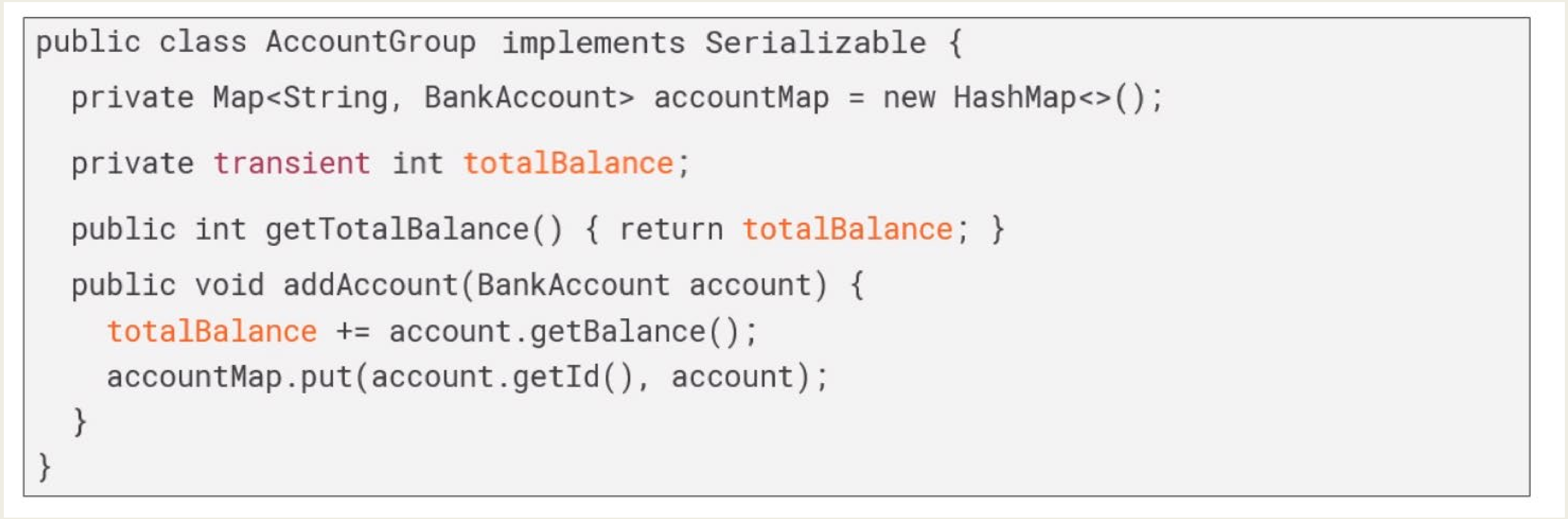
Normally restore value manually

Transient Fields



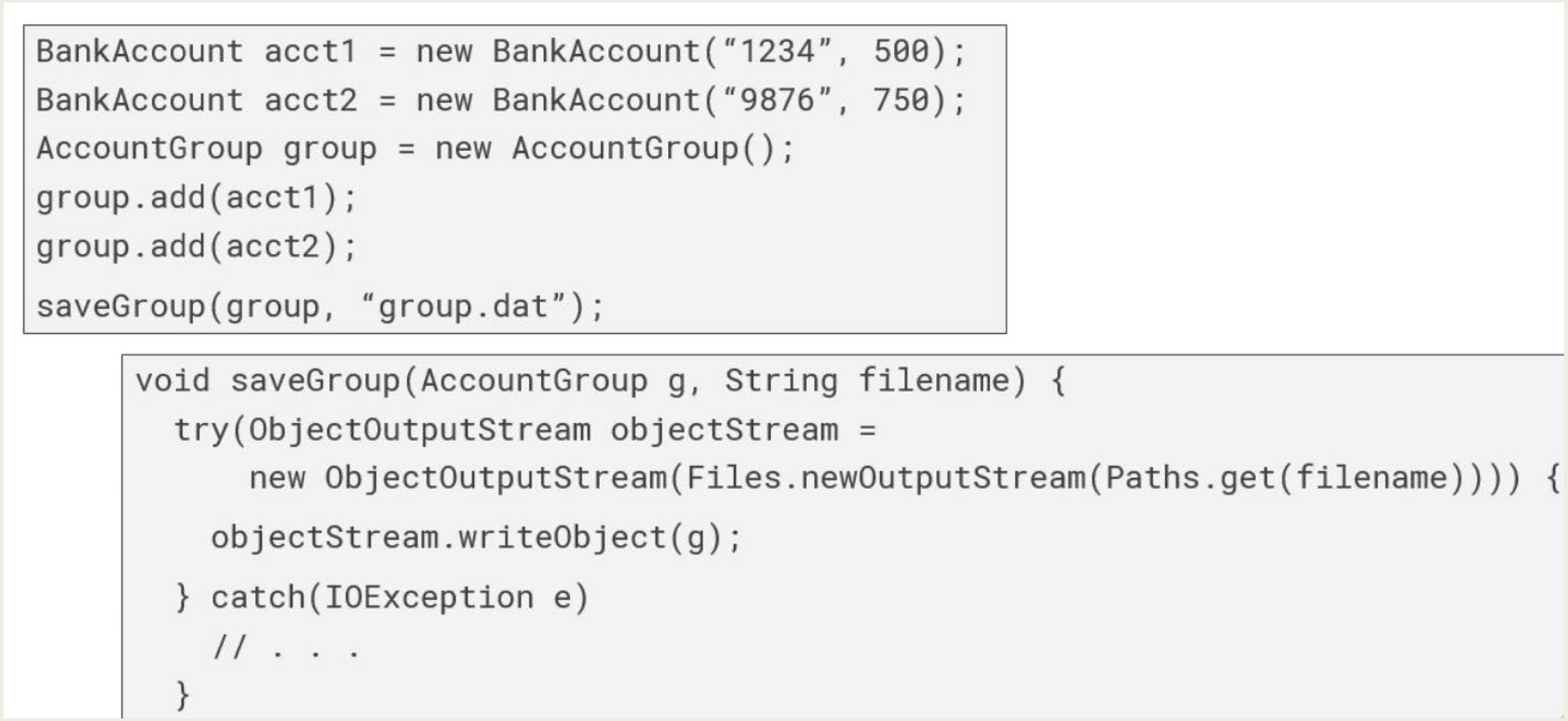
```
public class AccountGroup {
  private Map<String, BankAccount> accountMap = new HashMap<>();

  private int totalBalance;

  public int getTotalBalance() { return totalBalance; }

  public void addAccount(BankAccount account) {
    totalBalance += account.getBalance();
    accountMap.put(account.getId(), account);
  }
}
```

Transient Fields



```java
public class AccountGroup  implements Serializable {
  private Map<String, BankAccount> accountMap = new HashMap<>();

  private transient int totalBalance;

  public int getTotalBalance() { return totalBalance; }

  public void addAccount(BankAccount account) {
    totalBalance += account.getBalance();
    accountMap.put(account.getId(), account);
  }
}
```

