Java NIO vs. IO

Jakob Jenkov
Last update: 2014-06-23

When studying both the Java NIO and IO API's, a question quickly pops into mind:

When should I use IO and when should I use NIO?

In this text I will try to shed some light on the differences between Java NIO and IO, their use cases, and how they affect the design of your code.

Main Differences Betwen Java NIO and IO

The table below summarizes the main differences between Java NIO and IO. I will get into more detail about each difference in the sections following the table.

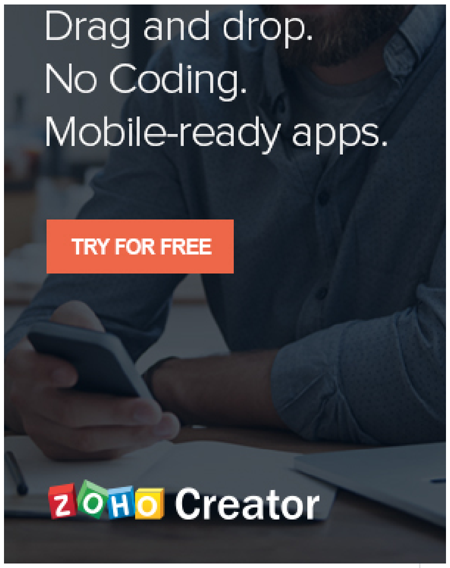
IO	NIO
Stream oriented	Buffer oriented
Blocking IO	Non blocking IO
	Selectors

Stream Oriented vs. Buffer Oriented

The first big difference between Java NIO and IO is that IO is stream oriented, where NIO is buffer oriented. So, what does that mean?

Java IO being stream oriented means that you read one or more bytes at a time, from a stream. What you do with the read bytes is up to you. They are not cached anywhere. Furthermore, you cannot move forth and back in the data in a stream. If you need to move forth and back in the data read from a stream, you will need to cache it in a buffer first.

Java NIO's buffer oriented approach is slightly different. Data is read into a buffer from which it is later processed. You can move forth and back in the buffer as you need to. This gives you a bit more flexibility during processing. However, you also need to check if the buffer contains all the data you need in order to fully process it. And, you need to make sure that when reading more data into the buffer, you do not overwrite data in the buffer you have not yet processed.



data in the buffer you have not yet processed.

Blocking vs. Non-blocking IO

Java IO's various streams are blocking. That means, that when a thread invokes a `read()` or `write()`, that thread is blocked until there is some data to read, or the data is fully written. The thread can do nothing else in the meantime.

Java NIO's non-blocking mode enables a thread to request reading data from a channel, and only get what is currently available, or nothing at all, if no data is currently available. Rather than remain blocked until data becomes available for reading, the thread can go on with something else.

The same is true for non-blocking writing. A thread can request that some data be written to a channel, but not wait for it to be fully written. The thread can then go on and do something else in the mean time.

What threads spend their idle time on when not blocked in IO calls, is usually performing IO on other channels in the meantime. That is, a single thread can now manage multiple channels of input and output.

Selectors

Java NIO's selectors allow a single thread to monitor multiple channels of input. You can register multiple channels with a selector, then use a single thread to "select" the channels that have input available for processing, or select the channels that are ready for writing. This selector mechanism makes it easy for a single thread to manage multiple channels.

How NIO and IO Influences Application Design

Whether you choose NIO or IO as your IO toolkit may impact the following aspects of your application design:

1. The API calls to the NIO or IO classes.
2. The processing of data.
3. The number of thread used to process the data.

The API Calls

Of course the API calls when using NIO look different than when using IO. This is no surprise. Rather than just read the data byte for byte from e.g. an `InputStream`, the data must first be read into a buffer, and then be processed from there.

The Processing of Data

The processing of the data is also affected when using a pure NIO design, vs. an IO design.

