Basics of programming 3

Java utilities

Serialization basics

- Problem
  - let's save our objects and later read them back
  - what should be stored?
    - objects' attributes
    - associations
    - static fields?
- Simple solution: *serialization*
  - built-in Java feature
  - converts objects' data and their associations to and from byte-streams

Serialization concepts

- Serialization
  - converting objects into binary form (byte stream)
    - also called marshalling, deflating
  - binary data can be stored, transmitted, etc.
- Deserialization
  - converting binary data (byte stream) into objects
    - also called unmarshalling, inflating
  - binary data can be read from a file, got from a network connection, etc.

Serialization example: write

```
import java.io.Serializable;
public class SerializableClass implements Serializable
{ ... }
```

```
//import java.io.*;
...
SerializableClass ser = ...;
try {
        FileOutputStream f =
                        new FileOutputStream(”filename”);
        ObjectOutputStream out =
                        new ObjectOutputStream(f);
        out.writeObject(ser);
        out.close();
}
catch(IOException ex) { ... }
```

Serialization example: read

```
//import java.io.*;
...
SerializableClass ser2;
try {
        FileInputStream f =
                        new FileInputStream("filename");
        ObjectInputStream in =
                        new ObjectInputStream(f);
        ser2 = (SerializableClass)in.readObject();

        in.close();

} catch(IOException ex) {
        ...
} catch(ClassNotFoundException ex) {
        ...
}
```

Rules of serialization

- Only classes implementing interface *Serializable* can be serialized
  - if superclass implements, it's OK
  - arrays, String, Integer, Double, etc. OK
- Interface *Serializable*
  - no methods
  - just formal notification for the compiler
- *Not serializable*
  - *Object, Socket, Input/OutputStream, System, etc.*

Rules of serialization

- What is serialized?
  - primitive attributes
  - serializable attributes
    - recursively
- What is not serialized?
  - static fields
  - *transient* fields

```
public class Serial implements Serializable {
        transient private String secret;
        private String other;
        ...
```

Serialization process

- Serialization is recursive
  - how to avoid cyclic graphs?
  - object's data are written only once
  - consecutively only reference is written

```
out.writeObject(a);
out.writeObject(b);
out.writeObject(a); // only reference!
```

- Serialization of inherited members
  - starts from topmost serializable superclass

Serialization process 2

- Let's have the following classes!

```
class Student implements
    Serializable {
  String name;
  University uni;
  Address a;
  double average;
  // ctr, set, get
}
```

```
class Address implements
    Serializable {
  String country,
    city, street;
  // ctr, set, get
}
```

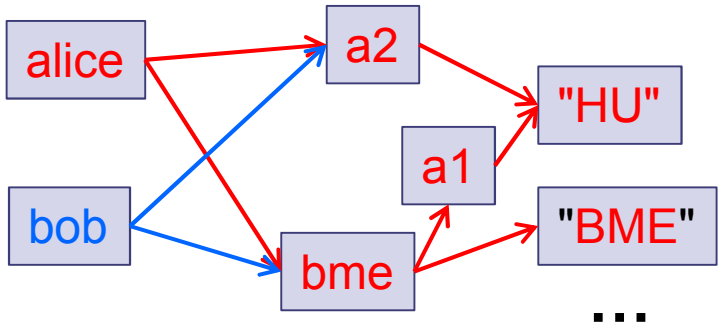
```
class University implements
    Serializable {
  String name;
  Address a;
  // ctr, set, get
}
```

Serialization process 3

- Let's have the following objects!

```
Address a1 = new Address("HU", "Bp", "Műegyetem rkp 3");
Address a2 = new Address("HU", "Bp", "Alkotás u. 10");

University bme = new University("BME", a1);

Student alice = new Student("Alice", bme,  a2);
Student bob   = new Student("Bob", bme, a2);
```

```
ObjectOutputStream oos = ...;
oos.writeObject(alice);
oos.writeObject(bob);
oos.close();
```



Objects' equality

- `==` operator
  - reference based equality
- **`boolean equals(Object o)`**
  - content based equality
  - recursion advised
  - *default implementation is reference based*