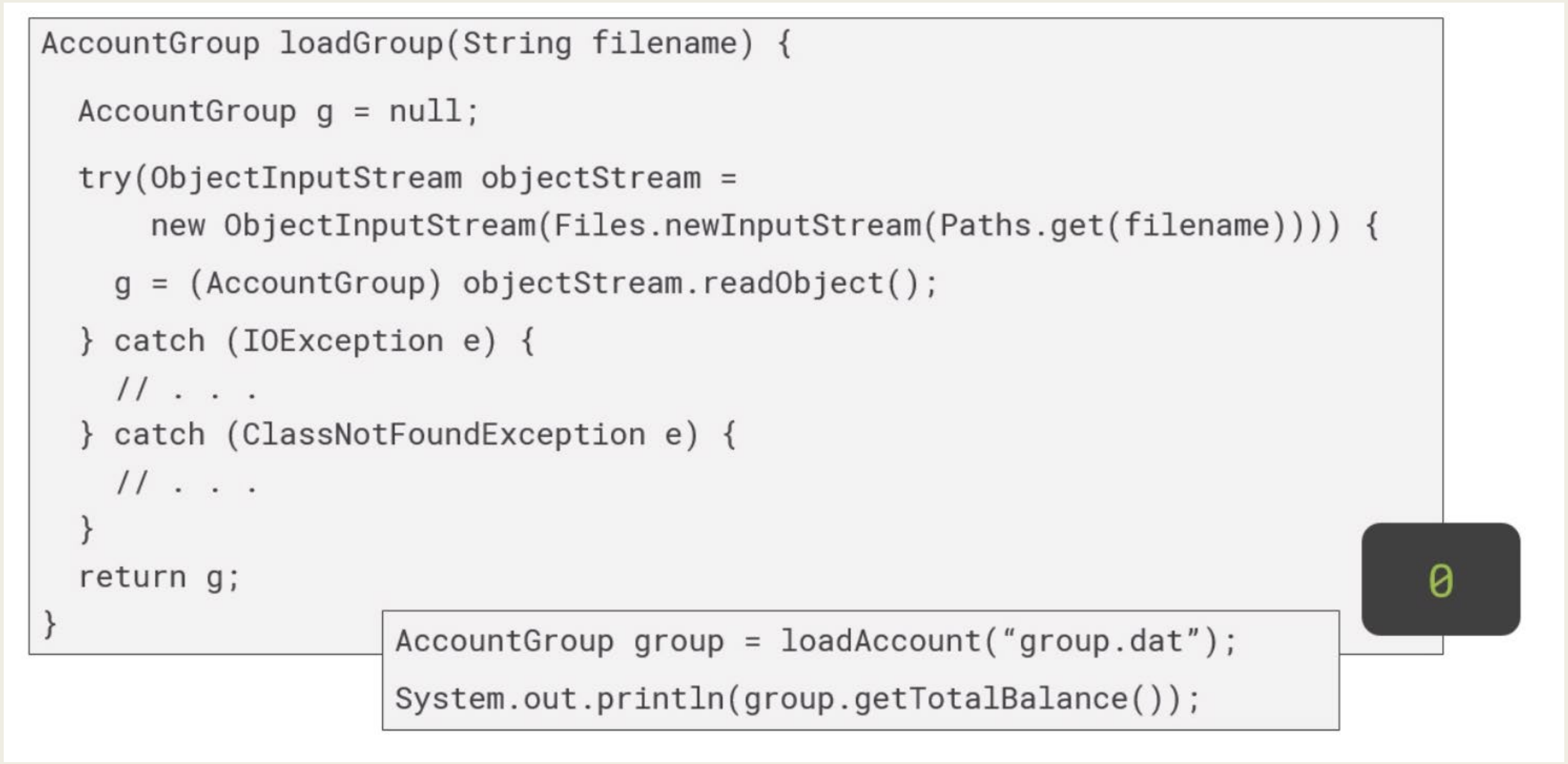
Serializing with a Transient Field



```
BankAccount acct1 = new BankAccount(“1234”, 500);
BankAccount acct2 = new BankAccount(“9876”, 750);
AccountGroup group = new AccountGroup();
group.add(acct1);
group.add(acct2);
saveGroup(group, “group.dat”);
```

```
void saveGroup(AccountGroup g, String filename) {
  try(ObjectOutputStream objectStream =
      new ObjectOutputStream(Files.newOutputStream(Paths.get(filename)))) {
    objectStream.writeObject(g);
  } catch(IOException e)
    // . . .
  }
```

