Hochschule Konstanz
Fakultät Informatik

Software Engineering

12 - FileIO

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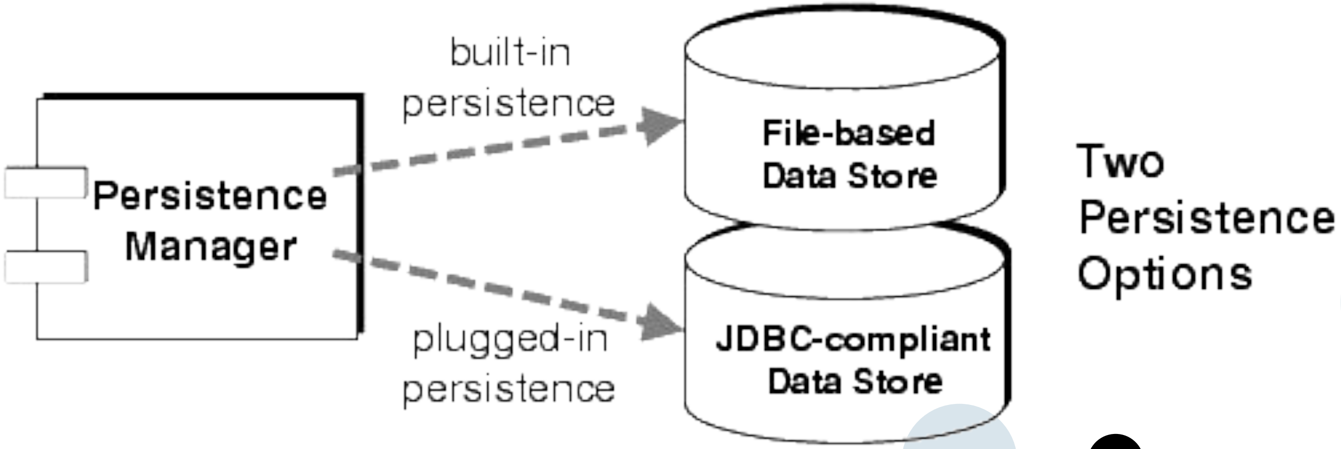
Persistence

Persistence is the characteristic of data or state that outlives the lifetime of a process or program.

Persistence can be implemented using file-based data storage or a database.

Databases will be introduced in the lecture Software Architecture.

Here we will look at two file-based mechanisms, XML and JSON.



XML

XML is the Extensible Markup Language.

It was first introduced in 1996 (same year as Java) and was a huge hype around year 2000, together with the rise of the Internet.

It is based on SGML, a framework for markup languages.

It is intended to be well readable by humans and machines alike.

XML documents can be compliant to a grammar, expressed in DTD (Document Type Definition) or XSD (XML Schema Definition).

Tags are enclosed in < and >

Data in XML

The following XML document contains data about a book: its title, authors, date of publication, and publisher.

```xml
<Book>
    <Title>Parsing Techniques</Title>
    <Authors>
        <Author>Dick Grune</Author>
        <Author>Ceriel J.H. Jacobs</Author>
    </Authors>
    <Date>2007</Date>
    <Publisher>Springer</Publisher>
</Book>
```

XML in Scala

Scala’s development started in 2003 at the height of XMLs popularity.

XML was directly integrated into the core of the language. In order to achieve this the < and > were not used as brackets (i.e. for generic types as in Java).

It is now separated out into a library.

To add it, include the following into your sbt.build file:

```
libraryDependencies += "org.scala-lang.modules" %%
"scala-xml" % "2.4.0"
```

XML Literals

In Scala an XML data structure can directly be assigned to a variable or returned as a result of a function.

```
val data = <people><person><name>joe</name><age>40</age></person>
<person><name>mary</name><age>39</age></person></people>
```

To insert data values, curly braces work as a template.