Comparisons

- Natural
  - implements interface `Comparable<T>`
  - `int compareTo(T o)`

$$\text{this} < o \leftrightarrow \text{this.cmp}(o) < 0$$
$$\text{this} = o \leftrightarrow \text{this.cmp}(o) = 0$$
$$\text{this} > o \leftrightarrow \text{this.cmp}(o) > 0$$

  - single implementation per class
  - set at compile time
    - tricks are allowed ☺

Comparisons

- Comparator based
  - *Strategy* pattern: responsibility separately
  - `interface Comparator<T>`
  - `int compare(T o1, T o2)`
    - compares *T*-s

$$o1 < o2 \leftrightarrow cmp(o1,o2) < 0$$
$$o1 = o2 \leftrightarrow cmp(o1,o2) = 0$$
$$o1 > o2 \leftrightarrow cmp(o1,o2) > 0$$

  - `boolean equals(Object obj)`
    - compares *Comparator*s

Comparison example: sorting

```
public class X
implements Comparable<X> {
  int q;
  ...
  public int compareTo(X x){
    return q-x.q;
  }
}
```

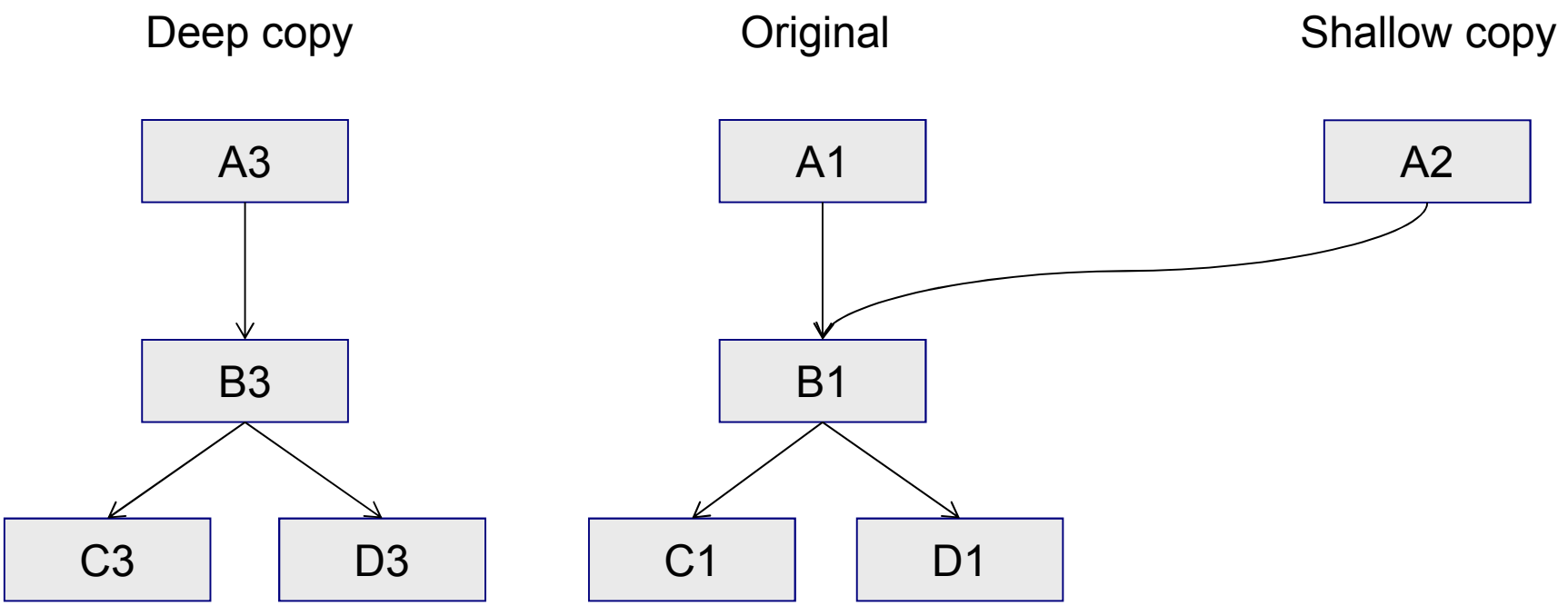
```
public class XC1
implements Comparator<X> {
  public int compare(X x1, X x2){
    return x2.q-x1.q;
  }
}
```

```
List<X> l =
     new ArrayList<>();
...

// natural ordering
Collections.sort(l);

// comparator ordering
Collections.sort(l,
                 new XC1());
```