Deserializing with a Transient Field

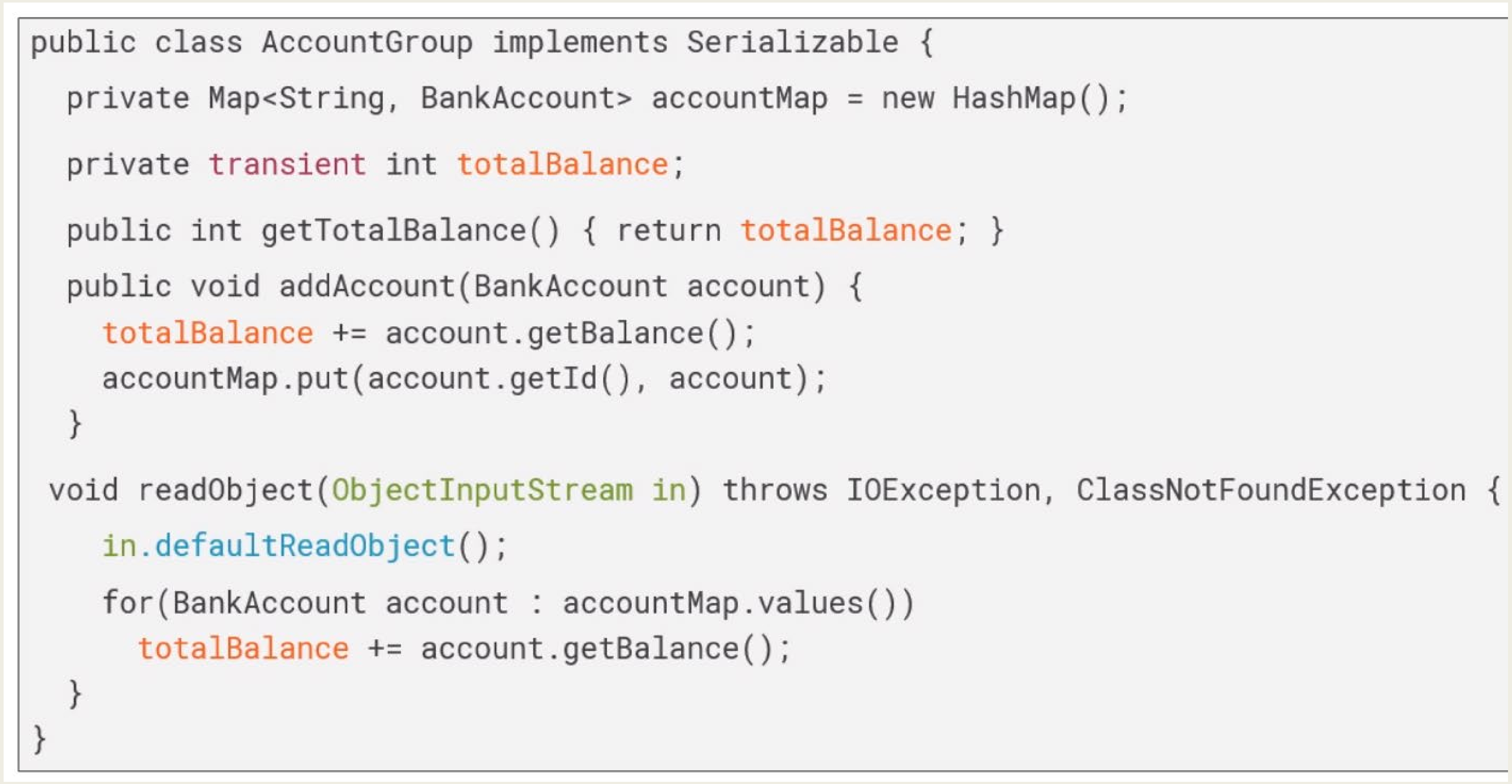


```
AccountGroup loadGroup(String filename) {

  AccountGroup g = null;

  try(ObjectInputStream objectStream =
      new ObjectInputStream(Files.newInputStream(Paths.get(filename)))) {

    g = (AccountGroup) objectStream.readObject();

  } catch (IOException e) {
    // . . .
  } catch (ClassNotFoundException e) {
    // . . .
  }
  return g;
}
```

```
AccountGroup group = loadAccount("group.dat");

System.out.println(group.getTotalBalance());
```

