Basics of programming 3

Java input/output

Wrapper classes

Wrapper classes

- For each primitive type a class is defined
  - Integer, Byte, Boolean, etc.
  - sometimes an object is needed
- Constructors
  - `Integer(int i)`, `Integer(String s)`
- Constants
  - MAX_VALUE, MIN_VALUE, SIZE
  - NaN, NEGATIVE_INFINITY, etc.

Wrapper classes and boxing

- Transformations
  - rotateLeft, reverse, signum, etc.
- Conversion methods
  - **intValue()**, **longValue()**, **parseInt(String s)**, **valueOf(...)**
- Wrapper ↔ primitive conversion is automatic

```
int a = 2;
Integer b = 3;
a = a + b;
Integer d = 3+3;  // int -> Integer
System.out.println(d*3); // Integer -> int
```

Wrapper classes and boxing 2

- Conversion is not efficient

```
public static void main(String args[]) {
        Integer i1 = Integer.parseInt(args[0]);// boxing
        Integer i2 = Integer.parseInt(args[0]);// boxing

        i1.equals(i2);          // true, no boxing
        i1 == i2;               // only if -128<i1≤127
        i1 <= i2;               // true, boxing
        i1++;                   // incr, boxing
        i1 > 120;               // boxing
}
```

Exception handling

Exceptions in C++

- Classic exception handling

```
try {
   ...
} catch (E e) { // E type exception
} catch (...) { // everything else
   ...
   throw;
}
```

- No declared exception type
  - STL introduced class *exception*

Exceptions in **`Java`**

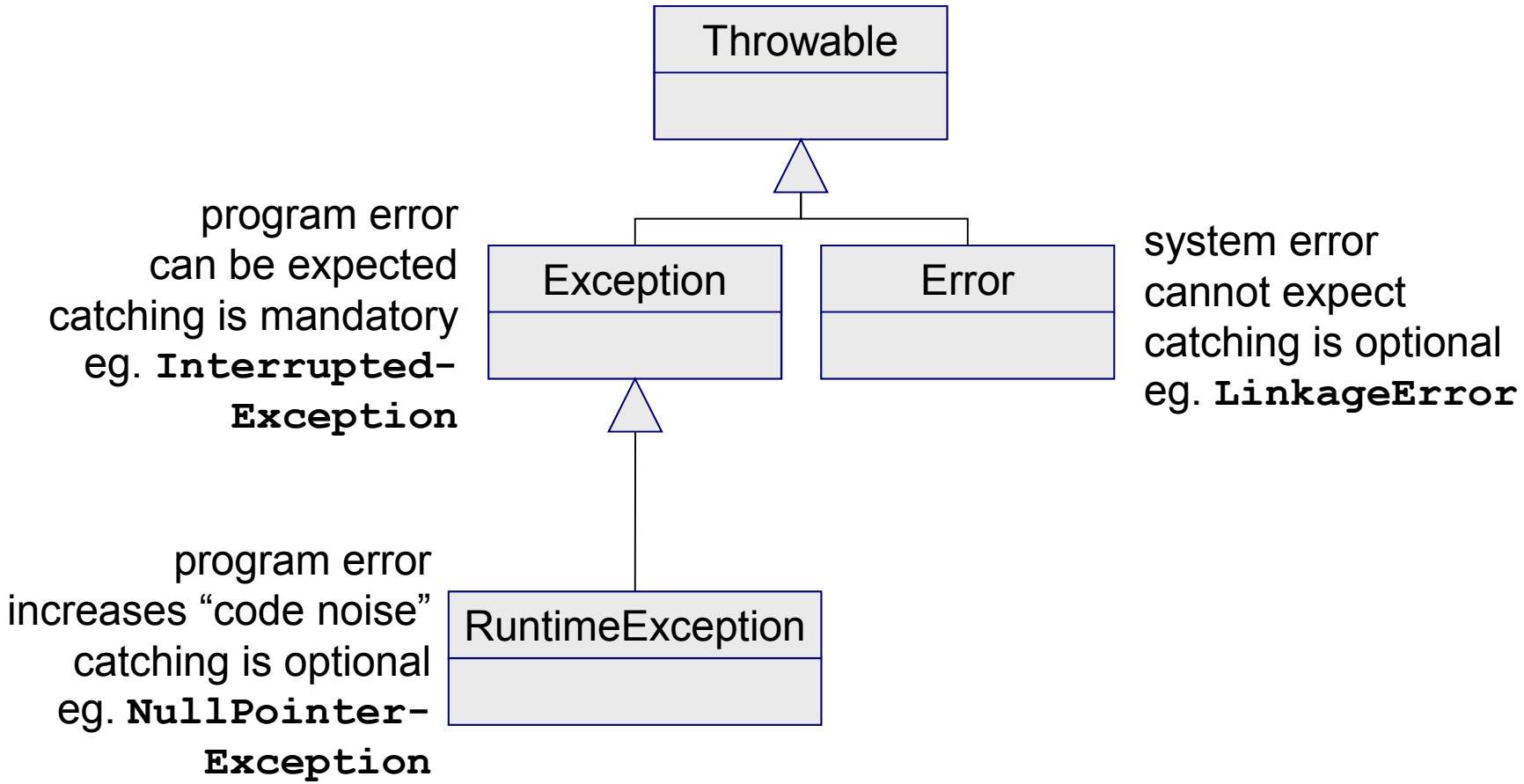
- based on C++
- common exception superclass
  - **`Throwable`**
- all possible exceptions must be declared
  - **`throws`**
- superclasses for different error types
  - **`Exception`**, **`RuntimeException`**, **`Error`**
- closing block: **`finally`**
- see also: *try with resources* (Java7)

