

Date and Time, I/O Streams

Agenda

- Java 7 Date Time API
- Java 8 Date Time API
- Typical Uses of I/O System
- What Is a Stream?
- Byte Oriented Streams
- Character-Oriented Streams
- Buffered Input / Output

Java 7 Date Time API

Backstory

- The **Date** class was the work of James Gosling and Arthur van Hoff.
- Added in JDK 1.0, mostly deprecated in JDK 1.1, never removed.
- IBM donated **Calendar** class code to Sun.



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The Date class

- The **Date** class available in `java.util` package, this class encapsulates the ***current date*** and ***time***.
- The **Date** class supports two constructors.
- **Date ()**
This constructor initializes the object with the ***current date*** and ***time***.
- **Date (long millisec)**
This constructor accepts an argument that equals the ***number of milliseconds*** that have elapsed since **midnight, January 1, 1970**.

Getting Current Date and Time

- The **Date** object stores information about current date and time.

```
// Instantiate a Date object
```

```
Date date = new Date();
```

```
Fri Feb 07 09:40:51 EET
```

```
2020
```

```
// Display time and date using toString()
```

```
System.out.println(date);
```

- Methods **getTime()** and **System.currentTimeMillis()** return the current date and time as milliseconds since **January 1st 1970**.

```
Date date = new Date();
```

```
long currentTime1 = date.getTime();
```

```
System.out.println(currentTime1);
```

```
1581061806149
```

```
1581061806149
```

```
long currentTime2 = System.currentTimeMillis();
```

```
System.out.println(currentTime2);
```

Useful Methods of the Date class

- **long getTime()**
Returns the number of milliseconds that have elapsed since January 1, 1970.
- **void setTime(long time)**
Sets the time and date as specified by time, which represents an elapsed time in milliseconds from midnight, January 1, 1970.
- **boolean after(Date date)**
Returns true if the invoking Date object contains a date that is later than the one specified by date, otherwise, it returns false.
- **boolean before(Date date)**
Returns true if the invoking Date object contains a date that is earlier than the one specified by date, otherwise, it returns false.
- **int compareTo(Date date)**
Compares the value of the invoking object with that of date.

Problems Getting a Date class

- Conceptually an instant, not a date
- Properties have random offsets:
 - Some **zero-based**, like **month** and **hours**
 - Some **one-based**, like **day of the month**
 - **Year** has an **offset of 1900**
- Mutable, not thread-safe
- Not internationalizable
- Millisecond granularity
- Does not reflect UTC



The GregorianCalendar Class

```
Calendar calendar = new GregorianCalendar();

//set date to 05.02.2020 15:37
calendar.set(Calendar.YEAR, 2020);
calendar.set(Calendar.MONTH, 1); // 1 = February
calendar.set(Calendar.DAY_OF_MONTH, 5);
calendar.set(Calendar.HOUR_OF_DAY, 15); // 24 hour
clock
calendar.set(Calendar.MINUTE, 37);

// get date components
int year = calendar.get(Calendar.YEAR);
int month = calendar.get(Calendar.MONTH);
int dayOfMonth = calendar.get(Calendar.DAY_OF_MONTH);
int hourOfDay = calendar.get(Calendar.HOUR_OF_DAY);
int minute = calendar.get(Calendar.MINUTE);
int second = calendar.get(Calendar.SECOND);

//add one day
calendar.add(Calendar.DAY_OF_MONTH, 1);

Date date = calendar.getTime();

System.out.println(date);
```

Thu Feb 06 15:37:27 EET
2020

- The **GregorianCalendar** is a concrete implementation of a **Calendar** class that implements the **normal Gregorian calendar** with which you are familiar.
- The **getInstance()** method of **Calendar** returns a **GregorianCalendar** initialized with the **current date and time** in the default locale and time zone.

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Useful Methods of the Calendar class

- **`void add(int field, int amount)`**
Adds the specified (signed) amount of time to the given time field, based on the calendar's rules.
- **`int get(int field)`**
Gets the value for a given time field.
- **`Date getTime()`**
Gets this Calendar's current time.
- **`long getTimeInMillis()`**
Gets this Calendar's current time as a long.
- **`boolean isLeapYear(int year)`**
Determines if the given year is a leap year.

Useful Methods of the Calendar class

- **`void set(int field, int value)`**
Sets the time field with the given value.
- **`void set(int year, int month, int date)`**
Sets the values for the fields year, month, and date.
- **`void setTime(Date date)`**
Sets this Calendar's current time with the given Date.
- **`void setTimeInMillis(long millis)`**
Sets this Calendar's current time from the given long value.
- **`void setGregorianChange(Date date)`**
Sets the GregorianCalendar change date.

Problems Getting a Calendar class

- Conceptually an instant, not a calendar.
- Zero-based offsets
- Stores internal state in two different ways
 - *milliseconds from epoch*
 - *set of fields*
- Has bugs and performance issues
- Mutable, not thread-safe



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Java 8 Date Time API

Backstory

- 2002 - Stephen Colebourne starts open source Joda-Time project
- 2005 - Release of Joda-Time 1.0
- 2007 - JSR 310, for inclusion in Java
- 2011 - Release of Joda-Time 2.0
- 2014 - Finally, the date and time API is in Java 8

New Packages

- **`java.time`**
instants, durations, dates, times, time zones, periods.
- **`java.time.format`**
formatting and parsing.
- **`java.time.temporal`**
field, unit, or adjustment access to temporals.
- **`java.time.zone`**
support for time zones.
- **`java.time.chrono`**
calendar systems other than ISO-8601.