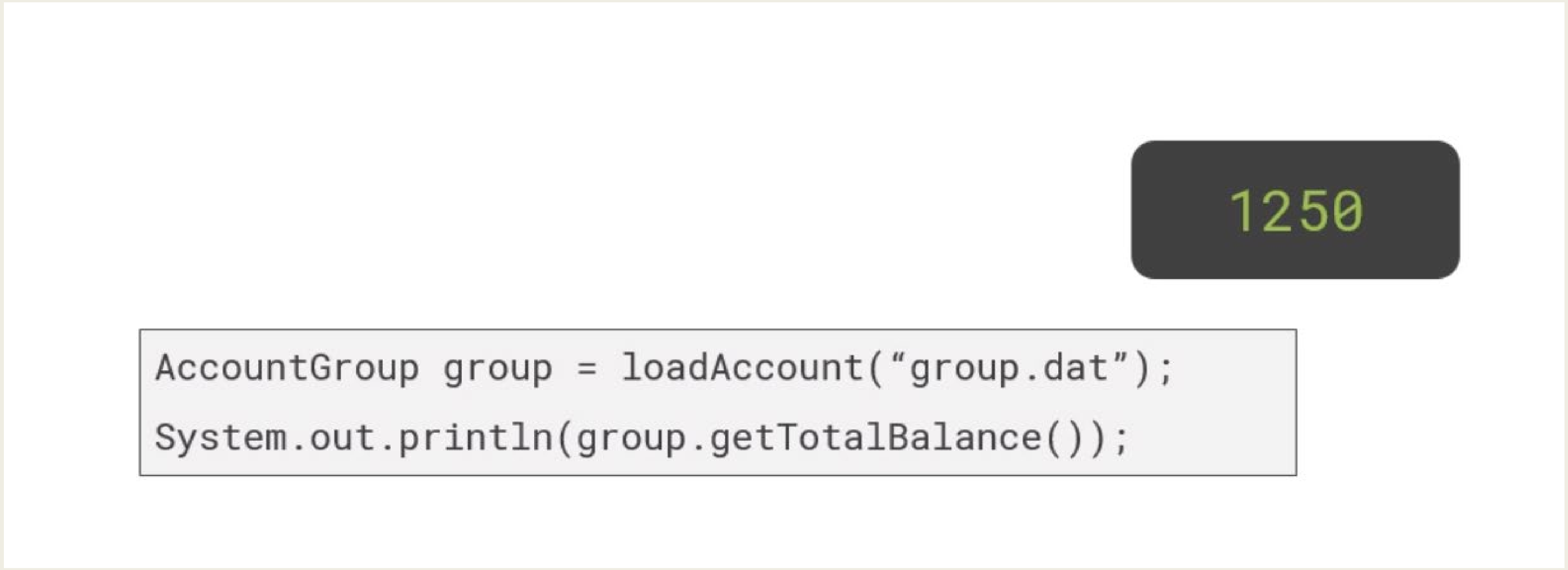
```
0
```

Transient Fields



```
public class AccountGroup implements Serializable {
  private Map<String, BankAccount> accountMap = new HashMap();
  private transient int totalBalance;
  public int getTotalBalance() { return totalBalance; }
  public void addAccount(BankAccount account) {
    totalBalance += account.getBalance();
    accountMap.put(account.getId(), account);
  }
 void readObject(ObjectInputStream in) throws IOException, ClassNotFoundException {
    in.defaultReadObject();
    for(BankAccount account : accountMap.values())
      totalBalance += account.getBalance();
  }
}
```

Deserializing with a Transient Field



```
1250
```

```
AccountGroup group = loadAccount("group.dat");
System.out.println(group.getTotalBalance());
```

Summary

Serialization provides object persistence

- *Files, databases*
- *Between processes, across networks*

Serializable types

- *Primate types implicitly serializable*
- *Classes must implement Serializable*
  - No methods to implement

Types that perform serializing/deserializing

- *ObjectOutputStream*
- *ObjectInputStream*

Summary

- Serial version unique identifier
  - *Used to determine version compatibility*
  - *Java calculates by default*
    - Changes to type changes value
    - Breaks compatibility
  - *Can explicitly set*
    - Add serialVersionUID field
    - Calculate initial value with serialver utility
    - Value maintained across versions
    - Gives developer control

Summary

- Can customize serialization process
  - *writeObject*
    - Called to serialize object
    - Receives ObjectOutputStream
  - *readObject*
    - Called to deserialize object
    - Receives ObjectInputStream
  - *Use transient to exclude fields*
    - Useful when value can be derived
    - Can manually set during deserialization

QUESTIONS?