Copying objects

- Implementing **`java.util.Cloneable`**
- Overriding **`Object.clone()`**
  - calling **`super.clone()`** is advised
  - *Object.clone()* is tricky: instantiates subclass
    - attributes get assignment from those of the cloned object
- *Shallow copy*
  - Only references are copied
    - e.g. Copy of a Vector has references to the original objects
- *Deep copy*
  - recursive copy
    - e.g. correct String implementation in C++

Deep and shallow copy



Copy: no superclass, naïve

```
// this example is a naïve implementation
public class A implements Cloneable {
      B b;
      public Object clone() { // shallow
            A a2 = new A();
            a2.b = b;
            return a2;
      }
      public Object clone() { // deep
            A a3 = new A();
            a3.b = (B)b.clone();
            return a3;
      }
      ...
}
```

Copy: superclass declared

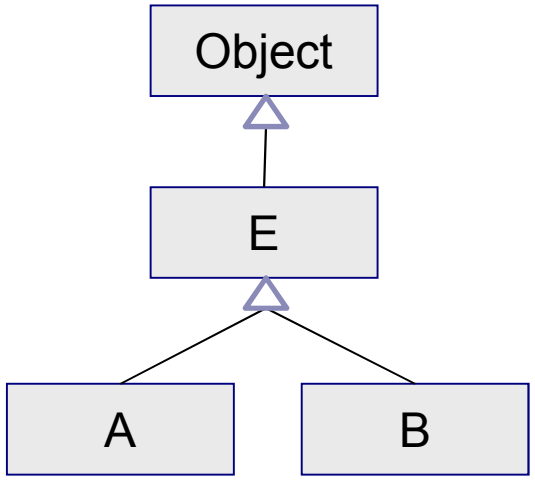
```
public class A extends E {
      B b;
      public Object clone() { // shallow
            A a2 = (A)super.clone(); // !!!
            a2.b = b;
            return a2;
      }

      public Object clone() { // deep
            A a3 = (A)super.clone();
            a3.b = (B)b.clone();
            return a3;
      }
      ...
}
```

Calls *clone()* in superclass, creates object of *class A*

Clone implementation

```
public class E implements Cloneable {
  public Object clone() {
    try { return super.clone(); // Object.clone(), needed!
    } catch (CloneNotSupportedException e) {}
    return null;
  }
}
```

```
public class A extends E {
  B b;
  public Object clone() {
    A a3 = (A)super.clone();
    a3.b = (B)b.clone(); // deep
    return a3;
  }
  ...
}
public class B extends E { ... }
```



Copy constructor?

```
public class A {
      B b;
      public A(A a) {
        this = (A)a.clone(); // DON'T!!!
      }
      public A(A a) {
        this.b = (B)a.b.clone(); // ctr vs clone
      }
      public A(A a) {
        this.b = new B(a.b); // inheritance?
      }
      ...
}
```

Deep clone vs. Copy ctr

- (Java vs C++)

	Pros	Cons
Deep clone	works with abstract classes	**new** is omitted -> who is allocating memory (C++)?
Copy ctr	homogeneous, uses **new;** **delete** is OK (C++)	problem with abstract classes

Fast identity: *hash*

- *public int hashCode()*
  - returns object-specific int
    - *a.equals(b)==true → a.hashCode() == b.hashCode()*
    - purpose: store and find objects effectively
      - e.g. HashMap, HashSet
  - possible implementation in *Object*: memory address
- Good hash function is an art
  - minimize clustering, etc
  - more details in *Theory of Algorithms*

Implementing hash function

```
class Test {
        Object o1; // any kind of object
        Object o2;
        ...
        Object on;
        public int hashCode() {
                int h = 0;

                h = 31*h+o1.hashCode(); // recursion
                h = 31*h+o2.hashCode();
                ...
                h = 31*h+on.hashCode();

                return h;
        }
}
```