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Design Principles

- Distinguish between machine and human views.
- Well-defined and clear purpose.
- Immutable, thread-safe.
- Reject **null** and bad arguments early.
- Extensible, by use of strategy pattern.
- Fluent interface with chained methods.

Commonly Used Classes

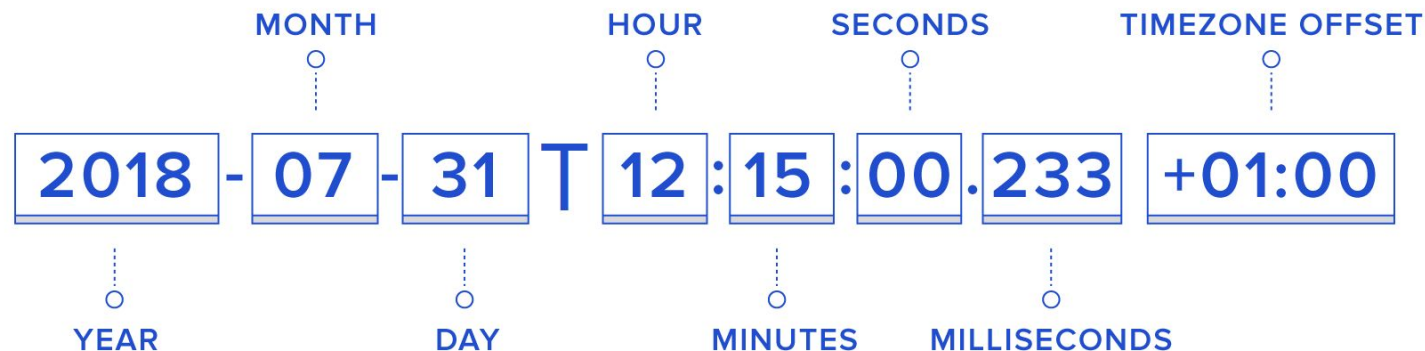
- **LocalDate**
 - ISO 8601 *date without time zone* and *time*
 - Corresponds to SQL DATE type
- **LocalTime**
 - ISO 8601 *time without time zone* and *date*
 - Corresponds to SQL TIME type
- **LocalDateTime**
 - ISO 8601 *date* and *time without time zone*
 - Corresponds to SQL TIMESTAMP type
- **DateTimeFormatter**

Formatter for displaying and parsing date-time objects



The ISO 8601 Standard

- The **International standard** for representation of ***dates*** and ***times***.
- Uses the ***Gregorian calendar system***.
- Ordered from most to least significant: *year, month, day, hour, minute*.
- Each date and time value has a ***fixed number of digits with leading zeros***.
- Uses four-digit year at minimum, **YYYY**.



The LocalDate Class

- Obtain a **LocalDate** object corresponding to the *local date of today*.

```
LocalDate localDateNow = LocalDate.now();  
System.out.println(localDateNow);
```

2020-02-07

- Create a **LocalDate** object from *year, month* and *day* information.

```
LocalDate localDate = LocalDate.of(2020, Month.MARCH, 16);  
System.out.println(localDate);
```

2020-03-16

The LocalDate Class

- Access the date information of a `LocalDate` object.

```
int year = localDate.getYear();
Month month = localDate.getMonth();
int dayOfMonth = localDate.getDayOfMonth();
int dayOfYear = localDate.getDayOfYear();
DayOfWeek dayOfWeek = localDate.getDayOfWeek();

System.out.println("Year: " + year);
System.out.println("Month: " + month);
System.out.println("Day of Month: " + dayOfMonth);
System.out.println("Day of Year: " + dayOfYear);
System.out.println("Day of Week: " + dayOfWeek);
```

```
Year: 2020
Month: MARCH
Day of Month: 16
Day of Year: 76
Day of Week: MONDAY
```

The LocalDate Class

- Simple date calculations with the `LocalDate` object.

```
LocalDate localDate = LocalDate.of(2020, Month.MARCH, 16);  
System.out.println(localDate);  
  
localDate = localDate.minusYears(2);  
localDate = localDate.plusMonths(5);  
localDate = localDate.minusDays(132);  
localDate = localDate.plusWeeks(4);  
System.out.println(localDate);
```

2020-03-16

2018-05-04

The `LocalTime` Class

- Create a `LocalTime` object that represents the *exact time of now*.

```
LocalTime localTimeNow = LocalTime.now();  
System.out.println(localTimeNow);
```

```
12:10:18.625
```

- Create a `LocalTime` object from a specific *amount of hours, minutes, seconds* and *nanoseconds*.

```
LocalTime localTime = LocalTime.of(15, 30, 25, 845);  
System.out.println(localTime);
```

```
15:30:25.000000855
```

The `LocalTime` Class

- Access the time information of a `LocalTime` object.

```
int hour = localTime.getHour();
int minute = localTime.getMinute();
int second = localTime.getSecond();
int nanoOfSeconds = localTime.getNano();

System.out.println("Hour: " + hour);
System.out.println("Minute: " + minute);
System.out.println("Second: " + second);
System.out.println("Nano of Seconds: " + nanoOfSeconds);
```

```
Hour: 15
Minute: 30
Second: 25
Nano of Seconds: 845
```