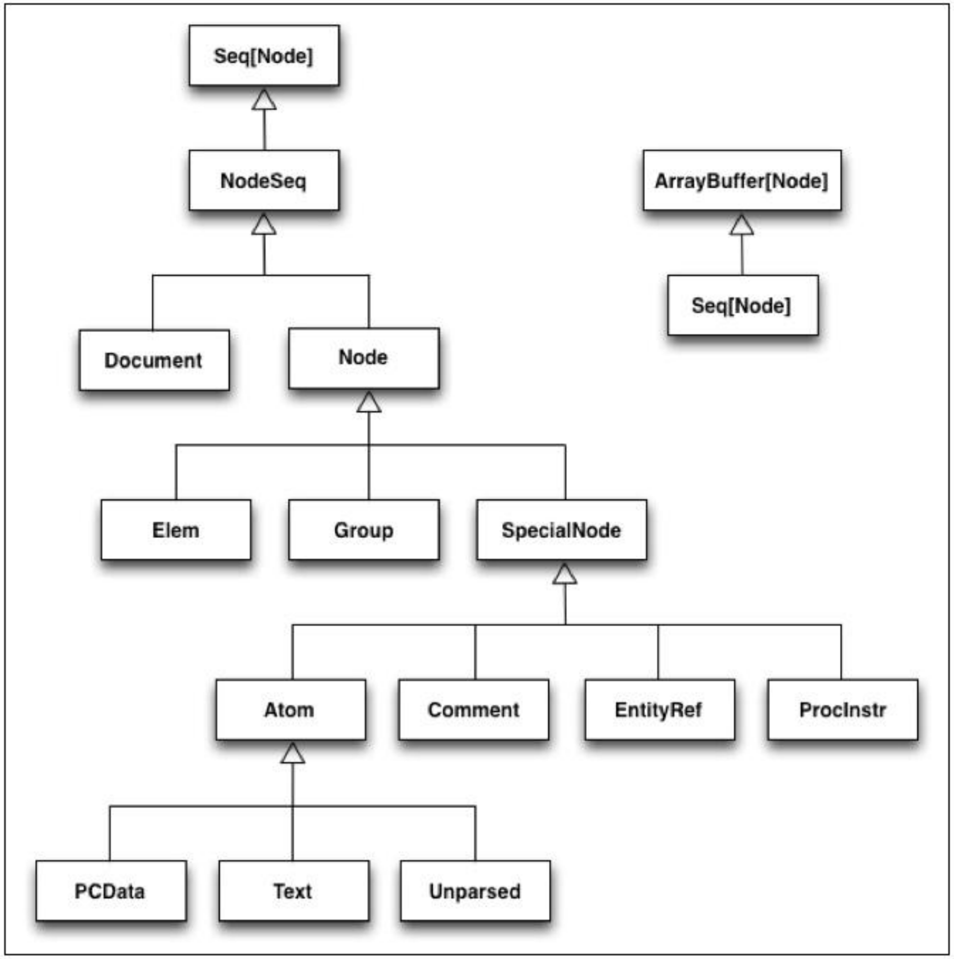
```
def toXml() = <person><name>{ name }</name><age>{ age
}</age></person>
```

toXML in Scala

```scala
class Person(name : String, age : Int){
    def toXml() = <person><name>{ name }</name><age>{ age }</age></person>
}
object xml {
    val people = List( new Person("Alice", 16), new Person("Bob", 64) )
    val data = <people>{ people.map(p => p.toXml()) }</people>
    def main(args : Array[String]) = println(data)
}
```

NodeSeq and Elem

The most important types used in the XML library are NodeSeq and Elem



Methods of Elem

x \ "div"	Searches the XML literal x for elements of type <div>. Only searches immediate child nodes (no grandchild or “descendant” nodes).
x \\ "div"	Searches the XML literal x for elements of type <div>. Returns matching elements from child nodes at any depth of the XML tree.
x.attribute("class")	Returns the value of the given attribute in the current node. **<a x="10" y="20">foo</a>.attribute("x")** // returns Some(10).
x.attributes	Returns all attributes of the current node, prefixed and unprefixed, in no particular order. scala> **<a x="10" y="20">foo</a>.attributes** res0: scala.xml.MetaData = x="10" y="20"
x.child	Returns the children of the current node. **<a><b>foo</b></a>.child** // returns <b>foo</b>.
x.copy(...)	Returns a copy of the element, letting you replace data during the copy process.
x.label	The name of the current element. **<a><b>foo</b></a>.label** // returns a.
x.text	Returns a concatenation of text(n) for each child n.
x.toString	Emits the XML literal as a String. Use scala.xml.PrettyPrinter to format the output, if desired.

