

JAVA

Input/Output

Overview

- package java.io
 - basic input/output
 - streams
 - bytes
 - since JDK1.1 Reader and Writer
 - chars (Unicode)
- package java.nio – since JDK1.4
 - channels, buffers
 - increased performance
 - classes from java.io internally reimplemented via java.nio
- java.io.Console
 - since JDK 6
 - access to the character console (if exists)
- NIO.2 – since JDK 7
 - mainly the package java.nio.file
 - operations with files, walking trees,...

I/O

Path

Path

- `java.nio.file.Path`
 - interface
 - represents a path
 - obtaining a path
 - `Paths.get(String first, String... more)`
 - static method
 - ex.
`Path p = Paths.get("home", "petr", "text.txt");`
 - `FileSystems.getDefault().getPath(String first, String... more)`
 - `Path.get()` – uses a default filesystem

Path – methods

- path comparison
 - equals(), startsWith(), endsWith()
- relativization

```
Path p1 = Paths.get("joe");
Path p2 = Paths.get("sally");
Path p1_to_p2 = p1.relativize(p2); // -> ../sally
```
- obtaining actual path of a symlink
 - toRealPath()
- Path implements Iterable<Path>
 - iterates over the path's components
- normalize()
 - removing redundant path elements
 - d1/../d2/ => d1/d2
- ...

Path – watching for changes

- WatchKey register(WatchService watcher, WatchEvent.Kind<?>... events)

```
WatchService watchService =
    FileSystems.getDefault().newWatchService();
WatchKey key = this.path.register(watchService,
    ENTRY_CREATE, ENTRY_DELETE);
while (true) {
    for (WatchEvent<?> l : key.pollEvents()) {
        ...
    }
    boolean valid = key.reset();
    if (!valid) {
        ...
    }
}
```

java.nio.file.Files

- only static methods
 - copy(.. src, .. target, CopyOptions... options)
 - CopyOptions
 - REPLACE_EXISTING
 - COPY_ATTRIBUTES
 - NOFOLLOW_LINKS
 - move(.. src, .. target, CopyOptions... options)
 - CopyOptions
 - ATOMIC_MOVE
 - REPLACE_EXISTING
 - delete(), deleteIfExists()
 - byte[] readAllBytes(Path p)
 - List<String> readAllLines(Path path)
 - Path write(Path path, byte[] bytes, OpenOption... options)
 - Path write(Path path, Iterable<? extends CharSequence> lines, Charset cs, OpenOption... options)

CopyOptions, OpenOptions,...

- interfaces
- used in methods of the Files class
- implementations
 - StandardCopyOptions
 - enum (ATOMIC_MOVE, COPY_ATTRIBUTES,...)
 - StandardOpenOptions
 - enum (APPEND, READ, WRITE,...)
 - LinkOptions
 - enum (NOFOLLOW_LINKS)

java.nio.file.Files

- (cont.)
 - Path createLink(Path link, Path existing)
 - Path createSymbolicLink(Path link, Path target, FileAttribute<?>... attrs)
 - createDirectory(Path dir, FileAttribute<?>... attrs)
 - createDirectories(Path dir, FileAttribute<?>... attrs)
 - createFile(Path path, FileAttribute<?>... attrs)
 - createTempFile(String prefix, String suffix, FileAttribute<?>... attrs)
 - createTempFile(Path dir, String prefix, String suffix, FileAttribute<?>... attrs)
 - “test” methods
 - isDirectory()
 - isRegularFile()
 - is....()

java.nio.file.Files

- walking a file/direcotory tree
 - Path walkFileTree(Path start, FileVisitor<? super Path> visitor)
 - method of Files
 - interface FileVisitor<T>
 - FileVisitResult preVisitDirectory(T dir, BasicFileAttributes attrs)
 - FileVisitResult postVisitDirectory(T dir, IOException exc)
 - FileVisitResult visitFile(T file, BasicFileAttributes attrs)
 - FileVisitResult visitFileFailed(T file, IOException exc)

java.nio.file

- example – deleting a complete tree of files/directories

```
Path start = ...
Files.walkFileTree(start, new SimpleFileVisitor<Path>() {
    public FileVisitResult visitFile(Path f,
        BasicFileAttributes attrs) throws IOException {
        Files.delete(file);
        return FileVisitResult.CONTINUE;
    }
    public FileVisitResult postVisitDirectory(Path dir,
        IOException e) throws IOException {
        if (e == null) {
            Files.delete(dir);
            return FileVisitResult.CONTINUE;
        } else {
            throw e;
        }
    }
});
```

java.io.File

- since Java 1.0
 - java.nio.files.Path – since Java 7
 - java.io.File is not deprecated
 - used in many places in the std. library
- also represents a path
 - similar usage as Path
 - but Path has better functionality
- conversions between them
 - File.toPath()
 - Path.toFile()

