jPOS
.org

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# Copyright notice

# Preface

This document covers **jPOS 2.0.8**.

# Chapter 1. The jPOS Project

# 1.1. About jPOS.org

The jPOS project is hosted at **http://jpos.org**. For an up to date list of project resources, you can visit the **http://jpos.org/resources** page there. In order to stay up-to-date with jPOS news, you may want to visit the jPOS website at **http://jpos.org** as well as its blog at **http://jpos.org/blog**. There's also a low traffic **jPOS News** mailing list where we post important announcements, such as a the availability of new versions of this guide. You're encouraged to register by visiting the project's main page at **http://jpos.org**.

Code is hosted at **http://github.com/jpos/jPOS**.

You may also want to follow us on Twitter, where we keep a list of users who regularly tweet about jPOS at **@apr/lists/jpos** [http://twitter.com/apr/lists/jpos].

In addition, you may want to subscribe to our **users' mailing list (jpos-users@googlegroups.com [mailto:jpos-users@googlegroups.com])** [http://groups.google.com/group/jpos-users].

Commit notifications can be tracked by following **@jposcommits** [http://twitter.com/jposcommits].

We are also active in **Slack** [https://jpos.slack.com]. Please request an invitation via e-mail to **support@jpos.org** [mailto:support@jpos.org].

If you happen to tweet about jPOS, please use the hash tag `#jPOS` so we can follow you.

# 1.2. jPOS License

jPOS is distributed under the **GNU Affero General Public License version 3**.

### IMPORTANT NOTICE

If you don't plan to release your jPOS based application under a compatible license (see **AGPL 3.0 FAQ** [http://www.fsf.org/licensing/licenses/agpl-3.0.html] where you can find a license compatibility matrix) **you need to buy a commercial license** (you can contact us using the **contact form** [http://jpos.org/contact?p=CL.Proguide]).

# 1.3. About ISO-8583

We assume the reader is familiar with the ISO-8583 standard.

For starters, you can take a look at the Wikipedia **ISO_8583** [http://en.wikipedia.org/wiki/ISO_8583] page and the **Section 2.1, "An ISO-8583 primer"** of this document, but for any serious work you need to get a copy of the standard from **http://www.iso.org**.

This is a high level standard where vendors have implemented it in slightly different ways. You also need the protocol specifications for your particular interchange.

If you are starting a new payments application and you have full control over your spec, you may want to consider using the ISO-8583 v2003 based jPOS Common Message Format described in **http://jpos.org/doc/jPOS-CMF.pdf**.

The jPOS-CMF is an open source project, you can get the DocBook sources in the jPOS Github reporitory at **http://github.com/jPOS/jPOS-CMF** and modify it to fit your needs. This is an open spec, we expect institutions using it to get in touch with us in order to improve it.

# 1.4. Downloading jPOS

The community edition of jPOS can be downloaded from the **jPOS Download** [http://jpos.org/download] page.

The repository has many branches and tags. Unless you are dealing with a legacy jPOS application, You want to use the `master` branch.

If you are looking for older jPOS versions, you can find them in the **SourceForge** [http://sourceforge.net/projects/jpos/files/jpos/] repository but please note all development activity takes place in the **Github** [http://github.com/jpos/jPOS] repository, though.

# 1.5. Directory structure

jPOS uses **Gradle** [http://www.gradle.org/] with a **multi-module** setup.

The modules are defined in the `settings.gradle` file and listed below:

- **jpos** : this is the jPOS system
- **compat_1_5_2** : compatibility with older versions

You’ll find the jPOS sources in the `jpos/src` directory.

```
|-- COPYRIGHT                                                               ❶
|-- CREDITS
|-- LICENSE
|-- README.md                                                               ❷
|-- build.gradle                                                            ❸
|-- settings.gradle                                                         ❹
...
...

|-- gradlew                                                                 ❺
|-- gradlew.bat
|-- gradle
|   `-- wrapper
|       |-- gradle-wrapper.jar
|       `-- gradle-wrapper.properties
...
...
|-- jpos                                                                    ❻
|   |-- build.gradle
|   |-- src
|   |   |-- main
|   |   |   |-- java
|   |   |-- main
|   |   |   |-- resources
|   |   |-- dist                                                            ❼
|   |   |   |-- bin
|   |   |   |   |-- bsh
|   |   |   |   |-- q2
|   |   |   |   |-- start
|   |   |   |   `-- stop
|   |   |   |-- cfg
|   |   |   |   |-- packager
|   |   |   |   |   |-- base1.xml
|   |   |   |   |   |-- base24-eps.xml
|   |   |   |   |   |-- base24.xml
...
...
|   |   |   |-- deploy
|   |   |   |   |-- 00_logger.xml
|   |   |   |   `-- 99_sysmon.xml
|   |   |   `-- log
|   |   |       `-- q2.log
...
...
```

❶ Copyright notice

❷ Readme file in markdown format shown in the **Github** [https://github.com/jpos/jPOS] repository

❸ Main Gradle configuration file

❹ Gradle's `settings` file, lists the modules to be compiled, in this case, `jpos` and `compat_1_5_2`.

❺ It is recommended that you install Gradle locally, but for a quick build, you can use the Gradle wrapper (`gradlew` in Unix, `gradlew.bat` in Windows).

❻ Home for the jPOS module

❼ Template for a production distribution directory with its deploy, cfg, bin and log directories

```
|-- compat_1_5_2                                                     ❶
|   |-- build.gradle
|   |-- compat_1_5_2.iml
|   |-- src
|   |   `-- main
|   |       `-- java
|   |           `-- org
|   |               `-- jpos
|   |   |   `-- resources
...
...
|-- legal                                                            ❷
|   |-- cla-template.txt
|   |-- ccla-template.txt
|-- incoming                                                         ❸
...
...
```

❶ Backward compatibility with version 1.5.2
❷ Legal directory with contributor license agreements
❸ Contributed files not yet merged into jPOS. Now with Git and pull requests, this directory will be removed at some point.

Unless you’re dealing with a legacy jPOS system, you probably don’t want to use the `compat_1_5_2` module.

# 1.6. Using jPOS

You don’t have to build jPOS in order to use it in your projects, although you are welcome to try and build it (see **Section 1.7, “Building jPOS”**) for learning purposes or if you want to contribute to the project.

jPOS produces Maven compatible `poms` and regularly publishes releases to **Maven Central** [http://search.maven.org].

If you want to use it from Maven, you can add this dependency to your `pom`:

Here is a sample POM

```
<dependency>
    <groupId>org.jpos</groupId>
    <artifactId>jpos</artifactId>
    <version>2.0.8</version>
</dependency>
```

or Gradle dependency:

```
org.jpos:jpos:2.0.8
```

The stable release is 2.0.8, development release is 2.0.9-SNAPSHOT.

jPOS uses the following dependency not available in Maven central, so you need to add the following repository

- **http://download.oracle.com/maven** (required by Berkeley DB Java Edition)

> We publish SNAPSHOT daily builds (i.e. version 2.0.9-SNAPSHOT) to the **jPOS Maven repository** [http://jpos.org/maven] and stable releases to Maven Central. Please note the **compat_1_5_2** module is only published to jPOS Maven repo.

if you use Gradle, you can configure:

```
repositories {
    mavenCentral()
    maven { url 'http://jpos.org/maven' }
    maven { url 'http://download.oracle.com/maven' }
    mavenLocal()
}

dependencies {
    compile org.jpos:jpos:2.0.8
    testCompile 'junit:junit4.8.2'
}
```

> If you're building a jPOS application, the easiest way is to clone the **jPOS Template** [http://github.com/jpos/jPOS-template] project and take it from there.

# 1.7. Building jPOS

jPOS uses **Gradle** [http://www.gradle.org/] as its build system. For a quick build, you don't even need to install Gradle, you can use the handy `gradlew` (or `gradlew.bat` if you're on Windows) Gradle *wrapper* that automatically downloads Gradle for you, but for daily development, it's a good idea to install it locally.

> Whenever we mention the `gradle` command in this guide, you can either use your locally installed Gradle, or the `gradlew` wrapper scripts mentioned above.

> Gradle has the ability to run in background, dramatically reducing the load time. In order to enable that feature, you can use its `--daemon` parameter or
>
> ```
> export GRADLE_OPTS=-Dorg.gradle.daemon=true
> ```

## 1.7.1. Available tasks

Running `gradle tasks` provides a list of available tasks.

Most of them are standard in the Gradle build system and have self-explanatory names (i.e. `jar` to build the jPOS jar, `javadoc` to build the javadoc documentation). A few deserve further explanation, though:

- **`installApp`** is a handy task defined in the `jpos` module that can be used to create a runtime environment inside the `build/installs` directory. That runtime envirnoment copies all the scripts coming from the `src/dist` directory and it's ready to execute the jPOS system using the `bin/q2` (or `bin\q2.bat`) scripts. The `installApp` task is similar to running the `dist` task to create a `tar.gz` tarball and then extracting that tarball into a local directory, ready to run.

- `version` can be used to build jPOS and run it to query its own version.

**Note about releases**

jPOS stable releases (non SNAPSHOTS) are signed and published to Maven Central. If you are trying to build a stable release, you'd have to hack `build.gradle` to trick the `isSnapshot` variable to be true, otherwise the build will fail because you don't have the PGP private keys required to sign a build.

If you're making some changes to jPOS off a stable release, you should change the version number to avoid confusion.

But remember, you don't have to build jPOS in order to use it, just add it to your *pom* as a dependency.

**The *clean* task is your friend**

Out of all the available tasks, there's one that will keep you out of trouble: **clean**. While Gradle is very smart when it comes to figuring out which dependencies have been modified and need to be rebuilt, there's nothing like the extra confidence that a good old `clean` gives. When in doubt, `gradle clean`.

# 1.8. Running jPOS

From the `jpos` directory, run `gradle installApp` to create a working jPOS in the `build/install/jpos` directory.

Change directory there and you will see a `jpos-x.x.xjar` (i.e `jpos-1.9.9-SNAPSHOT.jar`).

You can run the jar using `java -jar jpos-1.9.1-SNAPSHOT.jar` or use the `bin/q2` or `bin/q2.bat` scripts.

Once started, the output should look like this:

```
<log realm="org.jpos.q2.qbean.SystemMonitor" at="2016-08-27T22:26:51.720">
  <info>
               OS: Linux (3.14.35-28.38.amzn1.x86_64)
     process name: 19213@ip-172-30-0-180
             host: ip-172-30-0-180/52.5.73.144
              cwd: /opt/local/jpos
       free space: 133.3 GiB
     usable space: 123.3 GiB
          version: 2.0.7-SNAPSHOT (bdcac3f)
         instance: b1016676-b840-4fb6-916b-37c4b4355c45
           uptime: 00:00:00.691 (0.460000)
       processors: 2
           drift : 0
    memory(t/u/f): 75/14/60
         encoding: UTF-8
         timezone: Etc/UTC (Coordinated Universal Time) Z
    watch service: sun.nio.fs.LinuxWatchService
            clock: 1472336811 2016-08-27T22:26:51.720Z
     thread count: 10
     peak threads: 10
     user threads: 6
            Thread[Reference Handler,10,system]
            Thread[Finalizer,8,system]
            Thread[Signal Dispatcher,9,system]
            Thread[RMI TCP Accept-0,5,system]
            Thread[pool-1-thread-1,5,main]
            Thread[Q2-b1016676-b840-4fb6-916b-37c4b4355c45,5,main]
            Thread[DestroyJavaVM,5,main]
            Thread[Thread-2,5,main]
            Thread[Timer-0,5,main]
            Thread[SystemMonitor,5,main]
    name-registrar:
      Q2: org.jpos.q2.Q2
      logger.Q2: org.jpos.util.Logger
  </info>
</log>
```

You may want to review the content in the `deploy` directory, that comes from the `src/dist` source tree.

# Chapter 2. About ISO-8583

# 2.1. An ISO-8583 primer

This section contains general information about the ISO-8583 International Standard.

## 2.1.1. International standard ISO 8583

**Financial transaction card-originated messages Interchange message specifications**.

You have to read it, period. And you have to read the correct one (1987/1993/2003) for your particular interchange. And you also have to read your vendor-specific interchange specs as well.

But while you manage to gather all that information, let’s have a look at this brief introduction. When talking about ISO-8583, we have to be aware of the difference between:

- message format (its binary representation),
- wire protocol (how a message is transmitted over the wire), and
- message flow (e.g., send request for authorization, wait for response, retransmit, reversal, etc.).

## 2.1.2. Message format

ISO-8583 messages are composed by fields, which are represented in different ways. Basically we have the following structure:

### Table 2.1. ISO-8583 message structure

| Field # | Description |
|---|---|
| 0 - MTI | Message Type Indicator |
| 1 - Bitmap | 64 (or 128) bits indicating presence/absence of other fields |
| 2 .. 128 | Other fields as specified in bitmap |

The bitmaps are encoded in network byte order, with the most significant bit (leftmost bit) of the first byte indicating presence of a secondary bitmap. Then, the next bit towards the right indicates presence of field 2, the next one refers to field 3, and so on.

So let’s have a look at a simple example:

### Table 2.2. Sample 0800 message

| # | Name | Value | Hex Value |
|---|---|---|---|
| 0 | MTI | 0800 | 08 00 |

| # | Name | Value | Hex Value |
|---|---|---|---|
| 1 | PRIMARY BITMAP | Indicates presence of fields 3, 11 and 41 | 20 20 00 00 00 80 00 00 |
| 3 | PROCESSING CODE | 000000 | 00 00 00 |
| 11 | SYSTEM TRACE AUDIT NUMBER | 000001 | 00 00 01 |
| 41 | TERMINAL ID | 29110001 | 32 39 31 31 30 30 30 31 |

Here is the binary representation of our 0800 message:

```
080020200000008000000000000000013239313130303031
```

In the previous example, 0800 is the **message type indicator (MTI)**; The first position represents ISO-8583 version number:

- 0 for version 1987
- 1 for version 1993
- 2 for version 2003
- 3-7 reserved for ISO use
- 8 is reserved for national use
- 9 is reserved for private use

The second position represents **message class**:

- 0 is reserved for ISO use
- 1 authorization
- 2 financial
- 3 file update
- 4 reversals and chargebacks
- 5 reconciliation
- 6 administrative
- 7 fee collection
- 8 network management
- 9 reserved for ISO use

The third position is the **message function**:

- 0 request
- 1 request response
- 2 advice
- 3 advice response
- 4 notification
- 5-9 reserved for ISO use

And the last position is used to indicate the **transaction originator**:

- 0 acquirer
- 1 acquirer repeat
- 2 card issuer
- 3 card issuer repeat
- 4 other
- 5 other repeat
- 6-9 reserved for ISO use

So "0800" is a *version 1987 network management request*.

Next we have field 1, the primary bitmap:

### Table 2.3. Primary Bitmap

| byte | hex value | bit value | field # |
|---|---|---|---|
| 0 | 20 | 0010 0000 | 3 |
| 1 | 20 | 0010 0000 | 11 |
| 2 | 00 | 0000 0000 | |
| 3 | 00 | 0000 0000 | |
| 4 | 00 | 0000 0000 | |
| 5 | 80 | 1000 0000 | 41 |
| 6 | 00 | 0000 0000 | |
| 7 | 00 | 0000 0000 | |

So now that we’ve parsed the MTI (0800) and bitmap (2020000000800000), we know that fields 3, 11 and 41 are present. So our next field is number 3.

## ISO-8583 fields

There are many field types:

- Fixed length
  - Numeric
  - Alphanumeric
  - Binary
- Variable length with a max length 99
  - Numeric
  - Alphanumeric
  - Binary
- Variable length with a max length 999
  - Numeric
  - Alphanumeric
  - Binary
- Variable length with a max length 9999 (available starting in ISO-8583 version 2003)
  - Numeric

    - Alphanumeric
    - Binary
- Nested message

So far, so good, this is very simple stuff, isn't it? The problem is not complexity but diversity, ISO-8583 is not specific about how a given field is represented, so you can have a numeric field represented as a sequence of ASCII characters, EBCDIC characters, BCD, etc.

Variable length fields have a prefix specifying its length, but how this is represented is not defined. Different vendors use different representations (e.g., BCD, EBCDIC, binary value).

In our example, field #3 is using a BCD representation in network byte order, so a value of "000000" is represented with just three bytes whose hex values are "00 00 00". Same goes for field #11 whose value is "000001" - it is represented as "00 00 01". In our example, field #41 is an eight-byte alphanumeric field represented as eight ASCII characters

```
     Message: 08002020 00000080 00000000 00000001
              32393131 30303031

         MTI: 0800
      Bitmap: 20200000 00800000
    Field 03: 000000
    Field 11: 000001
    field 41: 3239313130303031 (ASCII for "29110001")
```

Let's have a look at another sample message:

## Table 2.4. Another 0800 message

| # | Name | Value | Hex Value |
|---|---|---|---|
| 0 | MTI | 0800 | 08 00 |
| 1. | PRIMARY BITMAP | Indicates presence of secondary bitmap plus fields 3, 11, 41 and 60 | A0 20 00 00 00 80 00 10 |
| 1 | SECONDARY BITMAP | Indicates presence of field 70 | 04 00 00 00 00 00 00 00 |
| 3 | PROCESSING CODE | 000000 | 00 00 00 |
| 11 | SYSTEM TRACE AUDIT NUMBER | 000001 | 00 00 01 |
| 41 | TERMINAL ID | 29110001 | 32 39 31 31 30 30 30 31 |
| 60 | RESERVED FOR PRIVATE USE | jPOS 1.9.1 | 00 10 6A 50 4F 53 20 31 2E 39 2E 31 |
| 70 | NETWORK MANAGEMENT INFORMATION CODE | 301 | 03 01 |

Two new fields are present: #60 and #70. Here is our message representation:

```
         Message: 0800A020 00000080 00100400 00000000
                  00000000 00000001 32393131 30303031
                  00106A50 4F532031 2E392E31 0301

             MTI: 0800
  Primary bitmap: A0200000 00800010
Secondary bitmap: 04000000 00000000
        Field 03: 000000
        Field 11: 000001
        Field 41: 3239313130303031 (ASCII for "29110001")
        Field 60: 0010 6A504F5320312E392E31 (length=10, value="jPOS 1.9.1") ❶
        Field 70: 0301
```

❶ In this example, the length prefix in field 60 is expressed as a 2-byte BCD number; therefore, a length of 10 is encoded as 0010 in hexadecimal.

Let’s break down this bitmap:

## Table 2.5. Primary Bitmap

| byte | hex value | bit value | field # |
|---|---|---|---|
| 0 | A0 | 1010 0000 | secondary bitmap present plus #3 |
| 1 | 20 | 0010 0000 | 11 |
| 2 | 00 | 0000 0000 | |
| 3 | 00 | 0000 0000 | |
| 4 | 00 | 0000 0000 | |
| 5 | 80 | 1000 0000 | 41 |
| 6 | 00 | 0000 0000 | |
| 7 | 10 | 0001 0000 | 60 |

## Table 2.6. Secondary Bitmap

| byte | hex value | bit value | field # |
|---|---|---|---|
| 0 | 04 | 0000 0100 | 70 |
| 1 | 00 | 0000 0000 | |
| 2 | 00 | 0000 0000 | |
| 3 | 00 | 0000 0000 | |
| 4 | 00 | 0000 0000 | |
| 5 | 00 | 0000 0000 | |
| 6 | 00 | 0000 0000 | |
| 7 | 00 | 0000 0000 | |

To make things more complex to developers, different vendors choose different padding styles when handling odd-length BCD fields. So in order to represent "003" one vendor may use two bytes with the values `"00 03"` while others may use `"00 30"` or even `"00 3F"`.

Same goes for variable-length fields: field length as well as field values can be padded to the left or to the right (that’s not defined by ISO-8583, it’s just a matter of fact of different implementations).

Then we have nested fields - some implementations use "reserved for private use" fields to carry other ISO-8583 messages. These messages are usually packed as variable-length binary fields as seen by the outer message.

You will see that jPOS handles this problem in a very simple way so you don’t have to worry about this low-level stuff.

## 2.1.3. Wire protocol

Once we have a binary representation of a given ISO-8583 message, we have to transmit it over the wire using some communication protocol (e.g., TCP/IP, UDP, X.25, SDLC, SNA, ASYNC, QTP, SSL, HTTP, you name it).

That communication protocol is not part of the ISO-8583 standard, so different vendors have chosen different protocols.

Many implementations (especially the older ones) require support for some kind of routing information (e.g., a CICS transaction name), so they use different sorts of `headers`.

A few of them (especially stream-based ones) require some kind of trailers as well.

So, the wire protocol is composed by:

- An optional header / message boundary delimiter
- ISO-8583 message data
- An optional trailer (sometimes used as a message boundary delimiter)

A TCP/IP-based implementation may use a couple of bytes to indicate message length, so our 0800 example described earlier would be sent as:

```
00 46 08 00 A0 20 00 00  00 80 00 10 04 00 00 00
00 00 00 00 00 00 00 00  00 01 32 39 31 31 30 30
30 31 00 10 6A 50 4F 53  20 31 2E 34 2E 31 03 01
```

0046 being the message length expressed in network byte order.

But this is just one way of specifying message length. Other implementations may choose to send four ASCII bytes, e.g.:

```
30 30 34 36 08 00 A0 20  00 00 00 80 00 10 04 00
00 00 00 00 00 00 00 00  00 00 00 01 32 39 31 31
30 30 30 31 00 10 6A 50  4F 53 20 31 2E 34 2E 31
03 01
```

`30 30 34 36` being the ASCII representation of "0046".

Some implementations count the size of the message length indicator — in the previous example the four bytes "0046" — so instead of sending "0046" they would send "0050".

A few of them perform odd things with those headers, flagging rejected messages (e.g., you send a 0100 and instead of receiving a 0110 with a suitable response code you get back your own 0100 with some proprietary flag in the header indicating for example a temporarily failure such as destination unreachable).

It’s very important to read your interchange specification(s) as early as possible during your development.

jPOS deals with the wire protocol by using a set of classes called **channels** that implement the **ISOChannel** [http://jpos.org/doc/javadoc/org/jpos/iso/ISOChannel.html] interface that hides the wire protocol details.

## 2.1.4. Message flow

Message flow will vary depending on your particular interchange specification. But let’s have a look at a simple example:

### Table 2.7. Sample authorization

| Time | Acquirer | Issuer | Description |
|---|---|---|---|
| $t_0$ | 0100 --> | | authorization request |
| $t_1$ | | <-- 0110 | authorization response |

While this is the typical case (you send a request, you get a response), sometimes there are temporary failures, and you don’t get a response. You have to reverse the previously transmitted transaction and then either retry your authorization request, abort that transaction or get an authorization approval by other means (e.g., by phone) and send an advice.

### Table 2.8. Authorization timeout

| Time | Acquirer | Issuer | Description |
|---|---|---|---|
| $t_0$ | 0100 --> | | authorization request |
| $t_1$ | | | no response |
| $t_3$ | 0400 --> | | reverse previous authorization |
| $t_4$ | | <-- 0410 | reverse received |
| $t_5$ | 0120 --> | | authorization advice |
| $t_6$ | | <-- 0130 | advice received |

Depending on your particular implementation, you may be able to send retransmissions as well (e.g., 0101 after an unanswered 0100). Some implementations use private messages (e.g., 9600) to request extended time to process a transaction. So you can see it is very important to become familiar with your interchange specifications and its expected message flow as early as possible.

jPOS provides tools to deal with message structure, wire protocol and message flow, but it’s the responsibility of your higher-level application to interface the message flow with your business logic.

A real example may help you get the idea of what kind of information is exchanged during an authorization request and response. See below:

### Table 2.9. Sample authorization request

| Fld # | Description | Value | Comments |
|---|---|---|---|
| 0 | MTI | 0100 | Authorization request |
| 2 | Primary Account Number | 4321123443211234 | |
| 3 | Processing Code | 000000 | |
| 4 | Amount transaction | 000000012300 | i.e., 123.00 |
| 7 | Transmission data/ time | 0304054133 | MMYYHHMMSS |
| 11 | System trace audit number | 001205 | |
| 14 | Expiration date | 0205 | YYMM |
| 18 | Merchant Type | 5399 | |
| 22 | POS Entry Mode | 022 | Swiped Card |
| 25 | POS Condition Code | 00 | |
| 35 | Track 2 | 4321123443211234=0205.. | |
| 37 | Retrieval Reference Number | 206305000014 | |
| 41 | Terminal ID | 29110001 | |
| 42 | Merchant ID | 1001001 | |
| 49 | Currency | 840 | US Dollars |

### Table 2.10. Sample authorization response

| Fld # | Description | Value | Comments |
|---|---|---|---|
| 0 | MTI | 0110 | Authorization response |
| 2 | Primary Account Number | 4321123443211234 | |
| 3 | Processing Code | 000000 | |
| 4 | Amount transaction | 000000012300 | i.e., 123.00 |
| 7 | Transmission data/ time | 0304054133 | MMYYHHMMSS |
| 11 | System trace audit number | 001205 | |
| 14 | Expiration date | 0205 | YYMM |
| 18 | Merchant Type | 5399 | |
| 22 | POS Entry Mode | 022 | Swiped Card |

| Fld # | Description | Value | Comments |
|---|---|---|---|
| 25 | POS Condition Code | 00 | |
| 35 | Track 2 | 4321123443211234=0205.. | |
| 37 | Retrieval Reference Number | 206305000014 | |
| 38 | Authorization number | 010305 | |
| 39 | Response code | 00 | Approved |
| 41 | Terminal ID | 29110001 | |
| 42 | Merchant ID | 1001001 | |
| 49 | Currency | 840 | US Dollars |

# 2.2. jPOS approach to ISO-8583

This chapter describes how jPOS handles ISO-8583 messages.

## 2.2.1. ISOMsg & Co.

jPOS' internal representation of an ISO-8583 message is usually an ISOMsg object (or an ISOMsg's subclass).