In an IO design you read the data byte for byte from an `InputStream` or a `Reader`. Imagine you were processing a stream of line based textual data. For instance:

```
Name: Anna
Age: 25
Email: anna@mailserver.com
Phone: 1234567890
```

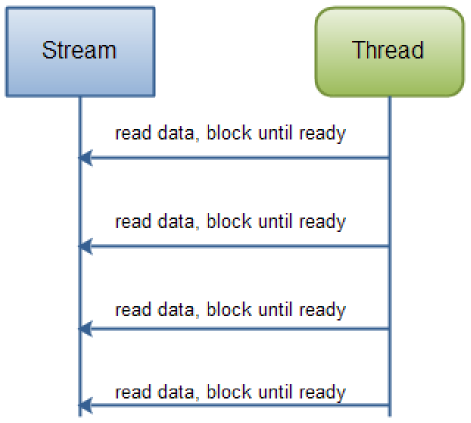
This stream of text lines could be processed like this:

```
InputStream input = ... ; // get the InputStream from the client socket

BufferedReader reader = new BufferedReader(new InputStreamReader(input));

String nameLine   = reader.readLine();
String ageLine    = reader.readLine();
String emailLine  = reader.readLine();
String phoneLine  = reader.readLine();
```

Notice how the processing state is determined by how far the program has executed. In other words, once the first `reader.readLine()` method returns, you know for sure that a full line of text has been read. The `readLine()` blocks until a full line is read, that's why. You also know that this line contains the name. Similarly, when the second `readLine()` call returns, you know that this line contains the age etc.

readLine() call returns, you know that this line contains the age etc.

past reading a certain piece of data in the code, the thread is not going backwards in the data (mostly not). This principle is also illustrated in this diagram:


Stream
Thread
read data, block until ready
read data, block until ready
read data, block until ready
read data, block until ready

Java IO: Reading data from a blocking stream.

A NIO implementation would look different. Here is a simplified example:

```
ByteBuffer buffer = ByteBuffer.allocate(48);

int bytesRead = inChannel.read(buffer);
```

Notice the second line which reads bytes from the channel into the `ByteBuffer`. When that method call returns you don't know if all the data you need is inside the buffer. All you know is that the buffer contains some bytes. This makes processing somewhat harder.

Imagine if, after the first `read(buffer)` call, that all what was read into the buffer was half a line. For instance, "Name: An". Can you process that data? Not really. You need to wait until at leas a full line of data has been into the buffer, before it makes sense to process any of the data at all.

So how do you know if the buffer contains enough data for it to make sense to be processed? Well, you don't. The only way to find out, is to look at the data in the buffer. The result is, that you may have to inspect the data in the buffer several times before you know if all the data is inthere. This is both inefficient, and can become messy in terms of program design. For instance:

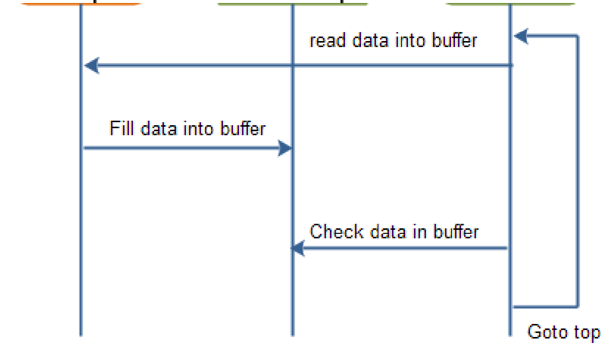
```
ByteBuffer buffer = ByteBuffer.allocate(48);

int bytesRead = inChannel.read(buffer);

while(! bufferFull(bytesRead) ) {
    bytesRead = inChannel.read(buffer);
}
```

The `bufferFull()` method has to keep track of how much data is read into the buffer, and return either `true` or `false`, depending on whether the buffer is full. In other words, if the buffer is ready for processing, it is considered full.

The `bufferFull()` method scans through the buffer, but must leave the buffer in the same state as before the `bufferFull()` method was called. If not, the next data read into the buffer might not be read in at the correct location. This is not impossible, but it is yet another issue to watch out for.

