Chapter-7
Java NIO

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This Presentation:

- What NIO provides
- A short “tutorial-like” introduction to NIO

What is Java NIO?

- Stands for New IO.
- Started off as a JSR under Sun’s JCP (JSR51).

“APIs for scalable I/O, fast buffered binary and character I/O, regular expressions, charset conversion, and an improved filesystem interface.”

Should I Stop Using `java.io`?

- Nope
- `java.nio` is not a replacement for `java.io`
- NIO addresses different needs
- `java.io` is not going away

What Makes Up NIO?

- Buffers
- Channels
- Selectors
- Regular Expressions
- Character Set Coding

How does it do it?

- An API for scalable I/O operations on both files and sockets, in the form of either asynchronous requests or polling;
- An API for fast buffered binary I/O, including the ability to map files into memory when that is supported by the underlying platform;
- An API for fast buffered character I/O, including a simple parsing facility based upon regular expressions and a simple printf-style formatting facility;

JDK 1.4.x

- Provides the package java.nio

- This package is a subset of JSR-51. In particular, proposed file-handling functionality is absent

So what does NIO give us?

- A lot – but not everything
- Native code is still required – but you lose portability
- …but some of the things that could be done before only with native code are now provided in NIO

The java.nio API

- java.nio
  - □ java.nio.*
  - □ java.nio.charset and java.nio.charset.spi
  - □ java.nio.channels and java.nio.channels.spi