The `LocalTime` Class

- Simple time calculations with the `LocalTime` object.

```
LocalTime localTime = LocalTime.of(15, 30, 25, 845);  
System.out.println(localTime);
```

```
15:30:25.000000845
```

```
localTime = localTime.minusHours(27);  
localTime = localTime.plusMinutes(179);  
localTime = localTime.minusSeconds(683);  
localTime = localTime.plusNanos(8345);  
System.out.println(localTime);
```

```
15:18:02.000009190
```


The LocalDateTime Class

- The `LocalDateTime` class represents a local date and time ***without any time zone information***.
- You could view the `LocalDateTime` as a combination of the `LocalDate` and `LocalTime` classes.

```
LocalDateTime localDateTime = LocalDateTime  
    .of(2020, Month.MARCH, 16, 15, 30, 25, 845);  
  
System.out.println(localDateTime);
```

```
2020-03-16T15:30:25.000000845
```

The DateTimeFormatter Class

- The `DateTimeFormatter` class is used to *parse* and *format dates* represented with the classes in the Java 8 date time API.
- The `DateTimeFormatter` class contains a *set of predefined constant* which can *parse* and *format dates* from *standard date formats*.
- Each of these predefined `DateTimeFormatter` instances are *preconfigured* to format and *parse dates to / from different formats*.

```
// Some of DateTimeFormatter constant
DateTimeFormatter.BASIC_ISO_DATE

DateTimeFormatter.ISO_LOCAL_DATE
DateTimeFormatter.ISO_LOCAL_TIME
DateTimeFormatter.ISO_LOCAL_DATE_TIME

DateTimeFormatter.ISO_DATE
DateTimeFormatter.ISO_TIME
DateTimeFormatter.ISO_DATE_TIME

DateTimeFormatter.ISO_WEEK_DATE
DateTimeFormatter.ISO_ZONED_DATE_TIME
DateTimeFormatter.ISO_INSTANT
```

The DateTimeFormatter Class

- The `format()` method is declared on both the *formatter objects* and the *date/time objects*.

```
LocalDateTime localDateTime = LocalDateTime.now();  
System.out.println(localDateTime);
```

```
String basicIsoDate = localDateTime.format(  
    DateTimeFormatter.BASIC_ISO_DATE);  
String isoDateTime = localDateTime.format(  
    DateTimeFormatter.ISO_DATE_TIME);  
String isoLocalDateTime = localDateTime.format(  
    DateTimeFormatter.ISO_LOCAL_DATE_TIME);  
String isoWeekDate = localDateTime.format(  
    DateTimeFormatter.ISO_WEEK_DATE);
```

```
2020-02-07T13:16:46.454  
20200207  
2020-02-07T13:16:46.454  
2020-02-07T13:16:46.454  
2020-W06-5
```

Others useful Classes and Interfaces

- **Temporal**

Basic interface for **DateTime** classes

LocalDate / **LocalTime** / **LocalDateTime** ...

- **Instant**

Start of nanoseconds in timeline. Useful for timestamp

- **Clock**

Allowing **Temporal** creation with alternate clock

- **TemporalAmount**

Basic interface for classes that represent amount of time

Duration / **Period**

The Instant Class

- Point on a discretized time-line
- Stored to nanosecond resolution
 - `long` for seconds since epoch, and
 - `int` for nanosecond of second
- Convert to any date time field using a **Chronology**
- Use for event time-stamps

The Clock Class

- Gets the current instant using a time-zone

Use instead of `System.currentTimeMillis()`

Use an alternate clock for testing `Clock`

```
ZoneId zoneId = ZoneId.of("Europe/Kiev");  
ZonedDateTime localDateTime = ZonedDateTime.now(Clock.system(zoneId));  
  
System.out.println(localDateTime);
```

```
2020-02-07T13:48:25.821+02:00[Europe/Kiev]
```

The Period Class

- A length of elapsed time. Defined using calendar fields
years, months, and days (not minutes and seconds).
- Takes time zones into account for calculation.

```
LocalDateTime localDateTime = LocalDateTime.now();  
String dateTime = localDateTime.format(  
    DateTimeFormatter.ofLocalizedDateTime(FormatStyle.MEDIUM));  
System.out.println(dateTime);
```

```
Period period = Period.of(2, 7, 15);  
localDateTime = localDateTime.plus(period);
```

```
dateTime = localDateTime.format(  
    DateTimeFormatter.ofLocalizedDateTime(FormatStyle.MEDIUM));  
System.out.println(dateTime);
```

```
7 ЛЮТ. 2020 14:00:56  
22 ВЕР. 2022 14:00:56
```

The Duration and Chronology

- The **Duration** class
 - Precise length of elapsed time, in nanoseconds
 - Does not use date-based constructs like years, months, and days
 - Can be negative, if end is before start
- The **Chronology** interface
 - Pluggable calendar system
 - Provides access to date and time fields
 - Built-in
 - ISO8601 (default): **IsoChronology**
 - Chinese: **MinguoChronology**
 - Japanese: **JapaneseChronology**
 - Thai Buddhist: **ThaiBuddhistChronology**
 - Islamic: **HijrahChronology**



Staying Constant

- Day of week, for example

`DayOfWeek.FRIDAY`

- Month , for example

`Month.MAY`

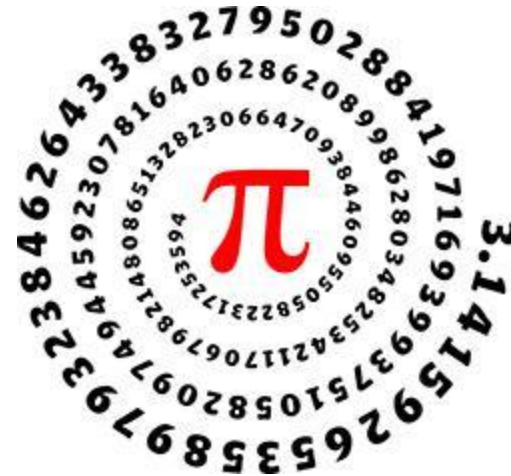
- Time units, for example

`ChronoUnit.DAYS`

- Other useful constants:

`LocalTime.MIDNIGHT` // 00:00

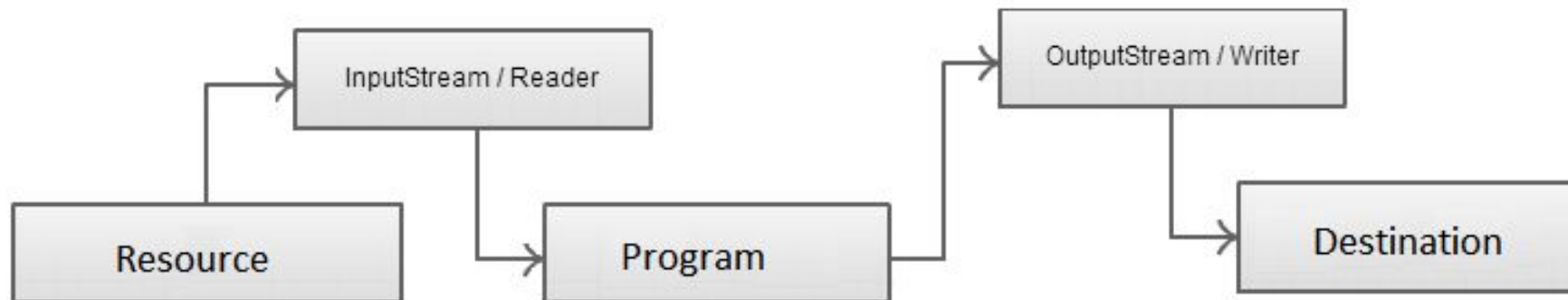
`LocalTime.NOON` // 12:00



Input/Output Streams API

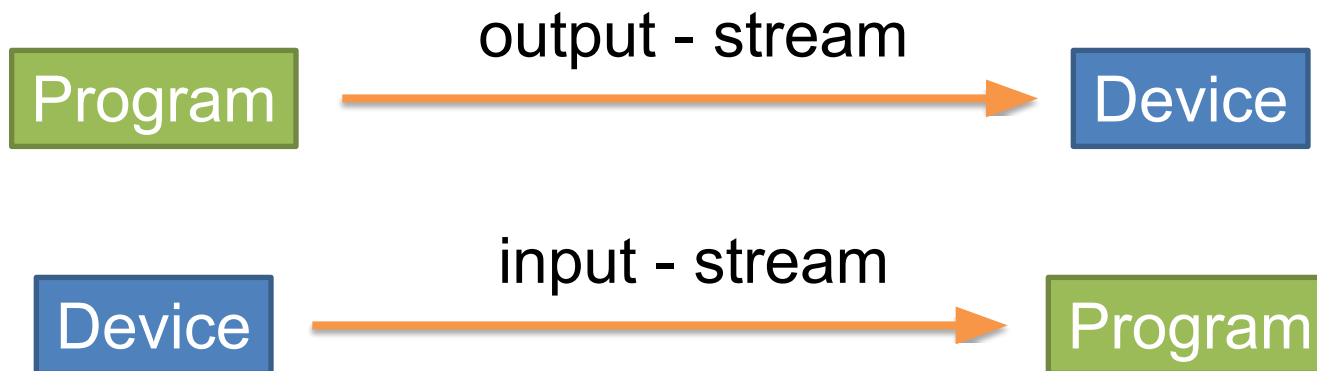
What Is a Stream?

- A **stream** is an ***ordered sequence of bytes*** of undetermined length.
- **Input streams** move bytes of data ***from some generally external source to Java program***.
- **Output streams** move bytes of data ***from Java program to some generally external source***.



Streams

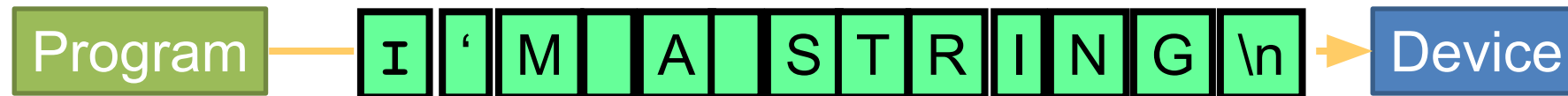
- Usual Purpose:
Storing data to «nonvolatile» devices, e.g. harddisk.
- Classes provided by package `java.io`.
- Data is ***transferred*** to devices by **streams**



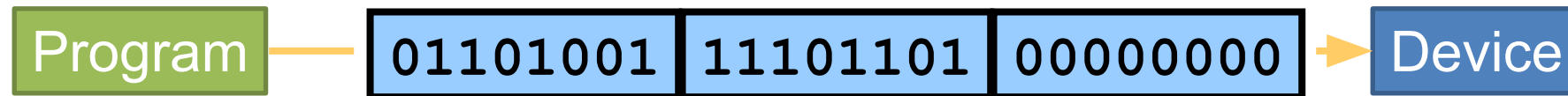
Streams

- JAVA distinguishes between **2 types** of **streams**:

- **Text Streams**, containing "*characters*"



- **Binary Streams**, containing **8 bit information**



Streams

- Streams in JAVA are ***Objects***, of course!
 - **2 types** of streams (**text** / **binary**) and
 - **2 directions** (**input** / **output**)
- Results in **4 base-classes** dealing with **I/O**:
 1. **Reader** : text-input
 2. **Writer** : text-output
 3. **InputStream** : byte-input
 4. **OutputStream** : byte-output



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The File Class

- A `File` object can refer to *either a file*:

```
File file = new File("data.txt");
```

- or a *directory*:

```
File file = new File("D:\\development");
```

The File Class

```
String dirName = "D:\\Development";
String fileName = "data.txt";

File newDirectory = new File(dirName);
boolean isDirCreated = newDirectory.mkdir();

if (isDirCreated) {
    File newFile = new File(dirName + File.separator + fileName);
    boolean isFileCreated = newFile.createNewFile();

    if (isFileCreated) {
        System.out.println(newFile.getCanonicalPath());
    }
}
```


Useful Methods of the File class

- **isFile() / isDirectory()**

Returns **true** if and only if the file denoted by this abstract pathname is a file (directory).

- **canRead()**

Returns **true**, if the specified file exists its path name and the file is allowed to be read by the application.

- **canWrite()**

Returns **true** if the application to write to the file, else the method returns **false**.

- **length()**

Length of the file in bytes (**long**) or 0 if nonexistent.

- **list()**

If the **File** object is a directory, returns a **String** array of all the files and directories contained in the directory; otherwise, **null**.

- **mkdir()**

Creates a new subdirectory.

- **delete()**

Deletes the directory or file and returns **true** if successful.

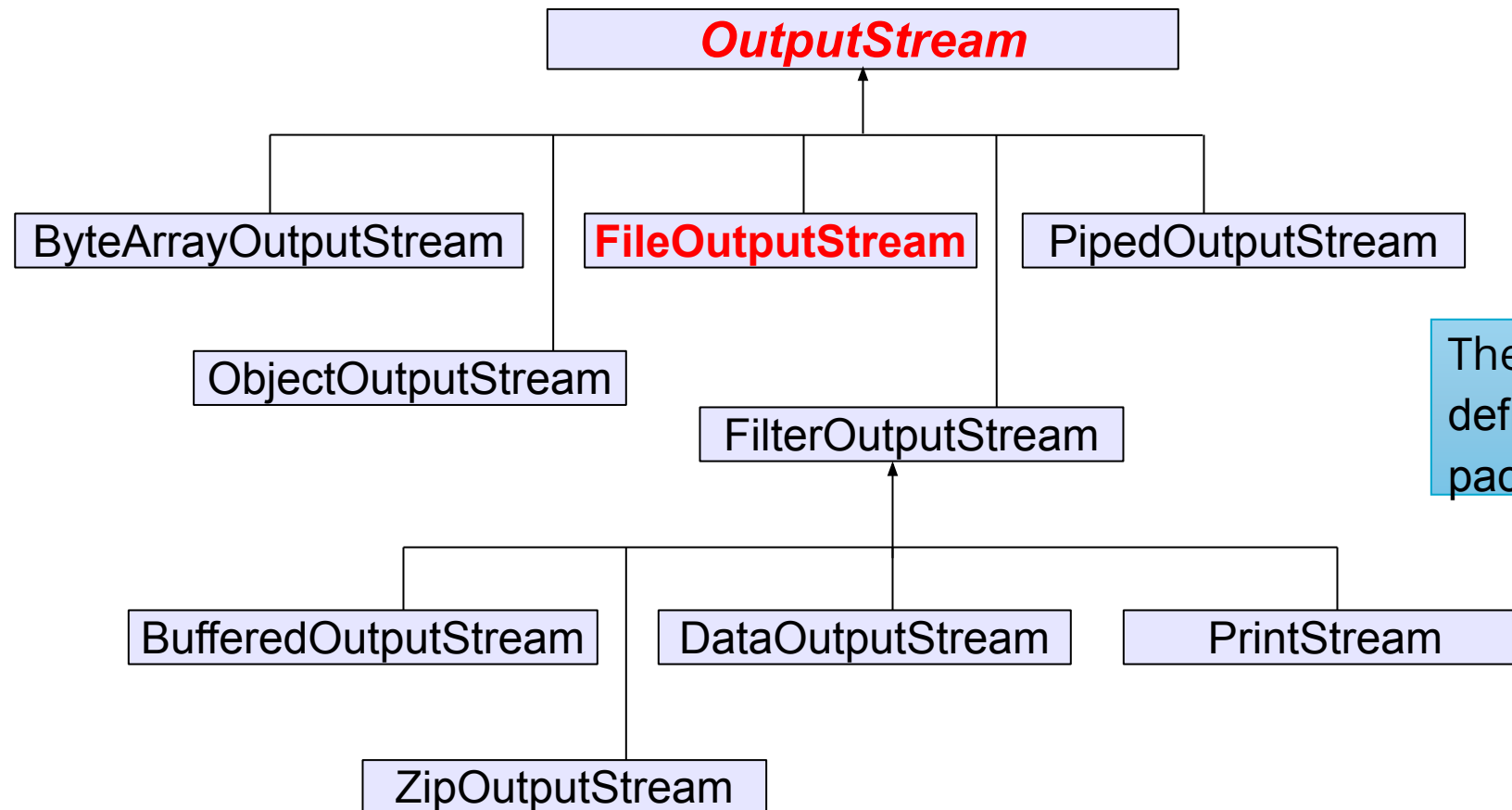
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Binary Files