Enum: an object type

- Enums have their own class
  - attributes
  - methods
- Enums are
  - serializable
  - printable
  - for-each-able
  - switch-case-able

```
public enum Planet {
    Mercury, Venus, Earth, Mars,
    Jupiter, Saturn, Uranus, Neptune
}
```

Enum example

```
public enum Planet { // complex enum
    Mercury(3.3e23, 2.44e6), Venus(4.868e24, 6.052e6),
      Earth(5.972e24, 6.371e6), Mars(6.417e23, 3.39e6),
      Jupiter(1.899e27, 6.991e7), Saturn(5.684e26, 5.823e7),
      Uranus(8.681e25, 2.536e7), Neptune(1.024e26, 2.462e7);

    private final double mass, radius; // kg, m

    Planet(double m, double r) { mass = m; radius = r;}

    public double mass() { return mass; }
    public double radius() { return radius; }
    public double sGrav() { return 6.674e-11*mass/radius/radius; }
}
```

```
for (Planet p : Planet.values()) {
       System.out.println(p+": "+p.sGrav());
}
```

Enum example 2

```
enum Letter {A, B, C}
```

```
Letter e = Letter.A;
switch (e) {
      case A: System.out.println("A!"); break;
      case B: System.out.println("B!"); break;
      case C: System.out.println("C!"); break;
}
```

Static import of members

```
import static mypackage.Letter.*;
```

```
if (e == B) { ... }
```

Enum methods

- **`String name()`**
  - name of the enum constant
- **`int ordinal()`**
  - serial number
- **`static <T extends Enum<T>> T valueOf([Class<T> enumType,] String name)`**
  - returns enum const from (type and) name
- **`static <T extends Enum<T>> T[] values()`**
  - returns the constants of the enum type

Variable parameters

- Pre 1.5: array is passed
  - uncomfortable

```
void foo(String s, Object[] oa) { for (Object o : oa) …; }
```

- 1.5: *varargs*
  - both arrays and sequences are accepted
  - at the end of parameter list only

```
void foo(String s, Object… oa) { for (Object o : oa) …; }
```

```
Object[] oo = {"a", "b", "c"};
foo("X", oo);
foo("X", "j", "k", "l", "m", "n");
```

Annotations

- Adding plus information to the source code

```
public @interface Copyright {
    String value() default "2008 Me";
}
@Copyright("2008 Bytemongers Limited")
public class ÁrvíztűrőTükörfúrógép { ... }
```

  - *Declaration: interface starting with a @*
  - *Methods describe the annotation's members*
    - *return value primitive, String, Class, enum*
  - *Members might have a default value*

Using annotations

- Annotations describe metadata
  - used by compilers
  - code generators
  - etc.
- E.g.: method overload:

```
@Override
public int read() throws IOException {
        return super.read();
}
```

Utility classes

- String handling
  - *StringTokenizer*: splits strings into tokens
  - *StringBuffer*, *StringBuilder*: *effective string handling*
- Calendar handling
  - *Date*, *Calendar*, *GregorianCalendar*
- Mathematics
  - *Random*: generating random numbers
  - *Math*, *StrictMath*: math functions (sin, exp, etc)
- Scanner
  - helps reading from streams

StringBuffer and StringBuilder

- Mutable string representations
- Used for string-intensive operations
  - concatenation (append, concat, insert, etc.)
  - character modification, deletion, etc.
- StringBuffer
  - multithreaded, slower
- StringBuilder
  - single-threaded, faster

StringTokenizer

- Problem
  - Parsing lines
    - configuration files
    - scripts
    - etc.
- Solution
  - Splitting lines into tokens (words)
    - *String.split*: String to array
    - *StringTokenizer*: String to tokens
  - Delimiter to be specified

StringTokenizer

- Constructors
  - tokenizer has to be initialized first
  - StringTokenizer(String str)
    - delimiters: space, tab, newline, carriage-return, form-feed
  - StringTokenizer(String str, String delim)
    - sets delimiter characters as well
  - StringTokenizer(String s, String d, boolean retDels)
    - sets delimiters and returns them