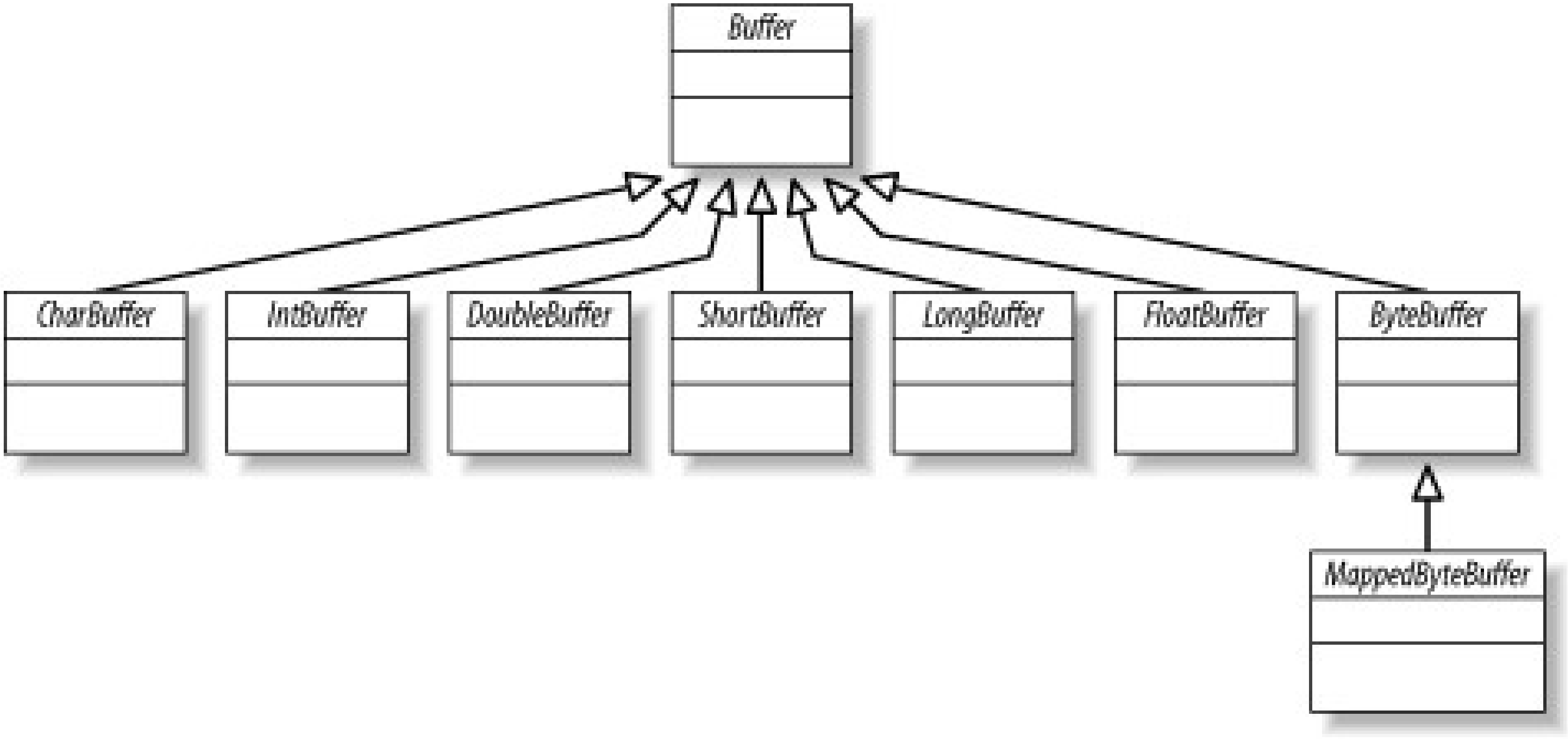
java.nio.*

- A whole set of abstract buffers classes, all extending the abstract class java.nio.buffer
- eg: ByteBuffer, CharBuffer, DoubleBuffer, FloatBuffer, IntBuffer, LongBuffer, ShortBuffer
- Set of methods: reset(), flip(), etc.
- 0 <= *mark* <= *position* <= *limit* <= *capacity*

NIO Buffers

- Fixed size containers of primitive data types
  - ByteBuffer, CharBuffer, FloatBuffer, etc.
- Byte buffers are special, used for I/O with channels
- Direct and Non-direct ByteBuffers
  - Direct ByteBuffers address raw memory – direct I/O
- Buffers can be views of other buffers or wrap arrays
- Byte order (endian-ness)
  - Affects byte swabbing in views of ByteBuffers

Buffer Classes



Hello NIO Example?

```
    import java.nio.ByteBuffer;
    import java.nio.channels.WritableByteChannel;
    import java.nio.channels.Channels;

    public class HelloWorldNio
    {
          public static void main (String [] argv)
                 throws Exception
          {
                 String hello = "Hello World" + System.getProperty
    ("line.separator");
                 ByteBuffer bb = ByteBuffer.wrap (hello.getBytes ("UTF-8"));
                 WritableByteChannel wbc = Channels.newChannel (System.out);

                 wbc.write (bb);
                 wbc.close();
          }
    }
```

java.nio.channels

- Selector provider in .channels.spi provides the abstract class by which the Java virtual machine maintains a single system-wide default provider instance

- The provider provides instances of DatagramChannel, Pipe, Selector, ServerSocketChannel, and SocketChannel