Reading from XML

Parse the XML using \ and \\

```
scala> val x = <div class="content"><p>Hello</p><p>world</p></div>
x: scala.xml.Elem = <div class="content"><p>Hello</p><p>world</p></div>

scala> x \ "p"
res0: scala.xml.NodeSeq = NodeSeq(<p>Hello</p>, <p>world</p>)


scala> x \\ "p"
res1: scala.xml.NodeSeq = NodeSeq(<p>Hello</p>, <p>world</p>)
```

An Example: Stock

toXML

```
case class Stock(symbol: String, businessName: String, 
price: Double) {

  // convert Stock fields to XML
  def toXml = {
    <stock>
      <symbol>{symbol}</symbol>
      <businessName>{businessName}</businessName>
      <price>{price}</price>
    </stock>
  }

}
```

An Example: Stock

fromXML

```
object Stock {

  // convert XML to a Stock
  def fromXml(node: scala.xml.Node):Stock = {
    val symbol = (node \ "symbol").text
    val businessName = (node \ "businessName").text
    val price = (node \ "price").text.toDouble
    new Stock(symbol, businessName, price)
  }

}
```

JSON

JSON is the JavaScript Object Notation.

It is the data-oriented subset of JavaScript and was formally described by Douglas Crockford, a pioneer in JavaScript in the early 2000s.

JSON data can directly be assigned to a JavaScript variable. It is very common in browser-server communication but has become a very widespread data transfer format.

JSON uses name-value-pairs to address data.

As data types it has only Number, String, Boolean, Array and Object.

Data in JSON

An example of Data in JSON format:

```
{
    "Book":
        {
            "Title": "Parsing Techniques",
            "Authors": [ "Dick Grune", "Ceriel J.H. Jacobs" ],
            "Date": "2007",
            "Publisher": "Springer"
        }
}
```

JSON in Scala

JSON is supported by many languages and is used as data transport format across many systems and languages.

However, in all languages besides JavaScript, JSON needs to be mapped to and from language-internal concepts, i.e. a map.

For this we need a library to support the mapping.

There are a number of libraries.

We will use the one supported by Play: Play-Json.

To include it include the following into your sbt.build file:

```
libraryDependencies += "com.typesafe.play" %% "play-json" % "3.0.4"
```

Play-Json: Basic Datatypes

Play-Json can convert data using Json.toJson for datatypes it knows.

```
import play.api.libs.json._

// basic types
val jsonString = Json.toJson("Fiver")
val jsonNumber = Json.toJson(4)
val jsonBoolean = Json.toJson(false)

// collections of basic types
val jsonArrayOfInts = Json.toJson(Seq(1, 2, 3, 4))
val jsonArrayOfStrings = Json.toJson(List("Fiver", "Bigwig"))
```

Play-Json:Maps

To simulate the name-value-pairs of JSON, Play-Json uses the map notation.

```
import play.api.libs.json.{ JsNull, Json, JsString, JsValue }
val json: JsValue = Json.obj(
  "name" -> "Watership Down",
  "location" -> Json.obj("lat" -> 51.235685, "long" -> -1.309197),
  "residents" -> Json.arr(
    Json.obj(
      "name" -> "Fiver",
      "age" -> 4,
      "role" -> JsNull
    ),
    Json.obj(
      "name" -> "Bigwig",
      "age" -> 6,
      "role" -> "Owsla"
    )
  )
)
```

Play-Json: Own Datatypes

To convert your own data type T (case classes), provide an (implicit) implementation for a Writes[T]

```scala
case class Location(lat: Double, long: Double)


import play.api.libs.json._

implicit val locationWrites = new Writes[Location] {
  def writes(location: Location) = Json.obj(
    "lat" -> location.lat,
    "long" -> location.long
  )
}

val json = Json.toJson(Location(51.235685, -1.309197))
```