- Stores ***binary images of information*** identical to the binary images stored in main memory.
- Example: *writing of the integer '42'*
 - Text-File: "**42**" (internally translated to 2 **16-bit** representations of the characters '**4**' and '**2**')
 - Binary-File: **00101010**, one byte (= **42** decimal)

Byte-Oriented Output Stream Classes

- The following is the *byte-oriented output stream* class hierarchy:



The `ZipOutputStream` is defined in `java.util.zip` package

Methods of OutputStream Class

- Writing data:
 - **write(...)** methods write data to the stream. Written data is buffered.
 - Use **flush()** method to flush any buffered data from the stream.
 - throws **IOException** if an I/O error occurs.
- There are **3** main write methods:
 - **void write(int data)**
Writes a single character (even though data is an integer, data must be set such that: $0 \leq \text{data} \leq 255$)
 - **void write(byte[] buffer)**
Writes all the bytes contained in buffer to the stream
 - **void write(byte[] buffer, int offset, int length)**
Writes length bytes to stream starting from **buffer[offset]**

Methods of OutputStream Class

- **flush()**
 - To improve performance, almost all output protocols buffer output.
 - Data written to a stream is not actually sent until buffering thresholds are met.
 - Invoking **flush()** causes the **OutputStream** to clear its internal buffers.
- **close()**
 - Closes stream and releases any system resources.

Creating a FileOutputStream Instance

```
String fileName = "data.txt";

String str = "Hello I/O!";
byte[] wData = str.getBytes();

try (FileOutputStream fileOutputStream =
        new FileOutputStream(fileName /*, true */)) {

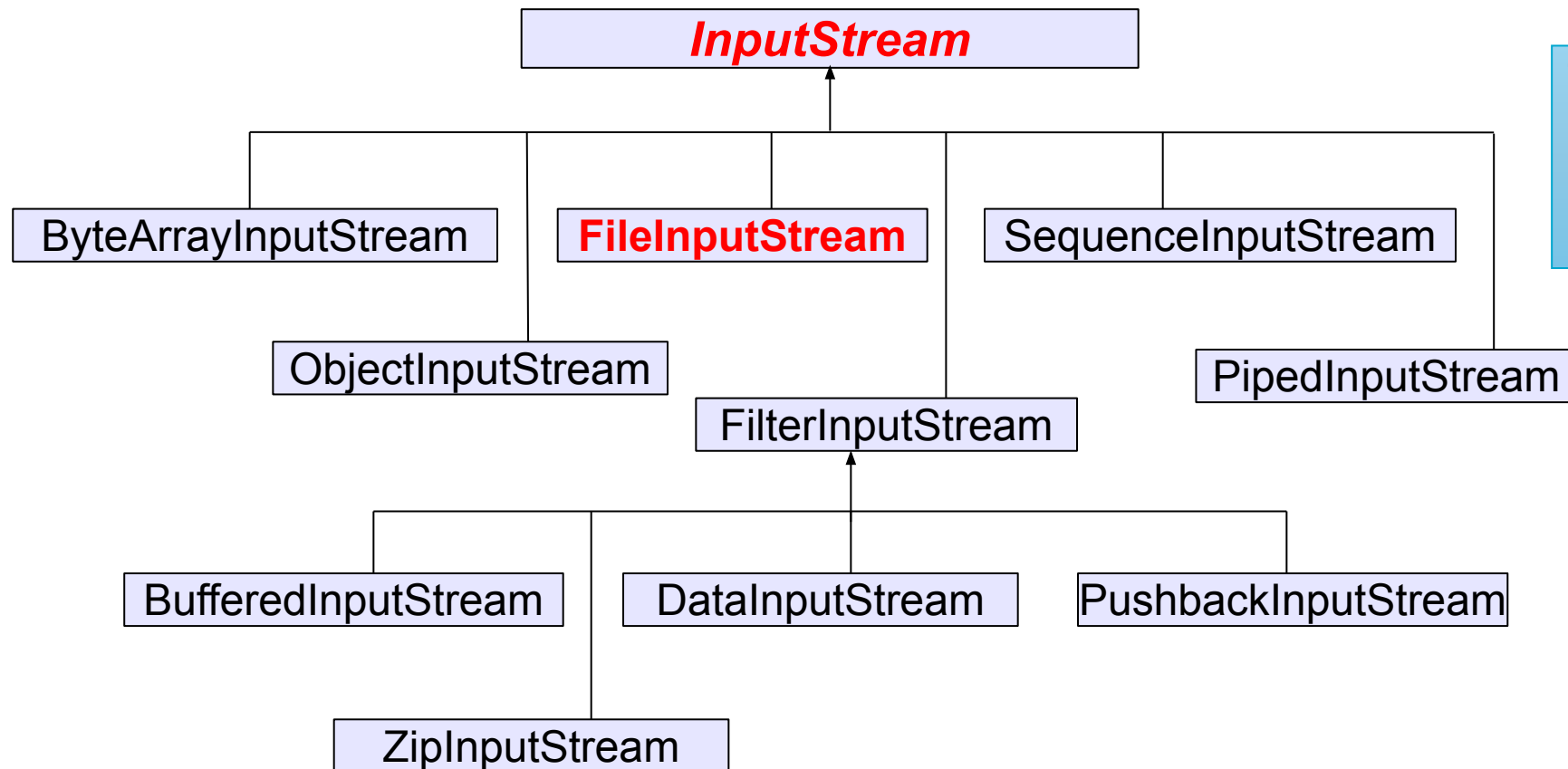
    fileOutputStream.write(wData);
    System.out.println("Was wrote " + wData.length + " bytes");

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