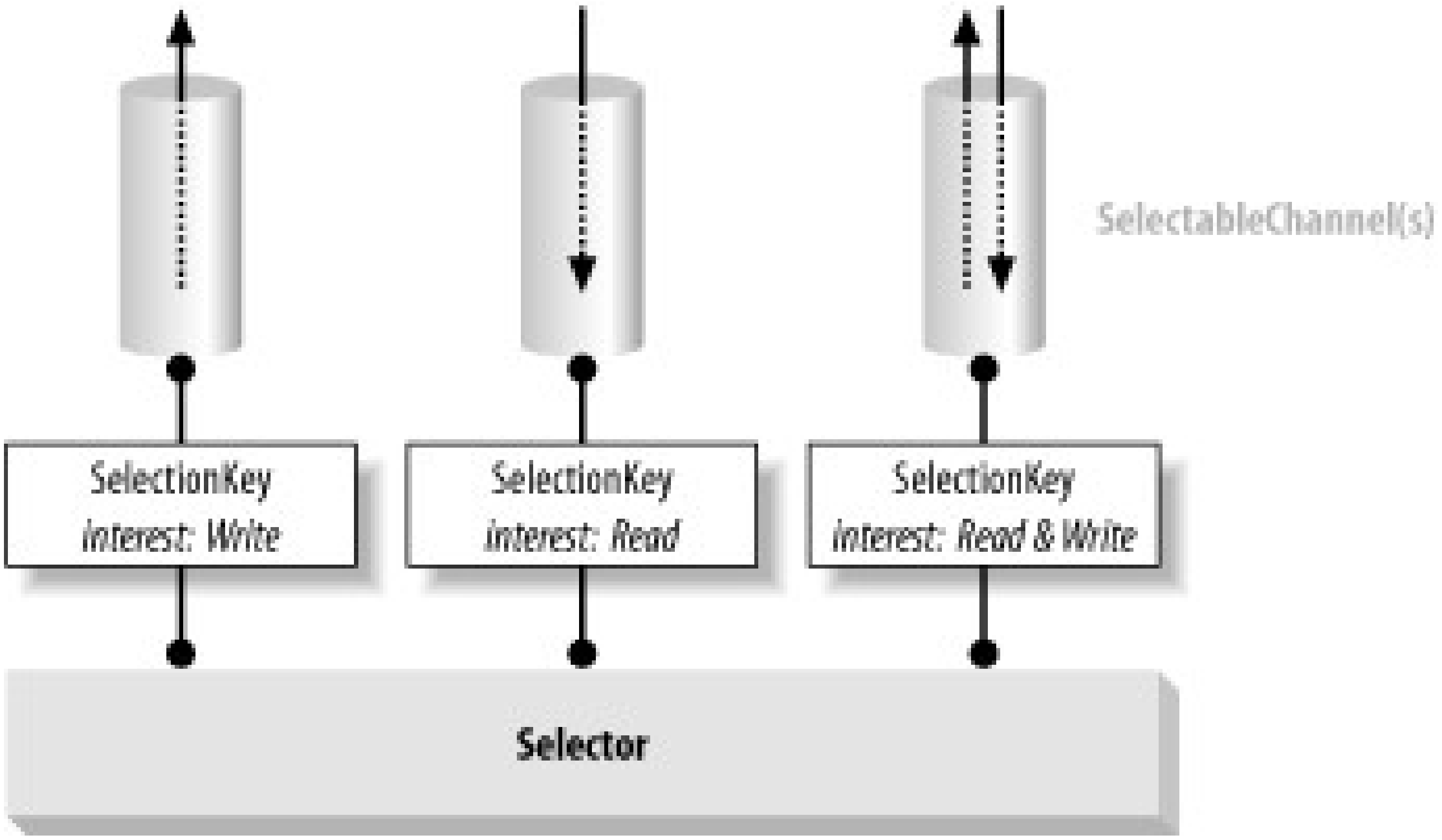
NIO Channels

- New I/O metaphor: Conduit to an I/O service (“nexus”)
- Channels do bulk data transfers to and from buffers
  - `channel.write (buffer)   ~=   buffer.get (byteArray)`
  - `channel.read (buffer)    ~=   buffer.put (byteArray)`
- Scatter/gather, channel-to-channel transfers
- Three primary channel implementations
  - FileChannel: File locks, memory mapping, cross-connect transfers
  - Sockets: Non-blocking, selectable, async connections, peers
  - Pipe: loopback channel pair, selectable, generic channels
- Selectable Channel Implementations are pluggable (SPI)

NIO Selectors

- Multiplexing Channels – Readiness Selection
- Selectable Channels are registered with Selectors
  - SelectionKey encapsulates selector/channel relationship
- A subset of *ready* channels is *selected* from the Selector's set of registered channels (**`Selector.select()`**)
  - *Selected Set contains those keys with non-empty Ready Sets*
- Each SelectionKey holds an Interest Set and a Ready Set
  - *Possible members of Interest Set: accept, read, write, connect*
  - *Ready set is a subset of interest set –as-of the last* ***`select()`*** *call*
- Readiness Selection means less work – ignore idle channels