The ISOMsg class uses the **Composite pattern** (see Design Patterns, elements of Reusable Object-Oriented Software by Gamma, Helm, Johnson and Vlissides)

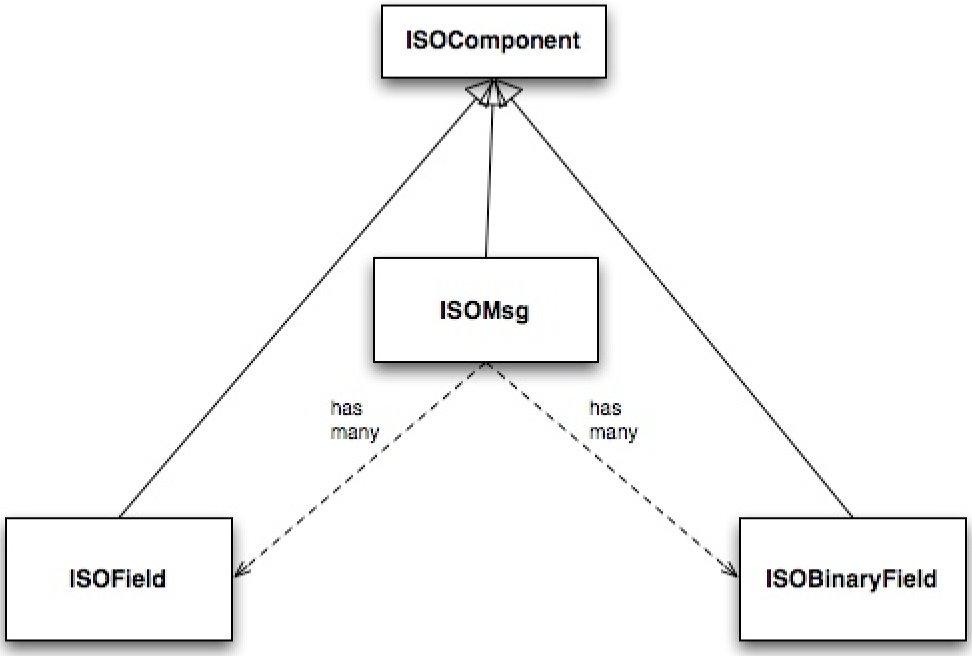
ISOMsg, ISOField, ISOBitMapField, ISOBinaryField and any custom field type that you may implement are subclasses of ISOComponent. Let's have a look at ISOComponent's methods:

```
public abstract class ISOComponent implements Cloneable {
    public void set (ISOComponent c) throws ISOException;
    public void unset (int fldno) throws ISOException;
    public ISOComponent getComposite();
    public Object getKey() throws ISOException;
    public Object getValue() throws ISOException;
    public byte[] getBytes() throws ISOException;
    public int getMaxField();
    public Hashtable getChildren();
    public abstract void setFieldNumber (int fieldNumber);
    public abstract void setValue(Object obj) throws ISOException;
    public abstract byte[] pack() throws ISOException;
    public abstract int unpack(byte[] b) throws ISOException;
    public abstract void dump (PrintStream p, String indent);
    public abstract void pack (OutputStream out) throws IOException, ISOException;
    public abstract void unpack (InputStream in) throws IOException, ISOException;
}
```

This approach has proven to be really useful and maps quite well to the ISO-8583 message structure.

There are many situations where some methods are not applicable (i.e., getChildren() has no meaning in a leaf field, same goes for methods such as getMaxField()), but as a general rule, using the same super-class for ISOMsg and ISOFields has proven to be a good thing. You can easily assign an ISOMsg as a field of an outer ISOMsg.

The following diagram shows how some ISOComponents interact with each other.




The following code can be used to create an internal representation of our 0800 message (described in **An ISO-8583 primer**).

```
import org.jpos.iso.*;

ISOMsg m = new ISOMsg();
m.set (new ISOField (0, "0800"));
m.set (new ISOField (3, "000000"));
m.set (new ISOField (11, "000001"));
m.set (new ISOField (41, "29110001"));
m.set (new ISOField (60, "jPOS 6"));
m.set (new ISOField (70, "301"));
```

We are just calling `ISOComponent.set (ISOComponent)` method.

In order to reduce typing and improve code readability, ISOMsg provides some handy methods such as

```
ISOMsg.setMTI (String)
```

```
and
```

```
ISOMsg.set (int fieldNumber, String fieldValue)
```

implemented like this:

```
    public void set (int fldno, String value) throws ISOException {
        set (new ISOField (fldno, value));
    }
    public void setMTI (String mti) throws ISOException {
 if (isInner())
     throw new ISOException ("can't setMTI on inner message");
 set (new ISOField (0, mti));
    }
```

So the previous example can be written like this:

```
ISOMsg m = new ISOMsg();
m.setMTI ("0800");
m.set (3, "000000");
m.set (11, "000001");
m.set (41, "29110001");
m.set (60, "jPOS 6");
m.set (70, "301");
```

ISOMsg is one of the most used classes in typical ISO-8583-based jPOS applications. While you can subclass it, you probably won't have to. If there's a single class in all jPOS that you want to study in great detail, this is it.

We recommend you to have a look at its **API documentation** [http://jpos.org/doc/javadoc/org/jpos/iso/ISOMsg.html] and play with its helper methods such as clone, merge, unset, etc.

## 2.2.2. Packing and unpacking

ISOComponents have two useful methods called:

```
public abstract byte[] pack() throws ISOException;
public abstract int unpack(byte[] b) throws ISOException;
```

`pack` returns a `byte[]` containing the binary representation of a given component (can be just a field or the whole ISOMsg); `unpack` does the opposite and also returns the number of consumed bytes.

jPOS uses a **Peer pattern** that allows a given ISOComponent to be packed and unpacked by a peer class, *plugged* at runtime.

You use

```
public void setPackager (ISOPackager p);
```

in order to assign a packager to a given `ISOMsg`, i.e:

```
ISOPackager customPackager = MyCustomPackager ();
ISOMsg m = new ISOMsg();
m.setMTI ("0800");
m.set (3, "000000");
m.set (11, "000001");
m.set (41, "29110001");
m.set (60, "jPOS 6");
m.set (70, "301");
m.setPackager (customPackager);
byte[] binaryImage = m.pack();
```

In order to unpack this `binaryImage` you may write code like this:

```
ISOPackager customPackager = MyCustomPackager ();
ISOMsg m = new ISOMsg();
m.setPackager (customPackager);
m.unpack (binaryImage);
```

It is very easy to create protocol converters using jPOS, e.g.:

```
ISOPackager packagerA = MyCustomPackagerA ();
ISOPackager packagerB = MyCustomPackagerB ();
ISOMsg m = new ISOMsg();
m.setPackager (packagerA);
m.unpack (binaryImage);
m.setPackager (packagerB);
byte[] convertedBinaryImage = m.pack();
```

`ISOMsg.pack()` delegates message packing/unpacking operations to its underlying "peer" ISOPackager. The code looks like this:

```
public byte[] pack() throws ISOException {
    synchronized (this) {
        recalcBitMap();
        return packager.pack(this);
    }
}
```

`packager.pack(ISOComponent)` also delegates its packing/unpacking duties to an underlying `ISOFieldPackager`. There are `ISOFieldPackager` implementations for many different ways of representing a field. It is very easy to create your own, if required.

The following code is used by an `ISOFieldPackager` implementation to pack and unpack fixed-length alphanumeric fields:

```
public byte[] pack (ISOComponent c) throws ISOException {
    String s = (String) c.getValue();
    if (s.length() > getLength())
        s = s.substring(0, getLength());
    return (ISOUtil.strpad (s, getLength())).getBytes();
}
public int unpack (ISOComponent c, byte[] b, int offset)
    throws ISOException
{
    c.setValue(new String(b, offset, getLength()));
    return getLength();
}
```

jPOS comes with many `ISOFieldPackager` implementations so you'll probably never have to write your own. Names chosen are somewhat cryptic, though.

Many people are using them for their own custom packagers so we'll probably have to live with those names for a while.

As a general rule, all `ISOFieldPackagers` live under package `org.jpos.iso` and start with the name **`IF`** which stands for "ISO Field", but that's just an arbitrary naming convention. You can name and place your own ISOFieldPackager implementations at your will.

So we have things like this:

### Table 2.11. ISOFieldPackagers

| Name | Purpose |
|---|---|
| IF_CHAR | Fixed length alphanumeric (ASCII) |
| IFE_CHAR | Fixed length alphanumeric (EBCDIC) |
| IFA_NUMERIC | Fixed length numeric (ASCII) |
| IFE_NUMERIC | Fixed length numeric (EBCDIC) |

| Name | Purpose |
|---|---|
| IFB_NUMERIC | Fixed length numeric (BCD) |
| IFB_LLNUM | Variable length numeric (BCD, maxlength=99) |
| IFB_LLLNUM | Variable length numeric (BCD, maxlength=999) |
| IFB_LLLLNUM | Variable length numeric (BCD, maxlength=9999) |
| … | … |
| … | … |

## 2.2.3. Creating custom packagers

jPOS provides the ability to create customized packagers for different kind of ISO-8583 implementations. Over the last few years, several developers have contributed their customized ISOPackagers and ISOFieldPackagers, so chances are good that you can find an implementation suitable for you, or something very close to what you need as part of jPOS distribution.

Before writing your own packager, have a look at the classes under `jpos/src/main/java/org/jpos/iso/packager` directory.

Writing a packager is very easy. There’s a support class called ISOBasePackager that you can easily extend, e.g.:

```
public class ISO93APackager extends ISOBasePackager {
    protected ISOFieldPackager fld[] = {
    /*000*/ new IFA_NUMERIC (  4, "Message Type Indicator"),
    /*001*/ new IFA_BITMAP  ( 16, "Bitmap"),
    /*002*/ new IFA_LLNUM   ( 19, "Primary Account number"),
    /*003*/ new IFA_NUMERIC (  6, "Processing Code"),
    /*004*/ new IFA_NUMERIC ( 12, "Amount, Transaction"),
    /*005*/ new IFA_NUMERIC ( 12, "Amount, Reconciliation"),
    ...
    ...
    ...
    public ISO93APackager() {
        super();
        setFieldPackager(fld);
    }
}
```

So the programmer’s task (BTW, an easy but boring one) is to verify that every single field in your packager configuration matches your interchange specifications.

An ISOPackager is not required to extend the supporting class ISOBasePackager, but we’ve found it quite convenient for most situations.

while you write your own packager implementation, we recommend you to write a unit test for it. Have a look at the `jpos/src/test/java/org/jpos/iso/…` directory to find some sample unit tests that can be used as a starting point.

After adding several packagers to our repository, jPOS developer Eoin Flood came up with a good idea: a *GenericPackager* that one could configure by means of an XML file. The GenericPackager configuration looks like this:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<!DOCTYPE isopackager PUBLIC
        "-//jPOS/jPOS Generic Packager DTD 1.0//EN"
        "http://jpos.org/dtd/generic-packager-1.0.dtd">

<!-- ISO 8583:1993 (ASCII) field descriptions for GenericPackager -->

<isopackager>
  <isofield
      id="0"
      length="4"
      name="Message Type Indicator"
      class="org.jpos.iso.IFA_NUMERIC"/>
  <isofield
      id="1"
      length="16"
      name="Bitmap"
      class="org.jpos.iso.IFA_BITMAP"/>
  <isofield
      id="2"
      length="19"
      name="Primary Account number"
      class="org.jpos.iso.IFA_LLNUM"/>
  <isofield
      id="3"
      length="6"
      name="Processing Code"
      class="org.jpos.iso.IFA_NUMERIC"/>
  <isofield
      id="4"
      length="12"
      name="Amount, Transaction"
      class="org.jpos.iso.IFA_NUMERIC"/>
  <isofield
      id="5"
      length="12"
      name="Amount, Reconciliation"
      class="org.jpos.iso.IFA_NUMERIC"/>
  <isofield
      id="6"
      length="12"
      name="Amount, Cardholder billing"
      class="org.jpos.iso.IFA_NUMERIC"/>
      ...
      ...
      ...
</isopackager>
```

We now have XML configurations for most packagers under the `org.jpos.iso.packager` package. They are available in the `jpos/src/main/resources/packager` directory.

If you are to develop a custom packager, we encourage you to use GenericPackager with a suitable custom configuration file instead. It will greately simplify your task.

If you’re using Q2 to configure your packagers, GenericPackager uses the "packager-config" property in order to determine its configuration file.

The XML based packager configuration can be either placed in the operating system or inside a jar within the classpath, GenericPackager has the ability to read it as a resource.

If you need support for nested messages, you may want to have a look at `jpos/src/main/resources/org/jpos/iso/packager/genericpackager.dtd` as well as examples such as `jpos/src/dist/cfg/packager/base1.xml` (see field 127).

## 2.2.4. Managing the wire protocol with ISOChannel

jPOS uses an interface called `ISOChannel` to encapsulate wire protocol details.

`ISOChannel` is used to send and receive `ISOMsg` objects. It leverages the **peer pattern** where its *peer* is an `ISOPackager` instance. It has `send` and `receive` methods as well as means to `set` and `get` a peer packager:

```
...
public void send (ISOMsg m) throws IOException, ISOException;
public ISOMsg receive() throws IOException, ISOException;
public void setPackager(ISOPackager p);
public ISOPackager getPackager();
...
```

Although not meaningful under all possible situations, `ISOChannel` has a few connection-related methods as well:

```
...
public void connect () throws IOException;
public void disconnect () throws IOException;
public void reconnect() throws IOException;
public void setUsable(boolean b);
public boolean isConnected();
...
```

In order for applications to bind jPOS components at runtime, there's a Singleton class called `org.jpos.util.NameRegistrar` where you can register and get references to Objects. The ISOChannel interface provides handy methods to access ISOChannels at runtime by their name.

```
...
public void setName (String name);
public String getName();
...
```

ISOChannel extends ISOSource which reads like this:

```
public interface ISOSource {
    public void send (ISOMsg m)
        throws IOException, ISOException, VetoException;
    public boolean isConnected();
}
```

Different interchanges use different wire protocols. jPOS encapsulates that functionality in completely isolated ISOChannel implementations. It comes with many implementations and it's easy to write your own, perhaps taking advantage of the `BaseChannel` as a super class.

### Table 2.12. Sample ISOChannel implementations

| Name | Description |
|---|---|
| ASCIIChannel | 4 bytes message length plus ISO-8583 data |
| LogChannel | Can be used to read jPOS's logs and inject messages into other channels |
| LoopbackChannel | Every message sent gets received (possibly applying filters). Very useful for testing purposes. |

| Name | Description |
|---|---|
| PADChannel | Used to connect to X.25 packet assembler/dissamblers |
| XMLChannel | jPOS Internal XML representation for ISO-8583 messages |
| … | … |
| … | … |

(see `org.jpos.iso.channel.\*` for a complete list)

Out of all channel implementations, PADChannel deserves a special note. Most TCP/IP based ISO-8583 wire protocol implementations use some kind of indicator to easily detect message bounderies. Most of them use a packet length header so the receiving implementation can tell apart a given ISO-8583 packet from the next one.

On the other hand, implementations that do not use any message boundary indicator are typically migrations from older packet-based networks such as X.25 and assume that a given ISO-8583 packet will come in a single TCP/IP packet, which is **absolutely wrong**. Intermediate networks may split packets (depending on the MTUs involved) or join packets on retransmissions.

PADChannel use no message boundary indicator, it reads the ISO-8583 message on-the-fly. It does the right thing. Unfortunately, unless you have another PADChannel on the other endpoint, you'll probably have to deal with the problem mentioned in the previous paragraph.

### Example 2.1. ISOChannel example

```
import org.jpos.iso.*;
import org.jpos.util.*;
import org.jpos.iso.channel.*;
import org.jpos.iso.packager.*;

public class Test {
    public static void main (String[] args) throws Exception {
        Logger logger = new Logger();
        logger.addListener (new SimpleLogListener (System.out));
        ISOChannel channel = new ASCIIChannel (
            "localhost", 7, new ISO87APackager()
        );
        ((LogSource)channel).setLogger (logger, "test-channel");
        channel.connect ();

        ISOMsg m = new ISOMsg ();
        m.setMTI ("0800");
        m.set (3, "000000");
        m.set (41, "00000001");
        m.set (70, "301");
        channel.send (m);
        ISOMsg r = channel.receive ();
        channel.disconnect ();
    }
}
```

While we'll see many examples similar to the previous one throughout this document, where a simple main() method takes care of instantiating and configuring several jPOS components, later we'll introduce **Q2**, jPOS's component assembler. We **strongly recommend** to use Q2 to run jPOS. It will make your life easier.

Q2 lets you define your jPOS-based application in a very simple, easy to create and easy to maintain set of XML configuration files.

We recommend that you wait until we talk about Q2 before diving into coding your own jPOS-based application. Using code like the previous example is good to learn jPOS but not to run it in a production environment.

In addition, you usually don't deal directly with a channel using its `send` and `receive` methods. You typically interact with it via a multiplexer (`MUX`) or a server (`ISOServer`).

If you have a look at the ISOChannel implementations (most of them live in org.jpos.iso.channel package) you'll notice that many of them extend `org.jpos.iso.BaseChannel`.

BaseChannel is an abstract class that provides hooks and default implementations for several methods that are useful when writing custom channels. While you don't necesarily have to extend BaseChannel to write a custom channel, you'll probably find it very useful.

Depending on your wire protocol, you'll probably only need to extend BaseChannel and just override a few methods, i.e:

```
protected void sendMessageLength(int len) throws IOException;
protected int getMessageLength() throws IOException, ISOException;
```

(see jpos/src/main/java/org/jpos/iso/channel/CSChannel.java for an example).

You may also want to have a look at the LoopbackChannel implementation for an example of an ISOChannel that doesn't extend BaseChannel.

# Filtered Channels

Many ISOChannels implement `FilteredChannel` which looks like this:

```
public interface FilteredChannel extends ISOChannel {
    public void addIncomingFilter (ISOFilter filter);
    public void addOutgoingFilter (ISOFilter filter);
    public void addFilter (ISOFilter filter);
    public void removeFilter (ISOFilter filter);
    public void removeIncomingFilter (ISOFilter filter);
    public void removeOutgoingFilter (ISOFilter filter);
    public Collection getIncomingFilters();
    public Collection getOutgoingFilters();
    public void setIncomingFilters (Collection filters);
    public void setOutgoingFilters (Collection filters);
}
```

The `ISOFilter` interface is very simple as well:

```
public interface ISOFilter {
    public ISOMsg filter (ISOChannel channel, ISOMsg m, LogEvent evt)
        throws VetoException;
    }
}
```

Whenever you add a filter (be it incoming, outgoing, or both) to a FilteredChannel, all messages sent or received by that channel are passed through that filter.

Filters give you the opportunity to stop a given message from being sent or received by that channel, by throwing an ISOFilter.VetoException.

Let's have a look at a very simple filter, DelayFilter:

```
public class DelayFilter implements ISOFilter, ReConfigurable {
    long delay;
    public DelayFilter() {
        super();
        delay = 0L;
    }
   /**
    * @param delay desired delay, expressed in milliseconds
    */
    public DelayFilter(long delay) {
        super();
        this.delay = delay;
    }
    public void setConfiguration (Configuration cfg) {
        delay = cfg.getInt ("delay");
    }
    public ISOMsg filter (ISOChannel channel, ISOMsg m, LogEvent evt)
    {
        evt.addMessage ("<delay-filter delay=\""+delay+"\"/>");
        if (delay > 0L)
            ISOUtil.sleep(delay);
        return m;
    }
}
```

DelayFilter simply applies a given delay to all traffic being sent or received by a given channel. It can be used to simulate remote host delays, a good tool for testing purposes.

But the filter method has the ability to modify the `ISOMsg` object or to just replace it with a new one. A handy `LogEvent` is provided for log/audit purposes.

The previous code introduces a few classes and interfaces, namely `Configuration`, `LogEvent`. We'll talk about these important parts of jPOS soon.

jPOS comes with many general purpose filters:

- `MD5Filter` can be used to authenticate messages;
- `MacroFilter` can be used to expand internal variables and sequencers; and
- `XSLTFilter` can be used to apply XSLT Transformations to ISO-8583 messages.

There's a popular filter called `BSHFilter` that can execute **BeanShell** [http://www.beanshell.org] code placed in an external file that can be modified at runtime without restarting the system, providing an excellent way to make quick changes (which are welcome during tests and initial rounds of certifications - the BSH code can be easily migrated to Java later).

We've seen full applications implemented as BSH-based filters. Those are very difficult to maintain and are significantly slower than business logic implemented in Java code. We encourage you to use this handy scripting capability as a tool for hot-fixes and testing and remember to move the code to Java as soon as you can.

# 2.2.5. Accepting connections with ISOServer

`ISOServer` listens in a given port for incoming connections and takes care of accepting them and passing control to an underlying ISOChannel implementation.

Once a new connection is accepted and an ISOChannel is created, a ThreadPool-controlled Thread takes care of receiving messages from it. Those messages are passed to an ISORequestListener implementation.

### Example 2.2. ISOServer

```
import org.jpos.iso.*;
import org.jpos.util.*;
import org.jpos.iso.channel.*;
import org.jpos.iso.packager.*;

public class Test {
    public static void main (String[] args) throws Exception {
        Logger logger = new Logger ();
        logger.addListener (new SimpleLogListener (System.out));
        ServerChannel channel = new XMLChannel (new XMLPackager());
        ((LogSource)channel).setLogger (logger, "channel");
        ISOServer server = new ISOServer (8000, channel, null);
        server.setLogger (logger, "server");
        new Thread (server).start ();
    }
}
```

The third argument of ISOServer's constructor is an optional ThreadPool. Should you pass a null parameter there, a new ThreadPool is created for you, which defaults to 100 threads. (`new ThreadPool (1,100)`)

Once again, we show this sample code for educational purposes. In real life applications, you want to use Q2's `QServer` component instead.

In order to test the previous server Test program (which is listening on port 8000), you can use a simple *telnet* client where you will be able to type an XML-formatted ISO-8583 message, e.g.:

```
$ telnet localhost 8000
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
```

Now if you have a look at your running Test program you'll see something like this:

```
<log realm="server" at="Fri May 17 08:11:34 UYT 2002.824">
    <iso-server>
        listening on port 8000
    </iso-server>
</log>
```

Back on your telnet session, you can type in an XML formatted ISO-8583 message like this:

```
<isomsg>
 <field id="0" value="0800"/>
 <field id="3" value="333333"/>
</isomsg>
```

(please note XMLChannel expects <isomsg> as well as </isomsg> to be placed as the first thing in a line)

Your test program will then show:

```
<log realm="server.channel" at="Fri May 17 07:56:58 UYT 2002.407">
 <receive>
  <isomsg direction="incoming">
   <field id="0" value="0800"/>
   <field id="3" value="333333"/>
  </isomsg>
 </receive>
</log>
```

As stated above, you can add an ISORequestListener to your ISOServer that will take care of actually processing the incoming messages. So let’s modify our little Test program to answer our messages. Our Test class has to implement ISORequestListener, e.g.:

```
public class Test implements ISORequestListener {
    ...
    ...
    public boolean process (ISOSource source, ISOMsg m) {
        try {
            m.setResponseMTI ();
            m.set (39, "00");
            source.send (m);
        } catch (ISOException e) {
            e.printStackTrace();
        } catch (IOException e) {
            e.printStackTrace();
        }
        return true;
    }
    ...
    ...
}
```

You have to assign this request listener to your server. You can do this assignment with the following instruction:

```
server.addISORequestListener (new Test ());
```

The full program looks like this:

```
import java.io.*;
import org.jpos.iso.*;
import org.jpos.util.*;
import org.jpos.iso.channel.*;
import org.jpos.iso.packager.*;

public class Test implements ISORequestListener {
    public Test () {
        super();
    }
    public boolean process (ISOSource source, ISOMsg m) {
        try {
            m.setResponseMTI ();
            m.set (39, "00");
            source.send (m);
        } catch (ISOException e) {
            e.printStackTrace();
        } catch (IOException e) {
            e.printStackTrace();
        }
        return true;
    }

    public static void main (String[] args) throws Exception {
        Logger logger = new Logger ();
        logger.addListener (new SimpleLogListener (System.out));
        ServerChannel channel = new XMLChannel (new XMLPackager());
        ((LogSource)channel).setLogger (logger, "channel");
        ISOServer server = new ISOServer (8000, channel, null);
        server.setLogger (logger, "server");
        server.addISORequestListener (new Test ());
        new Thread (server).start ();
    }
}
```

Now try to telnet to port 8000 and send another XML-formatted ISO-8583 message. You'll get a response, with a result code "00" (field 39), e.g.:

```
    (you type)
    <isomsg>
     <field id="0" value="0800"/>
     <field id="3" value="333333"/>
    </isomsg>

    (and you should receive)
    <isomsg direction="outgoing">
      <field id="0" value="0810"/>
      <field id="3" value="333333"/>
      <field id="39" value="00"/>
    </isomsg>
```

ISOServer uses a ThreadPool in order to be able to accept multiple connections at the same time. Every socket connection is handled by a single thread. If your request listener implementation takes too long to reply, new messages arriving over that session will have to wait for their response.

To solve this problem, your ISORequestListener implementation should run in its own thread pool so that its process(…) method will just queue requests to be processed by a peer thread.

Before worrying too much about handling simultaneous transactions, you'll be happy to know that jPOS has a `TransactionManager` that deals with that. We'll cover it very soon, keep reading.

ISOServer uses ISOChannel implementations to pull ISOMsgs from the wire. These ISOChannels can, of course, have associated filters as described earlier.

In modern jPOS applications ISOServer is usually managed by the QServer service (see QServer). The ISORequestListener is usually a thin implementation that forwards the request to the TransactionManager.

## 2.2.6. Multiplexing an ISOChannel with a MUX

Imagine an acquirer implementation that receives several requests at a time from several POS terminals and has to route them to an issuer institution by means of an ISOChannel.

While you can establish one socket connection per transaction, it is common use to setup just one socket connection (handled by an ISOChannel instance) and multiplex it.

So a MUX is basically a **channel multiplexer**. Once you have instantiated a MUX, you just send a request and wait for the response.

Originally, the MUX interface look like this:

```
public interface MUX {
    public ISOMsg request (ISOMsg m, long timeout) throws ISOException;
    public boolean isConnected();
}
```

- The `ISOMsg request(ISOMsg, long)` method queues a request to be sent by the underlying ISOChannel(s) and waits for the response up to the timeout specified in milliseconds. It either returns a response or null.
- `isConnected()` is self explanatory, it returns true if the underlying channel(s) are connected.

MUX is an interface that can have many different implementations. Depending on the implementation and the configuration the value returned by `isConnected()` might not be reliable (it could return true even on an unconnected channel).

Recently [1] we've added the ability to asynchronously queue requests, the new MUX interface has another `request` method that returns immediately and calls an ISOResponseListener (with an optional handBack Object).