StringTokenizer

- int count tokens()
  - returns number of tokens
- boolean hasMoreElements
- boolean hasMoreTokens
  - returns if tokenizer has more tokens
- Object nextElement
- String nextToken
  - next token is returned
- String nextToken(String delim)
  - next token with changed delimiters (prevails)

StringTokenizer example

```
StringTokenizer st =
      new StringTokenizer("alpha beta gamma");
while (st.hasMoreTokens()) {
      System.out.println(st.nextToken());
}
```

```
alpha
beta
gamma
```

Time-related classes

- Date
  - represents an instant in time
    - millisec precision
  - mostly deprecated
- Calendar
  - abstract
  - for conversion between dates and time fields
- GregorianCalendar *extends Calendar*
- LocalTime, LocalDate, etc (since Java 8)
- DateFormat
  - for formatting and parsing date strings

Date

- Date() and Date(long d)
  - ctr-s for *now* and *d* (ms since epoch 1970-01-01UTC00:00:00)
- boolean after/before(Date d)
- int compareTo(Date d)
- int equals(Object o)
  - trivial comparisons
- long getTime()
  - ms since epoch
- String toString()
  - returns time in "*dow mon dd hh:mm:ss zzz yyyy*" format

Calendar

- Represents a date
  - abstract class
  - static method *getInstance()* returns current date
- Handling with generic methods
  - *add(f, delta)*
  - *set(f, delta), get(f), clear(f)*
  - *roll(f, delta)*
    - adds, sets, rolls, gets, clears field *f* (with *delta)*
    - adjusts if necessary
    - *f* is specified by constant values

Calendar

- Constants for fields
  - DATE, DAY_OF_MONTH, DAY_OF_WEEK, DAY_OF_YEAR
  - WEEK_OF_MONTH, WEEK_OF_YEAR
  - ERA, YEAR, MONTH, MINUTE, SECOND, MILLISECOND
  - AM_PM, HOUR_OF_DAY (0-24), HOUR (0-12)
  - ZONE_OFFSET
- Constants for values
  - JANUARY, FEBRUARY, MARCH, etc
    - starts with JANUARY==0 **!!!**
  - MONDAY, TUESDAY, etc
    - SUNDAY==0, MONDAY==1, etc
  - AM, PM
  - (GregorianCalendar: AD, BC)

Calendar

- Methods for everything
  - boolean after/before(Object when)
  - int clear()
  - int get[Actual]Maximum(f)
  - int get[Actual]Minimum(f)
  - int getGreatestMinimum(f)
  - int getLeastMaximum(f)
  - get/setFirstDayOfWeek
  - get/setMinimalDaysInFirstWeek
  - …

GregorianCalendar

- Extends Calendar
  - Constructors
    - year, month, day *[,hour, minute [, second]]*
  - Constants
    - *AD, BC*
  - Methods
    - setGregorianChange(Date date)
    - Date getGregorianChange()
    - boolean isLeapYear()
    - …

Calendar example

```
Calendar c = new GregorianCalendar(1996,0,23);//96-01-23
c.set(Calendar.MONTH, Calendar.MAY); // 1996-05-23
c.set(Calendar.DATE, 31);            // 1996-05-31

c.add(Calendar.MONTH, 15);           // 1997-08-31
c.roll(Calendar.DATE, 10);           // 1997-08-10

DateFormat df = DateFormat.getDateTimeInstance();
System.out.println(df.format(c.getTime()));
   // Aug 10, 1997 12:00:00 AM
```

LocalTime, LocalDate, etc

- Simple time and date handling classes
  - package *java.time (since Java 8)*
  - more OO-like than Date or Calendar
    - getters/setters, isAfter, isBefore, isEqual, until, etc
    - static factory methods (now, of, etc.)
  - no timezone
  - immutable
- *LocalTime*: time only (hours, mins, secs)
- *LocalDate*: date only (year, month, day)
- *LocalDateTime*: date and time combined