Play-Json: Automated Macro

A macro allows to discover the structure automatically for case classes. A macro is translated at compile time into code similar to the above.

```
case class Location(lat: Double, long: Double)

object Location {

   import play.api.libs.json._
   implicit val locationWrites = Json.writes[Location]

}


val json = Json.toJson(Location(51.235685, -1.309197))
```

Play-JSON: Reading from JSON

Reading from JSON is very similar to reading from XML. Also use the methods \ and \\.

```
val lat = (json \ "location" \ "lat").get
// returns JsNumber(51.235685)
```

Play-JSON: Converting Data Types

Similar to the conversion to JSON for your own data type T, data can be converted automatically by providing a Reads[T]

```
import play.api.libs.json._
case class Location(lat: Double, long: Double)
object Location {
 //implicit def locationFormat = Json.format[Location]
 implicit def locationWrites = Json. writes[Location]
 implicit def locationReads = Json. reads[Location]
}
val locationInJson = Json. toJson(Location(51.235685, -1.309197))
val jsonStr=locationInJson.toString()
Json.parse(jsonStr).validate[Location]  match {
 case JsSuccess(location, _) => println(location)
 case JsError(_) => println("parsing failed")
}
```

Play-JSON: Converting Data Types using Macros

Similar to the conversion to JSON for your own data type T, data can be converted automatically by providing a Reads[T]

```
case class Location(lat: Double, long: Double)

import play.api.libs.json._

implicit val locationReads = Json.reads[Location]

val locationFromJson: JsResult[Location] = Json.fromJson[Location](jsonString)

locationFromJson match {
  case JsSuccess(l: Location, path: JsPath) => println("Lat: " + l.lat)
  case e: JsError => println("Errors: " + JsError.toJson(e).toString())
}
```

Writing to a File in Scala

To write to a file, Scala reuses Java.

Create a File with a name, then use a PrintWriter with it.

```
import java.io._

val pw = new PrintWriter(new File("hello.txt" ))

pw.write("Hello, world")

pw.close
```

Reading from a File

The XML library provides a method to load XML directly

```
val file = scala.xml.XML.loadFile("grid.xml")
```

Scala.io has a Source class to load text files

```
val source: String = Source.fromFile("grid.json").getLines.mkString
val json: JsValue = Json.parse(source)
```

Example Person

```
case class Date(year: Int = Today.year, month: Int = Today.month, day: Int = Today.day)

object Date {
 implicit val dateFormat = Json.format[Date]
}

case class Person(name:String, birthdate:Date)  extends Ordered[Person]{
 override def compare(that: Person) =  this.age - that.age
 def age = birthdate.fullYearsSince
 def age(date:Date) = birthdate.fullYearsSince(date)
}

object Person {
 //implicit val personFormat = Json.format[Person]
 implicit val personWrites = Json.writes[Person]
 implicit val personReads = Json.reads[Person]
```

Test for Person

```
class PersonSpec extends WordSpec {
"A Person born on 4th of July in 1971" should {
val peter = new Person("Peter", new Date(1971, 7, 4))
"convert to JSON" in {
 val json = Json.toJson(peter)
 json.toString() should be
("{\"name\":\"Peter\",\"birthdate\":{\"year\":1971,\"month\":7,\"day\":4}}")
}
"convert from JSON " in {
 val json = Json.toJson(peter)
 json.asOpt[Person] match {
   case Some(person) => person should be (peter)
   case None => fail
 }
}
"convert from JSON String" in {
 val json = Json.toJson(peter).toString()
 Json.parse(json).validate[Person] match {
   case JsSuccess(person, _) => person should be (peter)
   case JsError(_) =>fail
 }
}
```

Task: Implement FileIO

Implement FileIO using XML

Implement FileIO using Json

Hide both implementations behind the same Interface

Make use of Dependency Injection to switch between these two implementations