Path / file separators

- fields of `java.io.File`
 - `static String pathSeparator`
 - `static char pathSeparatorChar`
 - path separator
 - `static String separator`
 - `static char separatorChar`
 - name separator in paths
- a method of `java.nio.file.FileSystem`
 - `String getSeparator()`

Streams

Overview

- since Java 1.0
- **InputStream**
 - `int read()`
 - reads one byte from an input (returns -1 if the end is reached)
 - `int read(byte[] b)`
 - reads several bytes (returns number of read bytes or -1)
- **OutputStream**
 - `void write(int b)`
 - `void write(byte[] a)`
- all other I/O classes derived from the **InputStream/OutputStream**
 - children are used
 - **InputStream** and **OutputStream** are abstract

Input streams

- `ByteArrayInputStream`
 - reads from a buffer in memory
- `StringArrayInputStream`
 - converts a string to an input stream
- `FileInputStream`
 - reads from a file
- `PipedInputStream`
 - "reading" end of a pipe
 - for data passing between threads
- `SequenceInputStream`
 - concatenation of several streams

- all of them has only basic `read()` methods
 - reading by bytes

Output streams

- `ByteArrayOutputStream`
 - writes to a buffer in memory
- `FileOutputStream`
 - writes to a file
- `PipedOutputStream`
 - "writing" end of a pipe
 - for data passing between threads
- **no** `StringArrayOutputStream`
 - `ByteArrayOutputStream` can be used
- all of them has only basic `write()` methods
 - writing by bytes

Filters

- `FilterInputStream`
- `FilterOutputStream`
- **abstract classes**
 - many children
- via filters, further functionality is added to the basic streams
 - a filter receives another stream as a parameter of the constructor
 - data are read/written through the filter
- basic streams are almost always used via a stream
- several filters can be applied over a single stream

Types of filters

- `DataOutputStream`
 - defines the write method for all primitive types
- `DataInputStream`
 - defines the read method for all primitive types
 - reads data in the same format as written by `DataOutputStream`
 - the format is platform independent
- `BufferedInputStream`
- `BufferedOutputStream`
 - do not add new read/write methods
 - I/O will be buffered
 - basic streams are not
 - capacity of the buffer can be specified

Types of filters

- `LineNumberInputStream`
 - **information about current line**
- `PushbackInputStream`
 - **can return data back to the stream**

Types of filters

- `PrintStream`
 - writes data in a human readable form
 - `DataOutputStream` writes data to be read by `DataInputStream`
 - defines methods `print()` and `println()` for "all" types
 - method `printf()`
 - as `printf` in C
 - method `flush()`
 - writes the buffer to an underlying stream
 - `PrintStream` is automatically buffered
 - `flush()` is called automatically when a new line is written
 - autoflush after each write can be set in a constructor
 - methods do not throw `IOException`
 - method `checkError()`

Usage

- layering filters over basic I/O streams

```
DataInputStream di = new DataInputStream(  
    new BufferedInputStream (  
        new FileInputStream("file.txt")));  
int a = di.readInt();  
long b = di.readLong();
```

```
DataOutputStream ds = new DataOutputStream(  
    new BufferedOutputStream (  
        new FileOutputStream("file.txt")));  
ds.writeInt(100);  
ds.writeLong(1234L);
```

Reader & Writer

Overview

- since Java 1.1
- char-oriented I/O
 - char = 2 bytes
- streams are not deprecated
 - few of them are
- `Reader`
 - defines the `read` method for reading a char and array of chars
- `Writer`
 - defines the `write` method for writing a char and array of chars
- `Reader` and `Writer` – **abstract classes**
- `InputStreamReader`, `OutputStreamWriter`
 - creating `Reader/Writer` from a stream

Types of I/O

- similar to streams

InputStream	Reader
	InputStreamReader
OutputStream	Writer
	OutputStreamWriter
FileInputStream	FileReader
FileOutputStream	FileWriter
StringBufferInputStream	StringReader
-	StringWriter
ByteArrayInputStream	CharArrayReader
ByteArrayOutputStream	CharArrayWriter
PipedInputStream	PipedReader
PipedOutputStream	PipedWriter

Filters

- again similar to streams

FilterInputStream	FilterReader
FilterOutputStream	FilterWriter
BufferedInputStream	BufferedReader
BufferedOutputStream	BufferedWriter
PrintStream	PrintWriter
LineNumberInputStream	LineNumberReader
PushbackInputStream	PushbackReader