LocalDate, LocalTime example

```
LocalDate d1 = LocalDate.of(1996,1,23); //96-01-23
LocalDate d2 = d1.plusDays(100);        //96-05-02
// also plusWeeks, plusMonths, plusYears, etc
// also same with minus...
```

```
LocalTime t1 = LocalTime.of(14,32,56); // 14h 32m 56s
LocalTime t2 = LocalTime.of(15,10);    // 15h 10m 00s
boolean b = t1.isBefore(t2);           // true
// minusSeconds, minusMinutes, minusHours, minusNanos,
// plusSeconds, plusMinutes, plusHours, plusNanos, etc
```

```
LocalDateTime dt1 = t1.atDate(d1);  // 96-01-23 14:32:56
LocalDateTime dt2 = d2.atTime(t2);  // 96-05-02 15:10:00
long hours = dt1.until(dt2, HOURS); // 2400 hours inbetween
```

Random

- For generating random numbers
  - constructors
    - *default*: seed automatically set
    - *seeded* (param *long*), deterministic *(setSeed)*
  - *nextXXX()*
    - uniform distribution
    - *boolean*, *bytes*, *int*, *long*: result in type's range
    - *double*, *float*: result in range [0.0, 1.0)
    - *nextInt(int n)*: between 0 and *n* (exclusive)
  - *nextGaussian()*
    - normal distribution (mean: 0, std dev: 1)

Math/StrictMath

- Utility classes
  - java.lang.Math, java.lang.StrictMath
- Contants
  - E, PI
- Functions
  - abs, signum, sqrt, *cbrt, ceil, floor, round, rint,*
  - sin, cos, tan, *sinh, cosh, tanh*
  - asin, acos, atan, atan2
  - pow, exp, *expm1,* log, log10, *log1p, scalb,*
  - max, min, *nextAfter, nextUp,* toDegrees, toRadians

Big numbers

- BigInteger
  - arbitrarily big decimal integers
  - static consts
    - *0 (ZERO)*, *1 (ONE)*, *10 (TEN)*
  - constructors for byte[], random, long, int or String params
  - operators as methods
    - *add*, *abs*, *and*, *pow*, etc
  - modifiers
    - *setBit*, *testBit*, etc
  - accessors
    - *toByteArray*, *toString*, *longValue*, etc

Big numbers

- BigDecimal
  - arbitrarily big decimal floating point numbers
  - static consts
    - *0 (ZERO)*, *1 (ONE)*, *10 (TEN)*
    - *rounding (ROUND_DOWN, ROUND_UP, ROUND_HALF_UP, etc)*
  - constructors for char[], String, BigInt., double, long, int params
  - operators as methods
    - *add*, *abs*, *round*, *pow*, etc
  - modifiers
    - *setScale*, *testBit*, etc
  - accessors
    - *scale, precision, toBigInteger*, *toString*, *doubleValue*, etc

Scanner

- Character based input
  - BufferedReader
    - awkward
    - complex
    - nonlegible
  - Scanner
    - direct access to resource
    - iterator-like usage
    - conversion to primitive types

Scanner

- Constructors
  - params: *File*, *InputStream*, *Path*, *Readable*, *String*
- Methods
  - *hasNext[XXX]*
  - *next[XXX]*
    - BigDecimal, BigInteger, boolean, byte, double, …
  - *useDelimiter(Pattern|String), delimiter()*
  - *useRadix(int radix), radix()*
    - for setting/getting delimiter and radix
  - *findInLine, skip, match, etc*

Properties

- Config file handling
  - name-value pairs in text format
  - how to handle it correctly?
    - own parser and generator: overkill
    - standard helper class: *Properties*
- *Properties* class
  - Map interface
  - convenient reading-writing
    - multiple formats supported

Properties

- *java.util.Properties* class
  - Map interface *(String key, String value)*
  - *getProperty* (with def val), *setProperty*
    - getting – setting properties
  - *Set<String> stringPropertyNames()*
    - set of keys as strings
  - *load(InputStream or Reader)*
    - reading from any source
    - wide range of formats supported
  - *store(OutputStream or Writer, String comments)*
    - writing content to any target (file, network, etc)
  - XML format also supported