```
Was wrote 10 bytes
```

Byte-Oriented Input Stream Classes

- The following is the *byte-oriented input stream* class hierarchy:



The **ZipInputStream** is defined in `java.util.zip` package

Methods of InpupStream Class

- Reading data:
 - **read()** methods will block until data is available to be read and return the number of bytes read.
 - **-1** is returned if the Stream has ended.
 - throws **IOException** if an I/O error occurs.
- There are 3 main read methods:
 - **int read()**
Reads a single byte. Returns it as integer.
 - **int read(byte[] buffer)**
Reads bytes and places them into buffer. Returns the number of bytes read.
 - **int read(byte[] buffer, int offset, int length)**
Reads up to length bytes and places them into buffer. First byte read is stored in **buffer[offset]**. Returns the number of bytes read.

Methods of InpupStream Class

- **available()**
Returns the number of bytes which can be read without blocking.
- **skip(long n)**
Skips over a number of bytes in the input stream.
- **close()**
Closes stream and release any system resources.

Creating a FileInputStream Instance

```
byte[] rData = new byte[15];

try (FileInputStream fileInputStream = new FileInputStream(fileName)) {

    int byteAvailable = fileInputStream.available();
    int byteCount = fileInputStream.read(rData, 0, byteAvailable);

    System.out.println("Was read " + byteCount + " bytes");
    System.out.println(Arrays.toString(rData));
    System.out.println(new String(rData));

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

```
Was read 10 bytes
[72, 101, 108, 108, 111, 32, 73, 47, 79, 33, 0, 0, 0, 0, 0]
Hello I/O!
```

Creating a FileInputStream Instance

```
String fileName = "data.txt";

try (FileInputStream fileInputStream = new FileInputStream(fileName)) {

    int b = 0;

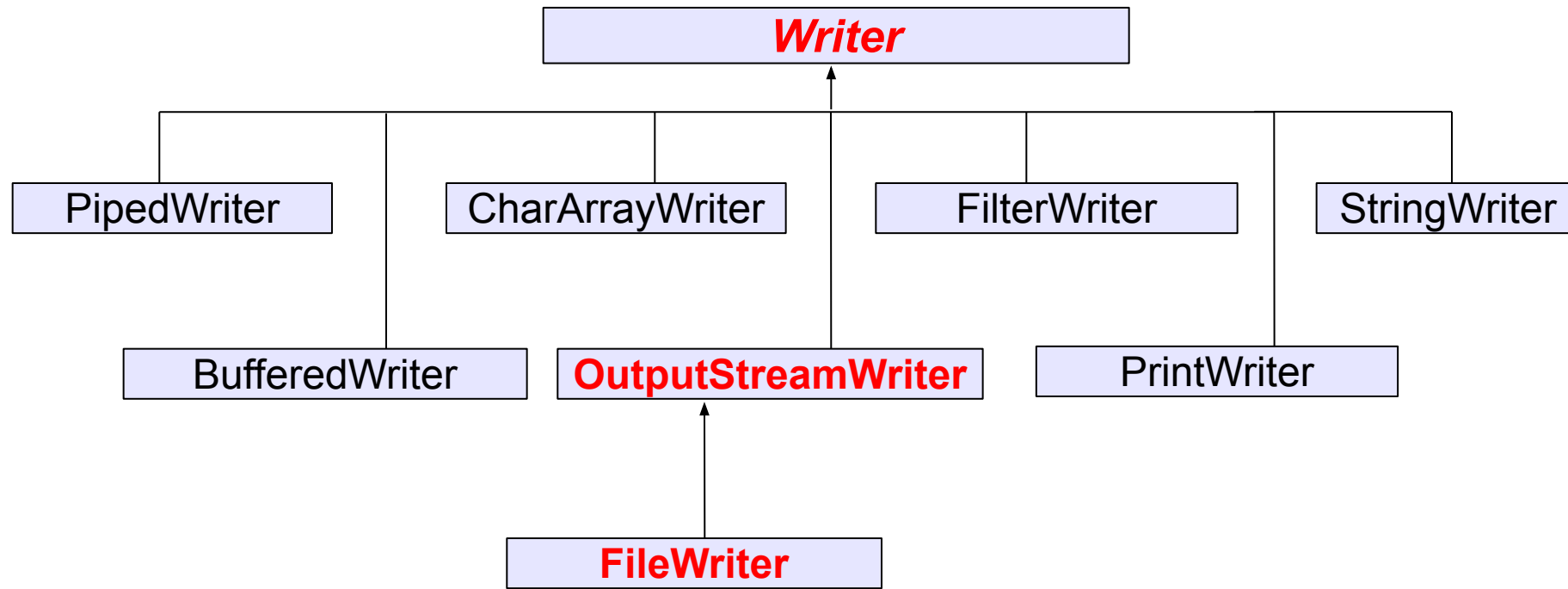
    while ((b = fileInputStream.read()) != -1) {
        System.out.print( (char)b );
    }

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