Exceptions in **Java**

```
void foo(String s) throws IOException {
        …
}
```

```
FileInputStream fis = new FileInputStream("a");
try {
        ...
        foo(s);
        ...
} catch (IOException e) {
        ...
        throw e;
} finally {
        fis.close();
}
```

Exception hierarchy



Cascade exceptions

```
public AST parseFile(File f) throws ParseException {
        AST ast = new AST();
        try {
                …
        } catch (IOException e) {
                ParseException pe = new ParseException();
                pe.initCause(e);
                throw pe;
        }
        …
        return ast;
}
```

```
try { ast = parseFile(f); }
catch (ParseException pe) { pe.printStackTrace(); }
```

Cascade exceptions 3

```
ParseException
        at Test2.parseFile(Test2.java:19)
        ...

Caused by: IOException
        at Test2.nextString(Test2.java:12)
        ...
        at Test2.parseFile(Test2.java:17)
```

- in **`Throwable`** *cause* can be set since Java 1.4
- shown in the *stack-trace*

Java System Class

System class

- **`in, out, err`**
  - static variables
  - store reference to stdin, stdout, stderr
  - have setter methods
- **`gc()`**
  - starts garbage collection
- **`exit(int)`**
  - exits JVM
- **`getProperty/getProperties, setProperty...`**
  - getting system-wide info, like user dir location, etc

Java IO Basics

Java IO basic principles

- Stream-based communication
  - UNIX legacy
- Two basic types
  - char → unicode, conversion (charset, linefeed)
  - byte → octets, no conversion
- Filtering
  - different functionalities (compression, conversion, etc)
  - IO functionalities can be combined
- package java.io

  http://download.oracle.com/javase/6/docs/api/java/io/package-summary.html

Basic IO Interfaces

	Input	Output
Char	Reader BufferedReader CharArrayReader FilterReader FileReader ...	Writer BufferedWriter CharArrayWriter FilterWriter FileWriter PrintWriter ...
Byte	InputStream ByteArrayInputStream FileInputStream FilterInputStream PipedInputStream ...	OutputStream ByteArrayOutputStream FileOutputStream FilterOutputStream PipedOutputStream ...

Reader methods

- read()

  read(char[] buf*, int off, int len*)
  - reads *len* chars
- mark(int limit), reset(), markSupported()
  - marking and resetting
- skip(long n)
  - skipping *n* chars
- close()
  - closes stream
- ready()
  - is ready to be read

Writer methods

- write(int c)

  write(char[] buf, *int off, int len*)

  write(String s, *int off, int len*)
  - writes *len* chars
- flush()
  - flushes the stream
- close()
  - closes stream
- Writer append(...)
  - similar to *write*, but returns writer
  - enables cascasding: `w.append("a").append("b");`

Special readers

- BufferedReader
  - buffers content, can read whole lines
- CharArrayReader / StringReader
  - reads from a char array or string
- FilterReader
  - abstract class with delegation implemented
- FileReader
  - reads from a file

Reader example

- Reading lines from a file
  - printing to standard output

```
FileReader fr = new FileReader(”hello.txt”);
BufferedReader br = new BufferedReader(fr);
while (true) {
      String line = br.readLine();
      if (line == null) break;
      System.out.println(line);
}
br.close();
```

Special writers

- BufferedWriter
  - buffered output
- CharArrayWriter / StringWriter
  - writes into a charArray or a String
  - toString, toArray, size, etc.
- FilterWriter
  - abstract class with delegation implemented
- FileWriter
  - writer that writes into a file
- PrintWriter
  - prints formatted data: print, println, printf, etc.