If the buffer is full, it can be processed. If it is not full, you might be able to partially process whatever data is there, if that makes sense in your particular case. In many cases it doesn't.

The is-data-in-buffer-ready loop is illustrated in this diagram:

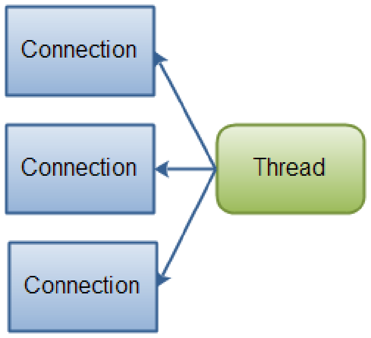


Java NIO: Reading data from a channel until all needed data is in buffer.

Summary

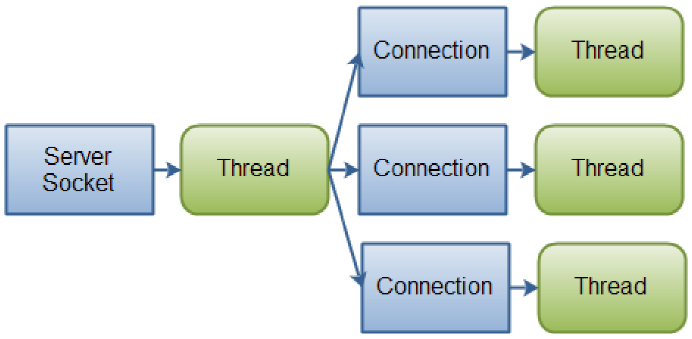
NIO allows you to manage multiple channels (network connections or files) using only a single (or few) threads, but the cost is that parsing the data might be somewhat more complicated than when reading data from a blocking stream.

If you need to manage thousands of open connections simultanously, which each only send a little data, for instance a chat server, implementing the server in NIO is probably an advantage. Similarly, if you need to keep a lot of open connections to other computers, e.g. in a P2P network, using a single thread to manage all of your outbound connections might be an advantage. This one thread, multiple connections design is illustrated in this diagram:



Java NIO: A single thread managing multiple connections.

If you have fewer connections with very high bandwidth, sending a lot of data at a time, perhaps a classic IO server implementation might be the best fit. This diagram illustrates a classic IO server design:



Java IO: A classic IO server design - one connection handled by one thread.

Share Tweet

Jakob Jenkov

5 Comments **tutorials.jenkov.com** 1 **Login**

Recommend 5 **Share** **Sort by Best**

Join the discussionâ€¦

Tomer Ben David â€¢ 2 years ago
Perfect! So Clear!
2 | â€¢ Reply â€¢ Share â€º

Bharath Paturi â€¢ 2 years ago
nice examples regarding when to apply NIO or IO
1 | â€¢ Reply â€¢ Share â€º

המבקר â€¢ a year ago
thanks for explaining it so clearly
| â€¢ Reply â€¢ Share â€º

Sai Dubbaka â€¢ a year ago
Nice post, Thanks
| â€¢ Reply â€¢ Share â€º

Cognos Chen â€¢ 2 years ago
Helpful ! Thank you!
| â€¢ Reply â€¢ Share â€º

ALSO ON **TUTORIALS.JENKOV.COM**

HTML Text Formatting Elements
2 comments • 2 years ago•
Jakob Jenkov — yes

Java JSON Tutorial
1 comment • 2 years ago•
Ravi — simple and nice

Android Buttons
1 comment • 2 years ago•
Nicolas Ta — Thanks, Short and easy to understand

Android Web Apps Using Android WebView
12 comments • 2 years ago•
Jakob Jenkov — Hi Eric, to do that you must load the content of the URL into a byte array, manipulate that byte array, and then pass the manipulated byte array on to the WebView. To do so …

Subscribe **Add Disqus to your site Add Disqus Add** **Privacy**