Selectors, Keys and Channels



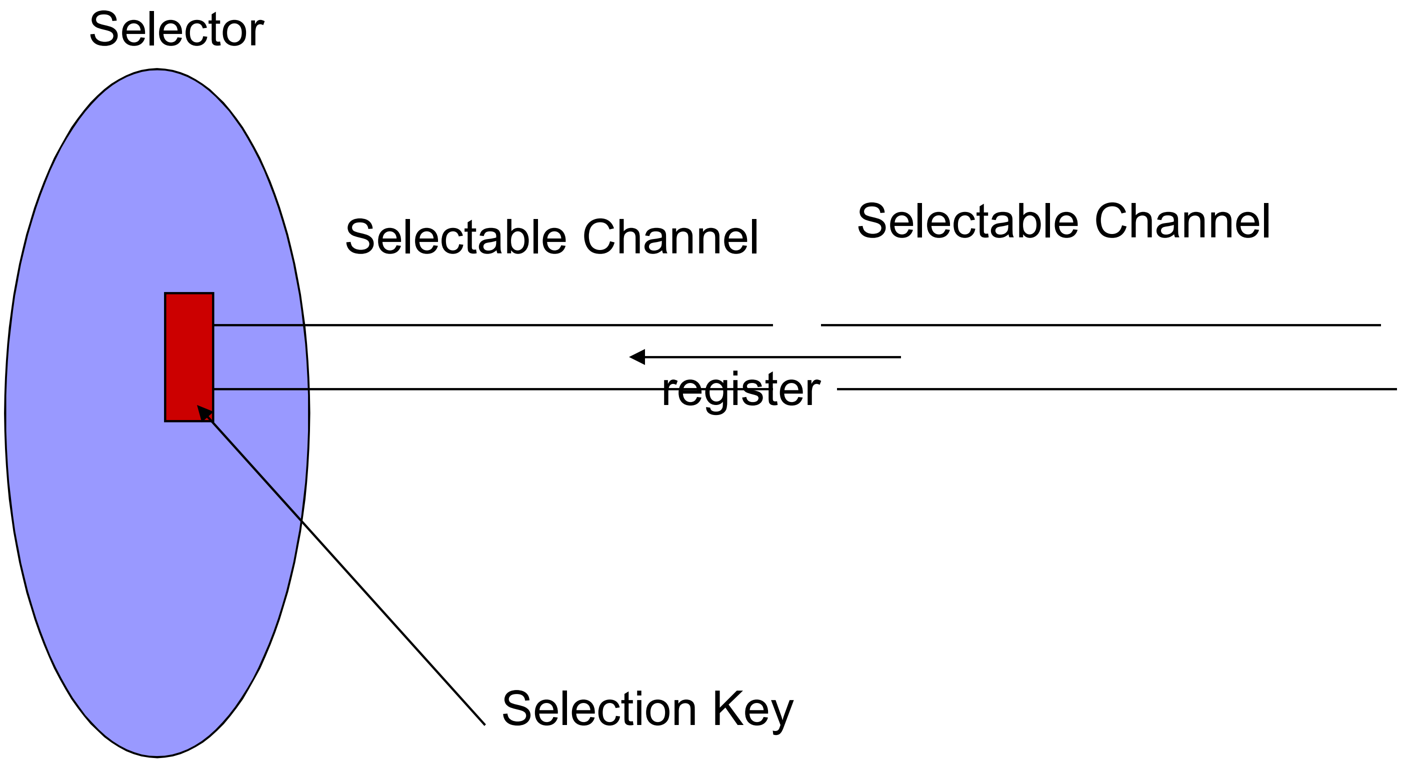
Registering With a Selector

```
ServerSocketChannel serverChannel = ServerSocketChannel.open();
Selector selector = Selector.open();

serverChannel.socket().bind (new InetSocketAddress (port));
serverChannel.configureBlocking (false);
serverChannel.register (selector, SelectionKey.OP_ACCEPT);
```

The Selection Process

- Create a Selector and register channels with it
    - The **`register()`** method is on SelectableChannel, not Selector
- Invoke **`select()`** on the Selector object
- Retrieve the Selected Set of keys from the Selector
    - Selected set: Registered keys with non-empty Ready Sets
    - **`keys = selector.selectedKeys()`**
- Iterate over the Selected Set
    - Check each key's Ready Set (set of operations ready to go as-of last **`select()`**)
    - Remove the key from the Selected Set (**`iterator.remove()`**)
        - Bits in the Ready Sets are never reset while the key is in the Selected Set
        - The Selector never removes keys from the Selected Set – you must do so
    - Service the channel (**`key.channel()`**) as appropriate (read, write, etc)


Selector
Selectable Channel
Selectable Channel
register
Selection Key

Selectors

- A selector maintains three sets of selection keys
  - □ The *key set*
  - □ The *selected-key set*
  - □ The *cancelled-key*

- Event driven – block for events on selection

- Selection is done by select(), selectNow() and select(int timeout). Returns the selected key set.

Selection Keys

- A selection key is created each time a channel is registered with a selector

- A selection key contains two *operation sets*
  - Interest Set
  - Ready Set

Conclusion

- Useful and long awaited addition to Java
- Will make message-passing applications more scalable