```
public interface MUX {
    ...
    ...
    public void request
        (ISOMsg m, long timeout, ISOResponseListener r, Object handBack)
    throws ISOException;
}
```

This new asynchronous way of calling the MUX is available in the `QMUX` implementation of the `MUX` interface but it has not been back-ported to the `ISOMUX` implementation which is going to be deprecated in future versions of jPOS. ISOMUX has a `queue` method that can be used to achieve a similar asynchronous behavior.

In order to send responses to the appropriate sending thread, a `MUX` implementation uses selected fields from the original `ISOMsg` request expected to be present in the `ISOMsg` response. Although not part of the `MUX` interface, implementations such as QMUX (the new one) and

[1] jPOS 1.6.1

ISOMUX (the old one) have a protected method called `String getKey(ISOMsg m)` that returns a matching key based on the `ISOMsg` content.

QMUX reads an XML file that honors a `<key>nn,nn,nn</key>` child element and can be used to easily set the appropriate matching key.

The default implementation uses fields such as 41 (Terminal ID) plus field 11 (Serial Trace Audit Number) to create an unique key. You can override `getKey()` in order to use other fields.

## Example 2.3. MUX example

```
...
...
MUX mux = (MUX) NameRegister.get ("mux.mymultiplexer");
...
...
```

```
ISOMsg m = new ISOMsg();
m.setMTI ("0800");
m.set (11, "000001");
m.set (41, "00000001");
ISOMsg response = mux.request (m, 30000);
if (response != null) {
    // you've got a response
} else {
    // request has timed out
    // you may want to reverse or retransmit
}
```

When a message arrives to MUX’s underlying ISOChannel, the MUX implementation checks to see if that message’s *key* is registered as a pending request.

Should that key match a pending request, the response is handed to the waiting thread. If the key was registered as a request, or the response comes in too late then that response is (depending on the configuration) ignored, forwarded to an ISORequestListener or to a well defined Space queue. (see QMUX for details).

Under many situations, the same channel that a client application may use to send requests and wait for responses may also receive requests coming from the remote server.

Those *unmatched requests* coming from the remote server are delegated to an `ISORequestListener` (or a well defined "unhandled" Space queue).

Let’s have a look at the ISORequestListener interface:

```
public interface ISORequestListener {
    public boolean process (ISOSource source, ISOMsg m);
}
```

Imagine we want to answer the 0800 echo requests arriving to our MUX. We can write the following implementation:

```
public class EchoHandler extends Log
     implements ISORequestListener
{
     public boolean process (ISOSource source, ISOMsg m) {
         try {
             if ("0800".equals (m.getMTI())) {
                 m.setResponseMTI ();
                 m.set (39, "00");
                 source.send (m);
             }
         } catch (Exception e) {
             warn ("echo-handler", e);
         }
         return true;
     }
}
```

# Chapter 3. Support classes

## 3.1. jPOS' Logger

Yet another Logger subsystem?

You may wonder why we’ve chosen to develop our own Logger subsystem. The answer is very simple: when we wrote it, there were no other suitable logger subsystems available. Log4j was just a tiny library hosted in IBM alphaWorks.

You may wonder why we don’t deprecate it now that there are other options available. The main difference between our logger sub-system and other logger sub-systems out there is that we deal with **live objects**. A LogEvent holds live objects that can be handled by the LogListeners, for example to protect sensitive information (PCI requirement) or to act on special conditions (i.e. e-mailing an Operator on an Exception without having to parse the serialized message).

While other logger subsystems are mostly "line oriented", jPOS' is mostly "transaction oriented". A jPOS LogEvent is likely to carry information for the whole transaction making it very suitable for audit and debugging purposes.

In order to avoid the initial desire to get rid of the jPOS Logger and use your the logger you’re used to use, you may want to consider jPOS' as an **Event Logger**, or **Audit Log**. We don’t use it to add debug or trace statements in applications, we use it to log business related data.

You can still use your preferred logger subsystem as part of your business logic.

jPOS’s logger subsystem is very easy to extend, so one can easily plug in other logger engines (such as Log4j, commons logging or the new JDK’s 1.4 logging stuff), but that has little use. One of the benefit of our logger is the fact that it produce easy to read (very lightweight) and easy to parse XML output. The `LogChannel` for example can read a jPOS log file and parse ISO-8583 messages from it. If you plug another layer of logging on top of it, the output is likely to add per-line timestamps that will render the file difficult to parse.

Our logger is implemented by the following main classes:

### Table 3.1. Logger’s main classes

| Class | Description |
|---|---|
| Logger | Main logger class |
| LogListener | Listens to log events |
| LogSource | A log event producer has to implement LogSource |
| LogEvent | The Log Event |

The `Logger` class has the following important methods:

```
public class Logger {
   public static void log (LogEvent ev);
   ...
   public void addListener (LogListener l);
   public void removeListener (LogListener l);
   public boolean hasListeners();
   ...
   ...
}
```

`LogSource` looks like this:

```
public interface LogSource {
   public void setLogger (Logger logger, String realm);
   public String getRealm ();
   public Logger getLogger ();
}
```

And `LogEvent`:

```
public class LogEvent {
   public LogEvent (LogSource source, String tag);
   ...
   ...
   public void addMessage (Object msg);
   ...
}
```

(please take a look at **jPOS's javadoc** [http://jpos.org/doc/javadoc/org/jpos/util/LogEvent.html] or source code for a full description)

Here is a simple way to create a Logger:

```
Logger logger = new Logger();
logger.addListener (new SimpleLogListener (System.out));
```

Now you can easily attach that logger to any jPOS component implementing LogSource such as channels, packagers, multiplexers, etc. You can easily call:

```
component.setLogger (logger, "some-component-description");
```

You can use jPOS's logger subsystem to log events of your own. In those cases, you have to either implement LogSource or extend or use the the `org.jpos.util.SimpleLogSource` class or better yet, use the newer `org.jpos.util.Log` class.

Then you can write code like this:

```
LogEvent evt = new LogEvent (yourLogSource, "my-event");
evt.addMessage ("A String message");
evt.addMessage (anyLoggeableObject);
Logger.log (evt);
```

The `Loggeable` interface is a very simple way of letting an object render itself:

```
public interface Loggeable {
   public void dump (PrintStream p, String indent);
}
```

Most of jPOS's components already implement the `Loggeable` interface, but you can easily wrap any given object with a Loggeable class that holds the former object as its payload, e.g.:

```
package net.swini.util;

import java.io.PrintStream;
import org.jpos.util.Loggeable;

public abstract class LoggeableBase implements Loggeable {
    protected String toXML (String tag, String value, String indent) {
        StringBuffer sb = new StringBuffer (indent);
        sb.append ('<');
        sb.append (tag);
        sb.append ('>');
        sb.append (value);
        sb.append ("</");
        sb.append (tag);
        sb.append ('>');
        return sb.toString ();
    }
    public abstract void dump (PrintStream p, String indent);
}

package net.swini.util;

import java.io.PrintStream;
import net.jini.core.lookup.ServiceItem;
import net.jini.lookup.entry.ServiceInfo;

public class LoggeableServiceItem extends LoggeableBase {
    String tag;
    ServiceItem item;
    public LoggeableServiceItem (String tag, ServiceItem item) {
        super();
        this.tag  = tag;
        this.item = item;
    }
    public void dump (PrintStream p, String indent) {
        String inner = indent + "    ";
        p.println (indent + "<" + tag + ">");

        if (item.service != null) {
            p.println (toXML ("class", item.service.getClass().getName(), inner));
        } else {
            p.println (inner + "null item.service - (check http server)");
        }
        p.println (toXML ("id", item.serviceID.toString(), inner));

        for (int i=0 ; i<item.attributeSets.length ; i++) {
            if (item.attributeSets[i] instanceof ServiceInfo) {
                ServiceInfo info = (ServiceInfo) item.attributeSets[i];
                p.println (toXML ("name", info.name, inner));
                p.println (toXML ("manufacturer", info.manufacturer, inner));
                p.println (toXML ("vendor", info.vendor, inner));
                p.println (toXML ("version", info.version, inner));
                p.println (toXML ("model", info.model, inner));
                p.println (toXML ("serial", info.serialNumber, inner));
            }
            else {
                p.println (inner + "<attr>");
                p.println (inner + "  "+item.attributeSets[i].toString());
                p.println (inner + "</attr>");
            }
        }
        p.println (indent + "</" + tag + ">");
    }
}
```

There’s a general purpose Loggeable class called `SimpleMsg` which has an overloaded constructor for several commonly used Java types. You can easily add a `SimpleMsg` to your log stream with code like this:

```
...
...
evt.addMessage (new SimpleMsg ("demo", "boolean", true));
evt.addMessage (new SimpleMsg ("demo", "time", System.currentTimeMillis()));
evt.addMessage (new SimpleMsg ("demo", "dump", "TEST".getBytes()));
...
...
```

jPOS comes with several `LogListener` implementations and it's very easy to write your own. The ready available ones include:

### Table 3.2. LogListener

| Class | Description |
|---|---|
| SimpleLogListener | Dumps log events to a PrintStream (such as System.out) |
| RotateLogListener | Automatically rotate logs based on file size and time window |
| DailyLogListener | Automatically rotate logs daily. Has the ability to compress old log files |
| OperatorLogListener | Applies some filtering and e-mails log-events to an operator |
| ProtectedLogListener | Protect sensitive data from ISOMsgs in LogEvents for PCI compliance |
| SysLogListener | Forward log events to the operating system syslog. |

In the jPOS-EE code base you can find some additional logger implementations such as IRCLogListener that forwards LogEVents to an irc channel. In addition, there's a LogBack adaptor that let us capture other loggers output (i.e. log4j, commons-logging, etc.) into jPOS' log stream. This allows you to use your preferred logger API in your code while getting the output in a centralized jPOS file.

LogListeners are called synchronously, so one listener has the chance to modify a given LogEvent; for example, `ProtectedLogListener` analyzes received `LogEvents` and **protects** important information (such as track-2 data).

# 3.2. NameRegistrar

**org.jpos.util.NameRegistrar** is a very simple **singleton** class that can be used to register and locate jPOS components.

It's nothing but a simple, well-known Map where one can easily find components by an arbitrary name.

NameRegistrar has the following static methods:

```
public static void register (String key, Object value);
public static void unregister (String key);
public static Object get (String key)
    throws NameRegistrar.NotFoundException;
public static Object getIfExists (String key);
```

So you can write code like this:

```
...
...
ISOMUX mux = new ISOMUX (...);
NameRegistrar.register ("myMUX", mux);
...
...
```

and elsewhere in your application you can get a reference to your MUX with code like this:

```
    try {
        ISOMUX mux = (ISOMUX) NameRegistrar.get ("myMUX");
    } catch (NameRegistrar.NotFoundeException e) {
        ...
        ...
    }
```

```
or
```

```
  ISOMUX mux = (ISOMUX) NameRegistrar.getIfExists ("myMUX");
  if (mux != null) {
      ...
      ...
  }
```

Although we can use NameRegistrar in order to register jPOS components, sometimes it’s better to use the component’s setName(String name) method when available.

Most components have a setName (String name) method implemented like this:

```
  public class ISOMUX {
      ...
      ...
      public void setName (String name) {
          this.name = name;
          NameRegistrar.register ("mux."+name, this);
      }
      ...
      ...
```

The prefix `"mux."` is used here in order to avoid a clash of names in the registrar between different classes of components using the same name (i.e. `"mux.institutionABC"` and `"channel.institutionABC"`).

Different components use different prefixes as shown in the following table:

## Table 3.3. NameRegistrar’s prefix

| Component | Prefix | Getter |
|---|---|---|
| ConnectionPool | "connection.pool." | N/A |
| ControlPanel | "panel." | N/A |
| DirPoll | "qsp.dirpoll." | N/A |
| BaseChannel | "channel." | BaseChannel.getChannel |
| ISOMUX | "mux." | ISOMUX.getMUX |
| QMUX | "mux." | QMUX.getMUX |
| ISOServer | "server." | ISOServer.getServer |

| Component | Prefix | Getter |
|---|---|---|
| KeyStore | "keystore." | N/A |
| Logger | "logger." | Logger.getLogger |
| LogListener | "log-listener." | N/A |
| PersistentEngine | "persistent.engine." | N/A |
| SMAdapter | "s-m-adapter." | BaseSMAdapter.getSMAdapter |

While we try to keep the previous prefix table up to date, we suggest that you double-check it against the source code if you have problems getting references to your components.

Using the getter (when available) lets us write code like this:

```
try {
   ISOMUX mux = ISOMUX.get ("myMUX");
} catch (NameRegistrar.NotFoundeException e) {
   ...
   ...
}
```

that will in turn call `NameRegistrar.get ("mux.myMUX")`. Later, we’ll see that NameRegistrar is extensively used by jPOS' Q2 applications. Q2 takes care of configuring several jPOS components for you, but your code will have to locate them by a given name. That’s where `NameRegistrar` comes in to play.

Singletons are usually an illusion, you think there’s just one, but there might be more than one. If you have multiple classloaders in your application you may end up with multiple copies of a singleton, such as the NameRegistrar.

This problem does not exist if you run Q2 as a stand-alone application.

The `NameRegistrar` is a `Loggeable` object (see **Section 3.1, “jPOS' Logger”**) so its instance (`NameRegistrar.getInstance()`) can be added to a `LogEvent` in order to assist you during debugging sessions.

When running in a **Q2** environment we recommend to deploy a `sysmon` service in order to regularly view the NameRegistrar’s content.

# 3.3. Configuration

**org.jpos.core.Configuration** is a general purpose property container extensively used by jPOS components.

The Configuration interface looks like this:

```
package org.jpos.core;

public interface Configuration {
  public void put (String name, Object value);
  public String get (String propertyName);
  public String get (String propertyName, String defaultValue);
  public String[] getAll  (String propertyName);
  public int[] getInts  (String propertyName);
  public long[] getLongs (String propertyName);
  public double[] getDoubles (String propertyName);
  public boolean[] getBooleans (String propertyName);
  public int getInt (String propertyName);
  public int getInt (String propertyName, int defaultValue);
  public long getLong (String propertyName);
  public long getLong (String propertyName, long defaultValue);
  public double getDouble (String propertyName);
  public double getDouble (String propertyName, double defaultValue);
  public boolean getBoolean (String propertyName);
  public boolean getBoolean (String propertyName, boolean defaultValue);
}
```

Having our own Configuration interface lets us implement it in different ways. We have a very little class called SimpleConfiguration backed by a java.util.Properties, but nothing prevents us from creating a more sophisticated Configuration object capable of providing dynamic data (such as an SQLConfiguration, JavaSpacesConfiguration and the like).

jPOS-EE implements a SysConfigConfiguration that reads objects from its `sysconfig` SQL table.

We also have a very simple interface called Configurable:

```
package org.jpos.core;

public interface Configuration {
  public void setConfiguration (Configuration cfg)
     throws ConfigurationException;
}
```

Later, while looking at the Q2 application we'll see that Q2 pushes a configuration object by calling the `setConfiguration` method on `Configurable` objects.

```
<object name="myObject" class="com.mycompany.MyObject">
  <property name="myProperty" value="any Value" />
</object>
```

Should `com.mycompany.MyObject"` implement `Configurable`, Q2 would call its `setConfiguration()` method providing access to the underlying `myProperty` property.

It's interesting to note that Q2 provides the ability to have array of properties under the same name, i.e:

```
<object name="myObject" class="com.mycompany.MyObject">
 <property name="myProperty" value="Value A" />
 <property name="myProperty" value="Value B" />
 <property name="myProperty" value="Value C" />
</object>
```

where one can call handy methods like `String\[\] getAll(String)`.

`setConfiguration(Configuration cfg)` can check the Configuration object and might throw a `ConfigurationException` in case a required property is not present or is invalid.

# 3.4. SystemMonitor

**org.jpos.util.SystemMonitor** is a very simple class that periodically logs useful information such as the number of running threads, memory usage, etc.

Its constructor looks like this:

```
public SystemMonitor (int sleepTime, Logger logger, String realm)
```

See **javadocs** [http://jpos.org/doc/javadoc/org/jpos/util/SystemMonitor.html] for details.

Using SystemMonitor is very easy. You simply have to instantiate it with code like this:

```
...
...
new SystemMonitor (60*60*1000L, yourLogger, "system-monitor"); // dumps every hour
...
...
```

and it will dump info to your log every hour (60*60*1000 milliseconds). The output looks like this:

```
<info>
             OS: Mac OS X
           host: Macintosh-2.local/192.168.2.20
        version: 1.9.3-SNAPSHOT (d3c9ac3)
       instance: 38d512f6-f812-4d85-8520-cb96de2654a0
         uptime: 00:00:00.234
     processors: 2
          drift : 0
  memory(t/u/f): 85/7/78
        threads: 4
          Thread[Reference Handler,10,system]
          Thread[Finalizer,8,system]
          Thread[Signal Dispatcher,9,system]
          Thread[RMI TCP Accept-0,5,system]
          Thread[Q2-38d512f6-f812-4d85-8520-cb96de2654a0,5,main]
          Thread[DestroyJavaVM,5,main]
          Thread[Timer-0,5,main]
          Thread[SystemMonitor,5,main]
  name-registrar:
    logger.Q2.buffered: org.jpos.util.BufferedLogListener
    logger.Q2: org.jpos.util.Logger
</info>
```

Most output is self-explanatory, with some abbreviations, e.g., memory *t/u/f* stands for *total*, *used* and *free*. But there’s one, **drift**, that deserves some explanation.

In the old days of the initial JVM 1.02, where Threads were not native operating system threads (they were called *green threads*), it was very easy for a thread to interfere with other threads in the same JVM, so calls to set the thread priority, and even calls to `Thread.yield()` here and there in tight loops where necessary.

In order to detect situations where something was really wrong we devised a simple approach: the system monitor is supposed to sleep for a given period of time, and then wake up. If we sleep for say 3600 seconds, we should be waked up exactly 3600 later, right? When threads were cooperating that was kind of true, we wake up just a few milliseconds later which is reasonable, but when some threads were hogging the CPU, that wake up happens several hundred and sometimes thousand milliseconds later. That was an indication that one or more threads were running in a tight loop consuming too much CPU resources and needed further investigation.

Green Threads are over, we now have great support for native threads, but we left that *drift* indicator in the SystemMonitor and interesting enough, it's still very useful. When the system is running under heavy load, or on overloaded and poorly monitored virtualized environments, the drift goes up, to several seconds.

If we have a report for a slow jPOS application, we suggest to immediately take a look at that drift, if it looks weird, you know you need to start looking at the whole system performance instead of just your jPOS based application.

If you're using Q2, the default configuration deploys a `SystemMonitor` for you.

See `deploy/99_sysmon.xml`

# 3.5. Profiler

**org.jpos.util.Profiler** is a very simple and easy to use user-space Profiler. It leverages the Logger subsystem to provide accurate information about processing times.

These are Profiler's public methods:

```
    public void reset();
    public void checkPoint (String detail);
    public long getElapsed();
    public long getParcial();
```

See **javadocs** [http://www.jpos.org/doc/javadoc/org/jpos/util/Profiler.html] for details.

Profiler implements Loggeable, so you can easily add a Profiler Object to a LogEvent to produce convenient profiling information.

### Example 3.1. Profiler

```
Profiler prof = new Profiler();
LogEvent evt = new LogEvent (this, "any-transaction", prof);

// initialize message
ISOMsg m = new ISOMsg ();
m.setMTI ("1200");
...
...
prof.checkPoint ("initialization");

// send message to remote host
...
...
ISORequest req = new ISORequest (m);
mux.queue (req);
ISOMsg response = req.getResponse (60000);
prof.checkPoint ("authorization");

// capture data in local database
...
...
prof.checkPoint ("capture");
...
...
Logger.log (evt);
```

The "end" checkPoint is automatically computed at output time (that’s when Logger calls its log listeners).

The profiler output looks like this:

```
  prepare: org.jpos.jcard.PrepareContext [0.2/0.2]         ❶
  prepare: org.jpos.jcard.CheckVersion [0.1/0.3]           ❷
  prepare: org.jpos.transaction.Open [1.0/1.3]
  prepare: org.jpos.jcard.Switch [0.1/1.5]
  prepare: org.jpos.jcard.NotSupported [0.1/1.7]
  prepare: org.jpos.jcard.PrepareResponse [11.2/13.0]
  prepare: org.jpos.transaction.Close [0.2/13.2]
  prepare: org.jpos.jcard.SendResponse [0.0/13.3]
  prepare: org.jpos.jcard.ProtectDebugInfo [0.1/13.4]
  prepare: org.jpos.transaction.Debug [0.0/13.5]
   commit: org.jpos.transaction.Close [1.8/15.4]
   commit: org.jpos.jcard.SendResponse [2.2/17.6]
   commit: org.jpos.jcard.ProtectDebugInfo [0.3/17.9]
   commit: org.jpos.transaction.Debug [3.9/21.9]           ❸
  end [1.9/23.9]                                           ❹
```

❶ Partial 0.2 milliseconds, total so far, 0.2 milliseconds.
❷ CheckVersion took 0.1 milliseconds, so the total so far is 0.3 milliseconds.
❸ Total so far, 21.9ms.
❹ 1.9ms is the time between the last checkPoint and the log time.

# 3.6. DirPoll

Some jPOS-based applications have to interact with third-party legacy software (e.g., batch files coming from acquirers, retail applications, etc). Most of the time one can be lucky enough to deal with legacy applications capable of sending transactions over decent protocols but sometimes you are not that lucky and the best thing you can get is a disk-based interchange, i.e., they place a request in a given directory, you process that request and provide a response.

**org.jpos.util.DirPoll** uses the following directory structure (whose names are self explanatory):

```
..../archive
..../request
..../response
..../tmp
..../run
..../bad
```

and defines the following inner interfaces:

```
public interface Processor {
    public byte[] process(String name, byte[] request)
        throws DirPollException;
}
public interface FileProcessor {
    public void process (File name)
        throws DirPollException;
}
```

You can either create a Processor or a FileProcessor to handle incoming traffic.

Whenever a legacy application places a file in the `request` directory, your Processor (or FileProcessor) gets called, giving you a chance to process the given request and provide a response (if you're using a Processor, the response will be placed in the `response` directory).

## Example 3.2. DirPoll Processor

```
public class DirPollProcessor implements DirPoll.Processor {
    DirPollProcessor () {
        super ();
        DirPoll dp = new DirPoll ();
        dp.setLogger (logger, "dir-poll");
        db.setPath ("/tmp/dirpoll");
        db.createDirs ();
        db.setProcessor (this);
        new Thread (dp).start ();
    }
    public byte[] process (String name, byte[] b) {
        return ("request: " + name + " content="+ new String (b)).getBytes();
    }
}
```

DirPoll has provisions to handle different kind of messages with different priority based on its file extension, so you can call:

```
...
...
dp.addPriority (".A");
dp.addPriority (".B");
dp.addPriority (".C");
...
...
```

in order to raise ".A" priority over ".B" and ".C" requests (you can use any extension name).

Before processing a given request, `DirPoll` moves it to the `run` directory, and then either to the `response` directory or to the `bad` directory (in case something goes wrong and a `DirPollException` has been thrown).

If your application crashes, you have to take care of possible requests left sitting in the `run` directory. It is very important that your application writes the requests in the `tmp` directory (or any other temporary directory in the same file system) and then moves them (after a proper operating system close operation) to the `request` directory in order to guarantee that once a request is present in the `request` directory, it is ready for DirPoll to process.

Don’t trust your legacy application programmer. Please double check that the previous note has been taken into account.

# 3.7. ThreadPool

This class is going to be deprecated. Do not use in new code.

The ThreadPool is used by several jPOS components, such as the ISOServer, and it was a good helper class 10 years ago. We will replace it by components of the Java Executors Framework at some point.

**org.jpos.util.ThreadPool**, takes care of managing a pool of threads.

Its constructor looks like this:

```
    public ThreadPool (int initialPoolSize, int maxPoolSize)
```

(See **javadocs** [http://jpos.org/doc/javadoc/org/jpos/util/ThreadPool.html] for details).

It’s very useful to process short-lived threads, such as processing an authorization transaction. Instead of creating a new thread per transaction, you can create a ThreadPool at initialization time and then call its `execute(Runnable r)` method.

The thread will be returned to the pool when your `run()` method ends, so it is not a good idea to have long-running threads (e.g., a `for (;;) { … }` loop) in your Runnable.

There’s an inner interface called ThreadPool.Supervised that your Runnable can optionally implement:

```
    public class ThreadPool {
        public interface Supervised {
            public boolean expired ();
        }
    }
```

In this case, ThreadPool will call your `expired()` method, and - if true - will attempt to interrupt the expired thread. Note that while this does not guarantee that your thread will gracefully end, it gives you a chance to get out of a possible problem.

You can write some *self-healing* code in your `expired()` implementation, but please make sure your code won’t block for too long. Use only if you know what you’re doing.

ThreadPool implements ThreadPoolMBean, which exposes the following read-only properties:

```
    public int getJobCount ();
    public int getPoolSize ();
    public int getMaxPoolSize ();
    public int getIdleCount();
    public int getPendingCount ();
```

# Chapter 4. Packagers

# 4.1. Implementing Custom Packagers

jPOS comes with several ISOPackager and ISOFieldPackager implementations that can be used either out-of-the-box or as a reference to encode (pack) and decode (unpack) messages that are built on the ISO-8583 standard.

For a list of out-of-the-box packagers you may want to have a look at the following directories:

- `jpos/src/main/java/org/jpos/iso/packager` (Java based packagers)
- `jpos/src/main/resources/packager` (GenericPackager configurations accessible as a resource)
- `src/dist/cfg/packager` (GenericPackager configurations accessible as external files)

Although not required, most ISOPackager implementations extend the supporting class ISOBasePackager. This approach makes writing a custom packager a very simple task. It's basically just a matter of calling its `public void setFieldPackager (ISOFieldPackager[] fld)` method with a suitable array of ISOFieldPackagers.

Let's look at a sample implementation:

### Example 4.1. ISO-8583 version 1993 packager implementation

```
public class ISO93BPackager extends ISOBasePackager {
    private static final boolean pad = false;
    protected ISOFieldPackager fld[] = {
    /*000*/ new IFB_NUMERIC (  4, "Message Type Indicator", pad),
    /*001*/ new IFB_BITMAP  ( 16, "Bitmap"),
    /*002*/ new IFB_LLNUM   ( 19, "Primary Account number", pad),
    /*003*/ new IFB_NUMERIC (  6, "Processing Code", pad),
    /*004*/ new IFB_NUMERIC ( 12, "Amount, Transaction", pad),
    /*005*/ new IFB_NUMERIC ( 12, "Amount, Reconciliation", pad),
    /*006*/ new IFB_NUMERIC ( 12, "Amount, Cardholder billing", pad),
    /*007*/ new IFB_NUMERIC ( 10, "Date and time, transmission", pad),
    /*008*/ new IFB_NUMERIC (  8, "Amount, Cardholder billing fee", pad),
    /*009*/ new IFB_NUMERIC (  8, "Conversion rate, Reconciliation", pad),
    /*010*/ new IFB_NUMERIC (  8, "Conversion rate, Cardholder billing", pad),
    ...
    ...
    ...
    /*123*/ new IFB_LLLCHAR (999, "Reserved for private use"),
    /*124*/ new IFB_LLLCHAR (999, "Reserved for private use"),
    /*125*/ new IFB_LLLCHAR (999, "Reserved for private use"),
    /*126*/ new IFB_LLLCHAR (999, "Reserved for private use"),
    /*127*/ new IFB_LLLCHAR (999, "Reserved for private use"),
    /*128*/ new IFB_BINARY  (  8, "Message authentication code field")
    };
    public ISO93BPackager() {
        super();
        setFieldPackager(fld);
    }
}
```

We hope you see the key idea: writing a custom packager involves diving into your interchange specification and setting up a suitable kind of field packager for every possible field.

# 4.2. GenericPackager

After writing multiple ISOFieldPackager implementations, jPOS developer Eoin Flood came up with a nice idea: writing a GenericPackager that would read an XML configuration file and instantiate an ISOFieldPackager on-the-fly.

Because packagers are usually instantiated once during the life time of an application, there’s no performance impact between a packager implemented in pure Java or the GenericPackager that reads an XML only at initialization time.

Using this approach, the same packager we’ve seen in the previous example can be easily configured using `GenericPackager` and a simple XML file like this:

### Example 4.2. ISO-8583 version 1993 packager configuration

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<!DOCTYPE isopackager PUBLIC
        "-//jPOS/jPOS Generic Packager DTD 1.0//EN"
        "http://jpos.org/dtd/generic-packager-1.0.dtd">

<!-- ISO 8583:1993 (BINARY) field descriptions for GenericPackager -->

<isopackager>
  <isofield
      id="0"
      length="4"
      name="Message Type Indicator"
      pad="false"
      class="org.jpos.iso.IFB_NUMERIC"/>
  <isofield
      id="1"
      length="16"
      name="Bitmap"
      class="org.jpos.iso.IFB_BITMAP"/>
  <isofield
      id="2"
      length="19"
      name="Primary Account number"
      pad="false"
      class="org.jpos.iso.IFB_LLNUM"/>
  <isofield
      id="3"
      length="6"
      name="Processing Code"
      pad="false"
      class="org.jpos.iso.IFB_NUMERIC"/>
  <isofield
      id="4"
      length="12"
      name="Amount, Transaction"
      pad="false"
      class="org.jpos.iso.IFB_NUMERIC"/>
   ...
   ...
   ...
  <isofield
      id="126"
      length="999"
      name="Reserved for private use"
      class="org.jpos.iso.IFB_LLLCHAR"/>
  <isofield
      id="127"
      length="999"
      name="Reserved for private use"
      class="org.jpos.iso.IFB_LLLCHAR"/>
  <isofield
      id="128"
      length="8"
      name="Message authentication code field"
      class="org.jpos.iso.IFB_BINARY"/>
</isopackager>
```

GenericPackager uses a DTD defined in `main/resources/org/jpos/iso/packager/genericpackager.dtd` that looks like this:

```
<?xml version="1.0" encoding="UTF-8"?>

<!ELEMENT isopackager (isofield+,isofieldpackager*)*>
<!ATTLIST isopackager maxValidField CDATA        #IMPLIED>
<!ATTLIST isopackager bitmapField   CDATA        #IMPLIED>
<!ATTLIST isopackager firstField    CDATA        #IMPLIED>
<!ATTLIST isopackager emitBitmap    (true|false) #IMPLIED>
<!ATTLIST isopackager headerLength  CDATA        #IMPLIED>

<!-- isofield -->
<!ELEMENT isofield (#PCDATA)>
<!ATTLIST isofield id     CDATA        #REQUIRED>
<!ATTLIST isofield length CDATA        #REQUIRED>
<!ATTLIST isofield name   CDATA        #REQUIRED>
<!ATTLIST isofield class  NMTOKEN      #REQUIRED>
<!ATTLIST isofield token  CDATA        #IMPLIED>
<!ATTLIST isofield pad    (true|false) #IMPLIED>

<!-- isofieldpackager -->
<!ELEMENT isofieldpackager (isofield+,isofieldpackager*)*>
<!ATTLIST isofieldpackager id       CDATA        #REQUIRED>
<!ATTLIST isofieldpackager name     CDATA        #REQUIRED>
<!ATTLIST isofieldpackager length   CDATA        #REQUIRED>
<!ATTLIST isofieldpackager class    NMTOKEN      #REQUIRED>
<!ATTLIST isofieldpackager token    CDATA        #IMPLIED>
<!ATTLIST isofieldpackager pad      (true|false) #IMPLIED>
<!ATTLIST isofieldpackager packager NMTOKEN      #REQUIRED>
<!ATTLIST isofieldpackager emitBitmap (true|false) #IMPLIED>
<!ATTLIST isofieldpackager maxValidField CDATA        #IMPLIED>
<!ATTLIST isofieldpackager bitmapField CDATA        #IMPLIED>
<!ATTLIST isofieldpackager firstField  CDATA        #IMPLIED>
<!ATTLIST isofieldpackager headerLength  CDATA        #IMPLIED>
```

GenericPackager's DTD eases the configuration of nested messages (an ISO-8583 field that is a full ISO-8583 message itself), e.g.:

```
   ...
   ...
  <isofieldpackager
      id="127"
      length="255"
      name="FILE RECORS(S) ACTION/DATA"
      class="org.jpos.iso.IFB_LLHBINARY"
      packager="org.jpos.iso.packager.GenericSubFieldPackager">
      <isofield
          id="0"
          length="1"
          name="FILE UPDATE COD"
          class="org.jpos.iso.IFE_CHAR"/>
      <isofield
          id="1"
          length="19"
          name="ACCOUNT NUMBER"
          pad="true"
          class="org.jpos.iso.IFB_LLHNUM"/>
      <isofield
          id="2"
          length="4"
          name="PURGE DATE"
          pad="true"
          class="org.jpos.iso.IFB_NUMERIC"/>
      ...
      ...
      ...
  </isofieldpackager>
```

The `GenericPackager` uses an entity resolver that recognizes the PUBLIC DTD in order to avoid loading it over the internet. This is particularly important when you run your system in a DMZ with limited access to the outside world.