```
Hello I/O!
```

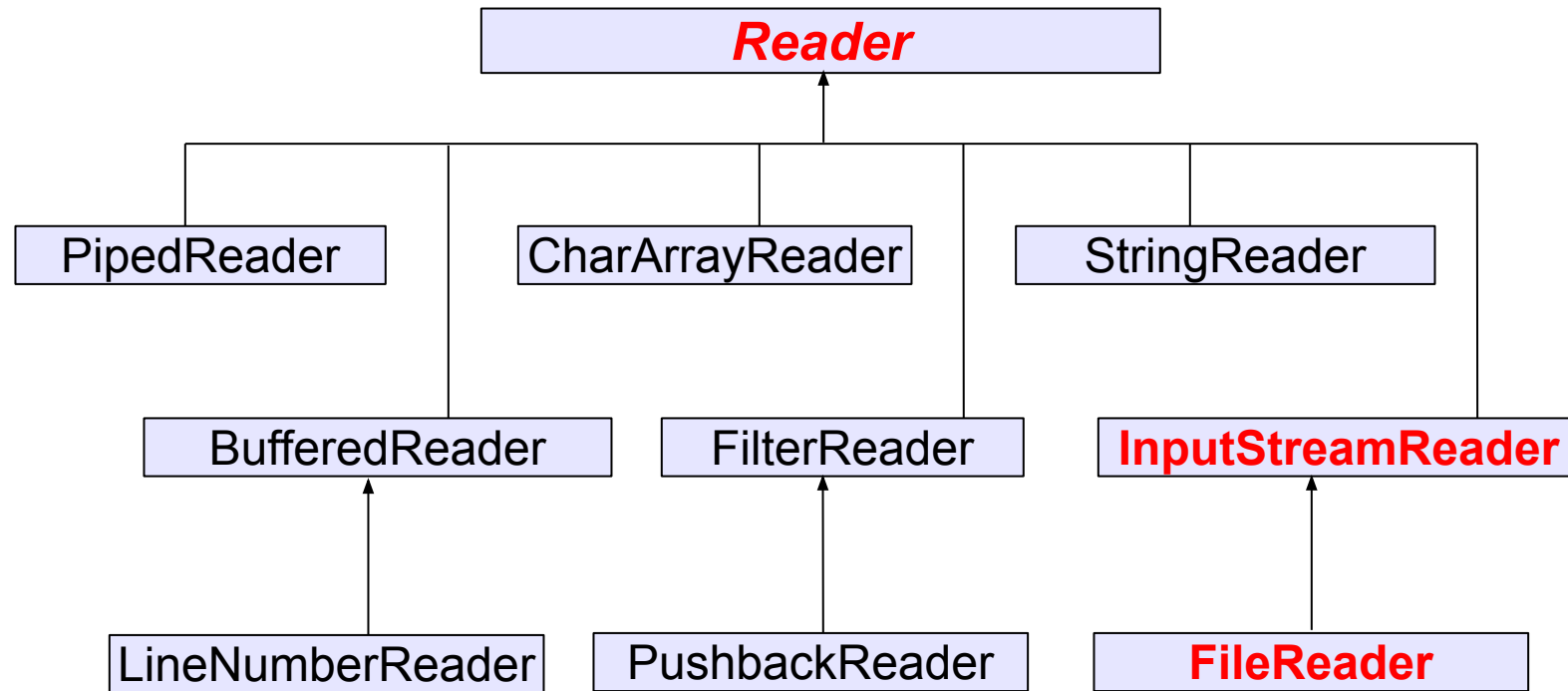
Character-Oriented Writer Classes

- The following is the *character-oriented output stream* class hierarchy:



Character-Oriented Reader Classes

- The following is the *character-oriented input stream* class hierarchy:



FileReader and FileWriter Classes

```
String fileName = "data.txt";
String data = "Hello Java I/O! Streams";

try (FileWriter fileWriter = new FileWriter(fileName /*, true*/ ))
{
    fileWriter.write(data);
} catch (IOException e) {
    e.printStackTrace();
}

try (FileReader fileReader = new FileReader(fileName)) {
    int c = 0;
    while((c = fileReader.read()) != -1) {
        System.out.print( (char)c );
    }
} catch (IOException e) {
    e.printStackTrace();
}
```

BufferedReader and BufferedWriter Classes

- The **BufferedReader** and **BufferedWriter** classes use an ***internal buffer*** to store data while reading and writing, respectively.
 - The **BufferedReader** class provides a new method **readLine()**, which reads a line and returns a **String** (without the line delimiter).
 - The **BufferedWriter** class provides a new method **newLine()**, which write a separator to the buffered writer stream.

BufferedWriter and BufferedReader Classes

```
String fileName = "data.txt";
String data = "Hello Java I/O Streams!";

try (BufferedWriter bufferedWriter = new BufferedWriter(
    new FileWriter(fileName , true))) {

    bufferedWriter.write(data);
    bufferedWriter.newLine();
    bufferedWriter.flush();

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


BufferedWriter and BufferedReader Classes

```
try (BufferedReader bufferedReader = new BufferedReader(  
    new FileReader(fileName))) {  
  
    String line = null;  
    while ((line = bufferedReader.readLine()) != null) {  
        System.out.print(line);  
    }  
  
} catch (IOException e) {  
    e.printStackTrace();  
}
```

```
Hello Java I/O Streams!  
Hello Java I/O Streams!  
Hello Java I/O Streams!  
Hello Java I/O Streams!
```

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Useful Links

- Java Basic I/O Tutorial
<http://docs.oracle.com/javase/tutorial/essential/io>
- Tutorialspoint Java.io package tutorial
<http://www.tutorialspoint.com/java/io>

Thanks for attention!