Writer example

- Print the first 10 squares
  - format: **X*X = Y**

```
FileWriter fw = new FileWriter("squares.txt");
PrintWriter pw = new PrintWriter(fw);
//PrintWriter pw =
// new PrintWriter("squares.txt", "ISO-8859-1");
for (int i = 1; i <= 10; i++) {
      pw.println(i+"*"+i+" = "+(i*i));
      //pw.printf("%d*%d = %d\n", i, i, i*i);
}
pw.close()
```

InputStream methods

- read(), read(byte[] buf*, int off, int len*)
  - reads *len* bytes
- mark(int limit), reset(), markSupported()
  - marking and resetting
- skip(long n)
  - skipping *n* bytes
- close()
  - closes stream
- ready()
  - is ready to be read
- available()
  - how many bytes can be read without blocking

OutputStream methods

- write(int c)

  write(byte[] buf, *int off, int len*)

  writes *len* bytes
- flush()
  - flushes the stream
- close()
  - closes stream

Special InputStreams

- ByteArrayInputStream
  - reads bytes from a byte array
- FileInputStream
  - reads bytes from a file
- FilterInputStream
  - abstract class with delegation methods

Special OutputStreams

- ByteArrayOutputStream
  - writes bytes into a byte array
- FileOutputStream
  - writes bytes to a file
- FilterOutputStream
  - abstract class with delegation methods

Standard IO

- java.lang.System revisited
  - *InputStream in*
    - standard input
    - byte based
  - *PrintStream out, err*
    - standard out, err
    - byte and char based

Standard IO example

- Reading from stdin, printing to stdout
  - *java.util.Scanner* later

```
InputStreamReader isr =
      new InputStreamReader(System.in);
BufferedReader br = new BufferedReader(isr);
while (true) {
      String line = br.readLine();
      if (line == null) break;
      System.out.println(line);
}
br.close();
```

java.io.File

- Meta-information about files and directories
  - trivial constructors
    - from String or other File objects
    - with path and filename
  - OS dependent info
    - path separator, directory separator
    - don't use "/", "\", ";", ":"
  - file operations
    - delete, create tmp file, access right modification
  - information
    - exists, name, parent, access rights, type, length, content

File example

- List recursively current directory

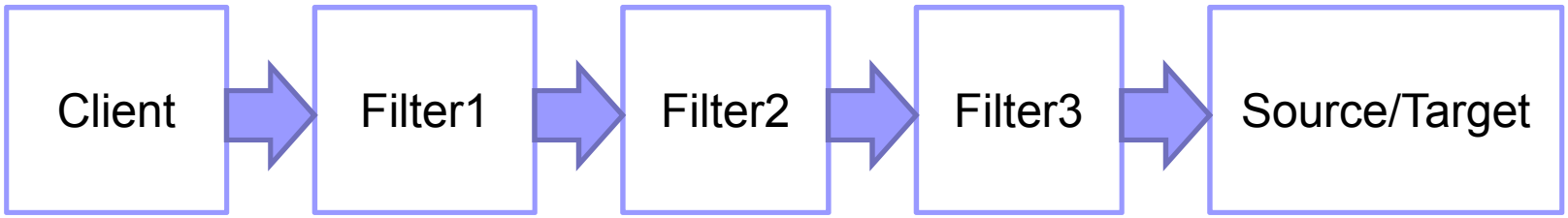
```
void lsdir(File f, String tab) {

   File[] list = f.listFiles();

   for (int i = 0; i < list.length; i++) {
      System.out.println(tab+list[i].getName());

      if (list[i].isDirectory()) {
         lsdir(list[i], tab+" ");
      }

   }
}
```

Java IO Filters

Filter pattern (decorator)

- Basic idea
  - same interface
  - modified functionality
  - calling other object's methods (delegation)
    - link of objects
- Sometimes new functionality as well
  - e.g. *BufferedReader*
    - readLine()
- Usually constructor initialization
  - `new BufferedReader(new InputStreamReader(System.in))`

Filter pattern in use



- Similar to UNIX pipelines
  - `ls -l | grep "^d" | sort -k 9 | tail -n 3`
- Data flow depends on type
  - reader / inputstream: to the left
  - writer / outputstream: to the right
- Filters don't know…
  - who called them
  - how delegee is implemented