Exception management

Exceptions

- almost “everything” in java.io throws IOException
 - extends Exception
 - needs to be caught/declared
- stream and readers/writers implements AutoCloseable
 - always use *try with resources*

File copy

```
try (InputStream is = new FileInputStream(finNm);
     OutputStream os = new FileOutputStream(foutNm)) {
    int c;
    while ((c = is.read()) != -1) {
        os.write(c);
    }
} catch (IOException ex) {
    // ...
}
```

GOOD

```
InputStream is;
OutputStream os;
try {
    is = new FileInputStream(finNm);
    os =
        new FileOutputStream(foutNm);
    int c;
    while ((c = is.read()) != -1) {
        os.write(c);
    }
    os.close(); is.close();
} catch (IOException ex) {
    // ...
}
```

BAD

RandomAccessFile

Overview

- reading and writing records from/to files
- movement over the file
- outside hierarchy of streams
- implements the interfaces `DataInput` and `DataOutput`
 - these interfaces are implemented by `DataInputStream` resp. `DataOutputStream`
 - methods `read` and `write` for primitive types
- opens the file for either reading only or reading and writing
 - the constructor parameter
 - "r" or "rw"

java.nio

NIO

Overview

- “new I/O”
- since JDK1.4
- better performance
 - closer to structures of I/O in OS
- classes from `java.io` (stream and reader/writer) reimplemented by classes from `java.nio`
- defines *channels* and *buffers*
 - communication with a channel is by buffer only
- `FileInputStream`, `FileOutputStream` and `RandomAccessFile`
 - **new method** `FileChannel getChannel()`
- `java.nio.channels.Channels`
 - methods for creation of Readers and Writers from channels

Usage

- `java.nio.ByteBuffer`
 - only possibility for communication with a channel

```
FileChannel fc =
    new FileOutputStream("data.txt").getChannel();
fc.write(ByteBuffer.wrap("Some text ".getBytes()));
fc.close();
```

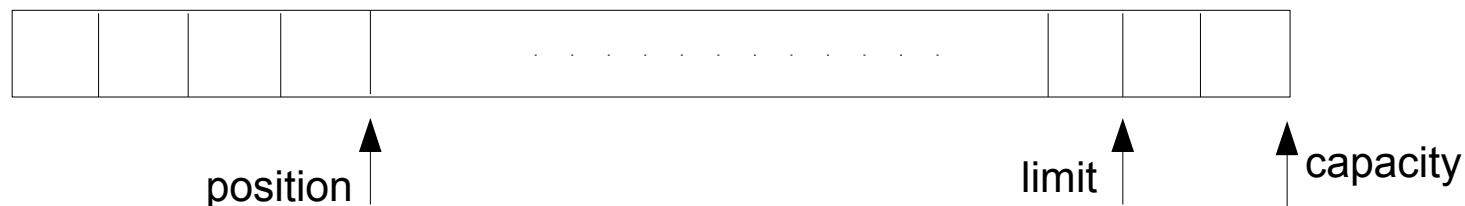
```
fc = new FileInputStream("data.txt").getChannel();
ByteBuffer buff = ByteBuffer.allocate(1024);
fc.read(buff);
buff.flip();
while(buff.hasRemaining())
    System.out.print((char)buff.get());
```

Buffer creation

- `ByteBuffer.wrap(byte[] b)`
 - static method
 - creates a buffer from an array of bytes
 - buffer is interconnected with the array
 - buffer capacity = `b.length`
- `ByteBuffer.allocate(int capacity)`
 - static method
 - allocates an empty buffer with specified capacity
- `ByteBuffer.allocateDirect(int capacity)`
 - static method
 - allocated buffer is “more” tied with OS
 - usage of the buffer should be faster
 - depends on OS

Buffer

- capacity
 - how many elements buffer contains
 - cannot be increased
- limit
 - index of the first element that will not be read or written
 - cannot be bigger than capacity
- position
 - index of the first element that will be written or read on a following operation
 - cannot be bigger than limit



Buffer: methods

- flip()
 - sets the limit to the current position and
 - sets the position to 0
- clear()
 - sets the limit to the capacity and
 - sets the position to 0
- mark()
 - sets the mark to the current position
- reset()
 - sets the position to the mark
 - does not remove the mark
- rewind()
 - sets the position to 0 and removes the mark

Copying between channels

- methods `transferTo()` and `transferFrom()`

```
public static void main(String[] args) throws
                                Exception {

    FileChannel
        in = new FileInputStream(args[0]).getChannel(),
        out = new FileOutputStream(args[1]).getChannel();

    in.transferTo(0, in.size(), out);

    // or:
    // out.transferFrom(in, 0, in.size());
}
```