In order to take advantage of the entity resolver, you need to make sure that your packager configuration starts with the following preamble:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<!DOCTYPE isopackager PUBLIC
        "-//jPOS/jPOS Generic Packager DTD 1.0//EN"
        "http://jpos.org/dtd/generic-packager-1.0.dtd">
```

# Chapter 5. Channels

jPOS comes with several channel implementations, most of which are available in the `src/main/java/org/jpos/iso/channel` directory.

## 5.1. TCP/IP Socket-based channels

Most TCP/IP-based channel implementations extend `org.jpos.iso.BaseChannel` and just override the `sendMessageLength` and `getMessageLength` methods.

Let’s have a look at `org.jpos.iso.channel.CSChannel`: it uses a two-byte message length header sent in network byte order (nbo) plus two bytes reserved for future use:

```
public class CSChannel extends BaseChannel {
    ...
    ...
    protected void sendMessageLength(int len) throws IOException {
        serverOut.write (len >> 8);
        serverOut.write (len);
        serverOut.write (0);
        serverOut.write (0);
    }
    ...
    ...
    protected int getMessageLength() throws IOException, ISOException {
        int l = 0;
        byte[] b = new byte[4];
        while (l == 0) {
            serverIn.readFully(b,0,4);
            l = ((((int)b[0])&0xFF) << 8) | (((int)b[1])&0xFF);
            if (l == 0) {
                serverOut.write(b);
                serverOut.flush();
            }
        }
        return l;
    }
}
```

Here is a partial list of current channel implementations (for a complete list, have a look at `jpos/src/main/java/org/jpos/iso/channel`):

| Class name | Wire protocol |
|---|---|
| CSChannel | LL LL 00 00 [header] ISO-DATA LL LL represents the [header+] ISO-DATA length in network byte order 00 00 reserved for future use The header is optional ISO-DATA: ISO-8583 image |
| NACChannel | LL LL [TPDU] ISO-DATA LL LL represents the TPDU+ISO-DATA length in network byte order Optional TPDU (transport protocol data unit) ISO-DATA: ISO-8583 image |
| NCCChannel | LL LL [TPDU] ISO-DATA LL LL represents the TPDU+ISO-DATA length in BCD (binary coded decimal) Optional TPDU (transport protocol data unit) ISO-DATA: ISO-8583 image |
| ASCIIChannel | LLLL [header] ISO-DATA LLLL four bytes ASCII [header+] ISO-DATA length Optional header ISO-DATA: ISO-8583 image |

| Class name | Wire protocol |
|---|---|
| RawChannel | LL LL LL LL [header] ISO-DATA LL LL LL LL is [header+] ISO-DATA length in network byte order<br><br>ISO-DATA: ISO-8583 image |
| VAPChannel | LL LL 00 00 header ISO-DATA LL LL represents the header+ISO-DATA length in network byte order 00 00 reserved for future use VAP-specific header ISO-DATA: ISO-8583 image |
| PADChannel | [header] ISO-DATA Stream-based channel reads messages on-the-fly without using any kind of message boundary indicator. |
| X25Channel | X25 is similar to PADChannel but uses a slightly different strategy. Instead of pulling an ISO-8583 from a stream, unpacking it on the fly, X25Channel attempts to read full TCP/IP packets by specifying a small timeout value. Whenever possible, PADChannel seems like a better solution; however, certain X.25 packet assembler/disassemblers sometimes send garbage over the wire (i.e. ETXs) which might confuse PADChannel. |
| XMLChannel | Send/Receive messages in jPOS’s internal XML message representation |
| LogChannel | Similar to XMLChannel, but you can feed it a jPOS Log, which is suitable to replay sessions |

# 5.2. SSL Channels

SocketFactories (like `ISOServer`), as well as most channels that inherit from `BaseChannel` can delegate socket creation to an optional socket factory.

We have two kinds of socket factories:

- `ISOClientSocketFactory`
- `ISOServerSocketFactory`

```
public interface ISOClientSocketFactory {
    public Socket createSocket(String host, int port)
        throws IOException, ISOException;
}

public interface ISOServerSocketFactory {
    public ServerSocket createServerSocket(int port)
        throws IOException, ISOException;
}
```

as well as a provider that implements both of them: `org.jpos.iso.GenericSSLSocketFactory`

Q2 services (actually the ChannelAdaptor and QServer qbeans), accept an optional *socketFactory* property in the channel configuration,

### Example 5.1. SocketFactory configuration

```
<channel-adaptor name='sslclient'
    class="org.jpos.q2.iso.ChannelAdaptor" logger="Q2">
 <channel class="org.jpos.iso.channel.NACChannel" logger="Q2"
       packager="org.jpos.iso.packager.ISO87BPackager">

  <property name="host" value="127.0.0.1" />
  <property name="port" value="10000" />
  <property name="timeout" value="360000" />
  <property name="socketFactory" value="org.jpos.iso.GenericSSLSocketFactory" />
 </channel>
 <in>sslsend</in>
 <out>sslreceive</out>
 <reconnect-delay>10000</reconnect-delay>
</channel-adaptor>
```

While `GenericSSLSocketFactory` can be used to demonstrate SSL support in jPOS, production-grade installations should consider it just a reference/sample implementation. It uses ${user.home}/.keystore with a default password, so **at the very least** you want to override its `getPassword()` method.

For backward compatibility, we also have a `SunJSSESocketFactory` implementation that uses `com.sun.net.ssl.internal.ssl.Provider`.

`GenericSSLSocketFactory` honors two very important properties:

- `addEnabledCipherSuite` and
- `addEnabledProtocol`

For PCI compliance, you want to make sure which protocols and ciphersuites you want to enable. If these properties are not configured, all protocols and ciphersuites available to the JVM will be enabled, something you probably don't want.

# 5.3. LoopbackChannel

Loopback channel bounces all received messages using a blocking queue. It can be used for simulation purposes. When using in combination with a suitable ISOFilter, you can modify the outgoing or incoming (bounced) message so it can easily simulate a response.

```java
package loopback;

import java.io.IOException;
import org.jpos.iso.ISOMsg;
import org.jpos.iso.ISOFilter;
import org.jpos.iso.ISOChannel;
import org.jpos.iso.ISOException;
import org.jpos.iso.channel.LoopbackChannel;
import org.jpos.util.LogEvent;

public class Test implements ISOFilter {
    public static void main (String[] args) {
        try {
            new Test().run();
        } catch (Exception e) {
            e.printStackTrace();
        }
    }
    public void run () throws ISOException, IOException {
        LoopbackChannel channel = new LoopbackChannel ();
        channel.addIncomingFilter (this);
        ISOMsg request  = createRequest();
        request.dump (System.out, "request>  ");
        channel.send (request);
        ISOMsg response = channel.receive();
        response.dump (System.out, "response> ");
    }

    private ISOMsg createRequest () throws ISOException {
        ISOMsg m = new ISOMsg ("0800");
        m.set (11, "000001");
        m.set (41, "29110001");
        m.set (70, "301");
        return m;
    }
    public ISOMsg filter (ISOChannel channel, ISOMsg m, LogEvent evt) {
        try {
            m.setResponseMTI ();
            m.set (39, "00");
        } catch (ISOException e) {
            e.printStackTrace();
        }
        return m;
    }
}
```

The previous program produces the following output:

```
request>  <isomsg>
request>    <field id="0" value="0800"/>
request>    <field id="11" value="000001"/>
request>    <field id="41" value="29110001"/>
request>    <field id="70" value="301"/>
request>  </isomsg>
response> <isomsg direction="incoming">
response>   <field id="0" value="0810"/>
response>   <field id="11" value="000001"/>
response>   <field id="39" value="00"/>
response>   <field id="41" value="29110001"/>
response>   <field id="70" value="301"/>
response> </isomsg>
```

For a better way to simulate a remote host, you can have a look at the **serversimulator** module in the jPOS-EE distribution.

# 5.4. ChannelPool

ChannelPool is an ISOChannel implementation that delegates channel operations to its children channels.

It can handle several children channels, making it suitable to implement transparent failover.

By using its `addChannel` and `removeChannel` methods, you can react to network problems on-the-fly without affecting higher-level layers of your application.

As an alternative to the `ChannelPool`, Q2 applications can use multiple `ChannelAdaptors` configured with the same set of Space queues (in/out). In addition, there's a `MUXPool` that provides failover as well as round-robin load balancing at the MUX level.

# 5.5. Channel Filters

Filters give the ability to alter an incoming or outgoing message.

jPOS comes with a few stock filters, mostly provided as proof-of-concept.

## 5.5.1. MD5Filter

On outgoing messages, the MD5Filter computes an MD5 hash of a key plus the content of a selected number of fields from the ISOMsg and places the hash in fields 64 (first half) and 128 (second half).

On incoming messages, it computes the same MD5 hash and verifies they match the one coming in fields 64 and 128.

Mentioning MD5 would probably guarantee your QSA to go ballistic. While using MD5 is better than no message authentication at all, please consider this filter as an example to implement MAC filters.

## 5.5.2. ChannelInfoFilter

In a Q2 environment where components are totally decoupled via multiplexers (MUX), and sometimes multiplexer pools (MUXPool), a client calling `MUX.request(...)` may not know which channel was actually used to send the message, or from which channel a response came. `ChannelInfoFilter` can place the channel name, and socket information in two customized fields.

Interesting enough, while ISO-8583 uses fields up to 128, you can internally use fields beyond that (any arbitrary number greater than 128 would do) to store that information, so you can configure your filter like this:

```
<channel class="org.jpos.iso.channel.NACChannel" logger="Q2"
      packager="org.jpos.iso.packager.GenericPackager">

 <property name="packager-config" value="jar:packager/iso87ascii.xml" />
 <property name="host" value="127.0.0.1" />
 <property name="port" value="9001" />
 <property name="timeout" value="360000" />
 <filter class='org.jpos.iso.filter.ChannelInfoFilter' direction='both'>
   <property name='channel-name' value='1000' />
   <property name='socket-info'  value='1001' />
 </filter>
</channel>
```

The log would show something like this:

```
   <isomsg>
     ...
     ...
     <field id="1000" value="selftest-adaptor"/>
     <field id="1001" value="127.0.0.1:51865 127.0.0.1:9001"/>
   </isomsg>
```

## 5.5.3. DelayFilter

The DelayFilter is a demo filter that honors a `delay` property and can be useful to delay messages as they come and go, useful for debugging/simulation purposes.

## 5.5.4. DebugFilter

The DebugFilter adds to the log an hex representation of the binary message as it comes and go through the wire. It's very useful in situations where you want to capture a message that is not properly unpacking without having to revert to `tcpdump` or `nc`. This filter is of course a no-no in a production environment (per PCI requirements).

## 5.5.5. ThroughputControlFilter

The ThroughputControlFilter honors two properties:

- `transactions` and
- `period` (in milliseconds).

and can be used to apply back pressure to a channel sending a large number of transactions. We can configure for example a maximum of 100 messages in a 1000 milliseconds period in order to make sure that this particular channel won't load the system with more than 100 TPS.

## 5.5.6. BSHFilter

The BSHFilter is one of the most useful, and one of the most abused filters. It allows you to run a **BeanShell** [http://beanshell.org] script that can be modified on the fly. It's extremely useful in situations where you need to add a field or two, or change the content of a given field, i.e. while testing on a tight certification window.

It is not intended to be used as a way to implement your business logic, BSH code is great, but tend to become brittle, difficult to refactor, test, you don't have IDE support, etc.

The configuration might look like this:

```
<channel ...>
 <filter class="org.jpos.bsh.BSHFilter" direction="outgoing" >
    <property name="source" value="cfg/myfilter.bsh" />
 </filter>
 ...
 ...
</channel>
```

Your `bsh` file will have access to the following variables:

- `message` - the ISOMsg to be filtered
- `channel` - a reference to the ISOChannel associated with this filter
- `header` - if a header is present (on received messages)
- `image` - the binary image of the message (on received messages)
- `evt` - a LogEvent that you can use to add information to the Log
- `cfg` - a reference to the configuration object

## 5.5.7. Aditional filters

Take a look at **Github repository** [https://github.com/jpos/jPOS/tree/master/jpos/src/main/java/org/jpos/iso/filter] for additional samples.

# Chapter 6. jPOS Space

the jPOS Space is a general-purpose coordination component inspired after **The Linda Coordination Language.** [1]

While jPOS's Space **is not** a Linda implementation, we highly recommend learning about **Linda** in order to better understand our Space component and motivation.

You can think about jPOS's Space component as being like a Map where its entries are lists of objects and its operations are fully synchronized.

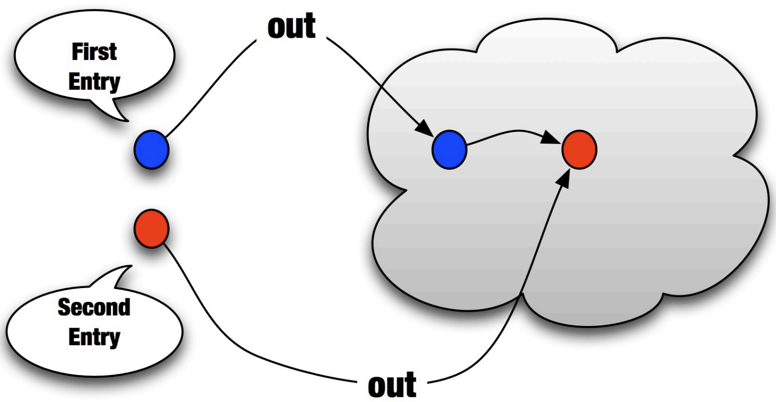
There are three basic operations:

- `void out (Object key, Object value)` Puts an object into the space. If an object under the given key already exists, the object is queued at the end of a list under that name.
- `Object rd (Object key)` Reads an object from the space under the given key. Blocks until an entry is present.
- `Object in (Object key)` Take the object off the queue. Block until the object under the given key is present.

We picked those cryptic operation names after the Linda Coordination Language basic operations, but could have used easier to remember names such as:

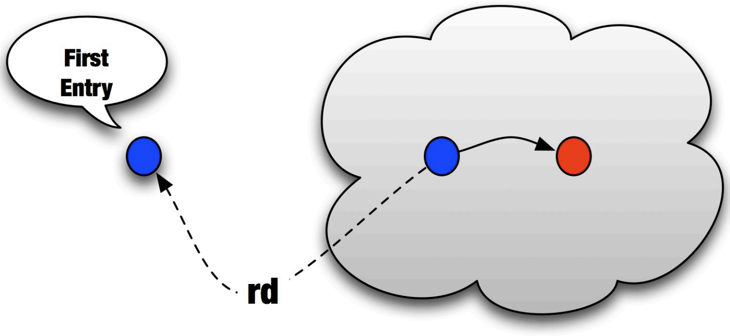
- **write** instead of *out*
- **read** instead of just *rd*
- **take** instead of *in*

After two consecutive *out* operations using the same *key* value, the Space would look like this (first entry is printed as a blue circle while the second one is red):

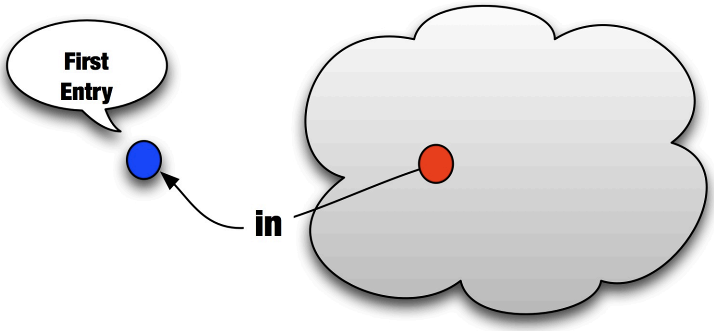



[1]See **http://www.cs.yale.edu/Linda/linda-lang.html**

Then an *rd* operation would return the first entry (the blue one), without removing it from the space. The space remains with two entries for that particular key.




The *in* operation on the other hand, takes the first entry (the blue one) off the Space, leaving the red one.




At this point, a new *rd* operation will return the second entry (the red one) and an *in* operation would return the red one as well, leaving the space empty (further *rd* or *in* operations on that particular key will block.

# 6.1. Space interface

In addition to those three basic operations, `org.jpos.space.Space` adds a few handy methods:

- `void out (K key, V value, long timeout)` Place an object into the space using an expiration timeout. The entry is automatically removed upon expiration.
- `V rd (K key, long timeout)` Wait a maximum of `timeout` milliseconds for a given entry; otherwise, return null.
- `V in (K key, long timeout)` Wait a maximum of `timeout` milliseconds for a given entry, and takes it; otherwise, return null.
- `V rdp (K key)` Read an entry if it exists (*p* for *probe*).
- `Vinp (K key)` Take an entry if it exists (again, *p* for *probe*).
- `void nrd (K key)` Block while key is present in the space. The operation name comes after *not read*.
- `V nrd (K key, long timeout)` Block up to timeout milliseconds while key is present in the space. If timeout is reached and key is still present, returns its value (as in *rdp*).

- `void push (K key, V value)` Same as `out` but the entry is placed at the head of the queue (like a Stack's push operation).
- `void push (K key, V value, long timeout)` Same as the previous `push` operation with a timeout in millis.
- `public void put (K key, V value)` Like a `Map.put` operation, a `Space.put` wipes all entries that may exist under a given key and puts just this one.
- `public void put (K key, V value, long timeout)` Same as previous one, but with a timeout.

See **Javadoc** [http://jpos.org/doc/javadoc/org/jpos/space/Space.html] for full details and additional helper methods (such as the handy `existAny(K[] keys)`).

While `org.jpos.space.Space` supports 'generics', current implementations does not guarantee object type. Use with care as an unexpected `ClassCastException` can occurr.

The Space interface is small enough to show here:

```
package org.jpos.space;

public interface Space<K,V> {
    public void out (K key, V value);
    public void out (K key, V value, long timeout);
    public V in  (Object key);
    public V rd  (Object key);
    public V in  (Object key, long timeout);
    public V rd  (Object key, long timeout);
    public V inp (Object key);
    public V rdp (Object key);
    public void push (K key, V value);
    public void push (K key, V value, long timeout);
    public boolean existAny (K[] keys);
    public boolean existAny (K[] keys, long timeout);
    public void put (K key, V value);
    public void put (K key, V value, long timeout);
}
```

# 6.2. Local Space interface

The `Space` implementation is designed to be easy to implement under different scenarios, such as persistent spaces, remote spaces, replicated spaces.

The `LocalSpace` interface enhances the `Space` interface in situations where the implementation runs in a single JVM, such as the `TSpace` implementation.

The additional methods include:

```
public interface LocalSpace {
    public void addListener (Object key, SpaceListener listener);
    public void addListener (Object key, SpaceListener listener, long timeout);
    public void removeListener (Object key, SpaceListener listener);
}
```

as well as some miscellaneous methods that could be expensive to transmit over the wire and were left out in the base `Space` implementation.

```
    public Set getKeySet ();
    public int size (Object key);
```

The `SpaceListener` implementation looks like this:

```
public interface SpaceListener {
    public void notify (Object key, Object value);
}
```

With the `LocalSpace` we can create event-driven consumers that allows us to reduce the number of threads. A good example is the thread-less lightweight `QMUX` implementation.

# 6.3. Space Factory

jPOS comes with several space implementations:

- **TSpace** : An in-memory space [2]
- **JDBMSpace** : a persistent JDBM based space implementation
- **JESpace** : a persistent Berkeley DB Java Edition based implementation

that can be instantiated using the SpaceFactory.

Although most Space implementations have either public constructors or factory methods that can be used to create instances of their respective classes, we highly recommend using the `SpaceFactory` as the entry point for space creation or to obtain references to spaces that were previously created.

### Example 6.1. Using the SpaceFactory

```
   import org.jpos.space.Space;
   import org.jpos.space.SpaceFactory;

   Space sp = SpaceFactory.getSpace();
```

The previous example returns a reference to the default space, which happens to be a TSpace implementation registered with the name `default`. It’s the same as calling:

```
   Space sp = SpaceFactory.getSpace("tspace");
```

…which is also the same as calling:

```
   Space sp = SpaceFactory.getSpace("tspace:default");
```

SpaceFactory decodes a space name based on the space implementation type, followed by an optional name and optional parameter(s): `spacetype\[:spacename\[:spaceparam}}`

### Table 6.1. Space Names

| Type | Implementation |
| --- | --- |
| tspace | Creates or returns a reference to a previously-created instance of `TSpace` |

[2]TSpace implements LocalSpace

| Type | Implementation |
|---|---|
| jdbm | Creates or returns a reference to a previously-created instance of `JDBMSpace`. This name accepts an optional parameter (after the Space name) which is a path to the persistent store, e.g., `jdbm:myspace:/tmp/myspace`. |
| je | Creates or returns a reference to a previously-created instance of `JESpace`. This name accepts an optional parameter (after the Space name) which is a path to the persistent store, e.g., `jdbm:myspace:/tmp/myjespace`. |
| spacelet | Returns a reference to a previously-created instance of `SpaceLet` |

Some components communicate through a **default space** that may change over time, so it is very important to `SpaceFactory.getSpace()` instead of instantiating your own. In previous versions, the default space was `transient:default`, and now is `tspace:default` but this may change in future versions of jPOS as new Space implementations become available.

By sticking to `SpaceFactory.getSpace()` jPOS will give you always the default space for the version you're using.

# 6.4. TSpace

TSpace replaces the old *TransientSpace* as the new default in-memory Space used by jPOS components.

It's the space you get when you call `SpaceFactory.getSpace()` and can be also instantiated using the `tspace:xxx` name (i.e. `SpaceFactory.getSpace("tspace:myspace")`).

TSpace implements the LocalSpace interface (see next **Section 6.2, "Local Space interface"**).

### Example 6.2. Sample TSpace use

```
import org.jpos.space.Space;
import org.jpos.space.SpaceFactory;

Space sp = SpaceFactory.getSpace();
sp.out("A", "The quick brown fox jumped over the lazy dog");
System.out.println (sp.rdp ("A"));
```

# 6.5. JDBMSpace

JDBMSpace is a persistent space based on the popular **jDBM** [http://jdbm.sourceforge.net/] key-value lightweight database.

It uses the SpaceFactory prefix `jdbm` that must be followed by a name, and an optional path, i.e.:

```
Space sp = SpaceFactory("jdbm:myspace");
```

or

```
Space sp = SpaceFactory("jdbm:myspace:data/myspace");
```

JDBMSpace is good and we've used it for a long time in production systems, but now there's a new faster and more reliable implementation, the `JESpace` (see **Section 6.6, "JESpace"**) based on Berkeley DB Java Edition.

# 6.6. JESpace

JESpace is a persistent space based on Berkeley DB Java Edition.

It uses the SpaceFactory prefix `je` that must be followed by a name, and an optional path, i.e.:

```
Space sp = SpaceFactory("je:myspace");
```

or

```
Space sp = SpaceFactory("je:myspace:data/myspace");
```

# 6.7. SpaceInterceptor

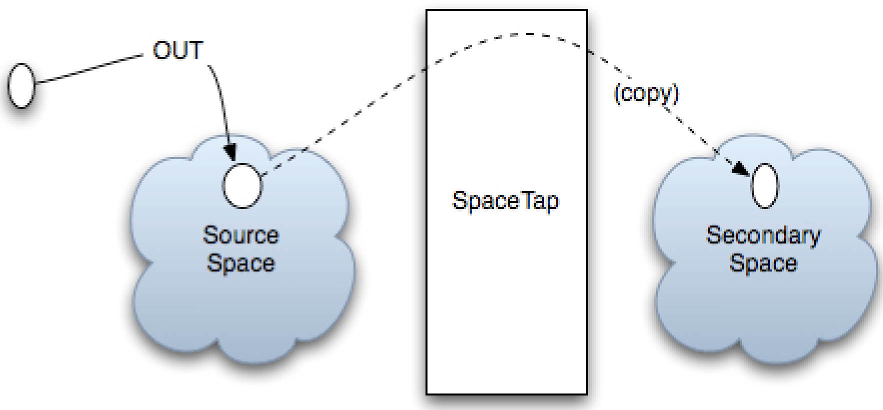
SpaceInterceptor implements the `Space` interface and can be used to intercept calls to a given Space without having to extend its implementation (See **Javadoc** [http://jpos.org/doc/javadoc/org/jpos/space/SpaceInterceptor.html] for full details).

Using a `SpaceInterceptor`, the developer can override specific methods in order to perform aditional tasks.

# 6.8. SpaceTap

SpaceTap is a `SpaceListener` that can be used to monitor a given LocalSpace for new entries under a given key.

Once a SpaceTap is created, it register itself as a listener in the source LocalSpace and copies all new entries to a destination space.




**Space Tap.**

If you have a source LocalSpace `ssp` and a destination LocalSpace `dsp` and you want to monitor an entry called "ERRORS", we can use code like this:

```
SpaceTap spt = new SpaceTap (ssp, dsp, "ERRORS", "ERRORS.COPY", 5000L);
```

If your "source" space and "destination" space are the same, you can use the shorter constructor:

```
SpaceTap (LocalSpace ssp, Object key, Object tapKey, long timeout);
```

The SpaceTap can be used for system monitoring purposes as it provides a non-intrusive way to "tap" any given space queue.

# 6.9. SpaceUtil

In **SpaceUtil** [http://jpos.org/doc/javadoc/org/jpos/space/SpaceUtil.html] we put together general purpose helper methods that can be used with any Space implementation.

- **`inpAll`** pulls all entries under a given key and return them in an array.
- **`wipe`** remove all entries under a given key
- **`nextLong`** When used in combination with a persistent Space (such as `JDBMSpace` or `JESpace`), this method can be used to easilyl implement sequencers, i.e:

```
import org.jpos.space.*;
Space sp = SpaceFactory.getSpace("je:sequencers");
long l = SpaceUtil.nextLong(sp, "traceno");
```

Regularly monitor this class, as we may add new helper methods in the future.

# Chapter 7. Q2

In jPOS versions earlier than 1.5.0, the `main` for the jPOS application was a component called **QSP**.

> The term **QSP** comes after the hamradio Q-signal codes and it means "Relay message for free". Because jPOS was used to *relay messages*, and it is free software, in the deep nerdy mind of the author, the term **QSP** made sense [1].
>
> That's one of the reasons you'll see so many _Q_s in the code (QServer, QMUX, Q2 …).

After deploying QSP in several mission-critical applications, we found that including all the components in a single [huge] XML configuration file was not a good idea.

- Although several QSP components supported some limited ReConfiguration, many others din't. As a result, major changes usually involved restarting the application (a very costly operation in a 24/7 system)
- If for some reason, the changes involved went beyond just tweaking a configuration file and required additional changes in a supporting jar file, the application had to be restarted (QSP didn't support dynamic classloading).
- Having a single big configuration file has proven to be error-prone. Although initially intended to be accessible to system operators, changing QSP files on critical systems became an *art* reserved for experienced operators.

Therefore, we've decided to use a simpler approach: A new container (called Q2, short for QSP version 2) with a file per component and a very simple lifecycle to ease the implementation of such components, called **QBeans** (Q2 Beans).

> We use the terms **QBeans** and **Q2 service** interchangeable.

QBeans are MBeans (see JMX specs) that implement the Q2's lifecycle (init/start/stop/destroy) set of operations. Q2 takes care of registering them with they system's MBeanServer.

## 7.1. Running Q2

Running Q2 is as simple as calling `java -jar jpos.jar`, provided the jPOS dependencies are available in the `lib` directory.

The reason why this works without setting a specific CLASSPATH is because we have configured the build system to produce a suitable MANIFEST.MF that contains the following relevant parts:

[1] **http://en.wikipedia.org/wiki/Q_code**

```
...
...
Main-Class: org.jpos.q2.Q2
Class-Path: lib/jdom-1.1.3.jar lib/jdbm-1.0.jar lib/je-4.1.10.jar lib/
 commons-cli-1.2.jar lib/jline-1.0.jar lib/bsh-2.0b5.jar lib/javatuple
  s-1.2.jar lib/xercesImpl-2.10.0.jar lib/org.osgi.core-4.3.1.jar lib/x
   ml-apis-1.4.01.jar
...
...
```

You can of course use the more convenient `bin/q2` script (or `bin\q2.bat` in Windows), but you don't have to worry about setting up a classpath if the `lib` directory relative to your current working directory has the appropriate support files.

Q2 accepts several command line switches; for a complete list, use `--help`, e.g.:

```
bin/q2 --help

usage: Q2
 -C,--config <arg>                 Configuration bundle
 -c,--command <arg>                Command to execute
 -d,--deploydir <arg>              Deployment directory
 -e,--encrypt <arg>                Encrypt configuration bundle
 -h,--help                         Usage information
 -i,--cli                          Command Line Interface
 -n,--name <arg>                   Optional name (defaults to 'Q2')
 -O,--osgi                         Start experimental OSGi framework
                                   server
 -p,--pid-file <arg>               Store project's pid
 -r,--recursive                    Deploy subdirectories recursively
 -s,--ssh                          Enable SSH server
 -sa,--ssh-authorized-keys <arg>   Path to authorized key file (defaults
                                   to 'cfg/authorized_keys')
 -sh,--ssh-host-key-file <arg>     ssh host key file, defaults to
                                   'cfg/hostkeys.ser'
 -sp,--ssh-port <arg>              ssh port (defaults to 2222)
 -su,--ssh-user <arg>              ssh user (defaults to 'admin')
 -v,--version                      Q2's version
```

Q2 has a reasonable set of defaults so you usually don't have to use any argument when calling it. A simple call to `bin/q2` should look like this:

```
<log realm="Q2.system" at="2016-10-16T20:19:41.174">
  <info>
    Q2 started, deployDir=/Users/apr/git/jpos/jpos/build/install/jpos/deploy
  </info>
</log>
```

Please pay attention to the `deployDir` shown in the previous log message. In this case, it reads `/home/jpos/git/jpos/jpos/build/install/jpos/deploy`

You can override the default deploy directory using the `--deploydir` (or just `-d`) option when calling Q2.

In this particular case, we are running off the `build/install/jpos` directory, because we called `gradle installApp` which is handy for local tests.

At start up time, Q2 scans the `deploy` directory looking for **deployment descriptors** (that we also call **QBean descriptors**). Those are tiny XML files that are used to start and configure Q2's services.

The directory is sorted in alphabetical order, providing an easy way to start services in an ordered way.

Q2 needs a logger, so the first thing it looks for is a logger configuration, which has a well known QBean descriptor name: **00_logger.xml**. This is the only special name used by Q2, and is required to provide some visibility into the start-up process. If there’s no `00_logger.xml` defining the **Q2** logger, Q2 creates one on the fly using a **SimpleLogListener** that outputs log events to `stdout`.

Having no `00_logger.xml` file in the `deploy` directory is similar to having one with just the following configuration:

```
<logger name="Q2">
  <log-listener class="org.jpos.util.SimpleLogListener" />
</logger>
```

The default jPOS distribution has two pre-configured files in the deploy directory:

- `00_logger.xml`
- `99_sysmon.xml`

Sysmon starts the jPOS **SystemMonitor** that outputs useful system health information every hour which is good to keep handy in production systems.

Please note that when using the `--cli` command line option that starts the jPOS command line interface, the default deploy directory is `deploy-cli` instead of `deploy`. This is to prevent starting services (such as as logger, system monitor) typically used in jPOS applications. You can of course use the `--deploydir` command line option and point it back to the default `deploy` directory.

The **CLI** can also be accessed via SSH using the `--ssh` command line option (in that case, the default deploy directory doesn’t change).

## 7.1.1. Command line options

The `--help` command line option is self-explanatory, it shows the list of available options. Same goes for `--version` it gives you output like this:

```
$ bin/q2 --version

jPOS 2.0.9-SNAPSHOT master/1592701 (2016-10-16 20:17:56 ART)
...
...
```

followed by the jPOS license in use (see **license** for details).

### `--cli`

CLI stands for jPOS Command Line Interface. When calling `bin/q2 --cli` you should see a prompt like this:

```
$ bin/q2 --cli

q2>
```

Typing *tab* will give you the list of available commands, e.g.:

```
clr             echo           help           logger_benchmark
shownr          smconsole      tmmon          version
date            env            install        man
shutdown        sysmon         tzcheck        deploy
exit            license        mem            sleep
tail            uptime
```

The *man* command can be used to get information about a given command, i.e.:

```
q2> man clr

Clear screen
```

Commands can be separated by a semi-colon, so you can — just for fun — type

```
q2> clr; echo Hello; sleep 5; echo jPOS
```

CLI commands are very easy to write, they just have to implement the **CLIContext** [http://jpos.org/doc/javadoc/org/jpos/q2/CLICommand.html] interface.

Just to give you an example, the `sleep` command is implemented like this:

```
public class SLEEP implements CLICommand {
    public void exec(CLIContext cli, String[] args) throws Exception {
        if (args.length > 1) {
            Thread.sleep(Long.parseLong(args[1]) * 1000);
        }
        else {
            cli.println("Usage: sleep number-of-seconds");
        }
    }
}
```

As mentioned above, when you type *tab*, jPOS gives you a list of commands. This may change in the future (as we move to OSGi and perhaps its console service) but right now, we have an easy way to detect CLI commands: **they live in the `org.jpos.q2.cli` package**.

If you navigate to **jpos/src/main/java/org/jpos/q2/cli** [https://github.com/jpos/jPOS/tree/master/jpos/src/main/java/org/jpos/q2/cli] you'll see files like:

```
CLR.java
COPYRIGHT.java
DATE.java
ECHO.java
HELP.java
INSTALL.java
LICENSE.java
MAN.java
MEM.java
SHOWNR.java
SHUTDOWN.java
SLEEP.java
SMCONSOLE.java
SYSMON.java
TAIL.java
TMMON.java
UPTIME.java
VERSION.java
```

The command `HELP` reads the manual pages for a given command from a resource named after the command and ending with the *.man* extension, so if you navigate to **resources** [https://

github.com/jpos/jPOS/tree/master/jpos/src/main/resources/org/jpos/q2/cli] directory, you'll see files like:

```
CLR.man
INSTALL.man
MEM.man
SHOWNR.man
SHUTDOWN.man
SMCONSOLE.man
TAIL.man
TMMON.man
```

Containing the help text for some commands.

CLI commands become more interesting when combined with the ability to "connect" to a JVM running Q2 from a remote location, i.e. using the `--ssh` command line option.

CLI commands use `jLine3` that supports tab completion and basic edit capabilities using the cursor, similar to those of `readline`. Try to type *tab* while typing a command, `jLine` will complete it for you.

Some CLI commands are just little proof-of-concept commands that we wrote while coding the CLI subsystem in order to test it, but a few deserve some additional comments:

- **shownr** will give you a useful dump of the `NameRegistrar`
- **sysmon** will give you output similar to the `SystemMonitor`
- **tail**, similar to the Unix command *tail* allows you to monitor the output of a jPOS logger in real-time.
- **tmmon** allows you to monitor the TransactionManager in real-time.
- **smconsole** is a wrapper around the old jPOS security console that allows you to call it from the jPOS jar so that you don't have to setup the full classpath.
- **install** extracts sample QBean descriptors from jars in the classpath and place them in the *deploy* directory

The last command *install* deserves further comment. In jPOS-EE we build applications off multiple little *modules* that are distributed via a Maven repository. Some of those require some configuration files that are usually placed in the `META-INF/q2/installs` directory.

If you look inside the jPOS jar, you'll see that the `META-INF/q2/installs` directory contain sample `deploy/00_logger.xml` and `deploy/99_sysmon.xml` that could be easily extracted using the aforementioned `install` command.

## --command <arg>

Can be used to run a CLI command from the command line, e.g.:

```
bin/q2 --command "install --force"
```

## --deploydir <arg>

If you want to use a deploy directory other than the default `deploy` you can use this `deploydir` option. This can be useful to run different environments (i.e. `deploy_prod` versus `deploy_test`).

## --recursive

This allows you to put some order and hierarchy into your deploy directory if it becomes too big. You can create sub directories to group together deployment descriptors associated with different subsystems.

## --config <arg>

During the migration from `QSP` to `Q2`, jPOS users were used to the monolithic `QSP` single XML file and while most users appreciated the value of the fine grained file-per-service configuration, a few others requested to keep the ability to run off a single configuration file.

To create a single config file, you can concatenate together multiple Q2 descriptors and wrap them with an outer root XML element. The name of the outer element is not defined, you can use anything you like, i.e: `<q2>` or `<bundle>` or any other name.

Here is a sample config:

```
<q2>
  <logger name="Q2" class="org.jpos.q2.qbean.LoggerAdaptor">
    <log-listener class="org.jpos.util.SimpleLogListener" />
  </logger>

  <sysmon logger="Q2">
   <attr name="sleepTime" type="java.lang.Long">3600000</attr>
   <attr name="detailRequired" type="java.lang.Boolean">true</attr>
  </sysmon>
</q2>
```

Running `bin/q2 --config your-config-file.xml` will basically extract each descriptor out of the config file and place it in the `deploy` directory before actually starting Q2.

## --encrypt <arg>

There are situations where you want to hide some service configuration from an occasional lurker. You can encrypt it using this command. The encryption key can be changed, but it ultimately is stored inside the program, so this is not very secure, but it's good enough to keep an operator from looking at your QBean descriptors.

The technique to encrypt a service is similar to the one used in the previous command `--config`, you create an XML file with the services you want to encrypt, wrapped by an outer XML root element (again, with any name you want) and call `bin/q2 --encrypt file-to-encrypt.xml`

If we call `bin/q2 --encrypt /tmp/sample.xml` the system will start, but if you look at the `deploy` directory, you'll see that the files that describe the logger and sysmon QBeans now look like this:

```
<protected-qbean>
  <data>6E6A0A545209A80B4AC2735F3DA72..............
  ....065345C9CC6FEAE4186D1AE8D4D4B2E54FEA1AB4777B3</data>
</protected-qbean>
```

Please consider this a small protection against an occasional observer.

# 7.2. Shutting down Q2

If we recall **Section 7.3, “Writing your first Q2 Script”**, we have a `QFactory.properties` file with some mappings, including a `shutdown` mapping:

```
shutdown=org.jpos.q2.qbean.Shutdown
```

So shutting down Q2 is as easy as deploying a QBean — let’s call it `shutdown.xml` — with content like this:

```
<shutdown />
```

The name `shutdown.xml` can of course be any other name you want.

The shutdown QBean is implemented like this:

```
package org.jpos.q2.qbean;
import org.jpos.q2.QBeanSupport;
public class Shutdown extends QBeanSupport {
    public void startService() {
        getServer().shutdown ();                                  ❶
    }
}
```

❶ This `getServer()` method gives us a reference to the Q2 server. It works because `Shutdown` extends `QBeanSupport` which in turn implements the method `setServer(Q2)` called by `Q2` via reflection as described in **Section 7.5, “QBeanSupport”**.

By deploying the `shutdown` QBean you have a clean way to stop a given Q2 instance without knowing its process ID.

jPOS provides a `bin/stop` script implemented like this:

```
#!/bin/sh

echo Stopping Q2
echo '<shutdown/>' > `dirname $0`/../deploy/shutdown.xml
```

`bin/start` which in turn calls `bin/q2` removes `deploy/shutdown.xml` before starting. If you use this shutdown technique using a shutdown name other than `shutdown.xml` and your find yourself in a situation where Q2 starts and then immediately stops, check the `deploy` directory for services deploying the Shutdown service.

# 7.3. Writing your first Q2 Script

Once you have your Q2 running and checking the `deploy` directory for new QBean descriptors (XML files) as well as the `deploy/lib` directory for new `jars`, you can try to deploy a QBean.

Just to test the waters, we’ll show you how to deploy a `BeanShell` [2] based QBean.

[2] **http://beanshell.org/**

Use your preferred text editor to write an XML file like this:

```
<script>
  log.info ("Hello jPOS!");
</script>
```

Let's call it `90_hello_jpos.xml` and save it in a temporary directory.

Now copy that file to your `deploy` directory and you should see output like this:

```
<log realm="Q2.system" at="Sat Oct 19 20:15:48 UYST 2013.237" lifespan="150ms">
  <info>
    deploy: /home/jpos/jpos/build/install/jpos/deploy/90_hello_jpos.xml
  </info>
</log>
<log realm="script" at="Sat Oct 19 20:15:48 UYST 2013.244">
  <info>
    Hello jPOS!
  </info>
</log>
```

That little script is equivalent to:

```
<qbean name='script' class='org.jpos.q2.qbean.BSH' logger='Q2'>
  log.info ("Hello jPOS!");
</qbean>
```

The reasons this works without specifying the class name, logger name are:

- If there's no `name` attribute, Q2 uses the root XML element name as the bean name, in this case *script*.
- If there's no `logger` attribute, Q2 assigns the default logger name `Q2`.
- If there's no `class` attribute, the root element name is used to find a resource with the mapping. The resource is placed in the **`QFactory.properties`** [https://github.com/jpos/jPOS/blob/master/jpos/src/main/resources/org/jpos/q2/QFactory.properties#L3]

As of this writing mapping, `QFactory.properties` looks like this:

```
logger=org.jpos.q2.qbean.LoggerAdaptor
shutdown=org.jpos.q2.qbean.Shutdown
script=org.jpos.q2.qbean.BSH
jython=org.jpos.q2.qbean.Jython
spacelet=org.jpos.q2.qbean.SpaceLet
sysmon=org.jpos.q2.qbean.SystemMonitor
txnmgr=org.jpos.transaction.TransactionManager
transaction-manager=org.jpos.transaction.TransactionManager
qmux=org.jpos.q2.iso.QMUX
channel-adaptor=org.jpos.q2.iso.ChannelAdaptor
qexec=org.jpos.q2.qbean.QExec
```

that explains the reason why you can write `<txnmgr>…</txnmgr>` or `<qmux>…</qmux>` without specifying a `class` attribute.

The previous BeanShell based QBean is very useful to run quick tests or hot fixes to a running jPOS system. Sometimes the Java code written inside the `<script>…</script>` XML elements need to use some XML reserved characters (like < or >). The easiest way to achieve that is to use a `CDATA` block, like this:

```
<qbean name='script' class='org.jpos.q2.qbean.BSH' logger='Q2'><![CDATA[ ❶
  log.info ("Hello jPOS!");
]]></qbean>                                                          ❷
```

❶ Note the `<![CDATA[ start`
❷ And its end `]]>`

## 7.4. QTest - a sample QBean

Here is sample code for a simple test QBean. We'll call it `QTest`:

```
package org.jpos.qtest;

import org.jpos.iso.ISOUtil;
import org.jpos.q2.Q2;
import org.jpos.q2.QBean;
import org.jpos.util.Log;

public class QTest implements QBean, Runnable {
    volatile int state;
    long tickInterval = 1000;                                    ❶
    Log log;

    public QTest () {
        super();
        state = -1;
        log = Log.getLog(Q2.LOGGER_NAME, "qtest");               ❷
        log.info ("constructor");
    }
    public void init () {
        log.info("init");
        state = STARTING;
    }
    public void start() {
        log.info ("start");
        state = STARTED;
        new Thread(this).start();
    }
    public void stop () {
        log.info ("stop");
        state = STOPPING;
    }
    public void destroy () {
        log.info ("destroy");
        state = STOPPED;
    }
    public void setTickInterval (long tickInterval) {
        this.tickInterval = tickInterval;
    }
    public long getTickInterval () {
        return tickInterval;
    }
    public void run () {
        for (int tickCount=0; running (); tickCount++) {
            log.info ("tick " + tickCount);
            ISOUtil.sleep (tickInterval);
        }
    }
    public int getState () {
        return state;
    }
    public String getStateAsString () {
        return state >= 0 ? stateString[state] : "Unknown";
    }

    private boolean running() {
        return state == QBean.STARTING || state == QBean.STARTED;
    }
}
```

❶ tickInterval is a custom attribute of this QBean
❷ in this example, we use the general purpose Q2 logger

# Building QTest

The easiest way to play with jPOS is to use the **jPOS Template** [https://github.com/jpos/jPOS-template] project.

Open a terminal (or Command window if you're on Windows), move to a temporary directory and type:

```
git clone git@github.com:jpos/jPOS-template.git qtest

---[ output should look like this ]---
Cloning into 'qtest'...
remote: Counting objects: 165, done.
remote: Compressing objects: 100% (70/70), done.
remote: Total 165 (delta 82), reused 162 (delta 81)
Receiving objects: 100% (165/165), 87.34 KiB | 101 KiB/s, done.
Resolving deltas: 100% (82/82), done.
```

Then `cd` to your newly created `qtest` directory and try:

```
mkdir -p src/main/java/org/jpos/qtest
```

Copy and paste the previous code in a file named `QTest.java`.

For your convenience, you can download the sources for `QTest` and `QTestMBean` classes from **jPOS examples** [http://us.jpos.org/examples/qtest-1.0.0.jar].

Now create an XML file, (let's call it `90_qtest.xml`) like this in the `src/dist/deploy` directory:

```
<qbean name='qtest' class='org.jpos.qtest.QTest' />
```

Now run `gradle installApp` or its handy abbreviation `gradle iA` (see **Section 1.7, "Building jPOS"** for additional information about how to run Gradle or its wrapper `gradlew` or `gradlew.bat`).

If you have `Gradle` installed, you should be able to run the previous command. Otherwise, there's a handy `gradlew` (and `gradelw.bat` if you're on Windows).

This is not going to work, but it's worth to run it and see the error so you can understand how Q2 loads its QBeans, which are actually **JMX MBeans** [http://docs.oracle.com/javase/tutorial/jmx/mbeans/].

The `gradle installApp` command should have created a jPOS application in the `build/install/qtest` directory, so you can navigate there (`cd buildl/install/qtest`) and call `bin/q2` (or `bin\q2.bat` if you are on Windows).

If you don't want to navigate to the `build/install/qtest` directory, you can call `gradle run` in the top level directory of the project or module. This is of course a bad idea for production as you would be loading Gradle in memory for no reason.

After running it, you should see output like this:

```
<log realm="Q2.system" at="Sun Oct 20 16:16:47 UYST 2013.61">
 <warn>
  Tidying build/install/qtest/deploy/90_qtest.xml out of the          ❶
  way, by adding .BAD
 </warn>
</log>

<log realm="Q2.system" at="Sun Oct 20 16:16:47 UYST 2013.62" lifespan="5ms">
 <info>
  deploy: /private/tmp/test/qtest/build/install/qtest/deploy/90_qtest.xml
  <exception name="MBean class org.jpos.test.QTest does not implement  ❷
DynamicMBean, and neither follows the Standard MBean conventions
(javax.management.NotCompliantMBeanException: Class org.jpos.test.QTest
is not a JMX compliant Standard MBean) ...
  ...
  ...
 </info>
</log>
```

❶ Q2 detects that there's a problem with this QBean. In order to prevent the problem from happening again, it renames it to an extension other than `.xml`, and as an eye-catcher, it calls it `.BAD`.

❷ The reason for the error is shown below: `QTest` is a not compliant MBean and can't be loaded+.

Q2 uses a JMX MbeanServer to create instances of QBeans, and JMX expects to pick some information about these classes using and interface named after the class name and ending with `MBean`.

So if we are loading a class called `org.jpos.test.QTest`, the JMX MBeanServer will attempt to load an interface called `org.jpos.test.QTestMBean` first, if it's not there, it won't load your QBean.

Now let's create that simple MBean file and place it in `src/main/java/org/jpos/test/QTestMBean.java`. It looks like this:

```
package org.jpos.qtest;

import org.jpos.q2.QBean;

public interface QTestMBean extends QBean {
    public void setTickInterval(long tickInterval) ;
    public long getTickInterval() ;
}
```

In addition, we need to change our `QTest` so that it `implements QBeanTest`. Because `QBeanTest` extends `QBean`, we can change:

```
public class QTest implements QBean, Runnable {
 ...
 ...
}
```

so that it reads

```
public class QTest implements QTestMBean, Runnable {
 ...
 ...
}
```

Now if you run `build/install/qtest/bin/q2` you'll see messages like:

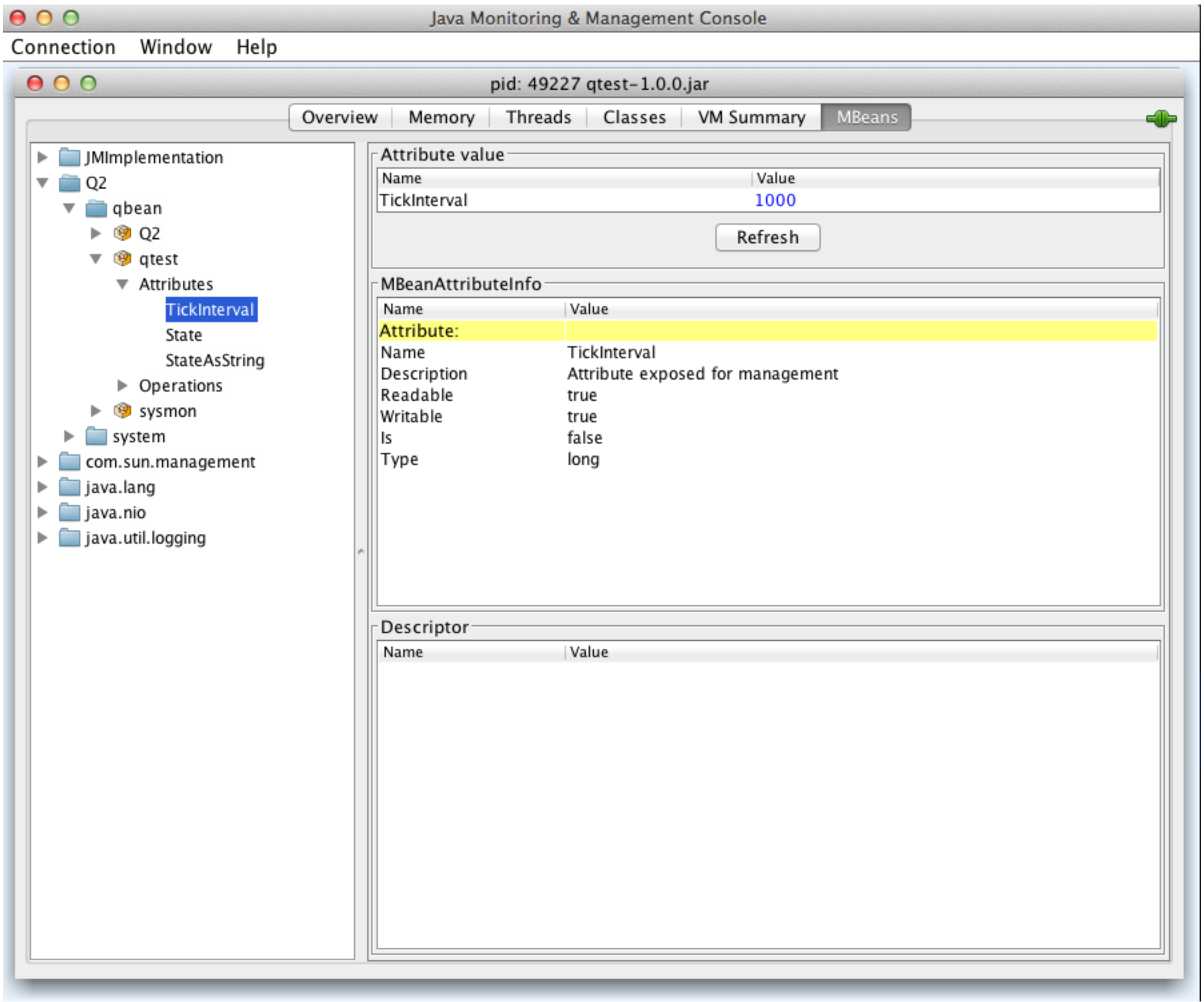
```
<log realm="qtest" at="Sun Oct 20 16:51:27 UYST 2013.28">
  <info>
    init
  </info>
</log>
<log realm="qtest" at="Sun Oct 20 16:51:27 UYST 2013.35">
  <info>
    start
  </info>
</log>
<log realm="qtest" at="Sun Oct 20 16:51:27 UYST 2013.37" lifespan="1ms">
  <info>
    tick 0
  </info>
</log>
...
...
<log realm="qtest" at="Sun Oct 20 16:51:28 UYST 2013.38">
  <info>
    tick 1
  </info>
</log>
...
...
<log realm="qtest" at="Sun Oct 20 16:51:29 UYST 2013.40">
  <info>
    tick 2
  </info>
</log>
```

Approximately every second we see a *tick* message, issues by our little `run()` method:

```
    public void run () {
        for (int tickCount=0; running (); tickCount++) {
            log.info ("tick " + tickCount);
            ISOUtil.sleep (tickInterval);
        }
    }
```

While Q2 is running and *ticking*, you can launch `jconsole`, connect to the running process and navigate to the `QTest` QBean attributes to see the `tickInterval`. You are free to change it to another value and that will change the behavior of the running QTest QBean.

The screen will look something like this:




If you are running Q2 using the `gradle run` tasks, you'll find out you won't get to see the Q2 MBean under the MBeans tabs, you'll see just the system MBeans.

The reason for this is that `com.sun.management.jmxremote` option is not set by default. If you're running the `bin/q2` script, there's a `-Dcom.sun.management.jmxremote` in the JVM invocation and that's the reason the Q2 MBeans can be managed.

## PUSH configuration - Setting QBean attributes

In the same way you can use `jconsole` to tweak the QBean attributes defined in the MBean, you can use the XML *attr* element in the QBean descriptor. Q2 will use the MBeanServer to send them via JMX.

So you can change the `90_qtest.xml` file (in the `src/dist/deploy`) directory to look like this:

```
<qbean name='qtest' class='org.jpos.qtest.QTest'>
  <attr name="tickInterval" type="java.lang.Long">5000</attr>
</qbean>
```

If no *type* attribute, the default is *java.lang.String*. `java.lang.Long` can be abbreviated as just `long`, same goes for `int (java.lang.Integer) and +boolean (java.lang.Boolean)`

## PULL configuration - implementing Configurable

Pushing configuration using attributes provides a lot of runtime flexibility, but requires a lot of boilerplate code with the MBean interfaces. Sometimes it's easier to just implement the very simple **Configurable** [http://jpos.org/doc/javadoc/org/jpos/core/Configurable.html] interface and adding a few child `property` elements in the QBean descriptor.

Let's change our QTest class to read like this:

```
package org.jpos.test;

import org.jpos.core.Configurable;
import org.jpos.core.Configuration;
import org.jpos.iso.ISOUtil;
import org.jpos.q2.Q2;
import org.jpos.q2.QBean;
import org.jpos.util.Log;

public class QTest implements QTestMBean, Runnable, Configurable {          ❶
    volatile int state;
    long tickInterval = 1000;
    Log log;
    boolean debug;                                                          ❷

    public QTest () {
        super();
        state = -1;
        log = Log.getLog(Q2.LOGGER_NAME, "qtest");
        log ("constructor");
    }
    public void init () {
        log ("init");
        state = STARTING;
    }
    public void start() {
        log ("start");
        state = STARTED;
        new Thread(this).start();
    }
    public void stop () {
        log ("stop");
        state = STOPPING;
    }
    public void destroy () {
        log ("destroy");
        state = STOPPED;
    }
    public void setTickInterval (long tickInterval) {
        this.tickInterval = tickInterval;
    }
    public long getTickInterval () {
        return tickInterval;
    }
    public void run () {
        for (int tickCount=0; running (); tickCount++) {
            log.info ("tick " + tickCount);
            ISOUtil.sleep (tickInterval);
        }
    }
    public int getState () {
        return state;
    }
    public String getStateAsString () {
        return state >= 0 ? stateString[state] : "Unknown";
    }
    public void setConfiguration (Configuration cfg) {                      ❸
        debug = cfg.getBoolean("debug", true);
    }

    private boolean running() {
        return state == QBean.STARTING || state == QBean.STARTED;
    }
    private void log (String message) {
        if (debug)                                                          ❹
            log (message);
    }
}
```

❶ Implement `Configurable`

❷ add a new *debug* boolean

❸ Actual implementation of the `Configurable` interface, picks the `debug` property from the XML configuration, defaulting to `true`

❹ Honor the debug property.

Now the `src/dist/deploy/90_qtest.xml` file would look like this:

```
<qbean name='qtest' class='org.jpos.test.QTest'>
  <property name="debug" value="false" />
</qbean>
```

If you want to set your properties in a separate file, you could `<property file="xxx" />` `instead of +<property name="xx" value="yy" />`, i.e:

```
<qbean name='qtest' class='org.jpos.test.QTest'>
  <property file="cfg/myconfig.cfg" />
</qbean>
```

and then add a file `src/dist/cfg/myconfig.cfg`, e.g.:

```
debug=false
```

The files in the `src/dist` directory get copied to `build/install` when we call `gradle installApp` or to the `build/distributions` when we call `gradle dist` and are subject to property expansion.

So if instead of writing `debug=false`, you put `debug=@debug@` (same goes if you use `<property name="debug" value="@debug@" />`), and you add a compile-time property called `debug` to your compile *target*, Gradle will propertly replace it when copying it to the destination directory.

In order to test this lets change the file in `src/dist/deploy/90_qtest.xml` to read like this:

```
<qbean name='qtest' class='org.jpos.test.QTest'>
  <property name="debug" value="@debug@" />
</qbean>
```

And add a top level file called `devel.properties` with a line like this:

```
debug=yes
```

Yes, Q2 understand *yes* and *no* in addition to *true* and *false*

When you call `gradle installApp`, the destination file in `build/install/qtest/deploy/90_qtest.xml` will have a `yes` instead of the `@debug@` token.

`devel` is the default Gradle target defined by jPOS and that's the reason it reads the `devel.properties` file. But you can override the target using the `-Ptarget=xxx` parameter, so you can for example create a file called `prod.properties` where `debug=no` and then call `gradle -Ptarget=prod clean installApp`.

Please note we've added `clean` as part of the build, reason is because the source file `src/dist/deploy/90_qtest.xml` didn't change, and the destination file `build/`

`install/qtest/deploy/90_qtest.xml` was created in the previous step (with the default `devel` target), Gradle assumes the file is up-to-date and do not attempt to re-generate it.

If you prefer to have more control over the XML inside your QBeans, like the one we use in the ChannelAdaptor, QMUX or the TransactionManager where we have child elements with their own hierarchy (like *filters*, *participants*, *queues*), you can implement `org.jpos.core.XmlConfigurable` instead of `Configuration` so that instead of a flat `Configuration` object, you receive an `org.jdom.Element` that you can use to interpret your own configuration.

## Honoring the *logger* and *realm* attributes

Q2 uses reflection to find out if a QBean has a method with the following signature: `void setLogger (String loggerName)`, and and optional `void setRealm (String realm)`.

We can take advantage of that feature by adding the following code to our QTest file:

```
    public void setLogger (String loggerName) {
        log = Log.getLog (loggerName, getClass().getName());
        setModified (true);
    }
    public void setRealm (String realm) {
        if (log != null)
            log.setRealm (realm);
    }
```

If you are starting to get worried about the large number of options you have when implementing a QBean, don't worry, there's a handy support class called `QBeanSupport` that you can extend in order to take advantage of all these features without having to write a lot of boilerplate code. We'll show you how to use it shortly, but if you want to understand how Q2 works, we suggest you follow this lengthly step-by-step explanation.

## Getting a reference to the Q2 server

If your QBean needs a reference to the Q2 server, it can implement the `setServer(Q2 server)` method. Q2 will push a reference to itself at configuration file.

## Getting a reference to the XML element representing the QBean descriptor

If your QBean has a method with the signature `void setPersist(Element e)`, Q2 will push the Element representing the QBean descriptor. This feature allows a QBean to implement the `QPersist` interface, that looks like this:

```
public interface QPersist {
    public Element getPersist ();
    public boolean isModified ();
}
```

If your `QBean` implements `QPersist` and its `isModified()` returns `true`, then Q2 will call its `getPersist()` to get a new QBean descriptor and will store it in the `deploy` directory.

This feature is rarely used in jPOS applications, but it’s there just in case you want to experiment with it. In our previous `jconsole` example, a change to the `tickInterval` done via JMX could be stored in the `90_qtest.xml` file automatically, so it can be honored on the next restart.

The name *persist* here is a really bad name, something like `getXmlDescriptor()` could have been better.

# 7.5. QBeanSupport

All the details described in our first implementation of `QTest` can be simplified by just extending **QBeanSupport** [https://github.com/jpos/jPOS/blob/master/jpos/src/main/java/org/jpos/q2/QBeanSupport.java].

`QBeanSupport` implement the `QBean` life-cycle methods `init()`, `start()`, `stop()` and `destroy()` and call the protected:

- initService
- startService
- stopService
- destroyService

providing suitable default implementations for those. These methods are implemented like this:

```
    public void init () {
        if (state == -1) {
            setModified (false);
            try {
                initService();
                state = QBean.STOPPED;
            } catch (Throwable t) {
                log.warn ("init", t);
            }
        }
    }

    public synchronized void start() {
        if (state != QBean.DESTROYED &&
            state != QBean.STOPPED   &&
            state != QBean.FAILED)
           return;

        this.state = QBean.STARTING;

        try {
           startService();
        } catch (Throwable t) {
           state = QBean.FAILED;
           log.warn ("start", t);
           return;
        }
        state = QBean.STARTED;
    }

    public synchronized void stop () {
        if (state != QBean.STARTED)
           return;
        state = QBean.STOPPING;
        try {
           stopService();
        } catch (Throwable t) {
           state = QBean.FAILED;
           log.warn ("stop", t);
           return;
        }
        state = QBean.STOPPED;
    }

    public void destroy () {
        if (state == QBean.DESTROYED)
           return;
        if (state != QBean.STOPPED)
           stop();

        if (scheduledThreadPoolExecutor != null) {
            scheduledThreadPoolExecutor.shutdown();
            scheduledThreadPoolExecutor = null;
        }
        try {
           destroyService();
        }
        catch (Throwable t) {
           log.warn ("destroy", t);
        }
        state = QBean.DESTROYED;
    }
```

You can see that they track and validate the state of the QBean, catch exceptions providing reasonable logging, etc.

In addition, `QBeanSupport` implements `Configurable` and exposes a `public Configuration getConfiguration()` method. It has a `setServer(Q2)` method so your implementation can call `getServer()` to get a reference to the Q2 system.

It also implements a `boolean running()` method so that your QBean can check if the QBean is still running and get out of a running loop.

`QBeanSupport` provides a handy `QBeanSupportMBean` so if your QBean does not expose any JMX attribute, you don’t even have to write an `xxxMBean` interface.

Our `Qtest` implementation could look like this:

```
package org.jpos.test;

import org.jpos.iso.ISOUtil;
import org.jpos.q2.QBeanSupport;

public class QTest extends QBeanSupport implements Runnable {
    @Override
    protected void startService() {
        new Thread(this).start();
    }
    public void run () {
        for (int tickCount=0; running (); tickCount++) {
            log.info ("tick " + tickCount);
            ISOUtil.sleep (cfg.getLong("tickInterval", 1000L));   ❶
        }
    }
}
```

❶ In this case, we are pulling the tickInterval from a *property* with a default to 1 second. We can off course add a `tickInterval` attribute and expose it in a `QTestMBean` interface as described in the previous section.

# 7.6. Dynamic classloading

In most applications, the business logic and packagers are available in the classpath, but there are situations where you need to apply a hot patch such as adding a new field packager, or an ISO filter, so we have provided this dynamic class loading capabilities.

If you know OSGi you can laugh as much as we do with our limited poor-man implementation, it has many drawbacks that we’ll explain below, but if you need to apply a hot patch until you can bounce the system and restart with a new build, you can appreciate that our dynamic classloading has some use.

In addition to the `deploy` directory that Q2 monitors to see changes in the deployed services, it also monitors the timestamp of the `deploy/lib` directory, and if changed, it scans all jars in there and add them to the URL classloader of the MBeanServer, used by Q2 to instantiate its QBeans.

The previous paragraph basically tells you all you need to know about jPOS' Q2 dynamic classloading. If you read it again, and understand every word, then you can skip to the next section. If you have doubts, we’ll try to clarify them below.

Let’s try a simple example. If you start Q2 in say the `/opt/local/jpos` directory, it will be monitoring the `/opt/local/jpos/deploy` directory for QBean descriptors and the `/opt/local/jpos/deploy/lib` for jars to be added to the classpath.

At start up the output will look like this:

```
<log realm="Q2.system">
  <info>
    Q2 started, deployDir=/opt/local/jpos/deploy
    ...
    ...
  </info>
</log>
```

If while Q2 is running you create a `lib` directory inside `deploy`, you'll see a message like this:

```
<log realm="Q2.system">
  <info>
    new classloader [58f0fa12] has been created
  </info>
</log>
```

If you then place a jar inside that new `lib` directory, **and you touch** `lib` directory so that it changes its timestamp, you'll see once again the message indicating that a new classloader has been created, but this time, it will contain your new jar.

If the `deploy/lib` directory is available, with jars in it, at Q2 start up time, it will of course be picked up.

The *and you touch* part mentioned above is important, because Q2 doesn't monitor the jars inside the lib directory, it monitors the timestamp of the `deploy/lib` directory itself. This gives us some kind of poor man ability to deploy several jars in an atomic way (to manually solve dependencies).

So now that the new jar is available in the classpath, you can deploy your QBean by adding its xml QBean descriptor in the `deploy` dir.

## Dynamically deploying QTest

If you've followed the instructions in **Section 7.4, "QTest - a sample QBean"**, you can copy `build/libs/qtest-1.0.0.jar` generated using `gradle jar` into another jPOS Q2 system (i.e. you could use the default jPOS distro clone) and follow the previous instructions to run it.

In addition to that, Q2 support remote dynamic classloading, so instead of placing your jar in the `deploy/lib`, you could load it from a remote URL.

For your convenience, we've placed a compiled version of qtest in the following URL: **`http://us.jpos.org/private/qtest-1.0.0.jar`**, so you can deploy in any Q2 system the following QBean:

```
<qbean name='qtest' class='org.jpos.qtest.QTest' logger='Q2'>
  <classpath>
    <url>http://us.jpos.org/examples/qtest-1.0.0.jar</url>
  </classpath>
</qbean>
```

A QBean can download its supporting classes from multiple URLs, the previous example could read:

```
<qbean name='qtest' class='org.jpos.qtest.QTest' logger='Q2'>
  <classpath>
    <url>http://us.jpos.org/examples/qtest-1.0.0.jar</url>
    <url>http://myhost.mydomain.com/another-dependency.jar</url>
    ...
  </classpath>
</qbean>
```

jPOS applications are usually mission critical and highly sensitive, so in most situations, it’s not a very good idea to download the implementation from remote sites.

But on a local DMZ where you have many nodes using the same code, it can come very handy to use this feature and download code from a local artifact server.

# Chapter 8. Q2 jPOS Services

Before Q2, in the old QSP days, we had a limited set of services that were migrated to Q2, usually using *adaptors*.

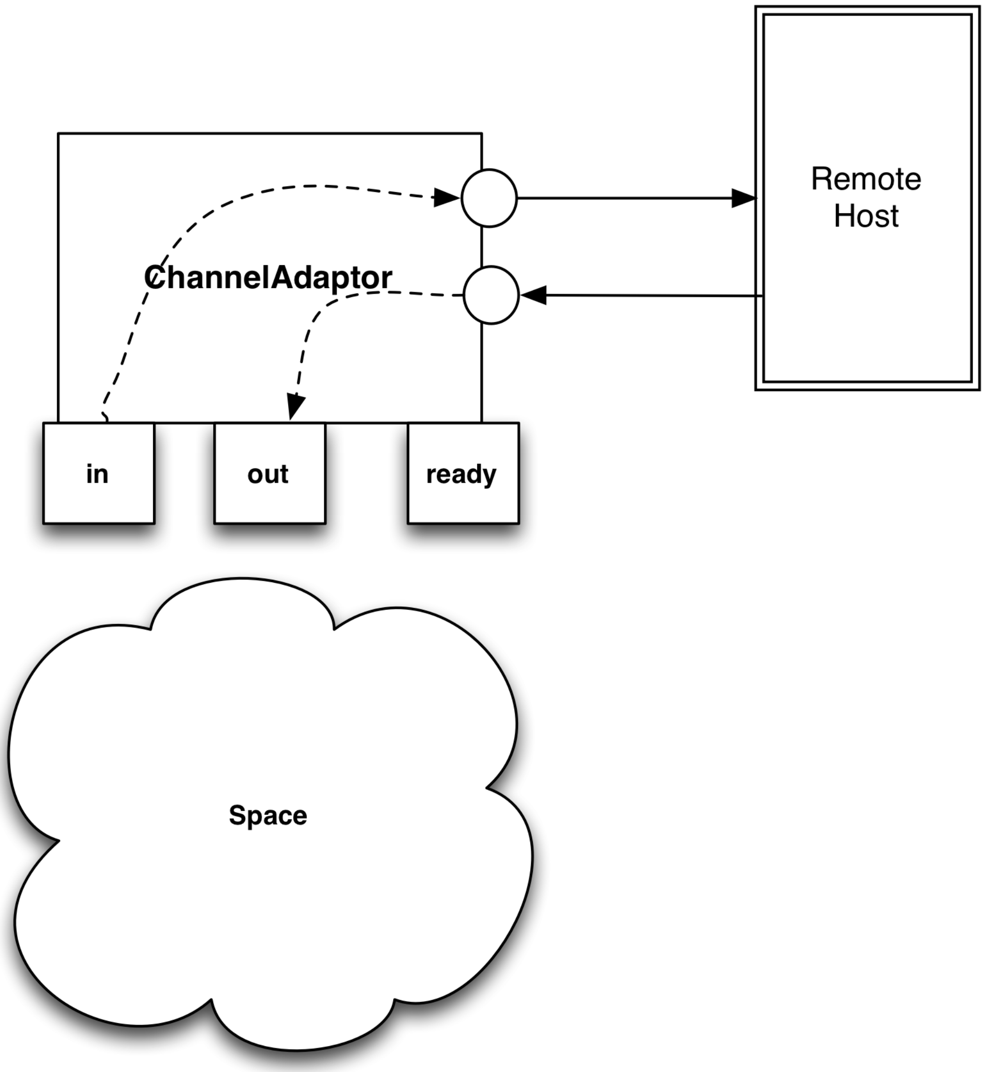
So the old QSP `channel` has now the corresponding `channel-adaptor` service, `dirpoll` has a `dirpoll-adaptor`, the `security` module has a `SMAdaptor` and `KeyStoreAdaptor` and so on.

We document in this chapter these adaptors, along with new services that have been implemented only in Q2.

# 8.1. ChannelAdaptor

When jPOS acts as client from a TCP/IP standpoint, you'd most likely use the `ChannelAdaptor` service to manage the low level socket connection.

The `ChannelAdaptor` uses the Space to communicate with other jPOS components, basically through two *Space queues*, one for **input** and the other one for **output**.



The *in* and *out* naming convention is easy to remember if we think of them as **seen from the component's perspective**.

So ChannelAdaptor is monitoring its input (*in*) queue for messages that are to be sent to the remote host, and places messages received from the remote host in its output (*out*) queue.

Most of the time, you won't have to deal with these queues, you'll just deal with the API provided by higher level components like **QMUX**.

## 8.1.1. QBean descriptor

As described in **Section 7.1, "Running Q2"**, Q2 sorts the XML descriptors available in the `deploy` directory alphabetically, as an easy way to orderly start services.

We usually use the prefix **10_** for channels, so that when other components (such as MUXes that use the prefix *20_*) start, they can use them right away on the first attempt.

So a reasonable name for a channel descriptor can be something like `10_xxx_channel.xml`.

```
<channel-adaptor name='your-channel' logger="Q2">          ❶
 <channel class="org.jpos.iso.channel.NACChannel"
       packager="org.jpos.iso.packager.GenericPackager"    ❷
       header="6000000000">                                ❸
  <property name="packager-config"                         ❹
           value="jar:packager/iso87binary.xml" />
  <property name="host" value="127.0.0.1" />               ❺
  <property name="port" value="8001" />
  <property name="timeout" value="300000" />               ❻
  <filter                                                  ❼
      class="org.jpos.iso.filter.YourIncomingFilter"
      direction="incoming" />
  <filter
      class="org.jpos.iso.filter.YourOutgoingFilter"
      direction="outgoing" />
 </channel>
 <in>your-channel-send</in>                                ❽
 <out>your-channel-receive</out>                           ❾
 <reconnect-delay>10000</reconnect-delay>                  ❿
</channel-adaptor>
```

❶ The element name `channel-adaptor` is defined in `QFactory.properties` (see **Section 7.3, "Writing your first Q2 Script"**) and implies that the class to be instantiated is `org.jpos.q2.iso.ChannelAdaptor`. You can of course use another root element name and add the `class` attribute if you wish.

❷ In this example we use the `GenericPackager` which is the most flexible one, but of course, you can use any other custom packager or some of the stock packagers such as `XMLPackager` or `XML2003Packager`. For a complete list of available packagers see **https://github.com/jpos/jPOS/tree/master/jpos/src/main/java/org/jpos/iso/packager**

❸ Although not defined in the `ISOChannel` interface, most channels have a `setHeader(String)` method. If the `header` attribute is present in the child `channel` element, ChannelAdaptor will use reflection to call it. How this string is interpreted is specific to each channel implementation, in this case, `NACChannel` assumes it's getting an hex string.

❹ The `Configuration` object is available to the packager, provided it implements the `Configurable` interface as it is the case of the `GenericPackager`.

❺ The `Configuration` object is also available to the channel implementation (in this case `NACChannel` which happens to implement the `Configurable` interface). The host and port properties in this case are self explanatory, they point to the remote host.

❻ Channel level timeout in milliseconds. If the channel does not receive any traffic in the configured timeout, it will disconnect. Having a channel level timeout as described here is **highly recommended**.

❼ The `channel` element can have multiple optional `filter` child elements (see **the section called “Filtered Channels”**). The `direction` attribute is optional, if not present (or if its value is `both`), the filter is configured to process both incoming as well as outgoing messages.

❽ Space queue used to receive messages to be transmitted to the remote endpoint.

❾ Messages received from the remote endpoint are placed in this queue.

❿ If the connection to the remote host breaks, ChannelAdaptor will try to reconnect after a reasonable delay, expressed in millis. If this element is not present, a default of 10 seconds (10000ms) will be used. === SSL connections

Most channel implementations accept a socket factory, that can be configured by adding the properties `socketFactory` with additional optional configuration properties required by its implementation.

In case of the provided `org.jpos.iso.SunJSSESocketFactory`, the additional properties are `storepassword`, `keypassword` and `keystore`.

The configuration would look like this:

```
<property name="socketFactory" value="org.jpos.iso.SunJSSESocketFactory" />
<property name="storepassword" value="password" />
<property name="keypassword"   value="password" />
<property name="keystore" value="cfg/mykeystore.ks" />
```

Please note that these properties are specific to the channel, so they go inside the *channel* element, not the outer *channel-adaptor* element.

## 8.1.2. Handling alternate connections

This is not a feature of the ChannelAdaptor but a feature of BaseChannel, a support class inherited by most channel implementations (but not all of them, so please check). Channel implementations extending BaseChannel can take advantage of the `alternate-host` with its companion `alternate-port` configuration property. There can be many of those, but the number of instances have to match (i.e. if you have 4 `alternate-host` definitions, you need to have 4 `alternate-port` definitions).

When ChannelAdaptor calls the `connect` method in the underlying channel, BaseChannel will attempt a connection to the main host/port. If that fails, it will attempt the alternate hosts list.

The configuration looks like this:

```
<channel-adaptor name='your-channel' logger="Q2">
 <channel class="org.jpos.iso.channel.NACChannel"
    ....
    ....
    <property name="alternate-host" value="192.168.1.2" />
    <property name="alternate-host" value="192.168.1.3" />
    <property name="alternate-host" value="192.168.1.4" />
    <property name="alternate-host" value="192.168.1.5" />
    <property name="alternate-port" value="1000" />
    <property name="alternate-port" value="1000" />
    <property name="alternate-port" value="1000" />
    <property name="alternate-port" value="1000" />
    ....
    ....
 </channel>
</channel-adaptor>
```

Same as with the previous SSL socket factory, these properties are specific to the channel, so they go inside the *channel* element, not the outer *channel-adaptor* element.

## 8.1.3. Channel timeout, keep-alive, connection-timeout

We strongly recommend that you add a channel-level timeout (expressed in milliseconds). There are many situations where a network connection can go wrong (i.e. an intermediate firewall may timeout an inactive socket connection without notify the endpoint). If you know that your link has to have traffic at least say every minute (i.e. because you’re sending network management 800-class messages back and forth), we recommend that you set a timeout for say 70 or 80 seconds.

You can increase that value, but making it very big will have a negative impact in your application that will learn that a channel is not usable only by the time it needs to send a real authorization message, causing a reconnection at that time, instead of ahead of time, while it was idle.

Setting the keep-alive (`true/false`) would set the low level `SO_KEEPALIVE` flag at the socket level for situations where no network management messages are exchanged.

The `connection-timeout` property can be used to set a smaller timeout at connect time, this is useful when combined with the `alternate-host` and `alternate-port` set of properties.