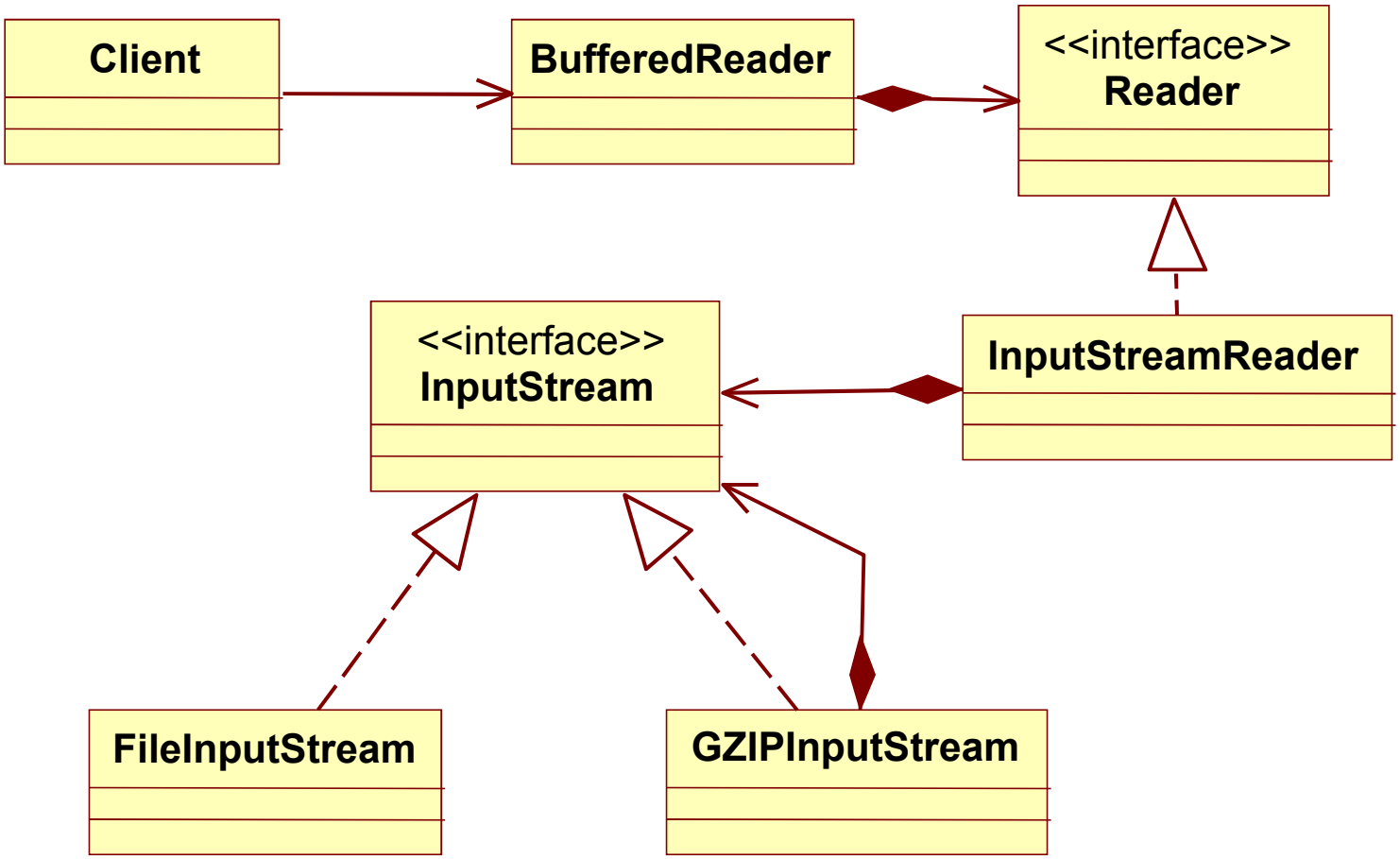
E.g.: Char and Byte conversion

- Reading
  - Source: *InputStream*
  - Client needs *Reader*
  - Solution: *InputStreamReader*
    - *Reader* interface, but *InputStream* source
- Writing
  - OutputStreamWriter
    - *Writer* interface, *OutputStream* target

E.g.: Compression 1

- GZIPInputStream
  - provide GZIP decompression
  - problem: *print lines from a GZIP compressed file*
    - *like in unix:* `zcat f.txt.gz`
  - file content: bytes
  - gzip compression: object that reads bytes, returns bytes and decompresses all along
  - lines are needed:
    - byte-char conversion
    - chars to lines