Using buffer

- views on buffers
- reading and writing primitive types
- methods on the ByteBuffer
 - asCharBuffer()
 - asDoubleBuffer()
 - asFloatBuffer()
 - asIntBuffer()
 - asLongBuffer()

```
ByteBuffer bb = ByteBuffer.allocate(1024);  
bb.asIntBuffer().put(1234);  
System.out.println(bb.getInt());
```

Endian

- by default the `ByteBuffer` uses *big endian*
- can be changed to *little endian*
 - method `order(ByteOrder b)`
 - the class `ByteOrder` has two static attributes of the type `ByteOrder`
 - `BIG_ENDIAN`
 - `LITTLE_ENDIAN`

Files mapped to the memory

- accessing a file like an array in memory
- method on a channel
 - MappedByteBuffer map()

```
public class LargeMappedFiles {
    static int length = 0x8FFFFFFF; // 128 Mb
    public static void main(String[] args) throws Exception {
        MappedByteBuffer out =
            new RandomAccessFile("test.dat", "rw").getChannel()
                .map(FileChannel.MapMode.READ_WRITE, 0, length);
        for(int i = 0; i < length; i++)
            out.put((byte) 'x');

        for(int i = length/2; i < length/2 + 6; i++)
            System.out.print((char) out.get(i));
    }
}
```

File locking

```
FileOutputStream fos = new
FileOutputStream("file.txt");
FileLock fl = fos.getChannel().tryLock();
if (fl != null) {
    System.out.println("File locked.");
    Thread.sleep(100);
    fl.release();
    System.out.println("File unlocked");
}
fos.close();
```

- exact behavior depends on OS
- only a part of file can be locked
- lock() – waits until a file is locked
- tryLock() – does not wait

... back to Path/Files

Opening files

- methods of Files
 - `BufferedReader newBufferedReader(Path p, Charset cs)`
 - `BufferedWriter newBufferedWriter(Path p, Charset cs, OpenOption... opts)`
 - `InputStream newInputStream(Path p, OpenOption... opts)`
 - `OutputStream newOutputStream(Path p, OpenOption... opts)`
 - `SeekableByteChannel newByteChannel(Path p, OpenOption... opts)`
 - `DirectoryStream<Path> newDirectoryStream(Path dir)`
 - ...

Console

Console

- access to the char console
 - not always available
- `System.console()`
 - obtaining the console
- `Console printf(String format, Object... args)`
 - as `printf()` in C
- `String readLine()`
 - returns a line (without the new line char at the end)
- `char[] readPassword()`
 - returns a line (without the new line char at the end)
 - typed characters are not shown
- `Reader reader()`
- `PrintWriter writer()`
 - returns reader/writer associated with the console

I/O

Compression

Overview

- package `java.util.zip`
- compression via filters
 - `FilterInputStream` and `FilterOutputStream`
- `CheckedInputStream`, `CheckedOutputStream`
 - provides check-sums of read/written data
- `InflaterInputStream`, `DeflaterOutputStream`
 - basic classes for compression and decompression
- `GZIPInputStream`, `GZIPOutputStream`
 - compression in the GZIP format
- `ZipInputStream`, `ZipOutputStream`
 - compression in the ZIP format

GZIP

- compression of a single file
- compatible with the UNIX programs gzip and gunzip

```
BufferedInputStream in = new BufferedInputStream(  
    new FileInputStream(args[0]));  
BufferedOutputStream out = new  
    BufferedOutputStream(  
        new GZIPOutputStream(  
            new FileOutputStream("test.gz")));  
int c;  
while((c = in.read()) != -1)  
    out.write(c);  
in.close();  
out.close();
```

ZIP

- compression of multiple files into a single archive
- compatible with ZIP programs
- creating an archive
 - `ZipOutputStream`
 - the method `putZipEntry(ZipEntry ze)`
 - next file to the archive
 - the class `ZipEntry`
 - name of the file
 - information about the file (size before/after compression, comment, check-sum,...)
- reading from an archive
 - `ZipInputStream`
 - the method `getNextEntry()`
 - `ZipFile`
 - the method `entries()` - returns `Enumeration`

ZIP

```
ZipOutputStream zos = new ZipOutputStream(  
    new BufferedOutputStream(  
        new FileOutputStream("test.zip")));  
zos.setComment("Test ZIP");  
for(int i = 0; i < args.length; i++) {  
    System.out.println("Storing a file: " + args[i]);  
    BufferedInputStream in = new BufferedInputStream(  
        new FileInputStream(args[i]));  
    zos.putNextEntry(new ZipEntry(args[i]));  
    int c;  
    while((c = in.read()) != -1)  
        zos.write(c);  
    in.close();  
}  
zos.close();
```



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