```
<channel-adaptor name='your-channel' logger="Q2">
 <channel class="org.jpos.iso.channel.NACChannel"
    ....
    ....
    <property name="connection-timeout" value="15000" />  <!-- 15 seconds -->
    <property name="timeout" value="300000" />            <!-- five minutes -->
    <property name="keep-alive" value="true" />
    ....
    ....
 </channel>
</channel-adaptor>
```

# 8.2. OneShotChannelAdaptor

Most host-to-host ISO-8583 links use persistent connections, and that's the reason we have to multiplex the messages using a MUX, but for situations where the host expects a single transaction per socket connection, we have the `OneShotChannelAdaptor`.

The configuration and behavior is very similar to the `ChannelAdaptor` (see **Section 8.1, "ChannelAdaptor"**), you just need to change the class name in the qbean descriptor.

It supports the following attributes:

### Table 8.1. OneShotChannelAdaptor Attributes.

| Name | Attribute |
|---|---|
| in | Input queue |
| out | Output queue |
| space | Optional space name, defaults to system's default space |
| max-connections | Maximum number of simultaneous connections to the remote host, defaults to 1 |
| max-connect-attempts | Maximum number of connections attempts for a single transaction, defaults to 15 |

## 8.2.1. QBean descriptor

```
<qbean name='your-channel' logger="Q2">
  class="org.jpos.q2.iso.OneShotChannelAdaptor"          ❶
 <channel class="org.jpos.iso.channel.NACChannel"
       packager="org.jpos.iso.packager.GenericPackager"
       header="6000000000">
  <property name="packager-config"
           value="jar:packager/iso87binary.xml" />
  <property name="host" value="127.0.0.1" />
  <property name="port" value="8001" />
  <filter
      class="org.jpos.iso.filter.YourIncomingFilter"
      direction="incoming" />
  <filter
      class="org.jpos.iso.filter.YourOutgoingFilter"
      direction="outgoing" />
 </channel>
 <in>your-channel-send</in>                                ❷
 <out>your-channel-receive</out>                           ❸
 <max-connections>5</max-connections>                      ❹
 <max-connect-attempts>3</max-connect-attempts>            ❺
</qbean>
```

❶ Please note we specify a class here.
❷ Space queue used to receive messages to be transmitted to the remote endpoint.
❸ Messages received from the remote endpoint are placed in this queue.
❹ Overrides default max-connections (currently 1)
❺ Overrides default max-connect-attempts (currently 15)

In addition to `org.jpos.q2.iso.OneShotChannelAdaptor` there's a new experimental `org.jpos.q2.iso.OneShotChannelAdaptorMK2` with the same functionality and a new implementation.

# 8.3. QMUX

**QMUX** is a modern and very simple, yet powerful, Q2 service that implements the **MUX** [http://jpos.org/doc/javadoc/org/jpos/iso/MUX.html] interface as described in **Section 2.2.6, "Multiplexing an ISOChannel with a MUX"**.

Users of the old **ISOMUX**, which is still available in the `compat_1_5_2` module are encouraged to upgrade to this new service.

QMUX uses the Space in order to communicate with the underlying channels; this strategy brings into play a whole new set of deployment options, including the ability to multiplex several channels for redundancy/load-balancing. These channels doesn't even have to run on the same machine. They could use distributed/remote space implementations. The new space-based code doesn't require an extra thread, something very useful in systems where a large number of MUXes are required.

## 8.3.1. QBean descriptor

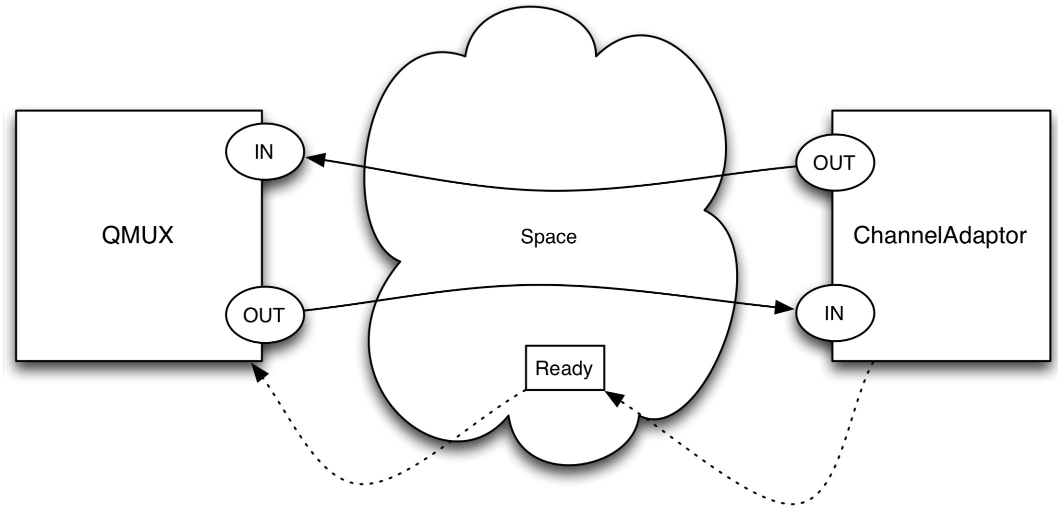
A QMUX configuration looks like this:

```
<mux class="org.jpos.q2.iso.QMUX" logger="Q2" name="mymux">
 <in>your-channel-receive</in>                                  ❶
 <out>your-channel-send</out>                                   ❷
 <ready>your-channel.ready</ready>                              ❸
</mux>
```

❶ The MUX `<in>` queue has to be named after the ChannelAdaptor's `<out>` queue.

❷ In the same way, the MUX's `<out>` queue needs to match the ChannelAdaptor's `<in>` queue.

❸ In order to provide a usable `MUX.isConnected()` method, the MUX needs to have a way to know if the underlying channel, loosely connected through the `in/out` queues is actually connected. The channel adaptor sets an entry in the space named after the channel's name with the extension `.ready` as true when connected, so the optional `ready` element has to match that name. If a `<ready>` element isn't present, `MUX.isConnected()` will always return true.




QMUX is registered in the NameRegistrar under the name provided in the qbean configuration file using the "`mux.`" prefix, ("mux.mymux" in our example) so that other components can get a reference, cast it to MUX and use its:

In order to handle messages arriving to QMUX that do not match a response QMUX is waiting for, we can attach one or more `ISORequestListeners`.

The XML configuration looks like this:

```
<mux class="org.jpos.q2.iso.QMUX" logger="Q2" name="mymux">
 <in>your-channel-receive</in>
 <out>your-channel-send</out>
 <ready>your-channel.ready</ready>
 <request-listener class="my.request.listener" logger="Q2" realm="myrealm">
  <property name="myproperty" value="abc" />
  <property name="myotherproperty" value="xyz" />
  <property file="cfg/myprop.cfg" />
 </request-listener>
</mux>
```

As an alternative (or in addition to the request listeners), we can define an `unhandled` queue. If messages arrive to QMUX and QMUX isn't waiting for it, it gets placed in the `unhandled` queue.

The configuration looks like this:

```
<mux class="org.jpos.q2.iso.QMUX" logger="Q2" name="mymux">
 <in>your-channel-receive</in>
 <out>your-channel-send</out>
 <ready>your-channel.ready</ready>
 <unhandled>myunhandledqueue</unhandled>
</mux>
```

In order for this mechanism to work, a separate jPOS service should be waiting for messages arriving to the `unhandled` queue.

In order to prevent a situation where a QMUX is configured to push messages to an `unhandled` queue and no service is listening to those messages, a 120 seconds timeout is used. So messages will be present for just 120 seconds. This little protection is intended to avoid out of memory issues.

### 8.3.2. MTI mapping and default key

QMUX use the MTI as well as fields *41* and *11* as its default key.

That default can be changed using the *<key>…</key>* elements in the QMUX configuration, i.e.:

```
<mux class="org.jpos.q2.iso.QMUX" logger="Q2" name="mymux">
 <key>42 41 11</key>                                            ❶
 <in>your-channel-receive</in>
 <out>your-channel-send</out>
 <ready>your-channel.ready</ready>
 <unhandled>myunhandledqueue</unhandled>
</mux>
```

❶ overrides default key.

In addition to the fields defined in the *<key>* element, QMUX maps each digit of the MTI to use as a key part in order to avoid mixing for instance a response for a 100-class message such as a `0100` with a reversal response. The reason for this additional mapping is because most reversals share the same STAN (field 11) with the original authorization.

Each of the three digits of the MTI gets mapped using the following default values:

- `0123456789`
- `0123456789`
- `0022446789`

The value `0123456789` means no special handling is required, a value of *0* in the first position of the MTI i.e. the first *0* in a *0100* message) will expect a *0* in that very same position in the response. The first position represents the ISO-8583 version number (see **Section 2.1, “An ISO-8583 primer”**), so if we send a 1987 message, we expect a 1987 response.

Same goes for the second position, if we send a *0100* we expect a *0110*, and that’s what the *0123456789* mapping does, it actually takes no action.

For the third position, we use the default value `0022446789`. That means that a *1* in the third position (i.e. a *0110*) will be considered a *0* when creating the MTI key part, so that a *0110* response will match the original *0100*.

These mappings can be changed using the *<mtimapping>* element in the QMUX configuration. The default values would be represented as:

```
<mux class="org.jpos.q2.iso.QMUX" logger="Q2" name="mymux">
 <mtimapping>0123456789 0123456789 0022446789</mtimapping>
 ...
 ...
</mux>
```

## 8.4. QServer

**QServer** is an adapter around `ISOServer` (see **Section 2.2.5, “Accepting connections with ISOServer”**) that interacts with other Q2 components, such as QMUX, using the Space by defining `in` and `out` queues, pretty much like the `ChannelAdaptor` does.

Despite the fact that QServer will act as a server from a TCP/IP standpoint, and it will listen to a configurable port, it can still be used to initiate transactions to the remote endpoint.

When acting as a server (from a transaction standpoint), the QServer is typically configured to forward transactions to a set of request listeners, but that’s not mandatory. It is possible to use `in/out` Space based queues and **connect** QServer to other components, such as QMUX (see **Section 8.3, “QMUX”**).

## 8.4.1. QBean descriptor

A QServer configuration looks like this:

```
<qserver name="xml-server" logger="Q2">                                   ❶
  <attr name="port" type="java.lang.Integer">8000</attr>                  ❷
  <channel name="xml.channel"
           class="org.jpos.iso.channel.XMLChannel"
           packager="org.jpos.iso.packager.XMLPackager">
  </channel>
  <request-listener class="my.request.Listener" logger="Q2">
    <property name="my-property" value="ABC" />
    <property name="my-other-property" value="XYZ" />
  </request-listener>
</qserver>
```

❶ `qserver` is defined in `QFactory.properties` and defaults to class `org.jpos.q2.iso.QServer`

❷ `port` is a JMX attribute honored by `QServer`. Other configuration options are pulled using a `Configuration` object.

The `qserver` element has been recently added to QFactory (>1.9.7); when running older versions, the QBean descriptor has to include the `class="org.jpos.q2.iso.QServer"` attribute.

QServer is registered in the `NameRegistrar` under the name provided in the qbean descriptor (**"xml-server"** in the previous example). In addition, the underlying `ISOServer` — instantiated by `QServer` — will register itself with the `NameRegistrar` using a prefix `"server."`, so in the previous example, `xml-server` will be a reference to the `QServer` object, and `server.xml-server` will have a reference to the `ISOServer` object.

The Channel definition used by `QServer` is the same as the one used by the `ChannelAdaptor`, where you can configure SSL support, packager-level logging, etc. Please read **Section 8.1, “ChannelAdaptor”** for details.

The request listeners are the same as those used by `QMUX` (see **Section 8.3, “QMUX”** for details). A `QServer` using a request listener would look like this:

```
<server name="jcard-server" class="org.jpos.q2.iso.QServer" logger="Q2">
  <attr name="port" type="java.lang.Integer">8001</attr>
  <channel name="jcard.channel"
           class="org.jpos.iso.channel.CSChannel"
           packager="org.jpos.iso.packager.GenericPackager" logger="Q2">
    <property name="packager-config" value="cfg/jcard.xml" />
    <property name="timeout" value="300000" />
  </channel>
  <request-listener class="org.jpos.jcard.Dispatcher" logger="Q2"
                    realm="incoming-request-listener">
   <property name="prefix"  value="org.jpos.jcard.Incoming_" />
   <property name="timeout" value="60000" />
   <property name="space"   value="tspace:default" />
   <property name="queue"   value="JCARD.TXN" />
   <property name="station" value="JCARD" />
  </request-listener>
</server>
```

You can of course define multiple request listeners, but we typically have just one that pushes the messages to the TransactionManager where the business logic can be implemented.

In situations where the system needs to initiate transactions to the remote host, `in` and `out` queues can be configured like in the `ChannelAdaptor`. These names (`in/out`) are seen from `QServer’s` perspective. Because a QServer can accept multiple simultaneous connections in different sockets, an outgoing message needs to select which socket to use. When using this `in/out` communication queues, QServer selects the latest socket (using the `ISOServer.getLastConnectedISOChannel()` method (see **QServer** [http://jpos.org/doc/javadoc/org/jpos/q2/iso/QServer.html]).

The configuration looks like this:

```
<qserver name="jcard-server"  logger="Q2">
  <attr name="port" type="java.lang.Integer">8001</attr>
  ...
  ...
  <in>your-server-receive</in>
  <out>your-server-send</out>
  <ready>your-server.ready</ready>
</qserver>
```

`QServer` can accept multiple simultaneous sockets (default 100) that can be configured using the JMX attributes `minSessions` and `maxSessions`, i.e:

```
  <attr name="minSessions" type="java.lang.Integer">10</attr>
  <attr name="maxSessions" type="java.lang.Integer">250</attr>
```

In addition, it can check the client’s IP address against **"allow"** and **"deny"** IP addresses (including suffix wildcards) and drop the connection if it’s not one of the allowed IP addresses. Here’s an example:

```
  ...
  ...
  <property name="allow" value="192.168.1.1" /> ❶
  <property name="allow" value="192.168.1.2" />
  <property name="allow" value="10.0.0.10" />
  <property name="deny"  value="10.0.*" />      ❷
  ...
  ...
```

❶ The first three IPs are *explicitly allowed*, even though the third one…

❷ …belongs to an IP range that is denied.

Some considerations:

- Explicit IPs (i.e., those without wildcards) will be checked and honored first. Then, the wildcard expressions will be checked, starting with the wildcard `"deny"` set, and following with the wildcard `"allow"` set.
- If only `"allow"` expressions are used, the default policy will be to *deny unmatching* IPs.
- If only `"deny"` expressions are used, the default policy will be to *allow unmatching* IPs.
- For *mixed* permissions (both, `"allow"` and `"deny"` present), the default policy will be to *deny unmatching* IPs.
- Use caution when using mixed permissions and wildcards. Due to the order of evaluation and default policies, some combinations may, at best, be redundant or unnecessary. At worst, they may make no sense at all (even denying connections from valid IPs).

The IP validation via the `allow` and `deny` set of properties, while very handy, should not to be used as a replacement for proper firewall rules.

# Chapter 9. TransactionManager

The TransactionManager (also called *TM* in this document) is just another Q2 Service, but it is such an important component in most jPOS based applications that it stands out, deserving its own chapter.

jPOS is typically used to implement mission-critical applications that have to carefully deal with error conditions.

When you access a web page and a transient network error occurs, you just hit the **reload** button on your browser. By contrast, a complex financial transaction involves a lot of activities such as contacting remote hosts, notifying risk management systems, placing holds in cardholder's credit accounts, database logging, etc.

So, if something goes wrong or your system just dies due to a power failure, it's more complicated than simply hitting the **reload** button: you have to reverse the impact of whatever actions had been taken up to the failure point.

The `org.jpos.transaction` package - along with the Q2-based **TransactionManager** implementation - provides a framework and set of components that can assist dealing with the previous scenario. This combination also fosters code reuse and *componentization*.

This doesn't mean a jPOS based application needs to use the TransactionManager. It's proven, it's fast, it's reliable, we are aware of use cases where the TM is used to process millions of transactions per day, we @jposconsulting use it in most of our applications, but it's up to you to use it or not.

The key class is the **TransactionParticipant** [http://jpos.org/doc/javadoc/org/jpos/transaction/TransactionParticipant.html] that exposes the following interface:

```
 public interface TransactionParticipant extends TransactionConstants {
     public int  prepare (long id, Serializable context);
     public void commit  (long id, Serializable context);
     public void abort   (long id, Serializable context);
 }


// the TransactionConstants interface provides the following definitions:

 public interface TransactionConstants {
     public static final int ABORTED  = 0;
     public static final int PREPARED = 1;
     public static final int RETRY    = 2;
     public static final int PAUSE    = 4;
     public static final int NO_JOIN  = 0x40;
     public static final int READONLY = 0x80;
 }
```

The TransactionManager implementation *drives* the transaction by calling all of its participants' `prepare` method. If all of them return `PREPARED` (indicating that they are ready to proceed with the transaction), then the transaction moves to the *COMMITTING* phase, at which point the TransactionManager will call all of the participants' `commit` method.

If one of the participants' `prepare` method returns `ABORTED`, then the transaction moves into an *ABORTING* phase, and all the participants previously called to get prepared will get a call to their `abort` method.

# 9.1. TransactionConstants

### Table 9.1. TransactionConstants

| Name | Value | Description |
|---|---|---|
| ABORTED | 0 | The participant is not prepared. Transaction should be aborted. |
| PREPARE | 1 | The participant is prepared to commit the transaction, provided all other participants down the list return PREPARED too. |
| RETRY | 2 | The transaction will be retried after a short period of time defined by the `retry-timeout` TransactionManager property (which defaults to 5 seconds). This can be used in situations where a transient error has been detected (such as a link down situation or a transient database issue). |
| PAUSE | 4 | The transaction will be paused and will be resumed in the following situations:<br><br>a) Some external thread calls resume in the transaction’s Context (provided the Context implements the Pausable interface)<br><br>b) A timeout specified by the Context’s Pausable interface occurs<br><br>c) A default timeout specified by the TransactionManager’s pause-timeout property (which defaults to five minutes) |
| NO_JOIN | 0x40 | This modifier is a hint to the TransactionManager to let it know that it is not required to call this participant’s `commit` or `abort` methods once the committing or aborting phase of the transaction is reached. |
| READONLY | 0x80 | This modifier is a hint to the TransactionManager to let it know that this participant has not modified any persistent information in the context, so saving a snapshot of the context is not required. |

Despite the fact that a partipant may indicate that it doesn’t want to JOIN a given transaction (by using the `NO_JOIN` run-time modifier), under certain recovery situations the TransactionManager may still call its `commit` or `abort` method, so the participant developer should be prepared to receive a `commit` or `abort` call for an unknown transaction. The code should check the `long id` and / or `Serializable context` in order to figure out what to do. That said, most participants returning `NO_JOIN` actually have empty `commit()` and `abort()` callbacks.

# 9.2. Transaction Context

The only constraint imposed on a Context implementation is that it has to implement the `java.io.Serializable` interface. That's because the TransactionManager has to write `snapshots` of it at different check points.

You can use any `Serializable` object, either a custom object such as an application-specific *Bean*, or a general-purpose object such as a `java.util.Map` implementation (e.g., a `Hashmap`).

But we found it very useful to use a general-purpose context holding two maps, a regular (persistent) map and a transient one, so that one can store serializable data that can be automatically persisted by the TransactionManager (for recovery purposes) as well as *live* references (such as a TCP/IP socket or a JDBC connection).

So there's a general purpose **Context** [http://jpos.org/doc/javadoc/org/jpos/transaction/Context.html] reference implementation that in addition implements the **Pausable** [http://jpos.org/doc/javadoc/org/jpos/transaction/Pausable.html] interface, required if you plan to use transaction continuations (`PAUSE` modifier).

This Context reference implementation has two kind of *put* operations:

```
    public void put (Object key, Object value)
```

and

```
    public void put (Object key, Object value, boolean persist)
```

When using the latter, if `persist == true`, then the object can get automatically persisted by the TransactionManager (if configured to do so, using the `persistent-space` property).

# 9.3. Context Recovery Interface

In the previous section, we described a Transaction Context holding two maps: a *transient* map and a *persistent* one.

In situations where the TransactionManager dies (e.g., during a power failure), a transaction could have been in its preparing, committing or aborting phase.

Either the commit or abort methods will be called on all participants, but before that happens, the TransactionManager gives the developer the opportunity to let the participants know that we are not dealing with a normal commit/abort but a recovery situation.

The developer may choose to implement the **ContextRecovery** [http://jpos.org/doc/javadoc/org/jpos/transaction/ContextRecovery.html] interface:

```
public interface ContextRecovery {
    public Serializable recover (long id, Serializable context, boolean commit); ❶
}
```

❶ the `commit` boolean parameter indicates whether the transaction is going to commit or abort.

The TransactionManager provides the opportunity to build up the transient part of the Context (e.g., re-establishing a JDBC connection, re-fetching a database record based on some persistent ID number , etc.).

While many participants can implement this interface, it is reasonable to have a single one, similar to the initial `PrepareContext`, that can put a recovery flag in the Context, re-establish JDBC connections, etc.

# 9.4. Assembly Line

It’s easier to understand the TM if we imagine an **assembly line**.

Here is an example of a typical transaction (in this case taken from the jCard system):

The TransactionManager encourages and allows developers to write reusable and configurable components called *Participants*. Here is a short description of a typical Balance Inquiry transaction, splitted into many small (easy to develop, easy to reuse, easy to maintain) participants:

### Table 9.2. AssemblyLine

| Name | Description |
|---|---|
| PrepareContext | We prepare the context with some handy objects, such as a transaction `TIMESTAMP`, a `Profiler` and optional user specific data required by all participants down the execution line. |
| CheckVersion | We usually receive messages using a specific version. In this case, jCard uses the **jPOS-CMF** [http://jpos.org/doc/jPOS-CMF.pdf] which has a specific field indicating the interchange version. This participant just check that and early aborts the transaction if it doesn’t match our expectations |
| Open | If version is OK, we probably want to log the message in a database. The `Open` participant gets a JDBC connection and starts a JDBC Transaction. |
| Switch | We’ll explain later the `GroupSelectors` that allows us to put together groups of partipants in the XML configuration. In this example, the selector returns a String with the following content: `"balanceinquiry prepareresponse logit close sendresponse"` indicating that the TM needs to execute the participants defined in those groups. |
| CheckFields | Different transactions require the presence of different ISO8583 fields in the incoming message. Some are mandatory, some are optional, this reusable participant takes care of that. For example, in the case of a balance inquiry, we want to make sure that we have fields that allows us to identify the card, transaction amount, etc. |
| CreateTranLog | If we reach this participant it means the incoming message is kinda OK, it has the proper version, it has the required mandatory fields, so we create a TranLog record. This is specific to jCard, but your |

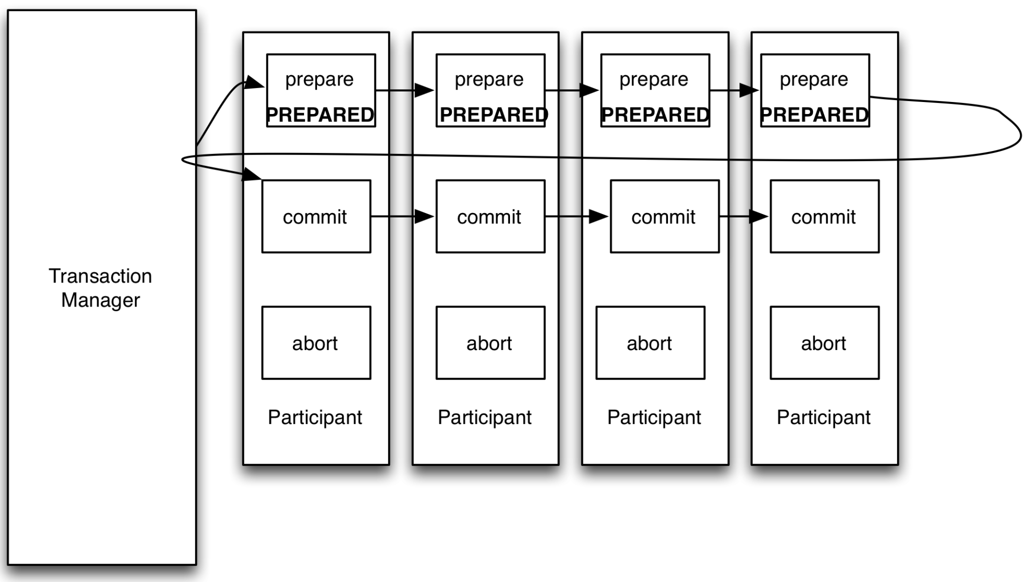
| Name | Description |
|---|---|
| | implementation is likely to require some kind of transaction log record. |
| CheckCard | In order to compute the balance of a given account, we first need to locate the card. This involves getting the card by different means, could be track1 data, track2 data, token, etc. The `CheckCard` participant takes care of that, and will place a handy Card object in the Context using a well known constant name (in the case of jCard, that constant is called `CARD` and is defined in the `org.jpos.ee.Constants` interface, but you can define it elsewhere, probably in an `enum`). |
| CheckTerminal | We need to check that the client terminal is valid, active, and perhaps check its capabilities in order to provide responses in different formats (i.e. for printing purposes) |
| CheckAcquirer | We need to know the acquirer, perhaps to validate fees involved in this transaction. |
| SelectAccount | We know the Card, so we know the CardHolder, depending on the transaction type and processing code, we may choose a different account (i.e. checking versus saving) |
| ComputeBalances | Now we know the account, so we compute its balances (available, accounting) and place it in the Context |
| PrepareResponse | We have the balances in the Context in `BigDecimal` objects under well known contant keys (i.e. `AVAILABLE_BALANCE`, `ACCOUNTING_BALANCE`), but we need to place those in the ISO8583 response, probably in field 54 (additional amounts). |
| LogIt | Remember we've created a `TranLog` record in the `CreateTranLog` participant above, now we need to pick some of the data we have been gathering in the Context and place it there, so that it gets persisted in a database row. |
| Close | Before we send a response, we need to commit the JDBC transaction and return the JDBC session to the pool. |
| SendResponse | Now we send the response back to the network |
| ProtectDebugInfo | The following participant (*Debug*) dumps the Context's content to the jPOS log, something very useful for debugging purposes, but there's some sensitive data in the Context, so this little participant take care of masking it. |
| Debug | Dumps the Context to the jPOS log. |

Here is the sample log:

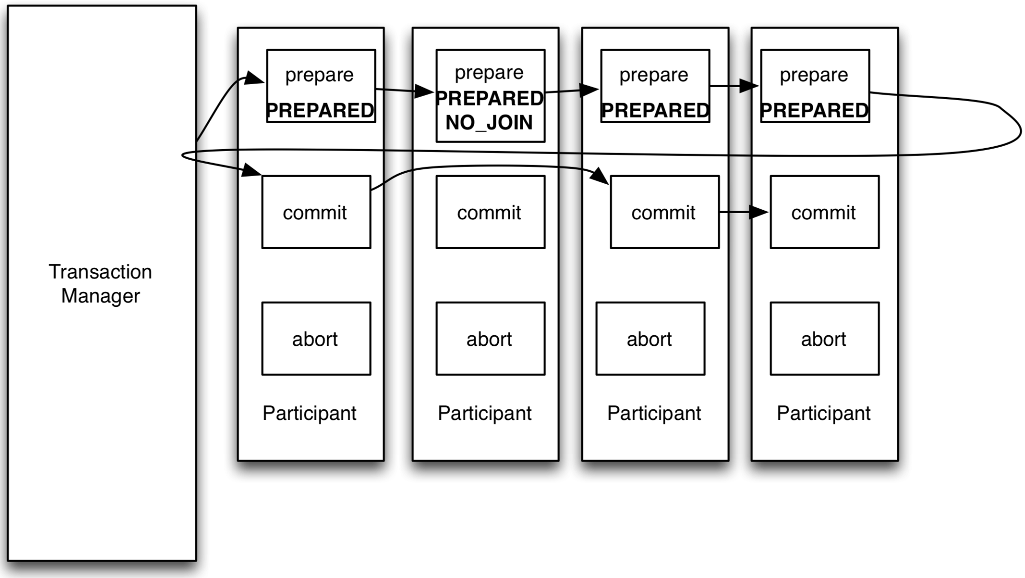
```
     prepare: org.jpos.jcard.PrepareContext NO_JOIN
     prepare: org.jpos.jcard.CheckVersion READONLY NO_JOIN
     prepare: org.jpos.transaction.Open READONLY NO_JOIN
     prepare: org.jpos.jcard.Switch READONLY NO_JOIN
    selector: balanceinquiry prepareresponse logit close sendresponse
     prepare: org.jpos.jcard.CheckFields NO_JOIN
     prepare: org.jpos.jcard.CreateTranLog NO_JOIN
     prepare: org.jpos.jcard.CheckCard NO_JOIN
     prepare: org.jpos.jcard.CheckTerminal NO_JOIN
     prepare: org.jpos.jcard.CheckAcquirer NO_JOIN
     prepare: org.jpos.jcard.SelectAccount NO_JOIN
     prepare: org.jpos.jcard.ComputeBalances NO_JOIN
     prepare: org.jpos.jcard.PrepareResponse NO_JOIN
     prepare: org.jpos.jcard.LogIt READONLY NO_JOIN
     prepare: org.jpos.transaction.Close READONLY
     prepare: org.jpos.jcard.SendResponse READONLY
     prepare: org.jpos.jcard.ProtectDebugInfo READONLY
     prepare: org.jpos.transaction.Debug READONLY
      commit: org.jpos.transaction.Close
      commit: org.jpos.jcard.SendResponse
      commit: org.jpos.jcard.ProtectDebugInfo
      commit: org.jpos.transaction.Debug
```

In a blue sky scenario like the previous one, the TM calls all participant’s `prepare` method, which return PREPARED, and then the `commit` method on those that have joined the transaction (by not returning the `NO_JOIN` modifier).

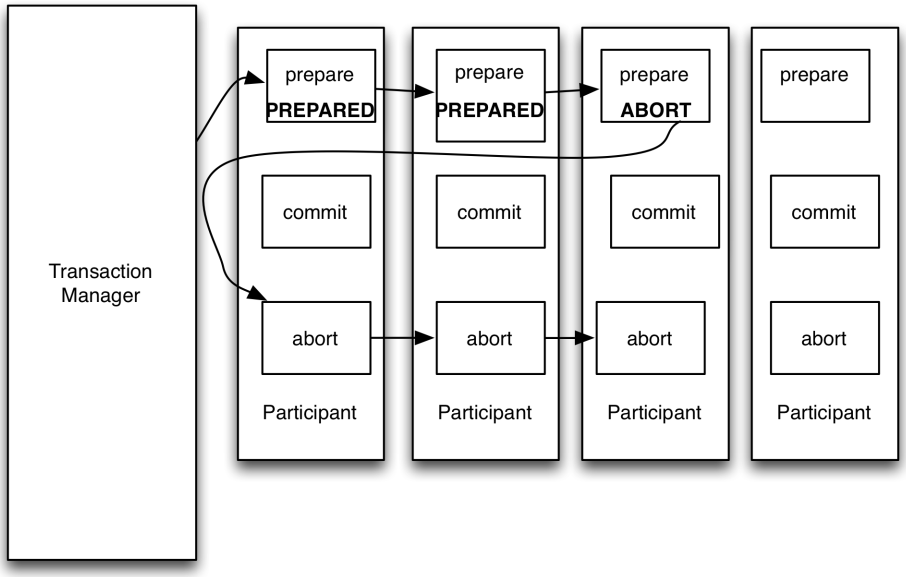
Here is a diagram for a situation where all participants return just `PREPARED` (meaning they DO want to join the transaction, so commit gets called).




When a participant adds the `NO_JOIN` modifier (by returning `PREPARED | NO_JOIN`), then the TM skips calling that participant’s `commit` method as shown in the following diagram.




If a participant returns `ABORT`, then the TM calls the `abort` operation in those participants already called that where `PREPARED` and did not return the `NO_JOIN` modifier so that they can take corrective action if required.




# 9.5. AbortParticipant

Imagine you have a list of participants that define a transaction, for example:

- `ValidateMessage` (sanity checks)
- `FetchData` (i.e. get Terminal/Merchant info from database)
- `QueryRemoteHost`
- `LogTransaction`
- `SendResponse`

If everything goes okay and all participants return `PREPARED`, then you'll have no problem reaching the last set of participants. By contrast, if for some reason a given participant fails (e.g., imagine `FetchData` fails), then the remaining participants down the list (in our example, FetchData through `SendRepsonse`) won't get called because the transaction manager will initiate the aborting procedure (which will call abort(id,context) only on the previously-called participants, i.e., only on ValidateMessage in our example).

In the previous example, while it's okay to ignore a call to the `QueryRemoteHost` participant, you may still want to send a response back to the client, or even log the transaction, so you do want to call `SendResponse`.

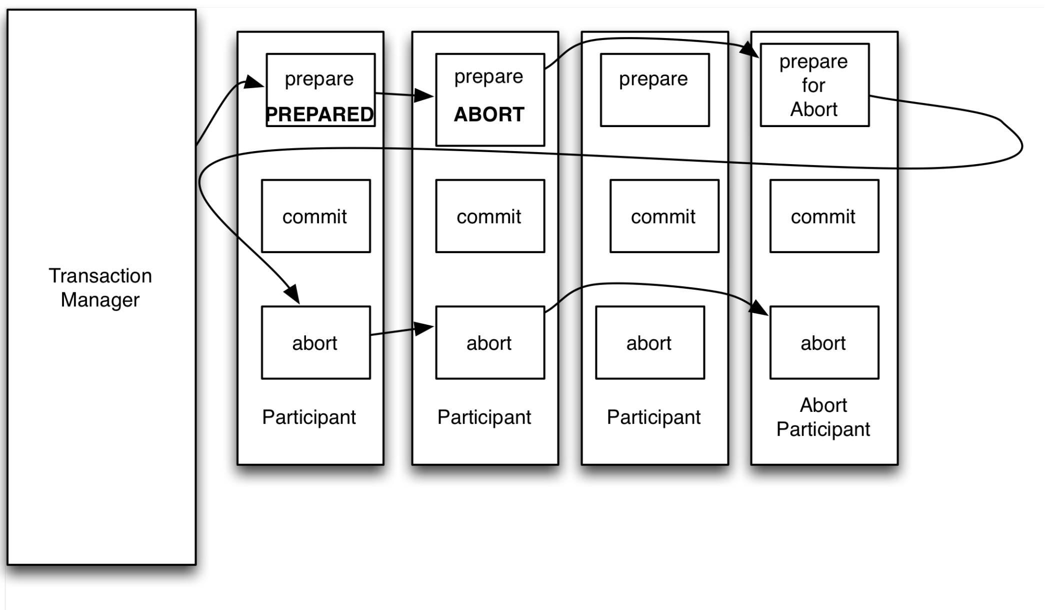
The **AbortParticipant** [http://jpos.org/doc/javadoc/org/jpos/transaction/AbortParticipant.html] is designed to solve this problem:

```
public interface AbortParticipant extends TransactionParticipant {
    public int  prepareForAbort (long id, Serializable context);
}
```

Participants implementing the `AbortParticipant` will get called even if the transaction is bound to abort.

If we use this technique to implement a `SendResponse` participant, as an additional protection it is a good idea to verify that we are not approving a transaction.

If you see the previous diagram, when participant 3 returns `ABORTED`, the last participant doesn't get called. If participant number four implements this `AbortParticipant` interface, the diagram would look like this:




# 9.6. GroupSelector

Having a configuration like this:

```
<txnmgr ...>
 <participant A />
 <participant B />
 <participant C />
 <participant D />
 ...
</txnmgr>
```

may be good for some small applications, but you risk ending up having to configure multiple transaction managers for different classes of transactions (e.g., network management, authorization, draft capture, etc.) or add complexity to participants in order to operate or do nothing depending on the transation type.

In order to simplify the TransactionManager configuration, we've added a very simple interface called `GroupSelector`:

```
  public interface GroupSelector extends TransactionParticipant {
      public String select (long id, Serializable context);
  }
```

A participant implementing the `GroupSelector` interface can modify the flow of a transaction by returning a space-separated list of group names (or can specify *null* to signify no action).

Our Q2-based TransactionManager reference implementation supports this interface and lets you design your own configuration file with a structure like this:

```
<txnmgr ...>
 <participant A />
 <participant B />
 ...
 ...
 <group name="GroupA">
  <participant A />
  <participant B />
  <participant C />
 </group>
 <group name="GroupB">
  <participant J />
  <participant K />
  <participant L />
 </group>
 <group name="GroupC">
  <participant X />
  <participant Y />
  <participant Z />
 </group>
 ...
 ...
</txnmgr>
```

### Example 9.1. Sample GroupSelector implementation

```
public class Switch implements GroupSelector {
    public int  prepare (long id, Serializable context) {
        return PREPARED | READONLY | NO_JOIN;
    }
    public void commit   (long id, Serializable context) { }
    public void abort    (long id, Serializable context) { }
    public String select (long id, Serializable context) {
        try {
            ISOMsg m = (ISOMsg) ((Context)context).get (ISOMSG);
            String groups = cfg.get (m.getMTI(), null);
            return groups;
        } catch (Exception e) {
            warn (e);
            return null;
        }
    }
}
```

By using the `Switch` presented in the previous example, you can write a TransactionManager configuration file like this:

```
...
...
<participant class="org.jpos.my.Switch" logger="Q2">
 <property name="0100" value="Authorization Response Log" />
 <property name="0200" value="Financial Response Log" />
 <property name="0220" value="Notification Response Log" />
 <property name="0221" value="Notification Response Log" />
 <property name="0420" value="Reversal Response Log" />
 <property name="0421" value="Reversal Response Log" />
 <property name="0500" value="BatchManagement Response Log" />
 <property name="0421" value="Reversal Response Log" />
 <property name="0800" value="NetworkManagement Response Log" />
</participant>
...
...
<group name="Financial">
 <participant class="com.my.company.CheckRequiredFields">
  <property name="fields" value="0,3,4,17,49,32,41,43,37,PAN,AMOUNT" />
 </participant>
 <participant class="com.my.company.CheckCurrency" />
 ...
 ...
</group>

<group name="Reversal">
 ...
 ...
</group>
...
...
```

Using the previous approach, the application can be designed using small reusable participants. Moreover, using XML entity expansion, the resulting configuration file can be very readable.

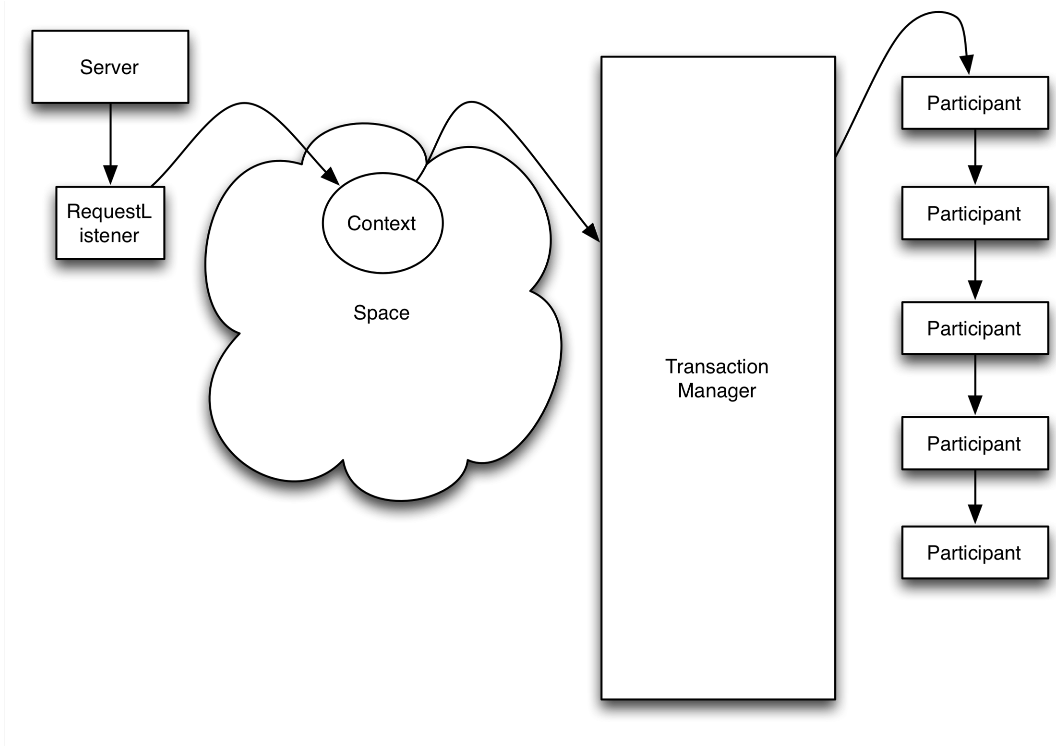
We have found it very useful to have very small participants to perform tasks like: Debug the context; introduce Delays (during testing); Open and Close O/R mapping sessions, etc.

## 9.7. TransactionManager implementation

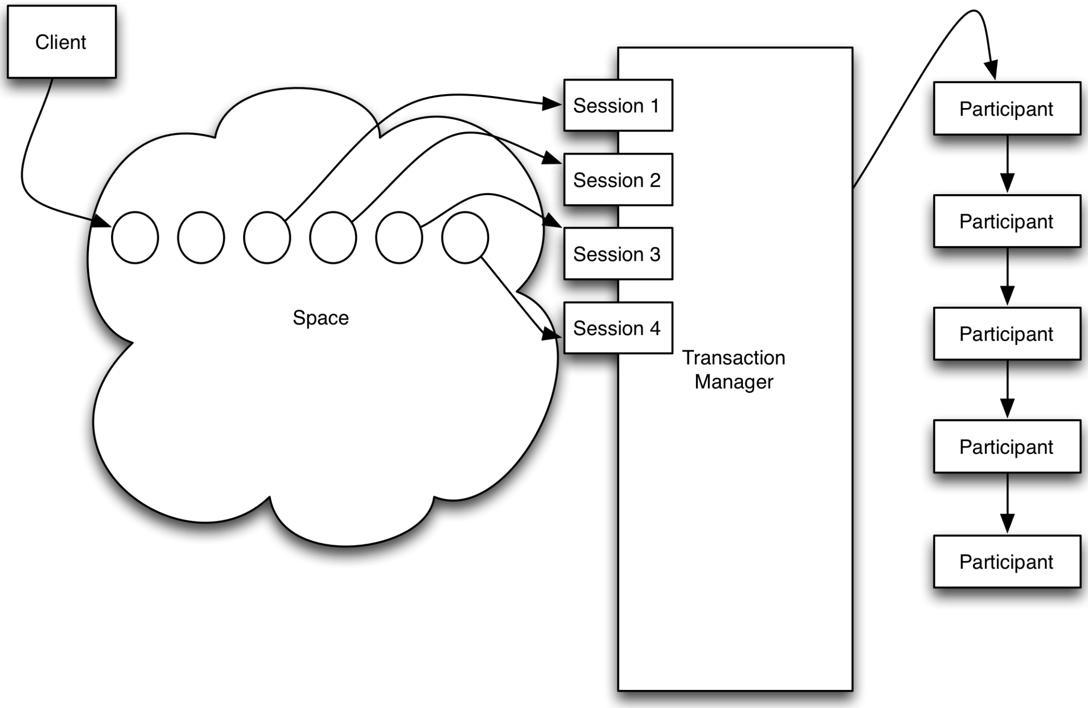
The `TransactionManager` is a jPOS Service that monitors a Space queue waiting for transactions to be processed. These transactions are expected to be any `Serializable` objects, but in most jPOS applications those are actually `org.jpos.transaction.Context` objects.

The following image shows a typical scenario:

- A QServer (or a QMUX) receives a message and delegate its handling to an `ISORequestListener` implementation
- The `ISORequestListener` creates an instance of a `Context`, puts there some information relevant to the transaction (such as a reference to the received `ISOMsg` and the originating `ISOSource`) and place it in a well known space, using a well known `key`. We use the space as a *queue* so we call it *queue*, but it's just a regular entry in the space under a well known name.
- The `TransactionManager` picks the entry from the space (using a regular `in` operation) and runs the previously described two-phase commit protocol on the configured participants.




Each participant is instantiated and configured just once by the TransactionManager at init time, they use the *Flyweight pattern*, but the TransactionManager uses several simultaneous sessions to handle transactions.




In the previous paragraph we mention that the TransactionManager uses the *Flyweight pattern*. It is extremely important to understand the pattern before implementing participants. Each participant is instantiated once, but multiple sessions can run simultaneously. In addition, sessions can be paused and continued. All session information must be stored in the Context, which the transaction manager appropriately sets before calling a participant, but **never ever** in member variables.

## 9.7.1. TM use of spaces

The TransactionManager uses 3 different spaces for operation.

We see in the previous diagram that the producer (depicted as *client* in the image) places entries in a Space, to be consumed by the TransactionManager.

This can be the general purpose *default* space (`tspace:default`), but in high demanding environments, it is possible to define a separate space, defined as `input-space`.

Internally, it also needs a transient space to keep track of the in-flight transactions. Again, if not specified, the TransactionManager will use `tspace:default`, but it is possible to configure a separate space for that using the `space` property in the XML configuration file.

For recovery purposes, a persistent space (defined with the property `persistent-space`) is required, i.e.: `je:XXXX` (XXXX being the name of the space). But taking snapshots to disk reduces the TM speed by probably an order of magnitude, and many applications that use the TransactionManager don't take advantage of its recovery features, this space defaults to an internal space.

## 9.7.2. Configuration

The TransactionManager is implemented by `org.jpos.transaction.TransactionManager` but `QFactory.properties` defines a couple of handy names for it:

- `txnmgr`, or
- `transaction-manager`

So a TM configuration can look like this:

```
<txnmgr name="myTM" logger="Q2" realm="TM">
  <property name="queue" value="myTMQueue" />
  ...
  ...
</txnmgr>
```

or

```
<transaction-manager name="myTM" logger="Q2" realm="TM">
  <property name="queue" value="myTMQueue" />
  ...
  ...
</transaction-manager>
```

The `name` attribute is not technically required, if ommitted, the transaction manager would get registered in the `NameRegistrar` using its root-element name (i.e.: `txnmgr` or `transaction-manager` depending on your configuration). But if you are deploying more than one TM in the same Q2 instance, the second one would get a `duplicate name` error, and your XML QBean descriptor would get renamed to `.DUP`. Using the `name` attribute with unique names solves the problem.

The TM requires a mandatory property (`queue`) and honors some optional ones, which have sensible defaults.

- **queue**
  This is the Space-based *queue* where the TM looks for transactions to be processed. As described above, these transactions are actually `Serializable` objects, typically an instance of `org.jpos.transaction.Context`. This is a mandatary property.
- **input-space**
  This is the Space where the TransactionManager's sessions wait for transactions to be queued. It defaults to the default space returned by `SpaceFactory.getSpace()` that is currently set to `tspace:default`.
- **space**
  Space used by the TransactionManager to handle in-flight transactions. The TM uses a Space-based circular queue. This Space also uses the system's default, but in high load systems it is reasonable to consider using a unique space for each TransactionManager.
- **persistent-space**
  If the application takes advantage of crash recovery features, a persistent space has to be defined. It can be any persistent space, such as `jdbm` or the more robust `je` based spaces (i.e. `je:mytm:/path/to/mytm`).
- **recover**
  When the TransactionManager starts, it checks the persistent space for in-flight transactions from a previous run. If this feature is not being used, it is recommended to set `recover` to false (although it doesn't hurt to keep it on in most situations).

- **debug**
  If true, the TransactionManager logs a small report after each transaction indicating which participants took place. The log looks like this:

```
<debug>
  txnmgr-1:2
          prepare: org.jpos.jcard.PrepareContext NO_JOIN
          prepare: org.jpos.jcard.CheckVersion READONLY NO_JOIN
          prepare: org.jpos.transaction.Open READONLY NO_JOIN
          prepare: org.jpos.jcard.Switch READONLY NO_JOIN
    groupSelector: notsupported prepareresponse close sendresponse
          prepare: org.jpos.jcard.NotSupported NO_JOIN
          prepare: org.jpos.jcard.PrepareResponse NO_JOIN
          prepare: org.jpos.transaction.Close READONLY
          prepare: org.jpos.jcard.SendResponse READONLY
          prepare: org.jpos.jcard.ProtectDebugInfo READONLY
          prepare: org.jpos.transaction.Debug READONLY
           commit: org.jpos.transaction.Close
           commit: org.jpos.jcard.SendResponse
           commit: org.jpos.jcard.ProtectDebugInfo
           commit: org.jpos.transaction.Debug
  head=3, tail=3, outstanding=0, active-sessions=2/2, tps=0, peak=0,
  avg=0.00, elapsed=22ms
</debug>
```

- **profiler**
  If the profiler property is set to true, in addition to the debug output, the TransactionManager records the time consumed by each participant callback. Setting profiler to `true` also sets `debug` to true automatically.

This adds the following information to the log

```
<debug>
  ....
  ....
  <profiler>
    prepare: org.jpos.jcard.PrepareContext [0.0/0.0]
    prepare: org.jpos.jcard.CheckVersion [0.0/0.0]
    prepare: org.jpos.transaction.Open [0.5/0.6]
    prepare: org.jpos.jcard.Switch [0.0/0.6]
    prepare: org.jpos.jcard.NotSupported [0.1/0.7]
    prepare: org.jpos.jcard.PrepareResponse [5.8/6.6]
    prepare: org.jpos.transaction.Close [0.0/6.6]
    prepare: org.jpos.jcard.SendResponse [0.0/6.6]
    prepare: org.jpos.jcard.ProtectDebugInfo [0.0/6.7]
    prepare: org.jpos.transaction.Debug [0.0/6.7]
     commit: org.jpos.transaction.Close [1.0/7.7]
     commit: org.jpos.jcard.SendResponse [4.3/12.0]
     commit: org.jpos.jcard.ProtectDebugInfo [0.2/12.3]
     commit: org.jpos.transaction.Debug [9.3/21.7]
    end [22.8/22.8]
  </profiler>
</debug>
```

- **sessions**
  Defines the number of simultaneous sessions (Threads) used to process transactions. Defaults to one. It is recommended to keep the `sessions` property within a reasonable value commensurate the number of CPU cores of the system. A large number here just slows down the capacity of the system.
- **max-sessions**
  In order to deal with occasional traffic spikes (sometimes caused by small network glitches), the TransactionManager can temporarily increase the number of sessions. This property defines that maximum. It defaults to the value set for `sessions`. For obvious reasons, `max-sessions` can't be less than `sessions`.

- **max-active-sessions**
  When using the TransactionManager *continuations* feature (where the prepare callback returns `PAUSE` modifier), it is possible that a small number of sessions can process a large number of in-flight transactions. Those transactions may place in the `Context` references to live objects such as JDBC sessions. In order to place a cap on the number of in-flight transactions to avoid exhausting resources (for example a JDBC pool), this `max-active-sessions` property can be set. The default is 0, which means no limit is imposed.

  If you're *pausing* your transactions, please read the previous paragraph multiple times and make sure you understand it.

- **call-selector-on-abort**
  The transaction manager calls the `prepare` method, and then, if the participant implements the `GroupSelector` interface, it calls its `select` method, regardless of the result of the `prepare` call. While in practice that's a reasonable and useful behavior, it can be argued that technically, the TM shouldn't call `select` if the transaction is bound to abort. We have provided this configuration parameter that can be set to `false` in order to enable that behavior.

### 9.7.3. TransactionStatusListener

It is possible to monitor a TransactionManager by adding a `TransactionListener`

The interface is very simple:

```
public interface TransactionStatusListener extends EventListener {
    public void update (TransactionStatusEvent e);
}
```

- see **TransactionStatusListener** [http://jpos.org/doc/javadoc/org/jpos/transaction/TransactionStatusListener.html] and
- **TransactionStatusEvent** [http://jpos.org/doc/javadoc/org/jpos/transaction/TransactionStatusEvent.html]

A `TransactionStatusListener` can be either added dynamically (using the `TransactionManager.addListener(TransactionStatusListener)` method) or using XML configuration like this:

```
<transaction-manager name="myTM" logger="Q2" realm="TM">
  ...
  ...
  <status-listener class="your.transaction.Listener" />
  ...
  ...
</transaction-manager>
```

standard logger, realm, and properties can be used.

Calls to the transaction status listener are synchronous, the implementation is expected to return really fast.

The `TMMON` CLI command (see **the section called “`--cli`”**) is an example of a `TransactionStatusListener` interface and so is the `org.jpos.transaction.gui.TMMonitor` implementation.

# 9.8. JSParticipant

The `org.jpos.transaction.participant.JSParticipant` is a handy stock participant that leverages Java 8 Nashorn.

Here is a sample invocation:

```
<participant class="org.jpos.transaction.participant.JSParticipant"
    logger="Q2" realm="js" src='deploy/test.js' />
```

And here is a sample script:

```
var K = Java.type("org.jpos.transaction.TransactionConstants");

var prepare = function(id, ctx) {
    var map = ctx.getMap();
    ctx.log ("Prepare has been called");
    ctx.log (map.TIMESTAMP);
    map.NEWPROPERTY='ABC';
    return K.PREPARED;
}

var prepareForAbort = function(id, ctx) {
    ctx.put ("Test", "Test from JS transaction $id");
    ctx.log ("prepareForAbort has been called");
    return K.PREPARED;
}

var commit = function(id, ctx) {
    ctx.log ("Commit has been called");
}

var abort = function(id, ctx) {
    ctx.log ("Abort has been called");
}
```

# Appendix A. Getting involved

Most action happens in the **jPOS Users** [http://groups.google.com/group/jpos-users] mailing list.

There you'll find over a thousand jPOS users and developers sharing useful information about jPOS and related technology, use cases as well as success stories.

There's an older **jPOS Developers** [http://tech.groups.yahoo.com/group/jpos-dev] mailing list that we keep as read-only reference, we rarely use it for new content.

The source code is hosted in **Github/jPOS** [http://github.com/jpos/jPOS]. Commits are automatically posted on Twitter **@jposcommits** [https://twitter.com/jposcommits] and the `#jpos` channel in `irc.freenode.net`.

There's a low traffic **jPOS Announcements** [http://jpos.org] mailing list and **jPOS Blog** [http://jpos.org/blog].

For additional resources, you can visit the **jPOS Resources** [http://jpos.org/resources] page.

### Example A.1. jPOS Team

See the **CREDITS** [https://github.com/jpos/jPOS/blob/master/CREDITS] page for a larger list of contributors. If you feel you belong to that list and you're not there, just drop us an email.

For significants code contributions to the project, users are required to sign a standard **Contributor License Agreement** [https://github.com/jpos/jPOS/blob/master/legal/cla-template.txt]. For company contributions, an additional **Corporate Contributor License Agreement** [https://github.com/jpos/jPOS/blob/master/legal/cla-template.txt] may be required.

You can find jPOS users online in `irc.freenode.net`, on the `#jpos` channel. jPOS Consulting office is usually online from 1600 to 2000 GMT.

# Appendix B. License

**GNU AFFERO GENERAL PUBLIC LICENSE**

Version 3, 19 November 2007



**Preamble**

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The "source code" for a work means the preferred form of the work for making modifications to it. "Object code" means any non-source form of a work.

A "Standard Interface" means an interface that either is an official standard defined by a recognized standards body, or, in the case of interfaces specified for a particular programming language, one that is widely used among developers working in that language.

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b. Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by a written offer, valid for at least three years and valid for as long as you offer spare parts or customer support for that product model, to give anyone who possesses the object code either (1) a copy of the Corresponding Source for all the software in the product that is covered by this License, on a durable physical medium customarily used for software interchange, for a price no more than your reasonable cost of physically performing this conveying of source, or (2) access to copy the Corresponding Source from a network server at no charge.
c. Convey individual copies of the object code with a copy of the written offer to provide the Corresponding Source. This alternative is allowed only occasionally and noncommercially, and only if you received the object code with such an offer, in accord with subsection 6b.
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