E.g.: Compression 1



E.g.: Compression 1

```
// reading bytes from file
InputStream fis = new FileInputStream("test.gz");
// un-gzipping bytes
InputStream gis = new GZIPInputStream(fis);
// converting bytes to characters
Reader isr = new InputStreamReader(gis);
// buffering characters into lines
BufferedReader br = new BufferedReader(isr);

while (true) {
      String line = br.readLine();
      if (line != null) System.out.println(line);
      else break;
}
br.close()
```

E.g.: Compression 2

- GZIPOutputStream
  - problem: *read lines and print to compressed file*

```
BufferedReader br = ...;
PrintWriter pw = new PrintWriter(
   new OutputStreamWriter(
      new GZIPOutputStream(
         new FileOutputStream("test.gz"))));
while (true) {
      String line = br.readLine();
      if (line != null) pw.println(line);
      else break;
}
br.close(); pw.close();
```

Own filter

- FilterInputStream, FilterOutputStream
- FilterReader, FilterWriter
  - same interface as superclass
  - default implementation is direct delegation
  - e.g.:

```
public int write(byte[] buf, int off, int len)
throws IOException {
        return out.write(buf, off, len);
}
```

Own filter 2

- Extend FilterXXX class
  - implement methods as you like
  - use *in* or *out* for delegation
  - don't forget constructor

```
public class MyInFilter
extends java.io.FilterInputStream {
      public MyInFilter(InputStream arg0) {
            super(arg0);
      }
      ...
}
```

Filter example: CryptoIS/1

```
public class CryptoIS extends FilterInputStream {
  int key;

  public CryptoIS(InputStream arg0, int k) {
    super(arg0);
    key = k;
  }
  private int convert(int c) {
    return c^key; // encrypt-decrypt via xor
  }
  public boolean markSupported() {
    return false;
  }
//...
```

Filter example: CryptoIS/2

```
//...
  public int read() throws IOException {
      int a = in.read();
      return (a<0) ? a : convert(a);
  }
  public int read(byte[] cbuf, int off, int len)
  throws IOException {
    int ret = in.read(cbuf, off, len);
    for (int i = 0; i < ret; i++) {
      cbuf[i+off] = (byte)convert(cbuf[i+off]);
    }
    return ret;
  }
}
```

Filter example: CryptoOS/1

```
public class CryptoOS extends FilterOutputStream {
  int key;
  public CryptoOS(OutputStream arg0, int k) {
    super(arg0);
    key = k;
  }

  private int convert(int c) {
    return c^key;
  }
  //...
```

Filter example: CryptoOS/2

```
  //...
  public void write(int b) throws IOException {
            out.write(convert(b));
  }
  public void write(byte[] cbuf, int off, int len)
  throws IOException {
    for (int i = 0; i < len; i++) {
      cbuf[i+off] = (byte)convert(cbuf[i+off]);
    }
    out.write(cbuf, off, len);
  }
}
```

Filter example: usage (to file)

```
// code snippet
try {
  OutputStream os =
    new FileOutputStream("test.txt");

  os = new CryptoOS(os, 13);

  Writer w =
    new OutputStreamWriter(os);
  PrintWriter pw = new PrintWriter(w);

  BufferedReader br = new BufferedReader(
    new InputStreamReader(System.in));
  //...
```

Filter example: usage (to file)

```
  //...

  String line;
  while (true) {
    line = br.readLine();
    if (line == null) break;
    pw.println(line);
  }
  br.close(); // only called on outermost filter
  pw.close(); // only called on outermost filter
} catch (Exception e) {
  e.printStackTrace();
}
```

Filter example: usage (from file)

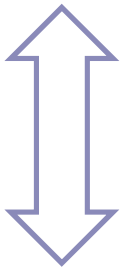
```
// code snippet
try {

  InputStream is = new
    FileInputStream("test.txt");

  is = new CryptoIS(is, 13);

  Reader r = new InputStreamReader(is);
  BufferedReader br = new BufferedReader(r);

  //...
```

Filter example: usage (from file)

```
  //...
  String line;
  while (true) {
    line = br.readLine();
    if (line == null) break;
    System.out.println(line);
  }
  br.close(); // only called on outermost filter

} catch (Exception e) {
  e.printStackTrace();
}
```

Filter example: result

```
h   e   l   l   o       w   o   r   l   d   !   \r \n
```



```
e   h   a   a   b   -   z   b  177   a   i   ,  \0  \a
101 104 97  97  98  4   122 98 127   97  105 44  0   7
65  68  61  61  62  2d  7a  62 7f    61  69  2c  00  07
```